

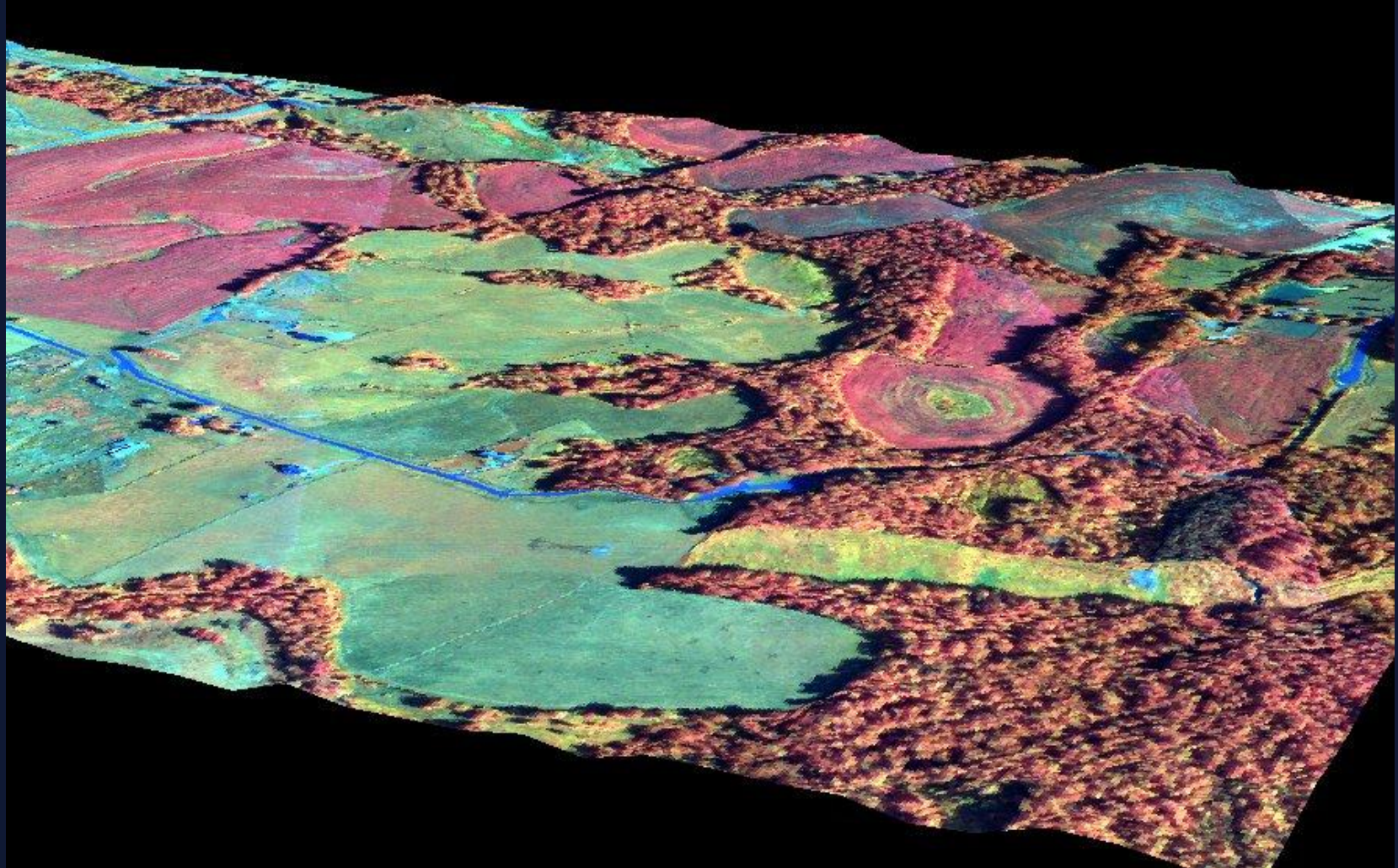
Hyperspectral Image Acquisition and Analysis

PECORA 15 Workshop 7

Airborne Remote Sensing: A Fast-track Approach to NEPA Streamlining for Transportation

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CASI Hyperspectral and Lidar DEM



Presentation Outline

- Project description
- Why hyperspectral?
- Casi image acquisition
- Creation of image map
- Analysis of hyperspectral imagery to produce wetland classification - validation & verification
- Conclusions

Project Objectives

- Need to know location and extent of wetlands within a future transportation corridor
- Acquire high spatial and spectral resolution imagery for semi rural area south east of High Point, NC
- Produce thematic vegetation map highlighting potential wetlands
- Combine imagery with topography from lidar

Project design

**Airborne Data
Collection**

**Data Processing /
Data Fusion**

**Analysis / Feature
Extraction**

**Validation &
Verification**

Ground-truth
(spectral,
biology)

**CASI &
GPS/IMU**
(hyperspectral)

Sensor / data
fusion radiometric,
atmospheric,
mosaic

**Spectral
Classifications**

**AeroScan
LIDAR**
(lidar)

DEM
(bare earth/canopy)

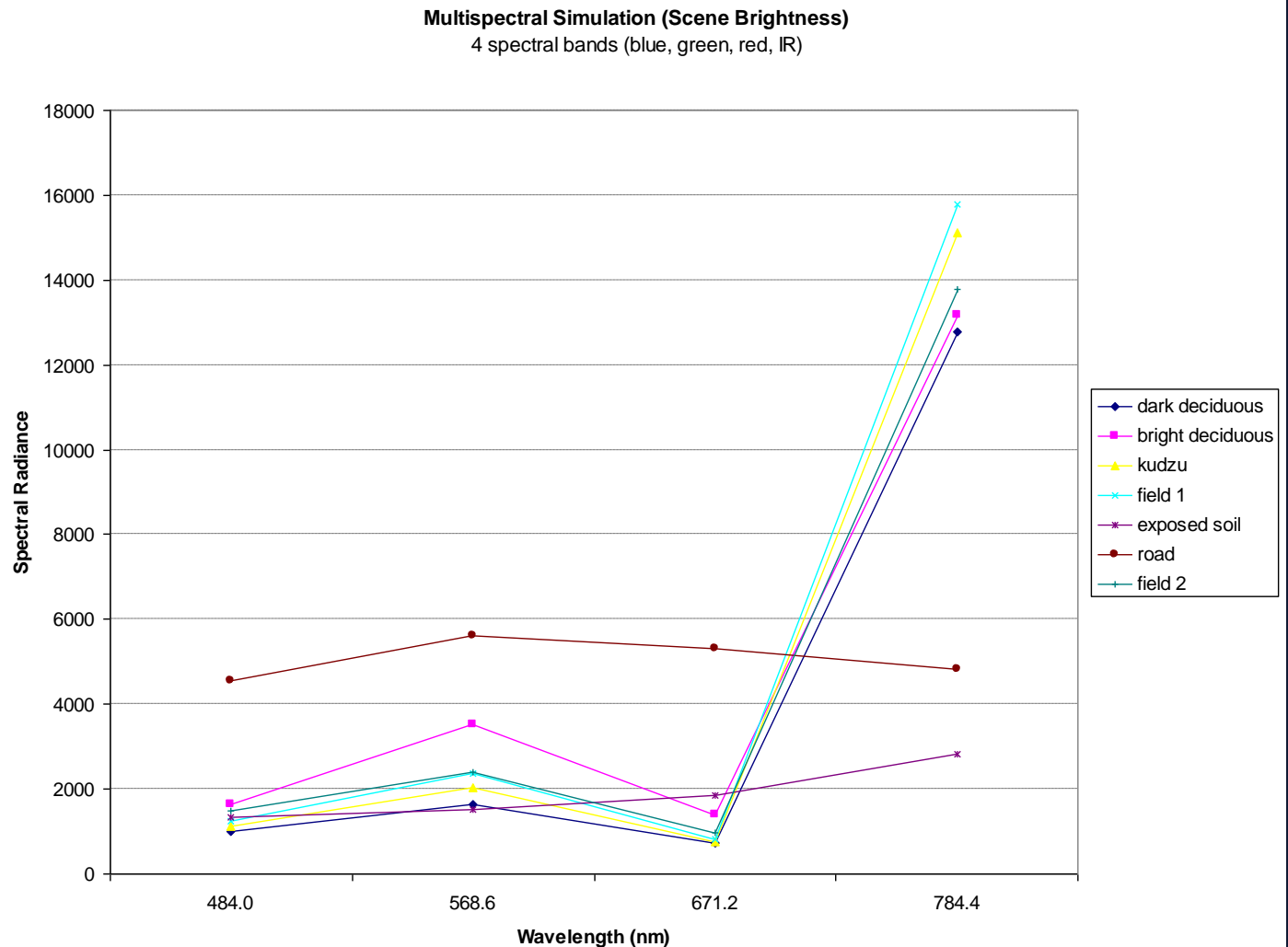
PRODUCTS
Wetlands &
land cover
classifications



Why hyperspectral?

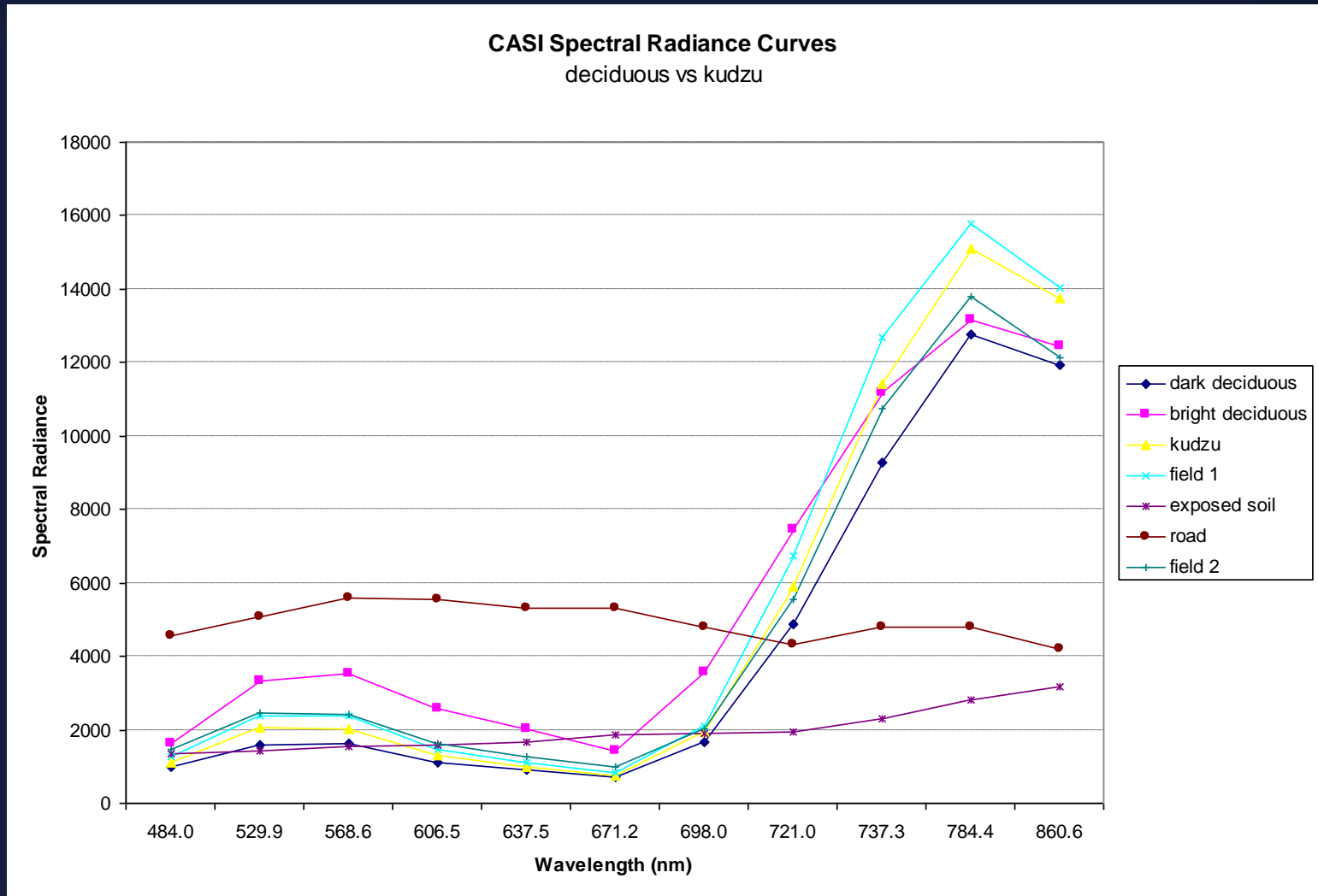
- Many narrow spectral bands offers the ability to separate community level (and species) land cover features.
- Hyperspectral provides subtle spectral signatures or curves of terrestrial targets.
- Using hyperspectral makes it easier to 'unmix' pixels, thus improving confidence in classification results.

Why hyperspectral?



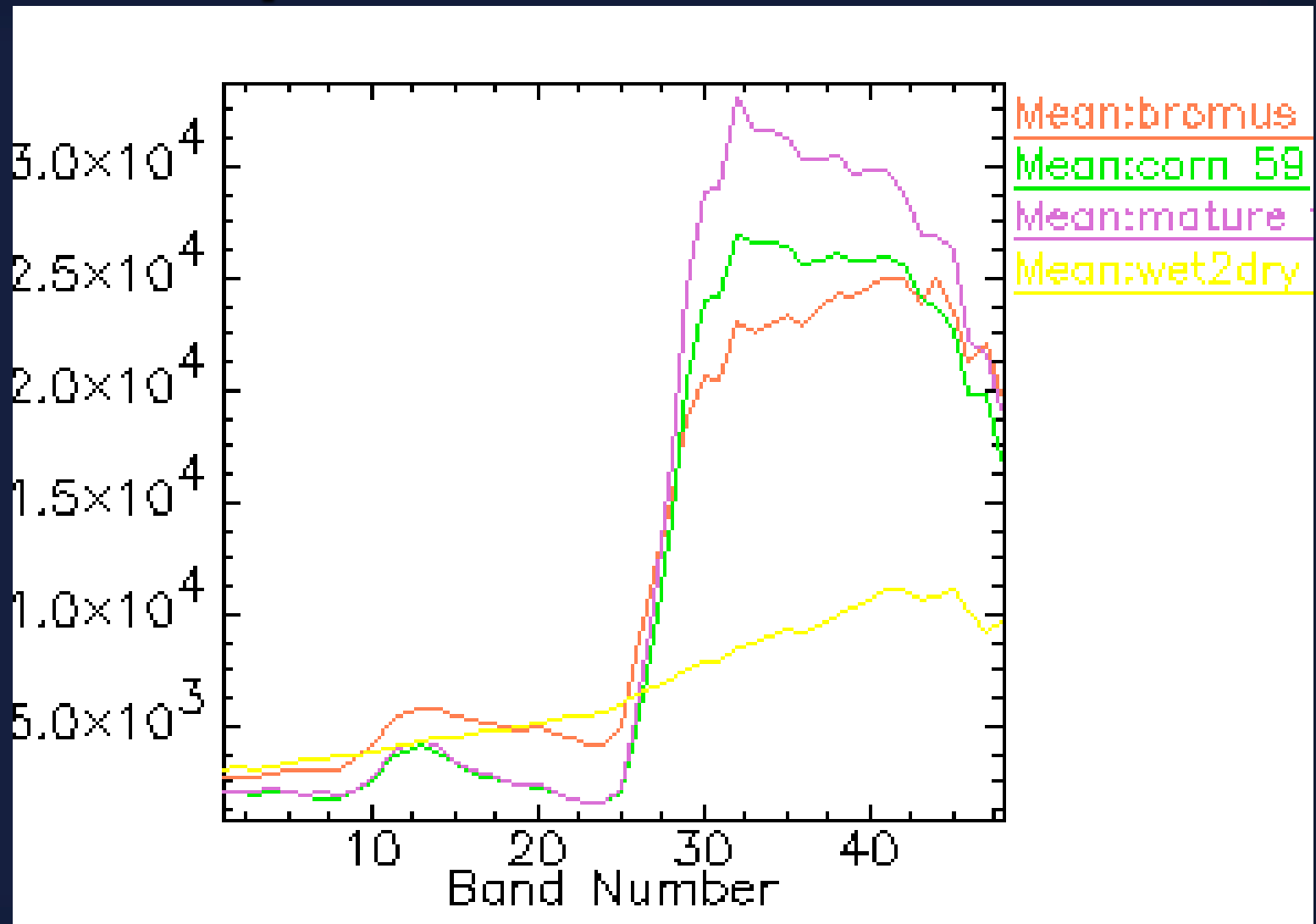
The use of only a few spectral bands reduces discrimination capabilities and can create more confusion/uncertainty in the final classification

Why hyperspectral?



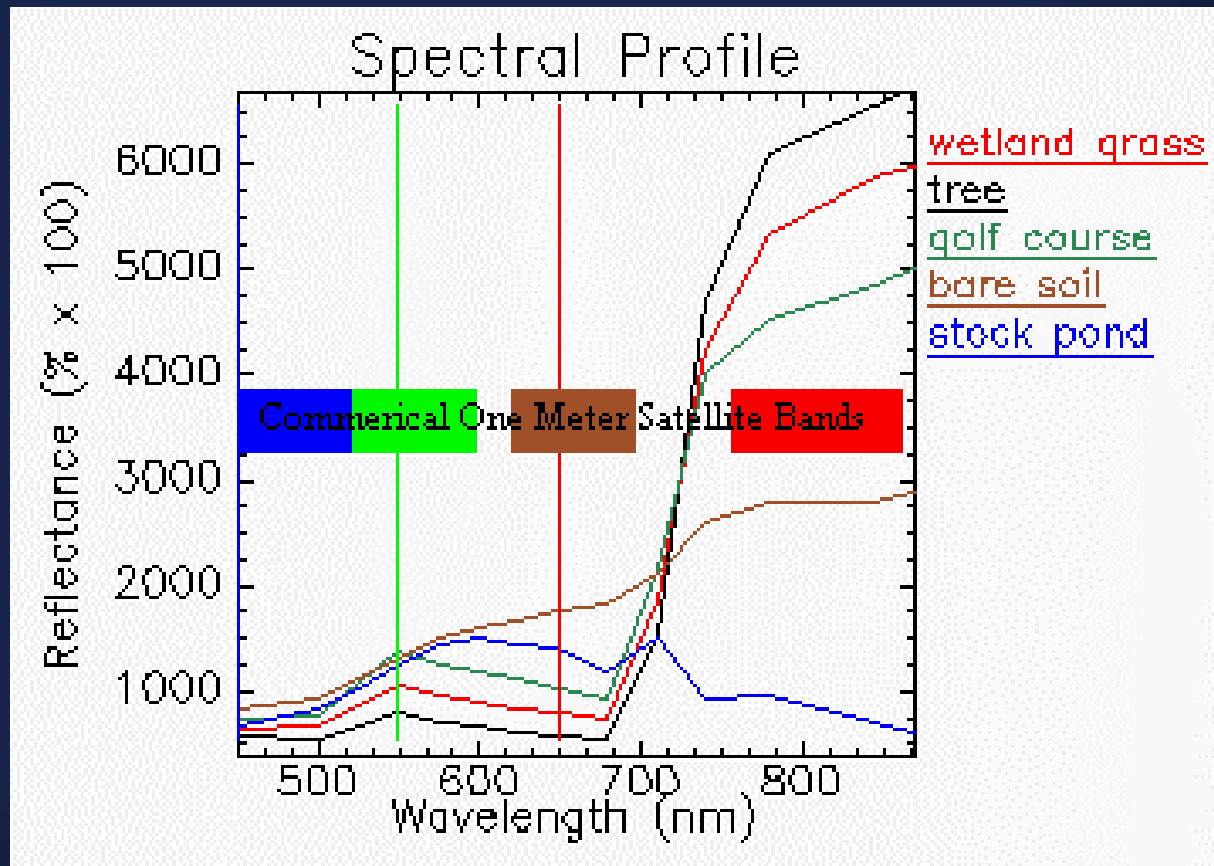
The use of many spectral bands allows for detailed discrimination of features

48 Spectral bands: Iowa 2002



The use of many spectral bands allows for detailed discrimination of features

Hyperspectral vs. Satellite



The use of many spectral bands allows for detailed discrimination of features

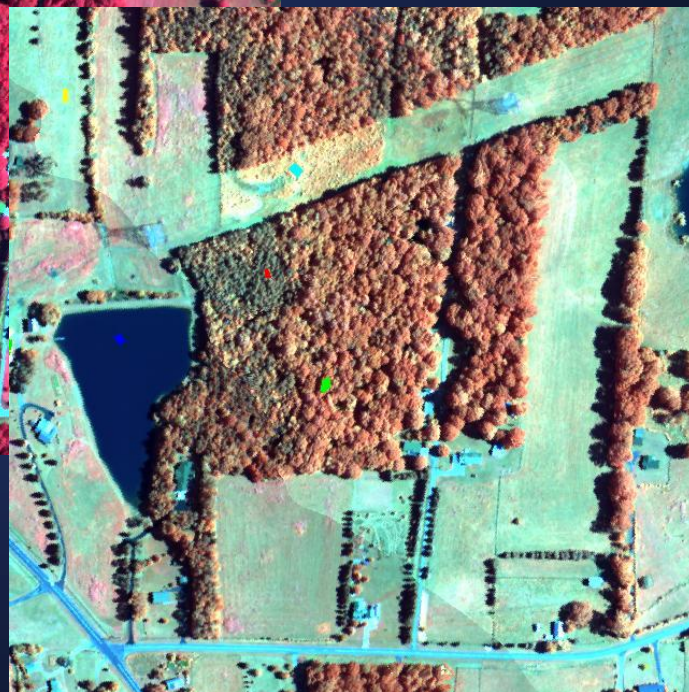
Why hyperspectral?



True color



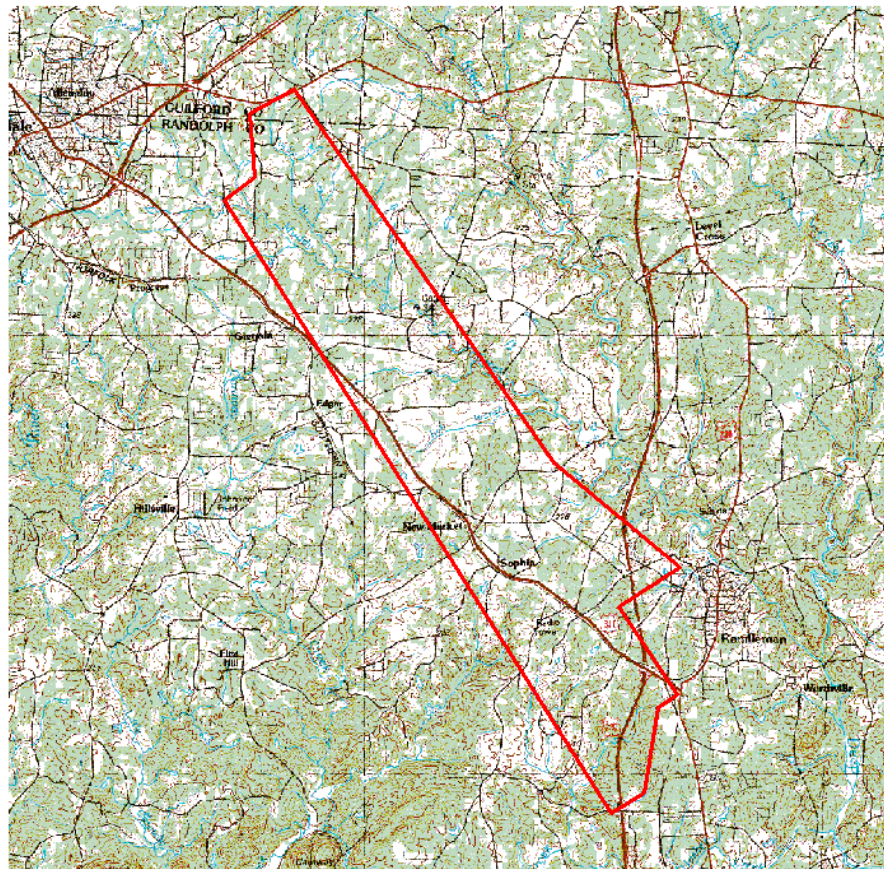
CASI False
color IR



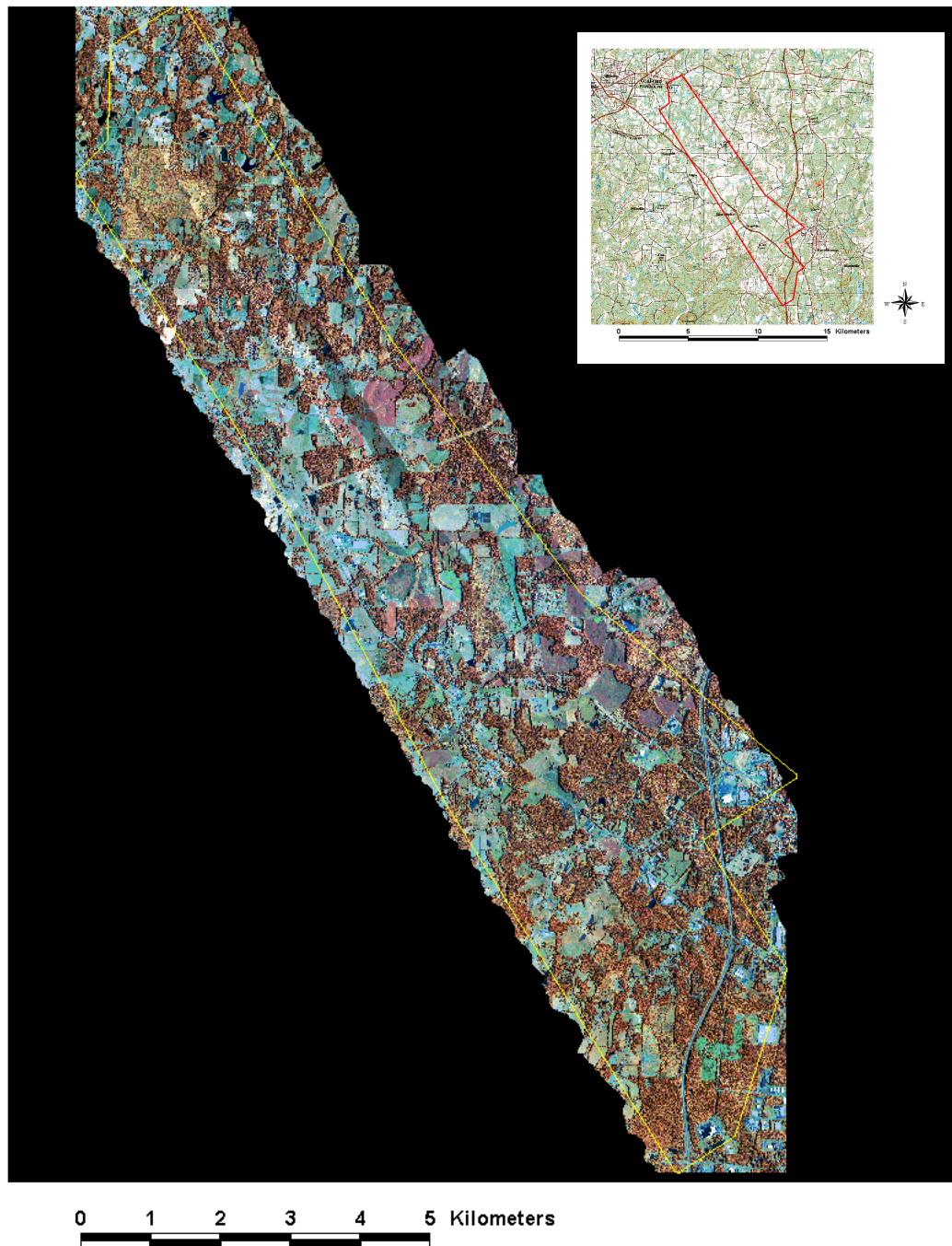
Simulated CIR

Project Area

↑
To High
Point



0 5 10 15 Kilometers

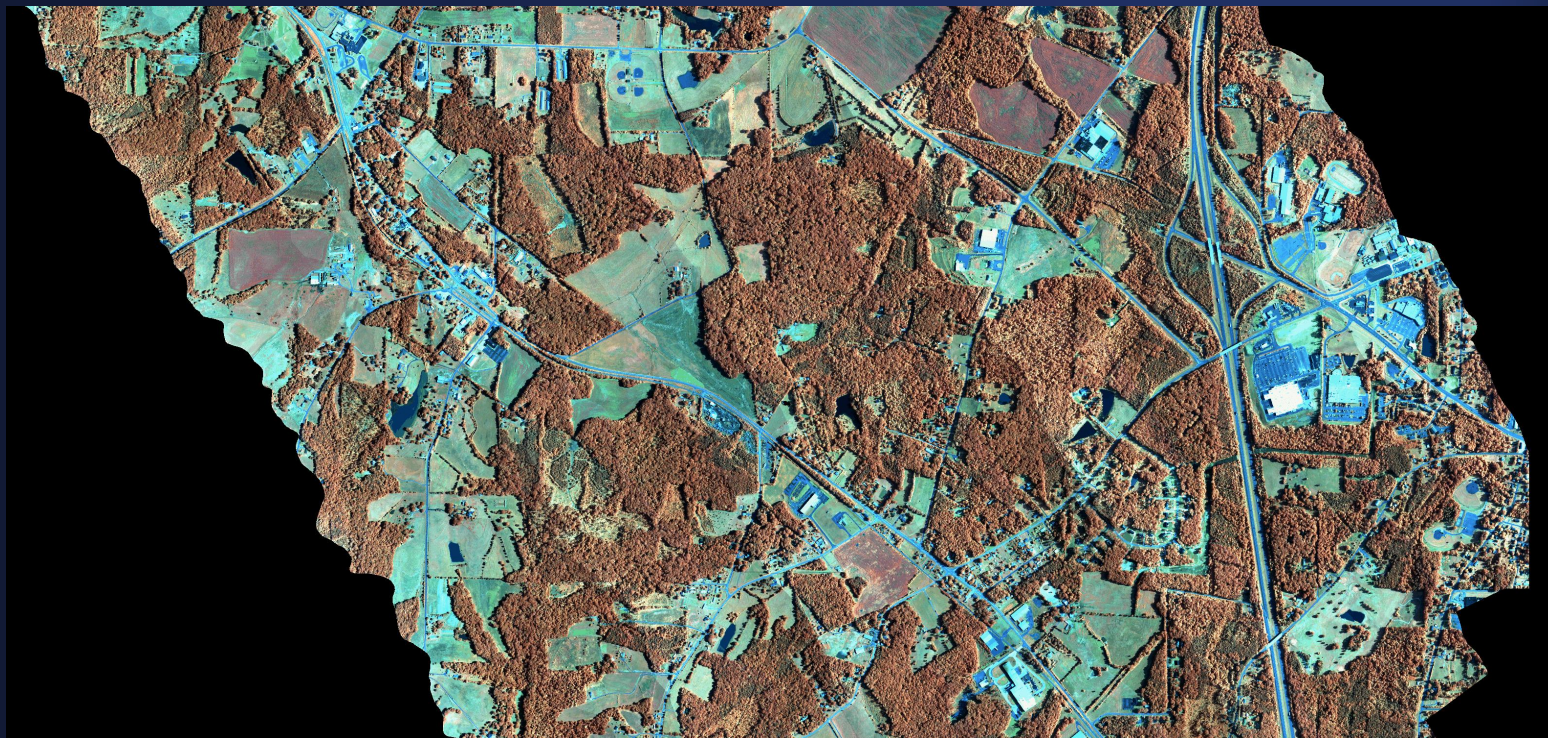


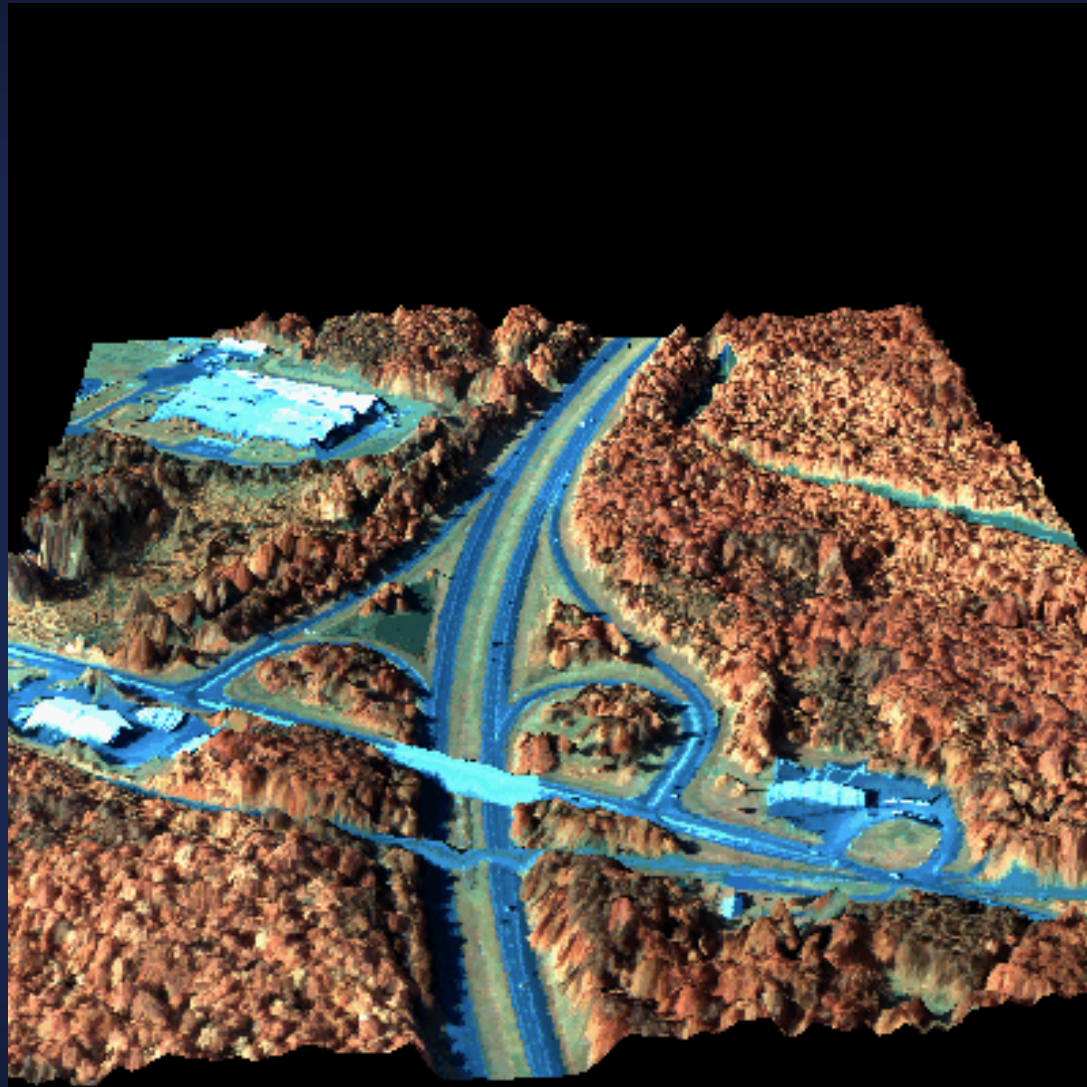
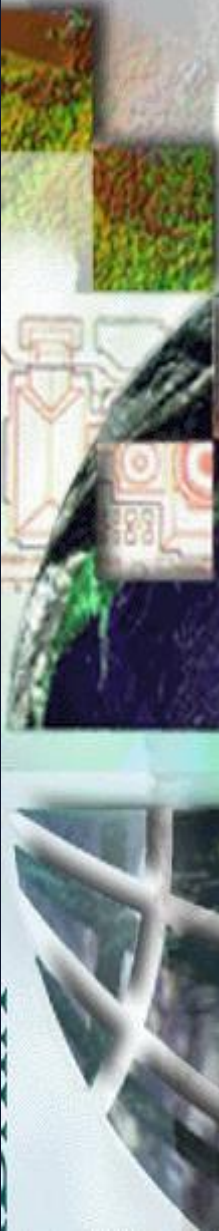
CASI mosaics of DOT project area

Spatial res: 1m
Spectral bands: 14

Red = 740 nm
Green = 710 nm
Blue = 550 nm

Mosaic 4





CASI 60cm Subarea

- Eleven spectral bands.
- 9 square kilometers.

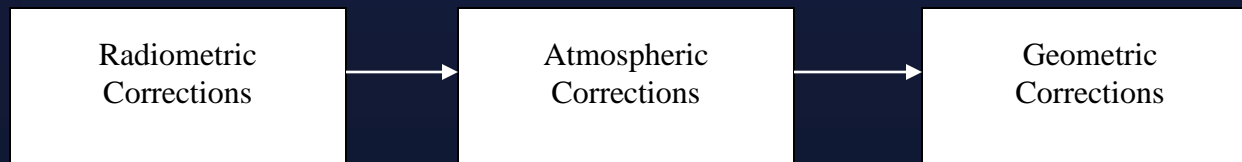


CASI Data Acquisition

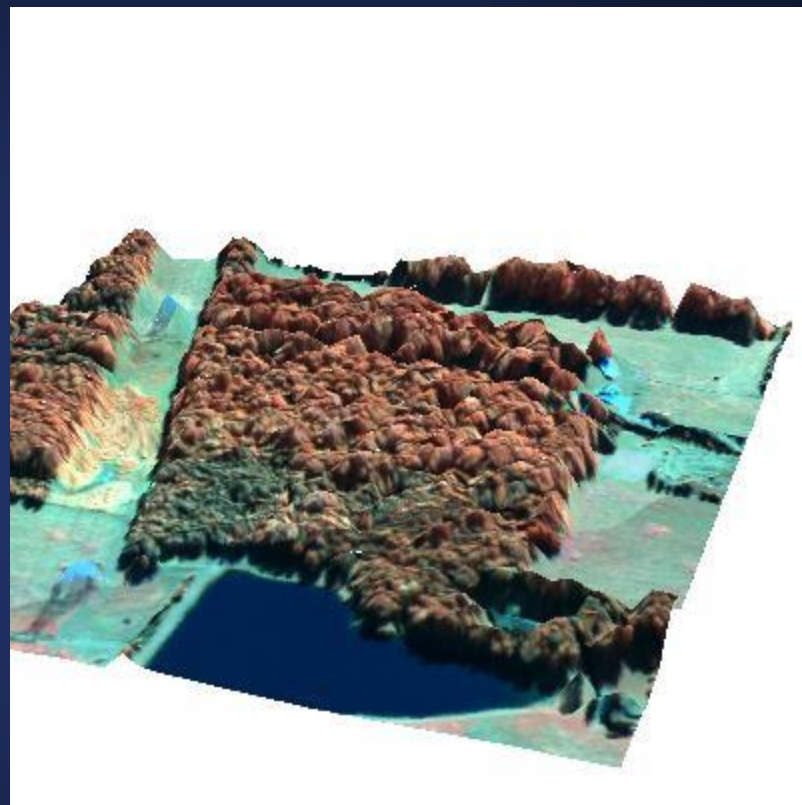
- Project area approximately 5 km x 18 km.
- Thirteen flight lines flown at one meter resolution (headings 330° and 150°, altitude 3150 ft. ASL).
- Fourteen spectral bands from 430 nm to 878 nm.
- Bandwidth: 15 nm (blue band 40 nm).
- Subarea imaged at 60 cm, 11 bands.
- Three hours to acquire data.

CASI Standard Processing

- Image data radiometrically corrected to standard radiance units (SRU's).
- Imagery combined with GPS / IMU data and geometrically corrected into five mosaics covering project area.
- Removal of atmosphere from image data, production of reflectance measurements.



Casi fused with Lidar



Spatial Accuracy Assessment

An independent spatial accuracy assessment was performed comparing image coordinates with 31 surveyed ground control points.

• TEST 1	X-coordinate (m)	Y-coordinate (m)
• Mean	-0.648	-0.875
• Std Dev.	0.843	1.018
• RMSE	1.055	1.372
• TEST 2	X-coordinate (m)	Y-coordinate (m)
• Mean	-0.878	-0.346
• Std Dev.	0.843	1.049
• RMSE	1.190	1.097

Keys to Successful Classification

- Radiometric integrity of the imagery and the quality of the ground truth.
- Precision geometric corrections to identify ground truth sites in the imagery. Also allows for sensor/data fusion to improve classification results.
- Hyperspectral bandset.
- Ground truth surveys by wetland biologist.
 - Calibration, validation & verification
- Addition of digital elevation data and hydric soils.

Ground truth, validation & verification

- Field visit 1
 - GPS, vegetation type, drainage, soil type
 - This information used to calibrate the spectral libraries (control)
- Analysis performed to produce preliminary classifications
- Field visit 2
 - validate classification results (test)
- Finalize spectral library and apply analysis

Wetland Criteria

- In order to be considered a wetland, an area must meet three criteria:
 - Drainage
 - Vegetation
 - Hydric Soils
- *“False wetland” sites may meet one or two of these criteria, but not all three.*

Treed Wetland



Wetland in a grazed field



Roadside Wetland



Wetland in pasture



Site 15, Wetland in Grazed Pasture



Wetland in pasture



False wetland



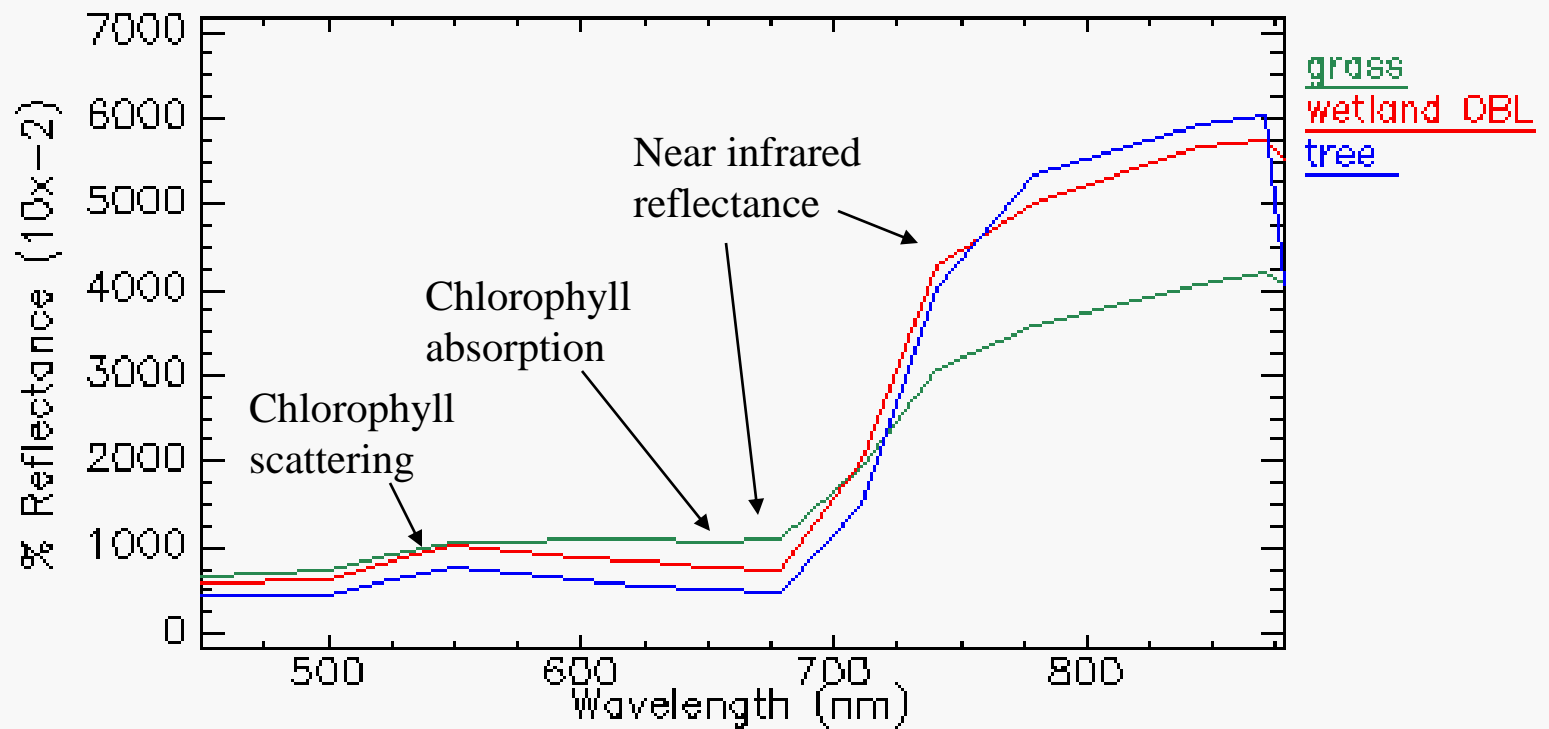
Classification Scheme

<i>Class</i>	<i>Description</i>
Wetland Vegetation	Juncus species (rushes), carex species (sedges) and rarely, typha species (cattail), impatiens capensis (forget-me-not), sagittaria latifolia (arrowhead), polygonum spp. (smartweed). Some members of poaceae grass family
Obligate Wetland (OBL)	Under tree cover: microsteris gracilis
	Wetland vegetation types are often mixed with each other and with non-wetland vegetation.
Willow class	
Obligate Wetland (OBL)	Salix nigra (black willow)
Facultative (FACW)	Rosa palustris (swamp rose) Sambucus Canadensis (elderberry) Faxinus pennsylvanica (green ash) Alnus serrulata (tag alder)
	Sometimes associated with wetlands, sometimes found in upland
Tree and Scrub/ Shrub	Acer rubrum (red maple) Liquidambar styraciflura (sweetgum) Liriodendron tulipifera (yellow poplar)
Facultative (FAC and FACU)	Lagustrum sinense (Chinese pivoit)
Upland (U)	Mostly deciduous tree, some conifer stands of varying height. Conifer classification shows spectral confusion with sedges and grasses. Development of a 'conifer mask' should minimize the confusion.
Sparse grass (non-wetland)	Members of Poaceae family
Facultative (FAC)	Lolium multiflorum
Facultative Upland (FACU)	Often associated with agriculture and urban development in this area.
Dense grass (non-wetland)	Often associated with agriculture and urban development in this area. Considered to be similar to sparse grass FAC but more dense.
Facultative (FAC) and Facultative Upland (FACU)	
Bare soil	Little or no vegetation present.

Spectral Library Generation

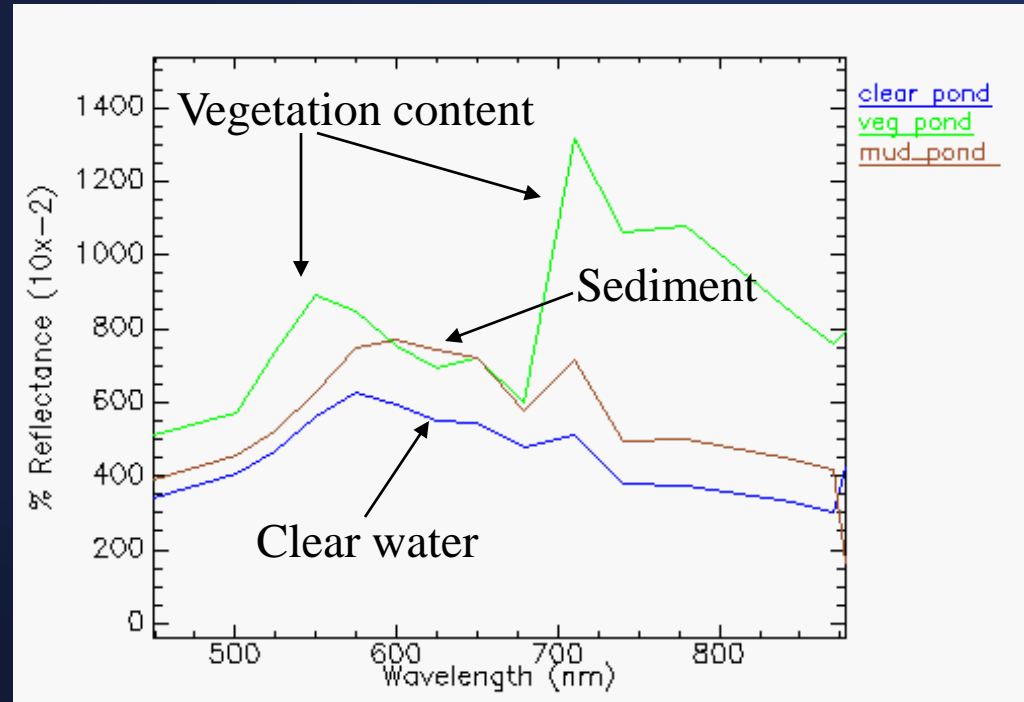
- Ground truth sites plotted on casi image mosaics.
- Noise reduction of imagery in ENVI software (MNF and PPI procedures).
- Spectrally pure pixels isolated in the imagery which coincide with ground truth sites.
- Reflectance values for each band are extracted from pure pixels to create spectral signature.

Spectral Signatures of Vegetation



Spectral Signatures of Water Bodies

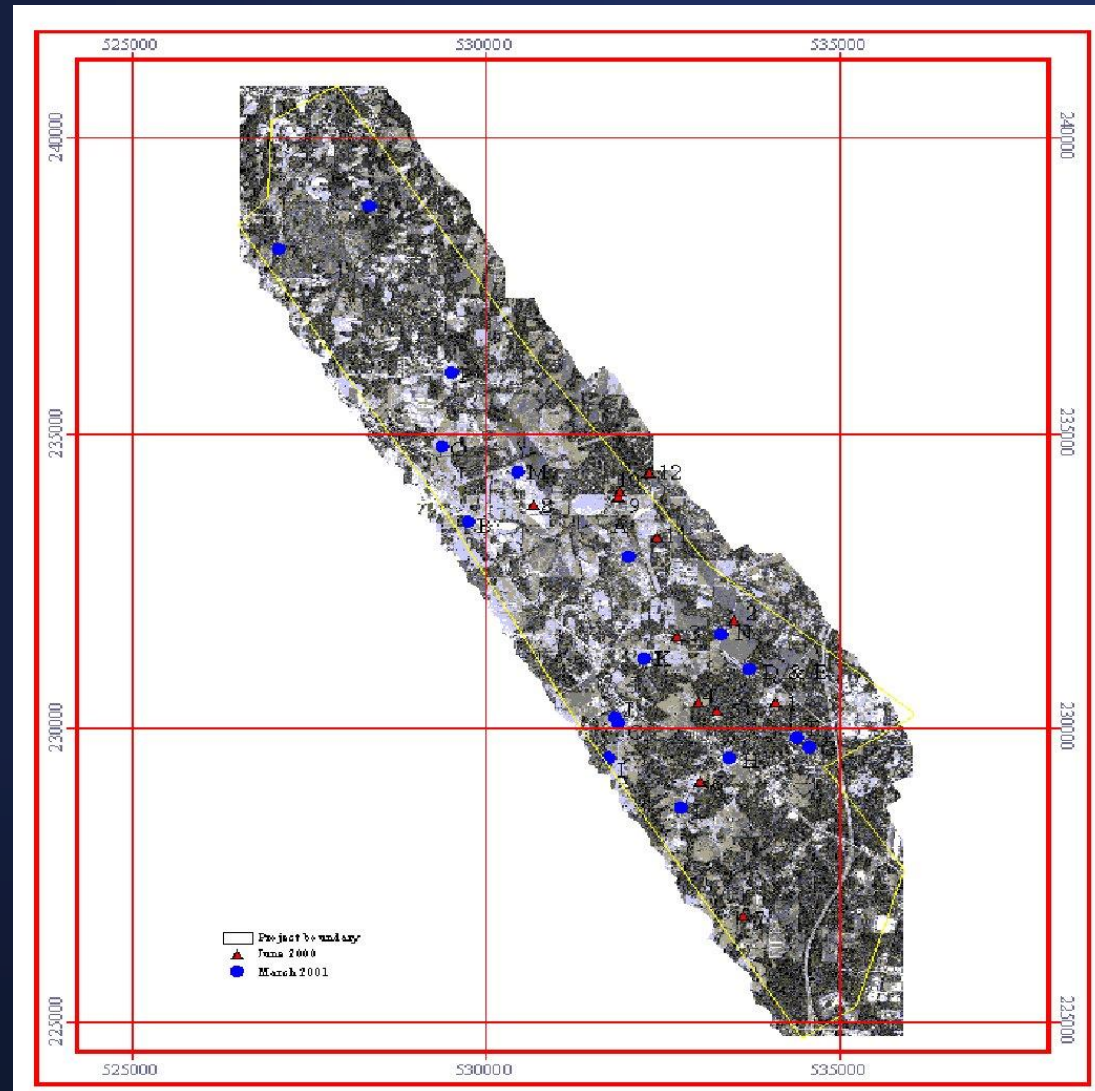
- Reflectance determined by water content (sediments, vegetation, organic and inorganic material)



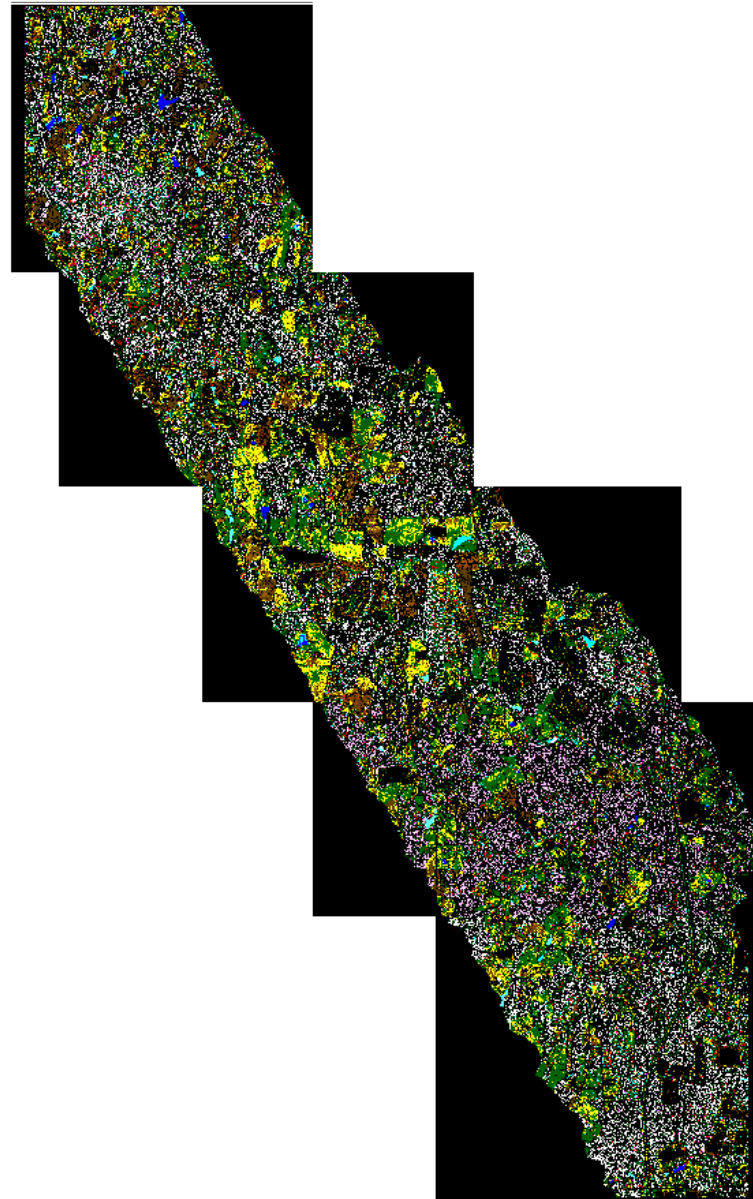
Wetland Vegetation Classification

- 32 spectral signatures for vegetation in the spectral library
- Seven thematic categories based on NWI Classification Scheme:
 - Tree/shrub
 - Bare soil
 - Dense grass and Sparse grass
 - Obligate wetland species
 - Facultative wetland species
 - Willow

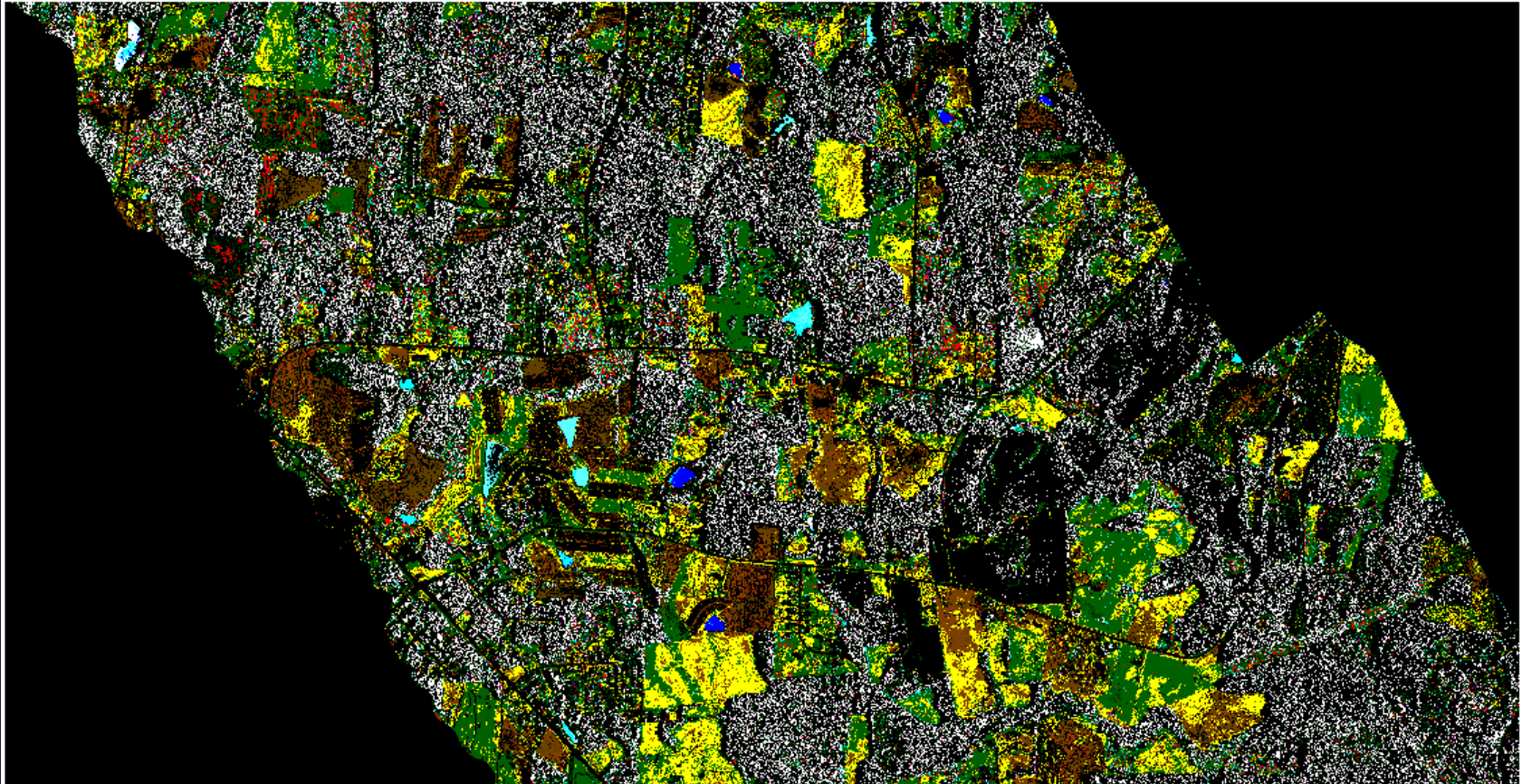
Ground Truth Sites, June 2000 and March 2001



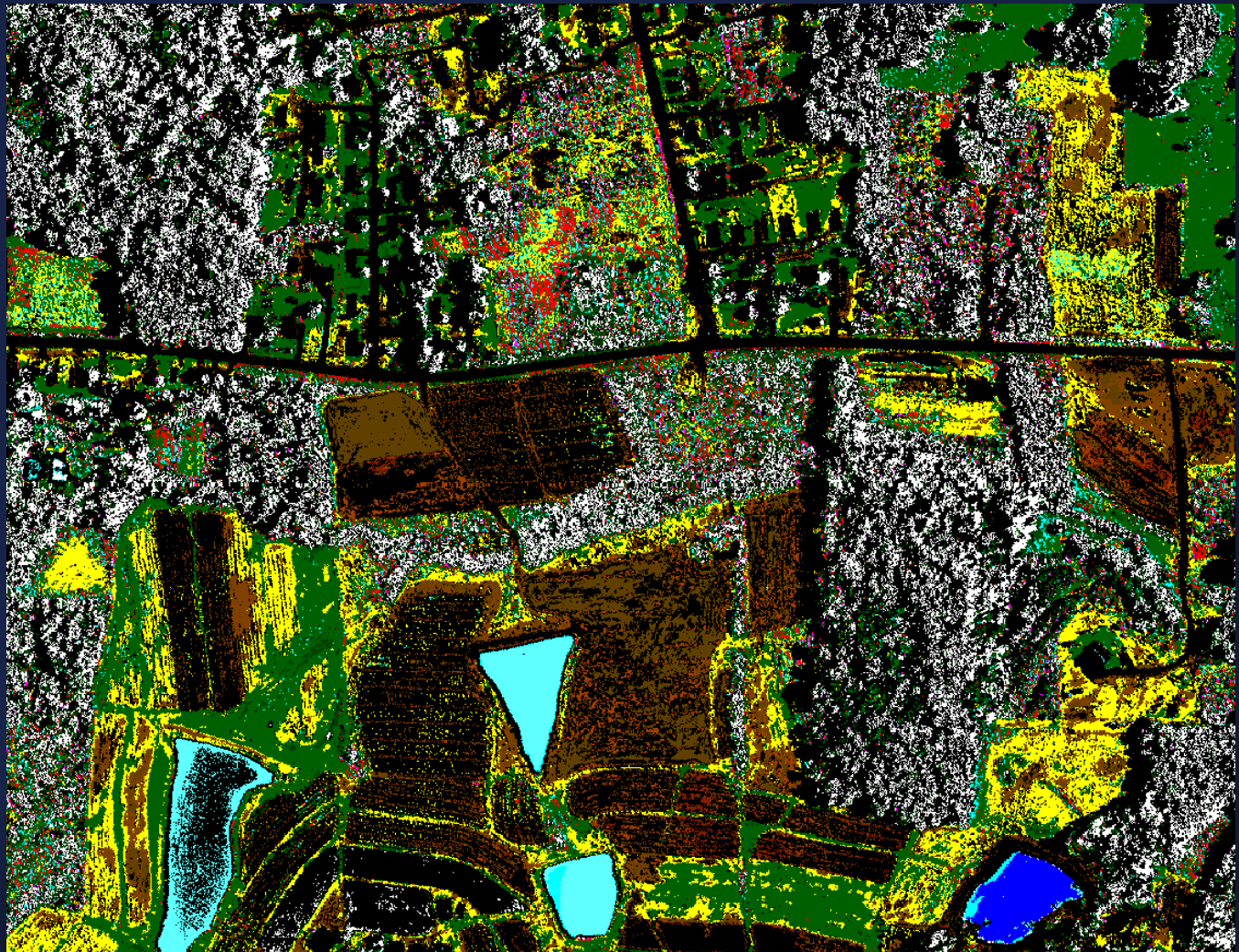
Thematic Classification



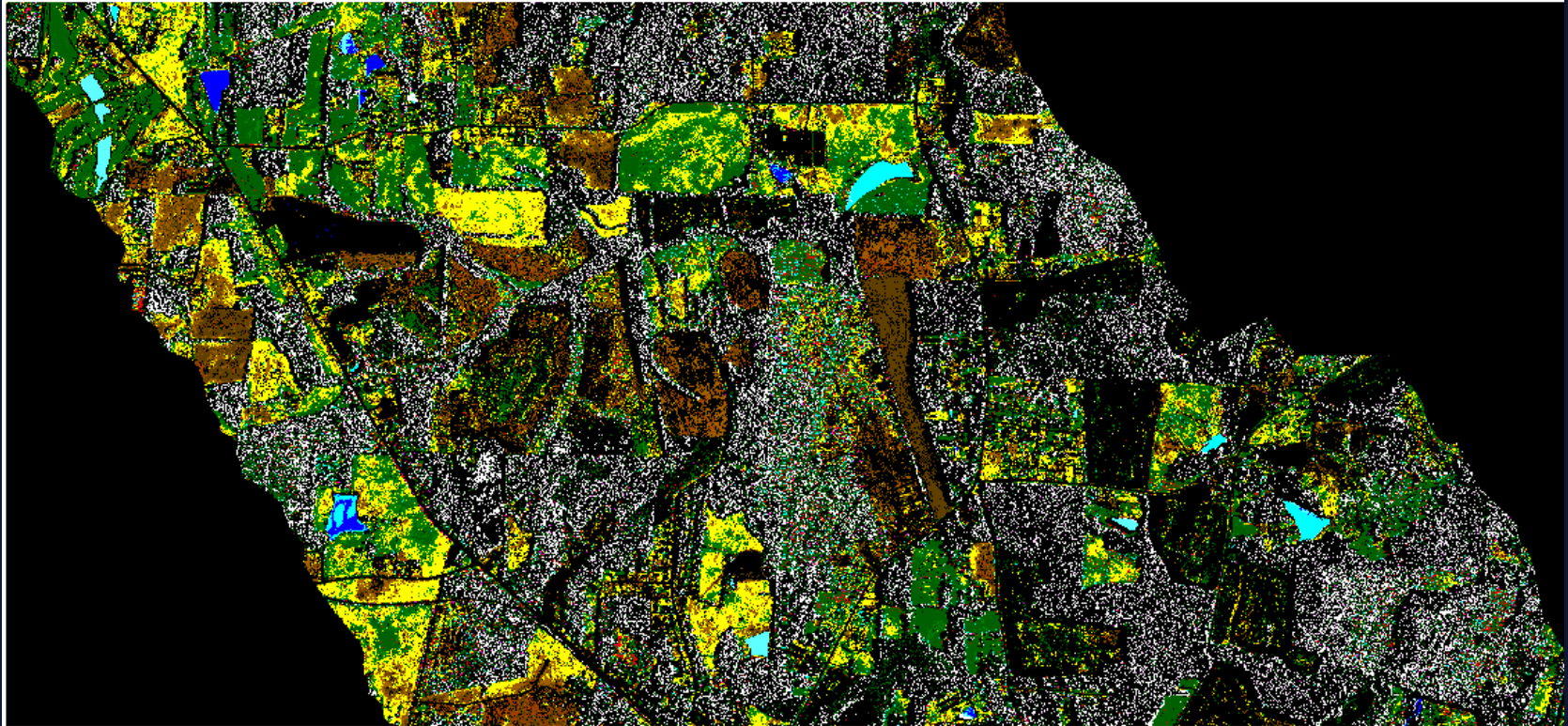
Mosaic 2 Thematic Classification



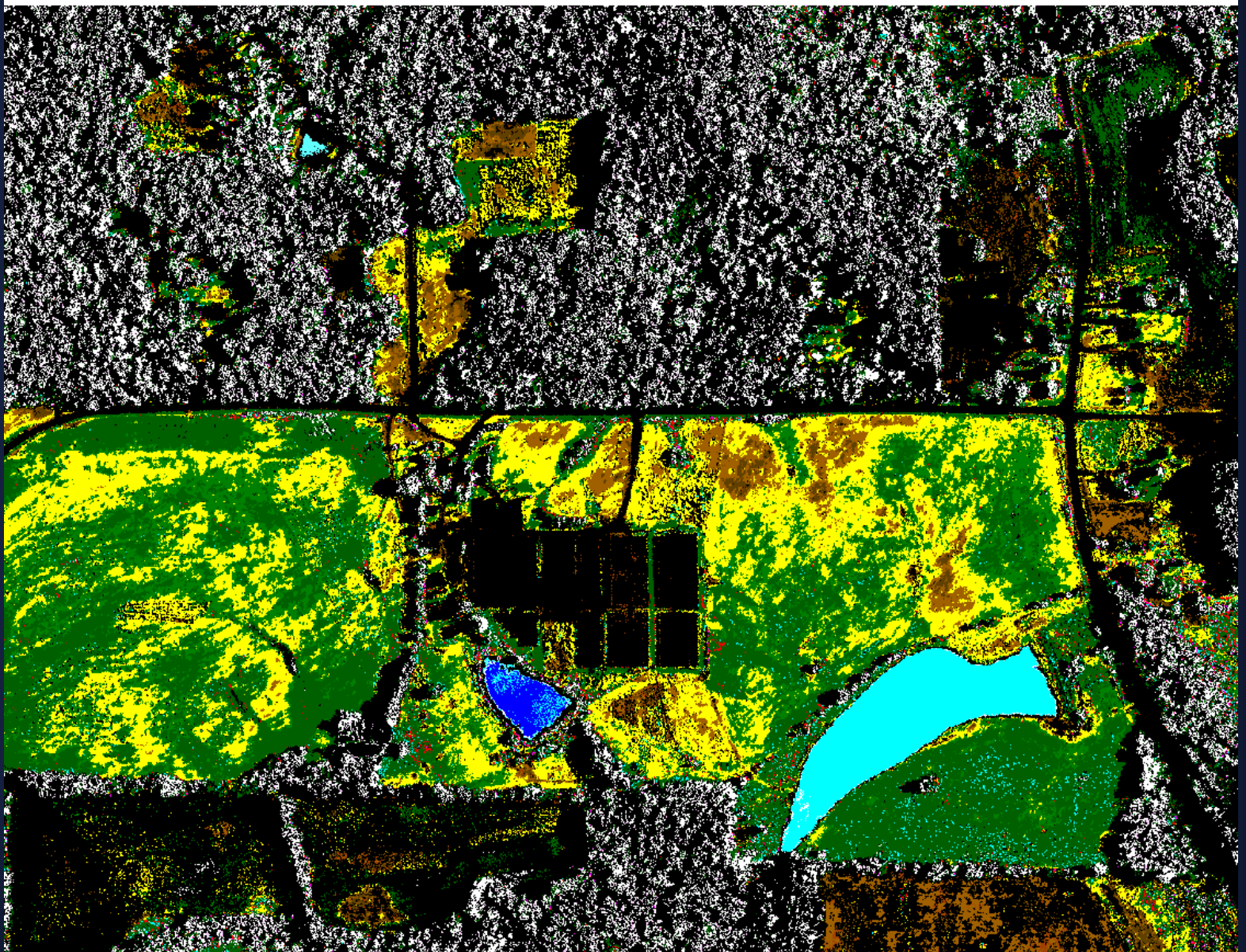
Mosaic 2 Classification: Subarea



Mosaic 3 Classification



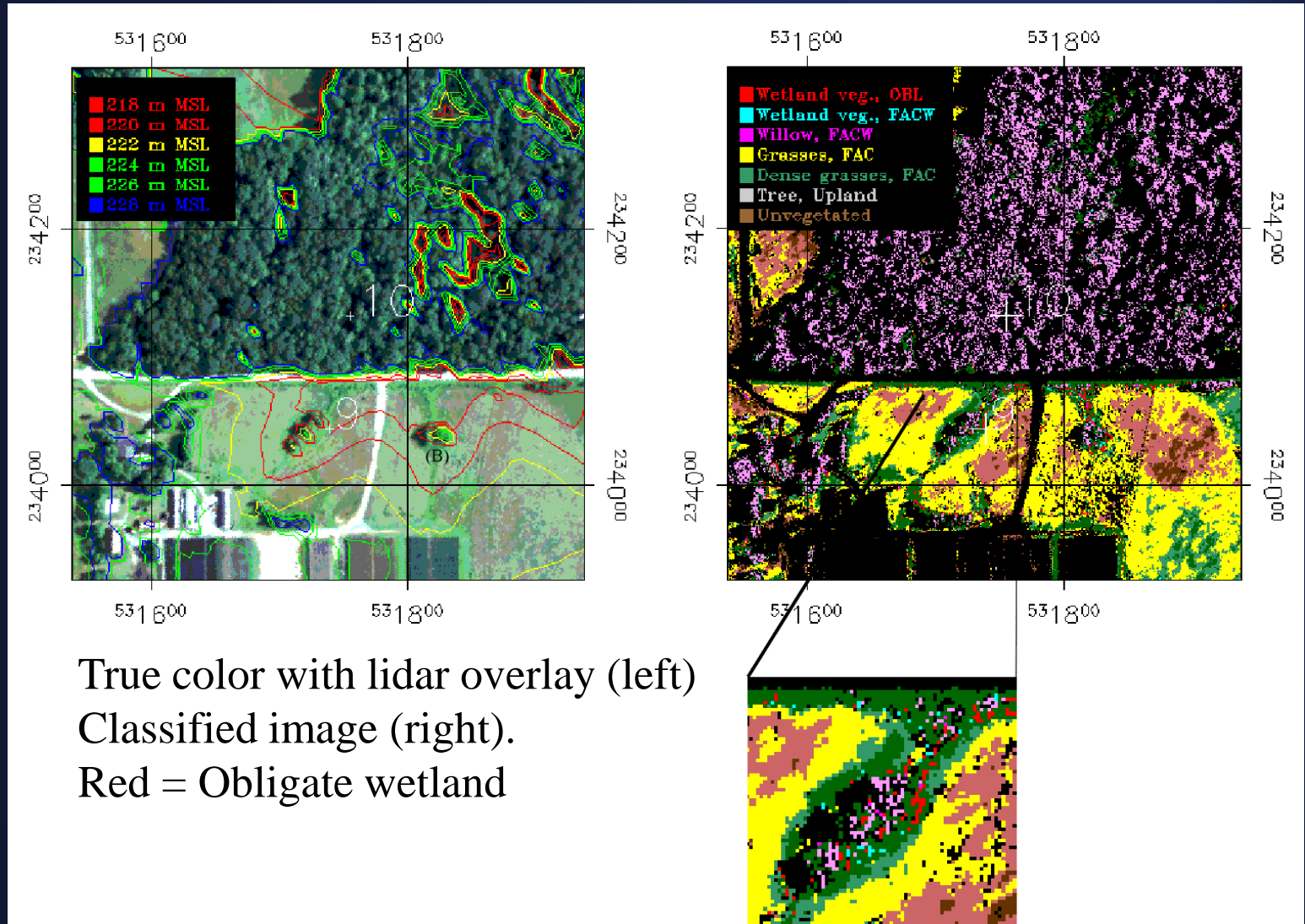
Mosaic 3 Classification: Subarea



Site 10, Natural spring in grazed field



Site 10, Two natural springs in grazed field



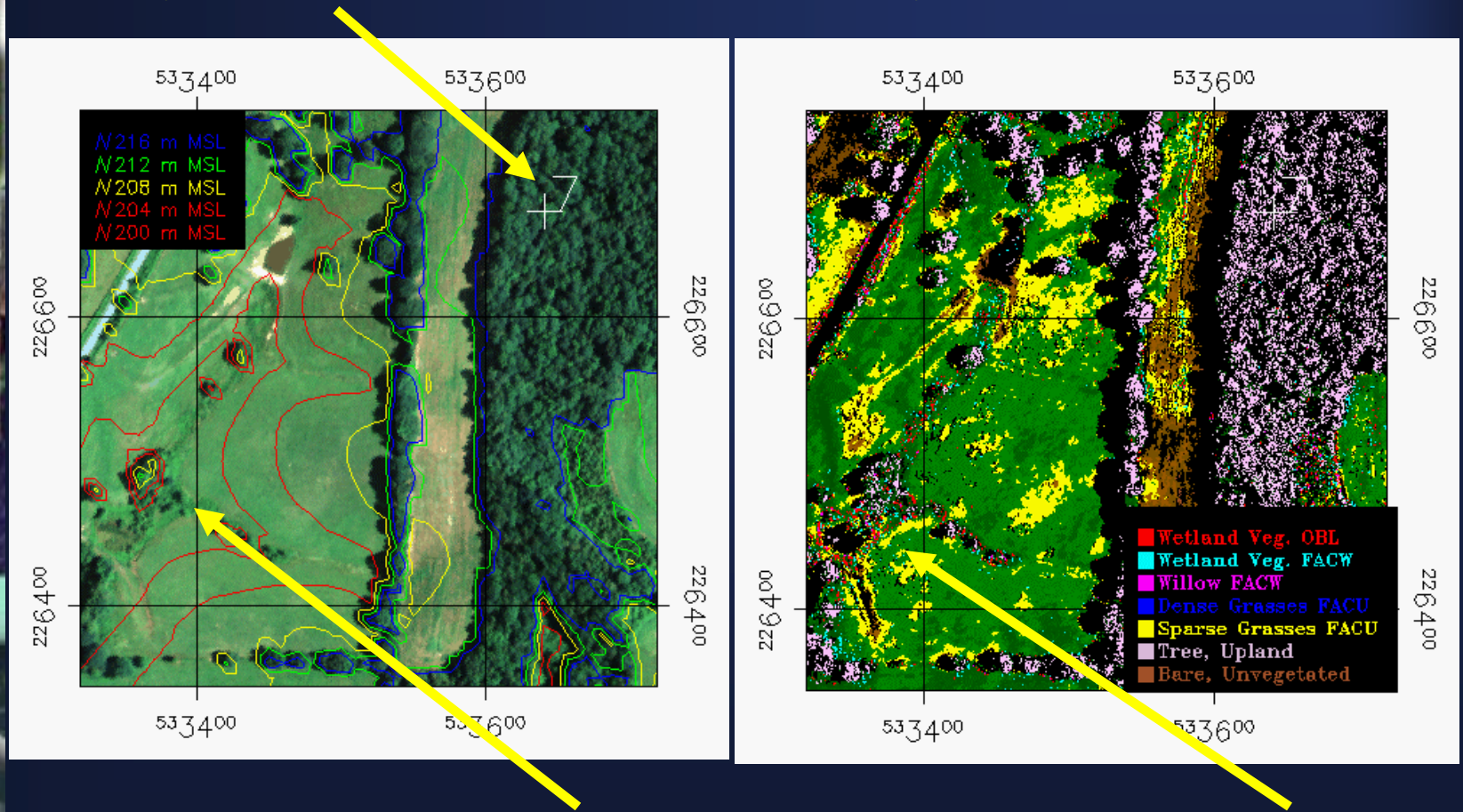


Site 7, narrow wetland drainage under mature tree canopy.

This type of wetland can not be classified in casi imagery collected in mid summer. However, LIDAR provided information re drainage and depressions.

Site 7, Treed Wetland

Surveyed wetland under tree canopy



Potential associated wetland indicated by drainage and casi classification

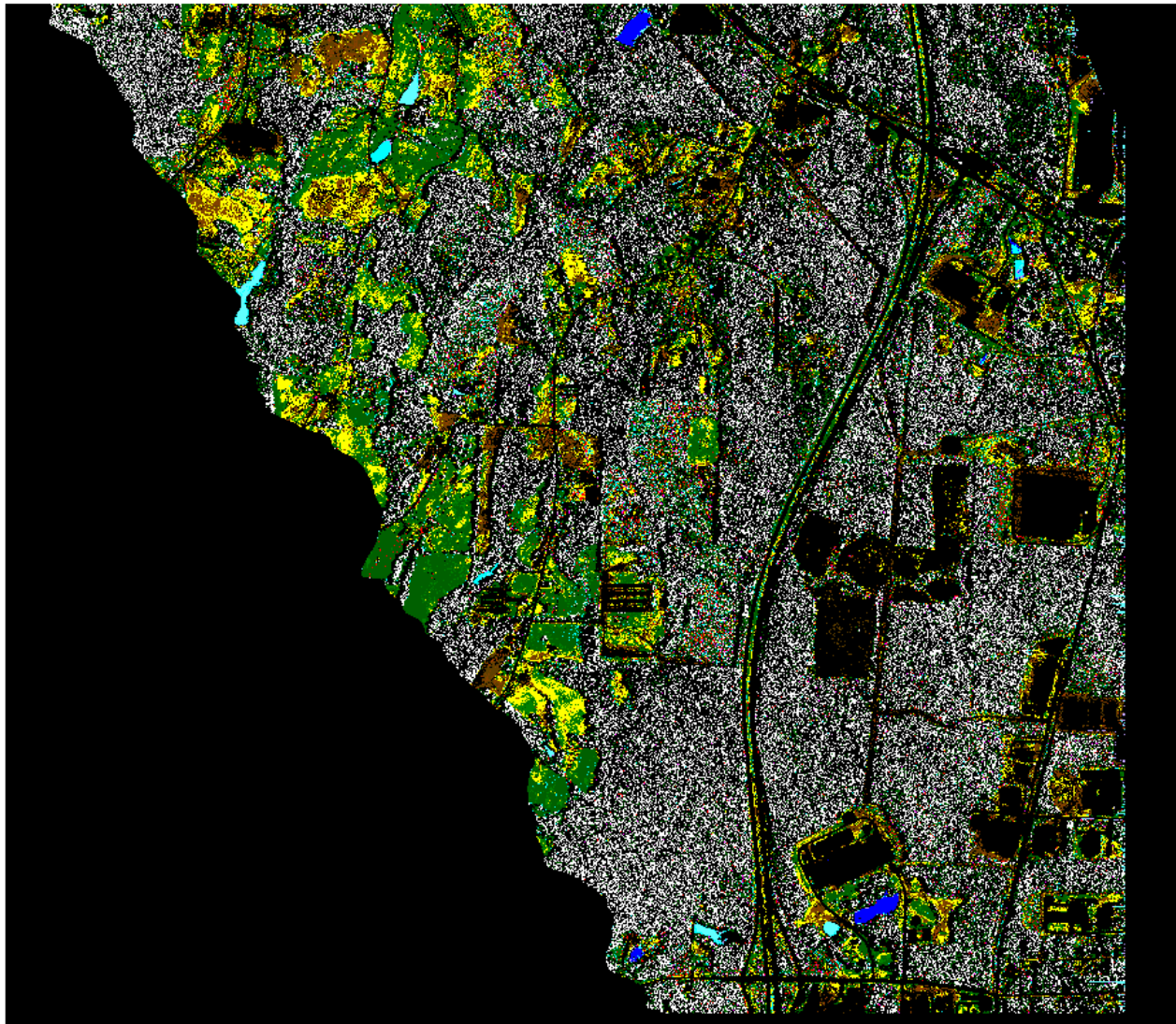
Classification Accuracy Assessment, Original Ground Truth Sites

- Twelve sites, ten wetland, two “false wetland”, four sites with tree cover.
- Total accuracy of 12 sites: 7 of 12 = 58%
- Accuracy of wetland sites: 6 of 10 = 60%
- Accuracy of non treed sites, wetland and non wetland: 7 of 8 = 88%

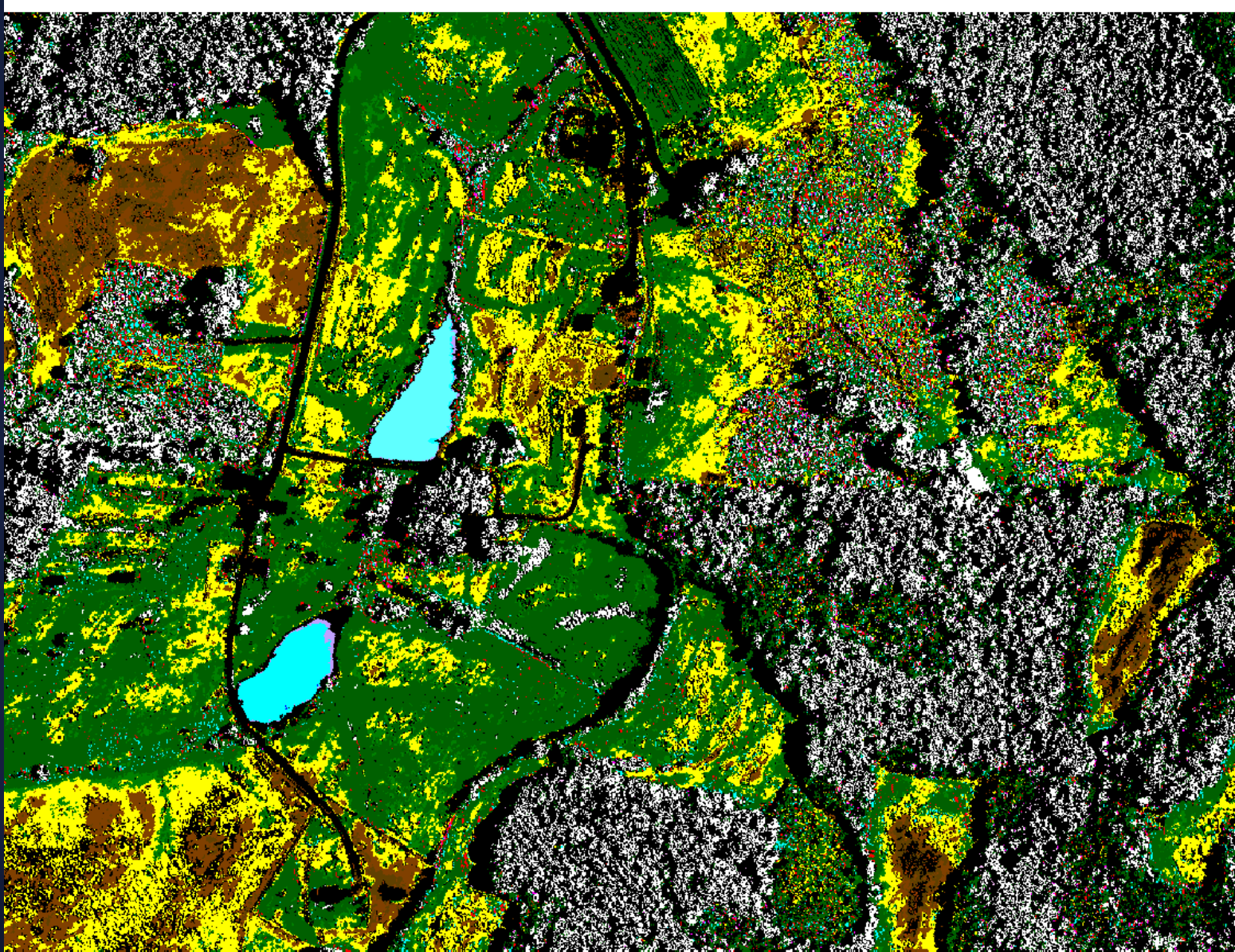
Conclusion of First Accuracy Assessment

- Small size and heterogeneity of wetlands make classification a challenge.
- Sites with tree cover are difficult to classify using CASI data alone. Lidar can identify drainage contours under tree canopy.
- Some wetland sites not classifying as wetland, suggesting more spectra should be added to spectral library.

Mosaic 5 Classification

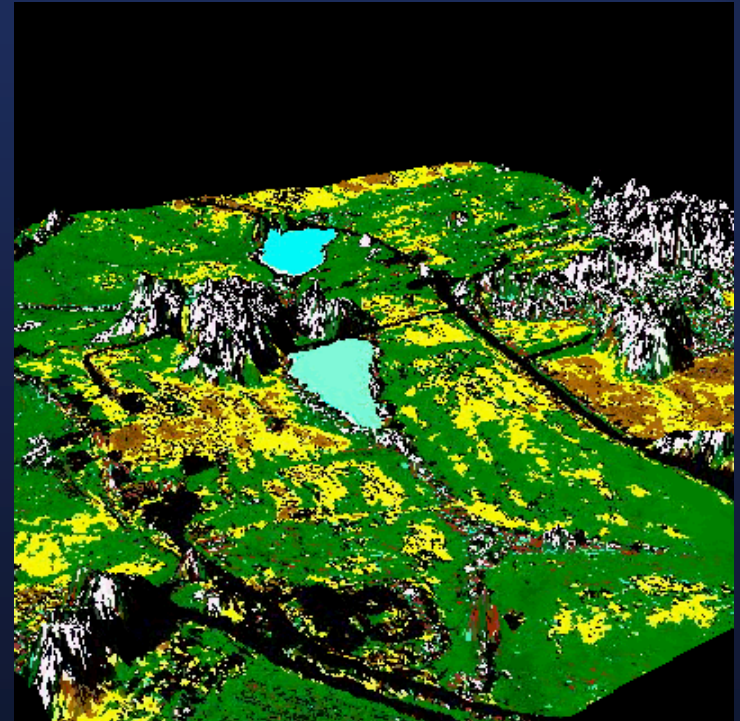
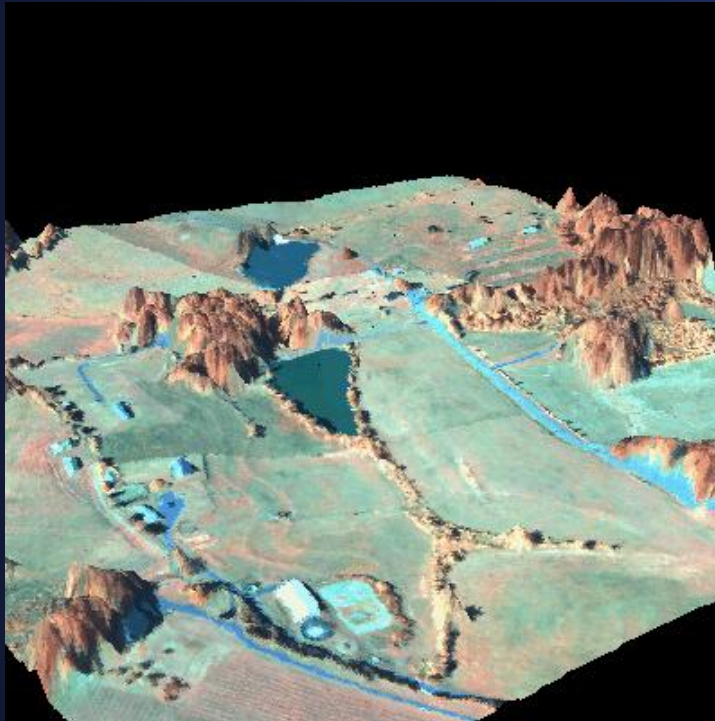


Mosaic 5 Classification: Subarea



Wetland Drainage into Pond

- Wetland vegetation in project area is typically isolated in small stands in drainage features. On the right, wetland vegetation is classified as red.



Classification Accuracy Assessment Number Two

- Fifteen sites identified from classified imagery and visited March 2001.
- Total sites correctly classified: 10 of 15 = 67%
- Accuracy of wetland sites: 7 of 7 = 100%
- Accuracy of non wetland sites: 3 of 8 = 38%

Conclusions of Second Classification Accuracy Assessment

- Some non wetland vegetation is incorrectly classified as wetland. Thematic map is “overclassified” for wetlands.
- True wetland areas are classified correctly.
- Additional data sources (lidar, hydric soils) can eliminate classified areas which do not meet drainage and hydric soils criteria.

General Conclusions

- An area 5 km x 18 km can be imaged in one day at meter and sub meter resolution. Spatial accuracies at the one meter level are measurable.
- 14 spectral bands can be acquired in the VNIR. Bandwidths are 15 nm (blue band is 40 nm).
- Precise georeferencing of casi and lidar data make integration seamless. Lidar data used in the casi image geocorrection to provide terrain elevations and used in analysis to indicate drainage and surface depressions.

General Conclusions (cont'd)

- Currently only airborne data provides the spatial and spectral resolution required to find small heterogeneous wetlands and altered wetlands.
- It is possible to classify wetland vegetation using casual hyperspectral imagery, very specific ground truth information and commercial image processing software.
- Water bodies are easily distinguished and a relative measure of their constituents (sediment, organic content) can be made without ground truth.

General Conclusion (cont'd)

- Currently some overclassification of wetland vegetation occurs and difficulties are encountered under tree cover.
- Classified casi maps made must be refined by integrating additional data from lidar and hydric soils maps. The additional information reduces the false positives found in vegetation maps derived solely from casi imagery.