Remote Sensing of Terrestrial and Submerged Aquatic Vegetation in Fire Island National Seashore

Y.Q. Wang
Department of Natural Resources Science
University of Rhode Island

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Outline

- Introduction
- Terrestrial Vegetation Mapping
- Submerged Aquatic Vegetation (SAV) Mapping
- Conclusions

Satellite Remote Sensing for FIIS Vegetation Mapping

The vegetation communities and spatial patterns on Fire Island National Seashore and other barrier islands are dynamic with the impacts from forces such as sand deposition, storm-driven over wash, salt spray, surface water, as well as human disturbances.

High spatial resolution satellite remote sensing offers an opportunity to map and monitor the dynamics of the vegetation on this barrier island.

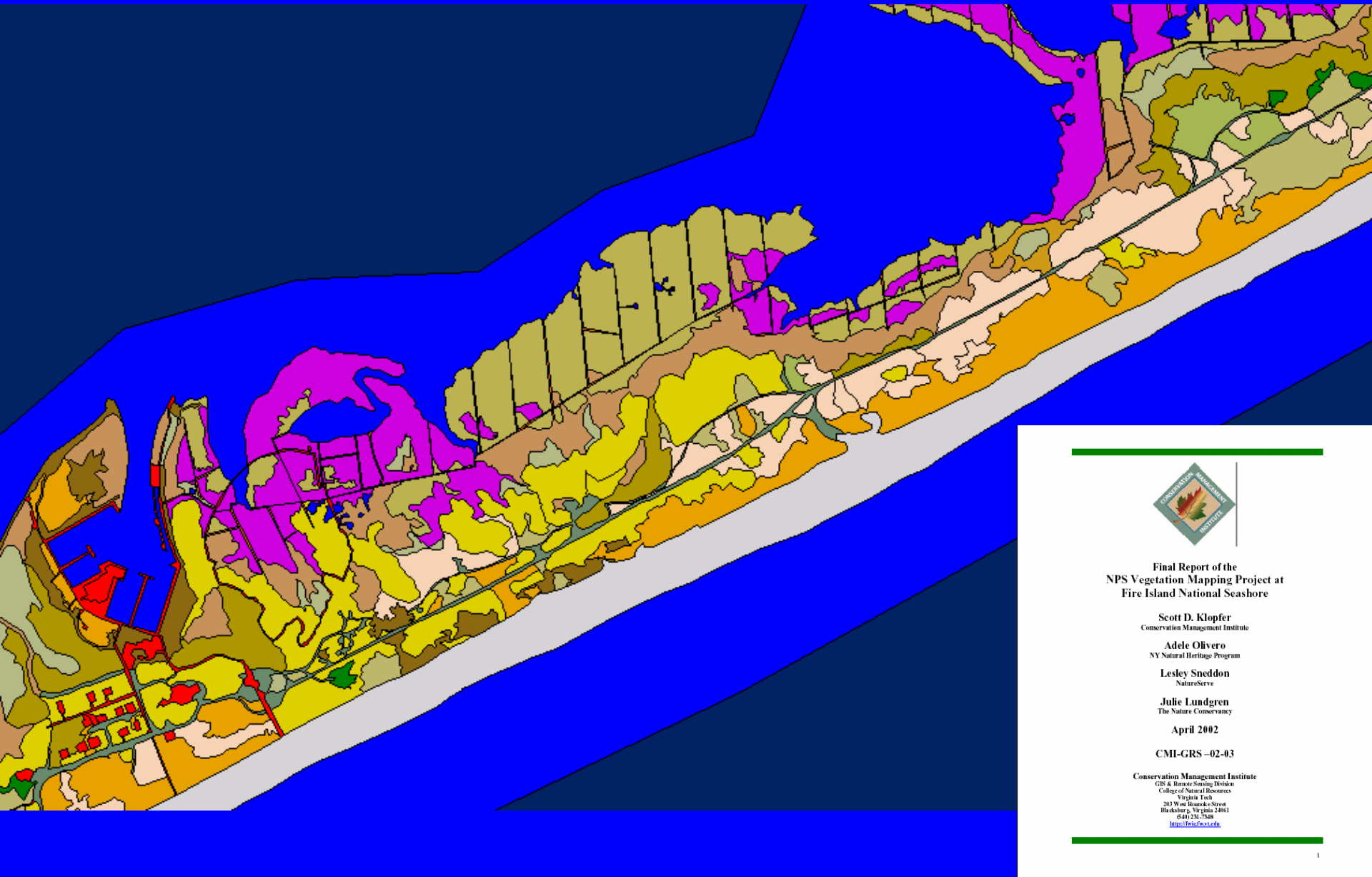
Recent Vegetation Map in FIIS

The most recent vegetation mapping project at FIIS was completed in 2002 (Klopfer, et al., 2002).

- The interpretation was based on 1997 color IR and true color 1:1,200 scale aerial photos.
- The photos were digitally scanned (600 dpi) and georeferenced.
- The classification System included 5 broadly defined vegetation groups (*salt marsh, dune grassland, dune shrublands, interdunal swales,* and *forests/shrublands*) and 39 subcategories.
- The minimum mapping unit was 0.25 ha.

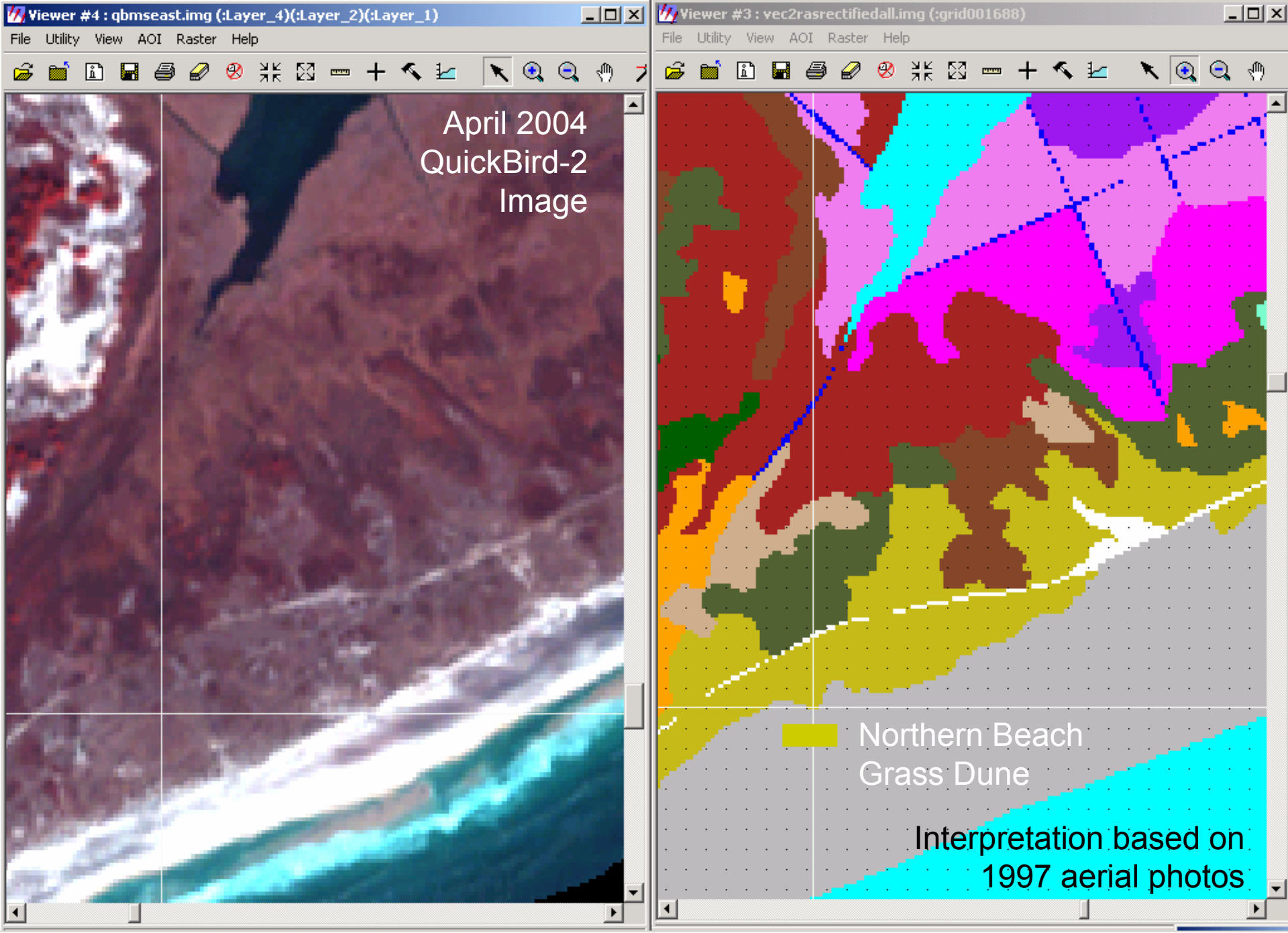
An Example of Scanned 1997 True Color Aerial Photo

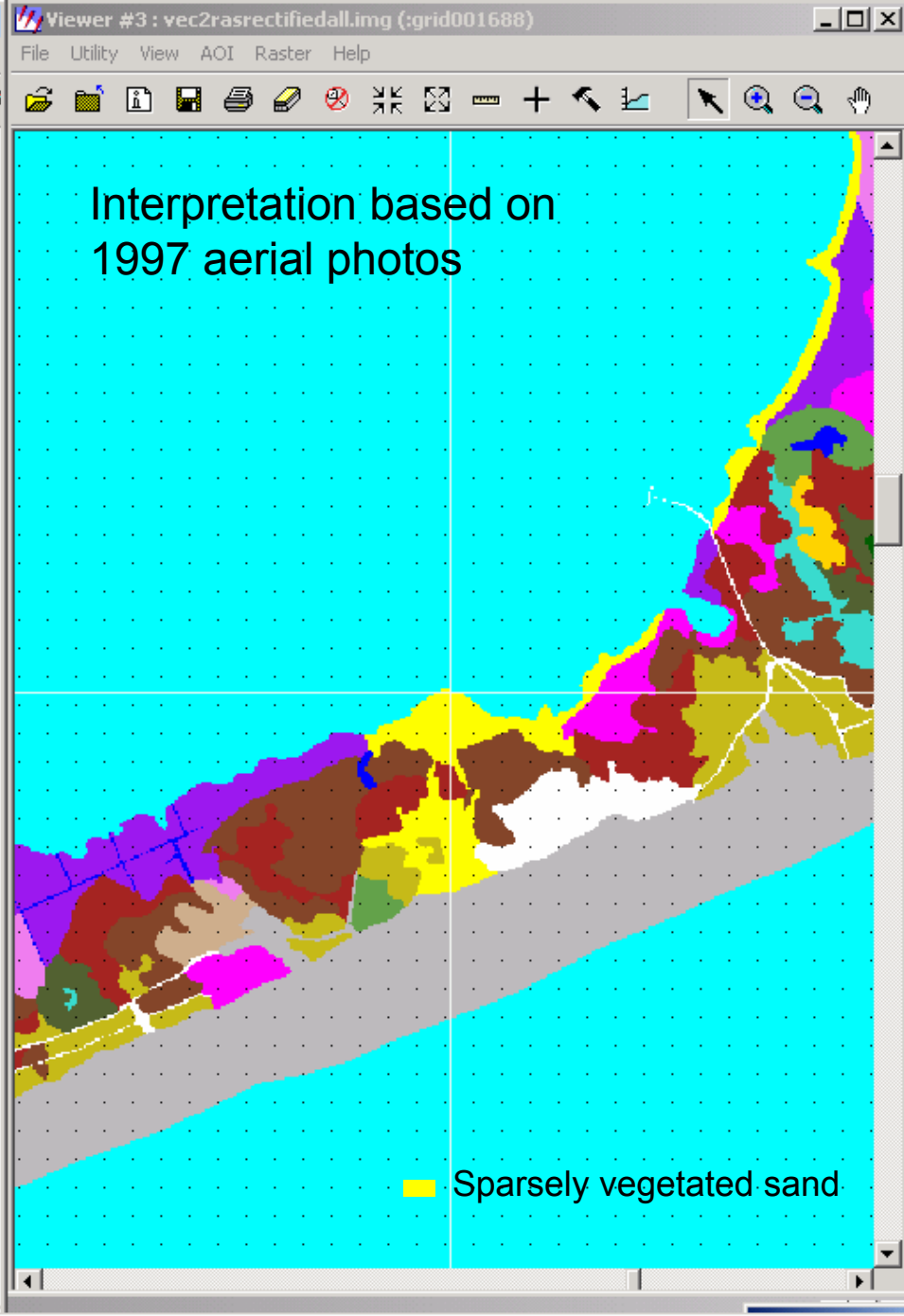
An Example of FIIS vegetation map – Phase I Map



Questions and Challenges

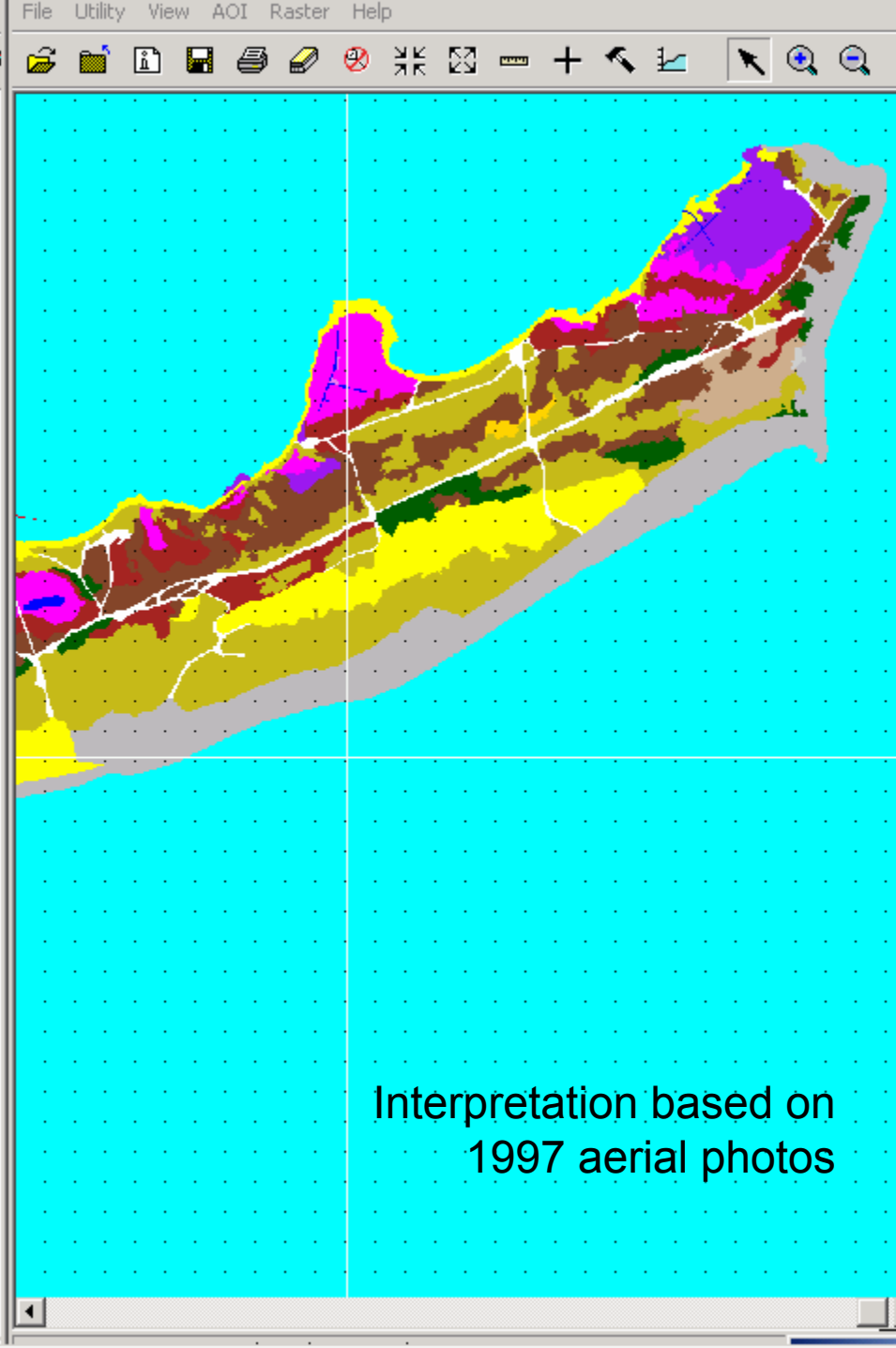
- Exploration of new data sources and approaches that could efficiently update vegetation maps is necessary for timely monitoring of the landscape dynamics
- Exploration of approaches for integrating data products from different sources so that comparisons or change analysis can be executed

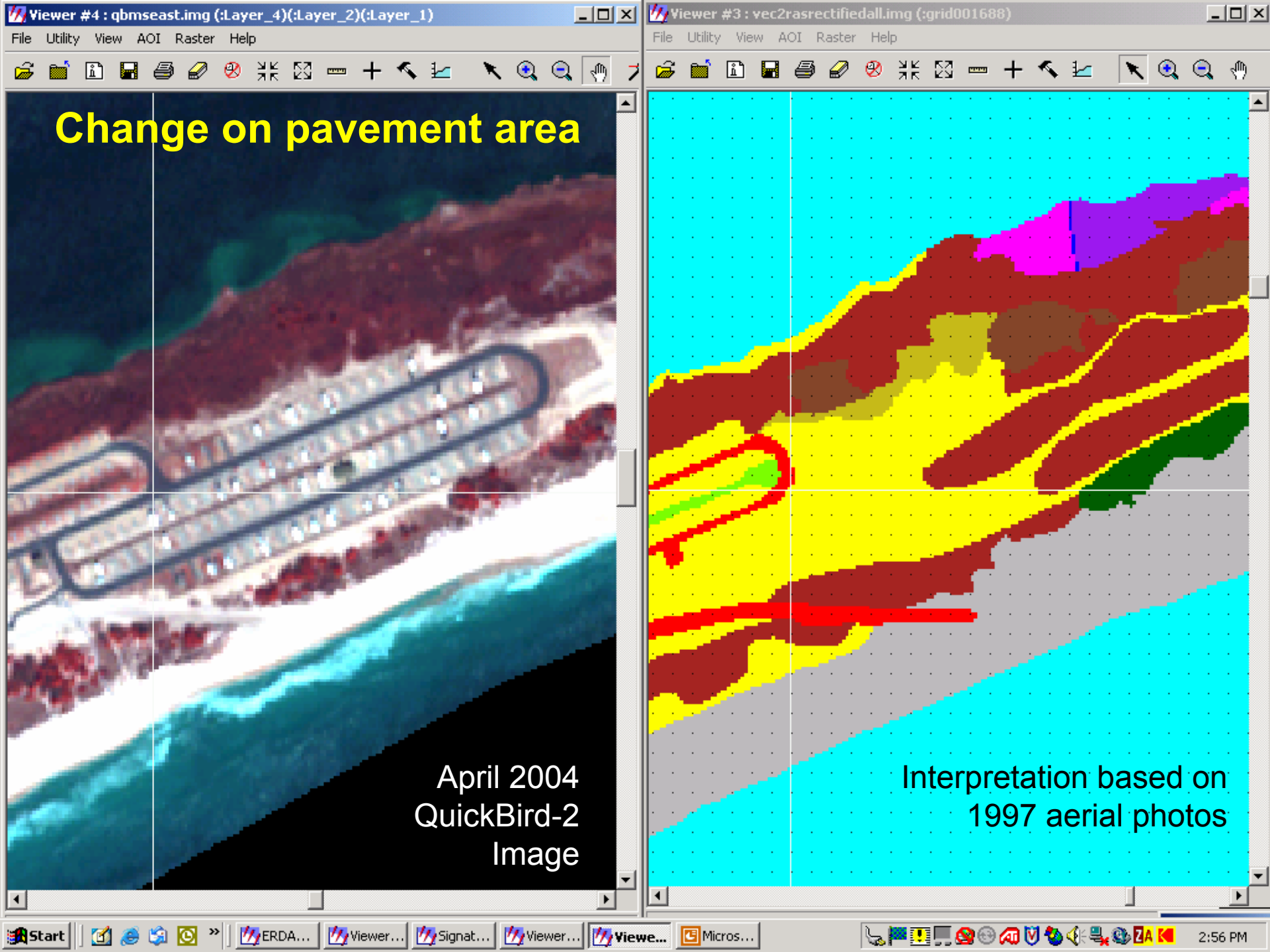

Viewer #4 : qbmseast.img (:Layer_4)(:Layer_2)(:Layer_1)
File Utility View AOI Raster Help
April 2004
QuickBird-2
Image
Viewer #3 : vec2rasrectifiedall.img (:grid001688)
File Utility View AOI Raster Help
Northern Beach
Grass Dune
Interpretation based on
1997 aerial photos
Start
ERDA...
Viewer...
Signat...
Viewer...
Viewe...
Viewer...
2:44 PM



Start ERDA... Viewer... Signat... Viewer... Viewe... Micros... 2:48 PM

Utility View AOI Raster Help
Change on beach area
April 2004 QuickBird-2 Image


File Utility View AOI Raster Help
Interpretation based on
1997 aerial photos


Viewer #4 : qbmseast.img (:Layer_4)(:Layer_2)(:Layer_1)
File Utility View AOI Raster Help
Change on pavement area
April 2004
QuickBird-2
Image
Viewer #3 : vec2rasrectifiedall.img (:grid001688)
File Utility View AOI Raster Help
Interpretation based on
1997 aerial photos
Start
ERDA...
Viewer...
Signat...
Viewer...
Viewe...
Micros...
2:56 PM

The Message

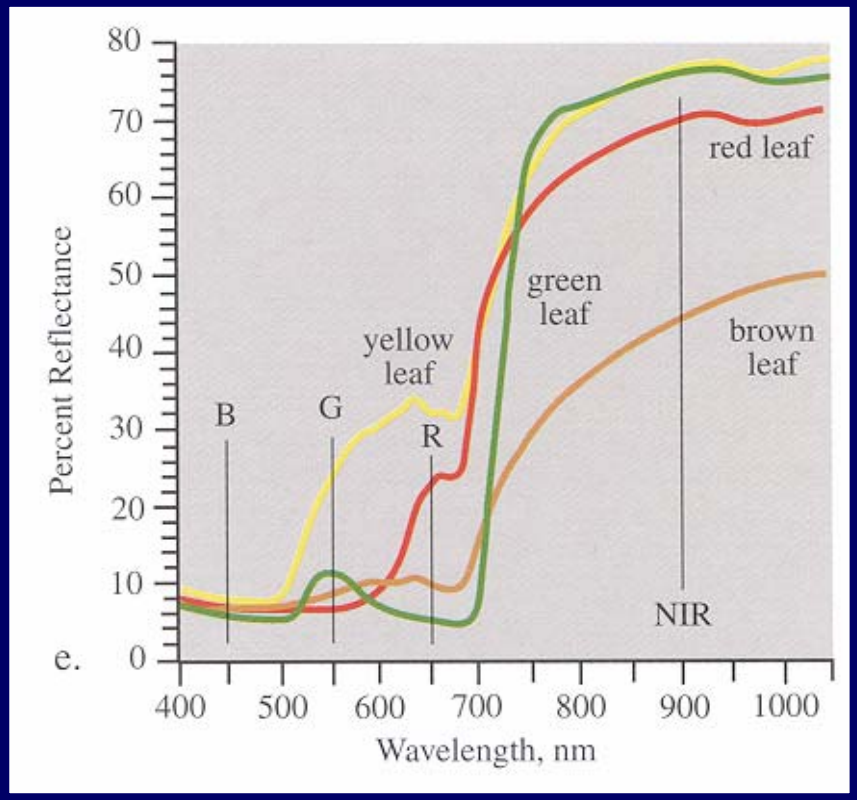
We need to keep the map updated, for areas both within and immediately adjacent to the park boundaries.

QuickBird-2 satellite

Spatial Resolutions:

Panchromatic data: 0.6-meter
Multispectral Data: 2.5-meter

1. Blue: 0.45 - 0.52 mm
2. Green: 0.52 - 0.60 mm
3. Red: 0.63 - 0.69 mm
4. Near-IR: 0.76 – 0.89 mm



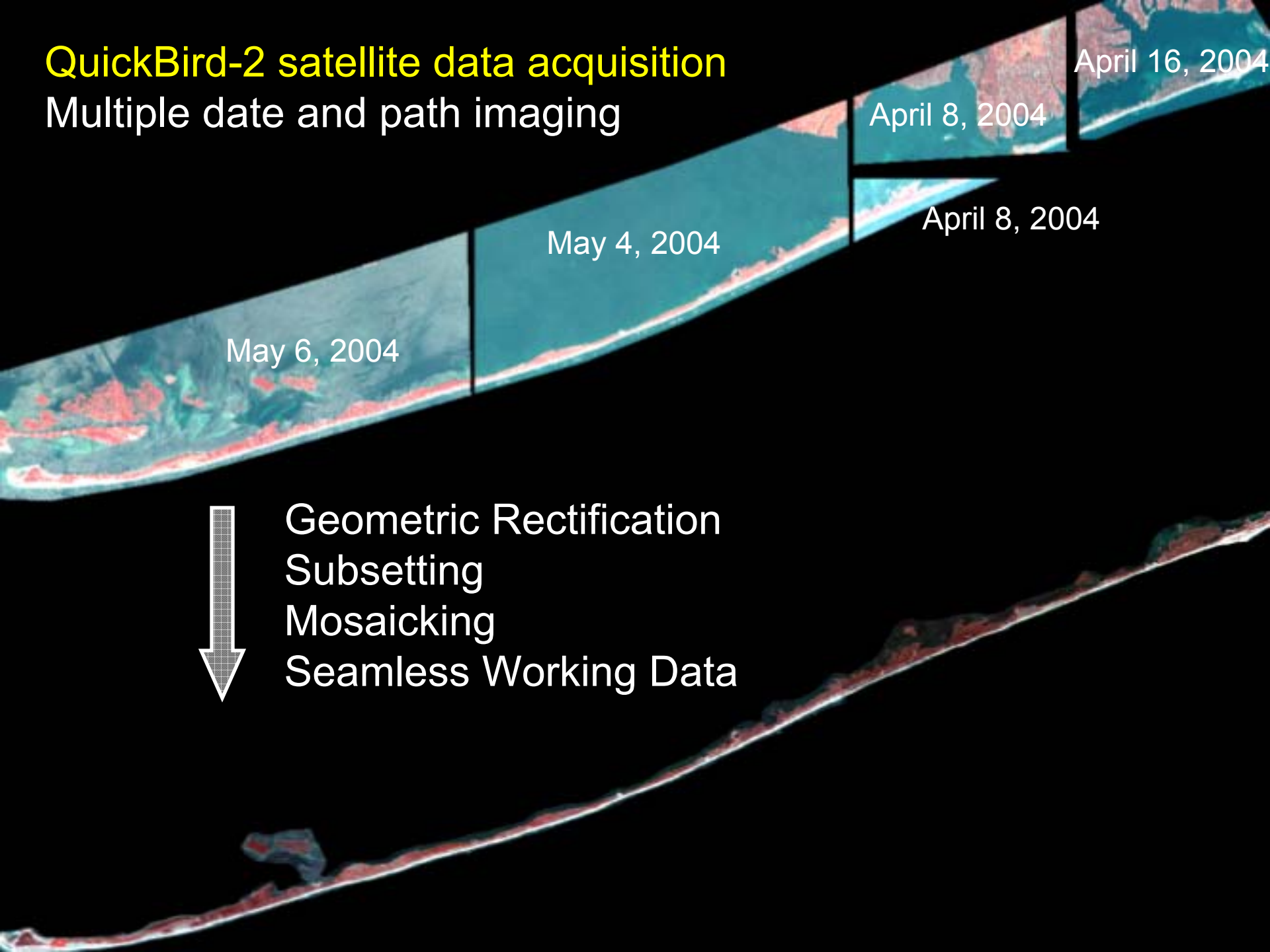
Panchromatic Images (0.6-m Spatial Resolution)

Objectives

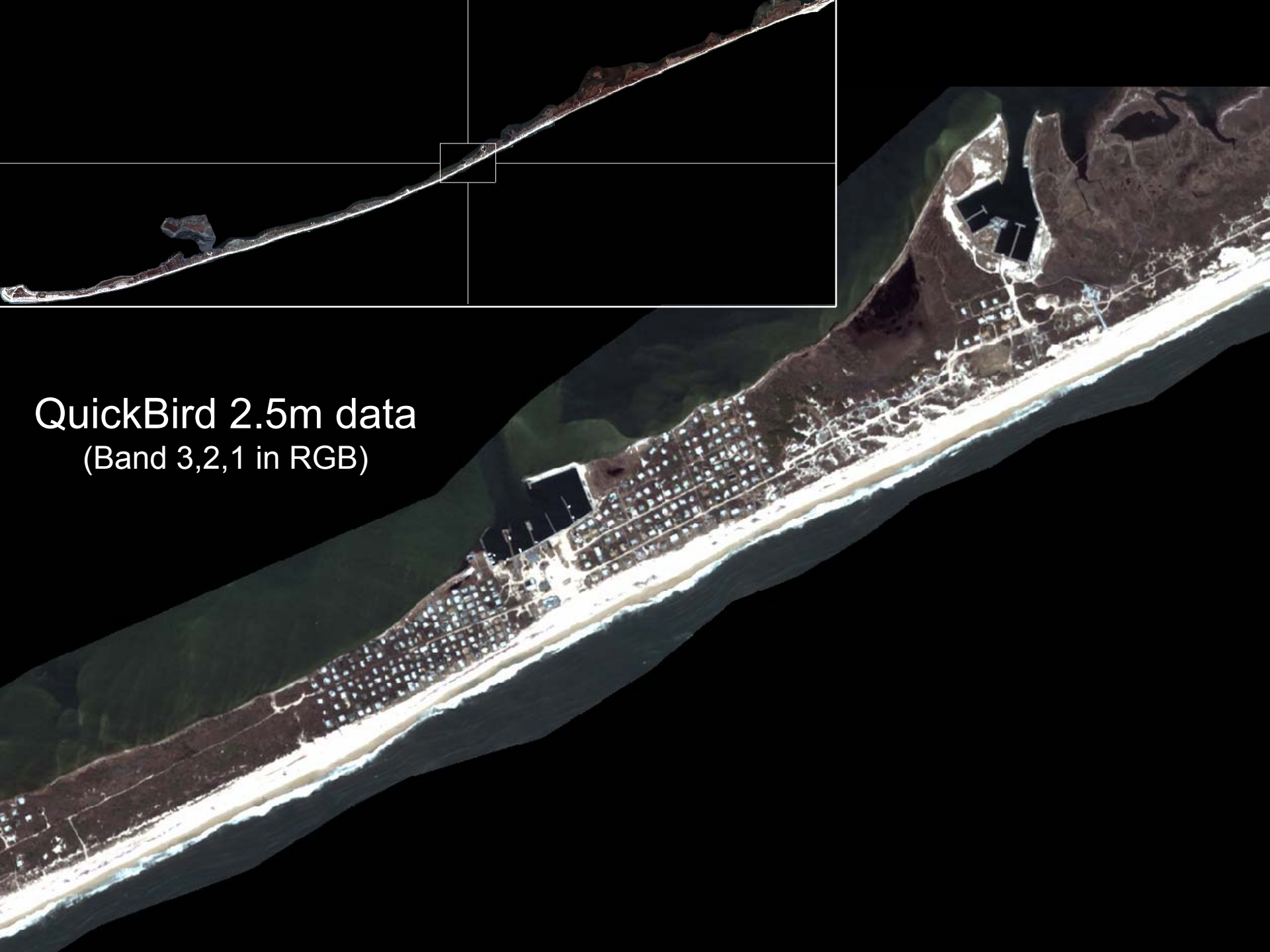
- Map terrestrial and submerged aquatic vegetation (SAV) within the FIIS boundary using high spatial resolution QuickBird-2 satellite remote sensing data.
- Compare and validate agreement between satellite derived vegetation maps and the delineation result from conventional aerial photo interpretation so that repeated monitoring of vegetation change and landscape dynamics using satellite remote sensing can be achieved.
- Develop and test a pilot protocol that could be transferable among NPS projects.

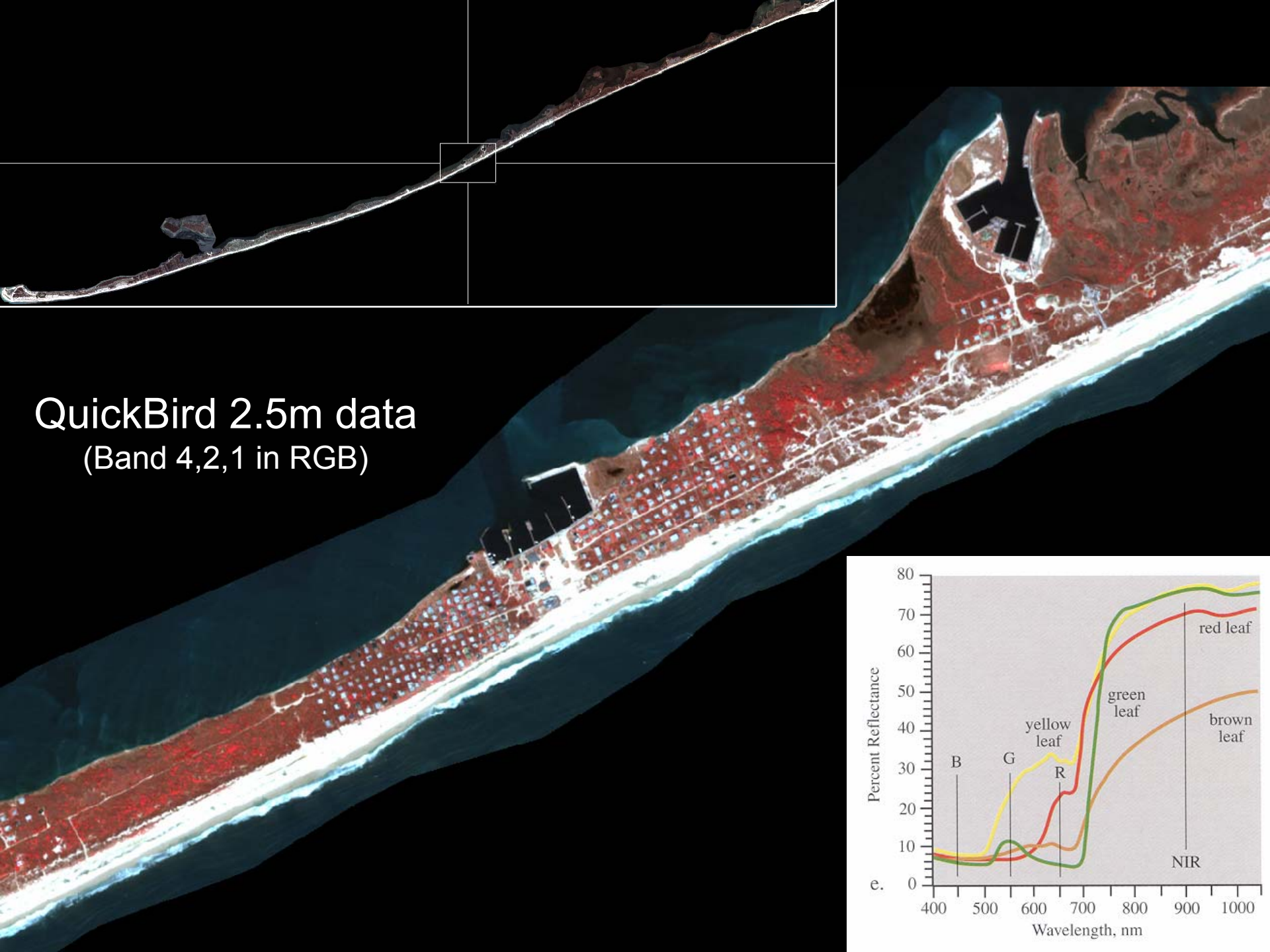
QuickBird-2 satellite data acquisition

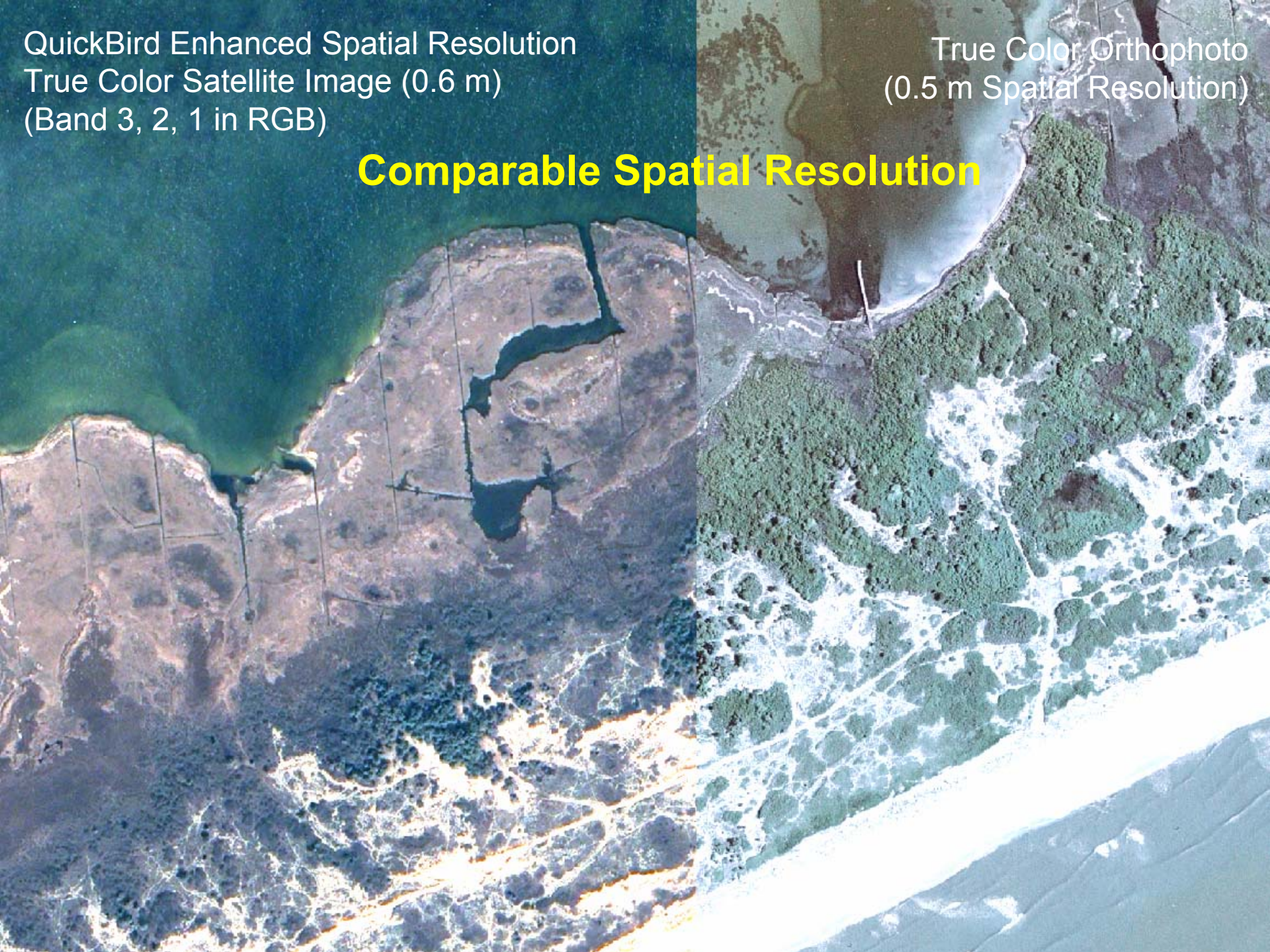
Multiple date and path imaging



Geometric Rectification
Subsetting
Mosaicking
Seamless Working Data


QuickBird 2.5m data
(Band 3,2,1 in RGB)


QuickBird 2.5m data
(Band 4,2,1 in RGB)
Percent Reflectance
Wavelength, nm
B
G
R
NIR
yellow leaf
green leaf
red leaf
brown leaf
0
10
20
30
40
50
60
70
80
400
500
600
700
800
900
1000


QuickBird Enhanced Spatial Resolution
True Color Satellite Image (0.6 m)
(Band 3, 2, 1 in RGB)
True Color Orthophoto
(0.5 m Spatial Resolution)
Comparable Spatial Resolution

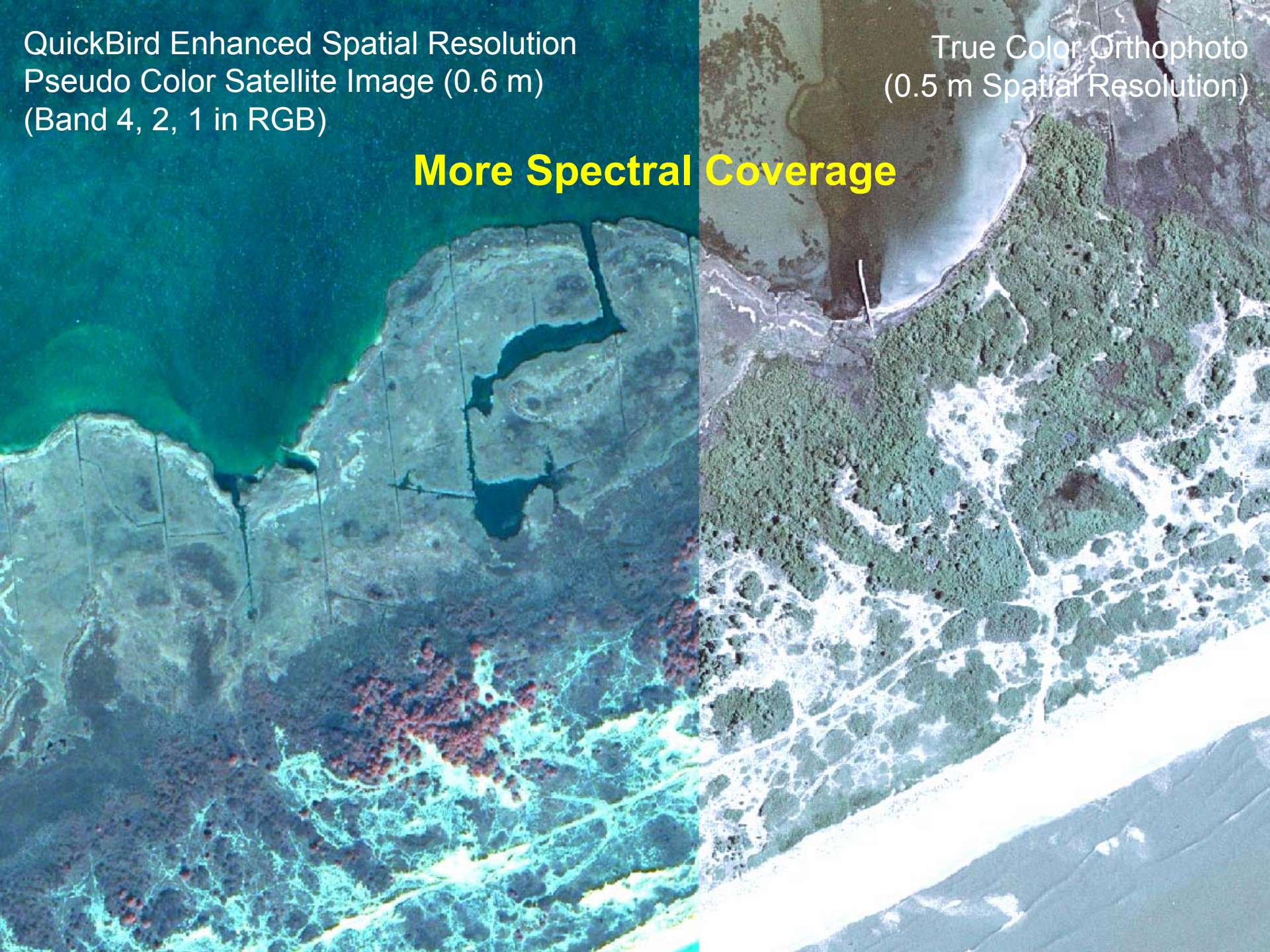
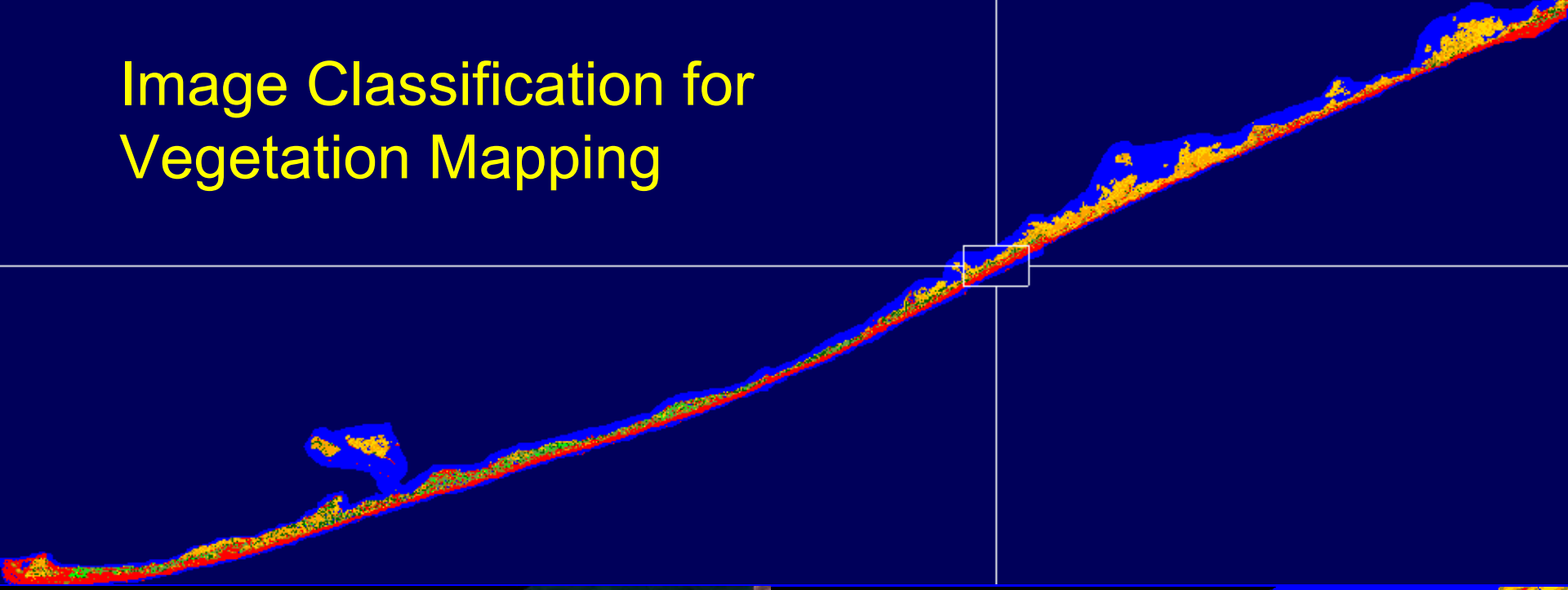
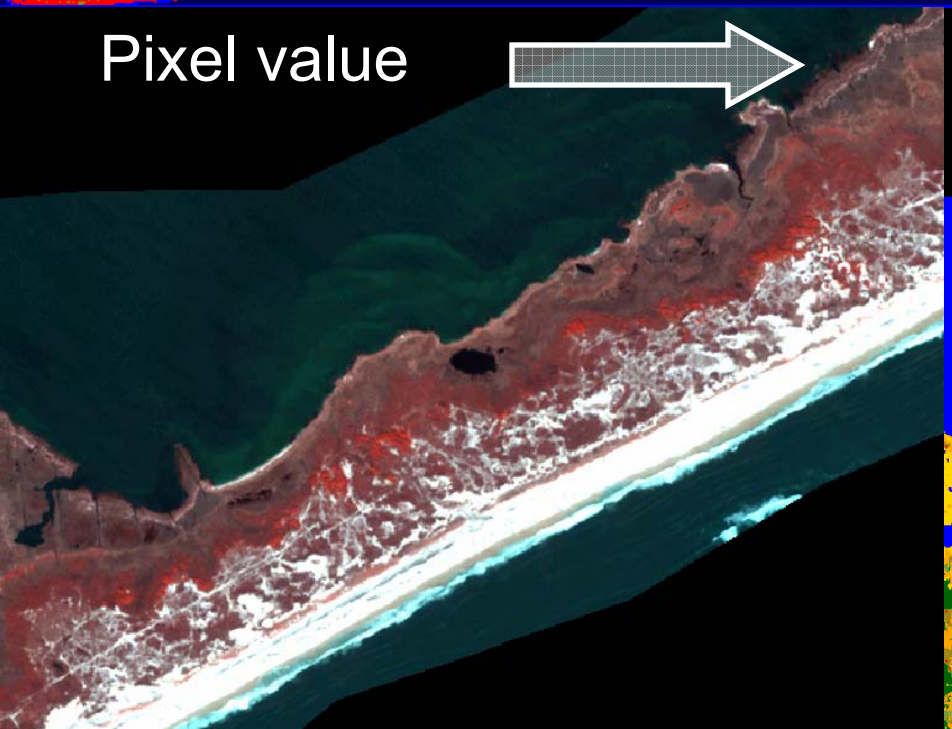
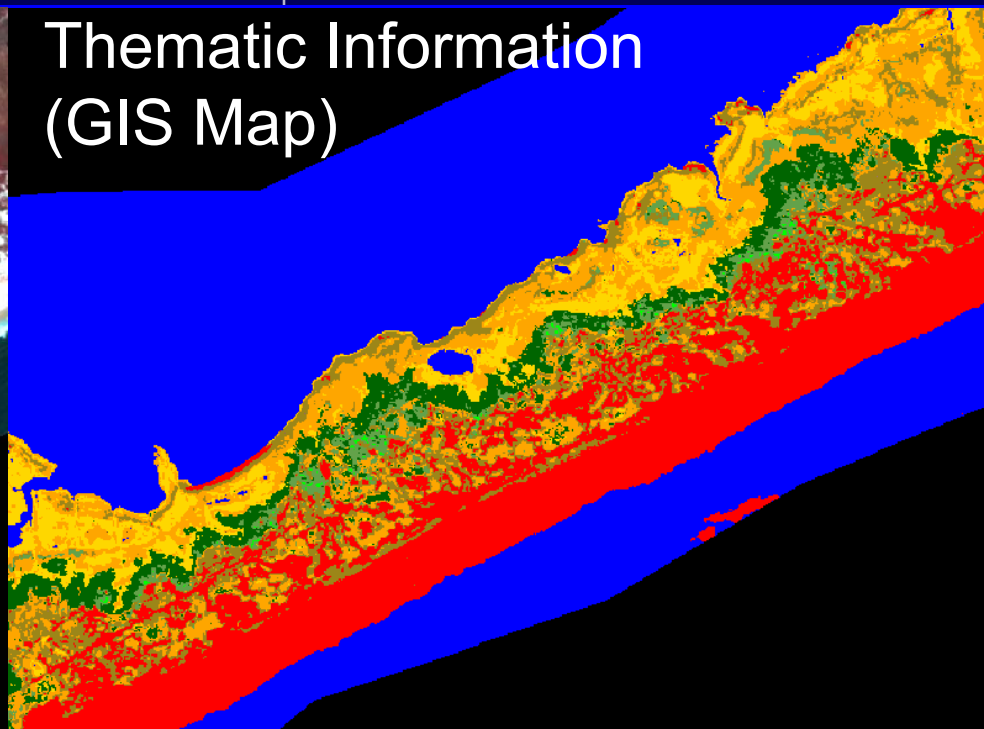

QuickBird Enhanced Spatial Resolution
Pseudo Color Satellite Image (0.6 m)
(Band 4, 2, 1 in RGB)
More Spectral Coverage
True Color Orthophoto
(0.5 m Spatial Resolution)

Image Classification for Vegetation Mapping







Classification System

Value

- Ocean/Bay
- Inland Water
- Residence Building
- Open Beach
- Lawn/Cut grass
- Pavement/ Parking Areas
- Paved/ Road
- Boardwalk/ Dock
- Sparsely Vegetated Sand
- Mosquito Ditch
- Rock piles/ Jetties
- Sand Road/ Path
- Maritime vine dune
- Overwash dune grassland
- Reedgrass Marsh
- Low Salt Marsh
- High Salt Marsh
- Japanese Black Pine Forest
- Northern Salt Shrub
- Pitch pine dune woodland
- Northern Interdunal Cranberry Swale
- Beach Heather Dune
- Maritime Deciduous Scrub Forest
- Brackish Meadow
- Acidic Red Maple Basin Swamp Forest
- Interdunal Beachgrass-Beach Heather Mosaic
- Northern Beach Grass Dune
- Northern Dune Shrubland
- Brackish Interdunal Swale
- Highbush Blueberry Shrub Forest
- Maritime Post Oak Forest
- Coastal Oak-Heath Forest
- Pitch pine - Oak Forest
- Cultivated Pasture

Manual Delineation to Digital Classification

(39 to 30 subcategories)

Class_Names

- Acidic Red Maple Basin Swamp For
- Autumn Olive
- Beach Heather Dune
- Brackish Interduneal Swale
- Brackish Meadow
- Coastal Oak-Heath Forest
- High Salt Marsh
- Highbush Blueberry Shrub Forest
- Japanese Black Pine Forest
- Lawn/Cut Grass
- Low Salt Marsh
- Maritime Deciduous Scrub Forest
- Maritime Holly Forest
- Maritime Post Oak Forest
- Maritime Vine Dune
- Northern Beach Grass Dune
- Northern Dune Shrubland
- Northern Interdunal Cranberry Sw
- Northern Salt Shrub
- Old Field Red-Cedar Forest
- Open Beach/Sand Road
- Overwash Dune Grassland
- Pavement
- Pitch Pine Dune Woodland
- Pitch Pine Oak Forest
- Reedgrass Marsh
- Sparsely Vegeted Sand
- Water

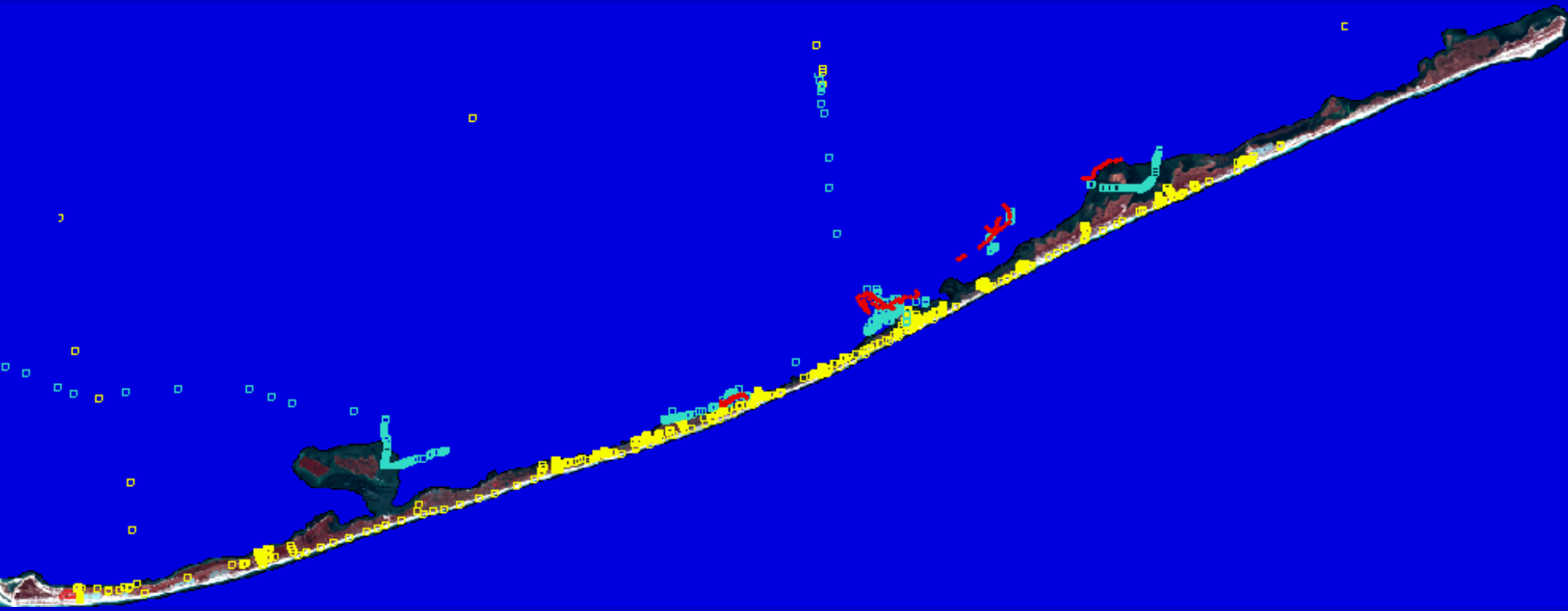
All vegetation types are adopted.

Ground Referencing

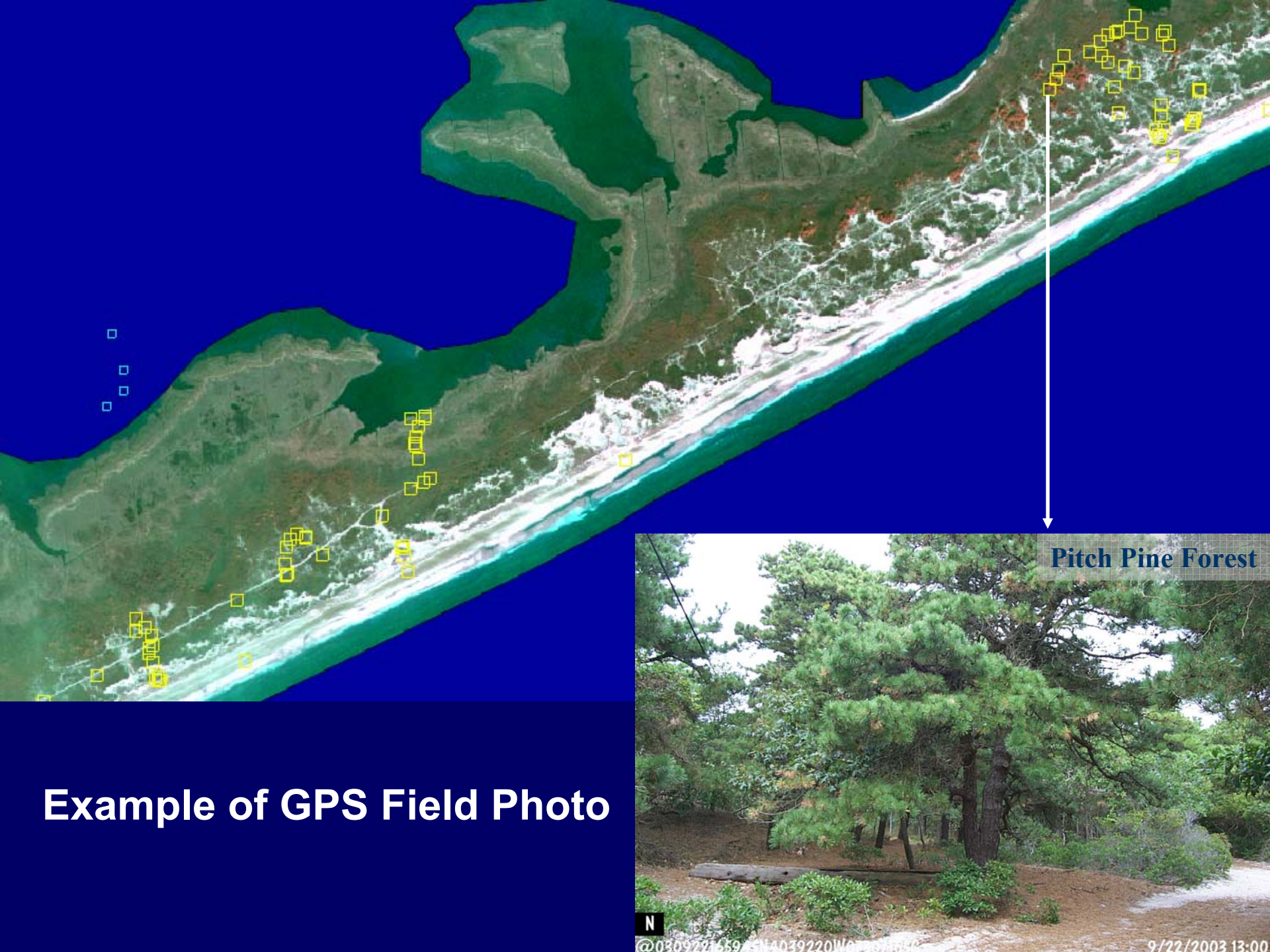
GPS-guided ground referencing for both terrestrial vegetation and SAV.

- About 780 georeferenced terrestrial field photos
- About 400 water surface SAV field photos
- 7 hours of underwater video covered 206 30-m transects of SAV beds

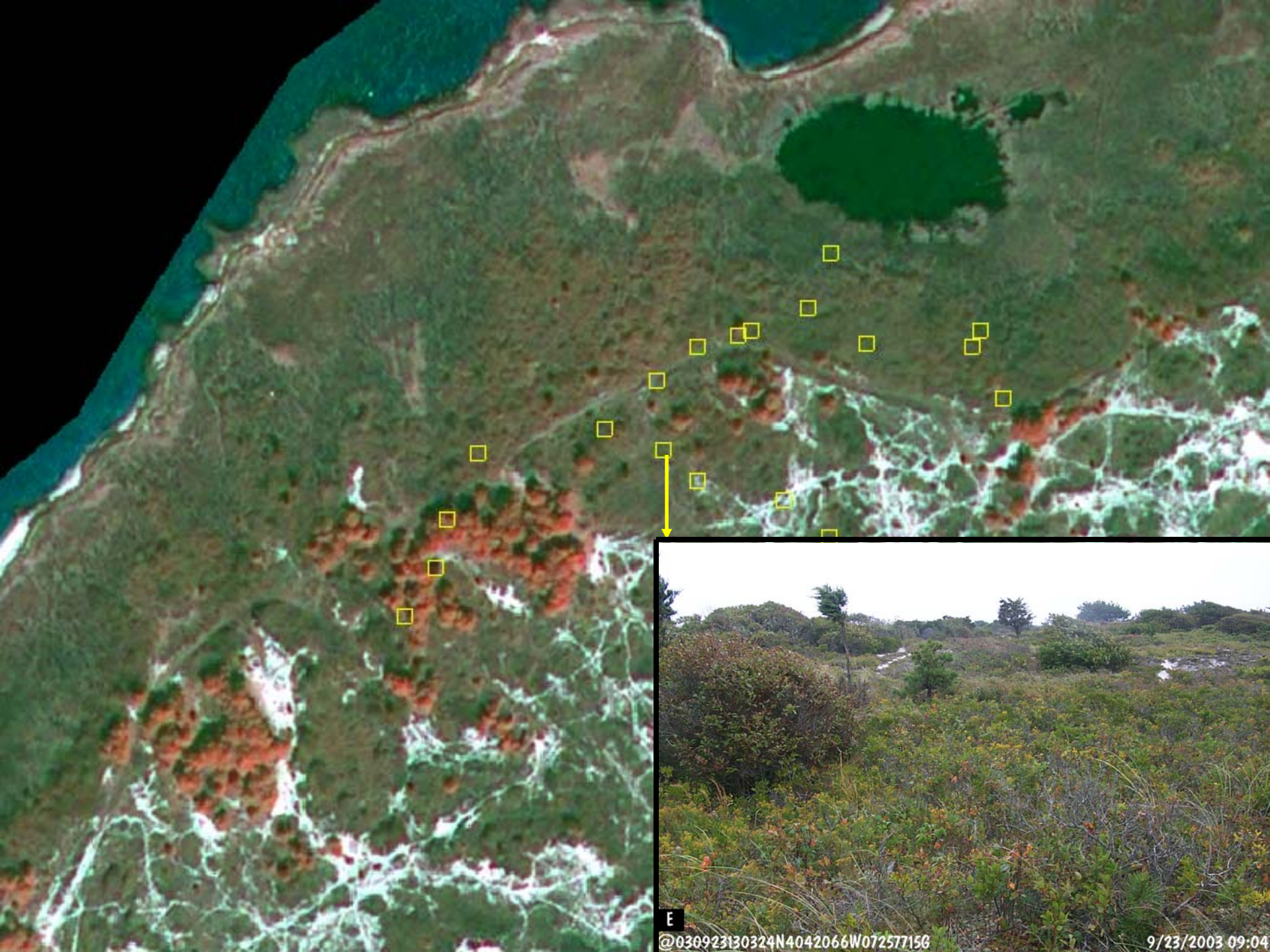
Locations of Field Observations



Yellow - Terrestrial
Cyan - SAV (Water Surface)
Red - Underwater video transects



Example of GPS Field Photo


E
@030923130324N4042066W07257715G
9/23/2003 09:04

Stratified Classification:

Masking out the categories using the existing vegetation map data so that the classification can be focused on the vegetation type and community identified by the NPS vegetation mapping project maps.

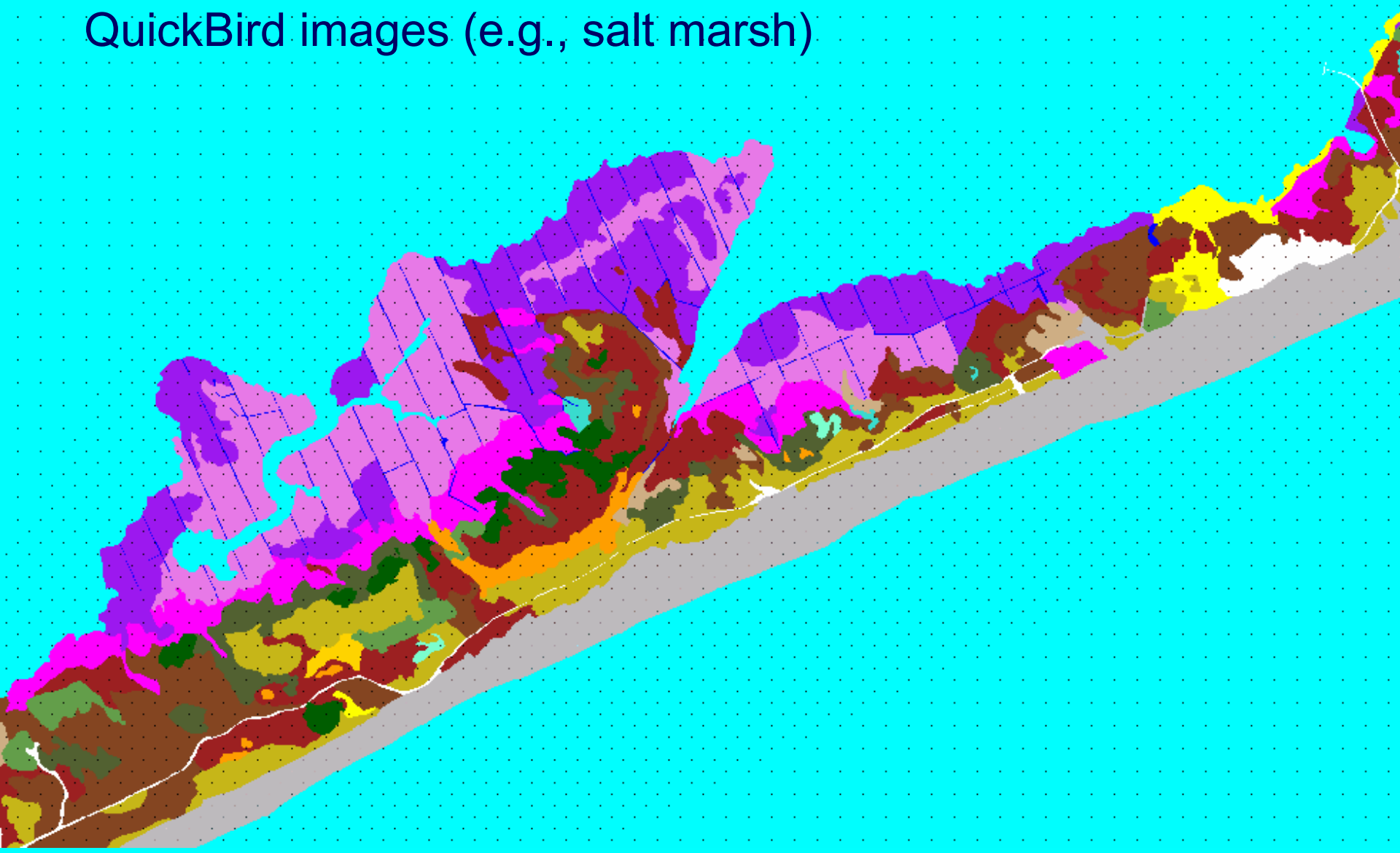
Advantages of this approach:

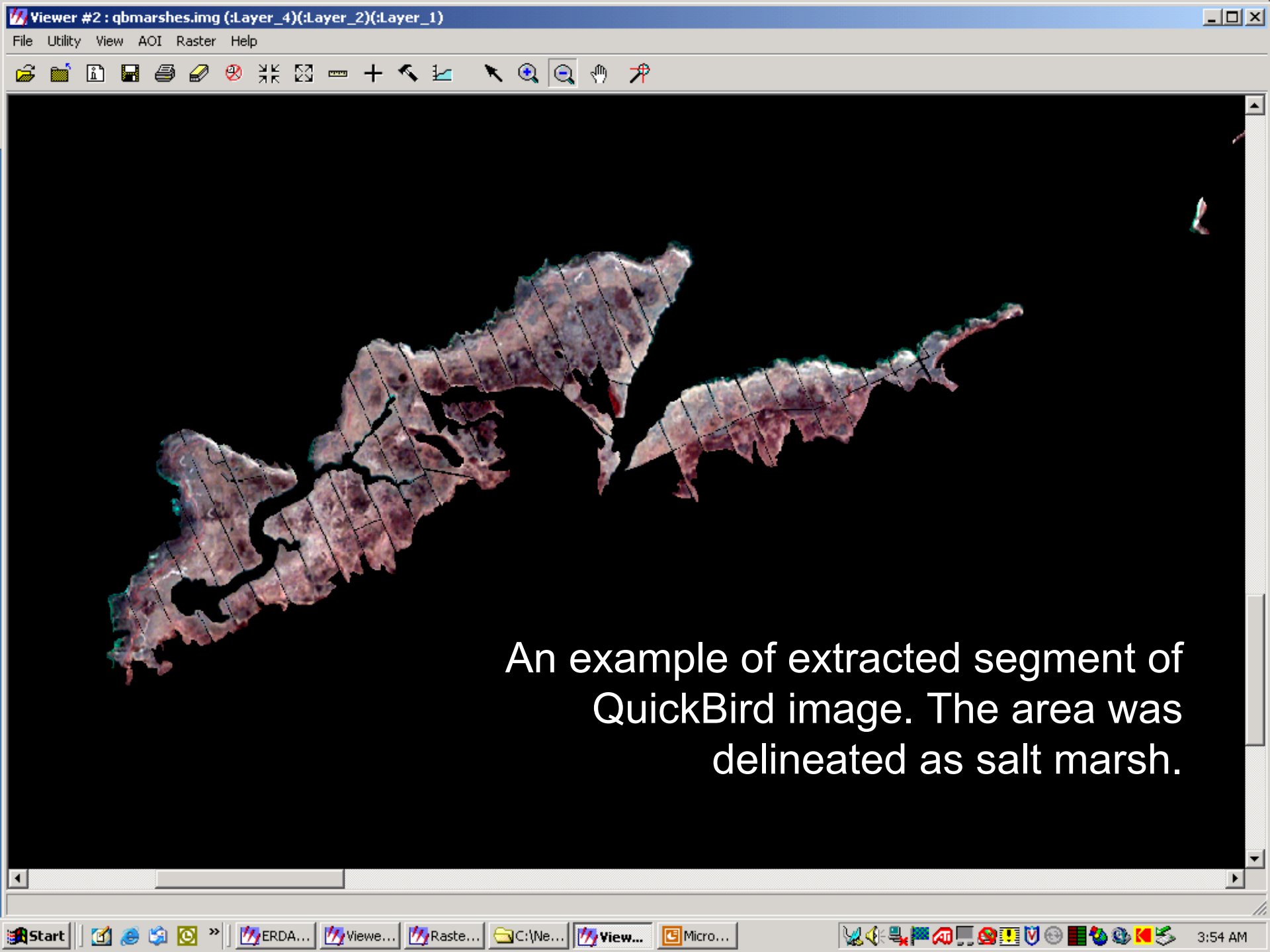
- Value the NPS vegetation mapping efforts
- Keep the classification system consistent
- Meet the goal of updating vegetation map
- Valid for change analysis and monitoring
- Simple protocol for future mapping replication.

Procedures for Stratified Classification

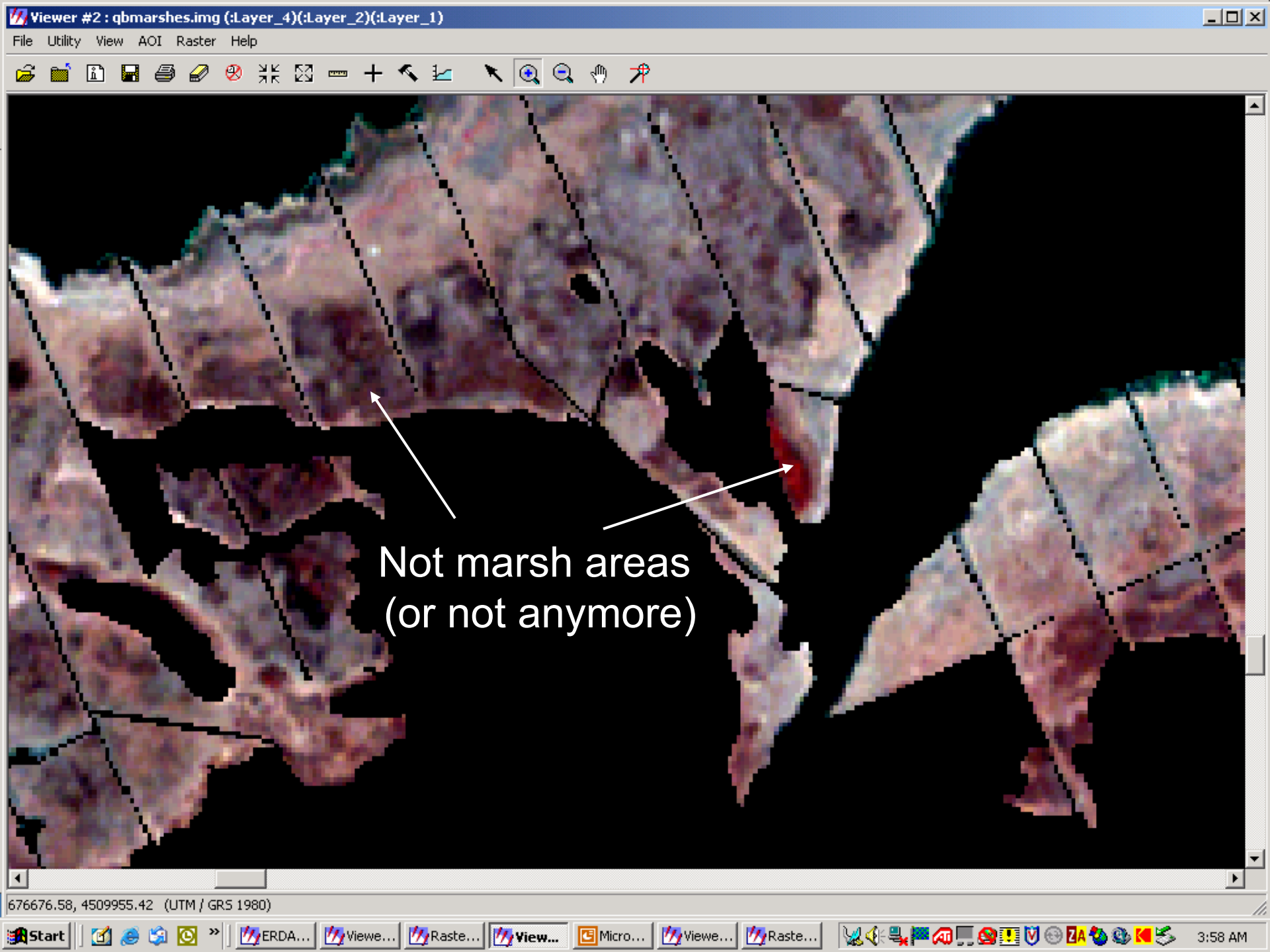
- Separate the FIIS study area into the East section for April 2004 image acquisitions, the West section for May 2004 image acquisitions, and the Williams Floyd Estate (WFE)
- Rasterize the existing GIS vegetation map and rectify the rasterized data to QuickBird image
- Reference the areas for each of the 30 defined land cover and vegetation categories from the rasterized vegetation map for the East, West, and WFE sections, respectively, for unsupervised classification (Masking-and-Classification)
- Overlay the results from unsupervised classification to build the final vegetation map.

An example:
Using the Phase I map to mask out the area of interest from QuickBird images (e.g., salt marsh)

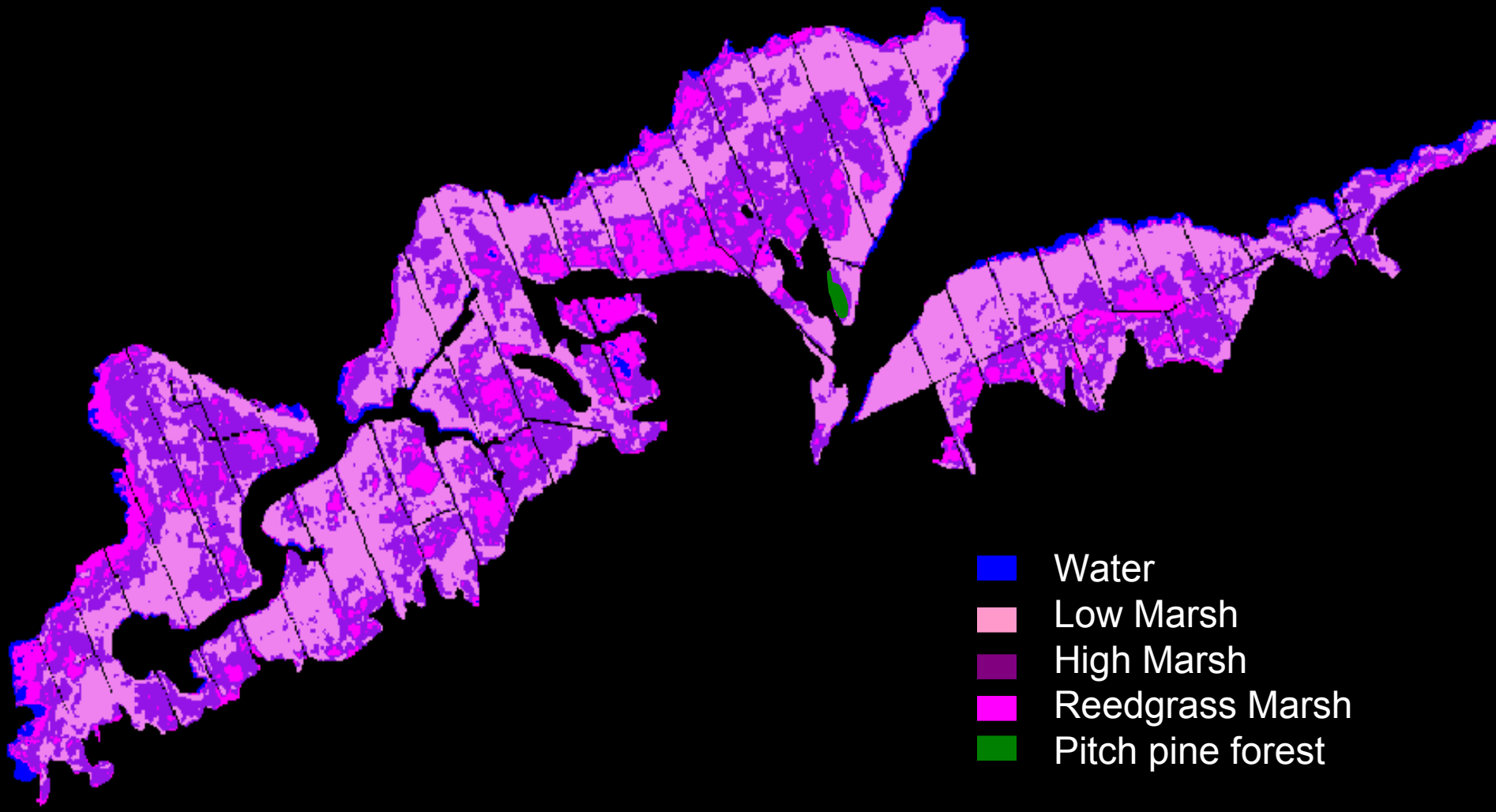




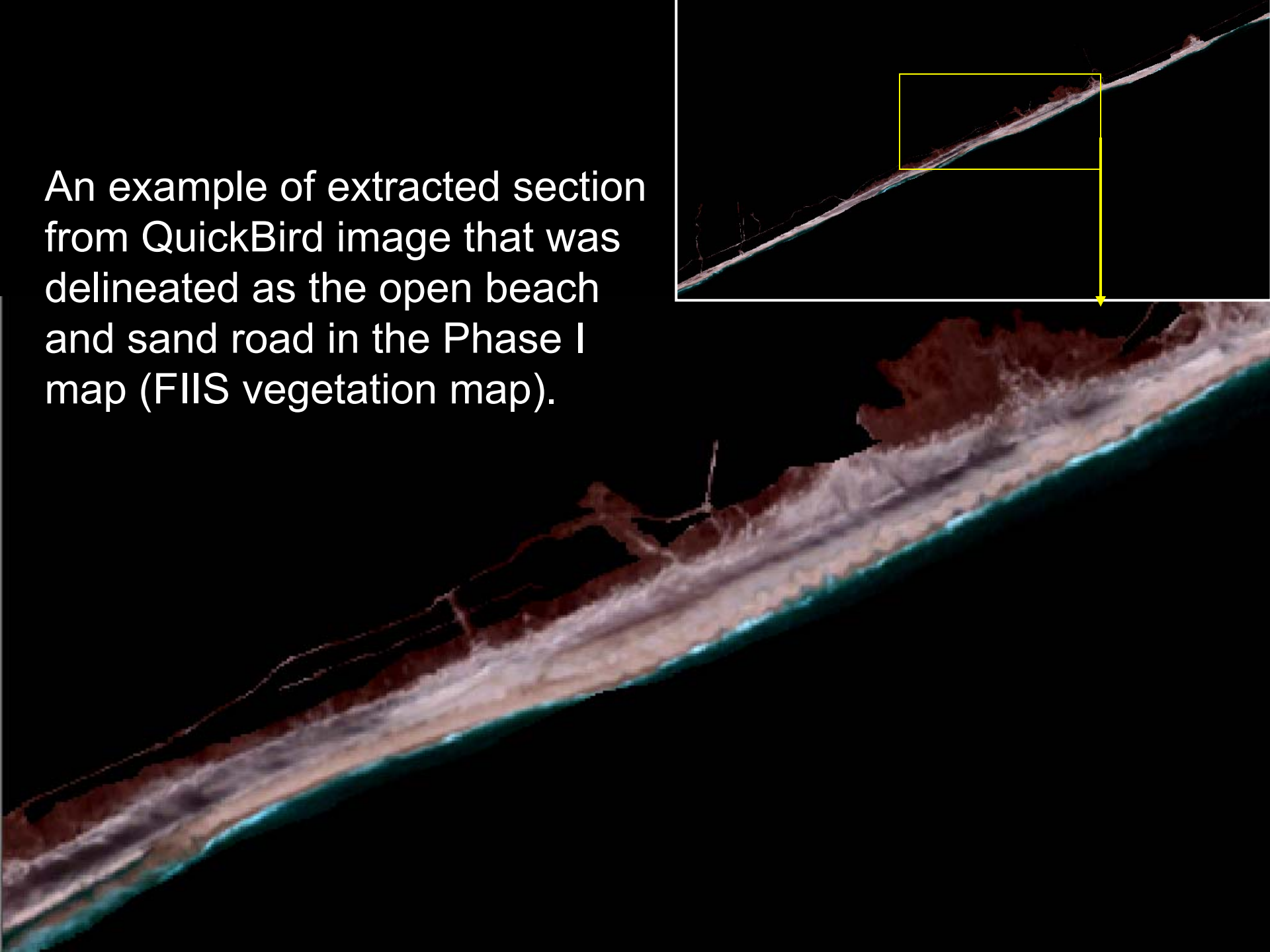
An example of extracted segment of QuickBird image. The area was delineated as salt marsh.

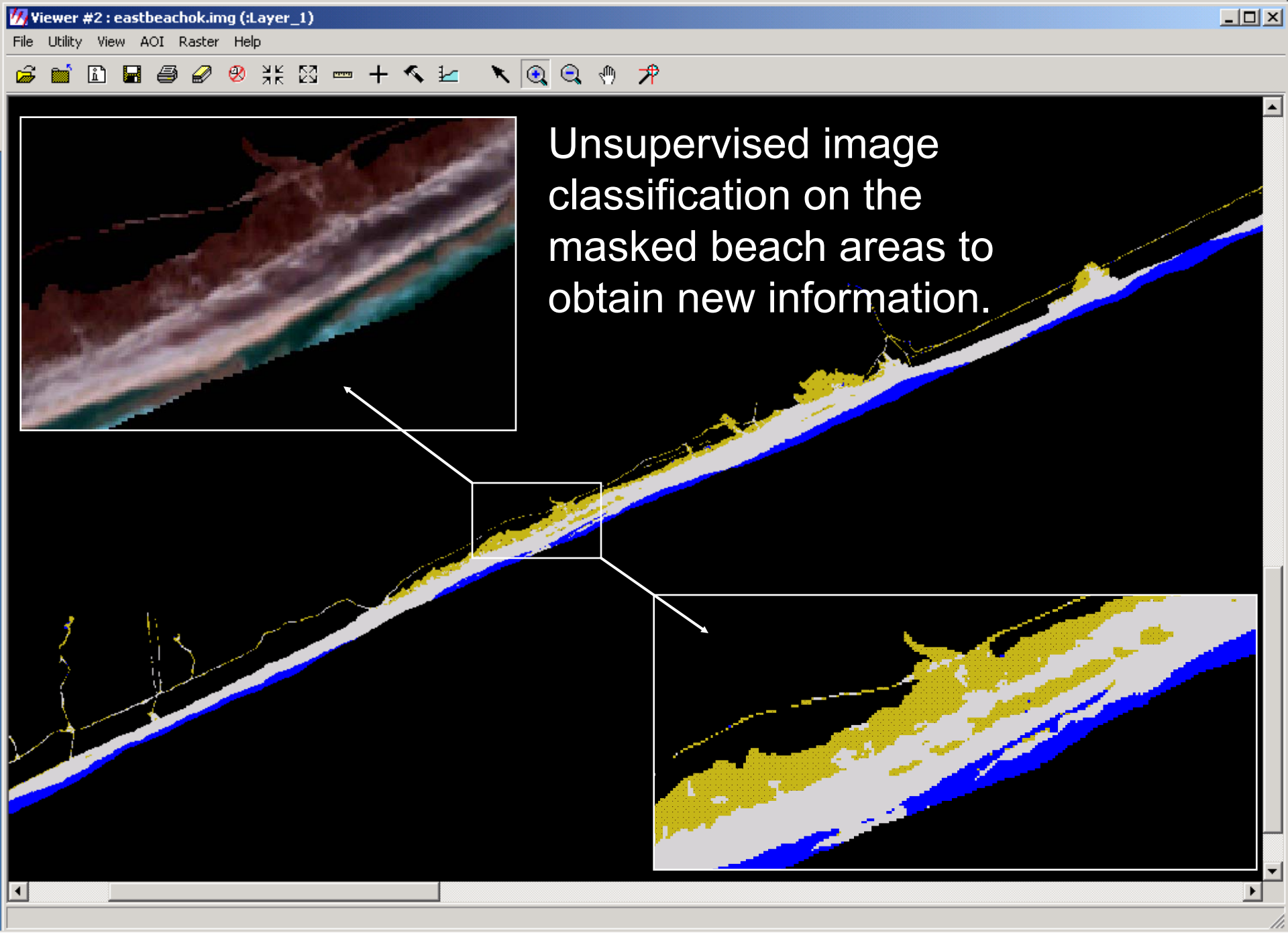

Viewer #2 : qbmarshes.img (:Layer_4)(:Layer_2)(:Layer_1)
File Utility View AOI Raster Help
Not marsh areas
(or not anymore)
676676.58, 4509955.42 (UTM / GRS 1980)
Start
ERDA...
Viewe...
Raste...
View...
Micro...
Viewe...
Raste...
3:58 AM

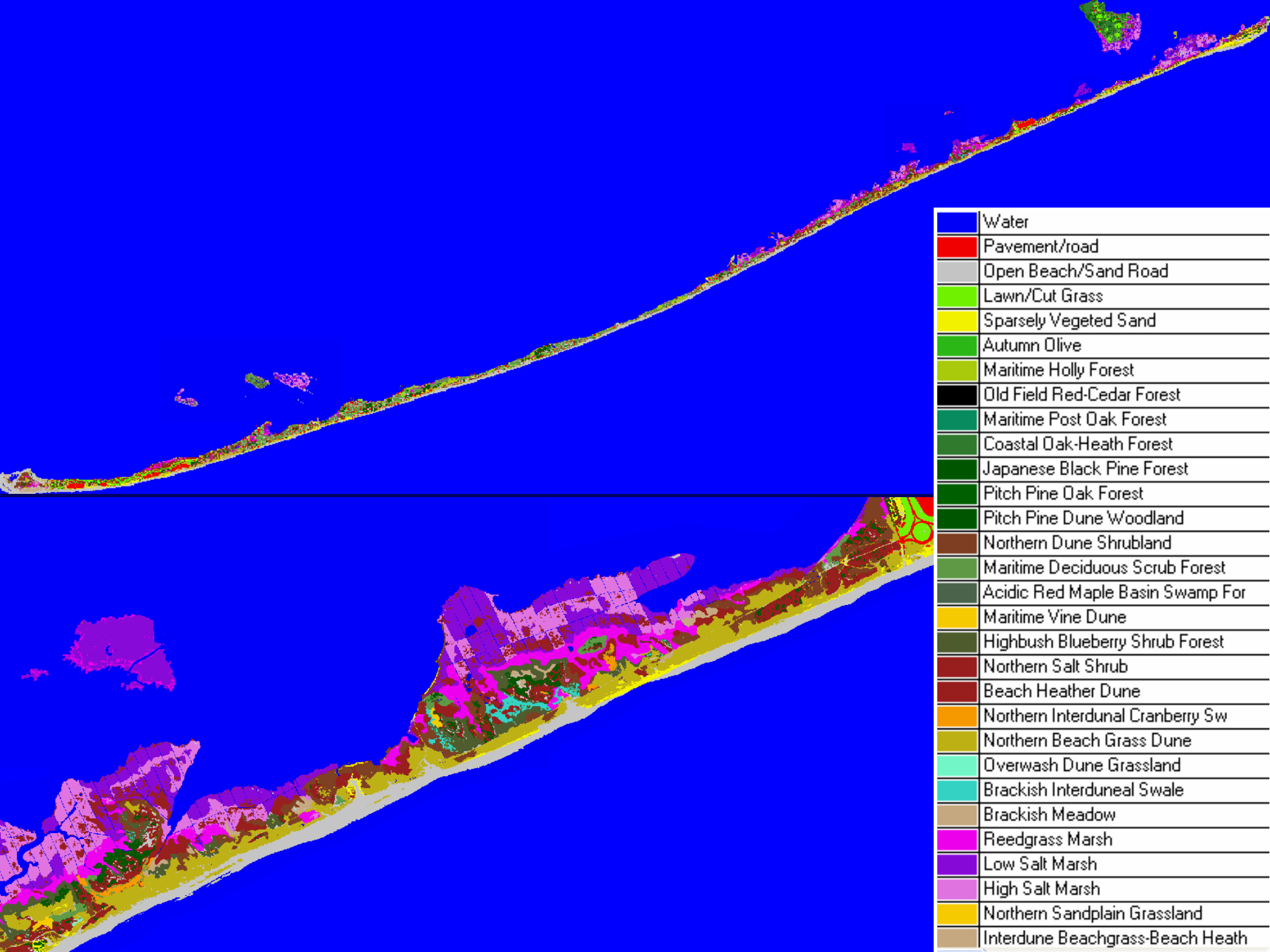
Updated marsh categories for this section



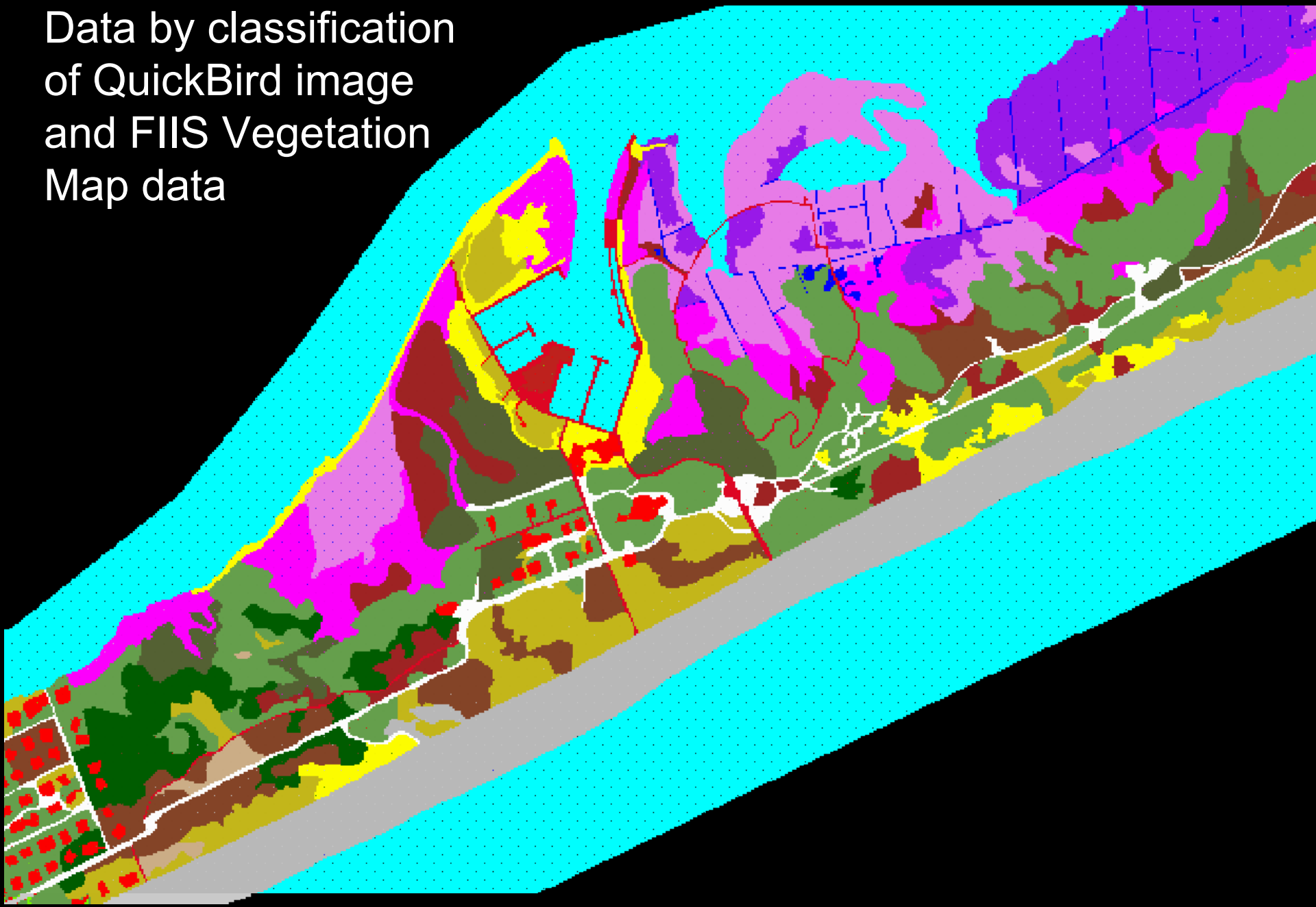
An example of extracted section from QuickBird image that was delineated as the open beach and sand road in the Phase I map (FIIS vegetation map).




Viewer #2 : eastbeachok.img (:Layer_1)
File Utility View AOI Raster Help
Unsupervised image classification on the masked beach areas to obtain new information.
Start
ERDAS I...
Viewer ...
Raster ...
C:\NetFiels
Viewer ...
Microsof...
3:33 AM


Water
Pavement/road
Open Beach/Sand Road
Lawn/Cut Grass
Sparsely Vegeted Sand
Autumn Olive
Maritime Holly Forest
Old Field Red-Cedar Forest
Maritime Post Oak Forest
Coastal Oak-Heath Forest
Japanese Black Pine Forest
Pitch Pine Oak Forest
Pitch Pine Dune Woodland
Northern Dune Shrubland
Maritime Deciduous Scrub Forest
Acidic Red Maple Basin Swamp For
Maritime Vine Dune
Highbush Blueberry Shrub Forest
Northern Salt Shrub
Beach Heather Dune
Northern Interdunal Cranberry Sw
Northern Beach Grass Dune
Overwash Dune Grassland
Brackish Interduneal Swale
Brackish Meadow
Reedgrass Marsh
Low Salt Marsh
High Salt Marsh
Northern Sandplain Grassland
Interdune Beachgrass-Beach Heath

Comparison of Vegetation Data by classification of QuickBird image and FIIS Vegetation Map data



Conclusion

- QuickBird data has the comparable spatial resolution and spectral advantage to produce vegetation maps.
- Referencing the existing vegetation map for stratified classification of QuickBird images is the key to maintain a creditable database for monitoring and updating practice.
- The final data product will meet the goal of updating FIIS vegetation map with finer spatial resolution
- The protocol is simple to follow and replication for other similar and future projects.

Submerged Aquatic Vegetation Mapping

SAV Mapping in FIIS

We adapted a classification scheme used by the New York Department of State's Division of Coastal Resources Office (NYDOS).

Our classification included presence and absence of SAV with subcategories of:

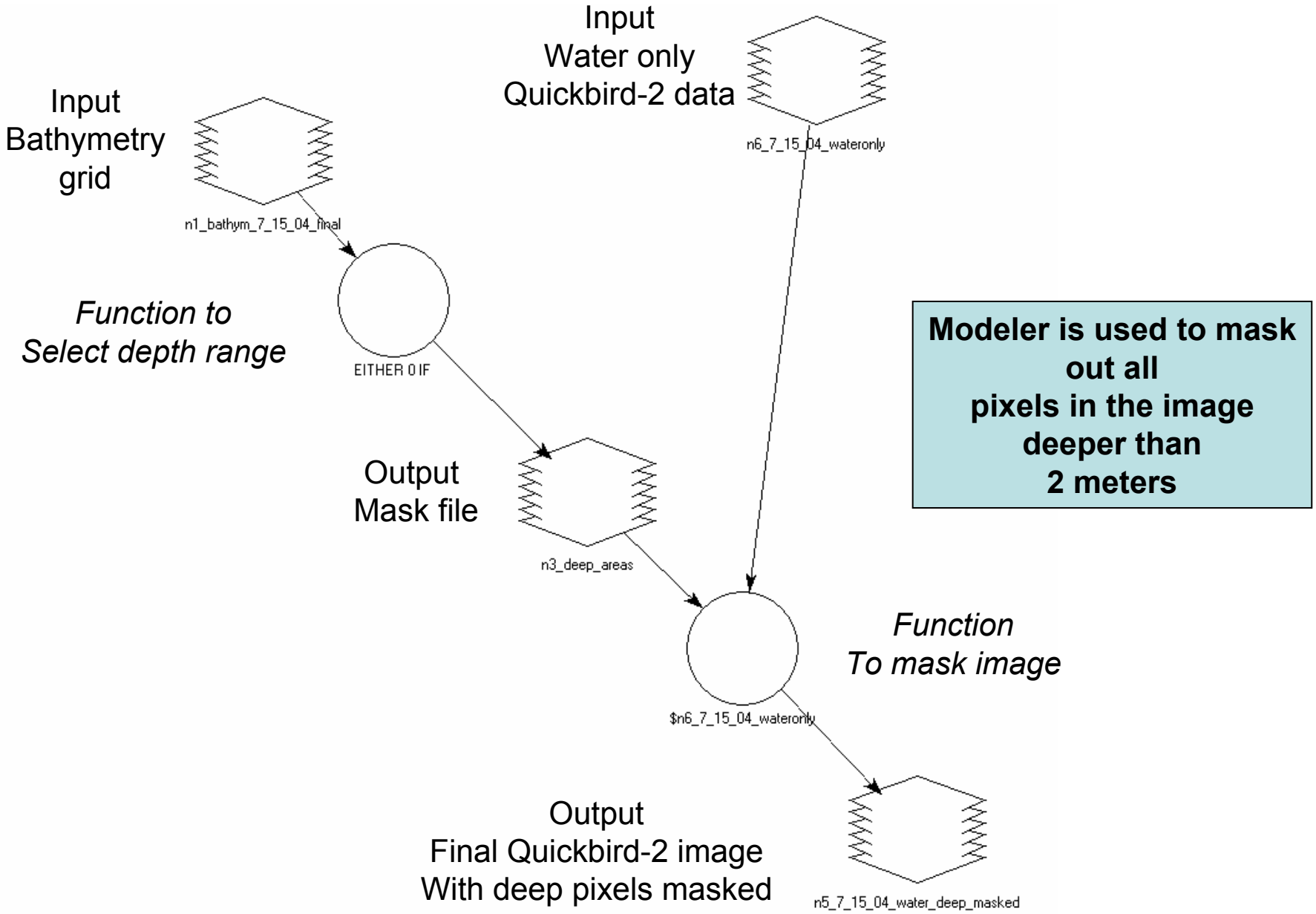
>25% seagrass cover = High Density Seagrass (HDS) < 25% Seagrass cover = Low Density Seagrass (LDS) < 5% Seagrass cover = Unvegetated bottom or Sand (SND).

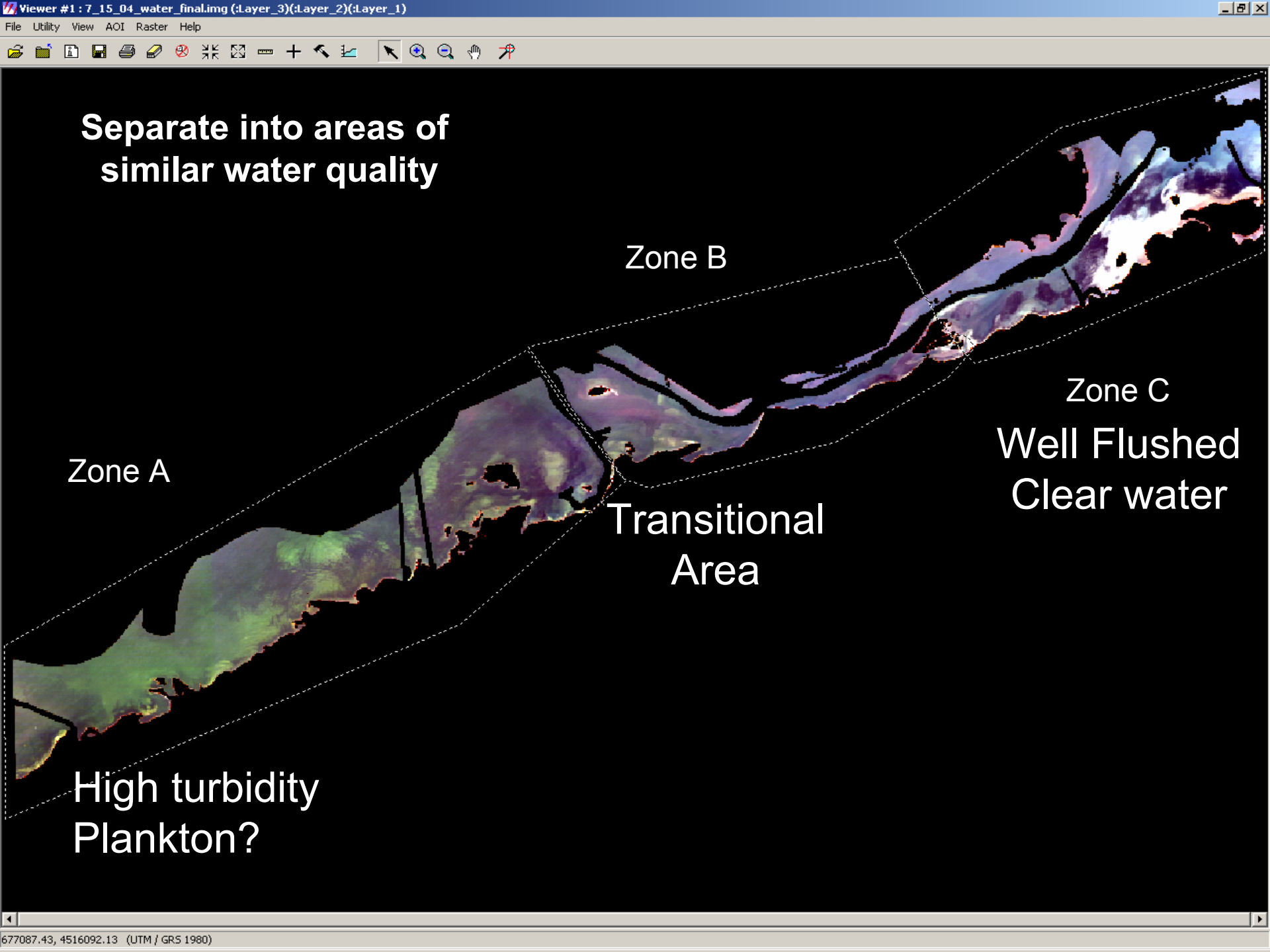
SAV Mapping

The albedo of deep water is confusing to that of a dense SAV bed. Therefore areas of deep water can be a considerable source of error for mapping SAV habitats.

We generated a bathymetric model to mask out all areas deeper than 2.5 meters mean low water in the study area.

We adopted the bathymetric data from the NOAA National Geophysical Data System (GEODAS), employed about 32,289 points from 19 surveys to generate the depth mask. We converted the point data into a 5 meter grid.

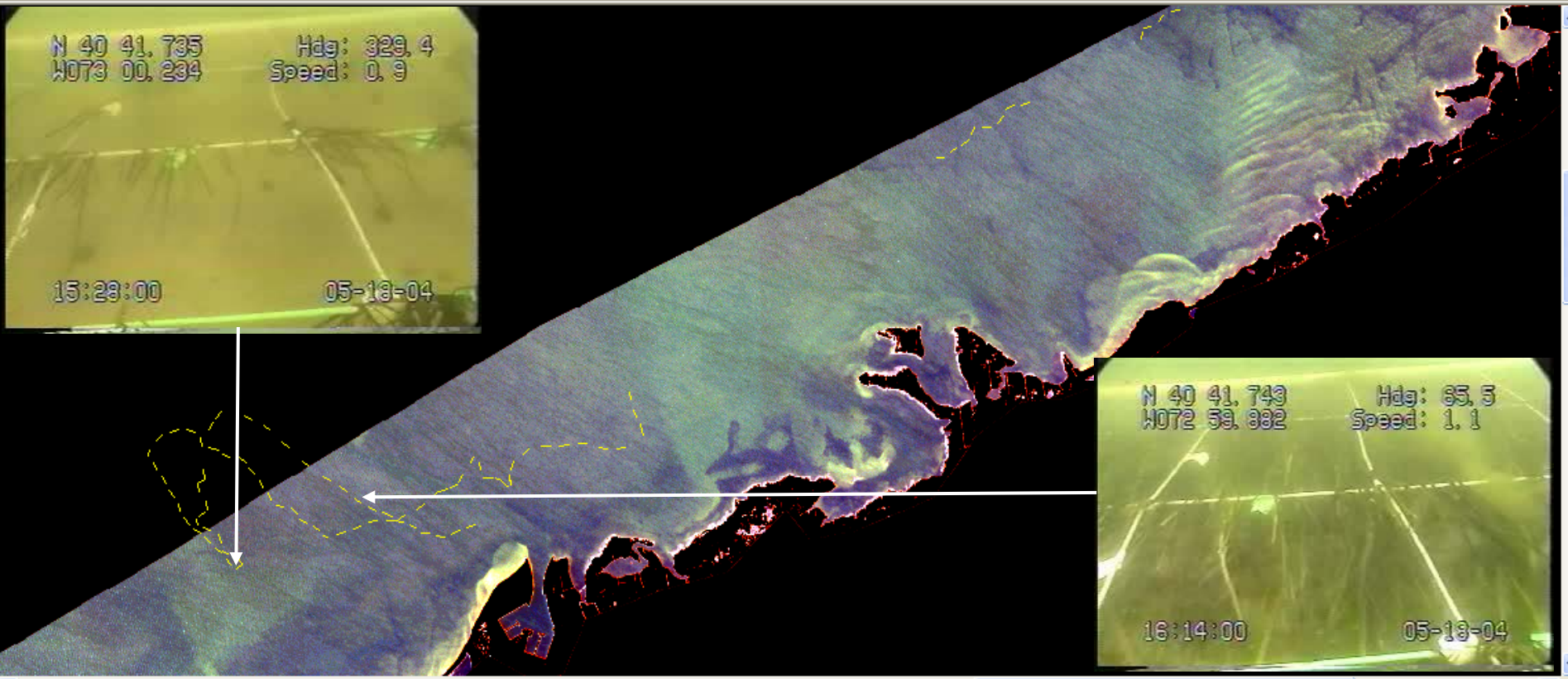

Input
Water only
Quickbird-2 data
n6_7_15_04_wateronly
Input
Bathymetry
grid
n1_bathym_7_15_04_final
Function to
Select depth range
EITHER 0 IF
Modeler is used to mask
out all
pixels in the image
deeper than
2 meters
Output
Mask file
n3_deep_areas
Function
To mask image
$n6_7_15_04_wateronly
Output
Final Quickbird-2 image
With deep pixels masked
n5_7_15_04_water_deep_masked


Viewer #1 : 7_15_04_water_final.img (:Layer_3)(:Layer_2)(:Layer_1)
File Utility View AOI Raster Help
Separate into areas of similar water quality
Zone B
Zone A
Zone C
Well Flushed Clear water
Transitional Area
High turbidity Plankton?
677087.43, 4516092.13 (UTM / GRS 1980)

Examples of GPS georeferenced Field Photos

Viewer #1 : transect_data.shp

File Utility View AOI Vector Raster Help



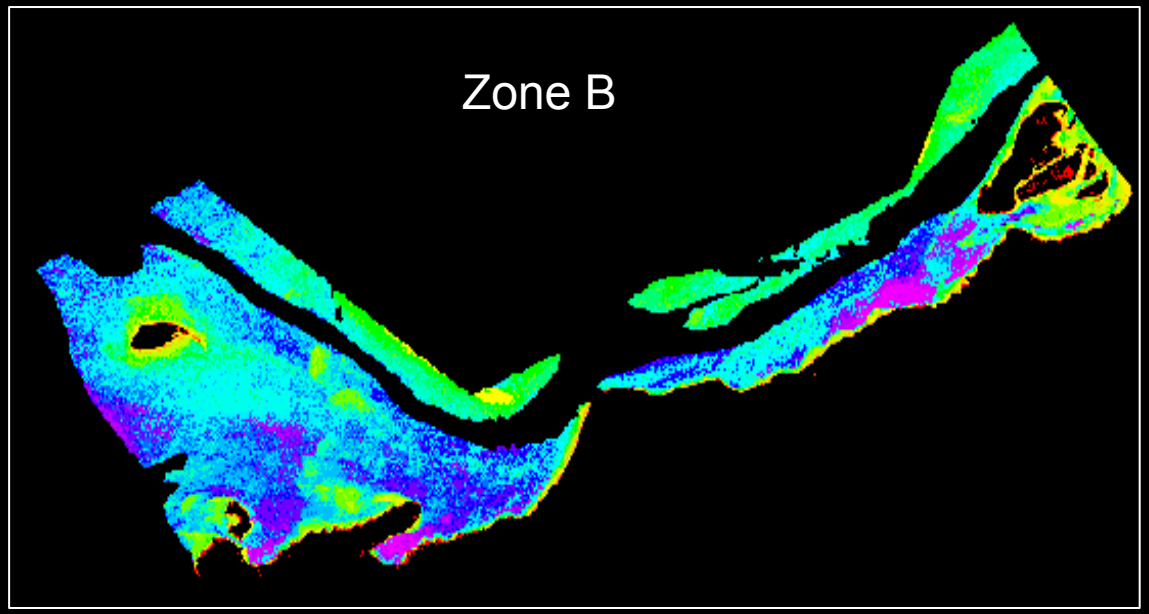
Attributes for d:/mike/fire_island/data/field_data/transect_data.shp

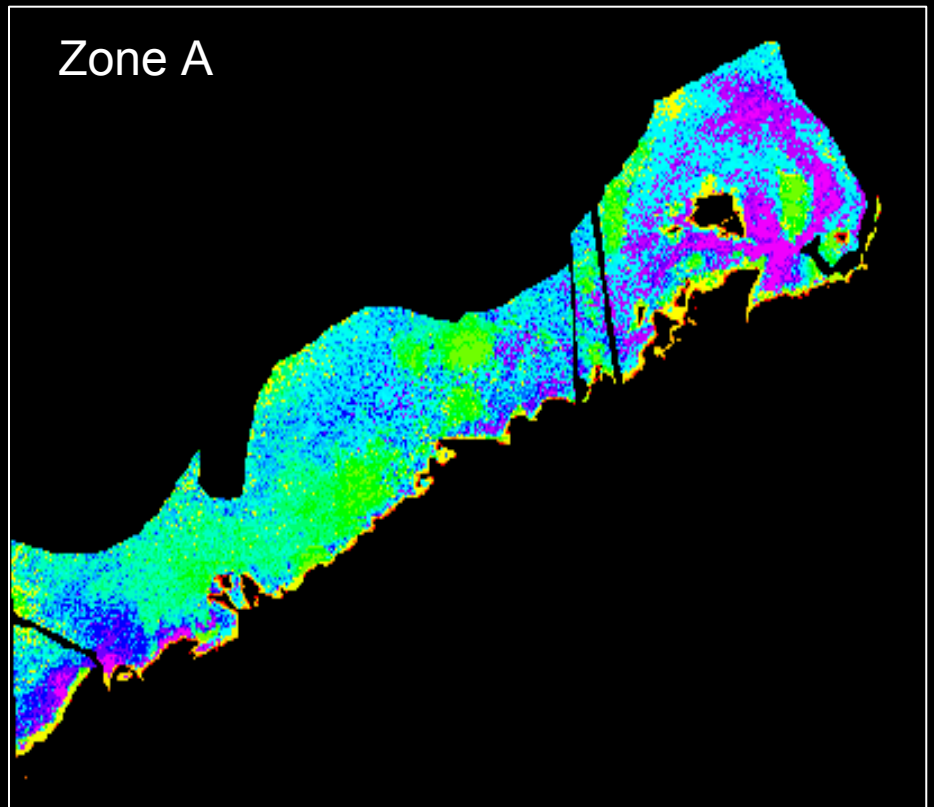
File Edit View Help

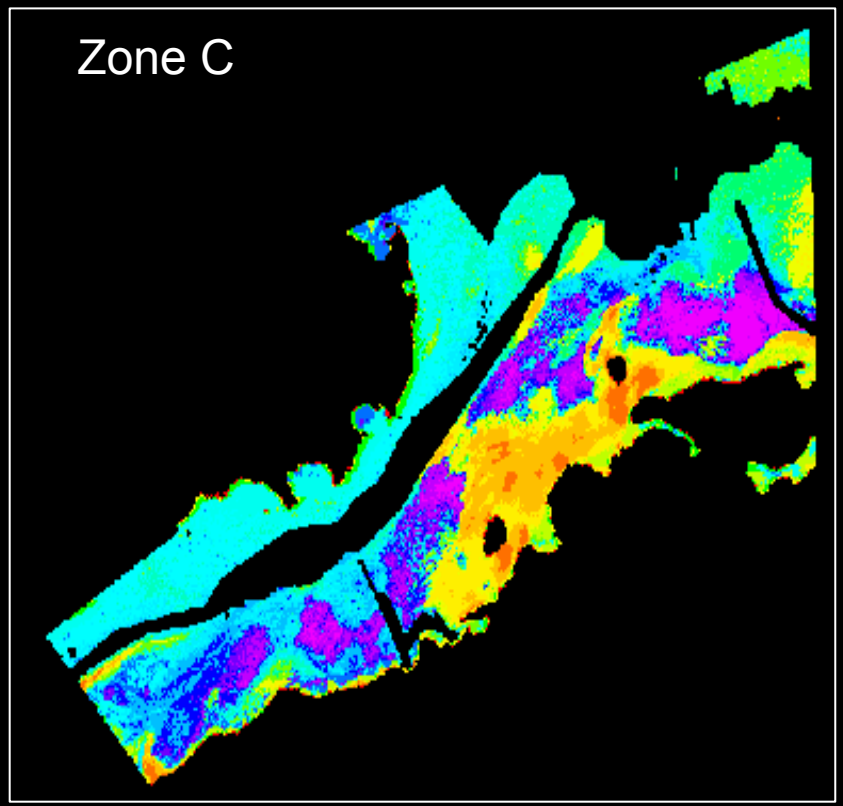
Record	Tot t	Veg T	P cov	species	video
60	65	61	0.93846153800	zostera	D:\mike\Fire_Island\DATA\Field_data\Video\51804160800.mpg
61	65	61	0.93846153800	zostera	D:\mike\Fire_Island\DATA\Field_data\Video\51804161000.mpg
62	53	53	1.00000000000	zostera	D:\mike\Fire_Island\DATA\Field_data\Video\51804161200.mpg
63	53	53	1.00000000000	zostera	D:\mike\Fire_Island\DATA\Field_data\Video\51804161400.mpg

start Ad... Mic... Unt... Arc AR... 2 W. ER... 2 v... 2 M. Vir... Address 3:41 PM

Class Names	Color
Unclassified	
Class 1	
Class 2	
Class 3	
Class 4	
Class 5	
Class 6	
Class 7	
Class 8	
Class 9	
Class 10	
Class 11	
Class 12	
Class 13	
Class 14	
Class 15	
Class 16	
Class 17	
Class 18	
Class 19	
Class 20	



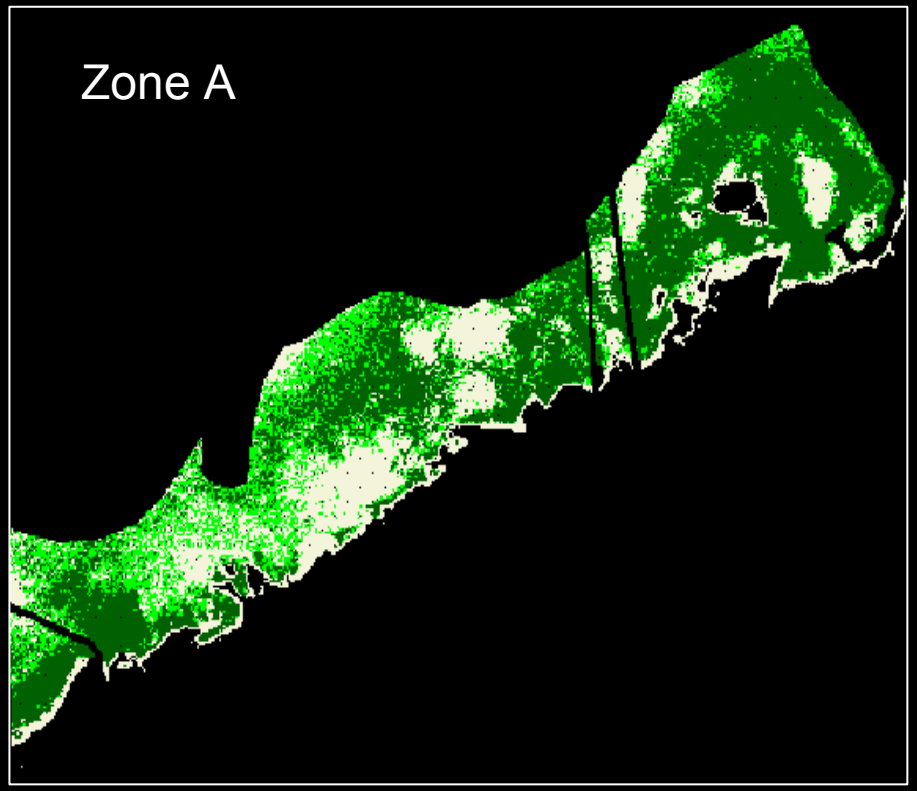


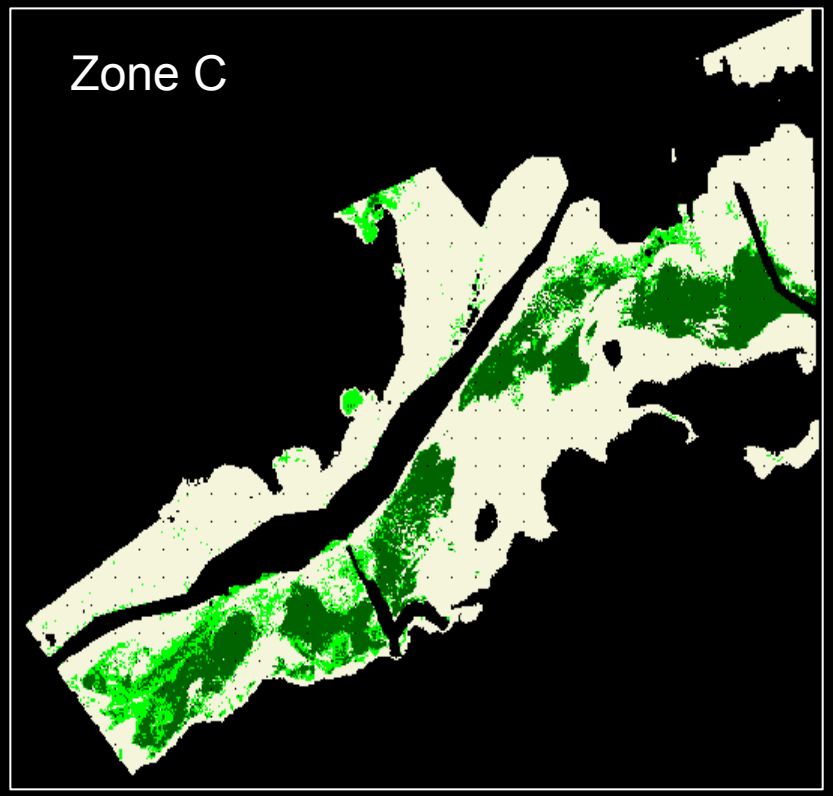


LDS

HDS

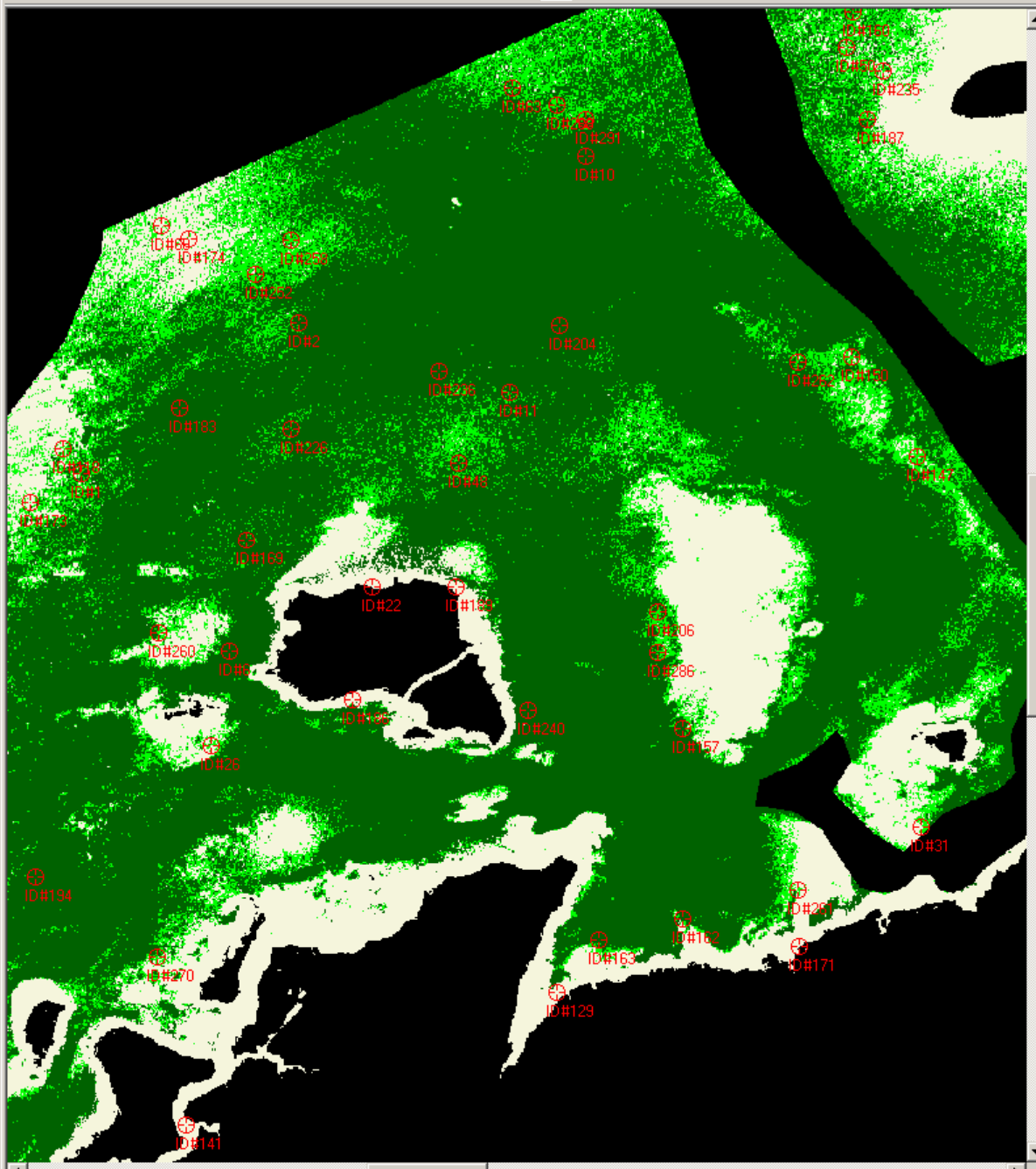
Unvegetated Bottom





Viewer #1 : 7_15_04_final_classification.img (:Layer_1)

File Utility View AOI Raster Help



Accuracy Assessment (7_15_04_final_classification.img) - Viewer# 1

File Edit View Report Help

Point #	Name	X	Y	Class	Reference
1	ID#1	675494.500	4511162.000	1	
2	ID#2	675987.000	4511504.500	1	
3	ID#3	670629.500	4507277.000	2	
4	ID#4	669939.500	4507044.500	1	
5	ID#5	686837.000	4515654.500	3	
6	ID#6	675829.500	4510759.500	1	
7	ID#7	672027.000	4508834.500	2	
8	ID#8	672974.500	4509024.500	1	
9	ID#9	669364.500	4507274.500	1	
10	ID#10	676637.000	4511879.500	1	
11	ID#11	676464.500	4511347.000	1	
12	ID#12	682139.500	4513074.500	3	
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14	ID#14	671529.500	4507859.500	2	
15	ID#15	683494.500	4513927.000	3	
16	ID#16	672499.500	4508857.000	2	
17	ID#17	670459.500	4506909.500	3	
18	ID#18	673379.500	4509014.500	2	
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21	ID#21	682852.000	4512882.000	3	
22	ID#22	676152.000	4510904.500	3	
23	ID#23	672947.000	4508397.000	3	
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26	ID#26	675787.000	4510544.500	2	
27	ID#27	683134.500	4513694.500	3	
28	ID#28	684482.000	4514719.500	2	
29	ID#29	670372.000	4507472.000	2	
30	ID#30	684714.500	4514172.000	1	
31	ID#31	677397.000	4510362.000	3	
32	ID#32	669164.500	4507342.000	3	
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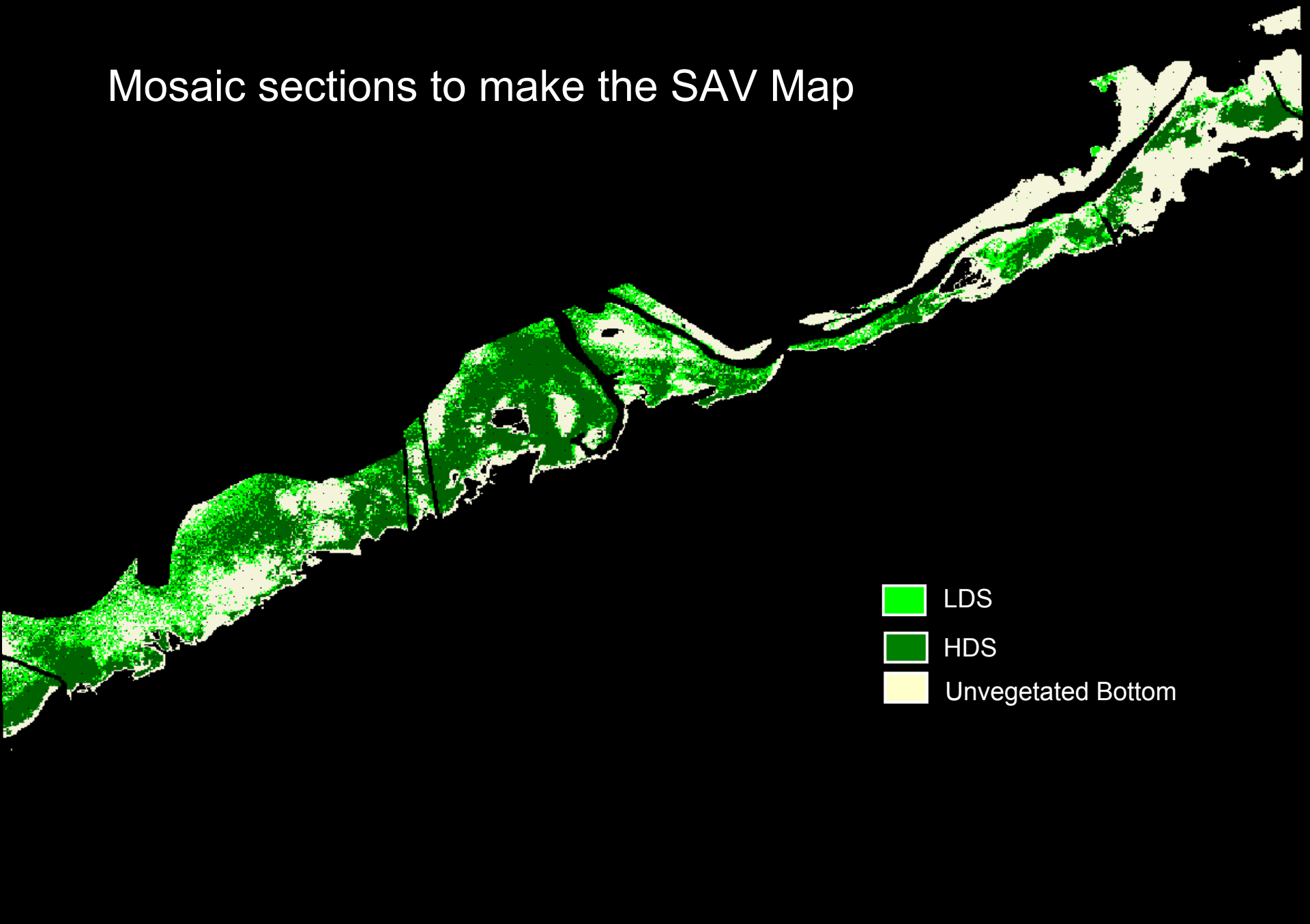
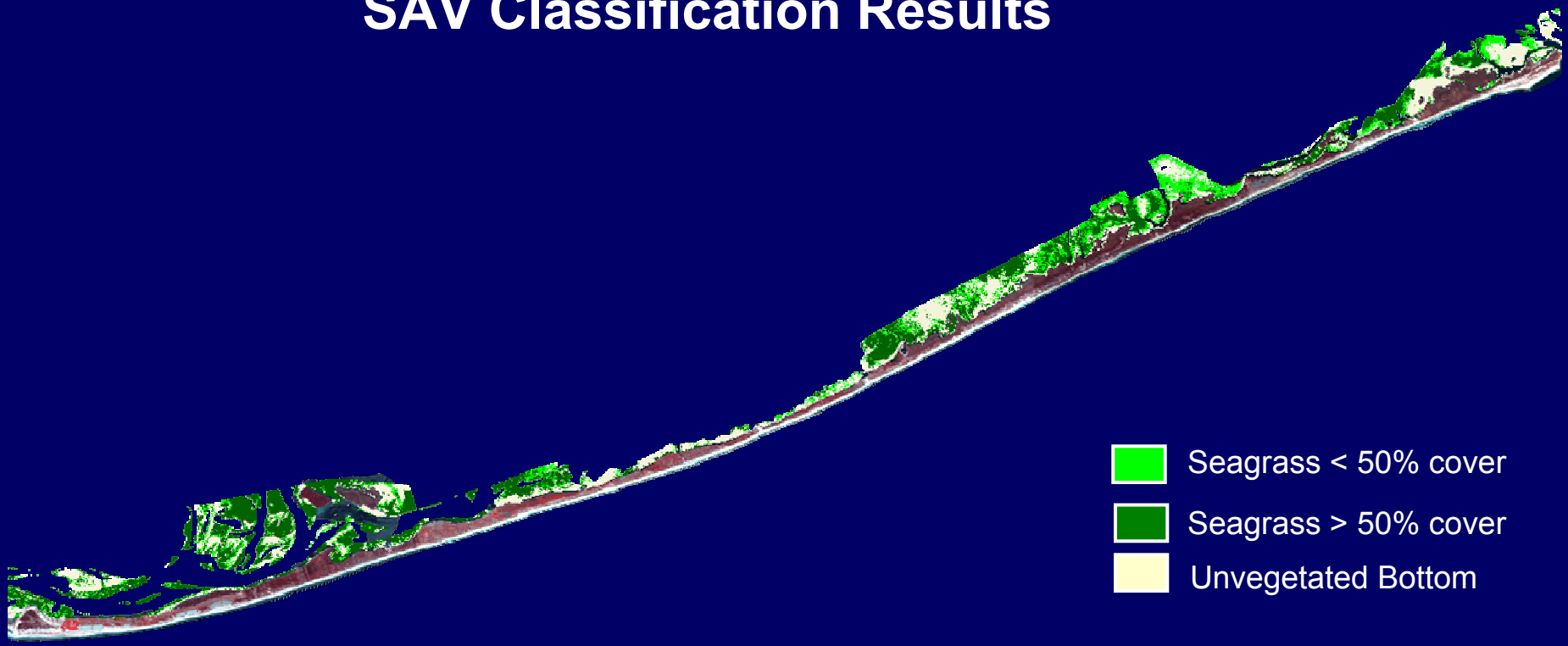
52	ID#52	679187.000	4511229.500	2	
53	ID#53	677632.000	4512369.500	3	
54	ID#54	672969.500	4509374.500	1	

Mosaic sections to make the SAV Map



SAV Classification Results



Class	Area (in hectares)	
	QB-2 2004	Aerial 2002
High Density Seagrass	1543.3	1300.9
Low Density Seagrass	703.5	167.4
Total	2246.8	1468.3

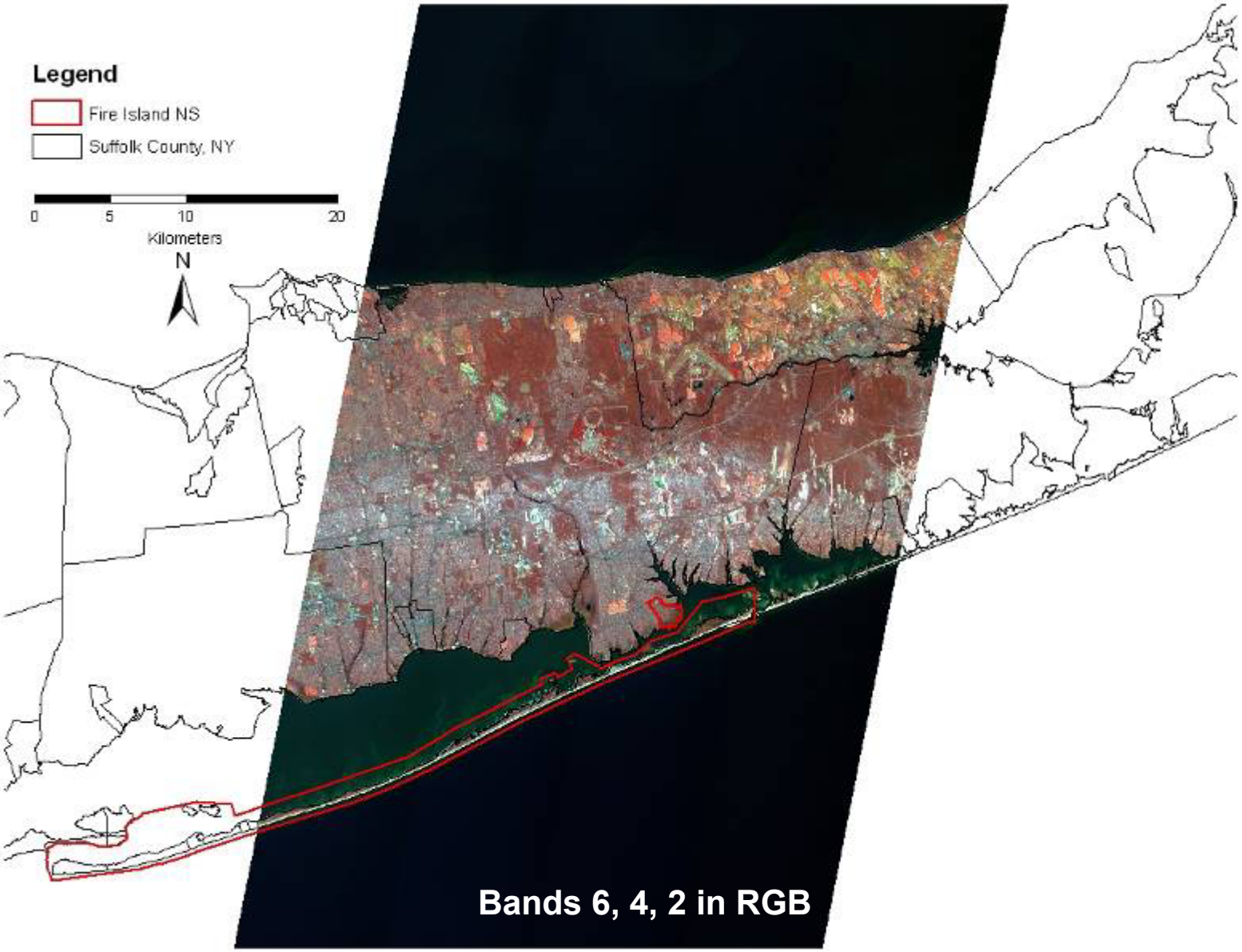
Advanced Land Imager (ALI) Data

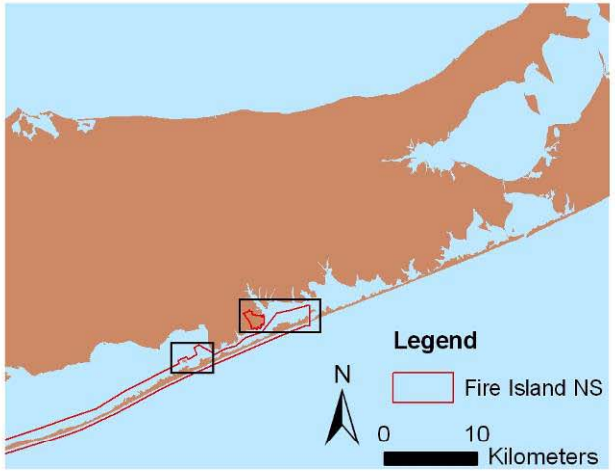
Although high spatial resolution of the QuickBird satellite data helped identify the spatial patterns of the SAV communities, the lack of information on shortwave spectral coverage limited the data capacity and quality of SAV classification and mapping.

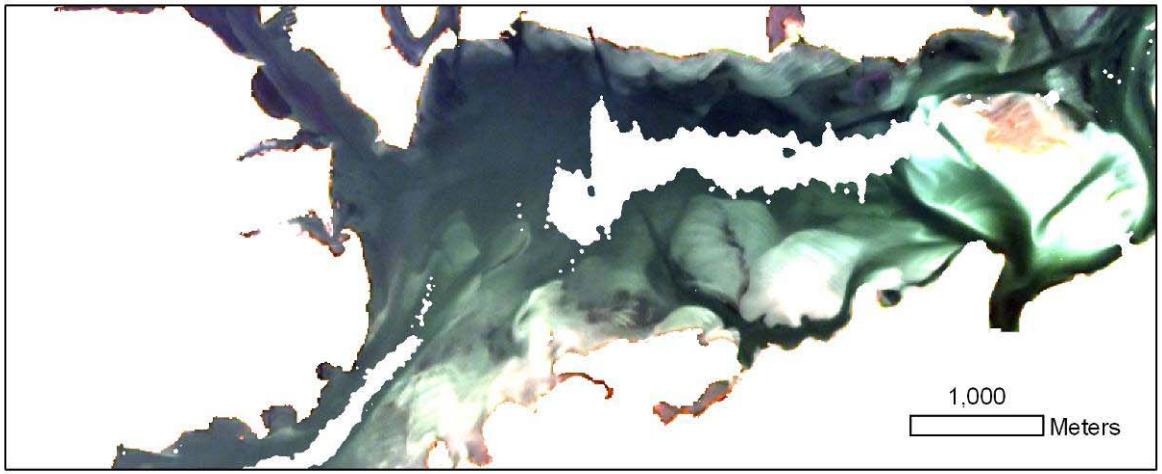
To improve this effort, we tested the Advanced Land Imager (ALI) sensor data on board EO-1 satellite that include more options on short wave spectral coverage.

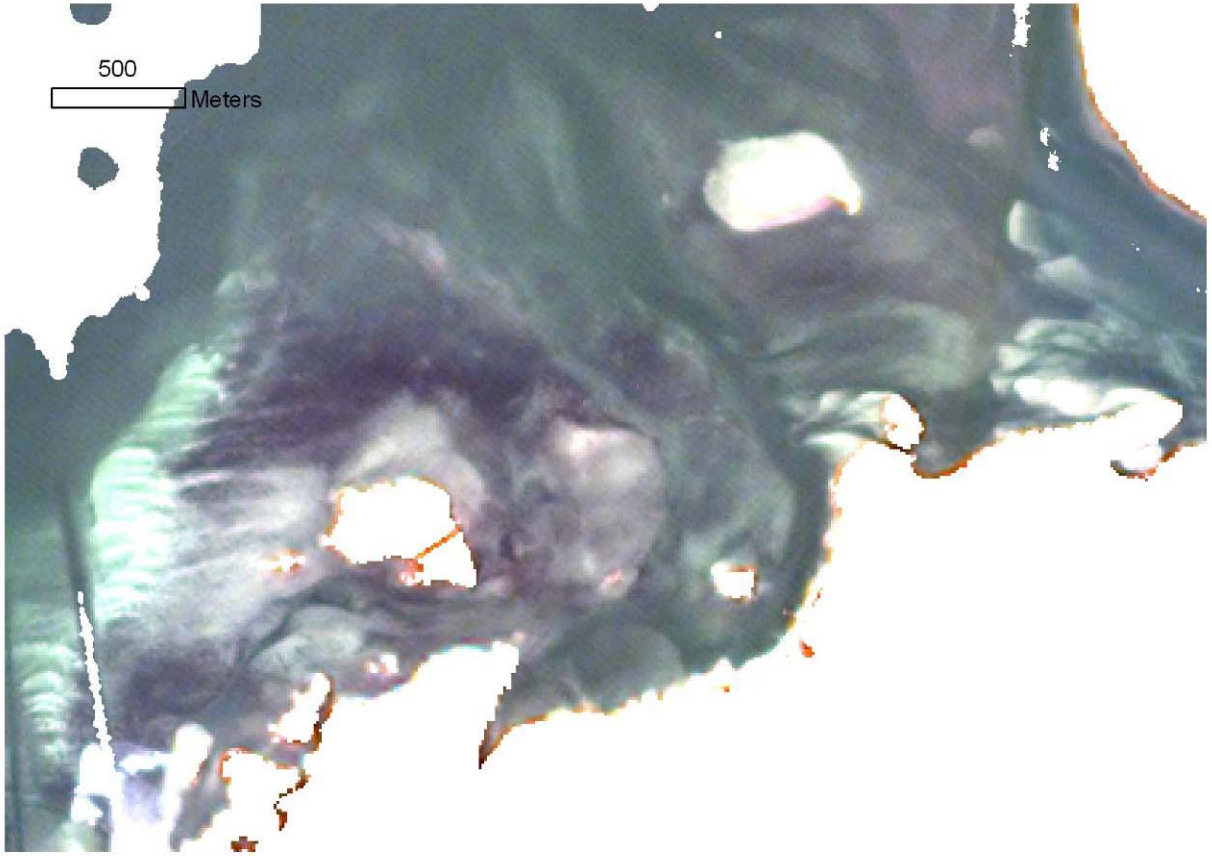
The noticeable spectral band that covers the short blue wavelength between 0.433-0.453 μm could provide better penetration for SAV identification.

ALI 30 m original data acquired on March 7, 2006

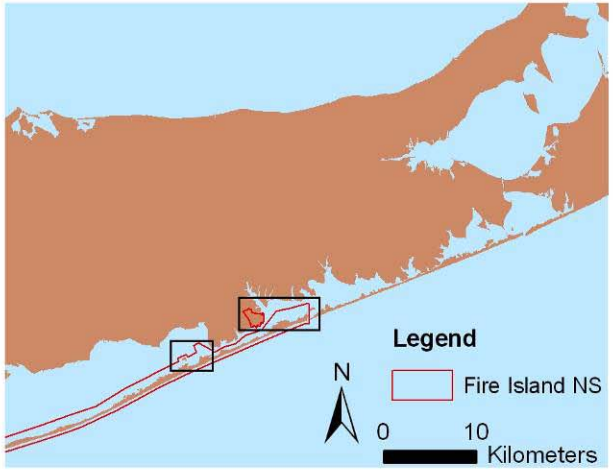








Subsetted ALI
Mar 7, 2006
Reflectance and
Resolution Merged
Data at 10-m
spatial resolution.



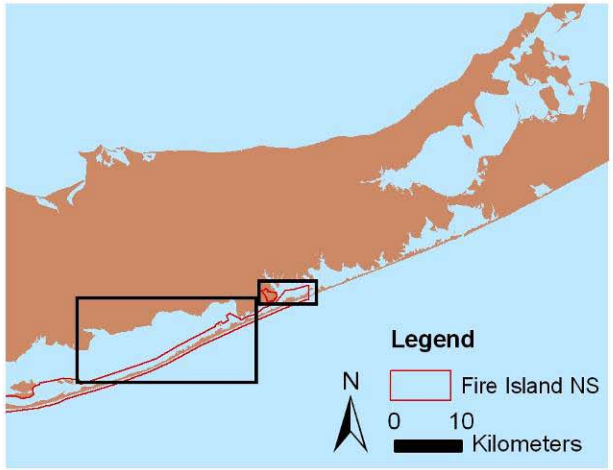
Unsupervised Classification of ALI Mar 7, 2006 displayed on orthophoto

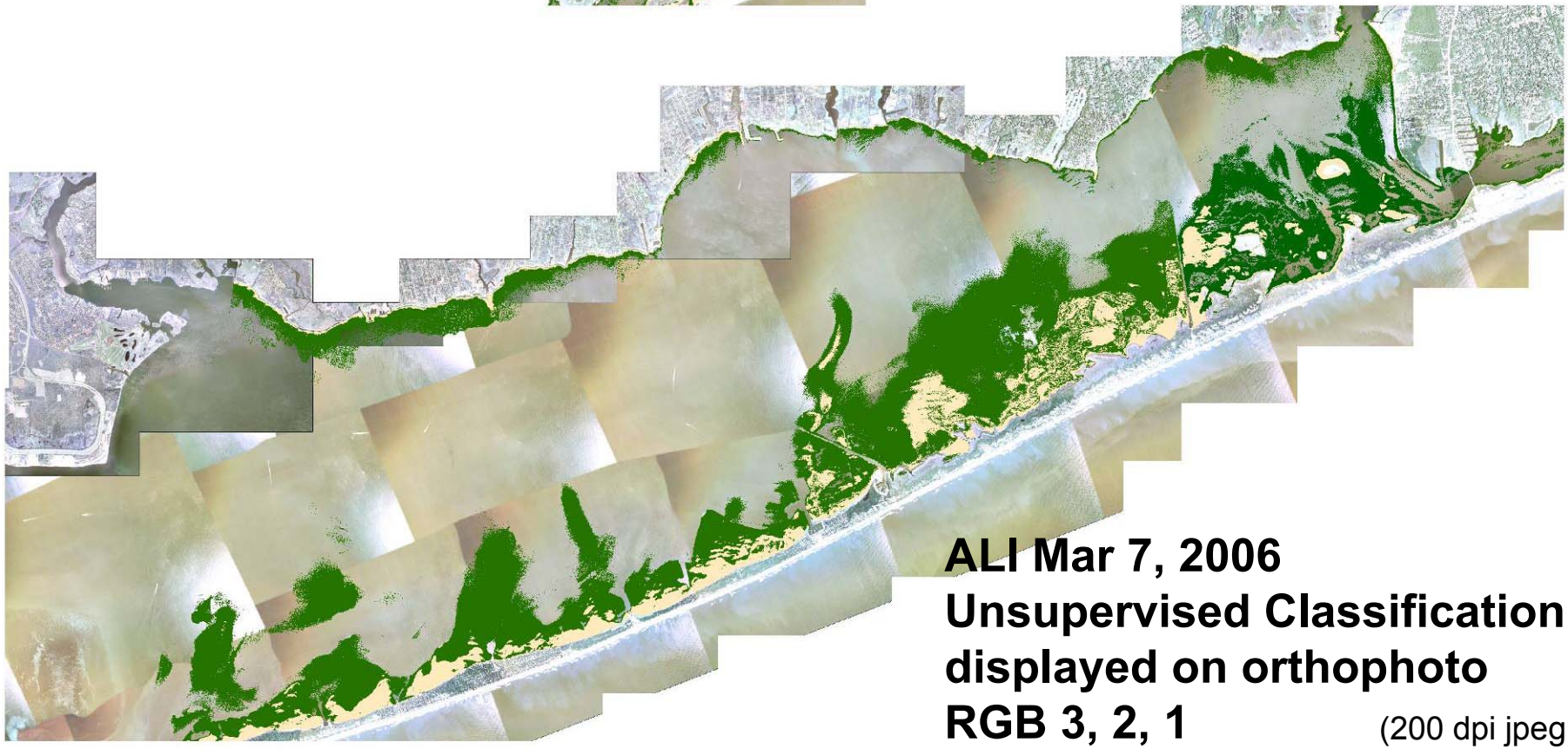
Legend

SND

VEG

(200 dpi jpeg)





ALI Mar 7, 2006
Unsupervised Classification displayed on orthophoto
RGB 3, 2, 1

(200 dpi jpeg)

Accuracy assessment for SAV classification by ALI data on EO-1 satellite

				Accuracy		
Class	Reference totals	Class totals	Number correct	Producers	Users	Kappa
HDS	63	75	55	87.3%	73.3%	0.63
LDS	49	75	41	83.7%	54.7%	0.42
SND	113	75	72	63.7%	96.0%	0.92

Overall Classification Accuracy = 75.7%

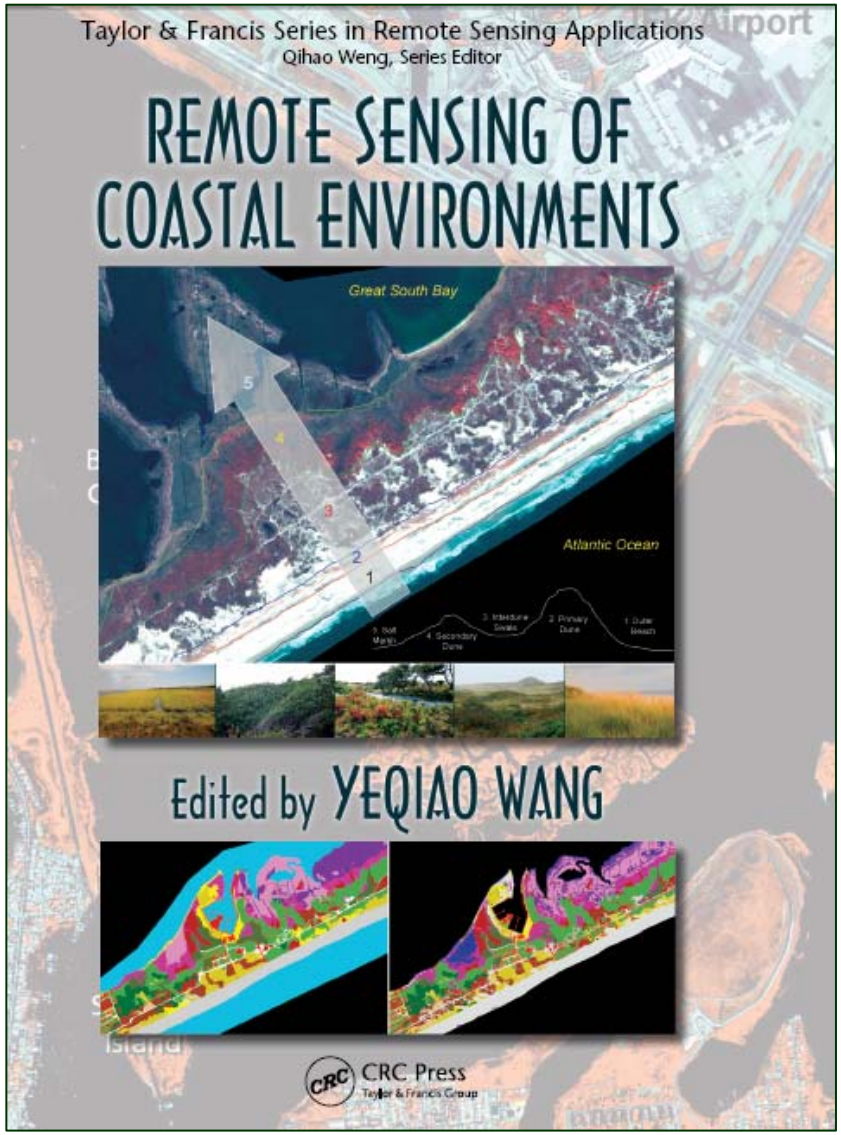
Overall Kappa Statistics = 0.64

Comparison of areas (ha.) of SAV classification using ALI and QuickBird data for the same study area

	ALI	Quickbird
HDV	765	713
LDV	525	501
SND	970	783
Other	888	1151

Conclusion

- Integration of bathymetry data, orthophotography, and GIS information is the key to establishing accurate classification of SAV.
- Although high spatial resolution satellite imagery data have advantages in mapping spatial details, acquisition of satellite imagery data is mostly out of the control of end users in term of getting the data for optimal times. This is particularly true for SAV mapping.
- We were unable to determine a unique contribution of the short wave blue band in classification of SAV using principal component analysis. Further testing is recommended for gaining insights about the effectiveness of ALI short blue wavelength in SAV mapping.



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UNIVERSITY OF Rhode Island

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