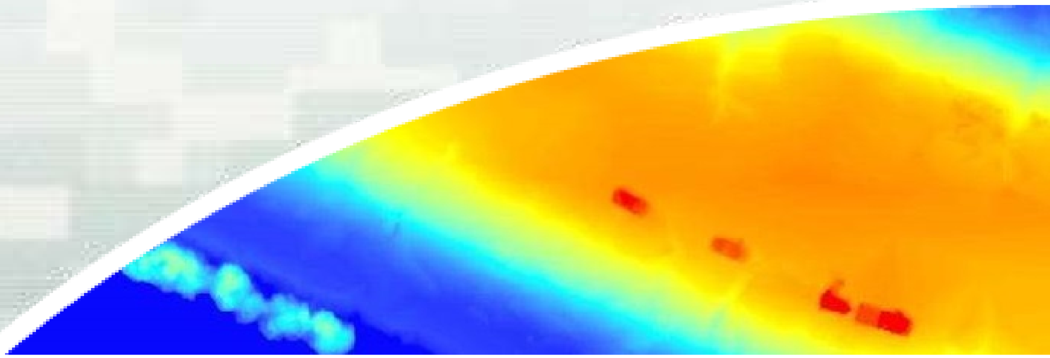
Utilization of Unmmaned Aerial Systems (UAS) for Vegetation Mapping and Restoration

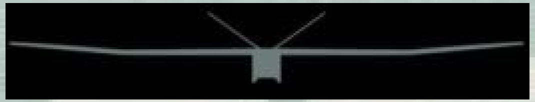


Jon Morton

Invasive Species Management Branch

South Florida Restoration Office

West Palm Beach, Florida



Jacksonville District UAS team

UNCLASSIFIED

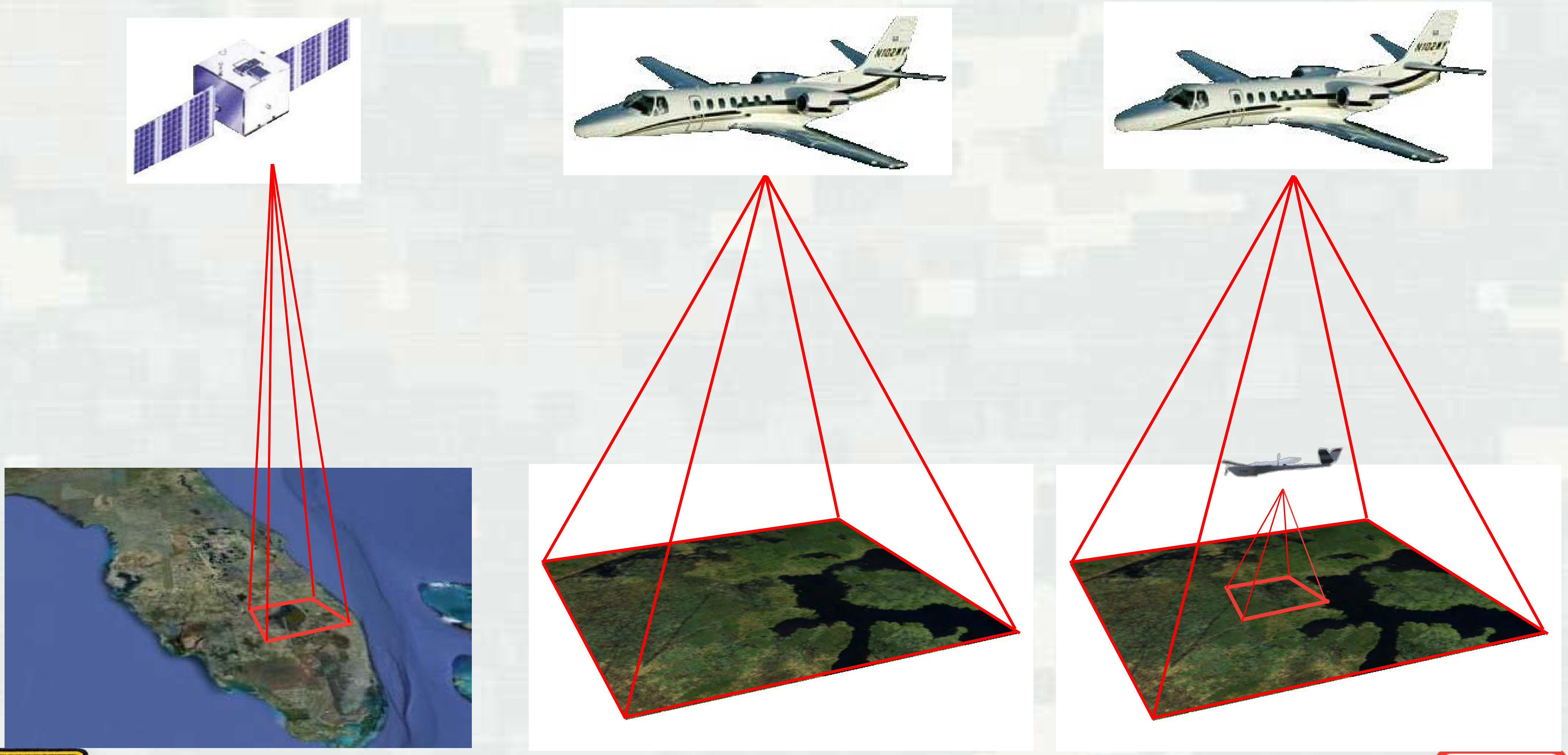
US Army Corps of Engineers
BUILDING STRONG®

UAV – THE NEED

- High resolution imagery for invasive species management and environmental restoration
- High temporal resolution (ability to quickly reacquire)
- Waterproof landing
- Responsive to users
- Sufficient payload capacity for future development

USACE Program Mission

Provide a Reliable Data Collection Tool to Support Aerial Mapping and Environmental Reconnaissance Missions



Airframe Evolution

- Airframe development
- “Truck” for geospatial payload

2006-2008: Polaris

2008-2009: Shoe/NOVA

2009-2010: NOVA/NOVA Block II

NOVA System

NOVA System Components

NOVA BLOCK III

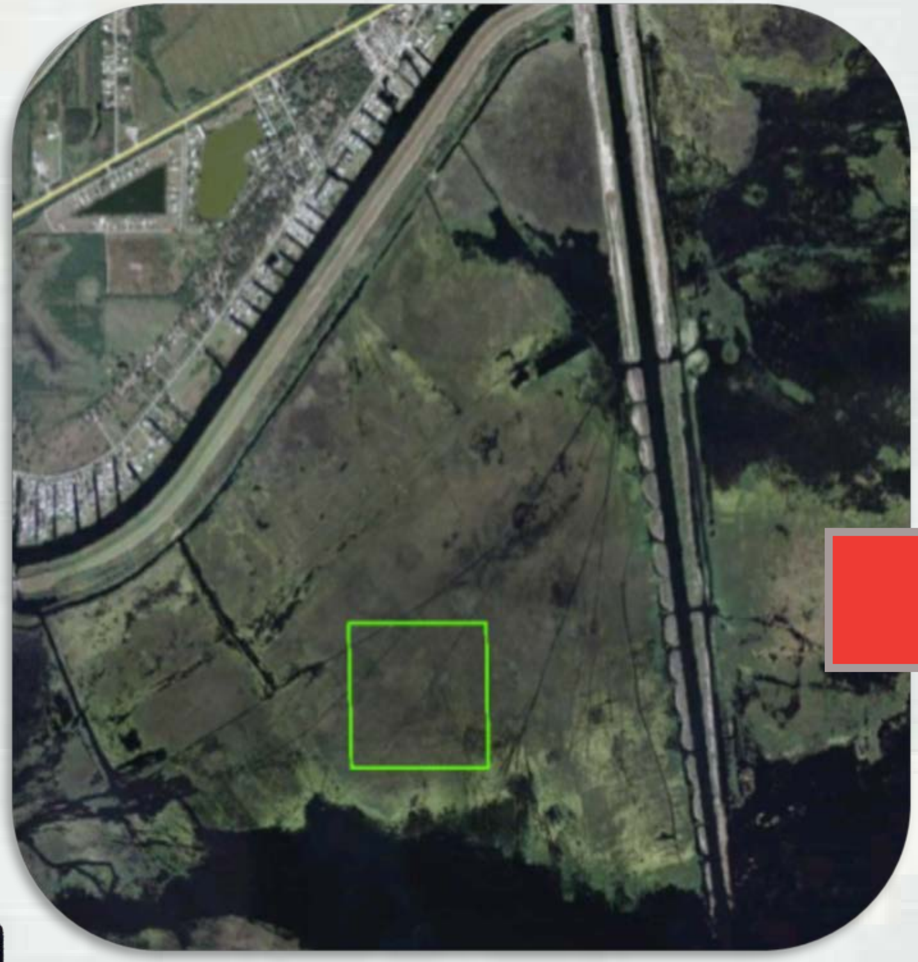
- “Commercialized” version of the Block II
- 6 cell lithium battery
- Connection improvements
- Established safety record with AED
- Procerus Kestrel Autopilot

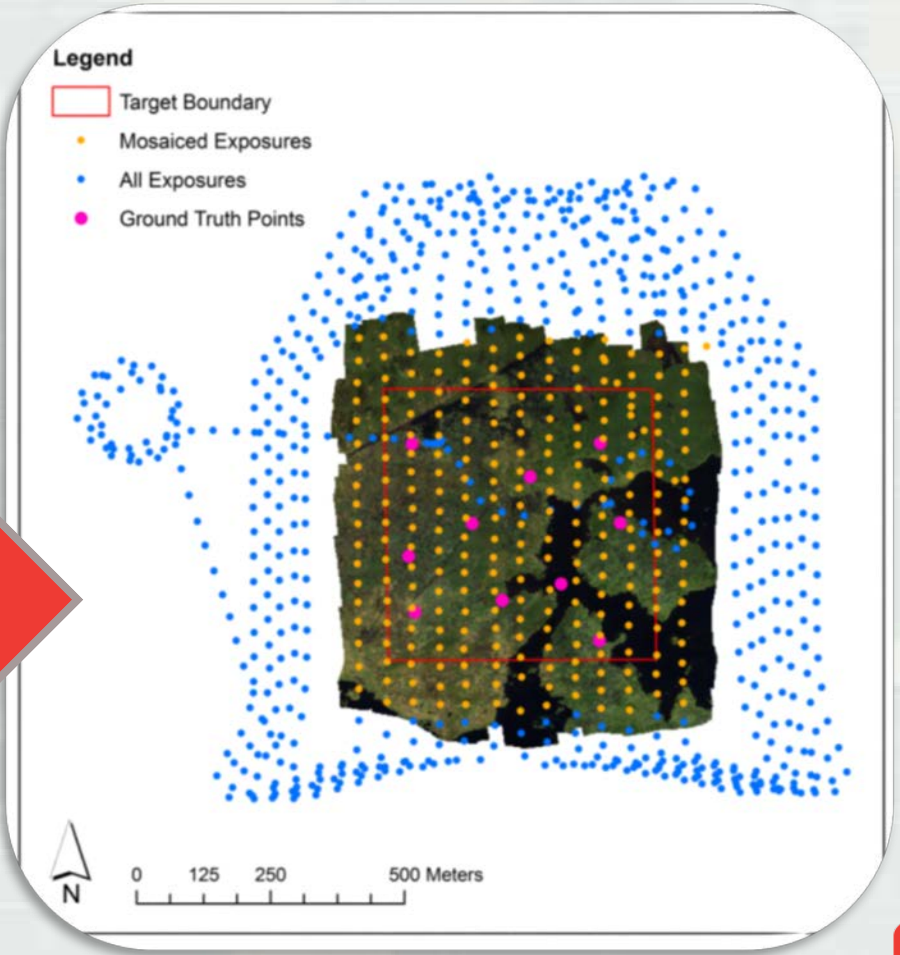
NOVA Specifications

- Fully Autonomous
- 2.7 m Wingspan
- 15 lbs. w/ Payload
- ~750 acres per lift @ 300m altitude
- ~50 kilometers per lift @ 300m altitude
- ~3.5cm @ 300m altitude
- Absolute spatial accuracy typically 2-4 meters (no ground control)
- Block II = 60 minute duration
- Block III = 90 minute duration

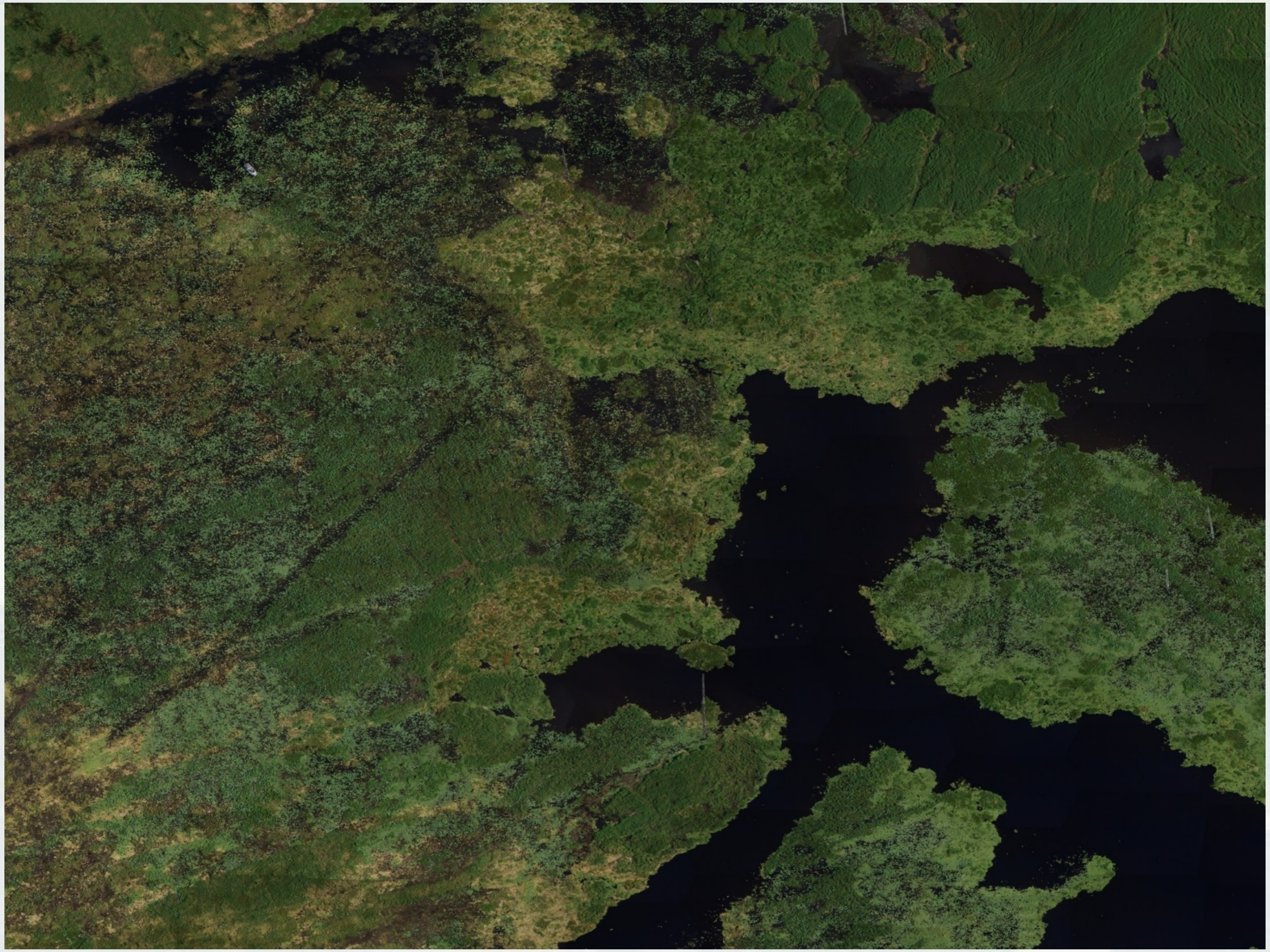
NOVA - Airboat Launch

Image Capture



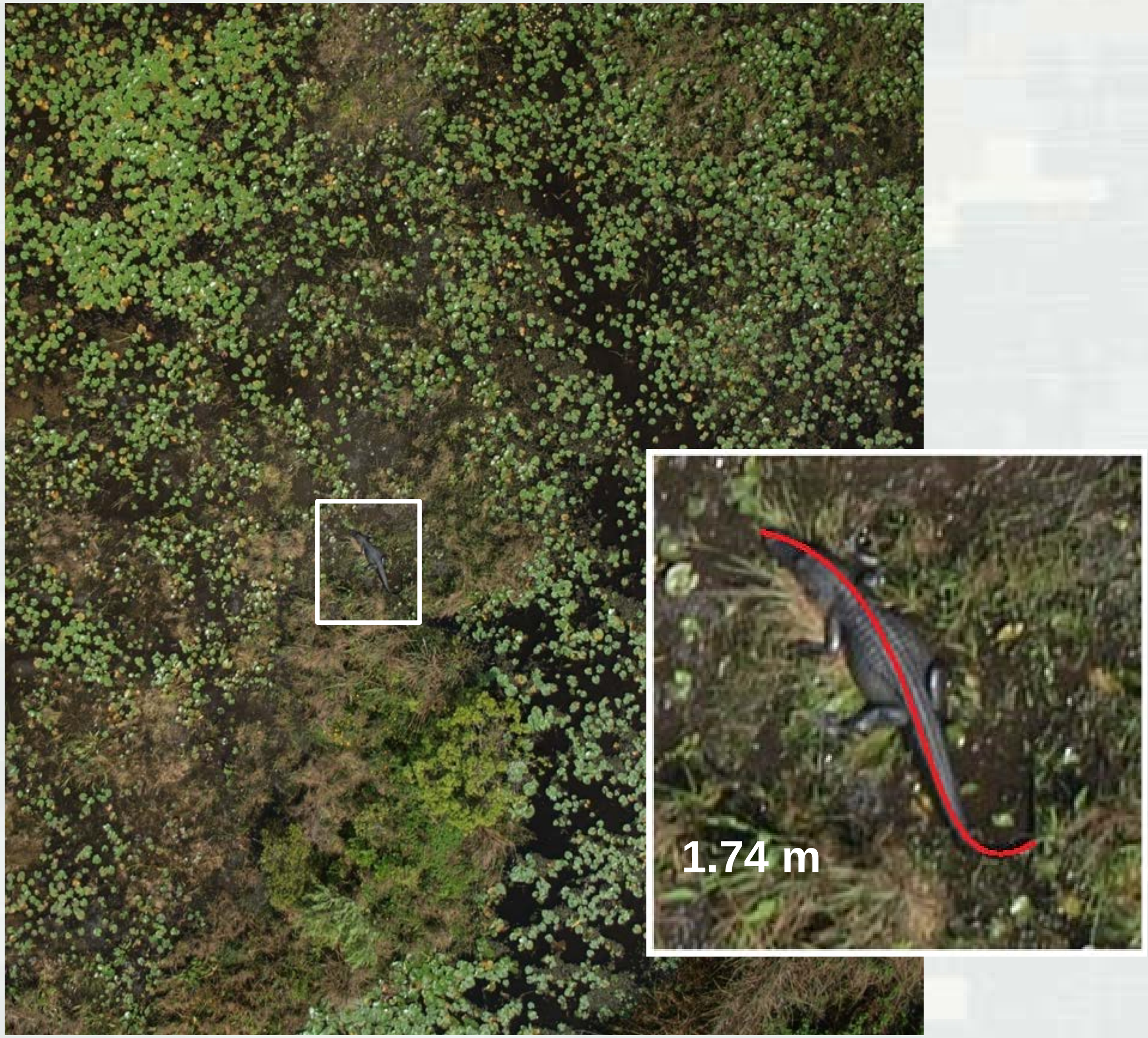


High Resolution Mosaic – 250 images



Mosaic Enlargement

Spatial Measurement




500%

Constraints

Constraints

We only fly in approved airspace, typically:

•Below 1200'
•5 nm outside of airports
•30 nm for large airports (MIA, TPA).
•Flight in this airspace possible, requires COA

AR 70-62 requires AWR:

•Airworthiness Qualification Level (AQL) 3
•Not undergone rigorous airworthiness qualification
•Avoid flying over people, roads, homes, etc.
•Limited to Line Of Sight operation (LOS)
•Depends on conditions, typically 1.5km

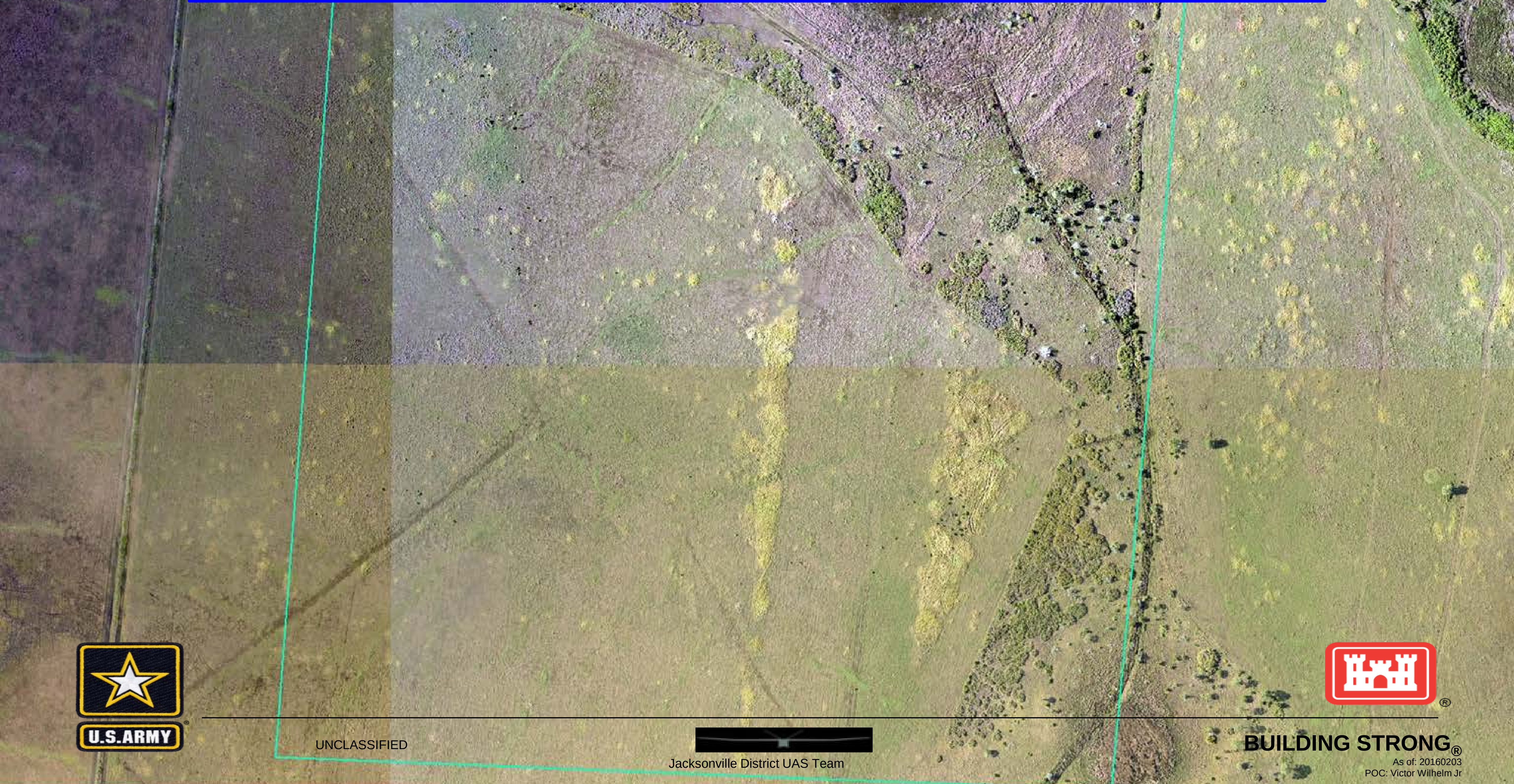
Airspace

Class G Airspace = GOOD for the most part.

NOVA: Applications

- Pre/active/post construction monitoring
- Asset/infrastructure management
- ***Invasive species surveillance and monitoring***
- ***Vegetation community mapping***
- ***Environmental restoration/engineering***

Untreated Cogongrass (Imperata cylindrical)



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Jacksonville District UAS Team

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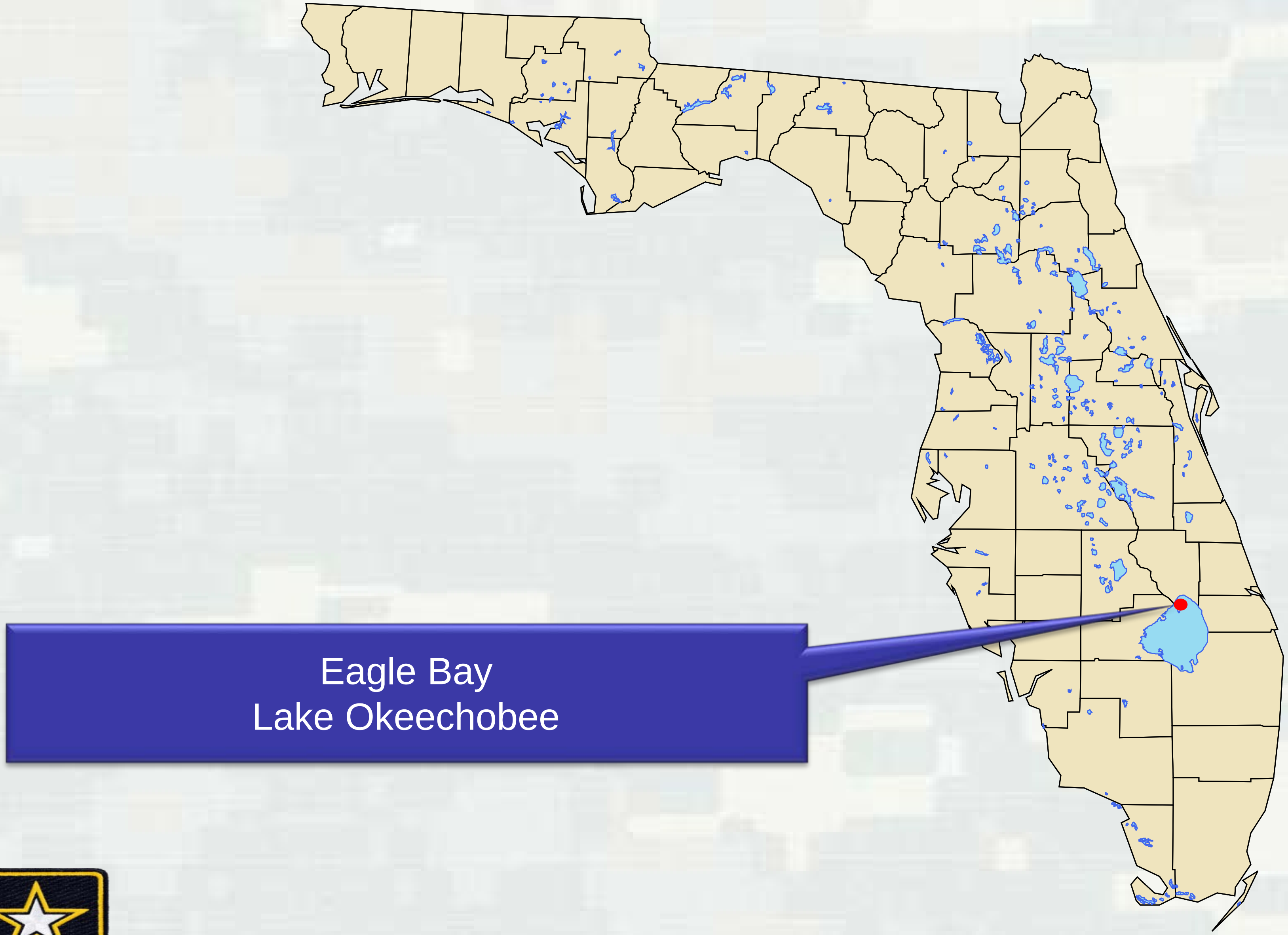
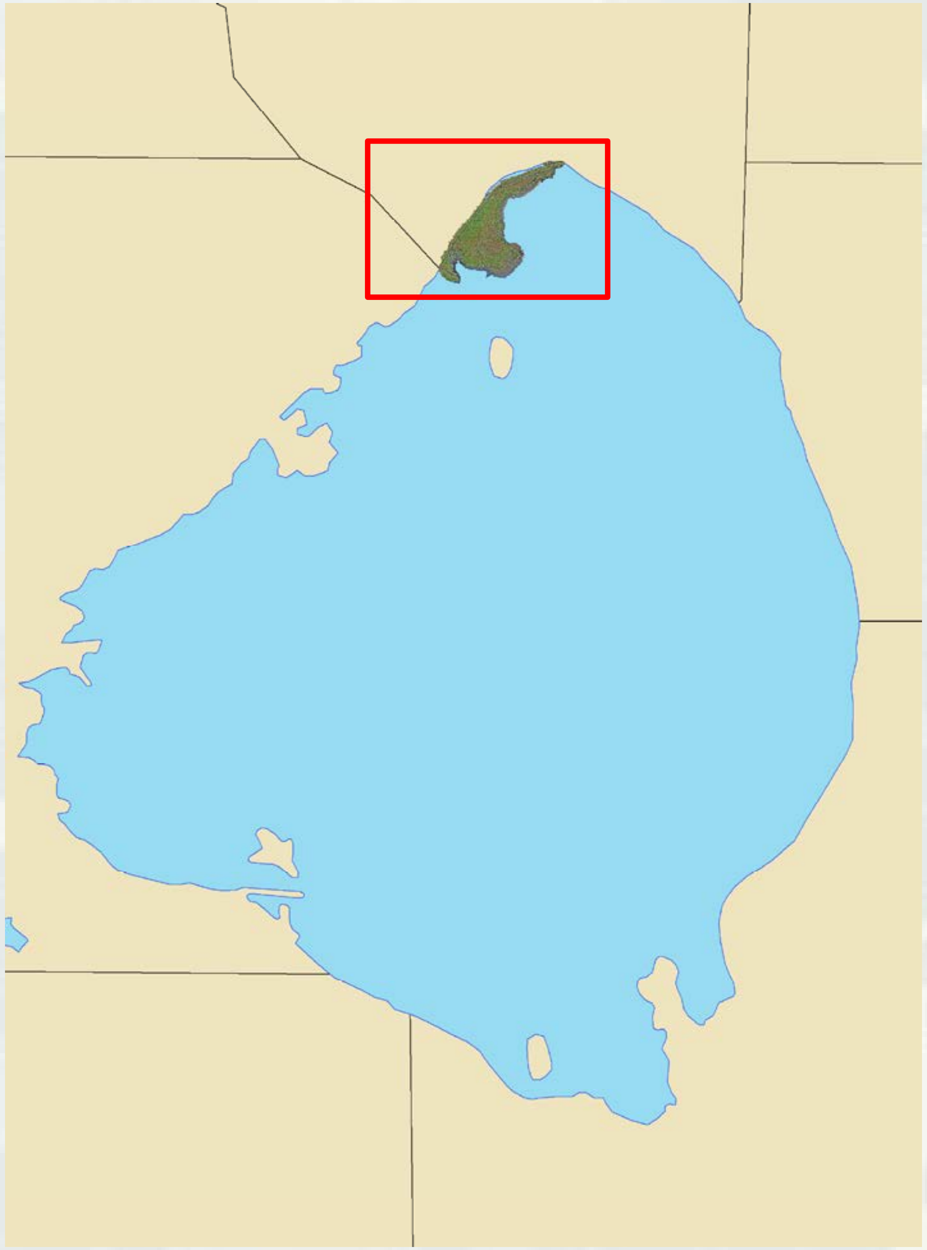
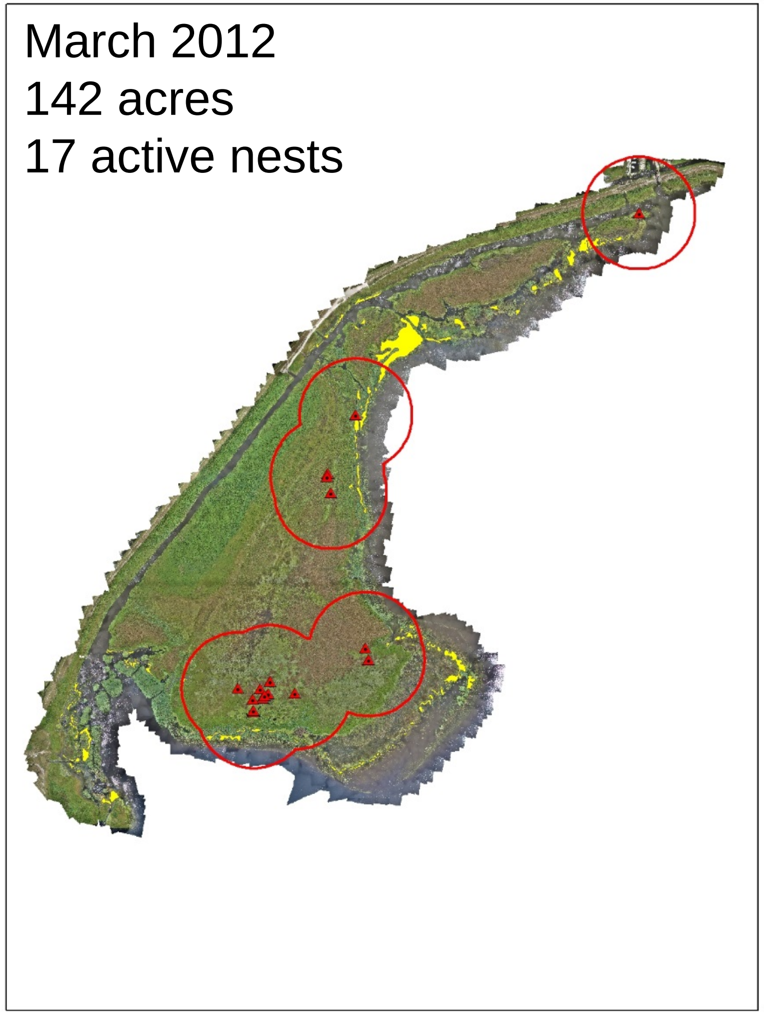
As of: 20160203

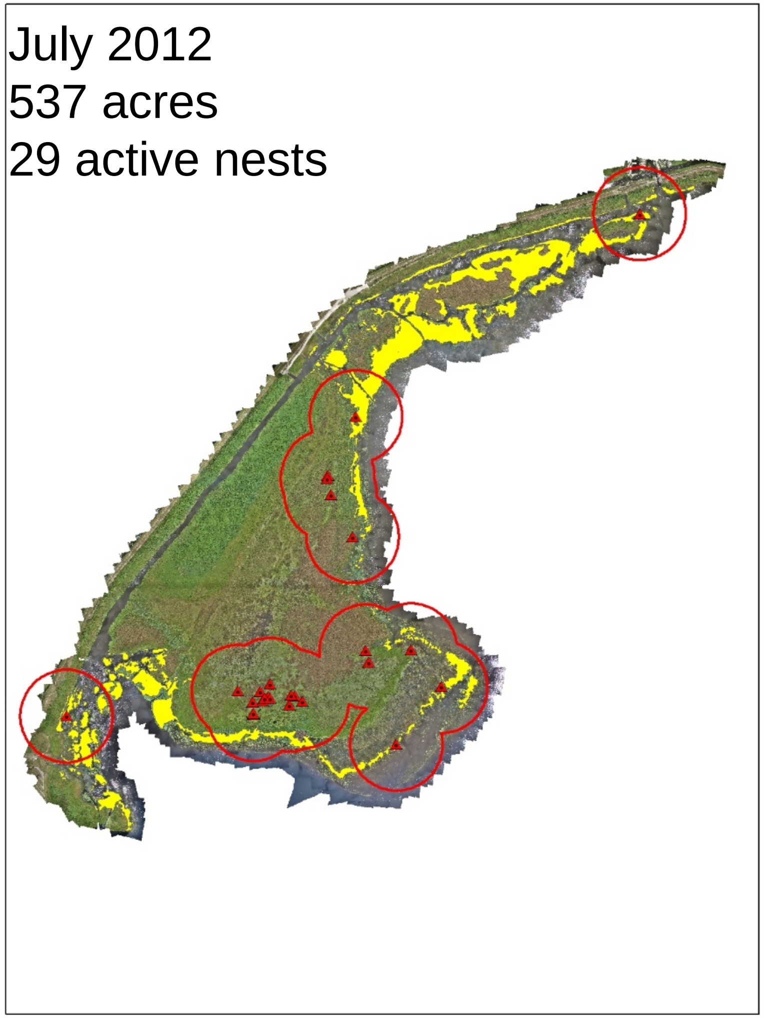
POC: Victor Wilhelm Jr

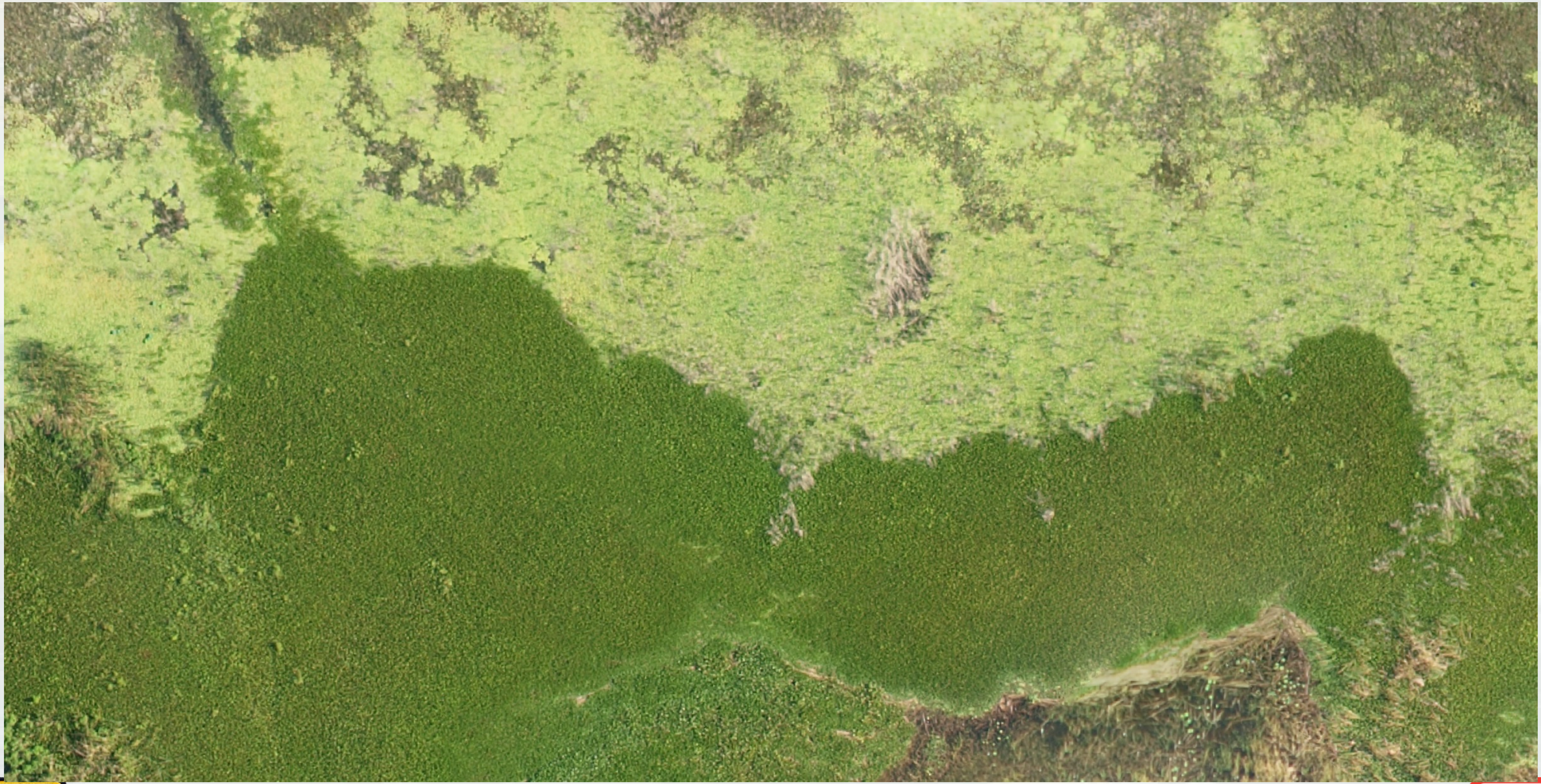

Eagle Bay
Lake Okeechobee



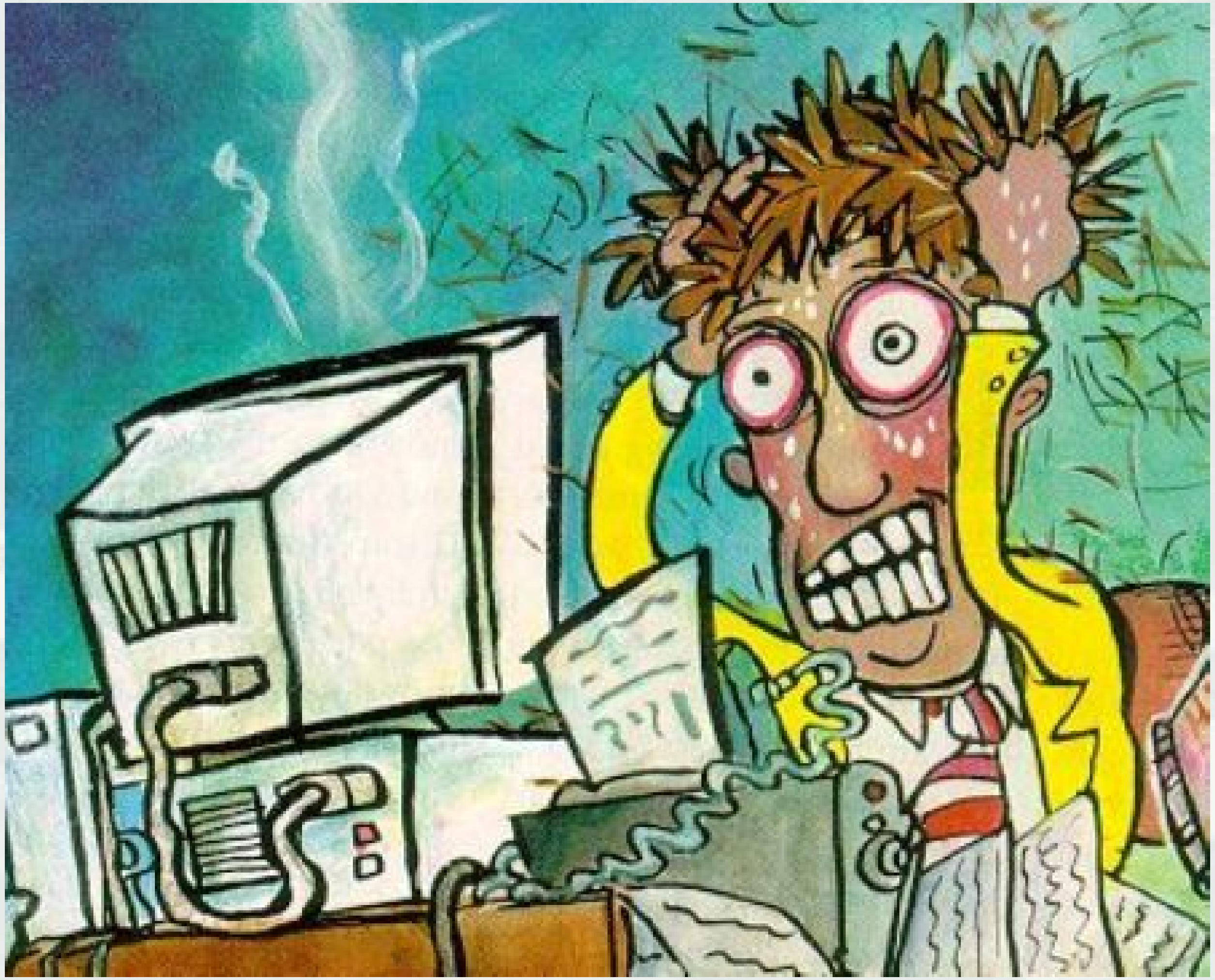
Invasive Species Management/Everglades Snail Kite Nesting Area



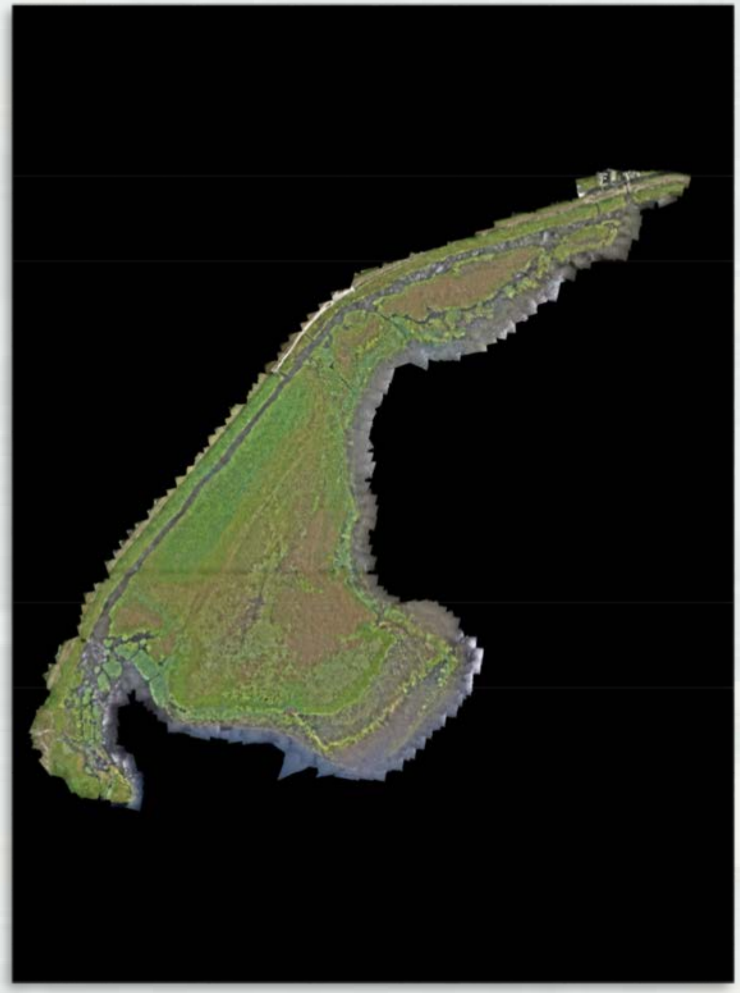




The need for auto-classification



Research



Dr Amr Abd-Elrahman, PhD
Geomatics Lead
University of Florida
Gulf Coast Research & Education Center

Roshan Pande, Post-Doc

Tao Liu, Post-Doc

Object-based Classification

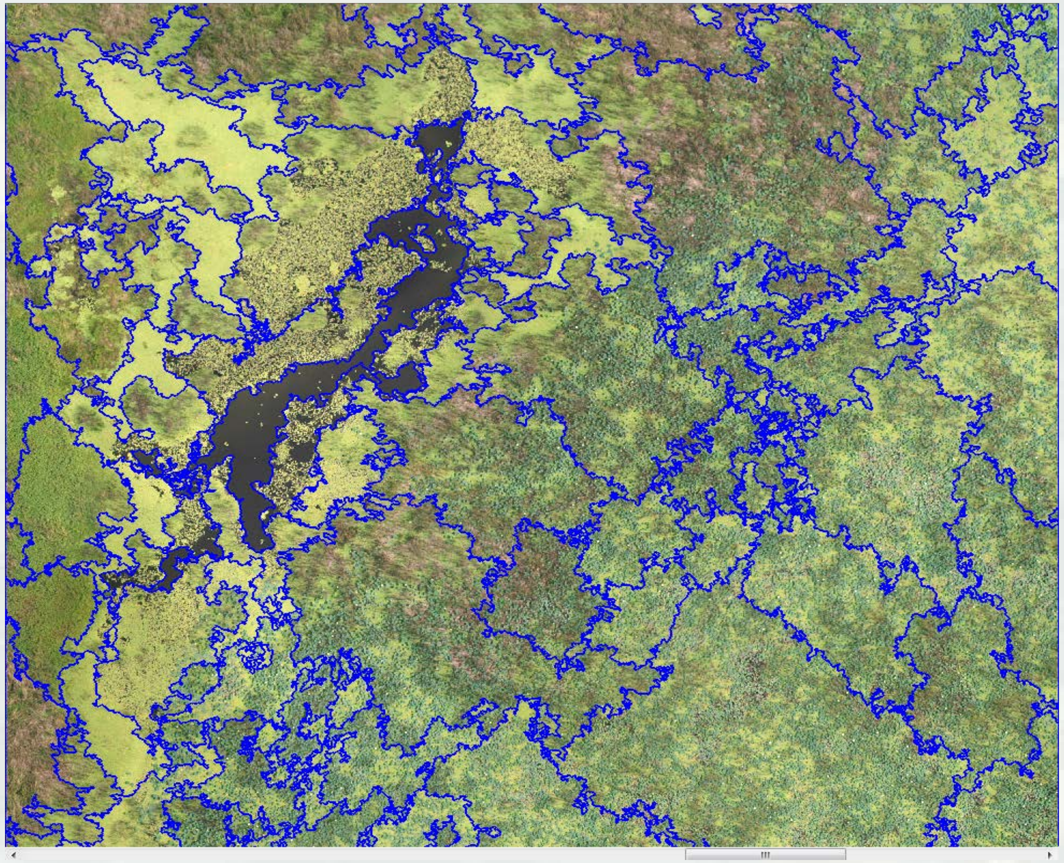
Goal:

- Map Invasive plants using spectral, textural and contextual object-based classification

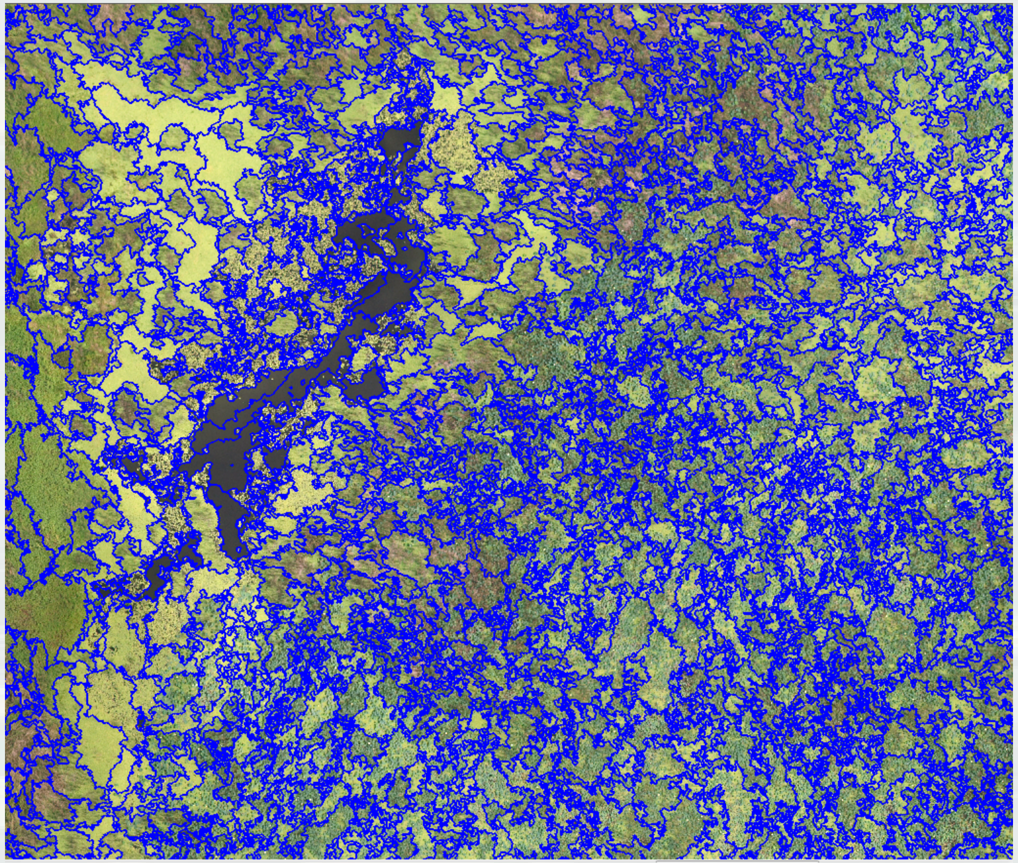
Objectives:

- Identify best spectral and textural features and segmentation scale(s)
- Test different machine learning classifiers e.g. Regression Tree (CART), Support Vector Machine (SVM), and Artificial Neural Network (ANN)
- Develop spectral, textural and contextual rules based on multi-scale segmentation

Examples of Segmentation at different scales

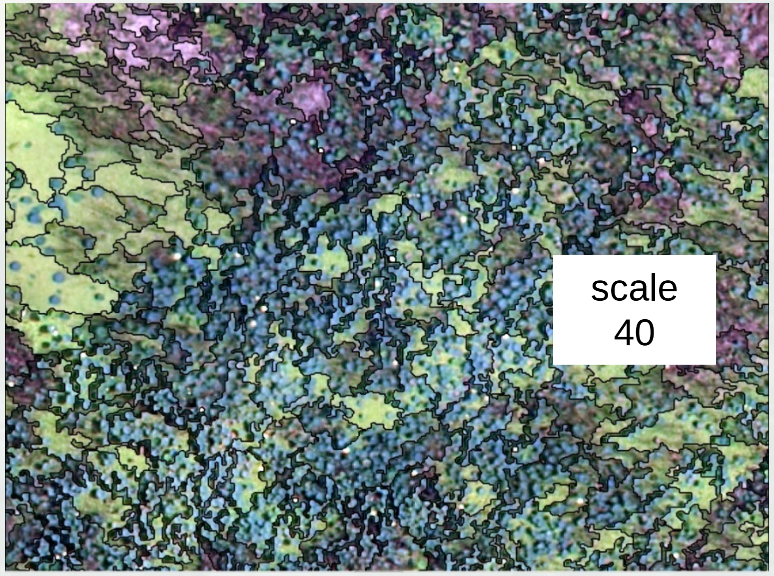


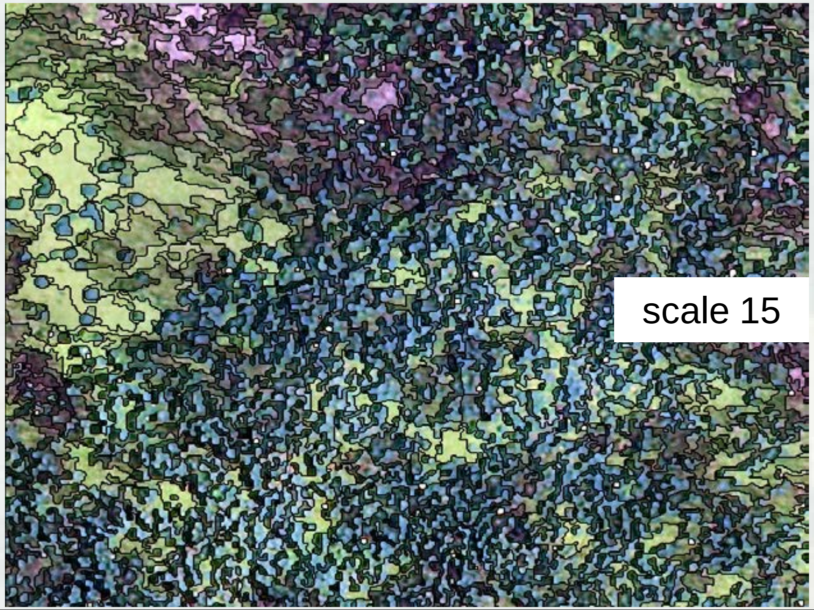
Segmentation : course (300) scale

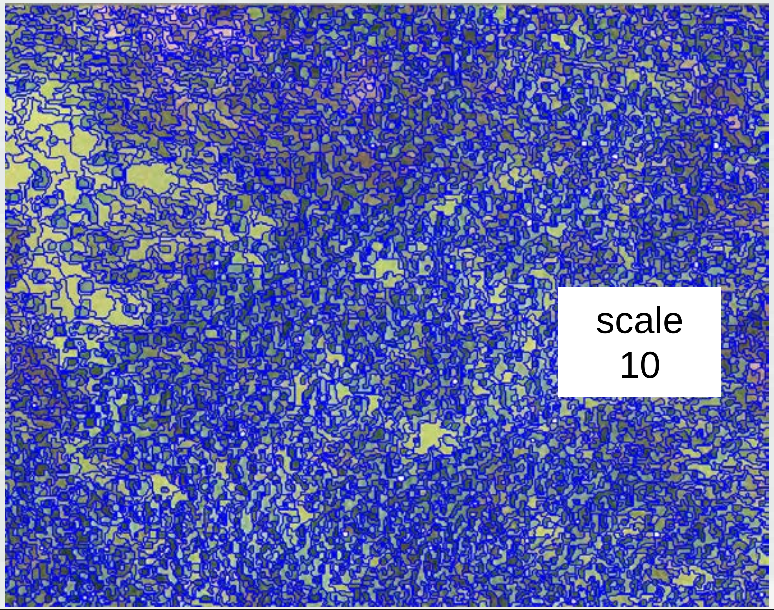


Segmentation: medium (75)scale


Original


scale
40


scale 15


scale
10

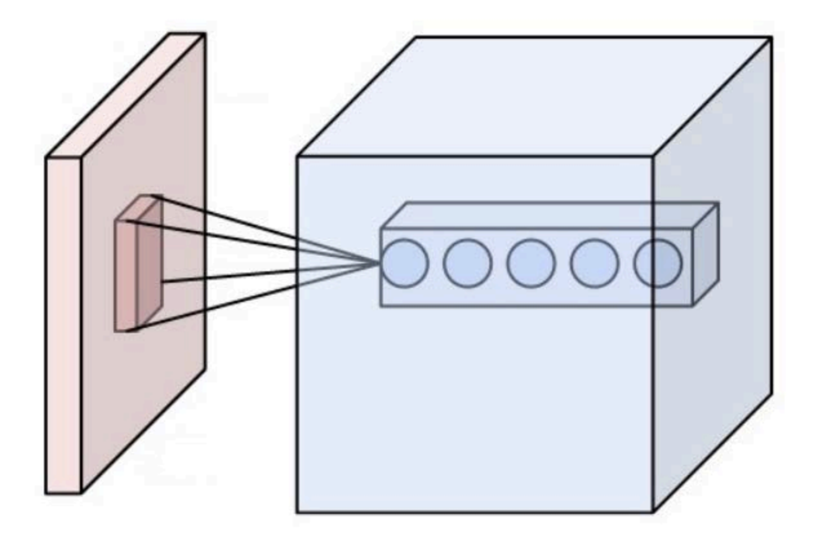
Accuracy Assessment

- Classified maps were matched against assessment data set and error matrices were developed.
- Accuracy values (overall accuracy and Kappa coefficients) were computed and used for assessment and comparison.

Classifier	Overall	Kappa
SVM	70.32%	0.654
ANN	69.44%	0.643
M L	58.18%	0.516
Pixel based SVM (downsized)	57.37%	0.513
Pixel based ML	50.94%	0.451
Pixel based ANN	53.62%	0.476

Classification Using Convolutional Neural Network(CNN)

- One type of feed-forward artificial neural network
- Workhorse for a lot of recording-breaking deep learning frameworks for computer vision tasks



https://en.wikipedia.org/wiki/Convolutional_neural_network

Distinguish features:

3D volumes of neurons

One single layer can be extended to multiple layers

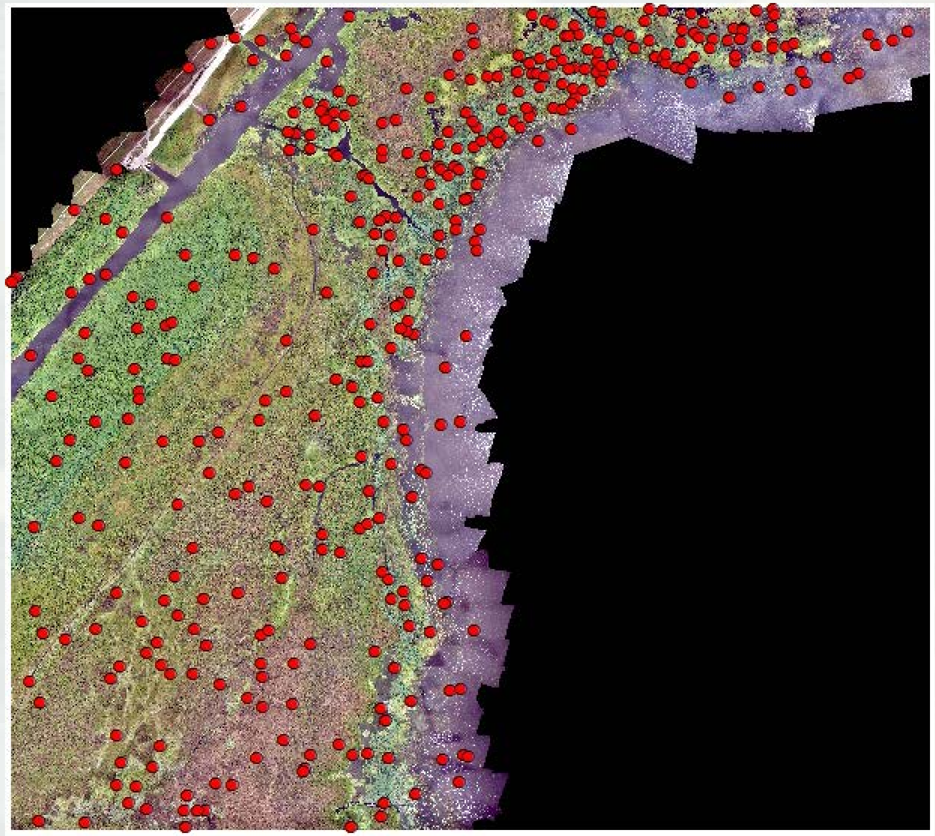
Local connectivity

Allow locally learned features to combine together to represent global feature

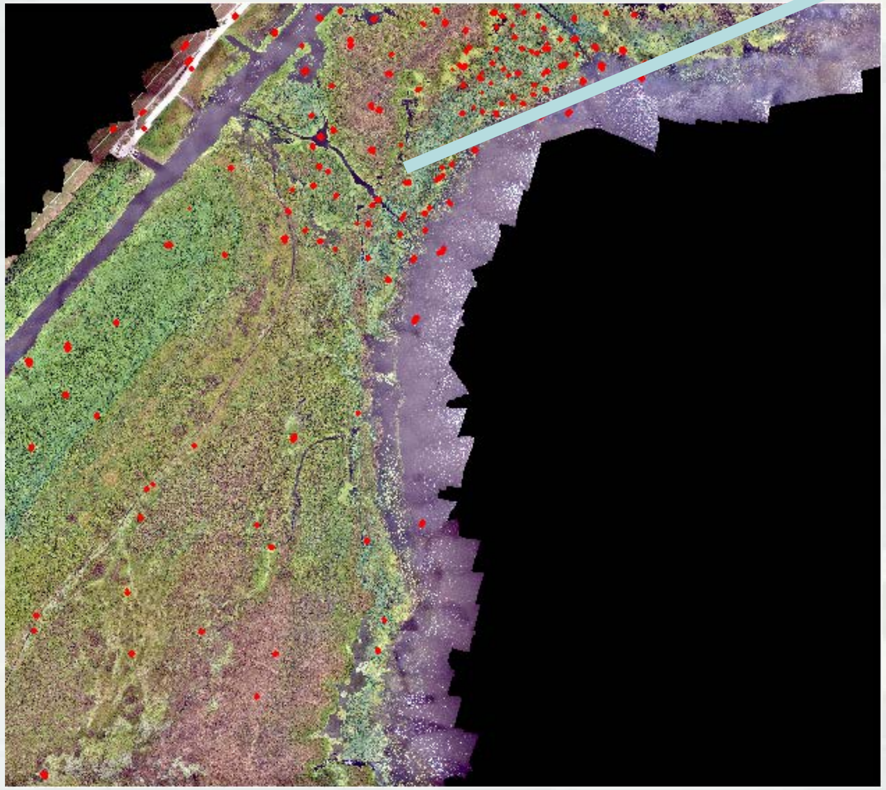
Shared weights

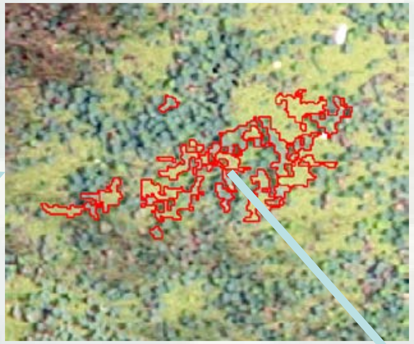
Each filter is applied to the entire image to create one layer

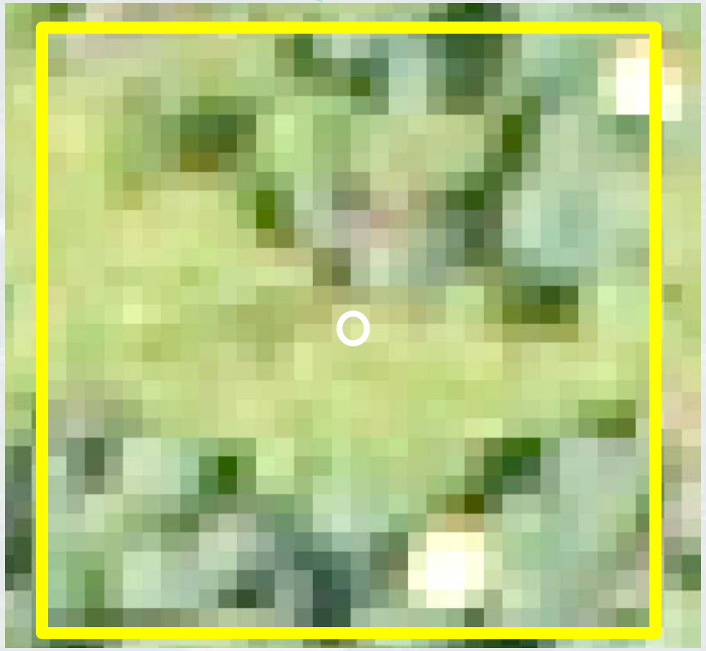
Second Testing Set



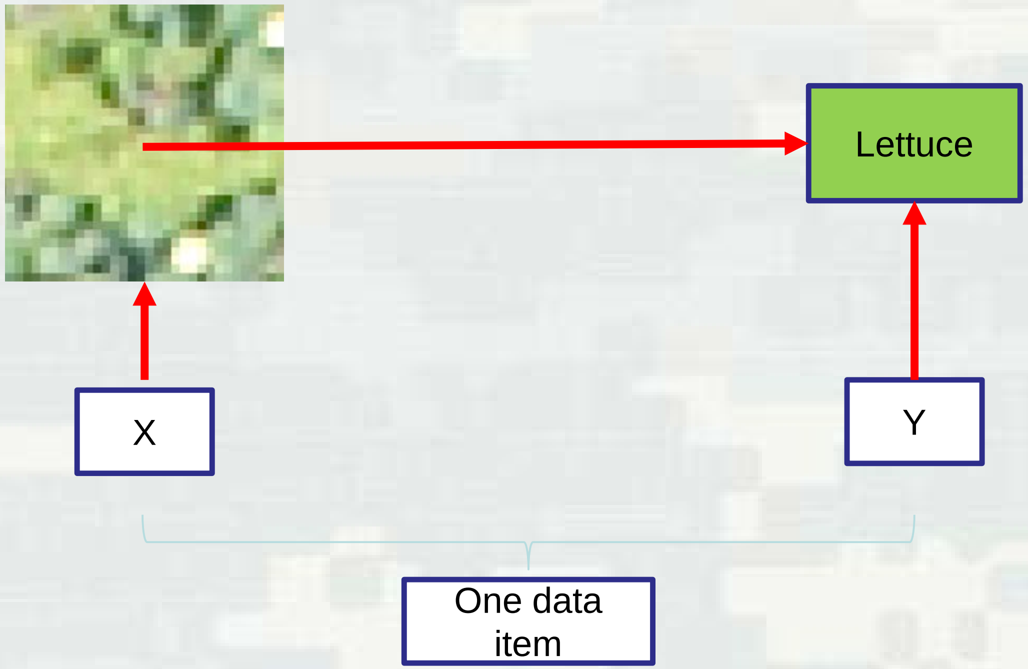
Extract training data







One data item



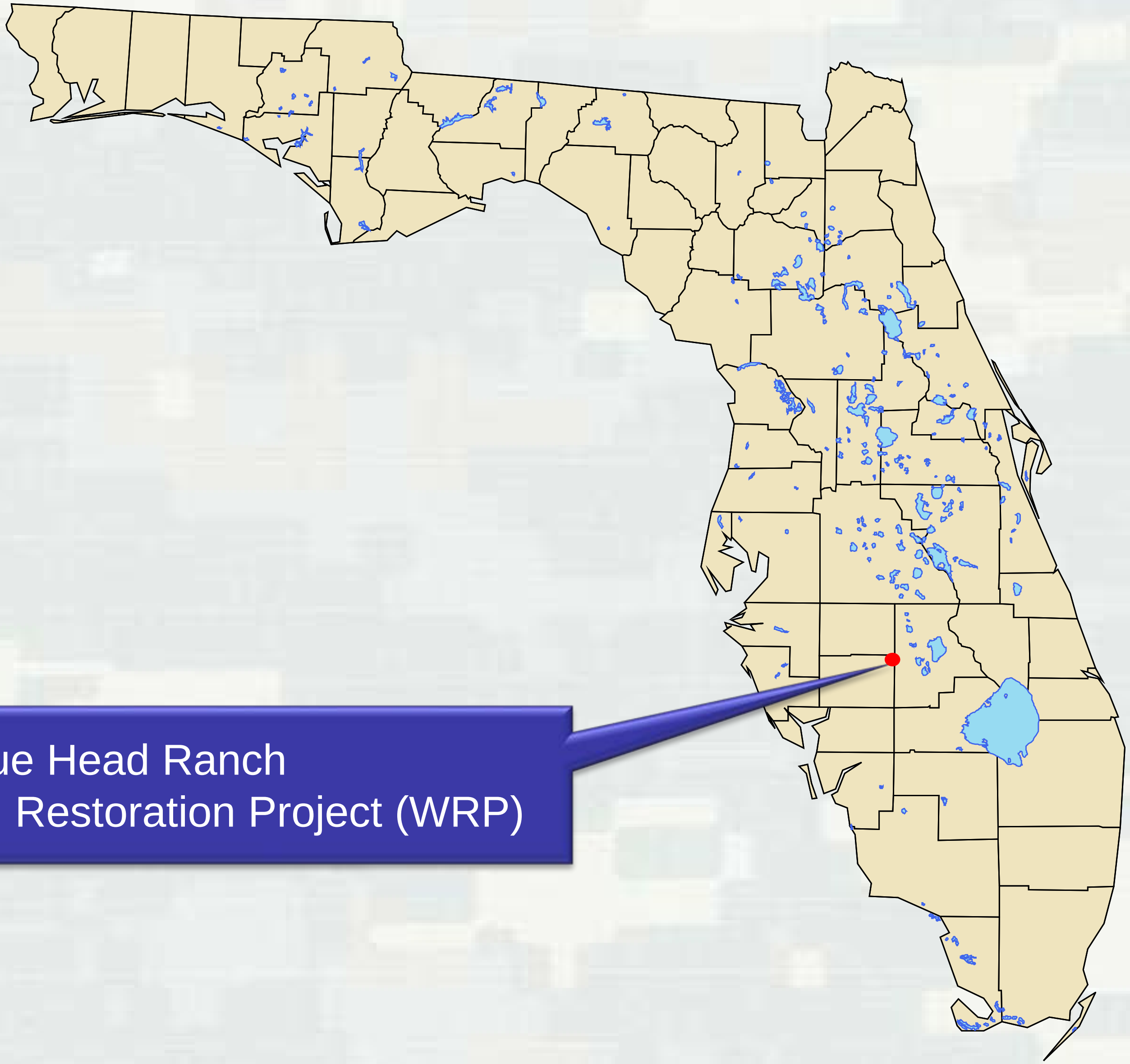
Result

Table 1 Accuracy of CNN result of first testing set

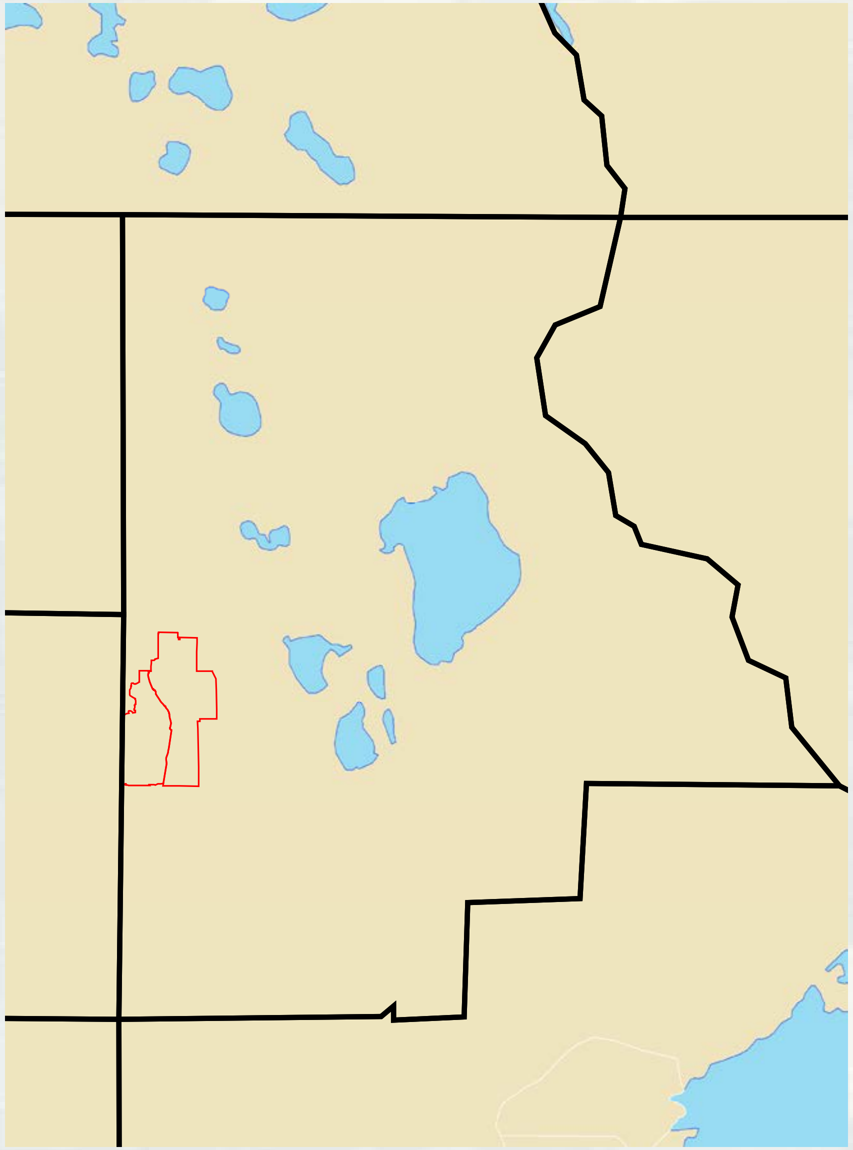
Approach	Overall Accuracy
CNN approach based on the first testing data set	79.88%
Best accuracy of object approach on the second testing data set	70.78%

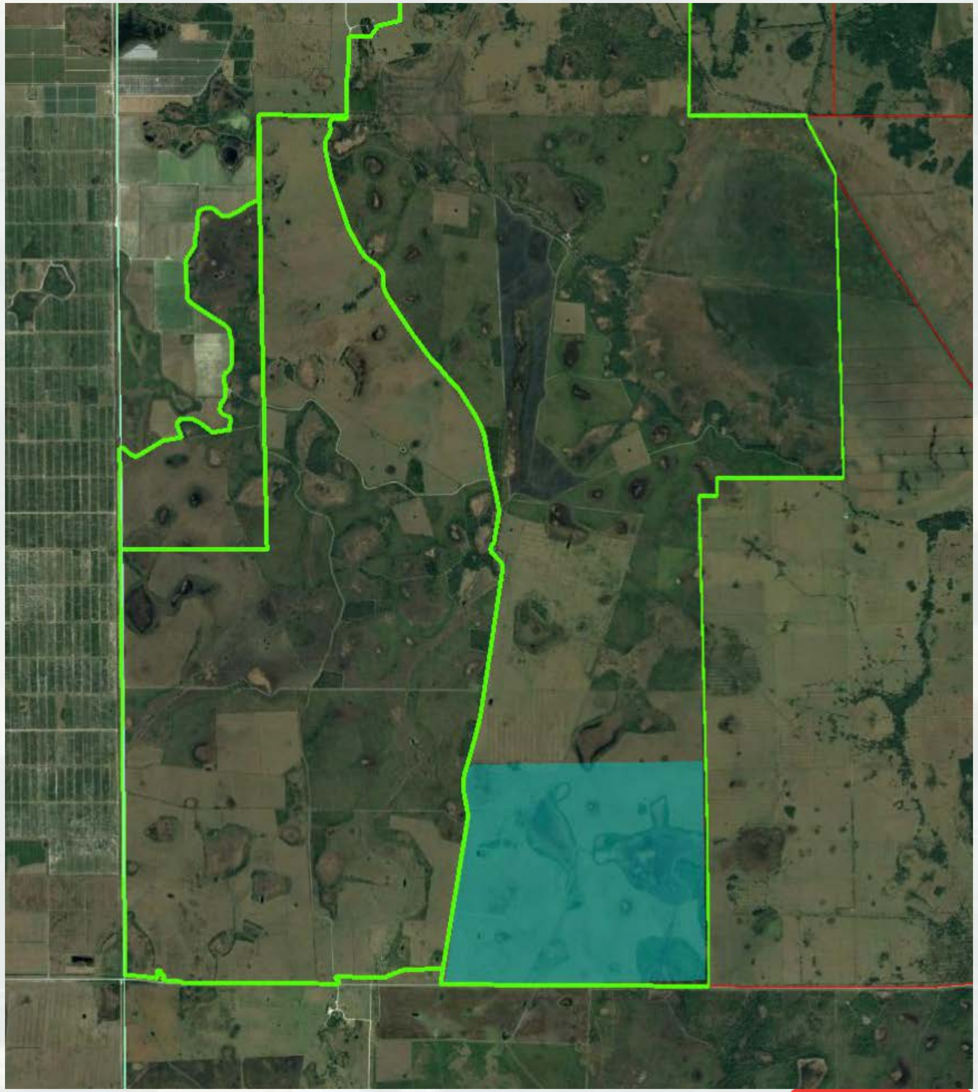
Approach	Classifier	Overall accuracy	Kappa coeff.
Object based	SVM	70.78%	0.659
	ANN	69.44%	0.643
	ML	58.18%	0.512
Pixel based on high resolution (8 cm) images	SVM	56.84%	0.503
	ANN	50.94%	0.441
	ML	53.62%	0.471
Pixel based on low resolution (30 cm) image	SVM	61.93%	0.560
	ANN	53.89%	0.474
	ML	52.81%	0.464

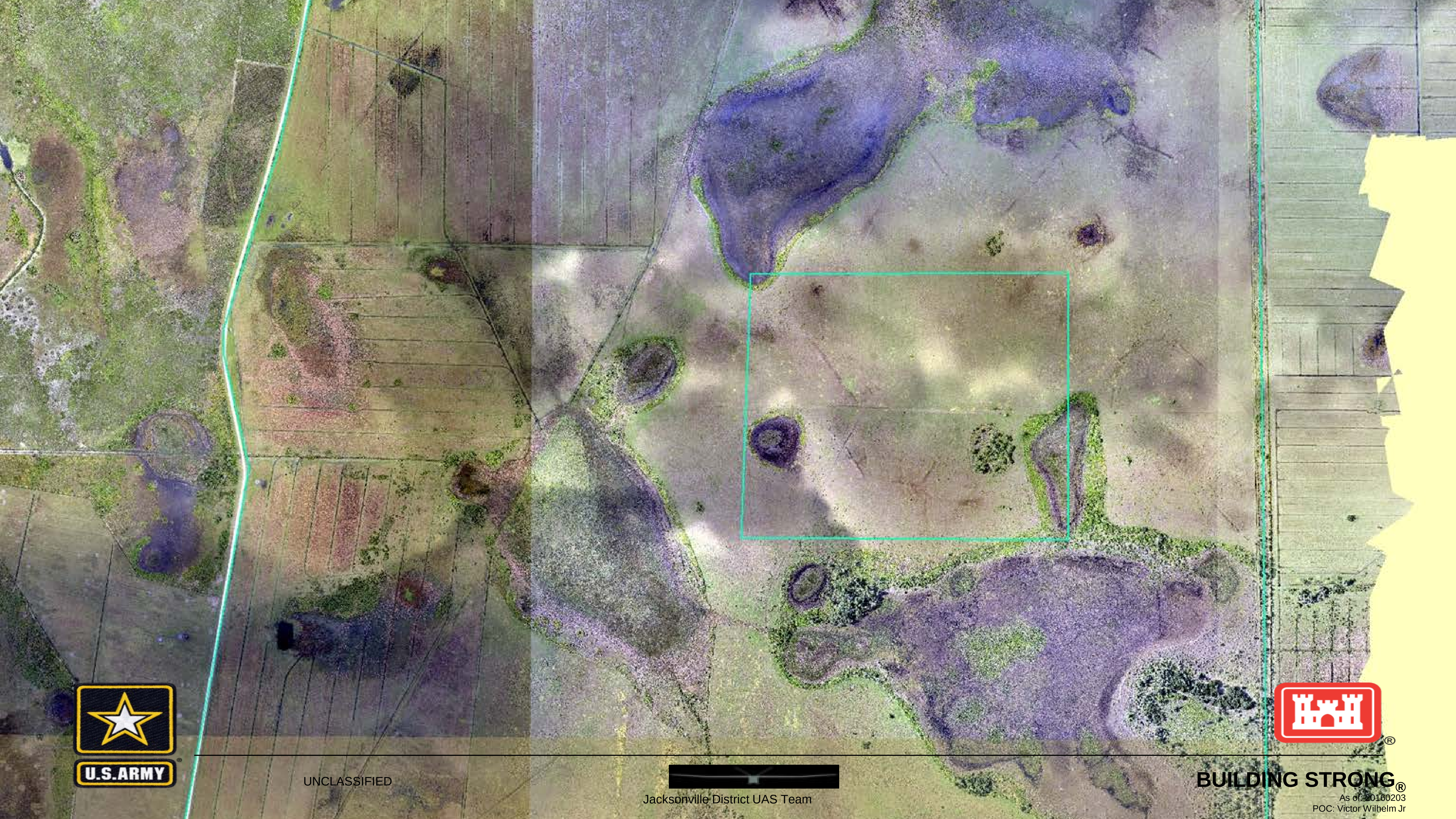
Current Research

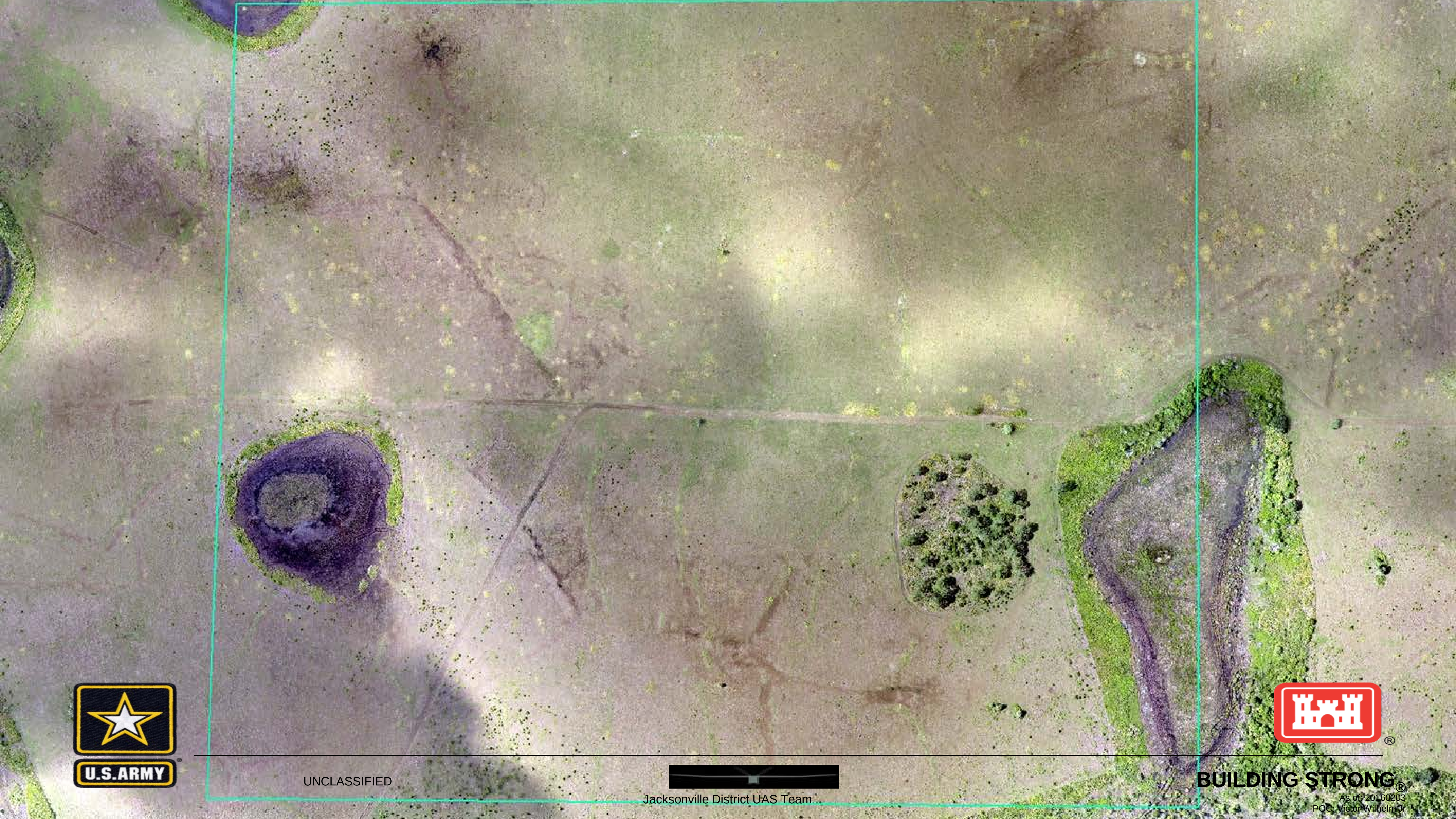


Blue Head Ranch
NRCS Wetland Restoration Project (WRP)

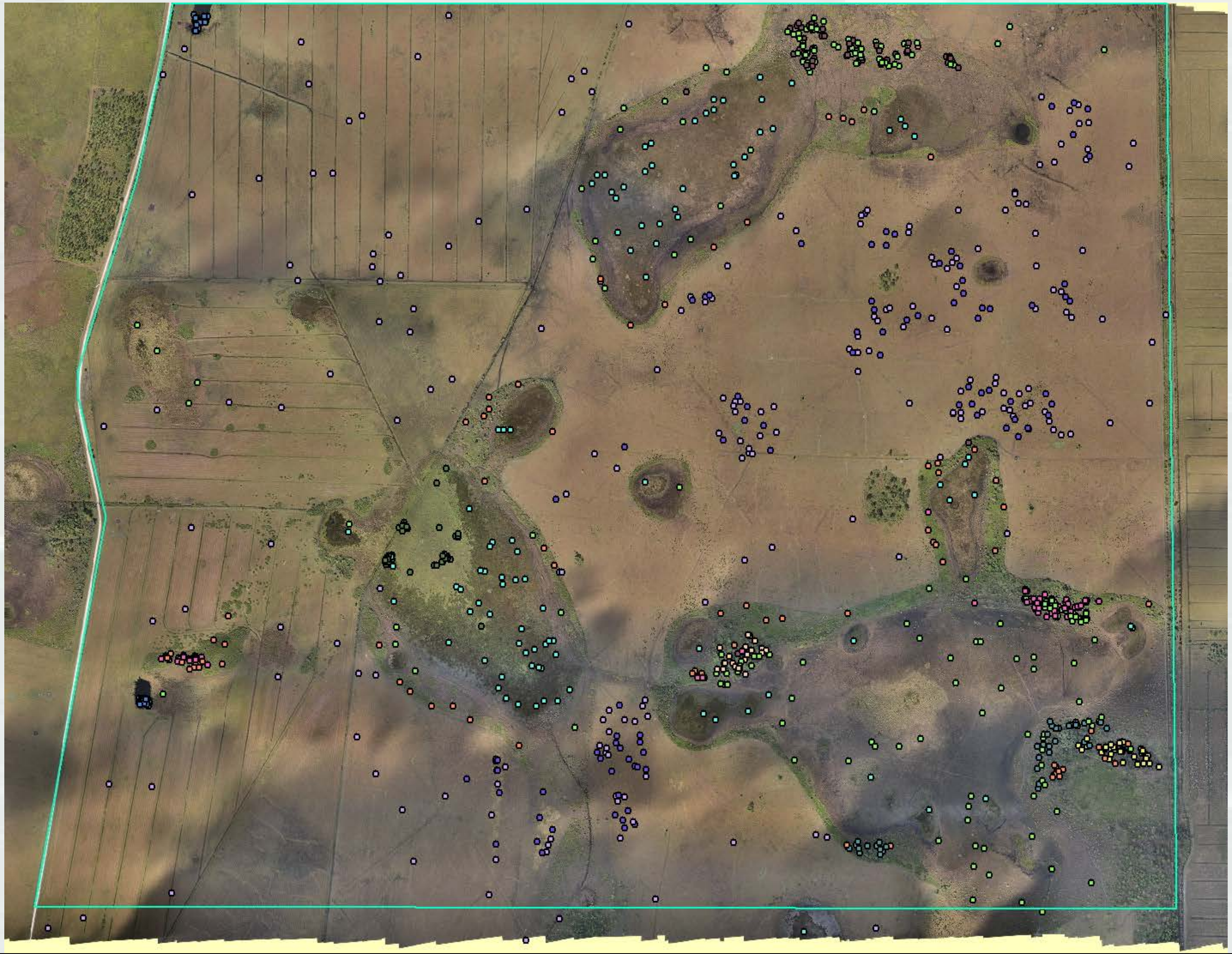





U.S.ARMY



Classifying Training Data



Classifying Training Data, cont

ClassID	Alias	Name	Community
1	MFG	Maidencane	Graminoid Freshwater Marsh
2	SUs	Saw Palmetto	Saw Palmetto Shrubland
3	WUs	Cabbage Palm	Cabbage Palm Upland
4	MFB	Hypericum	Broadleaf Freshwater Marsh
5	SSs	Willow	Willow Shrubland
6	Ei	Cogongrass	Cogongrass
7	SSm	Wax Mrytle	Wax Myrtle Shrubland
8	FHq	Live Oak	Hammock Forest (oak)
9	HFs	Cabbage Palm	Hammock Forest (palm)
10	WUpF	Slash Pine	Pine Flatwoods
11	IP	Mixed Pasture Gram	Improved Pasture
12	CP	Cattle Pond	Surface Water

Classifying Training Data, cont

BH_groundtruth_poly, 3/9/2016, Page 1

FID	Shape *	ID	Class_ID	Name	Level	Community
0	Polygon	1	MFGj	Soft Rush	4	Graminoid Freshwater Marsh
1	Polygon	2	MFG	Mixed Graminoid	3	Graminoid Freshwater Marsh
2	Polygon	3	SUs	Saw Palmetto	4	Saw Palmetto Shrubland
3	Polygon	4	SUs	Saw Palmetto	4	Saw Palmetto Shrubland
4	Polygon	5	WUs	Cabbage Palm	4	Cabbage Palm Upland
5	Polygon	6	WUs	Cabbage Palm	4	Cabbage Palm Upland
6	Polygon	7	SUs	Saw Palmetto	3	Saw Palmetto Shrubland
7	Polygon	8	MFGj	Soft Rush	4	Graminoid Freshwater Marsh
8	Polygon	9	MFGj	Soft Rush	4	Graminoid Freshwater Marsh
9	Polygon	10	MFGj	Soft Rush	4	Graminoid Freshwater Marsh
10	Polygon	11	MFG	mixed graminoid	3	Graminoid Freshwater Marsh
11	Polygon	12	MFBps	Pickerelweed-Duck Potato	4	Broadleaf Freshwater Marsh
12	Polygon	13	MFBps	Pickerelweed-Duck Potato	4	Broadleaf Freshwater Marsh
13	Polygon	14	MFGp	Maidencane	4	Graminoid Freshwater Marsh
14	Polygon	15	MFGj	Soft Rush	4	Graminoid Freshwater Marsh
15	Polygon	16	MFBh	Hypericum	4	Broadleaf Freshwater Marsh
16	Polygon	17	MFBps	Pickerelweed-Duck Potato	4	Broadleaf Freshwater Marsh
17	Polygon	18	MFGj	Soft Rush	4	Graminoid Freshwater Marsh
18	Polygon	19	SSs	Willow	4	Willow Shrubland
19	Polygon	20	MFBh	Hypericum	4	Broadleaf Freshwater Marsh
20	Polygon	21	SUs	Saw Palmetto	4	Saw Palmetto Shrubland
21	Polygon	22	Ei	Cogongrass	4	Cogongrass
22	Polygon	23	SSM	Wax Myrtle	4	Wax Myrtle Shrubland
23	Polygon	24	MFBps	Pickerelweed-Duck Potato	4	Broadleaf Freshwater Marsh
24	Polygon	25	MFBs	Pickerelweed-Duck Potato	4	Broadleaf Freshwater Marsh
25	Polygon	26	MFB	Mixed Broadleaf	3	Broadleaf Freshwater Marsh
26	Polygon	27	WUs	Cabbage Palm	4	Cabbage Palm Upland
27	Polygon	28	SUs	Saw Palmetto	3	Saw Palmetto Shrubland
28	Polygon	29	MFBps	Pickerelweed-Duck Potato	4	Broadleaf Freshwater Marsh
29	Polygon	30	SUs	Saw Pametto	4	Saw Palmetto Shrubland
30	Polygon	31	MFG	mixed graminoid	3	Graminoid Freshwater Marsh
31	Polygon	32	FHq	Live Oak	4	Hammock Forest (oak)
32	Polygon	33	FHs	Cabbage Palm	4	Hammock Forest (palm)
33	Polygon	34	FHq	Live Oak	4	Hammock Forest (oak)
34	Polygon	35	MFGp	Maidencane	4	Graminoid Freshwater Marsh
35	Polygon	36	MFGp	Maidencane	4	Graminoid Freshwater Marsh
36	Polygon	37	MFBps	Pickerelweed-Duck Potato	4	Broadleaf Freshwater Marsh
37	Polygon	38	MFBps	Pickerelweed-Duck Potato	4	Broadleaf Freshwater Marsh
38	Polygon	39	MFBps	Pickerelweed-Duck Potato	4	Broadleaf Freshwater Marsh
39	Polygon	40	MFBps	Pickerelweed-Duck Potato	4	Broadleaf Freshwater Marsh
40	Polygon	41	SUs	Saw Palmetto	4	Saw Palmetto Shrubland
41	Polygon	42	MFGj	Soft Rush	4	Graminoid Freshwater Marsh
42	Polygon	43	MFBps	Pickerelweed-Duck Potato	4	Broadleaf Freshwater Marsh
43	Polygon	44	MFBps	Pickerelweed-Duck Potato	4	Broadleaf Freshwater Marsh
44	Polygon	45	Ei	Cogongrass	4	Cogongrass
45	Polygon	46	Ei	Cogongrass	4	Cogongrass
46	Polygon	47	Sus	Saw Palmetto	4	Saw Palmetto Shrubland
47	Polygon	48	Ei	Cogongrass	4	Cogongrass
48	Polygon	49	HFs	Cabbage Palm	4	Hammock Forest (palm)
49	Polygon	50	SUs	Saw Palmetto	4	Saw Palmetto Shrubland
50	Polygon	51	SUs	Saw Palmetto	4	Saw Palmetto Shrubland
51	Polygon	52	WUpF	Slash Pine	4	Pine Flatwoods
52	Polygon	53	SUs	Saw Palmetto	4	Saw Palmetto Shrubland
53	Polygon	54	MFB	Mixed Broadleaf	4	Broadleaf Freshwater Marsh
54	Polygon	55	MFBps	Pickerelweed-Duck Potato	4	Broadleaf Freshwater Marsh
55	Polygon	56	SUs	Saw Palmetto	4	Saw Palmetto Shrubland
56	Polygon	57	WUpF	Slash Pine	4	Pine Flatwoods
57	Polygon	58	SUs	Saw Palmetto	4	Saw Palmetto Shrubland
58	Polygon	59	MFGp	Maidencane	4	Graminoid Freshwater Marsh
59	Polygon	60	MFB	Mixed Broadleaf	3	Broadleaf Freshwater Marsh
60	Polygon	61	MFBps	Pickerelweed-Duck Potato	4	Broadleaf Freshwater Marsh
61	Polygon	62	MFB	Mixed Broadleaf	3	Broadleaf Freshwater Marsh
62	Polygon	63	MFGj	Soft Rush	4	Graminoid Freshwater Marsh
63	Polygon	64	MFGj	Soft Rush	4	Graminoid Freshwater Marsh
64	Polygon	65	MFBps	Pickerelweed-Duck Potato	4	Broadleaf Freshwater Marsh
65	Polygon	66	MFB	Mixed Broadleaf	3	Broadleaf Freshwater Marsh
66	Polygon	67	SSm	Wax Myrtle	4	Wax Myrtle Shrubland
67	Polygon	68	SUs	Saw Palmetto	4	Saw Palmetto Shrubland
68	Polygon	69	MFB	Mixed Broadleaf	3	Broadleaf Freshwater Marsh
69	Polygon	70	MFB	Mixed Broadleaf	3	Broadleaf Freshwater Marsh
70	Polygon	71	SUs	Saw Palmetto	4	Saw Palmetto Shrubland

BH_groundtruth_poly, 3/9/2016, Page 2

FID	Shape *	ID	Class_ID	Name	Level	Community
71	Polygon	72	MFB	Mixed Broadleaf	3	Broadleaf Freshwater Marsh
72	Polygon	73	IP	Mixed Pasture Graminoid	2	Improved Pasture
73	Polygon	74	MFB	Mixed Broadleaf	3	Broadleaf Freshwater Marsh
74	Polygon	75	IP	Mixed Pasture Graminoid	2	Improved Pasture
75	Polygon	76	IP	Mixed Pasture Graminoid	2	Improved Pasture
76	Polygon	77	IP	Mixed Pasture Graminoid	2	Improved Pasture
77	Polygon	78	MFB	Mixed Broadleaf	3	Broadleaf Freshwater Marsh
78	Polygon	79	MFGj	Soft Rush	4	Graminoid Freshwater Marsh
79	Polygon	80	SUs	Saw Palmetto	4	Saw Palmetto Shrubland
80	Polygon	81	SUs	Saw Palmetto	4	Saw Palmetto Shrubland
81	Polygon	82	MFBps	Pickerelweed-Duck Potato	4	Broadleaf Freshwater Marsh
82	Polygon	83	Ei	Cogongrass	4	Cogongrass
83	Polygon	84	Ei	Cogongrass	4	Cogongrass
84	Polygon	85	Ei	Cogongrass	4	Cogongrass
85	Polygon	86	Ei	Cogongrass	4	Cogongrass
86	Polygon	87	Ei	Cogongrass	4	Cogongrass
87	Polygon	88	Ei	Cogongrass	4	Cogongrass
88	Polygon	89	SSm	Wax Myrtle	4	Wax Myrtle Shrubland
89	Polygon	90	SSm	Wax Myrtle	4	Wax Myrtle Shrubland
90	Polygon	91	SSm	Wax Myrtle	4	Wax Myrtle Shrubland
91	Polygon	92	SSm	Wax Mrytle	4	Wax Myrtle Shrubland
92	Polygon	93	SSm	Wax Myrtle	4	Wax Myrtle Shrubland
93	Polygon	94	SSm	Wax Myrtle	4	Wax Myrtle Shrubland
94	Polygon	95	SSm	Wax Myrtle	4	Wax Myrtle Shrubland
95	Polygon	96	SSm	Wax Myrtle	4	Wax Myrtle Shrubland
96	Polygon	97	SSs	Willow	4	Willow Shrubland
97	Polygon	98	SSs	Willow	4	Willow Shrubland
98	Polygon	99	SSs	Willow	4	Willow Shrubland
99	Polygon	100	SSs	Willow	4	Willow Shrubland
100	Polygon	101	CP	Cattle Pond	1	Surface Water
101	Polygon	102	CP	Cattle Pond	1	Surface Water

Vegetation Classification System for South Florida Natural Areas, 2009

Future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