

# Satellite Remote Sensing of Animal Feeding Operations: A Novel approach to Characterizing Sources of Environmental Exposures

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ISPRS Symposium: Advances in Geospatial Technologies for Health

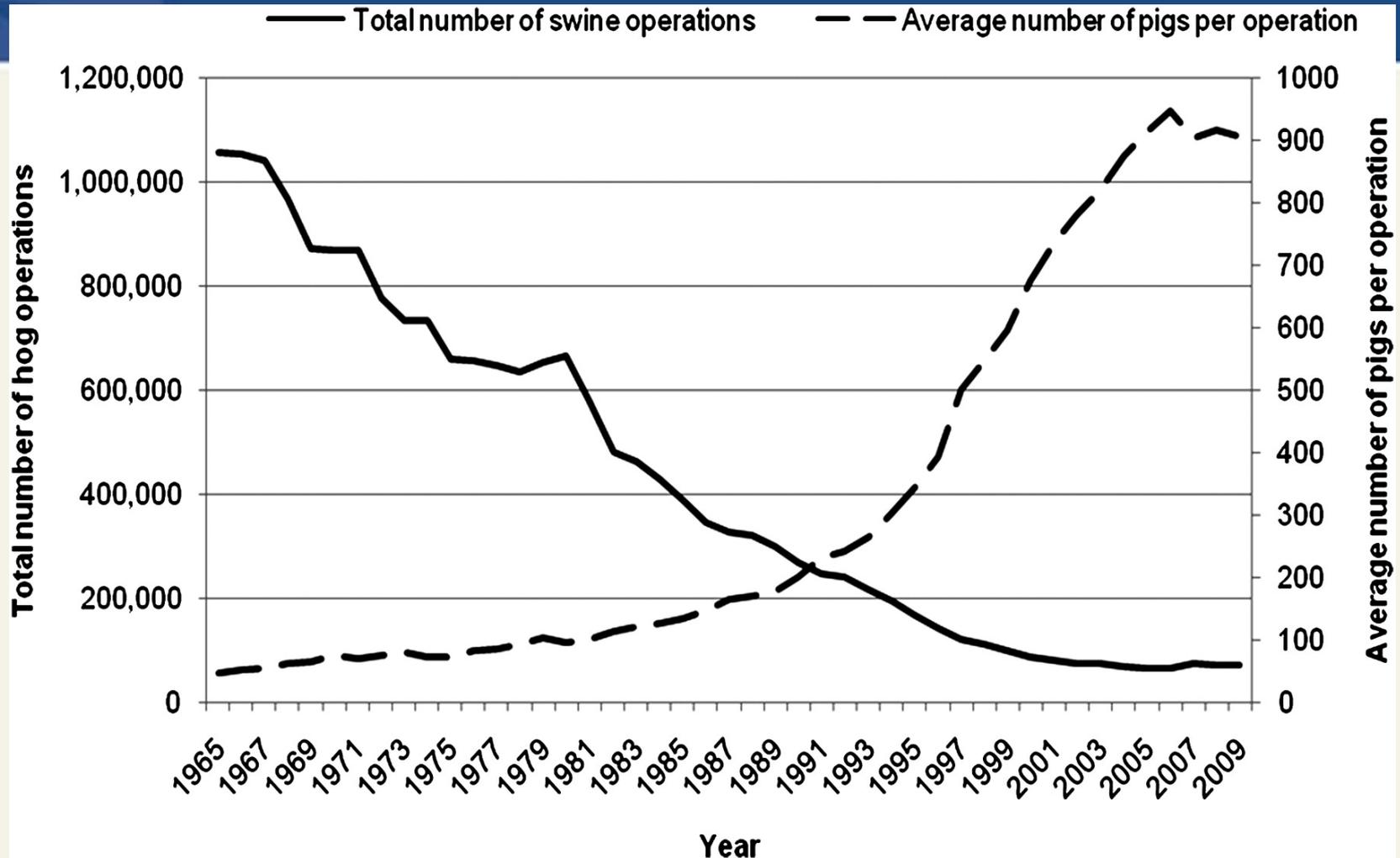
September 13, 2011

# Modern Food Animal Production

- High density confinement of animals raised for human food
- Congregate animals, feed, manure and urine, dead animals, and production operations on a small land area.
- Feed is brought to the animals rather than the animals grazing or otherwise seeking feed in pastures, fields, or on rangeland

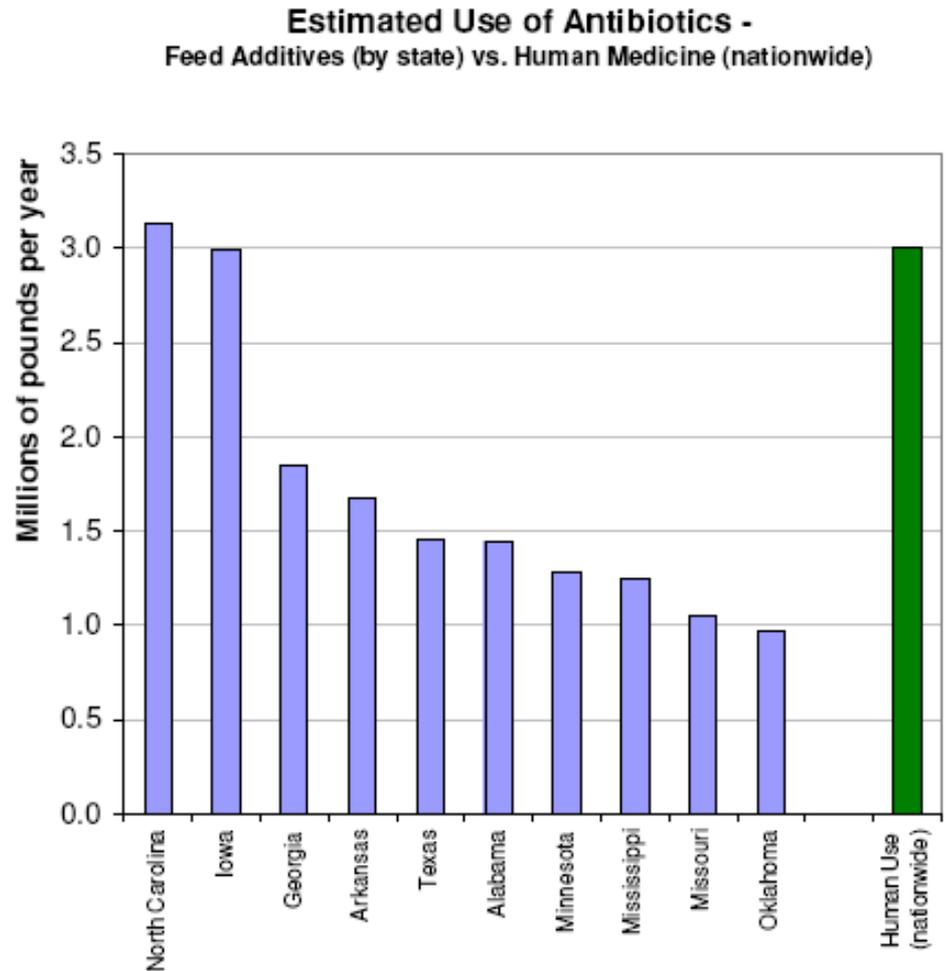


## Trends in hog operations in the United States



# What are the critical issues?

- Air, water, and soil pollution
- Antibiotic resistant bacteria
- Connecting exposures and adverse health impacts





# The importance of knowing locations

- Environmental modeling and monitoring
- Temporal trends in production, land use change, pollution, and associated health impacts
- Identifying areas of environmental and health risks
- Associating health impacts with location

Example:

Does an increased density of AFOs on a given regional scale predict environmental health outcomes of interest?

# Existing Data on Farm Locations



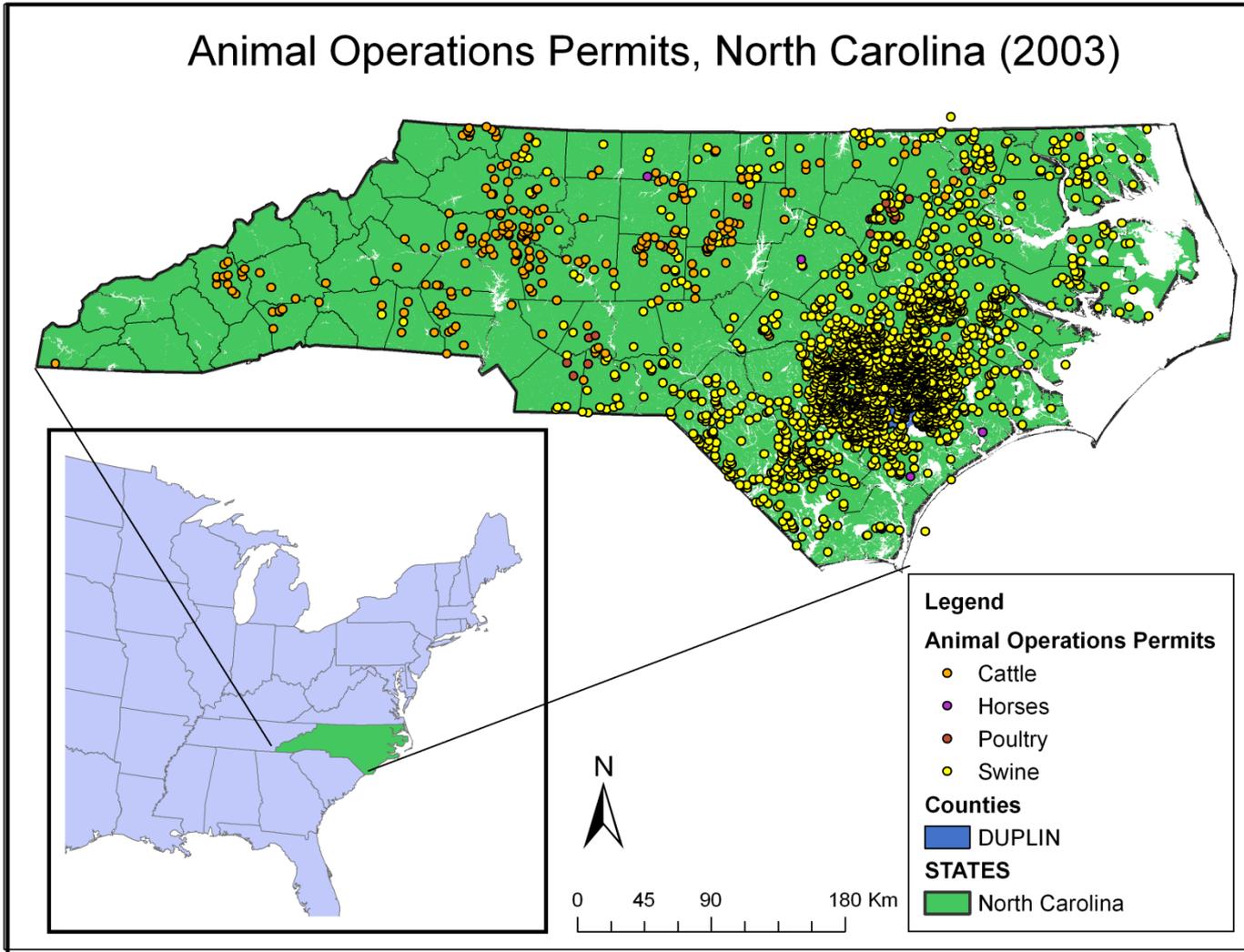
- 1) Temporality: every 5 years  
Scale: County and 6 digit HUC  
How: free to public through website

- 2) Clean Water Act Section 404: NPDES Permits  
Temporality: yearly  
Scale: Individual Farm  
How: query to State administrator of Permits (ex: DNR, DEP, DEQ)



# Geographic Location: Duplin County, NC

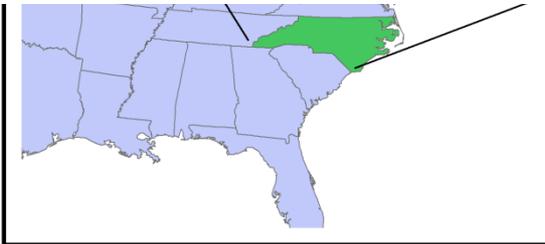
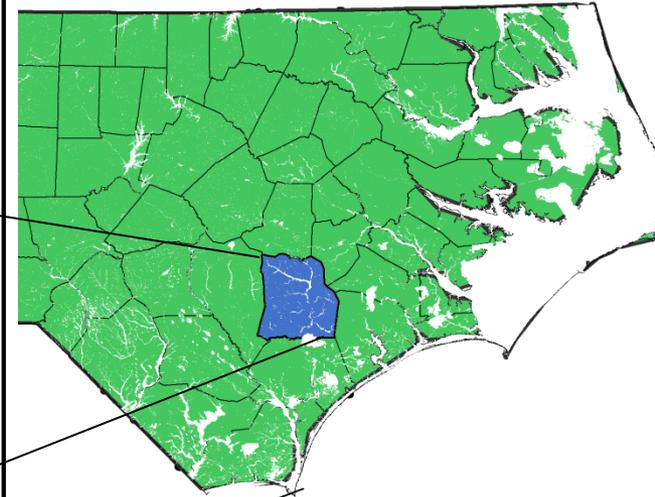
Animal Operations Permits, North Carolina (2003)



# Geographic Location: Duplin County, NC

## Duplin County, North Carolina

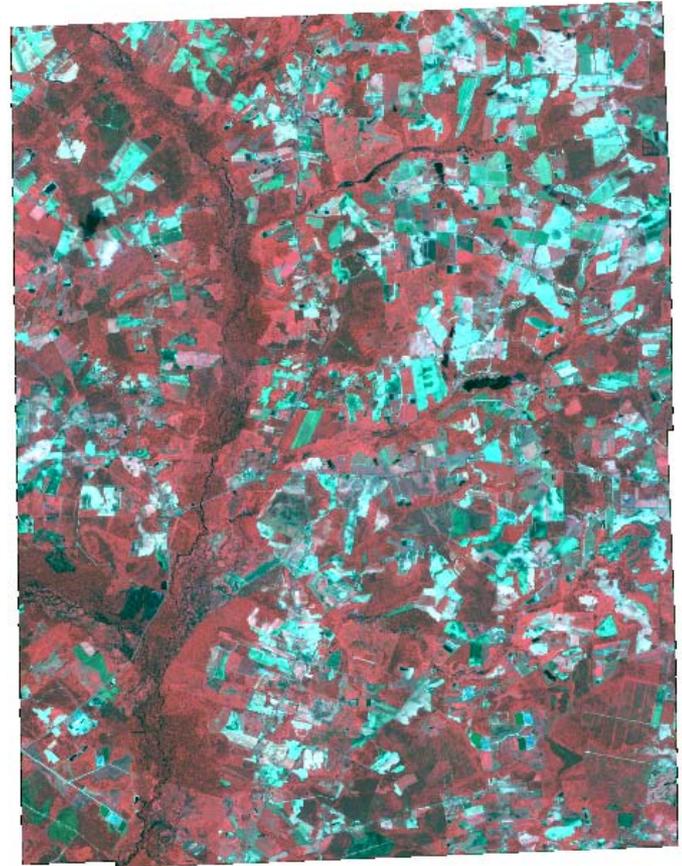
Anderson Quadrangle, Duplin County, North Carolina (2003)



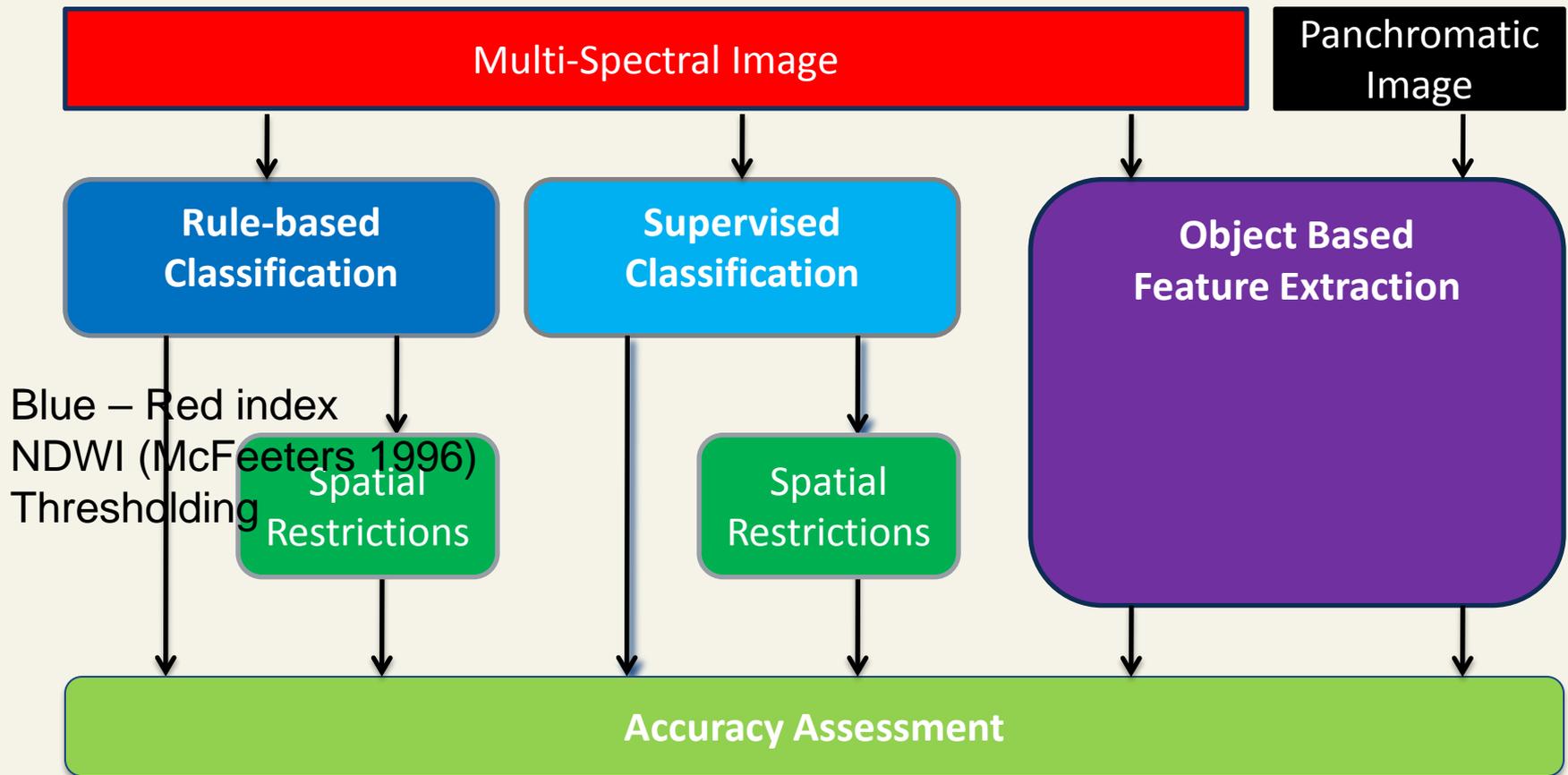
# Materials

## Imagery

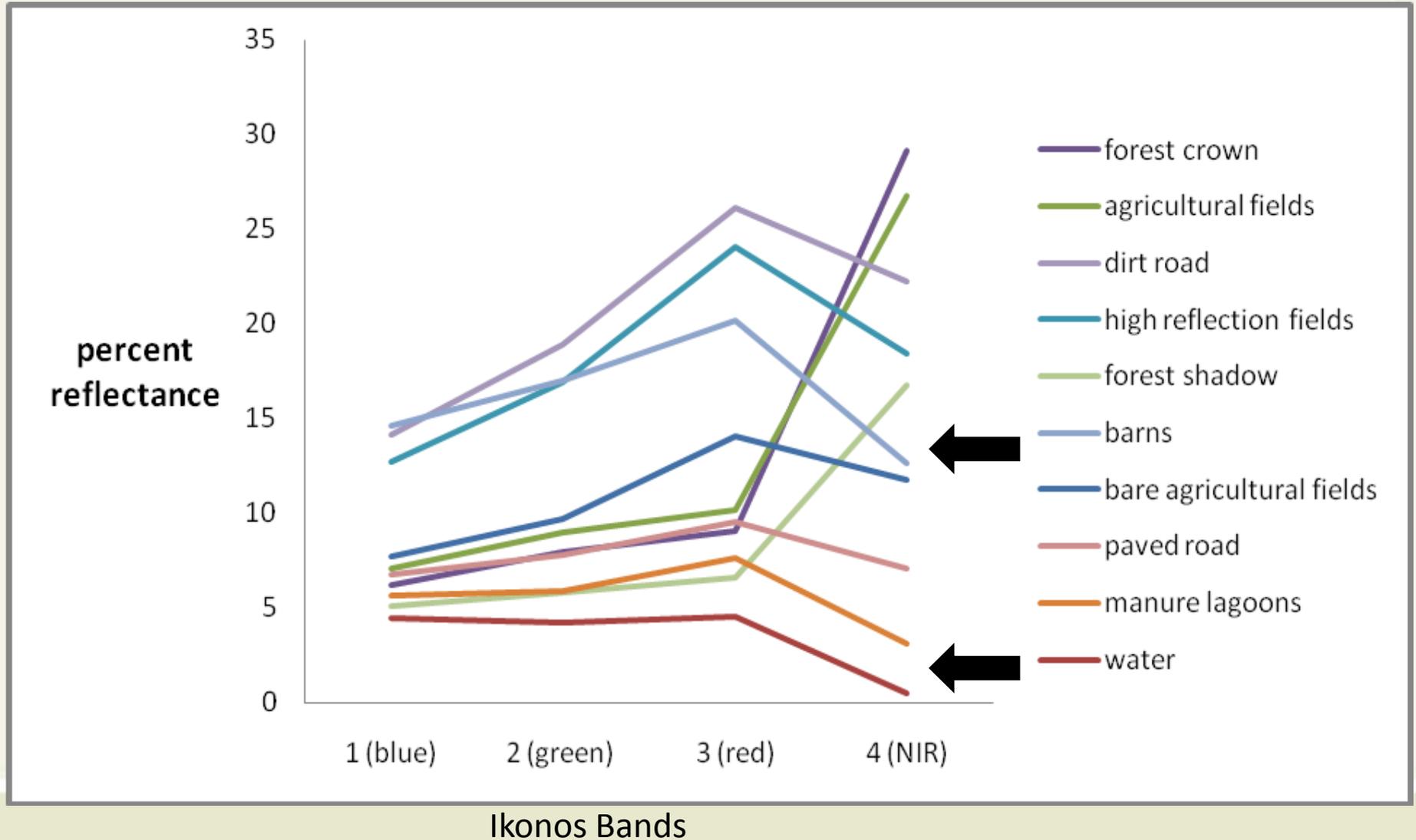
- IKONOS
  - June 25, 2003, Anderson Quadrangle, Duplin County
  - 4 band; Pansharpened:
  - 164 km<sup>2</sup>
- Software
  - Erdas Imagine & Imagine Objective
  - ArcGIS



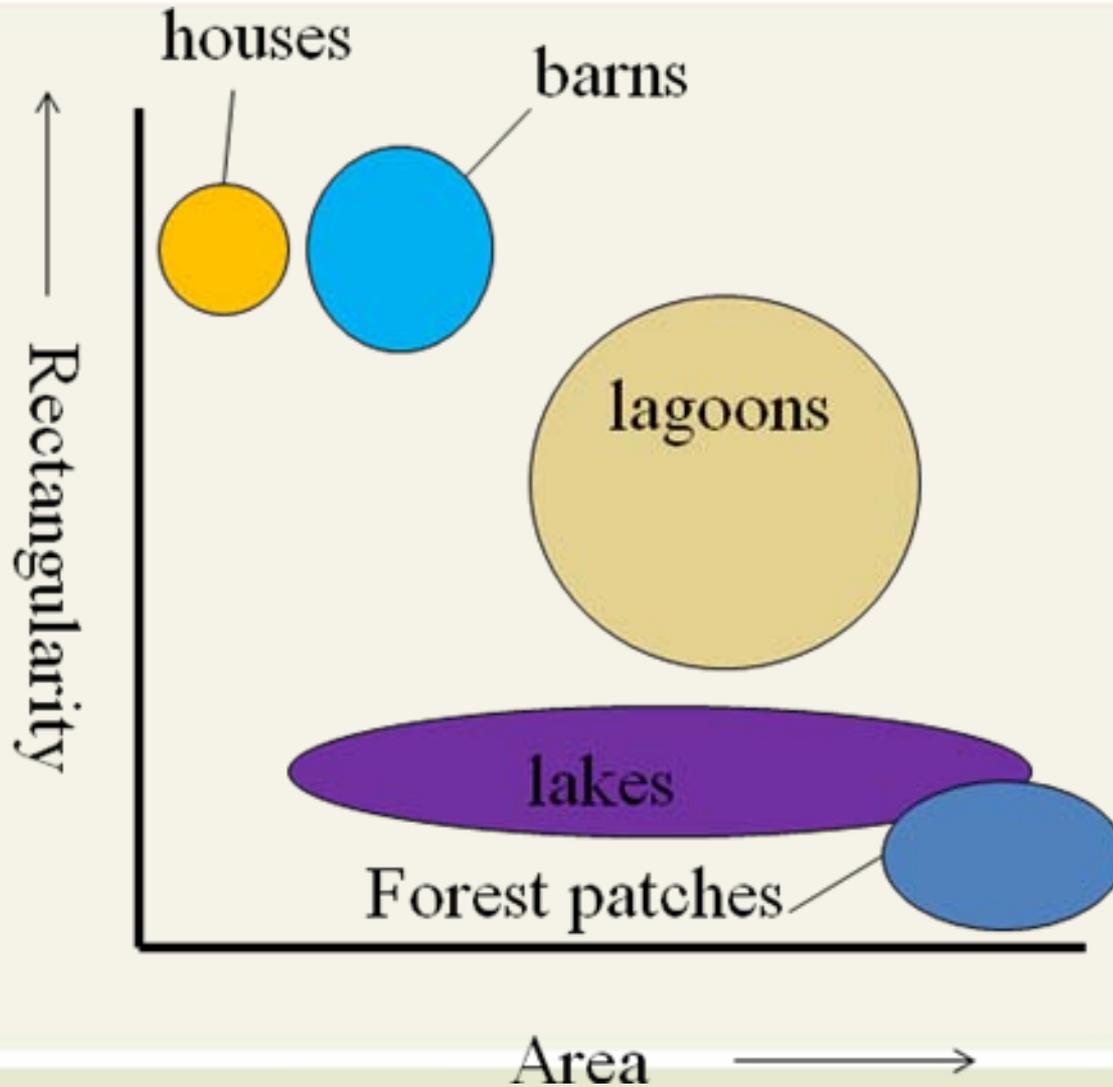
# Project Workflow: Using spatial and Spectral information

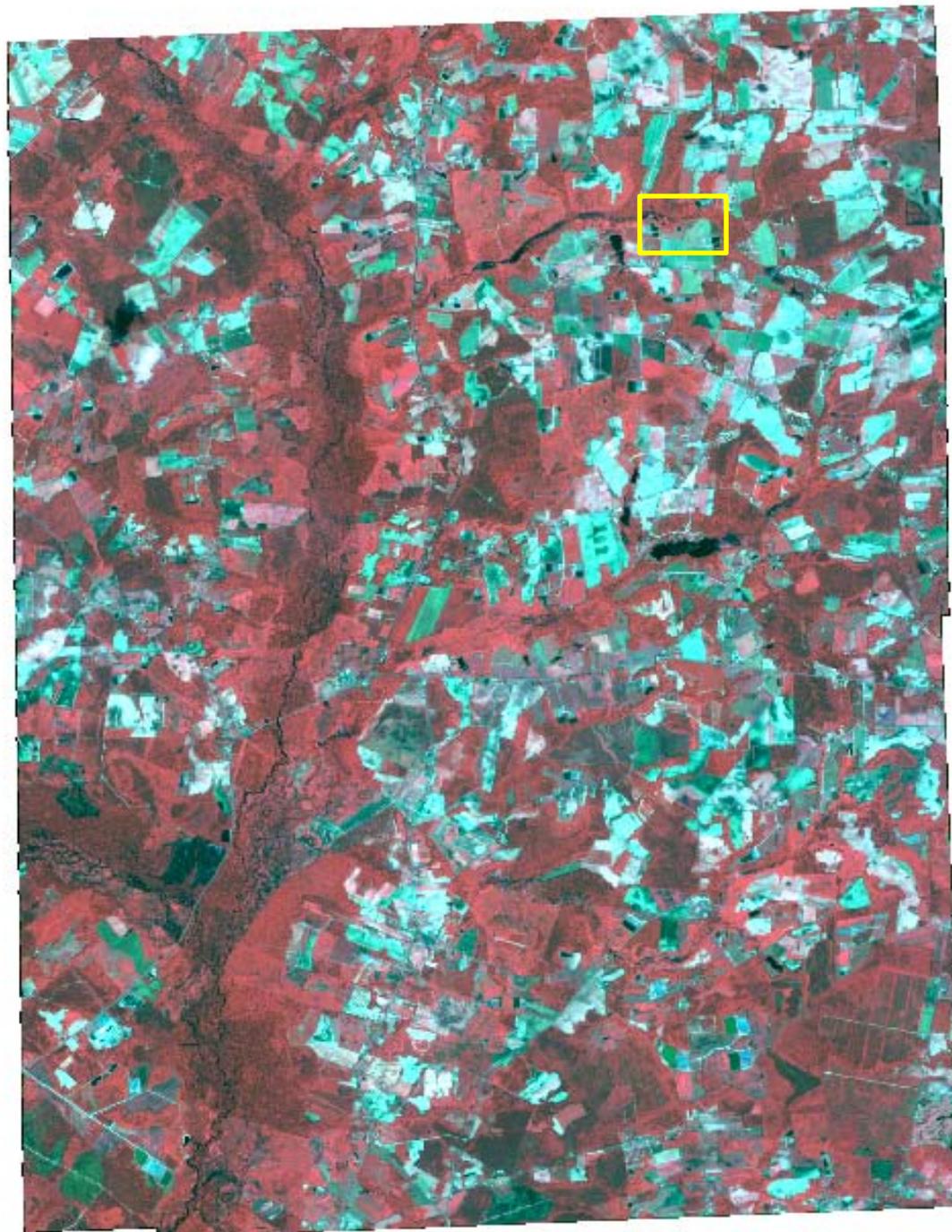


# Spectral Reflectance



# Spatial Characteristics

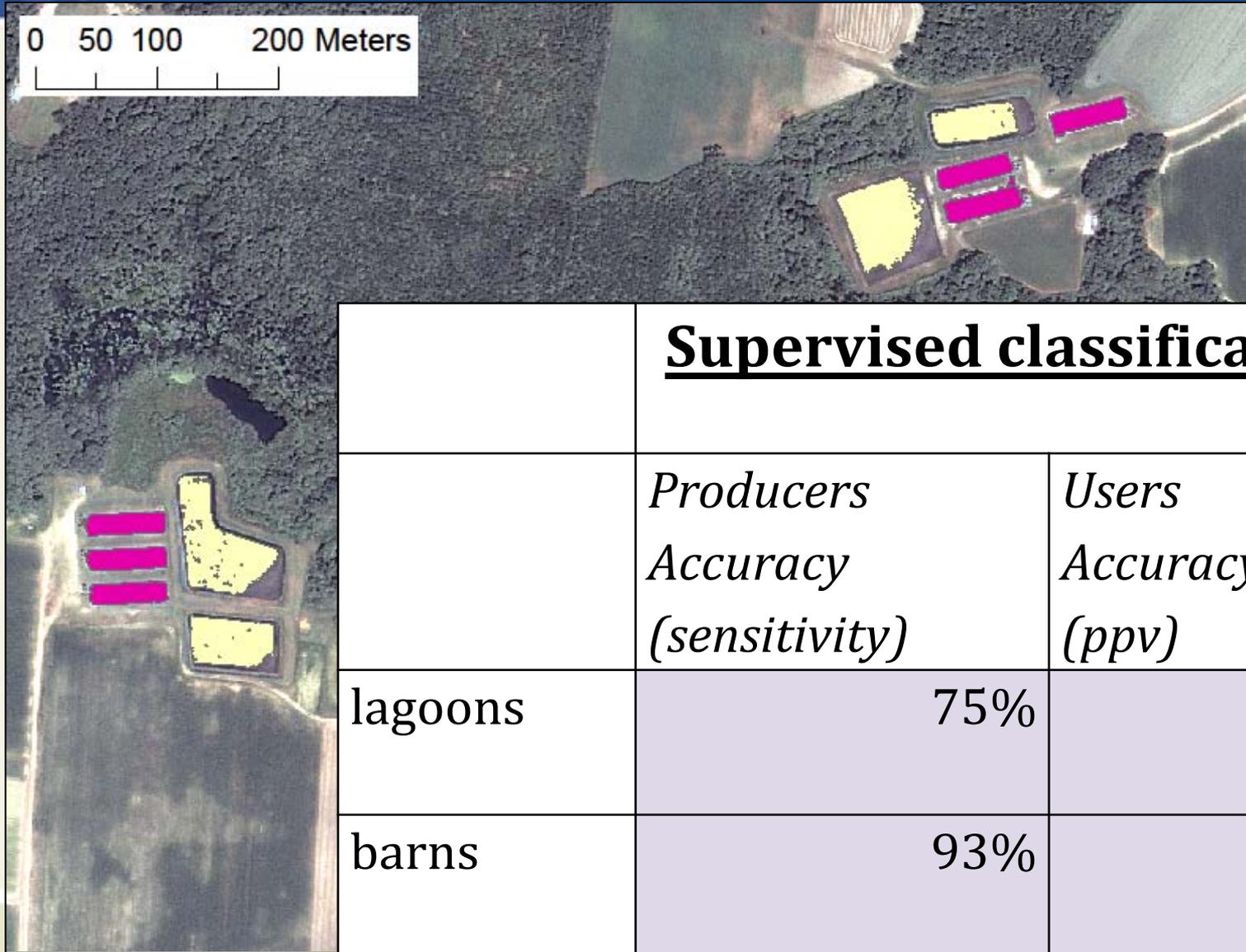




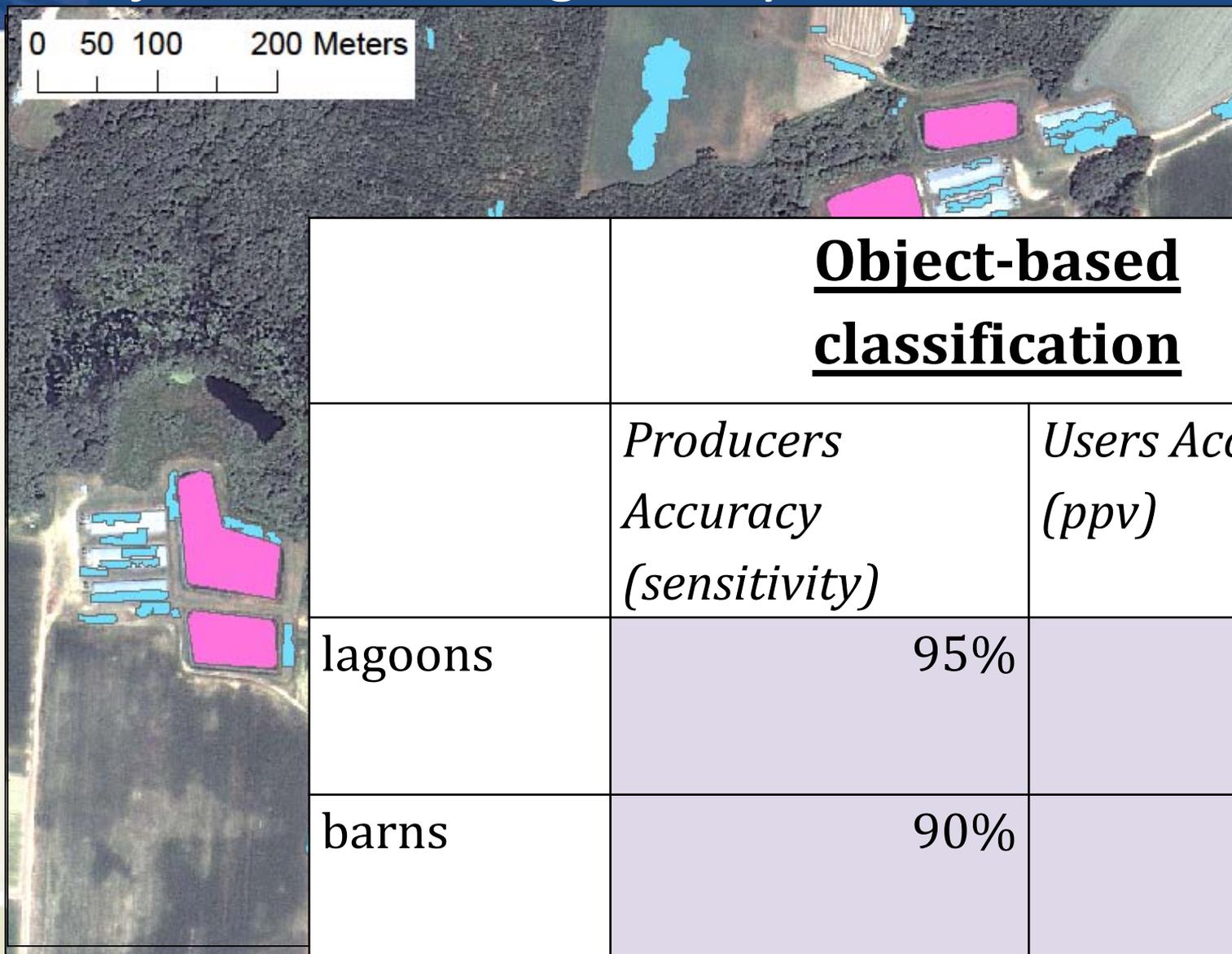
# Taking a closer look...



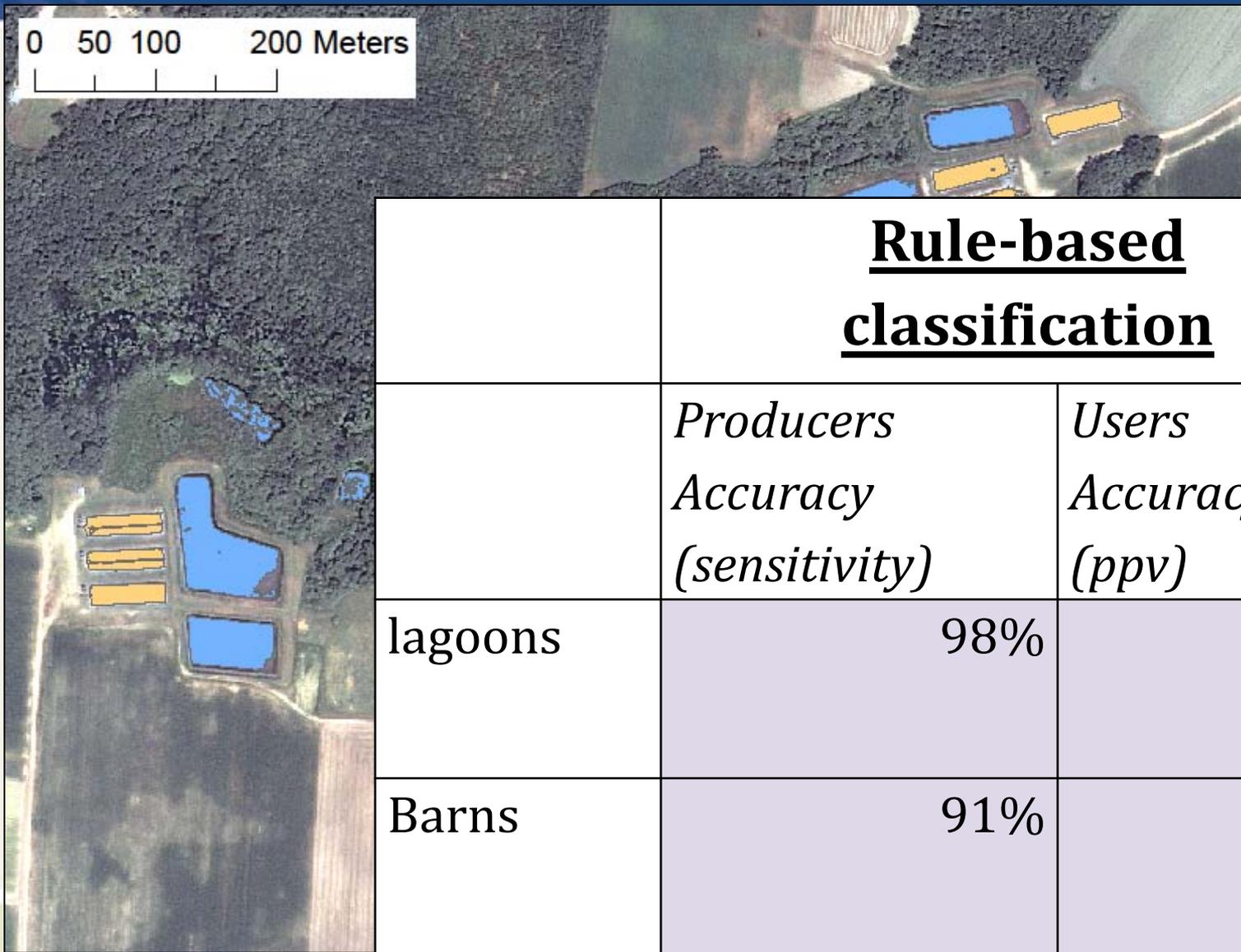
# Supervised Classification

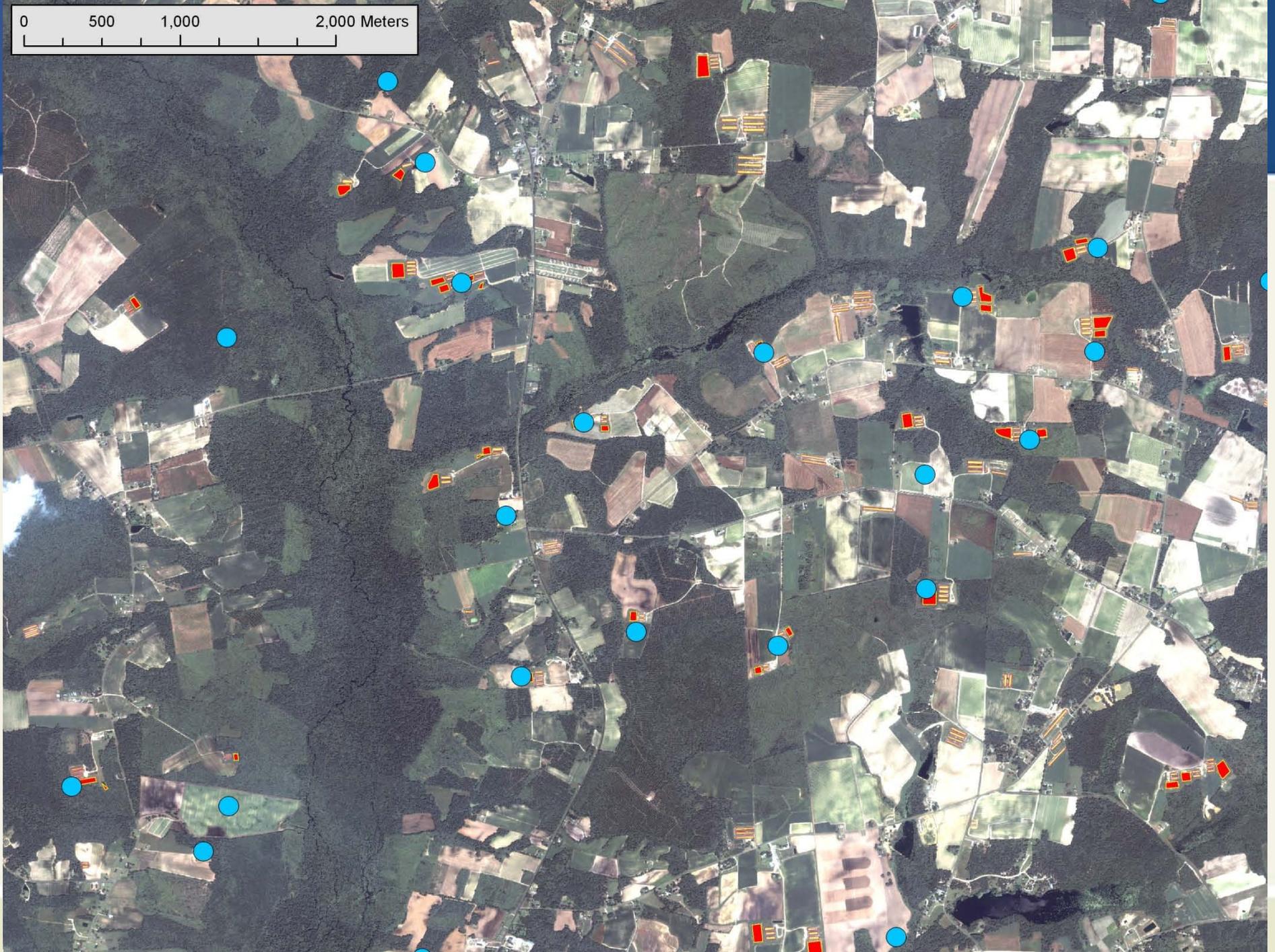
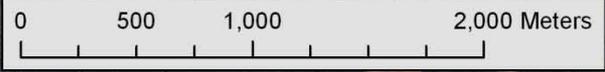


# Object Based Image Analysis



# Rule Based Classification





# Comparison to previous studies

	<b>Current Study</b>  <b>(rule based)</b>	<b>Garofalo &amp; Jennings (2004)</b>  <b>(Supervised class and geometric restrictions)</b>	<b>Engle (2006)</b>  <b>(OBIA)</b>
Lagoons	PA: 98% UA: 75%	PA: 79% UA: 53%	n/a
Barns	PA: 91% UA: 75%	PA: 76% UA: 56%	PA: 92% UA: 28%



# Conclusions

- Remote Sensing is an accurate, reliable and cost effective tool for mapping AFOs
- Can identify more farms with better accuracy than publicly available datasets
- I provide a novel methodology for documenting where AFOs exist which provides the groundwork for identifying the relationship between industrial food animal production and health impacts.
- This is an important advance; without this info, we cannot connect existence of farms to health in rigorous way.



# Strengths and Limitations

- + validation by dividing image
- + imagery is scalable, publicly available, effective, and captured at regular time intervals
- + demonstrates the value of high spatial resolution data to environmental issues of national and global extent
- + method can be used with other sources of imagery, including airborne imagery such as NAIP.
- irregularly shaped objects may be missed
- accuracy assessment



# Public Health Implications

- Enables longitudinal investigations of land use change and public health impacts
- Methodology can be applied to other environmental sources
- Enables surveillance of AFOs for use by environmental managers and public health researchers
- Informs environmental health policies
  - Quantitative risk assessment
  - Siting of AFOs
  - Emerging infectious disease surveillance policies



# Acknowledgements

- Silbergeld Lab staff and students
- Greg Glass and Tim Shields (JHSPH)
  
- Center for a Livable Future Pre-doctoral Fellowship
- Delta Omega Honor Society Scholarship
- Pew Charitable Trusts