APPLYING SOFIA CLASSIFICATIONS TO HERBACEOUS DOMINATED PLANT COMMUNITIES WITHIN THE HOLE-IN-THE-DONUT, EVERGLADES NATIONAL PARK

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NATIONAL PARK SERVICE

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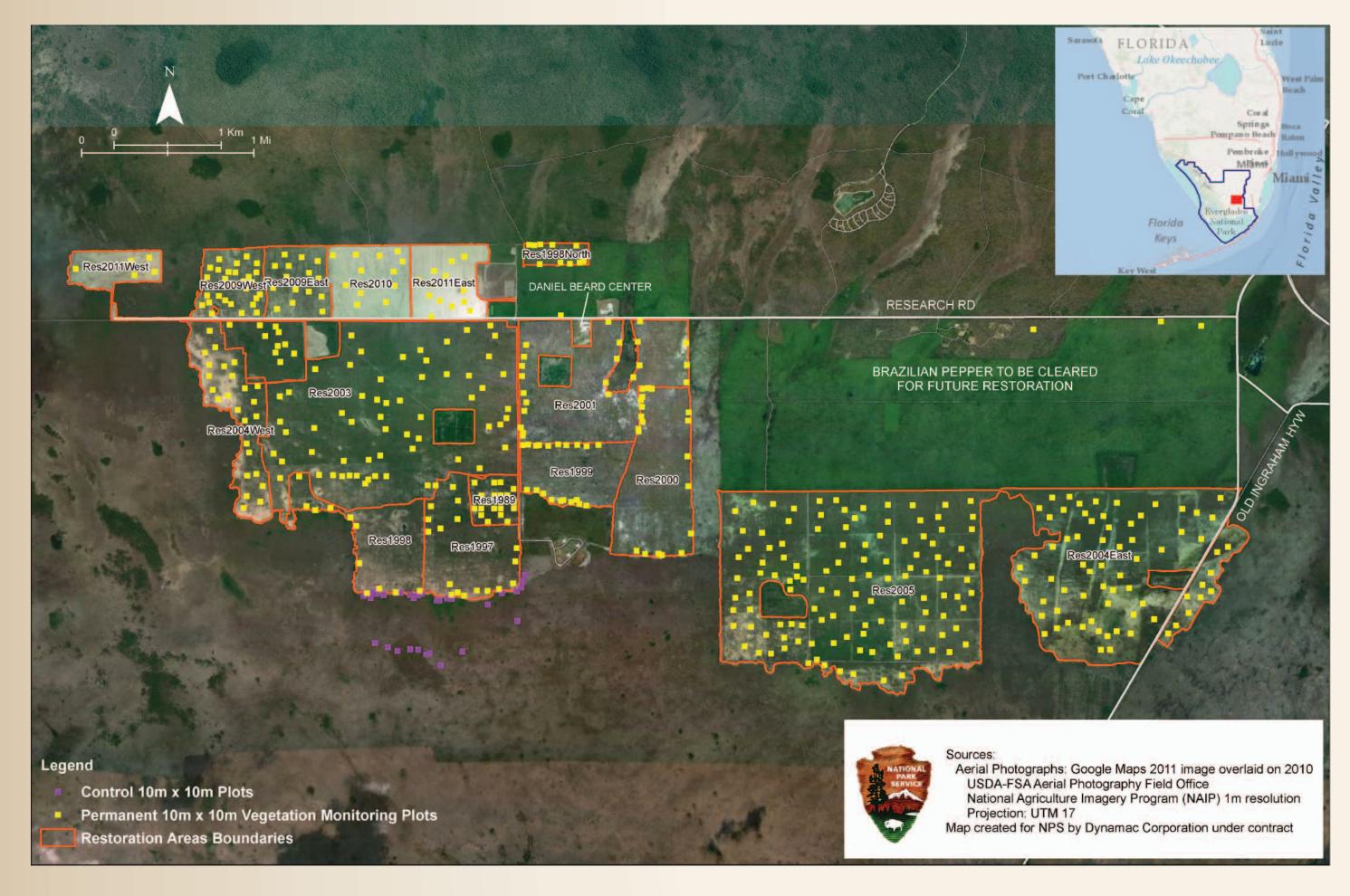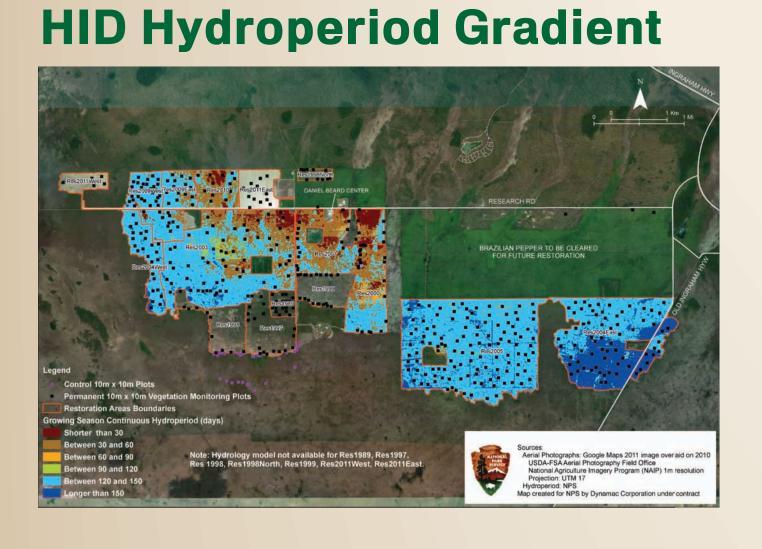A Subsidiary of CSS, Inc.

What is the HID?

Everglades National Park contains an area encompassing 6,600 acres (2,672 hectares, or 10.3 square miles) of former hydric marl prairie and pine rockland, which had been farmed, now called the Hole-in-the-Donut (HID). Farming activities stopped in the mid-1970s when the HID was incorporated in the Park. Despite various efforts to restore the area, the HID became a monotypic, Brazilian pepper (Schinus terebinthifolius) stand. Various control techniques were utilized, most of which did not have lasting positive results. In 1989, however, a pilot project using mitigation funds supplied by Miami-Dade County tested different treatment methods for successful restoration. One treatment method that successfully accomplished wetland restoration in HID involved the complete removal of disturbed substrate down to limestone bedrock.
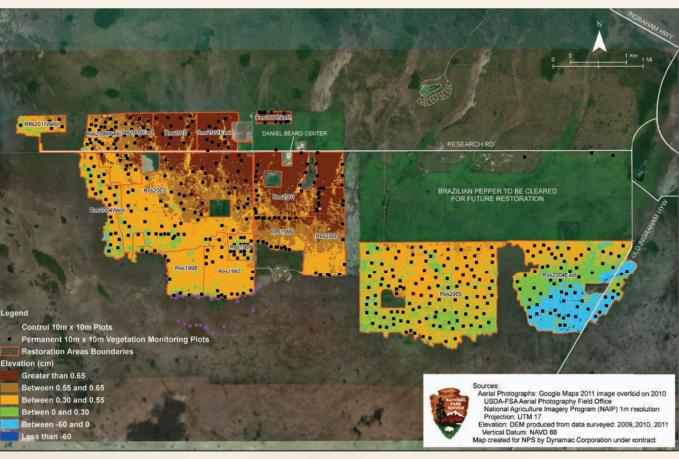
The 1989 successful wetland restoration study within the HID led to an accepted method of removal of all Brazilian Pepper and the soil below, leading to the permit issuances to restore the entire HID. In 1997, the first major Brazilian Pepper area was cleared to create a Restoration (Res) area (now called Res1997). The Park established permanent monitoring plots in Res1997 and control plots of natural undisturbed vegetation south of the HID. Each subsequent year, the Park service cleared remaining Brazilian pepper areas when mitigation funding was sufficient, and plots were established in new Restoration (Res) areas. Since 1989, the Park has restored approximately 4,879 acres to natural wetlands Scrub using the soil removal method.

HID Location and Restoration Area Boundary

HID Hydroperiod Gradient

HID Elevation Gradient

HID Restoration: Brazilian Pepper Clearing, Scraping, and Soil Removal

What restoration is ENP sponsoring in the HID?

The National Park Service is the sponsor of an In-Lieu-Fee (ILF) wetland mitigation project located in Everglades National Park, known as the Hole-in-the-Donut (HID). The National Park Service is dedicated to the functional assessment of the acreage restored in the HID ILF. The HID ILF mitigation project, when completed, will have restored 6,300 acres of wetlands that had devolved into a monotypic stand of Schinus (Schinus terebinthifolius), a complete functional wetland capacity loss, due to historic farming.
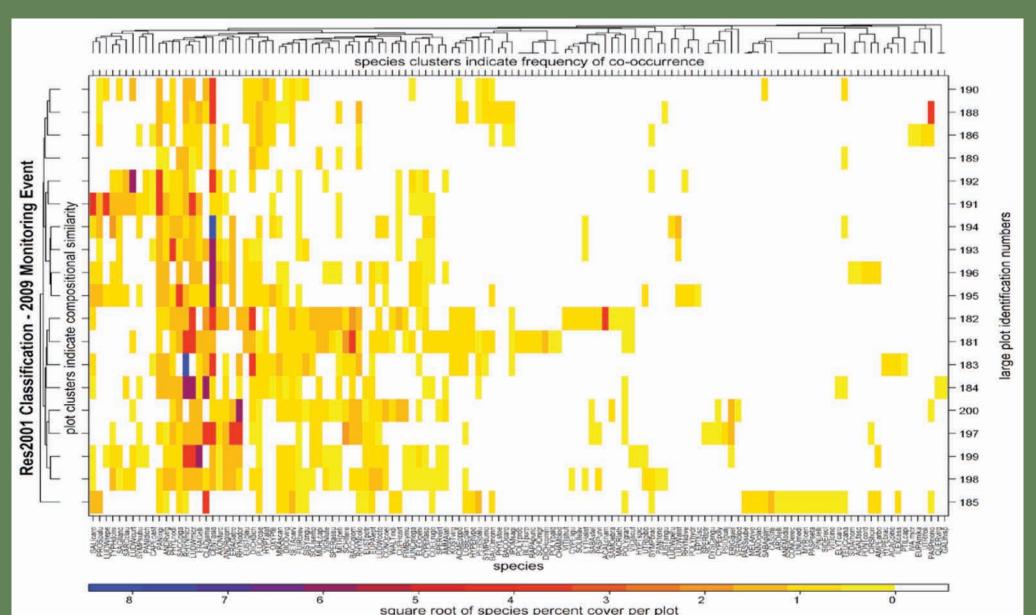
To identify and characterize distinct natural vegetation communities forming and present in the restored HID we used ordination, dendrogram (heat maps) classification, and plant species importance value assignment. Ordination methods simplify patterns within multivariate datasets and identify important gradients and relationships within biological communities. Detrended correspondence analysis (DCA) identified six (6) hydroperiod gradients impacting plant species composition. The preliminary classification was based on a square root transformed Bray-Curtis dissimilarity matrix to approximate normality. An agglomerative hierarchic clustering with average linkage criteria clustered the HID permanent vegetation monitoring plots and their species. Two-way

hierarchical plot and dendrogram classification resulted in species clustered in rows and vegetation monitoring plots in columns. The dendrograms along the vertical axis of the heat map, two-way hierarchic classification form clusters of vegetative monitoring plots. Clusters within the dendrogram are circumscribed with colored rectangles. Species composition similarity clustered the plots. Co-occurrence frequency clustered species. The box and whiskers graphs correspond to the clusters of monitoring plots in the dendrogram.
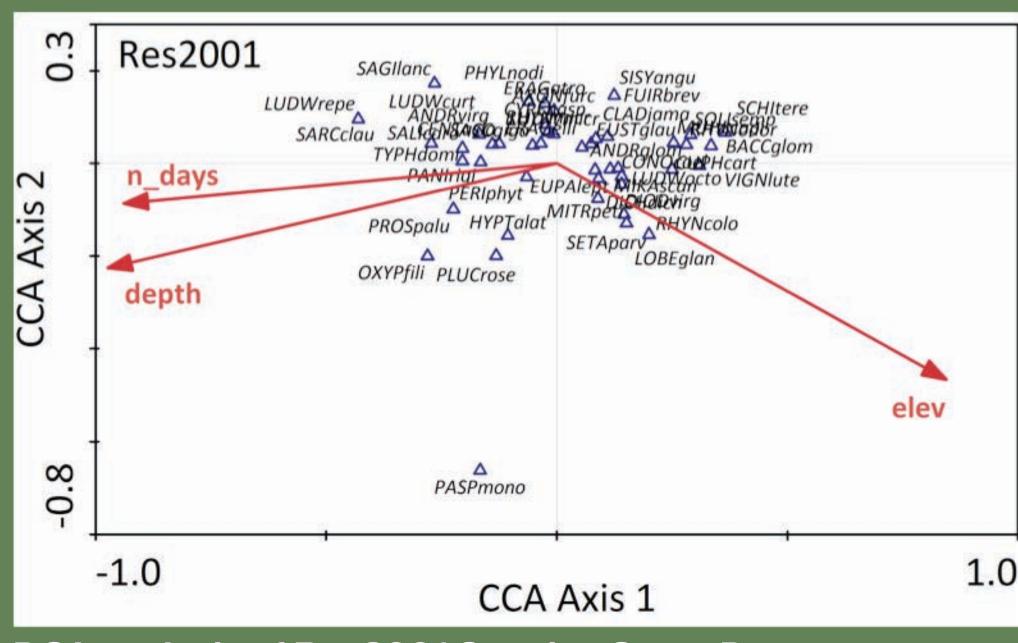
Canonical Correspondence Analysis (CCA) represents environmental variables as arrows. The direction the CCA arrow is pointing indicates the direction of that variable's increase. The length of the arrow indicates variable strength in predicting the plant community. The three (3) variables displayed are elevation (elev), annual water depth (depth) and average number of days inundated by water (n_days). We associated vegetation monitoring plot clusters with hydroperiod gradients that ordination identified. Importance value assignment identified dominant species within clusters.

Example: Restoration Area - Res2001

Res2001 Heat Map Plot Depicting a Two-way Hierarchical Clustering Analysis

Res2001 Plot Association with Plot Clusters Resulting From Classification Analysis

Res2001 Plot Classification

Res2001
distribution of large plot clusters versus elevation

large plot clusters

Canonical Correspondence Analysis (CCA) for Res2001

Res2001

n_days

depth

elev

CCA Axis 1

CCA Axis 2

DCA analysis of Res2001 Species Cover Data

DCA Axis 1 (eigenvalue = 0.275 or 27.5% of the variation in species occurrence) represents a successional gradient, with early successional species ordinated towards the left of the panel and later successional species towards the right. Many of the species to the left of the panel were more abundant early in the recovery of Res2001. Most species to the right in the panel became more frequent only in recent years. DCA Axis 2 (eigenvalue = 0.186 or 18.6% of the variation in species occurrence) represents a gradient of water affinities.
Collectively, the vegetation monitoring plot scores are following the successional gradient towards the later colonizing species at the right of the panel. Cladium jamaicense and Rhynchospora microcarpa occupy the later side of the successional gradient and are some main species toward which the community composition is increasingly shifting.
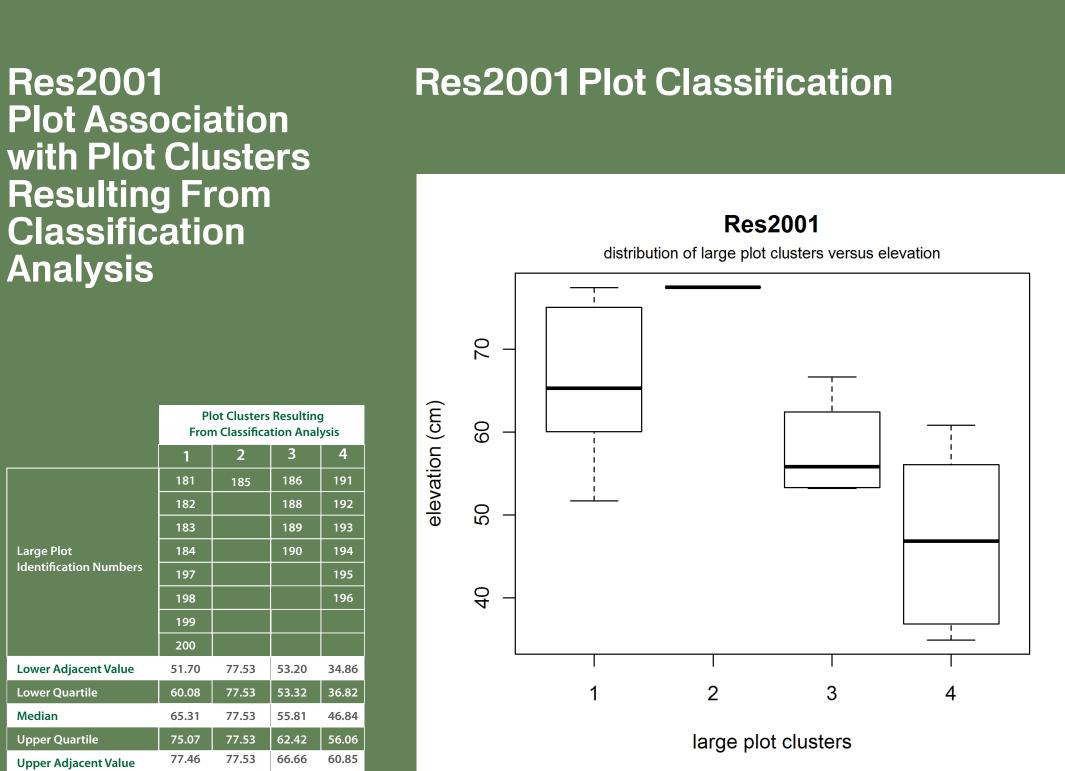
Detrended Correspondence Analysis (DCA) for Res2001

Res2001

DCA Axis 2

DCA Axis 1

SPECIES

MONITORING YEAR
2001
2002
2003
2004
2005
2007
2009

CCA Analysis of Res2001 Species Cover Data

Res2001 CCA Axis 1 appears to represent a gradient of areas sometimes inundated versus areas never inundated/water depth/elevation (Figure 3.2.20). CCA Axis 1 is significant at p = 0.001. Species with higher water and lower elevation affinities are ordinated towards the left of the panel. Species with lower water and higher elevation affinities are ordinated towards the right of the panel. CCA Axis 2 is not interpretable.

FLEPPC Plant Cover Percentage for Entire Large Plot Area Monitored

What is the restored HID becoming?

Native wetland species recruitment and establishment into a freshwater herbaceous marsh and prairie is occurring within the restored HID. Across the herbaceous and graminoid-dominated wetland community, multiple sub-community types are forming and can be classified and spatially mapped across hydrological and elevation gradients. During the past 15 years, vegetation monitoring and analyses in Restored HID have demonstrated increasing native plant diversity and coverage, with minimal re-colonization by Schinus terebinthifolius or other Florida Exotic Pest Plant Council (FLEPPC) species. We conducted analyses across hydroperiod and elevation gradients to better understand and characterize vegetative communities existing within the restored HID.

Preliminary and qualitative comparisons of the wetland community types to SOFIA Class Plant species assemblages are indicating that the following eight (8) wetland plant community types are present in the Restored HID, as of 2011 data. Further monitoring of the Restored HID areas this year will yield more refinement and different acreages. Land management practices (e.g., prescribed fire) contribute to the distribution and quantity of these various wetland community sub-classes.

SOFIA Classification Graminoid Freshwater Prairie -Sawgrass & Muhly (MFGPcm) at the Hole-In-The-Donut Restoration Area, Everglades National Park.

SOFIA Classification Graminoid Freshwater Prairie - Sawgrass & Beakrush (MFGPcr) at the Hole-In-The-Donut Restoration Area, Everglades National Park.

SOFIA Classification Graminoid Freshwater Marsh Marsh (MFG) at the Hole-In-The-Donut Restoration Area, Everglades National Park.

SOFIA Classification Graminoid Freshwater Prairie (MFGP) at the Hole-In-The-Donut Restoration Area, Everglades National Park.
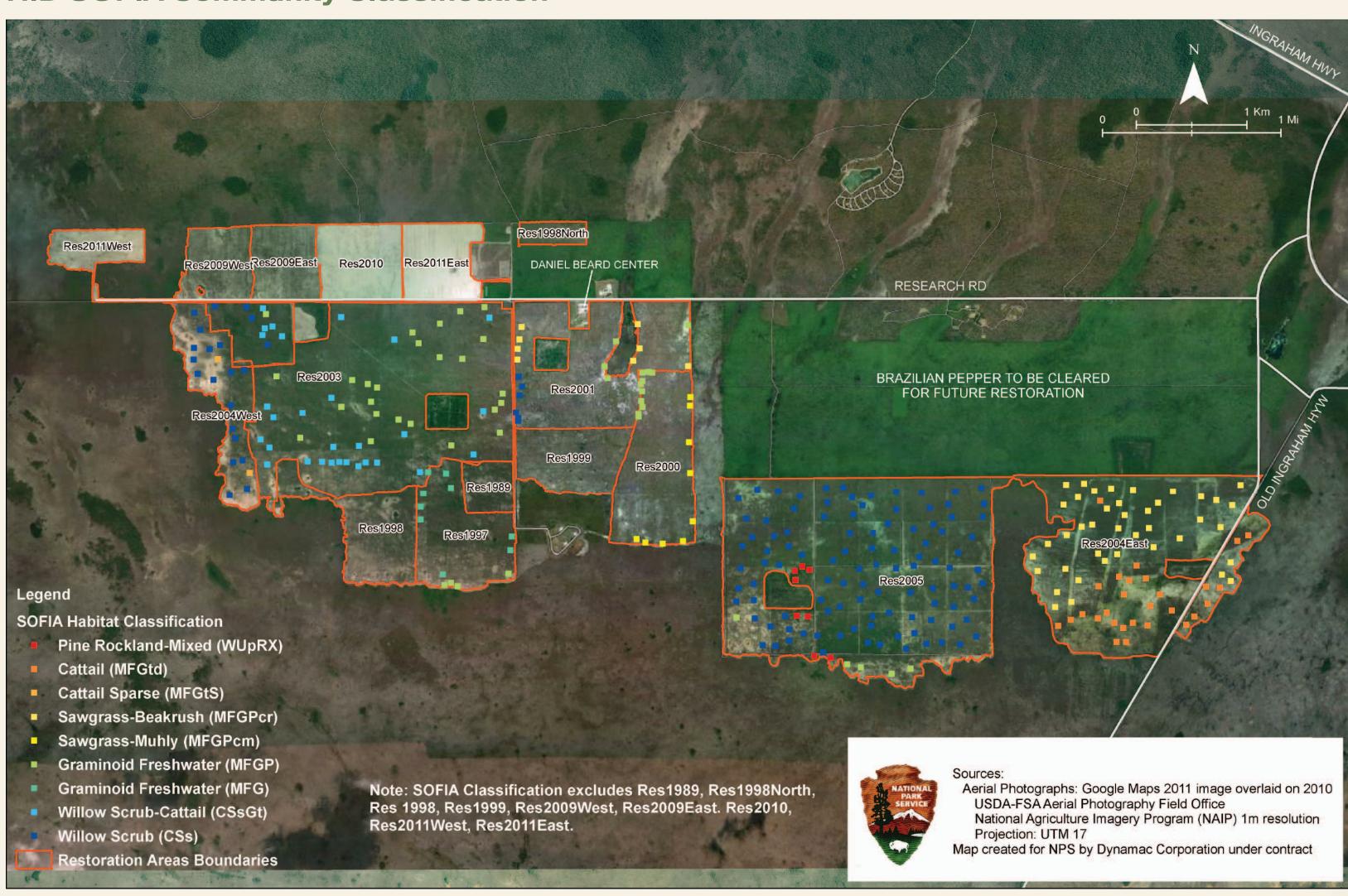
A total of 394 vascular plant species are reported within HID Vegetation Monitoring plots (VMPs) (excluding subspecies or varieties). Of the 394 total vascular plant species, 65 are not native to Everglades National Park, of which 11 are listed by the Florida Exotic Pest Plant Council (FLEPPC) as Invasive, and four (4) as potentially Invasive. Therefore, 84% of the vascular flora within the HID Restoration area VMPs is native. In addition, 20 plant taxa occurring with the HID VMPs are listed by the Florida Department of Agriculture and Consumer Services (FDACS): seven (7) endangered species, and 12 threatened species, and one (1) commercially exploited species

HID SOFIA Community Classification

Legend
SOFIA Habitat Classification
Pine Rockland-Mixed (WUpRX)
Cattail (MFGtd)
Cattail Sparse (MFGtS)
Sawgrass-Beakrush (MFGPcr)
Sawgrass-Muhly (MFGPcm)
Graminoid Freshwater (MFGP)
Graminoid Freshwater (MFG)
Willow Scrub-Cattail (CSsGt)
Willow Scrub (CSs)
Restoration Areas Boundaries

Note: SOFIA Classification excludes Res1989, Res1998North, Res1998, Res1999, Res2009West, Res2009East. Res2010, Res2011West, Res2011East.

South Florida Information Access (SOFIA) Vegetation Community Classes Across Clusters and Hole-In-The-Donut (HID) Restoration Areas (Res) Monitored During 2010 and 2011

SOFIA Raster Class ID	Restoration Area (Res)	Cluster	SOFIA Class ID	SOFIA Name	SOFIA Level
231130	Res2005	1	WUpRX	Pine Rockland-Mixed	5
423000	Res2005	1	CSs	Willow Scrub	3
423000	Res2001	4	CSs	Willow Scrub	3
423000	Res2005	1	CSs	Willow Scrub	3
423000	Res2005	1	CSs	Willow Scrub	3
423024	Res2003	1	CSsGt	Willow Scrub-Cattail	6
522000	Res1997	1	MFG	Graminoid Freshwater Marsh	1
523000	Res2005	1	MFGP	Graminoid Freshwater Prairie	3
523000	Res2000	2	MFGP	Graminoid Freshwater Prairie	3
523000	Res2005	2	MFGP	Graminoid Freshwater Prairie	3
523000	Res2001	3	MFGP	Graminoid Freshwater Prairie	3
523000	Res1997	1	MFGP	Graminoid Freshwater Prairie	3
523200	Res2000	2	MFGPcm	Sawgrass-Muhly	4
523400	Res2004East	2	MFGPcr	Sawgrass-Beakrush	4
523400	Res2001	3	MFGPcr	Sawgrass-Beakrush	4
522720	Res2004East	2	MFGtd	Cattail	4
522730	Res2004West	2	MFGtS	Cattail Sparse	4

Preliminary and qualitative comparisons of the wetland community types to SOFIA (http://sofia.usgs.gov) class plant species assemblages are indicating that the following nine (9) wetland plant community types are present in the Restored HID, as of 2011 data. Further monitoring of the Restored HID areas this year will yield more refinement and different acreages. Land management practices (e.g., prescribed fire) contribute to the distribution and quantity of these various wetland community sub-classes.

SOFIA Description

SOFIA Class ID	SOFIA Raster ID	SOFIA Name	SOFIA Level	SOFIA Description
CSs	423000	Willow Scrub	3	Willow (Salix caroliniana) characterized by canopy densities from 10% - 49% in a matrix of graminoids and/or herbaceous vegetation.
CSsGt	423024	Willow Scrub-Cattail	6	Willow (Salix caroliniana) scrub in a matrix composed predominately of Cattail (Typha spp.).
MFG	522000	Graminoid Freshwater Marsh	3	Graminoid dominated freshwater marsh.
MFGP	523000	Graminoid Freshwater Prairie	3	Short hydroperiod marsh characterized by a mix of graminoids that includes low-stature sawgrass (Cladium jamaicense), Muhly Grass (Muhlenbergia capillaris var. filipes), Little Bluestem (Schizachyrium scoparium), Gulfdune Paspalum (Paspalum monostachyum), Beakrush (Rhynchospora spp.), Black Sedge (Schoenus nigricans), among others.
MFGPcm	523200	Sawgrass-Muhly	4	Co-dominant mix of low stature Sawgrass (Cladium jamaicense) and Muhly Grass (Muhlenbergia capillaris var. filipes) dominated wet prairie (i.e., short hydroperiod marsh).
MFGPcr	523400	Sawgrass-Beakrush	4	Co-dominant mix of low stature Sawgrass (Cladium jamaicense) and Beakrush (Rhynchospora spp.).
MFGtd	522720	Cattail	4	Southern Cattail (Typha domingensis) and/or Broadleaf Cattail (T. latifolia) dominated marsh. 50% to 89% areal coverage of Cattail.
MFGts	522730	Cattail Sparse	4	10% to 49% areal coverage of Cattail.
WUpRX	231130	Pine Rockland-Mixed	5	Pine Rockland in a matrix composed of a co-dominant mix (60/40% split) of graminoids and shrubs.

Dendrogram Cluster Five Highest Dominant Species (1 being the most dominant) Per Elevation Gradient Category per Restoration Area (Res) for Monitoring Event Years 2009 & 2010.

Restoration Area (Res)	Cluster	Elevation Gradient Category	Species - 1	Species - 2	Species - 3	Species - 4	Species - 5
Res2003	1	High Elev (1)	Baccharis glomeruliflora	Salix caroliniana	Thelypteris kunthii	Andropogon glomeratus	Pityrogramma trifoliata
Res2000	1	High Elev (1)	Ludwigia microcarpa	Baccharis glomeruliflora	Rhynchospora odorata	Centella asiatica	Eragrostis elliottii
Res2001	1	High Elev (1)	Rhynchospora microcarpa	Ludwigia microcarpa	Cladium jamaicense	Rhynchospora odorata	Eragrostis elliottii
Res2003	2	High Elev (2)	Eragrostis elliottii	Eleocharis geniculata	Ludwigia microcarpa	Fimbristylis cymosa	
Res2005	2	High Elev (2)	Cladium jamaicense	Myrica cerifera	Baccharis glomeruliflora	Pinus elliottii	Rhynchospora divergens
Res2001	2	High Elev (2)	Centella asiatica	Paspalum monostachyum	Rhynchospora microcarpa	Panicum rigidulum	Pluchea rosea
Res2000	3	High Elev (3)	Muhlenbergia capillaris	Rhynchospora divergens	Cladium jamaicense	Rhynchospora microcarpa	Ludwigia microcarpa
Res2001	4	High Elev (3)	Centella asiatica	Eleocharis cellulosa	Ludwigia curtissii	Panicum rigidulum	Salix caroliniana
Res2005	1	High Elev (3)	Typha domingensis	Phyla nodiflora	Ludwigia microcarpa	Panicum rigidulum	Sagittaria lancifolia
Res2004West	1	High Elev (3)	Andropogon glomeratus	Andropogon glomeratus	Salix caroliniana	Ludwigia repens	Andropogon virginicus
Res2005	3	High Elev (3)	Eragrostis elliottii	Rhynchospora microcarpa	Eragrostis elliottii	Rhynchospora microcarpa	Eragrostis elliottii
Res2004East	2	Mid - Low Elev (4)	Rhynchospora microcarpa	Paspalum monostachyum	Eleocharis cellulosa	Typha domingensis	Panicum rigidulum
Res2004West	2	Mid - Low Elev (4)	Ludwigia repens	Proserpinaca palustris	Typha domingensis	Panicum rigidulum	Sagittaria lancifolia
Res1997	1	Mid - Low Elev (4)	Rhynchospora microcarpa	Rhynchospora divergens	Baccharis glomeruliflora	Conoclea coelestinum	Lycopodium cernuum
Res1997	1	Mid - Low Elev (4)	Centella asiatica	Rhynchospora microcarpa	Rhynchospora microcarpa	Andropogon virginicus	Dichanthelium erectifolium
Res2004East	1	Low Elev (5)	Typha domingensis	Eleocharis cellulosa	Utricularia purpurea	Utricularia cornuta	Utricularia gibba

Conclusion

Elevation surveys, biological monitoring, and biogeochemical research conducted by the HID ILF project restoration team validates that wetland functions have been returned to 4,410 acres of previously farmed land in the HID ILF. The HID-ILF funds long-term biological monitoring to document the ILF restoration project's capacity to restore biological wetland functions that were previously lost prior to NPS acquisition of the HID. Restored areas in the HID exhibit favorable species composition, colonization, and formation trends.

Data analyses demonstrate that National Park Service land management practices are successful at restoring the HID into functioning, freshwater herbaceous-dominated wetlands, with less than 0.30% nuisance, non-native (all FLEPPC Category I and II designated species) aggregate cover.