

The US Environmental Protection Agency's Regional Vulnerability Assessment Program (ReVA)

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ReVA: the Approach

ReVA's Integrated Assessment Framework Helps Organize Research Knowledge and Tools to Respond to Client Needs

- **Data acquisition / preparation** (*existing data*)
- **Extrapolation / interpolation**
- **Model development / forecasting** (*many separate models*)
- **Synthesis** (*many methods to address data issues and assessment questions*)
- **Scenario Analysis**
- **Visualization/Communication/Access to Information**

EDT

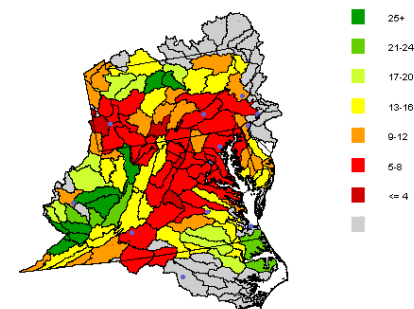
EDT = ReVA's web-based Environmental Decision Toolkit

Integration of Spatial Data: the Method Used Matters!

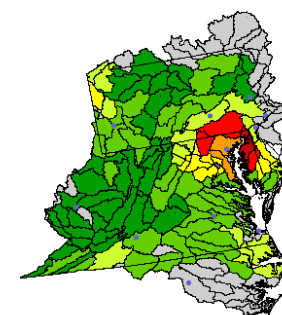
Is the method robust given the data being synthesized?

Method	Discontinuity	Skewness	Imbalance	Interdependency
Quantiles	Not sensitive	Not sensitive	Sensitive	Sensitive
Simple Sum	Not sensitive	Not sensitive	Sensitive	Sensitive
AHP	Not sensitive	Not sensitive	Not sensitive	Sensitive
PCA	Sensitive	Sensitive	Not sensitive	Not sensitive
State Space	Sensitive	Sensitive	Not sensitive	Not sensitive
Criticality	Not sensitive	Not sensitive	Sensitive	Sensitive
Overlay	Not sensitive	Not sensitive	Not sensitive	Not sensitive
Cluster	Not sensitive	Sensitive	Sensitive	Sensitive
SOM	Not sensitive	Sensitive	Sensitive	Sensitive

Best Quintile Counts



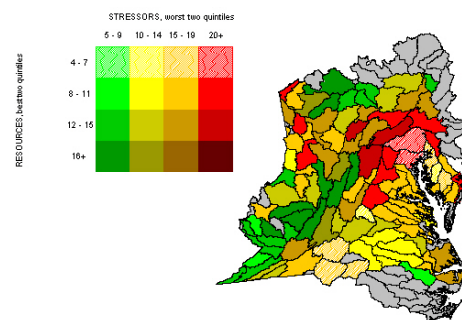
State Space



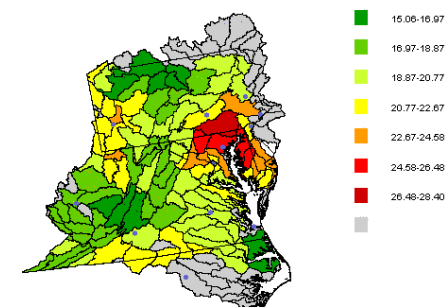
Is the method addressing the right question?

- Ranking Methods (*Condition*)
Quantiles, Sum of Ranks, AHP
- Distance from Reference Point (*Sustainability*)
PCA, State Space, Criticality
- Overlay of stressors/resources (*Value, vulnerability*)
- Grouping of Like Units (*Feasibility*)
Cluster Analysis, Self-Organizing Maps

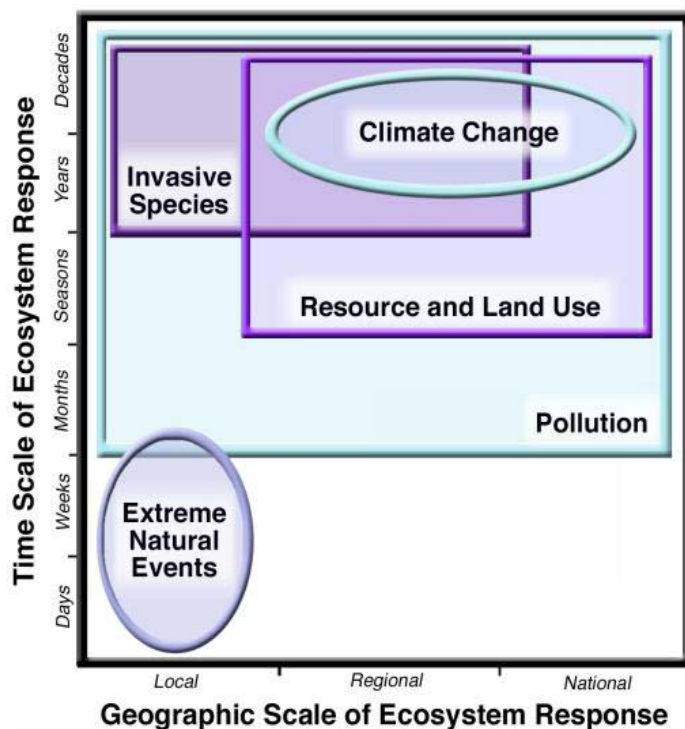
Stressor-Resource Overlay



Radar Area Summary



Future Scenarios: Projections of Major Drivers of Ecological Change (2020)



Despite compliance with environmental regulations, biological populations are declining.

Major drivers of change include:

- Land use change
- Resource extractions
- Pollution and pollutants
- Exotic invasive species
- Climate change

These drivers projected for the Mid-Atlantic Region

ReVA's Environmental Decision Toolkit (EDT)

- Web-based, integration and visualization
- Statistical application (S-PLUS), with mapped output
- Linked to ArcServe version for finer-resolution analysis
- Results as *relative* rankings within larger region
- Addresses multiple assessment questions
- Integration of data in subgroups (e.g. water, air) or subregions
- Weighting to reflect different values, perspectives
- Scaleable (national to local)
- Data access, interoperable, webserviceable

ReVA Process

Descriptive Spatial Data

(Landscape metrics, census variables, species counts, etc.)

Spatial Model Output

(NPS estimates, air deposition estimates, invasive species, etc.)

Environmental Decision Toolkit

- Integration into Indices of Condition and Vulnerability
- Visualization from multiple perspectives
- Enabling Multiple Criteria Decision-Making
- Individual variables and Composite indices

Forecast Scenarios:

Drivers of Ecological Change (land use, exotic species, resource extraction, pollution and pollutants, climate change)

Alternative Management Scenarios (trade-off analyses)

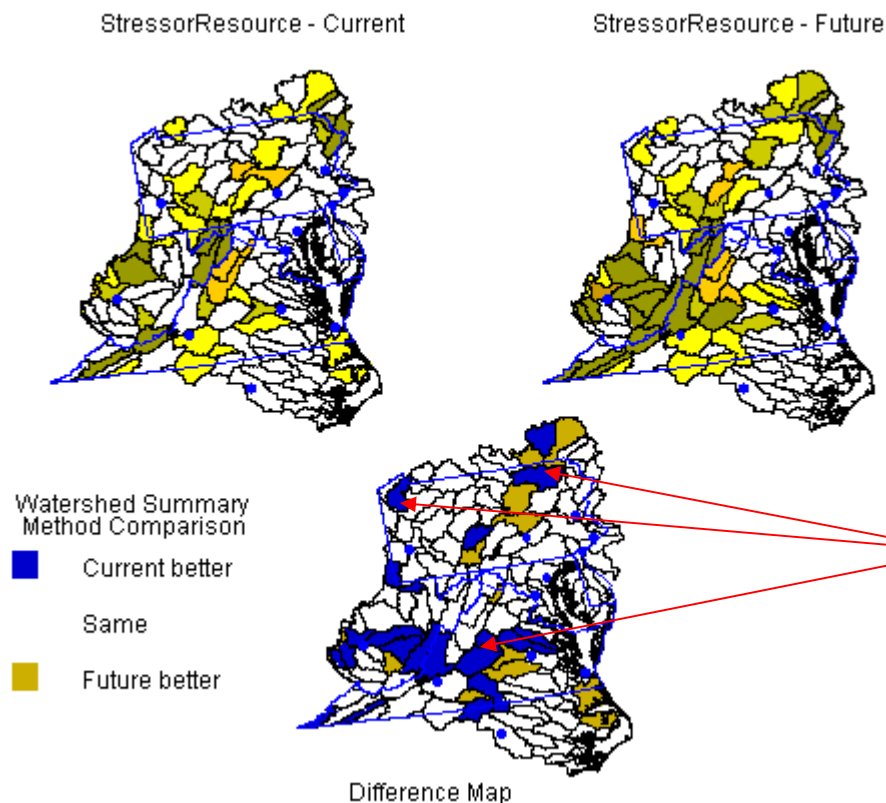
Descriptive Spatial Data

(Landscape metrics, population/demographic variables, etc.)

Spatial Model Output

(NPS estimates, air deposition estimates, invasive species, etc.)

Where will valued resources be subjected to additional stress?



Region 3 used the toolkit to prioritize the use of resources

Watersheds in blue - candidates for use of Region 3's discretionary funds for water monitoring, continuing existing projects, initiating new projects, partnerships with local communities for responsible development.....



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Regional Growth Decision Tool

[About the RGDT](#) | [How can I use the RGDT?](#) | [Use the RGDT](#) | [What is SEQL?](#) | [What is ReVA?](#)

[Home Page](#) > [Levels of Detail](#) > [Executive Summary](#) > SEQL Overview Map

Sustainable Environment for Quality of Life (SEQL) study: 15-county area surrounding Charlotte, NC. Two alternative futures projected to 2030

View Scenario Maps

Select Layers to Display:

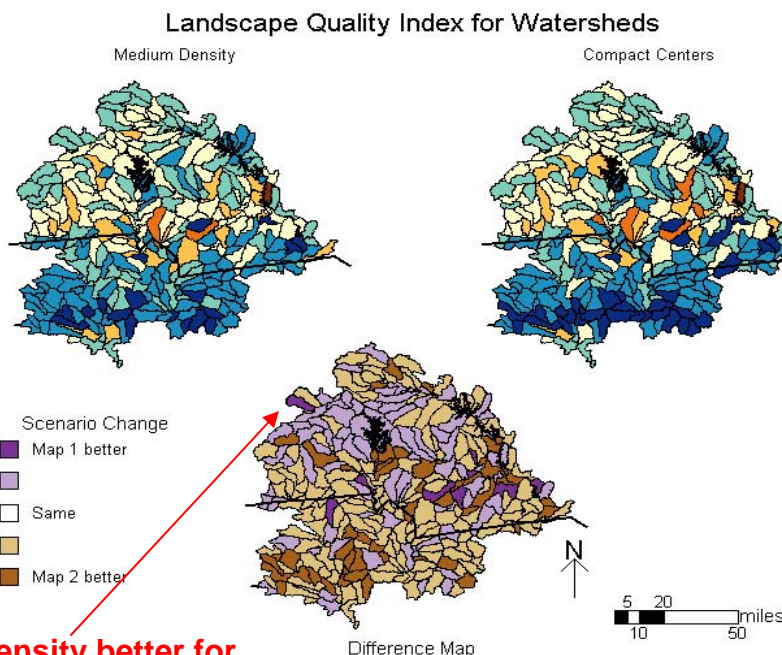
- ☐ County Lines
- ☐ Cities
- ☒ State Boundary
- ☐ Interstate Roads

<< Back Redraw Map

Landscape Quality Index for Watersheds

Variables

- Percent any agricultural land
- Total agriculture land on steep slopes (9% slope)
- Percent barren landcover - natural
- Percent forest landcover
- Percent natural grass land cover
- Percentage of land that is edge forest class
- Road density
- Crop land cover along streams - 60 meters
- Forest land cover along streams - 60 meters
- Natural grass land cover along streams - 60 meters
- Percent shrub land cover
- Stream density
- Percent urban landcover
- Percent wetlands land cover

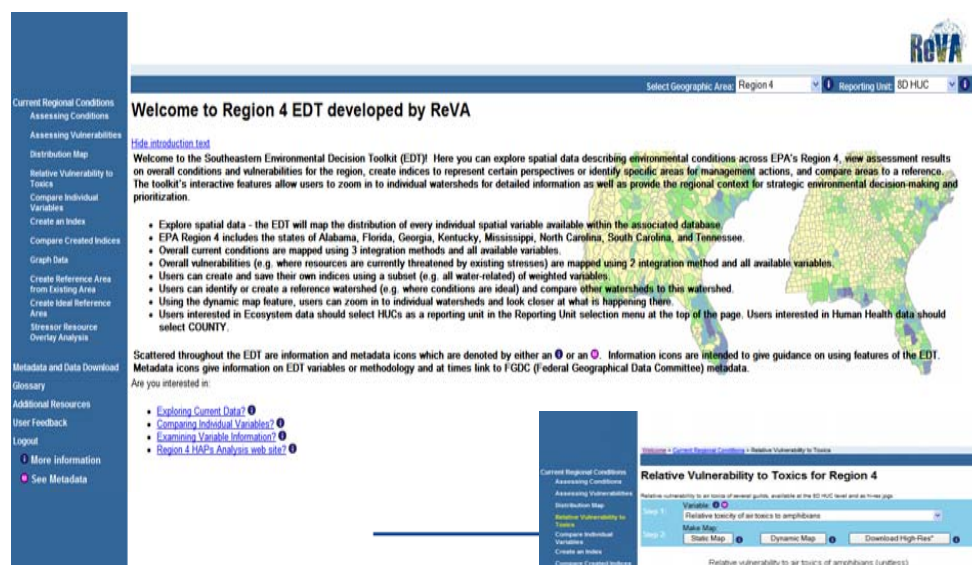


Trade-offs: Medium Density better for individual watershed; Compact Centers better for region

[Print File](#)

If you would like more detailed data, please go to the [Management Summary page](#).

SE Region – Air Toxics Policy Tool





Welcome to Region 4 EDT developed by ReVA





[Hide introduction text](#)

Welcome to the Southeastern Environmental Decision Toolkit (EDT). Here you can explore spatial data describing environmental conditions across EPA's Region 4, view assessment results on overall conditions and vulnerabilities for the region, create indices to represent certain perspectives or identify specific areas for management actions, and compare areas to a reference. The toolkit's interactive features allow users to zoom in to individual watersheds for detailed information as well as provide the regional context for strategic environmental decision-making and prioritization.

- Explore spatial data - the EDT will map the distribution of every individual spatial variable available within the associated database
- EPA Region 4 includes the states of Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee.
- Overall current conditions are mapped using 3 integration methods and all available variables.
- Overall vulnerabilities (e.g. where resources are currently threatened by existing stresses) are mapped using 2 integration method and all available variables.
- Users can create and save their own indices using a subset (e.g. all water-related) of weighted variables.
- Users can identify or create a reference watershed (e.g. where conditions are ideal) and compare other watersheds to this watershed.
- Using the dynamic map feature, users can zoom in to individual watersheds and look closer at what is happening there.
- Users interested in Ecosystem data should select HUCs as a reporting unit in the Reporting Unit selection menu at the top of the page. Users interested in Human Health data should select COUNTY.

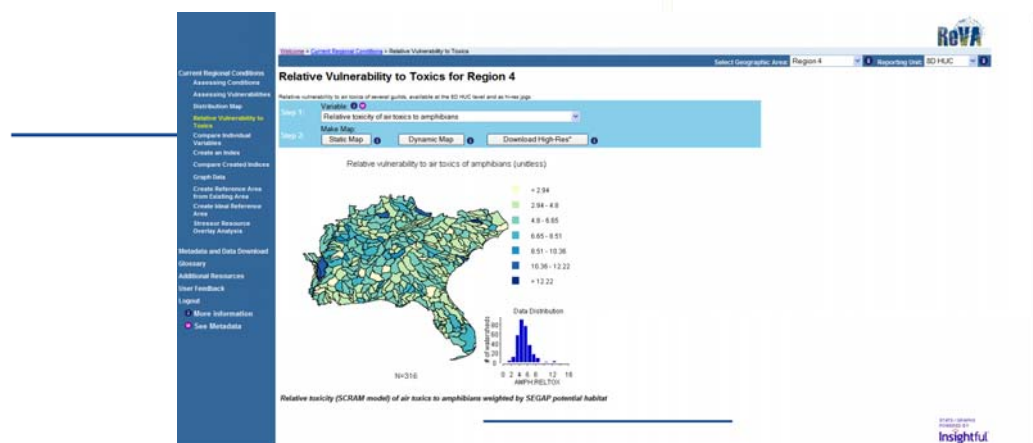
Scattered throughout the EDT are information and metadata icons which are denoted by either an  or an . Information icons are intended to give guidance on using features of the EDT. Metadata icons give information on EDT variables or methodology and at times link to FGDC (Federal Geographical Data Committee) metadata.

Are you interested in:

- [Exploring Current Data?](#) 
- [Comparing Individual Variables?](#) 
- [Examining Variable Information?](#) 
- [Region 4 HAP's Analysis web site?](#) 

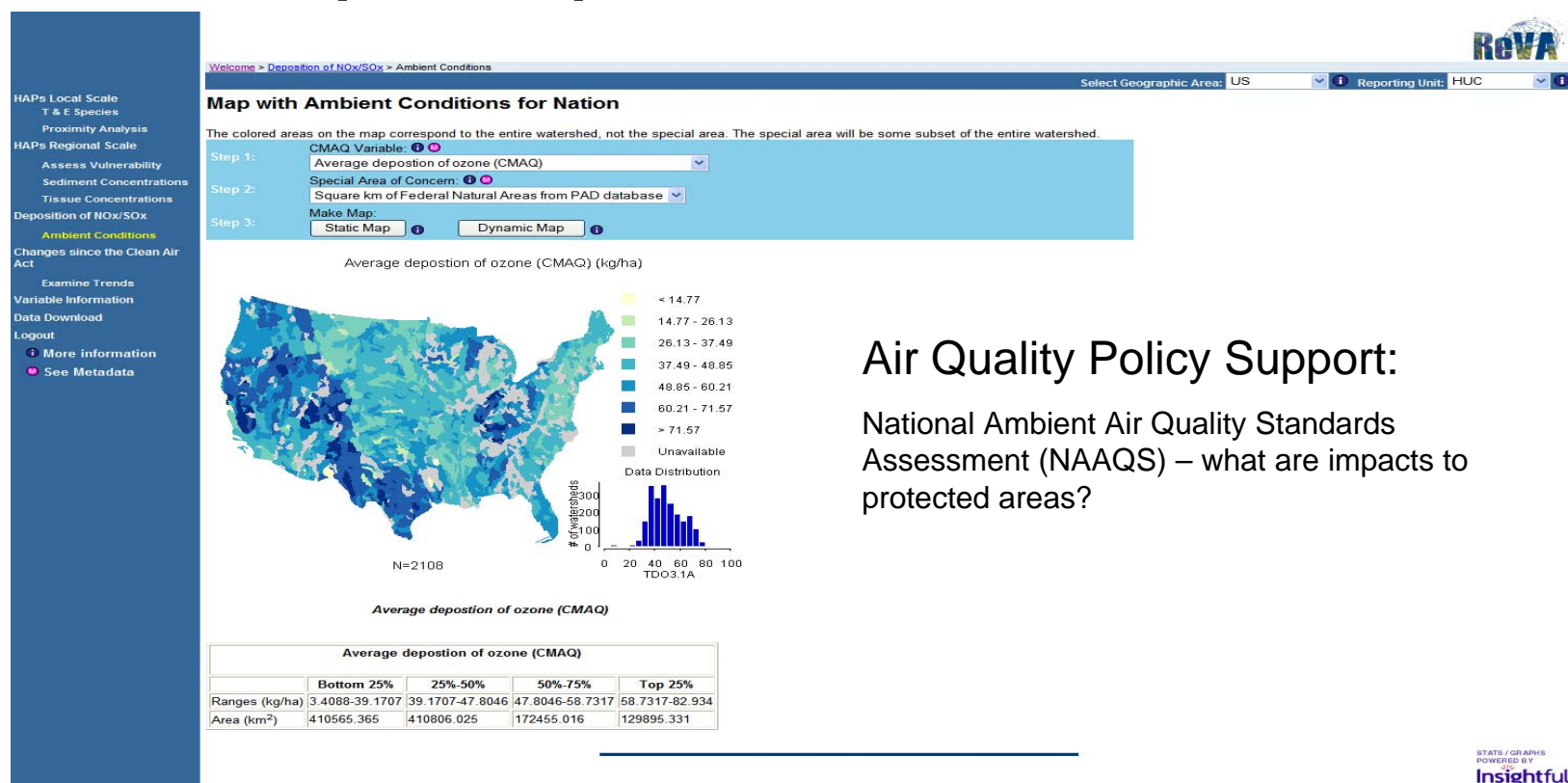
Residual Risk Assessment

EPA required to assess the residual risk after the maximum achievable clean-up of emissions under current technology (MACT) for air toxics. If risk to T&E species, migratory bird species, or human welfare is “high”, EPA Administrator has authority to regulate.



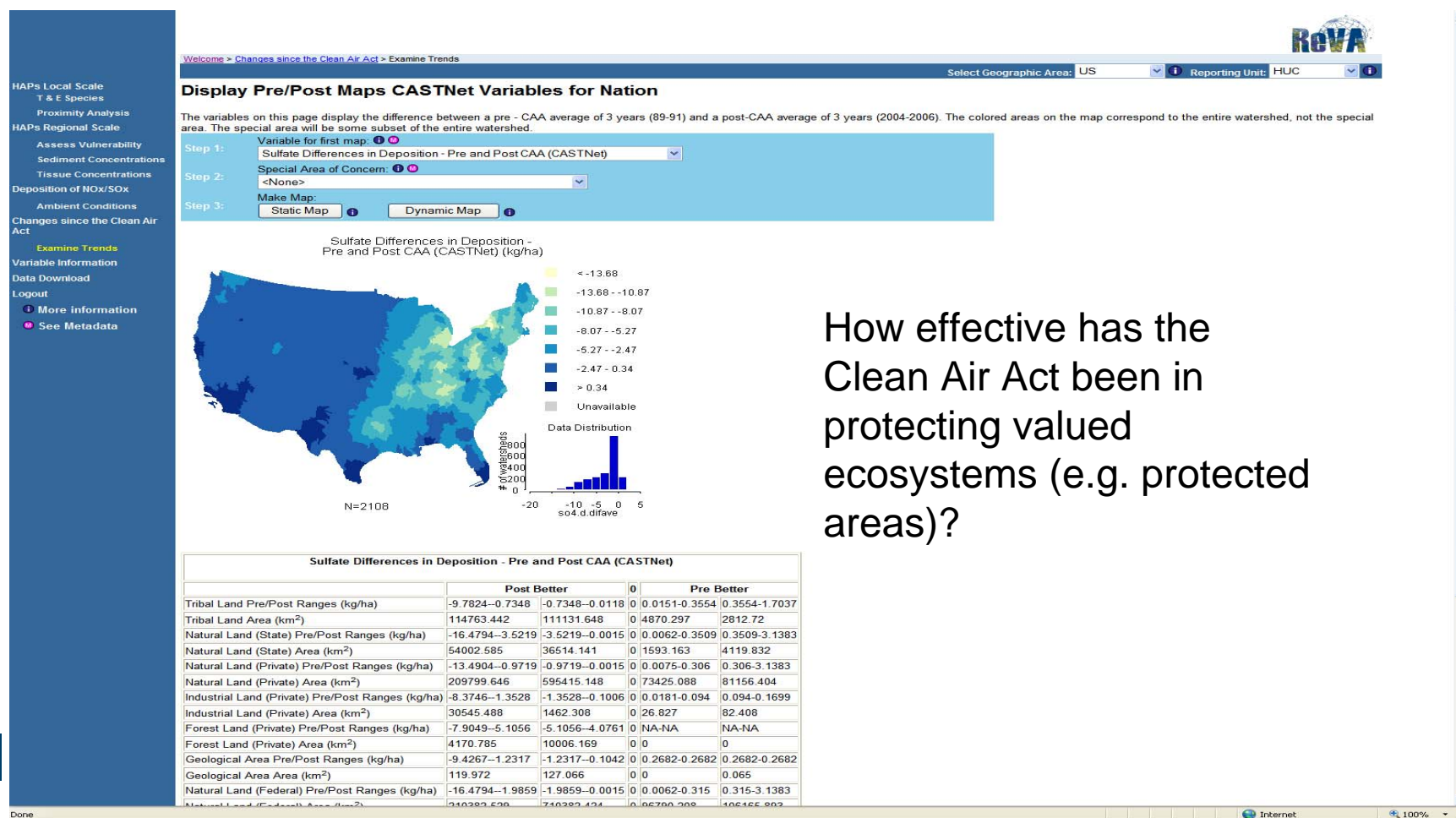


National Environmental Assessment Toolkit (NEAT)





NEAT: Performance Measures



How effective has the Clean Air Act been in protecting valued ecosystems (e.g. protected areas)?



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

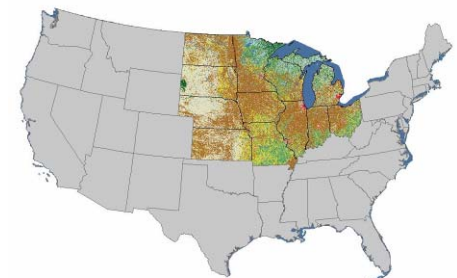
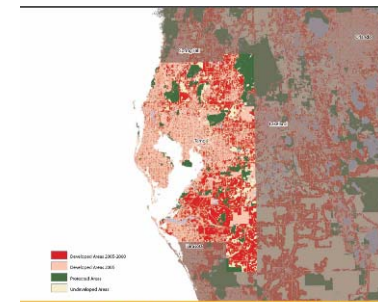
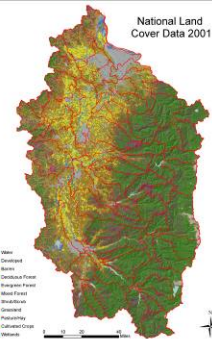
How does the bundle of ecosystem services provided by selected ecosystem types—wetlands and coral reefs—change under alternative management options at multiple scales?

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?

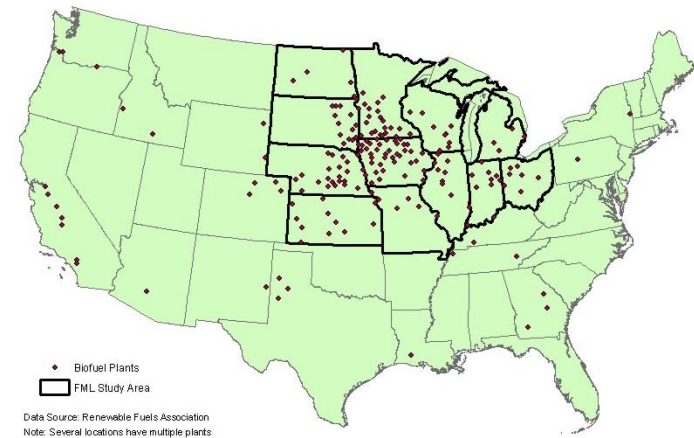
Place-based projects include...

- *Coastal Carolinas*
Development, Sea Level Rise, agriculture, coastal storms, water quality, air quality
- *Willamette Valley*
Development, water quality, habitat, timber, agriculture, carbon
- *Tampa Bay region*
Population growth, development, water supply, habitat, climate change, sea level rise
- *Future Midwestern Landscapes*
Biofuels, agriculture, water quality, water supply, soil loss, habitat, carbon



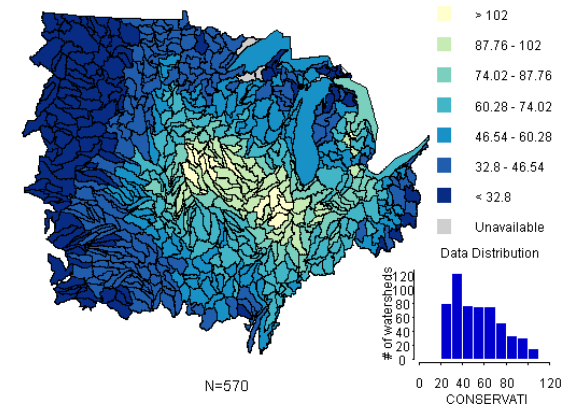
Change drivers of interest for Midwestern place-based study

- Biofuels
 - Potential for rapid, large-scale changes in land use or land management
 - Implicit trade-offs among ecosystem services
- Agricultural conservation practices
 - Existing area of large investment, uncertain benefit
 - Increasing interest in ecosystem service-based incentives and markets



Locations of ethanol biorefineries and FML boundary

Conservation program participation (dollars/acre)



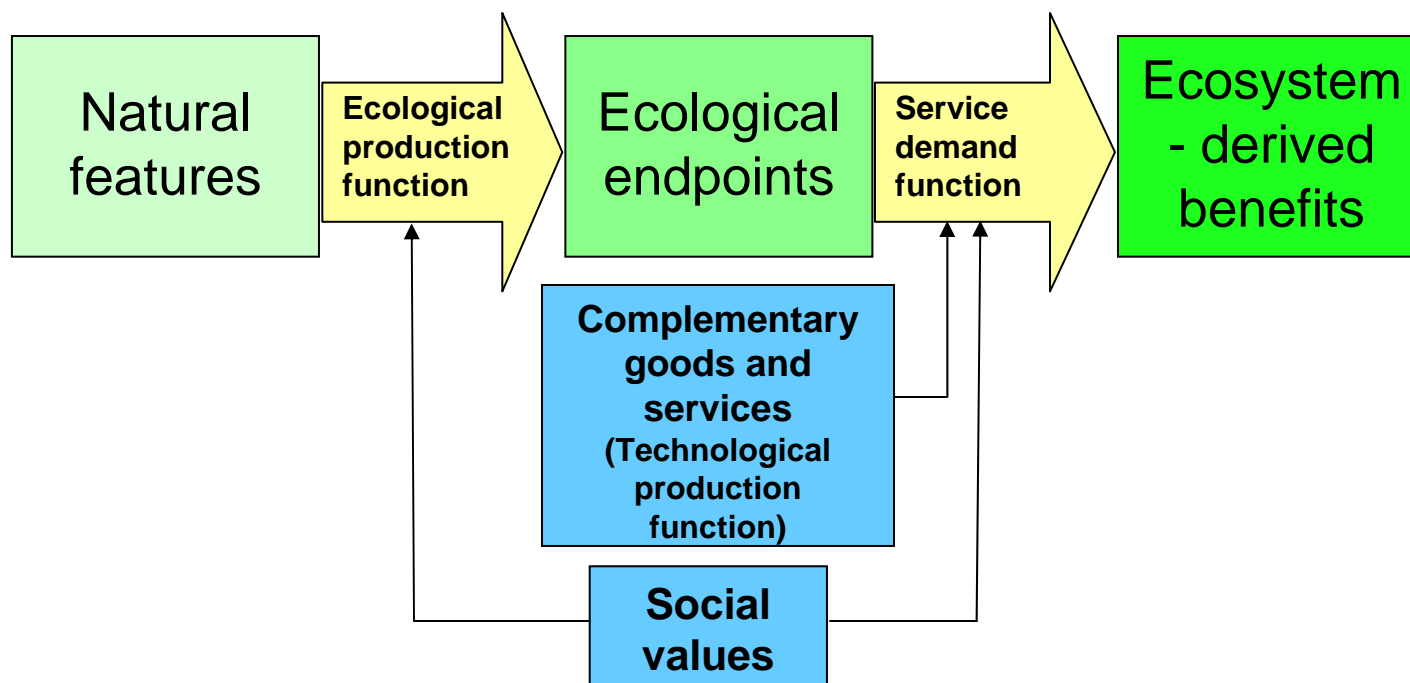
Problem statement

- How do structures, functions and processes of Midwestern ecosystems contribute to societal well-being?
- How can we quantify the ecological, technological, and service demand functions of the Midwest landscapes?
- How will today's land use decisions affect trade-offs of future ecosystem services? What land-use/land cover configurations afford the best combinations of ES based on society's values?
- What indicators of ecosystem service changes communicate the vulnerabilities and opportunities to decision-makers?
- How can we facilitate conservation and restoration of ecosystem services through existing or future market structures or policies?

Services of interest in FML Study (examples)

- ***Carbon storage***
- ***Water supply***
- ***Flood moderation***
- ***Water quality***
- ***Biodiversity***
- ***Air quality***
- ***Food production***
- ***Biofuel feedstock production***

Ecosystem Services Framework



Wainger and Boyd

Quantifying production functions is long-term research

Short-term analysis of ecosystem service endpoints

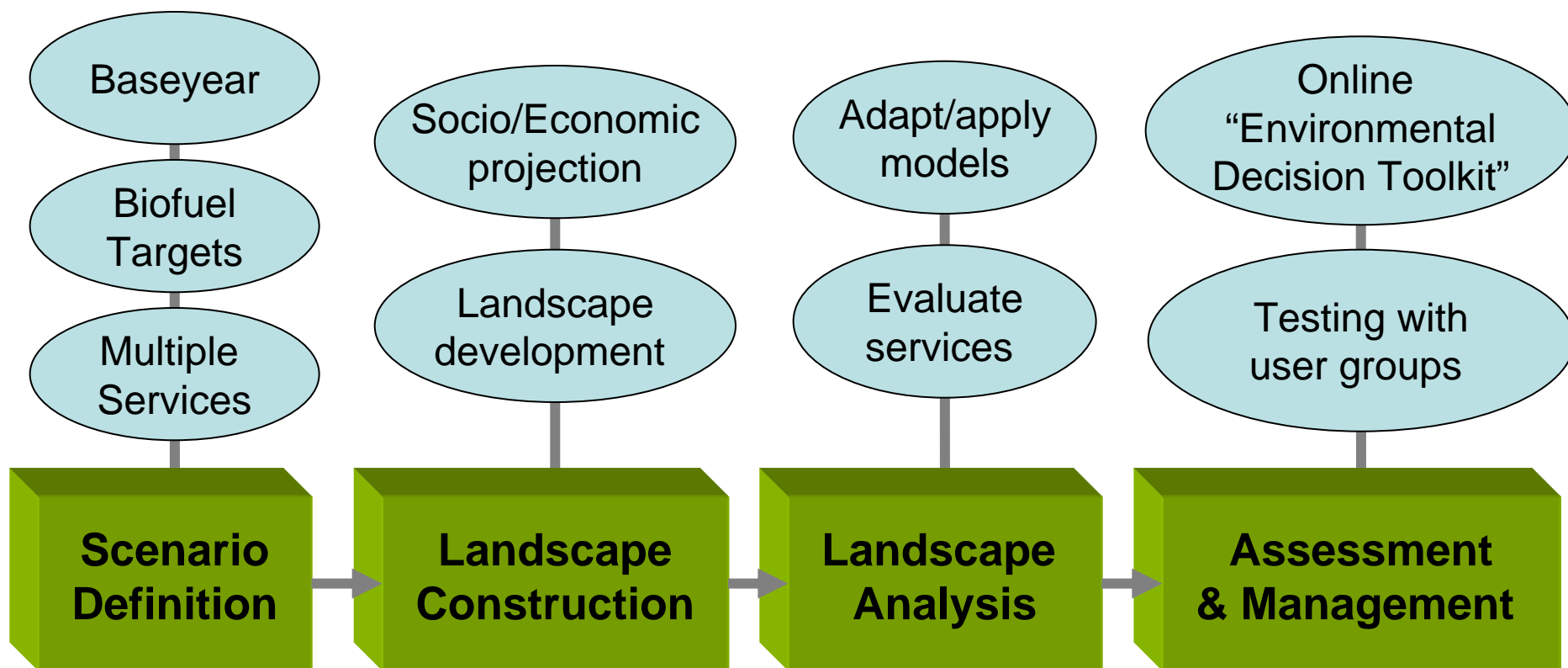
Supply and Demand Metrics

- Quality
- Quantity
- Vulnerability
 - Exposure
 - Ecological Resilience
 - Social Resilience

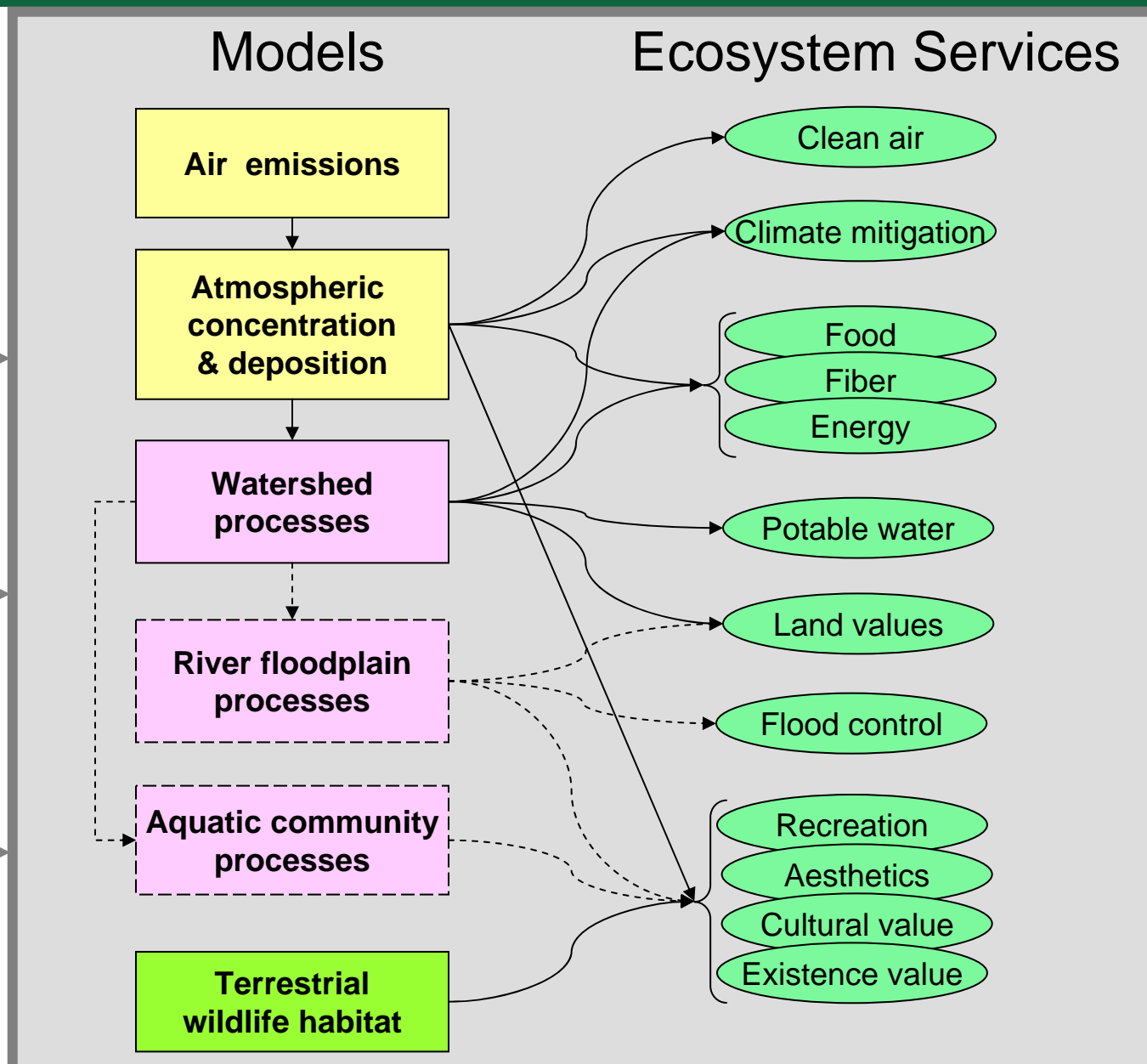
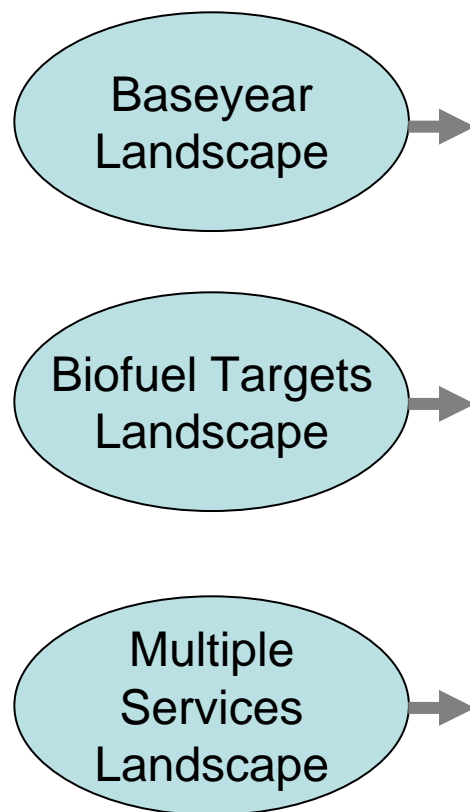
Interim Products:

- *Acquire regionally consistent, available data*
- *Clients (case studies) will help identify meaningful indicators through use of spatial data exploration tool (FML-EDT)*

Overview of alternative-futures research approach



Scenario Analysis



Biofuel Targets Scenario (2022)

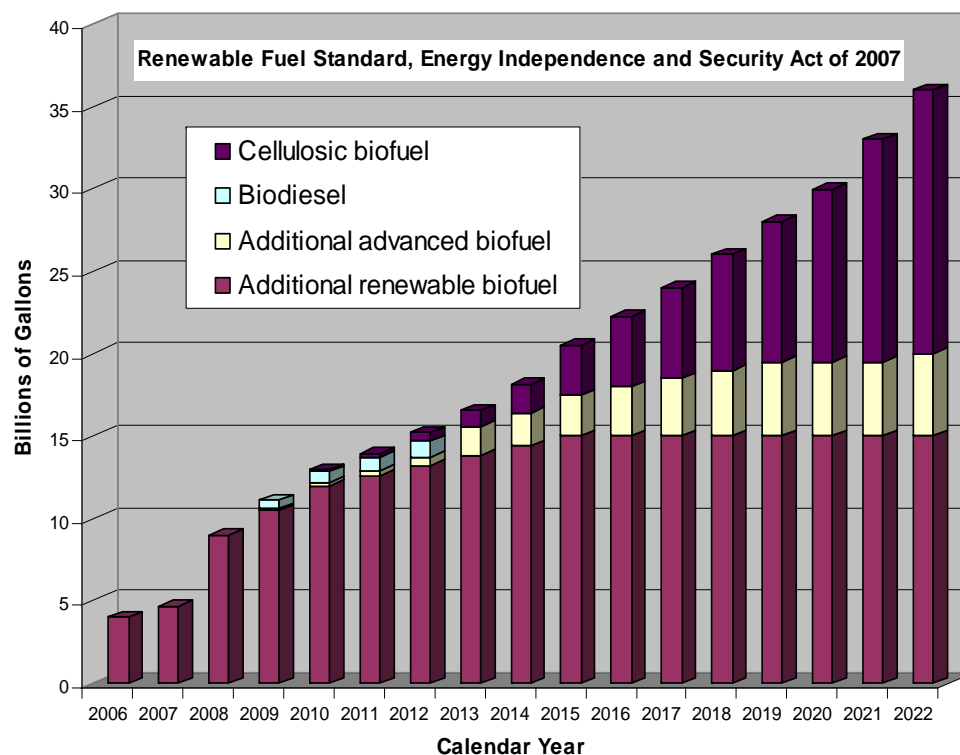
**Market Allocation (MARKAL)
econometric model (NRMRL)**

- Energy supply and demand

Sets conditions for:

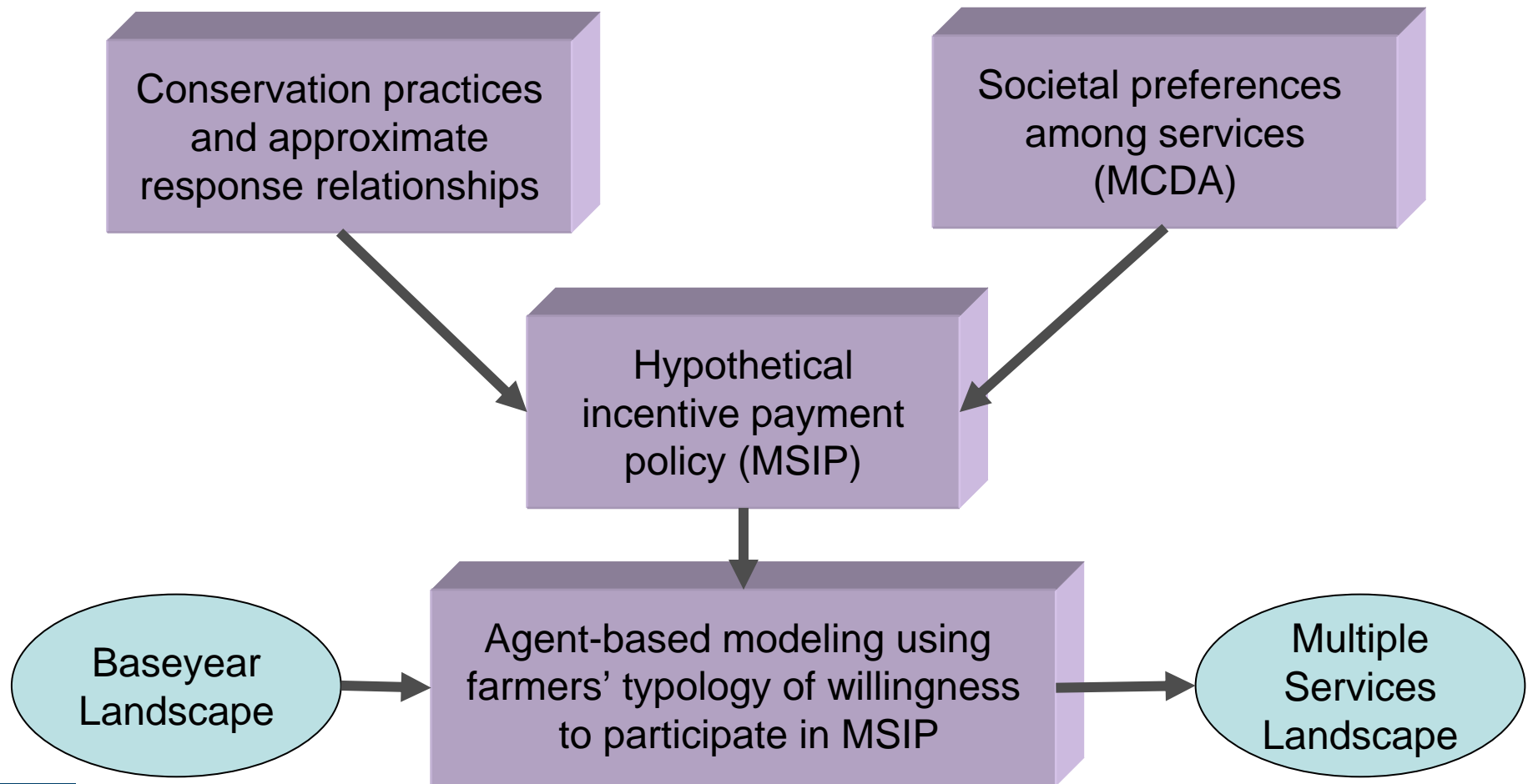
**Food and Agricultural Policy
Research Institute (FAPRI)
econometric model
(ISU/CARD)**

- Net returns (profits – costs)
drivers
- Number of acres / region

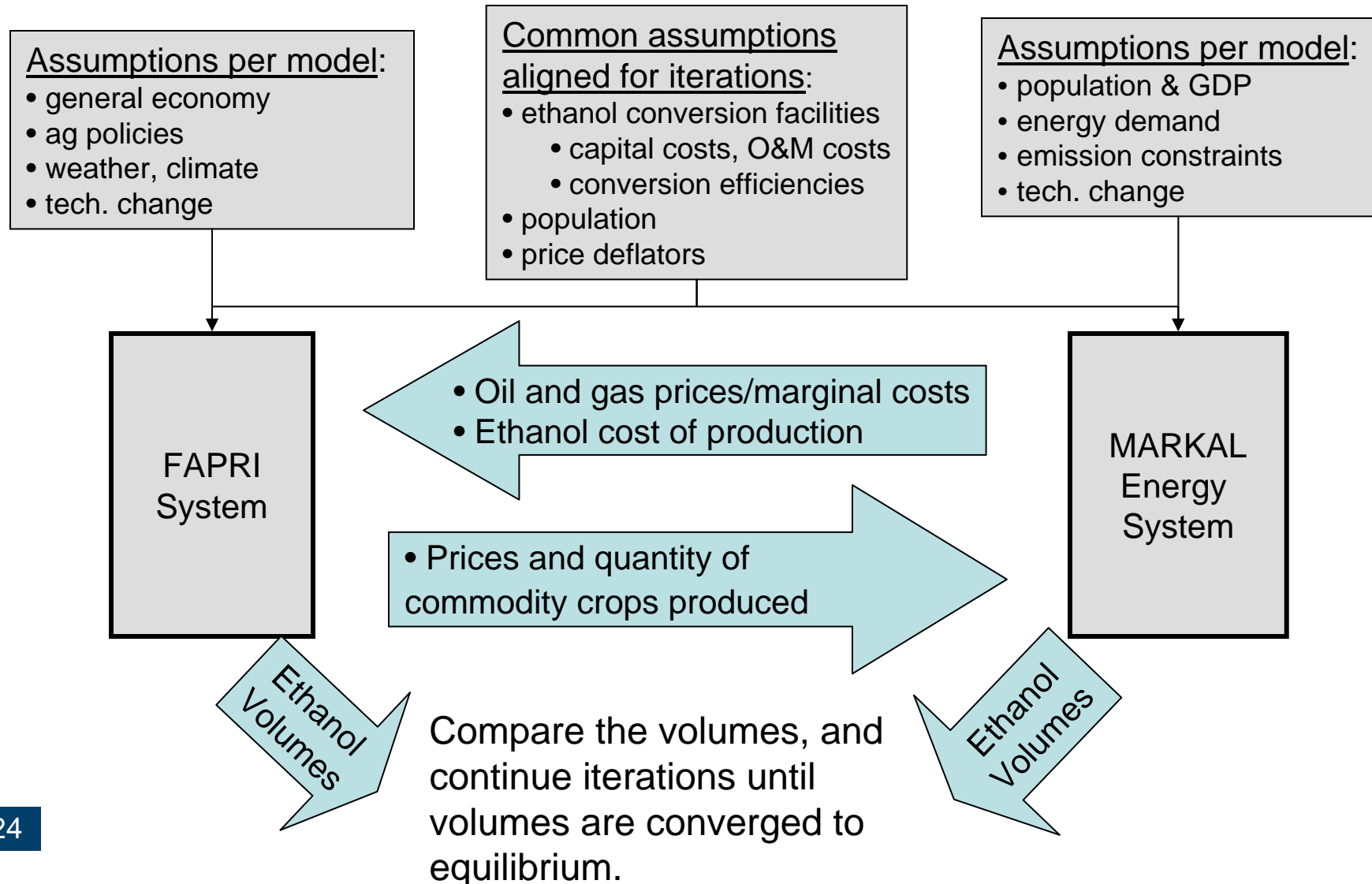


Results disaggregated using soils data, tillage practices, etc.

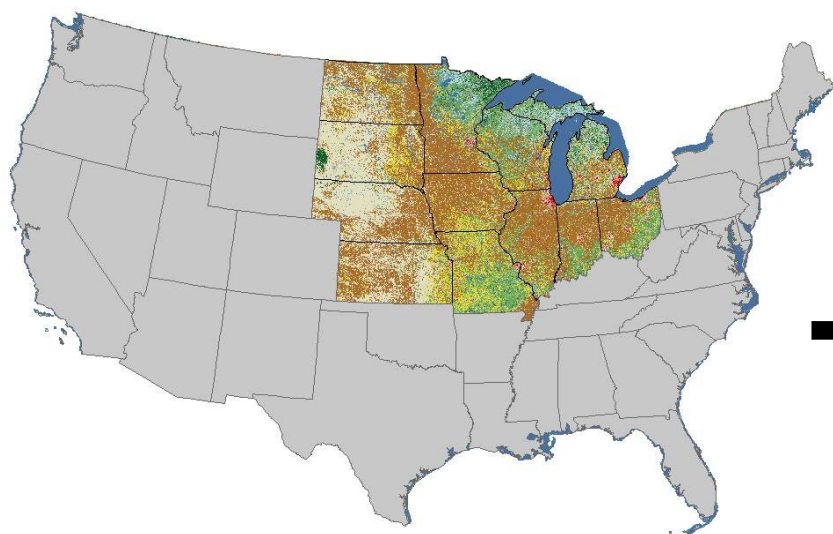
Multiple Services Scenario (2022)



Capturing Energy and Agriculture Market Dynamics through EPA and Iowa State/CARD Interaction

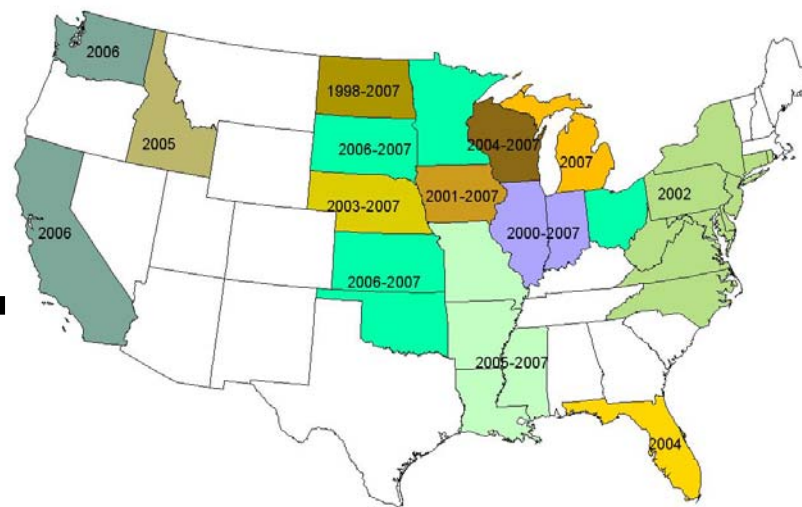


Base Year Scenario



NLCD 2001/2002

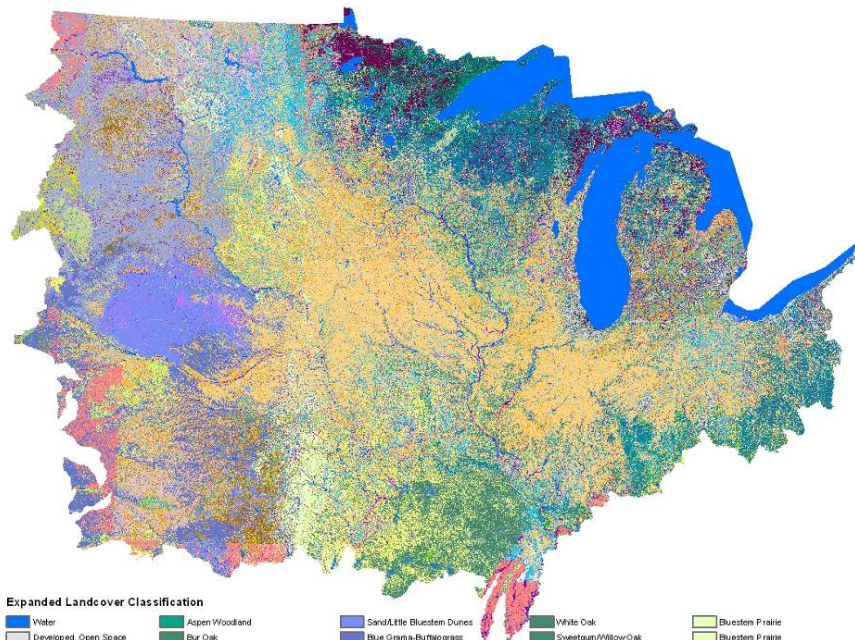
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NASS Cropland Data
Layers



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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

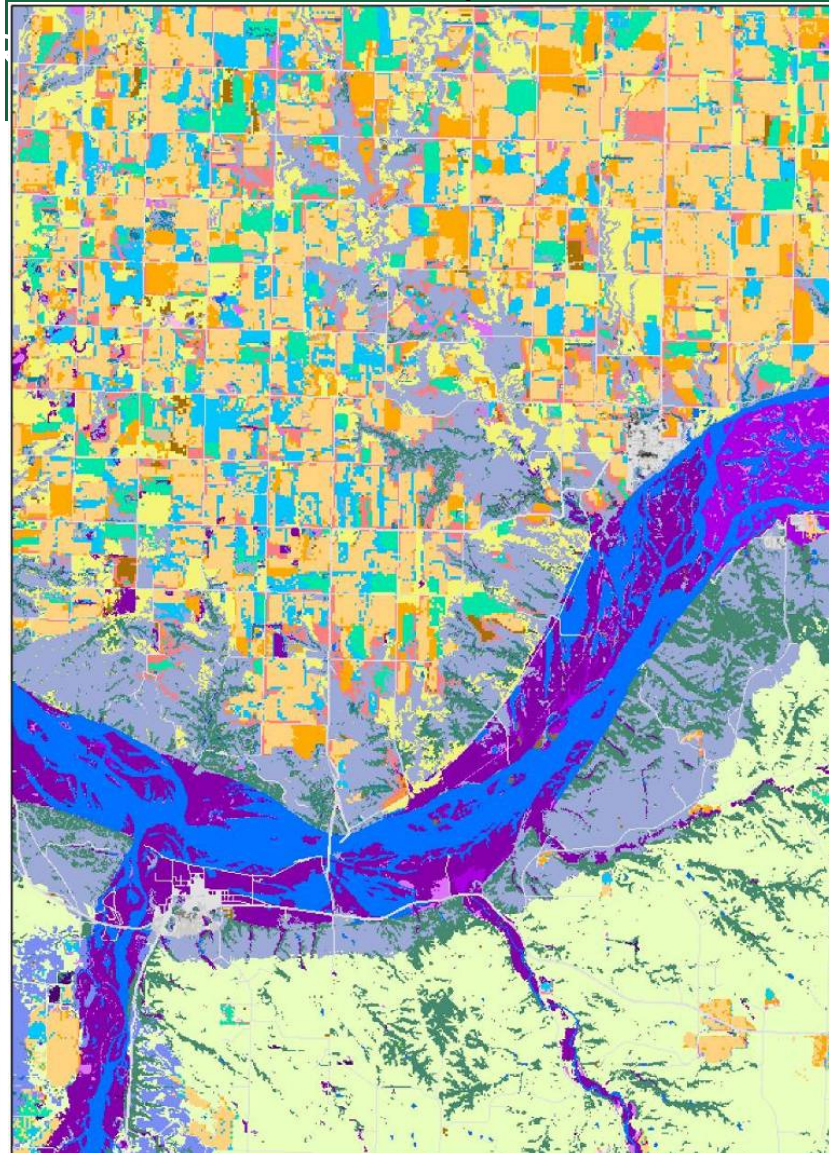
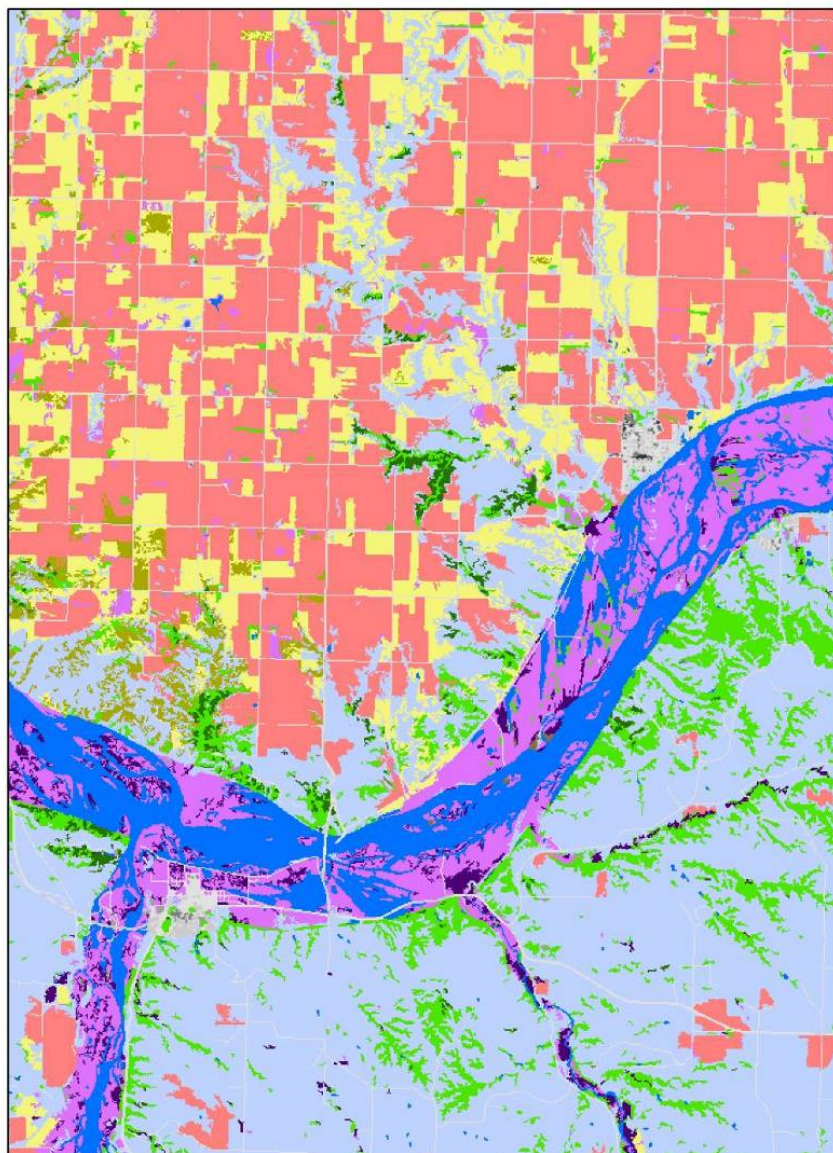
Expanded Landcover Classification

Water	Aspen Woodland	Sand/Little Bluestem Dunes	White Oak	Bluestem Prairie
Developed, Open Space	Bur Oak	Blue Grama-Buttergrass	Sweetgum/Willow Oak	Bluestem Prairie
Developed, Low Intensity	White Bark Pine	Bluestem Prairie	Yellow Poplar/White/Red Oak	Bluestem Prairie
Developed, Medium Intensity	White Spruce	Saltbrush-Greasewood	Dedicated Flatwood	Little Bluestem/Indiangrass/Wintergrass
Developed, High Intensity	Lumber Pine	Riparian Woodland	White Oak	Black Ash/Elm/Red Maple
Barren Land	Lodgepole Pine	Cottonwood-Willow	Swamp Chestnut/Cherrybark Oak	Willow/Water/Dian/leaf Oak
Undefined Deciduous Forest	Douglas Fir	Riparian	Live Oak	Jack Pine/Swale
Undefined Evergreen Forest	Ponderosa Pine	Riparian	Aspen	Orest Plains/Riparian
Undefined Mixed Forest	Spruce Sup Alpine Fir	Douglas Fir	White/Black/Red Oak	Floodplain Riverbirch/Sycamore
Undefined Shrub/Scrub	Bristlecone Pine	Shrubland	Grass/Shrub Balds	Floodplain Sweetgum/Willow Oak
Undefined Grassland/Herb.	Juniper-Pinyon Pine	Ponderosa Pine	Jack Pine	Floodplain Sweetgum/Willow Oak
Undefined Pasture Hay	Aspen	Introduced Woody Wetland	Longleaf Pine	Floodplain Black Ash/Elm/Maple
Undefined Crop	Red Alder	Introduced Upland Herbaceous	Virginia Pine	Black Spruce/Tamarack/Peatland
Undefined Woody/Wetland	Black Sagebrush	Introduced Upland Herbaceous	Willow/Water/Dian/leaf Oak	Swamp Riverbirch/Sycamore
Undefined Herbaceous Wetland	Saltbrush-Greasewood	Introduced Upland Herbaceous	Red Pine	Coastal Plain Swamp
Monoculture Corn	Black Sagebrush	Introduced Herbaceous Wetland/Riparian	Missouri Glades	Black Ash/Elm/Maple Swamp-Bog
Monoculture Soybean	Big Sagebrush	Introduced Upland Tree	Post/Blackjack Oak	Prairie Pothole Wetland
Monoculture Wheat	Salt Desert Shrub	Recently Logged	Balsam Fir	Violet Meadow/Prairie Marsh
Monoculture Cotton	Sagebrush/Grass	Recently Logged	Hemlock Yellow Birch	Coastal Herbaceous Marsh
Corn/Soy	Chokeberry-Serviceberry Rose	Ruderal Forest	Shortleaf Pine/Oak	Appal. Shrub/Herbaceous Wetland
Corn/Wheat	Sand Sage Prairie	Sand Shimmer Oak	Chestnut Oak	Laurentian-Acadian Herbaceous Wetland
Corn/Other	Chokeberry-Serviceberry Rose	Big Sagebrush	Sugar Maple/Beech	Bluestem Depressional Wetland
Corn/Fallow	Gambel Oak	Aspen	Loblolly Pine-Hardwood	Alkali Casaton-Tobosa Grass
Soybean/Wheat	Mesquite	Sugar Maple	Shortleaf Pine/Oak	Alkali Casaton-Tobosa Bottom land
Soybean/Other	Ponderosa Pine	White/Black/Red Oak	Chestnut Oak	White Oak
Soybean/Fallow	Juniper-Pinyon Pine	White Oak	Post/Blackjack Oak	Shortleaf Pine/Oak
Wheat/Other Crop	Big Sagebrush/Bluebunch Wheatgrass	Oak	Dedicated Shrubland	Sweetgum/Willow Oak River Flatwoods
Wheat/Fallow	Big Sagebrush	Oak-Hickory	Bur Oak	Black Oak Bluff/Grassland
Cotton/Other	Big Sagebrush	White/Black/Red Oak	Pin Oak	Pin Oak/Sweetgum Wet Flatwood
Misc Grain/Fallow	Blue Grama/Western Wheatgrass	Post/Blackjack Oak	Grass/Shrub Bald	Ruderal Shrub Forest
Other Crop/Fallow	Grass/Lily-Threesawn	White/Black/Red Oak	Glade	Ruderal Mixed Forest
Alfalfa Hay	Grass/Lily-Threesawn	Black Oak	Red Pine	Ruderal Mixed Forest
Alfalfa Hay/Other	Rough Fescue-Bluebunch Wheatgrass	Post/Blackjack Oak	White Cedar	Managed Tree Plantation
Fallow	Rough Fescue-Idaho Fescue	Sugar Maple/Beech/Yellow Birch	Lake Prairie	Managed Tree Plantation
Sparsely Vegetated	Wheatgrass-bluestem-Neelgrass	Sugar Maple/Basswood	Bluestem Prairie	Introduced Wetland Vegetation
Sparsely Vegetated	Tall Fescue	Chestnut Oak	Bluestem Savannah/Woodland	Modified/Managed Tallgrass
Sparsely Vegetated	Alpine Rangeland	Yellow Poplar/Hemlock	Little Bluestem/Post Oak	
Aspen Forest/Parkland	Bluestem Gramin Prairie	Sugar Maple/Beech	Karl Plain Prairie	

Megan Mehaffey

NLCD 2001

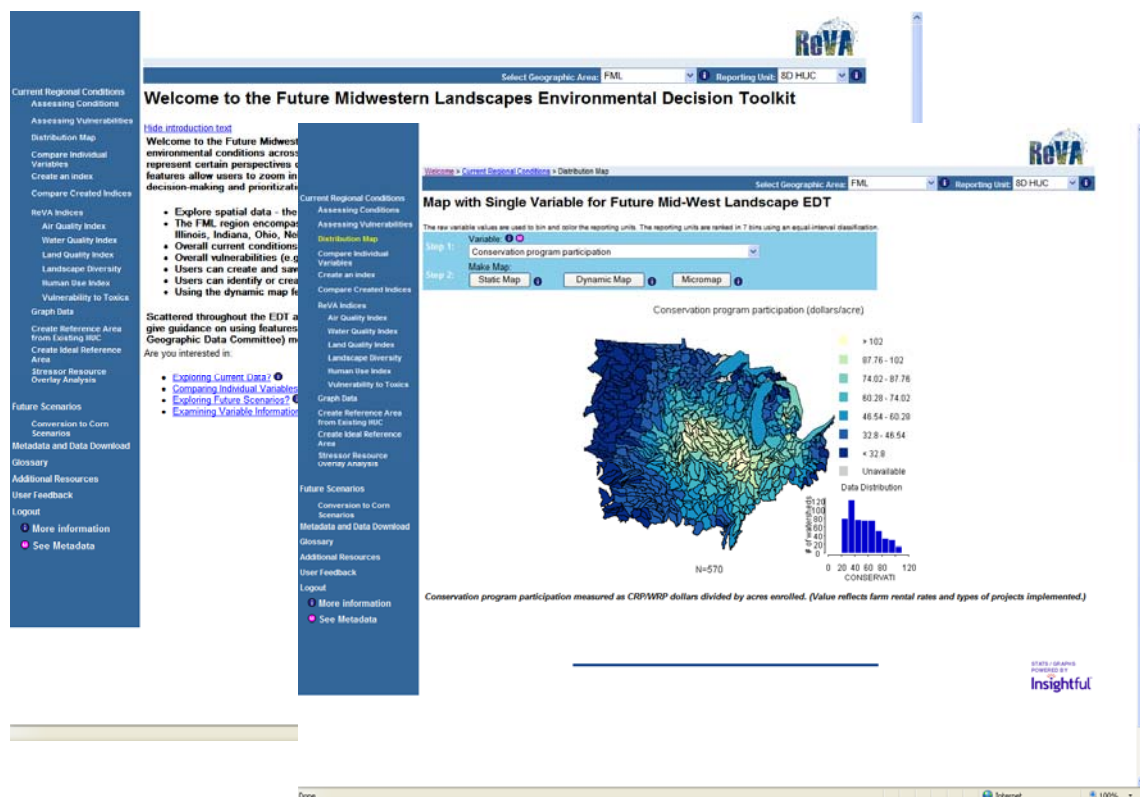
NLCD Expanded 2001



27 Pasture Row crops

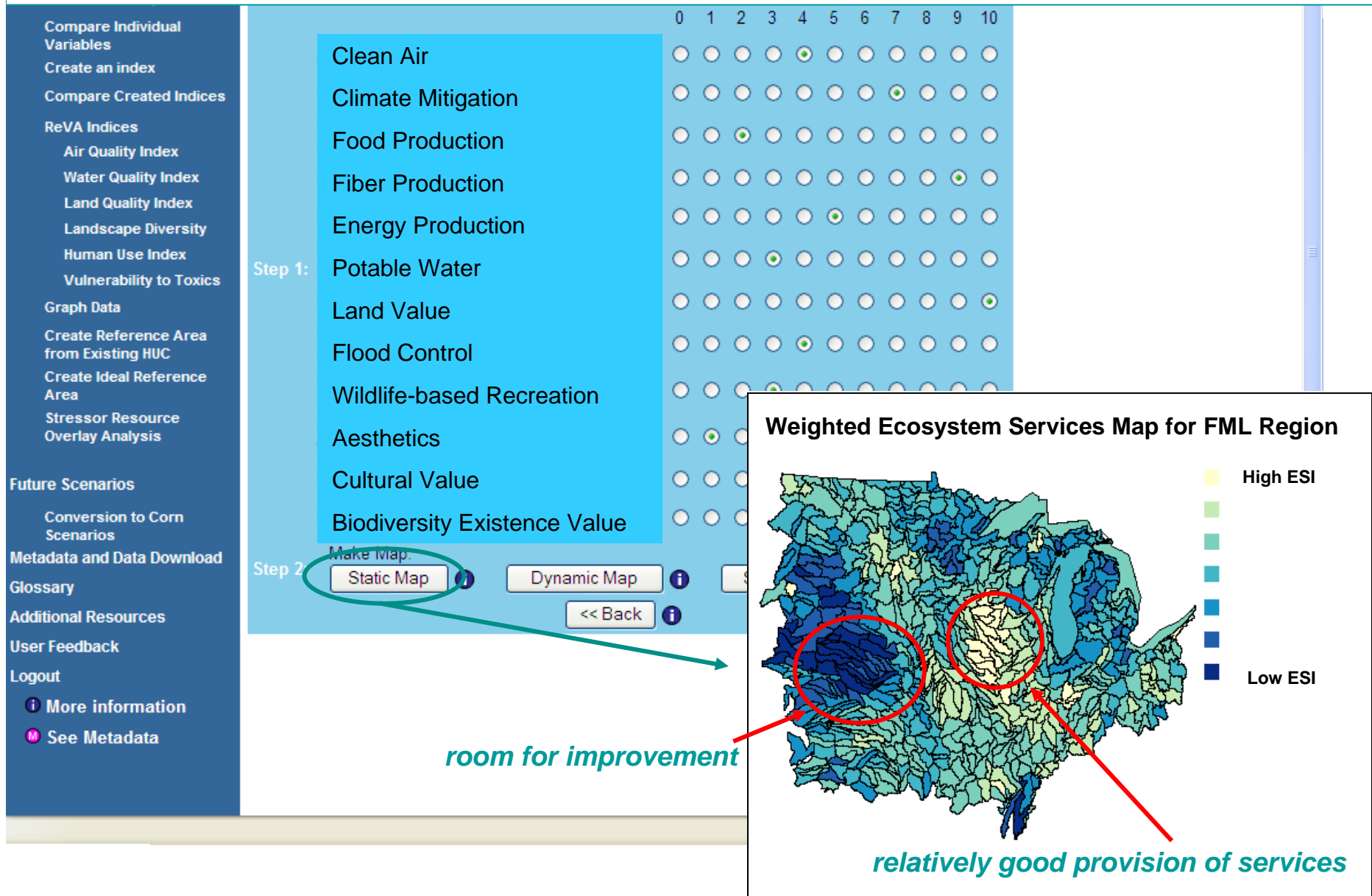
Corn monoculture Pasture
Alfalfa/Hay
Soybean in rotation
Corn in rotation

The Future Midwestern Landscapes Environmental Decision Toolkit (FML-EDT)



- User-friendly tool for decision-makers
- Structured around ES themes to promote problem solving
- Reduce complex information into useable performance metrics
- Promote understanding of cause/effects resulting from policy choices

Future capability: Build an ecosystem service index (ESI) combining user-weighted values

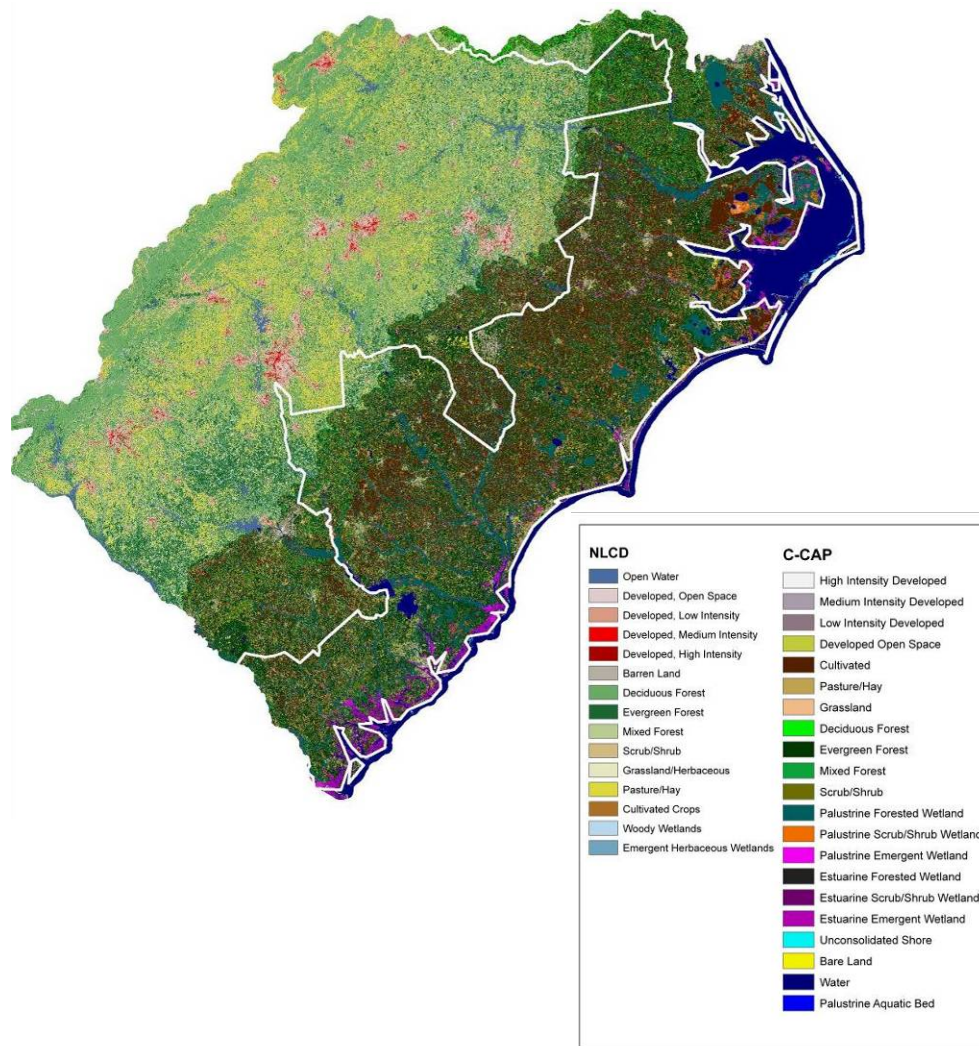
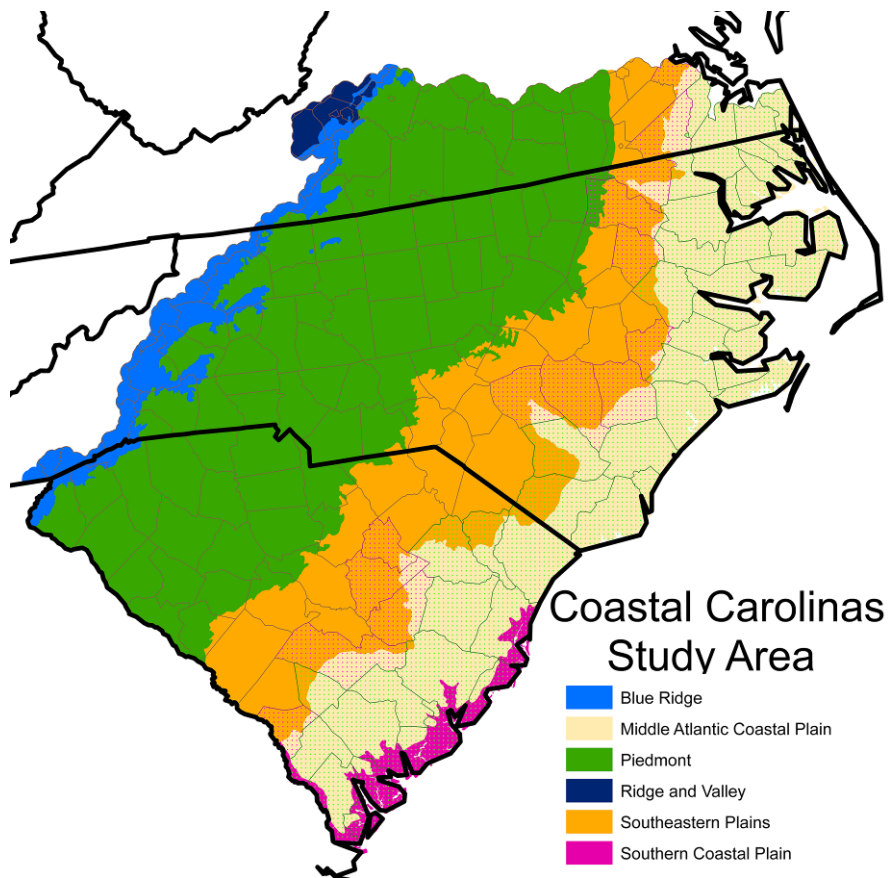




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<i>Assessing Existing & Baseline Future Conditions</i>	<i>Evaluating Opportunities for Action</i>	<i>Analysis Components</i>
Nutrients / GOM / Great Lakes		
Which watersheds are generating the most N and P to GOM?	Which watersheds are generating the most controllable N and P to GOM?	Establish model based on farm & landscape characteristics (e.g., areas with high fertilizer inputs, leaky soils/ geology, minimal conservation practices implemented)
Which watersheds are generating the most N and P to Great Lakes?	Which watersheds are generating the most controllable N and P to Great Lakes?	Establish model based on farm or urban & landscape characteristics
	How can conservation practices be targeted to cost-effectively reduce N, P exports to major waterbodies?	Identify leakiness factors by watershed or sub-watershed location , loadings, attenuation characteristics, existing BMPs
Which stream reaches have ecological components vulnerable to nutrient pollution?	How can conservation practices be targeted to cost-effectively reduce N, P exports to vulnerable streams?	Identify where functions have high likelihood of being restorable. (ie, moderately impacted with high opportunities for cost-effective BMPs)
Where are the biggest changes in stream chemistry likely to occur if biofuel production increases?	What level of nutrient export might be generated with alternative management aimed at fulfilling multiple services?	Scenario Analysis - nutrient export indices
Water Quality for Drinking		
Where are people exposed to health risks from nitrates in groundwater?	Where can practices be implemented to increase the safety of the groundwater supply?	Population exposed, % marginal farmland, restorable wetlands
Where are municipal surface water intakes (SWI) at risk for increased treatment requirements? (from development, nitrogen pollution, etc.)	Where could practices be targeted to protect SWIs?	% natural veg in surface water protection watershed (identify watersheds near thresholds?) vs. land conversion pressure
Recreational hunting		
Where are recreational hunting options the most scarce?	Where are opportunities to cost-effectively increase recreational hunting opportunities?	e.g., Green ratio vs. population
Existence Values - Terrestrial habitats		
Which habitats are vulnerable?	Which habitat patches are the most critical to preserve?	Documented, likely, and potential occurrences of rare species and natural communities combined with opportunities for green corridors, reduced fragmentation, etc. (e.g., something like FNAI)
Where are rare habitats experiencing the greatest stress?	Which areas are the most critical to restore to protect scarce habitat?	Land conversion potential; cumulative impacts of land conversion; x FNAI-like layer

The Coastal Carolinas Project



Coastal Carolinas

The Coastal Carolinas Ecosystem Services Initiative is being developed to address a variety of issues related to impacts from global change and coastal development. The initiative will focus on:

- Mapping and quantifying coastal ecosystem services.**
- Establishing the relationships between human land use, air, land, and aquatic processes, and coastal ecosystem services.**
- Developing models and information to estimate how changing land use, sea level, and storm frequency and intensity may impact future coastal 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.**



Coastal Carolinas Alternative Futures

Sea Level Rise:

Slow (current rate)

Medium (1 m by 2100)

Fast (3 m by 2100)

Development Response:

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

Hurricane SLOSH Model

-  Water
-  Category I
-  Category II
-  Category III
-  Category IV
-  Category V



Questions?