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ECOSYSTEMS SERVICES RESEARCH PROGRAM

BUILDING A SCIENTIFIC FOUNDATION FOR SOUND ENVIRONMENTAL DECISIONS

Using Ecosystem Services to Inform Policy Decisions and Adaptive Management: Examples from the US Environmental Protection Agency's Research Program

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- Rick A. Linthurst, National Program Director, ESRP
- National Ecosystem Services Mapping Team
- Wetlands Ecosystem Services Team (W-EST)
- Future Midwestern Landscapes (FML) Team
- Willamette Ecosystem Services Project (WESP) Team

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US EPA Ecosystem Services Research New Directions 2009-2014

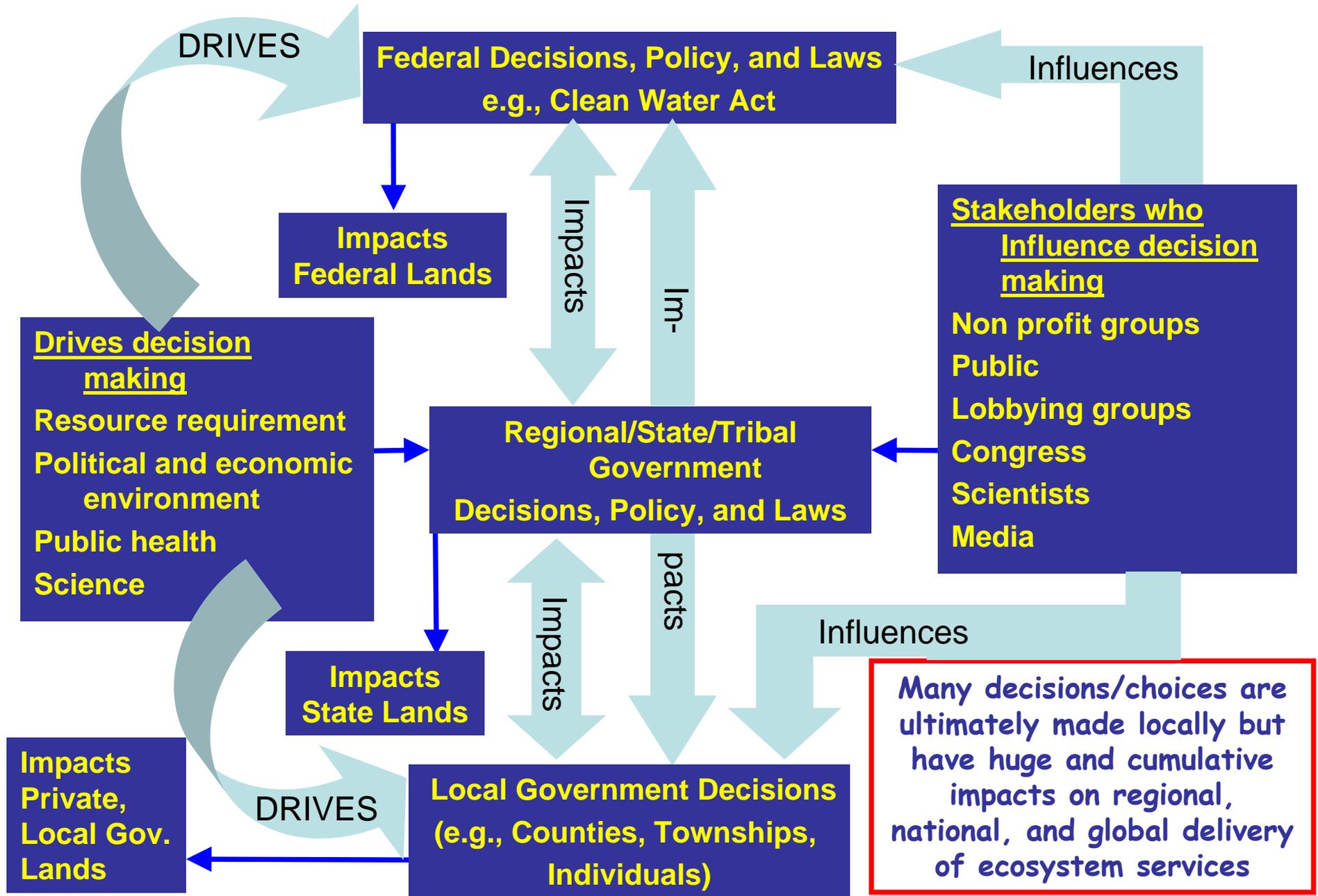
Vision

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.

Decision Making Occurs at Multiple Levels





Questions Posed by Decision-Makers

National Scale

What policies are needed to reduce the hypoxic zones in the Gulf of Mexico and Lake Erie?

How do we ensure adequate habitat for federally protected migratory species?

How do we evaluate areas to optimize the production of ecosystem services through programs such as the Dept of Agriculture's Conservation Reserve Program?

What restoration methods work where?

How can we quantify the success of environmental protection legislation?

Regional Scale

How do we target watersheds for improving water quality most efficiently? Which linkages among watersheds are the most critical for reducing pollution downstream?

How can this region accommodate an increasing population and maintain good air quality?

Where are the areas most vulnerable to multiple stresses?

How effective are local conservation measures in protecting migratory bird stopovers?

How effective are local BMPs in protecting large water bodies?

Local Scale

What can I do to protect water quality on my property?

How can I attract more wildlife (e.g. songbirds)?

How can community zoning ensure adequate green space?

How many people can our available water resources supply?

How can we reduce traffic congestion in developing neighborhoods?

A Multi-pronged Approach

Pollutant-Based Ecosystem Services Research

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

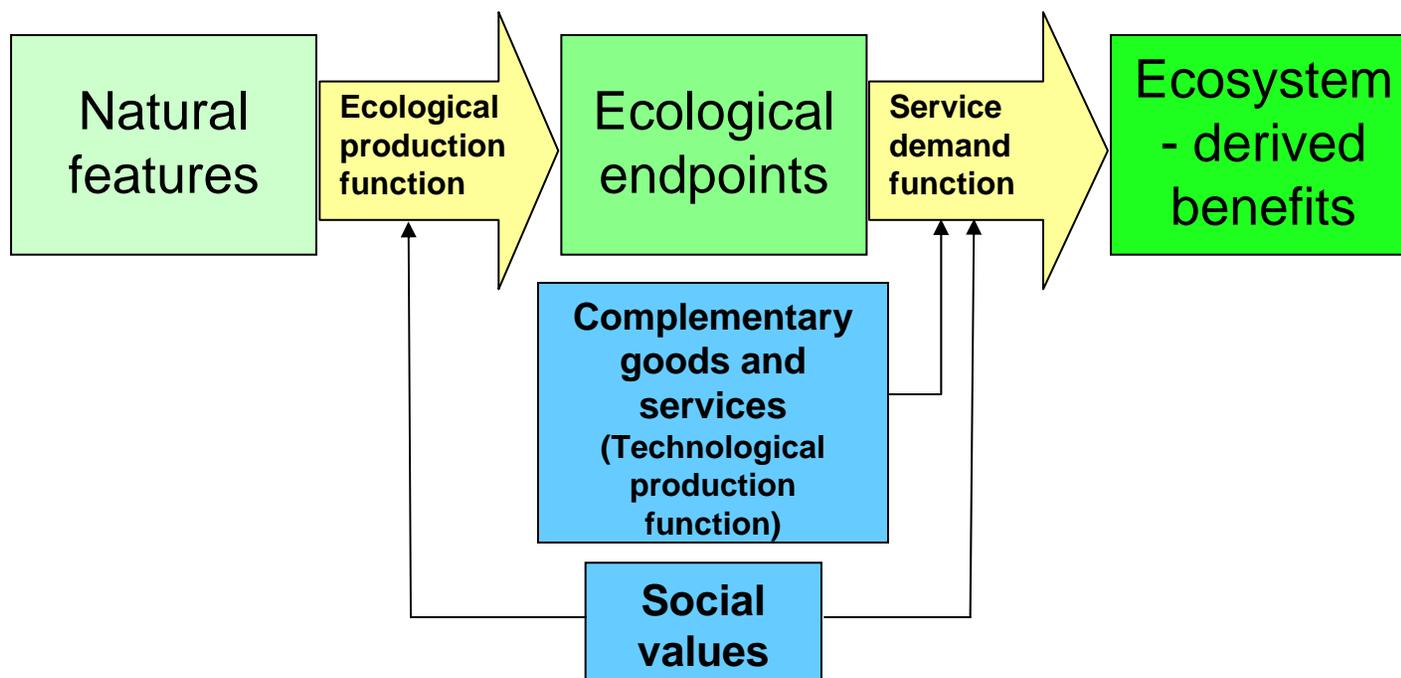
Ecosystem-Based Ecosystem Services Research

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

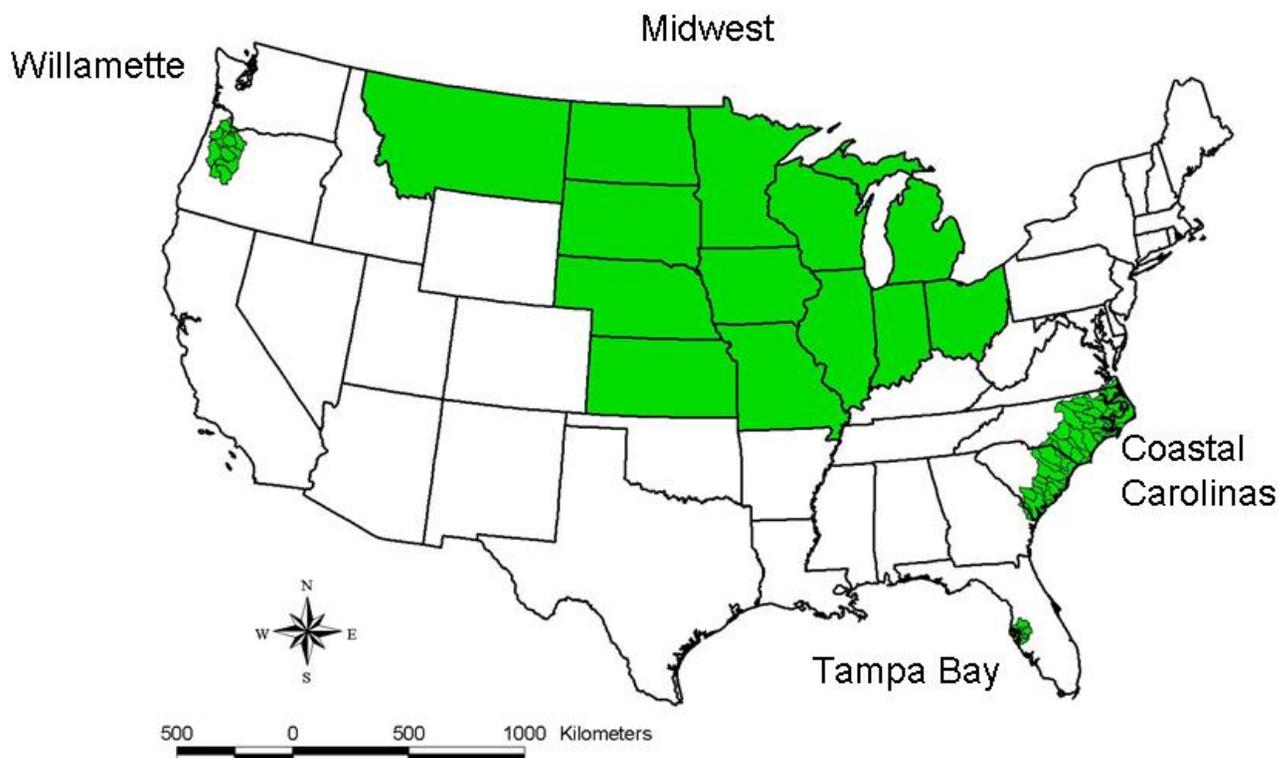
How does the bundle of ecosystem services for all ecosystems within an “ecosystem service district” change under alternative management options?

Ecosystem Services Framework



Wainger and Boyd 2008

Place-based Studies

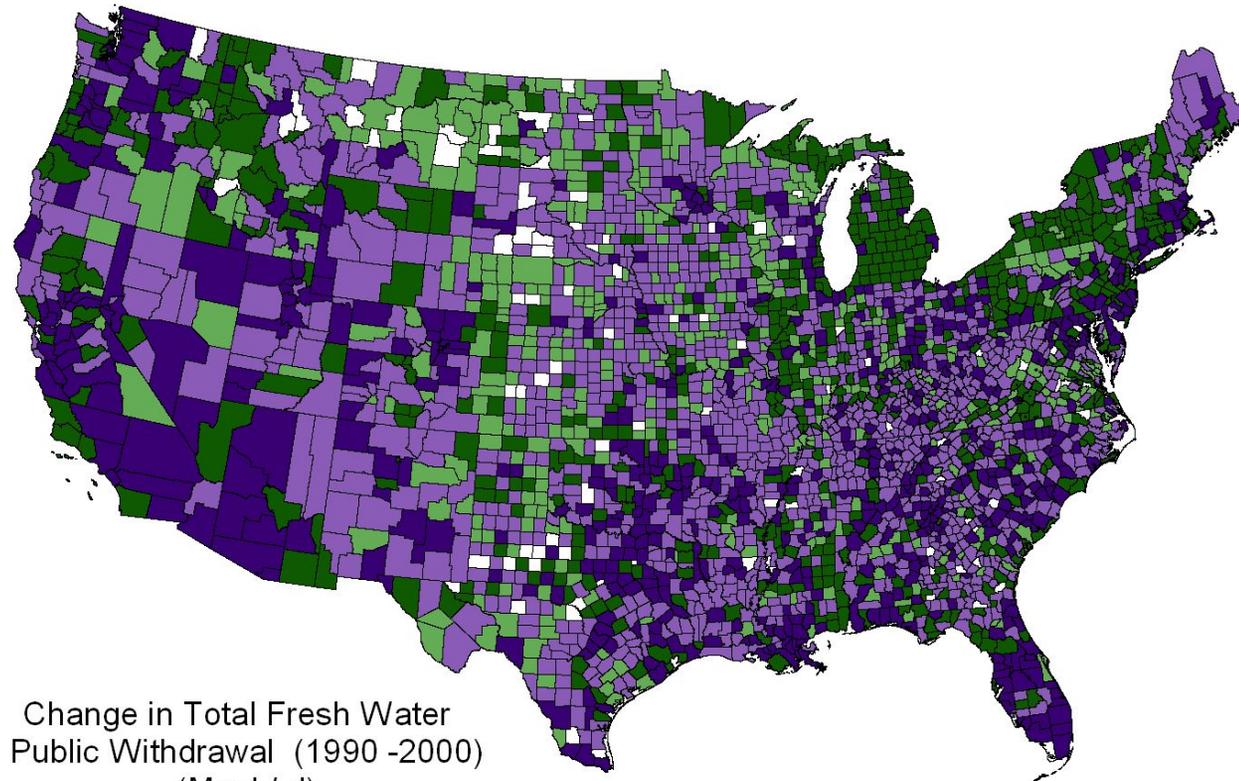




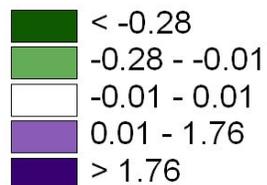
National Mapping Theme Goals

- To collaborate with and to provide landscape science support to place-based, wetlands, coral reefs, and nitrogen ESRP studies
- 
- To develop a publicly accessible and scalable National Atlas of Ecosystem Services with the intent **goal of impacting decision-making**

Examples of National Mapping Effort: Water Supply as a Valued Service



Change in Total Fresh Water
Public Withdrawal (1990 -2000)
(Mgal / d)



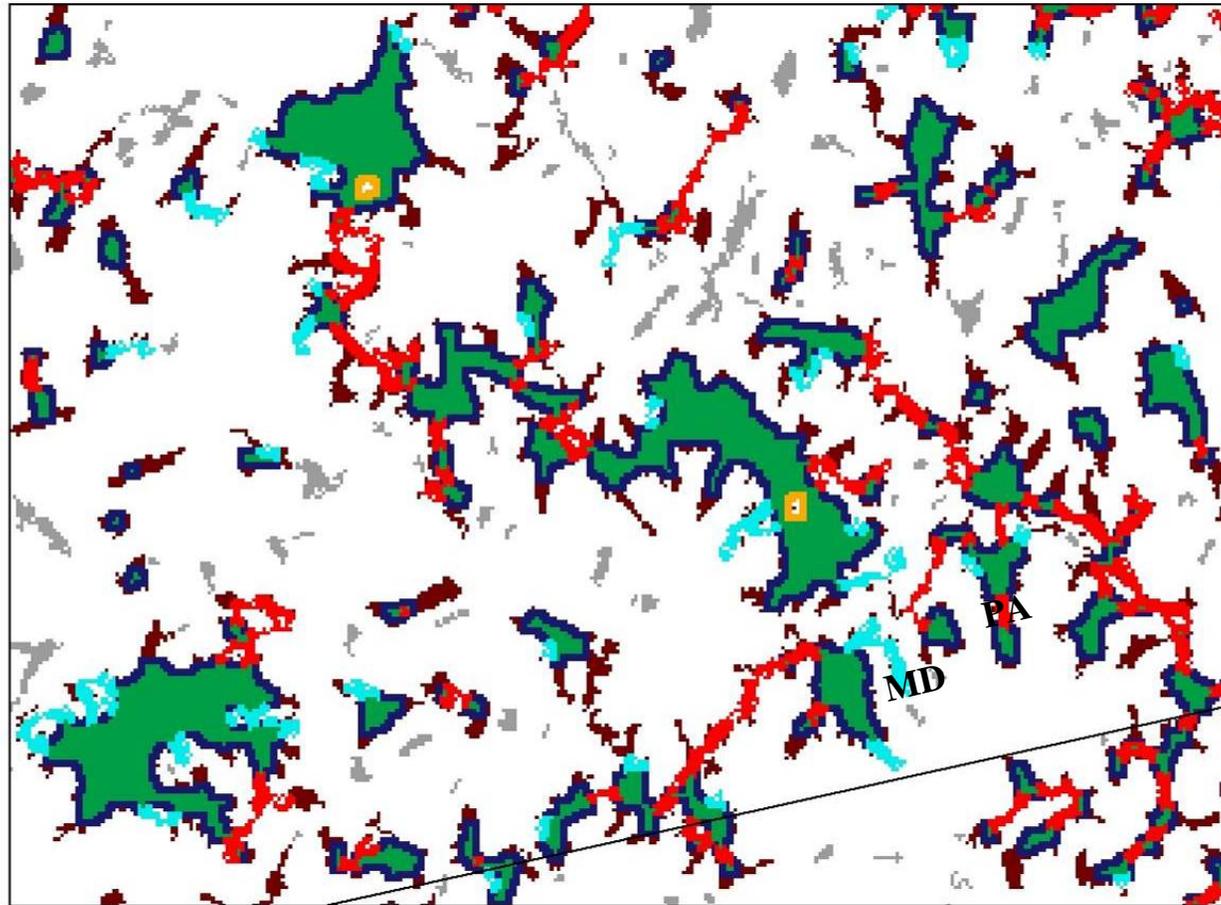
Source of water use data:
<http://water.usgs.gov/watuse/data/2000/>

Megan Mehaffey

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

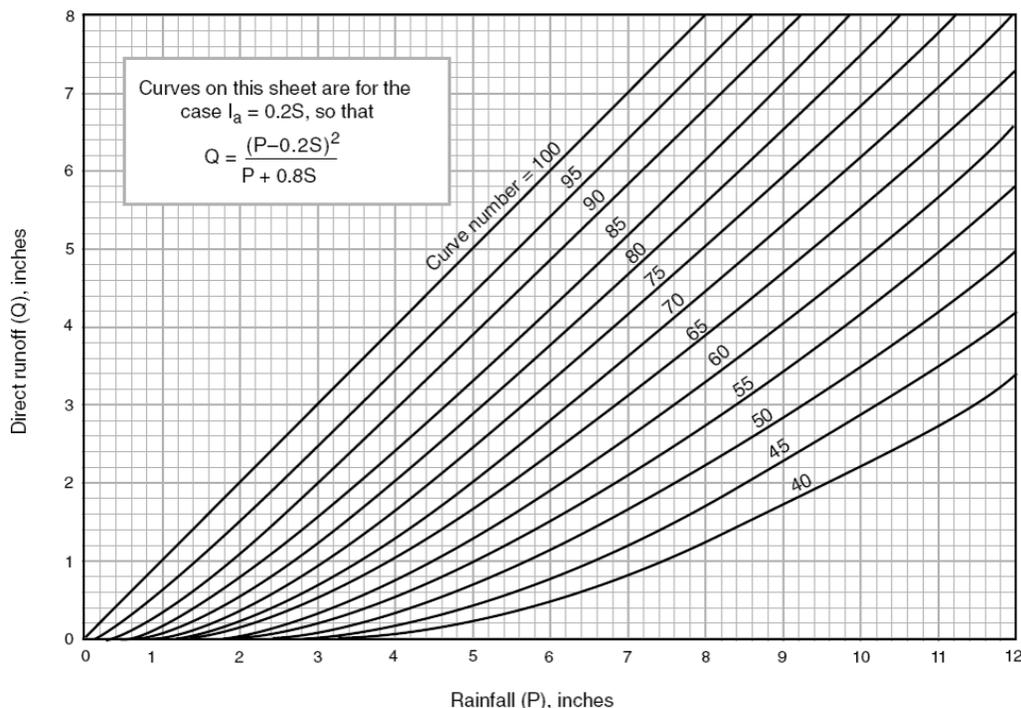
Branch Edge Islet Core Bridge Loop Perforation

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/>

Examples of Ongoing Atlas Work

Flood Mitigation using Soil Conservation Service Curve Number Approach

Jim Wickham, Tim Wade, Landscape Ecology Branch, ESD



Generalized Curve Numbers

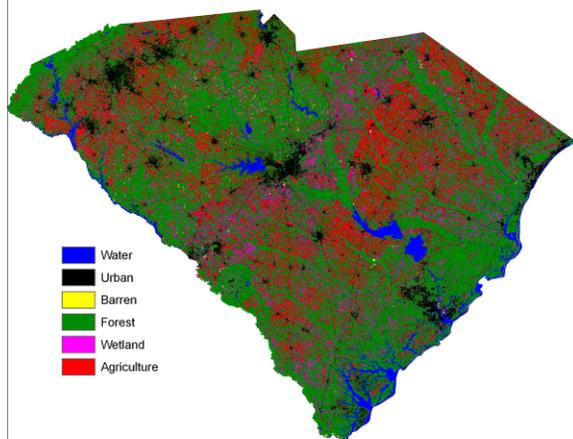
Hydrologic Soil Group

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	

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

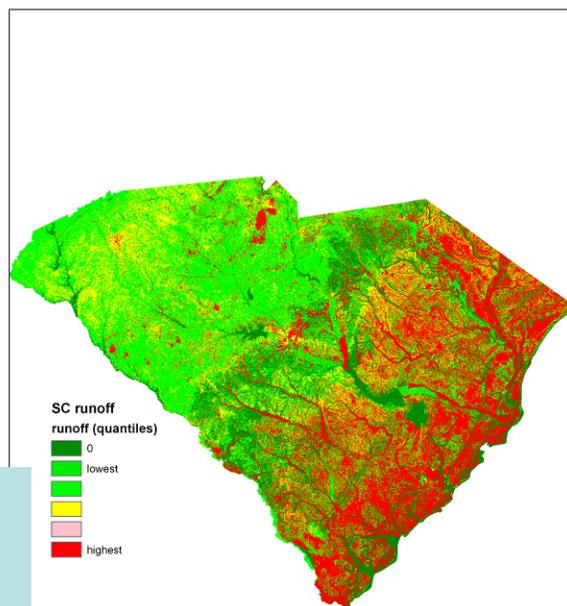
Water Yield using SCS Curve Number Approach

South Carolina Land Cover

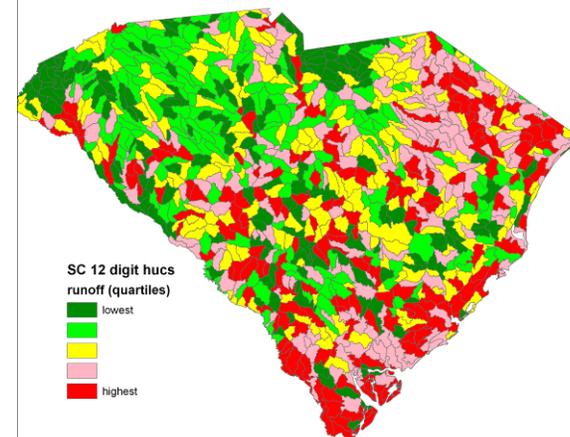


Calculations of CN based on NLCD land cover and SSURGO soils data

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



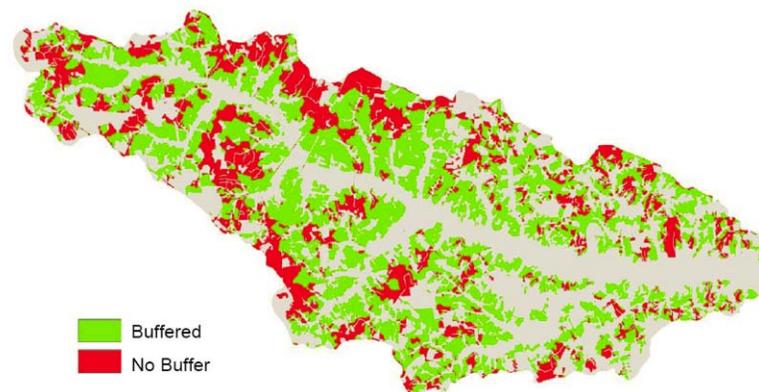
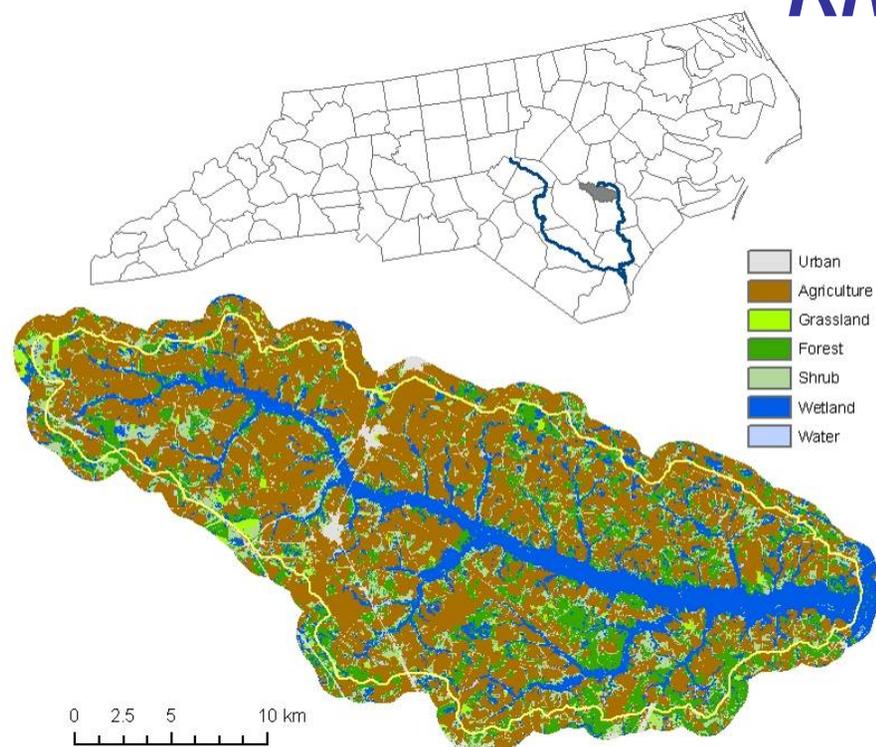
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Water Quality -- Nutrient Attenuation/Removal by Riparian Buffers

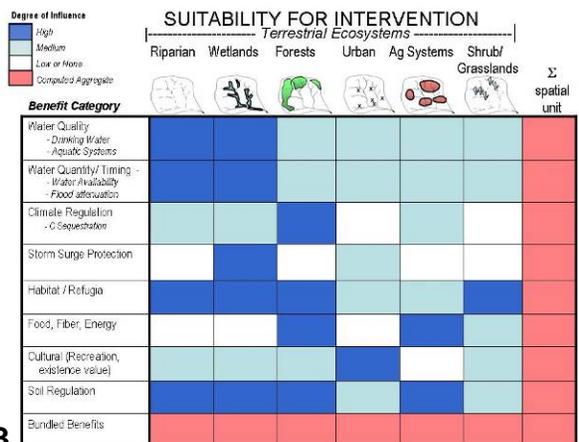
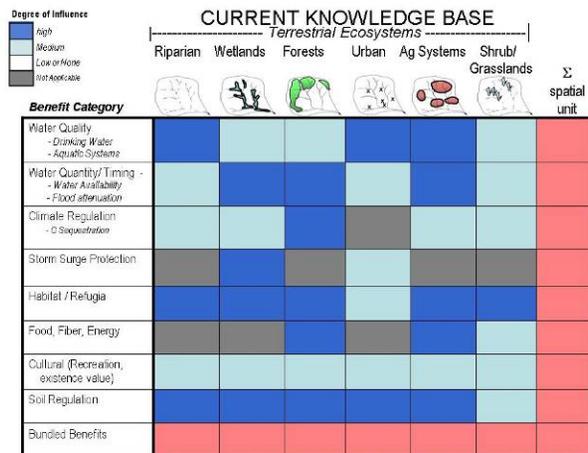
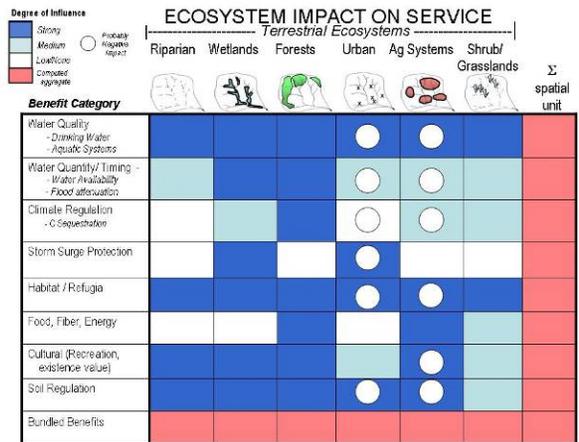
Goshen Swamp Tributary of NE Cape Fear River



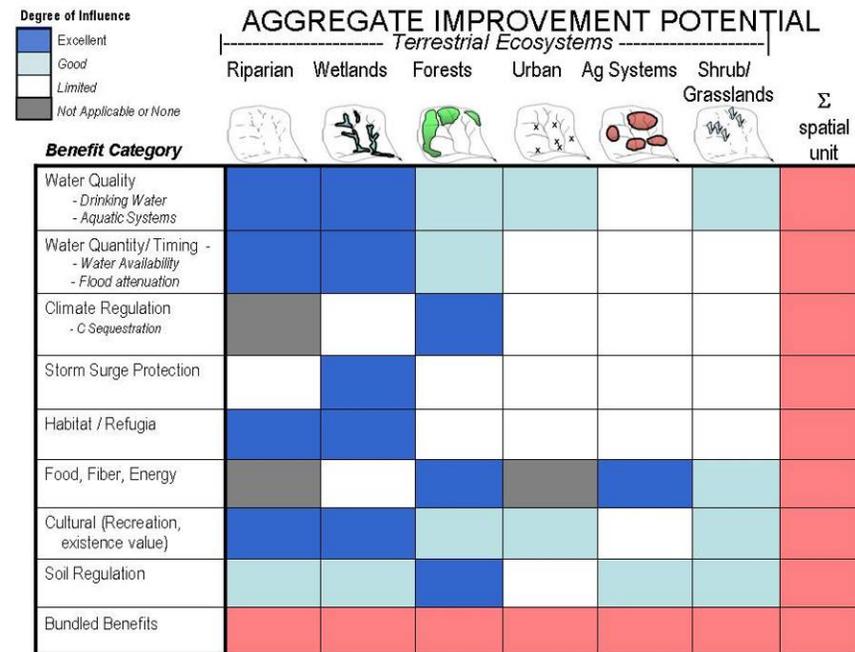
67 % of Ag buffered
33 % not buffered

U.S. Environmental Protection Agency
Office of Research and Development

Jay Christensen

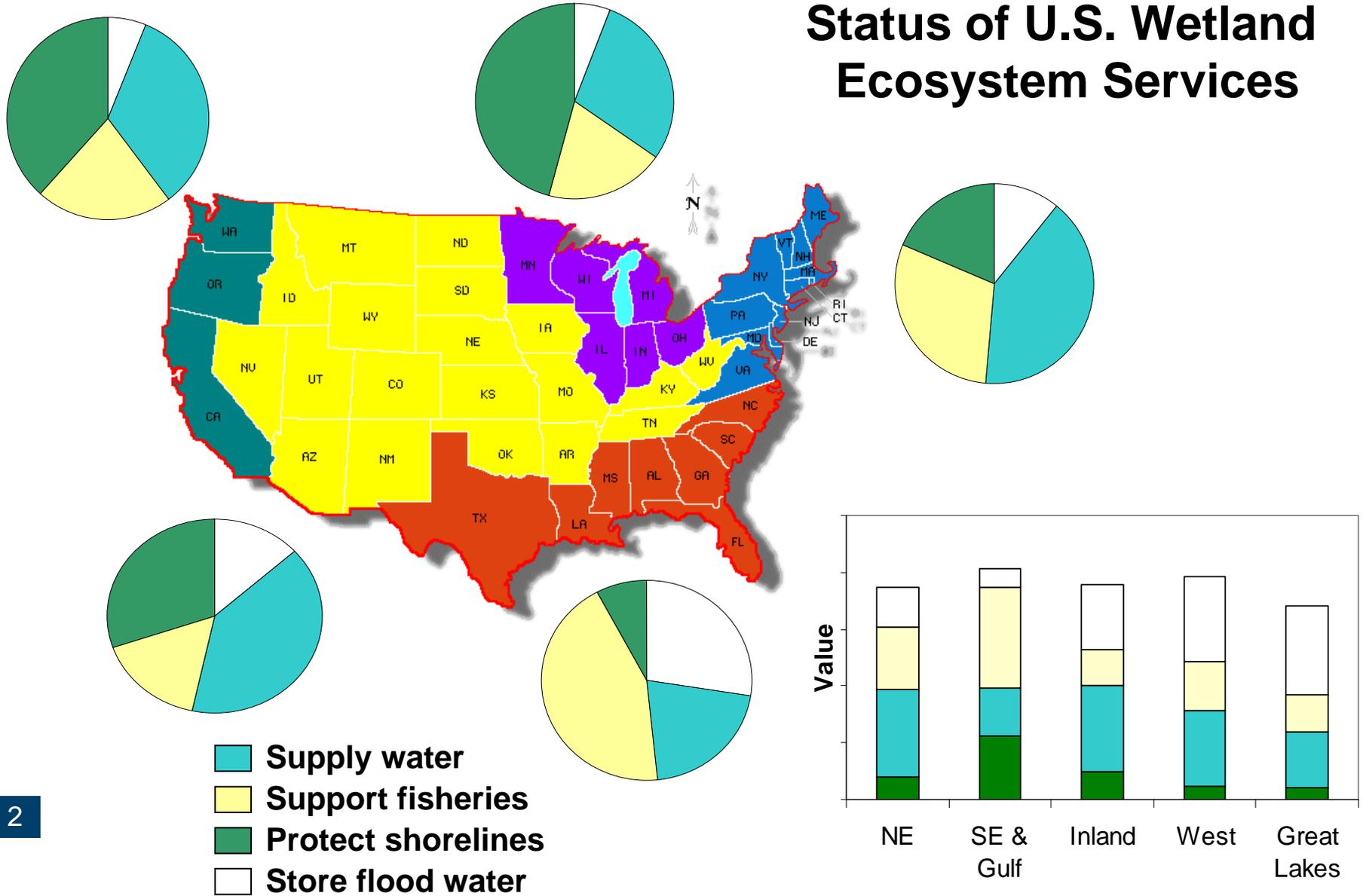


Composite scoring to guide potential investments in protection and mitigation



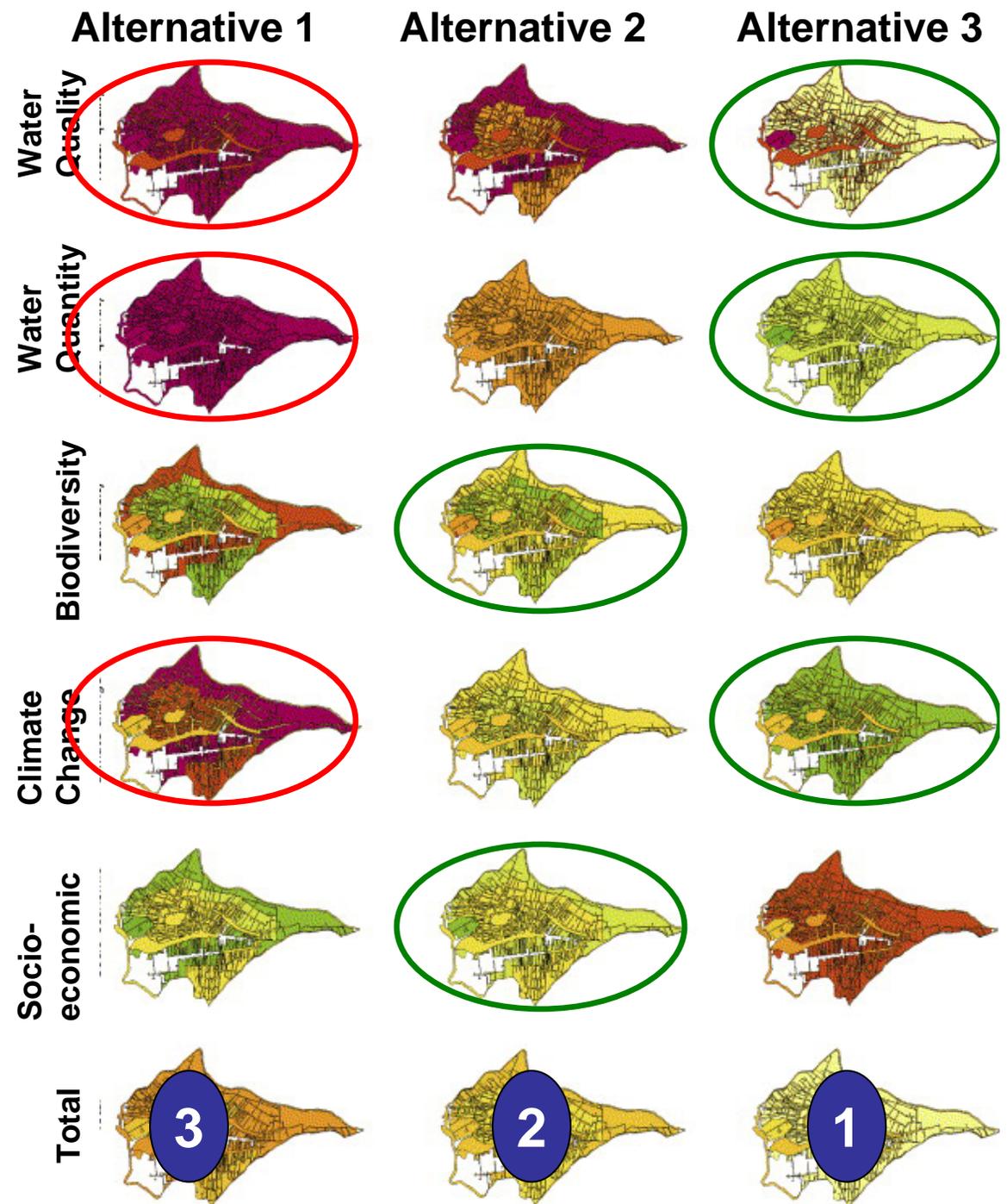
Or..... to prioritize needed research

Status of U.S. Wetland Ecosystem Services



Decision Support

- Performance of three management alternatives on five policy objectives and overall performance of alternatives.



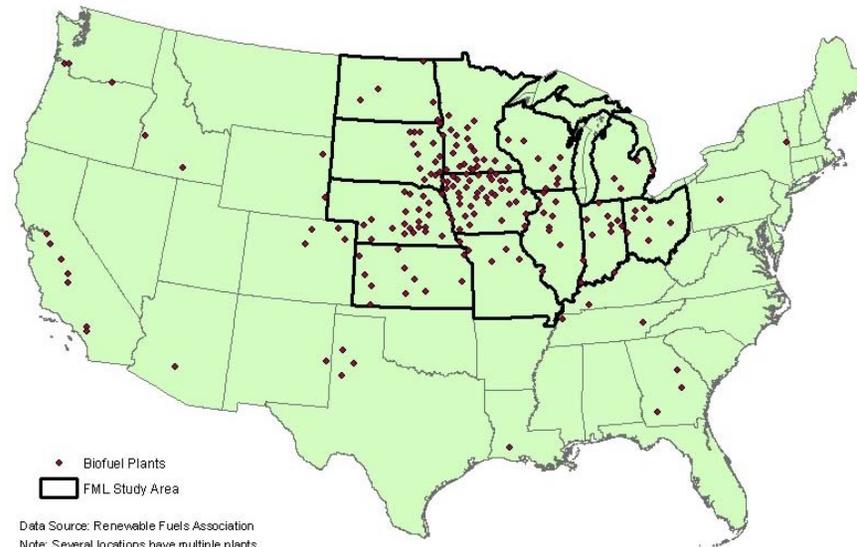
Regional-scale Ecosystem Services Research: The Future Midwestern Landscapes (FML) Place-based Study

National Policy Issues:

- Energy Security
- Conservation Policy
- Water Quality (e.g. nutrient loading to Gulf of Mexico)

Regional Policy Issues:

- permitting of facilities under Clean Water Act/Clean Air Act
- Sustainability of regional services



Study area showing ethanol biorefineries

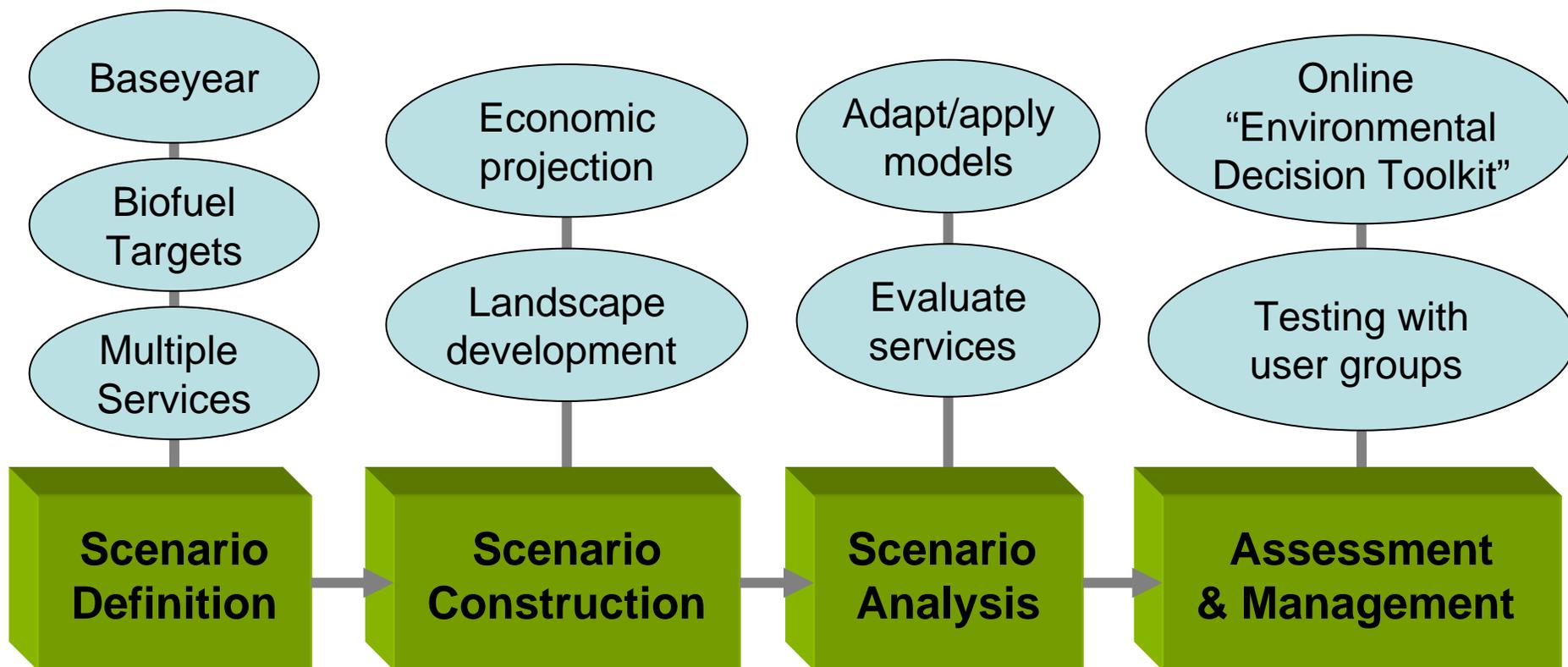
FML Problem Statement (decision maker's perspective)

- How do the landscapes of the Midwest – including working lands, conserved areas, wetlands, lakes, and streams – contribute to societal well-being?
- How will today's land use decisions affect current and future trade-offs of ecosystem services?
- What policies or market options would help sustain a broad spectrum of the ecosystem services that society values?

FML Problem Statement (researcher's perspective)

- How do **structures, functions and processes** of Midwestern ecosystems produce services to society?
- How can we **quantify** these services?
- What **landscape configurations** (land uses and management) afford the best combinations of ecosystem services?
- What **indicators** of ecosystem service changes are most useful to decision-makers?
- How can we **facilitate** conservation and restoration of ecosystem services through existing or future market structures or policies?

Overview of alternative-futures research approach



Biofuel Targets Scenario (2022)

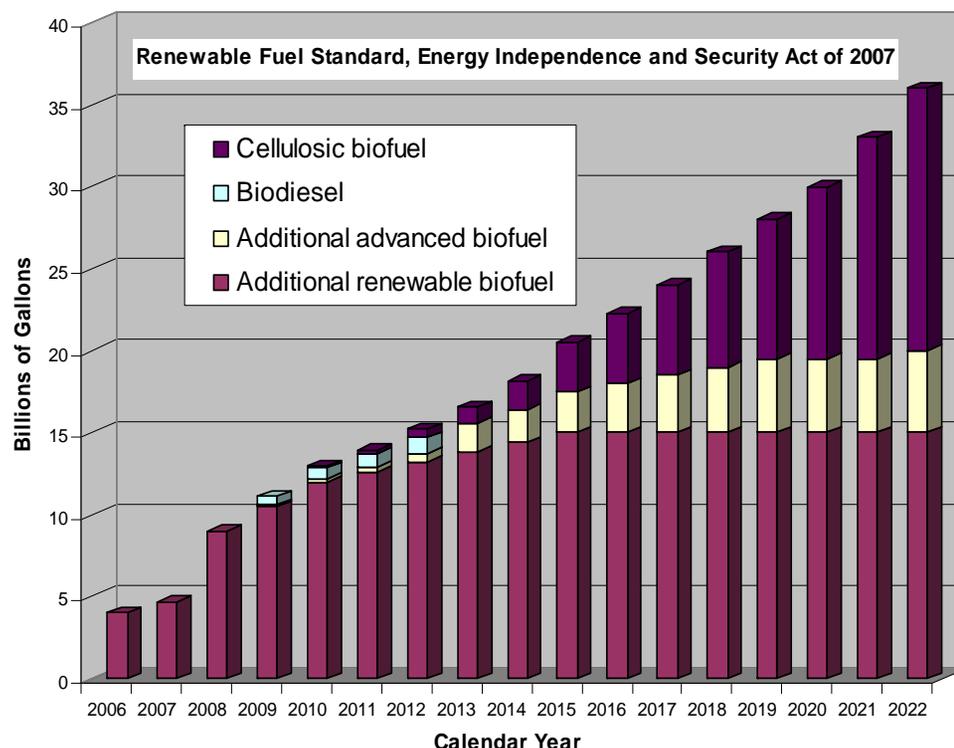
Market Allocation (MARKAL) econometric model (EPA)

- Energy supply and demand

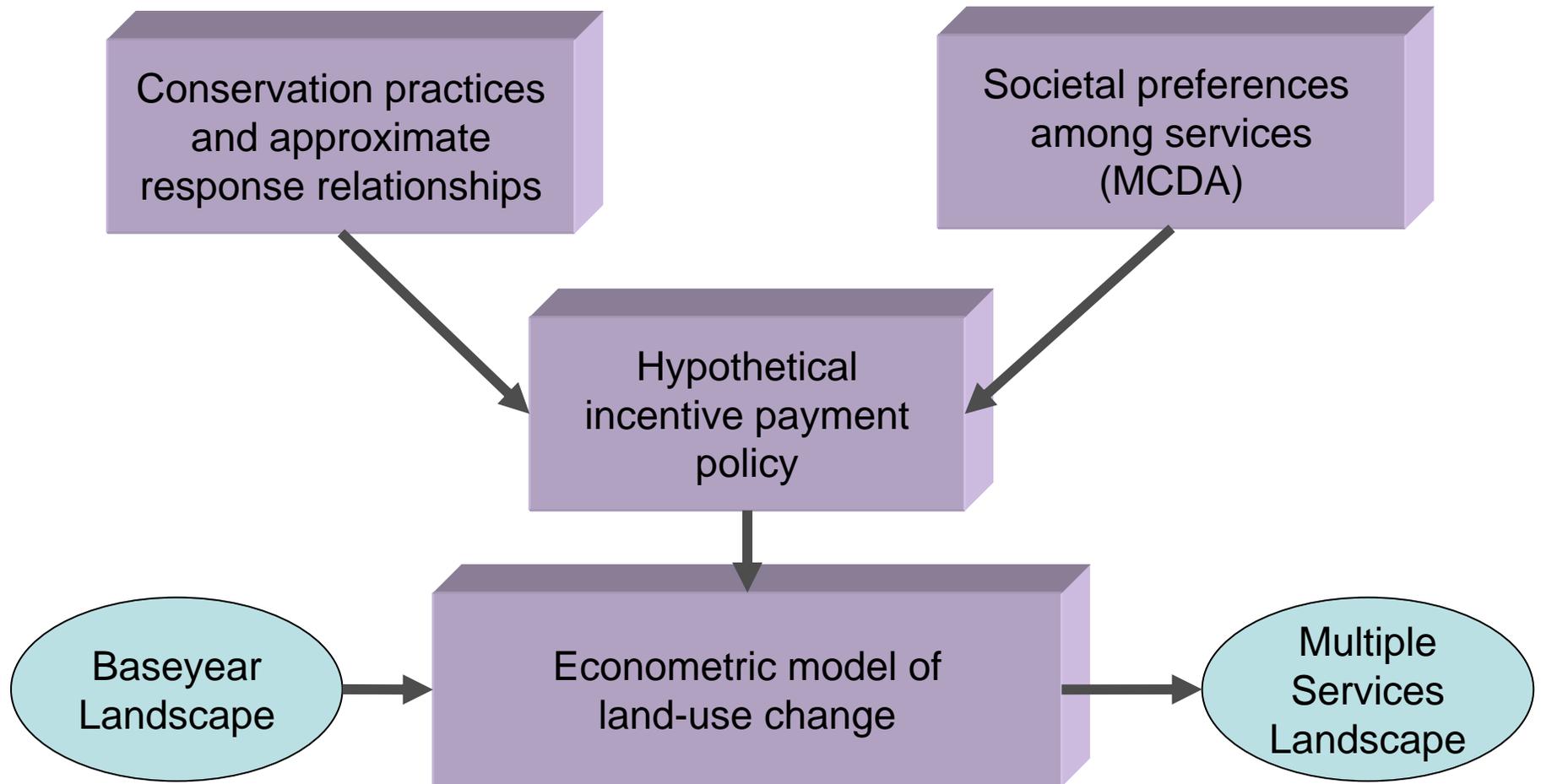
Sets conditions for:

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

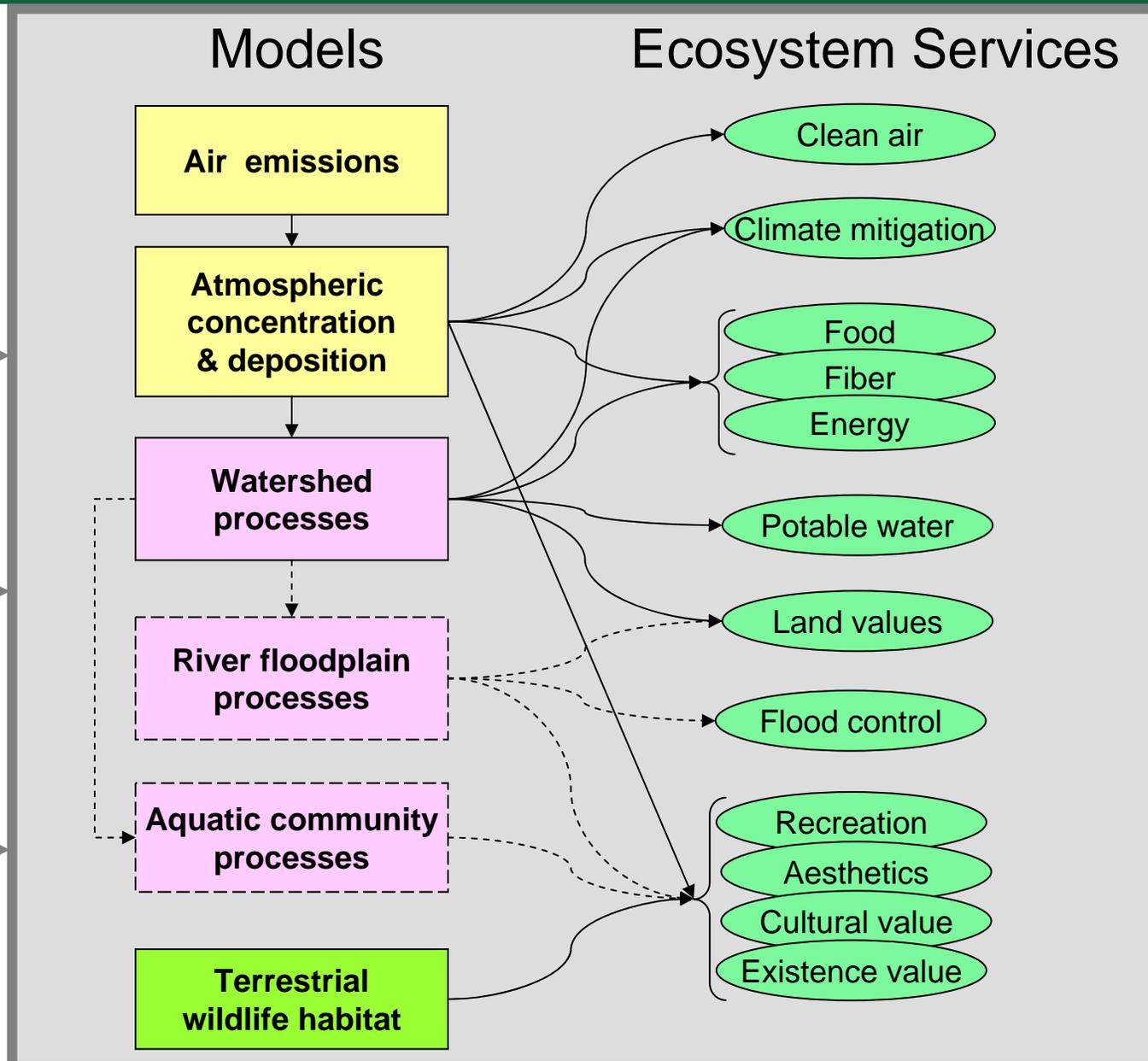
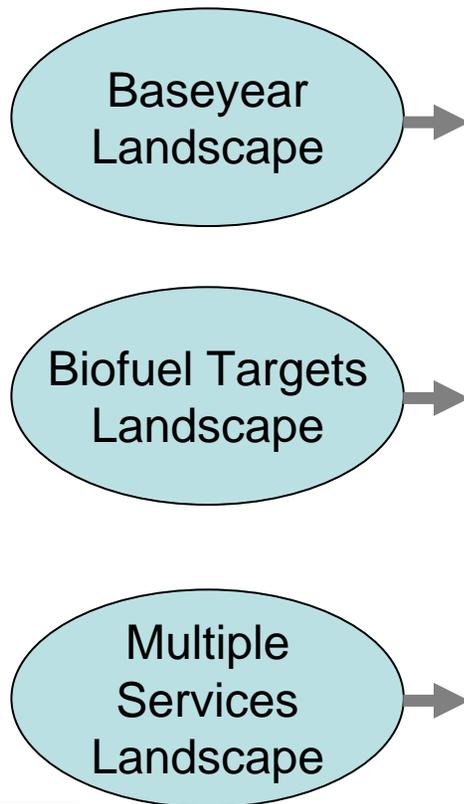
- Prices and regional acreages
- Disaggregated using soils, tillage practices, etc.



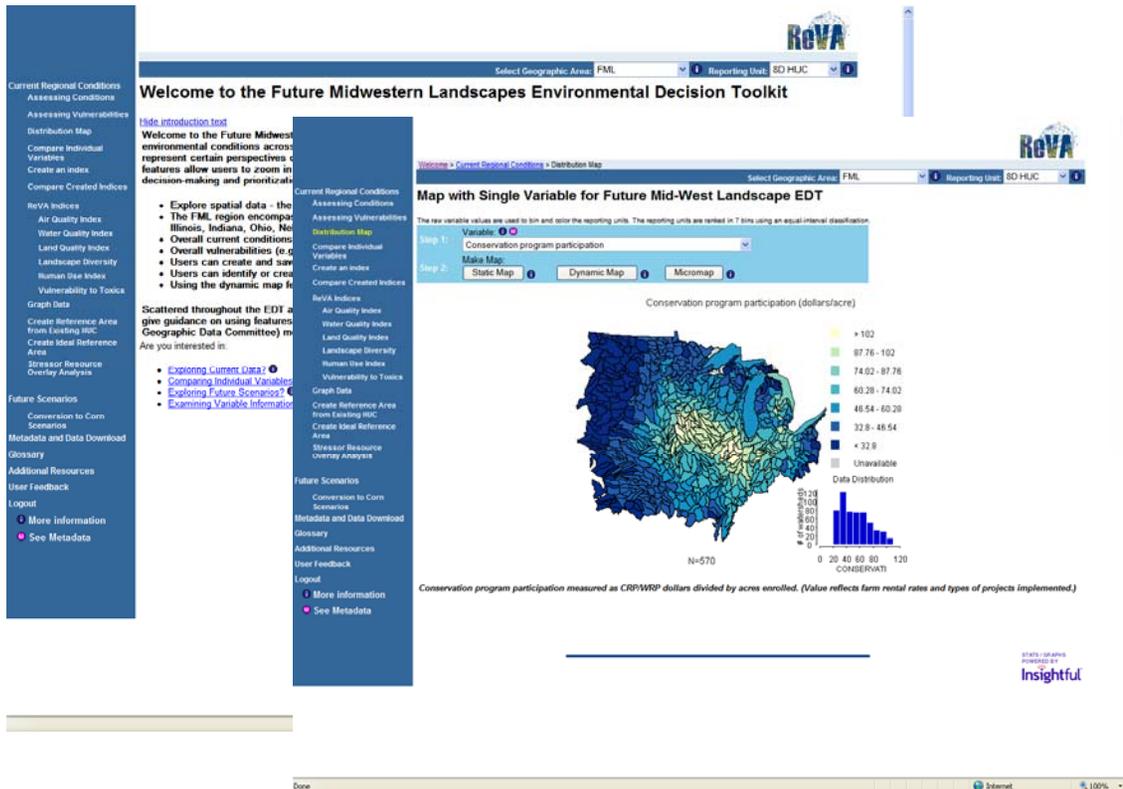
Multiple Services Scenario (2022)



Scenario Analysis



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

Compare Individual Variables
Create an index
Compare Created Indices
ReVA Indices
Air Quality Index
Water Quality Index
Land Quality Index
Landscape Diversity
Human Use Index
Vulnerability to Toxics
Graph Data
Create Reference Area from Existing HUC
Create Ideal Reference Area
Stressor Resource Overlay Analysis
Future Scenarios
Conversion to Corn Scenarios
Metadata and Data Download
Glossary
Additional Resources
User Feedback
Logout
More information
See Metadata

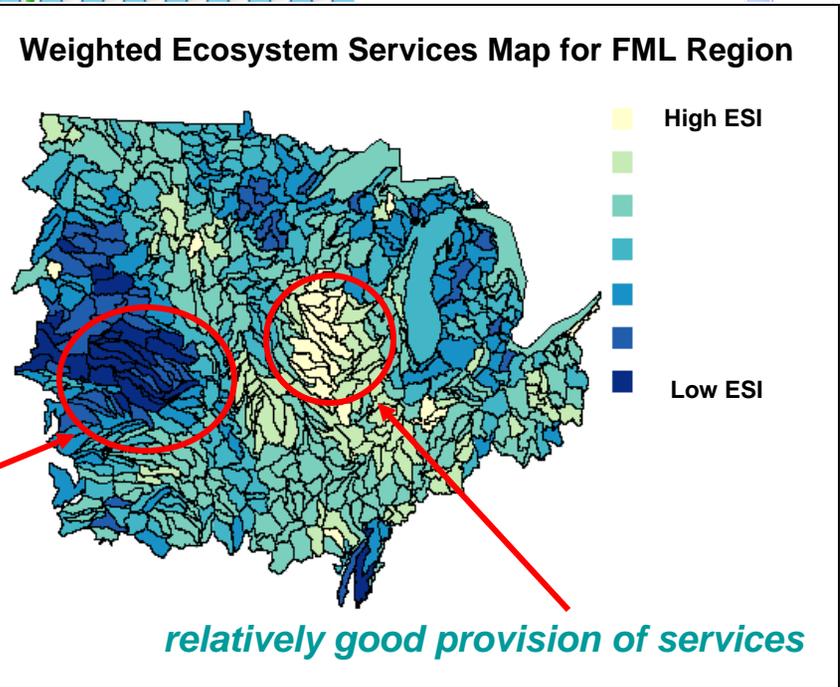
Step 1:

- Clean Air
- Climate Mitigation
- Food Production
- Fiber Production
- Energy Production
- Potable Water
- Land Value
- Flood Control
- Wildlife-based Recreation
- Aesthetics
- Cultural Value
- Biodiversity Existence Value

Step 2:

Make Map
Static Map
Dynamic Map
<< Back

0 1 2 3 4 5 6 7 8 9 10



room for improvement

Water Quality -- Nutrient Attenuation/Removal by Riparian Buffers

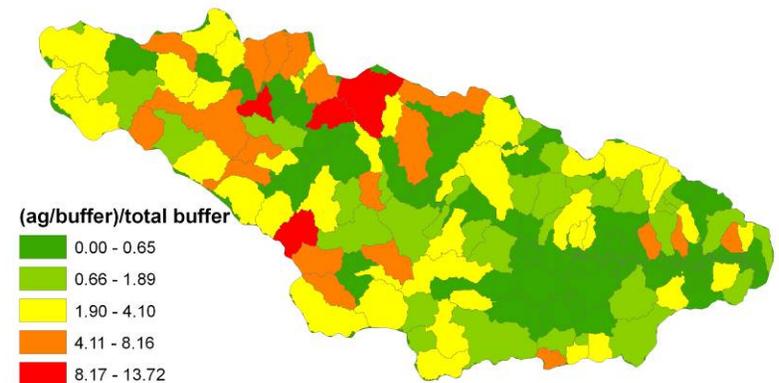
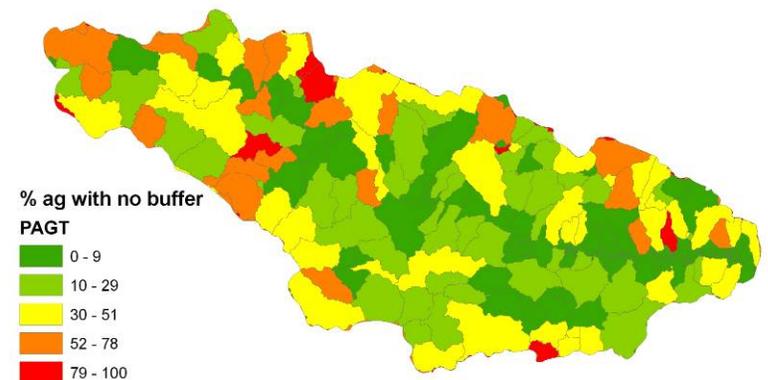
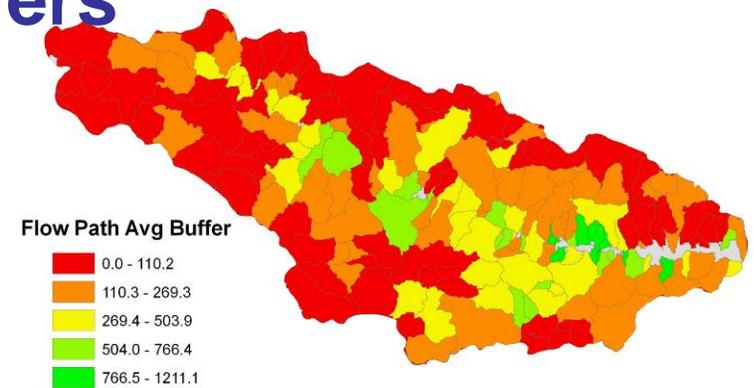
Riparian metrics being tested

- 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

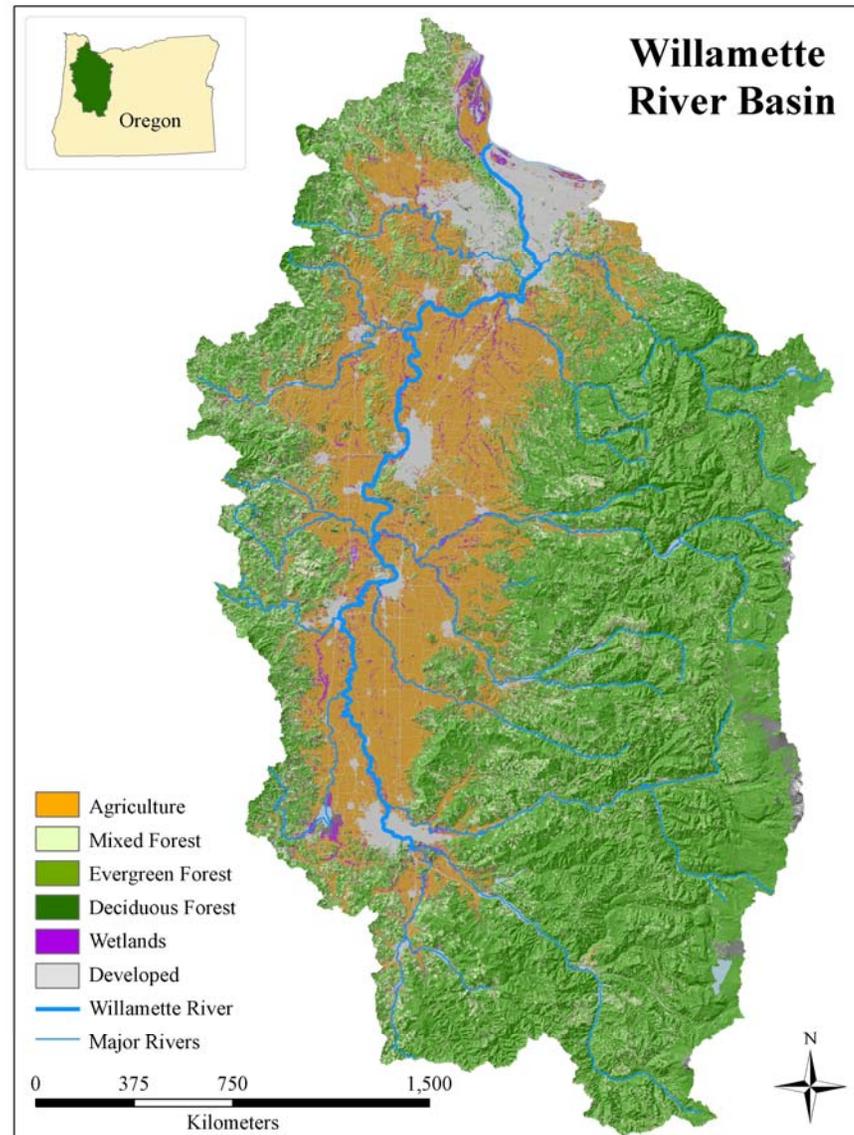
- Sum of Ag/Buffer Ratio / total buffer length



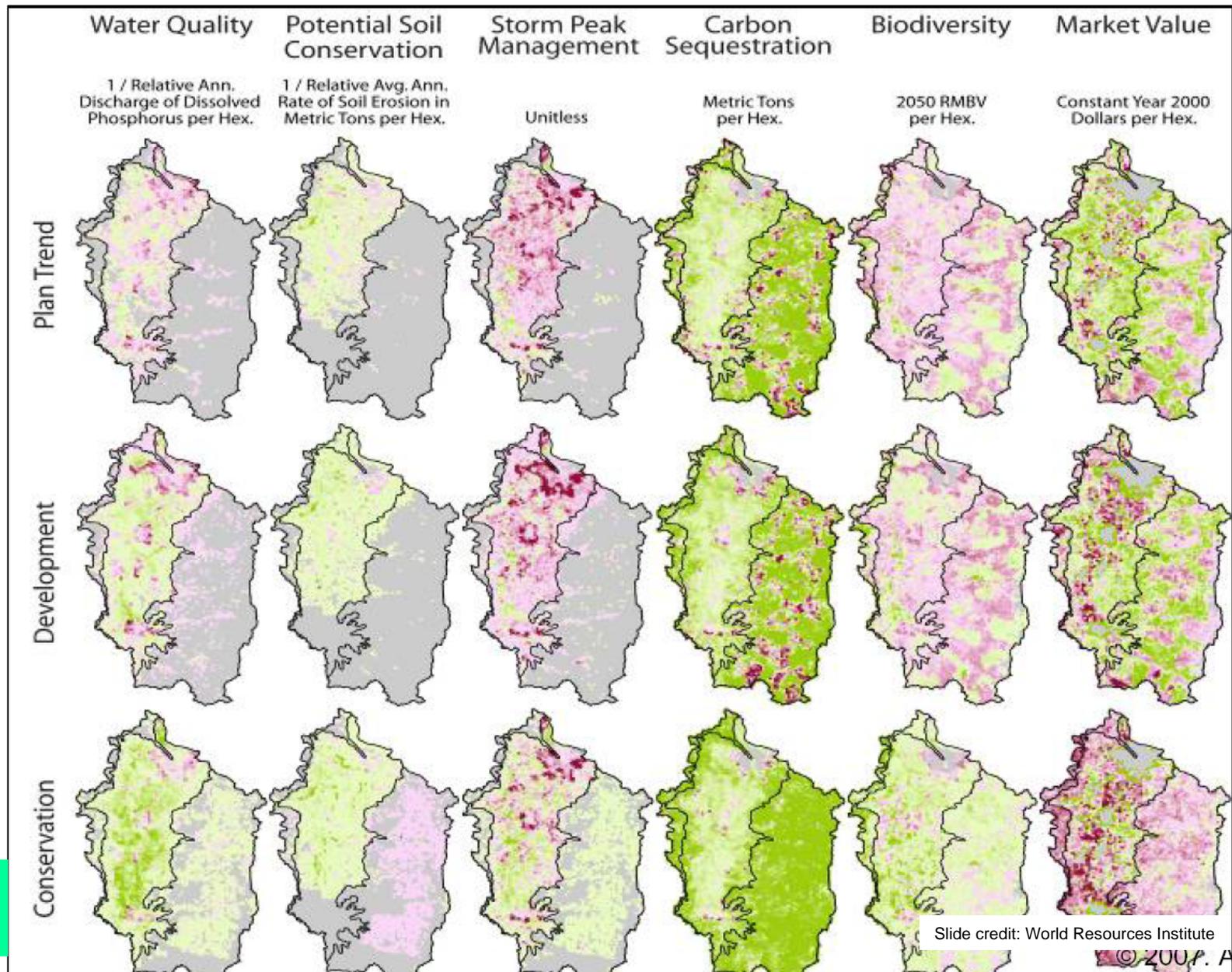
Jay Christensen

Watershed-scale Ecosystem Services Research: The Willamette

~30K km²
13th largest river in U.S.



Ecosystem Service Mapping, Willamette Basin



Slide credit: World Resources Institute

© 2004 P. A.



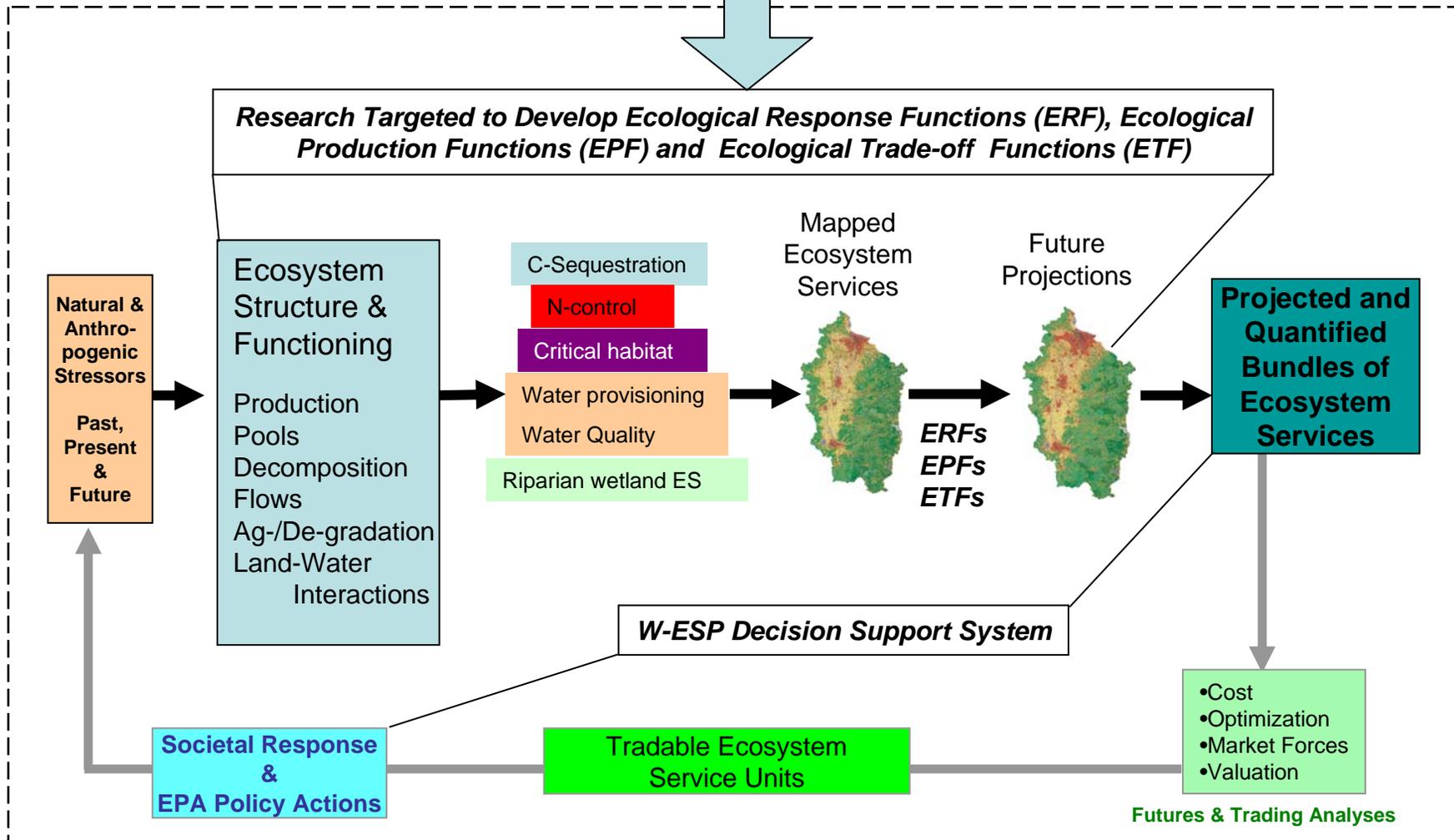
Desired Outcomes:

- Clean rivers
- Fish & Wildlife
- Flood control
- Timber & Crops
- Wetlands

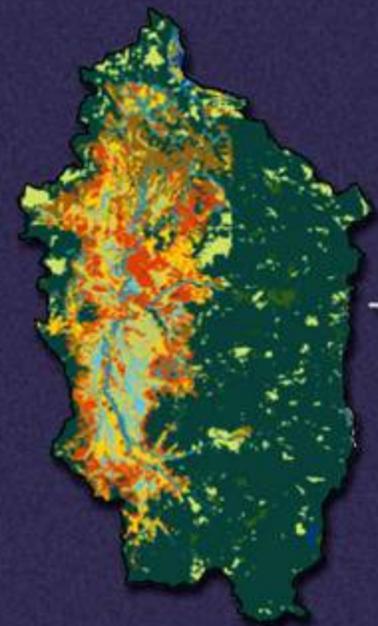
Forcing Variables:

- Predicted climate change
- Air pollution
- Land use management
- Population growth

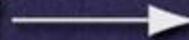
Place-Based Societal Issues & Values



Trajectories of Landscape Change in the Willamette Basin



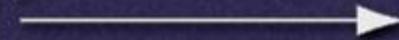
Pre-EuroAmerican Settlement



Circa 1990



Conservation 2050



Plan Trend 2050



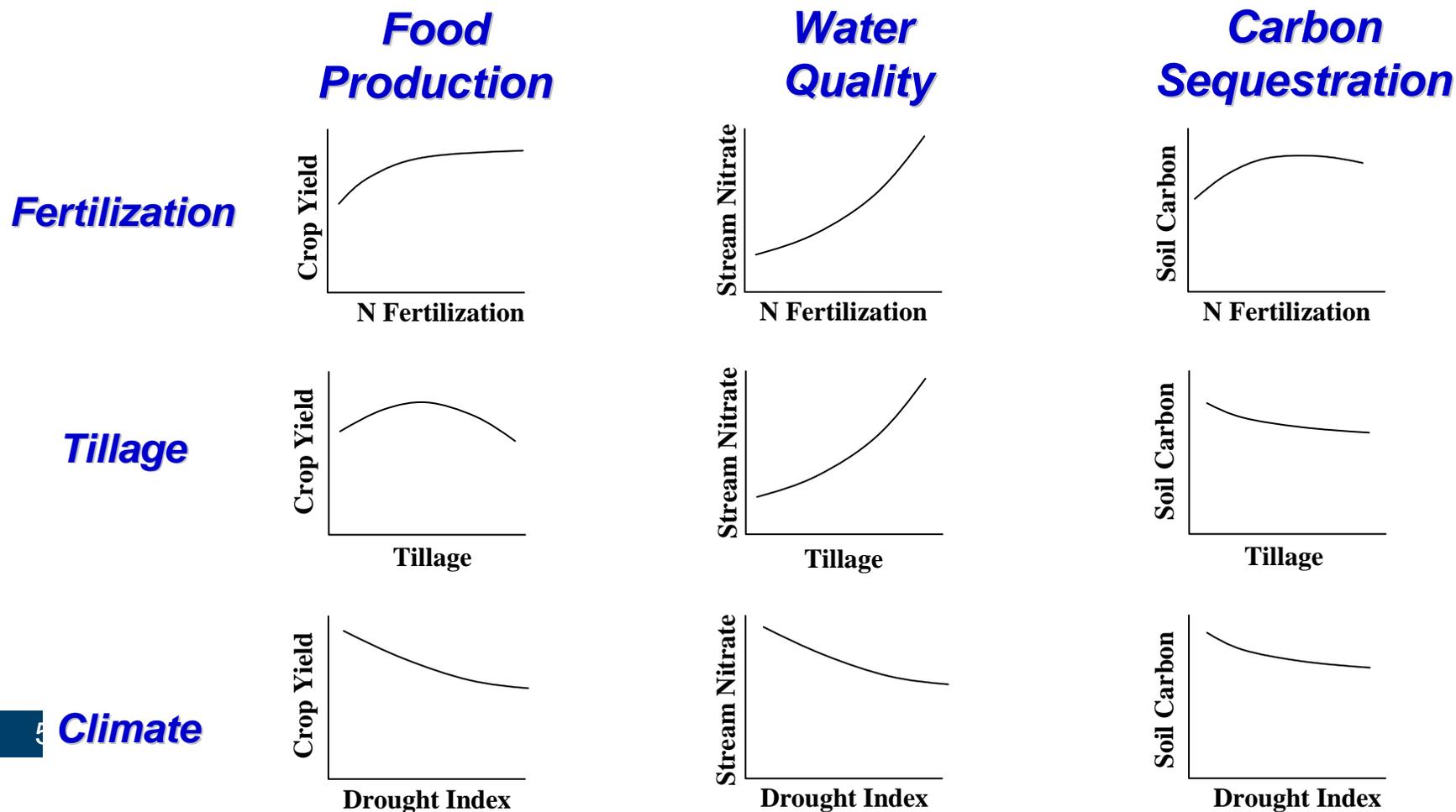
Development 2050

Translating services into quantifiable spatial metrics



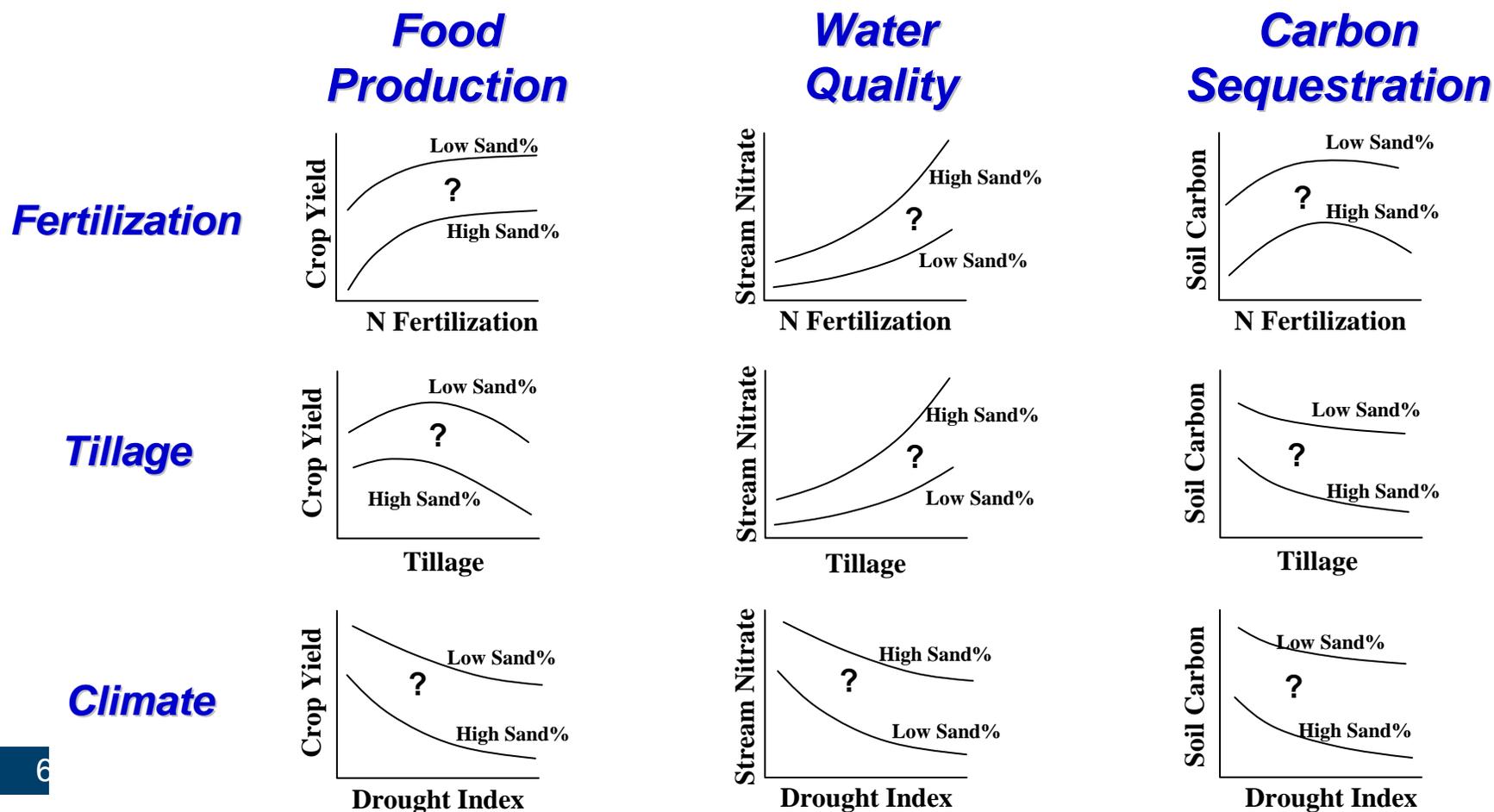
Some Agricultural ERFs & ETFs

- Read vertically to compare responses (ERFs) of a given service to 3 different stressors
- Read horizontally to assess trade-offs (ETFs) among 3 services at any given stressor level



ERFs, ETFs Have Many Dimensions

Example 1: soil particle size modifies the effects of the 3 stressors



ERFs, ETFs Have Many Dimensions

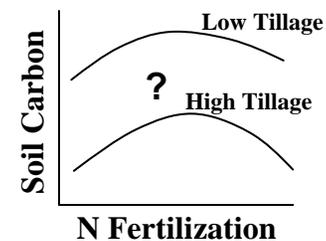
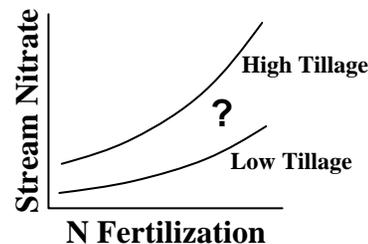
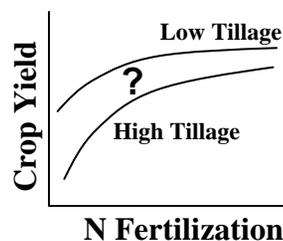
Example 2: the 3 stressors at left have interactive effects

Food Production

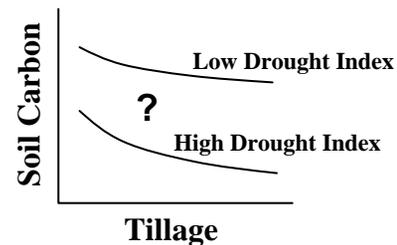
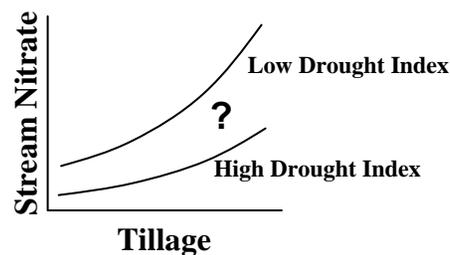
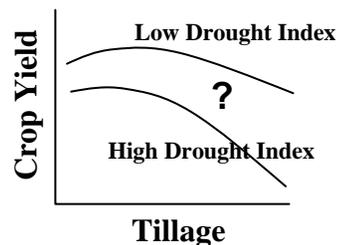
Water Quality

Carbon Sequestration

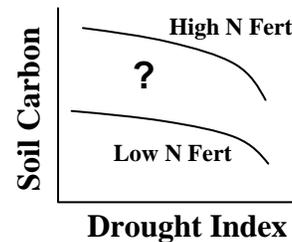
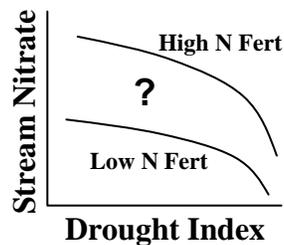
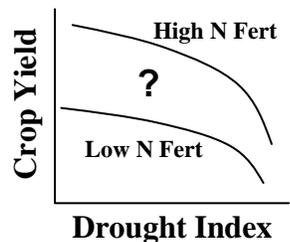
Fertilization



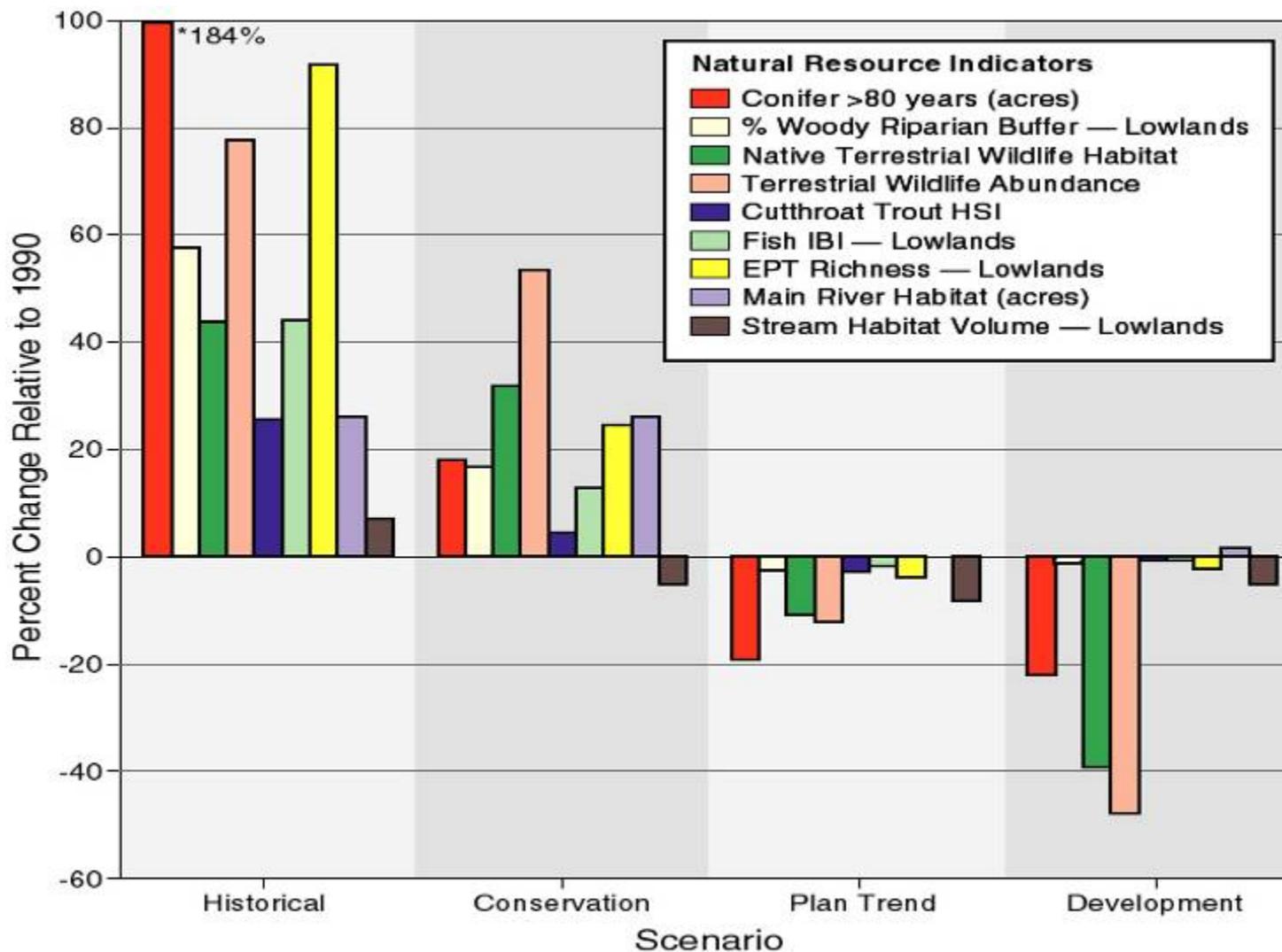
Tillage



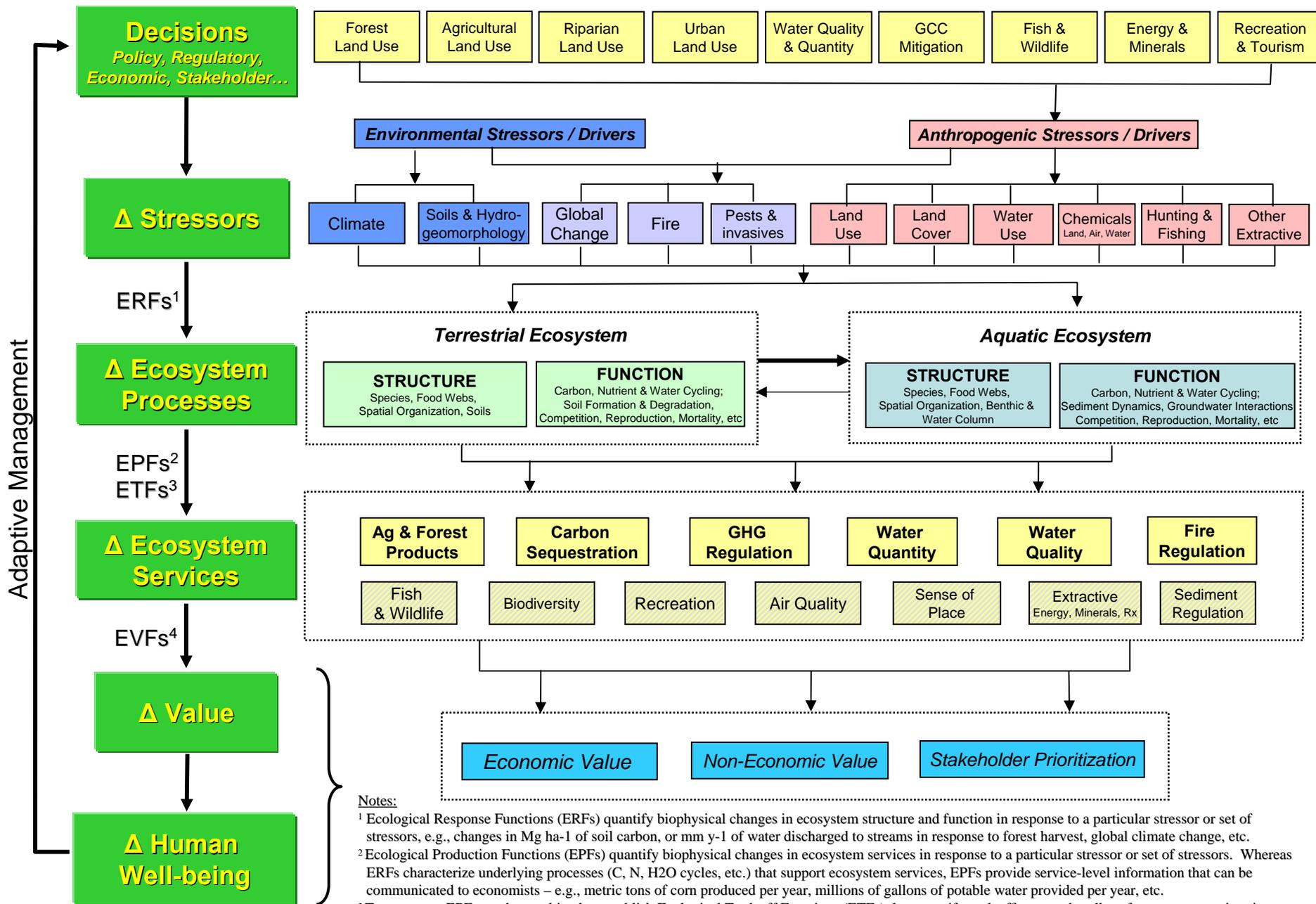
Climate



Willamette Basin Alternative Futures Scenario Evaluations



Willamette Conceptual Model





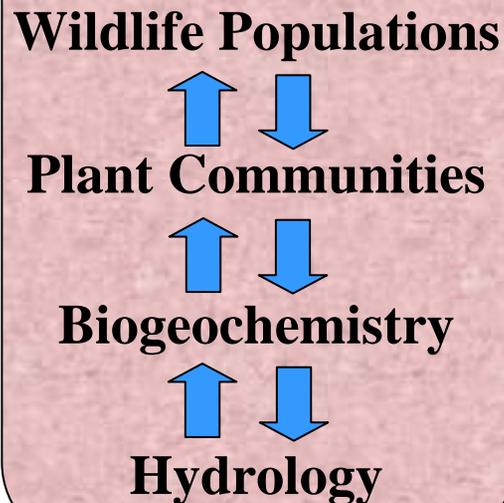
Multi-Model Approach

Stressors

- **Land Use**
 - Forest
 - Agriculture
 - Riparian
 - Urban
- **Global Change**
 - Climate
 - CO₂
 - N deposition
- **Chemicals**
 - Fertilizers
 - Pesticides



Models

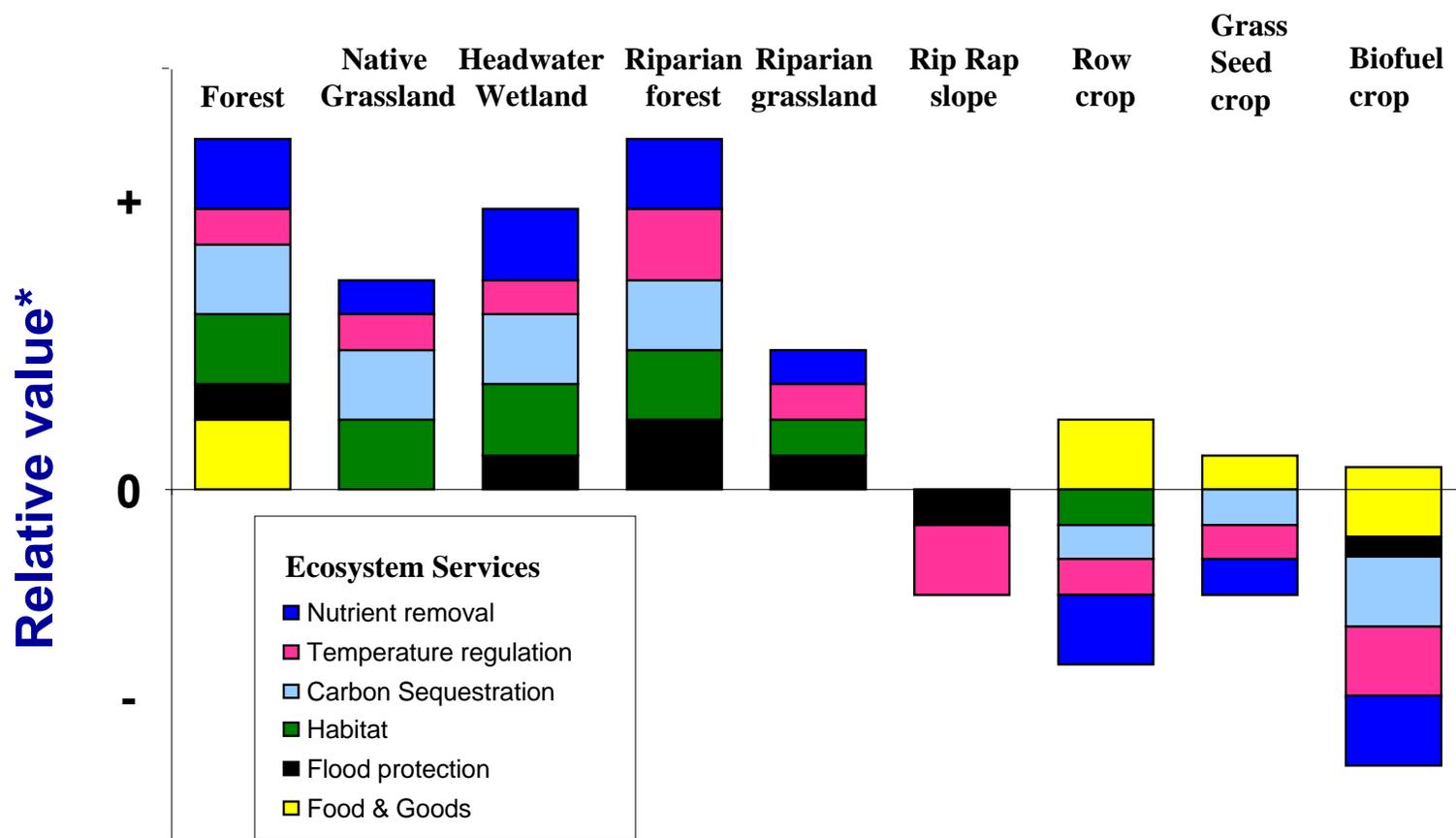


Terrestrial Services

- Ag products
- Forest products
- C sequestration
- Nutrient regulation
- GHG regulation
- Habitat quality
- Wildlife populations

Aquatic Services

- Water quality
- Water quantity
- Fish & waterfowl



*Relative value could be a rate, say kg/ha/yr, or represent economic or social value.

A photograph of a field of yellow flowers, possibly sunflowers, at sunset. The sky is a mix of orange, yellow, and purple, with the sun low on the horizon. The flowers are in various stages of bloom, some fully open and some as buds. The overall mood is serene and natural.

Questions?

<http://www.epa.gov/ecology>

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