South Florida National Parks
Vegetation Map Accuracy Assessment
Final Report - Cooperative Agreement #H5120040010

Keith A. Bradley and Steven W. Woodmansee
bradley@regionalconservation.org

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Submitted by
The Institute for Regional Conservation
22601 S.W. 152 Avenue, Miami, Florida 33170
George D. Gann, Executive Director

Submitted to
Matt Patterson
South Florida / Caribbean Network Coordinator
National Parks Service
18001 Old Cutler Road, Suite 419
Palmetto Bay, Florida 33157

Introduction

Between 1995 and 1999 the Center for Remote Mapping Science at the University of Georgia (UG) and the South Florida Natural Resources Center at Everglades National Park developed a vegetation map of three National Park units in South Florida: Everglades National Park (EVER), Biscayne National Park (BISC), and Big Cypress National Preserve (BICY), a combined area of 10,000 km^2. Mapping was conducted via interpretation of 1:40,000 color infrared aerials flown in 1994 and 1995 augmented by limited field surveys. A minimum mapping unit of 0.5 ha was established, although smaller mapping units were sometimes used.

The vegetation classification that was used by the UG was a three-tiered hierarchical classification - the Everglades Vegetation Classification System (Jones and Remillard 1997, Madden et al. 1999). The classification system covers EVER, BICY, Biscayne National Park, and adjacent conservation areas. It consists of seven major vegetation classes, each class having a number of sub-classes. These vegetation classes include Forest, Scrub, Savanna, Prairies and Marshes, Shrublands, Exotics, and additional categories (e.g. Water, Mud). Subclasses within each class are derived mostly from dominant species. Each subclass may have additional subcategories within it, for example pine savanna has three subcategories: pine mixed with palms, pine mixed with hardwoods, and slash pine with cypress. Ultimately there are 73 distinct vegetation types (including non-vegetated open water, beaches, and mud).

The National Park Service (NPS), in an effort to continually improve the vegetation mapping in its park units, entered into a cooperative agreement with The Institute for Regional Conservation (IRC) to conduct an accuracy assessment of the vegetation map developed for two park units, EVER and BICY. Methodology for this assessment was developed by the NPS and IRC. The methodology developed for ground truthing had several goals: 1) To provide quantitative data on the vegetation composition and structure at each sample location, 2) To verify how accurately polygons were classified using color infrared aerials, and, 3) To verify how accurately the boundaries of polygons were drawn.

The current report details final results of the project and includes analyses of the existing vegetation maps.

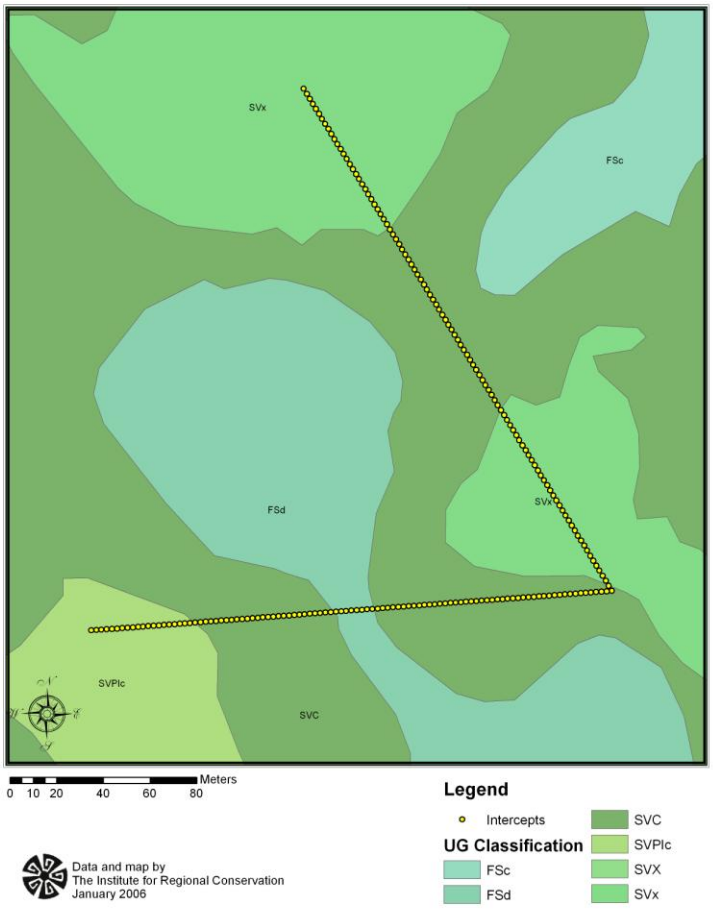
Cover Photo of a myriad of plant communities at Big Cypress National Preserve by Steven W. Woodmansee.

Methods

Part I: Analyses from Existing Data

From 2002 through 2004 IRC conducted a quantitative plant inventory of the BICY, Florida. Transects were established to quantify the abundance of plant species in the BICY. Three hundred starting points distributed throughout the BICY were selected. The locations of starting points were weighted by the total area of each plant community in the BICY, so that sampling by plant community would correlate with the total area of each plant community in the preserve. At each starting point two 250 m transects were run at random compass headings separated by at least 30 degrees. The beginning and end of each transect was recorded with a handheld GPS unit (accuracy average <10m). Along each transect all plant species that intercepted each 2.5 m point (excluding the starting point) were recorded. Transects usually crossed more than one habitat type (Figure 1), not by design but because of extreme habitat heterogeneity.

Figure 1: Example of a floristic inventory transect and its intercepts



Data for 60,000 intercepts was collected throughout the preserve. A total of 534 plant species were recorded on the intercepts. These data were used to conduct an assessment of the vegetation map of the BICY prepared by the UG between 1995 and 1999. To conduct the accuracy assessment all intercept data was georeferenced. Only beginning and end coordinates of transects were collected in the field. These GPS coordinates were error checked and then used to create 2-point line features representing the 600 transects. Using the ArcGIS 9.0 extension XTools Pro version 2.0, 101 equidistant points were created along the length of each transect, including the beginning and end points. Each of these points was coded with a unique ID identical to a unique ID in Microsoft Access tables containing the intercept and plant data. The starting point was then discarded, with 100 point features remaining on each line representing intercepts.

Because transects crossed multiple habitats, many intercepts were very close to or on edges of the vegetation polygons. Because of GPS error and georeferencing errors, a decision was made by IRC and NPS to exclude data from any intercept that was within 20 m of a UG polygon boundary. Using ArcGIS a 20 m buffer was created around each polygon edge that was crossed by a transect. Any intercept that lay within this buffer was eliminated.

To conduct the accuracy assessment a query was constructed in Microsoft Access that showed the plant species recorded in each polygon, how many intercepts each plant was detected on in each polygon, the UG vegetation classification of that polygon, and the nativity of each plant species. Three biologists with extensive floristic field experience in the BICY (Keith Bradley, Steven Woodmansee, and Jimi Sadle) studied this data and made one of three characterizations for each polygon:

1) Sample doesn't match original polygon classification.
2) Sample may not match, but can't determine dominant vegetation using intercept data.
3) Sample and polygon classification match.

In many cases the intercept data sample size was insufficient to make a decision. For example, the transect may have crossed the edge of a polygon for only a short distance, and only a few intercepts were within the polygon and more than 20 m from the polygon edge. In such cases the sample size was too small to make inferences about the plant community based on the few plant species that were recorded at the intercepts. In other cases, even with a large sample size, the intercept data was ambiguous and did not allow for a determination of the vegetation type. This was often because our transects crossed vegetation types, thus showing a mix of plant species for one of the UG polygons that would typically not be found in close association. For example, live oak, a hammock species, and pop ash, a swamp species would have been recorded within a single UG polygon. This could have been caused not because of an error on UG's part, but because we crossed a small area of new habitat that would have been smaller than UG's minimum mapping unit size.

Bradley conducted an initial classification of each polygon. To decrease bias, Woodmansee and Sadle each classified half of the polygons independently without viewing Bradley's classification. After this was done a query was created to isolate polygons that Woodmansee and Sadle classified differently than Bradley. The three biologists then reviewed each of the disagreements together and did a final classification. Differences were found to be almost always the result of typographical errors and not disagreements over classification, so this extra step was useful to minimize errors.

Part II: Field Assessment

At the onset of the field assessment, NPS pared down the original 73 vegetation types to 60 by excluding types not found in the two parks studied (Appendix 1). Five sample stations in each of these 60 vegetation types were initially selected for sampling. Accuracy assessment sample stations were selected in advance by the NPS. A large list of random sample stations was developed for each vegetation type. Sample stations were initially rejected if they fell less than 60 m inside the boundaries of UG vegetation polygons. This was to ensure that 40 m transects, described below, fell completely within UG's polygons, even with 10-20 m of GPS error. Following randomization, sample sites were selected for efficient access (e.g. near roads or ATV trails), but with some sites in more remote areas to ensure that geographic heterogeneity was captured. An attempt was made to select clusters of points (with each point in a different vegetation type when possible) to minimize transportation time between sites. These methods were selected to ensure that a balanced assessment of vegetation types was sampled, while ensuring a cost-effective sampling design.

Field crews consisted of two IRC staff that had a good knowledge of the flora of both national park units. Sample sites were located in the field by UTM coordinates using a handheld GPS receiver. Sites were accessed by foot, helicopter, ATV, and boat. Upon reaching the site, the vicinity (i.e. within 20 m of the GPS point) was examined to determine whether the site was representative of the surrounding area. If the site was found to be located on an ecotone or obviously within an inclusion, this was recorded and the sample site was moved into the principal local vegetation type, and UTM coordinates of the new location were recorded. If the point was shifted due to proximity to or inclusion in an ecotone, notes were collected on the vegetation type at the original sample location.

At the sample plot location, four 40 m-long transects were established at cardinal directions (N, S, E, W) (Figure 2). Vegetation data along each transect (within 10 m of either side) was recorded. For each transect, estimates of the overall plant cover of each physiognomic stratum present (Table 1), physiognomically defined vegetation class from the National Vegetation Classification System (Table 2), and the identity and cover class of all plant species contributing an estimated 5% cover or greater in each stratum was recorded. For each plot, the overall height class of the stratum and of individual species was recorded. If a stratum (e.g. trees, shrubs, etc.) was present, but no species had a cover of 5% or greater, the cover and height of the most dominant (i.e. highest cover) species in the stratum were recorded. If the transect transitioned beyond the vegetation community boundary in which the central sampling point was located, the point at which the transect exceeded the boundary and nature of the change were recorded in the notes (e.g. "entered buttonwood forest at 35 m on west transect"), and data was not recorded from the portion of transect in the new vegetation community. If the new community was smaller than the minimum mapping unit (0.5 ha), the new community was noted as an inclusion, otherwise it was assumed that it was sufficiently large enough to have been mapped. In addition to collecting data that was useful for Accuracy Assessment, the methodology was developed to provide data useful to future vegetation classifications based on field data.

Figure 2: Field assessment plot design

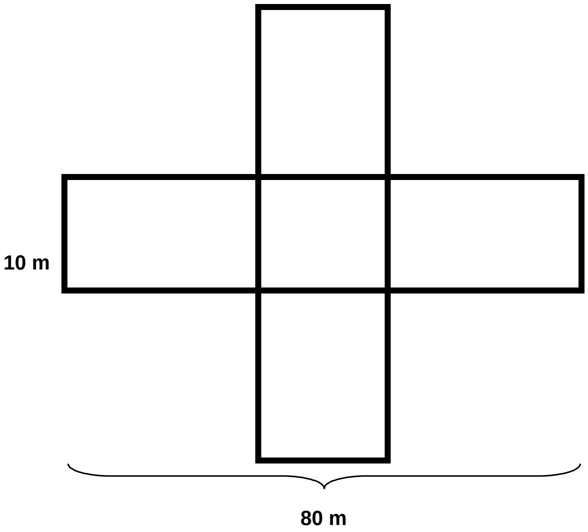


Table 1. Definitions of physiognomic strata.

Stratum	Definition
Emergent	Trees standing above a forest canopy (e.g. royal palms or Jamaica dogwoods)
Canopy	Tallest ±even-height stratum of trees (= woody plants 5 m or more in height)
Subcanopy	Stratum of trees beneath a forest canopy
Shrubs	Stratum of woody plants between 0.5 and 5 m in height
Dwarf shrubs	Stratum of woody plants 0.5 m tall or less
Herbaceous	Stratum of non-woody plants regardless of height
Non-vascular	Stratum of bryophytes or lichens
Vine/Liana	All vines regardless of height
Epiphyte	All epiphytes regardless of height, include plants that are typically epiphytic (e.g. *Tillandsia fasciculata*) but are growing on the ground in the plot and note that they are growing terrestrially.

Table 2. Definitions of physiognomically defined vegetation classes from the National Vegetation Classification System.

Type	Indication
Forest	Closed tree canopy (*i.e.* greater than 60% canopy cover)
Woodland	Tree canopy present but less than 60% cover
Shrub	No trees, woody vegetation less than 5 m tall present
Dwarf Shrub	No trees or full sized shrubs, shrubs 0.5 m or shorter present
Herbaceous	No woody plants, herbaceous plants present
Non vascular	No vascular plants, non-vascular plants present

For each sampling point, an estimate of the overall coverage by non-vegetated substrate was recorded for each of the substrate types listed on the data sheet, the overall physiognomic type represented by the vegetation community was noted, and a brief description of the vegetation community (e.g. “sparse slash pine woodland with muhly/bluestem understory”) was recorded in the notes section of the data sheet. If the community was sparsely vegetated, that was recorded by checking the “sparsely vegetated” line. Any federal or state listed vascular plants were noted.

Data Analysis

Data analyses were conducted to identify rates of two kinds of mapping errors: 1) Polygon misclassifications, and 2) Incorrect boundary delineations. Preliminary analysis was conducted by reviewing the field data collected at each sampling site, including physiognomic class, canopy classes and their vegetation cover, species composition and cover of dominant species, and field notes describing each site. Based on this data review, we designated each site with a vegetation class following Jones and Remillard 1997. This was then compared with the UG mapping data. Where there were differences, we again reviewed the field data to ensure that we did not make a classification error. For each sampling site we determined whether the vegetation had been classified correctly by UG or not.

In addition to analyzing errors in classification as described above, we also determined whether the boundaries of each polygon in which we sampled were correct are not. This was determined in two ways. Transect lengths of less than 40 m which crossed into a new vegetation type were selected and these polygons were marked as having boundary errors. In addition, we marked polygons as having boundary errors when we had to move the sample site position because it was on or close to the ecotone of two vegetation types.

Chi square tests were conducted to compare ratios of misclassified samples between parks and vegetation types. All statistical tests were performed with SPSS 13.0 with a significance level of $P < 0.5$.

Data Management

Plot data was entered into a relational database (Microsoft Access). The database contains all of the information collected on the Accuracy Assessment Data Sheet (Attachment 1):

- the plot code (a unique plot identifier)
- the UTM coordinates of the plot and the datum
- the physiognomic vegetation class of the plot
- the cover class and identity of non-vegetated areas of the plot
- the overall height class and cover class of each vegetation stratum in the plot
- the height class and cover class along each cardinal transect of each dominant species in the stratum. Dominant species are defined as those having greater than 5% cover or those in the stratum having the greatest cover (when no species exceeds 5% cover in the stratum).
- a brief description of the vegetation community in the plot
- transect lengths, the transect direction (i.e. N, S, E, W), and a description of the new community if any of the transects left the original vegetation community.

Results

Part I: Analyses from Existing Data from the Big Cypress National Preserve

After buffering and excluding points that were within 20 m of polygon edges, a total of 34,924 intercept points were usable, 58.2% of the entire data set. The usable intercepts lay within 437 vegetation polygons representing 37 vegetation types on the UG vegetation maps (Table 3).

When conducting our assessment, we were liberal with making some decisions in distinguishing between highly similar vegetation types. For example, it is difficult to distinguish between Cypress Domes (FSd) and Cypress Strands (FSc) based solely on our intercept data. In such cases where the intercept data could have represented more than one similar community, the original UG classification was designated as correct.

Of the 437 polygons for which IRC staff had data, 173 polygons were classified as incorrect and 163 as correct. An additional 101 polygons were indeterminable (Figure 3). Indeterminable polygons were recorded as such because of small sample sizes, unusual mixes of species, or because habitats are too difficult to distinguish based solely on species occurrences and not vegetation structure. Thus, excluding those that were indeterminable, 51.5% were incorrectly classified in the original vegetation map (Table 3).

Figure 3: Analyses from existing inventory data

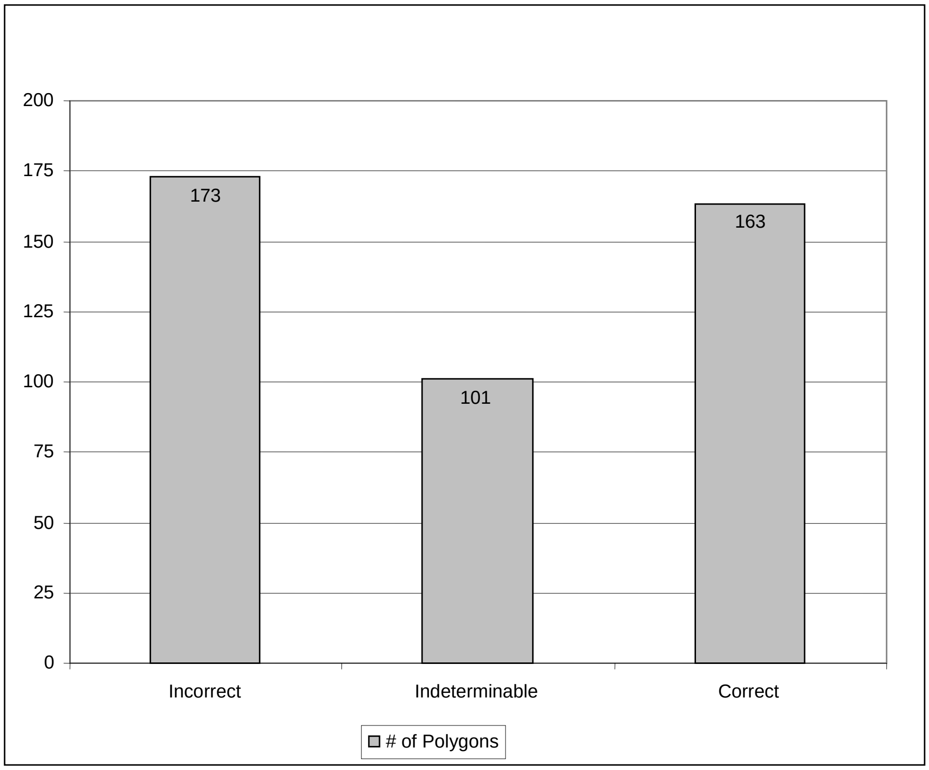


Table 3: Analyses from Existing Data Results by Vegetation Class drawn from Bradley *et al.* (2005)

Vegetation Code(n=37) [1]	Vegetation Type	Total Polygons	Count Incorrect	Count Indeterminate	Count Correct	Percent Incorrect
E	Exotics	2	2	0	0	100.0%
EM	Exotics-Cajeput	2	2	0	0	100.0%
FC	Forest-Cabbage Palm	2	2	0	0	100.0%
FMx	Forest-Mangrove-Mixed mangrove	2	1	0	1	50.0%
FO	Forest-Oak-Sabal	11	7	1	3	70.0%
FSa	Forest-Swamp Forest-Mixed hardwoods, Cypress and Pine	6	3	3	0	100.0%
FSb	Forest-Swamp Forest-Bayhead	8	4	3	1	80.0%
FSc	Forest-Swamp Forest-Cypress Strands	44	12	9	23	34.3%
FSCpi	Forest-Swamp Forest-Cypress-Pines	6	4	0	2	66.7%
FSd	Forest-Swamp Forest-Cypress Strands Cypress domes/heads	44	9	7	28	24.3%
FSh	Forest-Swamp Forest-Mixed hardwood swamp forest	19	13	1	5	72.2%
FSx	Forest-Swamp Forest-Cypress-Mixed Hardwoods	21	6	6	9	40.0%
FT	Forest-Subtropical Hardwood Forest	13	5	1	7	41.7%
HI	Additional Categories-Cultural Area Features-Structures and Cultivated Lawns	4	2	1	1	66.7%
PC	Prairies and Marshes-Cattail	2	1	1	0	100.0%
PE	Prairies and Marshes-Non-graminoid Emergent Marsh	9	6	3	0	100.0%
PG	Prairies and Marshes-Graminoid Prairie/Marsh	11	6	2	3	66.7%
PGc	Prairies and Marshes-Graminoid Prairie/Marsh-Sawgrass	22	16	4	2	88.9%
PGct	Prairies and Marshes-Graminoid Prairie/Marsh-Tall sawgrass	4	2	1	1	66.7%
PGe	Prairies and Marshes-Graminoid Prairie/Marsh-Spike rush	1	0	1	0	0.0%
PGs	Prairies and Marshes-Graminoid Prairie/Marsh-Cordgrass	5	0	1	4	0.0%
PGx	Prairies and Marshes-Graminoid Prairie/Marsh-Mixed graminoids	29	12	6	11	52.2%
SB	Shrublands	1	0	0	1	0.0%
SBs	Shrublands-Willow	5	3	1	1	75.0%
SH	Scrub-Hardwood scrub	14	5	8	1	83.3%
SMr	Scrub-Mangrove scrub-Red mangrove	1	0	0	1	0.0%
SP	Scrub-Saw palmetto scrub	10	1	5	4	20.0%
SS	Scrub-Bay-Hardwood scrub	1	0	1	0	0.0%
SVC	Savanna-Cypess savanna	32	7	8	17	29.2%
SVCd	Savanna-Cypess savanna-Dwarf cypress	11	3	1	7	30.0%
SVCpi	Savanna-Cypess savanna-Cypress with pine	6	1	3	2	33.3%
SVpi	Savanna-Pine savanna	12	6	5	1	85.7%
SVPIc	Savanna-Pine savanna-Slash pine with cypress	13	4	4	5	44.4%
SVPIh	Savanna-Pine savanna-Slash pine with hardwoods	8	7	1	0	100.0%
SVPM	Savanna-Palm savanna	4	4	0	0	100.0%
SVx	Savanna-Pine savanna-Slash pine mixed with palms	49	14	13	22	38.9%
W	Additional Categories-Open Water	3	3	0	0	100.0%

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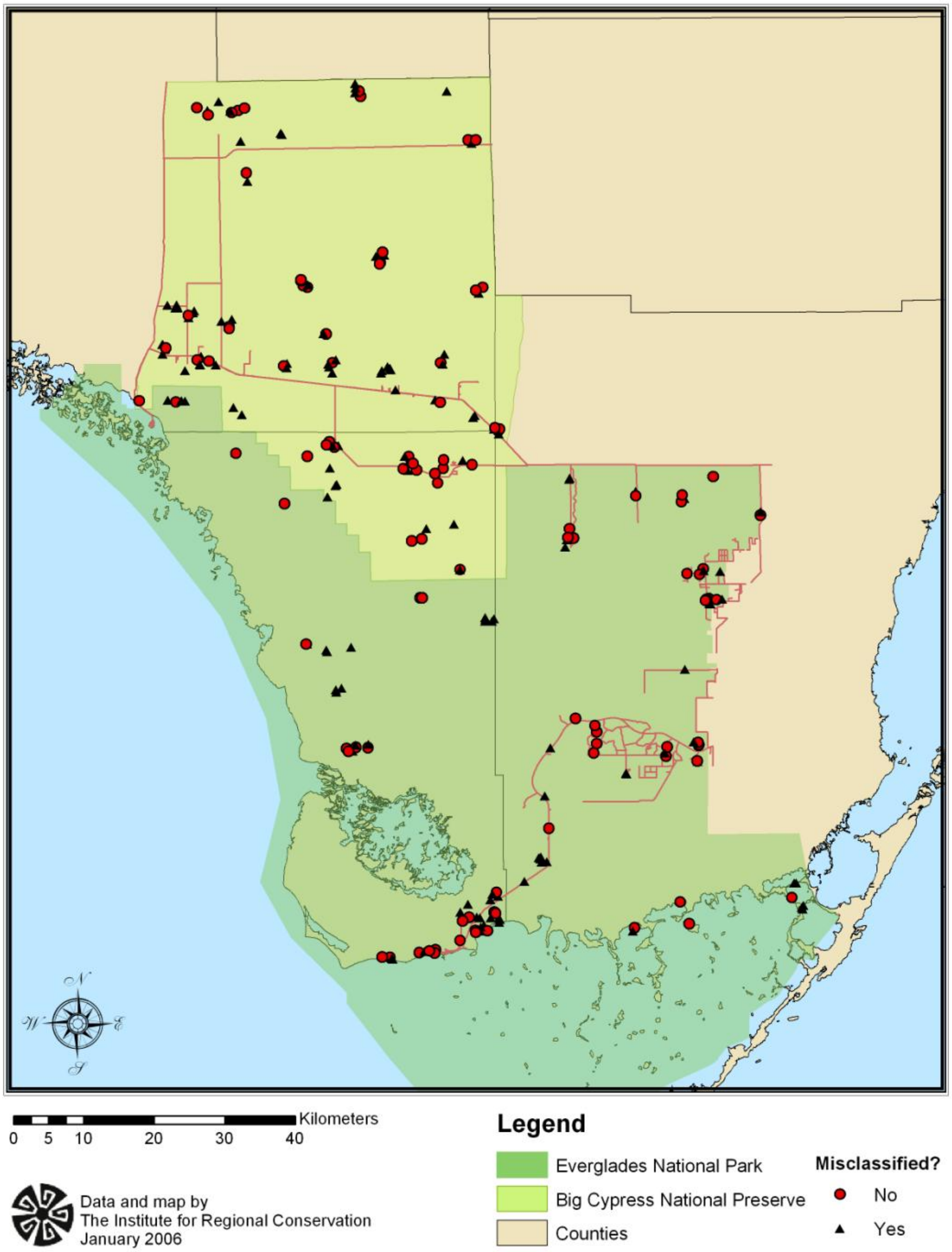
[1] Codes from Jones and Remillard (1997), also see Appendix 1.

Part II: Field Assessment

Between August 31, 2004 and March 5, 2005, data was collected at 254 sample sites (Figure 4). The sampling was stopped before completion of the target of 300 sample stations. Initial data suggested strongly that our 254 samples were sufficient for preliminary analyses and decision making. NPS and IRC agreed to stop field data collection and proceed with analyses. One hundred and thirty-one samples were collected in EVER and 123 were collected in the BICY.

Figure 4: Sites Sampled in Field Assessment (n = 254)



Data and map by
The Institute for Regional Conservation
January 2006

At the 254 sample sites, 58 vegetation types as classified by the UG were sampled (Table 4). The original goal was to sample five examples of each of the 60 vegetation types. Five or more samples from 33 vegetation types were gathered. In addition, four samples of 13 vegetation types, three samples of nine types, and two samples of three types were collected. The 12 vegetation classes for which only two or three samples were collected are rare communities (e.g. beaches, groundsel bush shrubland) and examples large enough to sample were difficult to find.

Table 4: Field Assessment Error Ratio

Vegetation Code[2]	Vegetation Type (n=58)	Total Polygons	Count Incorrect	Count Correct	Percent Incorrect
BCH	Beaches	3	3	0	100.0%
E	Exotics	5	1	4	20.0%
EC	Exotics-Australian Pine	4	1	3	25.0%
EM	Exotics-Cajeput	5	4	1	80.0%
EO	Exotics-Lather leaf	5	2	3	40.0%
ES	Exotics-Brazilian pepper	5	2	3	40.0%
FB	Forest-Buttonwood	4	1	3	25.0%
FC	Forest-Cabbage Palm	5	5	0	100.0%
FM	Forest-Mangrove	3	2	1	66.7%
FMa	Forest-Mangrove-Black mangrove	3	2	1	66.7%
FMx	Forest-Mangrove-Mixed mangrove	3	1	2	33.3%
FO	Forest-Oak-Sabal	5	1	4	20.0%
FSa	Forest-Swamp Forest-Mixed hardwoods, Cypress and Pine	4	4	0	100.0%
FSb	Forest-Swamp Forest-Bayhead	5	3	2	60.0%
FSc	Forest-Swamp Forest-Cypress Strands	5	3	2	60.0%
FSCpi	Forest-Swamp Forest-Cypress-Pines	5	5	0	100.0%
FSd	Forest-Swamp Forest-Cypress Strands Cypress domes/heads	5	1	4	20.0%
FSh	Forest-Swamp Forest-Mixed hardwood swamp forest	5	5	0	100.0%
FSx	Forest-Swamp Forest-Cypress-Mixed Hardwoods	5	3	2	60.0%
FT	Forest-Subtropical Hardwood Forest	4	3	1	75.0%
MUD	Mud	4	2	2	50.0%
PC	Prairies and Marshes-Cattail	4	4	0	100.0%
PE	Prairies and Marshes-Non graminoid Emergent Marsh	4	3	1	75.0%
PEb	Prairies and Marshes-Non graminoid Emergent Marsh-Broadleaf emergents	3	2	1	66.7%
PG	Prairies and Marshes-Graminoid Prairie/Marsh	5	2	3	40.0%
PGc	Prairies and Marshes-Graminoid Prairie/Marsh-Sawgrass	6	2	4	33.3%
PGct	Prairies and Marshes-Graminoid Prairie/Marsh-Tall sawgrass	4	1	3	25.0%
PGe	Prairies and Marshes-Graminoid Prairie/Marsh-Spike rush	5	2	3	40.0%

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[2] Codes from Jones and Remillard (1997), also see Appendix 1

Vegetation Code	Vegetation Type (n=58)	Total Polygons	Count Incorrect	Count Correct	Percent Incorrect
PGj	Prairies and Marshes-Non graminoid Emergent Marsh-Black rush	3	1	2	33.3%
PGm	Prairies and Marshes-Non graminoid Emergent Marsh-Muhly grass	5	3	2	60.0%
PGp	Prairies and Marshes-Non graminoid Emergent Marsh-Common reed	6	6	0	100.0%
PGs	Prairies and Marshes-Graminoid Prairie/Marsh-Cordgrass	4	1	3	25.0%
PGx	Prairies and Marshes-Graminoid Prairie/Marsh-Mixed graminoids	5	1	4	20.0%
PH	Prairies and Marshes-Halophytic herbaceous prairie	3	2	1	66.7%
PHg	Prairies and Marshes-Halophytic herbaceous prairie-Graminoid	5	2	3	40.0%
PHs	Prairies and Marshes-Halophytic herbaceous prairie-?	5	3	2	60.0%
SB	Shrublands	4	1	3	25.0%
SBb	Shrublands-Groundsel bush	2	2	0	100.0%
SBf	Shrublands-Pop ash	5	3	2	60.0%
SBs	Shrublands-Willow	5	5	0	100.0%
SBy	Shrublands-Cocoplum	5	2	3	40.0%
SC	Scrub-Saw palmetto scrub	2	2	0	100.0%
SH	Scrub-Hardwood scrub	5	4	1	80.0%
SM	Scrub-Mangrove scrub	4	3	1	75.0%
SMa	Scrub-Mangrove scrub-Black mangrove	3	1	2	33.3%
SMI	Scrub-Mangrove scrub-White mangrove	2	2	0	100.0%
SMr	Scrub-Mangrove scrub-Red mangrove	5	5	0	100.0%
SMx	Scrub-Mangrove scrub-Mixed	5	5	0	100.0%
SP	Scrub-Saw palmetto scrub	5	3	2	60.0%
SS	Scrub-Bay-Hardwood scrub	3	2	1	66.7%
SVC	Savanna-Cypress savanna	7	1	6	14.3%
SVCd	Savanna-Cypress savanna-Dwarf cypress	5	1	4	20.0%
SVCpi	Savanna-Cypress savanna-Cypress with pine	5	4	1	80.0%
SVPI	Savanna-Pine savanna	4	0	4	0.0%
SVPIc	Savanna-Pine savanna-Slash pine with cypress	5	4	1	80.0%
SVPIh	Savanna-Pine savanna-Slash pine with hardwoods	4	1	3	25.0%
SVPM	Savanna-Palm savanna	4	4	0	100.0%
SVx	Savanna-Pine savanna-Slash pine mixed with palms	5	3	2	60.0%

A total of 148 points out of 254 were misclassified (58.0%). Table 4 shows the accuracy ratio by classification type based on multiple samples per class. Forty-five actual vegetation types, thirteen fewer than classified by UG, were sampled. Accuracy for a given vegetation type ranged from 0% to 100%. Cypress savannas (SVC) were the most frequently misclassified; only one of the seven samples of this community (14.3%) was correctly identified by UG. Other ecosystems which were frequently misclassified included Oak forest (FO), Exotics (E), and Mixed graminoid prairies (PGx). Some systems which were always correctly identified included Mixed mangrove scrub (SMx), Willow shrublands (SBs), Pine savannas (SVPI), and Cabbage palm forest (FC).

Between parks, BICY had 74 out of 123, or 60.2%, and EVER had 73 out of 131, or 55.7%, vegetation types misclassified. There was no correlation between misclassification and park sampled ($x^2 = 0.512$, $P = 0.474$).

While 58.0% of the sample polygons were misclassified, these classification errors represented the highest level of precision of the vegetation classification system to the level of subclasses and subcategories. These subclasses and subcategories represented dominant species within each major vegetation class. Data was also analyzed to determine the degree of accuracy for the seven types of major vegetation class (approximating Physiognomic levels in the National Vegetation Classification System), which represents overall vegetation structure rather than dominant species (e.g. forest or savanna). At this level of major vegetation class 28.7% of the polygons were misclassified (73 of 254). Thus, half of the classification errors occurred at the first level in the vegetation classification hierarchy. Accuracy within the major vegetation classes range from 22.2% incorrect to 38.5% incorrect (Table 5). Scrub was most frequently misclassified and Exotics the most frequently correct.

Table 5: Summary of Seven Major Vegetation Classes

Major Vegetation Class	# Incorrect	Total	Percentage Wrong
Exotics	4	18	22.2%
Forest	16	60	26.7%
Other (non vegetative)	2	6	33.3%
Prairies and Marshes	19	79	24.1%
Savanna	17	51	33.3%
Scrub	10	26	38.5%
Shrubland	5	14	35.7%

While there was a significant difference in misclassification rates between classes ($x^2 = 268.139$, $P < 0.001$), no clear patterns of misclassification within any major vegetation class is discernable. Table 6 summarizes the classification errors made by UG for the major vegetation classes. While Prairies and Marshes were frequently classified as Scrub, it was also sometimes mapped as Exotic, Other, Savanna, and Shrubland. Forests were classified by the UG as Savannah, Scrub, and Shrubland. The only consistent misclassification was that of Shrublands being categorized as Forest (n=5).

Table 6: Misclassifications of Major Vegetation Classes by the University of Georgia

	Class Reported by UG						
Class as Observed by IRC	Exotic	Forest	Other	Prairies and Marshes	Savanna	Scrub	Shrubland
Exotic	-	2	0	1	1	0	0
Forest	2	-	0	0	1	7	6
Other	0	1	-	0	0	1	0
Prairies and Marshes	4	0	1	-	3	7	4
Savanna	2	8	0	4	-	3	0
Scrub	2	1	2	3	0	-	2
Shrubland	0	5	0	0	0	0	-

To determine the frequency of boundary delineation errors, the number of times new plant communities were encountered along transects was calculated. In 58 polygons we intercepted new vegetation communities larger than the minimum mapping unit on transects representing 22.8% of the total sample points. This indicates that the polygon boundaries, at the very least, were incorrect as all sample points were originally selected to be a minimum of 60 m from a mapped polygon edge. No transects should have crossed into new habitats, unless those new habitats were smaller than the UG minimum mapping unit. In addition, 33 sample points, or 13.0%, were moved from their original position in the field in order to wholly fit them within a vegetation type. A total of 74 out of 254 sample points, or 29.1%, had at least one of these boundary errors.

A potential explanation for the high rates of misclassifications and incorrect boundaries is successional change over the last 10 years since the vegetation mapping was conducted by the UG (Madden et al., 1999). Notes and data recorded during field work were reviewed for every sample point. It was determined that a total of five out of 254 sample points could have potentially changed over this time period (Table 7). Two sample sites apparently have changed due to restoration and exotic removal. Both were located within recently restored areas of the Hole-in-the-Donut in EVER. The three other sample sites in question may or may not have changed and they include one with dead exotics, one which had burned recently, and one that may have had a dominant vegetation shift (pine/cypress). Other sample sites may have undergone succession, but this was indeterminable based upon the data.

Table 7: Plots which may have undergone succession between original mapping by University of Georgia and IRC field sampling

Plot Code	University of Georgia Vegetation Type	Observed Vegetation Type	Succession?	Comments
86	Exotics-Cajeput	Savanna-Pine savanna	Possible	Melaleuca was killed, but may not have been a dominant prior to treatment
91	Savanna-Pine savanna-Slash pine with cypress	Savanna-Cypess savanna-Cypress with pine	Possible	Similar ecosystems, slight shifts in pine/cypress cover could cause shift in classification
137	Prairies and Marshes-Non graminoid Emergent Marsh-Muhly grass	Prairies and Marshes-Graminoid Prairie/Marsh-Mixed graminoids	Yes	Removal of soil in restoration caused change
138	Shrublands-Groundsel bush	Prairies and Marshes-Graminoid Prairie/Marsh-Mixed graminoids	Yes	Removal of soil in restoration caused change
148	Scrub-Mangrove scrub-Mixed	Prairies and Marshes-Graminoid Prairie/Marsh-Sawgrass	Possible	Fire may have caused succession from Scrub to Prairie

Summary

In summary, of the 437 polygons within the Existing Data Analyses (Part I), 173 polygons were classified as incorrect and 163 as correct. An additional 101 polygons were indeterminable and were excluded from analyses resulting in 51.5% misclassified polygons. Of the 254 sample stations which were visited during the Field Assessment (Part II), 168 (66.1%) were either misclassified or had some kind of boundary error. One hundred forty seven of those points were misclassified (58.0%) and 74 (29.1%) had boundary errors. Fifty-four (21.3%) were both misclassified and had boundary errors. After combining the two types of analyses the average number of misclassified polygons was 54.4% (Table 8).

Table 8: Summary of Results

Dataset	Total Polygons Misclassified	Total Polygons Correct	% Polygons Misclassified	Total polygons with boundary errors	% Polygons with boundary errors	Total misclassified polygons with boundary errors
Field Assessment Analyses	148	106	58.0%	74	29.1%	54
Analyses from Existing Data	173	163	51.5%	n/a	n/a	n/a
Combined	321	269	54.4%	n/a	n/a	n/a

Discussion and Recommendations

It is evident that the methodology used by the UG to create vegetation maps of EVER and BICY was not effective. This is most likely due to the lack of effective ground truthing, and perhaps more importantly much of the mapping was done by biologists that were unfamiliar with South Florida plant communities.

It is unclear how polygon boundaries were so frequently incorrectly delineated. It is our experience in using aerials that vegetation boundaries may be difficult to separate between some vegetation classes (e.g. common reed marsh (PGp) and cattail marsh (PC)), and easier in most others (e.g. bayhead (FSb) and graminoid prairie (PG)). Given these cases, proper delineation of ecosystem boundaries should have been straightforward even if the polygons were misclassified.

In some vegetation mapping projects, the vegetation classification system itself can cause problems if categories are unclear or poorly defined. We do not think that using the Jones and Remillard (1997) classification would have caused problems in map classification. This was evident since UG made half of their misclassification mistakes at the level of major vegetation class. The major vegetation classes represent habitats with major differences in vegetation structure and in most cases should be easily distinguishable on aerial photographs.

It is recommended that the NPS create new vegetation maps of BICY and EVER. New methodology used in creating these maps should be tested for efficacy using segments of each park before continuing onward to the rest of each conservation area.

Research Personnel

Project organization and development was conducted by Keith Bradley, Principal Investigator, in collaboration with Craig Smith and Matt Patterson, NPS employees and co-principal investigators. Project design was developed by Keith Bradley, George Gann, and NPS staff including: Craig Smith, Jim Burch, Matt Patterson, Frank Partridge, Andrea Atkinson, and Brian Witcher. Data analyses were conducted by Keith Bradley and Steven Woodmansee. Field Assessment research was conducted by IRC staff including: Keith Bradley, Steven Woodmansee, Jimi Sadle, Stephen Hodges, Emilie Verdon, Melissa Abdo, and Eric Fleites.

Citations

Bradley, K.A., S.W. Woodmansee, J.L. Sadle, and G.D. Gann. 2005. A Quantitative Plant Inventory of the Big Cypress National Preserve, Florida. February 27, 2005. The Institute for Regional Conservation, Miami, FL.

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Appendix 1: Vegetation Types of Everglades National Park and the Big Cypress National Preserve, following Jones and Remillard (1997)

Vegetation Code	Vegetation Type
BCH	Beaches
E	Exotics
EC	Exotics-Australian Pine
ES	Exotics-Brazilian pepper
EM	Exotics-Cajeput
EO	Exotics-Lather leaf
FB	Forest-Buttonwood
FC	Forest-Cabbage Palm
FM	Forest-Mangrove
FMa	Forest-Mangrove-Black mangrove
FMx	Forest-Mangrove-Mixed mangrove
FMr	Forest-Mangrove-Red mangrove
FO	Forest-Oak-Sabal
FT	Forest-Subtropical Hardwood Forest
FSb	Forest-Swamp Forest-Bayhead
FSc	Forest-Swamp Forest-Cypress Strands
FSd	Forest-Swamp Forest-Cypress Strands Cypress domes/heads
FSx	Forest-Swamp Forest-Cypress-Mixed Hardwoods
FSCpi	Forest-Swamp Forest-Cypress-Pines
FSh	Forest-Swamp Forest-Mixed hardwood swamp forest
FSa	Forest-Swamp Forest-Mixed hardwoods, Cypress and Pine
MUD	Mud
PC	Prairies and Marshes-Cattail
PG	Prairies and Marshes-Graminoid Prairie/Marsh
PGs	Prairies and Marshes-Graminoid Prairie/Marsh-Cordgrass
PGx	Prairies and Marshes-Graminoid Prairie/Marsh-Mixed graminoids
PGc	Prairies and Marshes-Graminoid Prairie/Marsh-Sawgrass
PGe	Prairies and Marshes-Graminoid Prairie/Marsh-Spike rush
PGct	Prairies and Marshes-Graminoid Prairie/Marsh-Tall sawgrass
PH	Prairies and Marshes-Halophytic herbaceous prairie
PHs	Prairies and Marshes-Halophytic herbaceous prairie-?
PHg	Prairies and Marshes-Halophytic herbaceous prairie-Graminoid
PE	Prairies and Marshes-Non graminoid Emergent Marsh
PGj	Prairies and Marshes-Non graminoid Emergent Marsh-Black rush
PEb	Prairies and Marshes-Non graminoid Emergent Marsh-Broadleaf emergents
PGp	Prairies and Marshes-Non graminoid Emergent Marsh-Common reed
PGm	Prairies and Marshes-Non graminoid Emergent Marsh-Muhly grass
SVC	Savanna-Cypress savanna
SVCpi	Savanna-Cypress savanna-Cypress with pine
SVCd	Savanna-Cypress savanna-Dwarf cypress
SVPM	Savanna-Palm savanna
SVPI	Savanna-Pine savanna
SVx	Savanna-Pine savanna-Slash pine mixed with palms
SVPIc	Savanna-Pine savanna-Slash pine with cypress

Vegetation Code	Vegetation Type
SVPIh	Savanna-Pine savanna-Slash pine with hardwoods
SS	Scrub-Bay-Hardwood scrub
SH	Scrub-Hardwood scrub
SM	Scrub-Mangrove scrub
SMa	Scrub-Mangrove scrub-Black mangrove
SMx	Scrub-Mangrove scrub-Mixed
SMr	Scrub-Mangrove scrub-Red mangrove
SMI	Scrub-Mangrove scrub-White mangrove
SP	Scrub-Saw palmetto scrub
SC	Scrub-Saw palmetto scrub
SB	Shrublands
SBy	Shrublands-Cocoplum
SBb	Shrublands-Groundsel bush
SBf	Shrublands-Pop ash
SBm	Shrublands-Wax myrtle
SBs	Shrublands-Willow
W	Water