Linking Land Cover to Water Quality

Weeks Bay Watershed, Alabama

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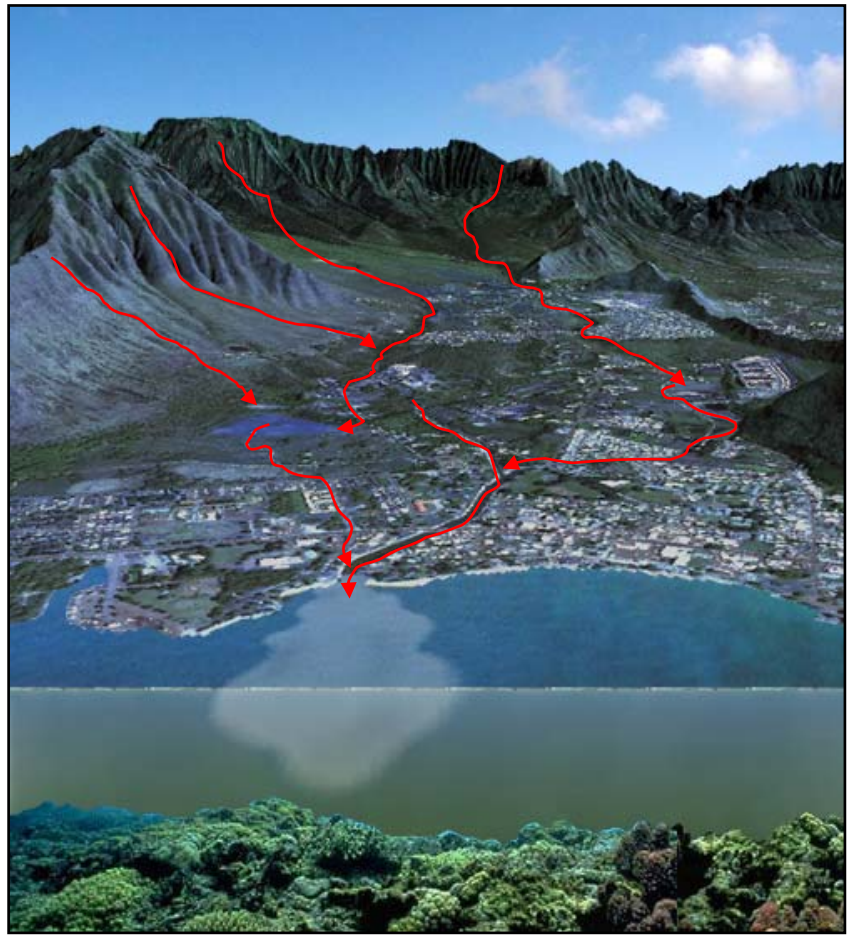
NOAA Coastal Services Center

Outline

A. Land Cover and Water Quality

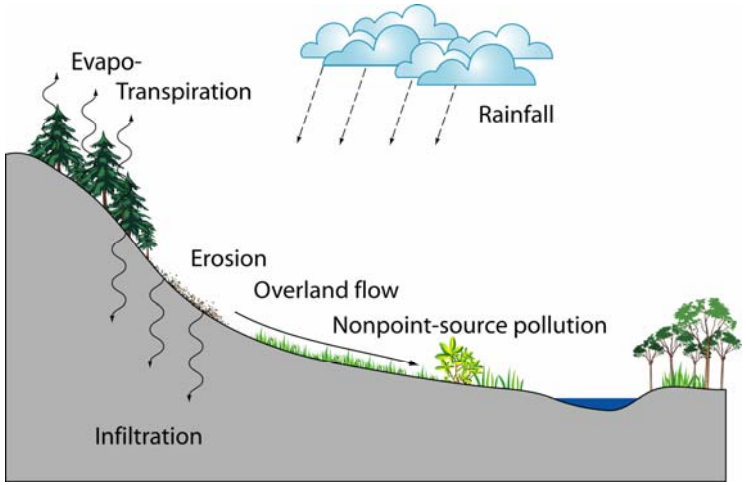
B. The Project at the Weeks Bay National Estuarine Research Reserve (NERR)

C. Three-Tier Strategy to Address Nonpoint Source Pollution



Understanding Runoff Generation

- Controlled by
  - Climate
  - Vegetation
  - Land cover and use
  - Soil properties
  - Topography
  - Rainfall characteristics



Land Use and Imperviousness

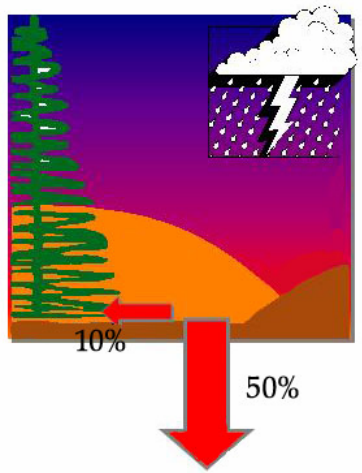
INTENSITY OF LAND USE

AMOUNT OF IMPERVIOUS SURFACE

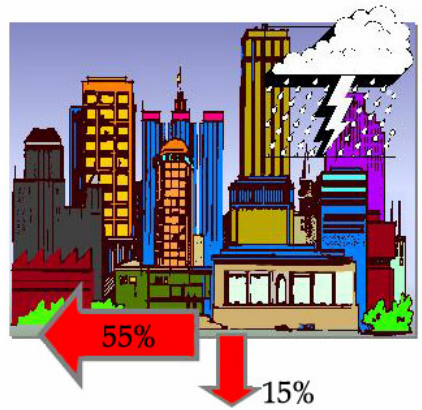
POTENTIAL WATER QUALITY ISSUES

Development Impacts on Runoff

- Groundwater recharge decreases because less water infiltrates
- Increased runoff volume and speed
- Impervious surfaces retain heat, which increases runoff temperatures
- Stormwater runoff picks up pollutants



A: Pre-Development



Source: Nonpoint Education for Municipal Officials (NEMO)

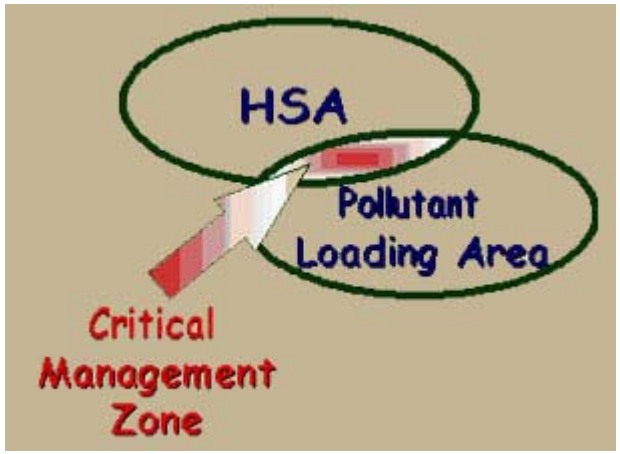
B: Post-Development

The Pollutants in Polluted Runoff

- Sediment:
  - cropland, lawns and gardens, forestry activities, roadways, construction sites, and stream-bank erosion
- Nutrients:
  - cropland, lawns and gardens, livestock operations, wildlife, septic systems, and land receiving waste application
- Pathogens:
  - livestock, wildlife, septic systems, land receiving waste application, and urban runoff
- Toxic contaminants (including pesticides):
  - roadways, mining operations, cropland, lawns and gardens, and forestry

Nonpoint Source Pollution

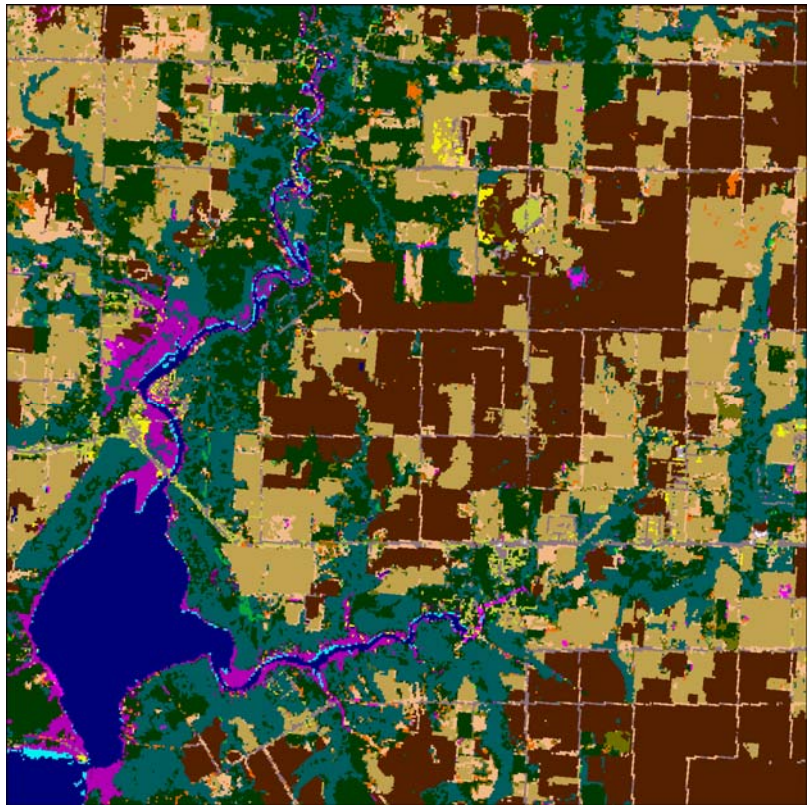
- Nonpoint source (NPS) pollutants comes from many different areas
- NPS pollutants are mobilized in areas where hydrologically sensitive areas (saturated zones) intersect with pollutant loading areas
- These areas are the “critical management zones”



Source: Soil and Water Lab, Cornell University

Land Cover Data

- Coastal-Change Analysis Program
  - Regional planning and assessments
  - Habitat fragmentation analyses
  - Conservation site selection
  - Habitat management
  - Model input; decision support tools/systems
  - Impervious surface estimates
  - Nonpoint source pollution assessment



Coastal NLCD Classification Scheme

Developed
- Developed, high intensity
- Developed, medium intensity
- Developed, low intensity
- Developed, open space

Agricultural
- Cultivated crops
- Pasture/hay

Rangeland
- Grassland/herbaceous
- Scrub/shrub

Forest land
- Deciduous forest
- Evergreen forest
- Mixed forest

Barren land
- Barren land
- Unconsolidated shore

Water and submerged land
- Open water
- Palustrine aquatic bed
- Estuarine aquatic bed

Wetlands
- ***Woody wetlands***
  - Palustrine forested wetland
  - Palustrine scrub/shrub wetland
  - Estuarine forested wetland
  - Estuarine scrub/shrub wetland
- ***Herbaceous wetlands***
  - Palustrine emergent wetland
  - Estuarine emergent wetland

Perennial ice/snow

Tundra/Alaska only classes
- Dwarf scrub*
- Sedge/herbaceous*
- Lichens*
- Moss*

*NLCD – **National Land Cover Database**

Developed

Storm runoff may contain…

Nutrients:	Lawn fertilizers and septic system effluent
Pathogens:	Malfunctioning septic system, pet waste
Sediment:	Construction, road sand, erosion from lawns and gardens
Toxins:	Household products, pesticides, industrial pollutants
Debris:	Litter and illegal dumping

Agriculture, Grassland, Bare Land

Storm runoff may contain…

Nutrients:	Fertilizers from farms, parks, golf courses
Pathogens:	Domestic animal and wildlife waste
Sediment:	Erosion from agricultural fields
Toxins:	Pesticides from agricultural lands and golf courses
Debris:	Litter and illegal dumping

Forest and Scrub/Shrub

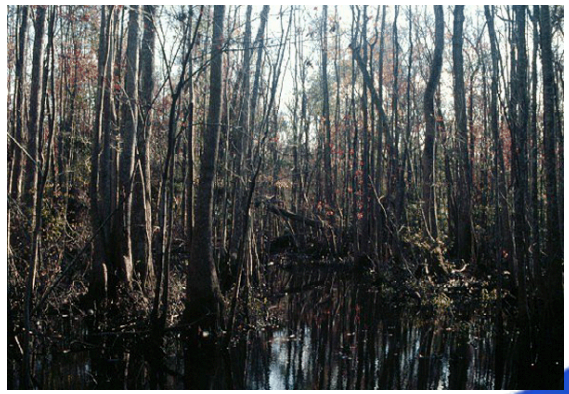
Storm runoff may contain…

Nutrients:	Animal waste
Pathogens:	Animal waste
Sediment:	Erosion from logging operations
Toxins:	
Debris:	

Wetland

Storm runoff may contain…

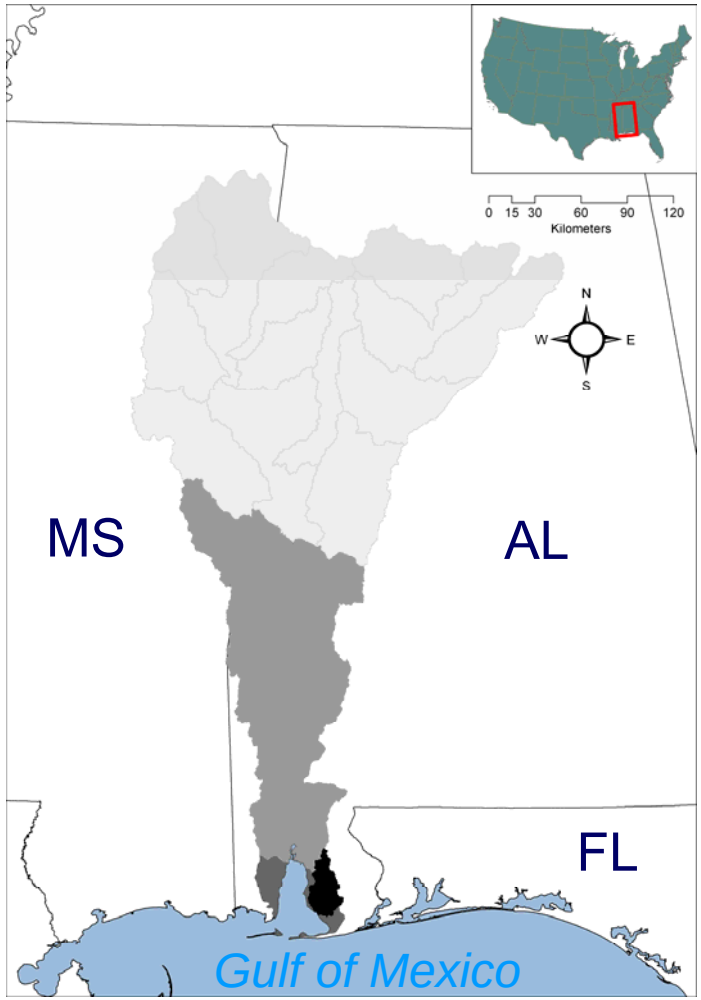
Nutrients:	Animal waste
Pathogens:	Animal waste
Sediment:	Erosion from logging operations
Toxins:	
Debris:	



Using Watersheds as a Framework

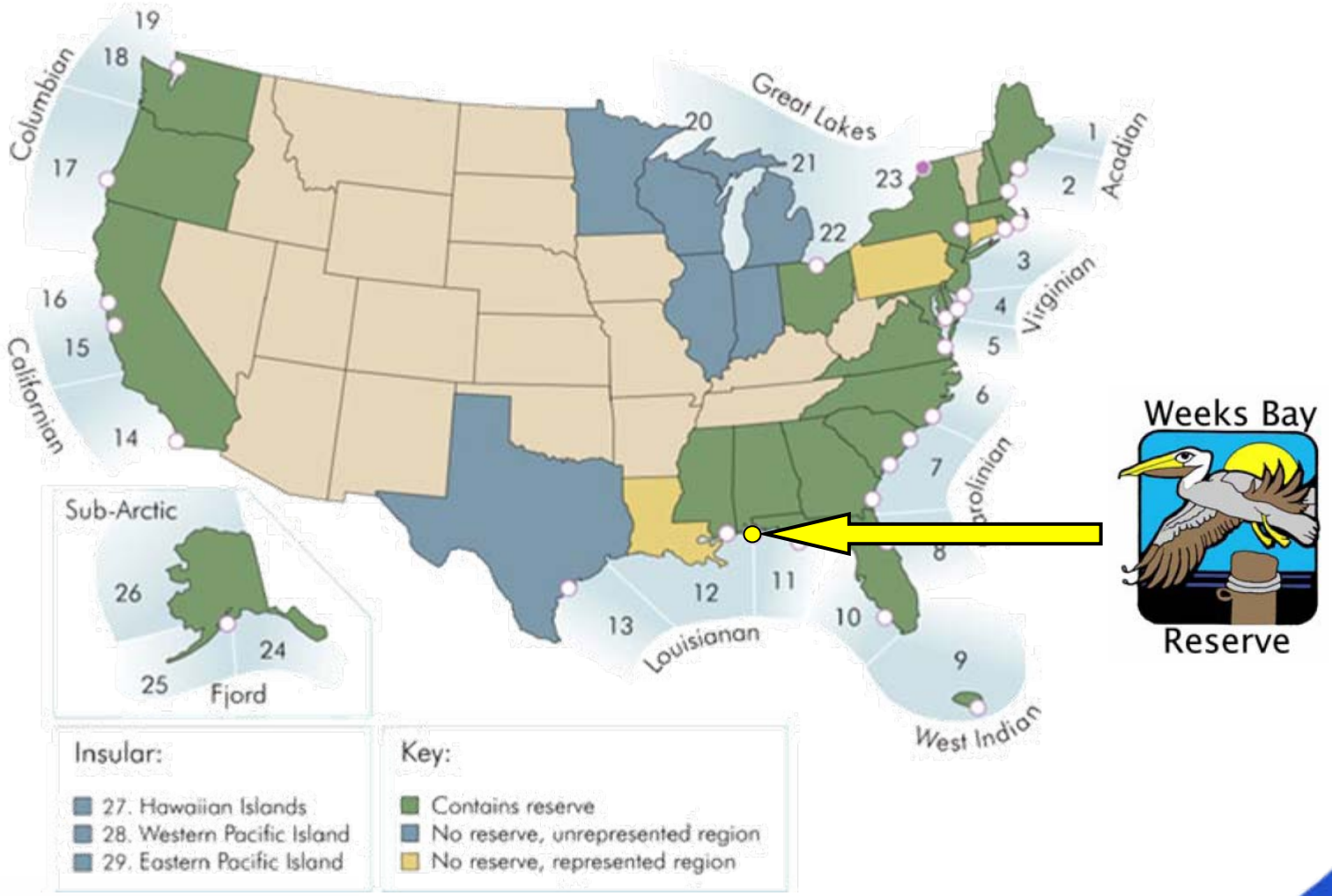
- Definition:
  - *"An area of land that drains water, sediment, and dissolved materials to a common outlet."*

    (Dunne and Leopold, 1978)
- Hierarchical organization
  - Hydrologic Units (USGS*)
    - Region (U.S. Southeast)
    - Sub-region
    - Accounting unit
    - Cataloging unit
    - *Management unit*



*USGS – **U.S. Geological Survey**

National Estuarine Research Reserves



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Weeks Bay

- 12.25-square-kilometer estuary
  - Representative of the Mobile Bay system (Mississippi Delta subcategory of the Louisiana biogeographic province)
- Habitat types:
  - Tidal wetlands
  - Swamps
  - Salt marshes
  - Aquatic grass beds
  - Maritime and palustrine upland forests
  - Pitcher plant bog
  - Benthic estuarine sediments

- Freshwater inputs from the Fish and Magnolia Rivers

Protecting Weeks Bay

- Outstanding National Resource Water (1992)
  - Designated by the Alabama Department of Environmental Management (ADEM)
  - Helped secure §319 Nonpoint Source Pollution funds (1994)
- Weeks Bay Watershed Project (1993 – present)
  - Diverse partnership: Weeks Bay NERR, local agencies, businesses, watershed residents
  - Goal: to improve and maintain water quality to meet or exceed state water-quality standards for Swimming, and Fish and Wildlife water-use classifications
- Watershed Management Plan (1995, updated 2002)

Watershed Management Plan

- Environmental impacts:
  1. Decreased biological productivity
  2. Human health threats
  3. Habitat and resource loss
  4. Increased flooding

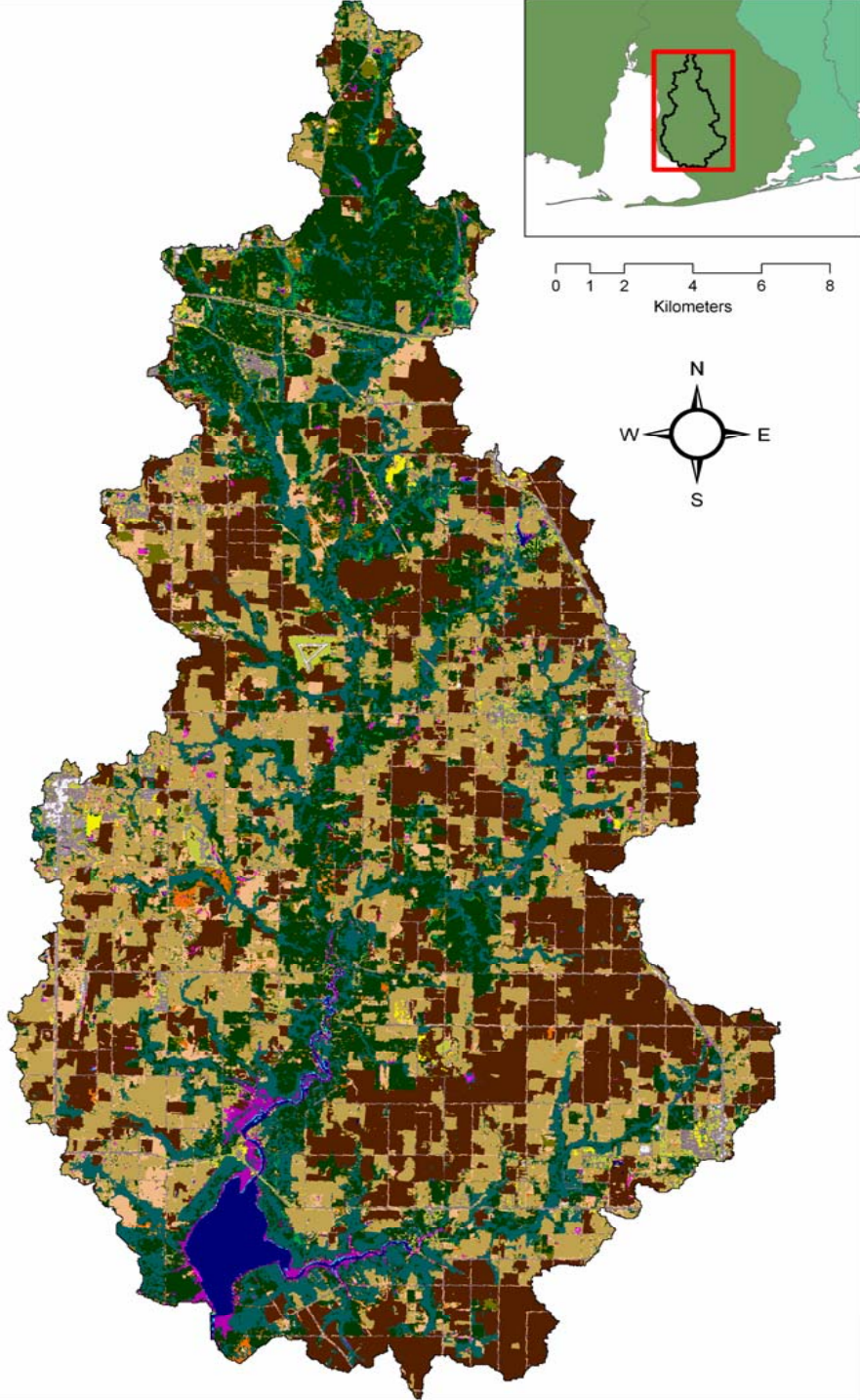
- Objectives (14 total):
  1. *Reduce nonpoint source pollution* from agricultural activities
  2. *Reduce nonpoint source pollution* from construction and land clearing activities
  3. *Reduce nonpoint source pollution* from residential sources

  …….

  14. *Cooperate and partner with other Federal, State, and local agencies* to achieve the objectives and strategies described in the Watershed Management Plan

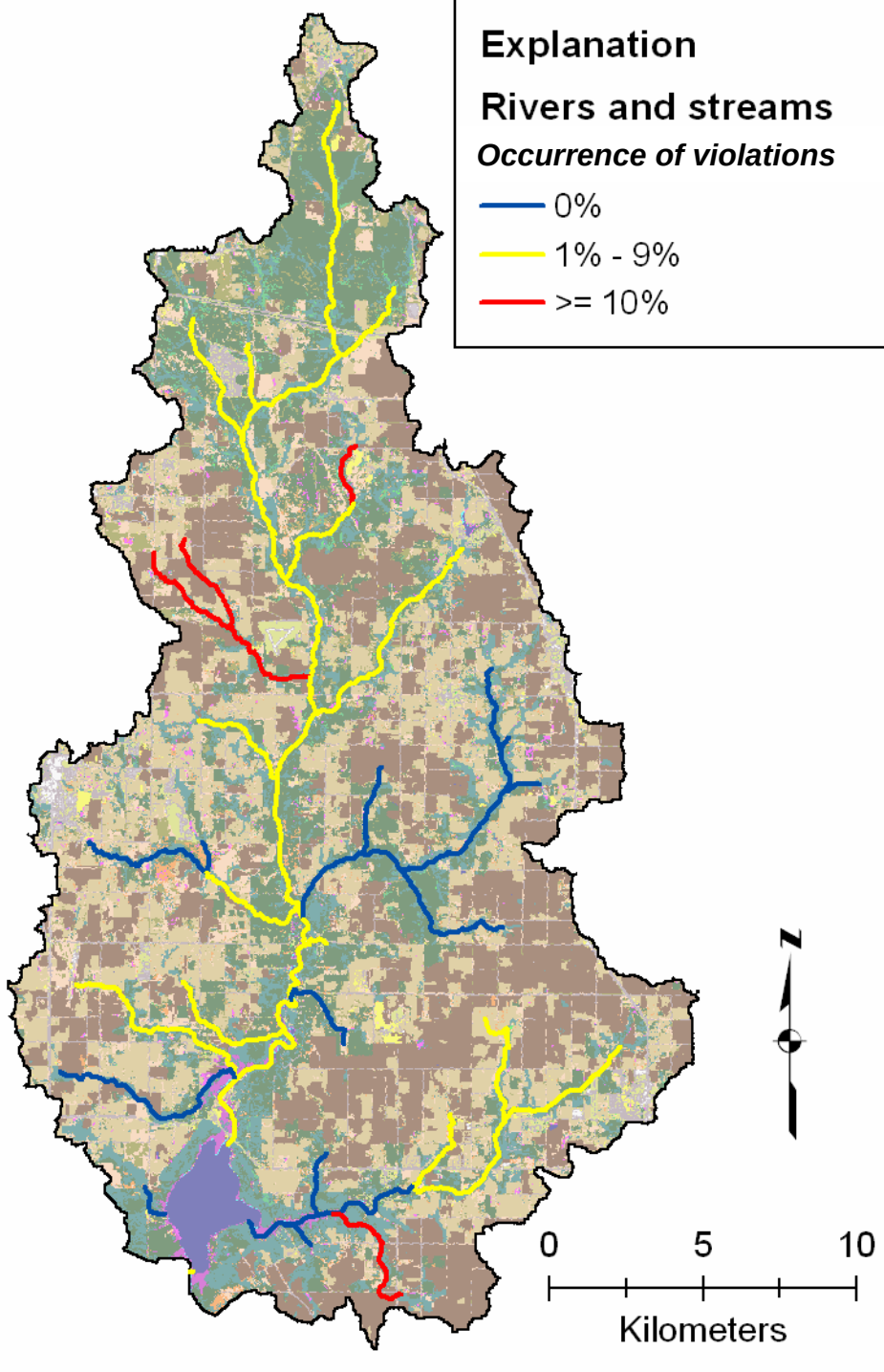
Weeks Bay Watershed

- Baldwin County, Alabama
- 605-square-kilometers
- 12.25-sq.-km. estuary
- Two major rivers:
  - Fish River
  - Magnolia River
- Land cover:
  - Cropland, pasture and hay, forest, urban
- Fecal coliform is the issue!

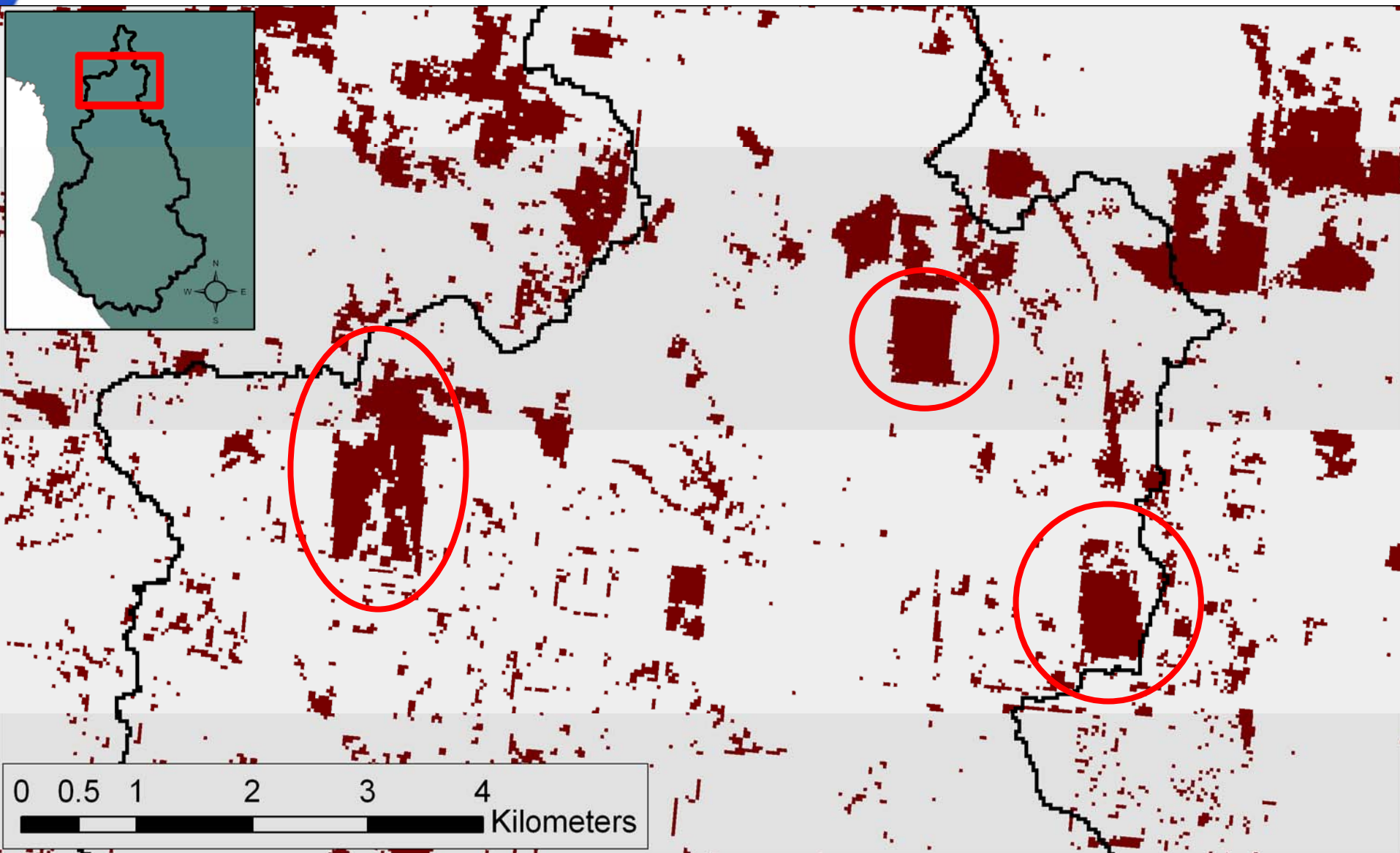


Weeks Bay Watershed

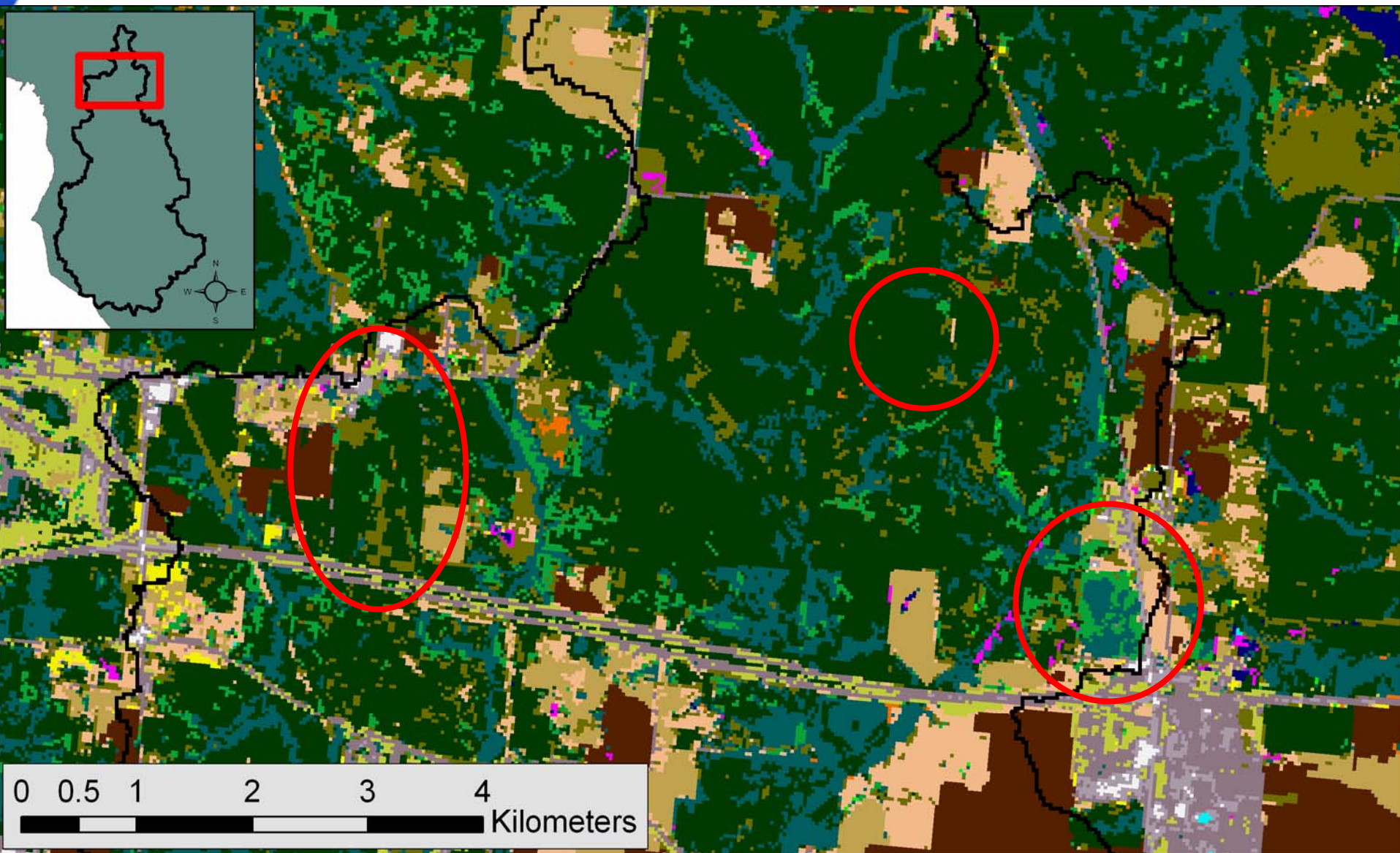
- Oyster beds closed to harvest due to high fecal coliform counts
- Water-quality sampling
  - Geological Survey of Alabama
  - Weeks Bay Water Watch
- Fecal coliform observations
  - Violation if ≥ 2,000 colonies per 100 milliliters
- Need to identify sources



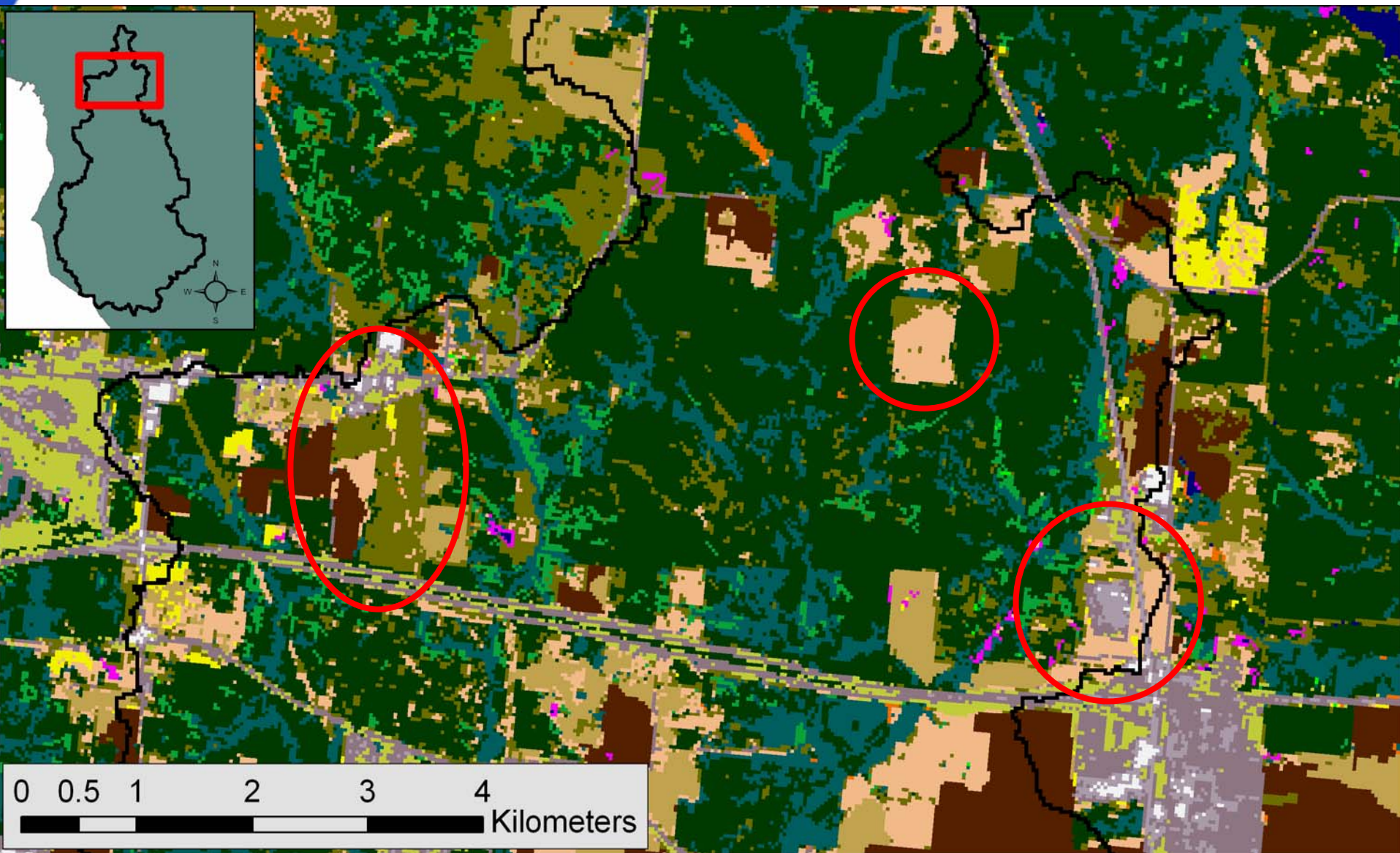
Land Cover Change Detection



C-CAP Land Cover – 1996

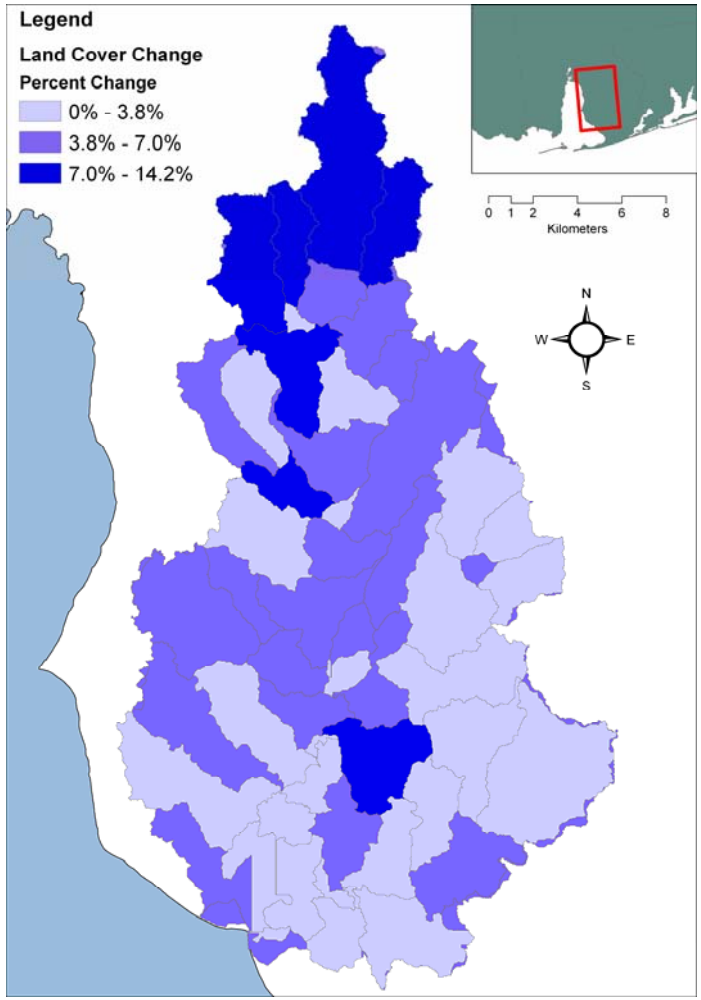


C-CAP Land Cover – 2001



Land Cover Change Analysis

- Era: 1996 to 2001
- Areas of greatest change are shown in dark blue
- Most change occurred along Interstate 10 corridor
- Forest conversion to cultivated and developed classes predominates



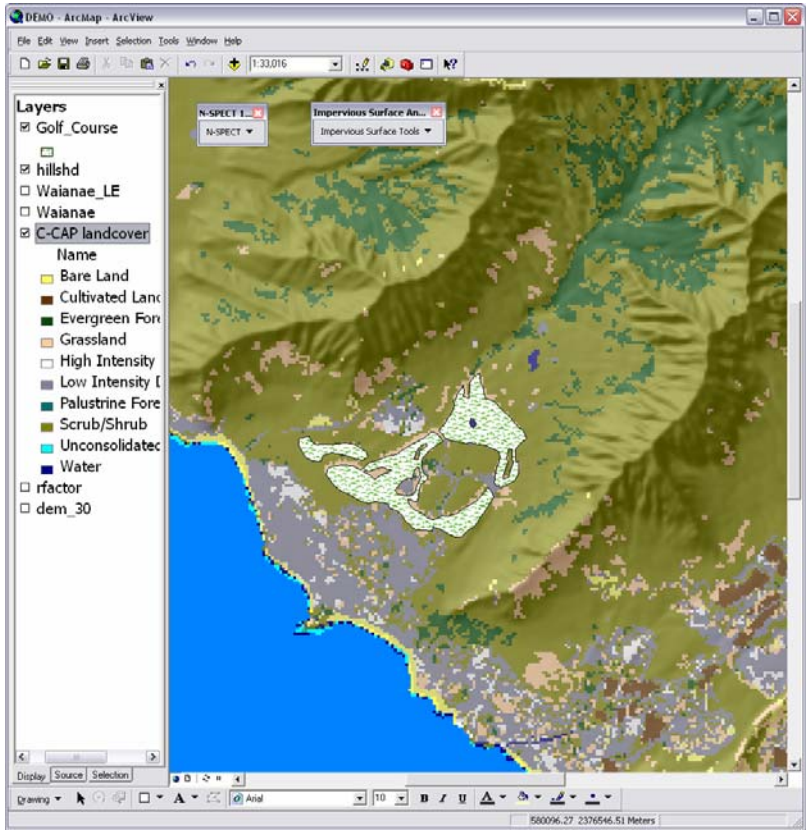
Information and Tools

- Environmental Indicators
  - Open space
  - Canopy cover
  - Developed areas

- Spatial Decision Support Systems (DSS)
  - *Impervious Surface Analysis Tool (ISAT)*
    - Calculates impervious surface areas
  - *Nonpoint-Source Pollution and Erosion Comparison Tool (N-SPECT)*
    - Calculates eroded sediment loads and polluted runoff loads

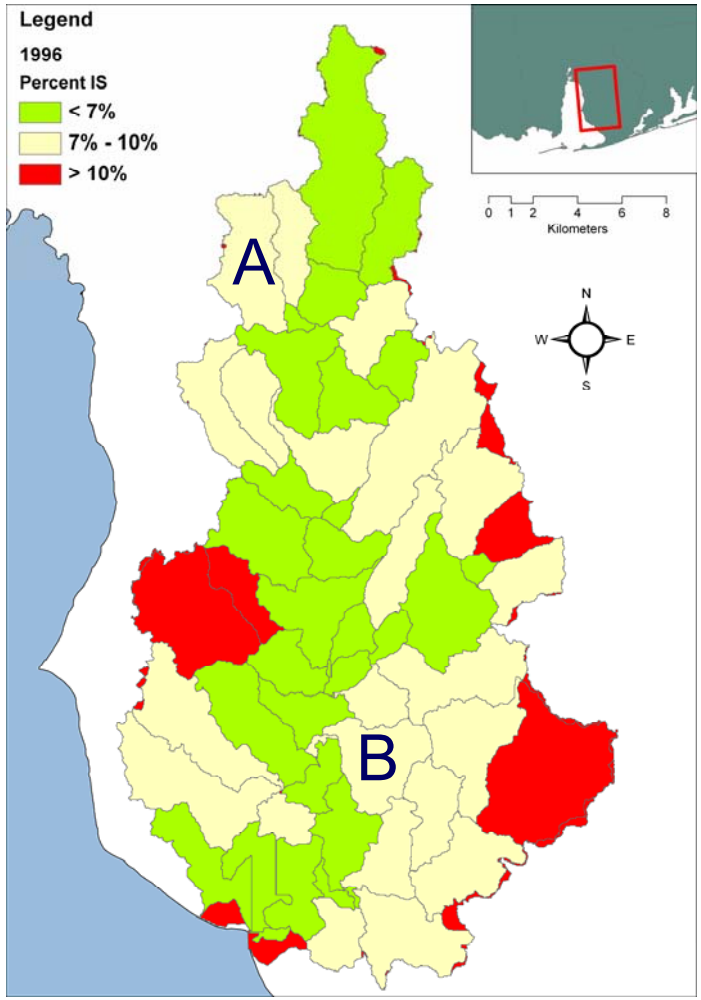
Common Characteristics

- Spatial DSS
  - Function as geographic information system (GIS) extensions
  - Can perform scenario analyses (e.g. development, rezoning, restoration)
  - Results can be used to create map products



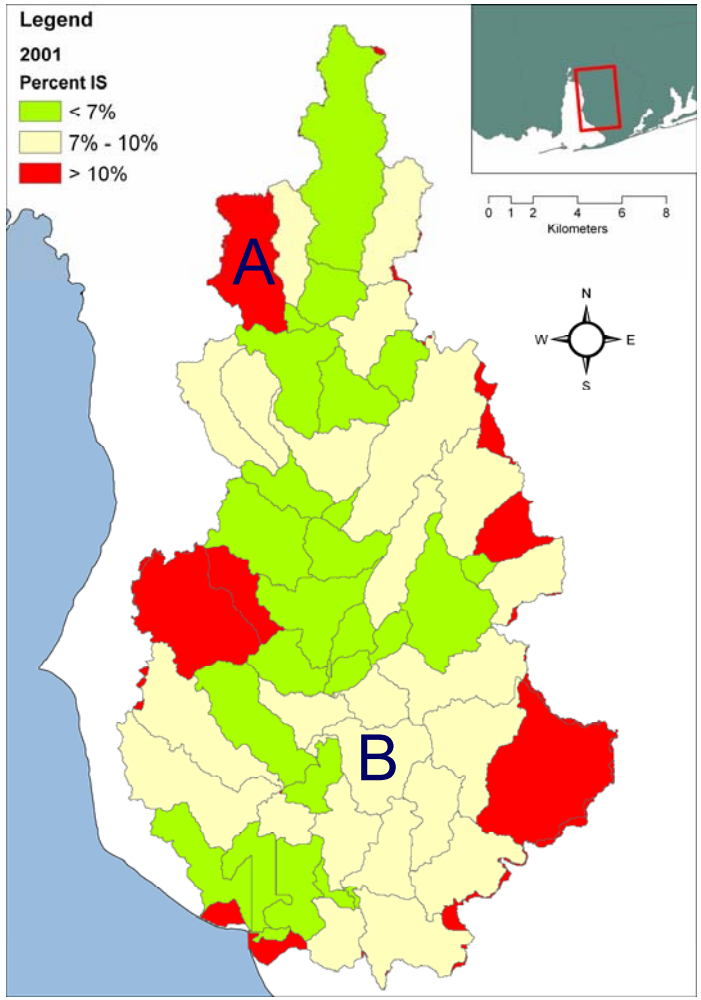
Impervious Surfaces – 1996

- Total watershed = 7.5%
- Subwatershed totals:
  - A = 8.46%
  - B = 7.99%



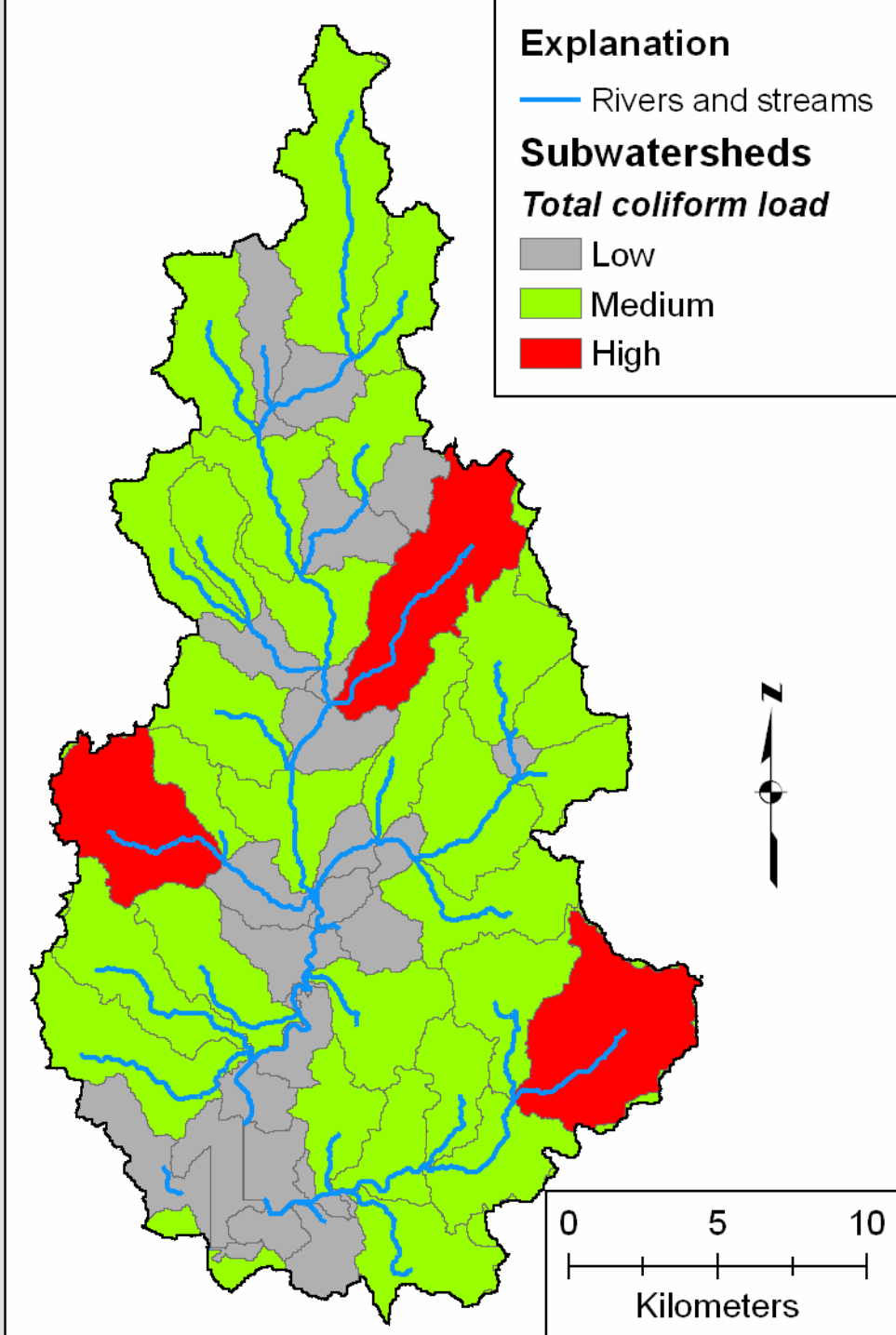
Impervious Surfaces – 2001

- Total watershed = 7.9%
- Subwatershed totals:
  - A = 10.23%
  - B = 9.86%
- Impervious cover change:
  - A = 1.77%
  - B = 1.87%



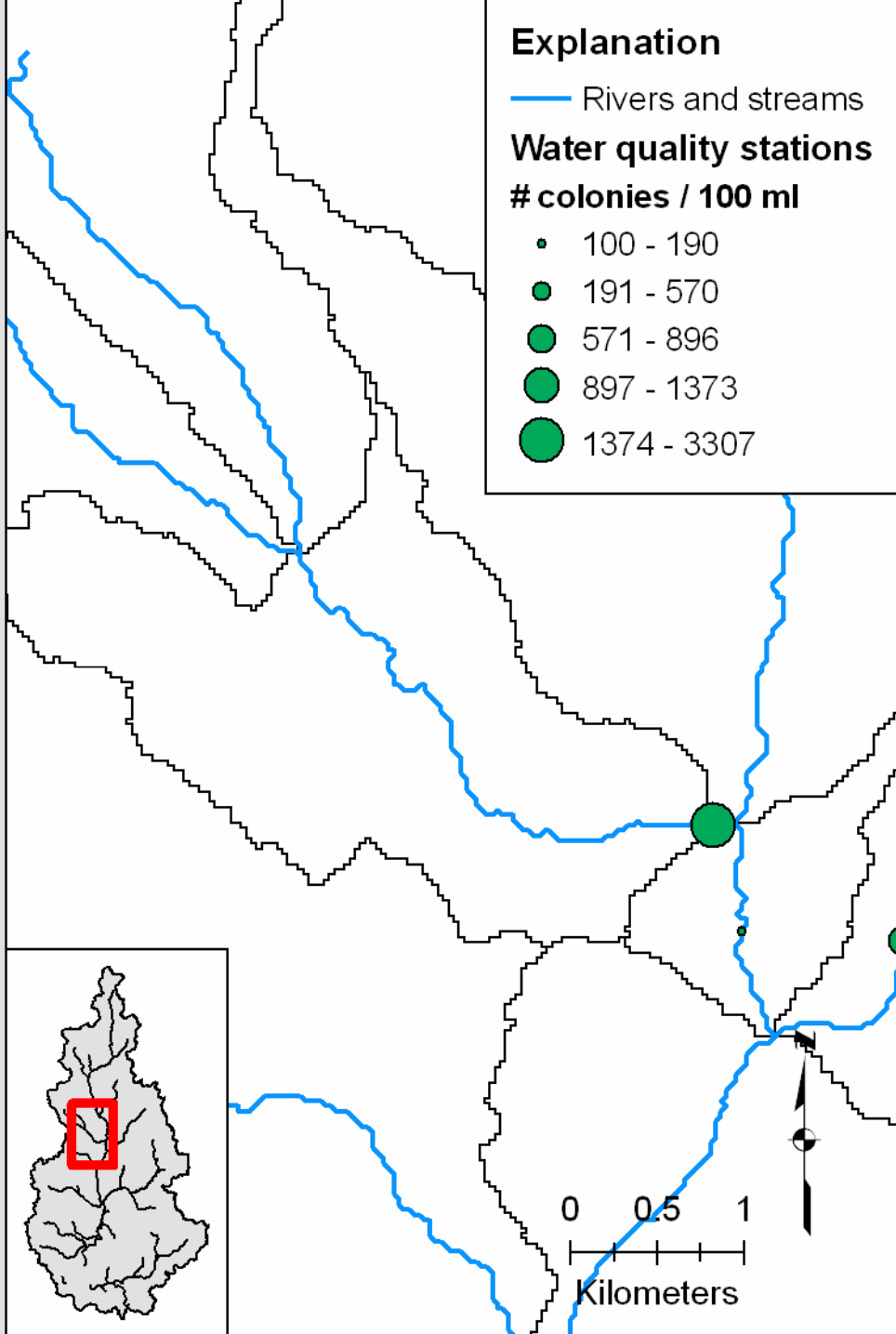
Weeks Bay Watershed

- 2001 land cover data
- Total coliform load summarized for each subwatershed
- Areas that potentially contribute high amounts can be targeted
  - Best Management Practices
  - Hypothesis formulation



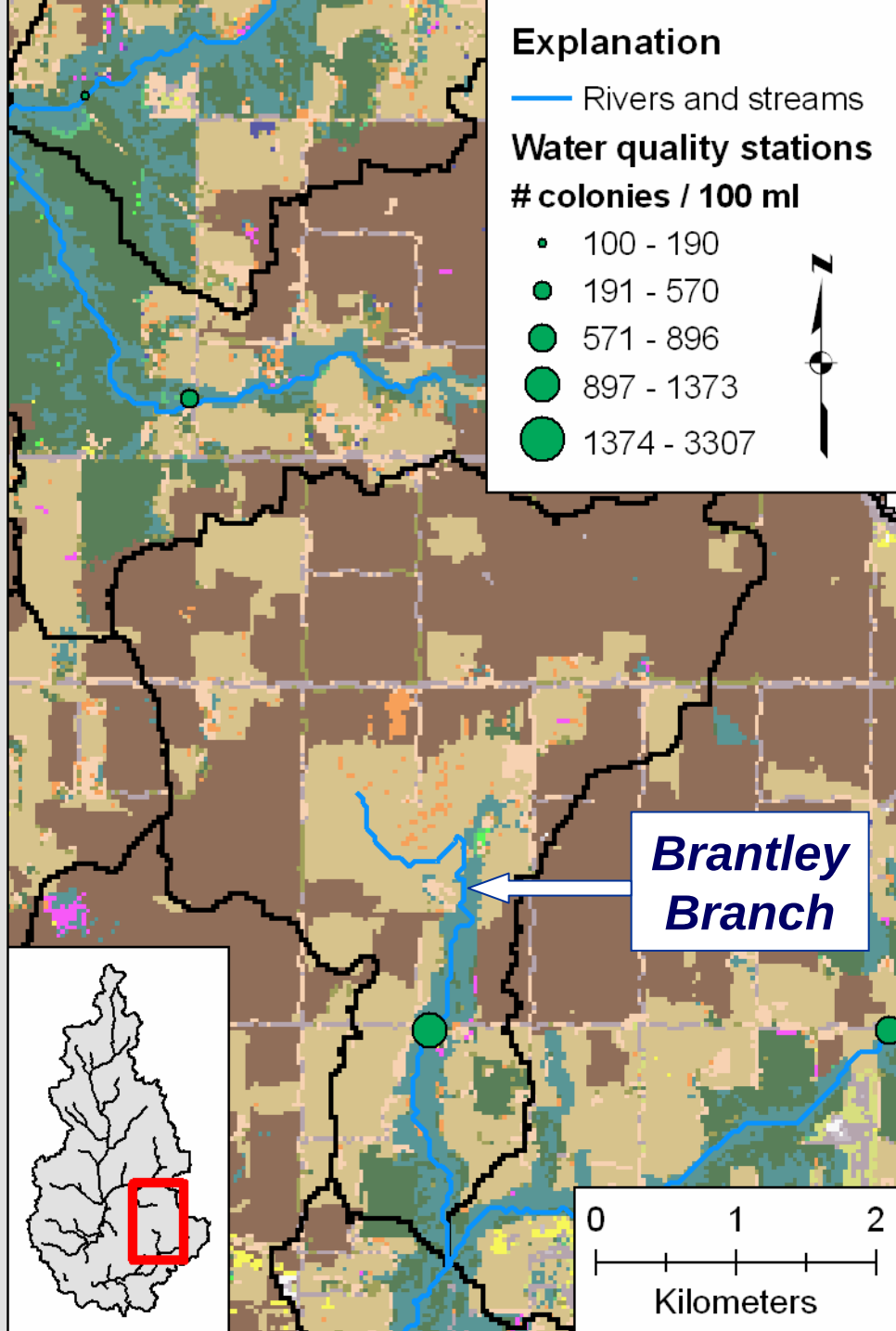
Weeks Bay Watershed

- Caney Branch, tributary of Fish River
- Consistently high fecal coliform counts
- Cause believed to be cattle in close proximity to stream



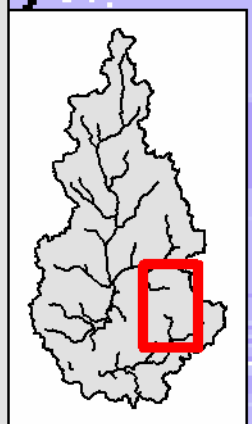
Weeks Bay Watershed

- Brantley Branch, tributary of Magnolia River
- Consistently high fecal coliform counts
- Cause unknown
- Land cover shows
  - Cultivated areas
  - Pastures adjacent to stream
  - Poor riparian conditions
  - Residential areas



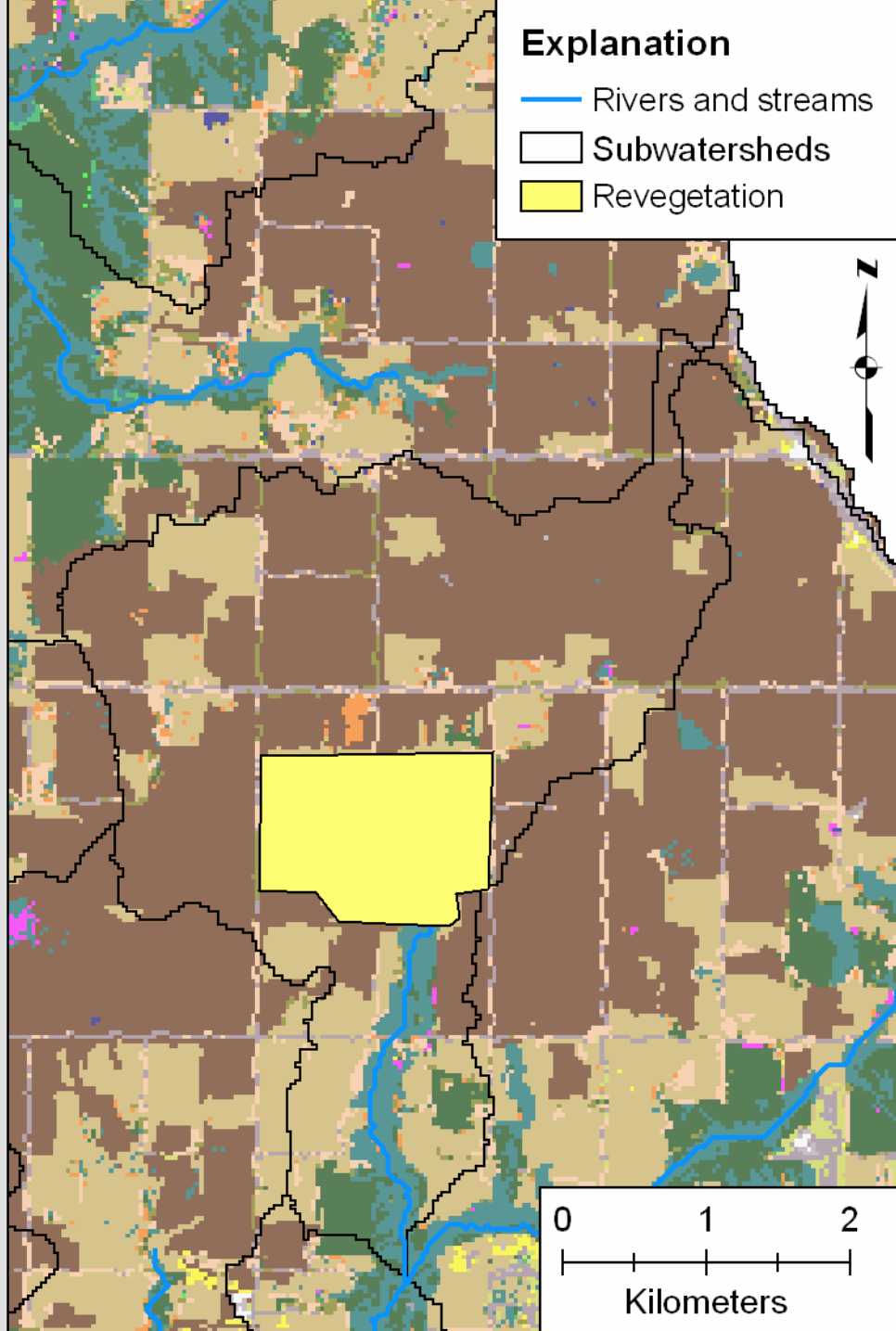
Weeks Bay Watershed

- Brantley Branch, tributary of Magnolia River
- N-SPECT output to identify "source" areas
  - Dark blue = high values
  - Light blue = low values
- Potential sources?



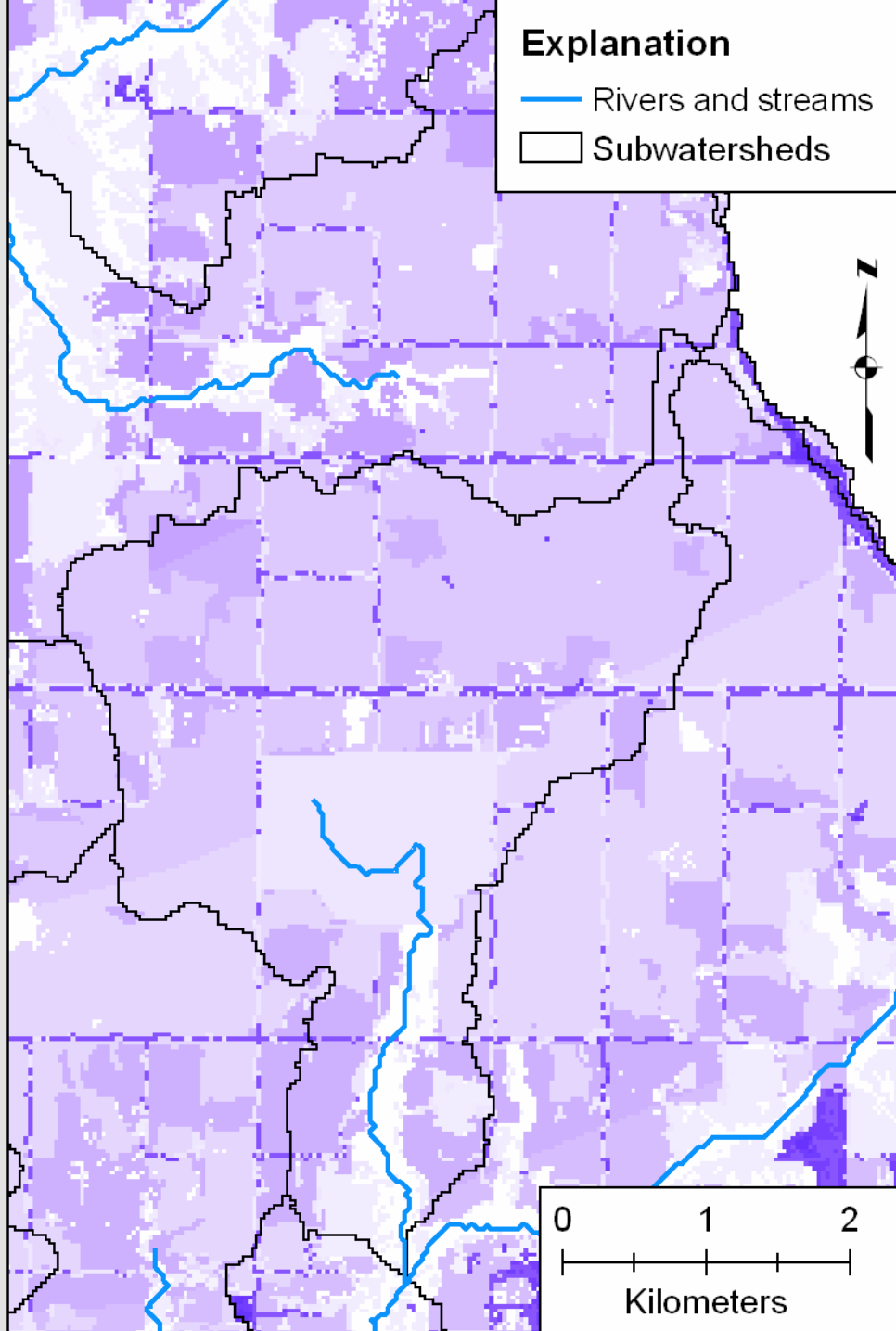
Weeks Bay Watershed

- Brantley Branch, tributary of Magnolia River
- Scenario analysis
  - Land use change
  - Exclude cattle
- Net change of coliform load from study area?



Weeks Bay Watershed

- Brantley Branch, tributary of Magnolia River
- Scenario analysis
  - Land use change
  - Exclude cattle
- Net change of coliform load from study area
  - 50% decrease



The NEMO Strategy

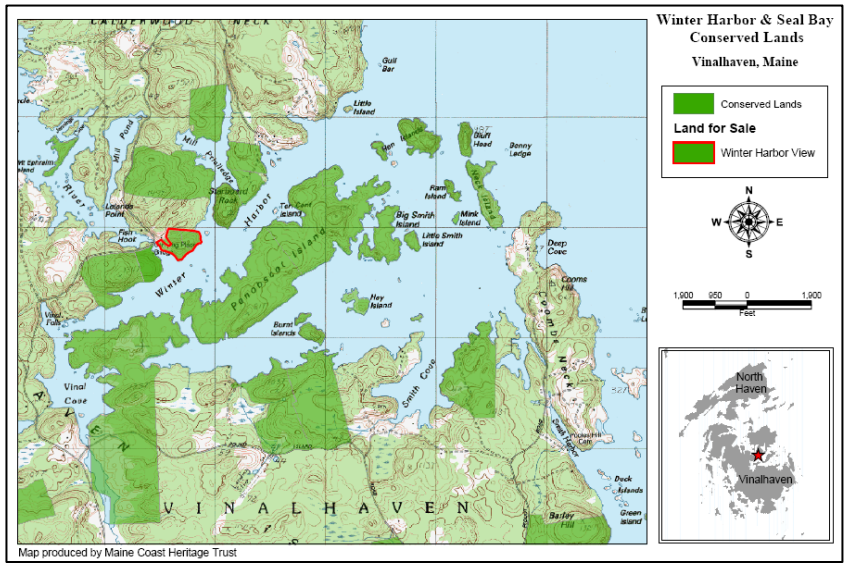
Three-Tier Strategy to Address Nonpoint Source Pollution

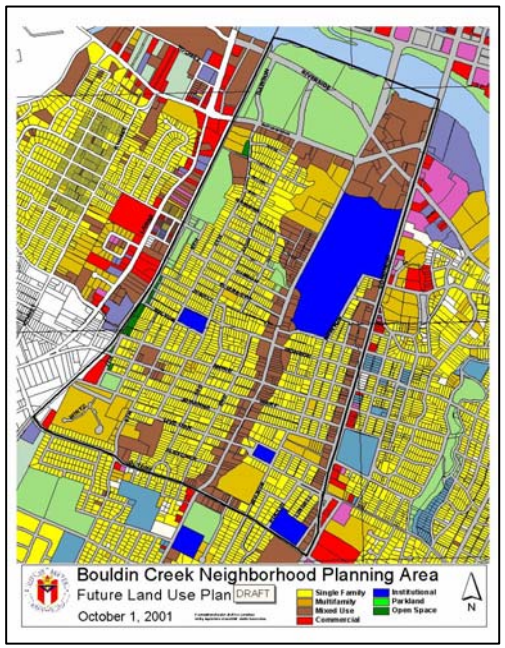
Plan	*Natural resource–based planning*
Minimize	*Low-impact site design*
Mitigate	*Best Management Practices (BMPs)*

*NEMO – Nonpoint Education for Municipal Officials

Natural Resource–Based Planning

- Inventory important natural resources
- Assess and prioritize natural resources
- Incorporate assessment into land use plan
- Implement land use plan
- Review site plans





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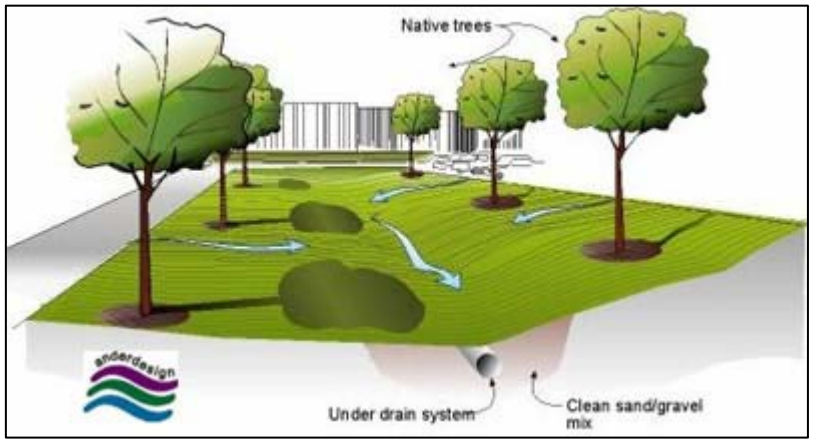
Low Impact Site Design

- Reduce and disconnect impervious surfaces
- Increase infiltration
- Promote use of vegetation and setbacks
- Maintain natural-flow pathways
- Consider different development patterns
- Evaluate alternative materials (e.g., porous pavement)



Courtesy: Pierce County, Washington State University Extension

BMP Implementation

- Educate local community
- Use structural BMPs:
  - Filtration (e.g., vegetated buffers, grassed swales)
  - Infiltration (e.g., porous pavements)
  - Ponds (e.g., detention and retention)
  - Wetlands

Source: Stormwater Center, University of New Hampshire

It's up to you – it's your watershed!

- Critical considerations:
  - How is water quality a land use issue?
  - How can planning and design solutions address water quality?
  - How are other local factors (i.e., social and economic) affected by water-quality issues?
  - How do political boundaries affect the decision-making process?

Photograph: Kathy Hicks

For More Information

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