Florida Vegetation and Land Cover Data Derived from 2003 Landsat ETM+ Imagery

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Introduction

In 1990, the Florida Fish and Wildlife Conservation Commission (FWC) completed a project to map Florida vegetation and land cover using 1985-89 Landsat Thematic Mapper satellite imagery (Kautz et al. 1993). The resulting digital database contained 17 natural and semi-natural land cover types, 4 land cover types indicative of human disturbance, and 1 water class. Over the last decade, this digital database has been put to many uses. For example, staff of many state and local programs who make decisions concerning the Florida environment often have used the FWC vegetation and land cover data as indicative of current conditions on the ground. In addition, FWC staff used the vegetation data to create potential habitat models for over 130 rare and imperiled species of wildlife (Cox et al. 1994, Cox and Kautz 2000). In turn, the potential habitat models of rare and imperiled wildlife formed the basic information set used to identify strategic habitats for biodiversity conservation in Florida (Cox et al. 1994, Kautz and Cox 2001). The results of the FWC strategic habitat modeling project have been widely used in Florida to help guide land acquisition, land use planning, development regulation, and land management programs.

However, over time, the 1985-89 vegetation and land cover data set became increasingly out of date. Since completion of the earlier data set, Florida's resident and tourist populations have continued to grow, converting both natural and disturbed areas of the Florida landscape to human uses. By 2003 (the year of the imagery used in this project), the earlier data set (comprised mostly of 1986-87 imagery) was about 16-17 years old, and could no longer be considered current. Not only was the earlier vegetation and land cover data set becoming out of date, but so were the wildlife and strategic habitat models that were based on that data. In order to keep our vegetation, land cover, and wildlife habitat models current, FWC staff realized the need to develop a new, updated vegetation and land cover map for Florida.

Objective

The purpose of this project was to create an updated digital vegetation and land cover data set for Florida derived from 2003 Landsat Enhanced Thematic Mapper satellite imagery.

Methods

Fourteen Landsat scenes cover the state of Florida (Figure 1). We mapped one Landsat scene at a time using a series of iterative steps and ancillary data sets for this project. Ancillary data sets included 1995 land use/land cover data created by Florida's water management districts and the Florida Department of Environmental Protection, U. S. Fish and Wildlife Service National

Wetlands Inventory (NWI) digital boundaries of Florida wetlands, detailed digital soils (SSURGO) data sets, the FWC 1985-89 land cover map (Kautz et al. 1993), and 1999 digital orthographic quarter quadrangle (DOQQ) aerial photography. The following is a general description of the steps taken to create the updated vegetation and land cover data set.

Preparation of Landsat Imagery

Raw Landsat Enhanced Thematic Mapper+ imagery with a pixel size of 30 m was purchased from the U. S. Geological Survey's EROS Data Center in Sioux Falls, South Dakota (http://edc.usgs.gov/). The following steps were taken to prepare the imagery for classification.

1. Raw Landsat ETM+ imagery was projected to Albers HPGN using ERDAS Imagine v.8.6 image processing software.

2. The projected imagery was geo-referenced to U. S. Census Bureau (http://www.census.gov/geo/www/maps/) TIGER road files using the Image Analysis extension of ArcView GIS v.3.3. All scenes were geo-referenced with at least 20 control points to a root-mean-square (RMS) positional accuracy of <0.5 pixel (<15m).

3. The imagery was then clipped along the coastlines, if necessary, to reduce file size and increase effectiveness of classifications.

Classification

All classification was conducted in ArcView GIS v.3.3 using the Image Analysis extension. Normalized Difference Vegetation Index (NDVI) ratio bands were created for each scene. The NDVI provided a measure of vegetation density that was used to aid in class discrimination. Image classification proceeded according to the following general steps:

1. Unsupervised classifications were performed on each entire Landsat scene. Initial classifications were performed on all six 30 m pixel spectral bands. The number of resultant spectral classes was typically set to 75-100.

2. The 75-100 spectral classes resulting from Step 1 were reviewed individually. Each spectral class was visually checked against the Landsat imagery as well as the ancillary data. If any of the spectral classes consistently identified a specific target land cover type (e.g., mangrove swamp, pine forest, coastal strand), those spectral classes were labeled according to the vegetation or land cover type they represented, and those classes were considered final and were excluded from further analyses.

3. All unlabeled pixels remaining after Step 2 were then subjected to additional unsupervised classifications. Differing band combinations (i.e., subsets) often were used to group similar areas to a distinct cover type. Resultant spectral classes varied from a few to over 50. At this point the process became iterative, and these steps were repeated until all pixels fell into a specific land cover type or into a larger, temporary grouping

(e.g., disturbed). Additionally, areas with unique features or areas resulting in classification "confusion" would be clipped from the scene. Unsupervised classification would then be performed only on the clipped areas.

4. The data sets resulting from Step 3 that consistently represented a specific natural land cover type were assigned the appropriate label, were added to the final data set, and were excluded from further analyses.

5. Agricultural and urban land use classes from the 1995 digital data set of statewide land use/land cover were then used as an overlay. Spectral classes that had been identified as disturbed and that fell within the agricultural or urban land use class overlay were isolated. Unsupervised classification was performed on these areas to spectrally isolate agricultural areas from urban areas.

6. By comparing the spectral classes resulting from Step 5 with the ancillary data sets (i.e., 1995 land use/land cover, 1999 DOQQs), disturbed spectral classes were categorized into six agricultural land use classes (i.e., improved pasture, unimproved pasture, sugar cane, citrus, row and field crops, other agriculture), two urban classes (i.e., high density urban, low density urban), and extractive (i.e., mining). All pixels in these classes were added to the final data set and were excluded from further analyses. Visual interpretation of the spectral classes and the Landsat imagery was often required in areas where there was new urban growth and where agricultural lands were in a bare soil state, creating a false urban signature. Very often it was necessary to isolate these areas individually and assign the appropriate label. Areas that classified as disturbed but were not within the agricultural and urban lands overlay were checked visually against the Landsat imagery and other ancillary data layers. Often these disturbed areas were new areas of agriculture or urban lands, or they represented recent land clearings due to silvicultural practices or other unknown causes.

7. Once an entire scene had been analyzed in the above manner, the biologist then examined specific geographic areas of similar physiographic features (e.g., coastal wetlands, xeric ridges), and, if necessary, performed additional unsupervised classifications on any remaining classes of pixels that could not be separated based on spectral information developed at the level of the entire Landsat scene. Any classes that consistently represented a specific land cover type were assigned the appropriate land cover label, added to the final data set, and excluded from further analyses.

8. Any remaining areas that did not have a specific land cover label were visually reviewed in relationship to the Landsat imagery, land use/land cover data, and DOQQs. If possible, unlabeled groups of pixels were assigned to appropriate land cover types by hand, and were added to the final data set and excluded from further analyses.

9. Once all pixels within a Landsat scene had been classified, labeled, and added to the final data set comprising the updated vegetation and land cover map, specific areas of the map were visited in the field for ground-truthing. Any mistakes discovered in the ground-

truthing process were then corrected to create a final draft vegetation map covering the entire Landsat scene.

10. The final draft vegetation and land cover map for each scene was then reviewed by the project manager. The project manager compared each draft map against ancillary data sets and identified specific problem areas that either needed checking for accuracy or correction. Project manager recommendations were then returned to staff to make corrections needed to produce a final vegetation and land cover data set for each Landsat scene.

11. Early in the project, a number of the Landsat scenes purchased from EROS Data Center were from 2000-2002, and final drafts of vegetation and land cover for these scenes were based on these earlier dates. However, as luck would have it, 2003 was a good year for cloud-free satellite imagery in Florida. Thus, not only were the later scenes in the project mapped using only 2003 imagery, but also new 2003 Landsat ETM+ imagery was purchased for the entire state, and the new imagery was used to update disturbed areas of all earlier scenes to 2003 according to the following procedure (Table 1).

    a. Unsupervised classifications were conducted for an entire 2003 scene.
    b. Spectral classes representing sparsely vegetated areas (e.g., disturbed areas) were isolated.
    c. Disturbed areas from the 2003 imagery that were classified as natural vegetation in the earlier imagery (2000-2002) were isolated and further examined.
    d. The areas of new disturbance were then classified into appropriate categories.
    e. Additionally, other changes between the two scenes were examined and updated if necessary.
    f. All changes and updates between the two scene dates were then incorporated into the previously classified map to produce a new vegetation and land cover data set for each scene that reflected conditions in 2003.

12. Once a scene was complete and updated, if necessary it was edge-matched and merged with adjacent scenes that had previously been completed. Upon completion of last scene, all scenes were then merged, forming a single statewide map.

Final 2003 Vegetation and Land Cover Data Set

The final 2003 digital data set covering all of Florida (Figure 2) contained 43 vegetation and land cover types, as compared to the 22 types appearing in the earlier data set (Kautz et al. 1993). The new map contained 26 natural and semi-natural vegetation types, 16 types of disturbed lands (e.g., agriculture, urban, mining), and 1 water class (Table 2).

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Table 1. Landsat ETM+ scenes and dates used to map Florida vegetation and land cover.

Path	Row	1999-2002 Image Date	2003 Image Date
15	41	01/06/01	02/13/03
15	42	02/05/00	02/13/03
15	43		02/13/03
16	39		03/24/03
16	40	04/03/01	03/24/03
16	41	04/03/01	03/24/03
16	42	12/26/99	01/19/03
16	43		02/04/03
17	39	02/05/01	03/31/03
17	40	03/28/02	03/31/03
17	41	02/24/02	03/31/03
18	39	10/26/01	03/22/03
19	39		01/08/03
20	39		01/15/03

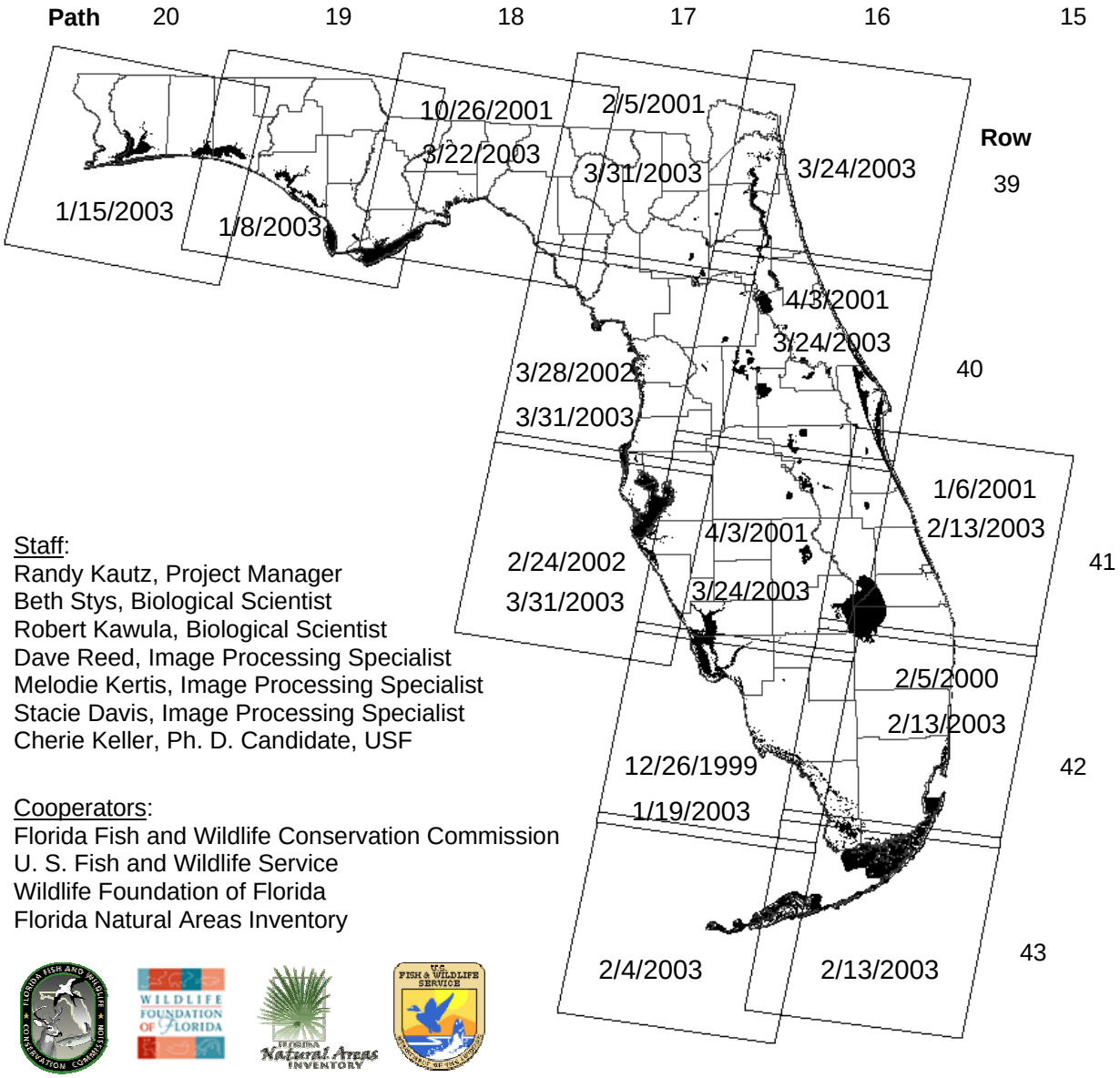
Table 2. Class values and names for the 2003 and 1985-89 Florida vegetation and land cover data sets.

2003 Class Value	2003 - Class Name	1985-89 Class Value	1985-89 – Class Name
1	Coastal strand	1	Coastal strand
2	Sand/beach	22	Urban/barren
3	Xeric oak scrub	6	Xeric oak scrub
4	Sand pine scrub	4	Sand pine scrub
5	Sandhill	5	Sandhill
6	Dry prairie	2	Dry prairie
7	Mixed hardwood-pine forest	7	Mixed hardwood-pine forest
8	Hardwood hammocks and forests	8	Hardwood hammocks and forests
9	Pinelands	3	Pinelands
10	Cabbage palm-live oak hammock	8	Hardwood hammocks and forests
11	Tropical hardwood hammock	9	Tropical hardwood hammock
12	Freshwater marsh and wet prairie	11	Freshwater marsh and wet prairie
13	Sawgrass marsh	11	Freshwater marsh and wet prairie
14	Cattail marsh	11	Freshwater marsh and wet prairie
15	Shrub swamp	15	Shrub swamp
16	Bay swamp	14	Bay swamp
17	Cypress swamp	12	Cypress swamp
18	Cypress/pine/cabbage palm	12	Cypress swamp
19	Mixed wetland forest	13	Mixed hardwood swamp
20	Hardwood swamp	13	Mixed hardwood swamp
21	Hydric hammock	8	Hardwood hammocks and forests
22	Bottomland hardwood forest	17	Bottomland hardwood forest
23	Salt marsh	10	Salt marsh
24	Mangrove swamp	16	Mangrove swamp
25	Scrub mangrove	16	Mangrove swamp
26	Tidal flats	10	Salt marsh
27	Open water	18	Open water
28	Shrub and brushland	20	Shrub and brushland
29	Grassland	19	Grassland
30	Bare soil/clearcut	22	Urban/barren
31	Improved pasture	19	Grassland
32	Unimproved pasture	19	Grassland
33	Sugarcane	19	Grassland
34	Citrus	19	Grassland
35	Row and field crops	19	Grassland
36	Other agriculture	19	Grassland
37	Exotic plants	21	Exotic plants
38	Australian pine	21	Exotic plants
39	Melaleuca	21	Exotic plants
40	Brazilian pepper	21	Exotic plants
41	High impact urban	22	Urban/barren
42	Low impact urban	22	Urban/barren
43	Extractive	22	Urban/barren

Florida Fish and Wildlife Conservation Commission

Landsat Vegetation Map Update Project

Landsat TM Scenes and Dates



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Florida Natural Areas Inventory

Figure 1. Locations and dates of Landsat Enhanced Thematic Mapper scenes used to map Florida vegetation and land cover to 2003.