MIAMI-DADE COUNTY ENVIRONMENTALLY ENDANGERED LANDS PROGRAM MANAGEMENT PLAN

PART II: MANAGEMENT OF SPECIFIC HABITAT TYPES

CHAPTER 1: THE PINE ROCKLAND HABITAT

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List of Acronyms

DERM	**Department of Environmental Resources Management**
EEL	**Environmentally Endangered Lands**
ENP	**Everglades National Park**
FLEPPC	**Florida Exotic Pest Plant Council**
FNAI	**Florida Natural Areas Inventory**
FTBG	**Fairchild Tropical Botanic Garden**
FWCC	**Florida Fish and Wildlife Conservation Commission**
GIS	**Geographic Information System**
IRC	**The Institute for Regional Conservation**
MDC	**Miami-Dade County**
NAM	**Natural Areas Management**
NFC	**Natural Forest Community**
RIFA	**Red Imported Fire Any**
SSC	**Species of Special Concern**
USFWS	**United States Fish and Wildlife Service**

1.0 Introduction

Pine rocklands are one of the priority ecosystems for conservation efforts in the Miami-Dade County (MDC) Environmentally Endangered Lands (EEL) Program. As settlers arrived in the area that is now Miami-Dade County, they found that rocklands in the Miami Rock Ridge, in general, were the most suitable areas for settlement. The relatively high elevation of the pine rocklands in the landscape provided reasonable protection against flooding, while allowing the people to remain close to valuable natural resources such as agricultural soils, timber, and fisheries.

Unfortunately, this ecosystem has now been almost entirely destroyed by agricultural, urban, and suburban development. Current estimates suggest that less than 1.8% of the original 126,500 acres of pine rockland ecosystem outside of Everglades National Park (ENP) remains today in Miami-Dade County. These approximately 2,273 acres of pine rocklands exist in scattered, small parcels. Furthermore, the pine rockland fragments that do remain have suffered from impacts of forest fragmentation, fire suppression, exotic pest invasions, and other forms of disturbance. Therefore, pine rockland fragments that have been acquired by the EEL program must be managed to ensure their long term viability.

1.1 Overview of the Pine Rockland Ecosystem

The pine rockland ecosystem is the most diverse ecosystem in the EEL program. This ecosystem contains a wide-ranging assemblage of rare plants and animals. Many organisms restricted to the habitat are endemic, occurring nowhere else in the world. These organisms are part of a diverse system that is influenced by a number of natural stressors, such as fires, the regular occurrence of tropical cyclones, and the rather sporadic incidence of frosts. These natural processes shape the structure and composition of pine rocklands and determine the ecological characteristics of the ecosystem.

The pine rockland ecosystem is a pine woodland growing in a thin layer of sand or loam in a matrix of exposed oolitic limestone substrate. Pre-drainage hydrology of pine rocklands varied greatly depending upon elevation, with some pine rocklands probably never flooding and others probably flooding annually for short periods during the summer wet season. Typically pine rocklands consist of three vegetation layers – a canopy, a subcanopy, and an herb layer. The canopy of pine rocklands is dominated by a single species, South Florida slash pine[1]. The subcanopy of pine rocklands consists of an array of temperate and tropical hardwoods and palms. Palms in this layer include saw palmetto, cabbage palm, and silver palm, with saw palmetto being the most common and typically a dominant species in all pine rockland areas. The herb layer consists of temperate and tropical forbs, grasses, ferns, and sedges. At present, examples of the common herbs in pine rocklands are the pine fern, low rattlebox, and Florida five-petalled leafflower (Bradley, unpublished data).

Pine rockland occurs in South Florida and on several islands in the Bahamian archipelago. In southern Florida, it is found in Miami-Dade County, Monroe County in the lower Florida Keys,

[1] For reference, a table of all species common names and equivalent scientific names discussed throughout the management plan is provided in Appendix A.

and small areas of the Big Cypress National Preserve in Collier and Monroe counties. This chapter will focus on the pine rockland ecosystem in Miami-Dade County, where the ecosystem has been almost entirely destroyed by agricultural, urban, and suburban development. Only scattered, small parcels remain today. The pine rockland fragments that do remain have suffered from impacts of forest fragmentation, fire suppression, exotic pest invasions, and other forms of disturbance. Fragments that have been acquired by the EEL program must be managed to ensure their long term viability.

1.2 Purpose

The purpose of this plan is to contribute to the preservation of the natural resources in pine rockland sites owned and/or managed by EEL. To achieve this purpose, this management plan provides:

- A brief description of the values and justification for conservation of pine rocklands
- A historical perspective of pine rockland presence in the landscape of the county
- Current conditions of the pine rockland habitat
- Main threats to the pine rockland habitat
- Perceived trends within the pine rockland habitat
- Management issues that are important to conservation of pine rocklands
- Guidelines for future public use
- Priorities for monitoring and research

This plan draws from other resources, including the Restoration Plan for Dade County's Pine Rockland Forests Following Hurricane Andrew (DERM 1995), the Miami-Dade County Habitat Management Plan (Miami-Dade County Natural Areas Management Working Group 2004), and the pine rockland chapter of the South Florida Multi-Species Recovery Plan (USFWS 2000). Recommendations from these documents, as well as many other resources cited in the references section, have been reviewed, and when relevant and acceptable, used in this management plan. This chapter is intended not only to guide management of pine rocklands on EEL sites, but also other pine rockland fragments in Miami-Dade County.

2.0 Historical Reference Conditions for the Pine Rockland Ecosystem

This section describes the historical condition of Miami-Dade County pine rocklands, as they existed prior to major human disturbance. In considering conservation goals and alternatives, the historical condition described is regarded as the baseline for the ecosystem. Utilizing these conditions as a basis for weighing the importance of conservation efforts will aid in the preservation of the valuable resources associated with pine rocklands in Miami-Dade County and South Florida overall.

2.1 Original Pine Rockland Distribution in Miami-Dade County

Pine rockland in Miami-Dade County historically occurred on the Miami Rock Ridge. The Miami Rock Ridge is an oolitic limestone formation that extends from north of downtown Miami in a southwesterly arc to Mahogany Hammock in ENP, varying in width from four (4) to ten (10) miles. In historic conditions, the ridge was at a higher elevation than the adjacent marshes of the Everglades, with small wetland prairies dissecting the ridge into numerous, distinct islands (**Figure 1**). This matrix of limestone and prairies allowed the Everglades to drain into Biscayne Bay.

On the Miami-Rock Ridge, pine rockland was historically the dominant habitat. Of the 151,000 acres that the ridge historically occupied, almost all of the area was pine rockland. Only small areas of the ridge were occupied by rockland hammock or other ecosystems.

2.2 Physiography

As discussed above, pine rocklands in Miami-Dade County occur on the Miami Rock Ridge. This ridge varies in elevation between two (2) and 20 feet above sea level. Elevations are highest in the Coconut Grove area and generally decline to the south (Craighead 1971). Other relevant aspects of the physiography (geology, soils, and hydrology) of the pine rocklands are discussed in the paragraphs below.

2.2.1 Geology

The geology and soils of Miami-Dade's pine rocklands have a relatively simple structure and are derived from recent geologic history. The surface rocks of the county, exposed in many locations, are nearly all Miami Limestone, a formation produced in the most recent interglacial period of the Pleistocene Epoch when sea level was about 25 feet above today's level. The interglacial period gradually ended about 100,000 years before present. The parent material deposited during the interglacial time was grains of calcium carbonate, formed by two shallow-marine processes. Along the eastern edge of the county's mainland where accumulations were thicker, the material consisted of small (but visible) egg-shaped grains of calcium carbonate called "ooids." These oolitic deposits thinned westward, away from the deeper waters of the Atlantic, where they intergraded with fine-grained (microscopic) calcium carbonate particles deposited from marine algae and the shells of tiny animals called bryozoans in a calmer shallow marine interglacial environment away from more turbulent coastal waters. (Lodge 2005)

The most recent glacial period (with the glacial maximum occurring approximately 20,000 years ago), caused much lower sea levels that exposed the sediments. The oolites were initially sand-

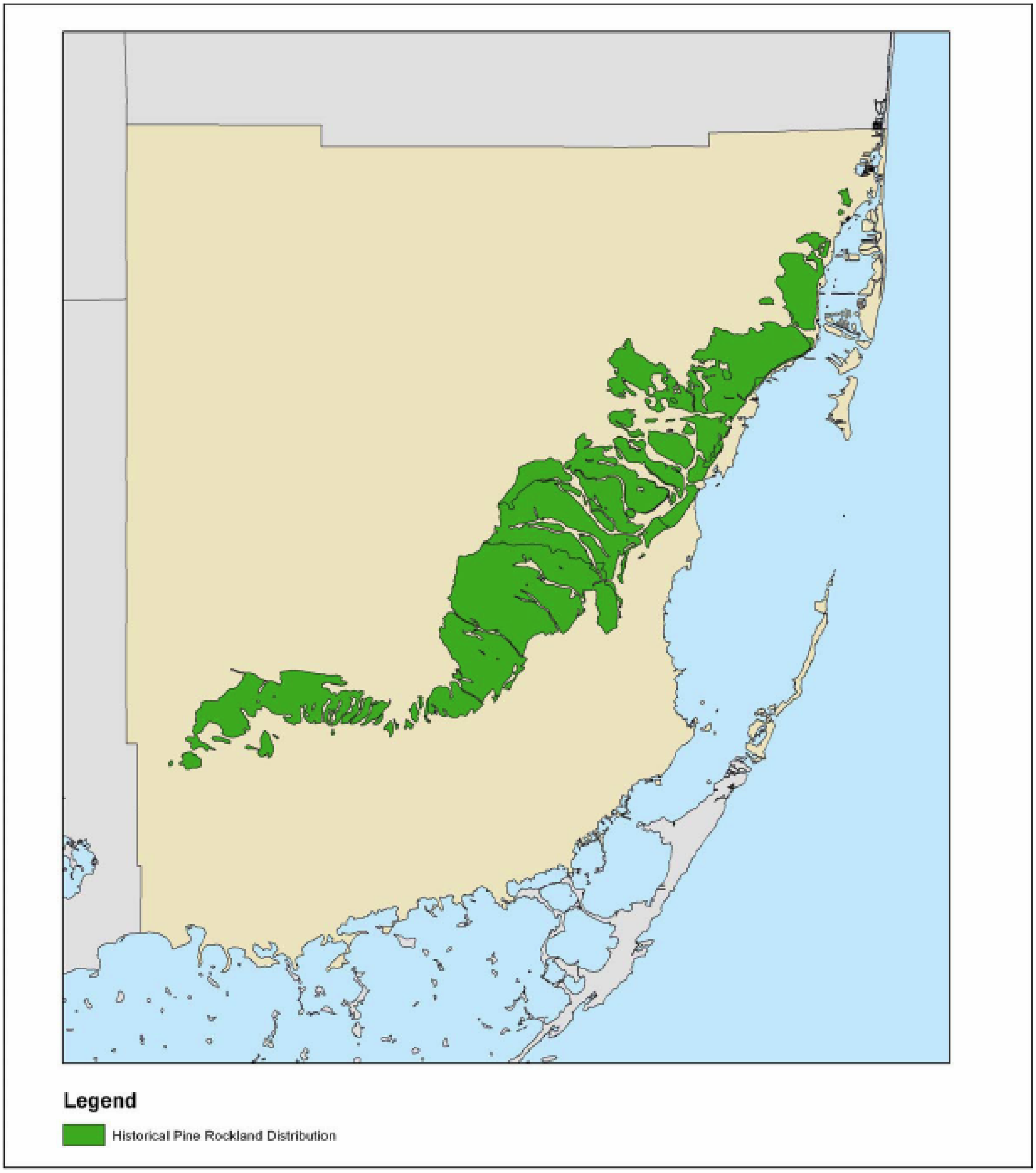

Figure 1: Historical Pine Rockland Habitat Distribution in Miami-Dade County

Project: Miam-Dade County Environmentally Endangered Lands Program Management Plan
Location: Miami-Dade County, Florida
Source: Keith A. Bradley, Unpublished Data

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like and subject to wind redistribution and dune formation. Percolation of rainwater gradually solidified the grains by recrystallization into the soft rock we now recognize as Miami Limestone. (Lodge 2005)

2.2.2 Soils

The presence of a limestone substrate is a major defining character of the pine rockland ecosystem which differentiates it from other types of pine-dominated ecosystems in Florida. Soils in pine rocklands, when present, are usually nutrient-poor sand or loam in a matrix of exposed oolitic limestone. Soil type varies with geographic location on the Miami Rock Ridge. There are two main soil types in Miami-Dade's pine rocklands outside of ENP. The USDA (1996) has mapped these as Cardsound Rock Outcrop Complex and Opalocka Rock Outcrop Complex. Each of these soils, when present, typically occurs as thin layers over the oolitic limestone substrate, with much of the limestone breaking the surface of the soil deposit. Opalocka Rock Outcrop Complex soil occurs north of the Goulds region. Robertson (1955) referred to the region covered by this soil as the northern Biscayne pinelands. This soil is a highly permeable quartz sand, which is usually white to brown in color (USDA 1996) and slightly basic (Craighead 1971, USFWS 2000). The amount and depth of the quartz sands varies with latitude. To the north, where the Miami Rock Ridge formerly merged with the sandy Atlantic Coastal Ridge, sands were probably very extensive and deep (examples are now destroyed). On some more northerly pine rockland fragments that currently exist, such as the Ludlam Pineland and Rockdale Pineland EEL sites, the sands can be several feet thick and have areas with little or no exposed limestone. In contrast, pine rocklands further south, such as those at Larry and Penny Thompson Park, have thinner deposits of sand, which cover less area.

Cardsound Rock Outcrop Complex soil occurs south of the Goulds Region. Robertson (1955) referred to the region covered by these soils as the southern Biscayne pinelands. This silty loam soil is slightly basic (Craighead 1971, USFWS 2000) and dark reddish to brown in color (typically called "Redland Soil") (USDA 1996). It was from the color of this soil that the "Redlands" area of southern Miami-Dade County derived its name. Cardsound soil is usually only about four (4) inches thick and soil permeability is moderately slow (USDA 1996). Unlike Opalocka soil, there is very little visible Cardsound soil in pine rocklands. The existing deposits usually cover very small areas of a few square meters or less.

Pine rocklands are also known to contain features called solution holes. Solution holes are "steep-sided pits of varying sizes formed by the dissolution of rock below the surface followed by collapse at the top" (Myers and Ewel 1990). Deeper deposits of typically organic soil, non-characteristic of the typical nutrient-poor sand or loam found in pine rocklands, may be found within these holes.

2.2.3 Hydrology

Pre-drainage hydrology of pine rocklands varied greatly depending upon elevation. Some pine rocklands, especially those further north in the county, probably never flooded, or flooded for only very brief periods during major high water events. Other pine rocklands, such as those along the west edge of the western Miami Rock Ridge or along the edges of the Transverse Glades, probably flooded annually for short periods during the summer wet season. Pine rocklands on Long Pine Key in ENP may flood for 20 to 60 days per year (Duever et al. 1979), because these are at lower elevations than most pine rocklands outside of ENP.

2.3 Climate

Miami-Dade County has a subtropical climate that can be divided into two distinct seasons: a mild dry season and a hot rainy season. The dry season is characterized by mild temperatures, relatively low humidity, and very little rain. This season usually ranges from late October to mid May. Occasional cold fronts arriving from Canada are the primary force of weather during the dry season, disrupting a mild easterly flow off the Atlantic Ocean. High temperatures are generally around 80 degrees and low temperatures can vary from the low 30s inland to the low 60s near the coast. Temperatures below 32 degrees occur some years. Humidity levels are generally low with dew points below 60 degrees. The start of the wet season is different every year, but it generally starts in mid May and lasts through October. The average temperatures during the wet season range from the upper 80s along the coast to the mid 90s inland. Precipitation amounts can be copious with monthly totals ranging from five (5) to nine (9) inches and an annual average of 58 inches. The distinct mark of the wet season is consecutive days of high humidity with dew points at or well above 60 degrees.

June 1 through November 30 marks the annual hurricane season. During this period Miami-Dade County may be crossed by one or more tropical cyclones, including tropical depressions, tropical storms, and hurricanes. The main impact of these storms is the strong winds. Hurricanes have winds in excess of 74 miles per hour and can bring large amounts of rainfall in very short time periods, causing regional flooding.

2.4 Vegetation Structure and Composition

Typically pine rocklands consist of three vegetation layers that vary in importance and diversity according to specific local conditions. A canopy normally dominated by pine trees is followed by a subcanopy composed of an array of temperate and tropical hardwoods and palms and a diverse herb layer of a combination of forbs, grasses, ferns, and sedges. Details of the structure and species richness of each of these layers is provided in the following paragraphs. Please refer to **Appendix B** for pictures of historical vegetation structure and composition.

2.4.1 Canopy

The canopy of pine rocklands is dominated by a single species, South Florida slash pine, which historically ranged in height from approximately 65 to 90 feet (Craighead 1971, Snyder et al. 1990). Diameters of pines historically ranged up to 24 to 30 inches (Craighead 1971, Robertson 1955). Platt et al. (2002) reported pre-Hurricane Andrew pine densities on fragmented pine rockland sites of between 211 and 975 trees per acre. In the Long Pine Key area of ENP, pre-Hurricane Andrew slash pine densities were recorded at 185 to 477 trees per acre (Snyder et al. 1990) and 294 to 863 trees per acre (Platt et al. 2002). Germination of South Florida slash pine occurs from October to December. Seedling survival is higher where there is more soil moisture (McMinn 1970). Seedlings will remain in a fire resistant “grass stage” for two (2) to five (5) years. While in this grass stage the pines can re-sprout from the root collar after a fire (Ketcham and Bethune 1963), allowing some to survive. Hofstetter (1973) reported that fires cause an 87%

mortality of seedlings less than five (5) feet tall and 50% mortality for those 6.6 to 19.8 feet tall. Seedlings have improved survivability in areas with less duff accumulation (Klukas 1973).

2.4.2 Subcanopy

The subcanopy of pine rocklands consists of a diverse mix of temperate and tropical hardwoods and palms. Almost 100 native plant species may be present in the subcanopy of Miami-Dade's pine rocklands (Bradley, unpublished data). Palms in this layer, all fairly common, include saw palmetto, cabbage palm, and silver palm, with saw palmetto being the most common and typically a dominant species in all pine rockland areas. Where pine rocklands historically experienced seasonal flooding, or had a shallow depth to the water table, cabbage palm becomes a more dominant species.

Common hardwoods in pine rocklands presently include live oak, poisonwood, southern sumac, white indigo berry, myrsine, West Indian-lilac, snowberry, nettletree, rough velvetseed, and willow bustic (Bradley, unpublished data). The ratio of temperate species to tropical species declines from north to south, with many temperate species becoming absent towards the southern end of the Miami Rock Ridge, and many tropical species becoming absent to the north. The subcanopy in the north may resemble a central Florida sandhill more than a pine rockland further south on the ridge. Historical composition and relative abundance of understory hardwoods may have differed from current coverage.

In addition to the above hardwoods there are many small shrubs or sub-woody species that can be conspicuous components of pine rocklands. These include lacy bracken fern, dwarf live oak, pineland croton, pineland snowberry, partridge pea, and wild sage.

Subcanopy height and density varies temporally and spatially depending on time since fire, freezes, and distance to rockland hammock communities. Fires, discussed in more detail in Section 2.6.1 below, historically occur naturally every three (3) to seven (7) years and kill or top-kill hardwoods. Freezes and cold weather kill or top-kill more sensitive tropical hardwoods such as poisonwood and West Indian-lilac (Olmsted et al. 1993). Diversity and stem density of hardwoods is usually higher in close proximity to rockland hammocks, which serve as a source for seed rain into the pine rocklands.

No historical data are known that quantified the original density of palms and hardwoods in pine rockland prior to non-indigenous settlement. Photos from the early 1900s show areas with a very low palm/shrub layer (less than two feet), but it is difficult to know how representative these photos are of pine rocklands as a whole (**Appendix B**). Pine rocklands probably had a subcanopy layer mostly less than two (2) feet tall. Overall cover of palms and shrubs was probably less thas 25%, with a great degree of patchiness resulting in some very open areas and some very dense areas.

2.4.3 Herb Layer

Over 225 species of herbs may be found in the pine rocklands of Miami-Dade County (Bradley, unpublished data). The herb layer consists of forbs, grasses, ferns, and sedges. This herb layer is much more diverse and has a greater cover where the subcanopy layer is sparse. This herb layer, much like the subcanopy, consists of temperate and tropical species, but also has a component of endemic species. At present, the most common herbs in Miami-Dade County pine rocklands, in descending order, are pine fern, low rattlebox, Florida five-petalled leafflower, rhizomatous bluestem, coastal bedstraw, three-seeded mercury, crimson bluestem, pitted stripeseed, Florida whitetop, and wire bluestem (Bradley, unpublished data). The composition and relative abundance of herbs in MDC pine rocklands may have differed historically from present populations.

Composition of the herb layer varies greatly with geographic location, soils, and hydrology. Like the subcanopy, more temperate species are to the north and tropical species to the south. The herb layer in sandy areas of the northern Biscayne pinelands may resemble central Florida sandhill ecosystems. Low elevation areas that flooded seasonally consist of plant species that are common in marl prairies, such as rhizomatous bluestem, muhlygrass, sawgrass, and starrush whitetop.

The diversity and density of the herb layer is reduced in areas of heavy hardwood density, such as near rockland hammocks. Hardwoods limit the herb layer by limiting sunlight penetration to the ground and by producing a layer of leaf litter that can smother small herbs and limit their germination.

2.5 Association with Other Habitat Types

Prior to non-indigenous settlement of Miami-Dade County, pine rockland habitat was the dominant plant community on the Miami Rock Ridge. Pine rocklands merged into other habitats, and under proper circumstances succeeded to or from these other habitats. Ecotones between pine rockland and other habitats were historically important habitat for many plant and animal species.

Rockland hammocks historically occurred across the range of pine rocklands in Miami-Dade County. Rockland hammocks are closed canopy hardwood forests usually dominated by tropical tree species and the temperate live oak. Rockland hammocks covered small areas of a few acres up to several hundred acres. They occurred in areas that were protected from the fires that burned pine rocklands, typically on the edges of wetlands or in association with abundant solution holes in the oolitic limestone. Pine rockland can succeed into rockland hammock in the absence of fire, and rockland hammocks can succeed into pine rockland with frequent fires. Many plant species grow primarily at the ecotone between pine rockland and rockland hammock, including several that are now rare or imperiled. The ecotone was also very important for wildlife, which used both ecosystems. The rockland hammock ecosystem is discussed as an independent chapter in this management plan.

Alexander (1967) reported results of a 25-year study on pine rockland to rockland hammock succession. He reports:

> "…a complete change from pineland fire-climax to a well-established climatic climax of West Indian tropical flora with *Lysiloma bahamensis* acting as the invader tree can occur in 25 years in southern Florida."

This statement that pine rocklands can succeed to rockland hammocks within two (2) to three (3) decades of fire suppression has been mistakenly inferred by many readers. While pine rocklands are fire climax communities, that is, pinelands thrive in an ecosystem subjected to a natural frequency of fires, Alexander's statement may not be applicable to all pine rocklands in Miami-Dade County. Alexander's results, while accurate for his study, cannot be extrapolated to most pine rockland fragments since his study site was right between two hammocks. Most pine rockland sites in the County occur far away from hammocks.

Alexander's study area, established by Phillips (1940) 25 years previously, was situated between Castellow and Ross Hammocks, which were only separated by about 500 feet. This 500 foot gap was filled with a narrow strip of pine rockland. Succession between the Phillips and Alexander studies was undoubtedly rapid due to heavy seed rain from the adjacent hammocks. Hardwood stem densities, (e.g. false tamarind) may have been high at the study site even before fire suppression. Stem densities are typically higher adjacent to rocklands because of heavy seed rain, but frequent fires keep overall biomass low.

Long-term fire suppression in other pine rockland sites has resulted in conditions similar to Alexander's at only a few sites – all adjacent to rockland hammocks. The Camp Owaissa Bauer Addition EEL site serves as an example. Even in this situation, the succeeded flora consists of a low diversity of trees, shrubs, and herbs and does not approach the biological diversity of mature rockland hammocks. This can be observed in the vicinity of Alexander's study. The area is dominated by wild tamarind and several other hardwoods, but vegetation structure and composition is clearly distinct form the interiors of the adjacent hammocks.

More typically, pine rocklands that have been fire suppressed and are not close to rockland hammocks develop into dense shrublands. Height and coverage of understory palms, especially saw palmetto and cabbage palm, increases as do understory hardwoods such as wax myrtle, myrsine, and marlberry. Most fire suppressed sites also have dense coverage of exotic pest plants, especially Brazilian pepper and Burma reed. As a general rule, pine rocklands do not succeed to rockland hammocks without the proper seed sources, and even then the time to reach complete succession to a climax rockland hammock is unknown.

Marl prairies dissected the Miami Rock Ridge, dividing the pine rocklands into a series of isolated islands. Marl prairies are short hydroperiod wetlands with a marl soil substrate that is derived from the precipitation of calcium carbonate from periphyton. The marl prairies that were adjacent to pine rocklands were mainly treeless, dominated by forbs, grasses, and sedges. Water stood or flowed through these prairies for up to several months during the summer wet season. Where pine rockland and marl prairie intersected there was a mix of plant species common to both communities. It is likely that wildlife use was heavy, especially for terrestrial animals that visited the edges of the marl prairies for drinking water. The marl prairie ecosystem is discussed as an independent chapter in this management plan.

2.6 Historical Successional Processes

The pine rockland ecosystem is subject to a number of natural stressors, which influence community structure and composition. In some circumstances the pine rockland community can succeed into other ecosystems. Natural processes that determine the ecological characteristics of pine rocklands include fires, the regular occurrence of tropical cyclones, and the rather sporadic incidence of frosts.

2.6.1 Fire

Fire in pine rocklands
Photo by Keith Bradley, IRC

Fire frequency for pine rocklands in Miami-Dade County is generally accepted as about once every three (3) to seven (7) years (Hofstetter 1973, Snyder 1990, USFWS 2000), although Olmsted and Loope (1984) suggest that 3-7 years may be too frequent for young pines to attain a large enough size to survive a fire. It has been suggested that these fires are usually ignited by lightning in the summer rainy season between June and October (Doren et al. 1993), or between April and June (Beckage et al. 2003). Given that lightning strikes occur year-round, and begin to increase in the transition from the dry season to the wet season between March and May (Hodanish et al. 1997), ignition probably occurred most frequently in the spring when vegetation was at its driest (Beckage et al. 2003). Since lightning strikes can occur year-round (Hodanish et al. 1997), fires probably occurred throughout the year, but more frequently in the spring and/or summer when lightning is much more frequent.

Long-term temporal patterns of fire occurrence were probably influenced by El Niño induced climate oscillations, resulting in very short times between fires during some decades, and very long intervals in other decades (Beckage et al. 2003). Periods of short intervals may have been important in reducing shrub biomass. Longer intervals may have allowed for pine seedlings to grow and reach canopy height, which 3-7 year fire intervals may have prevented (Olmsted and Loope 1984).

Fires set by indigenous people may have also influenced pine rocklands and may have differed from theoretical natural fire regimes (Pyne et al. 1982). Fires may have been set by Tequesta Indians to assist hunting efforts and maintain coontie, an important food source (Van Essen 2006). The amount, type, and seasonality of aboriginal burning are unknown.

2.6.2 Tropical Cyclones

June 1 through November 30 marks the annual hurricane season. During this period Miami-Dade County may be crossed by one or more tropical cyclones, including tropical depressions, tropical storms, and hurricanes. The main impact of these storms is the strong winds. Hurricanes have winds in excess of 74 miles per hour. These storms can also bring large amounts of rainfall in very short time periods and cause regional flooding.

Tropical cyclones can have significant impacts on pine rocklands. Strong winds can topple pine trees. On Long Pine Key in ENP, Hurricane Andrew caused the deaths of 20 to 32% of pine trees in the two (2) years after the storm, with local mortality ranging from only 3 to 4% up to 50 to 60% (Platt et al. 2000). Larger pine trees were more likely to be killed than smaller trees (Platt et al. 2000). Hurricane Donna in 1960 is reported to have snapped or toppled one (1) to two (2) pine trees per acre on Long Pine Key (Craighead 1971). Hurricane Andrew also toppled, defoliated, or top killed understory hardwoods, reducing subcanopy densities.

Hurricanes can also cause high storm surges, which can temporarily flood coastal pine rocklands. Salt damage can kill vegetation, including trees, palms, hardwoods, and herbs. In 1992, Hurricane Andrew's storm surge reached almost 17 feet at the Deering Estate South Addition and EEL site, covering pine rocklands. In addition to the pine rockland being flooded, a five (5) to ten (10) foot tall and 15 to 30 foot wide rack line of dead vegetation and debris was deposited in the pine rockland. The area covered by the rack line has now succeeded from pine rockland to a dense shrubland covered by hardwoods, which invaded the rich organic soils left by the decomposing debris.

2.6.3 Freezes

Freezes and cold weather kill or top-kill many plant species in pine rocklands, especially tropical hardwoods (Olmsted et al. 1993). Because some pine rocklands can have a large component of tropical species, freezes can have a major impact, at least temporarily. Freezes can be very beneficial in removing living hardwood biomass (FNAI and FDNR 1990), but will leave a large amount of dead woody matter. This dead material is later removed by fires.

2.7 Rare Organisms

Plant and animal species in any ecosystem range from abundant to extremely rare, even under completely natural conditions. Prior to non-indigenous settlement, some plant and animal species in pine rocklands were undoubtedly rare even before major human influences. Because botanical exploration did not start in Miami-Dade County with any significance until the late 1800s, and poor data was collected even then, we will never fully know the historical abundance of most plant species. It is also likely that some plant species were never recorded by any botanist and were lost due to habitat destruction or disturbance without the knowledge of the botanical community. Examples of plant species that may have been historically rare include Bahama manjack and Carter's orchid.

3.0 Current Conditions, Threats, and Trends

This section discusses the current state of the pine rockland ecosystem in Miami-Dade County including not only the properties owned and/or managed by EEL, but those owned by other public entities and private landowners.

3.1 Current Distribution of Pine Rocklands

The distribution of the pine rockland ecosystem has declined dramatically following non-indigenous settlement. At present conditions, almost 84% of the historic Miami Rock Ridge (approximately 126,500 acres), is now covered by agriculture, suburban lands, or urban lands, with only small isolated areas of natural vegetation still existing. The remaining portion of the ridge (approximately 24,500 acres) is located within ENP (**Figure 2**). A survey conducted from 2004 to 2005 of all remaining forest fragments in Miami-Dade County outside of ENP found that only 1.8% of the historical extent of pine rocklands remained (Bradley, unpublished data). Only 2,273 acres of the historical estimate acreage of pine rocklands were found to remain. The geographic range of pine rocklands has been reduced as well – the northern 12 miles of the Miami Rock Ridge have been completely developed.

In 2005 there were 126 pine rockland fragments in Miami-Dade County outside of ENP (Bradley, unpublished data). These fragments ranged from 0.25 acres to 800 acres, with a mean size of 15.6 acres and a median size of 4.3 acres. **Figure 2** shows the current versus historical pine rockland habitat distribution in Miami-Dade County.

3.2 Physiography

Today’s level of human population and urban development in Miami-Dade County was made possible by a significant effort to drain the landscape. This drainage and dewatering process brought about other changes that are briefly discussed in the following sections.

3.2.1 Soils

Pine rockland soils are generally unchanged from historical conditions. Because the dominant substrate of pine rocklands is oolitic limestone, there is little that can be done to it. Pockets of soil, either quartz sand or loam, cannot erode because they are in depressions in the limestone.

The largest change to pine rockland soils is the accumulation of duff and usually organic soil on fire suppressed sites. Under historical conditions, periodic fires limited the growth of hardwood species that produced leaf litter, and also burned any that did accumulate. On many sites this organic layer is now several inches thick and completely covers the limestone substrate.

Soils may have also changed in pine rocklands that previously flooded for short periods during the summer rainy season. Dry conditions tend to reduce organic accumulations, principally because of the lack of protective soil moisture and increased combustion in fires.

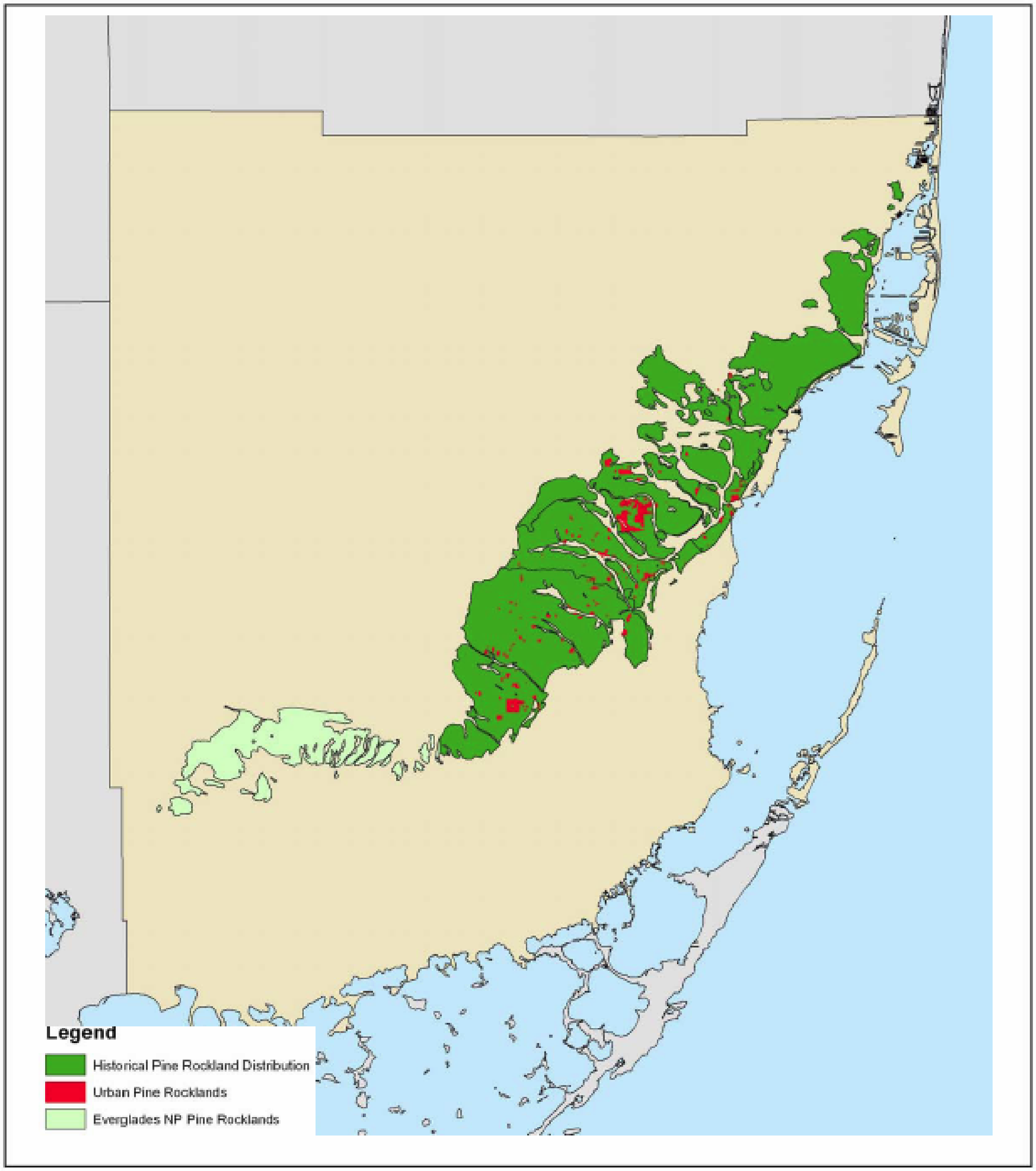

Figure 2: Current Versus Historical Pine Rockland Habitat Distribution in Miami-Dade County

Project:	Miam-Dade County Environmentally Endangered Lands Program Management Plan
Location:	Miami-Dade County, Florida
Source:	Keith A. Bradley, Unpublished Data

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3.2.2 Hydrology

The historical hydrology of Miami-Dade County has been dramatically and permanently altered. The water table throughout the county has dropped due to wide-scale drainage projects (see Part I of this management plan). The water table has decreased throughout the entire range of pine rocklands. For many forest fragments at high elevations, this is probably not of ecological significance. Some pine rocklands, however, were close to the water table and probably flooded periodically (see section 2.2.3). With the lowered water table these sites never flood today and many plant species' roots probably no longer reach ground water.

3.2.3 Sea Level Rise

Sea level rise may become a major environmental concern in South Florida if projected trends continue. The South Florida Regional Planning Council is anticipating a five (5) foot rise in sea level over the next 200 years. Sea level rise has already been implicated in the reduction of pine rockland habitat in the lower Florida Keys (Ross et al. 1994), and the complete loss of pine rocklands on Key Largo (Alexander 1953).

Sea level rise in Miami-Dade County will initially impact only the few coastal pine rocklands, especially the Deering South Addition, an EEL site on Biscayne Bay. Loss of the pine rockland ecosystem will be initiated not by inundation, but by saltwater intrusion to the water table, killing pine rockland plant species. A more detailed Geographic Information Systems (GIS) analysis is needed, but many pine rocklands may not be impacted directly because of their high elevation and inland locations.

3.3 Climate

It has been suggested that the climate of Miami-Dade County has changed with the drainage of wetlands (Marshall and Pielke 2004). Marshall and Pielke have hypothesized that prior to drainage, a persistent moisture flux from heat-retaining wetlands prevented freezing temperatures. Post-drainage freezes may have become more common.

In contrast to the findings of Marshall and Pielke (2004), large cities, such as greater-Miami, are known to act as heat islands because of the heat retention by manmade structures. Urban heat islands can be as much as two (2) to ten (10) degrees warmer than surrounding areas. Global warming is also a factor, which may raise temperatures in Miami-Dade County.

Changes in climate may have many effects, although they are hard to predict. Possible impacts may be changes in flowering and fruiting phenology of plants, fewer (or more) freezes changing hardwood subcanopy structure and composition, changes in soil moisture and thereby seed germination, changes in plant respiration rates, and susceptibility to biological invasions by exotic organisms.

3.4 Vegetation Structure and Composition

Although the same three vegetation layers are still conceptually present in existing fragments of pine rocklands, in many cases they depart significantly from the original structure and species richness. The following paragraphs describe some of the most relevant changes and use the description made in the previous section for comparison purposes.

3.4.1 Canopy

The historical canopy of pine rocklands, consisting of South Florida slash pine, was significantly altered following non-indigenous settlement. The first major impact to the pine canopy was logging. Large scale logging took place in Miami-Dade County from the very early 1900s to the 1950s (Craighead, 1971, Wade et al. 1980, USFWS 2000). Although some small areas of Long Pine Key in ENP were never logged, it is likely that all or nearly all areas of pine rockland outside of the national park were logged. Craighead (1971) reports a discussion with a mill owner in 1952 who stated that during World War II every pine that could be made into a 2x4 was cut down.

Following the end of logging activities, the pine canopy recovered in most pine rockland fragments by 1992, resulting in an even-aged stand of mature pines. In August 1992, Hurricane Andrew hit South Florida, and in the two years following almost the entire canopy of pine in Miami-Dade County outside of ENP was lost. While hurricane winds killed many trees, the main source of mortality was a widespread outbreak of a variety of beetles and weevils in the weakened trees after the storm, including *Ips* species (*I. calligraphis, I. avulsus,* and *I. grandicollis*), *Hylobius pales,* and *Pachylobius picivoris* (DERM 1995).

In the mid 1990s, efforts were made to reestablish pine trees on sites where they were lost. Pine seedlings were planted on 22 preserves, including 12 EEL sites (**Table 1**). Many of these trees are now 6 to 15 feet tall. A negative result of the reintroduction of pines has been the establishment of extreme densities of trees in some places due to overplanting. Mortality in many plantings was much lower than anticipated. In addition, few sites where pines have been planted have burned. Fires would have resulted in much natural mortality, limiting tree densities.

Because of fire suppression, some pine rockland fragments now have a canopy of hardwoods. The most common canopy hardwood is wild-tamarind. Exotic hardwoods may also be common canopy trees in fire-suppressed sites, including Australian umbrella tree and woman’s tongue .

Table 1: Seedling pine plantings on Miami-Dade County preserves

Preserve	Owner
A.D. Barnes Park	Parks
Andrew Dodge Pineland	DERM
Black Creek Forest	EEL
Boystown Pineland	EEL
Deering Estate at Cutler	Parks
Eachus Pineland	EEL
Goulds Pineland	EEL
Larry & Penny Thompson Park	Parks
Ludlum Pineland	EEL
Martinez Pineland	Parks
Miami Metrozoo	Parks
Navy Wells Pineland	Parks
Ned Glenn Nature Preserve	EEL
Nixon Smiley Addition	EEL
Nixon Smiley Pineland	Parks
Palm Drive Pineland	EEL
Rockdale Pineland	EEL
Ron Ehman Park	Parks
Seminole Wayside Park	Parks
Trinity Pineland	EEL
Tropical Park	Parks
West Biscayne Pineland	EEL

3.4.2 Subcanopy

Subcanopy densities are now much denser and taller than they were under historical conditions. Conditions are site specific and vary according to geographic location, fire frequency, and distance to seed sources (especially rockland hammocks). Sites that have received frequent fires, such as Ludlam Pineland, are probably close to historic conditions, with short palm and hardwoods at low stem densities. Other sites, such as Navy Wells #23, are probably very different than they were historically. This site now has a tall understory of hardwoods with a very high stem density.

3.4.3 Herb Layer

The herb layer naturally has the highest diversity of plant species and a diverse array of rare plant species. Like the subcanopy layer, the herb layer varies greatly between forest fragments. Some sites that burned frequently and have sparse subcanopy layers have diverse herb layers. Other sites with dense subcanopies that result in low light penetration and thick duff accumulations have lost almost all herbaceous species. The overall herb layer in pine rockland fragments has been degraded, with a loss in density and diversity.

3.4.4 Edges

Historically, edges in the pine rockland ecosystem were limited to ecotones with other habitat types, especially rockland hammocks and marl prairies (see Sections 2.5 above and 3.5 below). Because of forest fragmentation, all pine rockland fragments now have edges with artificial communities, including lawns, agricultural fields, roads, and other vacant land. Edges create a unique ecotone that can have impacts to the interior of natural sites (See Part I). Edges of pine rockland fragments vary greatly in vegetation structure and composition, depending upon fire history, soil disturbance, and management history. These edges typically have dense growths of exotic and ruderal plant species. Abundant exotic plants include Brazilian pepper and Burma reed. Initial establishment of these exotic plants on edges allows their population sizes to build in disturbed soils, and then intact pine rocklands in the interior of the sites are subsequently invaded due to a heavy seed rain.

3.5 Association with Other Habitat Types

As discussed in Section 2.5, pine rockland was historically associated with other habitat types, especially rockland hammock and marl prairie. Today, most preserves have only a single habitat type and have no natural ecotones with other habitats. Exceptions on EEL sites include Silver Palm Groves, which has a small rockland hammock, and Nixon Smiley Pineland Addition, which has several small marl prairies. The loss of ecotone habitat has resulted in the loss of many populations of plant species restricted to the habitat, and has probably reduced the value of pine rockland for some wildlife species.

3.6 Successional Processes Under Current Conditions

Because of forest fragmentation, human intervention, and a mosaic of urban lands between pine rockland fragments, successional processes now differ than those discussed in Section 2.6. These changes are discussed below.

3.6.1 Fire

Since pine rocklands are fire climax communities, natural fire frequency is of great importance. However, fire periodicity, behavior, and intensity have all been changed on pine rockland fragments. Under historical conditions, pine rockland fragments burned every three (3) to seven (7) years, often in large landscape-scale, wind-driven fires. These fires were usually in the spring or summer. Following fragmentation, fire periodicity has lengthened considerably at most sites. Fire has been completely eliminated at some sites. This change can be attributed to two causes: intentional fire suppression by people and the elimination of large scale landscape-level fires because of the destruction of natural areas.

In addition to periodicity, fire behavior has changed. Natural fires were usually wind-driven head fires that were ignited by lightning. Fires now start for a variety of reasons, including lightning, arson, accident, and by prescription. Many fires, especially prescribed fires, are backing fires burning into the wind. These are slow moving fires and can damage feeder roots of many plants. They are typically used because they are easier to control.

Fire intensity has changed with the reduction in fire periodicity. Heavier fuel buildups between fires result in hotter temperatures and higher flames. Intense fires can have long-lasting impacts when they occur. Fires that are too intense can result in massive mortality of pines, saw palmettos, understory hardwoods, and herbs. Following the fires, sites can be invaded more readily by exotic pest plant species, especially natal grass, and ruderal species. Long term vegetation recovery following intense fires has not been studied.

3.6.2 Tropical Cyclones

There has been much recent discussion about global warming and hurricane activity. Some argue that global warming is resulting in stronger, more intense tropical cyclones (Webster et al. 2005). Some, however, argue against this (Hoyos et al. 2006). Regardless of this debate, the widespread changes in the overall landscape of Miami-Dade County and the changes to pine rockland communities result in different effects of tropical cyclones on the pine rockland ecosystem.

Under natural conditions (see Section 2.6.2) hurricanes can cause mortality of some pine trees, but mortality rates are fairly low in large pine rockland areas like Long Pine Key in ENP (Platt et al. 2000). Outside of the national park, Hurricane Andrew in 1992 resulted in the mortality of almost 100% of the pine canopy of most forest fragments. While hurricane winds killed many trees, the main source of mortality was a widespread outbreak of a variety of beetles and weevils in the weakened trees after the storm, including *Ips* species (*I. calligraphis, I. avulsus,* and *I. grandicollis*), *Hylobius pales*, and *Pachylobius picivoris* (DERM 1995). This massive outbreak did not occur in ENP. It has been hypothesized that the damage to urban fragments was due to higher stress levels on pine trees due to decreased water levels, pollutants, fragmentation, and altered fire regime (DERM 1995, Doren 1993).

Logging of pine trees in the 1930s and 1940s resulted in a mainly even-aged stand of pine trees in most forest fragments. Most pine rockland sites before Hurricane Andrew had mature pines; few sites had a varied stand age consisting of mature, sapling, and seedling trees. Once Hurricane Andrew's winds killed trees and subsequent insect outbreaks killed remaining adults, no young pines were present in the subcanopy to replace the dead adults.

3.6.3 Human Controlled Processes

In some pine rockland fragments, hardwood removal has been done to either replace fire or prepare a site for prescribed fire. For example, hardwoods in the pine rockland at Camp Owaissa Bauer, a preserve managed by the Miami-Dade County Parks Department, were removed by hand to prepare the site for prescribed fire. Timber thinning and mechanical hardwood removal have not been attempted in Miami-Dade's pine rocklands.

3.7 Rare Organisms

Despite the very small area of remaining pine rockland, only a few species have been documented as lost from the habitat. However, many species are considered to be in precarious conditions and could easily be lost in the near future.

Endangered pineland poinsettia
Photo by Keith Bradley, IRC

3.7.1 Plants

Pine rocklands are habitat to a large number of rare organisms, including species that are considered by one or more agencies and organizations as Endangered, Threatened, or Critically Imperiled. These plant species are now rare because of extensive habitat loss due to development, fire suppression, exotic plant invasions, and poaching. The natural range of some of these plant species does not extend south as far as ENP, and therefore, they only exist in pine rockland outside of the protected area of the park. Two examples of these rare endemics are Goulds wedge sandmat and Mosier's false boneset (Bradley and Gann 1999). Narrowleaf hoarypea, formerly known only from Miami-Dade's pine rocklands, is now believed to be extinct (Gann et al. 2002). **Table 2** shows a list of rare plant species, which occur in pine rocklands of Miami-Dade County, including ENP.

Table 2: Rare plant species which occur in Miami-Dade County EEL preserves

Common Names	Scientific Name	State	Federal	FNAI	IRC
Tenlobe false foxglove	*Agalinis obtusifolia*				SF1
White colic-root, bracted colic-root	*Aletris bracteata*	E			
Mexican alvaradoa	*Alvaradoa amorphoides*	E		S1	
Crenulate leadplant	*Amorpha herbacea* var. *crenulata*	E	E	S1	SF1
Pineland-allamanda, Pineland golden trumpet	*Angadenia berteroi*	T			
Blodgett's wild mercury, Blodgett's silverbush	*Argythamnia blodgettii*	E	C		
Largeflower milkweed	*Asclepias connivens*				SFH
Dixie aster, Whitetop aster	*Aster tortifolius*				SF1
Carter's orchid	*Basiphyllaea corallicola*	E		S1	SF1
Flor de pasmo	*Bletia patula*				SFX
Pinepink	*Bletia purpurea*	T			
Pineland strongback	*Bourreria cassinifolia*	E		S1	SF1
Mosier's false boneset	*Brickellia mosieri*	E	C	S1	
Locustberry	*Byrsonima lucida*	T			
Powdery strap airplant	*Catopsis berteroniana*	E		S1S2	
Goulds wedge sandmat	*Chamaesyce deltoidea* subsp. *adhaerens*	E	E	S1	SF1
Wedge sandmat	*Chamaesyce deltoidea* subsp. *deltoidea*	E	E	S1	
Pineland deltoid spurge, Pineland sandmat	*Chamaesyce deltoidea* subsp. *pinetorum*	E	C	S1	

Common Names	Scientific Name	State	Federal	FNAI	IRC
Garber's sandmat	*Chamaesyce garberi*	E	T	S1	
Southern Florida sandmat	*Chamaesyce pergamena*	T			
Porter's sandmat	*Chamaesyce porteriana*	E			
White sunbonnets	*Chaptalia albicans*	T			
Satinleaf	*Chrysophyllum oliviforme*	T			
Dress goldenaster	*Chrysopsis linearifolia* subsp. *dressii*				SFH
Butterfly pea, Atlantic pigeonwings	*Clitoria mariana*				SF1
Florida silver palm	*Coccothrinax argentata*	T			
Coffee colubrina, Greenheart	*Colubrina arborescens*	E			
Florida snake-bark, Cuban nakedwood	*Colubrina cubensis* var. *floridana*	E		S1	
Bahama manjack, Bahama geiger	*Cordia bahamensis*				SFX
Quailberry, Christmasberry	*Crossopetalum ilicifolium*	T			
Rhacoma, Maidenberry	*Crossopetalum rhacoma*	T			
Lobed croton	*Croton lobatus*				SF1
American dodder	*Cuscuta americana*				SF1
Blodgett's swallowwort	*Cynanchum blodgettii*	T			
Florida flatsedge	*Cyperus floridanus*	E		S1	SF1
Florida prairieclover	*Dalea carthagenensis* var. *floridana*	E	C	S1	SF1
Florida ticktrefoil	*Desmodium floridanum*				SF1
Sand tricktrefoil	*Desmodium lineatum*				SF1
Pinebarren ticktrefoil	*Desmodium strictum*				SF1
Caribbean crabgrass	*Digitaria filiformis* var. *dolichophylla*	T			
Everglades crabgrass, Twospike crabgrass	*Digitaria pauciflora*	E	C	S1	SF1
Coker's beach creeper	*Ernodea cokeri*	E		S1	SF1
Dog fennel, Yankeeweed	*Eupatorium compositifolium*				SF1
Small's milkpea	*Galactia smallii*	E	E	S1	
Beach verbena, Coastal mock vervain	*Glandularia maritima*	E			
Bearded skeleton grass	*Gymnopogon ambiguus*				SF1
Slim skeleton grass, Shortleaf skeleton grass	*Gymnopogon brevifolius*				SF1
Sneezeweed, Purple sneezeweed	*Helenium flexuosum*				SF1
White-ironwood, Inkwood	*Hypelate trifoliata*	E		S1	SF1
Krug's holly, Tawnyberry holly	*Ilex krugiana*	T			
Man-in-the-ground, Bejuco colorado	*Ipomoea microdactyla*	E		S1S2	
Rockland morningglory	*Ipomoea tenuissima*	E		S1S2	
Pineland clustervine	*Jacquemontia curtisii*	T			
Joewood	*Jacquinia keyensis*	T			
Shrub eupatorium	*Koanophyllon villosum*	E			
Hammock lantana, Hammock shrubverbena	*Lantana canescens*	E		S1	SF1
Pineland lantana, Rockland shrubverbena	*Lantana depressa*	E			
Drysand pinweed	*Lechea divaricata*	E			
Sand flax	*Linum arenicola*	E	C	S1S2	
Carter's flax	*Linum carteri* var. *carteri*	E	C	S1	SF1
Small's flax	*Linum carteri* var. *smallii*	E			
Pineland blackanthers	*Melanthera parvifolia*	T			
Woolly pyramidflower, Teabush, Broomwood	*Melochia tomentosa*				SFX
Wild basil, Wild sweet basil	*Ocimum campechianum*	E			

Common Names	Scientific Name	State	Federal	FNAI	IRC
Wedgelet fern	*Odontosoria clavata*	E			
Florida dancinglady orchid	*Oncidium ensatum*	E		S1	SF1
Thicket bean	*Phaseolus polystachios* var. *sinuatus*				SFX
Southern fogfruit	*Phyla stoechadifolia*	E			
Florida Keys blackbead	*Pithecellobium keyense*	T			
Pineland poinsettia, Pineland spurge	*Poinsettia pinetorum*	E			
Small's milkwort, Tiny polygala	*Polygala smallii*	E	E	S1	
Tall jointweed	*Polygonella gracilis*				SF1
Britton's ponthieva, Britton's shadow witch	*Ponthieva brittoniae*	E		S1	SF1
Longstalked-stopper	*Psidium longipes*	T			
Bahama wild coffee	*Psychotria ligustrifolia*	E		S1	
Bahama ladder brake	*Pteris bahamensis*	T			
Giant orchid	*Pteroglossaspis ecristata*	T			
Small-leaf snoutbean	*Rhynchosia parvifolia*	T			
Bahama sachsia	*Sachsia polycephala*	T			
Blodgett's sage, Yucatan sage	*Salvia micrantha*			SX	SFX
Curtiss' nutrush	*Scleria ciliata* var. *curtissii*				SF1
Havana skullcap	*Scutellaria havanensis*	E			
Eaton's spike-moss	*Selaginella armata* var. *eatonii*	E			
Bahama senna, Chapman's wild sensitive plant	*Senna mexicana* var. *chapmanii*	T			
Havana greenbrier, Everglades greenbrier	*Smilax havanensis*	T			
Black nightshade	*Solanum chenopodioides*				SF1
Mullein nightshade	*Solanum donianum*	T			
Everglades Keys false buttonweed	*Spermacoce terminalis*	T			
	Spiranthes amesiana				SFX
Southern lady's-tresses	*Spiranthes torta*	E		S1	SF1
Hidden dropseed	*Sporobolus compositus* var. *clandestinus*				SF1
Everglades key pencilflower	*Stylosanthes calcicola*	E			
Narrowleaf hoarypea	*Tephrosia angustissima* var. *angustissima*	E		SH	SFX
Coral hoarypea	*Tephrosia angustissima* var. *corallicola*	E		S1	SF1
Scurf hoarypea	*Tephrosia chrysophylla*				SF1
Spiked hoarypea	*Tephrosia spicata*				SF1
West Indian-lilac, Florida clover ash	*Tetrazygia bicolor*	T			
Reflexed wild-pine, Northern needleleaf	*Tillandsia balbisiana*	T			
Stiff-leaved wild-pine, Cardinal airplant	*Tillandsia fasciculata* var. *densispica*	E			
Banded wild-pine, Twisted airplant	*Tillandsia flexuosa*	T			
Giant wild-pine, Giant airplant	*Tillandsia utriculata*	E			
Florida Keys noseburn	*Tragia saxicola*	T			
West Indian trema, Pain-in-the-back	*Trema lamarckianum*	E			
Florida gamagrass	*Tripsacum floridanum*	T			
Carter's pinelandcress	*Warea carteri*	E	E		SFH
Shyvine, Viperina	*Zornia bracteata*				SF1

Key: E = Endangered; T = Threatened; C = Commercially Exploited; S1 or SF1 = Critically Imperiled; S2 = Imperiled; SH or SFH = Historical; SX or SFX = Extirpated

Source: The Institute for Regional Conservation

3.7.2 Animals

Because of Miami-Dade County's location at the tip of the Florida peninsula, proximity to the Caribbean, and unique habitat characteristics, the fauna of pine rocklands has distinct characters not shared by other pine habitats to the north. While most of the pine rockland fauna is derived from the temperate fauna of the southeastern United States, it also has tropical and endemic taxa not found in other parts of the state (Snyder et al. 1990). Many of the rare species present in pine rocklands have wide distributions, such as the bald eagle, and small pine rockland fragments in the EEL system may not be critical to their survival because the habitat is only used occasionally. However, a few taxa have extremely limited distributions and are found nowhere else in the world outside of South Florida's pine rocklands. Management of EEL sites may be critical in preventing their extinction. **Table 3** shows a list of impacted animal species that utilize pine rocklands and do not have stable populations elsewhere in the state. This list is restricted to species that are Federally-listed as Endangered or Threatened or are a candidate for listing by the U.S. Fish and Wildlife Service (USFWS); are State-listed as Endangered, Threatened or a Species of Special Concern (SSC) by the Florida Fish and Wildlife Conservation Commission (FWCC); or have a Florida Natural Areas Inventory (FNAI) ranking of S3 (rare and/or localized within the state) or worse. Detailed accounts are given for a select few that are more highly dependent upon pine rocklands in Miami-Dade County and therefore, upon the EEL pine rockland sites.

Table 3: Rare animal species that utilize pine rockland in Miami-Dade County

Scientific Name	Common Name	State	Federal	FNAI
Anaea troglodyta floridalis	Florida leafwing butterfly		Can	
Dendroica kirtlandii	Kirtland's warbler	E	E	
Drymarchon corais couperi	Eastern indigo snake	T	T	G4T3/S3
Elanoides forficatus	Swallow-tailed kite			G5/S2
Eumops glaucinus floridanus	Florida mastiff bat	E		G5T1/S1
Falco peregrinus	Peregrine falcon	E		
Falco sparverius paulus	Southeastern American kestrel	T		
Gopherus polyphemus	Gopher tortoise	SSC		G3/S3
Haliaeetus leucocephalus	Bald eagle	T	T	G4/S3
Liguus fasciatus	Florida tree snail	SSC		
Pituophis melanoleucus mugitus	Florida pine snake	SSC		G4T3?/S3
Sciurus niger shermani	Sherman's fox squirrel	SSC		G5T3/S3
Strymon acis bartrami	Bartram's hairstreak butterfly		Can	
Tantilla oolitica	Rimrock crowned snake	T		G1G2Q/S1S2

Key:
E = Endangered; T = Threatened; Can = Candidate; S = Sate; G = Global; T = Indicates subspecies;
1 = Critically Imperiled; 2 = Imperiled; 3 = Rare and/ or Localized; 4 = Apparently Secure;
5 = Demonstrably Stable

- Gopher tortoise – This state-listed Species of Special Concern has been recorded in pine rocklands in Miami-Dade County, including some EEL sites where it is limited to the northern Biscayne pinelands which possess the sandy soils required by this species. Gopher tortoise burrows provide important habitat for numerous other species so management for gopher tortoises benefits a wide range of wildlife.

Gopher tortoise
Photo by Valerie Chartier, URS

Rimrock crowned snake
Photo by Barry Mansell
www.flmnh.ufl.edu/natsci/herpetology/fl-guide

- Rimrock crowned snake – This small species of fossorial snake is endemic to rockland habitats extending along the Miami Rock Ridge in Miami-Dade County down into the Middle Florida Keys of Monroe County. Very little is known about this elusive snake, but limited findings and drastic reduction of its native habitat have gained it a classification of Threatened by the State of Florida.

- Florida leafwing butterfly – This subspecies is endemic to South Florida and the Florida Keys, occurring only in pine rocklands containing pineland croton, its sole host plant. Once widespread in Miami-Dade County, habitat loss has depleted its numbers and restricted its presence to Long Pine Key in ENP and Big Pine Key in the lower Florida Keys. EEL pinelands along the edge of ENP may be crucial for this species' recovery. This species is a candidate for federal listing.

Florida Leafwing
Photo by David L Lysinger
www.miamiblue.org

Bartrum's Scrub-Hairstreak
Photo by David L. Lysinger
www.miamiblue.org

- Bartram's hairstreak butterfly – This subspecies is endemic to South Florida and the Florida Keys, occurring only in pine rocklands containing pineland croton, its sole host plant. Once widespread in Miami-Dade County, habitat loss has depleted its numbers and largely restricted its presence to Long Pine Key in ENP and Big Pine Key in the lower Florida Keys. There appear to be some small, localized populations just outside of ENP and sightings of this species have been confirmed as far away as the Miami Metro Zoo. This species is a candidate for federal listing.

3.8 Fragmentation, Ownership, and Preservation Status of Remaining Fragments

Pine rocklands in Miami-Dade County are owned by a variety of public agencies and private individuals. Properties owned by public agencies are usually preserves, although there are some major exceptions. Most privately-owned pine rockland fragments have the potential to be developed, although a few sites are maintained as preserves by their owners. About 26% of the remaining pine rockland acreage in Miami-Dade County is privately owned. Each ownership category is discussed in more detail below.

3.8.1 Fragmentation

The pine rockland ecosystem has been extensively fragmented. Only 1.8% of the historical extent of pine rocklands remain outside of ENP, with only 2,273 acres of historically estimated 127,000 acres left (Bradley, unpublished data). Fragments range from 0.25 acres to 800 acres, with a mean size of 15.6 acres and a median size of 4.3 acres.

3.8.2 EEL Program

The EEL program owns approximately 474 acres of pine rockland on 24 sites. All of this acreage will be protected and managed in perpetuity.

3.8.3 Parks & Recreation Department

The Miami-Dade County Parks and Recreation Department owns or leases about 817 acres of pine rockland on 15 properties. On some of these sites, the pine rockland is not fully protected, including 255 acres at Miami Metrozoo, which may be developed in part by the Parks and Recreation Department for other purposes.

3.8.4 Other Public Lands

Several public agencies own pine rockland fragments, including the U.S. Government (mostly the Department of Defense), and the School Board of Miami-Dade County.

The Miami-Dade County School Board owns seven pine rockland fragments totaling 49.3 acres. These sites include the 6.4 acre Ron Ehman Park, the 10.4 acre Ned Glenn Nature Preserve, a 15.6 acre property at Moody Drive and the Florida Turnpike, 2.6 acres at Southwest 216th Street and 129th Avenue, 10.8 acres at Southwest 199th Avenue and 324th Street, 4.8 acres at Robert Morgan Education Center at Southwest 184th Street and 122nd Avenue, and 4.3 acres at Southwest 224th Street and 115th Avenue. Ron Ehman Park and the Ned Glenn Nature Preserve are somewhat secure from development via agreements with Miami-Dade County. The School Board plans to develop schools on the other sites.

The U.S. Government owns a number of pine rockland fragments. The Department of Defense owns 177 acres of pine rockland at the Richmond Pineland Complex surrounding Miami-Metrozoo. One 67-acre parcel that was formerly the U.S. Naval Observatory was recently deeded to the University of Miami. Other federal land in the complex could be developed, or again transferred to private ownership. The U.S. Board of Prisons also owns a 21.3 acre pine rockland fragment at the Complex.

The U.S. Department of Agriculture owns 8.3 acres of pine rockland at the Subtropical Horticulture Research Station (Chapman Field) at Old Cutler Road and Southwest 136th Street. Pine rockland fragments on this site are poorly managed and could be developed.

Two municipal governments own pine rockland fragments. The City of South Miami owns the 0.4 acre Girl Scout Little House. The Village of Palmetto Bay owns a 4.7 acre pine rockland at Coral Reef Park.

The Miami-Dade County Department of Environmental Resources Management (DERM) owns and maintains a small preserve, exclusive of the EEL program – the 2.8 acre Andrew Dodge Pineland. In addition, the Miami-Dade County Department of Enterprise Technology Services also owns 9.2 acres of pine rockland at a communication facility on Southwest 264th Street adjacent to the Camp Owaissa Bauer Addition EEL site. The EEL program has successfully negotiated with the Department of Enterprise Technology Services to restore and manage the property.

The pine rockland referred to as the Navy Wells Pineland Preserve at Southwest 192nd Avenue and 360th Street contains almost 300 acres of pine rockland. The entire pine rockland area has been traditionally managed in its entirety by the Parks and Recreation Department. This pine rockland fragment does however have several owners. The Miami-Dade County Parks and Recreation Department owns 198.4 acres of pine rockland here. The Florida Keys Aqueduct Authority, an entity created by legislation by the State of Florida in 1937 to provide drinking water to the Florida Keys, owns 77.3 acres of the pine rockland. The U.S. Government owns an additional 20.7 acres. The County Property Appraiser database indicates the address of the Miami Federal Courthouse for the four (4) individual parcels that they own.

3.8.5 Private Preserves

Few privately owned pine rockland preserves exist. Exceptions include the 13-acre Pine Ridge Sanctuary owned by Terry and Barbara Glancy, a 1.5-acre preserve and another 0.75 acre preserve owned by The Institute for Regional Conservation (IRC), and the 7.8-acre Porter Russell Pineland Preserve owned by the Tropical Audubon Society.

3.8.6 Natural Forest Community System

The Natural Forest Community System (NFC) consists of 127 pine rockland fragments and 46 rockland hammock fragments that are protected in part from development by the Miami-Dade County Tree and Forest Resources Protection ordinance. Since the 1990s, NFC acreage had dropped greatly, a continuing trend, even though they are legally protected. Much habitat clearing is done illegally. Some of these NFC fragments are cherished by their owners and will not be developed, at least in the near term, but they are typically poorly managed.

3.8.7 Other

The largest private landowner of Pine Rocklands is the University of Miami, who owns about 132 acres at the Richmond Pineland Complex. The University owns two distinct parcels. One 65-acre parcel is the University South Campus off of Southwest 152nd Avenue, just west of Miami Metrozoo. The University currently has plans to develop this property for private homes, destroying the pine rockland. The second parcel, recently transferred from the U.S. Government, is 67 acres at Southwest 168th Street and 117th Avenue. The University has not announced its plans for the property, but full preservation is unlikely.

3.9 Future Preservation Estimates

There are currently about 1,092 acres of pine rocklands that are protected by government agencies or private organizations and citizens. The EEL program has almost exhausted all opportunities for new pine rockland acquisitions because remaining pine rocklands are owned by unwilling sellers or are too small. The largest remaining areas of pine rockland that are not preserved are within the Richmond Pineland Complex and are owned by the Department of Defense, Federal Board of Prisons, University of Miami, and Miami-Metrozoo. These areas total to about 585 acres. Even if half of this acreage is acquired by EEL or other wise preserved, and the EEL makes two more planned acquisitions in other parts of the county, there is likely to be no more than about 1,400 to 1,500 acres of pine rockland preserved in perpetuity in Miami-Dade County.

3.10 Exotic Organisms

Several non-indigenous plant and animal species have become, or could potentially become, pest species affecting the quality of the pine rockland remnants in EEL sites. Some of the plant and animal species are briefly discussed below.

Miami-Dade County pineland with invading Burma reed
Photo by Keith Bradley, IRC

3.10.1 Plants

Exotic plant species occur in every pine rockland fragment in Miami-Dade County. In botanical surveys of 99 pine rockland fragments in 2004 and 2005, 173 exotic plant taxa were recorded. The most frequently recorded exotic plants, in decreasing order of frequency, were Brazilian pepper, Burma reed, woman's tongue, natal grass, shrubverbena, Australian umbrellatree, gold coast jasmine, shrubby false buttonweed, wild bean, and China brake. Of these 173 exotics, 57 are listed as Category I or II invasive species by the Florida Exotic Pest Plant Council (FLEPPC) (**Appendix C**).

The most problematic invasive plant species in pine rocklands include Brazilian pepper, Burma reed, and natal grass. These species are aggressive invaders and once established can spread very quickly throughout a site if they are not managed.

3.10.2 Animals

Since virtually all exotic animal introductions have been human-mediated, a population boom in Miami-Dade County over the last 30-40 years has resulted in a dramatic increase in the number of established exotic species in this area. As a result, populations of exotic animals have invaded all available habitats within urbanized Miami-Dade County, including pine rocklands, and many species are expanding their range into the neighboring wilderness areas. The most frequently observed animal species in Miami-Dade pine rocklands is often the introduced brown anole. While the full biological and ecological implications of this invasion are poorly understood, there are certain species that are clearly more problematic than others. Feral domestic cats also commonly have negative impacts on pine rockland EEL sites. For a discussion on *F. catus*, please refer to Section 5.2.2.2 of Part I of this document. Other species that are known to have potential detrimental impacts to pine rockland communities are discussed below in further detail and **Table 4** includes a list of exotic species that are commonly found in Miami-Dade pine rocklands.

Table 4: Exotic animals commonly present in pine rockland habitat in Miami

Scientific Name	Common Name
Aedes aegypti	Yellow fever mosquito
Aedes albopictus	Asian tiger mosquito
Anolis sagrei	Brown anole
Apis mellifera	Honey bees
Boa constrictor	Boa constrictor
Bufo marinus	Cane toad
Cactoblastis cactorum	Cactus moth
Canis familiaris	Feral domestic dog
Ctenosaura similis	Spiny tail iguana
Hemidactylus garnotti	Indo-Pacific gecko
Hemidactylus mabouia	Tropical gecko
Felis catus	Feral domestic cat
Iguana iguana	Green iguana
Mus musculus	House mouse
Musca domestica	House fly
Osteopilus serpentrionalis	Cuban treefrog
Paratachardina lobata lobata	Lobate lac scale
Psittacidae family	Parrots and parakeets
Rattus rattus	Black rat
Ramphotyphlops braminus	Brahminy blind snake
Saissetia coffeae	Hemispherical scale
Solenopsis invicta	Red imported fire ant
Sturnus vulgaris	European starling
Zachrysia provisoria	Cuban tree snail

- Red imported fire ant – The red imported fire ant (RIFA) was introduced into the U.S. from Brazil into either Mobile, Alabama or Pensacola, Florida between 1933 and 1945 and is now widespread throughout the southeastern U.S. (Collins and Scheffrahn 2001). RIFA have been documented to cause harm to humans and wildlife as well as economic harm (Stimac and Alves 1994; Collins and Scheffrahn 2001; Willcox and Giuliano 2006). RIFA are omnivorous, but they tend to prefer insects as their primary food source (Willcox and Guiliano 2006). *S. invicta* have a number of impacts on wildlife. They have eliminated many areas of native ant populations through competition and predation as well as eliminating food sources utilized by some wildlife species. Ground-nesting wildlife is especially susceptible to RIFA. Within Nixon Smiley Pineland, *S. invicta* have the potential to affect ground-nesting birds; small mammals; reptiles such as Florida box turtles, native lizard and snake species; and native invertebrates (Willcox and Giuliano 2006). While fire ants are found in a range of habitats, within Miami-Dade County's natural areas, they are most closely associated with pine rocklands because of the drier upland environment and the open canopy.

- European starling – Starlings were introduced to New York in the 1890's and have since successfully colonized most of North America (Ehrlich et al. 1988). Starlings are prevalent in most any habitat type with suitable nesting habitat, including tree cavities, bird boxes or buildings. They are, however, partial to areas with low forest density, leaving pine rockland habitat to be a preferred natural setting in South Florida. An abundance of birds that dwell in tree cavities, such as woodpeckers, also make pine rocklands more susceptible to damage from these birds. Starlings not only compete with the native birds for tree cavities, but have even been observed evicting woodpeckers from their nests to claim the cavity for their own (Stevenson and Anderson 1994).

- Parrots and parakeets – Over twenty species of parrots and parakeets have been observed nesting in the wild in South Florida (FWC 2007). Due to their flocking behavior and more aggressive mannerisms, they out-compete native birds for both food and space, claiming fruits, nuts and tree cavities for themselves (Taylor et al. 2004). In addition, they contribute to the spread of exotic plants through seed dispersal (Snyder et al. 1990). While members of this family occur in many South Florida habitats, the previously mentioned habits make them particularly harmful in pine rocklands where there is a high concentration of native bird species that depend upon tree cavities and where management of exotic plants is already challenging due to complications related to burning.

- Lobate lac scale - The lobate lac scale, a scale insect that is native to India and Sri Lanka, was found in Broward County in 1999, and has since become widespread in southern Florida. The species belongs to the lac scale family, Kerriidae, the best-known species of which is the true lac scale insect. The lobate lac scale has been found mostly on woody dicotyledonous plants. It infests the woody portions of twigs and small branches and less frequently main stems under one inch in diameter. It not usually found on branches or main stems greater than approximately one inch in diameter. It has not been observed on foliage. Some woody plant species appear to be highly susceptible, including certain natives, e.g., wax-myrtle, cocoplum, buttonwood, strangler-fig, myrsine, bay species, and wild-coffee. Lobate lac scale is more commonly known for its damage to hammock systems, but it is also a concern in pine rocklands due to its preference for certain rare bushes, particularly Florida prairieclover and crenulate leadplant.

3.11 Other Problem Species

Many native plant species can be considered problem species in pine rocklands. Some native species become aggressive and can out-compete other native species when artificial habitat changes occur, such as drainage, intense fires, or fire suppression. While these species are native, control efforts should still be used when required to maintain desirable ecosystem structure and composition. Problem species include cabbage palm, muscadine grape, southern sumac, lacy bracken fern, and earleaf greenbrier.

In addition to the above species, all native hardwoods can be considered problem species in the absence of fire. Common hardwoods include live oak, poisonwood, and myrsine.

Two native plant species that occur in pine rocklands commonly cause dermatitis in sensitive people. These are poisonwood and poison-ivy. Both are common pine rockland species. Lower densities of both can be achieved by proper management of pine rocklands. Densities of both, especially poisonwood, can increase dramatically with fire suppression.

3.12 Pollutants

Although there are innumerable types of pollutants that could potentially affect EEL pine rockland sites, the primary sources of concern are dumping, mosquito spraying, pesticides (insecticides, herbicides, fungicides, miticides, nematicides), nutrients, sediments, animal wastes, miscellaneous household and industrial chemical wastes, and wind-blown debris. Please refer to Part I, Section 5.2.5 of this management plan for details about these potential threats.

3.13 Cultural Resources

The potential exists for the presence of Native American artifacts in pine rocklands because small game hunting would likely have occurred in such wooded areas and close to rivers. The pineland’s higher ground would help protect populations from hurricane-related storm surges. There would not, however, likely be a higher probability of evidence of indigenous groups in pine rocklands than in hammocks or coastal areas.

4.0 Management Issues

This section describes the most important issues that require attention for the successful management of pine rockland sites. While drafting these guidelines the team paid attention to the main goals outlined for pine rockland habitat by the Miami-Dade County Natural Areas Management Plan (DERM 1995, USFWS 2000).

4.1 Acquisition Needs for Remaining Pine Rockland Fragments

Management Policy

The EEL program should make every attempt to identify and acquire any remaining pine rockland fragments within Miami-Dade County suitable for conservation.

There are few remaining pine rockland fragments in Miami-Dade County that are suitable for acquisition. Every attempt should be made by the EEL program to acquire any of these remaining pine rocklands before they are developed. However, prior to attempting acquisition each site must individually be approved by the Board of County Commissioners for acquisition and funding must be in place. Finally, the seller must be willing to sell the property.

The largest of these fragments occur in the Richmond Pine Rocklands surrounding Miami Metrozoo. There are two preserved pine rockland areas here, Larry & Penny Thompson Park and Martinez Pineland, both owned by the Parks and Recreation Department. Negotiations are currently underway for the EEL program to begin management of pine rockland at Miami Metrozoo. There are other areas of high-quality pine rockland, many with populations of endangered species, that are suitable for EEL acquisition. These include properties owned by the University of Miami, U.S. Coast Guard, and Department of Defense.

Other owners of significant pine rockland areas in Miami-Dade County include the Miami-Dade County School Board, Retreat Construction Corp, Barbara Hampson-Keller, and several other private owners. Some of these are probably unwilling sellers.

Some of the pine rockland fragments that are suitable for acquisition are listed in **Table 5**.

Table 5: Pine rockland fragments suitable for acquisition in Miami-Dade County. Sites currently listed by the EEL program are marked with an asterisk (*)

Property Name	Pine Rockland Acres	NFC Code	Address	Comments
Accursio Pineland	4.8	P-347	SW 348 St. & ca. 204 Ave.	High quality pine rockland
*Kings Highway (CARL 14)	23.5	P-313	SW 304 St. & 203 Ave.	Probably unwilling seller
Hattie Bauer Addition	7.8	P-308	SW 268 St. & 157 Ave.	Adjacent to Hattie Bauer EEL site
* School Board (CARL 10)	15.6	P-275	SW 268 St. & 132 Ave.	
*Northrop Pineland	16	P-312	SW 296 St. & 207 Ave.	EEL Preparing to Acquire
*Wilkins-Pierson	12.5	P-14	SW 184 St. & 164 Ave.	Probably unwilling seller
*Quail Roost Addition	ca. 6	P-144	SW 204 St. & 147 Ave.	Adjacent to Quail Roost

Property Name	Pine Rockland Acres	NFC Code	Address	Comments
				EEL site
Retreat Construction Corp	13.5	P-414	SW 352 St. & 192 Ave.	Probably unwilling seller
*Richmond Pine Rocklands - Federal Properties	177	P-391	SW 152 St. & 117 Ave.	No comment
*Navy Wells #2, School Board	10.8	P-329	SW 324 St. & 199 Ave.	No comment
Shields Pineland	6.3	P-421	SW 226 St. & 190 Ave.	No comment
University of Miami South Campus	65	P-391	SW 152 St. & 124 Ave.	No comment
*University of Miami, former Naval Observatory	67	P-391	SW 168 St. & 117 Ave.	No comment

4.2 Mitigation/Management for Fragmentation Effects

Management Policy

All possible effort shall be taken to maintain and reestablish biological connectivity between pine rockland EEL sites and other natural areas by creation of greenways, acquisition and restoration of vacant land between parcels, and encouraging appropriate zoning around and between parcels.

As discussed in Part I, Section 5.2.3, greenways, stepping stones and between-site re-vegetation could improve biological connectivity between isolated natural area fragments. Actions that may be particularly valuable for enhancing pine rockland habitat are discussed below.

4.2.1 Acquisition and Restoration of Vacant Land between Parcels

The EEL program should consider the acquisition of vacant lands between pine rockland sites for restoration and use as “stepping stones” between forest fragments. As discussed in 4.2.1 above, hardwoods that could invade pine rocklands and require later removal should not be planted close to pine rocklands. Re-vegetated stepping stones will provide food and cover for wildlife, making it easier for them to move between pine rockland fragments. Water features, including shallow ponds and wetlands, should be considered to enhance wildlife habitat.

Miami-Dade County pineland with adjacent development
Photo by Keith Bradley, IRC

4.2.2 Zoning Around and Between Parcels

The EEL program should encourage zoning around its properties that is most compatible with management of pine rockland fragments. Proper management of pine rockland fragments includes prescribed burning (which can generate heavy amounts of smoke), controlled access by people, and minimizing edge effects. Surrounding land use can impact any of these management techniques.

Retaining agricultural lands (AU), where they already exist, around and between EEL sites is preferred. If residential development is planned around EEL sites, larger lot sizes such as EU-2 (5 acres) and EU-1C (2.5 acres), are much preferred over small lots (all RU types), to maximize open space and limit pollution runoff. Construction of hospitals, schools, apartments, and hotels around EEL sites should be discouraged because of conflicts with smoke generation during prescribed fires. In support of this, the EEL program should develop a map of smoke corridors for EEL properties during prescribed burning, which the Miami-Dade County Planning and Zoning Department could utilize to more effectively plan zoning and natural areas protection in these areas.

4.3 Targets for Vegetation Structure

Management Policy

Pine rockland EEL sites shall be managed in an attempt to restore or approach historical vegetative structure conditions, including the management of canopy density, understory density, herb layer density and diversity, and exotics at preserve edges.

Historical and current vegetation conditions have been discussed in Sections 2.4 and 3.4, respectively. This section discusses management of vegetation structure and composition. In general, pine rockland sites should be managed in an attempt to restore or approach historical conditions. Some aspects of vegetation may need to be managed outside of historical parameters to deal with the constraints imposed on management by extremely fragmented forest conditions.

4.3.1 Canopy Density

Pine rocklands should be managed to retain a canopy of South Florida slash pine and hardwoods should not be allowed to reach canopy stature. Historical densities of pines in pine rocklands ranged from about 200 to 900 per acre (Snyder et al., 1990, Platt et al. 2002). However, due to reduced fire frequency, pine rockland sites should be managed for a sparser canopy of pines than they historically had, perhaps ranging from 25 to 225 trees per hectare, a quarter of the historic density.

Reduced pine canopies are now desirable because future fire frequencies, though targeted to occur at three (3) to seven (7) year intervals, will likely occur much less frequently than planned. Because of neighboring structures, roads and highways, and dense populations, some pine rockland sites may be impractical to burn at all. Pine trees generate large amounts of needle duff which is normally consumed by fires. In the absence of regular fires the duff accumulates, decomposes, and creates an organic soil layer. Under this scenario some native pine rockland herbs and grasses, including endemics and imperiled species, disappear. Remaining pine rockland fragments with dense pine canopies have a greatly reduced herb diversity. Even if sites do burn occasionally, but less frequently than three (3) to seven (7) years, herbaceous richness will decline and when fires do occur they will generate more heat. These more intense fires are more likely to kill pines and other desirable species.

Experimentation will be required to determine appropriate densities. At some sites with dense canopy trees or saplings, trees should be removed to achieve lower densities. Prescribed fires may also be used to reduce densities of sapling pine trees. Conversely, some pine rockland sites may need pine reintroductions or augmentations to reach target densities. Pines can be planted as tubelings or directly seeded (Mayo 2000). If using tubelings, pine plantings on a single site should be sparser than needed for target densities. Periodic plantings at intervals of five (5) to ten (10) years should be used to achieve target densities to achieve a multi-aged pine stand. If using seeds, the seed source should be local, preferably from Miami-Dade County. As has been done in the past, all pines currently utilized for reintroductions or augmentations on pine rockland EEL sites, whether tubelings or seeds, should originate from local sources.

4.3.2 Understory Density

Understory vegetation densities should be managed in an effort to attain historical conditions. As noted previously, understory heights were probably less than two (2) feet and overall shrub and palm cover less than 25%. Ludlum Pineland serves as an example of a site that is probably close to desired conditions.

Reaching this condition would require hardwood and palm reduction at most pine rockland sites, preferably by prescribed fire or mechanical removal followed by prescribed fire. Reduction of understory densities, including hardwoods and palms, would result in better conditions for prescribed fire. With less fuel, fires are easier to control, produce much less smoke, have less chance of reaching the pine canopy, and result in lower fire temperatures that may be beneficial to native herbs and make sites less prone to invasion by exotic and ruderal plant species. While not preferred, in the absence of fire, manual or mechanical removal, herbicide application, or a combination of techniques could be utilized to manage understory density in pine rocklands.

4.3.3 Herb Layer

Herb layers should be managed to have a diversity of native species that are indigenous to the pine rockland community. Following recommended canopy (see Section 4.3.1) and subcanopy (see Section 4.3.2) management guidelines should be sufficient at most sites to achieve a desired dense and diverse herb layer. A density target is not provided here because herb layer density and composition is so variable in pine rocklands. Canopy and subcanopy management focuses primarily on restoring the historical fire regime at pine rocklands. Reintroduction or augmentation of native grasses and forbs may be required at some sites. The details of this practices will be included at the site-specific plans level in Part III of this document.

At pine rockland sites that have been subjected to fire suppression, the diversity of forbs, grasses, and sedges can be greatly reduced. Following treatment of the canopy and subcanopy, and reintroduction of fire, many species may reappear from a soil seed bank or dormant roots.

Following restoration by prescribed burning, many fire-suppressed sites would benefit from the replanting of native herbs. Native species should be used that were historically on or in the vicinity of the pine rockland fragment being restored. Lists of appropriate species can be found online at www.regionalconservation.org in the Natives for Your Neighborhood and Floristic Inventory of South Florida databases. Any reintroductions or augmentations should use germplasm from pine rocklands as close to the introduction site as possible to ensure that similar genetic material is used.

If the application of prescribed fire is absolutely impossible, there are several alternatives that are available, although less desirable. These options include grazing, herbicide application, and mechanical treatment. The benefits and disadvantages of these alternatives are detailed in Section 4.6.4 of this management plan, Alternatives to Prescribed Burning.

4.3.4 Edges

Edges of pine rocklands should be managed to eliminate the occurrence of exotic pest plants (especially Brazilian pepper, Burma reed, and natal grass) and minimize ruderal species that may invade pine rocklands after fires.

Open areas with exposed limestone at the edges of pine rocklands (such as fire breaks) can often be refugia for pine rockland herbs where habitat quality has degraded in the interior of sites. Removal of all loose soil by mechanical scraping, resulting in the exposure of oolitic limestone, around the edges of pine rockland sites could be beneficial. Pine rockland herbs should colonize scraped areas. An added benefit is that exposed limestone is poor habitat for many exotic and ruderal species that are a threat to pine rocklands. Scraped open areas at the edges of pine rocklands should be put on a mowing cycle that allows indigenous pine rockland herbs to flower and fruit before being mowed again, perhaps at a three (3) to six (6) month cycle. Some chemical control of exotic ruderal plant species would also be beneficial to native species colonizing the area.

4.4 Rare Organisms

Management Policy

Natural populations of rare organisms should be managed to ensure their long-term survival on pine rockland EEL sites. Where appropriate, rare organisms should be augmented, reintroduced, or introduced to sites where they are either rare, extirpated, or within their natural ranges, respectively.

EEL’s pine rockland sites should be managed to provide habitat for rare organisms indigenous to the ecosystem. Small fragments of pine rockland are suitable habitat for many species of plants, small vertebrates, and invertebrates. Rare plants and animals that could be managed on EEL sites, in conjunction with ecosystem management, are discussed below.

4.4.1 Plants

Pine rocklands are habitat to a large number of rare plants, including species that are considered by one or more agencies and organizations as Endangered, Threatened, or Critically Imperiled. Some of these plant species only occur in Miami-Dade’s pine rocklands outside of ENP, making the proper management of EEL’s pine rocklands important to prevent their extinction. Two examples of these rare endemics are Goulds wedge sandmat and Mosier's false boneset (Bradley and Gann 1999).

General management recommendations for the pine rockland ecosystem, discussed in this chapter, should be sufficient for the preservation of most rare plant species. The use of prescribed fire is the most critical habitat management tool needed to ensure the survival of rare plant species. However, extra precaution should be taken around rare plant populations to prevent trampling when removing fuel. Hand removal of duff layers around plants to reduce fire temperatures would also be beneficial.

Species-specific management of plants should be needed very rarely. In some situations, discussed on a case by case basis in Part III of this management plan, special management techniques may be beneficial to extremely rare plants. Small, isolated populations of rare plants may suffer from reduced pollination (or no pollination) because of extirpation of pollinators, genetic bottlenecks causing reduced fitness, increased herbivory or parasitism, or loss in stochastic events (floods, hurricanes, car crashes, tree falls, chemical spills, etc.) because of initial small population sizes. Such rare plant populations would benefit from more specific management techniques, when it concurs with habitat management, including cross pollination from other populations (or transplants between populations), reintroduction of pollinators, and establishment of greenways or stepping stones between isolated populations to facilitate pollinator travel resulting in gene flow between populations.

It is also recommended that ex-site collections of rare plants be maintained to prevent their extirpations or extinctions. Such collections of some species are already being maintained by Fairchild Tropical Botanic Garden (FTBG), the Center for Plant Conservation, Marie Selby Botanical Gardens, and IRC. Where rare plants have been extirpated from sites within their historic ranges, they could be reintroduced from these collections. Specific examples are detailed in Gann et al. (2002) and discussed for specific sites in Part III of this management plan.

4.4.2 Animals

Management goals for native fauna in general should be aimed at simply restoring and maintaining natural pine rocklands habitats, in an effort to support the associated animal communities. In addition, the following species should receive special attention as outlined below.

- Gopher tortoise – Management efforts should aim to preserve large tracts of habitat that are burned at regular intervals to maintain a dense herb layer. Translocation of this species should be avoided and, when necessary, done only with extreme caution due to an upper respiratory tract infection caused by *Mycoplasma agassizii* currently infecting wild populations of gopher tortoise.

- Rimrock crowned snake – Many of the EEL sites along the Miami Rock Ridge of eastern Miami-Dade County are within the historic range of this species and contain appropriate habitat. Efforts should be made to maintain rockland habitat in those parks. Additionally, this species appears to be somewhat tolerant of marginal habitats so areas surrounding these sites, even urban development, should be encouraged to incorporate natural landscaping and to provide cover material for refugia.

- Florida leafwing butterfly – EEL pinelands along the edge of ENP may be crucial for this species' recovery. To assist in this process, further habitat loss from development and fire suppression, resulting in succession, must be stemmed. Other threats to this species include chemical impacts of pesticides used in mosquito control and overcollection for commercial and recreational purposes.

- Bartram's hairstreak butterfly – In order for this species to recover, further habitat loss from development and fire suppression, resulting in succession, must be stemmed. Other threats to this species include chemical impacts of pesticides used in mosquito control and overcollection for commercial and recreational purposes.

4.5 Exotic Organisms

The invasion of exotic organisms, especially plants, into pine rocklands is one of the greatest threats to the ecosystem. As discussed in Part I, Section 5.2.2.1 and 5.2.2.2 of this management plan, exotic organisms can disrupt and alter ecosystem processes, vegetation structure, and composition. Management of exotic plants and animals is discussed below.

4.5.1 Plants

Management Policy
Exotic plants must be eliminated from pine rockland EEL sites or maintained at very low densities. Planting of these species on pine rockland EEL sites is forbidden.

Exotic plant species are present on all pine rockland fragments (see section 3.10.1). Exotic plant species that are listed as Category I or II invasives by the FLEPPC (www.fleppc.org) should be prioritized for removal from pine rocklands. Sparse populations of exotic pest plants should be removed before removal of denser stands to maximize restored habitat area. Following removal of sparse populations, denser populations, especially those in more degraded habitat areas, should be removed. General guidelines for exotic plant control in pine rocklands are discussed here, and site–specific management is discussed in Part III of this plan.

Prescribed fire can be used as the main technique to control exotic plants. Fires can kill individuals of many species (e.g. Brazilian-pepper), limit their populations sizes, and, most significantly, return pine rockland sites to conditions unfavorable for exotic plant invasions. Fire management is discussed in detail in Section 4.6.

In the absence of fire, chemical control of exotic plant species has been and should remain the preferred management technique. For some species, especially smaller populations, manual removal hand pulling, digging, or cutting) can also be used. Control of especially dense populations of exotic plants in degraded pine rocklands or in disturbed areas adjacent to pine rocklands may require more planning than removal of sparse populations. For these areas, in addition to chemical control and manual removal, management may require bulldozing or the use of other machinery.

All exotic plant control methods in pine rocklands should limit soil disturbance. Soil disturbances can create opportunities for invasion of the same exotic plant being removed or for new exotic or ruderal species. While utilizing techniques such as hand pulling or digging, soil disturbance should be reduced as much as possible. Chemical control or cutting of exotic plants can also be employed as alternatives to soil disturbing activities.

4.5.2 Animals

Management Policy

Control measures must be developed and implemented at pine rockland EEL preserves to halt and reverse the spread of invasive naturalized exotic animal species and to prevent the establishment of new exotic animal species populations

Populations of exotic animals in the pine rockland community should be evaluated for their impact to these habitat. In addition to feral domestic cats, already discussed Part I of this management plan (see Section 5.2.2.2), the following non-indigenous animals have the potential to impact pine rockland communities to varying degrees. Non-indigenous animals should be targeted for removal from pine rockland fragments, especially when they alter ecosystem processes, compete with native wildlife, or damage native plant species. Control of some species may be impractical or even impossible.

Red imported fire ant – Fire ants may be controlled by treating individual mounds or through broadcast treatments. While broadcast treatments are more effective at eliminating entire colonies, this technique should generally be avoided in EEL pine rocklands so as not to impact populations of native ant species. There are many options for mound treatment, but the most appropriate and effective in natural areas is probably placing toxic bait directly on individual mounds. Biological controls are also being tested in Florida and may prove to be appropriate for EEL sites. These include a decapitating fly of the genus *Pseudacteon* which attacks fire ant workers and a fire ant disease, *Thelohania solenopsae* (Willcox and Giuliano 2006).

European starling – Numerous products exist for controlling starlings, but many of these would likely disturb native birds as well. There are auditory repelling devices designed to target this species by emitting their distress calls, but experimentation should be done prior to installation to ensure that they only impact starlings. Even if effective, this method may only work in smaller pineland fragments where enough devices could be set up to cover the entire area.

Parrots and parakeets – Managing for members of the Psittacidae family may not be possible. These birds are highly charismatic and are adored by the public. Any large-scale effort to control their populations will likely be met with outrage. The only option may be monitoring of nest cavities and manual removal of non-native birds.

Lobate lac scale – Protected pine rockland areas should be monitored for the presence of this species and control measures implemented in the area if detected. Some woody plant species appear to be highly susceptible, including certain natives, e.g., wax-myrtle, strangler-fig, myrsine, swamp bay, and wild-coffee. Control can be accomplished in part by following regular subcanopy management recommendations – cutting and burning. In some cases, especially for rare plants, an insecticidal solution may be applied for several weeks to kill the scales. Treatment of lobate lac scale is particularly important in areas with rare bushes, especially Florida prairieclover and crenulate leadplant, which have been observed with infestations.

4.6 Fire Management

Management Policy

Fire management on all pine rockland EEL sites shall concentrate on a prescribed burning program, along with hardwood control and installation and maintenance of fire breaks. The prescribed burning program must account for seasonality of burns, personnel necessary, the risk of wildfires, and actual application, including safety measures and effectiveness. Alternatives to prescribed burning will only be utilized as a last resort.

Since pine rocklands are fire climax communities, fire management, along with exotic plant control, is one of the most critical techniques required to restore and manage pine rocklands. Site-specific recommendations and objectives for prescribed fires will be presented in Part III of this management plan. General recommendations for fire management are discussed here, including hardwood control, fire breaks, prescribed burning, and alternatives to prescribed burning.

4.6.1 Hardwood Control

Manual, mechanical, or chemical hardwood control will be required at many pine rockland sites to prepare for prescribed fires. The amount of woody material to be removed should be coordinated with the burn team. Hardwood and palm densities should be reduced prior to burning to reduce burn temperatures. An added benefit is the reduction of smoke levels during and post-fire, and less need for mop up.

Pineland with hardwood invasion
Photo by Keith Bradley, IRC

4.6.2 Fire Breaks

Fire breaks should be maintained or installed around all pine rocklands. Construction of these fire breaks is necessary to permit access for fire fighting equipment and staff. Fire breaks are also essential to protection of structures and surrounding properties if and when wildfires occur.
Only general considerations about fire breaks are made here in Part II. Their specific location on each site is discussed in Part III of this management plan.

Though utilizing existing rights-of-way as fire breaks is preferred, fire break construction may require destruction of some pine rockland habitat. Nevertheless, fire breaks, and the consequent habitat destruction, are necessary to properly control a burn, and if fires cannot be set then the entire site will degrade, making the cost of limited habitat destruction worthwhile. Fire breaks should be cleared to bare rock or soil, which will not only prevent ground fires from crossing them, but will create habitat for pine rockland plant species and limit invasion of exotic and ruderal plant species (see Section 4.5.1 above).

4.6.3 Prescribed Burning

As discussed in Section 2.6.1 above, large wind-driven fires historically swept across the South Florida landscape every three (3) to seven (7) years, especially in the spring and summer. More recently, as discussed in Section 3.6.1, fire frequency has been drastically reduced or eliminated on most sites, resulting in changed vegetation structure, decreased plant diversity, and increased fuel loads. To compensate for the lack of natural fires, prescribed burns should be applied to pine rocklands every three (3) to seven (7) years.

4.6.3.1 Seasonality

Historically, while fires were probably the most frequent in spring and summer, they probably also occurred at other times of the year (see Section 2.6.1). Prescribed fires should be set whenever it is possible to do so, regardless of season. Different burn seasons may have different impacts on vegetation, but a lack of fire is much more problematic than a burn outside of preferred season. Dry season (i.e. the spring months up until May or June, depending on weather conditions), backing fires are preferred on fire-suppressed sites because they are more effective in reducing hardwood densities than wet season burns, especially when applied at short intervals. The first burn may result in temporarily increased hardwood stem density due to coppicing from plant bases, but subsequent burns begin to kill these hardwoods after their food reserves are exhausted.

4.6.3.2 Application

Prescribed burns should be applied in any way that burn teams designate as controllable, whether they are head fires, backing fires, or flanking fires, as long as fire intensity is limited. The application of fire is more critical than the type of fire, as long as fires do not become so intense as to become uncontrollable, create a crown fire, or overheat understory palms and herbs. As described above, dry season backing fires are preferred on fire-suppressed sites.

4.6.3.3 Wildfires

In addition to providing a critical ecosystem function, the application of prescribed fires to pine rockland fragments serves as protection to structures and people who live or work near the fragments. Many fragments have dangerously high fuel loads. Wildfires started by arson or by accident can create dangerous conditions and can result in destruction of property, including homes, and even loss of life. Wildfires are much more difficult for firefighters to manage than prescribed fires. Wildfires may not even be reached by emergency personnel quickly enough to prevent loss of property or life.

In addition to collateral, off-site damage, wildfires can cause unexpected damage on county owned pine rockland fragments. Emergency personnel regularly install fire lines with bulldozers or bombardiers to fight wildfires, or even clear areas of habitat, resulting in loss of habitat and opportunities for invasion of exotic pest plants. Regular use of prescribed fire is a feasible way to reduce the threat of dangerous wildfires. Restrictions on the use of prescribed fire could result in loss of property or life.

4.6.3.4 Personnel

As discussed in Part I of this management plan, finding personnel to conduct prescribed fires in Miami-Dade County has been a major obstacle in the proper management of pine rocklands. The Florida Division of Forestry (FDOF) has been used on all prescribed burns, often with assistance from the few county staff with appropriate training. Unfortunately, FDOF's presence in Miami-Dade County is very limited, and even when time allows they are usually reluctant to set fires for liability reasons, even though they have legal protection (Brenner and Wade 2003). Attempts to reach an agreement with fire crews at ENP to allow them to burn county properties have stalled.

The EEL program should investigate the use of private contractors to implement an effective fire management program (see also Part I, Section 5.2.1). Several companies in Florida provide this service and their use in Miami-Dade County should be encouraged. Costs of using private contractors may be much higher than using FDOF, but the absence of fires will result in increasing hardwood removal costs, decreasing habitat quality, and increasing threat of damaging wildfires.

4.6.4 Alternatives to Prescribed Burning

If the application of prescribed fire is absolutely impossible, there are several alternatives that are available, although less desirable. These options include grazing, herbicide application, and mechanical treatment. Grazing, such as by goats, has the disadvantage of introducing trampling effects, nutrients from feces, and possible spread of exotic pest plant seeds. Both herbicide application and mechanical treatments have the disadvantage of requiring that dead woody material be removed from the site following treatment to limit the amount of decomposing vegetation that would create organic soils. Even with physical removal after treatment, organic matter from all plants on the site will eventually accumulate, leaving an organic soil, and thereby reducing diversity of native herbs and potentially introducing invasive species. Physical removal after treatment can also cause disturbances. In addition, none of these techniques replicate a fire's ability to return nutrients to the soil for short periods of time, a process that is critical to many pine rockland plant species. These alternative techniques, as opposed to prescribed burning, require a significantly greater labor commitment from personnel and come at a significant ecological cost.

4.7 Management after Tropical Cyclones

Management Policy

Post-storm evaluations shall be conducted at all pine rockland EEL sites to determine the extent and severity of damage to vegetation, wildlife, and structures. After inspection, an action plan shall be developed to mitigate any impacts caused by the event.

As discussed in 2.6.2 and 3.6.2, tropical cyclones, including tropical storms and hurricanes, can break or topple pine trees, make pine trees susceptible to pest insect outbreaks, and defoliate or damage understory hardwoods. Storms can also blow manmade debris into pine rocklands, including large items such as shipping containers and boats, which can damage vegetation and soils. In addition to these direct effects, post-storm impacts from people can also be considerable, including dumping, habitat clearing, and establishment of campgrounds or temporary homes.

Establishment of post storm security should be a top priority, including temporary erection of fences, gates, and signs. If existing signs are destroyed, inexpensive, temporary "no dumping" signs should be installed liberally around property perimeters. Sites should be inspected regularly for dumping and trespassing.

Maintenance of a sparse pine canopy, as discussed in Section 4.3.1, will limit outbreaks of pest insects, including *Ips* beetles, following storms. If infestations do begin, trees can be protected by the application of Onyx, a bark-adhering formulation of bifenthrin that is applied to bark. Infested trees should be cut down and sprayed with Onyx. If other chemicals are available for this use, they can be tried as well.

4.8 Hydrological Restoration

Management Policy
The EEL program will support any large scale restoration project which would be beneficial to the hydrological restoration of pine rockland EEL sites.

Pine rocklands are upland communities but have been stressed by a lowered water table, for example, in recovery from wind damage or fires. Though it is unlikely that any small scale, site specific project, could occur to remedy this problem, large scale restoration would be very beneficial to stressed pine rocklands. While such large scale restoration projects are not feasible for the EEL program to accomplish alone, EEL would support and partner with any existing or proposed restoration plans that would attempt to elevate water tables closer to historic levels. Water levels that re-hydrate adjacent wetlands would be very advantageous for the adjacent pine rocklands.

4.9 Soil Management

Management Policy
Soil on pine rockland EEL sites shall be managed by prescribed burning. Direct use of fertilizers and other nutrient applications are forbidden on any pine rockland EEL site.

Pine rockland soils are naturally nutrient poor. However, successional changes lead to changes in the soil. In the absence of fire, hardwoods invade pine rockland habitat, resulting in inhibition of pine regeneration. As hardwoods invade, accumulation of organic matter in the soils and increased shading results in an increase in soil moisture, which inhibits fires that maintain the pine rockland community.

Because pine rockland soils are naturally nutrient poor, proper ecosystem management (particularly burning) will maintain the low fertility of pine rockland soils. Accumulation of organic matter increase the nutrient levels and favor the invasion of pine rockland habitat by hardwoods. Winter backing burns can be used to reduce the levels of organic matter in the soil of those sites where the accumulation is already higher than desirable.

Direct use of fertilizers and other nutrient applications are forbidden. Inputs from off-site nutrient sources that migrate into pine rocklands should be prevented and controlled in case they are occurring. Source reduction of nutrients might be needed to reduce edge-of-field and leaching from neighboring agricultural areas (see Part I, Section 5.2.5).

4.10 Cultural Resources

Management Policy

EEL Program will protect any archeological, historic, and cultural resources found in its properties. Management of those resources will comply with mandates from the Florida Statutes [Sections 267.061 (a) and (b)].

Cultural resources on pine rockland EEL sites should be managed in accordance with the management policy for all Miami-Dade County EEL preserves. Please refer to Part I, Section 3.3 of this management plan for details about management of cultural resources on EEL sites.

4.11 Pollution Control

Management Policy

Pollution on pine rockland EEL sites shall be managed through source reduction in and around all sites.

Generally, the goal of source reduction to control pollutants applies to all pine rockland EEL sites in the same manner as it does for all other EEL sites. Please refer to Sections 5.2.5 and 5.4.3 in Part I of this management plan for management and contingency management of pollutants in and around EEL preserves.

4.12 Landscaping Considerations

Management Policy

All landscaping that occurs adjacent to pine rockland EEL sites should avoid exotic plants or problematic native plant species that could possibly invade EEL sites.

Landscaping adjacent to pine rocklands should be done to minimize the threat of invasive exotic plants and also native plant species that could become maintenance problems in the ecosystem. No plant species listed by the FLEPPC as Category I or II (**Appendix C**) should be planted on EEL sites. Exotic plant species that can naturalize, even those not listed by FLEPPC, should not be planted on EEL sites. Lists of exotic species that naturalize in South Florida can be found online at www.regionalconservation.org in the Floristic Inventory of South Florida database, or at www.plantatlas.usf.edu/, the Atlas of Florida Vascular Plants. Cultivated trees that are FLEPPC listed or that naturalize should be removed from EEL sites where they are already present.

Native hardwood species that may invade pine rocklands should not be used, including live oak, wild tamarind, gumbo limbo, and others. Where already cultivated on EEL sites, their removal should be considered.

Native plant species that are suitable for cultivation on EEL sites can be found in the Natives for Your Neighborhood database online at www.regionalconservation.org. Using this database, lists of pine rockland species can be generated specific for each zip code in Miami-Dade County.

4.13 Off-site Exotic Plant and Animal Sources

Management Policy
A dual approach that includes source reduction and removal of existing species shall be used in managing exotic plants and animals in and around pine rockland EEL sites.

As discussed throughout Parts I and II of this management plan, exotic flora and fauna becoming invasive within EEL sites is a major problem. This is especially true for pine rockland EEL sites. A dual approach that includes source reduction and removal of existing species will be most efficient in managing exotic species in native ecosystems. Possible sources of exotic species into pine rockland sites include:

- Escape of exotic pets being imported for the exotic pet trade
- Dumping of exotic pets that have become unwanted by their owners
- Wind dispersion of seeds (especially after major storm events such as hurricanes)
- Water dispersion of seeds
- Animal dispersion of seeds
- Intentional introduction of exotic species for drainage or landscaping

The EEL program should work with adjacent landowners where feasible, including public agencies and private landowners, to eliminate exotic plant populations. Reduction or elimination of pest plants near pine rockland EEL sites will decrease invasion rates and reduce long-term management costs.

4.14 Restoration of Pine Rockland on Degraded Soils

Management Policy
Restoration of pine rockland on degraded soils within pine rockland EEL sites shall consist of soil management, weed control, and planting of advantageous species.

At many sites, as discussed individually in Part III of this management plan, it will be desirable to reestablish pine rockland vegetation in areas with degraded soils, such as rock-plowed or bulldozed soils. Unlike the re-creation of rockland hammock habitat, discussed in Chapter X, re-creation of pine rocklands are much more difficult and the process has not been fully developed. Gann (2006) details the currently known best practices for replanting pine rocklands. The discussion below draws from Gann (2006).

All loose soil and organic material on the site should be removed so that almost the entire ground surface consists of bare oolitic limestone. Pines (which will suffer large mortality) should be planted at densities of one plant per 50 to 100 square feet, from three (3) to seven (7) gallon containers or smaller. Palms and subshrubs, including saw palmetto, silver palm, coontie, quailberry, pineland croton, and gopher apple should be planted throughout the restoration area. Larger hardwoods should be avoided.

Weeds should be controlled aggressively on the site to avoid establishment of an organic layer and a seed bank of unwanted species. Control can be achieved by hand pulling, chemical control, or other means, but as much of the plant material should be removed from the sites as possible.

Herbaceous species, including forbs, grasses, and sedges, may recruit naturally on the site soon after soil clearing. They may establish from persistent roots (depending on site history), from a seed bank, or from seed rain from nearby pine rockland. Herb cover can be augmented several months after planting of pines, palms, and subshrubs to re-create the diversity of pine rocklands typical of the project area. Plant species that already occur on the site's intact pine rockland, or those that are historically known from the area, should be used.

After all plants are installed, two (2) to three (3) inches of pine straw should be placed throughout the site. During establishment the site should be watered to ensure survival of as many plants as possible, as often as once per day for several weeks after installation. Watering should be decreased as quickly as possible to prevent weed invasions. Weeds should be controlled monthly until the project is self-sustaining. Additional applications of pine straw may be required. Pine straw should be clean, having no seeds. Pine straw can also be collected within pine rockland on the same site as the planting area if there is enough. This would have the added benefit of introducing seeds of pine rockland plant species from the same property.

4.15 Security

Management Policy

In the event of any security breach at any pine rockland EEL site, the site manager (or any persons observing such a violation) should report such actions to the Miami-Dade County Police Department, for proper investigation.

At times, it may be necessary to enforce certain security measures to ensure the preservation of EEL pine rockland sites. These measures, which include but are not limited to, fencing, signage, patrolling by county personnel, and continuous staffing of entrances to sites, are similar for all EEL sites. Please refer to Part I, Section 5.4.5 of this management plan for details about the security management policy for EEL preserves.

4.16 Partnerships

The EEL program has partnered with several Miami-Dade County agencies and organizations in an effort to better protect and preserve EEL sites. These agencies include Miami-Dade County Natural Areas Management (NAM), Miami-Dade County Park and Recreation Department, IRC, FTBG, and the Nature Conservancy. Please refer to Part I of this management plan for details about these agencies, and others, and how they play a role in the EEL program.

5.0 Public Use of the Pine Rockland EEL Properties

Consistent with the defined goals of the EEL Program (refer to Part I, Section 5.3), prospective public uses of pine rockland sites should avoid potential ill effects. Public use on all pine rockland EEL sites will be managed in accordance with all management policies outlined in Part I of this management plan. Part III of this management plan will provide site-specific information for the uses that are allowed in each of the EEL preserves, taking into consideration the need for preservation as well as the opportunities for primarily passive recreation.

6.0 Monitoring, Research, and Information Needs

Management Policy

Long-term biological research and monitoring must be conducted on pine rockland EEL sites to determine appropriate vegetation densities, control exotic and problematic plant species, and determine restoration needs following fires. Furthermore, any research that benefits pine rockland EEL sites should be encouraged and permitted.

General monitoring, research, and information needs have been discussed in Part I of this management plan. Long-term management of pine rocklands poses several challenges that will require specific research to overcome. Additional issues that should be studied include:

- Appropriate densities of pine trees and understory shrubs and hardwoods
- Control of some exotic and problematic plant species including:
  - Natal grass (currently being studied by Jennifer Possley at FTBG)
  - Lacy bracken fern control with Asulox
  - Control of growth and establishment of cabbage palmetto in drained pine rocklands
- Site recovery and determination of restoration needs following intense fires
- Recreation of pine rockland vegetation on disturbed soils

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APPENDIX A:
Scientific Names Table

Plants

Common Name	Scientific Name
crenulate leadplant	*Amorpha herbacea var crenulata*
Australian umbrellatree	*Schefflera actinophylla*
Bahama manjack	*Cordia bahamensis*
beggarticks	*Bidens alba* var. *radiata*
Brazilian pepper	*Schinus terebinthifolius*
brown anole	*Anolis sagrei*
Burma reed	*Neyraudia reynaudiana*
buttonwood	*Conocarpus erectus*
cabbage palm	*Sabal palmetto*
Carter's orchid	*Basiphyllaea corallicola*
China brake	*Pteris vittata*
coastal bedstraw	*Galium hispidulum*
cocoplum	*Chrysobalanus icaco*
coontie	*Zamia integrifolia*
crimson bluestem	*Schizachyrium sanguineum*
dwarf live oak	*Quercus minima*
earleaf greenbrier	*Smilax auriculata*
false tamarind	*Lysiloma bahamensis*
Florida five-petalled leafflower	*Phyllanthus pentaphyllus* var. *floridanus*
Florida prairieclover	*Dalea carthagenensis* var. *floridana*
Florida whitetop	*Rhynchospora floridensis*
gold coast jasmine	*Jasminum dichotomum*
gopher apple	*Licania michauxii*
Goulds wedge sandmat	*Chamaesyce deltoidea* subsp. *adhaerens*
gumbo limbo	*Bursera simaruba*
lacy bracken fern	*Pteridium aquilinum var. caudatum*
live oak	*Quercus virginiana*
low rattlebox	*Crotalaria pumila*
marlberry	*Ardisia escallonioides*
melaleuca	*Melaleuca quinquenervia*
Mosier's false boneset	*Brickellia mosieri*
muhlygrass	*Muhlenbergia capillaris*
muscadine grape	*Vitis rotundifolia*
myrsine	*Rapanea punctata*
narrowleaf hoarypea	*Tephrosia angustissima* var. *angustissima*
natal grass	*Rhynchelytrum repens*
nettletree	*Trema micrantha*
partridge pea	*Chamaecrista deeringiana*
pine fern	*Anemia adiantifolia*
pineland croton	*Croton linearis*
pineland snowberry	*Chiococca parvifolia*
pitted stripeseed	*Piriqueta caroliniana*
poison-ivy	*Toxicodendron radicans*
poisonwood	*Metopium toxiferum*
quailberry	*Crossopetalum ilicifolium*
red bay	*Persea borbonia*
rhizomatous bluestem	*Schizachyrium rhizomatum*
rough velvetseed	*Guettarda scabra*
saw palmetto	*Serenoa repens*

sawgrass	*Cladium jamaicense*
shrubby false buttonweed	*Spermacoce verticillata*
shrubverbena	*Lantana camara*
silver palm	*Coccothrinax argentata*
snowberry	*Chiococca alba*
South Florida slash pine	*Pinus elliottii* var. *densa*
southern sumac	*Rhus copallinum*
starrush whitetop	*Rhynchospora colorata*
strangler-fig	*Ficus aurea*
swamp bay	*Persea palustris*
three-seeded mercury	*Acalypha chamaedrifolia*
wax myrtle	*Myrica cerifera*
West Indian-lilac	*Tetrazygia bicolor*
white indigo berry	*Randia aculeata*
wild bean	*Macroptilium lathyroides*
wild sage	*Lantana involucrata*
wild-coffee	*Psychotria nervosa*
wild-tamarind	*Lysiloma latisiliquum*
willow bustic	*Sideroxylon salicifolium*
wire bluestem	*Schizachyrium gracile*
woman's tongue	*Albizia lebbeck*

Animals

Common Name	Scientific Name
Bartram's hairstreak butterfly	*Strymon acis bartrami*
black rat	*Rattus rattus*
European and African wild cat	*Felis silvestris*
European starling	*Sturnus vulgaris*
feral domestic cat	*Felis catus*
Florida box turtles	*Terrapene carolina*
Florida leafwing butterfly	*Anaea troglodyte floridalis*
gopher tortoise	*Gopherus polyphemus*
green iguana	*Iguana iguana*
lobate lac scale	*Paratachardina lobata lobata*
nine-banded armadillo	*Dasypus novemcinctus*
parrots and parakeets	Psittacidae family
red imported fire ant	*Solenopsis invicta*
rim rock crowned snake	*Tantilla oolitica*
true lac scale insect	*Kerria lacca lacca*
white-crowned pigeon	*Columba leucacephala*

APPENDIX B:
Historical Pictures of Pine Rocklands

Pine Rocklands in Miami-Dade County (1922)
Photo by: Herman Gunter

Pine Rocklands in Miami-Dade County (1922)
Photo by: Herman Gunter

Fire in Pine Rocklands in Miami-Dade County (1915 or 1916)
Photo by: J. K. Small

Pine Rocklands in Homestead, Florida (1910)
Photo by: Gibbons (of Katherine and Mildred Gibbons)

Logging in Pine Rocklands in Miami-Dade County (1916)
Photo by: J. K. Small

Pine Tree in Pine Rocklands in Miami-Dade County (1934)
Photo by: W. F. Jacobs

APPENDIX C:
List of Florida Invasive Plants

Florida Exotic Pest Plant Council's 2005

List of Invasive Species

Purpose of the List: *To focus attention on* --

- the adverse effects exotic pest plants have on Florida's biodiversity and plant communities,
- the habitat losses from exotic pest plant infestations,
- the impacts on endangered species via habitat loss and alteration,
- the need to prevent habitat losses through pest-plant management,
- the socio-economic impacts of these plants (e.g., increased wildfires in certain areas),
- changes in the seriousness of different pest plants over time,
- the need to provide information that helps managers set priorities for control programs.

DEFINITIONS: *Exotic*—a species introduced to Florida, purposefully or accidentally, from a natural range outside of Florida. *Native*—a species whose natural range included Florida at the time of European contact (1500 AD). *Naturalized exotic*—an exotic that sustains itself outside cultivation (it is still exotic; it has not "become" native). *Invasive exotic*—an exotic that not only has naturalized but is expanding on its own in Florida plant communities.

Abbreviations used:

for "Gov. list": **P** = Prohibited by Fla. Dept. of Environmental Protection, **N** = Noxious weed listed by Fla. Dept. of Agriculture & Consumer Services, **U =** Noxious weed listed by U.S. Department of Agriculture.
for "Reg. Dis.": **N** = north, **C** = central, **S** = south, referring to each species' current distribution in general regions of Florida (not its potential range in the state). See following map.

For additional information on distributions of particular species by county, visit the University of South Florida's Atlas of Florida Vascular Plants web site, www.plantatlas.usf.edu**. Many of those species entries also have habit and close-up pictures of the species.**

Additional images for some species may be found at the "Introduced Species" page on the Univ. of Florida Herbarium **website, at Fairchild Tropical Garden's** Virtual Herbarium, and the Godfrey Herbarium database, **Florida State University.**

For other additional information on plants included in this list, see related links and pages at this web site on the home page **menu.**

Category I - Invasive exotics that are altering native plant communities by displacing native species, changing community structures or ecological functions, or hybridizing with natives. *This definition does not rely on the economic severity or geographic range of the problem, but on the documented ecological damage caused.* **.**

Scientific Name	Common Name	EPPC Cat.	Gov. list	Reg. Dist.
Abrus precatorius	rosary pea	I		C, S
Acacia auriculiformis	earleaf acacia	I		S
Albizia julibrissin	mimosa, silk tree	I		N, C
Albizia lebbeck	woman's tongue	I		C, S
Ardisia crenata (= A. crenulata)	coral ardisia	I		N, C
Ardisia elliptica (=A. humilis)	shoebutton ardisia	I		S
Asparagus aethiopicus (= A. sprengeri; A. densiflorus misapplied)	asparagus-fern	I		C, S
Bauhinia variegata	orchid tree	I		C, S
Bischofia javanica	bischofia	I		C, S
Calophyllum antillanum (=C. calaba; C. inophyllum misapplied)	santa maria (names "mast wood," "Alexandrian laurel" used in cultivation)	I		S
Casuarina equisetifolia	Australian pine	I	P	N,C,S
Casuarina glauca	suckering Australian pine	I	P	C, S
Cinnamomum camphora	camphor-tree	I		N,C,S
Colocasia esculenta	wild taro	I		N,C,S
Colubrina asiatica	lather leaf	I		S
Cupaniopsis anacardioides	carrotwood	I	N	C, S
Dioscorea alata	winged yam	I	N	N,C,S
Dioscorea bulbifera	air-potato	I	N	N,C,S
Eichhornia crassipes	water-hyacinth	I	P	N,C,S
Eugenia uniflora	Surinam cherry	I		C, S
Ficus microcarpa (F. nitida and *F. retusa* var. *nitida* misapplied)	laurel fig	I		C, S
Hydrilla verticillata	hydrilla	I	P, U	N,C,S
Hygrophila polysperma	green hygro	I	P, U	N,C,S
Hymenachne amplexicaulis	West Indian marsh grass	I		C, S
Imperata cylindrica (*I. brasiliensis* misapplied)	cogon grass	I	N, U	N, C, S
Ipomoea aquatica	waterspinach	I	P, U	C
Jasminum dichotomum	Gold Coast jasmine	I		C, S
Jasminum fluminense	Brazilian jasmine	I		C, S
Lantana camara	lantana, shrub verbena	I		N,C,S
Ligustrum lucidum	glossy privet	I		N, C
Ligustrum sinense	Chinese privet, hedge privet	I		N,C,S
Lonicera japonica	Japanese honeysuckle	I		N,C,S
Lygodium japonicum	Japanese climbing fern	I	N	N,C, S
Lygodium microphyllum	Old World climbing fern	I	N	C, S
Macfadyena unguis-cati	cat's claw vine	I		N,C, S
Manilkara zapota	sapodilla	I		S
Melaleuca quinquenervia	melaleuca, paper bark	I	P, N, U	C, S
Mimosa pigra	catclaw mimosa	I	P, N, U	C, S
Nandina domestica	nandina, heavenly bamboo	I		N, C
Nephrolepis cordifolia	sword fern	I		N,C,S
Nephrolepis multiflora	Asian sword fern	I		C, S
Neyraudia reynaudiana	Burma reed, cane grass	I	N	S
Paederia cruddasiana	sewer vine, onion vine	I	N	S
Paederia foetida	skunk vine	I	N	N,C
Panicum repens	torpedo grass	I		N,C,S
Pennisetum purpureum	Napier grass	I		C, S
Pistia stratiotes	waterlettuce	I	P	N,C,S
Psidium cattleianum (=P. littorale)	strawberry guava	I		C, S

Scientific Name	Common Name	EPPC Cat.	Gov. list	Reg. Dist.
Psidium guajava	guava	I		C, S
Pueraria montana var. *lobata* (=*P. lobata*)	kudzu	I	N, U	N,C, S
Rhodomyrtus tomentosa	downy rose-myrtle	I	N	C, S
Rhoeo spathacea (see *Tradescantia spathacea*)				
Rhynchelytrum repens	Natal grass	I		N, C, S
Ruellia tweediana (= *R. brittoniana*)	Mexican petunia	I		N, C, S
Sapium sebiferum (= *Triadeca sebifera*)	popcorn tree, Chinese tallow tree	I	N	N, C, S
Scaevola taccada (=*Scaevola sericea, S. frutescens*)	scaevola, half-flower, beach naupaka	I		C, S
Schefflera actinophylla (=*Brassaia actinophylla*)	schefflera, Queensland umbrella tree	I		C, S
Schinus terebinthifolius	Brazilian pepper	I	P, N	N, C, S
Senna pendula var. *glabrata* (=*Cassia coluteoides*)	climbing cassia, Christmas cassia, Christmas senna	I		C, S
Solanum tampicense (=*S. houstonii*)	wetland night shade, aquatic soda apple	I	N, U	C, S
Solanum viarum	tropical soda apple	I	N, U	N, C, S
Syngonium podophyllum	arrowhead vine	I		C, S
Syzygium cumini	jambolan, Java plum	I		C, S
Tectaria incisa	incised halberd fern	I		S
Thespesia populnea	seaside mahoe	I		C, S
Tradescantia fluminensis	white-flowered wandering jew	I		N, C
Tradescantia spathacea (= *Rhoeo spathacea, Rhoeo discolor*)	oyster plant	I		S
Urochloa mutica (= *Brachiaria mutica)*	Pará grass	I		C, S

Category II - Invasive exotics that have increased in abundance or frequency but have not yet altered Florida plant communities to the extent shown by Category I species. *These species may become ranked Category I, if ecological damage is demonstrated.*

Scientific Name	Common Name	EPPC Cat.	Gov. list	Reg. Dist.
Adenanthera pavonina	red sandalwood	II		S
Agave sisalana	sisal hemp	II		C, S
Aleurites fordii (= *Vernicia fordii)*	tung oil tree	II		N, C
Alstonia macrophylla	devil-tree	II		S
Alternanthera philoxeroides	alligator weed	II	P	N, C, S
Antigonon leptopus	coral vine	II		N, C, S
Aristolochia littoralis	calico flower	II		N, C
Asystasia gangetica	Ganges primrose	II		C, S
Begonia cucullata	wax begonia	II		N, C
Blechum pyramidatum	green shrimp plant, Browne's blechum	II		N, C, S
Broussonetia papyrifera	paper mulberry	II		N, C
Callisia fragrans	inch plant, spironema	II		C, S
Casuarin cunninghamiana	Australian pine	II	P	C, S
Cecropia palmata	trumpet tree	II		S
Cestrum diurnum	day jessamine	II		C, S
Chamaedorea seifrizii	bamboo palm	II		S
Clematis terniflora	Japanese clematis	II		N, C
Cryptostegia madagascariensis	rubber vine	II		C, S
Cyperus involucratus (C. alternifolius misapplied)	umbrella plant	II		C, S
Cyperus prolifer	dwarf papyrus	II		C

Scientific Name	Common Name	EPPC Cat.	Gov. list	Reg. Dist.
Dalbergia sissoo	Indian rosewood, sissoo	II		C, S
Elaeagnus pungens	thorny eleagnus	II		N, C
Epipremnum pinnatum cv. Aureum	pothos	II		C, S
Ficus altissima	false banyan, council tree	II		S
Flacourtia indica	governor's plum	II		S
Hemarthria altissima	limpo grass	II		C, S
Hibiscus tiliaceus	mahoe, sea hibiscus	II		C, S
Ipomoea fistulosa (= *I. carnea* ssp. *fistulosa*)	shrub morning-glory	II	P	C, S
Jasminum sambac	Arabian jasmine	II		S
Kalanchoe pinnata	life plant	II		C, S
Koelreuteria elegans ssp. *formosana* (= *K. formosana; K. paniculata* misapplied)	flamegold tree	II		C, S
Leucaena leucocephala	lead tree	II		N, C, S
Limnophila sessiliflora	Asian marshweed	II	P	N, C, S
Livistona chinensis	Chinese fan palm	II		C, S
<u>*Melia azedarach*</u>	Chinaberry	II		N,C,S
Merremia tuberosa	wood-rose	II		S
Murraya paniculata	orange-jessamine	II		S
Myriophyllum spicatum	Eurasian water-milfoil	II	P	N, C, S
Nymphoides cristata	snowflake	II		C, S
Panicum maximum	Guinea grass	II		C, S
Passiflora biflora	two-flowered passion vine	II		S
Pennisetum setaceum	green fountain grass	II		S
Phoenix reclinata	Senegal date palm	II		C, S
Pittosporum pentandrum	Philippine pittosporum, Taiwanese cheesewood	II		S
Phyllostachys aurea	golden bamboo	II		N, C
Pteris vittata	Chinese brake fern	II		N, C, S
Ptychosperma elegans	solitary palm	II		S
Ricinus communis	castor bean	II		N, C, S
Sansevieria hyacinthoides	bowstring hemp	II		C, S
Scleria lacustris	Wright’s nutrush	II		C, S
Sesbania punicea	purple sesban, rattlebox	II		N, C, S
Solanum diphyllum	Two-leaf nightshade	II		N, C, S
Solanum jamaicense	Jamiaca nightshade	II		C
<u>*Solanum torvum*</u>	susumber, turkey berry	II	N, U	N, C, S
Sphagneticola trilobata (= *Wedelia trilobata)*	wedelia	II		N, C, S
Stachytarpheta urticifolia (= *S. cayennensis)*	nettle-leaf porterweed	II		S
Syagrus romanzoffiana (= *Arecastrum romanzoffianum)*	queen palm	II		C, S
Syzygium jambos	rose-apple	II		C, S
Terminalia catappa	tropical almond	II		C, S
Terminalia muelleri	Australian almond	II		C, S
Tribulus cistoides	puncture vine, burr-nut	II		N, C, S
Urena lobata	Caesar's weed	II		N, C, S
Vitex trifolia	simple-leaf chaste tree	II		C, S
Washingtonia robusta	Washington fan palm	II		C, S
Wedelia (see *Sphagneticola* above)				
Wisteria sinensis	Chinese wisteria	II		N, C
Xanthosoma Sagittifolium	malanga, elephant ear	II		N, C, S

Citation example:
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