TREC-RMC-2003-02

Final Report:

Land Cover Classification from Digital Color-Infrared Aerial Photos and GIS Parcel Database Maintenance In the Frog Pond

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Executive Summary

The Frog Pond Agricultural Area is a mixed land use region in southern Miami-Dade County. It shares its western border with Everglades National Park. A classification of the vegetation/land cover in the Frog Pond was requested by the South Dade Soil and Water Conservation District (SDSWCD) in order to establish a baseline from which to compare and interpret changes that may be related to hydrological and structural modifications being implemented by the federal government in the Everglades restoration effort. Classification was performed on an aerial infrared color photograph of the Frog Pond using Erdas Imagine 8.5. The vegetation associations, or habitats, were organized into six native, characteristically Everglades habitats, and three disturbed. Of the total 5,385 acres in the Frog Pond, 502 fell into the native habitats, and 1,174 into disturbed habitats. Together these comprise thirty-one percent of the total land area of the Frog Pond. Cattail, often an indicator of excess phosphorous in the Everglades, covers approximately forty-four acres; Elephant grass, an exotic invasive species, covers a minimum of 297 acres. We found no exotic species not mentioned in a 2000 report by the Center for Aquatic and Invasive Species. A second aspect of the study was to update the Geographic Information Systems database of land use that had been generated in 2001. Changes to the database were made using Arc/Info 8.1 and ArcView 3.2. A total of 377 acres in four leased agricultural parcels was removed from agriculture and became part of the Detention Pond. Erdas is very useful for its powerful unsupervised classification functions, although the user must make often difficult decisions about which resulting classes to combine. The suite of ESRI tools available in Arc/Info and ArcView provide flexibility, ease of vector editing and display and overlay capabilities. Bi-annual follow up studies are urged in order to understand the results of these modifications in the Frog Pond and also to provide a model for how to approach habitat change resulting from similar modifications elsewhere.

Table of Contents

1. Introduction

The Frog Pond Agricultural Area covers 5,385 acres in southern Miami-Dade County and shares its western border with Everglades National Park. Work is under way by the South Florida Water Management District (SFWMD) and the Army Corps of Engineers to implement hydrological and structural modifications in the Frog Pond as part of the federally authorized Comprehensive Everglades Restoration Program (CERP) and the Interim Operational Plan (IOP) for Protection of the Cape Sable Seaside Sparrow. The modifications in the Frog Pond were designed to restore fresh water flow to Taylor Slough, which originates in the western part of the Frog Pond and continues into Everglades National Park, and are part of an overall effort to restore the hydroperiods in the Everglades marshes. These changes are expected to affect vegetation cover in the Frog Pond. While the specific results of these altered water levels and timing of water deliveries are currently being studied by our group as well as others, it is expected that hydrophilic plant cover will increase as water levels rise and that the sustainability of other land uses in the Frog Pond may be affected. A classification of the vegetation/land cover as of 2002 was requested by the South Dade Soil and Water Conservation District (SDSWCD) in order to establish a baseline from which to compare and interpret vegetation changes that may be related to these modifications. As the study proceeded, it was decided to estimate the coverage of cattail and elephant grass, as indicators, respectively, of high nutrient levels in the soil and of an invasion by an exotic species.

A Geographic Information Systems (GIS) database of land use in the Frog Pond was created in 2001 under contract between the SDSWCD and TREC. This layer contains information on leased agricultural parcels provided by the SDSWCD and was constructed from existing GIS layers obtained from the SFWMD and Miami-Dade County's Information Technology Department (ITD). This database needed to be updated to reflect changes both in land uses, as well as in the gross land cover resulting from the hydrological and structural modifications.

In February 2003, the USGS provided Lidar elevation data for the C-111 drainage basin in shapefile format. This included more than 65,000 elevation points that fall within the Frog Pond's boundaries. (Previously available Lidar elevation data for this area consisted of contour lines which contain less detailed information than the points.) These new data were to be examined together with the resulting habitat classes.

Prior to this study, the Center for Aquatic and Invasive Plants (2000) completed a detailed examination of the invasive plants of the Frog Pond

2. Objectives

1) To classify and quantify the current vegetation structure in the Frog Pond, at the habitat level, and other land use cover in the Frog Pond.

2) To update and maintain the GIS database of land use, as well as overlay it with GIS layers that derive from the land cover classification study as well as with the Lidar elevation data.

3. Methods

3.1. Classification of land cover

The South Dade Soil and Water Conservation District contracted with GeoImaging, LLC for digital color-infrared aerial photography of the Frog Pond. Overflights were conducted on February 18 and April 4, 2002, and the mosaic image delivered to TREC results from these two separate dates (Map 1). The four image bands are blue, green, red and infrared (near); blue, green and infrared (rather than red) were chosen for the analysis, as the infrared band shows vegetation in reds. The images are registered to the Florida State Plane Coordinate system (NAD83) with a pixel size (resolution) of three feet. The photograph was classified using the computer package Erdas Imagine 8.5. Ground referencing was performed to ensure as accurate a classification as possible.

Following a visit to the Frog Pond with Joy Klein, Forest Restorationist and Education Coordinator at DERM, it was decided to classify the native plant associations into the following six Everglades habitats:

- Rocky Glades This habitat is characterized by abundant saw grass with frequent small clusters of native hardwood trees and/or individual trees. Poisonwood and willow bustic are common colonizing trees in the Rocky Glades, which, if left unburned, could develop into a poisonwood hammock. Lower stature grasses, including white-topped sedge, are also abundant. Sabal palm is in evidence.

- Rockland Hammock These hardwood hammocks are distinguished from Tropical Rockland Hammocks by the presence of live oak trees. Other important trees include willow bustic, poisonwood, strangler fig, and gumbo limbo.

- Saw Grass Prairie Saw grass, with other, lower stature grasses, dominates the relatively unbroken expanse of Prairie, with an occasional small cluster of, or individual, hammock trees and/or sabal palm.

- Slough Taylor Slough, one of two major sloughs in Everglades National Park, begins in the Frog Pond. Cattails dominate, with some willows and saw grass.

- Willow Head Willow is generally the only mature tree in these low-lying islands and is often surrounded by cattail, saw grass and one of several water-loving plants, possibly southern blue flag (*Iris virginica*).

- Tropical Rockland Hammock This type of hardwood hammock is nearly identical to the Rockland Hammock but lacks live oak.

Although it was known that some very disturbed, non-agricultural areas occur in the Frog Pond, their characteristics were not known until the study was undertaken. These are described in Results and Discussion.

The minimum habitat size in this study is 0.25 acres. Habitats less than 0.25 acres were included in the surrounding vegetation. Appendix 1 lists the scientific names of all plant species mentioned in this report.

To begin the classification procedure, a set of Areas of Interest (AOI's: polygons enclosing target areas) was digitized on the image around vegetation other than agricultural. These include both natural and exotic vegetation. The classification was conducted only on this vegetation, not on agriculture. An unsupervised (computer generated) classification was performed, with a specified set of 70 classes. These classes were then grouped based upon three types of reference information: 1) the discernible patterns in the original photograph; 2) the signatures' statistical proximity (a signature is a group of pixels from the original image that the computer has combined into one class based on its spectral properties); and 3) eight ground-referencing visits to the Frog Pond between September 2002 and April 2003. During these visits, GPS coordinates were recorded with a Garmin 76, and maps of the area were annotated to clarify the nature of the vegetation at specific areas. Classes which appeared to be fairly well dispersed and/or could not be precisely assigned to another class were reduced to an insignificant size by Erdas' Neighbor function, which permits the computer to assign pixels of the target class to a new class based upon its 'neighboring' pixels.

As familiarity with the Frog Pond's habitats increased, and the classification was yielding clearer habitat divisions, polygons were digitized in Arc/Info 8.1 over the aerial photo – with constant reference to the final classified image – to provide a GIS layer of these habitats. When the classification was nearly complete, the coverage of cattail and elephant grass were digitized. All maps included in this report were composed in ArcView 3.2.

3.2. The GIS database

The coordinates of the original parcel database were adjusted to the color infrared photograph purchased by the SDSWCD from GeoImaging, LLC, using Arc/Info and ArcView. The Detention Pond, an area scraped bare by the Army Corps of Engineers to serve as a water-holding area, was digitized from the aerial photo and the resulting polygon overlaid on the updated land use layer.

4. Results and Discussion

4.1. Classification of land cover

The native and disturbed, non-agricultural habitats together cover 1,676 acres, thirty-one percent of the Frog Pond's 5,385 acres. Table 1 summarizes the results of the classification process.

Map 2 shows the spatial distribution of these habitats as digitized. Map 3 is an acetate overlay on which are plotted the outlines of these digitized habitats; when overlaid on the classified image, Map 4, one can see some of the variability within each habitat.

4.1.1. Native Habitats

All areas in the Frog Pond show some evidence of disturbance by exotic invasive plant species. In the north, the exotic Burma reed grows along hammock edges where soil has accumulated to form a slight 'berm'. The occasional Brazilian pepper is seen in the Rocky Glades. Elephant grass abounds in the disturbed western block of the Frog Pond, including near Hammocks. Among the many unidentified lower-stature grasses seen growing in the Rocky Glades, it is likely that some of these are exotics as well. Nevertheless, the six native habitats identified in this study are essentially intact. Rockland Hammock, of which three were identified, occurs only in the northern part of the Frog Pond. The most extensive hammock, a Tropical Rockland Hammock of forty-four acres, lies in the center of the Frog Pond. There are many Willow Heads throughout the Frog Pond and stretches of Willow are found on the western half of the western block. Rocky Glades occurs in patches surrounding most of the hammocks and a small, remnant patch of Saw Grass Prairie is found in the center. Finally, the Slough emerges in the southern corner of the western block.

4.1.2. Disturbed areas

The following three disturbed categories were derived from the classification and field observations:

- Disturbed: Chinaberry The only area on the eastern side of the Frog Pond to be labeled Disturbed is a small tree island dominated by the exotic invasive tree, chinaberry; the island is bounded at least on its north edge, where the soil is a little higher, by elephant grass.

The most disturbed sector of the Frog Pond is the western block, the area framed by the turns in the L-31W canal and the berm running down the center of the Frog Pond. This block was probably farmed many years ago after rock-plowing the original Rocky Glades. In the aerial photo (Map 1) one can discern some man-made patterns in the form of vertical striations in the landscape, for example, along the central western portion of this block where willow grows in strips, as though planted. Signs of former plowing may be discerned at about 796000 W and 406000 N. Fifty-one acres of relatively undisturbed native Tropical Rockland Hammocks are found in this block, mostly in the northeastern part, and patches of Rocky Glades occur throughout, as do Willow and Willow Head. Two disturbed classes are described for this part of the Frog Pond.

Table 1. Types and Acreages of Frog Pond's Non-agricultural Habitats

	Acres	Major Native spp.	MajorExotic spp.
Native/Less Disturbed			
Rocky Glades	281	saw grass, poisonwood, willow bustic, white topped sedge, sabal palm	Brazilian pepper
Rockland Hammock	4	live oak, poisonwood, wax myrtle, willow bustic, sabal palm, strangler fig, elderberry, gumbo limbo, trema, tetrazygia, bay (red?/swamp?), muscadine grape, Boston fern	Burma reed
Saw Grass Prairie	6	saw grass, poisonwood or other typical hammock tree, lower-stature grasses	
Slough	51	saw grass, cattail, willow	elephant grass
Willow Head	7	willow, cattail, saw grass, southern blue flag (?)	
Tropical Rockland Hammock	153	all species that are found in Rockland Hammock, except live oak; slash pine	
Total acres of Native	***502***		
Disturbed			
Disturbed:Chinaberry	2	chinaberry	elephant grass
Disturbed:Mixed	1,017	saltbush, willow, cattail, occasional hammock tree spp.	elephant grass
Scraped: Recolonizing	16	not visited, hammock tree spp. seen along edges	
Willow	139	willow, saltbush, saw grass,	elephant grass
Total acres of Disturbed	***1,174***		
Total acres	***1,676***		

- Disturbed: Mixed The most common plants are the native saltbush and the exotic invasive elephant grass. These probably alternate according to micro-variations in the surface. There are also many lower-stature grasses, which we did not identify.

  Small groups of hammock species are included in this habitat, when they occur in strips, mostly along the block's berm-like boundaries, especially the southern and western edge. Poisonwood and willow bustic are among the most common here.

- Disturbed: Scraped This area applies uniquely to the scraped rectangular area in the southeast corner of the western block (a borrow pit?). Vegetation is rapidly colonizing here.

Cattail is an indicator of higher phosphorous levels than are normal for the nutrient poor Everglades soil conditions. Aside from the extensive cattail in the Slough in the southwest corner of this block, smaller patches were noted further north, primarily on the western side. It is also invading the southernmost part of the Detention Pond, beginning just south of the spillway. (The colonizing vegetation in the scraped areas was not studied.) A rough estimate of cattail coverage was calculated to be about 44 acres in the entire Frog Pond. Elephant grass coverage was also estimated, as it is probably the invasive species with the largest extent in the Frog Pond. There are at least 297 acres. Map 5 shows the known locations of what are most likely the greatest concentrations of these two species.

The report by the Center for Aquatic and Invasive Species (2000) listed all the exotic species mentioned in this report.

4.2. The GIS Database

In 2000, there were 2,466 acres under agriculture production in the Frog Pond. In 2002 the construction of the Detention Pond resulted in the removal from agriculture of all of parcels 1 and 2, and parts of parcels 4 and 5. The net loss of agricultural land use was 377 acres, or about 15 percent. The Detention Cell covers 991 acres, including approximately 68 acres of mostly natural habitats (Rockland Hammock, Tropical Rockland Hammock, Willow Head) that were spared. Map 6 shows the current land use in the Frog Pond.

Changes in the database reflect what was observed on the aerial photo and during ground-referencing visits. Agricultural land that appears fallow in the aerial photo continues to be categorized as 'farmed', if it previously was farmed, as fallow may be an inter-crop stage.

The new Lidar point data was overlaid with the habitat polygons, but the computer available for this study lacked sufficient memory for analysis.

5. Conclusions

The Frog Pond's non-agricultural habitats help maintain plant biodiversity and are also important for wildlife. While visiting the Frog Pond with DERM's Joy Klein, we saw panther #95 (later identified by staff from Everglades National Park) in the western block. This panther has also been sighted in Lucille Hammock further east, suggesting that the Frog Pond may well be one of many important corridors linking wild animals, including endangered ones, to Everglades National Park. Periodic burning, to maintain native plant biodiversity and reduce exotic invasive species, is suggested (Joy Klein, pers. comm.).

The process of classification is, to some extent, somewhat subjective and arbitrary. Decisions about which classes to group and where to 'draw lines' are often difficult. In certain parts of an image, several species may share the same class, and different classes might represent the same species in different parts of the image. The importance of ground-referencing cannot be overemphasized. In this respect, the interior of the western block in the Frog Pond is probably the area most in need of more intensive field visits. However, we believe we have established a baseline habitat classification sufficiently accurate to be used when the Frog Pond is again photographed for similar purposes.

A follow-up study is recommended on a bi-annual basis, beginning in early 2004, in order to assess and quantify the changes likely to occur following the 2002 modifications. The distribution of cattail should be monitored. The GIS database should be linked to hydrological data being collected by TREC researchers. Future studies could provide a model for understanding changes in other parts of the Everglades where similar modifications have been implemented or are under consideration. Analysis of the Lidar data, the most accurate and detailed elevation information available for this area, may prove useful for predicting some of the changes caused by alterations in hydrology and hydroperiod.

6. Acknowledgements

Joy Klein, Forest Restorationist and Education Coordinator at DERM, identified the major habitat types as well as some individual plant species. Her help is gratefully acknowledged, but any errors made in the labeling of these habitats are solely mine.

Bob Carew of the SDSWCD and Tina Dispenza of TREC kindly accompanied me on many of the ground verification visits.

Dr. Randall Stocker, Director of the Center for Aquatic and Invasive Plants, kindly sent us the 2003 report on exotic species in the Frog Pond.

7. References

Stocker, R.K. and K.A. Langeland. 2003. Long-term monitoring of Vegetation Trends at the Frog Pond, Homestead, FL. University of Florida / Institute of Food and Agricultural Services, Center for Aquatic and Invasive Plants, Final Report (May 2003).

APPENDICES

Appendix 1. Scientific Names of Plants Identified in the Frog Pond

Bay (Red? Swamp?) (*Perseus palustris*)
Boston fern (*Nephrolepsis exaltata 'Bostoniensis'*)
Brazilian pepper (*Schinus terebinthifolius*)
Burma reed (*Neyraudia reynaudiana*)
Cattail (*Typha* spp.)
Chinaberry (*Melia azedarach*)
Elderberry (*Sambucus simpsonii*)
Elephant grass (P*ennisetum purpureum*)
Gumbo limbo (*Bursera simaruba*)
Live oak (*Quercus virginiana*)
Muscadine Grape (*Vitis rotundifolia*)
Poisonwood (*Metopium toxiferum*)
Sabal palm (*Sabal palmetto*)
Saw grass (*Cladium jamaicense*)
Southern blue flag? (*Iris virginica)*
Strangler fig (*Ficus aurea*)
Tetrazygia (*Tetrazygia bicolor*)
Trema (*Trema micranthum*)
Wax myrtle (*Myrica cerifera*)
Willow bustic (*Dipholis salicifolia*)

Appendix 2. Maps

Map 1. Land Cover, Infrared Aerial Photograph, 2nd quarter 2002
Map 2. Land Cover, Digitized, 2nd quarter 2002
Map 3. Habitat Polygons
Map 4. Land Cover, Classified, 2nd quarter 2002
Map 5. Approximate Extent of Cattail and Elephant Grass, 2nd quarter 2002
Map 6. Land Use, January – July 2003

Map 1.

Frog Pond

Land Cover
Infrared Aerial Photo
2nd quarter 2002

Blue outline shows the boundary of the Detention Pond as of the 3rd quarter 2002

N

Scale 1:30 000

1000 0 1000 2000 ft

Projection Stateplane
Zone 3601 - NAD83

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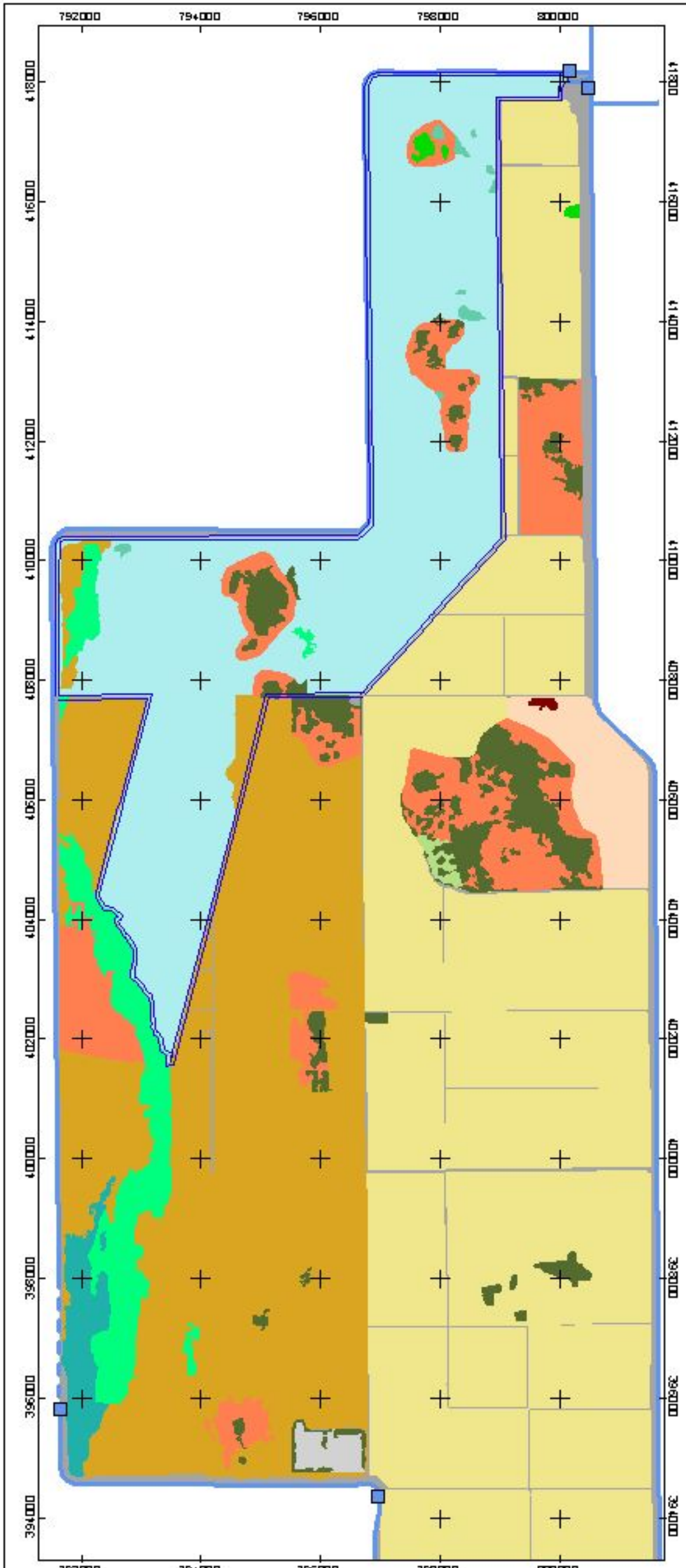
Map prepared by Karen Minkowski, UF-TREC

Data sources: Color infrared aerial photo, GeoImaging, LLC, 2002

Map 2.

Frog Pond

Land Cover, Digitized
2nd quarter 2002



Habitats

- Disturbed: Chinaberry
- Disturbed:Mixed
- Rockland Hammock
- Rocky Glades
- Saw Grass Prairie
- Disturbed: Scraped
- Slough
- Tropical Rockland Hammock
- Willow
- Willow Head

Other Cover

- Agriculture
- Not farmed
- Detention Pond
- Unpaved road

- Structure (SFWMD)
- Canal (SFWMD)
- Degraded Canal
- Detention Cell Boundary

N

Scale 1:30 000

1000 0 1000 2000 ft

Projection Stateplane
Zone 3601 - NAD83

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Map prepared by Karen Minkowski, UF-TREC

Data sources: Color infrared aerial photo, GeoImaging, LLC, 2002; vector layers, South Florida Water Management District

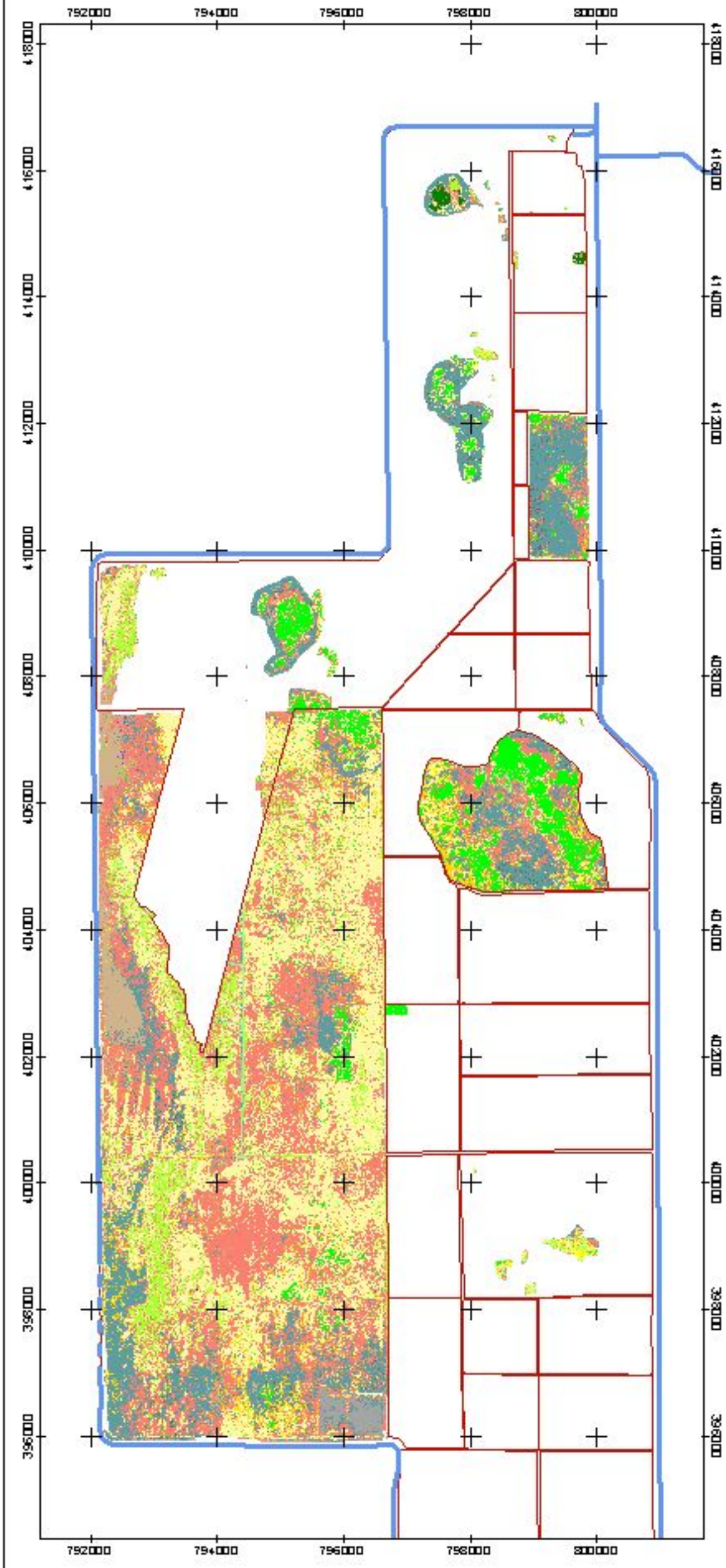
Map 3.

Frog Pond Habitat Polygons

Map 4.

Frog Pond

Land Cover, Classified
2nd quarter 2002



- Elephant Grass
- Mixed grasses/shrubs
- Rockland Hammock
- Rocky Glades
- Saltbush
- Saw Grass Prairie
- Scraped area
- Tropical Rockland Hammock
- Willow
- Agricultural parcel boundary
- Canal (SFWMD)
- Degraded Canal

N

Scale 1:30 000

1000 0 1000 2000 ft

Projection Stateplane
Zone 3601 - NAD83

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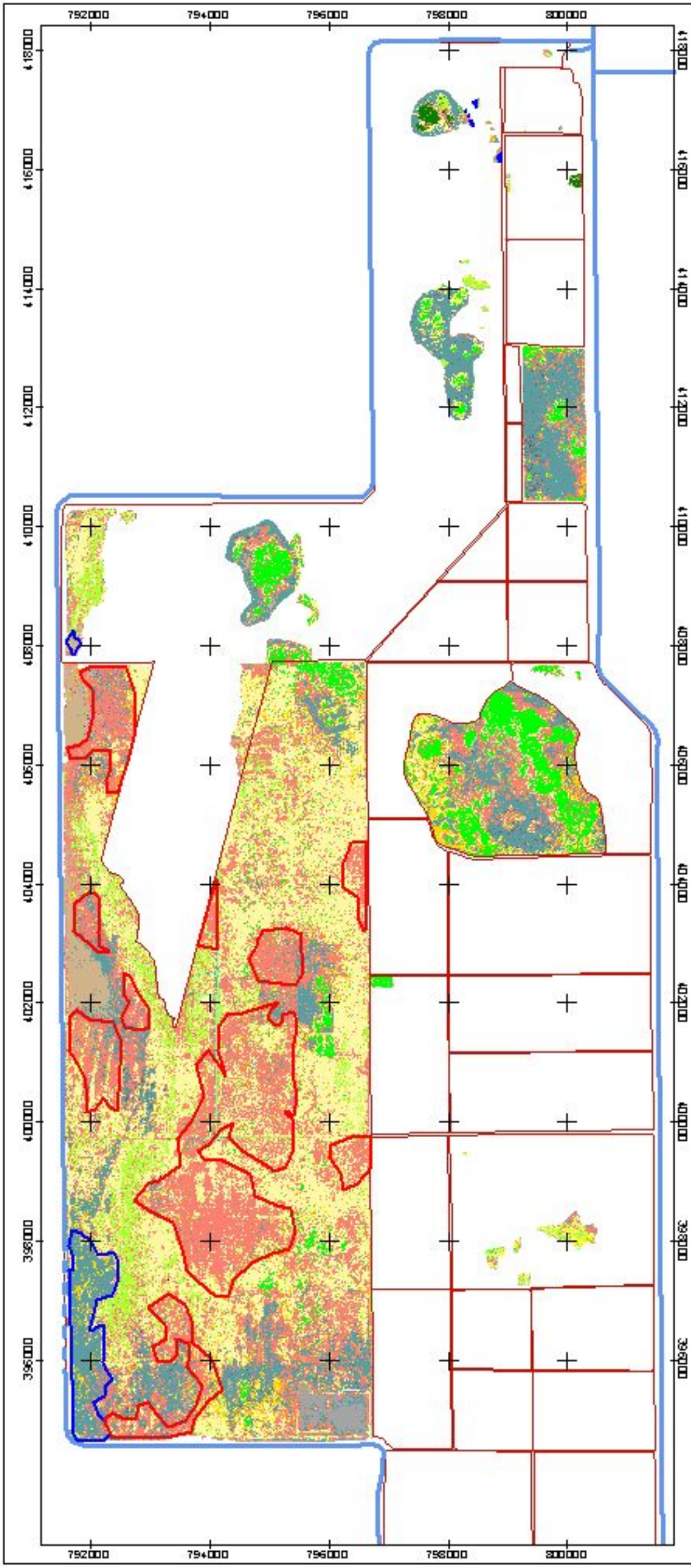
Map prepared by Karen Minkowski, UF-TREC

Data sources: Classified image derived from color infrared aerial photo, GeoImaging, LLC, 2002; SFWMD



Map 5.

Frog Pond

Approximate extent of
Cattail and Elephant Grass,
2nd quarter 2002

- Cattail
- Elephant Grass
- Elephant Grass
- Mixed grasses/shrubs
- Rockland Hammock
- Rocky Glades
- Saltbush
- Saw Grass Prairie
- Scraped area
- Tropical Rockland Hammock
- Willow
- Agricultural parcel boundary
- Canal (SFWMD)
- Degraded Canal

N

Scale 1:30 000

1000 0 1000 2000 ft

Projection Stateplane
Zone 3601 - NAD83

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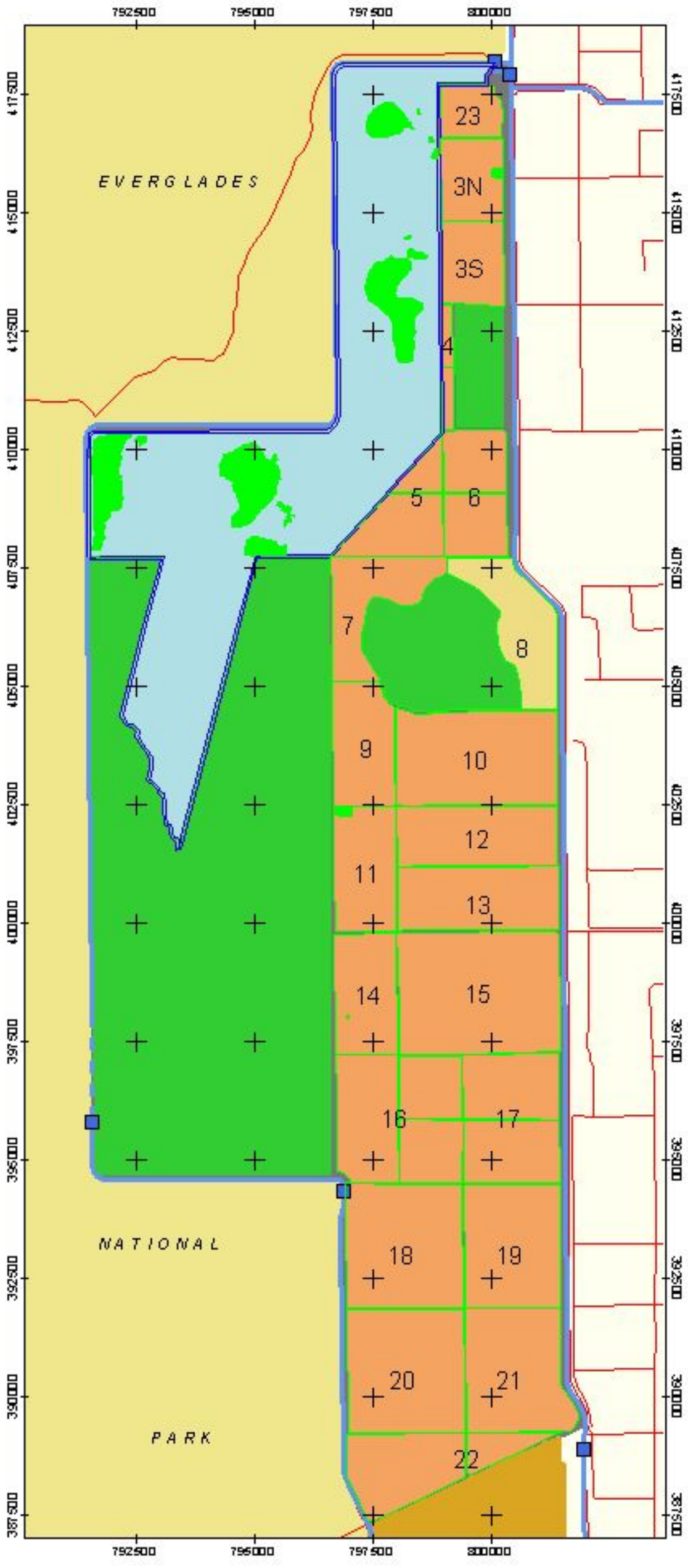
Map prepared by Karen Minkowski, UF-TREC

Data sources: Classified image veg_cl9e4.img derived from color infrared aerial photo, GeoImaging, LLC, 2002; SDSWCD; SFWMD

Map 6.

Frog Pond

Land Use
January - July 2003



- Farmed
- Unfarmed
- Designated Non-agricultural Parcel
- Other Non-Agricultural Vegetation
- Detention Pond
- Florida Game and Fish Parcel
- Unpaved road
- Agricultural parcel boundary
- Cell boundary
- Canal (SFWMD)
- Degraded Canal
- Structure (SFWMD)
- Road

N

2000 0 2000 4000 ft

Projection State Plane - Zone 3601 - NAD 83

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Map prepared by Karen Minkowski, UF-TREC

Data Sources: South Dade Soil and Water Conservation District; South Florida Water Management District; Miami-Dade County Information Technology Dept.