Mapping and the National Atlas of Ecosystem Services (NAtl-ES)

Annie Neale
Office of Research and Development
US EPA

Science Advisory Board Presentation
Environmental Processes and Effects Committee

July 14th, 2009
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EPA Mapping Team Members and Contributors

Jim Wickham
Don Ebert
Ric Lopez
Jay Christensen
Megan Mehaffey
Tim Wade
Taylor Jarnagin
Caroline Erickson
Ann Pitchford
Deb Chaloud
Dave Bradford
Bill Kepner
Paula Allen
Maliha Nash
Yongping Yuan
Nita Tallent-Halsell
Drew Gronewold
Michael Jackson

Drew Pilant
John Richardson
Robin Dennis
Ellen Cooter
Mark Johnson
Jana Compton and Nitrogen Team
Janet Keogh and Wetlands Team
Jeff Hollister
Paul Mayer
Tim Canfield
Jim Omernik
Steve Jordan
Hal Walker
Chuck Lane
Laura Jackson
Anne Rea

Expert (Special EPA Employee)
Dr. Charles Vörösmarty, CUNY

Goals of the ESRP Landscape Characterization and Mapping Theme

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

↕

To develop a publicly accessible and scalable National Atlas of Ecosystem Services in order to inform decision-making

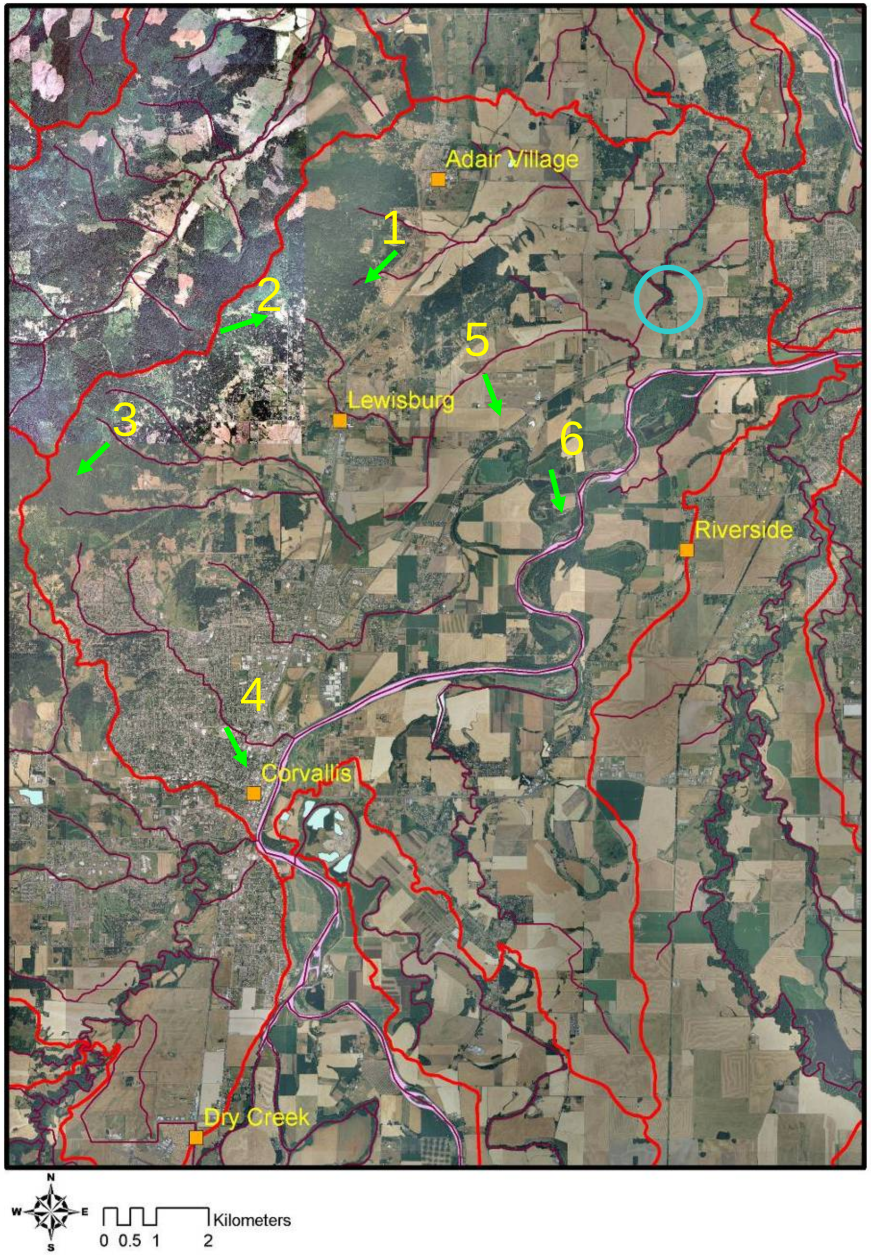
Vision for the National Atlas of Ecosystem Services

How many ecosystem services can you visualize in this image?

Imagine the flow of services into and out of this area

Now, imagine summarizing all of this somehow and mapping for nation!

Location, Location, Location!
(Spatial Pattern Matters)



Implementation Strategy embodies these principals:

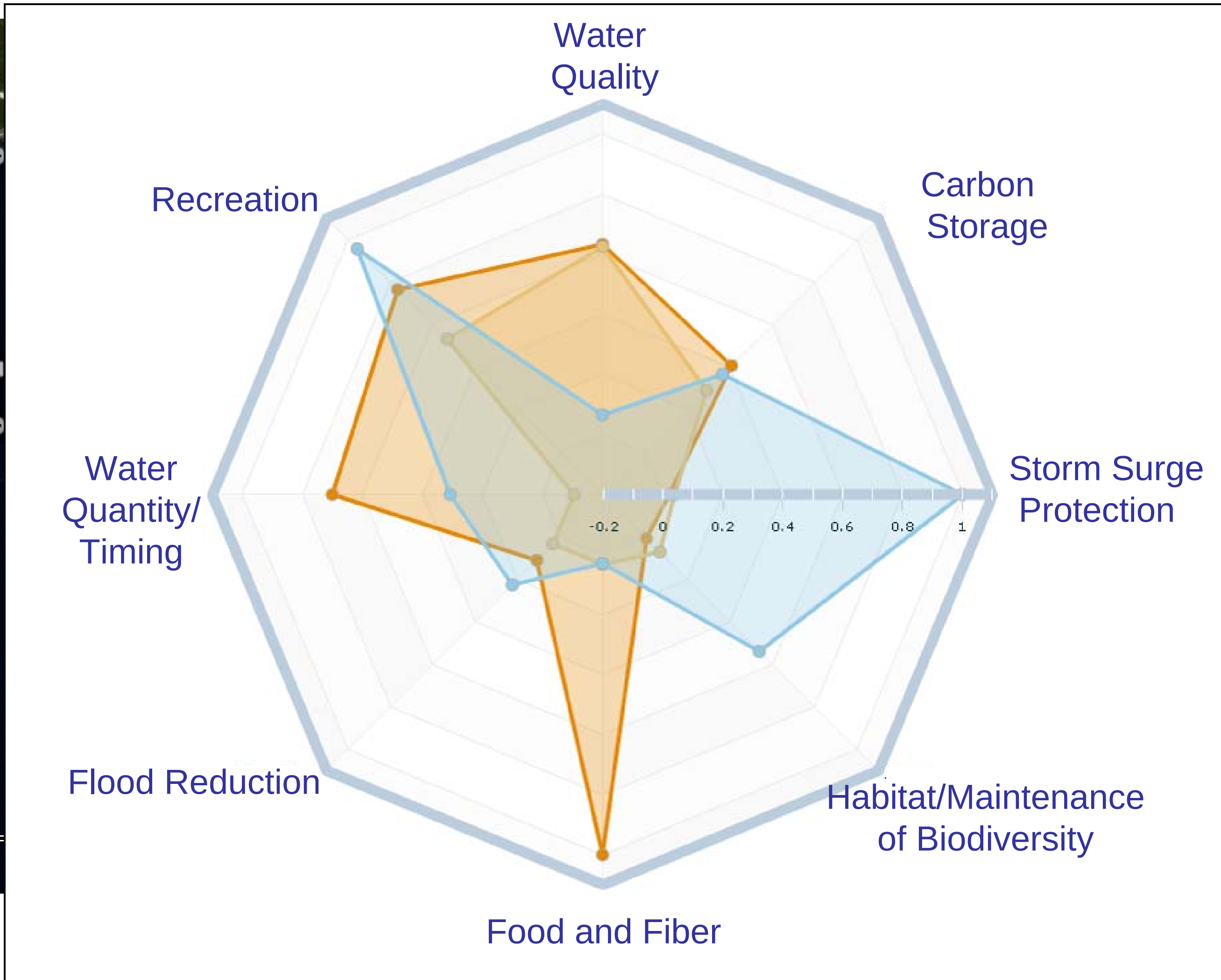
- Reliance on existing data, literature, models and tools while conducting additional research and keeping eye on future developments
- Emphasis on interaction with other ESRP projects and themes -- critical for linking functions to services
- Reliance on extramural participation
- Staged Implementation

What have we been up to? Presentation Outline

- Atlas Demonstration
- Partnership Development
- Ecosystems Services Indicators Calculation
- National Data Set Development
- Ecosystem Services Mapping Research

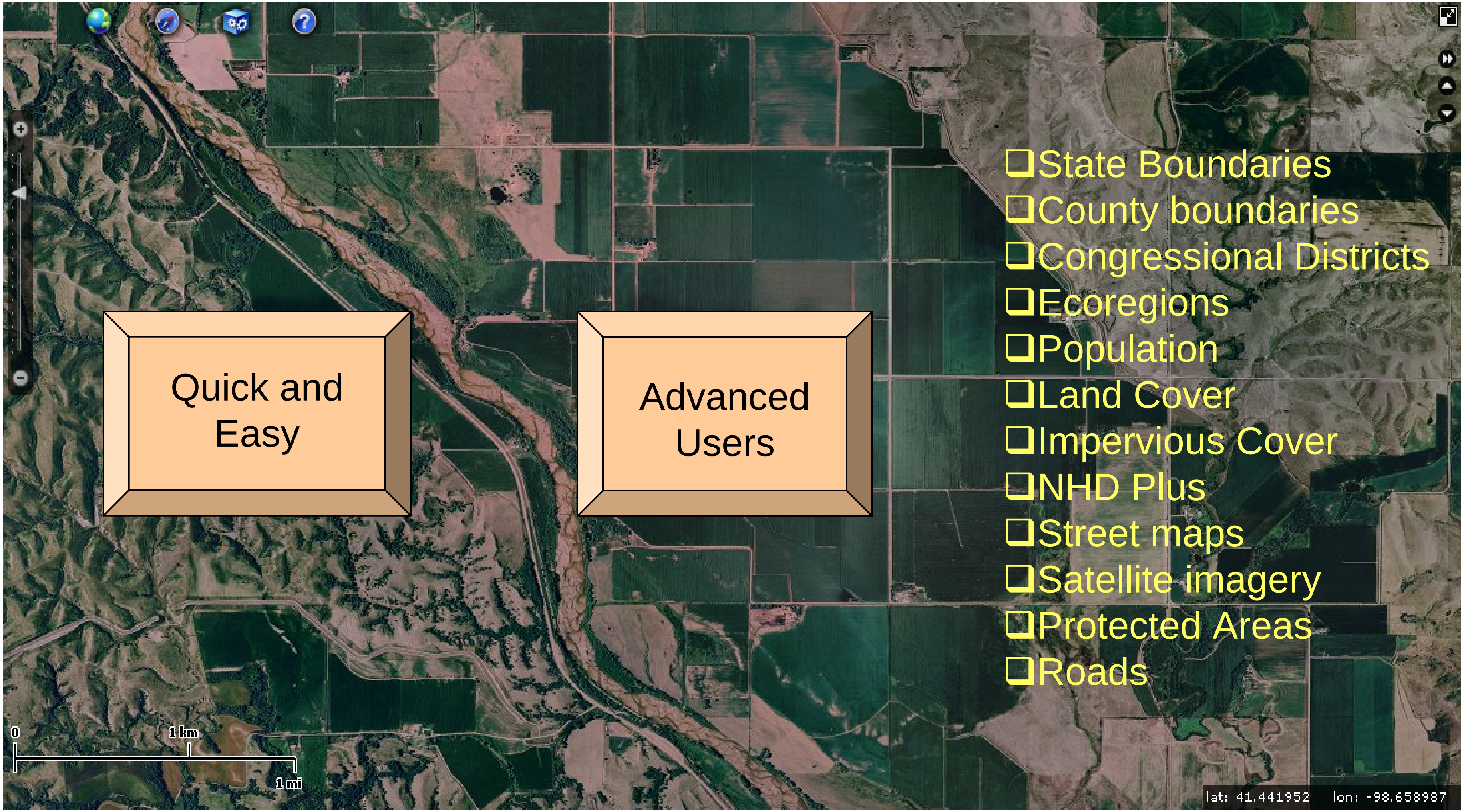
Atlas Demonstration Project

Atlas Demonstration -- Vision

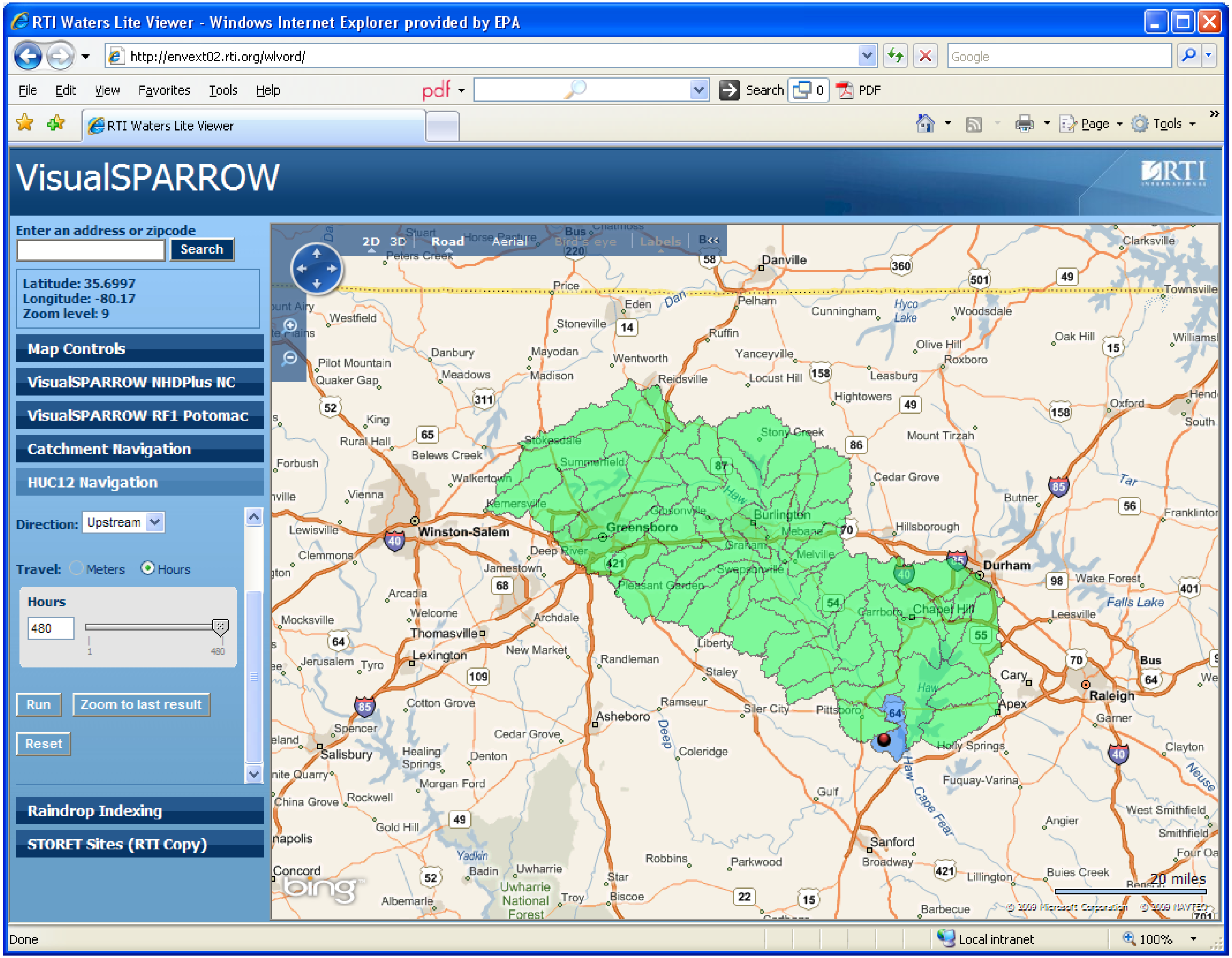


- **User will zoom to geographic area**
- **Contain series of background maps**
- **Select ecosystem services from Table of Contents**
- **Scalable**
- **Include change and future scenarios**
- **Allow analysis of multiple services**
- **Allow user to place their “area” in context of others**

Atlas Demonstration -- Vision

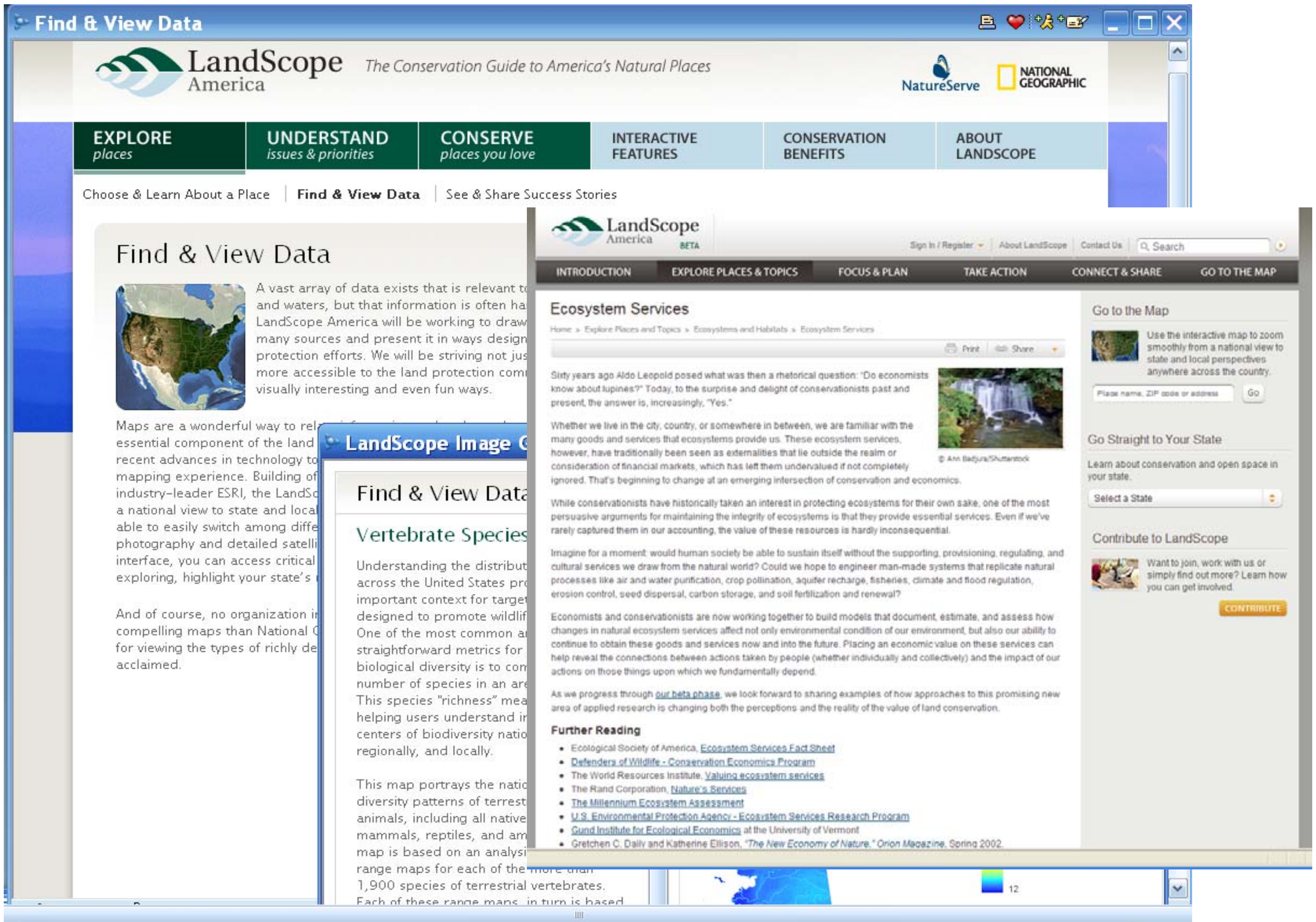


Atlas Demonstration -- Vision



Maintain upstream/ downstream connectivity

Atlas Demonstration



www.landscope.org

Partnership Development

Partnership Development

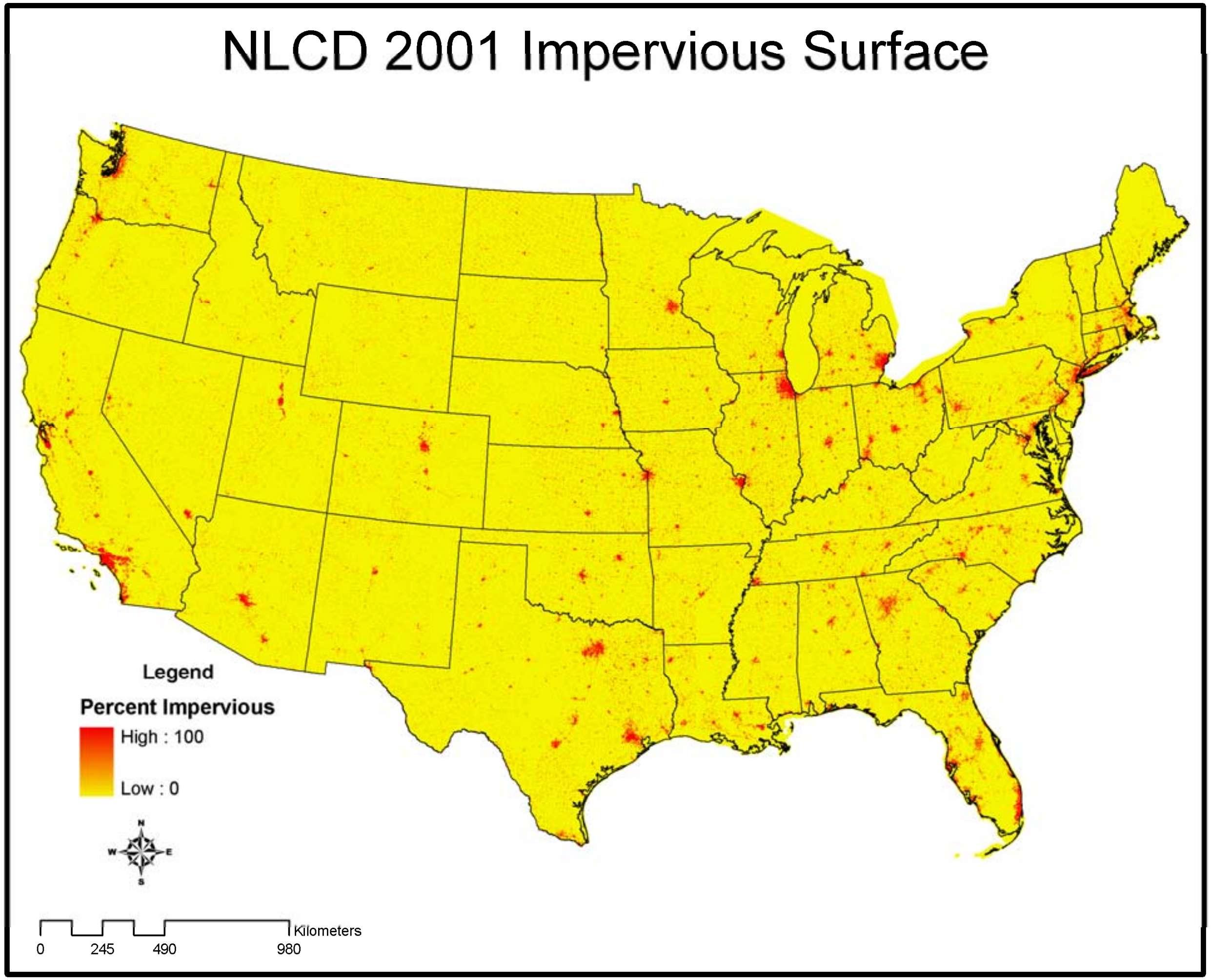
Vision of a National Atlas of Ecosystem Services Consortium

National Geographic, Frank Biasi
NatureServe, Kyle Kopas
GAP, USGS, Kevin Gergely
USGS, Geography, Roger Sayre
USGS, EROS Data Center
USGS SPARROW Group
USDA, USFS, David Nowak
USDA, USFS, David Wear
USDA, NASS, Rick Mueller
USDA, FSA, Rich Iovanna
Natural Capital Project
NRCS, Sharon Waltman
NCEAS
NOAA CREST

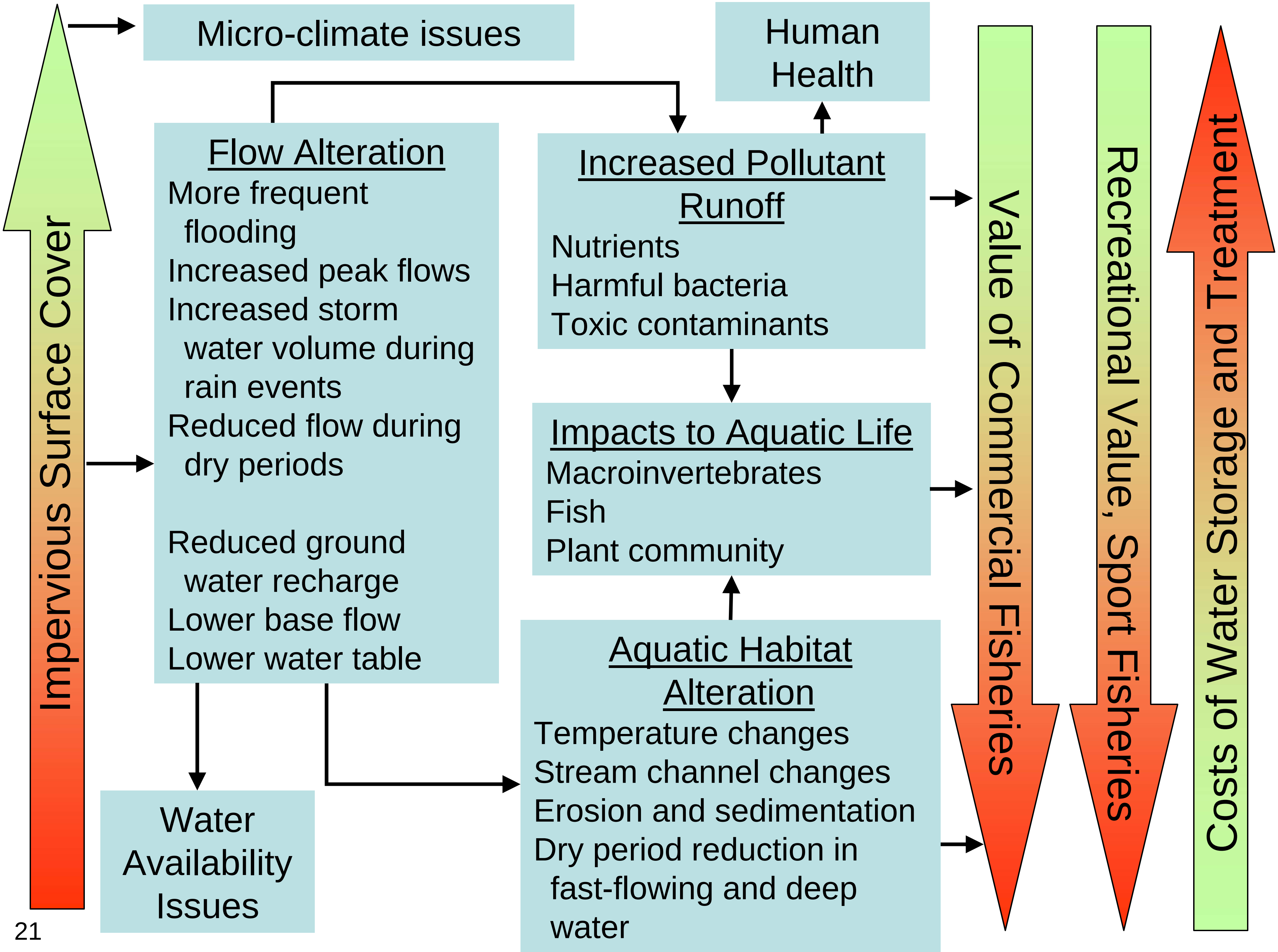
CUNY Environmental Cross-Roads Initiative
Iowa State University
UC Santa Barbara, Bren School of the Env.
University of Maryland
Duke University
Arizona State University
Rutgers University
University of Kiel

Ecosystem Services Indicators Calculation

Ecosystems Services Indicators Calculation

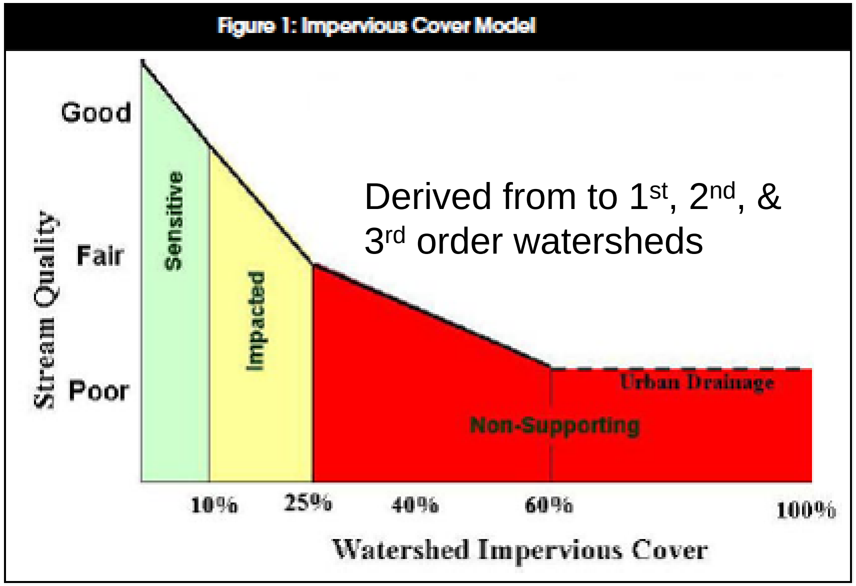


Don Ebert


Impervious Surface Cover
Micro-climate issues
Human Health
Flow Alteration
More frequent flooding
Increased peak flows
Increased storm water volume during rain events
Reduced flow during dry periods
Reduced ground water recharge
Lower base flow
Lower water table
Increased Pollutant Runoff
Nutrients
Harmful bacteria
Toxic contaminants
Impacts to Aquatic Life
Macroinvertebrates
Fish
Plant community
Aquatic Habitat Alteration
Temperature changes
Stream channel changes
Erosion and sedimentation
Dry period reduction in fast-flowing and deep water
Water Availability Issues
Value of Commercial Fisheries
Recreational Value, Sport Fisheries
Costs of Water Storage and Treatment

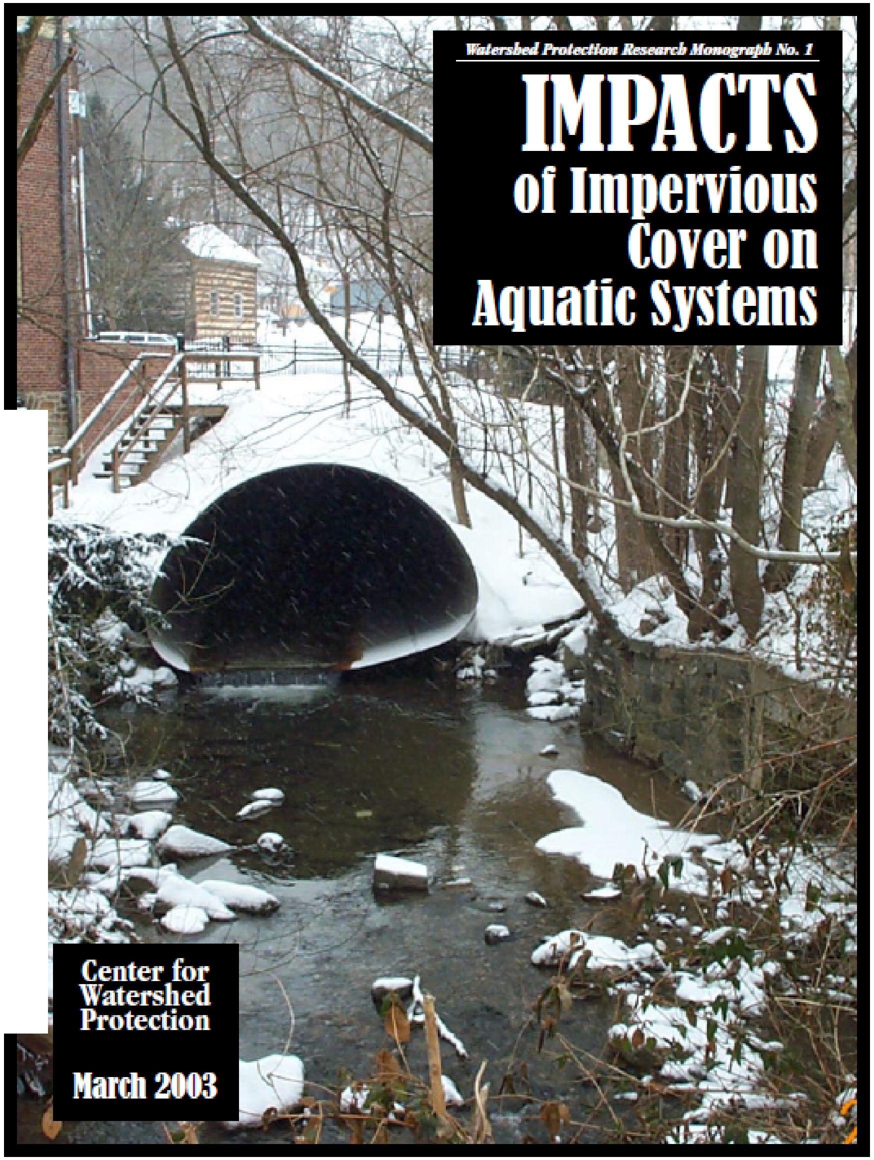
Landmark document published by Center for Watershed Protection in 2003

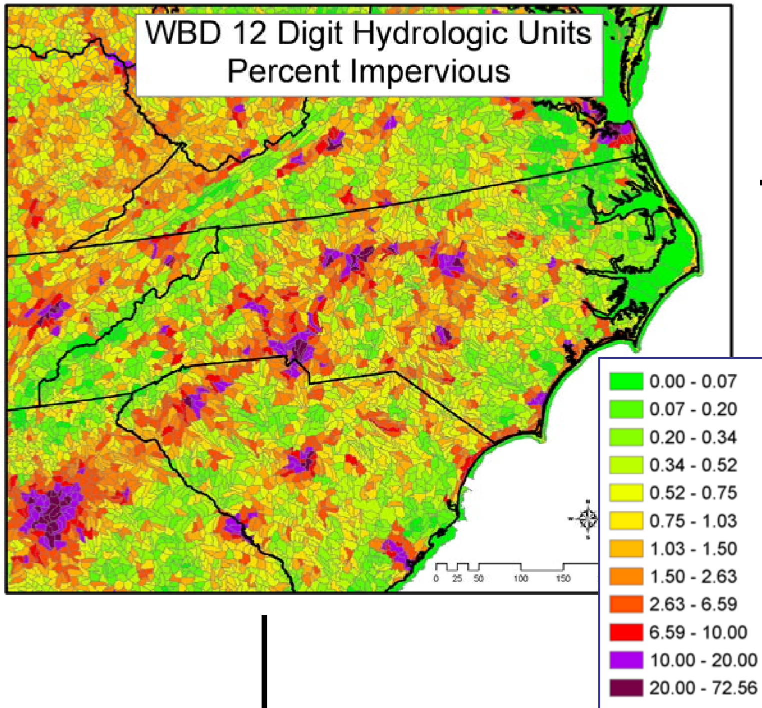
Reviewed and summarized 225 articles relating **impervious cover** to changes in hydrologic, physical, water quality or biological indicators of stream health

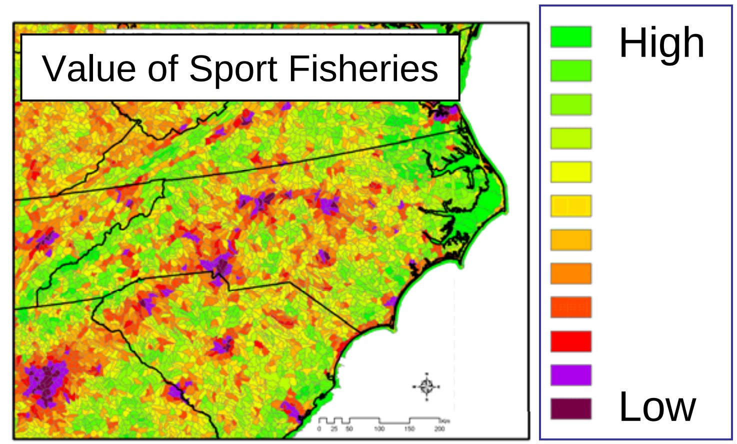


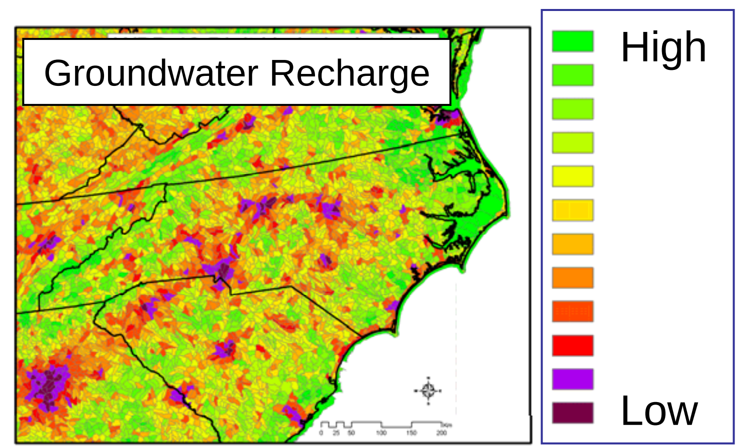
Derived from to 1st, 2nd, & 3rd order watersheds

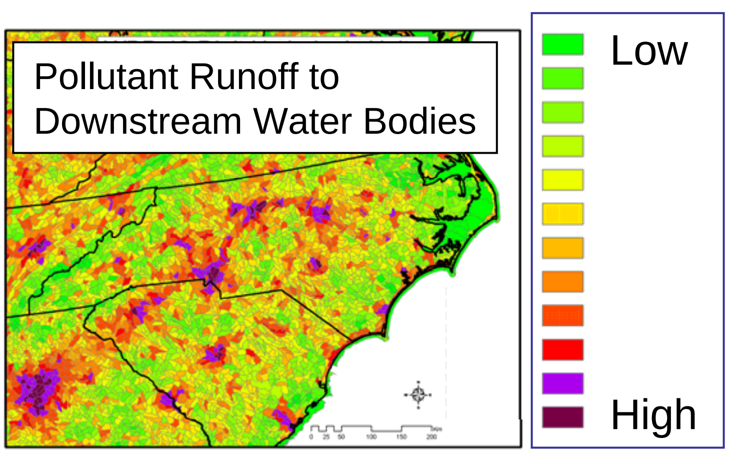
Schueler, 1994



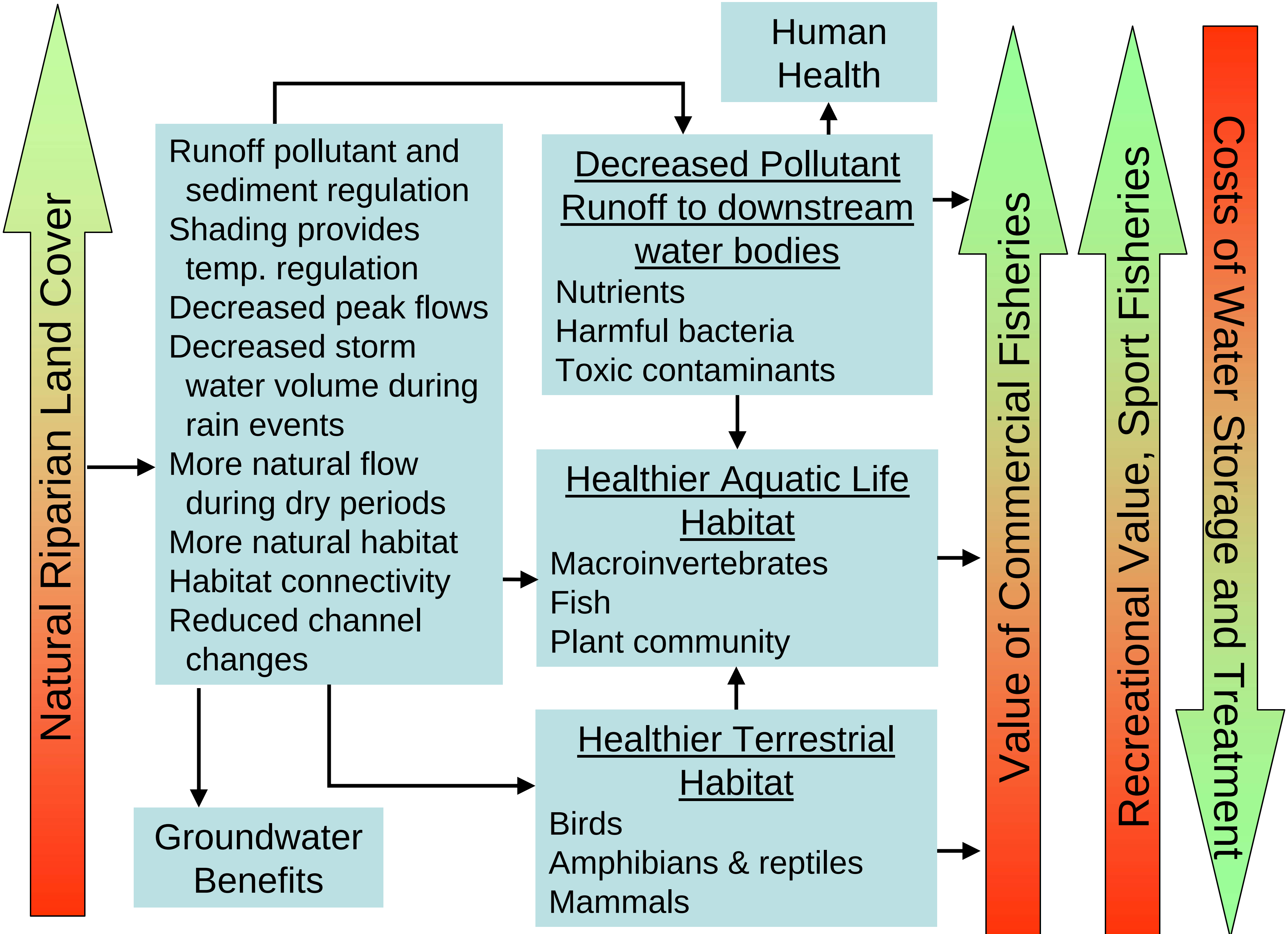


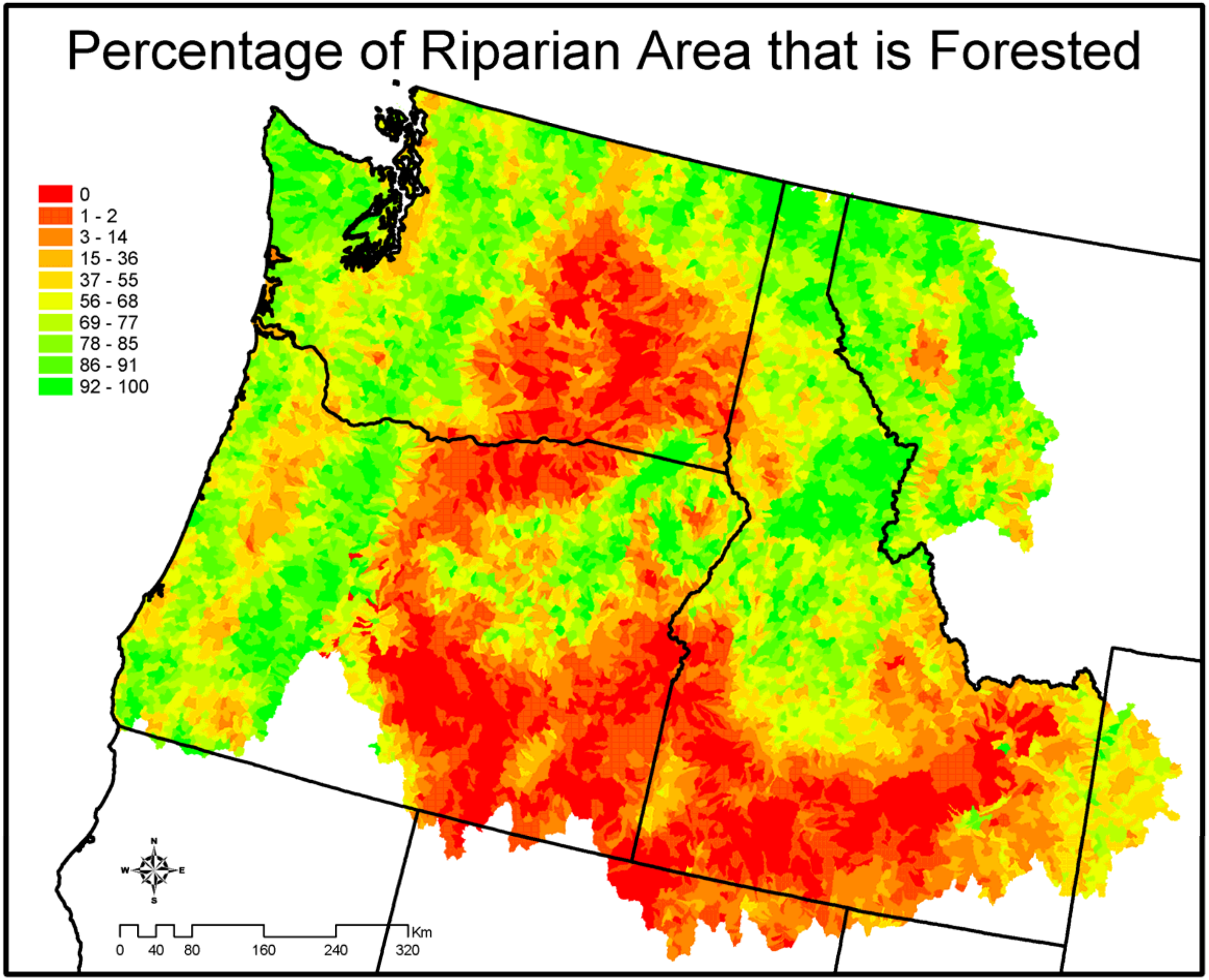






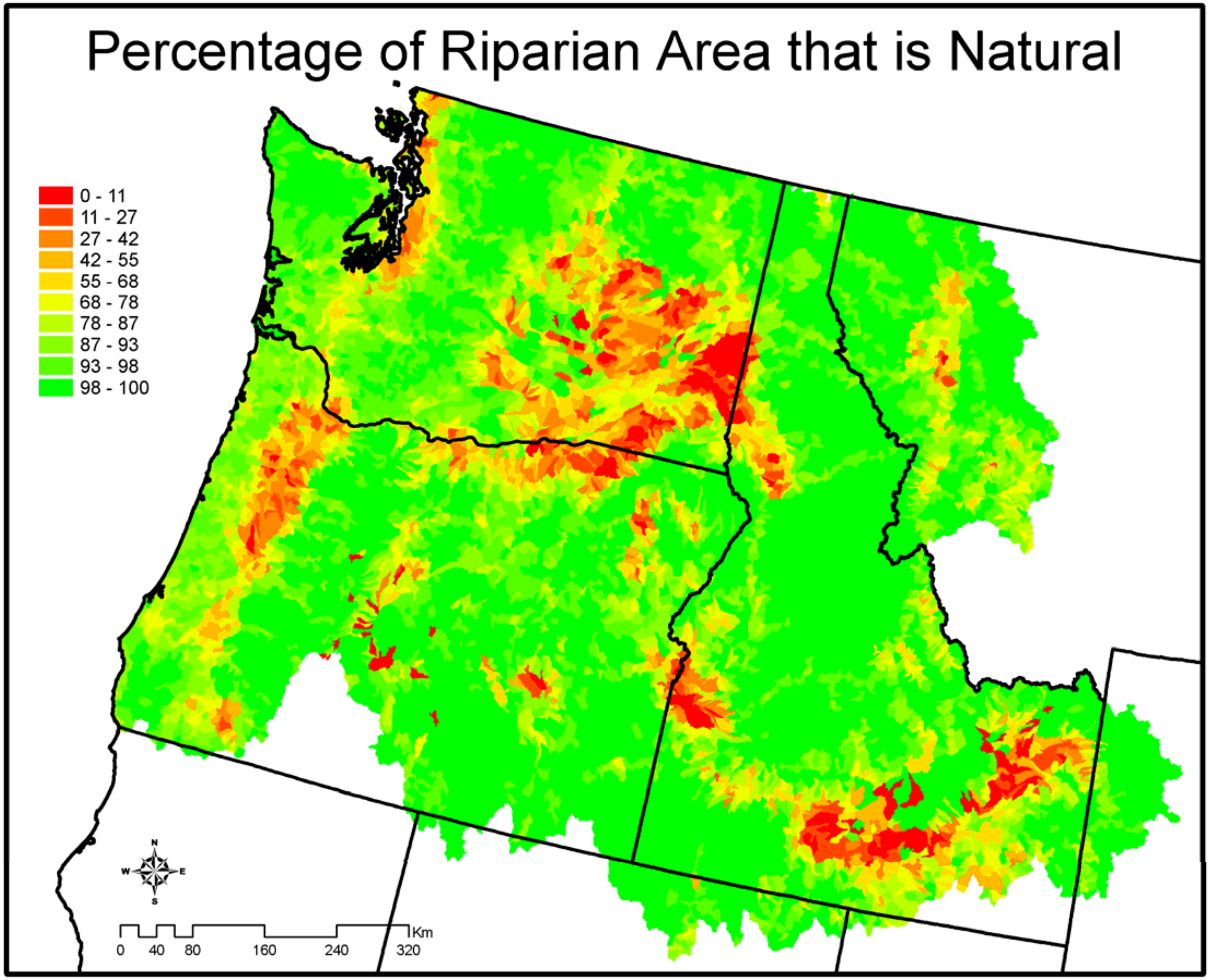
- Mock-up: Actual values for services will vary depending on biogeophysical settings (e.g., Omernik’s Ecoregions)


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
Groundwater Benefits
Human Health
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
Value of Commercial Fisheries
Recreational Value, Sport Fisheries
Costs of Water Storage and Treatment



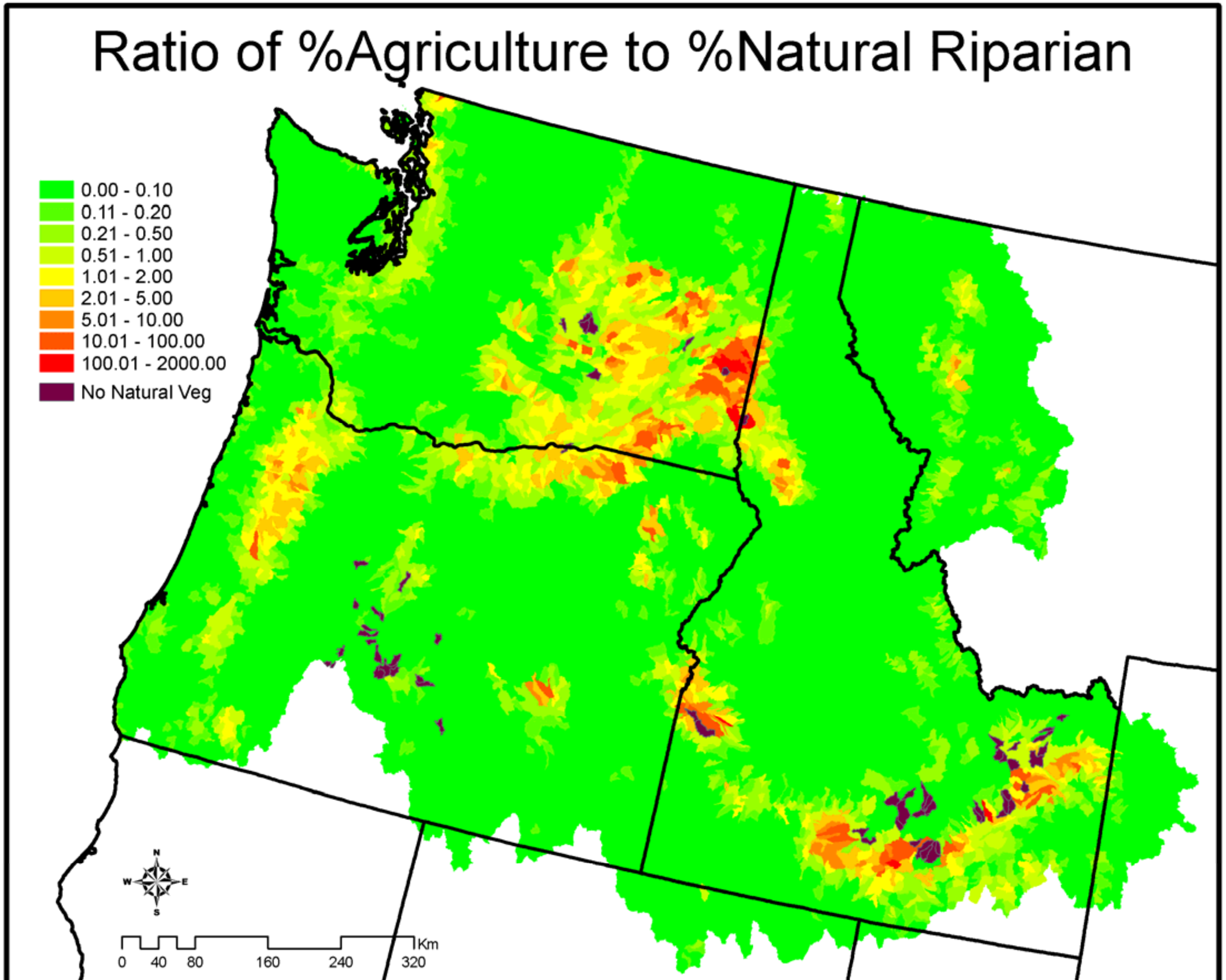
30 m buffer size

Don Ebert



General indicator for multiple ecosystem services

Don Ebert


Ratio of %Agriculture to %Natural Riparian
0.00 - 0.10
0.11 - 0.20
0.21 - 0.50
0.51 - 1.00
1.01 - 2.00
2.01 - 5.00
5.01 - 10.00
10.01 - 100.00
100.01 - 2000.00
No Natural Veg
N
W
E
S
Km
0
40
80
160
240
320

Don Ebert

National Data Set Development

Development Of National Data Sets Key To Mapping Ecosystem Services

- Soils Data – 30 m grids of soils variables for nation, joint effort EPA, NRCS, USGS

- 2009 Cropland Data Layer, 56 m grid of crop type for nation, joint effort, EPA, NASS

- Wetlands Data Layer, Joint venture with USGS EROS Data Center to attempt to develop an enhanced wetlands data layer for nation using predictive variable(s) to improve satellite-based remote sensing data classification accuracy:
  - Identified wetland locations/types (e.g., NWI)
  - Soil type (e.g., hydric soils)
  - Soil moisture
  - Topography (i.e., DEM-based)
  - Climate
  - Vegetation type (e.g., GAP, LANDFIRE)
  - Indices (e.g., Topographic Wetness Index)

Ecosystem Services Mapping Research -- Nutrient Attenuation

Ecosystem Services Mapping Research

- Joint goal of the *nitrogen group* and the *mapping group* to map nutrient attenuation by the landscape nationally.
  - John Harrison's work on nitrogen attenuation by lakes and reservoirs
  - Brian Hill's (and several others) work on nitrogen attenuation by streams, incorporating role of headwater streams
  - Developing new metrics/models to calculate nutrient removal by terrestrial components, e.g., wetlands, buffer strips, stream buffers

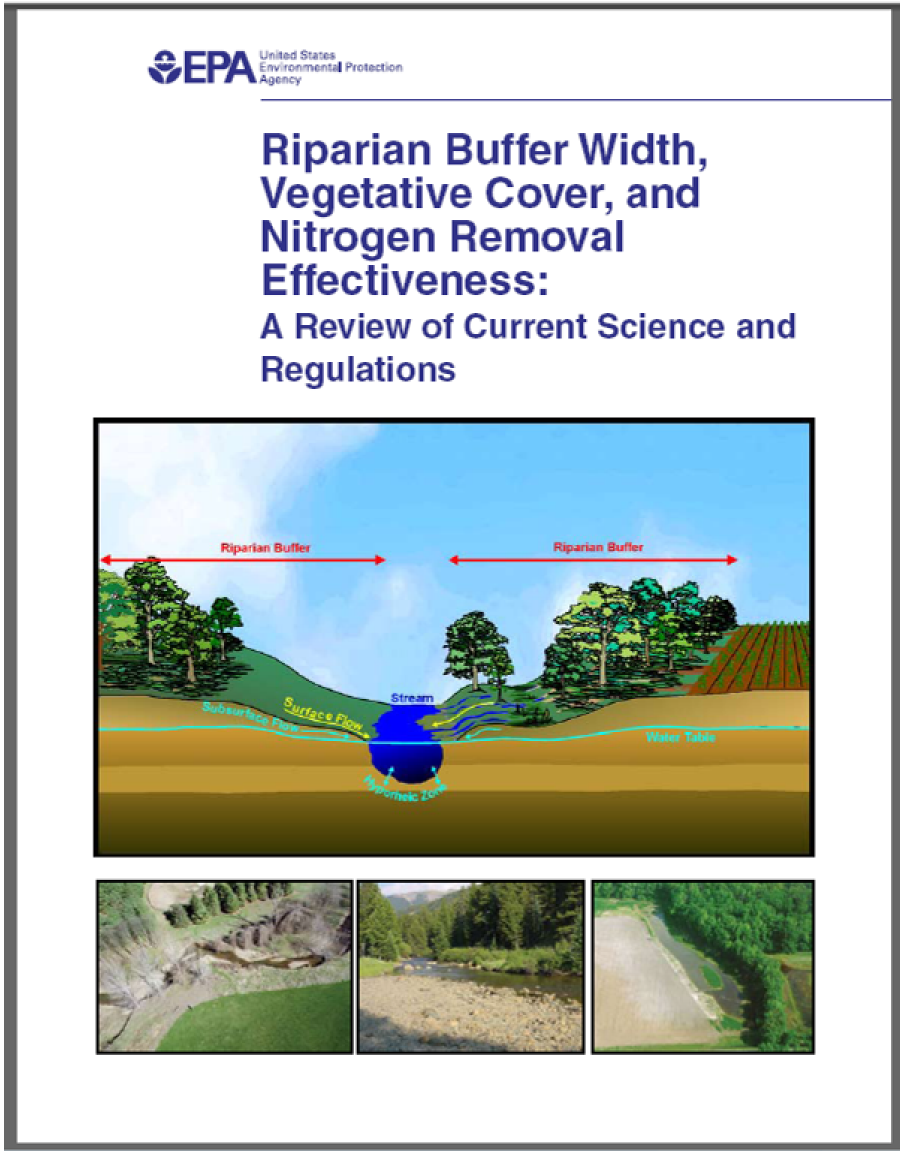
In 2005, Paul Mayer, Steven Reynolds, Jr. & Tim Canfield conducted an extensive literature review

- Soils
- Vegetation type
- Surface and subsurface benefits

Followed by paper in Journal of Environmental Quality in 2007 by Mayer et al.

Working with Paul Mayer and others to modify and use this effort in mapping nitrogen removal

Steve Jordan is undertaking similar review for nutrient attenuation by wetlands


EPA United States Environmental Protection Agency

Riparian Buffer Width, Vegetative Cover, and Nitrogen Removal Effectiveness:

A Review of Current Science and Regulations

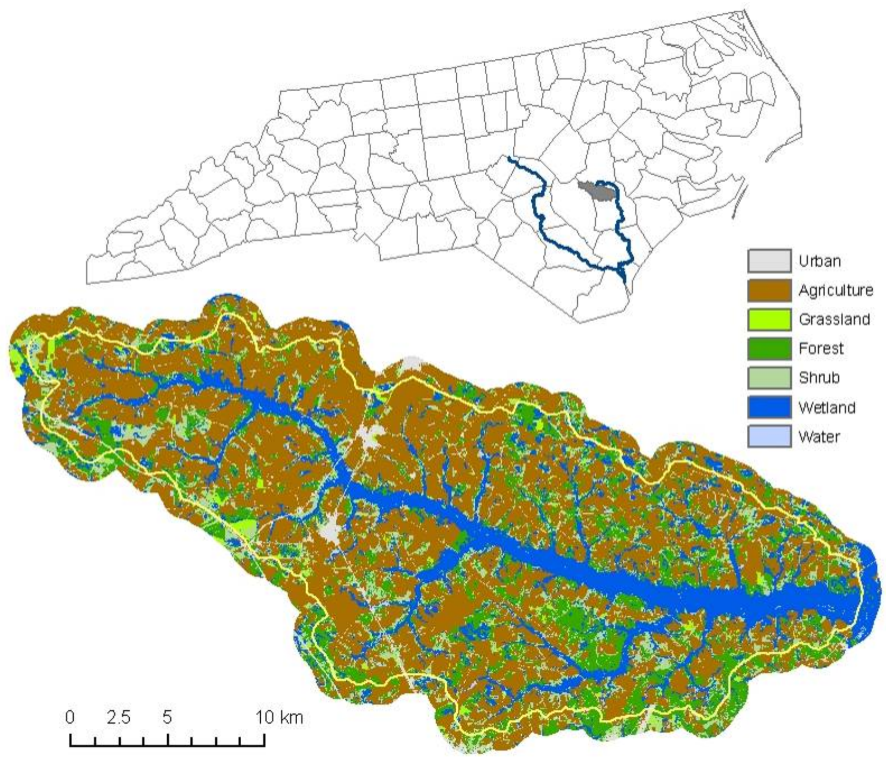
Developing New Metrics to Help Characterize Nutrient Attenuation/Removal by Riparian Buffers

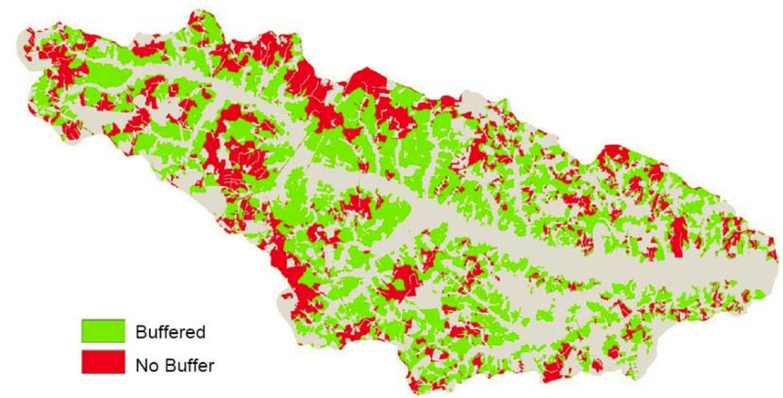
Jay Christensen, Ric Lopez, Annie Neale – Landscape Ecology Branch, ESD

- 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

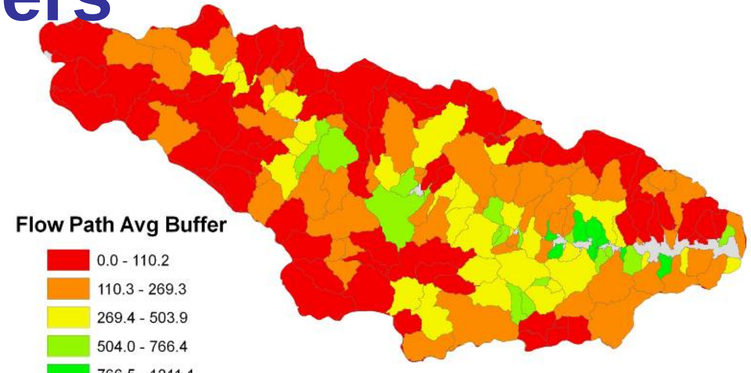




67 % of Ag buffered
33 % not buffered

Jay Christensen

Water Quality -- Nutrient Attenuation/Removal by Riparian Buffers

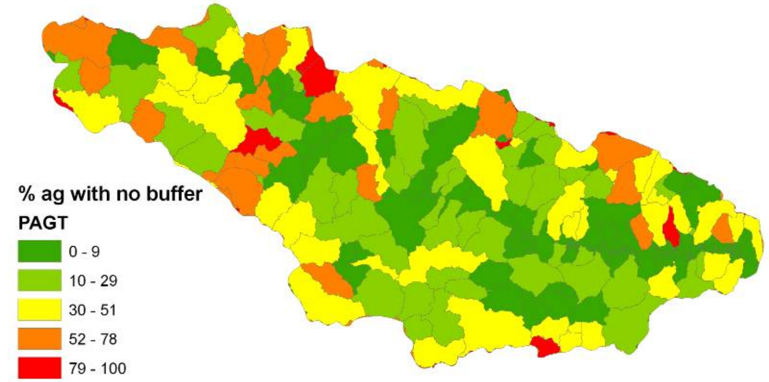


Riparian metrics being tested

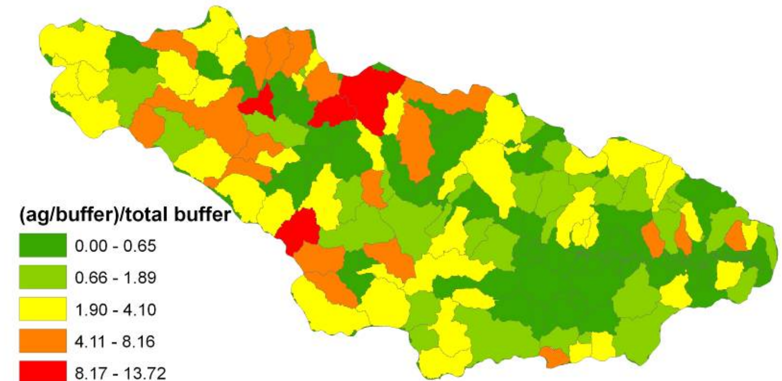
- Average Flow Path Buffer Width from Ag Cells (m)

  Based on Baker et al 2006

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



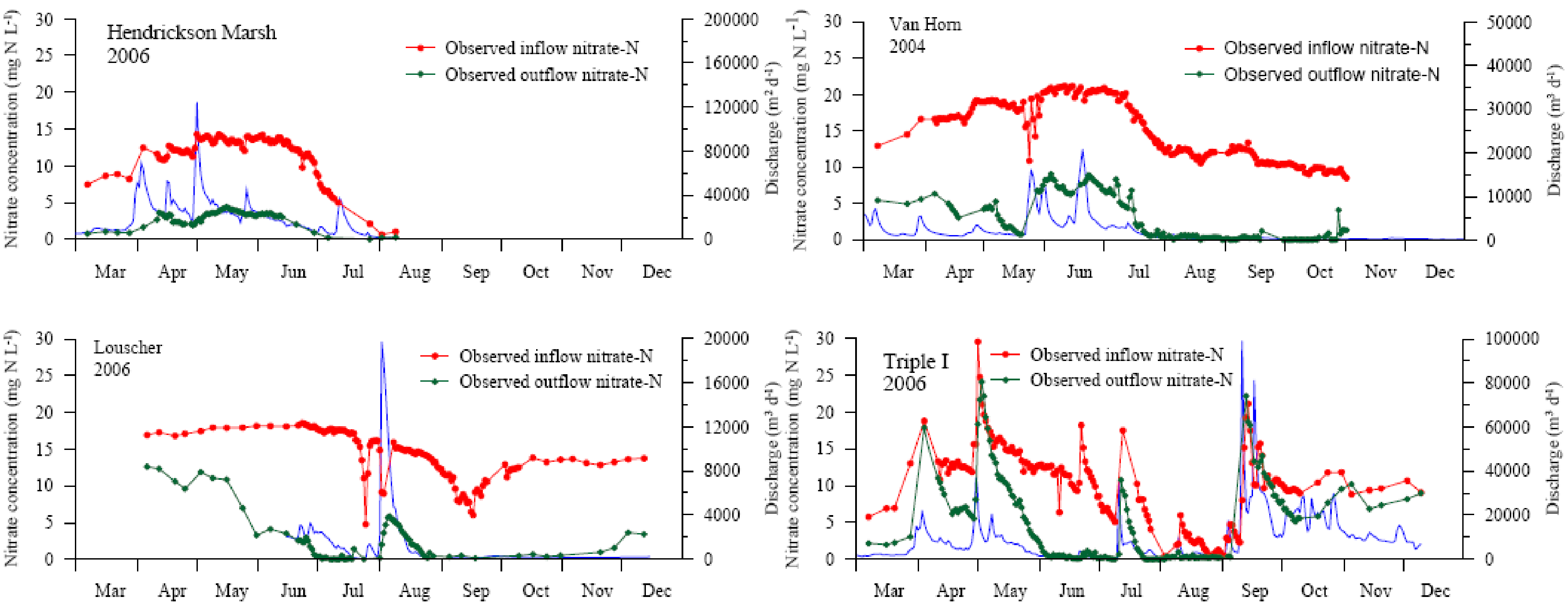
- Sum of Ag/Buffer Ratio / total buffer length



Jay Christensen

Benefits of Constructed Wetland Filters for Tile Drained Systems

0.5% - 2% wetland/watershed area ratio



Their results suggest that a 30% reduction in nitrate load from the UMR and Ohio River basins could be achieved using 210,000-450,000 ha of constructed wetlands

Potential Benefits of Wetland Filters for Tile Drainage Systems: Impact on Nitrate Loads to Mississippi River Sub-basins

U.S. Department of Agriculture

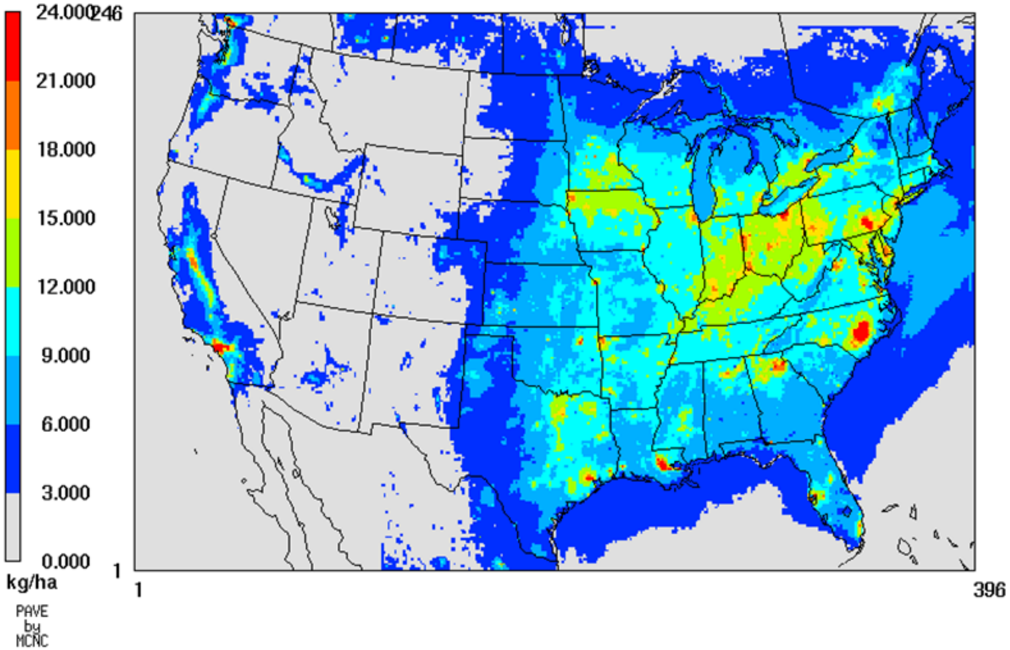
*Crumpton, W. G., G. A. Stenback, B. A. Miller, and M. J. Helmers

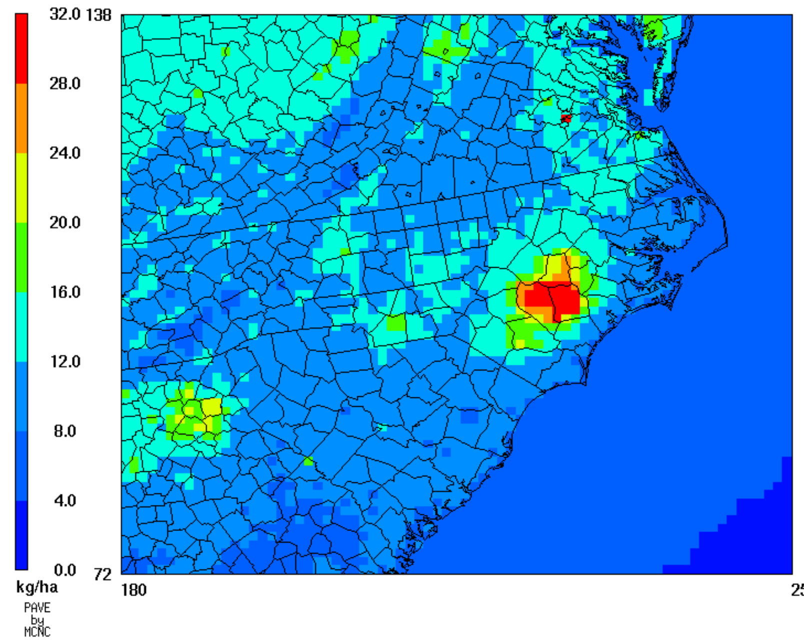
Nutrient Loads

- 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



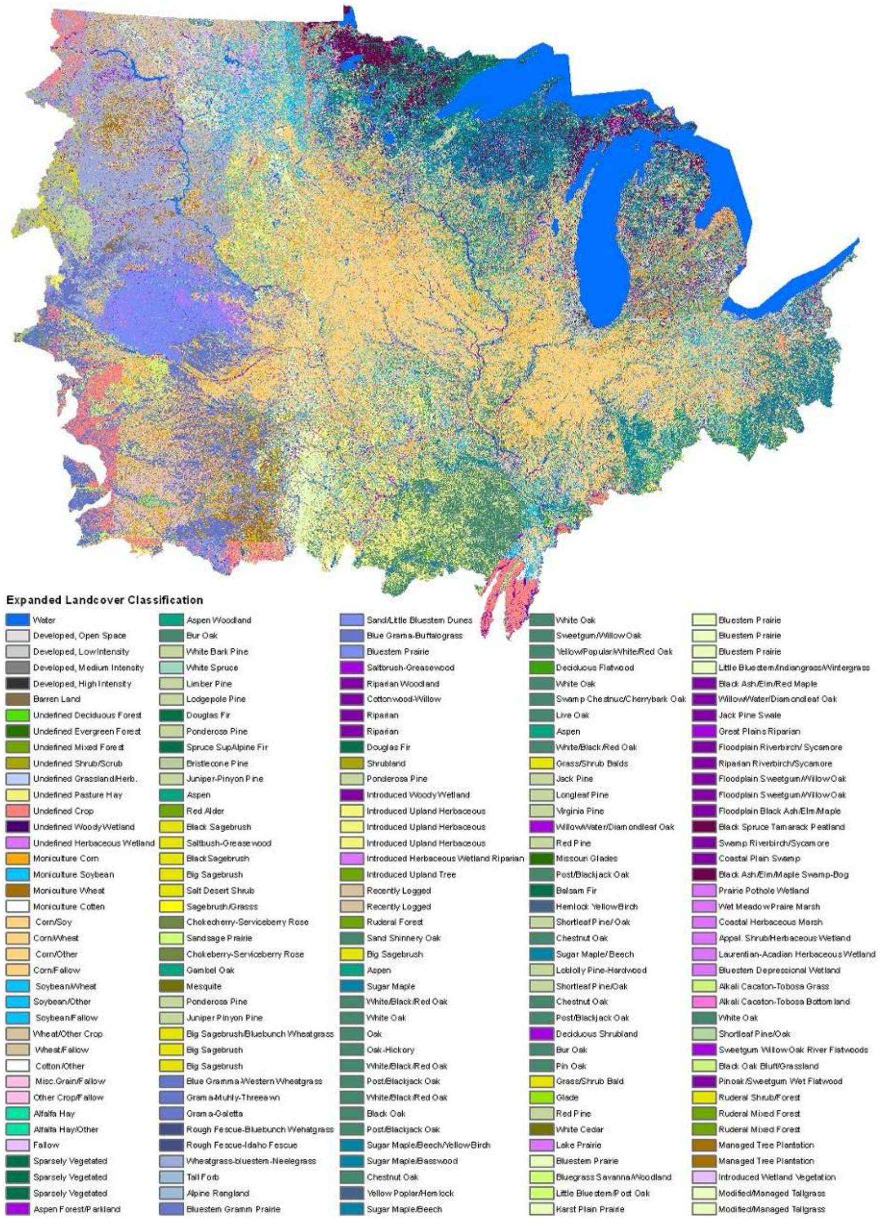


Models multiple air quality issues including nitrogen
Uses modeled meteorology data and 2002 National Emissions Inventory data
Outputs concentrations and deposition on an hourly basis.
Outputs data on a 12 X 12 Km² or 36 X 36 Km² grid cell basis.
Watershed Deposition Tool outputs to 8 or 12-digit HUC

Robin Dennis

Fertilizer Application

Megan Mehaffey – Landscape Ecology Branch, ESD



Enhanced Land Cover Data for FML– Combines the best of NLCD, NASS Crop Data Layer, and LANDFIRE using a set of rules

Includes crop type as well as rotation

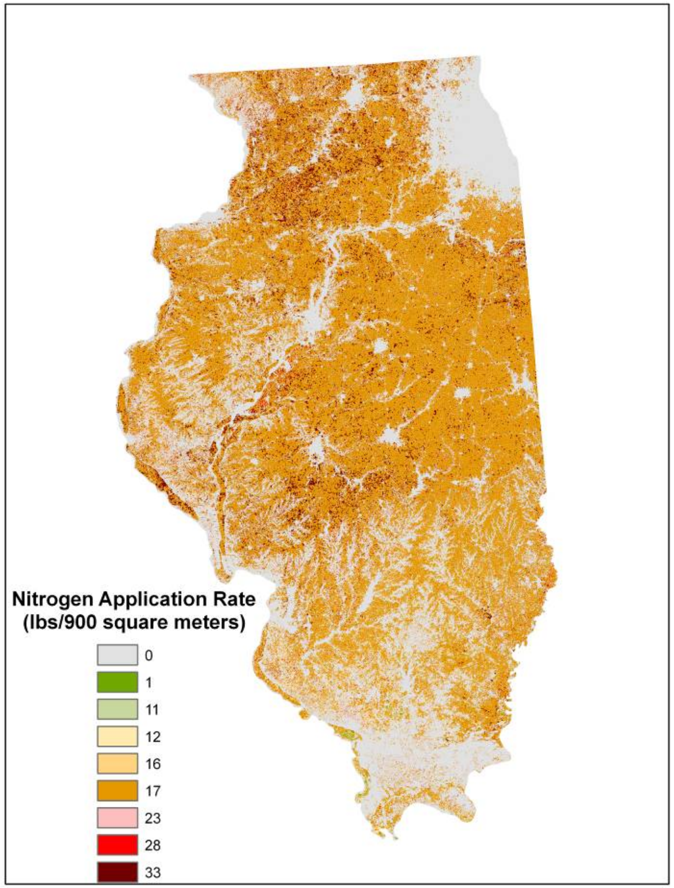
Implications for better estimation of nutrients and pesticides loads/export

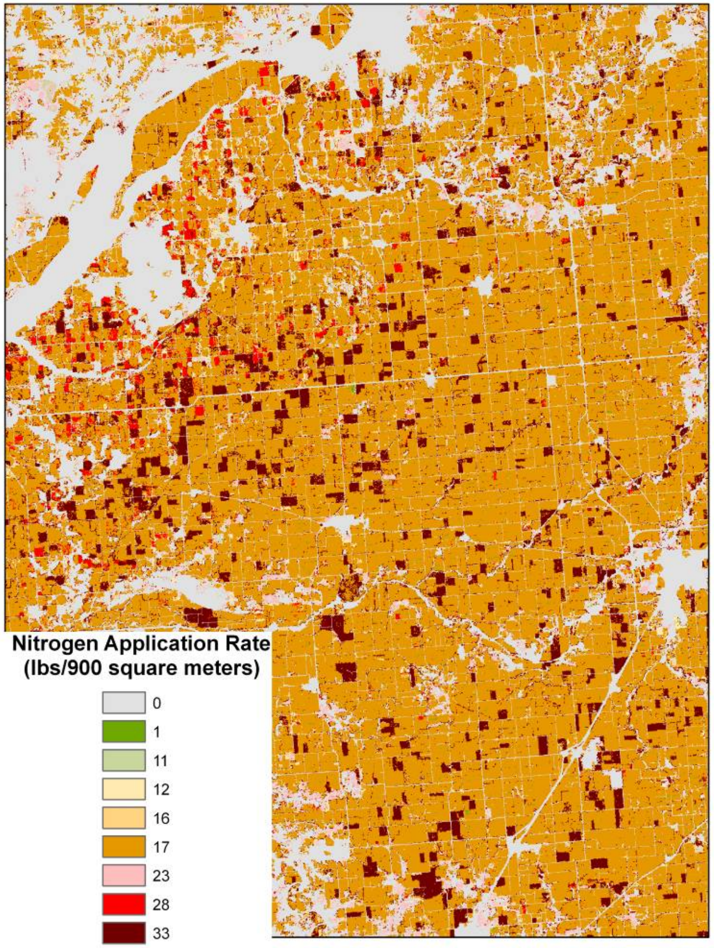
Better assessment of crop yields

Megan Mehaffey

Fertilizer Application

Megan Mehaffey – Landscape Ecology Branch, ESD



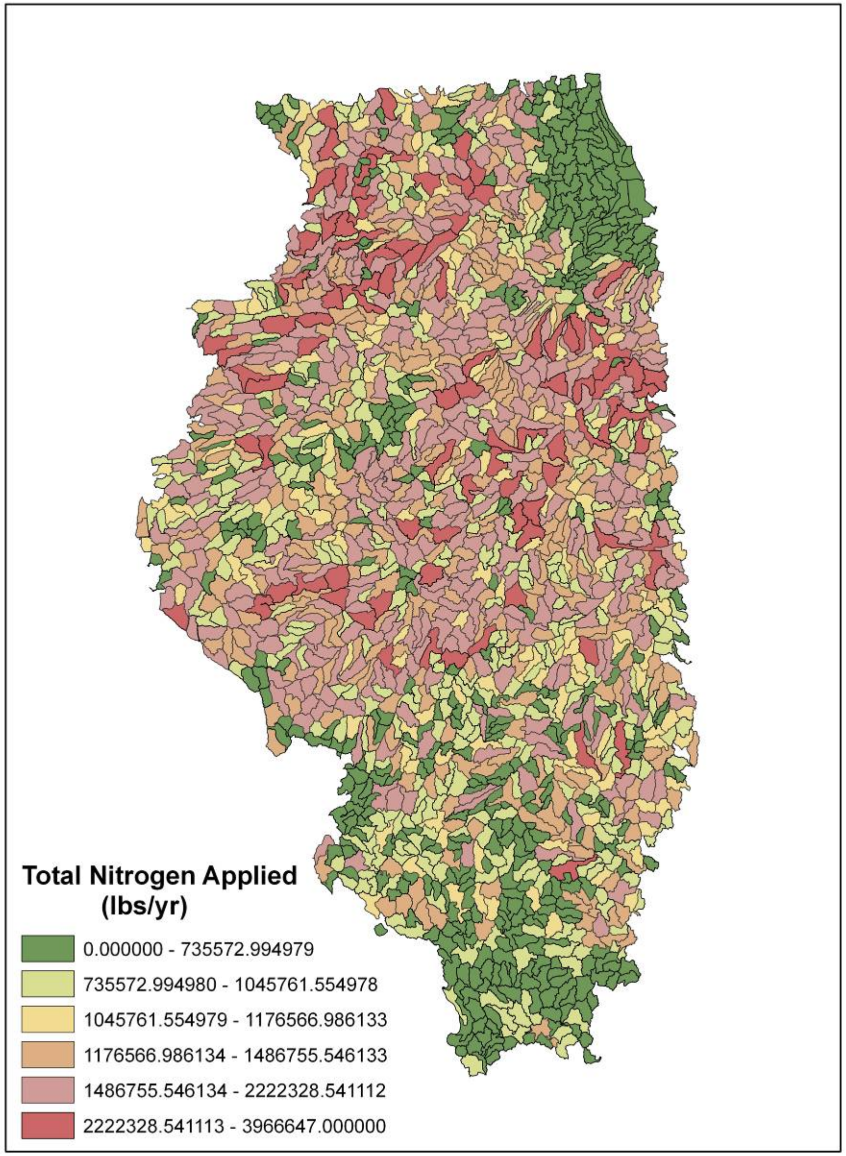


crop type X fertilizer application rate

Megan Mehaffey

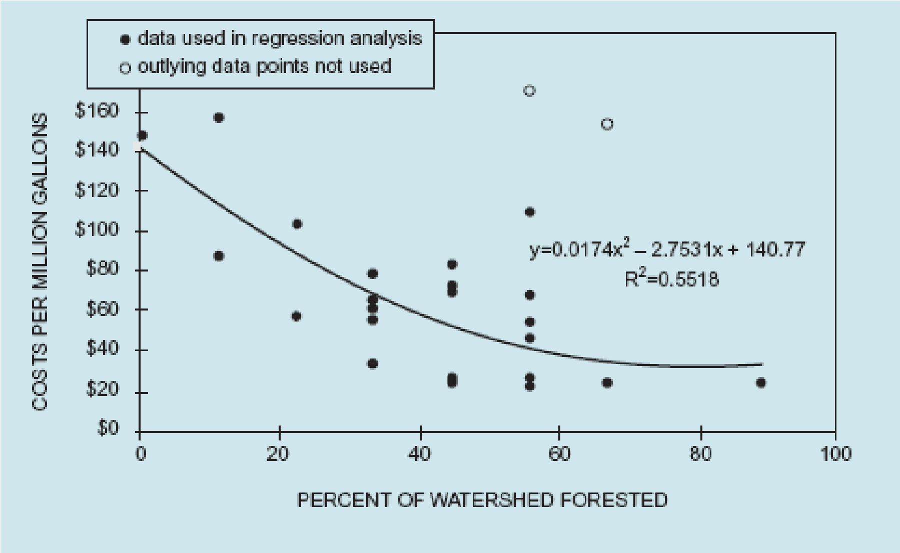
Fertilizer Application

Megan Mehaffey – Landscape Ecology Branch, ESD



Water Quality -- Drinking Water Sustainability

Jim Wickham, Tim Wade



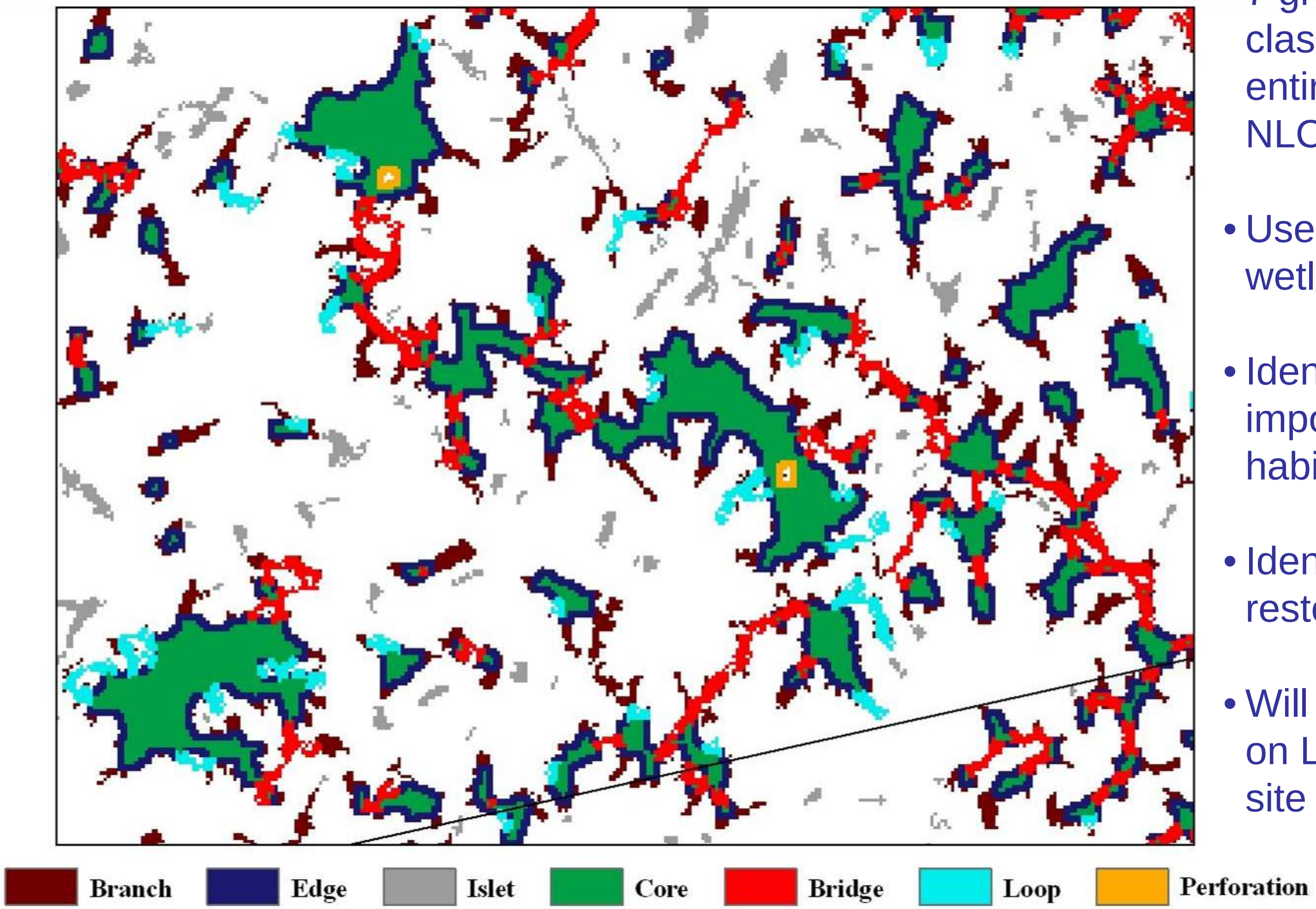
Source: Ernst (2004)
Finding: for every 10% loss of forest, treatment and chemical costs increased by 20%

- Acquired OW Drinking Water Source Water Intake points and wells for U.S. – Done
- Delineating watershed area contributing to those points – ~ 3500/6000 delineated
- Conduct landscape assessment of drinking water source areas
- Confidentiality issue
- Relate landscape metrics to intake water quality/degree of treatment required
- Relate to populations served & multiple benefits

Examples of Ongoing Atlas Work

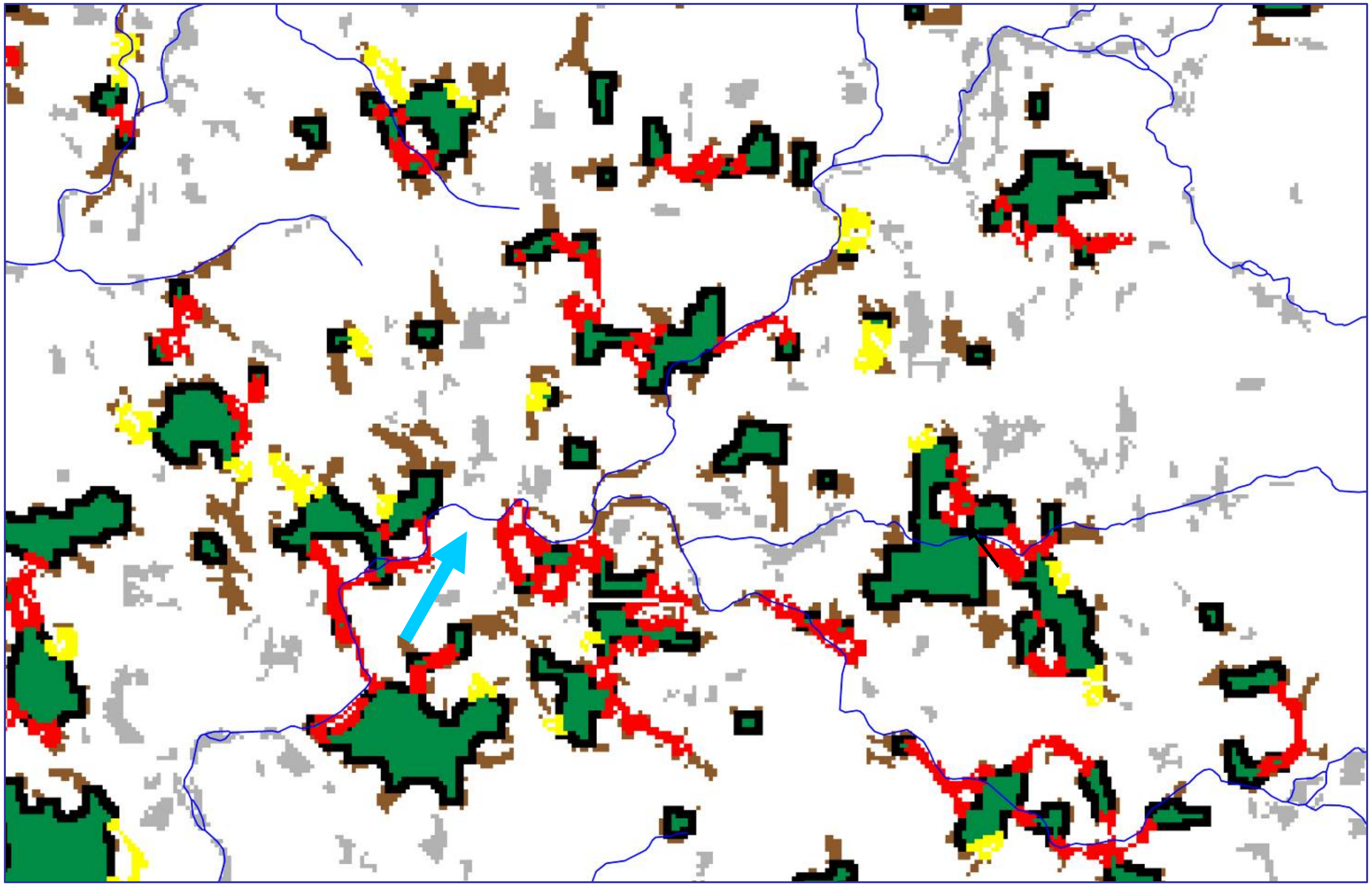
Terrestrial Habitat -- Green Infrastructure Approach (i.e., Hubs and Corridors

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/



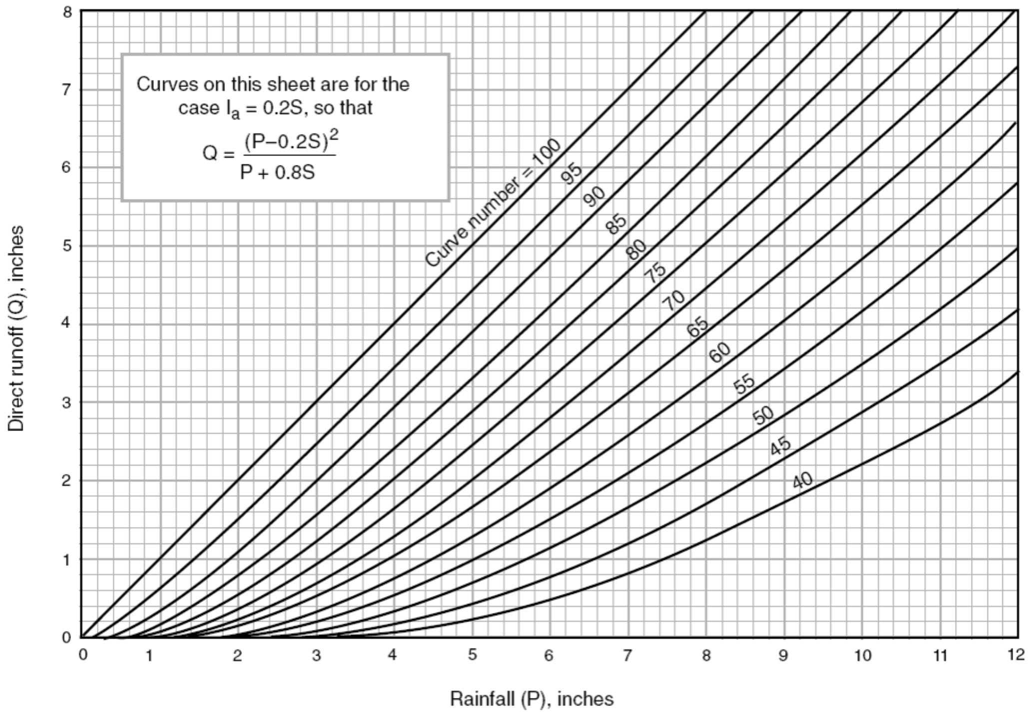
Core (hub) Bridge Loop Branch Islet (patch)

Can also add projected urban growth, impervious surface, etc.

Useful for land trusts in guiding land purchase

Examples of Ongoing Atlas Work
Water Quantity, Timing, Groundwater Recharge -- SCS Curve Number Approach

Jim Wickham, Tim Wade, Landscape Ecology Branch, ESD



Where $S = \frac{1000}{CN} - 10$

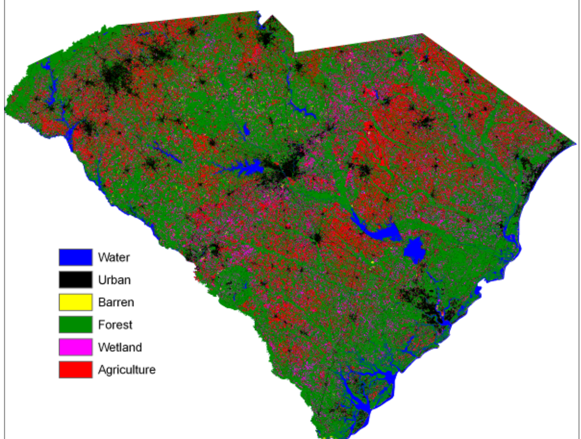
Generalized Curve Numbers

	Hydrologic Soil Group			
LC Class	A	B	C	D
Imp. Surf	98	98	98	98
Cropland	64	75	85	89
Pasture	39	61	74	80
Forest	30	55	70	77
Pin-jun		41	61	71
Wetlands	0-100			

Source: http://www.wsi.nrcs.usda.gov/products/w2q/H&H/docs/other/TR55_documentation.pdf

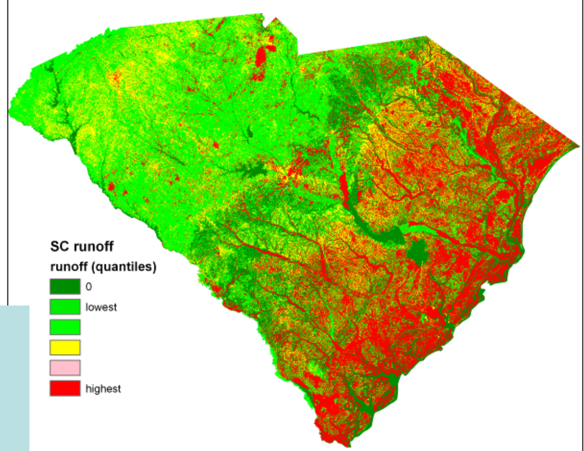
Water Yield using SCS Curve Number Approach

South Carolina Land Cover

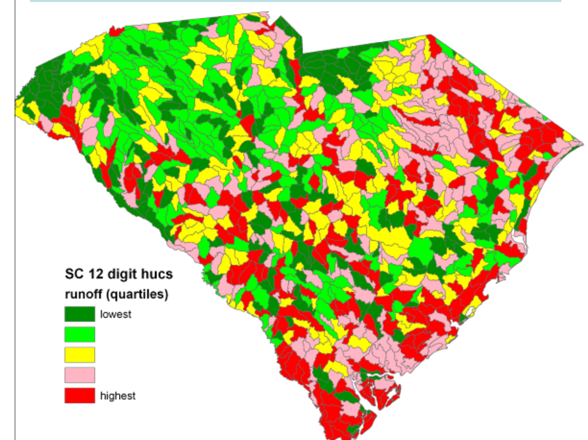


Calculations of CN based on NLCD land cover and SSURGO soils data

Discharge from 10 yr storm event (2 in) calculated for each 30 m pixel



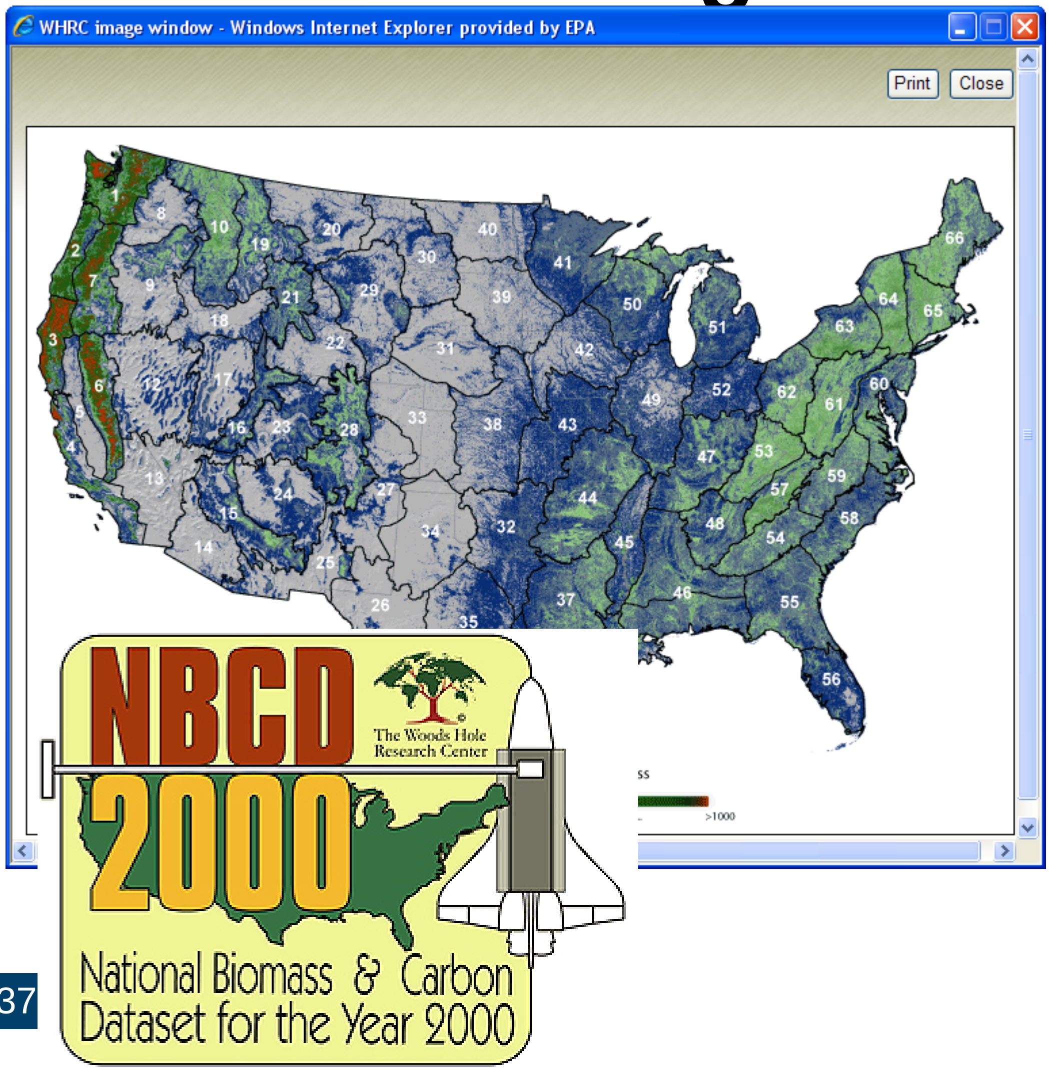
Discharge is routed from each 30 m pixel to the next until reaching HUC outlet



Discharge summarized for each 12 digit HUC for 10-yr storm event – investigating routing from one HUC to another to maintain hydrological network

Tim Wade

Carbon Storage and Sequestration

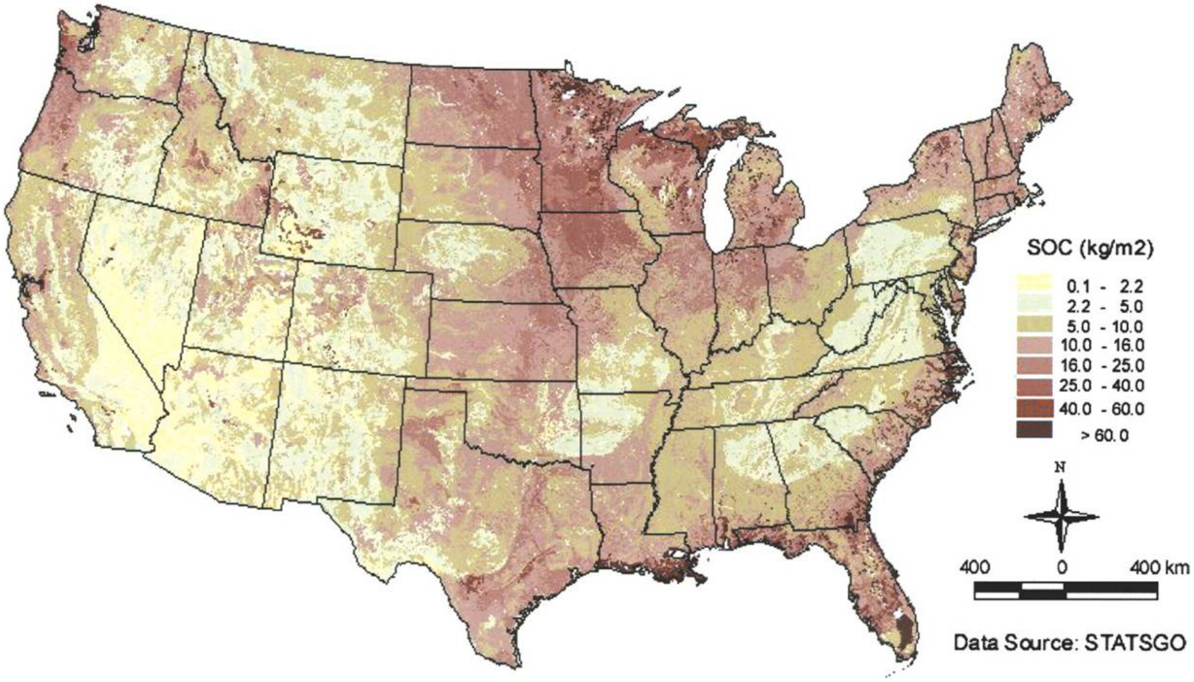


Empirical modeling effort using:

- USDA Forest Service Forest Inventory and Analysis
- High-resolution InSAR data (2000 Shuttle Radar Topography Mission)
- Optical remote sensing data acquired from the Landsat ETM+ sensor.
- National Land Cover Dataset 2001
- LANDFIRE
- National Elevation Dataset (NED)

Carbon Cycling – Carbon Storage

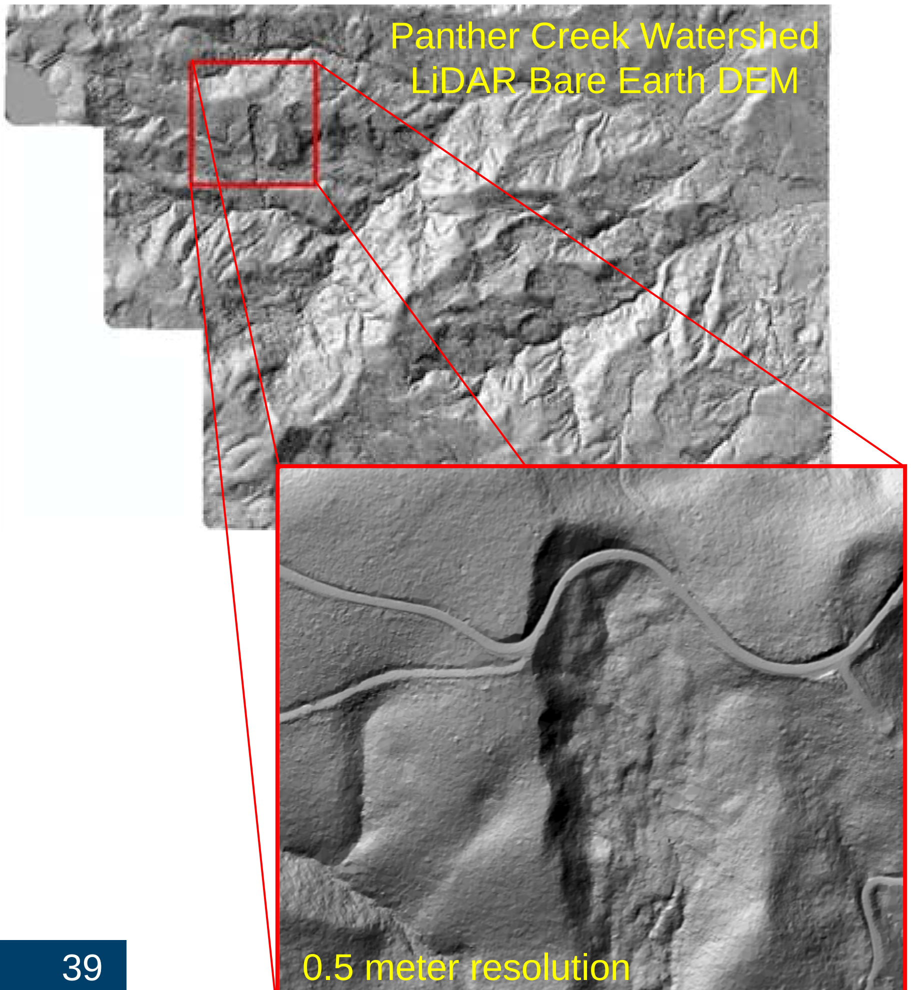
Spatial distribution of soil organic carbon (SOC) content to 2-m soil depths



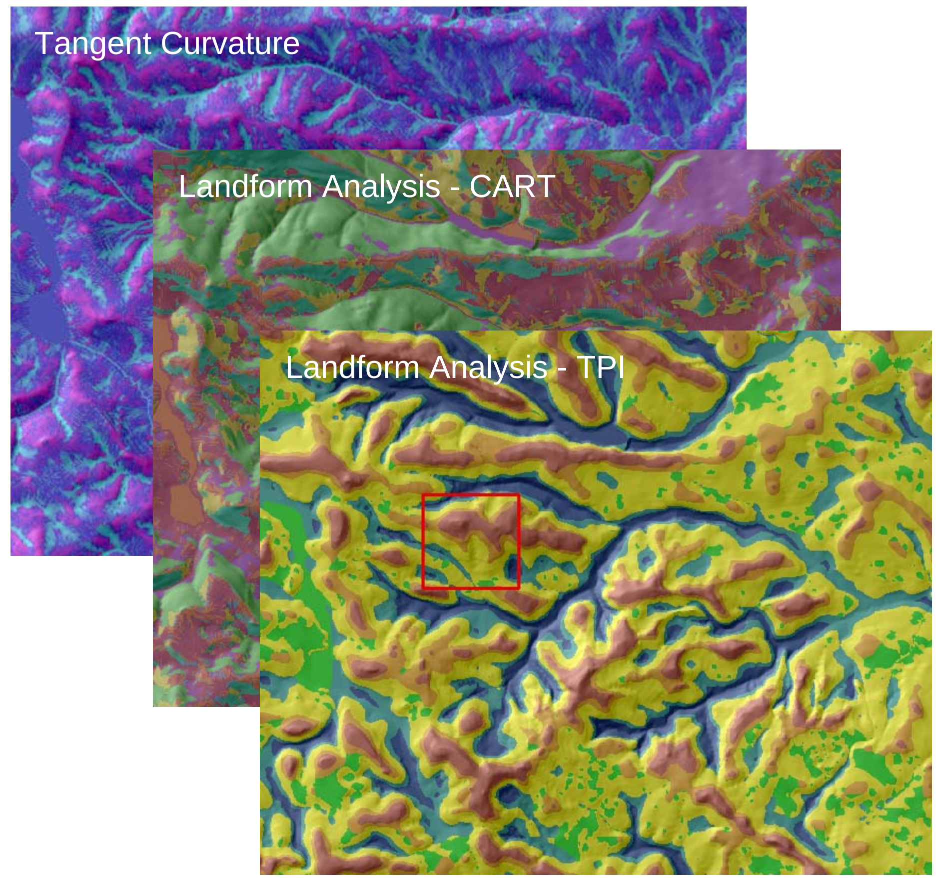
Developing similar using SSURGO

Source: Guo, Yinyan, Amundson, Ronald, Gong, Peng, Yu, Qian
Quantity and Spatial Variability of Soil Carbon in the Conterminous United States Soil Science Society of America Journal. 2006 70: 590-600

WESP – Quantifing Soil Carbon Stocks



Approach: Use quantitative terrain analysis to characterize topographic and environmental features that control soil carbon distribution across the landscape.



Ecosystem Services provided by Urban Ecosystems

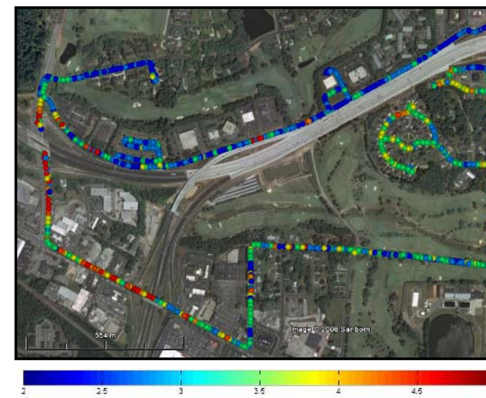
- In-depth analysis of urban areas with population ~> 100,000 using Urban Forest Effects Model (UFORE) and UFORE-Hydro in collaboration with USFS
  - Air pollutants removed by vegetation
  - Energy savings due to shading of buildings
  - Carbon storage benefits
  - Storm water runoff benefits
  - Water Quality benefits
- Near-roadway removal of pollutants by vegetation
- Developing other metrics
  - Heat Island Index
  - Indices of green places (parks)
  - Number of days exceeding air quality standards
  - Nighttime lights index
- Relate metrics to human health and possibly EJ

  Bird diversity – West Nile Virus

  PM$^{2.5}$ removal - Asthma

Mapping and human well-being

Monitoring and modeling to quantify pollutant filtration by near-roadway vegetative buffers



- **Stationary and mobile monitoring completed at two field sites in RTP, NC (n = 50 rush-hour periods).**
- **Data analysis begun on ambient concentrations of PM, CO, and black carbon downwind of roadside vegetation.**
- **Computational fluid dynamics modeling underway to simulate pollutant flow through various vegetation forms.**

Ecosystem service will be valued in ambient pollutant concentrations reduced and days of life extended.

U.S. Department of Transportation Federal Highway Administration

NCER STAR Science to Achieve Results

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GEO GROUP ON EARTH OBSERVATIONS

Technical Challenges

- Computing resources, technologically feasible but requires $$ investment
- Data accuracy –large national data sets are imperfect, will sometimes get it wrong. How do we convey that? How do we avoid, “my pixel is bad, the product is no good”
- Linking the services to beneficiaries ---how do we map this or is it enough to show the ontology?
- What can we do to best provide the foundational data for valuation?
- Data privacy issues – feasible to provide publicly available, fine-scale data, will there be privacy issues?
- Preferred modeling approach
  - Simple model applied fine-scale across the landscape vs.
  - Complex model applied to subset (by ecoregion), then extrapolated across landscape