Object-Oriented Land Cover/Land Use Mapping of Coastal Horry County, SC

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Project Team

- Chad Lopez – Fugro EarthData, Inc.
- Kass Green – Kass Green and Associates
- Mark Tukman – Tukman Geospatial
- Debra Wenner – Fugro EarthData, Inc.
- Tom Garigen and Leon Scott – Horry County government

Presentation Overview

1. Project area.
2. Classification scheme
3. Image preprocessing
4. Ancillary data
5. Image classification methods
   A. Delineation of land use land cover polygons from the ADS40 imagery using Definiens Professional software
   B. Calibration trip to the project area to understand variation on the ground,
   C. Collection of office sample sites
   D. Labeling of the polygons using Classification and Regression Tree (CART) analysis
   E. Validation trip
   F. Additional office sample site collection and CART analysis refinement
   G. Modeling and editing to correct residual map errors
6. Client review
7. Map finalization and delivery
8. Accuracy assessment
9. Conclusions

1. Project Area

- Horry County, South Carolina - 1134 sq miles.
- Mix of agriculture and tourism.
- From 1970 to 2008, Horry County's population has almost tripled, growing from 70,000 to almost 200,000 residents

2. Land Cover Land Use Classification Scheme

- Totally exhaustive
- Mutually exclusive
- Hierarchical
- Composed of labels and rules

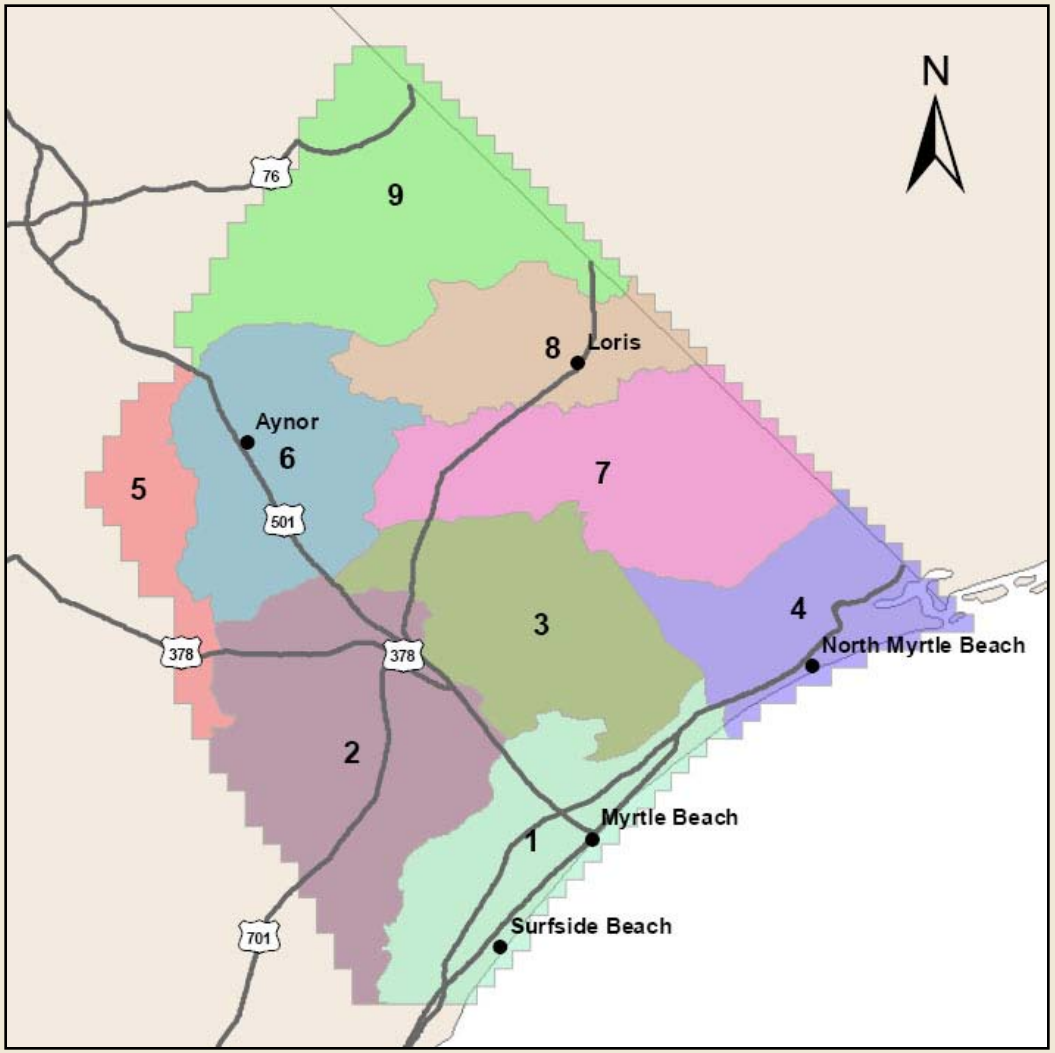
Classification Scheme Rules

THE MINIMUM MAPPING UNIT FOR MEDIUM DENSITY BUILT-UP IS 0.07 ACRE
THE MINIMUM MAPPING UNIT FOR LOW AND HIGH DENSITY BUILT-UP IS 0.25 ACRE
THE MINIMUM MAPPING UNIT FOR REMAINING CLASSES IS 0.5 ACRE
Low and Medium Density Built--up classes will receive a secondary label that describes natural land cover
If land area has been mapped in the Horry County 2008 planimetrics as impervious, then **Impervious**
Else if land area has been mapped in the Horry County 2008 planimetrics as water, then **Water**
Else if land area has been mapped in the Horry County 2008 planimetrics as structure, then **Structure**
Else if land area is >= 10% Built-up in Horry County planimetrics, then **Urban or Built-up Land**
If impervious percent cover > 10% and < 25% then **Low Density Built-up**
Else if impervious % cover >= 25% and <= 75% then **Medium Density Built-up**
Else if impervious % cover > 75% then **High Density Built-up**
Else if land area is periodically flooded and/or covered with water, or if image signature is “wet”, then **Wetland**
If salinity due to ocean-derived salts < 0.5 percent then **Palustrine Wetland**
If > or = 20% of non-water ground cover is tree canopy > or = 5 m in height, then **Palustrine Forested Wetland**
    If tree canopy is > or = 75% deciduous then **Deciduous Forested Wetland**
    Else if tree canopy is > or = 75% evergreen then **Evergreen Forested Wetland**
    Else **Mixed Forested Wetland**
Else **Other Palustrine Wetland**
Else if salinity due to ocean-derived salts > or = 0.5 percent, then **Estuarine Wetland**
If > or = 20% of non-water ground cover is tree canopy > or = 5 m in height, then **Estuarine Forested Wetland**
Else **Other Estuarine Wetland**
Else if land area is dominated by vegetation that has been planted or is intensely managed for the production of food or feed then, **Vegetated Agriculture**
If Agricultural land is > 50% covered in trees or vineyard, then **Orchards, Groves, Vineyards**
Else if Agricultural land is > than 50% covered in annual crops, then **Cropland**
Else **Other Vegetated Agriculture**
Else if land area as seen from above is barren (< 20% vegetative cover) but commonly used for planted crops, then **Cleared Agriculture**
Else if tree canopy > 20% of land area as seen from above and tree canopy > or = 5 m tall, then **Upland Forest**
If tree canopy > or = 75% deciduous then **Upland Deciduous Forest**
Else if tree canopy > or = 75% evergreen then **Upland Evergreen Forest**
Else **Upland Mixed Forest**
Else if land area as seen from above > than 20% grass & shrub cover and shrubs (woody plants less than 5 meters tall) are dominant, then **Shrub**
Else if land area as seen from above > than 20% grass & shrub cover and grass (grasses, forbs, and other herbaceous plants) is dominant, then **Grass**
    If land is intensively irrigated, fertilized and mowed and is used for golf then **Golf Course**
    Else **Grass**
Else if land area as seen from above > 80% covered with bare rock, gravel, sand, silt, clay or other earthen materials then **Bare Land**
    If land area is a beach, then **Beach**
If material is being regularly removed for industrial purposes, then **Mine**
Else **Bare Land**

3. Image Preprocessing

- The project imagery was collected by Fugro EarthData's Leica ADS40 digital airborne camera system in February, 2008 at a 6-inch spatial resolution
- Imagery was resampled to 1.2 meter pixels. However, the native 6 inch spatial resolution imagery remained at the Team's disposal for use in image interpretation.
- Based on the County's physiography and acreage, the Team decided to divide the project area into 9 processing regions

Processing Regions



4. Ancillary Data

Primary Data Layers	
Layer Name	**Role in LULC Mapping**
2008 Leaf-Off ADS40 Data	Used to create polygons and develop polygon measures for input into polygon labeling
2008 Planimetrics	
Hydrology	Overlaid and merged into map
Impervious Surfaces	Overlaid and merged into map
Structures	Overlaid and merged into map
Transportation	Overlaid and merged into map
2005 LIDAR Data	
Bare Earth LIDAR Data	Used as an input for polygon labeling
1st Return LIDAR Data	Used as an input for polygon labeling
2007 & 2008 Leaf-On Landsat TM Data	
Wetness, Brightness, Greenness	Used as an input for polygon labeling

Ancillary Data Layers	
Horry County Layers	**Boundaries**
Parcels	Horry County Boundary
Zoning	Processing Regions for this Project
Subdivisions	Extent of Earthdata Imagery
Parks	**Hydrography**
Flood Zones	NHD Water bodies
General - Base Cartography	NHD Flowlines
Boat Ramps	NHD Areas
BBQ Restaurants	Hydrologic Units
Cities	**Existing Land Cover Land Use**
Urban Areas (2000)	GAP
Transportation	NLCD
State Highways	**Eco-regions**
US Highways	Geologic Regions
Other Roads	**USGS DRG**
Railroads	Complete Horry County DRG
	Other
	NWI
	NRCS Soils

5. Classification Methods

1. Delineation of land use land cover polygons from the ADS40 imagery using Definiens Professional software
2. Calibration trip to the project area to understand variation on the ground
3. Collection of office sample sites
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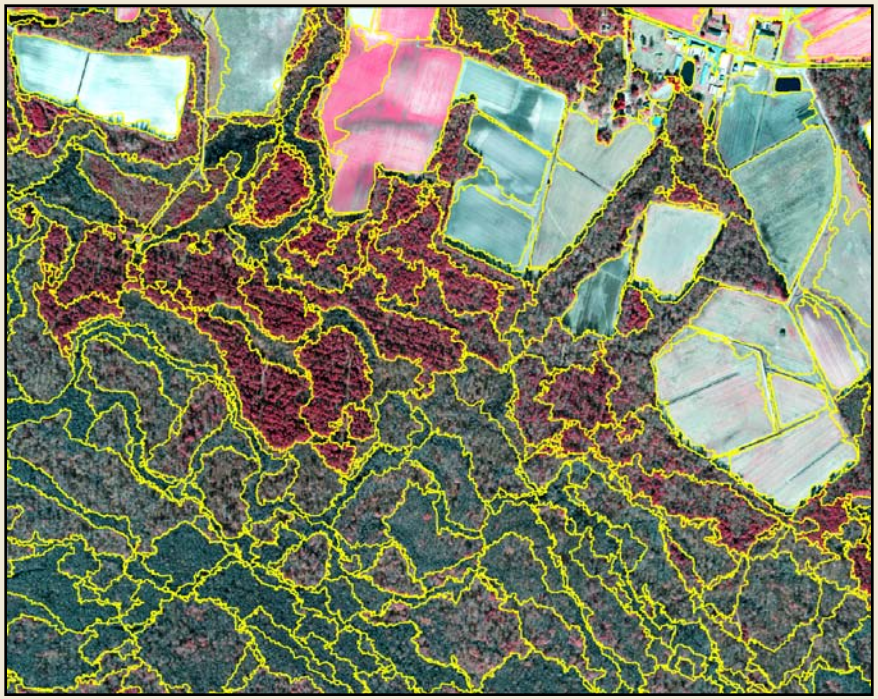
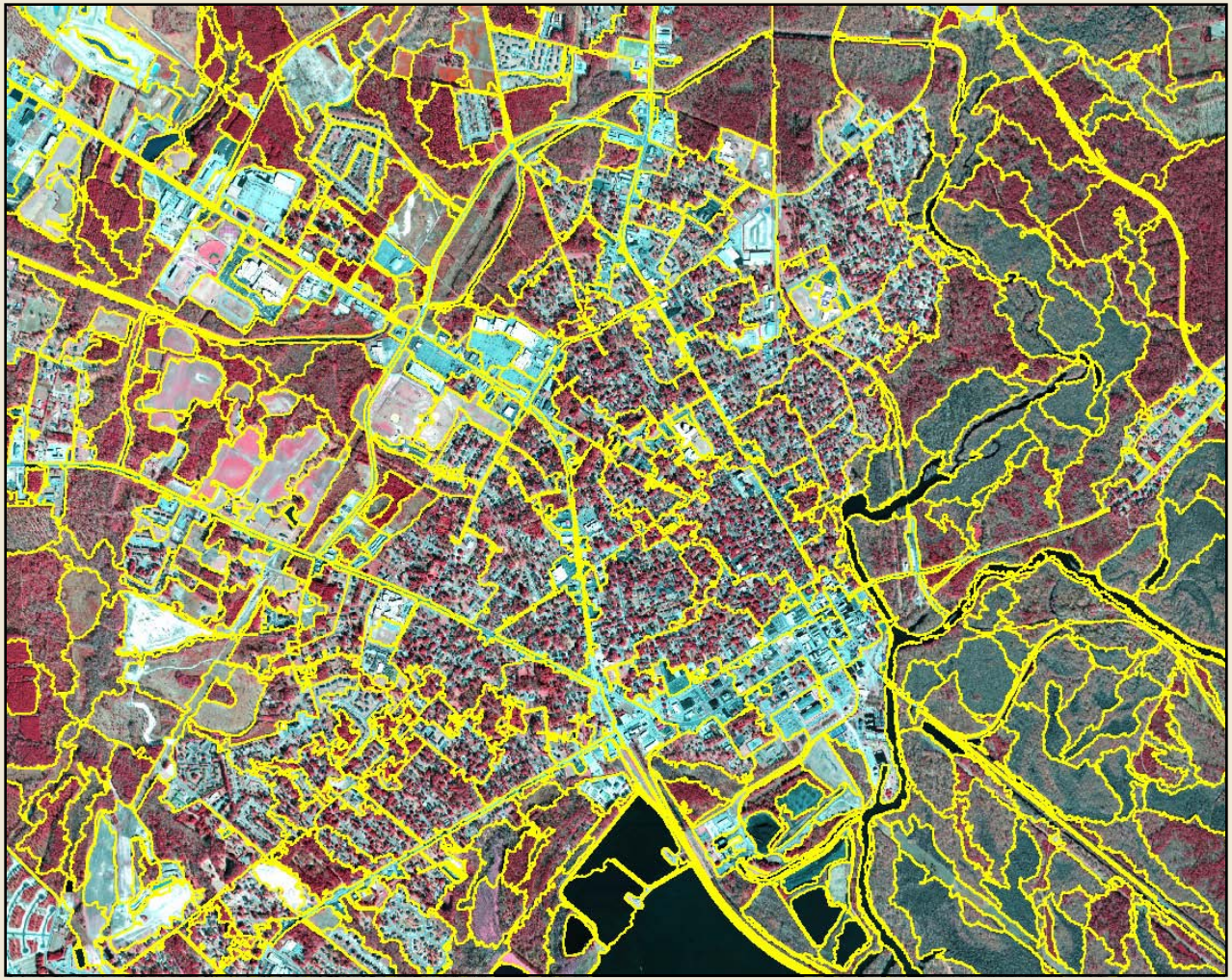
Object Oriented Chosen Because It

- Allows for the incorporation of context and shape measures in the classification,
- Better mimics traditional manual classification, and
- Facilitates consistent classification of complex features like forests which are comprised of a mixture of shadow and illuminated features in the imagery.



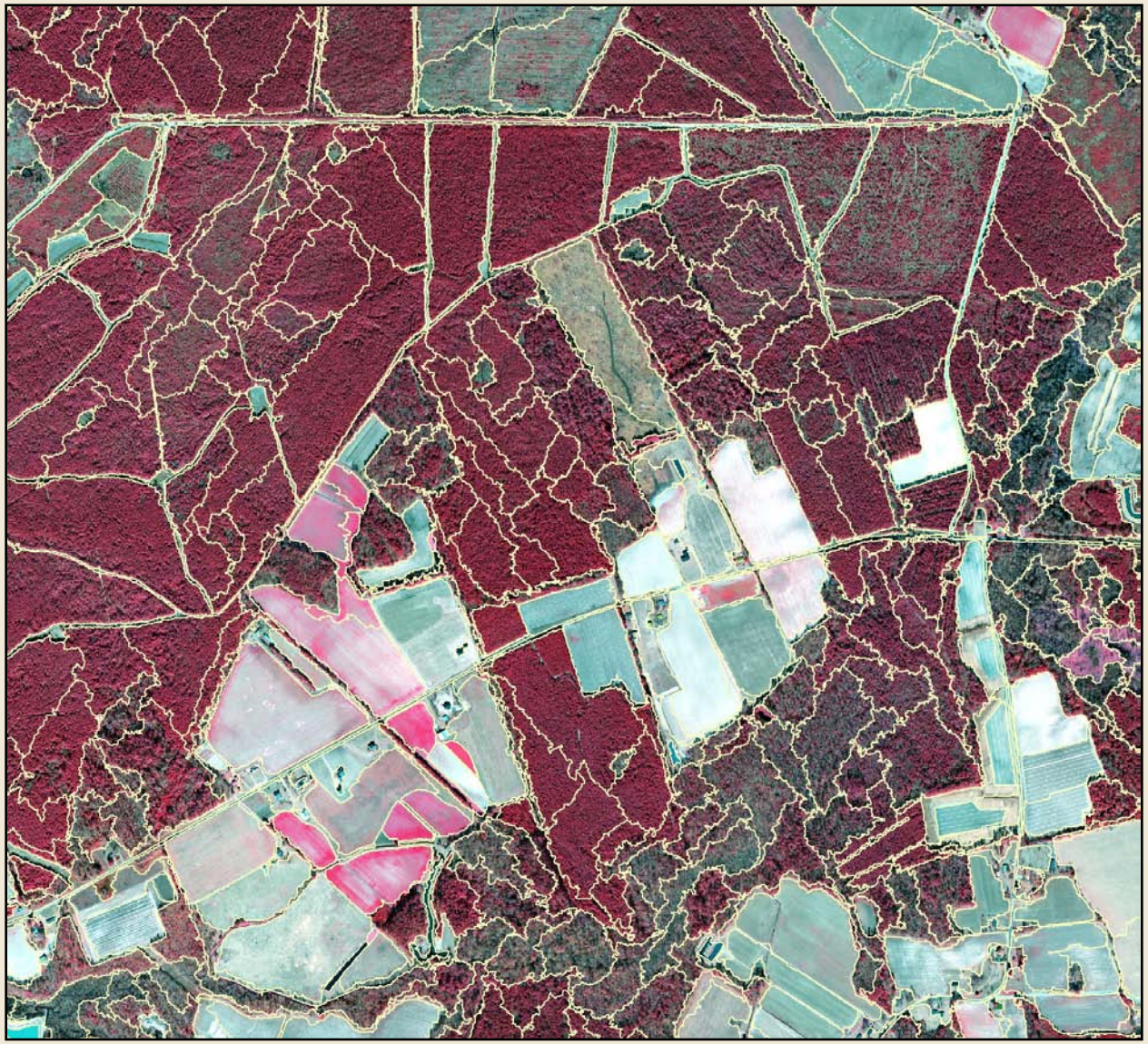
Tried Lots of Options



Final Polygon (Object) Delineation – Definiens Parameters

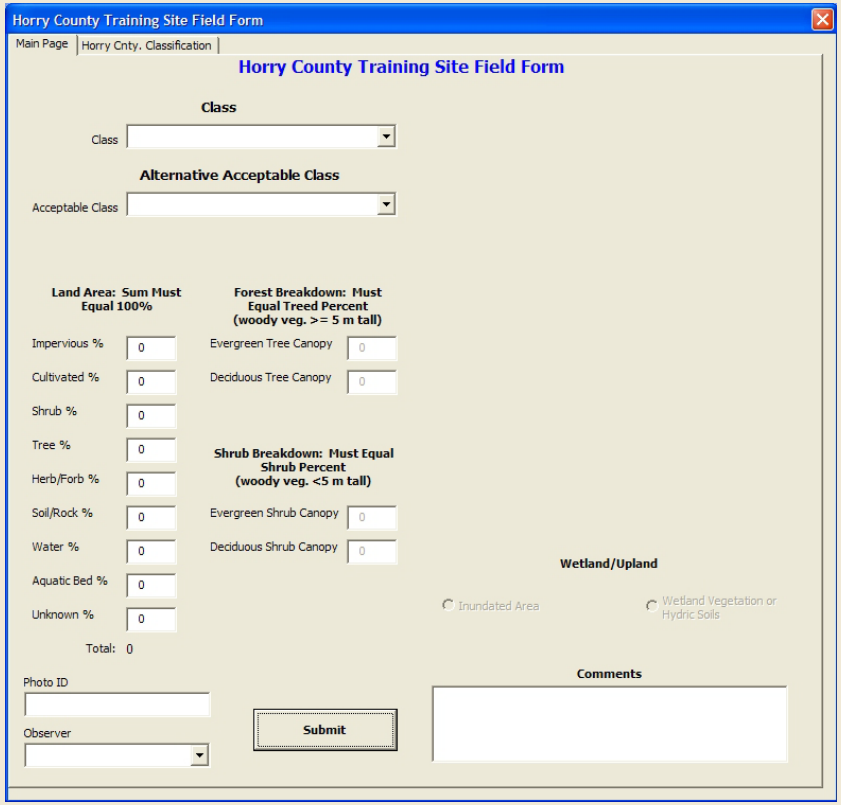
Band Combinations	Adaptive Texture (derived from ADS40 NIR) and NDVI. Texture band was weighted 1 and NDVI was weighted 0.8.
Polygon Smoothness	0.9
Polygon Compactness	0.1
Polygon Color	0.7
Polygon Shape	0.3
Scale	120

Final Polygons



Final Polygons

Calibration Trip



Office Site Collection

- Sites were chosen using the ADS40 digital imagery as visual reference.
- Office-collected sites were combined with field-collected sites as they were created but were also explicitly attributed as office-collected.
- Following office site collection, a random number generator was used to randomly select whether sites were to be used for polygon labeling using CART analysis or for subsequent accuracy assessment.

Polygon (Object) Labeling Using CART

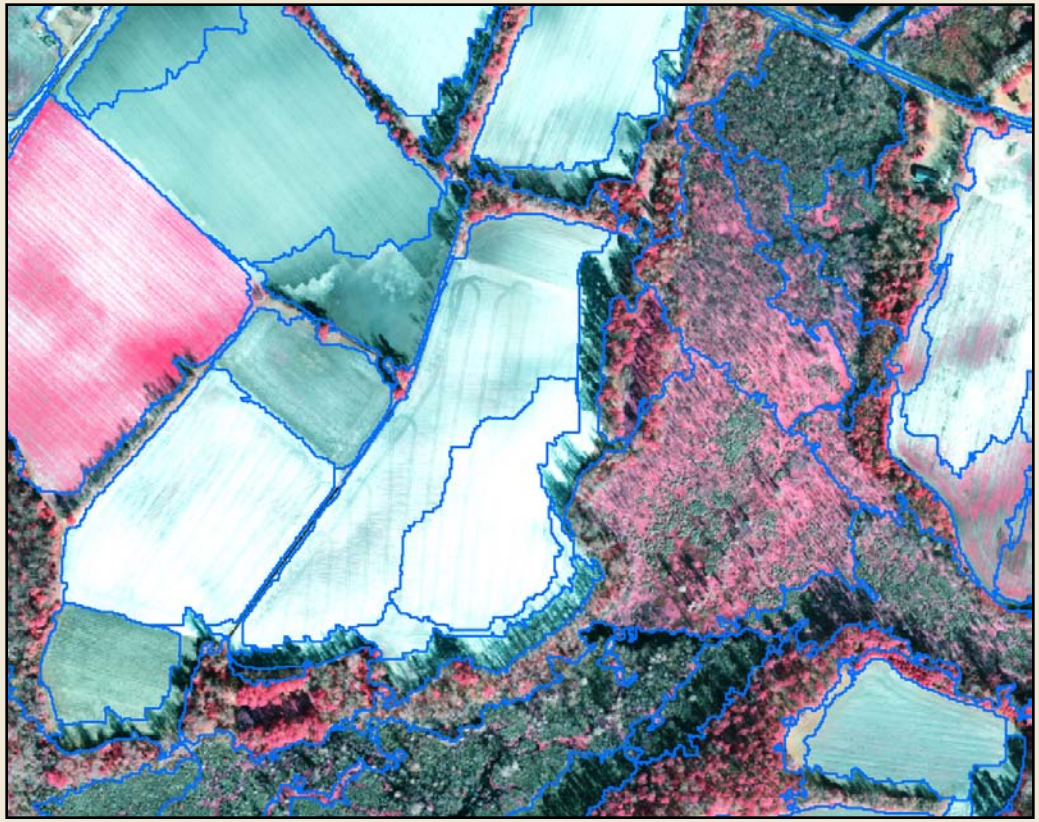
- CART “mines” the sample data and builds rules which are if-then statements in hierarchical “trees” that condition the prediction of land use land cover classes.
- It is a powerful data mining tool because
  - it can accept both continuous and categorical data inputs,
  - the results are easy to interpret,
  - unlike commonly used per pixel maximum likelihood classifiers, no assumptions are required concerning the distributions of the independent variables,
  - it identifies simple and complex relationships between variables that other techniques might not uncover, and
  - it forces consistency and analytical rigor into the segment labeling process.
- 61 Independent variables used including indices of shape, texture, ADS40 spectral response, Landsat spectral response, and lidar return.

Validation Trip and Additional Sites

- A week long validation trip was conducted to
  - Update the client
  - Check the preliminary map for errors
  - Collect 165 additional field sites

Modeling

- The Team also built deterministic GIS models to systematically label classes where high errors were observed. Examples of some models used were:
  - using hydrography data and GAP data (i.e. the GAP class “swamp”) to correct errors in Palustrine Other and Palustrine Forested Wetlands, and
  - modeling “shadow” polygons (from stands of trees) so that they receive the same label as the adjacent non-forested polygon.



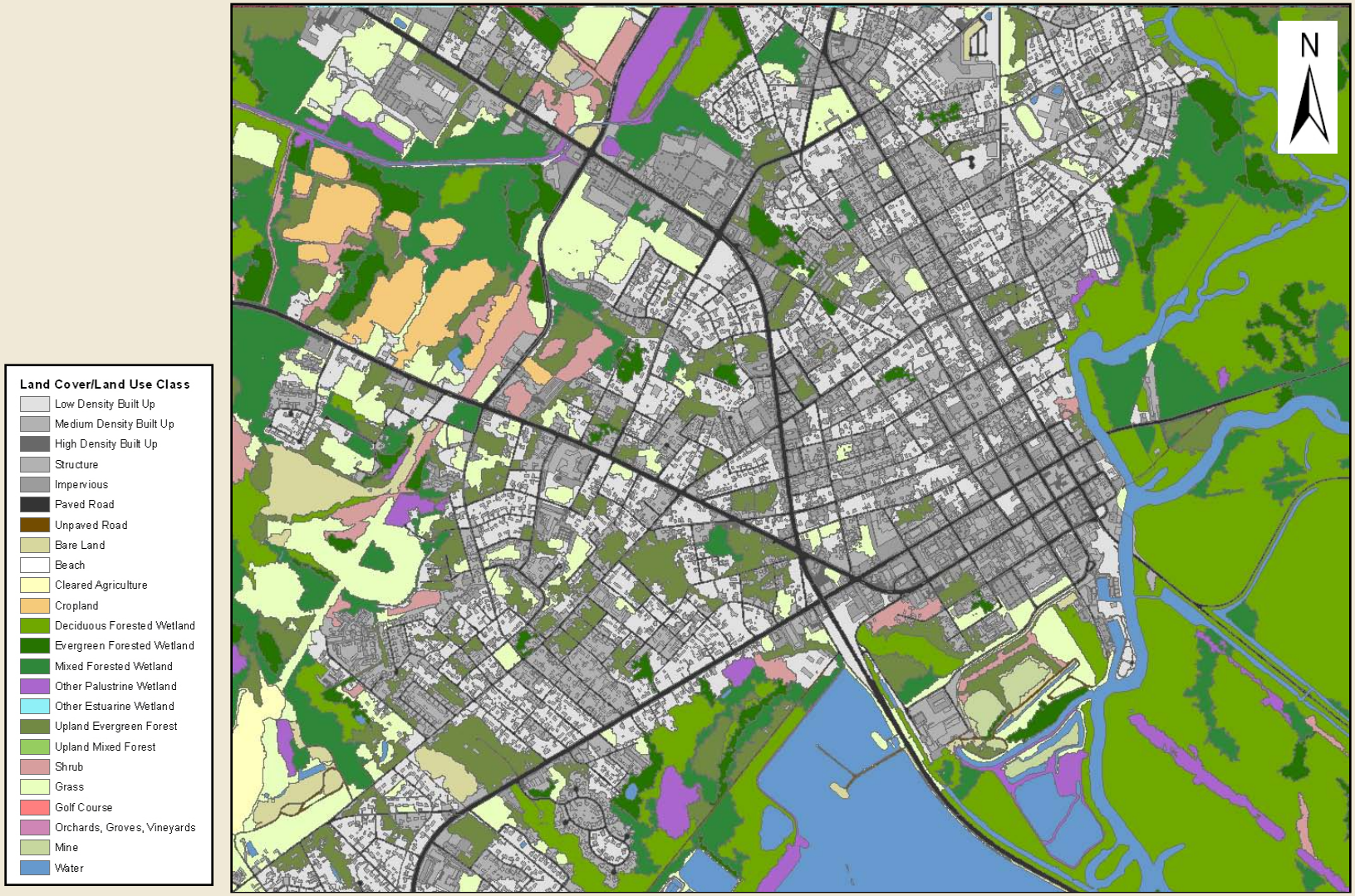
Modeling Built-up Classes

- The Low, Medium, and High Density Built-up polygons were labeled based on the percent impervious cover from the planimetric data.
- As defined by the classification scheme, a polygon became Low Density Built-up if it had between 10% - 25% impervious cover, Medium Density Built-up if it had between 25% - 75% impervious cover, and High Density Built-up if it had greater than 75% impervious cover.
- Determination of impervious percent cover was made by performing GIS overlays of the polygons and the 2008 updated planimetric impervious data. Each built-up polygon retained its original label received from the CART analysis or during the editing process as a secondary label.

Map Review

- Draft maps were sent to the client for review
- Client review ensures
  - The best possible review because the clients live in the project area and will always be more familiar with its land cover and land use than the briefly visiting image analysts.
  - Client buy-in (ownership of) to the map.

Finalization and Map Delivery - Conway

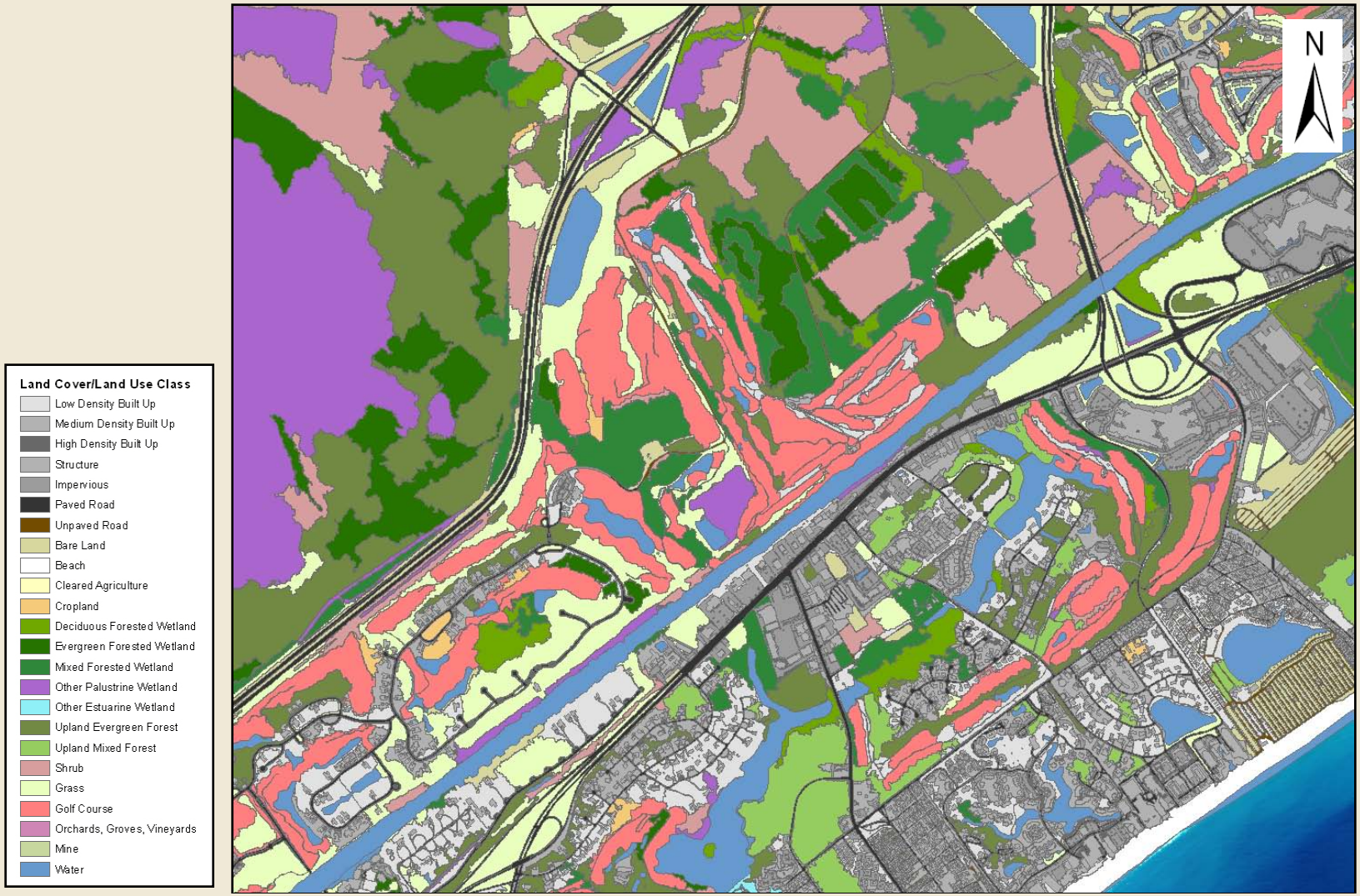


North Horry County

Land Cover/Land Use Class

- Low Density Built Up
- Medium Density Built Up
- High Density Built Up
- Structure
- Impervious
- Paved Road
- Unpaved Road
- Bare Land
- Beach
- Cleared Agriculture
- Cropland
- Deciduous Forested Wetland
- Evergreen Forested Wetland
- Mixed Forested Wetland
- Other Palustrine Wetland
- Other Estuarine Wetland
- Upland Evergreen Forest
- Upland Mixed Forest
- Shrub
- Grass
- Golf Course
- Orchards, Groves, Vineyards
- Mine
- Water

Myrtle Beach – Kingston Plantation



Preliminary Map Accuracy

Map	Land Cover/Land Use Class	Reference Sites											
		Bare	Cleared Ag	Cropland	Golf Course	Estuarine Wetland	Palustrine Other Wetland	Palustrine Forested Wetland	Upland Evergreen Forest	Shrub	Grass	Total	User's Accuracy
	Bare	15										15	100%
	Cleared Ag	2	24	2							2	30	80%
	Cropland			18	1						1	20	90%
	Golf Course				24							24	100%
	Estuarine Wetland	1				8				1	1	11	73%
	Palustrine Other Wetland		1				22			5		28	79%
	Palustrine Forested Wetland						2	29	1			32	91%
	Upland Evergreen Forest								23			23	100%
	Shrub		1				5		1	22		29	76%
	Grass	1		2			1			1	15	20	75%
	Total	19	26	22	25	8	30	29	25	29	19	232	
	Producer's Accuracy	79%	92%	82%	96%	100%	73%	100%	92%	76%	79%		86%

Final Map Accuracy

Map	Land Cover/Land Use Class	Reference Sites											
		Bare	Cleared Ag	Cropland	Golf Course	Estuarine Wetland	Palustrine Other Wetland	Palustrine Forested Wetland	Upland Evergreen Forest	Shrub	Grass	Total	User's Accuracy
	Bare	15										15	100%
	Cleared Ag		25	4							1	30	83%
	Cropland			18								18	100%
	Golf Course				25							25	100%
	Estuarine Wetland					8						8	100%
	Palustrine Other Wetland		1				26			3	1	31	84%
	Palustrine Forested Wetland						4	29				33	88%
	Upland Evergreen Forest								25			25	100%
	Shrub									24		24	100%
	Grass	4								2	17	23	74%
	Total	19	26	22	25	8	30	29	25	29	19	232	
	Producer's Accuracy	79%	96%	82%	100%	100%	87%	100%	100%	83%	89%		91%

Conclusions

- The use of adaptive texture data derived from the ADS40 near-infrared spectral band to create polygons from the imagery that served as the basis for classification – Make sure your polygons (objects) are good before you do anything else
- The use of the County's Lidar dataset in the CART polygon labeling. This dataset was important for distinguishing trees from shrubs – If you have lidar, use it.
- The combination of good image segments (polygons) used for classification and the County's planimetric data allowed for the automated classification of the land use classes High, Medium, and Low Density Built-Up – Use ancillary data, especially the client's ancillary data.
- The fully automated map (the preliminary map) had a very high overall accuracy of 86%. This is an extremely high accuracy for a map had not yet undergone editing – good planning will result in good maps.
- The final map had an overall accuracy of 91%. Most of the individual class accuracies were greater than 80% and many of them were greater than 95%, all of which are very superior accuracy results. Excellent execution will result in excellent maps.

How is Horry County Using the Data?

- Primary use is for hydrologic watershed modeling
  - The County lacked detailed high-resolution land cover/land use dataset
  - The new land cover/land used dataset will be used to create more accurate watershed models
  - Also pollutant runoff loading modeling
- Other potential uses:
  - Land use planning
  - Fire fuels modeling
  - Hurricane debris quantity estimating

Cheers to a Successful Project!