United States Environmental Protection Agency
www.epa.gov/ord/erp

ECOSYSTEMS SERVICES RESEARCH PROGRAM

BUILDING A SCIENTIFIC FOUNDATION FOR SOUND ENVIRONMENTAL DECISIONS

U.S. Environmental Protection Agency's Ecosystem Services Research Program and Ecosystem-Based Management

Deborah Mangis, Ph. D.
US Environmental Protection Agency
National Exposure Research Laboratory
Research Triangle Park, NC
mangis.deborah@epa.gov

Today's Presentation

- Original request – EPA and Ecosystem-based Management
- **Title: U.S. Environmental Protection Agency's Ecosystem Services Research Program and Ecosystem-Based Management**
- Current title: **U.S. Environmental Protection Agency's Ecosystem Services Research Program and it's applicability to EPA and Ecosystem-Based Management**

EPA

- Mission: to protect Human Health and the Environment
- A Regulatory Agency – not land management agency
- Protection via regulation. Other agencies manage land/activities/pollution sources to meet regulations/standards or goals

EPA Regulations

- Regulate by Media
  - Air
    - Primary NAAQS – for human health
    - Secondary NAAQs – for welfare
  - Water
    - Drinking water – Human health
    - Water quality – for human and ecosystem health
      - TMDL –total maximum daily loads,
      - To meet use designation: Fishable/swimmable criteria
      - Moving to watershed initiative
  - Soils
    - Superfund sites – for human and ecosystem health

EPA Regulations

- Regulate by Chemical
  - Pesticides
  - New chemicals – e.g. Nano materials?
  - Air pollutants (PM, O3, air toxics)
  - Water pollutants (N, P)

- Only ecosystem based regs are for Wetlands with goals of maintaining or restoring acreage

What is Ecosystem Based Management?

Ecosystem based management is an integrated approach to management that considers the entire ecosystem, including humans.

The goal of ecosystem-based management is to maintain an ecosystem in a healthy, productive and resilient condition so that it can provide the services humans want and need.

From consensus statement on marine ecosystem based management
http://www.compassonline.org/pdf_files/EBM_Consensus_Statement_v12.pdf

8 Core elements of EBM

1. Nature's Services – set goals to sustain services

2. Scientific Evidence- understand process that generate services

3. Geographic Scales- focus on a specific area

4. Ecological linkages- any ecosystem change affects other aspects

From: http://www.ebmtools.org/about_ebm.html

8 EBM Core Elements Cont'd

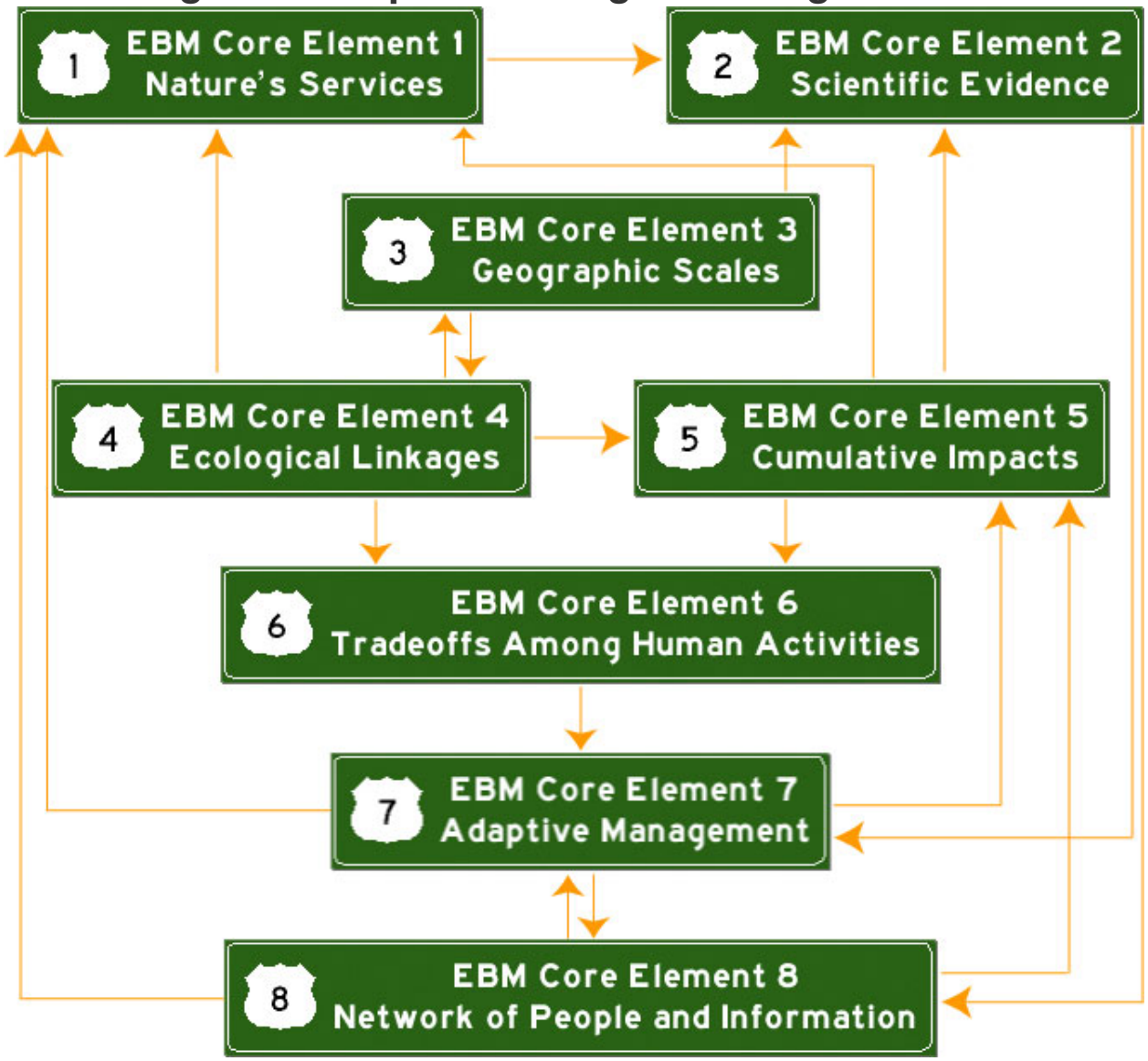
5. Cumulative impacts- human activities are additive on services – in time, space and sectors of economy

6. Tradeoffs among human activities- id and quantify tradeoff impacts

7. Adaptive Management- monitor services and adapt management as necessary

8. Network of people and information- learn about values and goals for services and communicate

Fig. 1 Conceptual Linkages Among the Core Elements

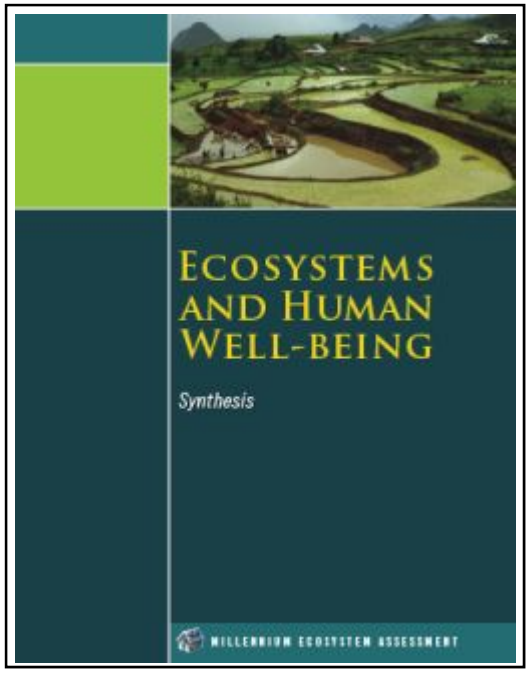


ORD Ecosystem Services Research Program

- Formerly ORD Ecological Research Program
- Realized our research was not really protecting ecosystems/environment
- Started changing our ecological research in 2007 to focus on Ecosystem Services

Millennium Ecosystem Assessment 2005

- All aspects of human well-being are dependent upon nature and the world's ecosystems
- Unless we account for the full value of ecosystem services, humans will continue to degrade and deplete natural systems.



ESRP's role is to provide the science to

- Clarify this dependence,
- Describe the full range of values, and
- Quantify what we know about different services – their status, trends, thresholds, trade-offs.

ORD Ecosystem Services Research
New Directions 2009-2014

- **Vision**
  A comprehensive theory and practice for quantifying ecosystem services, their value and their relationship to human well-being, is consistently incorporated into environmental decision making.
- **Goal**
  Transform the way we understand and respond to environmental issues by making clear how our management choices affect the type, quality and magnitude of the services we receive from ecosystems.

ESRP Major Research Questions

Pollutant-Based Ecosystem Services Research

How does a regulated pollutant—**nitrogen**—affect, positively and negatively, the bundle of ecosystem services at multiple scales?

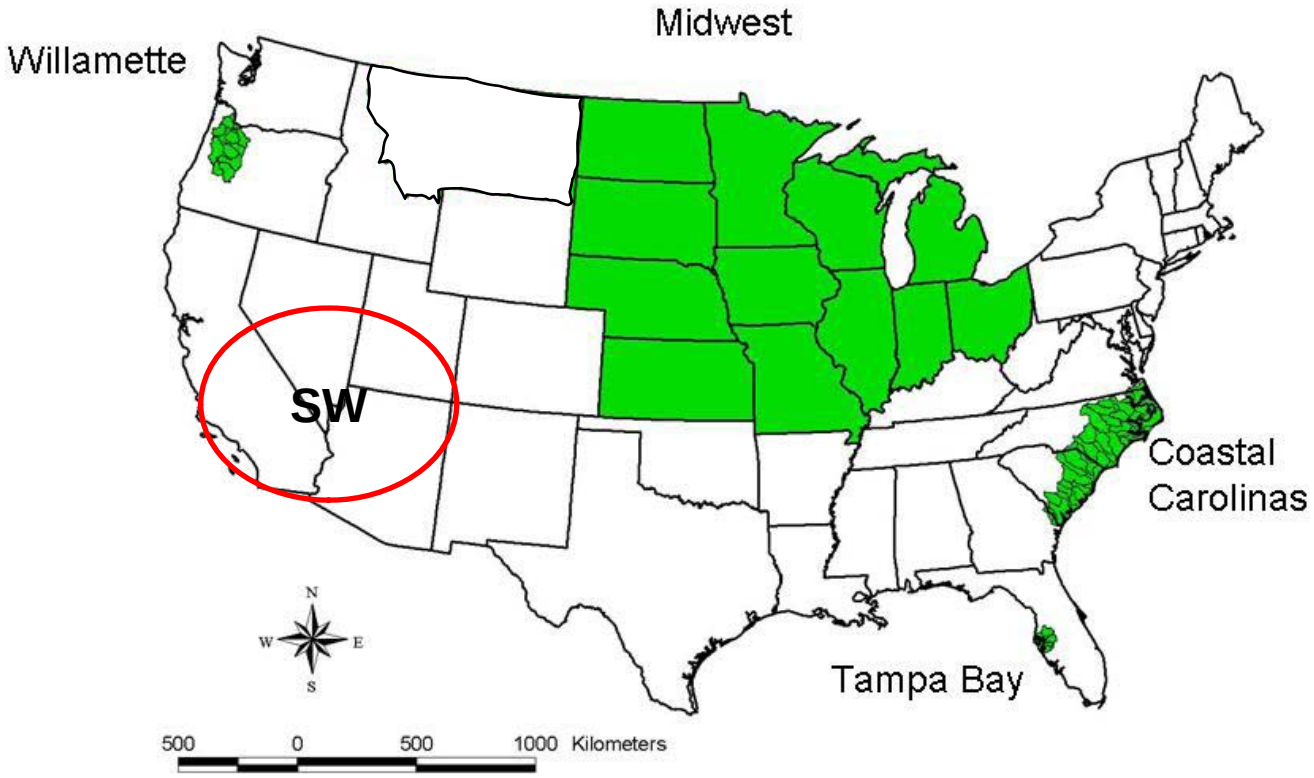
Ecosystem-Based Ecosystem Services Research

How does the bundle of ecosystem services provided by selected ecosystem types—**wetlands and coral reefs**—change under alternative management options at multiple scales?

Place-Based Ecosystem Services Research

How does the bundle of ecosystem services for all ecosystems within an **"ecosystem service district"** change under alternative management options?

Place Based Studies



Opportunity for coordinated site work: Standardization, Scaling, Applicability Testing, Collective Strength,….

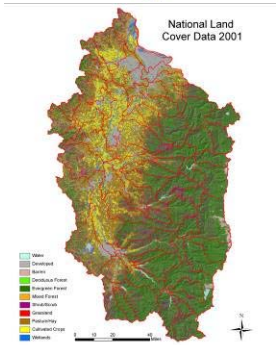
Place-based projects include…

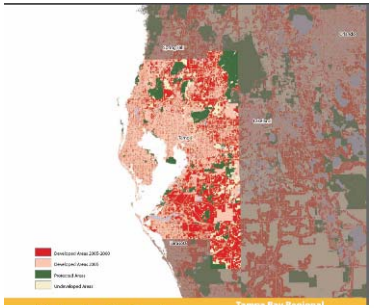
- ***Coastal Carolinas***
  Impact of Development, population growth, and climate change (including Sea Level Rise), on ecosystem services

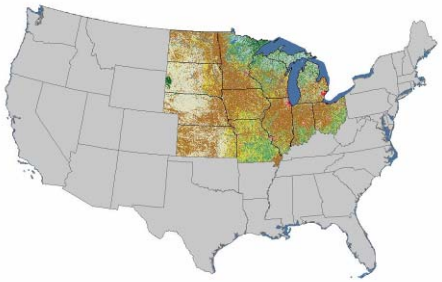
- ***Willamette Valley***
  Alternative futures development to 2050 on ecosystem services

- ***Tampa Bay region***
  Population growth scenarios impacts on ecosystem services

- ***Future Midwestern Landscapes***
  Effect of alternative biofuel scenarios on Ecosystem services





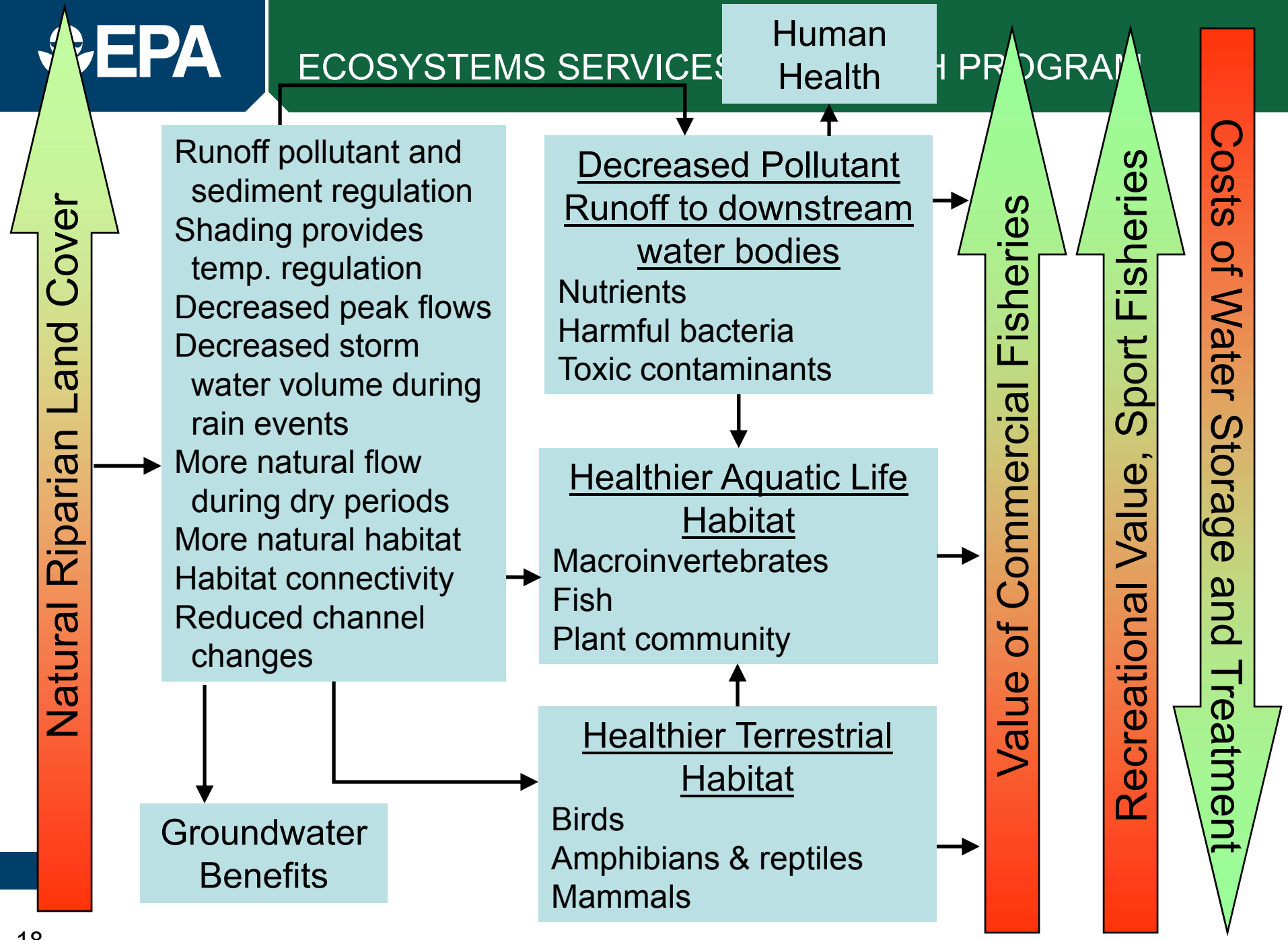


ESRP RESEARCH OBJECTIVES
Define ecosystem services in terms of their implications to human health and valuation
Map, Measure, and Monitor ecosystem services at multiple scales
Develop Predictive Models to forecast the effects of stressors on ecosystem services
Integrate Alternative Management Options/Scenarios/ and Forecasts
Develop a Decision Support Platform to inform decision makers
Change the way decision makers view the tradeoffs they make

Goals of the ESRP Landscape Characterization and Mapping Theme

To collaborate with and to provide landscape science support to place, ecosystem, and pollutant-based ESRP projects

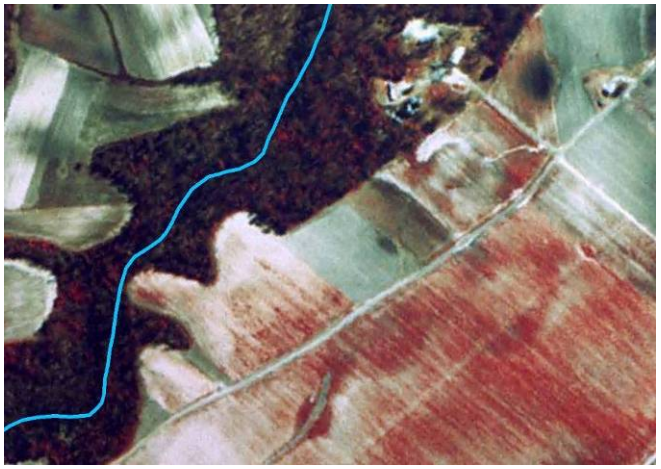
To develop a publicly accessible and scalable National Atlas of Ecosystem Services with the intent goal of impacting decision-making


Human Health
Natural Riparian Land Cover
Runoff pollutant and sediment regulation
Shading provides temp. regulation
Decreased peak flows
Decreased storm water volume during rain events
More natural flow during dry periods
More natural habitat
Habitat connectivity
Reduced channel changes
Decreased Pollutant Runoff to downstream water bodies
Nutrients
Harmful bacteria
Toxic contaminants
Healthier Aquatic Life Habitat
Macroinvertebrates
Fish
Plant community
Healthier Terrestrial Habitat
Birds
Amphibians & reptiles
Mammals
Groundwater Benefits
Value of Commercial Fisheries
Recreational Value, Sport Fisheries
Costs of Water Storage and Treatment

Developing New Metrics to Help Characterize Nutrient Attenuation/Removal by Riparian Buffers

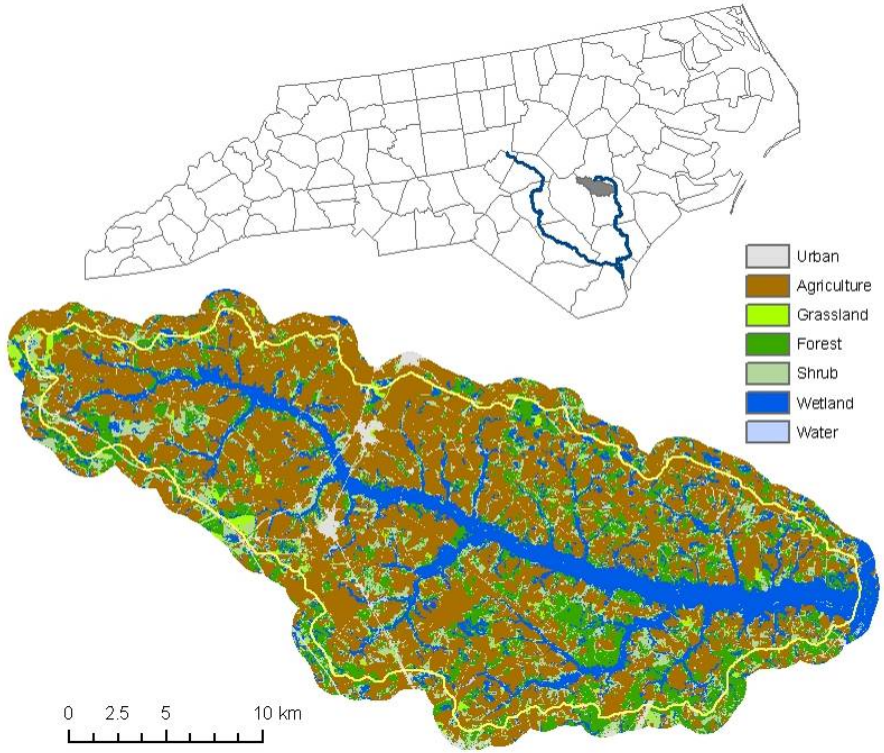
Jay Christensen, Ric Lopez, Annie Neale – Landscape Ecology Branch, ESD

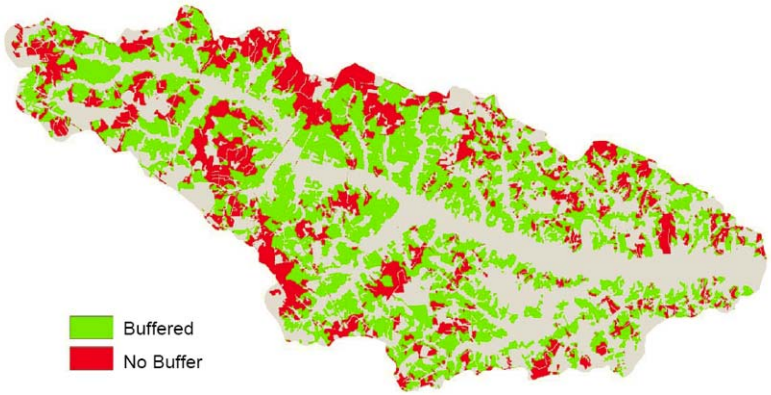
- Metric connecting riparian vegetation to upland sources of nutrients
- Test metric's ability to predict reduced nutrient loads
- Develop landscape model to determine nitrogen removal by riparian buffers
- Test using data of different resolutions
- Possibly test in SPARROW SE model
- Tie this work back to Mayer et al. literature review



Water Quality -- Nutrient Attenuation/Removal by Riparian Buffers

Goshen Swamp Tributary of NE Cape Fear River





67 % of Ag buffered
33 % not buffered

Jay Christensen

Water Quality -- Nutrient Attenuation/Removal by Riparian Buffers

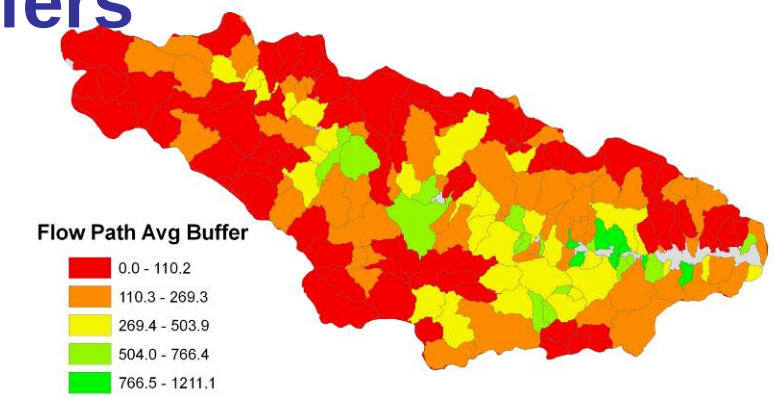
Riparian metrics being tested

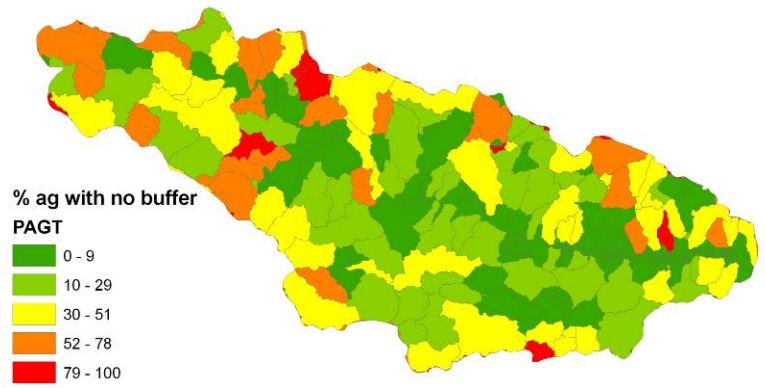
- Average Flow Path Buffer Width from Ag Cells (m)

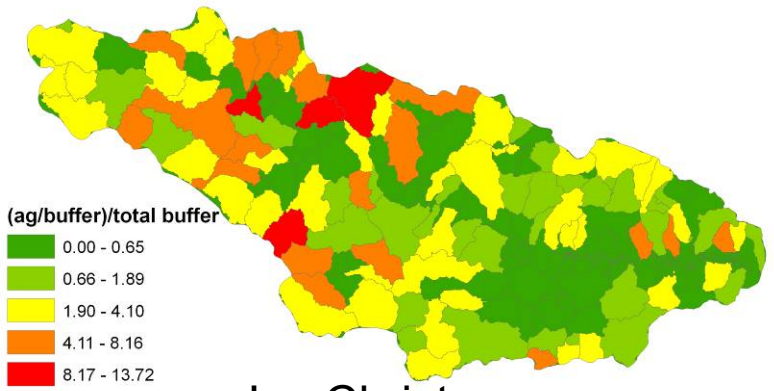
  Based on Baker et al 2006

- % Ag draining to stream without passing through naturally vegetated buffer

- Sum of Ag/Buffer Ratio / total buffer length

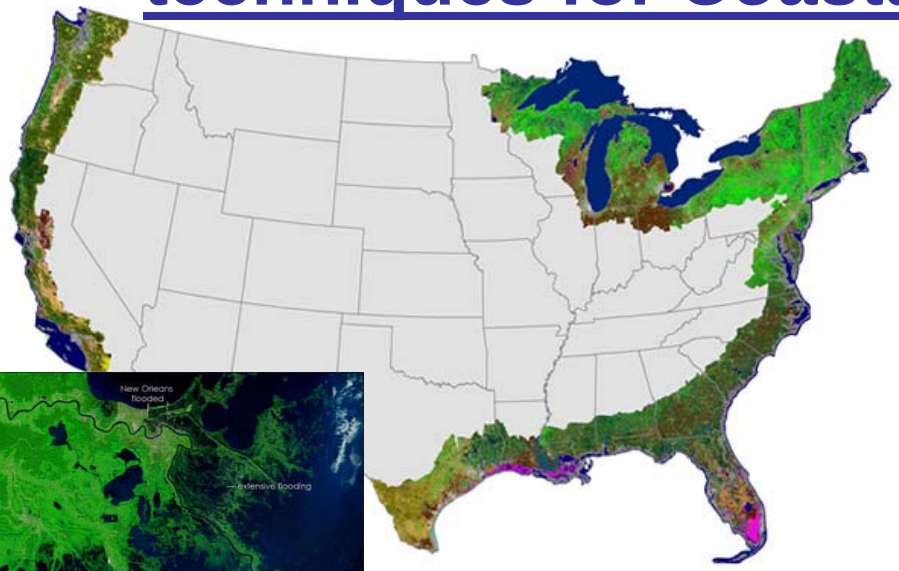






Jay Christensen

Application of 'modified-traditional' mapping techniques for *Coastal Wetlands*



Storm Surge Protection

Sea Level Rise

Mapping/modeling of:

- (Presence/Extent/Condition)
  Coastal wetland change using multi-spectral satellite data (in addition to soil moisture indices, NWI, presence of hydric soils, and other variables)
- (Ecosystem Services, including change)
  - Storm surge protection (SSP)
  - Wave energy and tidal energy attenuation, including analyses of sea level rise (SLR)
  - Production of commercially and recreationally important fish and birds
  - Pollutant accumulation/transformation
  - Provisioning of human recreational benefits and human aesthetic benefits

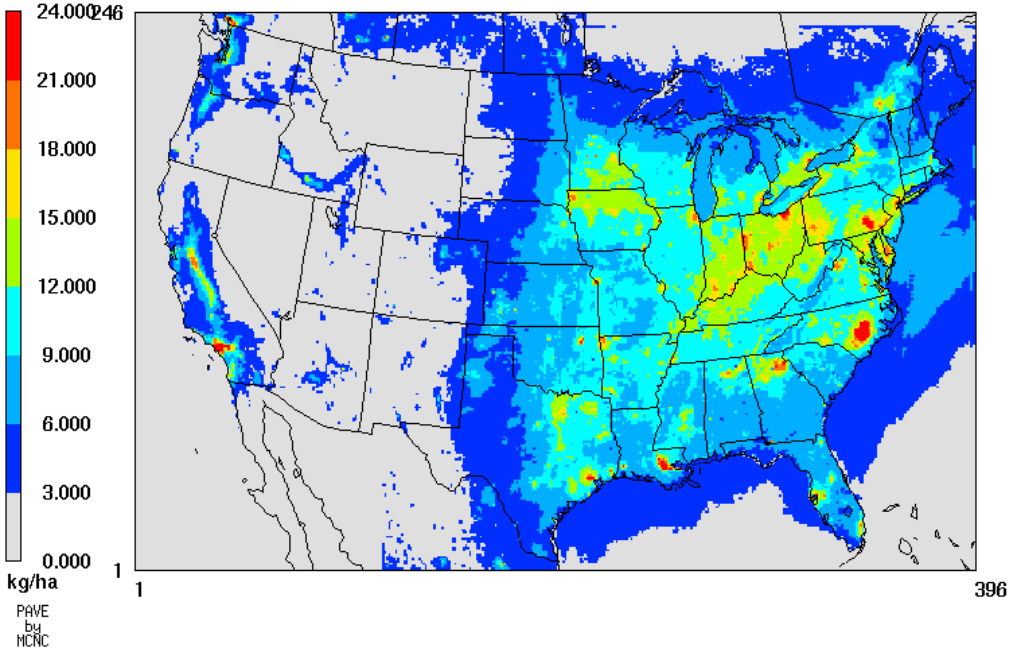
Ric Lopez

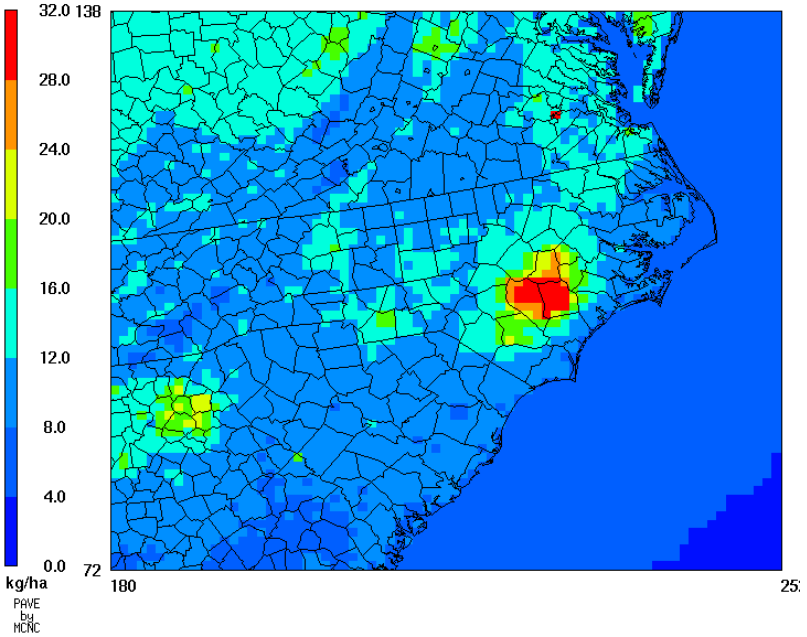
Nutrient Loads

- Joint goal of the nitrogen group and the mapping group to map nutrient loads nationally.
  - Cropland data layer + fertilizer application rates
  - Land use export coefficients and event mean concentrations (e.g., EPA PLOAD Users Manual, USDA MANAGE Data Base,)
  - Developing a CAFO coverage for nation
  - WWTP coverage for nation
  - GlobalNews Model, SPARROW, GWLF, WARMF
  - Atmospheric deposition -- CMAQ

Annual Total Deposition of Nitrogen (kg-N/ha)

Community Multiscale Air Quality (CMAQ) model





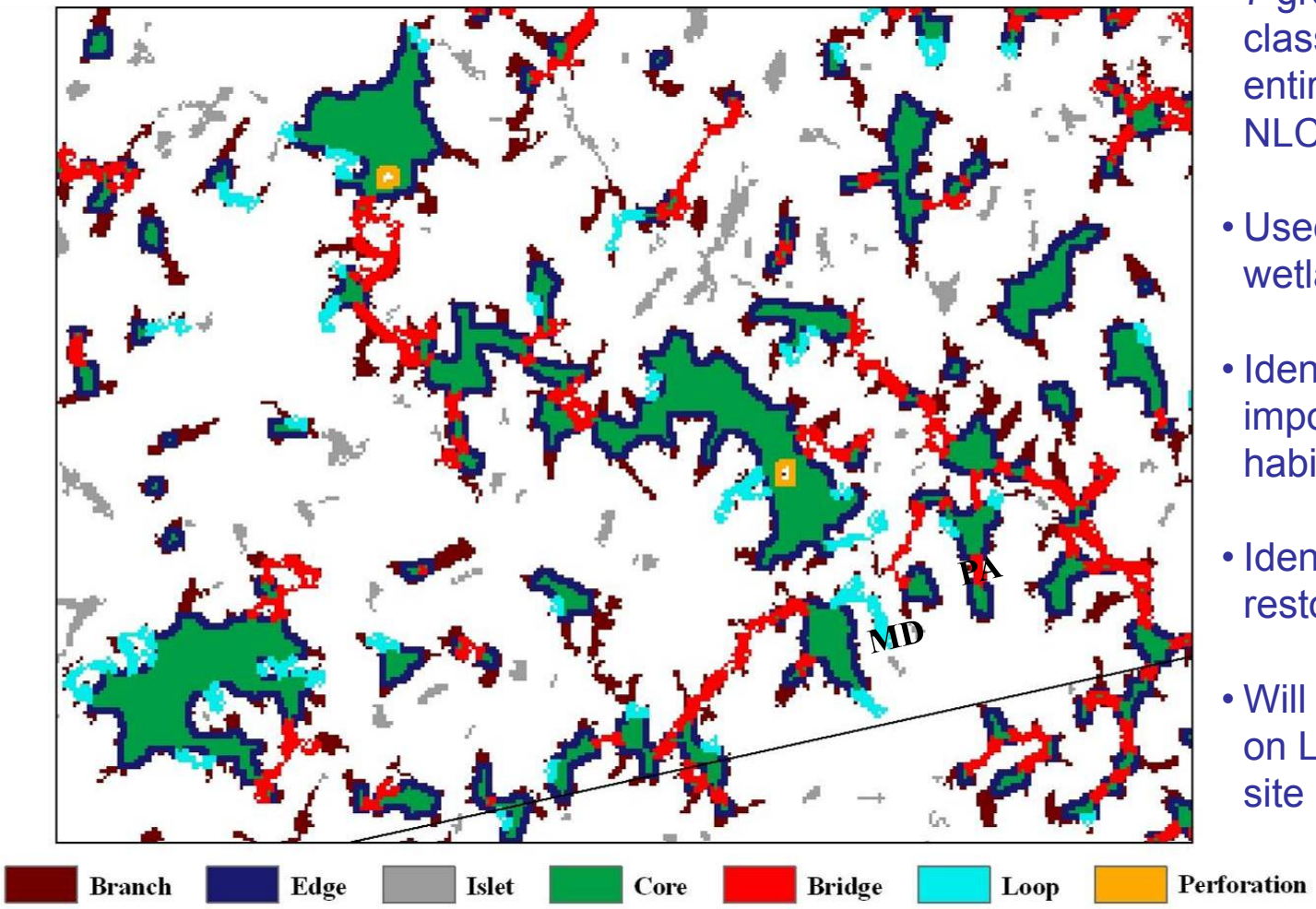
Models multiple air quality issues including nitrogen
Uses modeled meteorology data and 2002 National Emissions Inventory data
Outputs concentrations and deposition on an hourly basis.
Outputs data on a 12 X 12 Km^2 or 36 X 36 Km^2 grid cell basis.
Watershed Deposition Tool outputs to 8 or 12-digit HUC

Robin Dennis

Examples of Ongoing Atlas Work

Terrestrial Habitat -- Green Infrastructure Approach (i.e., Hubs and Corridors)

Jim Wickham, Tim Wade, Landscape Ecology Branch, ESD

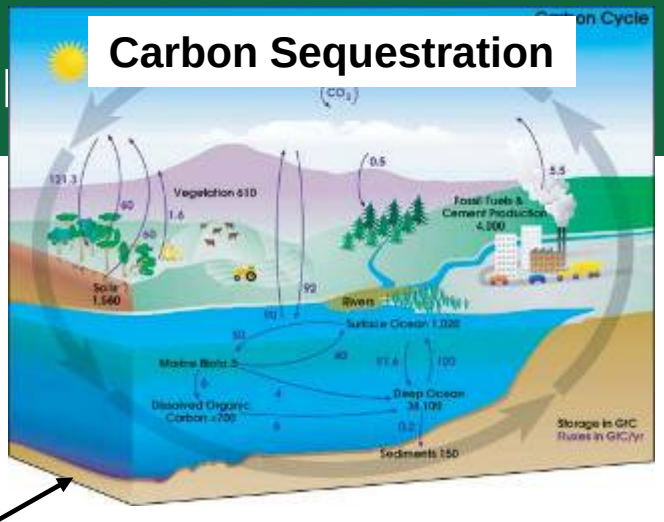


- 7 green infrastructure classes mapped for entire US based on NLCD 30 m data
- Used NLCD forest and wetland classes only
- Identifies potentially important wildlife habitat
- Identifies areas for restoration/protection
- Will soon be included on LandScope web site

Developed from: Vogt P, Riitters KH, Iwanoski M, et al. 2007. Mapping landscape corridors. Ecol. Indic. 7:481-488. http://forest.jrc.ec.europa.eu/biodiversity/GUIDOS/

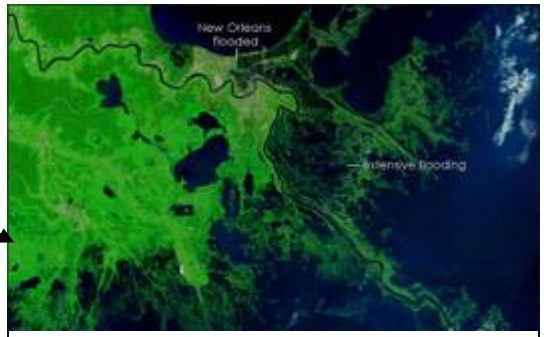
Wildlife Habitat

Fisheries Support



Carbon Sequestration

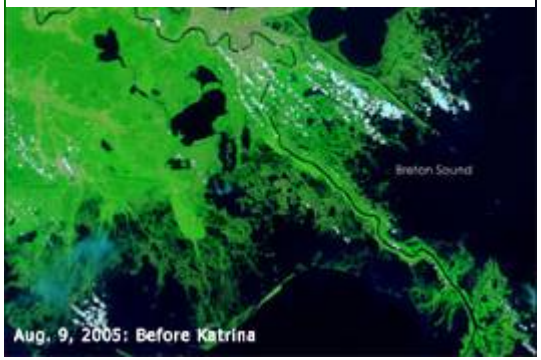
Core Wetland Services



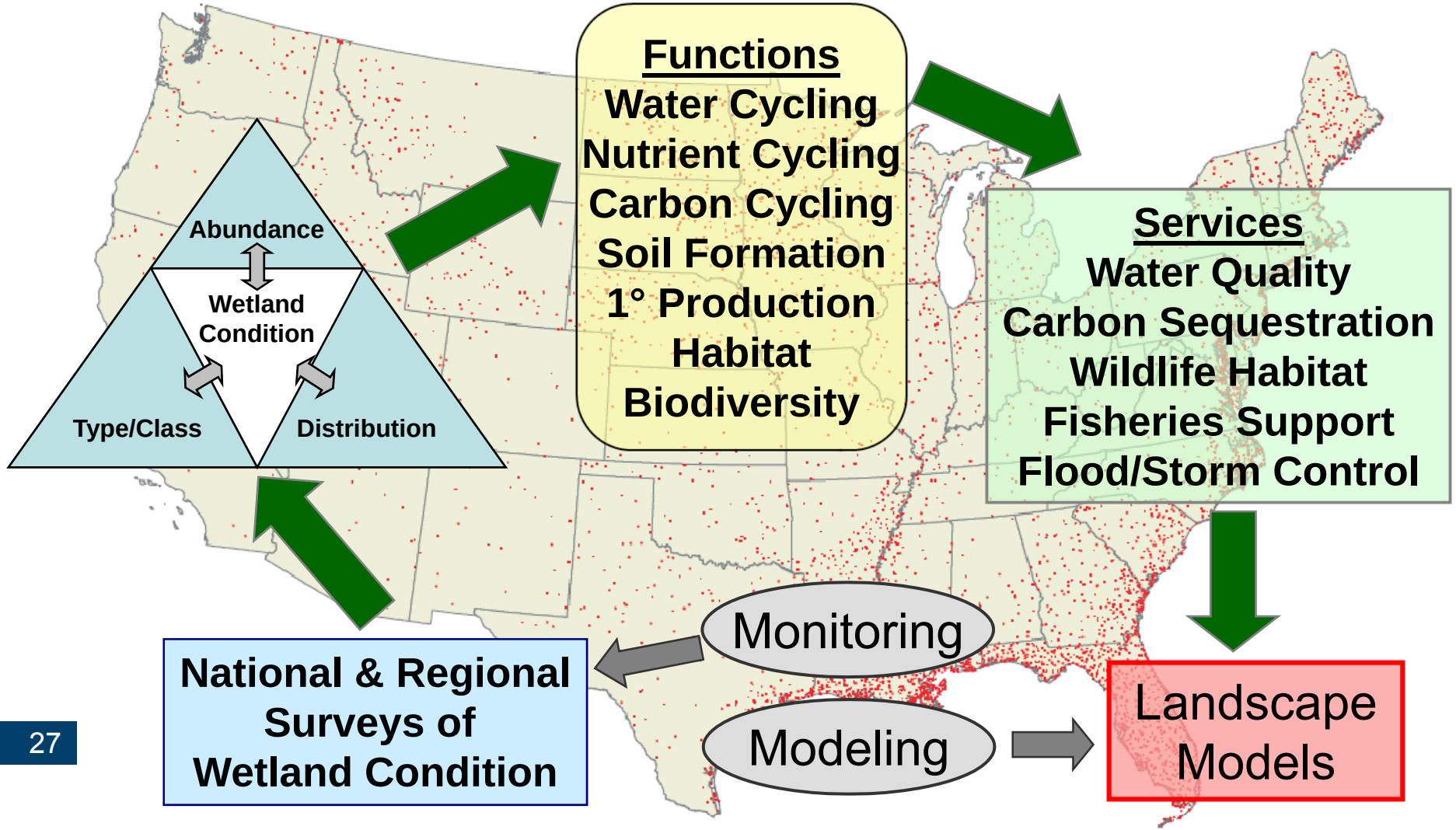
Flood/Storm Protection, Water Storage

Improve Water Quality

Human Well-being



Wetland Ecosystem Service Estimates



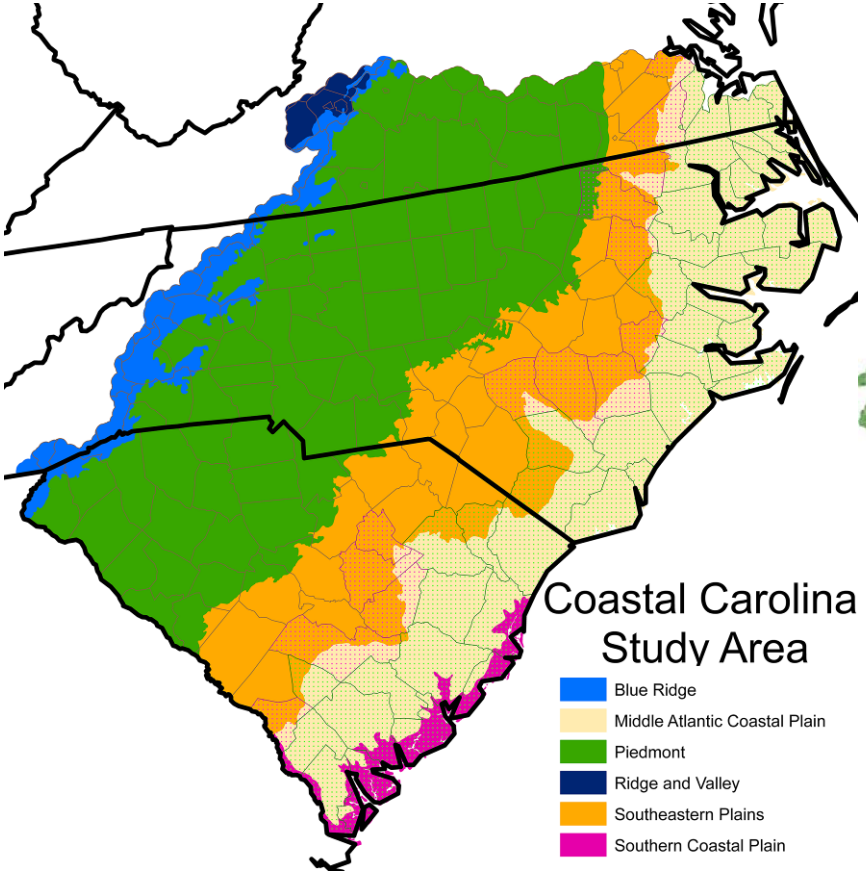
Coastal Carolinas

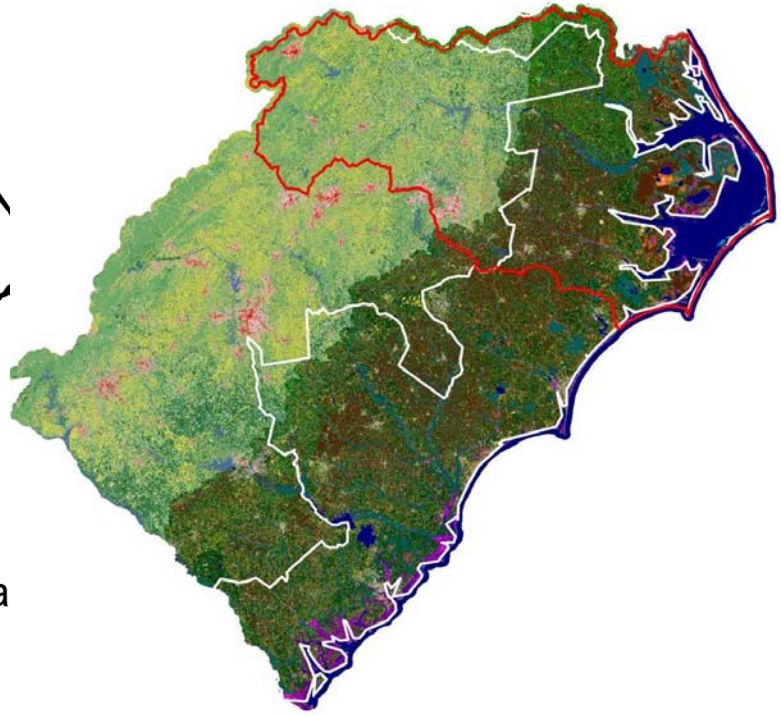
Will address impacts on coastal ecosystem services from global climate change and development. Will focus on:

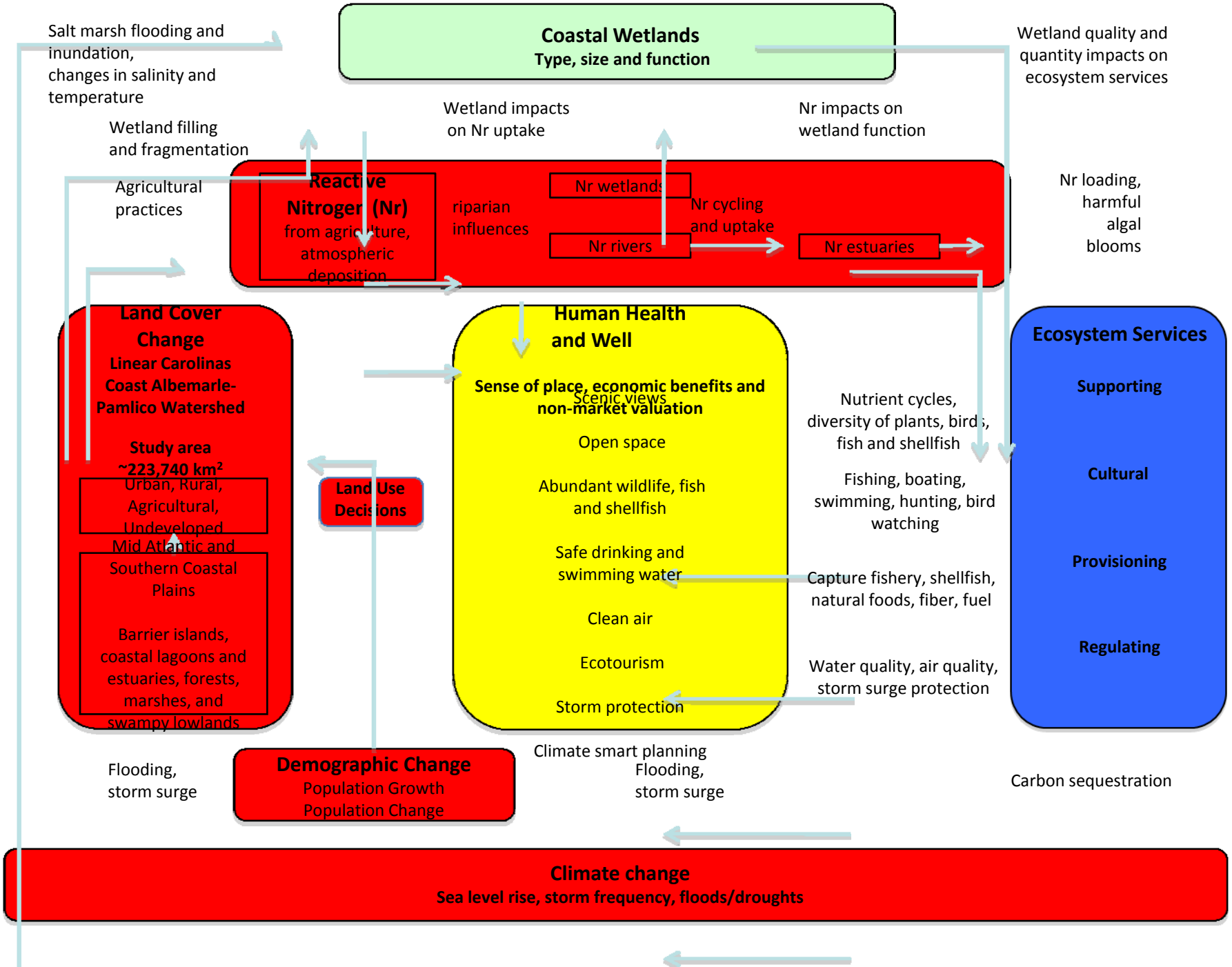
- **Mapping and quantifying coastal ecosystem services.**
- **Estimating how changing land use, sea level, and storm frequency and intensity may impact future coastal ecosystem services.**
- **Developing links for both the immediate 'linear' coast of North and South Carolina, and the effects on coastal areas from upstream portions of the Albemarle-Pamlico Estuary watershed (import and export of ecosystem services)**
- **Developing decision support tools which will help land use managers incorporate the full value of ecosystem services and the probable future impacts and costs of land use decisions.**

Hurricane Hugo

The Coastal Carolinas Project






Coastal Wetlands
Type, size and function
Salt marsh flooding and inundation, changes in salinity and temperature
Wetland quality and quantity impacts on ecosystem services
Wetland impacts on Nr uptake
Nr impacts on wetland function
Wetland filling and fragmentation
Agricultural practices
Reactive Nitrogen (Nr)
from agriculture, atmospheric deposition
riparian influences
Nr wetlands
Nr rivers
Nr cycling and uptake
Nr estuaries
Nr loading, harmful algal blooms
Land Cover Change
Linear Carolinas Coast Albemarle-Pamlico Watershed
Study area ~223,740 km²
Urban, Rural, Agricultural, Undeveloped
Mid Atlantic and Southern Coastal Plains
Barrier islands, coastal lagoons and estuaries, forests, marshes, and swampy lowlands
Land Use Decisions
Human Health and Well
Sense of place, economic benefits and non-market valuation
Scenic views
Open space
Abundant wildlife, fish and shellfish
Safe drinking and swimming water
Clean air
Ecotourism
Storm protection
Ecosystem Services
Supporting
Nutrient cycles, diversity of plants, birds, fish and shellfish
Cultural
Fishing, boating, swimming, hunting, bird watching
Provisioning
Capture fishery, shellfish, natural foods, fiber, fuel
Regulating
Water quality, air quality, storm surge protection
Carbon sequestration
Demographic Change
Population Growth
Population Change
Flooding, storm surge
Climate smart planning
Flooding, storm surge
Climate change
Sea level rise, storm frequency, floods/droughts

Potential Coastal Carolina Ecosystem Services to Evaluate (from the Millennium Ecosystem Assessment)

- **Supporting**
  - Nutrient regulation
  - Carbon sequestration
- **Regulating**
  - Climate regulation – storm surge protection, flood protection
  - Water purification (wetlands)
- **Provisioning**
  - Food (agriculture, fisheries)
  - Fiber (forests, agriculture (cotton))
  - Water quality and supply
- **Cultural**
  - Recreation – fishing, tourism
  - Aesthetics – sense of place

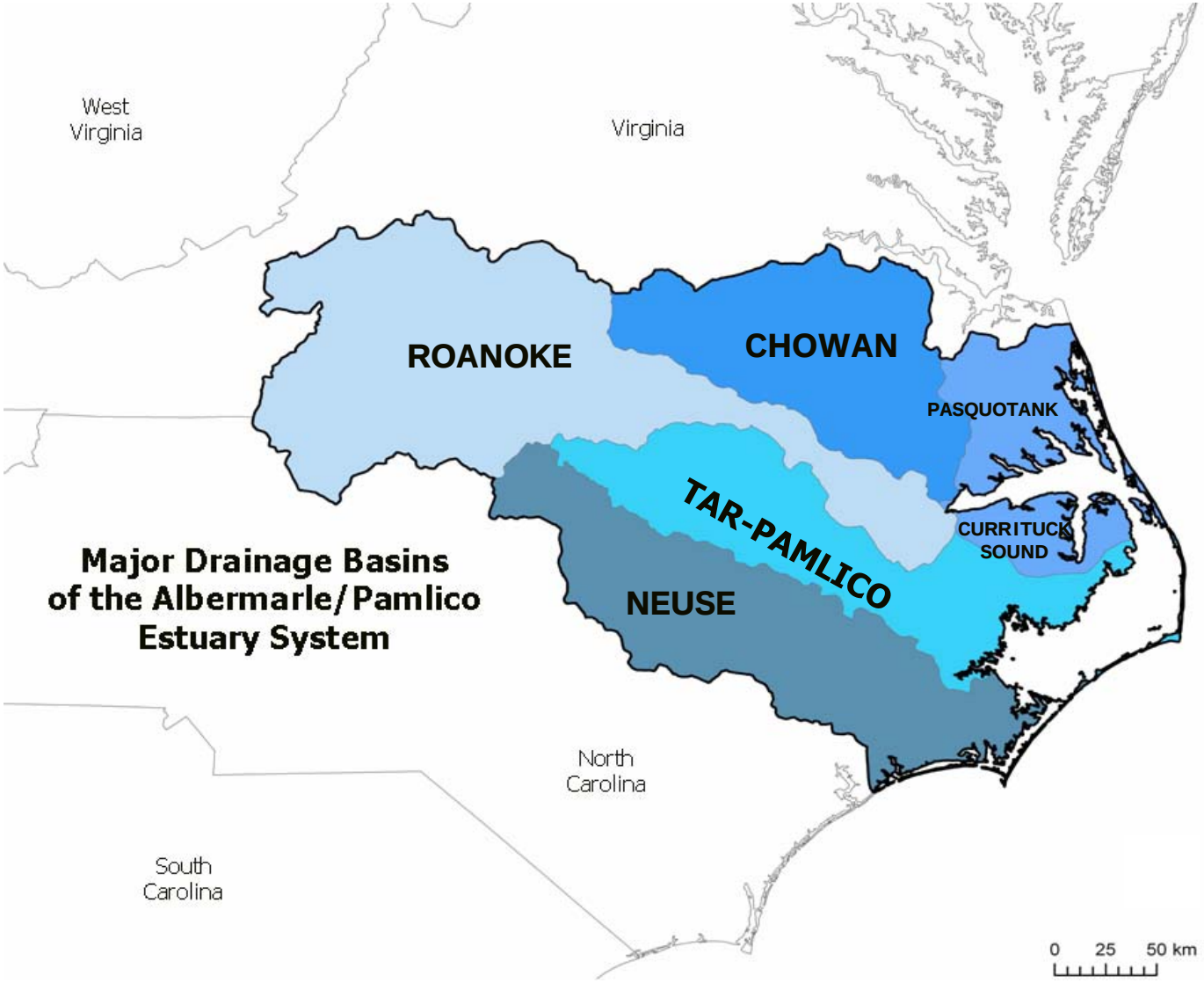
Examples of Ecoservices Metrics

Ecosystem Service	Measurements
Carbon Storage	Carbon stocks in plants and soil / Carbon accretion to wetland soil; flux of GHG
Fisheries Support	Commercial / Recreational Fish or Shellfish Quantity / Fish – Shellfish Habitat Quality; Feedstock for C/R fisheries
Flood Control/Storm Surge Protection / Water Storage	Extent of Wetland Attenuation of Storm Surge or Flood, Water Volume Capacity of Wetlands
Water Quality Improvement	Reactive Nitrogen / Phosphorus Removal / Water Clarification; Pesticide Trapping
Wildlife Support	Birdwatching (Biodiversity) Opportunities / Wildlife Prey Abundance / Breeding Bird Community

To be refined through ESRP studies

Public Input

- Have held meetings in NC and SC to get input into
  - Public values
  - Ongoing research


West Virginia
Virginia
ROANOKE
CHOWAN
PASQUOTANK
TAR-PAMLICO
CURRITUCK SOUND
NEUSE
Major Drainage Basins of the Albermarle/Pamlico Estuary System
North Carolina
South Carolina
0 25 50 km

APES Detailed Problem Statements

- **Type I.** What percent of APES HUC 12 streams are expected to demonstrate at least an X percent reduction in their provisioning of ecosystem service ***S*** in conjunction with stressor scenario ***A*** over the next 5, 10, and 20 years?

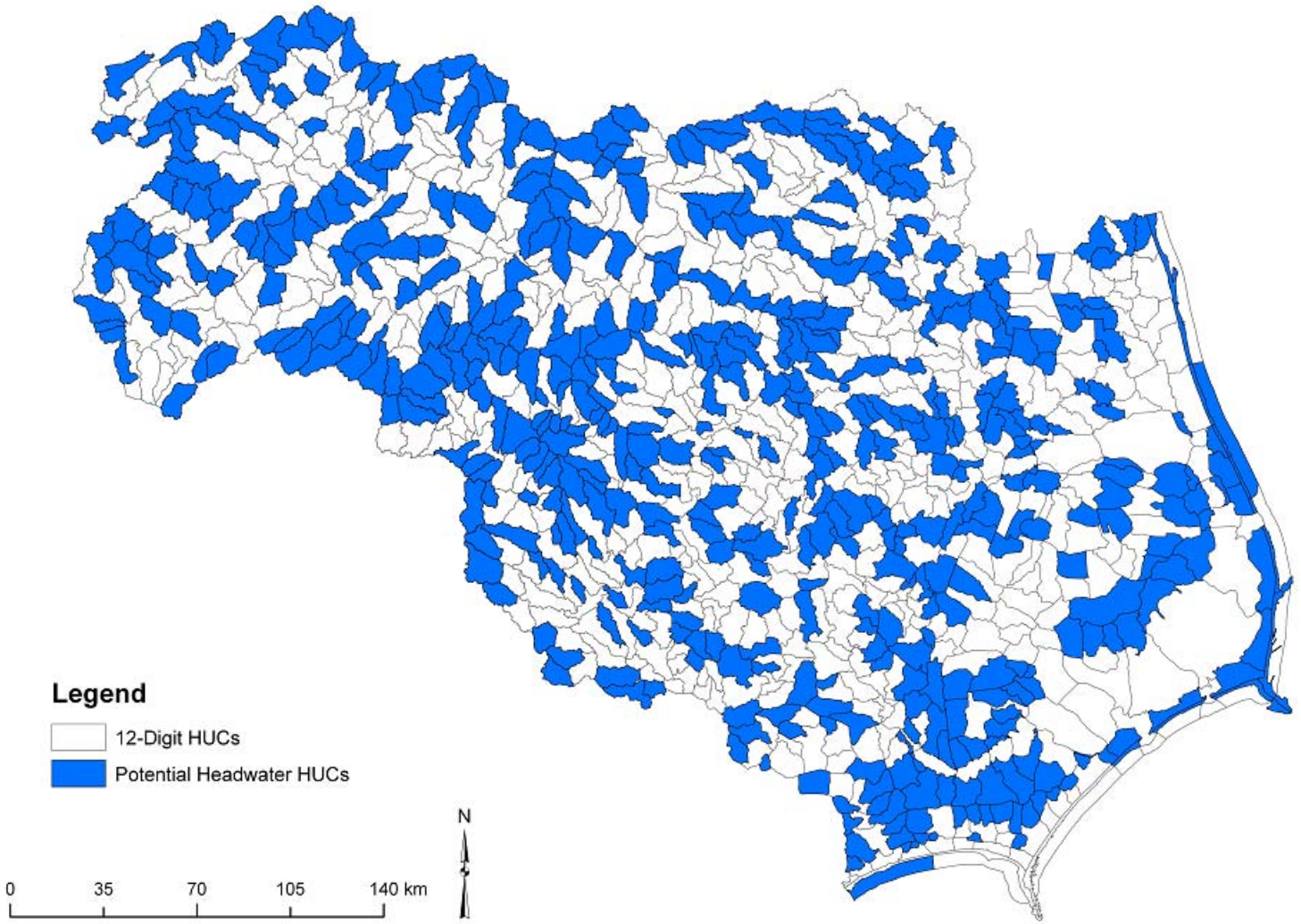
- **Type II.** What percent of APES HUC 12 streams are expected to have their provisioning of ecosystem service ***S*** below the threshold value of σ in conjunction with stressor scenario ***A*** over the next 5, 10, and 20 years?

  - Ecosystem services ***S*** are: (1) water quantity, (2) water quality, (3) habitat suitability for valued aquatic wildlife, (4) fishery production, and (5) contaminant-free fisheries.

  - Stressors of concern include: (1) regional climate change, (2) land cover conversion/build-out, (3) nitrogen source loadings, (4) mercury source loadings, and (5) pesticides source loadings.

  - Explicit uncertainty estimates required

Potential 12-Digit Headwater HUCs in the APES Region

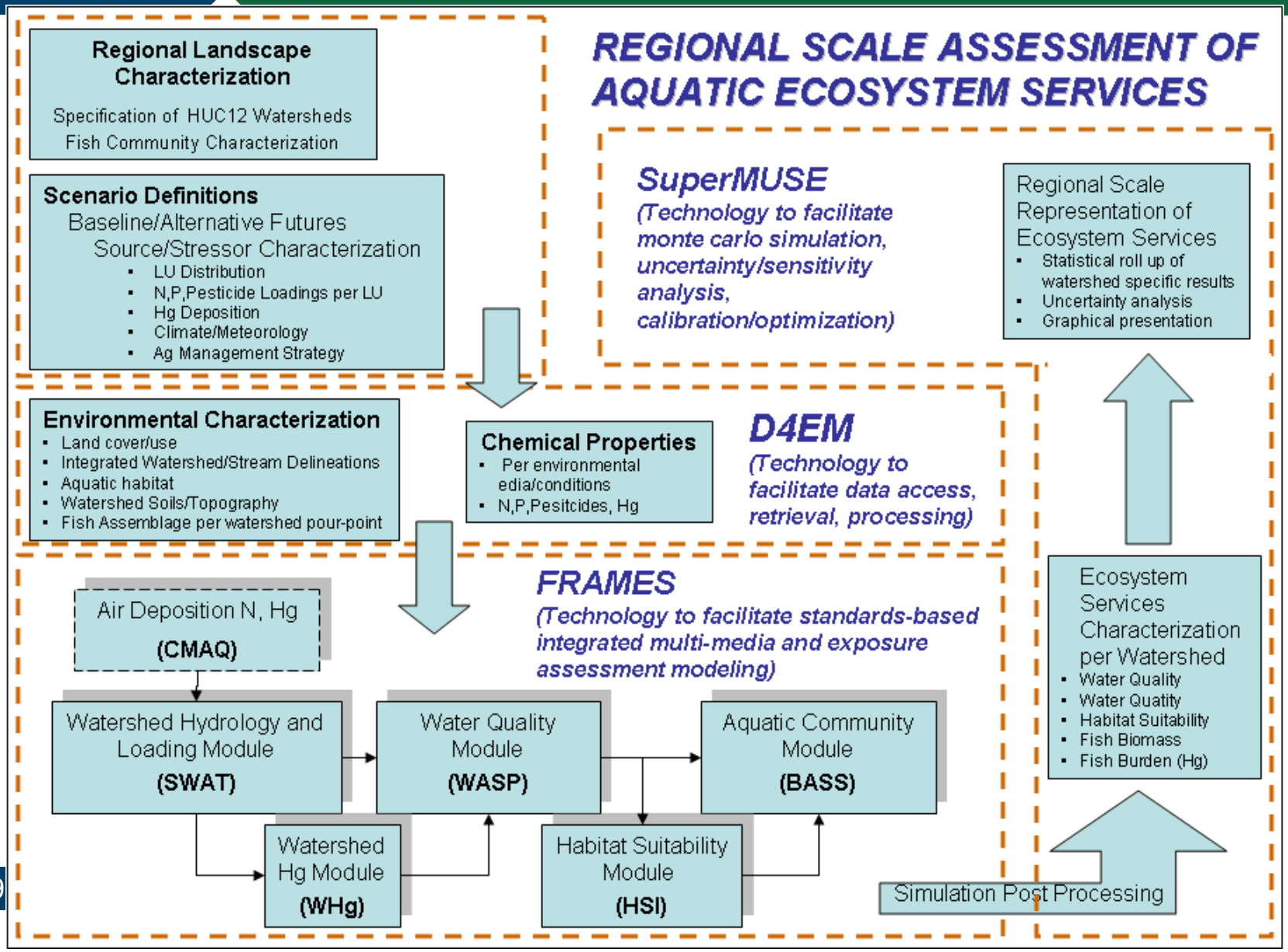


Data Needs for APES

- **Data accessed from National data sources**
  - –Meteorological data timeseries
  - –Watershed characterization
  - –Stream network
  - –Land cover
  - –Soils data

Data Needs for APES (cont'd)

- **Modeler supplied data**
  - –Watershed soil data
  - –Mercury properties
  - –Fish communities and densities (1 community/HUC)
  - –Fish properties (78 species, 4 properties each)
  - –Background concentration load fluxes (66)
  - –Deposition data (2/HUC)
  - –Stochastic variable distribution parameters (89)


REGIONAL SCALE ASSESSMENT OF AQUATIC ECOSYSTEM SERVICES
Regional Landscape Characterization
Specification of HUC12 Watersheds
Fish Community Characterization
Scenario Definitions
Baseline/Alternative Futures
Source/Stressor Characterization
LU Distribution
N,P,Pesticide Loadings per LU
Hg Deposition
Climate/Meteorology
Ag Management Strategy
SuperMUSE
(Technology to facilitate monte carlo simulation, uncertainty/sensitivity analysis, calibration/optimization)
Regional Scale Representation of Ecosystem Services
Statistical roll up of watershed specific results
Uncertainty analysis
Graphical presentation
Environmental Characterization
Land cover/use
Integrated Watershed/Stream Delineations
Aquatic habitat
Watershed Soils/Topography
Fish Assemblage per watershed pour-point
Chemical Properties
Per environmental edia/conditions
N,P,Pesitcides, Hg
D4EM
(Technology to facilitate data access, retrieval, processing)
FRAMES
(Technology to facilitate standards-based integrated multi-media and exposure assessment modeling)
Air Deposition N, Hg
(CMAQ)
Watershed Hydrology and Loading Module
(SWAT)
Water Quality Module
(WASP)
Aquatic Community Module
(BASS)
Watershed Hg Module
(WHg)
Habitat Suitability Module
(HSI)
Ecosystem Services Characterization per Watershed
Water Quality
Water Quatity
Habitat Suitability
Fish Biomass
Fish Burden (Hg)
Simulation Post Processing

Coastal Carolinas Alternative Futures

Development Response:	***Sea Level Rise:*** Slow (current rate)	Medium (1 m by 2100)	Fast (3 m by 2100)
Business as Usual	✔	✔	✔
Adaptation in Place	✔	✔	✔
Flee the Coast	✔	✔	✔

Models of Climate Change Effects:

SLOSH?

SLAMM?

Charleston Harbor

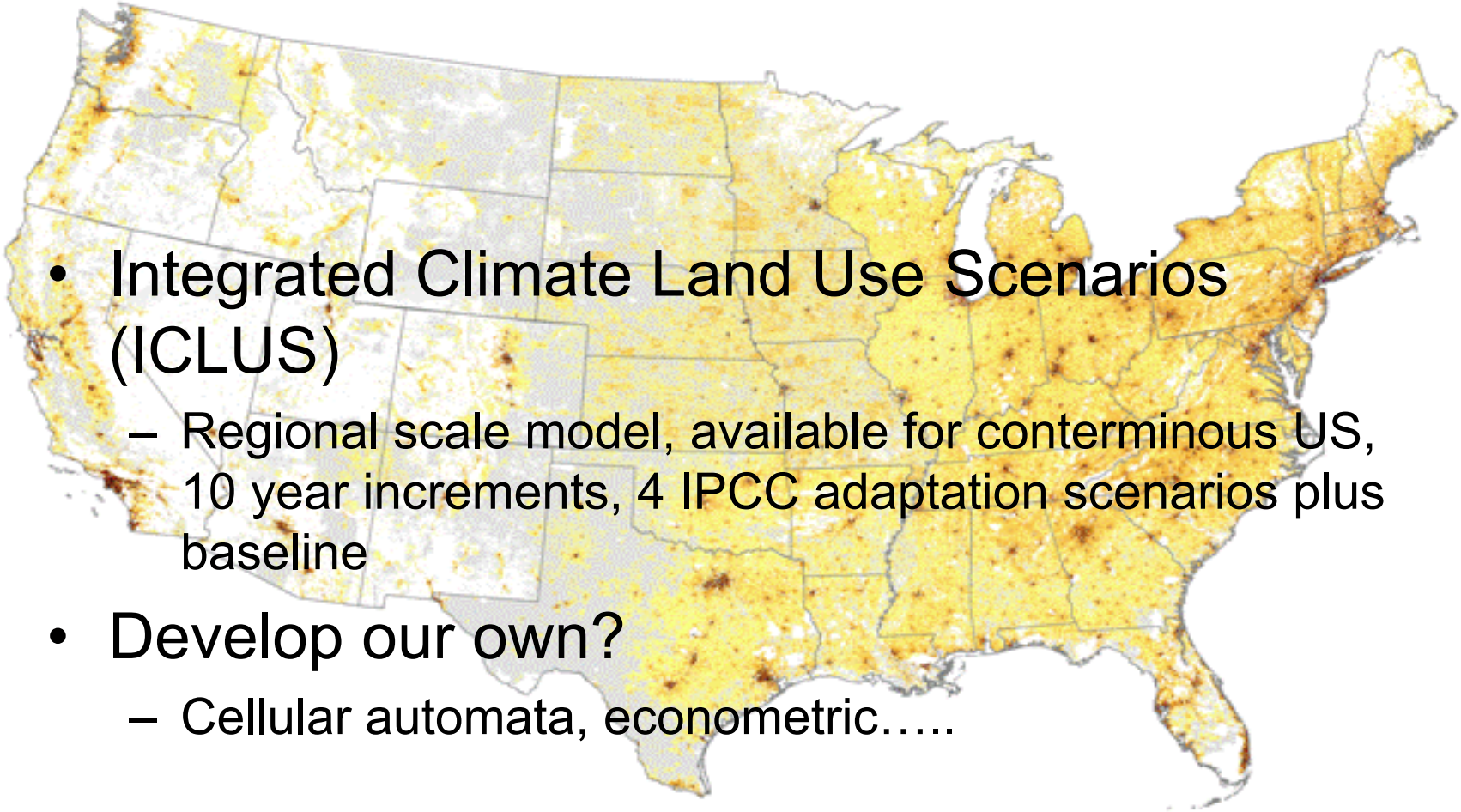
Mount Pleasant

Isle of Palms

Folly Beach

Physical process models - National Weather Service's Sea, Lake, and Overland Surge from Hurricanes (SLOSH) model

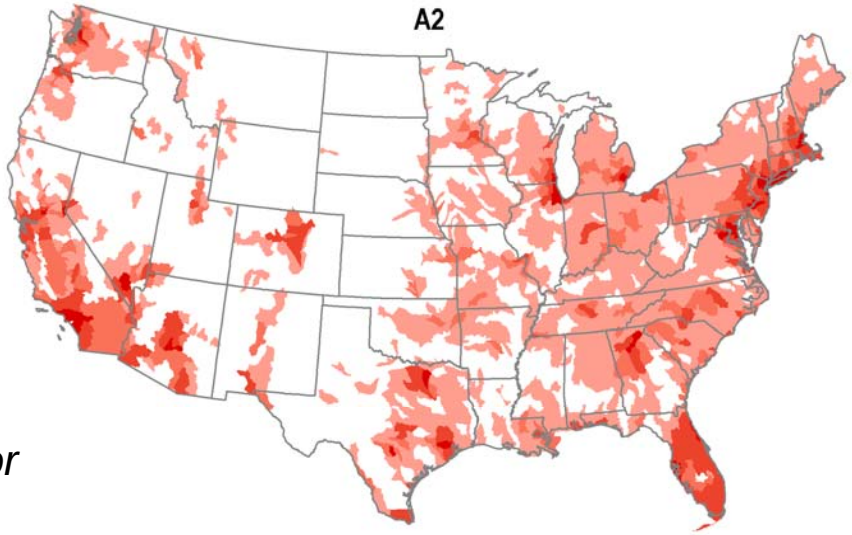
Models of Development Pressure



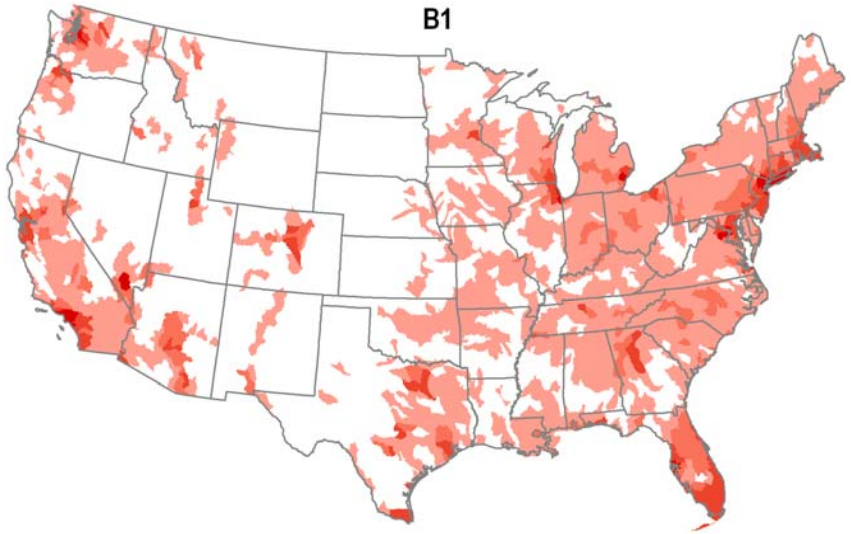
- Integrated Climate Land Use Scenarios (ICLUS)
  - Regional scale model, available for conterminous US, 10 year increments, 4 IPCC adaptation scenarios plus baseline
- Develop our own?
  - Cellular automata, econometric…..

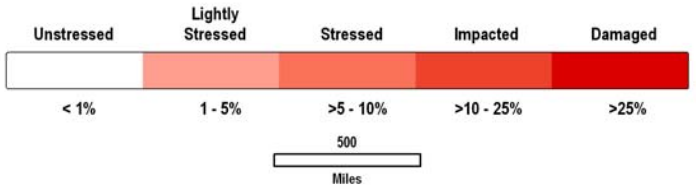
ICLUS Improvements & Additions

- Modify commercial/industrial land uses
  - conversion to and conversion from
- Regionalize housing density patterns
- Add mass transit
  - changes functional connectivity and influences growth patterns
- Update and validate migration data
  - IRS database on county to county movements from 1984 to 2007
- Update amenity data and change climate variables over time



ICLUS - Estimated percent impervious surface cover for two scenarios in 2100





Global Change Program is planning fall workshop to talk about how to bring in extreme events, reflect finer scales, possibly include SLAMM

N Questions for Place-based studies

- **What is the dominant source(s) of anthropogenic nitrogen in a placed-based location and why is it there (e.g., for CC CAFOs)?**
- **What service(s) are being the most compromised by that source of anthropogenic nitrogen?**
- **What is the spatial distribution of the service(s) that contributes to nitrogen loading and the service(s) that is compromised by excess nitrogen?**

CC Nitrogen and nutrient cycling

- focus of will be on three major drivers of change to ecosystem services:
- 1) The delivery of nutrients to local estuaries and changes in phytoplankton production and composition in response to sea level rise and different precipitation patterns associated with climate change;
- 2) demographic shifts associated with increasing human populations along the coast; and
- 3) changing land use in the coastal plains associated with increased agricultural production for biofuels.
- Nr research within Coastal Carolinas will characterize nutrient loading to the Albemarle-Pamilico Sound System from local and upstream watersheds, identify Nr–related ecosystem services, and the interaction of services and nutrient loading in response to sea level rise and population dynamics.

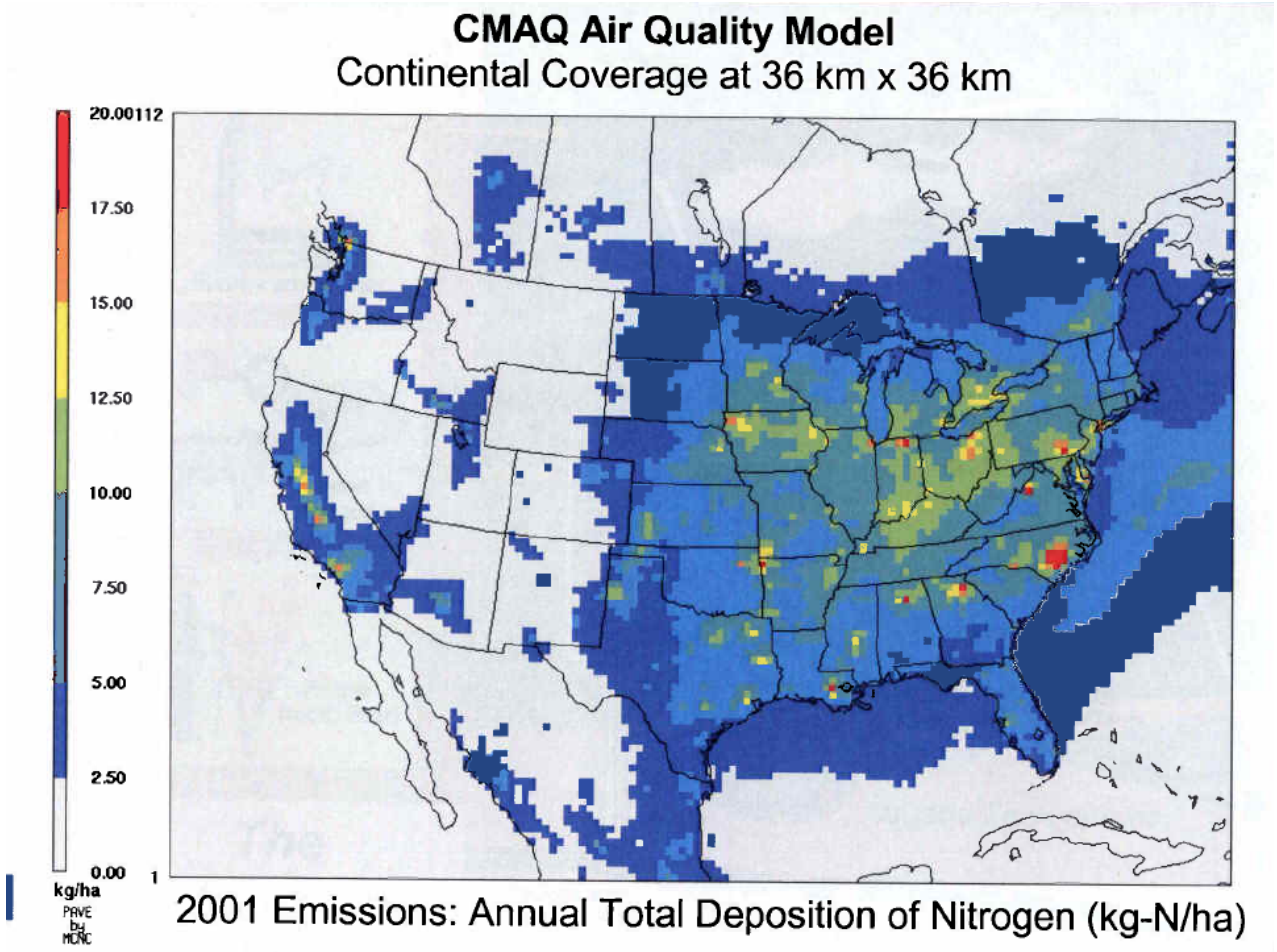
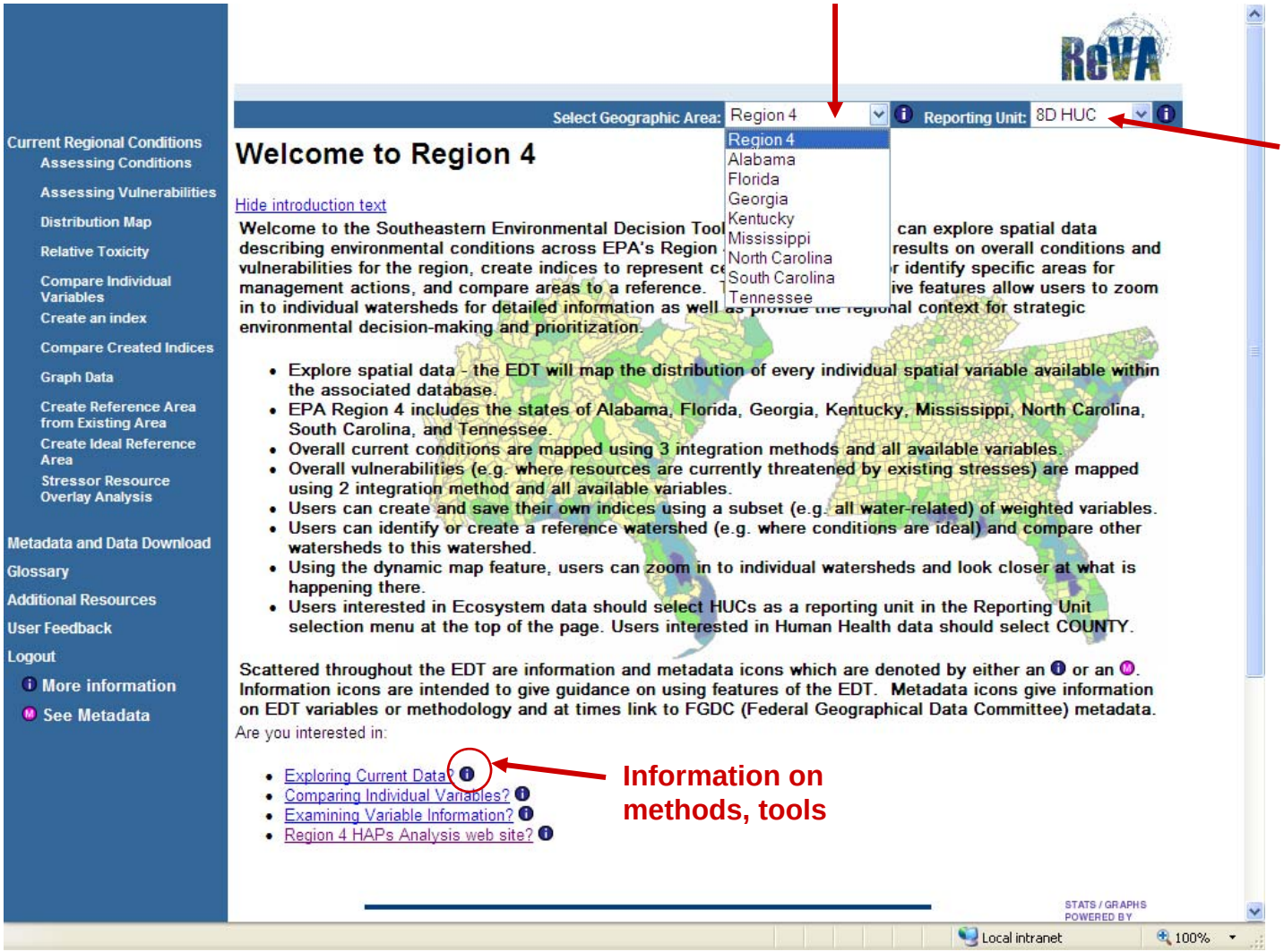


Figure 2: Nitrogen deposition over the continental US in 2001. Note the increased concentrations over coastal North Carolina (www.epa.gov/asmdnerl; Worthy, 2007).

Major Coastal Ecosystem Outputs

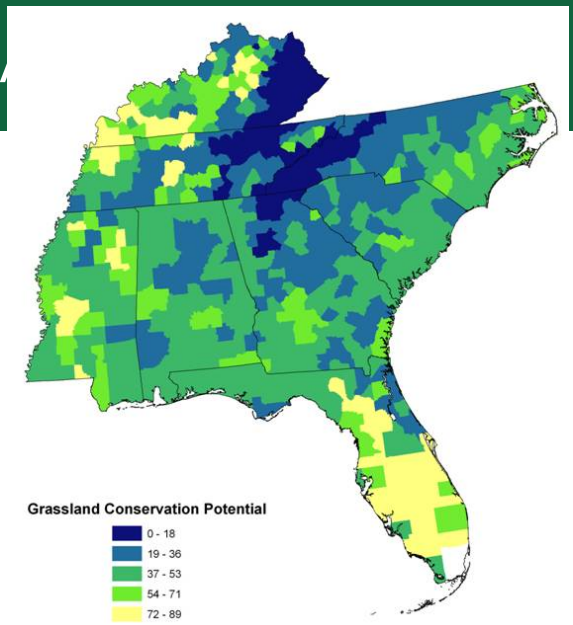
- Maps of existing coastal ecosystems and services,
- Maps emphasizing areas of potential impact from human demographic changes and climate change
- Maps of areas of potential mitigation value for offsetting impacts from human demographic changes and climate change
- Inventory of services with emphasis on those most vulnerable to climate change and demographic changes
- Metrics for estimating the full value of the services provided by coastal ecosystems
- Decision support system

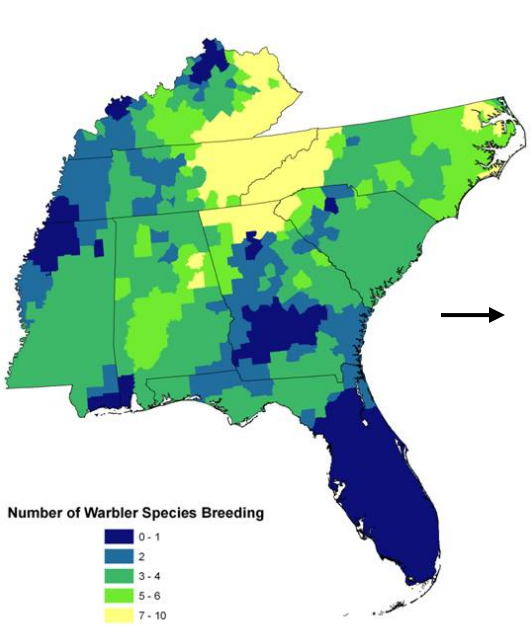
Continuing Development of Southeastern Environmental Decision Toolkit (EDT)

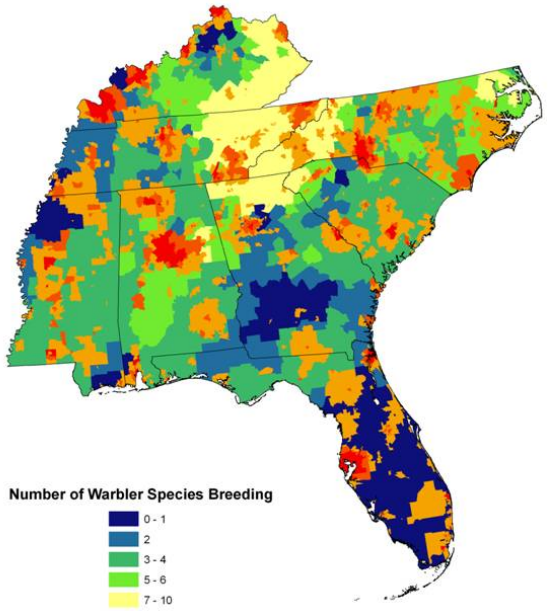


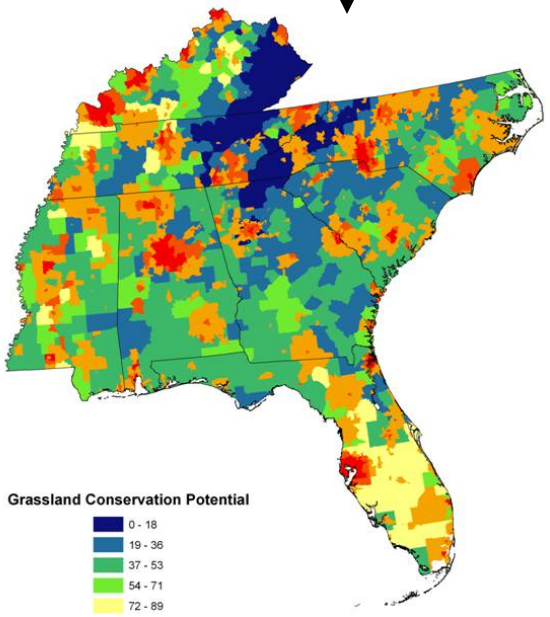
ReVA work in Southeast

- **Initiated as Vulnerability Assessment of Ecological and Human Populations to Hazardous Air Pollutants**
- **Collaboration with SE Regional Gap Analysis Program and TNC**
- **Combined point sources of HAP emissions with T&E species locations, modeled migratory bird stopovers, available habitat for sensitive guilds of species, and FWS SCRAM scores for individual species/HAP toxicities**
- **Purpose – early warning and targeting for management**



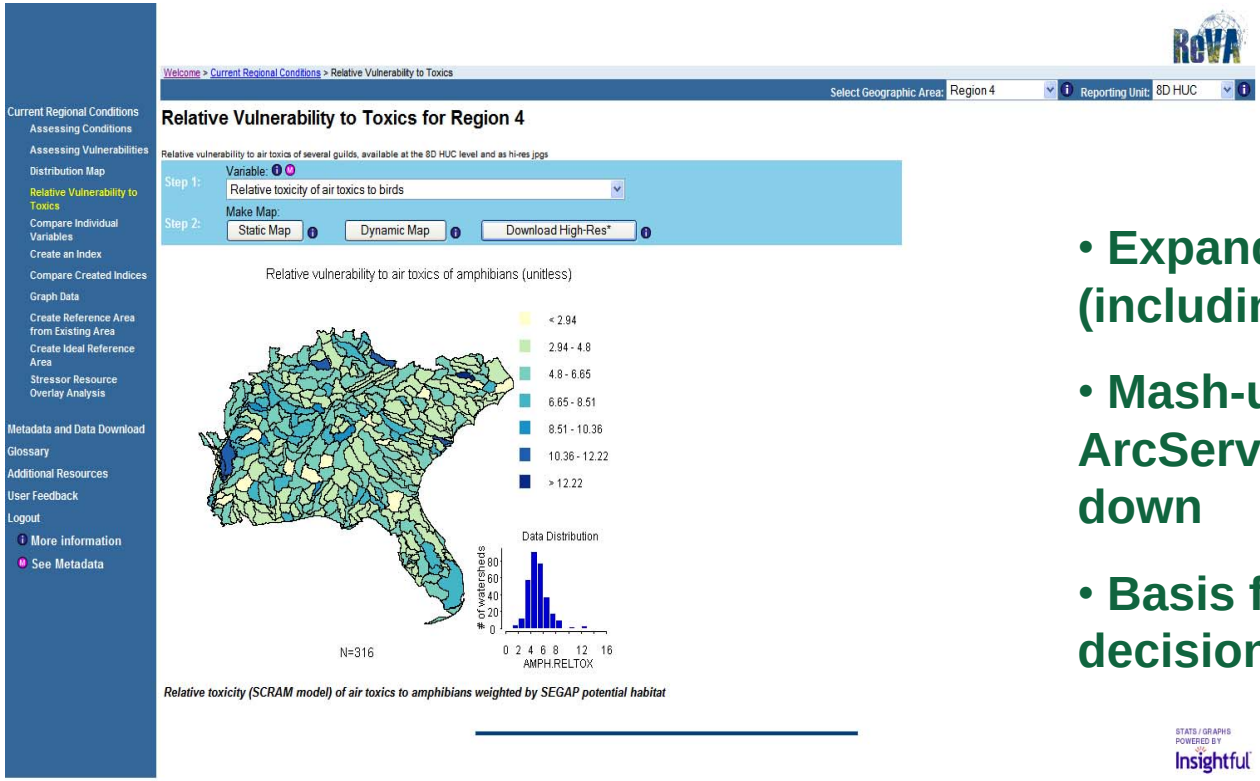






Continuing Development of Southeastern Environmental Decision Toolkit (EDT)

http://www.waratah.com/region4edt revaguest/anonymous

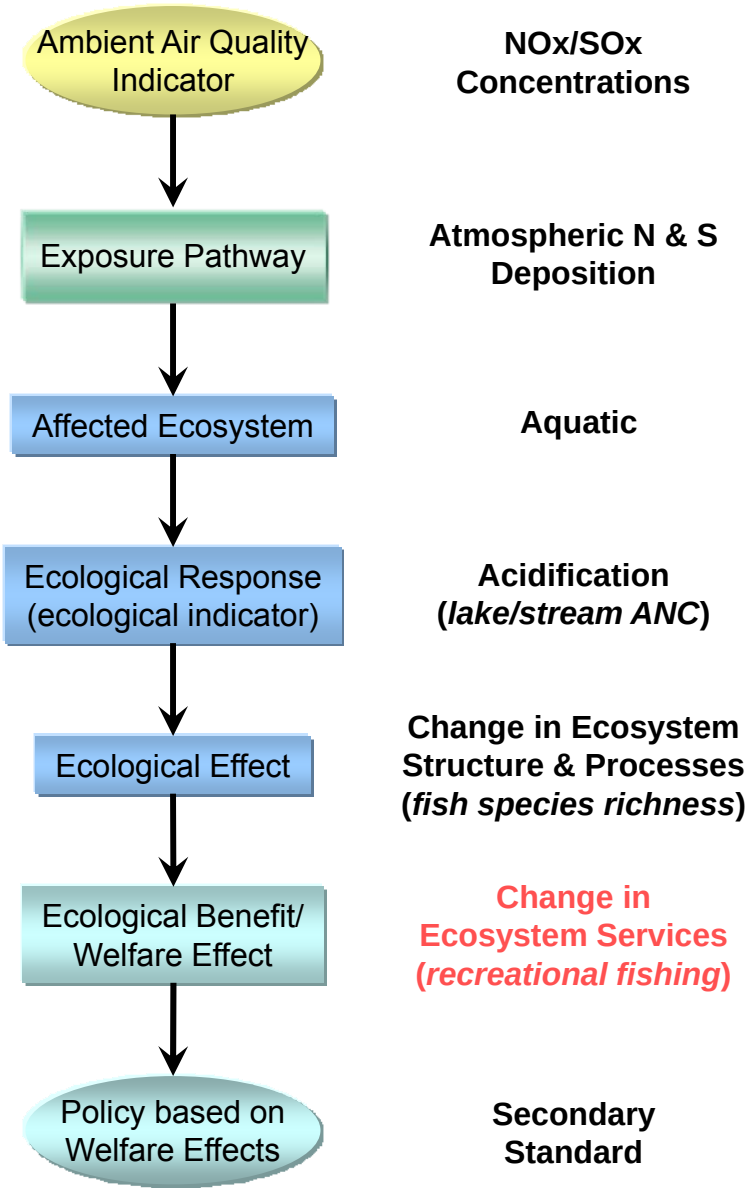


- **Expanded list of metrics (including ecosystem services)**
- **Mash-up between SPlus and ArcServe to allow detailed drill-down**
- **Basis for Coastal Carolinas decision toolkit**

Use of Ecosystem Services in EPA Reg Review

- **Ecosystem Services used in the NOx/SOx Secondary National Ambient Air Quality Standard Review**
  - **First multi pollutant NAAQS**
  - First Review under 2009 revised NAAQS process
  - **Ecosystem services used in the draft NOx/SOx Risk and Exposure Assessment (Being reviewed by CASAC today 7/22/09 and tomorrow)**

Conceptual Model for a Secondary Standard



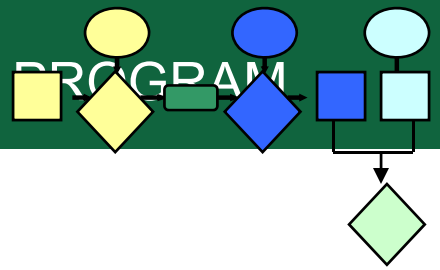
Ecosystem Services NO_x & SO_x

- **Supporting:**
  - Acidification: biomass production, nutrient cycling, water cycling, biodiversity
  - Nitrogen Enrichment: nutrient cycling, biodiversity

- **Provisioning:**
  - Acidification: fish (food), forest growth (fiber)
  - Nitrogen Enrichment: forest yields, fishing yields

- **Regulating:**
  - Acidification: water quality
  - Nitrogen Enrichment: climate (e.g. C sequestration, N_2O emission, CH_4 flux, water quality), water quality, fire frequency and intensity,

- **Cultural:**
  - Acidification: sport fishing, forest aesthetics
  - Nitrogen Enrichment: swimming, boating, biodiversity



Guidelines for Reviewing a Secondary NAAQS

- Are current standards requisite to protect against known or anticipated adverse effects?

- Standard based on the presence of the criteria pollutant in the ambient air and associated with known or anticipated adverse effects to public welfare
  - NO_x/SO_x effects due to deposition
  - Goal of Risk and Exposure Assessment (ESA) to show the relative risks to NO_x/SO_x pollution in sensitive ecosystems
  - REA examines total reactive N as well as relative importance of oxidized vs. reduced N
  - Role of ecosystem services

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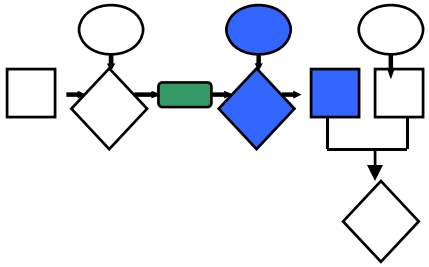
Ecological Analyses

Four targeted effect areas:

- Aquatic Acidification
- Terrestrial Acidification
- Aquatic Nutrient Enrichment
- Terrestrial Nutrient Enrichment



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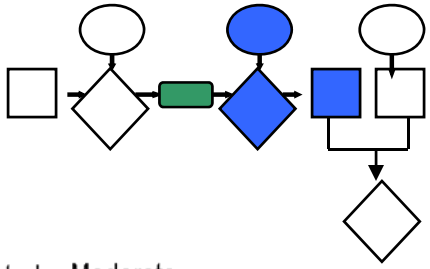
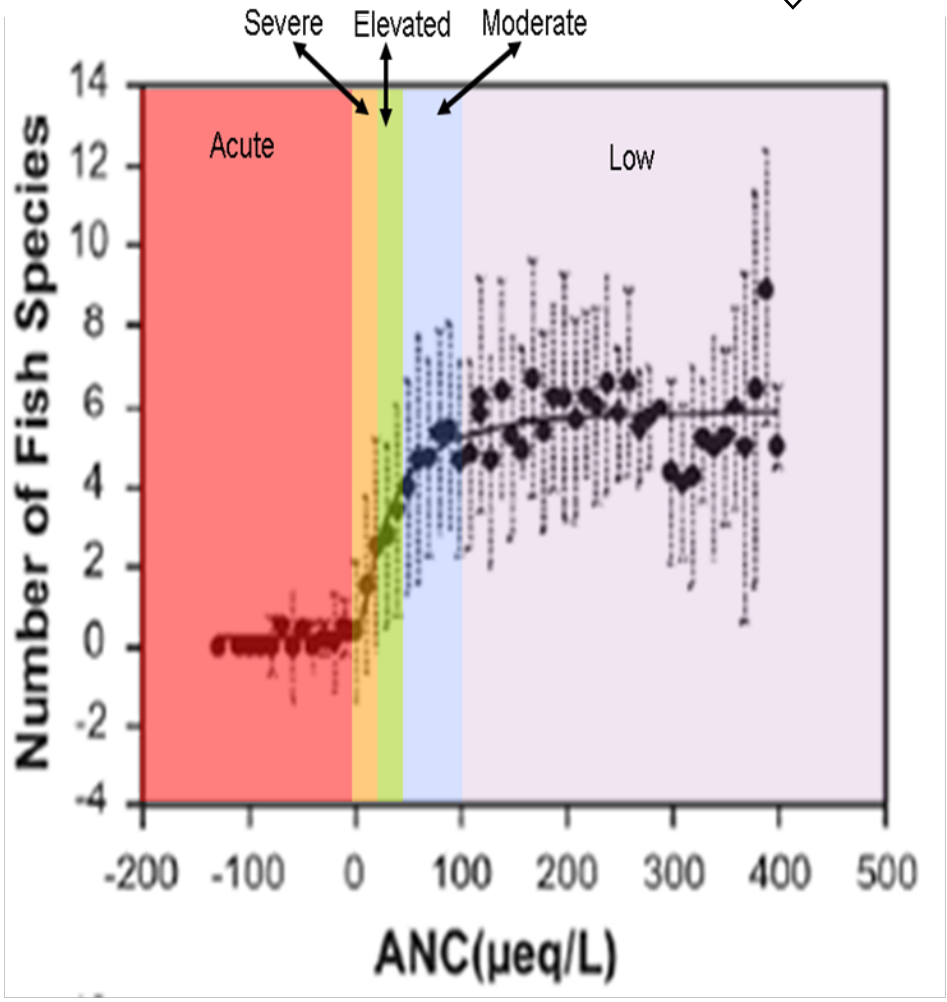
Aquatic Acidification



- Ecological Indicator
  - Acid Neutralizing Capacity (ANC) of surface waters
  - Best single indicator of biological response and health of aquatic communities in acid-sensitive systems
  - Lower ANC is 'bad', higher ANC is 'good'
- Ecosystem Services Affected
  - Recreational fishing
  - Fish species richness
  - Biodiversity



Source: Sullivan et al., 2006

Aquatic Acidification & Ecosystem Services

- Quantified Services
  - Recreational fishing (WI - ME)
    - More than 9% of adults fish
      - Results in 140.8 million activity days
      - Source: National Survey of Fishing, Hunting and Wildlife Associated Recreation (NFHWAR; U.S. Census Bureau, 2006)
      - $35.91/day in 2007 dollars (Kaval and Loomis, 2003)
      - Implied total annual value in NE = $5.06 billion
- Non-Quantified Services
  - Subsistence Fishing
  - Biologic Control
  - Hunting and Birdwatching
  - Aesthetic and Educational services

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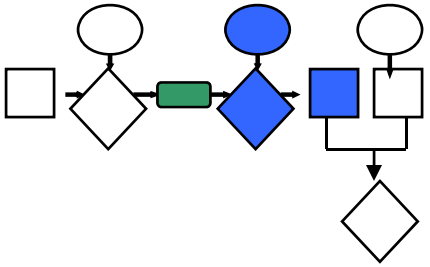
Terrestrial Acidification



- Ecological Indicator:
  - Base cation to Aluminum ratio in soils (0.6, 1.2, 10)
  - Effects on tree growth (sugar maple, red spruce)
- Case Study Locations:
  - Hubbard Brook Experimental Forest (NH)
  - Kane Experimental Forest (PA)
  - Scaled up to 24 states and correlated with Forest Service Forest Inventory Analysis database
- Current Conditions:
  - Used Critical Load analysis on tree plots
  - % Exceedance for sugar maple: 3-75% (n=4,992 plots, 24 states)
  - % Exceedance for red spruce: 3-36% (n=763 plots, 8 states)
- Ecosystem Services Affected:
  - Wood products, maple syrup production
  - Recreation, threatened and endangered species habitat

Terrestrial Acidification & Ecosystem Services

- Provisioning
  - 19% world maple syrup production; $157-168 million
  - 900 million board ft of sugar maple; 328 million board ft red spruce harvested
  - Modeled annual value of increased sugar maple volume = $1.64 million
- Cultural
  - > 30% visit wilderness areas; > 30% participate in day hiking
  - 83,821 hunting days; 122,200 wildlife viewing days
  - 22% of Vermont tourism for purpose of fall color viewing

Source: National Survey of Fishing, Hunting and Wildlife Associated Recreation (NFHWAR; U.S. Census Bureau, 2006)

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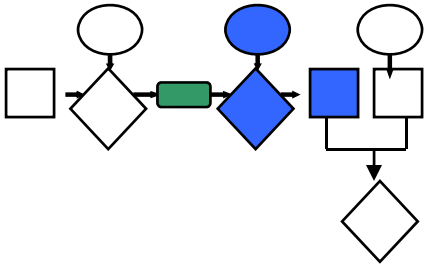
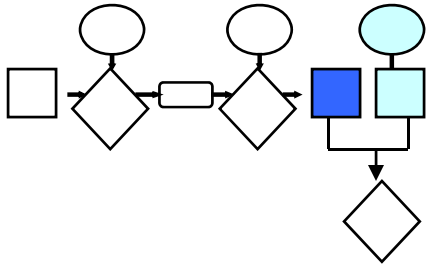
Aquatic Nutrient Enrichment



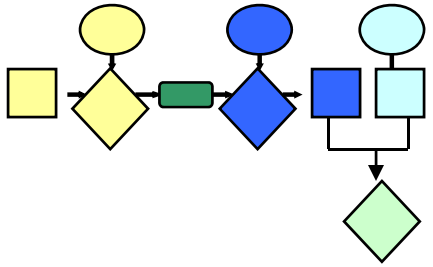
- Case Study analyses in the Potomac and Neuse Estuaries showed that reductions in atmospheric deposition alone would not solve coastal eutrophication problems due to multiple non-atmospheric inputs
- Rocky Mountain National Park
  - Studies show a strong relationship between aquatic eutrophication in high alpine lakes due to atmospheric deposition (sole source of N)
- **Ecosystem Services Affected:**
  - **Commercial and residential fishing**
  - **Recreation (boating & beach use) and housing prices**

Aquatic Nutrient Enrichment & Ecosystem Services



- Provisioning
  - 2007 commercial landings blue crab and striped bass $69 million (Chesapeake)
- Cultural
  - Recreational Fishing
    - 26.1 million activity days (NC-MA)
    - In analysis for Chesapeake estimated annual aggregate benefit 259.6 million (zero-out)
  - Other
    - 273 million activity days for motorboating, birdwatching and nonbeach coastal visits (NC-MA)
- Aesthetic
  - Housing values
- Nonuse

Issues for Next Review



- Relationships between ecosystem services and ecological indicators
  - Have we chosen adequate indicators, are there more appropriate ones?
  - What bundles of ecosystem services are associated with these ecological indicators?
- Quantification of incremental changes in the level of an ecological indicator
  - What's the impact of an ANC of 20 or 50 or 100 on an ecosystem service or on bundles of ecosystem services?
- Critical Loads:
  - Understand the relationships between critical loads for acidification and effects on ecosystem services
- Total Reactive Nitrogen
  - Is there a case for listing reduced nitrogen as a criteria pollutant?
- Relationship between deposition and ambient concentrations
  - Developing trade off curves for multi-pollutant standards
- Lots more…
  - Monitoring locations, monitoring NOy
  - Need for nationwide weathering rates
  - Further refine deposition estimates for wet and dry deposition for multiple species nationwide (issues of scale, terrain, etc.)

ESRP and EPA

- Increased recognition of ecosystem services within EPA Program Offices
- Office of Air and Radiation using ES in NOx/Sox secondary standards
- Office of water interested in using for wetlands, watershed management, National estuaries. Wetlands looking forward to better maps of national wetlands and services related to condition of wetlands
- Created new opportunities for Regional participation: Regional Environmental Monitoring and Assessment Program redirection

EPA ESRP contributions to EBM

1. Nature's Services – Quantifying services

2. Scientific Evidence- developing science to understand processes that generate services

3. Geographic Scales- **5 specific areas**

4. Ecological linkages- developing impacts of stressors/alternative management on ecosystems and services, and condition and ES

EPA ESRP contributions to EBM

5. Cumulative impacts- **evaluating ES under different scenarios – environmental and socioeconomic**

6. Tradeoffs among human activities- **developing decision support tools that can evaluate and quantify alternative scenarios**

7. Adaptive Management- **some monitoring – but not for management impacts**

8. Network of people and information- **in place based projects holding public meetings to determine values and goals for services and communicate**

Contacts

Ecosystems Services Research Program

Rick Linthurst, National Program Director

919-541-4909; linthurst.rick@epa.gov

National Mapping Project

Annie Neale, 919-541-3832, neale.anne@epa.gov

Wetlands Assessment Project

Janet Keough, 281-529-5025, keogh.janet@epa.gov

Coral Reefs Project

Bill Fisher, 850-934-9394, fisher.william@epa.gov

Coastal Carolinas Project

Deborah Mangis, 919-541-3086 mangis.deborah@epa.gov

Regional Vulnerability Assessment Program

Betsy Smith, 919-541-0620, smith.betsy@epa.gov

NOx/Sox secondary NAAQS

Anne Rea, 919-541- 0053 rea.anne@epa.gov

ICLUS Development (Global Change Program)

For More Information:

EPA's Environmental Science Connector: http:portal.epa.gov

Individual Projects Sites for ESRP, Nat'l Mapping, Wetlands, Coral Reefs, Coastal Carolinas….