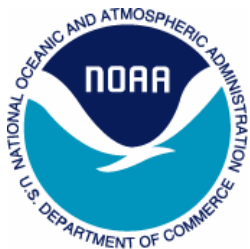


# Linking Land Cover to Water Quality

## Weeks Bay Watershed, Alabama

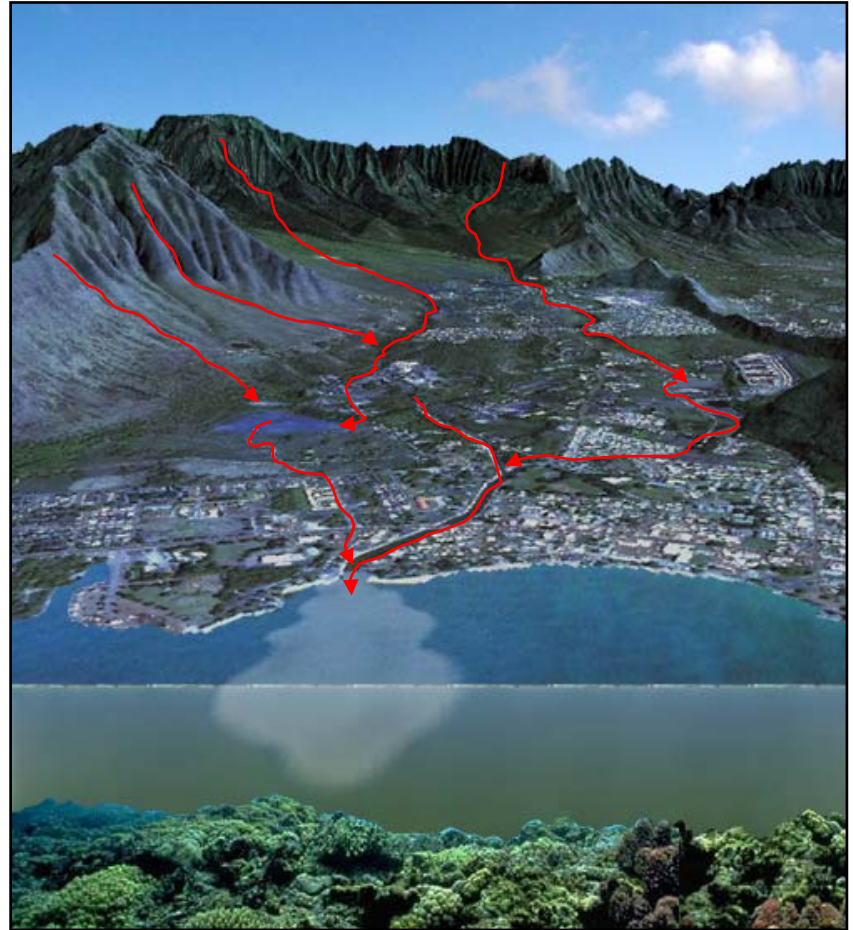


**Jamie Carter, IMSG PSGS**

**NOAA Coastal Services Center**

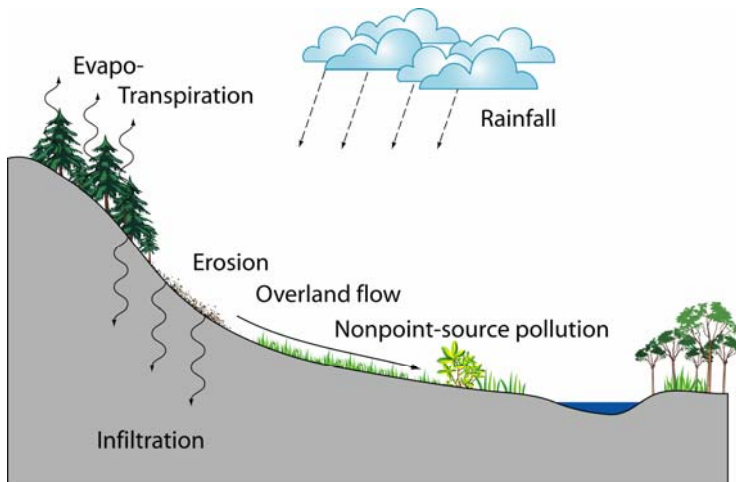
# Outline

- 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**

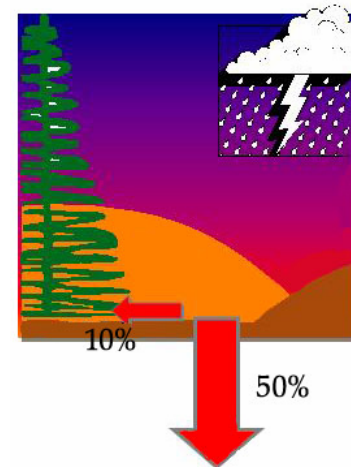
**AMOUNT OF IMPERVIOUS SURFACE**

**POTENTIAL WATER QUALITY ISSUES**

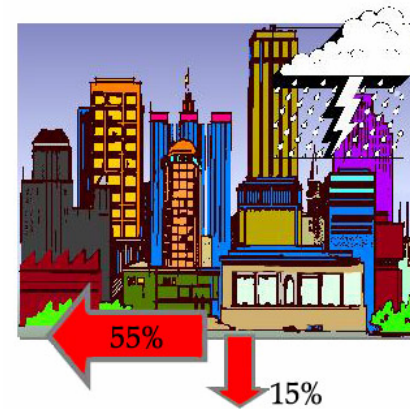


# Development Impacts on Runoff

- 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**



**B: Post-Development**

Source: Nonpoint  
Education for  
Municipal Officials  
(NEMO)



# The Pollutants in Polluted Runoff

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- **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”

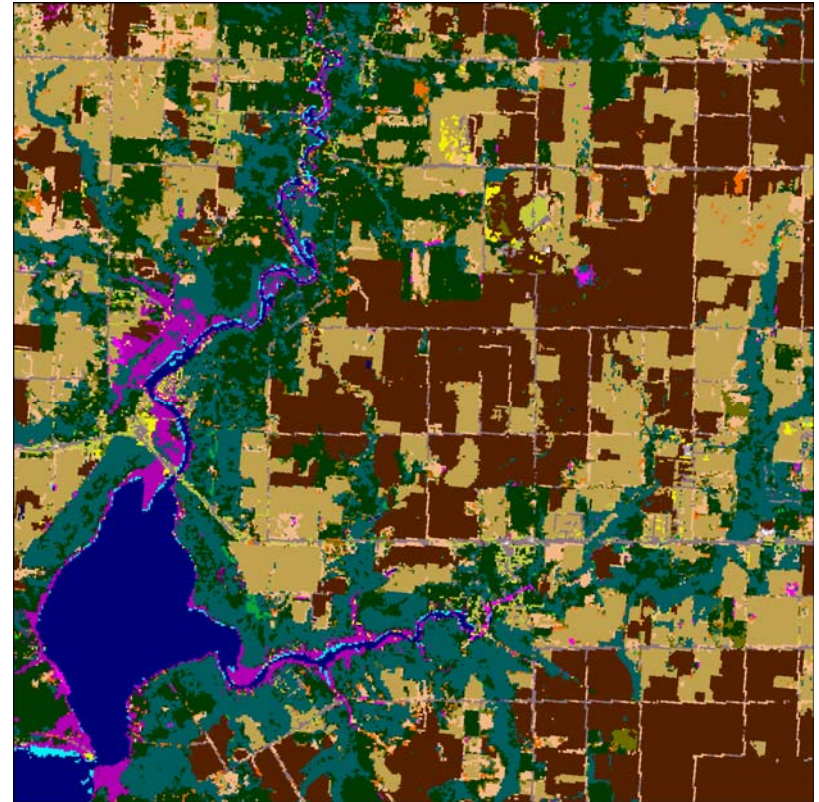


Source: Soil and Water Lab, Cornell University



# 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

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## **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\*



# Developed

*Storm runoff may contain...*

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



# Agriculture, Grassland, Bare Land

*Storm runoff may contain...*

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



# Forest and Scrub/Shrub

*Storm runoff may contain...*

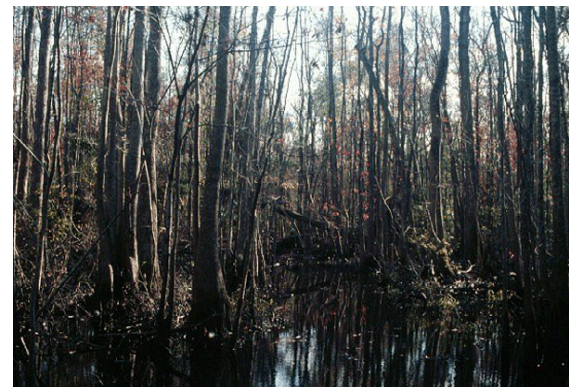
<b>Nutrients:</b>	Animal waste
<b>Pathogens:</b>	Animal waste
<b>Sediment:</b>	Erosion from logging operations
<b>Toxins:</b>	
<b>Debris:</b>	



# Wetland

*Storm runoff may contain...*

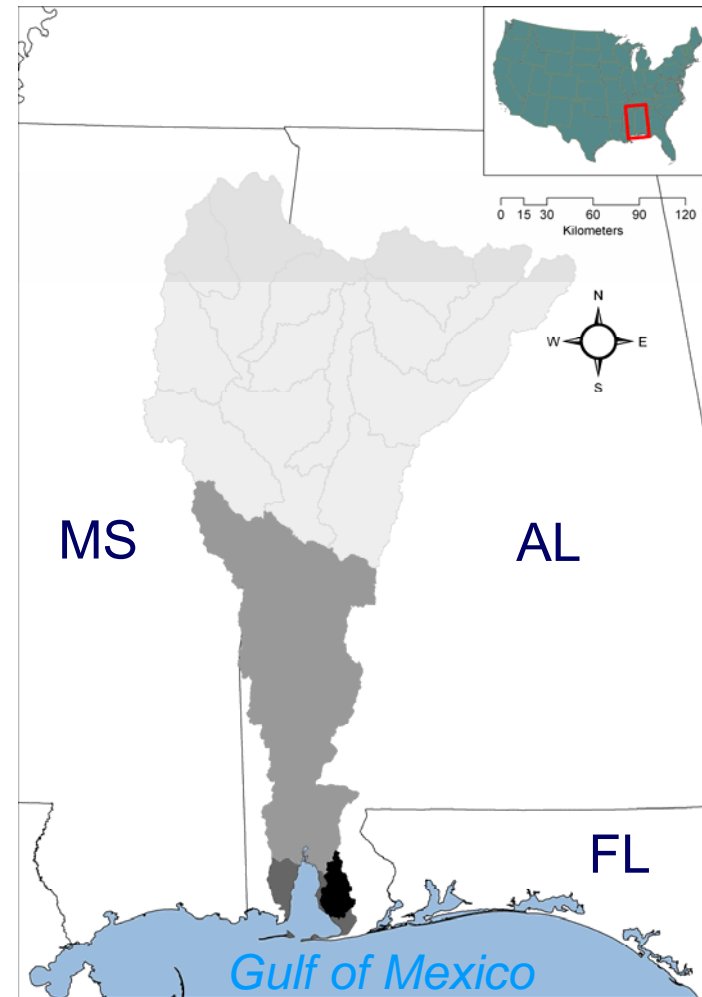
<b>Nutrients:</b>	Animal waste
<b>Pathogens:</b>	Animal waste
<b>Sediment:</b>	Erosion from logging operations
<b>Toxins:</b>	
<b>Debris:</b>	



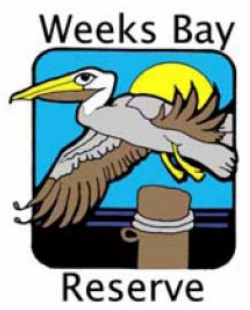
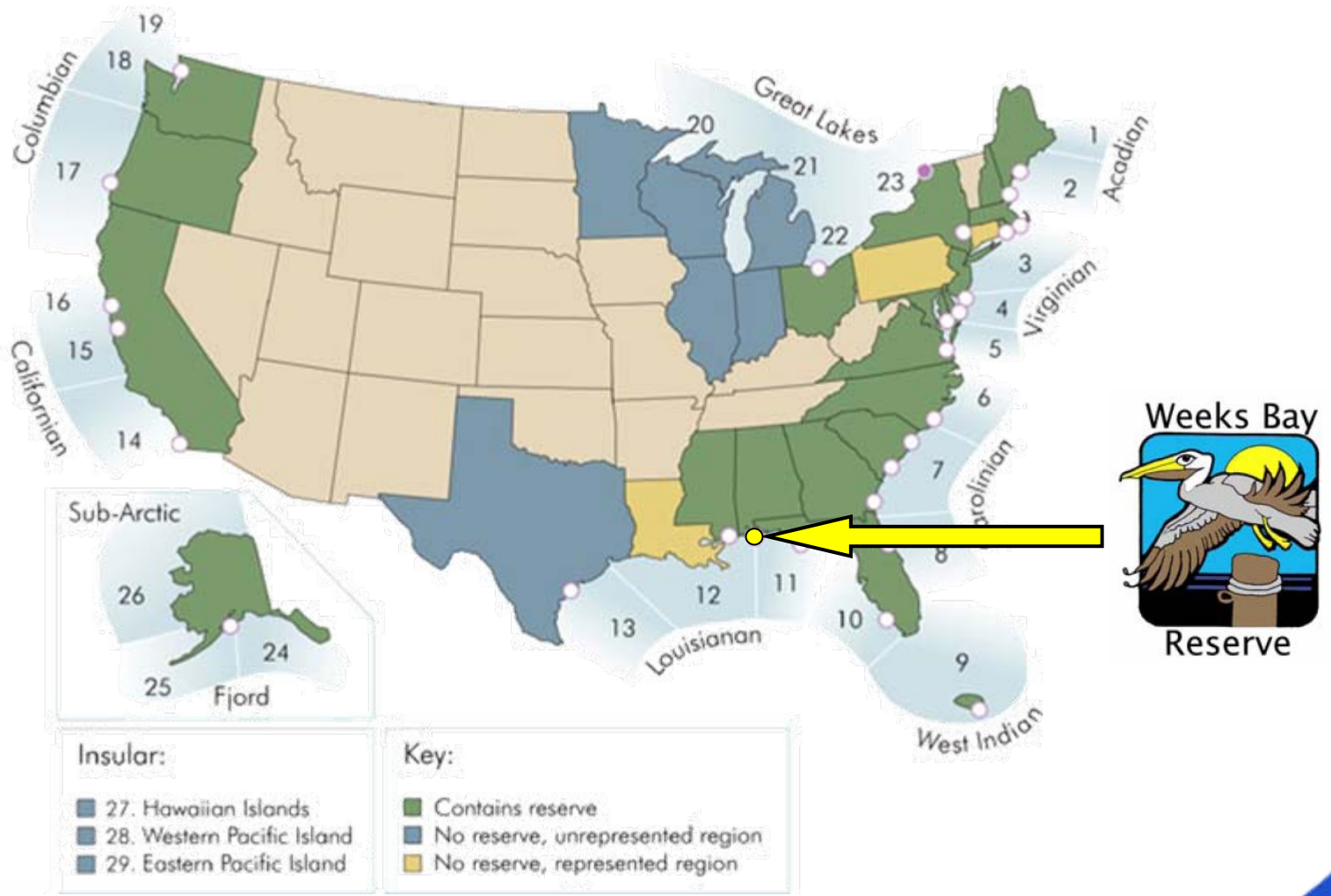
# Using Watersheds as a Framework

- 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*



# National Estuarine Research Reserves



# Weeks Bay

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- 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

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- 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

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- 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

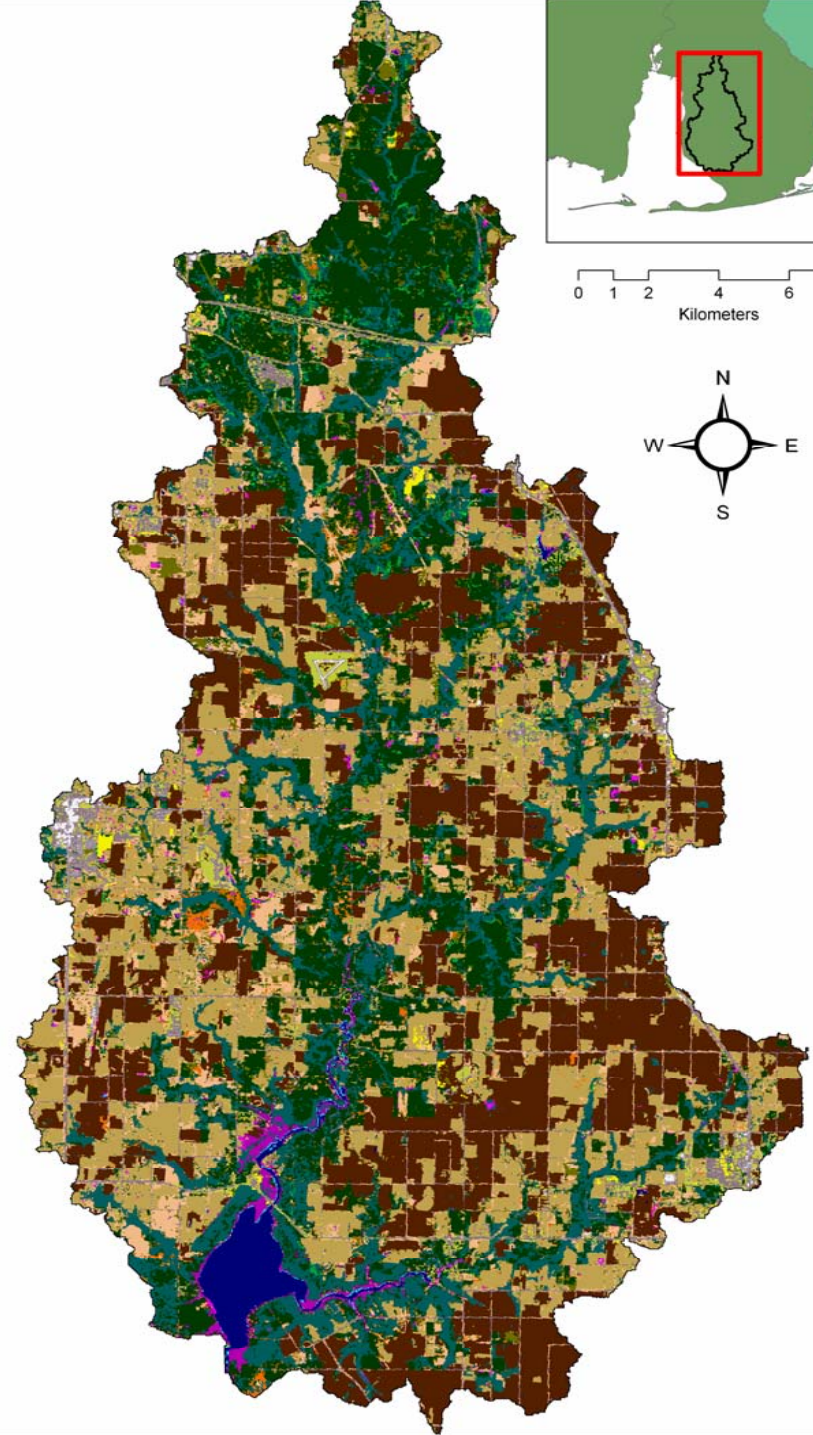
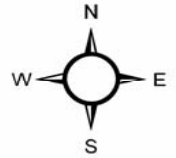


# Weeks Bay Watershed

- 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!

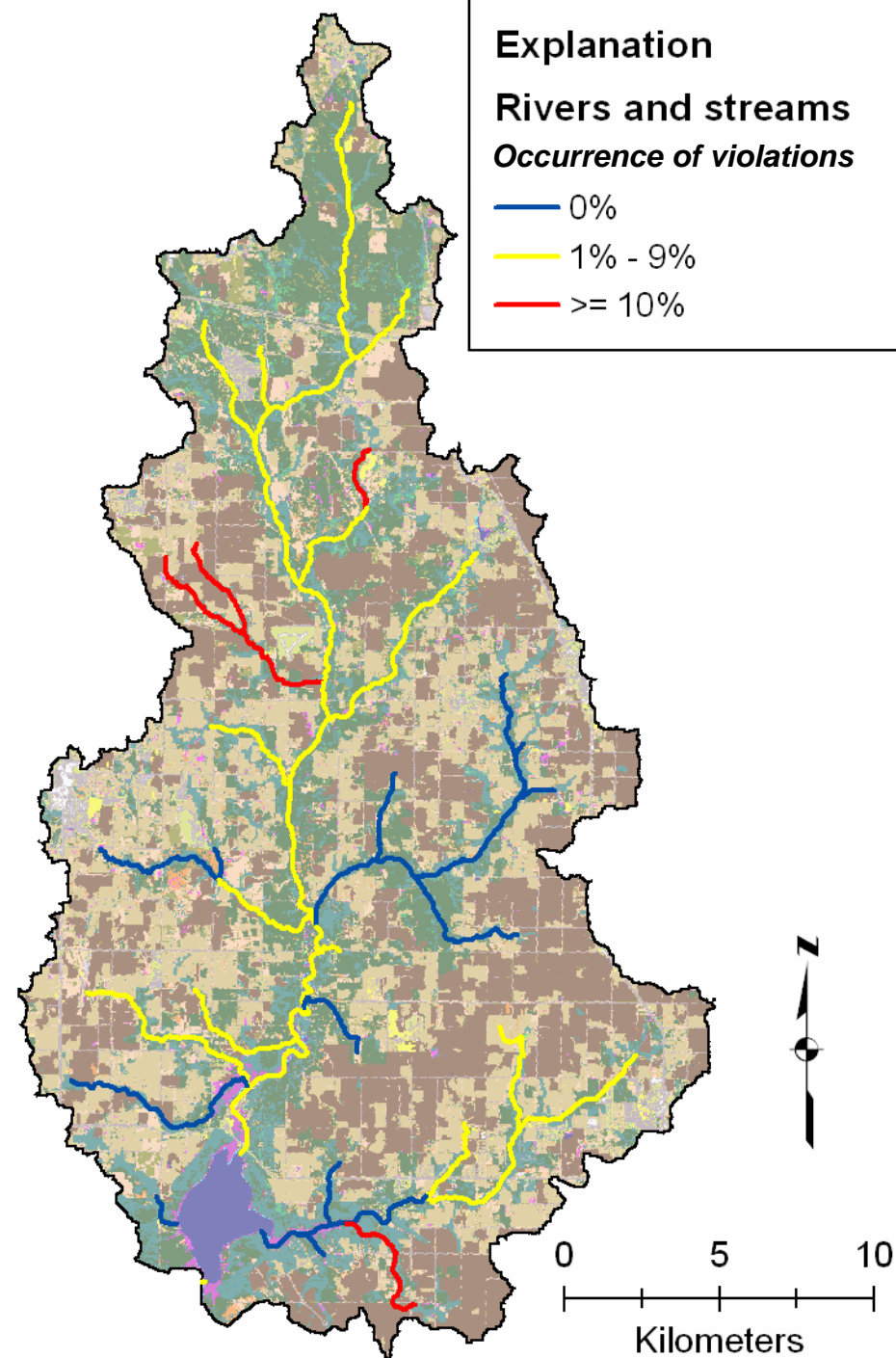


0 1 2 4 6 8  
Kilometers

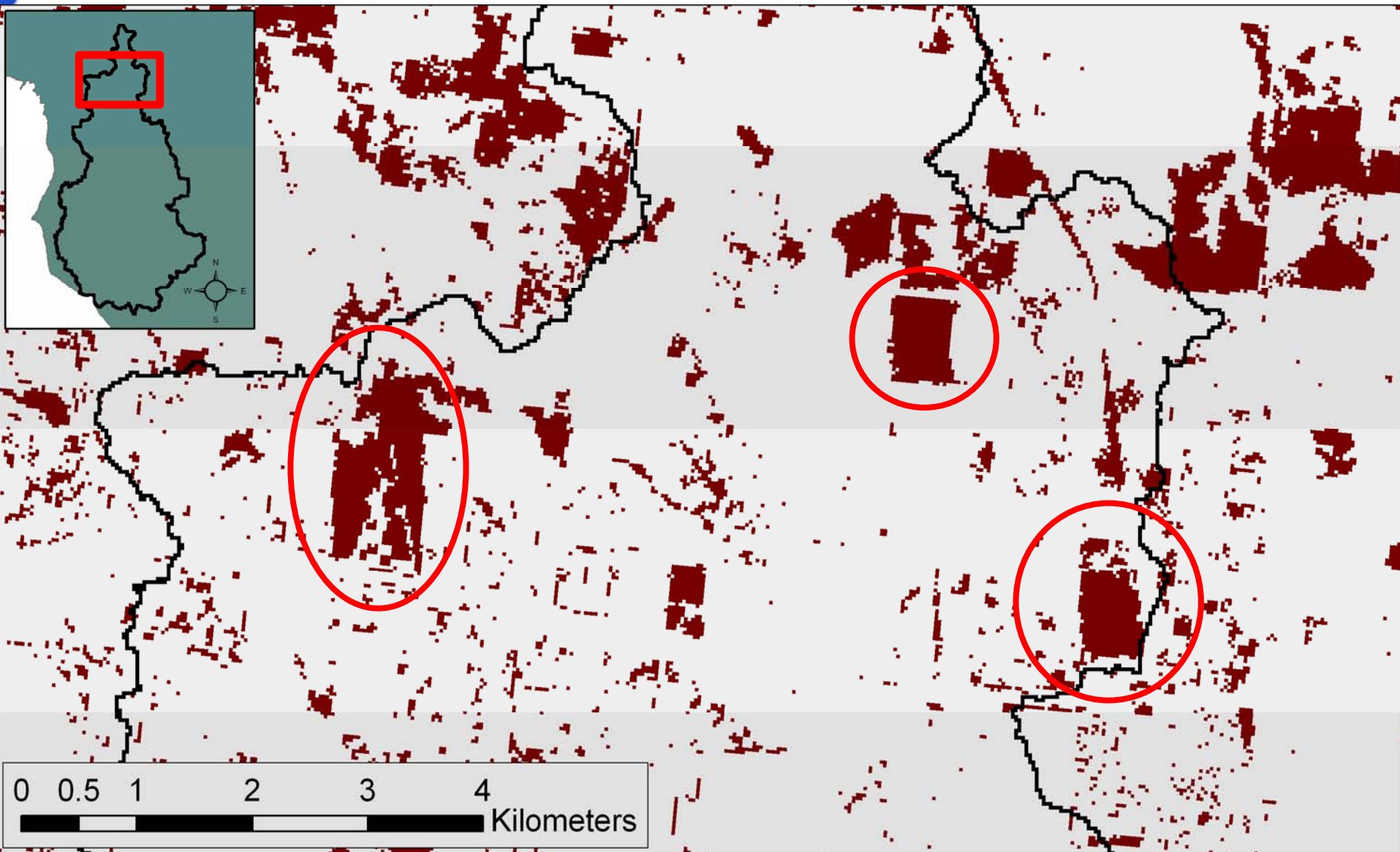


# Weeks Bay Watershed

- 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  $\geq 2,000$  colonies per 100 milliliters
- Need to identify sources

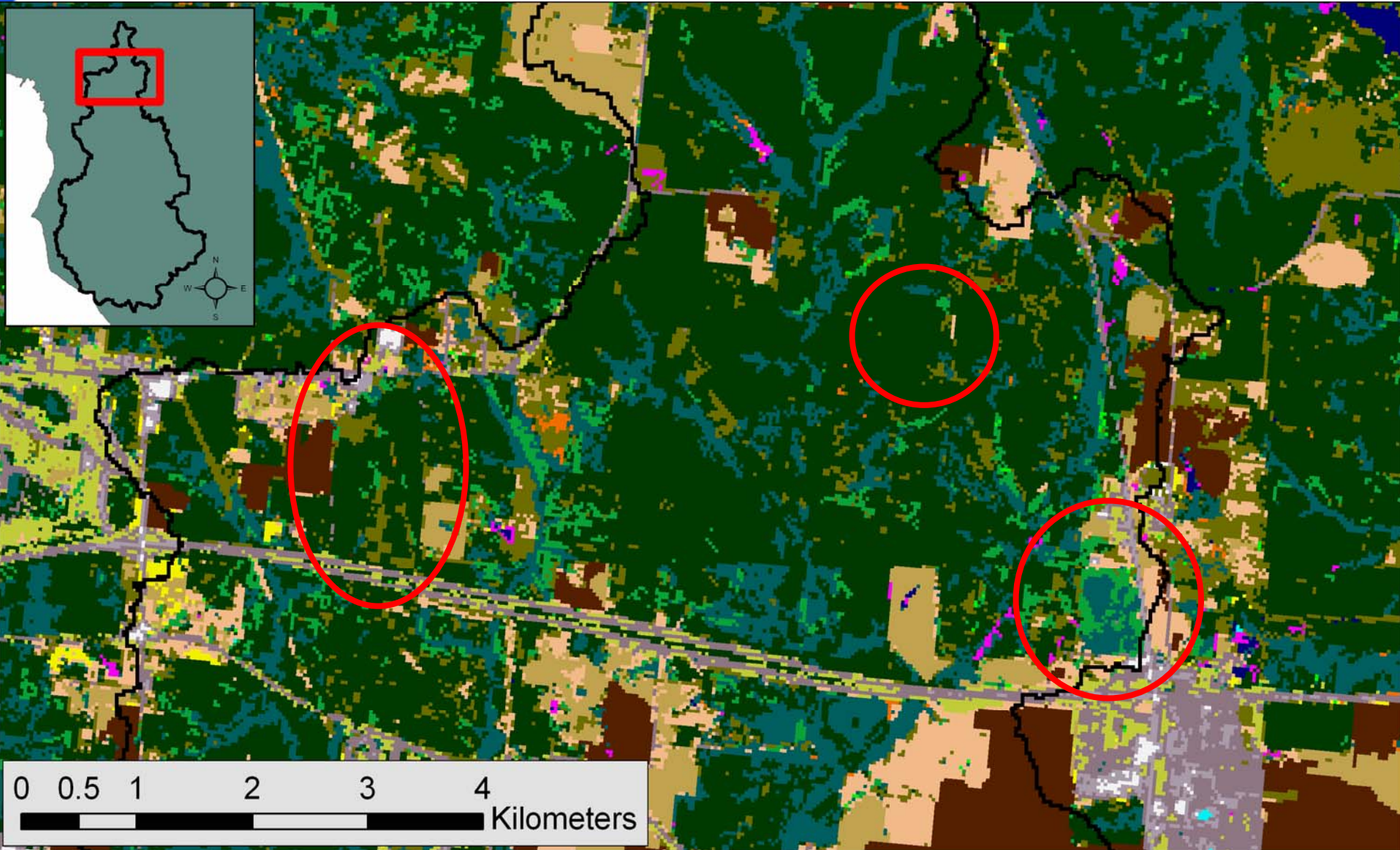


# Land Cover Change Detection

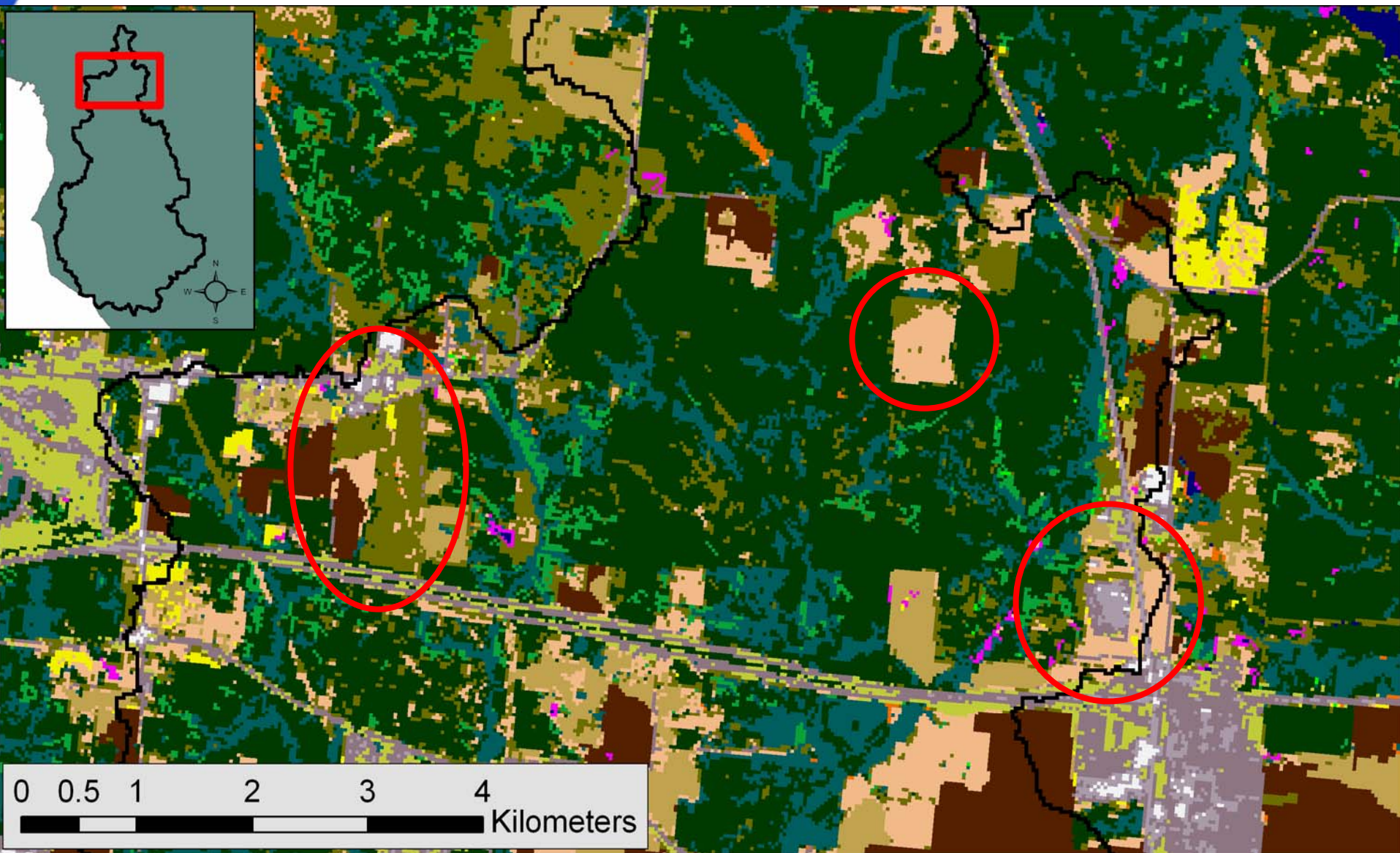


# C-CAP Land Cover - 1996

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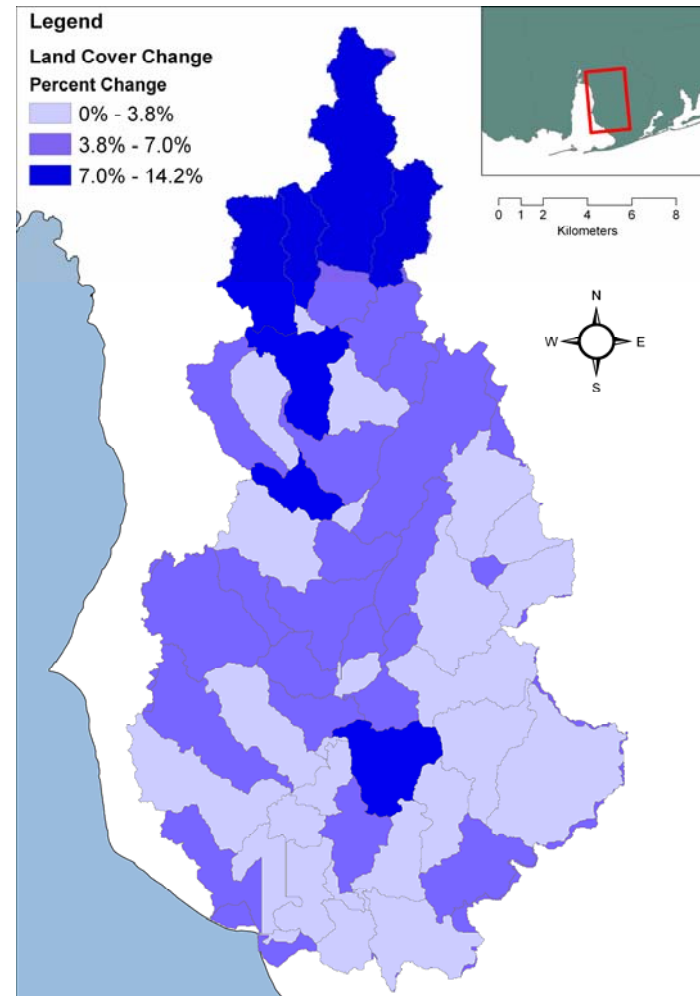


# C-CAP Land Cover - 2001



# 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

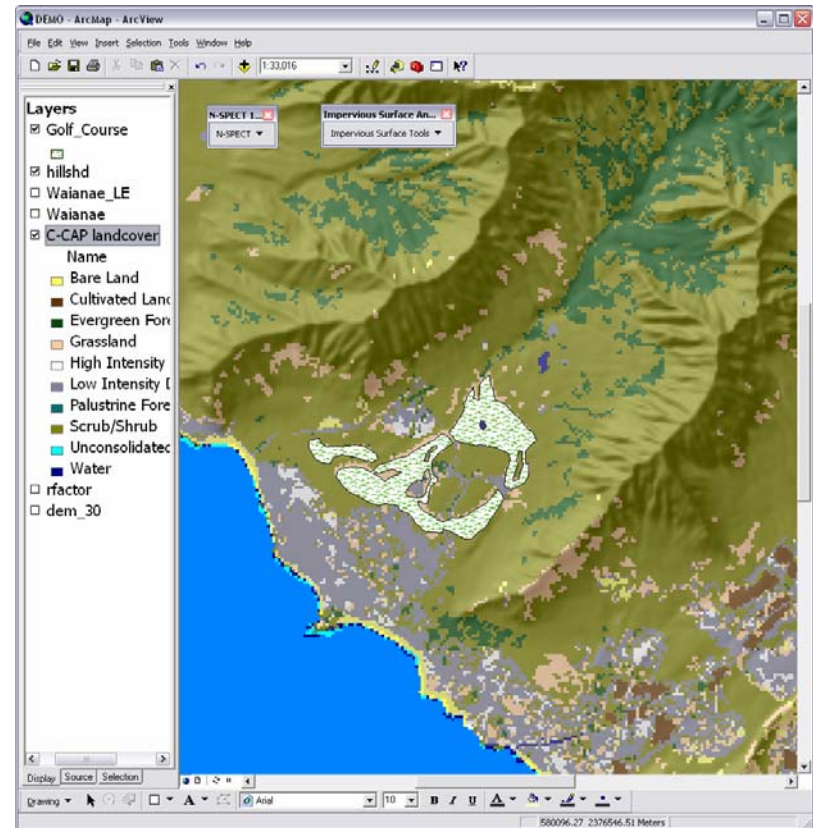
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- Environmental Indicators
  - Open space
  - Canopy cover
  - Developed areas
- Spatial Decision Support Systems (DSS)
  - *Impervious Surface Analysis Tool (ISAT)*
    - Calculates impervious surface areas
  - *Nonpoint-Source Pollution and Erosion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



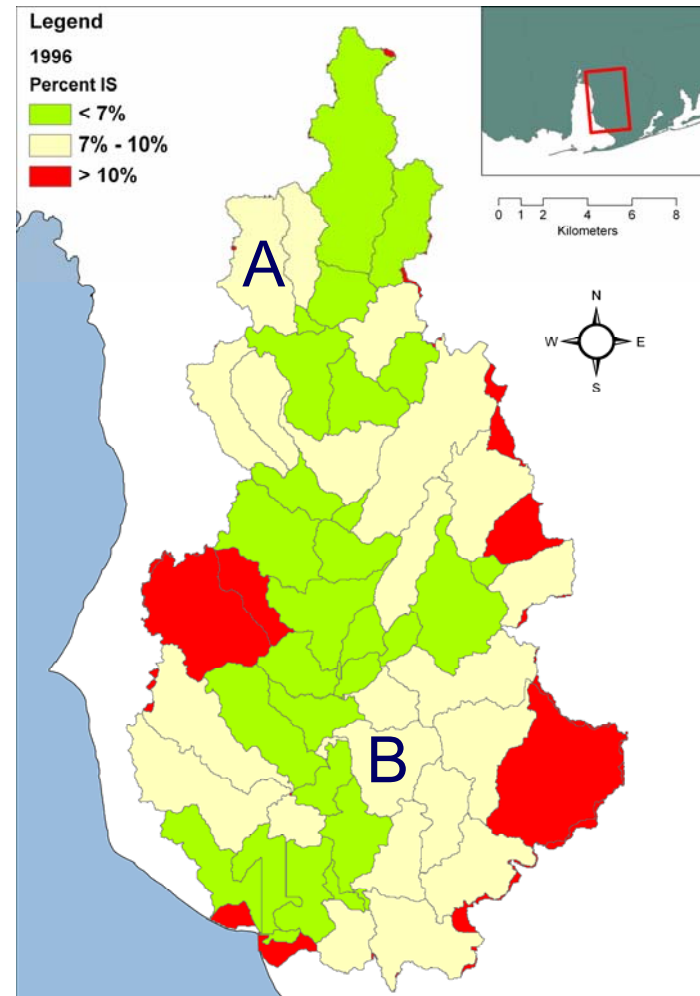
# Common Characteristics

- 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



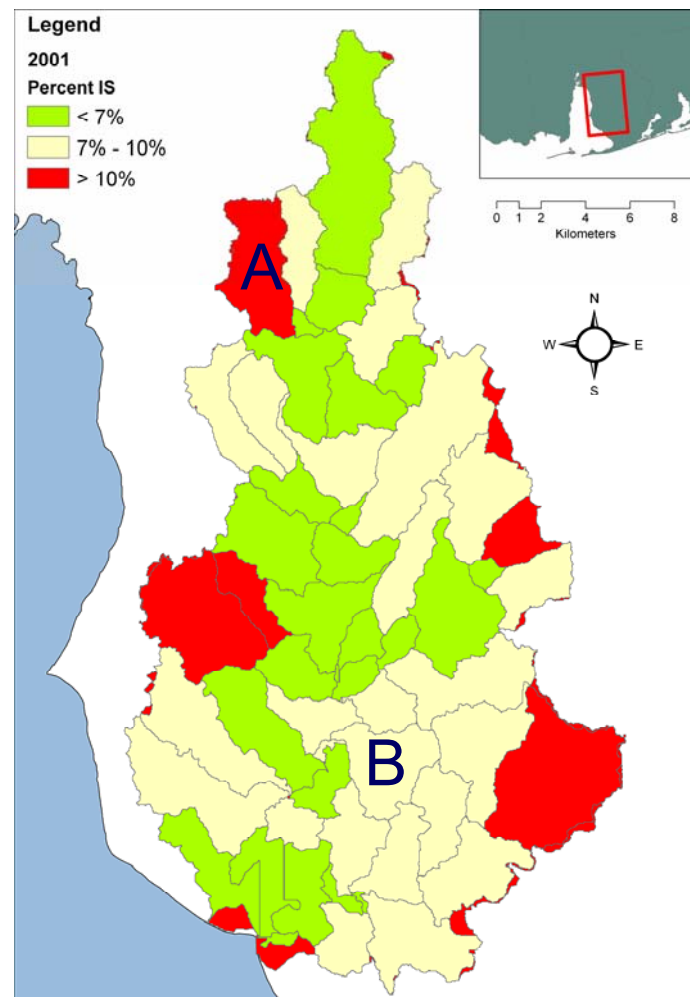
# Impervious Surfaces - 1996

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



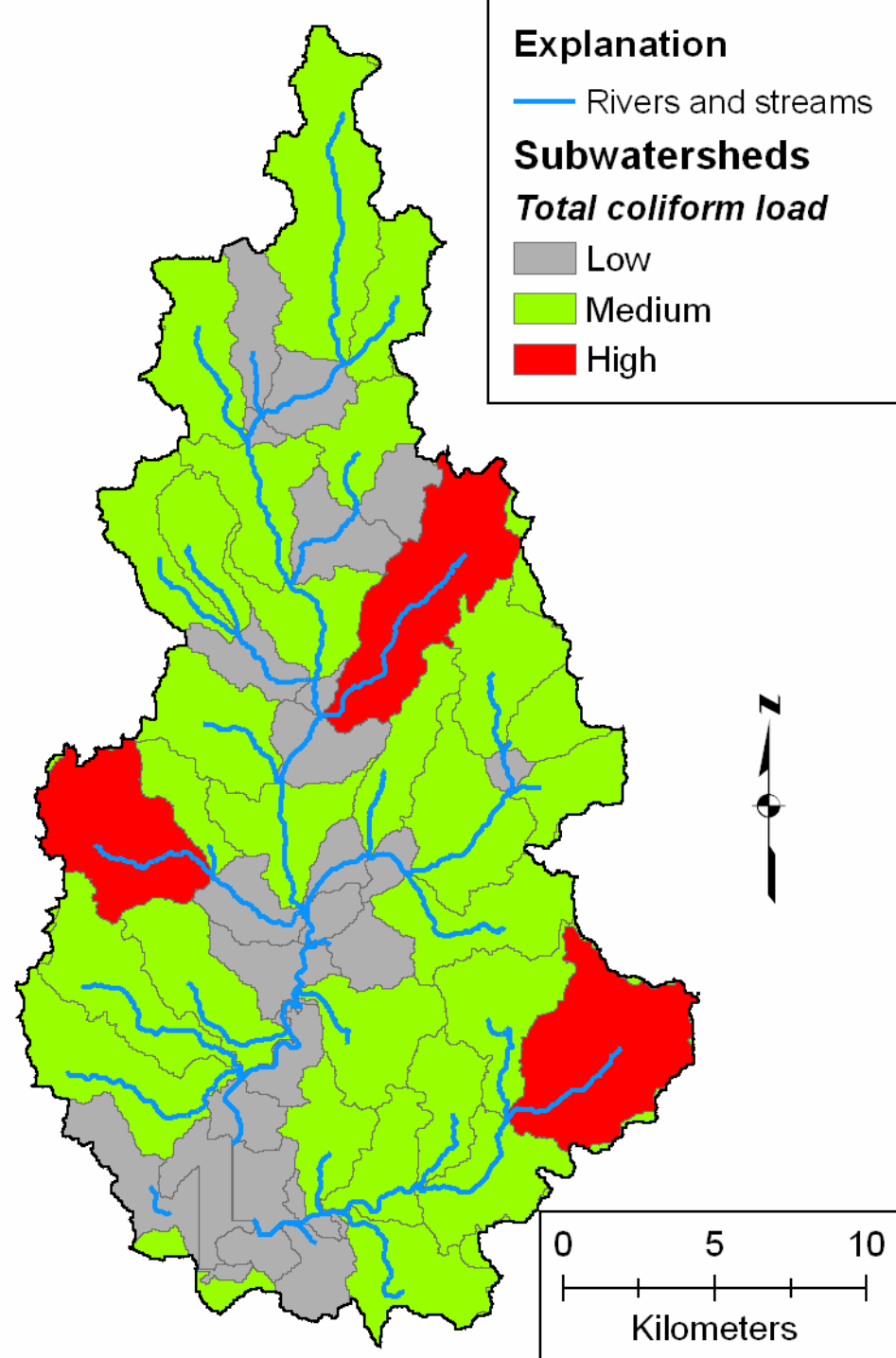
# Impervious Surfaces – 2001

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



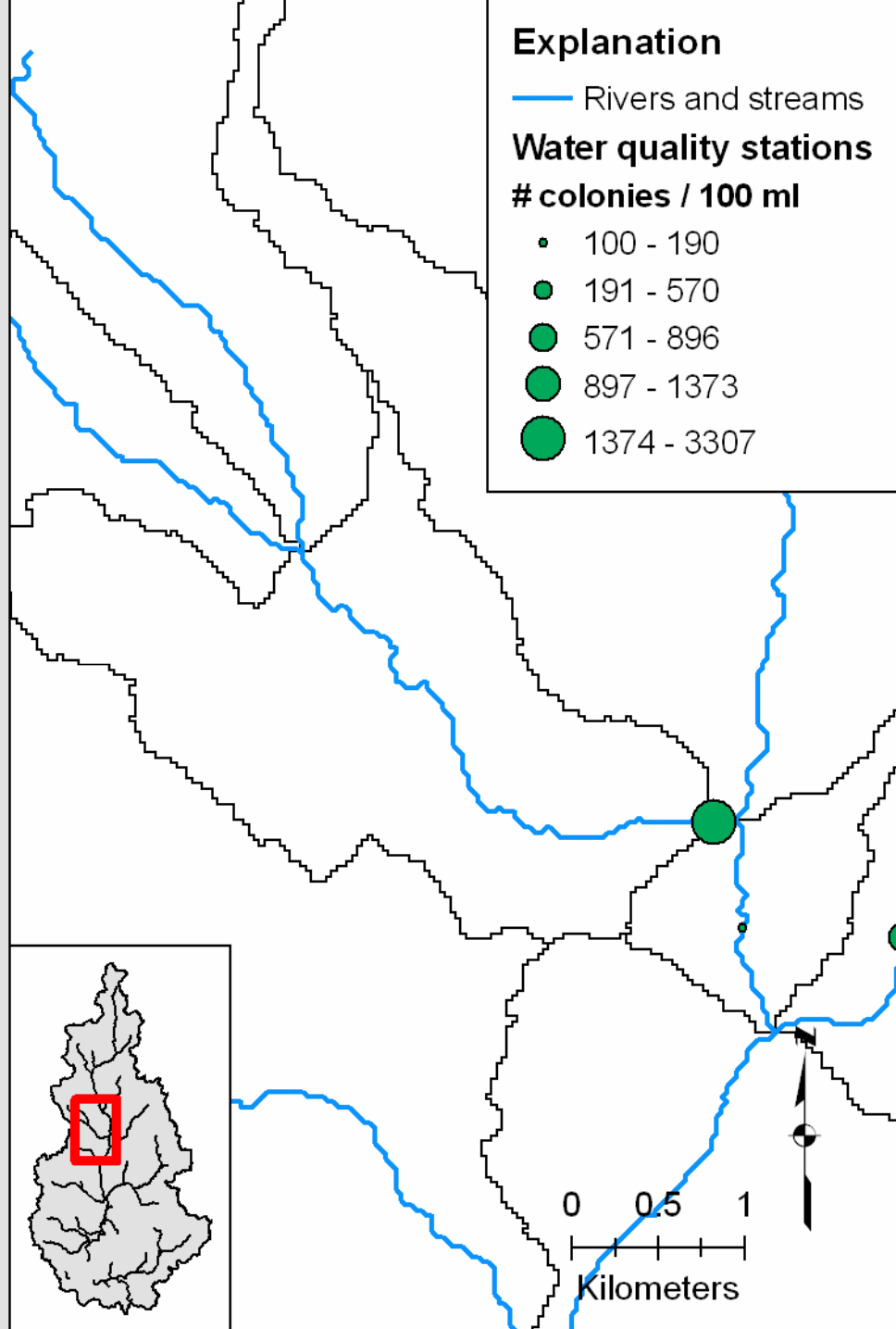
# Weeks Bay Watershed

- 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



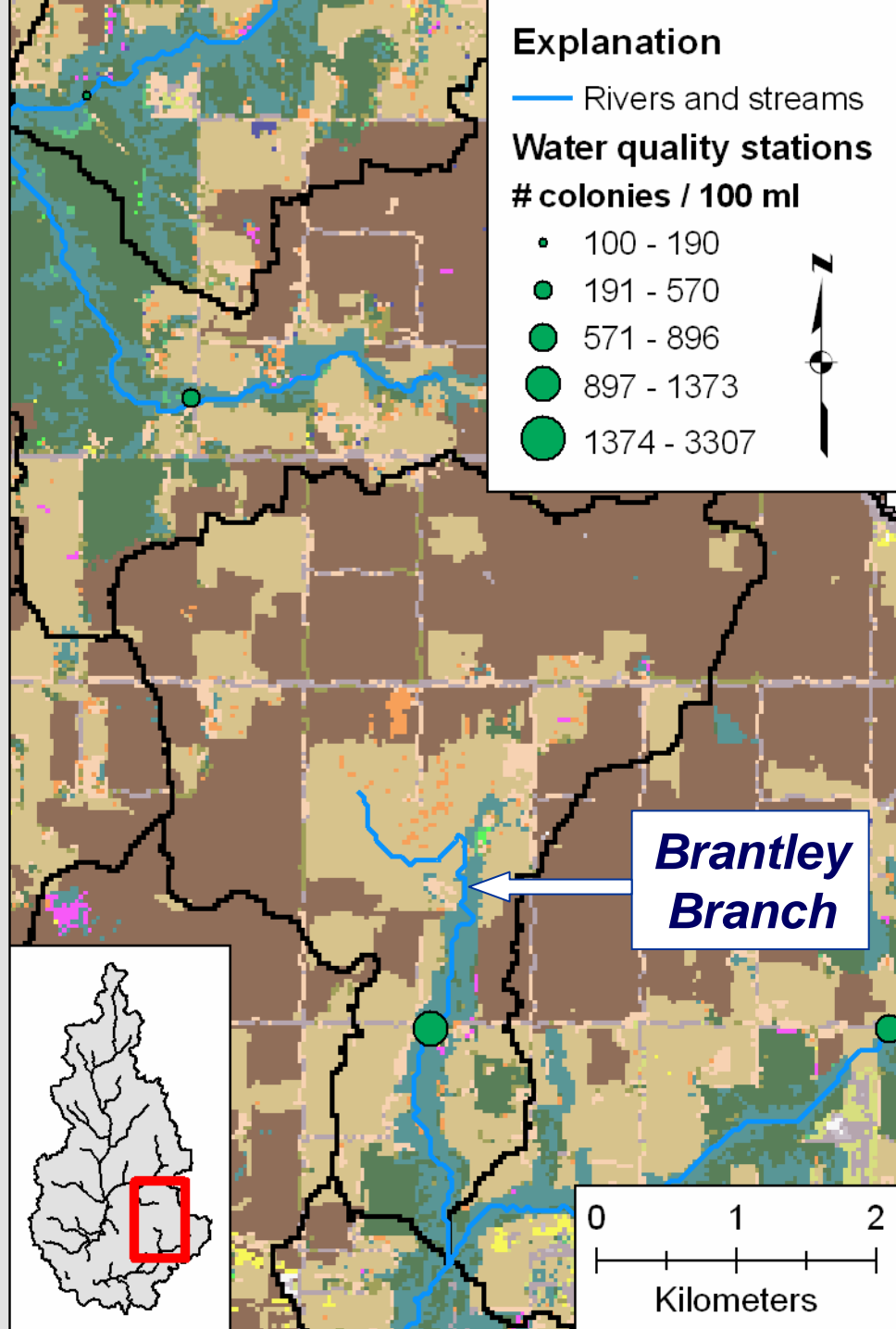
# Weeks Bay Watershed

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



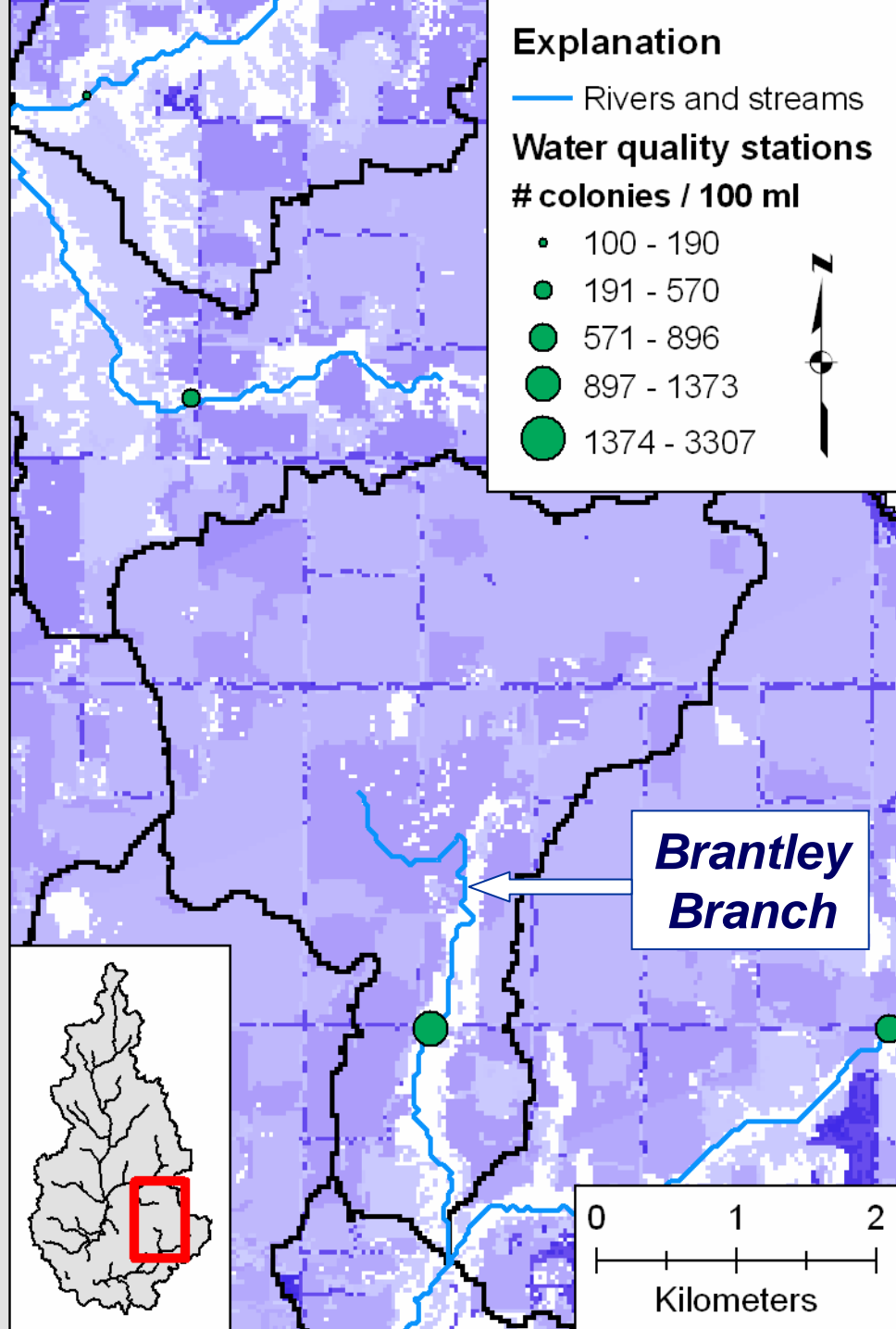
# Weeks Bay Watershed

- 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

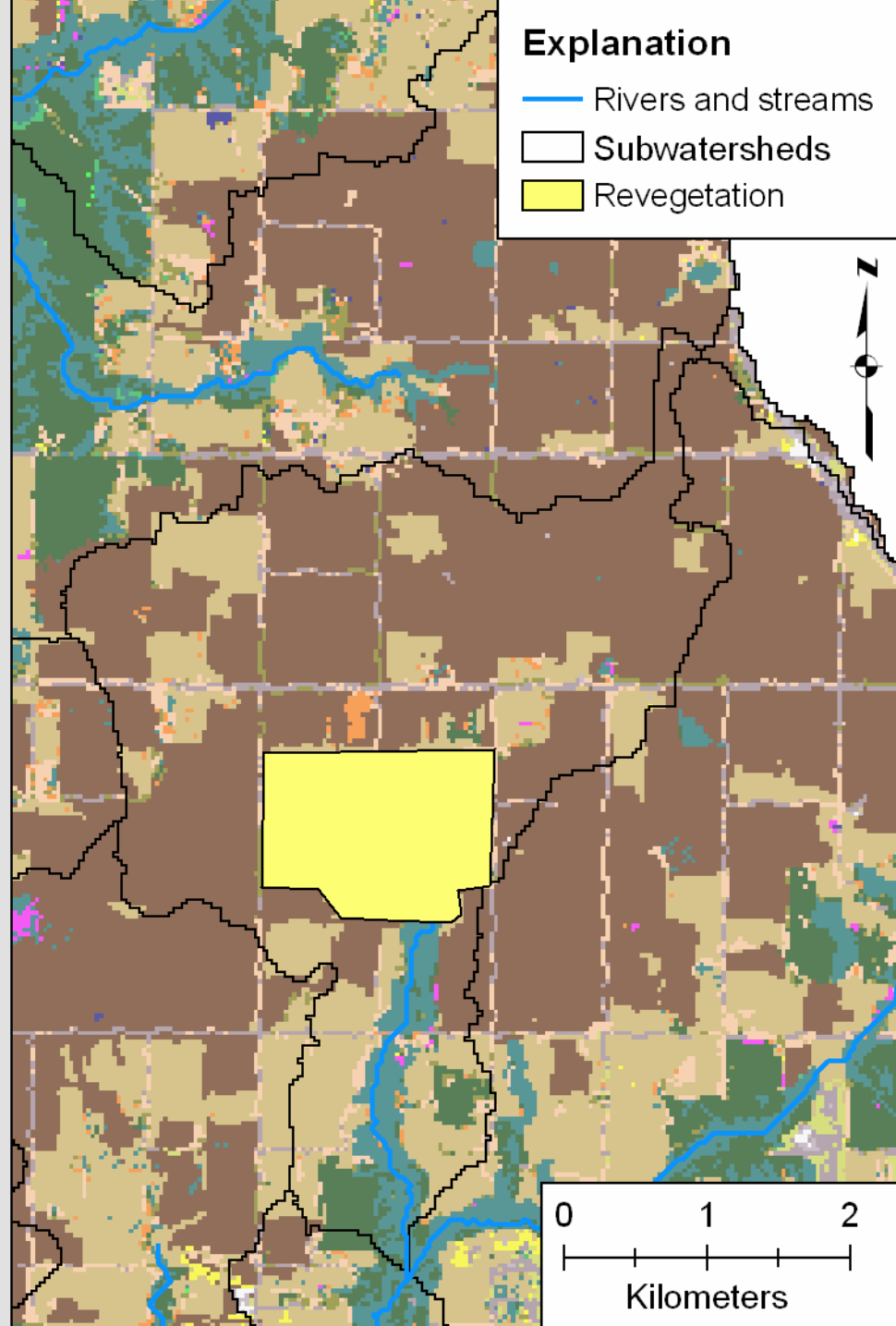
- Brantley Branch, tributary of Magnolia River
- N-SPECT output to identify “source” areas
  - Dark blue = high values
  - Light blue = low values
- Potential sources?





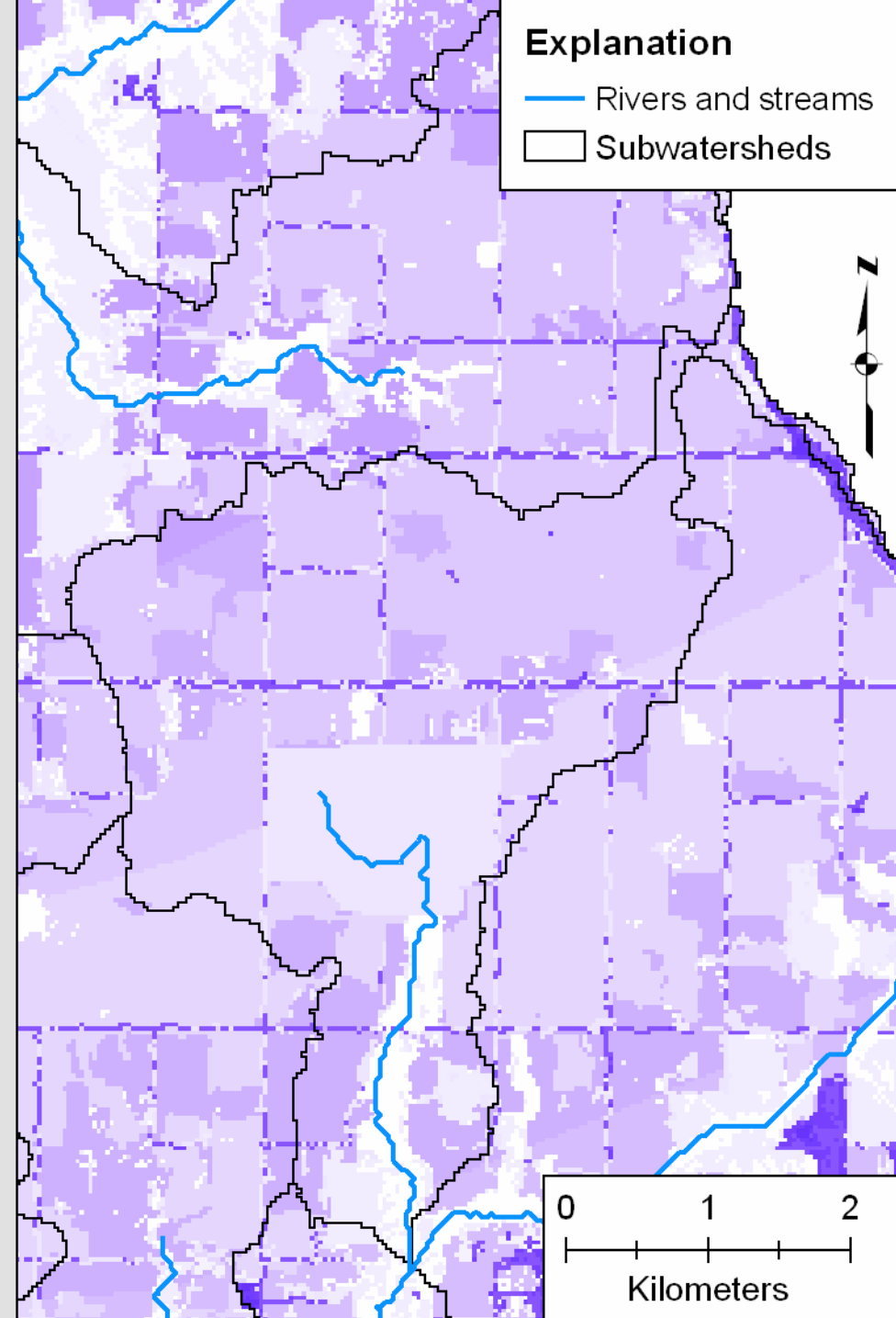
# Weeks Bay Watershed

- 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

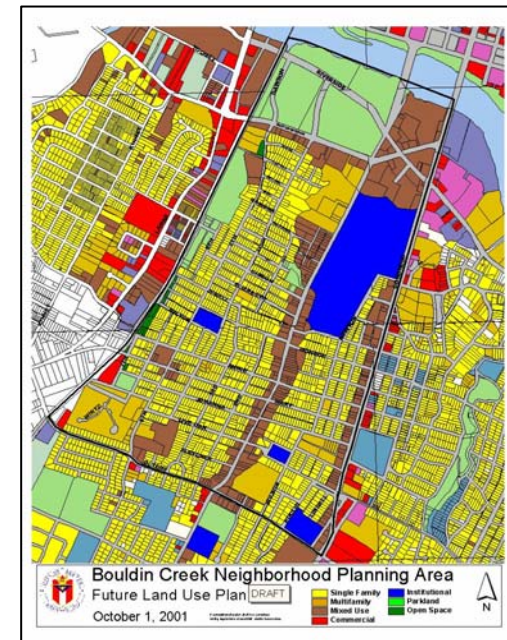
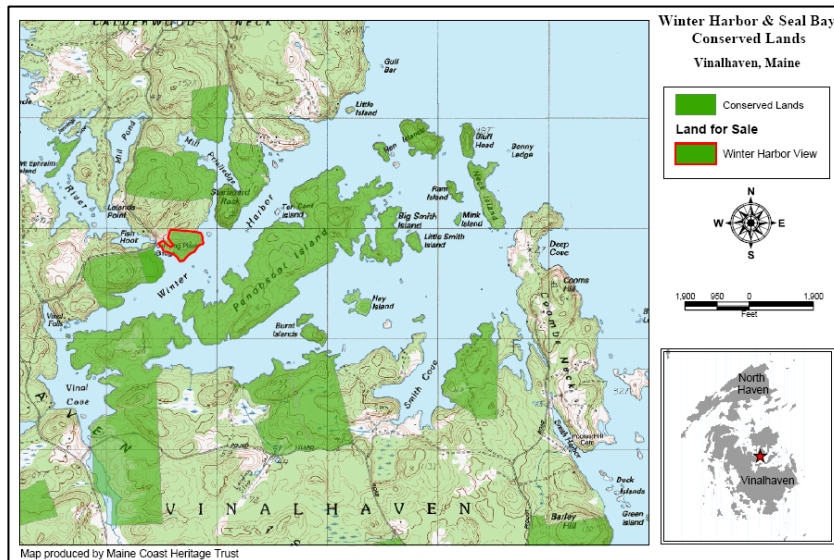
## Three-Tier Strategy to Address Nonpoint Source Pollution

Plan	<i>Natural resource–based planning</i>
Minimize	<i>Low-impact site design</i>
Mitigate	<i>Best Management Practices (BMPs)</i>



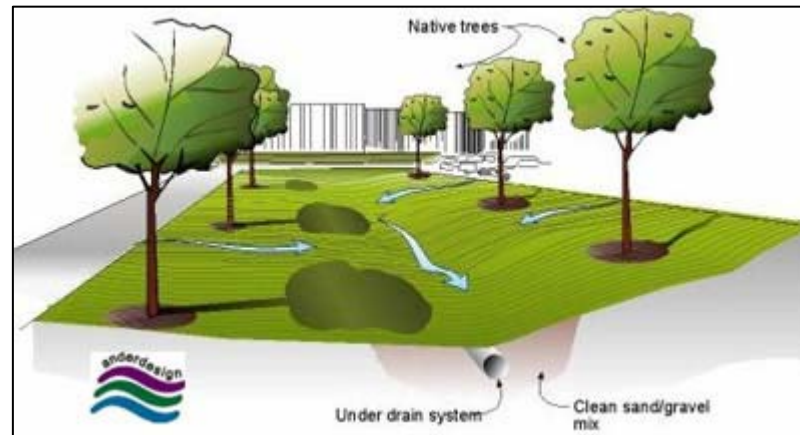
# Natural Resource-Based Planning

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



# 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!

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- 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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