Vegetation Mapping at Rookery Bay National Estuarine Research Reserve

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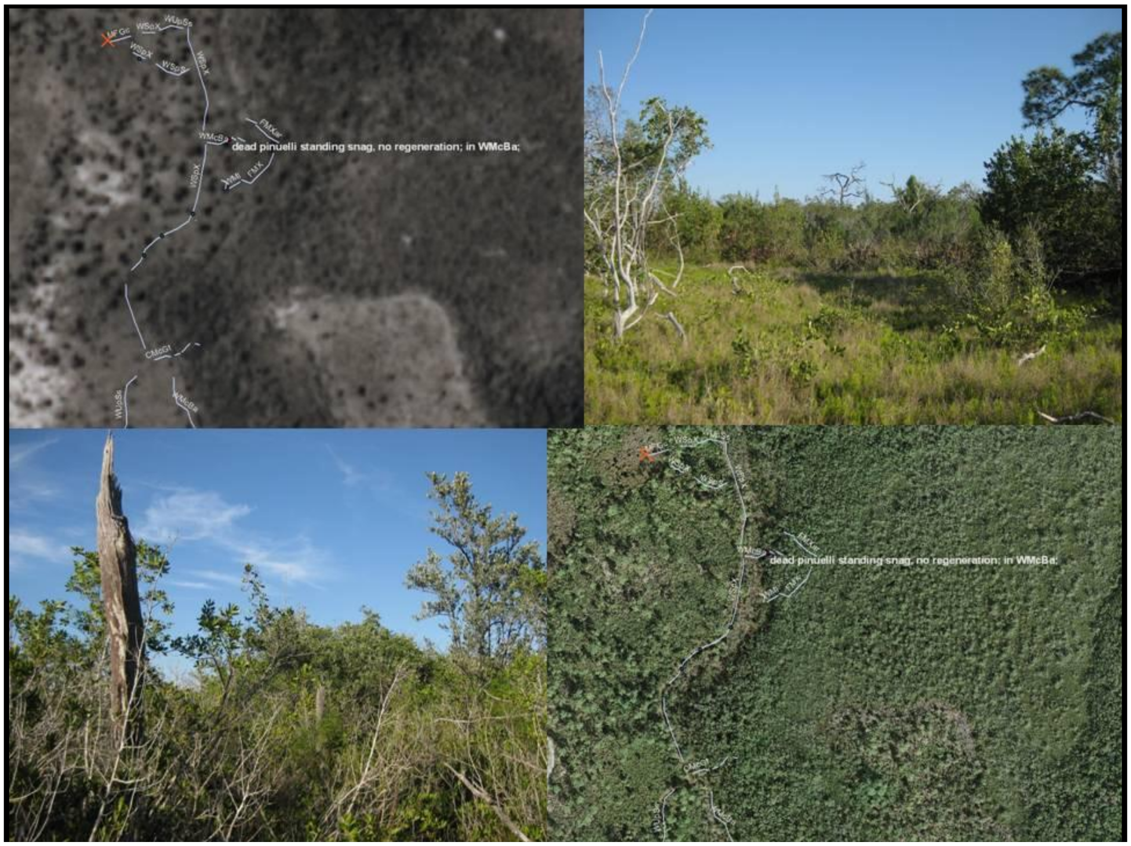

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1.0 - INTRODUCTION

Rookery Bay National Estuarine Research Reserve (RBNERR) includes 110,000 acres of coastal habitat in Southwest Florida, although the official boundary GIS data incorporates just under 100,000 acres, roughly half of which is sub-tidal (Figure 1). Although most of the area is aquatic or marine, it includes a variety of ecosystems from mangroves to pine flatwoods, freshwater wetlands, and rare xeric oak habitats in high relict dune ridges. A particularly notable xeric oak habitat is found on Sandhill, which is over 5m in elevation yet surrounded by mangroves. Due to its location of RBNERR to the city of Naples, much of the edge has been disturbed and/or hydrologically altered and infested by invasive exotic plants. Because of the diversity of habitats and elevations, the proximity to developed land, and the changes in hydrology, a detailed vegetation map is an important tool for the complex issues involved in land management. As the Reserve is largely Estuarine, mapping vegetation becomes essential to monitor long term expected changes with the acceleration in sea level rise.

The Institute for Regional Conservation (IRC) was contacted in October 2009 to discuss the possibility of continuing mapping efforts, for adjacent and overlapping (portions are co-mangaged) areas of Ten Thousand Islands National Wildlife Refuge (TTINWR). On June 1, 2010 a contract agreement between IRC and Friends of Rookery Bay was signed for a total of $60,000. Field work and GIS mapping efforts by IRC began in September 2010 and continued through July 1, 2011. Florida Gulf Coast University (FGCU) Students studying GIS assisted with the project during that time period.

2.0 - METHODS

A classified map with an extensive database, was assembled with past and present vegetation types and exotic species coverage's based on aerial photograph interpretation and field ground-truthing. Field work involved collecting global positioning system (GPS) data on dominant vegetation types, exotic plant species, and photographing typical vegetation types, exotic, threatened, and endangered species. A polygon map was hand-digitized starting with existing data from past maps as a base, and modified as ground-truthing progressed. FGCU students assisted with initial digitizing of open water boundaries. The map was completed in sections according to land management priorities set by RBNERR staff to contain prescribed burn units and exotic control/hydrological restoration areas.

The classified map is a continued work in progress to which RBNERR staff can add precision and data, by continuing the ground-truthing, and editing the polygons based on newly collected field data. Ground-truthed areas can be viewed as "complete," while all other areas will remain in "draft" form until additional data are incorporated. These areas are based on aerial photo interpretation and "extrapolation/interpolation" of the closest ground-truthing data. Although the goal of 5 x 5m mapping units was met in ground-truthed areas, the rest of the area remains to be refined.

A Yes/No field for ground-truthing is included for all polygons, but as cautionary note, it is important to note that only a portion of the larger polygons with "Yes" values may have been ground-truthed (see 2.4 below). To populate the Yes/No field the 'select by location' option in ArcMap, was utilize to select polygons that intersected or are contained inside portions of actual field data from both the field survey tracklog (polyline) and all point data. For example, if a track segment of 20 m long, extending into a large mangrove depression, and the signature is identical for the whole polygon on the aerial for 500+ m then the whole polygon is populated with "Yes" in the ground-truthed field. Roughly 13,000 acres or 25% of the 50,000 total acres (does not including large areas of open water that do not require ground-truthing) is considered ground-truthed using this methodology.

A variety of resources went into the production of the polygon vegetation map. Aerial photography utilized for this project ranged from infrared to true color, from 1995-2010, obtained from state and local government sources. Black and white photographs from the 1940s provided a historical reference for vegetation types. GIS data from broader scale mapping efforts were acquired from the RBNERR staff and the USGS (Andy From) prior to starting this project. After the initial vegetation type polygons were completed, ground-truthing focused heavily on known and suspected areas (based on similar aerial photo signatures) of exotic plant species infestations in the priority areas identified by RBNERR staff, using relatively new technology involving geodatabase software with GPS units (see 2.3 below). Finally, digital photographs were used to document the ground-truthed habitats.

2.1 – Existing Data Resources Utilized

Using the resources described below, and the field data collected during the project, a polygon map was generated using ArcGIS 9.3 personal geodatabase. Starting with existing GIS layers (described below), polygons were modified to match existing ground-truthed data and aerial photo signatures. Vegetation types were determined for each polygon, including a 1940 and 2010 layer. Exotic coverage was included for 2010, along with some pre-2010 data to indicate changes due to recent treatments that are evident in the field (see comments fields in geodatabase).

RBNERR Maps and GIS Layers
The aerial extent of forested and non-forested coastal habitats, as well as some habitat types and cover by exotic species exist for several important areas in the Reserve in GIS data format. These data served as guides, but not actual base layers, because most were derived from older aerial photos and digitized at a coarser scale. These data included data from state-wide coastline mapping efforts digitizing at 1:5,000 scale using 2004 DOQQ aerials (Florida Fish and Wildlife Research Institute 2006, http://ocean.floridamarine.org/acp/chacp/Geodata/HTML_Metadata/FL_State_Boundary.htm). Hard copy blue-line aerial photographs with hand-drawn vegetation types from past inventory projects, filed at RBNERR headquarters, were also examined and utilized as digitizing progressed.

USGS 2005 Mangrove Map
The boundaries of open water, mangrove, forested and non-forested coastal habitats were delineated using Collier County Property Appraiser's 2005 aerial photography by Andy From of

the USGS for portions of the Reserve adjacent to TTINWR. This layer was utilized directly as a base for outlining polygons in these areas. One problem with the layer is that the 2005 aerial photography has some geo-referencing errors, offsetting many of the lines to the east by several meters.

Collier County Property Appraiser's Aerial Photography
True-color, digital aerial photographs were taken by Collier County annually from 2000-2007, except for 2004 and most recently in 2009 and 2010 (http://www.collierappraiser.com). This exceptionally high quality imagery was used both in the field and for digitizing habitat types. Because these aerial photos were used so intensively, the geodatabase created for this project used the same projection as the aerial photos (NAD83 State Plane, Florida East). Each year, the Collier County Property Appraiser's aerial photographs from different years had advantages and disadvantages, as detailed below:

2000 rural imagery with 2-foot resolution was used frequently because it covered large areas of the Reserve. Because it marks 10 years prior to current mapping efforts, these aerials provided clues to the trends in longer term changes since 1940.

2002 imagery (and 2010 urban imagery) had higher spatial resolution than imagery from other years. 2002 aerial photos covered the western portion of the Reserve (an area not photographed in 2000), and the eastern portion adjacent to the Port of the Islands. This has more coverage of RBNERR than the 2010 aerials which only included the westernmost urban areas. Whenever possible, the higher resolution photographs were used, in particular because they distinguished cabbage palm (*Sabal palmetto*) from other tree canopies. As mentioned above, discussing the 2000 aerials, these aerials also provided clues to the trends in longer term changes since 1940. More importantly, these aerials were taken after a hard freeze in early 2001 which made it especially useful to identify the more cold tolerant black mangroves in basins mixed with other mangrove species which were frozen back and represented by grey top-killed trunks in the aerials.

2003 imagery was used mainly for large-scale printouts, because these 1-meter resolution maps covered the entire area. Also, some features were more easily distinguished in color; for example, graminoid areas and black mangrove areas showed up well.

2005, 2-foot resolution, images covered the entire area, and were darker overall, but showed good contrast between upland areas (light green) and mangroves (dark green). The 2005 photographs were not georeferenced the same as other photographs, and appeared to be offset several feet to the east throughout the mapping area.

2006 imagery was taken just after Hurricane Wilma (October 2005). These photos revealed the changes on the outer islands from erosion, and wind damage to mangrove canopies. Large areas of mangroves remained leafless for weeks to months after Wilma. The 2006 imagery was particularly useful for recognizing mixed mangrove forests, especially mature red and black mangrove forests. 2007 imagery also generally showed the areas as they had recovered from recent hurricanes but otherwise provided little data for this project.

2009 imagery was the most important layer for all dynamic coastal areas and for determining the extent of vegetation types because it was the most recent complete photographic collection available for the entire reserve despite only having 2 foot' pixels. Also, buttonwood and Brazilian pepper associations showed up nicely as lime green on the 2009 aerials. 2010 aerial photos included most of the northern half of the Reserve with high quality 6-inch pixel resolution, therefore, these images were used whenever possible.

Digital Orthophoto Quarter-Quadrangles (DOQQs)
Several aerial photographs, including the 1995 and 1999 infrared DOQQ aerial photos, were used for hand-digitizing habitats (Florida Department of Environmental Protection Land Boundary Information System; http://data.labins,org). These photos provided information on habitat signatures otherwise not evident in the true color imagery. True color photography was also available at this site in various projections. These photos were similar to Collier County Property Appraiser imagery, but generally had lower spatial resolution (up to 1-meter).

South Florida Water Management District Aerial Photography
These photographs, projected in NAD83 UTM 17N, are true color aerials in TIF format, and were taken of the outer islands and mangrove forests of TTINWR and RBNERR areas. We acquired these aerials directly from RBNERR staff, but they may be available to the general public from the SFWMD (http://www.sfwmd.gov). These aerials were especially useful in observing shoals and shallow areas in the submerged lands because they were taken at low tide.

1940s Aerial Photography
Georeferenced 1940s aerial photography was received from the USGS (Coffin et al. 2003; http://sofia.usgs.gov/projects/summary_sheets03/digarchive.html). These images were used to complete the 1940 vegetation layer. These black and white images vary in quality, often with good spatial resolution, but sometimes too dark or out of focus. Also, they were georeferenced with less precision than the newer aerial photographs due to a lack of obvious control points which did not change over time. However, to improve the 1940s layers, we added control points when digitizing in a specific area where the USGS layer is off more than 5-10m, utilizing the georeferencing toolbar in ArcGIS. After adding control points for that specific area and clicking 'rectify' a new image with better georeferencing for that specific area (not necessarily the entire aerial) would be created and labeled for that specific area. But not all done to same level of accuracy because the variability in image quality and sometimes was more difficult to find anything good to use as control points to improve georeferencing of parts of the image. RBNERR also provided additional versions of these aerial photographs from Collier County, some that was already georeferenced better which we used in our mapping. These images were in "negative" color scheme, but were reversed for use in digitizing polygons.

Archaeological Study 2003
A significant inventory of historical resources, including the outer islands of the TTINWR as far inland as Pumpkin Creek Mound, was conducted by several researchers (Beriault et al. 2003, Weisman and Collins 2003). These data include accurate GPS data delineating prehistoric shell middens and were used for generating polygons in the outer islands. Any mounds found during field survey work which was not recorded in previous research efforts were provided to archaeological staff involved in previous research on the Reserve.

Light Detection and Ranging (LiDAR) Data 2007
Elevation data acquired using LiDAR remote sensing technology acquired by the SFWMD in 2007 was relied on heavily for digitizing habitats in RBNERR. These data were instrumental in locating shell mounds and other above-mean-high-tide areas in these coastal systems. These new data improved the quality of this map relative to previous maps. Reliability of identifying uplands proved to be less than 100% as areas within mangroves with concentrations of organic debris periodically showed up as uplands, while other areas did not show up, presumably due to dense canopy closure. Nevertheless, these data were the most useful layer in this mapping effort. This layer was also secondarily used to analyze completed ground-truthed hand-digitized polygons to determine the mean and ranges of elevations for each of the major vegetation types. With these data some very rough speculation on future changes due to predicted changes in sea level were made.

2.2 – Vegetation Classification System

Vegetation types followed the Comprehensive Everglades Restoration Plan (CERP) codes (Rutchey et al. 2006; http://science.nature.nps.gov/im/units/sfcn/docs/Vegetation%20Classification%20-%20v6.15.09.xls). This system is hierarchical allowing for different levels of detail, depending on available data. For 1940 aerial interpretation only level 2 and 3 distinctions are possible wheras full detail (levels 5+) is possible when assesing current conditions in the field. Any vegetation types encountered in RBNERR during field work not found in the referenced report were documented. These habitat types were added to the classification system.

Other vegetation classification systems were secondarily designated using crosswalks created for the purpose of automatically populating data fields from the CERP codes. Florida Natural Areas Inventory (FNAI) natural communities were provided along with CERP habitat types for each habitat type polygon following the FNAI natural communities' guidelines (http://www.fnai.org/naturalcommguide.cfm). Florida Land Use Cover and Forms (FLUCFCS) classification system was also used based on Florida Department of Transportation (FDOT 2009) definitions, but these general codes were not updated following recent evaluation of that system done by the Florida Fish and Wildlife Conservation Commission (Kawula 2009). Finally, National Estuarine Research Reserve classification system was secondarily populated using a rough crosswalk, but will need considerable fine-tuning as some of the classification differed, or was difficult to crosswalk (Kutcher et al. 2011).

2.3 – Field Ground-Truthing
Ground-truthing methodology consisted of haphazard and stratified random sampling by transects on foot, covering as many signatures as possible in the field. Trimble Geo-Explorer hand-held and Thales Mobile Mapper GPS units were used in the field for data collection. Both units have ArcPad software and were used primarily with one polyline feature class with custom designed data fields with drop-down menus for vegetation type and exotic plant species density/cover codes exported from the geodatabase. Five additional point feature classes were used to document other exotic species, rare plants, rare or exotic animals, other points of interest,

and fixed point photographs. Both GPS units allowed for the use of digital aerial photography while in the field to help insure the location of signatures in question.

Exotic species were mapped using an existing geodatabase and methodology based on the FNAI Florida Invasive Plants Geodatabase project (http://fnai.org/invasivespecies.cfm), with modifications. These modifications included expanding the scope of species mapped, as well as incorporating survey track logs with percent cover of dominant exotic species along the track route to strengthen the dataset for production of polygon maps in the office. All Florida Exotic Pest Plant Council (FLEPPC) category I and II species were recorded in the field, as they were in the FNAI methods (FLEPPC 2009).

Meandering transects on foot were used with an emphasis on bisecting as many different signatures or vegetation types as possible, especially where exotic species are suspected. Transect locations were roughly plotted prior to field work based on priorities outlined by RBNERR staff. Priorities for transect locations also changed and evolved as progress was made in the vegetation map, and aerial photograph signature recognition improved. Transects were typically round-trip paths so that new territory was surveyed and usually were completed in one field day, with a few remote areas requiring overnight, primitive camping.

Polyline data were collected by streaming data by distance (5 meters). When more precise vertices were needed (<5m), they were added to the polylines manually while streaming. Each time a new vegetation type, or the same vegetation type with distinctly different exotic species canopy coverage, was entered in the field, a new line segment was initiated. Streaming continued until either vegetation type or exotic species canopy coverage changed, at which time the segment was ended and the fields of the associated database were populated accordingly. When more precision was needed, for example when a narrow (<5 meter wide) but distinct shell midden ridge extended into mangroves from a larger mound, manual points (using 30-point averaging option) were taken to assist when digitizing. Besides vegetation type and canopy coverage of exotics, a comments field was also used to describe co-dominants to assist in final habitat type determinations for the polygon map. These data are located in the IRC_Master_GDB.mdb geodatabase in the "field_survey_tracklog" feature class.

Exotic species with less coverage than could be recorded using the polyline method using the "field_survey_tracklog" were recorded as a point feature class which followed the FNAI methodology. For example, species like Brazilian Pepper (*Schinus terebinthifolius*), lather leaf (*Colubrina asiatica*), and sea-side mahoe (*Thespesia populnea*) were generally recorded using the polyline method, though when isolated individuals occurred in otherwise non-infested areas they were recorded as points. Uncommon exotic species were primarily recorded as points. All species were incorporated into the polygon map following fieldwork.

Any threatened or endangered plant species observed were recorded using the GPS and notes on abundance, phenology, and host plant for epiphytes were recorded in the comments field. State of Florida listed orchids and bromeliads were expected to be the most commonly recorded species, none of which were federally listed species. Areas with a high probability of rare plant occurrences were not given preference when ground-truthing, as when a threatened and endangered species (T&E) survey is conducted. Rare species were observed by chance while focusing on the primary goal of traversing as many exotic plant species-infested habitat types as possible. Taxonomy follows Wunderlin and Hansen (2003, 2011). These data are located in the IRC_Master_GDB.mdb geodatabase in the "Rare_plant_pts" feature class.

Periodically, when near the center of a characteristic vegetation type, exotic plant infestation, or other ecologically significant location, a fixed point photograph was taken. No marking in the field occurred; however, a higher precision GPS point was collected and stored in the "photo_pts" feature class in the IRC_Master_GDB.mdb geodatabase. Photographs were taken starting facing toward the north, then shooting adjacent areas in a clock-wise pattern. Any interesting plants or features were also photographed after completion of the cardinal directions. Most photos were taken in portrait orientation due to the thick vegetation, and sometimes shots of the canopy above were included. Photos from each fixed point were stored in a separate directory and provided to RBNERR digitally.

An additional point shape file was maintained for any other interesting features observed on the landscape. This included plant species not considered rare in South Florida, but not previously observed in the Reserve, as well as other features such as abandoned camps, junk piles, etc. Vegetation type features needing more precision than streaming with the polyline function provided were recorded into this feature class (as discussed above). These data were recorded in the "Misc_pts" features class in the IRC_Master_GDB.mdb geodatabase.

Finally, animal signs or direct observations of rare or exotic animals were occasionally recorded as point data. Visual observations of individuals, burrows, nests, or signs of Florida black bear (*Ursus americanus*), Florida panther (*Puma concolor coryi*), bald eagle (*Haliaaeetus leucocephalus*), and gopher tortoise (*Gopherus polyphemus*) were stored in the "rare_animal_pts" feature class in the IRC_Master_GDB.mdb geodatabase.

2.4 – Digitizing Following Ground-Truthing

All of these data in the ground-truthing feature classes were incorporated manually into the geodatabase. Large polygons generated from existing boundary layers and mangrove polygons from USGS formed the base layer to begin editing. FGCU students began the process by cutting up the large polygons according to open water boundaries and human-impacted lines, both of which often cover miles of zigs and zags through the mangroves. Next, the polygons in ground-truthed areas were further cut following aerial photograph signatures identified by the "field_survey_tracklog" feature class. Multiple years of aerial photographs were examined to assist with signature recognition. The 2007 LiDAR data were also used while digitizing polygons, especially to discern signatures blended together, such as small forested high spots in large expanses of mangroves.

Fields in the attribute table of the polygon map were populated for vegetation types from current conditions, 1940s or "pre-drainage" conditions, and for percent cover of exotic species. Notes from the comments fields were recorded in the polygon attribute table where applicable. All point feature classes were also examined while digitizing to help identify and populate data fields. Recently collected field data along with existing notes and maps from RBNERR staff were used to estimate pre-exotic control treatment coverage in previously treated areas whenever possible. For future work, the database was set up so that sites can be revisited, re-evaluated, and recorded by adding new exotics coverage and treatment fields.

Once existing ground-truthed data were incorporated into a polygon map for a specific area digitizing continued outward (using extrapolation) from the ground-truthed areas. The attribute table was populated with values based on aerial photo signature interpretation and LiDAR data according to the similarity of the closest ground-truthed polygons. Exotic species coverage was also entered into the attribute table according to general similarity and proximity to ground-truthed signatures.

A Yes/No field in the geodatabase identifies which polygons intersect with ground-truthing point or polyline data (see section 2.0 above). However, to determine which areas were actually ground-truthed, the field data (track and waypoint data) should be laid over the polygon map.

In some areas that were not ground-truthed and had signatures which were less than obvious, the habitat type was classified using a lower level of the South Florida vegetation classification system.

These areas would be prime candidates for future ground-truthing efforts when resources are available. Finally, when digitizing and populating the fields of the attribute table in areas not yet ground-truthed, areas with signatures which were difficult to discern often included comments such as “needs ground-truthing” or mentioned other alternative classification system values that the area could be called. By carefully recording this information, it is hoped that field data will eventually be collected over nearly all of the Reserve, which will assist with analysis of trends.

3.0 - RESULTS AND DISCUSSION

Data for field ground-truthing, utilized for digitizing the polygon map, came from over 100 km of track data with habitat and exotics coverage from within RBNERR. The majority of these data were collected between September 2010 and May of 2011 (Figure 2, Table 1) but some data were collected from 2003 (Terry Doyle) and 2006 when mapping TTINWR. . Within TTINWR, which includes RBNERR,, tracklog data used for ground-truthing totaled over 500 km (Figure 2). All of these data were important for signature recognition and “extrapolation/interpolation” when populating the vegetation and exotics fields in the polygon geodatabase in areas beyond where ground-truthing was conducted.

Miscellaneous points (376 points) were also utilized in digitizing efforts including past and present habitat data, 282 exotic plant points, 70 photo points, 56 rare plant points, and 7 rare animal points all collected within RBNERR boundaries. Of the 376 miscellaneous points, 127 points were taken to document areas with dead tree species with no live individuals or when regeneration of the species suggested a change in site conditions. This included 70 points for dead slash pine, 55 points for dead buttonwood, and 43 for dead sabal palm (some points listed more than one species).

A total of 70 “rare” plant locations were recorded during ground-truthing (Table 2). Barbwire cactus (*Acanthocereus tetragonus*) was most frequently recorded, often with a single point representing large patches followed by twisted wild pine (*Tillandsia flexuosa*).

Table 1: Total Field Survey Tracklog Distance

SITENAME	Method	Distance (m)	First Date	Last Date
RBNERR	Airboat	217	26-Oct-06	26-Oct-06
	Bicycle	4,390	10-Feb-11	28-Mar-11
	Boat and foot	2,090	15-Sep-03	26-Feb-04
	On foot	105,121	17-Apr-06	21-Aug-12
	Vehicle	1,518	13-May-11	13-May-11
	Subtotal:	113,337		
TTINWR	Airboat	111,008	24-Feb-04	02-Nov-07
	Boat and foot	2,289	15-Sep-03	24-Sep-03
	Canoe/kayak	155	13-Nov-07	13-Nov-07
	On foot	274,590	16-May-05	09-Mar-10
	Subtotal:	388,043		
	Total:	501,379		

Table 2: Rare Plant Points Recorded in RBNERR Boundaries (not including TTINWR)While Ground -Truthing Vegetation Types

Scientific Name	Common Names	Number of records	State Status
Acanthocereus tetragonus	Barbwire cactus, Dildoe cactus	10	T
Agave decipiens	False-sisal	5	
Ceratiola ericoides	Florida rosemary, Sand heath	3	
Gossypium hirsutum	Wild cotton, Upland cotton	1	E
Lechea cernua	Nodding pinweed	2	T
Lupinus diffusus	Skyblue lupine	1	
Lycopodiella cernua	Nodding club-moss	1	C
Opuntia stricta	Erect pricklypear	8	T
Polystachya concreta	Greater yellowspike orchid	1	E
Selaginella arenicola	Sand spike-moss	2	
Tillandsia flexuosa	Banded wild-pine, Twisted airplant	18	T
Tillandsia paucifolia	Twisted wild-pine, Potbelly airplant	2	
Tillandsia variabilis	Soft-leaved wild-pine, Leatherleaf airplant	2	T
	Total:	56	

A total of 7 rare animal points were added representing a bald eagle *(Haliaeetus leucocephalus)*, Florida panther (*Puma concolor coryi*), and an Eastern diamond-backed rattlesnake (*Crotalus adamanteus*). Also recorded were locations of spiny tailed iguanas (*Ctenosaura similis*) and wild pigs (*Sus scrofa*). A total of 70 photo points (Table 3) were taken within RBNERR boundaries including 61 fixed pointpoint-360 and 9 plant voucher photo points representing at least 43 CERP vegetation types.

Table 3: Photo Points Recorded in RBNERR Boundaries (Not including TTINWR) by CERP Vegetation Type

Photo Type	CERP Class_ID	Number of records
Directional	WMcBa	1
Fixed Point-360		4
Fixed Point-360	CMaSb	1
Fixed Point-360	CMcGd	1
Fixed Point-360	CMcGe	1
Fixed Point-360	CMcGj	1
Fixed Point-360	CMX	1
Fixed Point-360	CMXalSb	1
Fixed Point-360	CMXclGj	1
Fixed Point-360	FMa	2
Fixed Point-360	FMc	1
Fixed Point-360	FSt	1
Fixed Point-360	M	1
Fixed Point-360	MFGc	1
Fixed Point-360	MFGt	2
Fixed Point-360	MSGj	1
Fixed Point-360	MSGsd	1
Fixed Point-360	MUD	3
Fixed Point-360	OW	1
Fixed Point-360	SF	1
Fixed Point-360	SP	6
Fixed Point-360	WMa	1
Fixed Point-360	WMaG	2
Fixed Point-360	WMaS	1
Fixed Point-360	WMaSMl	1
Fixed Point-360	WMaSMX	1
Fixed Point-360	WMcBa	2
Fixed Point-360	WMcG	1
Fixed Point-360	WMcS	3
Fixed Point-360	WSh	2

Photo Type	CERP Class_ID	Number of records
Fixed Point-360	WSp	1
Fixed Point-360	WSpX	1
Fixed Point-360	WSsS	1
Fixed Point-360	WSsX	2
Fixed Point-360	WUCp	5
Fixed Point-360	WUh	3
Fixed Point-360	WUqSs	1
Plant Voucher		1
Plant Voucher	SMXal	1
Plant Voucher	WMaS	1
Plant Voucher	WMc	2
Plant Voucher	WMcSMl	1
Plant Voucher	WSpS	1
Plant Voucher	WSsS	1
Plant Voucher	WSsX	1
	Total:	70

3.1 - Vegetation Types Mapped in RBNERR

A map vegetation types for present (2010) and past (1940) is presented in Figures 3 and 4. These figures are mapped at level 3 of this hierarchical classification system (see section 2.2 above). A total of 29 Level 2 vegetation types and 88 at Level 3 were mapped within RBNERR boundaries (Table 4). For the purpose of this report it is not feasible to produce a figure of this scale to capture the full detail level of CERP vegetation types for 2010, but the data are available in the geodatabase. A total of 206 full detail CERP vegetation types (up through level 6) were mapped (Appendix I).

It is important to note that this mapping project remains a work in progress so many of the acreage numbers will change as RBNERR staff continues to gather field data and edit the polygon map. Approximately 9% of the area still contains NULL values for vegetation types centered in several areas including east of 951 north of Mclvane Marsh, south of Isles of Capri and around C.R. 92, and around Hog Key. Approximately 1.3% of the area is mapped as Level 2 Mangrove Forest (FM) and will need additional effort to break into lower level mapping units. Furthermore, only 7969.7 acres (8.2%) of the total area (open water areas not considered ground-truthed) are considered ground-truthed. As more field data are collected it is hoped that the polygons will be edited and adjusted for accuracy by RBNERR staff or a different contract.

Over half (57%) of the roughly 98,000 acres within RBNERR boundaries are mapped as open water, most of which is marine habitat but also includes some small areas of fresh and brackish water ponds embedded in the mangrove and marsh areas. Areas mapped as mud (MUD), 1627 acres (1.67%), were mostly shoals and sand bars visible from aerial photography reflecting areas exposed at low tides. Although 830 acres (0.9%) of the area was mapped as Submerged Aquatic

Vegetation including seagrass and algae, this is not considered a complete or precise number as these vegetation types were not ground-truthed. It is hoped that existing seagrass data from RBNERR staff and USGS researchers could someday be used to edit the polygons and produce a more accurate portrayal of these important features of the reserve.

Roughly half of the remaining (non-open water) areas consists of mangrove dominated areas including 18,563 acres (19%) mapped as mangrove forest (FM), 4,941 acres (5%) mangrove woodland (WM), 1,373 acres (1.4%) shrub mangrove (SM) and 1819 acres (1.9%) mangrove scrub (CM). Small areas of barren salt flats (SF) were also mapped totaling 11 acres (0.01%) but some smaller areas of salt flats not mapped can also be found within mangrove woodland (WM) and scrub mangrove (CM) habitats.

Roughly 100 acres (0.1%) were mapped as graminoid salt marsh communities (MSG). However, areas of scrub and woodland mangroves, which by definition ranges between 10-60% cover by mangroves, also function as marshes when they consist of graminoid species. This caveat is mentioned because it has already caused some confusion with those not familiar with the South Florida Vegetation Classification System. This makes the total salt and brackish marsh area approximately 1,065acres (1.1%) of combined mangrove woodland (WMcG, WMaG, WMXG) and scrub mangrove (CMG, CMcG, CMaG, CMlG, CMrG, CMXG) (Appendix I). Also approximately 429 acres (0.4%) of the total acreage is leather fern (*Acrostichum aureum*) dominated and also function as marshes (MFBa) although most is mapped as mangrove woodland (WMcBa and WMXBa) (Appendix I). Succulent dominated areas are similarly mostly embedded in mangrove scrub and woodland communities and total 206.7 acres (0.2%). These marsh areas are all combined in FNAI natural community classification, with some exceptions, and total 1670.4 acres (Appendix III).

Freshwater marsh (MF) covers 177 acres (0.18%) but similarly this is an underestimate because it does not include areas of scattered woody vegetation in graminoid dominated matrix. Freshwater scrub includes areas of marsh encroached by woody vegetation such as wax-myrtle (*Myrica cerifera*) and willow (*Salix caroliniana*) cover approximately 219 acres (0.2%). This habitat can be significantly altered by fire and is expected to change if the fire regime increases. In fact, some areas may have already been influenced by prescribed burning since this map was produced. This combination brings the total freshwater marsh acreage to 396 acres.

Moving up and inland from the open water, mangroves and marsh, putting them on the "front line" or edge of saltwater influence, 675 acres of Swamp Woodland were mapped. Approximately 155 acres of cabbage palm woodland (WSs) and 471 acres of hydric pine flatwoods (WSp) were mapped. These habitats will be affected with sea level rise. Approximately 98 acres of these "front line" woodlands can also be argued to function as freshwater marsh or wet prairie including areas of cypress woodland (WStG), hydric pine with graminoid understory (WSpG) and cabbage palm woodland (WSsG). These areas are not utilized in the marsh totals mentioned above. Additionally, areas dominated by leather fern (*Acrostichum aureum*) function as fresh to brackish marshes and are mapped as mangrove woodland and are therefore lumped with tidal marsh in FNAI classification (Appendix I).

Approximately 24 acres of cypress woodland (WSt) and 22 acres of swamp hardwood woodland (WSh) were also mapped. This habitat is mostly located in the "valleys" leading towards the marsh, mangrove and buttonwood dominating communities. Most often the hardwood woodlands lie in between the cypress swamps upstream and the brackish communities downstream suggesting perhaps that cypress is less salt tolerant than swamp hardwoods. furthermore, within the freshwater valleys and depressions are 87 acres of cypress forest (FSt) and roughly 1 acre of swamp hardwood forest (FSH). Some of the inland boundaries are in question, especially around some of the recently developed areas, so these numbers may change. Roughly 12 acres of freshwater swamp shrubland (SS) were also mapped including areas dominated by wax-myrtle and willow. These areas, especially the willow, often were located at the ends of the freshwater wetland “valleys” (downstream of the FSt/WSt areas).

Approximately 478 (0.5%) acres of hammock forest (FH), 857 (0.9%) acres of Woodland Upland (WU), 49 (0.05%) acres of Upland Scrub (CU) and 1.9 (0.002%) acres of upland shrubland (SU) comprise the higher non human-impacted areas and are distributed from the outer barrier islands to the inland boundaries, with the majority found inland. Cabbage palm hammock (FHa) covers roughly 12 acres and include both wetland and upland areas mostly inland. Coastal hammock forest (FHC) covers 231 (0.24%) acres largely centered on the middle islands and may include other types of hammock forest, most notably tropical hardwood hammock (FHS) and even buttonwood habitats but they are difficult to separate out using just aerial photography without ground truthing. A longer term project may be to eventually pull out higher diversity tropical hammocks from the current map from within FHC habitats, such as on Cannon Island. Approximately 165 acres (0.2%) of the area was mapped as upland hardwood woodland (WUh) which was most often found coastally and associated with Coastal Hardwood Hammock (FHC) edges or coastal berm habitats near the beaches. Additional coastal uplands will be mapped eventually in the NULL polygons around Hog Key. Temperate hammock (FHT) covers roughly 11 acres (0.01%) mostly inland associated with transitions between freshwater wetlands and fire dominated upland woodland habitats. Mesic pine flatwoods (WUp) covers 404 acres (0.4%) mostly inland but also on the northern barrier and middle islands such Keywadin Island. Live oak (*Quercus virginiana*) woodland with saw palmetto (*Serenoa repens*) cover 74 acres (0.1%) which in the past may have been mesic pine flatwoods, although it appears little has changed since 1940 judging by lack of slash pine stumps in the field and 1940 aerial signatures lacking the distinct dark shadows of tall slash pine.

The highest sandy areas are dominated by scrubby flatwoods (WUCp) cover 160 acres (0.2%) centered mostly along Shell Island Road and northward up towards the terminus of the Lely canal (Figure 3). Also 44 acres (0.04%) were mapped as xeric oak scrub (CUq) because they lacked slash pine and contained more rosemary (*Ceratiola ericoides* than in the scrubby flatwoods. An additional 6 acres (0.01%) of xeric hammock (FHX) were mapped representing long fire-suppressed areas of former scrubby flatwoods. All of these vegetation types were added as new types to the vegetation classification system of South Florida because they do not occur within the Everglades ecosystem for which the system was created. Sandhill represents the highest scrubby flatwoods area in the reserve and may have unique flora and fauna yet to be described and in general contain a high number of threatened and endangered species.

Shell mound areas mapped thus far include 98 acres (0.1%) of tropical hardwood shell mound habitat and 32 acres (0.03%) of woodland mound habitat. Fakahatchee Key is the largest shell mound solely managed by RBNERR. Former upland woodland portions of the mound, now partially tidally influenced, were mapped as buttonwood with succulents (WMcSM) totaling 11 acres (0.01%) and human impacted mound habitat (HIM) covered 58 acres (0.1%). The human impacted mound habitat was largely at the end of Shell Island road. Additional mound habitat may be found in some of the NULL polygons, including portions of Hog Key behind the coastal berm, and also perhaps small isolated sites scattered in the mangrove areas throughout the Reserve.

Human disturbed habitats total 1908 acres (2%). This includes areas mapped as Human Impacted (HI), spoil (SP), quarry or borrow pits (QUA), canals and ditches (CA), roads or truck trails (RD, ORV). These habitats are mostly along the urban interface but are also scattered throughout the Reserve, often associated with a greater percent cover by invasive exotic plant species.

Table 4: Level 2 and 3 CERP Vegetation Types (2010) in Polygon Map of RBNERR

Level 2	Level 3	Name	Acres	% of Total	Acres	% of Total
OW		Open Water	55,257.8	56.6%		
MUD		Mud	1,627.0	1.7%		
BCH		Beach	206.4	0.2%		
DG		Graminoid Dune	103.4	0.1%		
A	A	Submerged Aquatic Vegetation	24.5	0.03%		
AM	AM	Marine Aquatic Vegetation	805.8	0.8%	1,24.5	0.13%
	AMA	Marine Algae			56.2	0.06%
	AMS	Seagrass			625.1	0.64%
FM		Mangrove Forest	18,562.9	19.0%	1,294.1	1.32%
	FMa	Black Mangrove Forest			3,038.7	3.11%
	FMc	Buttonwood Forest			23.1	0.02%
	FMl	White Mangrove Forest			35.8	0.04%
	FMr	Red Mangrove Forest			6,682.8	6.84%
	FMrB	Red Mangrove Forest in recent shell berm			2.8	0.003%
	FMX	Mixed Mangrove Forest			7,474.7	7.65%
	FMXB	Mixed Mangrove Forest in recent shell berm			11.1	0.01%
WM		Mangrove Woodland	4,941.1	5.1%	8.0	0.01%
	WMa	Black Mangrove Woodland			3,707.6	3.80%
	WMaB	Black Mangrove Woodland in recent shell berm			1.1	0.001%
	WMc	Buttonwood Woodland			982.2	1.01%
	WMcB	Buttonwood Woodland-Broadleaf			0.3	0.00%
	WMcSM	Buttonwood Woodland-Succulent, Mound			10.7	0.01%
	WMl	White Mangrove Woodland			41.9	0.04%
	WMlB	White Mangrove Woodland in			0.5	0.0005

Level 2	Level 3	Name	Acres	% of Total	Acres	% of Total
		recent shell berm				%
	WMX	Mixed Mangrove Woodland			162.9	0.17%
	WMXB	Mixed Mangrove Woodland in recent shell berm			25.8	0.03%
SM		Mangrove Shrubland	1,372.5	1.4%	0.7	0.001%
	SMa	Black Mangrove Shrubland			3.2	0.003%
	SMc	Buttonwood Shrubland			4.6	0.005%
	SMl	White Mangrove Shrubland			21.0	0.02%
	SMr	Red Mangrove Shrubland			1,036.6	1.06%
	SMX	Mixed Mangrove Shrubland			306.4	0.31%
CM	CM	Mangrove Scrub	1,818.8	1.9%	9.1	0.01%
	CMa	Black Mangrove Scrub			124.5	0.13%
	CMc	Buttonwood Scrub			405.0	0.41%
	CMl	White Mangrove Scrub			99.7	0.10%
	CMr	Red Mangrove Scrub			335.4	0.34%
	CMX	Mixed Mangrove Scrub			845.2	0.87%
SF		Barren Salt Flat	11.4	0.01%		
MS		Salt Marsh	98.9	0.1%		
	MSG	Graminoid Salt Marsh			57.6	0.06%
	MSGj	Black Rush			41.1	0.04%
	MSS	Succulent Salt Marsh			0.3	0.0003 %
MF		Freshwater Marsh	177.3	0.2%		
	MFBa	Leather Fern			0.7	0.001%
	MFG	Graminoid Freshwater Marsh			128.9	0.13%
	MFGc	Sawgrass			15.8	0.02%
	MFGe	Spikerush			31.9	0.03%
CS		Swamp Scrub	218.9	0.2%		
	CSG	Swamp Scrub-Graminoid Marsh			8.9	0.01%
	CSm	Wax Myrtle Scrub			21.1	0.02%
	CSs	Willow Scrub			188.9	0.19%
FS		Swamp Forest	87.9	0.09%		
	FSH	Hardwood Swamp Forest			1.1	0.001%
	FSt	Cypress Forest			86.7	0.09%
WS		Swamp Woodland	674.6	0.7%	2.6	0.003%
	WSh	Hardwood Swamp Woodland			22.0	0.02%
	WSp	Pine Lowland			471.0	0.48%
	WSs	Cabbage Palm Lowland			154.9	0.16%
	WSt	Cypress Woodland			24.1	0.02%
SS		Swamp Shrubland	12.0	0.01%	3.6	0.004%

Level 2	Level 3	Name	Acres	% of Total	Acres	% of Total
	SSm	Wax Myrtle Shrubland			5.2	0.01%
	SSs	Willow Shrubland			3.2	0.003%
FH		Hammock Forest	478.1	0.49%		
	FHa	Cabbage Palm Hammock			12.1	0.01%
	FHC	Coastal Hardwood Hammock			346.5	0.35%
	FHM	Tropical Hardwood Shell Mound			102.0	0.10%
	FHS	Tropical Hardwood Hammock			0.4	0.00%
	FHT	Temperate Hardwood Hammock			11.3	0.01%
	FHX	Xeric Hammock			5.9	0.01%
WU		Upland Woodland	857.1	0.88%	.00002	<0.01%
	WUCp	Scrubby Flatwoods			160.0	0.16%
	WUh	Upland Woodland			164.8	0.17%
	WUM	Upland Woodland, Mound			31.5	0.03%
	WUp	Pine Upland			404.7	0.41%
	WUq	Live Oak Woodland			74.1	0.08%
	WUs	Cabbage Palm Upland			21.9	0.02%
SU		Upland Shrubland	1.9	0.00%		
	SUs	Saw Palmetto Shrubland			1.9	0.002%
CU		Upland Scrub	48.9	0.05%		
	CUG	Upland Scrub-Graminoid Prairie			0.2	0.0002 %
	CUq	Xeric Oak Scrub			43.5	0.04%
	CUW	Upland Hardwood Scrub			5.2	0.01%
E		Exotic Vegetation (Habitat Type Unclear)	23.9	0.02%		
	EcD	Australian Pine Dominant			20.7	0.02%
	Em	Melaleuca			2.3	0.002%
	EtD	Seaside Mahoe Dominant			0.9	0.001%
HI		Human Impacted	1,582.5	1.6%	1,523.8	1.56%
	HIM	Human Impacted, Mound			58.7	0.06%
CA		Canal	44.2	0.05%		
RD		Road	16.7	0.02%		
ORV		ORV Trail	1.2	0.00%		
QUA		Quarry (including Borrow Pit)	115.3	0.1%		
SP		Spoil	146.9	0.2%		
LEV		Levee	0.9	0.00%		
NULL		Incomplete	8,370.6	8.6%		
		Total:	97,689.7			

Vegetation types from the 1940 aerials were generally mapped at level 2 and 3 using aerial photograph interpretation along with clues from dead wood data logged in both the field survey tracklog and miscellaneous points feature classes. A total of 67 vegetation types were recognized (Table 5).

This includes 10,662 acres (11%) NULL values which is greater than the 9% NULL in 2010 CERP vegetation types (Table 4) due to some areas not being discernible and current ground-truthing is limited to locating dead wood relics from past habitats. Also it is important to note that the accuracy and precision of these mapping units is much lower than the 2010 layers and often signatures may be interpreted as multiple vegetation types. In these cases the range of possible vegetation types were recorded in the comments field with the most likely (determined by expert opinion) a recorded in the Class_ID_1940 field.

Besides ground-truthing being limited to locating dead wood in some areas, the aerial photograph quality from the 1940s varies greatly and is limited to black and white. Some areas are simply out of focus while in other areas great detail is visible. In addition to quality, the geo-referencing is problematic. A great deal of effort was spent in finding additional control points to better geo-reference aerials while digitizing specific areas and these aerials were provided to RBNERR digitally.

The goal of including the 1940's vegetation types was to evaluate the trends and changes in habitat over time. This analysis is discussed in Section 3.3.

Table 5: 1940 CERP Vegetation Types Mapped in RBNERR

Class_ID_1940	Name	acres	% total
OW	Open Water	55,682.1	57.00%
MUD	Mud	1,644.1	1.68%
BCH	Beach	365.4	0.37%
DG	Graminoid Dune	66.6	0.07%
AM	Marine Aquatic Vegetation	0.2	0.0002%
AMS	Seagrass	668.1	0.68%
FM	Mangrove Forest	5,041.4	5.16%
FMa	Black Mangrove Forest	1,882.1	1.93%
FMc	Buttonwood Forest	7.6	0.01%
FMr	Red Mangrove Forest	5,462.0	5.59%
FMX	Mixed Mangrove Forest	2,476.2	2.53%
FSt	Cypress Forest	46.5	0.05%
FStD	Cypress Forest-Dome	1.8	0.002%
FHC	Coastal Hardwood Hammock	231.4	0.24%
FHa	Cabbage Palm Hammock	1.8	0.002%
FHT	Temperate Hardwood Hammock	0.2	0.0002%
FHM	Tropical Hardwood Shell Mound	98.0	0.10%
FHX	Xeric Hammock	2.4	0.00%

Class_ID_1940	Name	acres	% total
WM	Mangrove Woodland	1,497.5	1.53%
WMc	Buttonwood Woodland	468.3	0.48%
WMcSM	Buttonwood Woodland-Succulent, Mound	15.8	0.02%
WMa	Black Mangrove Woodland	1,229.4	1.26%
WMaG	Black Mangrove-Graminoid	119.8	0.12%
WMX	Mixed Mangrove Woodland	227.5	0.23%
WMXB	Mixed Mangrove Woodland in recent shell berm	58.7	0.06%
WSp	Pine Lowland	879.4	0.90%
WSt	Cypress Woodland	90.7	0.09%
WSs	Cabbage Palm Lowland	129.9	0.13%
WSh	Hardwood Swamp Woodland	27.3	0.03%
WUp	Pine Upland	604.6	0.62%
WUpSs	Pine Upland-Saw Palmetto	0.1	0.0001%
WUs	Cabbage Palm Upland	8.0	0.01%
WUh	Upland Woodland	400.7	0.41%
WUM	Upland Woodland, Mound	106.4	0.11%
WUqSs	Live Oak Woodland with Saw Palmetto	3.4	0.004%
WUCp	Scrubby Flatwoods	170.0	0.17%
SM	Mangrove Shrubland	78.5	0.08%
SMa	Black Mangrove Shrubland	82.7	0.08%
SMc	Buttonwood Shrubland	0.3	0.0003%
SMr	Red Mangrove Shrubland	335.3	0.34%
SMX	Mixed Mangrove Shrubland	5.6	0.01%
SS	Swamp Shrubland	0.4	0.0004%
SUs	Saw Palmetto Shrubland	0.3	0.0003%
CM	Mangrove Scrub	2,010.5	2.06%
CMG	Mangrove Scrub-Graminoid	209.6	0.21%
CMa	Black Mangrove Scrub	11.2	0.01%
CMc	Buttonwood Scrub	369.6	0.38%
CMcG	Buttonwood Scrub-Graminoid	0.3	0.0003%
CMr	Red Mangrove Scrub	50.0	0.05%
CMX	Mixed Mangrove Scrub	3.3	0.003%
CS	Swamp Scrub	19.6	0.02%
CUW	Upland Hardwood Scrub	2.1	0.002%
CUq	Xeric Oak Scrub	57.6	0.06%
MSG	Graminoid Salt Marsh	2,261.6	2.32%
MSGj	Black Rush	271.2	0.28%
MFB	Broadleaf Emergent Marsh	2.5	0.00%
MFG	Graminoid Freshwater Marsh	394.0	0.40%

Class_ID_1940	Name	acres	% total
MFGc	Sawgrass	329.1	0.34%
MFGe	Spikerush	501.8	0.51%
HI	Human Impacted	94.3	0.10%
CA	Canal	1.2	0.001%
ORV	ORV Trail	0.8	0.0009%
QUA	Quarry	0.1	0.0001%
RD	Road	54.4	0.06%
SP	Spoil	88.9	0.09%
HIM	Human Impacted, Mound	21.4	0.02%
SF	Barren Salt Flat	54.5	0.06%
NULL		10,661.8	10.91%
	Total:	97,689.7	

3.2 - Acres Infested by Invasive Exotic Plant Species

Total Cover of Invasive Exotic Species is presented in Figure 5. Not all invasive exotics have been mapped because ground-truthing data was not available from all areas and the budget for the project was insufficient to cover all areas. Underestimates are expected from the outer islands including Keywadin where less digital ground-truthing data existed and also in areas not yet mapped such as around Hog Key. It is hoped that RBNERR Staff will be able to add data to these layers based on personal knowledge and through additional ground-truthing. Also several areas have been treated since ground-truthing, therefore new fields for more recent cover values will have to be added to the geodatabase over time to reflect changes due to land management activities.

Roughly 3,183 (3.3%) acres are mapped as being infested by invasive exotic species, ranging from areas of low (<1%) cover to completely dominated by invasive exotics (>95%) (Table 6). A total of 21 species were mapped in the polygon map while the remainder of exotics observed, including smaller infestations, were stored in the exotics point feature class in the field geodatabase (section 2.3). These additional species were also listed in the comments fields in the polygon geodatabase, especially when many uncommon invasive exotic species were found in a polygon. A total of 43 species are recorded in the exotic_plant_pts feature class of the IRC_Master_GDB geodatabase for RBNERR (excluding TTINWR) thus far totaling 281 points (Table 7). Among these data the majority, 22 species and 240 points are FLEPPC category I species. Category II species include 9 species and 21 points. Other exotic species not listed by FLEPPC may or may not be invasive (causing harm to the native ecosystem) but are definitely naturalized within the boundaries of RBNERR and include 12 species and 20 points.

Table 6: Invasive Exotic Infested Acreage in Polygon Map Thus Far in RBNERR (excluding TTINWR)

Cover	<1% (>0)	1-5%	5-25%	25-50%	50-75%	75-95%	>95%	Total Infested acres
combined	626.9	892.2	1,139.4	166.0	199.2	129.2	29.9	3,182.8
Melaleuca quinquenervia	438.7	216.5	90.6	114.7	47.8	8.9		917.3
Schinus terebinthifolius	1,105.8	485.2	625.9	94.6	160.9	16.4		2,488.8
Acacia auriculiformis	12.6	69.7	488.5	11.7	5.9			588.4
Casuarina equisetifolia	21.1	27.2	6.4	6.7	14.4	17.8		93.6
Colubrina asiatica	0.3							0.3
Imperata cylindrica	4.9	0.8				0.01		5.7
Lygodium microphyllum	851.6	23.6	12.8					888.0
Melinis repens	0.0	8.4	0.8	1.3	2.9			13.5
Panicum maximum					0.8			0.8
Sporobolus indicus var. pyramidale	37.7	14.8	9.2	5.0	0.2			66.8
Syzygium cumini	13.8	68.8	1.2					83.7
Ardisia elliptica		1.1						1.1
Crotalaria palida var. obovata		1.2						1.2
Cynodon dactylon					5.1			5.1
Heteropogon contortus					0.8			0.8
Panicum repens			0.1		3.8	2.6		6.4
Rhodomyrtus tomentosus	14.1	8.8	45.3	15.2	1.5			84.8
Sansevieria hyacinthoides		0.2			1.2			1.4

Cover	<1% (>0)	1-5%	5-25%	25-50%	50-75%	75-95%	>95%	Total Infested acres
Senna pendula var. glabrata			0.9	5.7				6.6
Tecoma stans	0.8	2.1	0.8					3.8
Urena lobata	1.3	10.6						11.9

Table 7: Species of Exotic Plants Recorded Thus Far in Point Feature Class in RBNERR (excluding TTINWR)

TXCODE	Scientific Name	Common Names	FLEP PC	# of points
Abruprec	*Abrus precatorius*	Rosary-pea, Crab-eyes	I	1
Acacauri	*Acacia auriculiformis*	Earleaf acacia	I	29
Albilebb1	*Albizia lebbeck*	Woman's tongue, Rattlepod	I	2
Ardielli	*Ardisia elliptica*	Shoe-button ardisia	I	3
bothpert	*Bothriochloa pertusa*	Pitted bluestem, Pitted beardgrass		1
Casuequi	*Casuarina equisetifolia*	Australian-pine, Horsetail casuarina	I	11
coconuci	*Cocos nucifera*	Coconut palm	II	1
Coluasia	*Colubrina asiatica*	Latherleaf, Asian nakedwood	I	7
crotpallobov	*crotalaria pallida* var. *obovata*	Bladderpod		2
Cupaanac	*Cupaniopsis anacardioides*	Carrotwood	I	1
Cynodact	*Cynodon dactylon*	Bermuda grass		2
Deloregi	*Delonix regia*	Royal poinciana, Flamboyán		1
Eragatro	*Eragrostis atrovirens*	Thalia love grass		1
Eugeunif	*Eugenia uniflora*	Surinam-cherry	I	1
Euphtiru	*Euphorbia tirucalli*	Pencil-cactus, Pencil tree, Indian tree spurg		2
hetecont	*Heteropogon contortus*	Tanglehead		2
Hibitili	*Talipariti tiliaceum (=Hibiscus tiliaceus)*	Seaside mahoe, Sea hibiscus, mahoe	II	1
Impecyli	*Imperata cylindrica*	Congongrass, Cogongrass	I	14
Kaladaig	*Kalanchoe daigremontiana*	Devil's-backbone		2
Kalapinn	*Kalanchoe pinnata*	Common liveleaf, Cathedral	II	4

TXCODE	Scientific Name	Common Names	FLEP PC	# of point s
		bells, Life plant		
Lygomicr	*Lygodium microphyllum*	Small-leaf climbing fern	I	73
Melaquin	*Melaleuca quinquenervia*	Punktree	I	29
Nephmult	*Nephrolepis brownii (=multiflora)*	Asian sword fern	I	3
Panimaxi	*Panicum maximum*	Guineagrass	II	4
Panirepe	*Panicum repens*	Torpedo grass	I	16
Phraaust	*Phragmites australis*	Common reed (native nuisance species)		1
Pistsrta	*Pistia stratiotes*	Water-lettuce	I	1
Platbifu	*Platycerium bifurcatum*	Staghorn Fern		1
Rhodtome	*Rhodomyrtus tomentosa*	Downy myrtle, Rose myrtle	I	16
Rhynrepe	*Rhynchelytrum repens*	Rose Natalgrass	I	2
Sanshyac	*Sansevieria hyacinthoides*	Bowstring-hemp, Mother-in-laws tongue	II	2
Scheacti	*Schefflera actinophylla*	Australian umbrellatree	I	3
Schitere	*Schinus terebinthifolius*	Brazilian-pepper	I	6
Sennpendgla b	*Senna pendula* var. *glabrata*	Valamuerto	I	6
Sporindipyra	*Sporobolus indicus* var. *pyramidalis*	West Indian dropseed		2
Stensecu	*Stenotaphrum secundatum*	St. Augustine grass		3
Syzycumi	*Syzygium cumini*	Jambolan-plum, Java-plum	I	12
Termmuel	*Terminalia muelleri*	Mueller's tropical-almond	II	1
Thespopu	*Thespesia populnea*	Portiatree	I	1
Urenloba	*Urena lobata*	Caesarweed	II	2
Urocmuti	*Urochloa mutica*	Paragrass	I	3
Washrobu	*Washingtonia robusta*	Desert palm, Washington fan palm	II	1
Wedetril	*Wedelia trilobata*	Creeping wedelia, Creeping oxeye	II	5
		FLEPPC I:	22	240
		FLEPPC II:	9	21
		Other:	12	20
		TOTAL:	43	281

The “siteunit” field was initially populated using a shapefile provided by RBNERR staff for only prescribed fire burn units. However, these designations often followed habitat lines such as mangrove to marsh or upland eco-tone lines which were edited while digitizing polygons. Many of these burn units may require further editing by RBNERR staff to better reflect current management objectives. Furthermore, much of the "siteunit" field remains as NULL so there is great potential to utilize this field to assist with management activities elsewhere in the Reserve.

Summary tables can then be easily generated by management unit using the siteunit field such as the summary of acreage covered by *Melaleuca* below (Table 8). *Melaleuca* is one of the most important of the invasive exotics in RBNERR, covering 917 acres (mapped so far), second only in extent and percent cover to Brazilian pepper which covers 2,489 acres (Table 6). *Lygodium* covers 888 acres overall but most is low in cover (Table 6). Burn units 7 (North Sector), 1 and 2 (Lely East and West), 7 (North Sector), 8 (Trash Road), 12 (Martin Parcel), 14 (Martin South), and 16 (Malt East) are the management units mapped with the greatest infestations of *Melaleuca* thus far. However, it is important to note that several of these areas have been treated for exotics since the time these areas were ground-truthed.

Table 8: Acreage of *Melaleuca* Mapped by Site Unit in RBNERR (excluding TTINWR)

SITEUNIT	0	<1%	1-5%	5-25%	25-50%	50-75%	75-95%	Total Acres (>0)
1 - Lely East	76.3	37.5	47.2	1.7	1.4	0.3	0.6	88.7
2 - Lely West	134.0	12.6	17.7	7.8	13.8	26.3	4.5	82.7
4 - Bathey West	140.8	0.5	3.2	0.7	0.1			4.4
5 - Bathey East	113.8	12.1	0.2		0.6			12.8
6 - Bathey South	266.7							0.0
7 - North Sector	128.3	249.7	68.0	33.7	21.9			373.3
8 - Trash Road	113.5	64.6	2.2					66.8
9 - PLR West	1,322.2	21.4	15.8					37.2
10 - Eagle Creek	41.7							0.0
11 - Fleisher Parcel	20.0							0.0
12 - Martin Parcel	58.1		11.0	1.1	4.0	3.0		19.2
13 - Pie Wedge	38.5	0.6	1.3	5.7				7.6
14 - Martin South	4.0	8.0	15.9	35.8	64.6	3.3		127.5
16 - Malt East	116.9	12.4	18.3	0.8	4.9	7.6	2.9	46.9
17 - SIR across Brigg	74.0			0.2				0.2
18a - North Briggs	11.8							0.0
18b - North Briggs Middle	17.0	0.8	0.5					1.3
18c - Briggs Northeast	13.0							0.0
19a - SS Briggs	20.8							0.0
19b - South Briggs	3.1							0.0
20 - Rosemary	145.0							0.0

SITEUNIT	0	<1%	1-5%	5-25%	25-50%	50-75%	75-95%	Total Acres (>0)
Lane								
21 - SIR east Briggs	35.6							0.0
22 - Bulger Hammock	2.6							0.0
23a - Snook Pond	10.6		0.7					0.7
23b - SIR Shell Mound	8.3							0.0
26 - Hall Bay	20.3							0.0
30 - Briggs Boardwalk	5.6							0.0
NULL Site unit	74,941.8	18.6	14.5	3.0	3.5	7.4	1.0	48.0
Total:	77,884.5	438.7	216.5	90.6	114.7	47.8	8.9	917.3

Mapping vegetation types and exotics together is at the core of the survey methods. In the data summaries done for TTINWR, habitats were listed by total percent infested and showed certain habitat types, such as buttonwood woodland (WMc), being nearly always infested by exotics like by Brazilian pepper (Barry 2009). This same pattern was observed in RBNERR boundaries excluding TTINWR. However, the total acreage of pine lowlands (WSp) and disturbed lands (HI) is much greater within RBNERR boundaries (471 and 1524 acres respectively) than in TTINWR (3 and 31 acres respectively). This difference, along with closer proximity to the city of Naples and a general greater urban interface, has led to overall greater exotic infestation. When additional exotics cover data are collected and entered, queries similar to those presented for TTINWR (Barry 2009) may shed more light on patterns of infestation; however, at this time it would be considered premature since more work remains to be done with respect to exotics cover data.

Even with incomplete exotics cover data, we can see some interesting patterns on the Reserve. Areas in RBNERR (excluding TTINWR) nearly dominated by invasive exotics (cover > 75%) were filtered out of the polygon map and ordered by acreage below, excluding <1 acre areas (Table 9). This table shows the obvious positive relationship with disturbance and exotics as the highest acreage of heavy infestation (Table 9) occurs in human impacted (HI) areas which represents only 1.6% of the total acreage (Table 4). It also reiterates the negative relationship with exotics and tidal influence as all except the buttonwood woodland (WMc) habitat, which is dominated by invasive exotics, are above tidal influence (i.e. not influenced by saltwater which limits the number of species with potential to invade an area). Areas mapped as Australian Pine Dominant (EcD), largely refer to areas of Cannon Island which were open water in 1940 but arose above tidal influence from sedimentation in part from long shore drift and thus do not have a specific habitat type.

Table 9: Total Acreage by Vegetation Type with Total Exotics Cover >75% (>1 acre)

Class_ID_LEVEL3	Name	acres
HI	Human Impacted	76.9
WSp	Pine Lowland	27.4
EcD	Australian Pine Dominant	14.8
WSs	Cabbage Palm Lowland	10.8
WUp	Pine Upland	10.6
WSt	Cypress Woodland	5.7
WMc	Buttonwood Woodland	3.4
WUh	Upland Woodland	2.6
MFG	Graminoid Freshwater Marsh	2.6
CA	Canal	1.2

3.3 - Vegetation Changes since 1940

One of the goals of mapping vegetation types from the 1940 aerials is to be able to examine areas which appear to have changed since 1940 and look for trends. Great care must be taken not to overanalyze these data because of the many problems encountered while digitizing and determining vegetation type from the 1940 aerial photographs (see Section 3.1). To limit the potential for misleading results, we have included only polygons that have been at least partially ground-truthed. These analyses should be considered a start and as more ground-truthing data is collected or more time is spent tightening up geo-referencing of the 1940 aerial photographs, analysis can be repeated with additional confidence in any trends identified.

Rather than simply comparing acreage totals from 1940 to 2010, it is more valuable to group polygons with similar types of change (i.e. marsh to mangrove, hydric pine to buttonwood). Also, because the precision in mapping in 1940 is much lower than 2010, lower levels of the hierarchical classification system were utilized, ranging from level 2 to 4, depending on the ability to recognize the signatures. Finally, height is less important than species, therefore some shrubland (S) and forested (F) polygons, especially those with buttonwood dominated vegetation types, were lumped for analysis. This is the same way the changes were analyzed for TTINWR (Barry 2009).

The grouped vegetation type changes, ordered by total acreage (i.e. relative importance), are listed below (Table 10). Only ground-truthed polygons which actually changed were included. Moreover, any areas mapped as human-impacted (HI, RD, ORV, CA, etc.) were excluded from analysis, as were any polygons containing NULL values for either 1940 or 2010. Data for RBNERR and TTINWR were pooled for analysis to increase the size of the data set, resulting in a total of 3,857 acres of polygons which actually changed. This is roughly 17% of the 23,293 total acres considered ground-truthed within the combined boundaries of TTINWR and RBNERR.

As with earlier analysis of TTINWR alone (Barry 2009), this overall analysis reveals the marsh vegetation types have changed most substantially and overwhelmingly towards mangrove dominated communities. Although the greatest change is the 837 acres which changed from marsh to scrub mangrove, it should be noted that many scrub mangrove areas (CM) still function as marsh (see discussion in Section 3.1). The more important group changes are from marsh to shrub mangrove (SM) and forest mangrove (FM) totaling 592 acres, especially because these signatures are more distinctly different in the 1940 aerial photography thus increasing confidence in classification. An additional 257 acres changed from mangrove woodland (WM) to mangrove forest (FM) and this undoubtedly includes acreage which was mangrove woodland dominated by graminoid thus functioning as marsh habitat in 1940. The same goes for the 116 acres which changed from scrub mangrove (CM) to mangrove shrubland (SM) and the 47 acres of scrub mangrove (CM) to mangrove forest (FM). When these distinct changes are totaled they comprise 760 acres or 3.3% of the total ground-truthed acreage. The probable causes of this dramatic change include rising sea level and a reduced freshwater flow from upstream , (Doyle and Krauss 2006, Krauss et al. 2011, Foster and Smith 2001).

Changes from buttonwood to mangrove were evident in many locations while ground-truthing because of the high density of, , old trunks and snags of buttonwood that are slow to decompose and remain in current mangrove dominated communities. This includes 55 locations recorded by GPS into the miscellaneous point feature class and many other records in the field survey tracklog. When buttonwood dominated communities (CMc, WMc, SMc, FMc), that changed to mangrove dominated communities (CM, WM, SM, FM), are combined they total 245 acres or 1% of the total ground-truthed acreage. In contrast, areas mapped as marsh or mangrove scrub (CM) or woodland (WM) communities in 1940 and buttonwood dominated communities in 2010, roughly 442 acres, may be less a reflection of real change and more an indication of the inability to distinguish buttonwood using 1940 aerial photograph interpretation. As a result of this lack of confidence in 1940 signature interpretation, most of these polygons were only identified only to level 2 which lumps buttonwood and mangroves. As for the marsh areas evident on the 1940 aerials, many are not in focus enough to identify presence of scattered shrub mangrove or buttonwood and these changes may sometimes be simple error and other times may in fact be a change.

Changes from cabbage palm or slash pine woodlands (WSs and WSp) to buttonwood (WMc/CMc, FMc/SMc) and to lesser extent mangrove dominated communities (WM, CM, SM) were also observed. We documented the change in the field from 43 points for dead cabbage palm with no regeneration and 70 points for dead slash pine with no regeneration in the miscellaneous points feature class. This change totals 145 acres or 0.6% of the total ground-truthed acreage. Additionally 79 acres of pineland (WSp/WUp) changed to cabbage palm woodland (WSs) which likely includes some temporary changes due to fire, but many areas appeared to be permanently changed with no sign of slash pine recruitment likely due to increases in salinity. In general, this shift to buttonwood in these community types will cause the greatest loss of biodiversity. Although many factors may be contributing to these observed changes, similar die-offs of cabbage palm and slash pine have been observed elsewhere in the state and linked to rising sea levels (Williams et al. 1999, Ross et al. 2008).

Other changes mapped for pine habitats (WUp) include 31 acres converting to live oak woodland (WUq) and 9.7 acres to hammock (FH) which most likely resulted from fire regime and not hydrology or salinities due to higher elevation. Those factors could also be indirectly reducing fire frequencies in surrounding habitats (i.e. mangrove encroachment) which would also act to reduce fire frequency in the overall area.

One observed change was restricted to within RBNERR boundaries along the inland areas mostly north of Henderson Creek. Areas of pine and palm recruitment were observed occurring in former freshwater wetland edges totaling 37 acres or 0.2% of the total ground-truthed acreage. These areas appear have been influenced by drainage or hydrological alteration upstream. This type of change has been described upstream in the Picayune Strand State Forest where hydroperiods were greatly reduced by construction of drainage canals (Burch et al. 1998, USACOE 2004, Barry and Woodmansee 2006).

Another important change is black mangrove dominated communities (CMa, WMa, SMa, FMa) to mud or open water. Including areas of partial die-off (i.e. FMa/SMa to WMa/CMa), this change totals 32 acres (<1% of the total ground-truthed acreage). Although these alterations may simply be recurring natural changes (Smith et al. 2003), these changes are quite visible even without-ground truthing and warrant more investigation as to the cause as discussed in the TTINWR report (Barry 2009). One of the possible causes, understanding that each die-off area may have multiple contributing factors, is rising sea level as black mangroves are considered less tolerant to changes in sea level (Snedaker 1995). Since that report, Jill Schmid of RBNERR (personal communication) confirmed that the elevations of the die-off areas were lower than the surrounding mangrove forest areas which were determined by using LiDAR data. Although subsidence would be expected after die off such as in the mud areas of the marshes (Krauss et al. 2011), elevation at the centers of living and stunted black mangrove areas are also lower than the surrounded taller black mangroves judging by water levels in the field (M. J. Barry, personal observation). Whether or not the cause is an increase in the duration of flooding due to sea level rise or some other factors such as changed salinities from freshwater drainage upstream or blocking of tidal flushes, the end result seems to be the same. The oldest of these areas, which were forested in 1940, are now open water habitat, while most of the more recent mud areas do not seem to be recovering quickly though there are a few exceptions. Other former black mangrove dominated areas in Everglades National Park have also had a succession to open water habitats (Keith Bradley, personal communication).

Table 10: Summary of Changes Since 1940 Mapped in RBNERR and TTINWR Combined (Ground Truthed Polygons Only, HI and NULL values excluded)

acres	1940	Present
836.6	Marsh	CM
296.4	Marsh	SM
295.5	Marsh	FM
286.1	Marsh	WMc/CMc
256.9	WM	FM
224.6	CM	WM
194.4	Marsh	WM
151.1	CM	WMc/CMc

acres	1940	Present
115.7	CM	SM
114.9	WMc/CMc	CM
104.1	WSp/WUp	WMc/CMc
78.7	WSp/WUp	WSs
68.0	SM	FM
58.5	WMc/CMc	WM
48.3	OW	SM
46.8	BCH	OW
46.7	CM	FM
37.6	Marsh	OW
34.4	WMc/CMc	FM
32.7	OW	FM
31.7	WMc/CMc	FMc/SMc
30.6	WSp/WUp	Wuq
28.7	WSs	WMc/CMc
26.4	FM	OW
23.8	Marsh	Cma
22.5	FMa/SMa	OW
22.3	FM	WM
20.6	WMc/CMc	SM
15.7	OW	BCH
14.8	FM	FMa/SMa
13.1	Marsh	WSp/WUp
10.9	WSt/FSt	WSp/WUp
10.6	Mound	FM
10.4	FM	BCH
10.3	Marsh	WSs
9.7	WSp/WUp	FH
9.6	FMa/SMa	WM
9.0	WMc/CMc	FMa/SMa
8.9	OW	CM
8.6	Berm_old	OW
8.2	CM	Cma
7.5	Berm_new	OW
6.2	FM	DG
6.0	WSs	FH
5.4	Cma	WM
5.1	FM	SM
4.9	Marsh	FMa/SMa
4.8	Berm_old	WMc/CMc

acres	1940	Present
4.7	Berm_new	DG
4.7	BCH	Wus
4.6	WSp/WUp	SS
4.4	FMa/SMa	FM
4.3	Marsh	SS
4.2	WSp/WUp	FMc/SMc
4.1	Marsh	FMc/SMc
4.0	FM	WMc/CMc
3.8	FMc/SMc	FM
3.8	WM	Berm_new
3.3	WM	OW
3.3	FM	Wus
3.0	Berm_old	FH
2.9	FM	Berm_new
2.9	WUCp/Cuq	WSs
2.9	WSt/FSt	WSs
2.9	Berm_old	BCH
2.7	WSp/WUp	SUs
2.6	SF	WM
2.5	Marsh	WSh
2.4	BCH	DG
2.3	OW	DG
2.3	WMc/CMc	Cma
2.3	CM	OW
2.2	OW	Wus
2.1	SM	WM
2.1	OW	WMc/CMc
2.0	WSs	Marsh
2.0	OW	WM
1.8	FM	Berm_old
1.8	WSp/WUp	SM
1.7	BCH	CUW
1.7	WMc/CMc	Marsh
1.6	WUCp/Cuq	Wuq
1.5	WSp/WUp	CM
1.5	Marsh	FH
1.5	WSp/WUp	FM
1.4	Berm_new	FM
1.4	WM	Cma
1.4	WSp/WUp	Marsh

acres	1940	Present
1.4	DG	Berm_old
1.3	WM	BCH
1.3	WMc/CMc	SF
1.3	Mound	FMc/SMc
1.2	WSp/WUp	Wus
1.1	WSs	FM
1.0	OW	Berm_new
1.0	WSs	WSh
1.0	SM	Berm_new
0.9	BCH	WMc/CMc
0.9	WM	E
0.9	FMc/SMc	SM
0.8	WSp/WUp	WSh
0.8	Berm_old	Berm_new
0.8	Berm_new	BCH
0.7	WMc/CMc	E
0.7	WM	SM
0.7	OW	CUW
0.6	WSt/FSt	SS
0.6	WM	WMc/CMc
0.6	WMc/CMc	Mound
0.6	WM	DG
0.6	BCH	WM
0.6	WSs	CM
0.6	WSs	SM
0.6	WM	CM
0.6	FMa/SMa	Berm_new
0.6	WSs	FMc/SMc
0.5	SF	CM
0.5	WMc/CMc	WSp/WUp
0.5	WM	CUW
0.5	SF	Cma
0.5	OW	Marsh
0.5	WSs	SF
0.4	WUCp/Cuq	FH
0.4	WM	FMa/SMa
0.4	WM	Berm_old
0.4	Marsh	E
0.4	CM	BCH
0.4	FM	CUW

acres	1940	Present
0.3	WMc/CMc	Berm_old
0.3	Mound	Berm_old
0.3	WSh	FS
0.3	WM	SF
0.3	Berm_old	FM
0.3	SUs	Wuq
0.3	SF	SM
0.2	SF	FM
0.2	WSp/WUp	WM
0.2	Mound	FMa/SMa
0.2	WM	Marsh
0.2	Berm_old	WM
0.2	WSs	WM
0.2	WM	WSp/WUp
0.2	WSs	SS
0.2	WMc/CMc	OW
0.1	OW	Berm_old
0.1	WSs	FS
0.1	FMc/SMc	FMa/SMa
0.1	CM	Marsh
0.1	WSp/WUp	SUC
0.1	SM	OW
0.1	WMc/CMc	BCH
0.1	OW	Cma
0.1	Berm_old	DG
0.1	Mound	WMc/CMc
0.1	OW	MSS
0.1	BCH	Berm_new
0.04	SS	SM
0.03	Berm_old	SF
0.02	SF	OW
0.01	Berm_old	WSs
0.004	WMc/CMc	WSh
3857.3		

Many of the other changes shown in Table 10 are better explained when separated out by general location relative to distance from the Gulf of Mexico. In a previous report (Barry 2009). Both RBNERR and TTINWR were divided into four vegetation zones based on general elevation and position in the landscape and by influences of ecological variables (Figure 5). These zones were proposed for analysis in order to independently assess the influences of hydrological alteration, fire suppression, freezes, storm erosion and sedimentation, and sea level rise. Zone 1 includes all the interior mainland uplands and freshwater wetlands, and areas which were marsh, scrub, or woodland in 1940 and could have been influenced by fire at that time. This zone includes areas that would have been most influenced by hydrological alteration, freeze events, alteration in fire regime, as well as sea level rise in lower elevation areas. Zone 2 was based on areas that were part of large expanses of mangrove forest in 1940 that would not have been influenced by fire, and perhaps not by freezes, but still may be strongly influenced by hydrological alteration upstream and sea level rise. Zone 3 encompasses the back bays and middle islands. This zone would be influenced by sea level rise, hydrological alteration upstream and storm events. Zone 4 refers to the outer islands which are prone to erosion from storm events. Though this was not separated out for the purpose of this report, the outer islands could be further separated to evaluate from the tip of Cape Romano northward due to the influence of long shore drift along these beaches.

The vegetative changes by zone discussed above are presented below (Appendix IV) and exhibit the same trends discussed in the report for TTINWR (Barry 2009). The most important observation from this table is the variety of shifts observed on the outer islands which are affected by both storm erosion and long shore drift. Reduction in non-tidal uplands in the outer islands (Zone 4) of TTINWR due to erosion may in fact be caused by an increase in the rate of sea level rise over time (Wanless and Parkinson 1989, Vlaswinkel et al. 2003). Furthermore, the observation of expanding red mangrove dominated areas in Zone 3 in TTINWR was also observed in RBNERR and may be caused by the soil building phenomena associated with these mangroves (Parkinson 1989, Wanless and Parkinson 1989, McKee et al. 2007). Most of the important trends of non-mangrove species die-off discussed above refer to the inland extent of mangroves (Zone 1) but were also observed to some degree in the other zones, especially in the middle islands (Zone 3).

3.4 - Analysis of Elevation by Vegetation Type using LiDAR

The combination of elevation and vegetation data provides many opportunities to increase our understanding of the general coastal ecology and we have barely begun to scratch the surface in terms of the potential uses of LiDAR. Using ESRI software, Josh O'Connor of USFWS, performed a spatial join between the ground-truthed polygons within both RBNERR and TTINWR boundaries and processed LiDAR (2007) data from the South Florida Water Management District. The resulting data set is provided in Appendix V. The mean elevation (feet), Standard Deviation, maximum and minimum values, and range were listed for each ground-truthed vegetation type polygon along with a count of rasters included in the analysis. A 10-foot raster data was utilized for the analysis.

Initial examination of these data (Appendix V) suggests that upland (WU, FH, CU, SU) and lowland pine and palm woodland communities (WSs, WSp) do indeed occur at higher elevations than mangrove and buttonwood dominated communities (CM, SM, WM, FM). However the buttonwood and mangrove dominated communities show greater variation in mean, maximum, minimum and standard deviation values making it difficult to discern elevation effects. These phenomena appear more clear cut when in the field and the variability in the data may be too great to statistically ascertain a difference. Indeed the buttonwood were observed on higher areas than mangroves based on water levels in the field but the variability in elevation is high in these areas. Additionally, LiDAR could be recording vegetative debris such as tree trunks, branches and up-rooted bases of dead mangroves which are then recorded erroneously as higher ground on the processed LiDAR data. In many cases it appears to be erroneous based on field ground-truthing, however in some cases such as larger areas of mixed mangrove forest (FMX) it seems that the building of organic soils may indeed have created higher zones as sea level has risen over the long term (McKee et al. 2007). In contrast, most of the buttonwood dominated areas (with exception of buttonwood scrub in marsh areas or woodland with leather fern) do not have as much build up of organic soils, thus making the elevations similar to each other. This makes ground-truthing of high spots showing up on the LiDAR important to determine if areas are actually high ground. An extreme example of this type of error is a hardwood swamp found just west of the Treviso Bay development where the LiDAR shows many high spots when in actuality most of the area is flooded swamp. The majority of the high spots are hummocks, debris, and a thick fern understory layer in a general low elevation swamp and it appears that the processed LiDAR data has overestimated general elevation. Just to complicate things, it is not completely inacurate As there was a small rise in the middle of the LiDAR clutter made the ground-truthing data collected extremely valuable to mapping.

A cursory attempt was made to apply this elevation mapping to current and potential shifts in ecotones with sea level rise. These data were then grouped by similar vegetative communities generally to level 2 or 3, with a goal of showing important ecotones, especially those associated with mangrove to non-mangrove areas (Table 11). Although these results are perhaps oversimplified, the goal was to estimate elevation limits for these important ecotones and to be able to make some general, coarse estimates of changes based on projected rise in sea level. This is not taking into consideration any hydrological influence or salinities, but rather is a general look at the possible changes which may continue to occur based solely on elevation.

Table 11: Mean Elevation by Combined Vegetation Types using LiDAR 2007 data

	minus SD (ft.)	plus SD (ft.)	Mean (ft.)
Xeric Oak Habitats (WUCp, CUq)	3.494	7.455	5.474
Combined Mound (FHM, WUM)	2.594	8.156	5.375
Combined Uplands (WU, FH, CU, SU)	2.200	3.766	2.983
Hydric Pine and Sabal (WSp, WSs, FHa)	1.411	2.673	2.042
Mean Freshwater Wetland (including marsh and forested wetlands)	0.886	1.898	1.392
all buttonwood vegetation types (except shell berm):	0.920	1.882	1.399
Only Buttonwood dominated:	1.106	2.214	1.660

all mangrove vegetation types combined (except shell berm)	0.911	1.809	1.360
mixed mangrove scrub (CMX)	0.832	1.814	1.323
All Mixed Mangrove scrub w/ succulents (CMXS) Vegetation Types combined	1.332	1.890	1.611
All Mixed Mangrove Scrub – marsh (CMXG)	0.747	1.532	1.139
Mixed Mangroves (WM, FM, CM, SM) combined	1.002	2.032	1.517
mangroves and leather fern (WM w/Ba)	0.937	2.326	1.632

To produce a map of these ranges in elevation, 6 categories were defined for the purpose of viewing the LiDAR data by elevation ranges. Initially the combined groups listed in Table 11 were utilized with the standard error ranges to come up with the categories. Then the categories were re-examined manually for accuracy primarily on the ground-truthed areas of RBNERR and adjusted to follow known ecotone areas. The resulting categories utilized for the generation of ecotone maps included <0 mostly referring to open water areas, 0-1.1 feet consisting of mangroves, 1.1-1.85 feet including a mix of areas of both mangroves and buttonwood, 1.85-2.67 feet including areas of cabbage palm and slash pine lowlands, 2.67-3.49 feet including uplands, and areas above 3.94 feet including high areas of shell mound and much of the scrubby flatwoods and xeric hammock habitats.

In general, these elevations seemed to match mapped polygons quite well in the northern and inland areas of RBNERR, especially for upland categories. However, all of these categories should be considered a preliminary result with much more analysis necessary to understand relationships of elevation to vegetation type. In fact in Cape Romano and some of the outer islands the edge of the uplands (transition from buttonwood) appears to be higher than the inland areas more closely analyzed. Although one cannot rule out errors in processing LiDAR, it may also simply be a result of more frequent impacts from storm high tide events favoring buttonwood over non-mangrove species. Inland areas are assumed to be more protected from tidal surges because of the expanse of mangrove swamps between uplands and open water.

Maps showing current conditions using these categories are presented in Figures 7 and 8. Because of the issues discussed above with the LiDAR data within ground-truthed areas of mangrove dominated areas, the existing mapped extent of mangroves is overlain to cover the LiDAR and to highlight the actual ecotone areas. Also note that some of the light red areas (1.85 to 2.67 feet) are actually dominated by buttonwood at Cape Romano and other outer island locations, differing from the inland areas of pine and palm (discussed above).

Sea level has risen 15-23 cm since 1940 (Maul and Martin 1993, Ross et al. 2008, Krauss 2011). IPPC (2007) reported a projected rise from 18 to 59 cm by 2100 due to human caused climate change. This was considered to be an underestimate due to great uncertainty relating to Greenland and Antarctic ice modeling as discussed in evaluation of possible ecological effects of climate change on Everglades National Park (Pearlstine et al. 2009). More recent estimates include projected rise by 2100 ranging from 74 to 190 cm (Vermeer and Rhamstorf 2009). Hansen and Sato (2011) suggested that data from satellites measuring recent rates of melting of ice especially in Greenland imply "the possibility of multi-meter sea level rise this century". Finally, in 2012 record melting was observed in Greenland surprising even Hansen himself further supporting these high-end estimates (http://science.nasa.gov/science-news/science-at-nasa/2012/24jul_greenland/, http://www.wunderground.com/blog/JeffMasters/archive.html?year=2012&month=07).

Therefore, to very roughly portray RBNERR vegetation with potential climate change scenarios, maps showing the same categories with an added 25 cm and 2 m of sea level rise are presented in Figures 9-12. The 25 cm rise (Figures 9 and 10) is assumed to occur towards the end of this century using the older projections (IPCC 2007) or could be as soon as the next several decades (Hansen and Sato 2011). The 2 m rise scenario (Figures 11 and 12) would be over a much longer term (earliest likelihood being around the end of the century).

In the maps (Figures 7 and 8), estimating vegetation extents with a 25 cm rise in sea level, the most notable changes are in the existing inland pine and palm lowlands (WSp, WSs) and marsh areas (MSG, CMG). It is likely that much of this acreage would be converted to buttonwood or mangrove dominated communities. With a 25 cm rise it is unknown what would happen to the existing mangrove areas because it would likely depend on effects of hydrological restoration upstream, the rate of sea level rise, the rate of soil building and the dominant species of mangroves in each specific area (Parkinson 1989, Wanless and Parkinson 1989, Snedaker 1995, McKee et al. 2007, Krauss 2011). Areas of uplands would however shrink, likely causing a great deal of biodiversity loss from the reserve even if mangrove acreage is maintained. These maps are presented to highlight areas which should be monitored closely in upcoming years. Furthermore, these areas should be closely examined for rare species which might benefit from human assistance if changes are rapid.

With a 2 m rise (Figures 9 and 10) upland areas would be reduced to only the highest areas including most importantly Sandhill, small areas currently dominated by scrubby flatwoods along Shell Island Road, and some of the higher portions of the mounds including Dismal and Fakahatchee Keys. Mangroves would encroach much further inland than current Reserve boundaries. Again mangrove extent would depend on many variables though open water coverage is likely where current mangroves exist. This map is provided mostly to illustrate where possible biodiversity refugia might exist over the long term thus giving these area greater importance for protection under current management regimes.

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APENDICES

Appendix I: CERP Vegetation Types (Full Detail) in polygon map of RBNERR

Class_ID	Name	acres	percent	FNAI_NC
FM	Mangrove Forest	1,294.11	1.32%	Tidal swamp
FMa	Black Mangrove Forest	3,038.71	3.11%	Tidal swamp
FMc	Buttonwood Forest	23.07	0.02%	Tidal swamp
FMl	White Mangrove Forest	35.75	0.04%	Tidal swamp
FMr	Red Mangrove Forest	6,682.62	6.84%	Tidal swamp
FMrB	Red Mangrove Forest in recent shell berm	2.77	0.0028%	Coastal berm
FMX	Mixed Mangrove Forest	2,273.54	2.33%	Tidal swamp
WMXG	Mixed Mangrove Woodland-Graminoid	0.43	0.0004%	Tidal marsh
FMXac	Black Mangrove-Buttonwood Forest	1.09	0.0011%	Tidal swamp
FMXB	Mixed Mangrove Forest in recent shell berm	11.07	0.01%	Coastal berm
FMXal	Black Mangrove-White Mangrove Forest	15.51	0.02%	Tidal swamp
FMXar	Black Mangrove-Red Mangrove Forest	4,867.18	4.98%	Tidal swamp
FMXcl	Buttonwood-White Mangrove Forest	16.76	0.02%	Tidal swamp
FMXcr	Buttonwood-Red Mangrove Forest	55.30	0.06%	Tidal swamp
FMXlr	White Mangrove-Red Mangrove Forest	245.30	0.25%	Tidal swamp
FSH	Hardwood Swamp Forest	1.12	0.0011%	Basin swamp
FSt	Cypress Forest	29.63	0.03%	Basin swamp
FStD	Cypress Forest-Dome	1.79	0.0018%	Dome swamp
FStH	Cypress-Hardwood Forest	1.07	0.0011%	Strand swamp
FStp	Cypress-Pine Forest	54.26	0.06%	Basin swamp
FHC	Coastal Hardwood Hammock	346.51	0.35%	Coastal berm
FHa	Cabbage Palm Hammock	12.06	0.01%	Hydric hammock
FHS	Tropical Hardwood Hammock	0.40	0.0004%	Prairie hammock
FHT	Temperate Hardwood Hammock	11.26	0.01%	Prairie hammock
FHM	Tropical Hardwood Shell Mound	101.95	0.10%	Shell mound
FHX	Xeric Hammock	5.89	0.01%	Xeric hammock
WM	Mangrove Woodland	8.02	0.01%	Tidal swamp
WMc	Buttonwood Woodland	380.33	0.39%	Tidal swamp
WMcG	Buttonwood Woodland-Graminoid	232.85	0.24%	Tidal marsh
WMcS	Buttonwood Woodland-Succulent	27.47	0.03%	Tidal marsh
WMcSM	Buttonwood Woodland-Succulent, Mound	10.71	0.01%	Shell Mound
WMcB	Buttonwood Woodland-Broadleaf	0.31	0.0003%	Tidal marsh
WMcBa	Buttonwood Woodland-Leather Fern	305.52	0.31%	Tidal marsh
WMcSMl	Buttonwood Woodland w/shrub white	13.96	0.01%	Tidal swamp

Class_ID	Name	acres	percent	FNAI_NC
	mangrove			
WMcSMr	Buttonwood Woodland w/shrub red mangrove	3.65	0.00%	Tidal swamp
WMcSMX	Buttonwood Woodland w/ mixed shrub mangrove	16.32	0.02%	Tidal swamp
WMcH	Buttonwood Woodland w/hardwoods	2.05	0.00%	Tidal swamp
WMa	Black Mangrove Woodland	776.05	0.79%	Tidal swamp
WMaG	Black Mangrove-Graminoid	72.70	0.07%	Tidal marsh
WMaS	Black Mangrove Woodland-Succulent	141.93	0.15%	Tidal marsh
WMaB	Black Mangrove Woodland in recent shell berm	1.14	0.00%	Coastal berm
WMaSMl	Black Mangrove Woodland w/shrub white mangrove	93.55	0.10%	Tidal swamp
WMaSMr	Black Mangrove Woodland w/shrub red mangrove	758.67	0.78%	Tidal swamp
WMaSMX	Black Mangrove Woodland w/ mixed shrub mangrove	1,864.71	1.91%	Tidal swamp
WMl	White Mangrove Woodland	0.14	0.0001%	Tidal swamp
WMlSb	White Mangrove Woodland-Batis	0.70	0.0007%	Tidal marsh
WMlBa	White Mangrove Woodland-Leather Fern	40.81	0.04%	Tidal marsh
WMlB	White Mangrove Woodland in recent shell berm	0.46	0.0005%	Coastal berm
WMlSMr	White Mangrove Woodland w/shrub red mangrove	0.28	0.0003%	Tidal swamp
WMX	Mixed Mangrove Woodland	29.19	0.03%	Tidal swamp
WMXalSb	Mixed Black and White Mangrove Woodland-Batis	1.70	0.0017%	Tidal marsh
WMXB	Mixed Mangrove Woodland in recent shell berm	25.81	0.03%	Coastal berm
WMXalSM Xlr	Mixed Black and White Mangrove Woodland with Mixed White and Red Mangrove Shrubland	14.97	0.02%	Tidal swamp
WMXacBa	Mixed Mangrove Woodland Conoerec, Avicgerm and Leather Fern	23.34	0.02%	Tidal swamp
WMXacS MX	Mixed Mangrove Woodland Conoerec, Avicgerm and Mixed Mangrove Shrubland	33.51	0.03%	Tidal swamp
WMXBa	Mixed Mangrove Woodland-Leather Fern	12.95	0.01%	Tidal marsh
WMXclBa	Mixed Buttonwood and White Mangrove Woodland-Leather Fern	27.16	0.03%	Tidal marsh
WMXG	Mixed Mangrove Woodland-Graminoid	0.84	0.0009%	Tidal marsh
WMXalSb	Mixed Black and White Mangrove Woodland-Batis	0.07	0.0001%	Tidal marsh

Class_ID	Name	acres	percent	FNAI_NC
WMXalBa	Mixed Black and White Mangrove Woodland-Leather Fern	18.80	0.02%	Tidal marsh
WS	Swamp Woodland	2.64	0.0027%	Basin swamp
WSp	Pine Lowland	0.00	0.0000%	Wet flatwoods
WSpG	Pine Lowland-Graminoid	67.29	0.07%	Wet flatwoods
WSpS	Pine Lowland-Shrub	150.87	0.15%	Wet flatwoods
WSpX	Pine Lowland-Mixed	252.88	0.26%	Wet flatwoods
WSt	Cypress Woodland	22.42	0.02%	Basin swamp
WStG	Cypress Woodland-Graminoid	1.64	0.0017%	Basin swamp
WSs	Cabbage Palm Lowland	1.83	0.0019%	Hydric hammock
WSsG	Cabbage Palm Lowland-Graminoid	19.02	0.02%	Hydric hammock
WSsGc	Cabbage Palm Lowland-Sawgrass	10.18	0.01%	Hydric hammock
WSsS	Cabbage Palm Lowland-Shrub	63.86	0.07%	Hydric hammock
WSsX	Cabbage Palm Lowland-Mixed	59.97	0.06%	Hydric hammock
WSh	Hardwood Swamp Woodland	22.01	0.02%	Basin swamp
WU	Upland Woodland	0.00	0.00000 %	
WUpS	Pine Upland-Shrub	4.25	0.0044%	Mesic flatwoods
WUpSs	Pine Upland-Saw Palmetto	398.87	0.41%	Mesic flatwoods
WUpX	Pine Upland-Mixed	1.67	0.0017%	Mesic flatwoods
WUsS	Cabbage Palm Upland-Shrub	0.34	0.0004%	Mesic hammock
WUsSs	Cabbage Palm Upland-Saw Palmetto	0.67	0.0007%	Mesic hammock
WUsX	Cabbage Palm Upland-Mixed	20.90	0.02%	Mesic hammock
WUh	Upland Woodland	164.80	0.17%	Coastal berm
WUM	Upland Woodland, Mound	31.53	0.03%	Shell Mound
WUqSs	Live Oak Woodland with Saw Palmetto	74.12	0.08%	Mesic hammock
WUCp	Scrubby Flatwoods	160.04	0.16%	Scrubby flatwoods
SM	Mangrove Shrubland	0.75	0.0008%	Tidal swamp
SMa	Black Mangrove Shrubland	3.16	0.0032%	Tidal swamp
SMc	Buttonwood Shrubland	4.61	0.0047%	Tidal swamp
SMl	White Mangrove Shrubland	21.02	0.02%	Tidal swamp
SMr	Red Mangrove Shrubland	1,036.64	1.06%	Tidal swamp
SMX	Mixed Mangrove Shrubland	119.53	0.12%	Tidal swamp
SMXal	Black Mangrove-White Mangrove Shrubland	8.73	0.01%	Tidal swamp
SMXar	Black Mangrove-Red Mangrove Shrubland	5.17	0.01%	Tidal swamp
SMXcl	Buttonwood-White Mangrove Shrubland	7.53	0.01%	Tidal swamp
SMXcr	Buttonwood-Red Mangrove Shrubland	6.70	0.01%	Tidal swamp
SMXlr	White Mangrove-Red Mangrove Shrubland	158.71	0.16%	Tidal swamp

Class_ID	Name	acres	percent	FNAI_NC
SS	Swamp Shrubland	3.64	0.0037%	Basin swamp
SSm	Wax Myrtle Shrubland	5.22	0.01%	Basin swamp
SSs	Willow Shrubland	3.19	0.0033%	Slough
SUs	Saw Palmetto Shrubland	1.91	0.0020%	Dry prairie
CM	Mangrove Scrub	9.07	0.01%	Tidal marsh
CMa	Black Mangrove Scrub	61.13	0.06%	Tidal swamp
CMaG	Black Mangrove Scrub-Graminoid	31.00	0.03%	Tidal marsh
CMaGd	Black Mangrove Scrub-Saltgrass	11.63	0.01%	Tidal marsh
CMaS	Black Mangrove Scrub-Succulent	20.66	0.02%	Tidal marsh
CMaSb	Black Mangrove Scrub-Saltwort	0.04	0.00004 %	Tidal marsh
CMc	Buttonwood Scrub	33.99	0.03%	Tidal swamp
CMcG	Buttonwood Scrub-Graminoid	140.95	0.14%	Tidal marsh
CMcGc	Buttonwood Scrub-Sawgrass	12.80	0.01%	Tidal marsh
CMcGd	Buttonwood Scrub-Saltgrass	16.20	0.02%	Tidal marsh
CMcGe	Buttonwood Scrub-Spikerush	56.86	0.06%	Tidal marsh
CMcGj	Buttonwood Scrub-Black Rush	131.54	0.13%	Tidal marsh
CMcGs	Buttonwood Scrub-Cordgrass	12.19	0.01%	Tidal marsh
CMcGt	Buttonwood Scrub-Cattail	0.19	0.0002%	Tidal marsh
CMcS	Buttonwood Scrub-Succulent	0.29	0.0003%	Tidal marsh
CMl	White Mangrove Scrub	31.74	0.03%	Tidal swamp
CMlG	White Mangrove Scrub-Graminoid	0.37	0.0004%	Tidal marsh
CMlGd	White Mangrove Scrub-Saltgrass	23.24	0.02%	Tidal marsh
CMlGj	White Mangrove Scrub-Black Rush	2.53	0.0026%	Tidal marsh
CMlGs	White Mangrove Scrub-Cordgrass	6.30	0.01%	Tidal marsh
CMlGsd	White Mangrove Scrub-Cordgrass/Saltgrass	1.62	0.0017%	Tidal marsh
CMlGt	White Mangrove Scrub-Cattail	0.92	0.0009%	Tidal marsh
CMlS	White Mangrove Scrub-Succulent	32.54	0.03%	Tidal marsh
CMlSs	White Mangrove Scrub-Glasswort	0.39	0.0004%	Tidal marsh
CMr	Red Mangrove Scrub	211.96	0.22%	Tidal swamp
CMrGc	Red Mangrove Scrub-Sawgrass	0.86	0.0009%	Tidal marsh
CMrGe	Red Mangrove Scrub-Spikerush	97.04	0.10%	Tidal marsh
CMrGt	Red Mangrove Scrub-Cattail	25.57	0.03%	Tidal marsh
CMX	Mixed Mangrove Scrub	373.66	0.38%	Tidal swamp
CMXG	Mixed Mangrove Scrub-Graminoid	3.67	0.0038%	Tidal marsh
CMXGe	Mixed Mangrove Scrub-Spikerush	20.52	0.02%	Tidal marsh
CMXGj	Mixed Mangrove Scrub-Black Rush	4.03	0.0041%	Tidal marsh
CMXGs	Mixed Mangrove Scrub-Cordgrass	0.25	0.0003%	Tidal marsh
CMXac	Black Mangrove-Buttonwood Scrub	0.49	0.0005%	Tidal marsh
CMXacGd	Black Mangrove-Buttonwood Scrub-	0.93	0.0010%	Tidal marsh

Class_ID	Name	acres	percent	FNAI_NC
	Saltgrass			
CMXacGe	Black Mangrove-Buttonwood Scrub-Spikerush	2.28	0.0023%	Tidal marsh
CMXacGj	Black Mangrove-Buttonwood Scrub-Black Rush	2.24	0.0023%	Tidal marsh
CMXacSb	Black Mangrove-Buttonwood Scrub-Saltwort	1.99	0.0020%	Tidal marsh
CMXal	Black Mangrove-White Mangrove Scrub	6.56	0.01%	Tidal swamp
CMXalGd	Black Mangrove-White Mangrove Scrub-Saltgrass	1.92	0.0020%	Tidal marsh
CMXalGj	Black Mangrove-White Mangrove Scrub-Black Rush	0.61	0.0006%	Tidal marsh
CMXalSb	Black Mangrove-White Mangrove Scrub-Saltwort	8.05	0.01%	Tidal marsh
CMXar	Black Mangrove-Red Mangrove Scrub	1.22	0.0012%	Tidal swamp
CMXarGe	Black Mangrove-Red Mangrove Scrub-Spikerush	5.91	0.01%	Tidal marsh
CMXcl	Buttonwood-White Mangrove Scrub	9.98	0.01%	Tidal swamp
CMXclG	Buttonwood-White Mangrove Scrub-Graminoid	0.50	0.0005%	Tidal marsh
CMXclGc	Buttonwood-White Mangrove Scrub-Sawgrass	2.11	0.0022%	Tidal marsh
CMXclGd	Buttonwood-White Mangrove Scrub-Saltgrass	17.41	0.02%	Tidal marsh
CMXclGe	Buttonwood-White Mangrove Scrub-Spikerush	8.36	0.01%	Tidal marsh
CMXclGj	Buttonwood-White Mangrove Scrub-Black Rush	35.00	0.04%	Tidal marsh
CMXclGs	Buttonwood-White Mangrove Scrub-Cordgrass	0.33	0.0003%	Tidal marsh
CMXclO	Buttonwood-White Mangrove Scrub-Open Marsh	2.33	0.0024%	Tidal marsh
CMXcrG	Buttonwood-Red Mangrove Scrub-Graminoid	1.21	0.0012%	Tidal marsh
CMXcrGc	Buttonwood-Red Mangrove Scrub-Sawgrass	163.24	0.17%	Tidal marsh
CMXcrGe	Buttonwood-Red Mangrove Scrub-Spikerush	1.86	0.0019%	Tidal marsh
CMXcrGs	Buttonwood-Red Mangrove Scrub-Cordgrass	0.51	0.0005%	Tidal marsh
CMXcrGt	Buttonwood-Red Mangrove Scrub-Cattail	0.84	0.0009%	Tidal marsh
CMXlr	White Mangrove-Red Mangrove Scrub	145.65	0.15%	Tidal marsh
CMXlrGj	White Mangrove-Red Mangrove Scrub-	21.42	0.02%	Tidal marsh

Class_ID	Name	acres	percent	FNAI_NC
	Black Rush			
CMXlrS	White Mangrove-Red Mangrove Scrub-Succulent	0.09	0.0001%	Tidal marsh
CSG	Swamp Scrub-Graminoid Marsh	8.91	0.01%	Depression marsh
CSm	Wax Myrtle Scrub	0.03	0.00003 %	Depression marsh
CSmG	Wax Myrtle Scrub-Graminoid Marsh	5.94	0.01%	Depression marsh
CSmGc	Wax Myrtle Scrub-Sawgrass	15.10	0.02%	Depression marsh
CSsG	Willow Scrub-Graminoid Marsh	9.65	0.01%	Depression marsh
CSsGc	Willow Scrub-Sawgrass	178.57	0.18%	Depression marsh
CSsGt	Willow Scrub-Cattail	0.71	0.0007%	Depression marsh
CUG	Upland Scrub-Graminoid Prairie	0.15	0.0002%	
CUW	Upland Hardwood Scrub	5.23	0.01%	
CUq	Xeric Oak Scrub	43.55	0.04%	Scrub
MSG	Graminoid Salt Marsh	2.53	0.00%	Tidal marsh
MSGd	Saltgrass	5.78	0.01%	Tidal marsh
MSGj	Black Rush	41.07	0.04%	Tidal marsh
MSGs	Cordgrass	49.24	0.05%	Tidal marsh
MSS	Succulent Salt Marsh	0.29	0.0003%	Tidal marsh
MFBa	Leather Fern	0.70	0.0007%	Tidal marsh
MFG	Graminoid Freshwater Marsh	10.65	0.01%	Depression marsh
MFGc	Sawgrass	15.81	0.02%	Depression marsh
MFGe	Spikerush	31.89	0.03%	Depression marsh
MFGt	Cattail	75.27	0.08%	Depression marsh
MFGtD	Cattail Dominant	11.21	0.01%	Depression marsh
MFGtS	Cattail Sparse	11.56	0.01%	Depression marsh
MFGP	Graminoid Freshwater Prairie	10.59	0.01%	Wet prairie
MFGPc	Sawgrass Prairie	9.66	0.01%	Wet prairie
DG	Graminoid Dune	103.44	0.11%	Beach dune
A	Submerged Aquatic Vegetation	24.55	0.03%	
AM	Marine Aquatic Vegetation	124.48	0.13%	
AMA	Marine Algae	56.21	0.06%	Marine algal bed
AMS	Seagrass	625.10	0.64%	Marine grass bed
Ec	Australian Pine	0.56	0.0006%	
EcD	Australian Pine Dominant	20.09	0.02%	
Em	Melaleuca	2.31	0.0024%	
EtDT	Treated Seaside Mahoe Dominant	0.89	0.0009%	Coastal berm
BCH	Beach	206.43	0.21%	Beach dune
HI	Human Impacted	1527.20	1.56%	Ruderal
CA	Canal	44.23	0.05%	
LEV	Levee	0.87	0.0009%	Ruderal

Class_ID	Name	acres	percent	FNAI_NC
ORV	ORV Trail	1.24	0.0013%	Ruderal
QUA	Quarry	115.27	0.12%	Ruderal
RD	Road	16.75	0.02%	Ruderal
SP	Spoil	146.91	0.15%	Ruderal
HIM	Human Impacted, Mound	58.68	0.06%	Shell Mound
MUD	Mud	1,627.03	1.67%	
FMr	Red Mangrove Forest	0.14	0.0001%	
OW	Open Water	55,257.79	56.56%	
SF	Barren Salt Flat	11.43	0.01%	
NULL		8,367.15	8.57%	
		97,689.74		

Appendix II

Summary of 2010 NERR Habitats Mapped thus far in Rookery Bay NERR			
NERR_CODE	NERR_Label	Number of CERP Vegetation Types	Acres
1130	Marine, Subtidal, Aquatic Bed	2	146.5
1131	Marine, Subtidal, Aquatic Bed, Rooted Algal	1	56.2
1133	Marine, Subtidal, Aquatic Bed, Rooted Vascular	1	625.1
2253	Estuarine, Intertidal Haline, Unconsolidated Shore, Sand	1	187.2
2261	Estuarine, Intertidal Haline, Emergent Wetland, Persistent	51	1,205.3
2262	Estuarine, Intertidal Haline, Emergent Wetland, Nonpersistent	7	270.5
2273	Estuarine, Intertidal Haline, Scrub-Shrub Wetland, BLE	32	5,510.4
2283	Estuarine, Intertidal Haline, Forested Wetland, BLE	20	16,983.4
2363	Estuarine, Supratidal Haline, Forested Wetland, BLE	6	39.0
5100	Palustrine, Perennial Water, Perennial Water	1	51,632.7
5120	Palustrine, Perennial Water, Unconsolidated Bottom	2	1,576.2
5232	Palustrine, Intermittent or Saturated, Emergent Wetland, Persistent	19	494.3
5243	Palustrine, Intermittent or Saturated, Scrub-Shrub Wetland, BLE	4	12.1
5250	Palustrine, Intermittent or Saturated, Forested Wetland	1	2.6
5252	Palustrine, Intermittent or Saturated, Forested Wetland, NLD	4	108.1
5253	Palustrine, Intermittent or Saturated, Forested Wetland, BLE	6	151.1

5254	Palustrine, Intermittent or Saturated, Forested Wetland, NLE	2	252.9
5255	Palustrine, Intermittent or Saturated, Forested Wetland, Mixed	2	151.9
6131	Upland, Supratidal, Herbaceous, Grassland	1	86.3
6154	Upland, Supratidal, Forested, NLE	2	21.0
6240	Upland, Inland, Scrub-Shrub Upland	2	3.5
6243	Upland, Inland, Scrub-Shrub, BLE	2	45.5
6250	Upland, Inland, Forested Upland	1	2.1E-05
6253	Upland, Inland, Forested, BLE	12	703.7
6255	Upland, Inland, Forested, Mixed	4	564.8
8000	Cultural Land Cover	5	1,729.9
8100	Developed Upland	1	16.7
8300	Developed and Managed Wetlands and Water	2	159.5
NULL	**INCOMPLETE DATA**	6	14,953.3
		194	97,689.7

Appendix III

FNAI Natural Communities	acres
OW	56,896.3
Basin swamp	142.6
Beach dune	309.9
Coastal berm	553.5
Depression marsh	375.3
Dome swamp	1.8
Dry prairie	1.9
Hydric hammock	166.9
Marine algal bed	56.2
Marine grass bed	625.1
Mesic flatwoods	404.8
Mesic hammock	96.0
Prairie hammock	11.7
Ruderal	1,808.2
Scrub	43.5
Scrubby flatwoods	160.0
Shell mound	202.9
Slough	3.2
Strand swamp	1.1
Tidal marsh	1,670.4
Tidal swamp	24,972.2

Wet flatwoods	471.0
Wet prairie	20.3
Xeric hammock	5.9
NULL	8,367.2
Total:	97,689.7

Appendix IV: Summary of Changes Since 1940 Mapped in RBNERR and TTINWR Combined (Ground Truthed Polygons Only) Analyzed by Vegetative Zone

1940	Present	zone1	zone2	zone3	zone4
BCH	Berm_new				0.05
BCH	CUW				1.74
BCH	DG				2.43
BCH	OW				46.84
BCH	WM				0.60
BCH	WMc/CMc				0.92
BCH	Wus				4.67
Berm_new	BCH				0.80
Berm_new	DG				4.75
Berm_new	FM				1.43
Berm_new	OW			4.56	2.94
Berm_old	BCH				2.85
Berm_old	Berm_new				0.83
Berm_old	DG				0.06
Berm_old	FH			2.97	
Berm_old	FM		0.28		
Berm_old	OW				8.62
Berm_old	SF			0.03	
Berm_old	WM				0.19
Berm_old	WMc/CMc		2.08	2.61	0.09
Berm_old	WSs			0.01	
CM	BCH				0.39
CM	Cma	3.95		4.20	
CM	FM	45.45	1.28		
CM	Marsh	0.11			
CM	OW	0.82		0.55	0.92
CM	SM	113.82	1.63	0.26	
CM	WM	212.56		11.99	
CM	WMc/CMc	150.13	0.96		
Cma	WM			5.39	
DG	Berm_old				1.36

1940	Present	zone1	zone2	zone3	zone4
FM	BCH				10.38
FM	Berm_new				2.93
FM	Berm_old		0.00		1.83
FM	CUW				0.38
FM	DG				6.17
FM	FMa/SMa		13.10	1.65	
FM	OW				26.40
FM	SM	0.07		4.03	0.99
FM	WM	20.84		1.44	
FM	WMc/CMc	0.00	0.86	0.83	2.28
FM	Wus				3.27
FMa/SMa	Berm_new				0.59
FMa/SMa	FM				4.37
FMa/SMa	OW		14.14	8.40	
FMa/SMa	WM		8.47	1.17	
FMc/SMc	FM	0.57	0.50	2.78	
FMc/SMc	FMa/SMa		0.11		
FMc/SMc	SM	0.85			
Marsh	CM	836.56			
Marsh	Cma	23.83			
Marsh	E	0.40			
Marsh	FH	1.49			
Marsh	FM	294.90		0.56	
Marsh	FMa/SMa	4.95			
Marsh	FMc/SMc	4.06			
Marsh	OW	37.64			
Marsh	SM	296.35			
Marsh	SS	4.27			
Marsh	WM	191.68	0.23	2.51	
Marsh	WMc/CMc	286.11			
Marsh	WSh	2.55			
Marsh	WSp/WUp	13.14			
Marsh	WSs	10.31			
Mound	Berm_old		0.31		
Mound	FM		1.08	9.53	
Mound	FMa/SMa			0.20	
Mound	FMc/SMc			1.26	
Mound	WMc/CMc			0.06	
OW	BCH				15.70
OW	Berm_new				1.05

1940	Present	zone1	zone2	zone3	zone4
OW	Berm_old				0.14
OW	CM	8.94			
OW	Cma			0.06	
OW	CUW				0.67
OW	DG				2.30
OW	FM	30.37		0.09	2.23
OW	Marsh	0.45			
OW	MSS			0.06	
OW	SM	46.50	0.02	0.51	1.24
OW	WM	1.98			
OW	WMc/CMc	0.80			1.33
OW	Wus				2.15
SF	CM	0.54			
SF	Cma			0.46	
SF	FM			0.22	
SF	OW			0.02	
SF	SM			0.27	
SF	WM	0.73		1.87	
SM	Berm_new				0.96
SM	FM	64.16			3.87
SM	OW	0.10			
SM	WM	2.14			
SS	SM	0.04			
SUs	Wuq	0.28			
WM	BCH				1.34
WM	Berm_new				3.85
WM	Berm_old				0.40
WM	CM	0.59			
WM	Cma				1.40
WM	CUW				0.48
WM	DG				0.61
WM	E				0.89
WM	FM	106.40	102.81	18.11	29.56
WM	FMa/SMa	0.22	0.09		0.10
WM	Marsh	0.20			
WM	OW				3.30
WM	SF				0.29
WM	SM		0.41		0.32
WM	WMc/CMc	0.64			
WM	WSp/WUp	0.17			

1940	Present	zone1	zone2	zone3	zone4
WMc/CMc	BCH				0.09
WMc/CMc	Berm_old				0.35
WMc/CMc	CM	114.42	0.09		0.39
WMc/CMc	Cma	0.91		0.32	1.07
WMc/CMc	E	0.74			
WMc/CMc	FM	30.29	0.71	2.92	0.49
WMc/CMc	FMa/SMa	8.86			0.12
WMc/CMc	FMc/SMc	31.41			0.33
WMc/CMc	Marsh	1.68			
WMc/CMc	Mound			0.63	
WMc/CMc	OW	0.01		0.14	
WMc/CMc	SF			1.30	
WMc/CMc	SM	19.87	0.06	0.71	
WMc/CMc	WM	45.17	4.64	7.89	0.76
WMc/CMc	WSh	0.00			
WMc/CMc	WSp/WUp	0.54			
WSh	FS	0.30			
WSp/WUp	CM	1.53			
WSp/WUp	FH	8.30		1.43	
WSp/WUp	FM	0.51	0.95		
WSp/WUp	FMc/SMc	4.25			
WSp/WUp	Marsh	1.40			
WSp/WUp	SM	1.76			
WSp/WUp	SS	4.56			
WSp/WUp	SUC	0.11			
WSp/WUp	SUs	2.73			
WSp/WUp	WM	0.21			
WSp/WUp	WMc/CMc	95.62	0.09	8.42	
WSp/WUp	WSh	0.83			
WSp/WUp	WSs	77.71		1.03	
WSp/WUp	Wuq	9.83		20.82	
WSp/WUp	Wus	0.34		0.85	
WSs	CM	0.29		0.30	
WSs	FH	5.95			
WSs	FM	1.08			
WSs	FMc/SMc	0.58			
WSs	FS	0.14			
WSs	Marsh	2.02			
WSs	SF	0.22		0.23	
WSs	SM	0.59			

1940	Present	zone1	zone2	zone3	zone4
WSs	SS	0.16			
WSs	WM			0.17	
WSs	WMc/CMc	26.08		2.64	
WSs	WSh	0.97			
WSt/FSt	SS	0.65			
WSt/FSt	WSp/WUp	10.90			
WSt/FSt	WSs	2.92			
WUCp/Cuq	FH		0.42		
WUCp/Cuq	WSs		2.92		
WUCp/Cuq	WU		2.10E-05		
WUCp/Cuq	Wuq	0.22	1.40		
				Total:	3,857.3

APPENDIX V:Elevation Statistics by CERP Vegetation Type Derived from LiDAR (2007)

CLASS_ID	MEAN	STD	COUNT	AREA	MIN	MAX	RANGE
QUA	-0.646449	0.4625580	17836	445900.0	-1.44789000	3.224400	4.672290
OW	-0.035802	1.2402400	660645	16516100.0	-5.22779000	6.239870	11.467700
CMXclO	0.279552	0.4903980	4059	101475.0	-0.75327500	3.206480	3.959750
CMrGe	0.514400	0.3993840	187521	4688030.0	-1.26743000	3.223990	4.491430
CMXcrGe	0.517770	0.2469090	3240	81000.0	-0.63621200	2.348780	2.984990
CMlG	0.646901	0.1676910	651	16275.0	0.19834000	1.437800	1.239460
MFGe	0.673362	0.3420290	606582	15164600.0	-0.54771900	4.001430	4.549150
CMrGt	0.696028	0.4422040	8928	223200.0	-1.48204000	3.790590	5.272630
AMS	0.706164	0.7445830	154	3850.0	-1.98674000	3.369770	5.356510
CMXlrGe	0.713622	0.5784400	15862	396550.0	-0.11815900	5.869630	5.987790
CMXcrGc	0.776058	0.6712200	172053	4301330.0	-1.75915000	4.473300	6.232440
CMXlrGs	0.813591	0.4920820	50927	1273180.0	-0.17789500	3.709230	3.887130
MUD	0.830802	0.5841410	88628	2215700.0	-2.92289000	4.433730	7.356610
CMlGt	0.833957	0.4725330	10462	261550.0	-0.57536900	3.618330	4.193700
CMX	0.836404	0.6320130	122127	3053180.0	-2.37841000	3.992410	6.370810
MFGtS	0.877717	0.5939940	25979	649475.0	-0.57607100	4.217810	4.793890
CMXcrGs	0.882366	0.3850830	1657	41425.0	0.11522100	2.670610	2.555390
CMrGsd	0.886173	0.4155740	20837	520925.0	0.26602400	3.477980	3.211950
MSGsd	0.887507	0.2945650	96523	2413080.0	-0.00390070	3.034350	3.038250
MFGt	0.920859	0.6271420	41264	1031600.0	-1.39060000	3.469430	4.860030
CMl	0.922055	0.3825160	39018	975450.0	-0.69000100	3.544900	4.234900

CLASS_ID	MEAN	STD	COUNT	AREA	MIN	MAX	RANGE
CMXarGe	0.949724	0.3390290	3748	93700.0	0.24443500	2.630240	2.385810
CMXGd	0.961917	0.2084130	314	7850.0	0.41907800	1.820340	1.401260
CMr	0.973267	0.7803690	215510	5387750.0	-2.16000000	5.017320	7.177320
CMlGj	0.983979	0.3770670	6692	167300.0	0.16272700	2.955710	2.792980
SS	0.990612	0.6163560	6198	154950.0	-0.85169700	3.701290	4.552980
CMXclGe	1.003960	0.2610260	14578	364450.0	0.50175500	2.421500	1.919750
CSsG	1.018350	0.6157760	16046	401150.0	-1.08271000	3.577980	4.660690
CMlGd	1.018830	0.3583660	283359	7083980.0	-0.85914000	3.938930	4.798070
CMXclG	1.029730	0.3527510	101	2525.0	0.22339800	2.071700	1.848300
CMXcrGt	1.032930	0.6073110	1461	36525.0	0.08884420	3.462340	3.373500
CMXlrGd	1.037170	0.3869770	123257	3081430.0	-0.13665300	3.433100	3.569750
CMlGsd	1.046870	0.4029190	84106	2102650.0	-0.39622800	3.648920	4.045150
WStG	1.056740	0.3401340	2856	71400.0	0.00435087	2.699780	2.695430
CMXGs	1.060480	0.4630670	35034	875850.0	-0.14724400	3.557940	3.705180
CMrGs	1.066670	0.4861860	111387	2784680.0	-0.40000100	4.179300	4.579300
CMaG	1.080510	0.4932510	24689	617225.0	0.00367204	3.384240	3.380570
CMXclGd	1.095610	0.4644740	25050	626250.0	-0.20248000	3.189590	3.392070
CMXclGc	1.110190	0.8364170	3024	75600.0	-1.77995000	3.837240	5.617190
CMXclGs	1.141350	0.4216110	26208	655200.0	-0.21000000	3.303510	3.513510
MFG	1.144250	0.3577340	8687	217175.0	-1.19470000	2.927150	4.121840
Em	1.149770	0.4109560	2007	50175.0	-0.23319200	3.665250	3.898440
MFGtD	1.153120	0.4454390	154579	3864480.0	-0.89810000	4.018650	4.916750
MSGd	1.153130	0.3731740	208142	5203550.0	-0.42879800	3.717880	4.146670
CA	1.188000	0.9754150	25884	647100.0	-3.00177000	4.793070	7.794840
CMXGe	1.194290	0.3146570	8499	212475.0	-0.20485200	4.050740	4.255590
CMlGs	1.194570	0.4304880	66850	1671250.0	-0.36986700	3.620660	3.990530
FStD	1.205390	0.3772290	3118	77950.0	0.06668650	4.628480	4.561790
FMr	1.211100	0.7507060	2098447	52461200.0	-3.77390000	13.195800	16.969700
MFGc	1.219640	0.4844620	23550	588750.0	-0.13260100	4.321570	4.454170
CMXGj	1.220030	0.3868790	7024	175600.0	0.19554400	2.893360	2.697820
CMrGc	1.221200	0.4566580	1597	39925.0	0.22093700	2.639780	2.418840
MFGPc	1.235980	0.4643670	10356	258900.0	0.03847290	3.758860	3.720380
CMlSs	1.255690	0.2741010	3468	86700.0	0.50529100	2.642510	2.137220
CMcGe	1.259070	0.3311410	91628	2290700.0	-0.09249460	3.923130	4.015630
CMXclS	1.271410	0.2552920	689	17225.0	0.66303900	2.175310	1.512280
CMcGs	1.271600	0.5067600	110127	2753180.0	-0.06126770	3.899450	3.960720
WMaG	1.275050	0.3888370	71313	1782830.0	0.10000000	3.196420	3.096420
CMcG	1.289850	0.4869870	90127	2253180.0	-0.54203700	4.214930	4.756970
CMlS	1.293100	0.2625720	1576	39400.0	0.48706600	2.403000	1.915940
WMaSMr	1.295810	0.6413260	209146	5228650.0	-1.92000000	4.279500	6.199510

CLASS_ID	MEAN	STD	COUNT	AREA	MIN	MAX	RANGE
SMXlr	1.297330	0.7547890	153985	3849630.0	-3.39001000	5.902160	9.292170
FMXlr	1.306320	0.4634520	466414	11660400.0	-1.39744000	8.434480	9.831920
SMl	1.312370	0.4421000	304975	7624380.0	-0.60816000	5.682820	6.290980
	1.323640	1.1937700	95032	2375800.0	-1.10549000	7.586040	8.691530
SF	1.324120	0.2668650	3766	94150.0	0.56845800	2.473210	1.904750
SUC	1.341060	0.4438520	4412	110300.0	0.23756000	2.957440	2.719880
CMcGj	1.344180	0.5697030	331885	8297130.0	-2.90001000	5.313230	8.213230
MFGP	1.345350	0.4649350	4583	114575.0	0.44359800	3.672320	3.228730
CMXclSs	1.346180	0.2881680	91	2275.0	0.95817200	2.033680	1.075500
WMXalSM Xlr	1.346570	0.4444200	22163	554075.0	-0.02542320	3.775130	3.800560
CMXclGj	1.347290	0.5204390	44917	1122930.0	-0.16258200	4.250260	4.412840
FStH	1.352580	0.4544760	1849	46225.0	0.15279500	3.099070	2.946270
WMX	1.354730	0.3635630	17160	429000.0	-0.15000000	3.651880	3.801880
CMcGc	1.358410	0.4700490	44275	1106880.0	-0.53224300	3.968910	4.501150
MSGj	1.368180	0.5660500	91194	2279850.0	-0.32872200	4.269480	4.598200
SMXcl	1.369160	0.4857880	46426	1160650.0	-1.06000000	4.437640	5.497650
CMXal	1.370700	0.2811480	11848	296200.0	0.36724300	2.881750	2.514500
WMlSMr	1.375250	0.4980690	14184	354600.0	-0.58786000	3.497310	4.085170
CSmGc	1.386160	0.5040130	26081	652025.0	-0.37822300	4.440730	4.818950
CSmG	1.395090	0.4767260	7491	187275.0	0.09457240	3.927330	3.832760
WMa	1.397680	0.4262950	65194	1629850.0	-0.97038400	3.721320	4.691700
CM	1.398750	0.2916000	663	16575.0	0.75110000	2.601750	1.850650
WMcSMl	1.404670	0.4210510	29840	746000.0	-0.30000100	4.227460	4.527460
CMaGd	1.405940	0.2494960	16399	409975.0	0.50704200	3.016540	2.509500
MSGs	1.406250	0.5378000	868431	21710800.0	-0.84864300	4.552200	5.400850
CMXSs	1.406800	0.1971030	975	24375.0	1.01425000	2.420330	1.406080
SMr	1.407310	0.8565370	178660	4466500.0	-2.92719000	9.043750	11.970900
WMc	1.415460	0.5909410	316360	7909000.0	-2.42001000	7.560140	9.980140
CMXlr	1.415650	0.9183700	135636	3390900.0	-1.33000000	6.320890	7.650890
SMXar	1.423310	0.2645110	2449	61225.0	0.70086200	2.862690	2.161830
SMc	1.424180	0.4508200	70183	1754580.0	-0.22000000	3.804350	4.024350
SMX	1.426350	0.4725210	54072	1351800.0	-0.34339300	4.003000	4.346400
WMXclBa	1.427340	0.3355320	7084	177100.0	0.40374000	3.163990	2.760260
CMXac	1.427460	0.2668660	858	21450.0	0.81477200	2.643080	1.828310
CMXcrG	1.440560	0.4649200	2111	52775.0	-0.80213800	2.572410	3.374540
MFGcS	1.451850	0.4135670	9473	236825.0	0.22518600	3.127430	2.902250
WMlBa	1.454220	0.8852080	15575	389375.0	-0.29654300	5.082950	5.379490
MSS	1.458550	0.1978030	99	2475.0	0.96823400	2.136350	1.168120
SMXcr	1.460930	0.4357000	43207	1080180.0	-0.59000100	4.337040	4.927040
WMXalBa	1.475350	0.5955170	30887	772175.0	-1.77000000	4.294580	6.064590

CLASS_ID	MEAN	STD	COUNT	AREA	MIN	MAX	RANGE
CMXalGd	1.477340	0.3746880	4338	108450.0	0.53253400	2.941920	2.409380
FMl	1.481720	0.4310790	67177	1679430.0	-1.81219000	4.831910	6.644090
CMXlrGj	1.507340	0.2672870	384	9600.0	0.98412100	2.443430	1.459310
CSsGc	1.508150	0.4387550	187224	4680600.0	-0.32735400	3.978300	4.305650
WMcSMX	1.514460	0.5573410	26714	667850.0	-0.01368200	4.382580	4.396260
CMXalGj	1.528580	0.3557960	1068	26700.0	0.65937800	3.252050	2.592670
CMa	1.529660	0.4828480	14710	367750.0	0.58079600	6.624900	6.044100
WMcH	1.530200	0.4832500	31286	782150.0	0.05000010	4.261310	4.211310
FMXal	1.533260	0.4366860	27045	676125.0	0.20989100	4.657790	4.447900
MFBa	1.543420	0.4025770	5590	139750.0	-0.04458800	3.754610	3.799200
WM	1.557390	0.6286210	12961	324025.0	0.01211040	4.800760	4.788650
FMc	1.563390	0.7030940	57640	1441000.0	-0.33908900	13.397900	13.737000
WMcSMr	1.565480	0.4958210	21787	544675.0	-0.88789700	3.812160	4.700060
SSa	1.565650	0.4614480	6307	157675.0	0.43486400	3.460600	3.025740
FMXac	1.570700	0.4756130	7018	175450.0	0.09506930	3.998480	3.903410
WMaSMX	1.581490	0.6918780	696533	17413300.0	-1.92752000	6.635380	8.562900
WMcG	1.597780	0.5390140	240368	6009200.0	-0.64710400	4.912360	5.559470
MFGcT	1.607020	0.4087420	9725	243125.0	0.55371300	2.978560	2.424850
CMXacGe	1.607460	0.2803310	3988	99700.0	0.92692800	3.190740	2.263820
WMcBa	1.618720	0.7278890	568626	14215700.0	-1.53000000	8.101860	9.631860
BCH	1.632350	1.4295600	53867	1346680.0	-3.28095000	6.874310	10.155300
FMX	1.640890	0.5046740	786821	19670500.0	-2.47563000	7.719440	10.195100
WSt	1.652800	0.4979380	16573	414325.0	-0.63855500	4.105110	4.743660
MSG	1.658220	0.3650470	3820	95500.0	-0.49852600	3.792680	4.291210
FMa	1.672660	0.3832810	913773	22844300.0	-4.24001000	5.150470	9.390480
WSs	1.675270	0.3507590	1920	48000.0	0.34506800	2.839470	2.494400
FHa	1.675890	0.4923880	43136	1078400.0	-0.42412500	4.399740	4.823870
FMXcl	1.676560	0.6141540	29712	742800.0	-1.22997000	7.374210	8.604190
WMXacBa	1.678300	0.5105630	31670	791750.0	-0.02665140	4.229080	4.255730
FSt	1.690960	0.5619360	8209	205225.0	-0.59087900	3.893870	4.484750
CMcS	1.696670	0.3959760	493	12325.0	0.89648800	4.433060	3.536570
SMXal	1.697030	0.3569100	13614	340350.0	-0.04000010	3.557550	3.597550
WMaSMl	1.702760	0.4453890	124948	3123700.0	-0.32000100	4.605430	4.925430
WSsGc	1.705690	0.4050870	17927	448175.0	0.24745100	3.931200	3.683750
CSG	1.708980	0.4288890	13258	331450.0	-0.23481300	3.691030	3.925840
CMXacGd	1.729670	0.3006960	1615	40375.0	0.91464100	3.355270	2.440630
WSsG	1.730750	0.4479290	46551	1163780.0	0.34076200	4.298420	3.957650
FMXar	1.736650	0.4118060	4598034	114951000.0	-2.41046000	7.258980	9.669440
CMlGc	1.745550	0.5768980	2958	73950.0	0.50130500	3.491960	2.990660

CLASS_ID	MEAN	STD	COUNT	AREA	MIN	MAX	RANGE
CMXalSb	1.745690	0.2919770	12091	302275.0	0.83242800	3.865380	3.032950
SSs	1.748510	0.7941820	4548	113700.0	-0.08184800	6.756970	6.838820
CSm	1.754470	0.6927170	51	1275.0	0.86109400	3.563350	2.702260
CMXGc	1.758560	0.5070920	404	10100.0	0.80462900	2.773380	1.968750
CMcGd	1.760860	0.4276990	28115	702875.0	-0.15015200	3.509700	3.659850
CMXlrS	1.776730	0.2712520	158	3950.0	1.00798000	2.673630	1.665650
FHS	1.789380	0.5442990	9923	248075.0	0.25087900	3.720220	3.469340
FMXcr	1.794840	0.8695480	138528	3463200.0	-1.60970000	9.477540	11.087200
WMaS	1.819590	0.5079620	62545	1563630.0	-0.26298900	4.811570	5.074560
CMaS	1.832760	0.4345300	7322	183050.0	0.67722800	3.447920	2.770690
WMl	1.840240	0.3775150	245	6125.0	0.99552300	3.388510	2.392980
FSH	1.840720	0.7135210	1713	42825.0	-0.18936200	3.522290	3.711650
EtDT	1.875700	1.0940500	1505	37625.0	-0.56532000	4.017710	4.583030
CMXcl	1.909990	0.7386080	10869	271725.0	0.13608400	4.226330	4.090250
CMc	1.919780	0.6337270	8154	203850.0	0.08800610	4.613380	4.525370
FStp	1.931050	0.5441480	80925	2023130.0	-1.16985000	6.704470	7.874310
WSsX	1.943150	0.5195090	69029	1725730.0	-0.56000100	5.995970	6.555970
WSpG	1.950150	0.4702500	107692	2692300.0	-0.71360800	5.195430	5.909040
WMXBa	1.965340	0.6037390	22569	564225.0	-0.07202300	3.883730	3.955750
CMXacSb	1.966010	0.2247380	3467	86675.0	1.28255000	3.148550	1.866000
CMXar	2.031720	0.3812410	1490	37250.0	0.95336600	3.736280	2.782920
WSpX	2.127250	0.4654160	350390	8759750.0	-0.01773760	5.066020	5.083750
WMcS	2.131480	0.6347150	27729	693225.0	0.17000500	7.639100	7.469100
WSsS	2.138800	0.8730100	67107	1677680.0	-1.23000000	7.898670	9.128670
WMcSM	2.171130	1.0848700	9761	244025.0	-0.00096661	9.346020	9.346980
SM	2.235660	0.9345930	566	14150.0	0.73484500	4.414420	3.679570
SSm	2.245250	1.0829400	9347	233675.0	-0.60000100	7.218280	7.818280
WSpS	2.298740	0.7023010	232087	5802180.0	-1.16303000	7.289660	8.452690
WUpX	2.306370	0.4622110	2914	72850.0	0.96698500	4.066950	3.099960
SP	2.381330	0.9310980	46705	1167630.0	-1.57747000	6.963420	8.540890
FMXB	2.467800	1.5942300	5634	140850.0	-0.36482100	7.090620	7.455440
ORV	2.477840	0.7063300	2173	54325.0	-0.13000000	4.525070	4.655070
FHT	2.567130	1.0141300	24602	615050.0	-0.56000100	6.499770	7.059770
LEV	2.583560	0.8363140	1506	37650.0	0.31750400	5.428790	5.111280
WUsS	2.606770	0.5053310	597	14925.0	1.55089000	4.529750	2.978860
SUs	2.666670	0.8317790	5013	125325.0	0.09030980	6.992250	6.901940
FMrB	2.666890	0.9744700	1900	47500.0	-1.19111000	4.779380	5.970490
WMaB	2.718140	1.1681900	780	19500.0	0.10872800	4.887380	4.778650
HI	2.812060	1.9839600	690016	17250400.0	-3.13498000	23.950700	27.085600
WUpSs	2.865990	0.7921370	579497	14487400.0	-0.85366900	8.880070	9.733740

CLASS_ID	MEAN	STD	COUNT	AREA	MIN	MAX	RANGE
CUW	2.933210	0.8667710	9010	225250.0	-1.21461000	5.837050	7.051660
DG	2.999370	0.9493850	28732	718300.0	0.71527700	7.320720	6.605440
WSh	3.173560	1.5825100	36342	908550.0	-0.26067400	7.348420	7.609100
WUh	3.236490	0.9148350	79991	1999780.0	-0.64455300	7.814530	8.459080
WMXB	3.260400	1.4710200	14263	356575.0	-2.62914000	7.755740	10.384900
WUpS	3.450990	0.2865770	329	8225.0	2.65817000	4.391720	1.733540
WMlB	3.585090	0.8293530	811	20275.0	0.74637600	5.526820	4.780450
RD	3.592950	1.1440400	68644	1716100.0	-0.98586800	10.059400	11.045300
WUqSs	3.642440	1.4008000	57298	1432450.0	-0.02343410	10.253100	10.276500
FHC	3.799080	0.9005360	64679	1616980.0	0.06759810	7.501710	7.434110
WMcB	3.866050	0.8061190	536	13400.0	1.55133000	5.324130	3.772800
WUM	3.915950	1.6115000	34366	859150.0	-1.03783000	13.617100	14.654900
WUsX	3.996770	1.0994200	19576	489400.0	1.33279000	7.994370	6.661580
WUsSs	4.542980	0.7347430	1177	29425.0	1.71772000	6.749040	5.031310
CUq	5.238510	1.5699100	24634	615850.0	0.83463500	9.483750	8.649110
FHX	5.567870	1.8873400	8921	223025.0	0.42608400	10.696600	10.270600
WUCp	5.616720	2.4851000	208642	5216050.0	0.16640800	25.393000	25.226600
FHM	6.833620	3.9502300	104104	2602600.0	0.22837500	23.622900	23.394600
HIM	7.955220	3.8984500	12010	300250.0	1.02002000	21.279400	20.259400