



ECOSYSTEMS SERVICES RESEARCH PROGRAM
BUILDING A SCIENTIFIC FOUNDATION FOR SOUND ENVIRONMENTAL DECISIONS

www.epa.gov/ord/erp

EPA's Future Midwestern Landscapes **Study**



Betsy Smith & Randy Bruins
Study Co-Leaders
Office of Research and Development
SAB Consultation, July 14, 2009

Photo: Iowa Pathways, Iowa Public Television

Study Contributors

❑ Office of Research and Development

- Rob Wolcott
- *National Exposure Research Laboratory*
 - Randy Bruins, Betsy Smith (Co-leaders)
 - Megan Mehaffey, Alex Macpherson, Ellen Cooter, Yongping Yuan, Jay Christensen, Charles Lane, Ken Fritz, Vasu Kilaru
- *National Risk Management Research Laboratory*
 - Tim Johnson, Rebecca Dodder, Ozge Kaplan, Curtis Cooper
- *National Health and Environmental Effects Research Laboratory*
 - Russell Kreis

❑ Region 7 (Kansas City)

- Brenda Groskinsky, Walt Foster

❑ Region 5 (Chicago)

- Mary White, Carole Braverman

❑ Office of Policy, Economics and Innovation

- Andrew Manale

Outside Partners to date

❑ Experts (Special EPA Employees)

- Lisa Wainger, U. of Maryland
- Liem Tran, U. of Tennessee
- Peter Woodbury, Cornell U.

❑ Iowa State University/CARD

- Silvia Secchi (now at SIU-C)
- Amani Elobeid
- Simla Tokgoz

❑ USDA Farm Service Agency

- Richard Iovanna

Presentation Outline

- Design decisions governing study structure and approach
 - Spatial & temporal scales, boundaries
 - Modeling approach
 - Future scenarios
 - Ecosystem services
- Progress to date
 - Efforts completed
 - Methodological issues addressed
 - Partnerships established
- Current efforts and challenges

Presentation Outline

- Design decisions governing study structure and approach
 - Spatial & temporal scales, boundaries
 - Modeling approach
 - Future scenarios
 - Ecosystem services
- Progress to date
 - Efforts completed
 - Methodological issues addressed
 - Partnerships established
- Current efforts and challenges

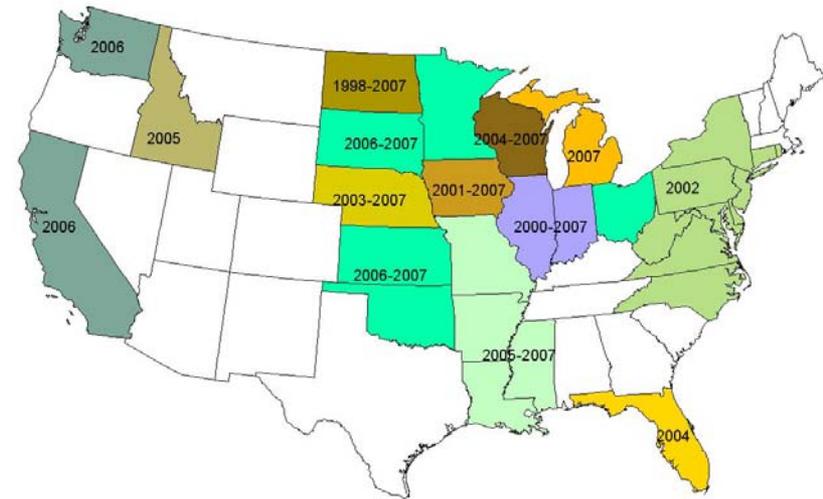
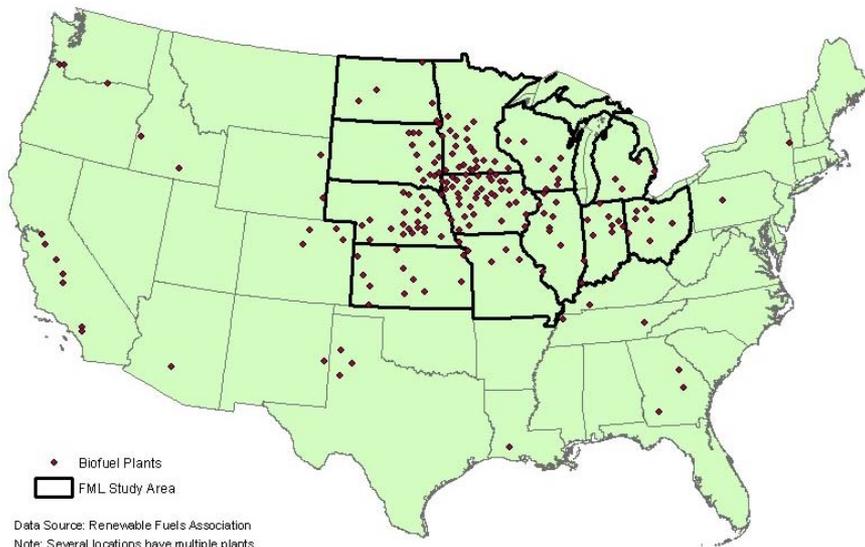
Decision-makers' needs

- How will today's land use decisions affect **trade-offs** of future ecosystem services?
- What land-use configurations afford the **best combinations** of ecosystem services?
- What **indicators** of ecosystem service changes communicate the vulnerabilities and opportunities?
- How can we **facilitate** conservation and restoration of ecosystem services?

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

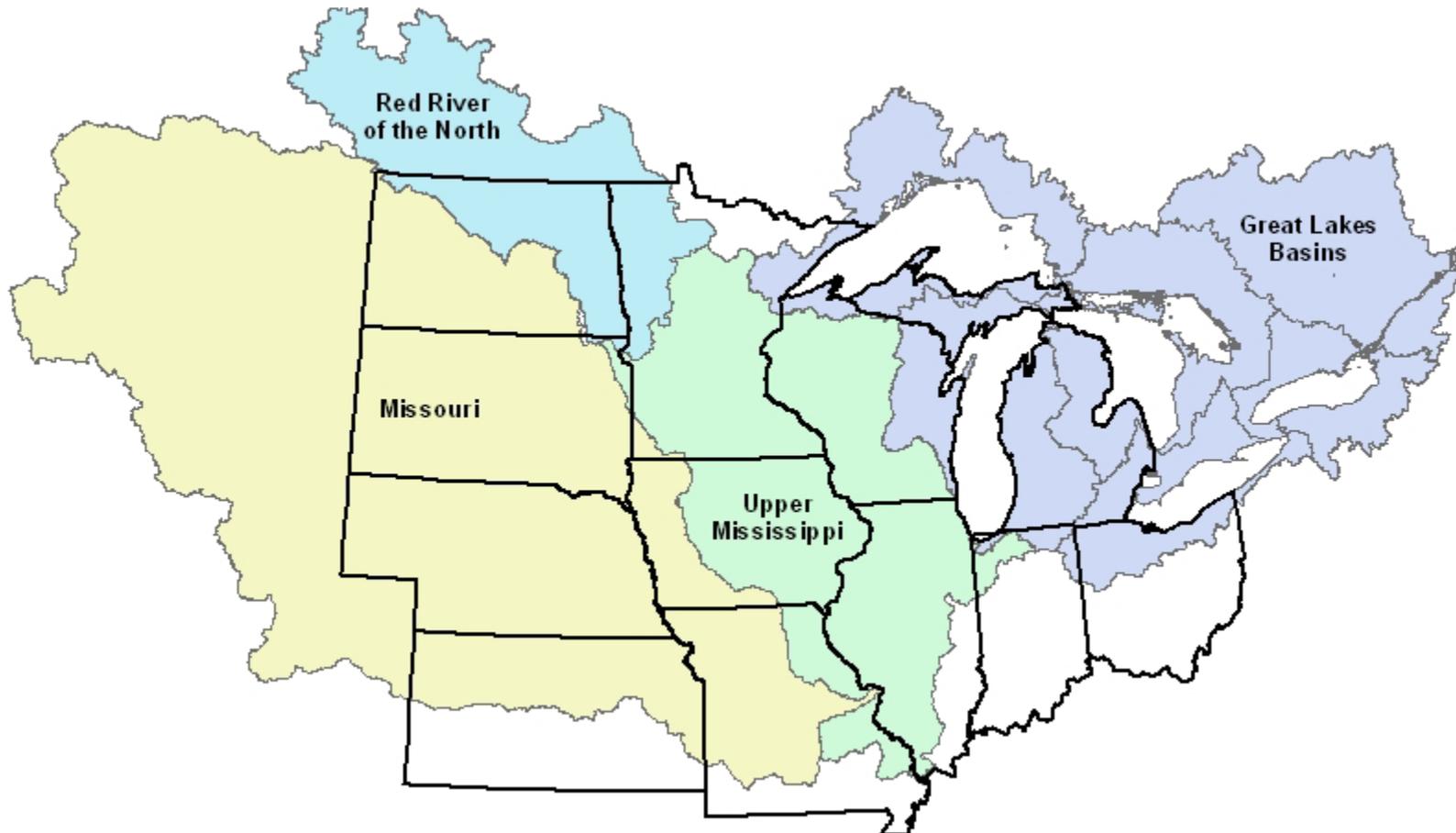
FML Study Boundary



showing ethanol biorefineries

NASS Cropland Data Layers

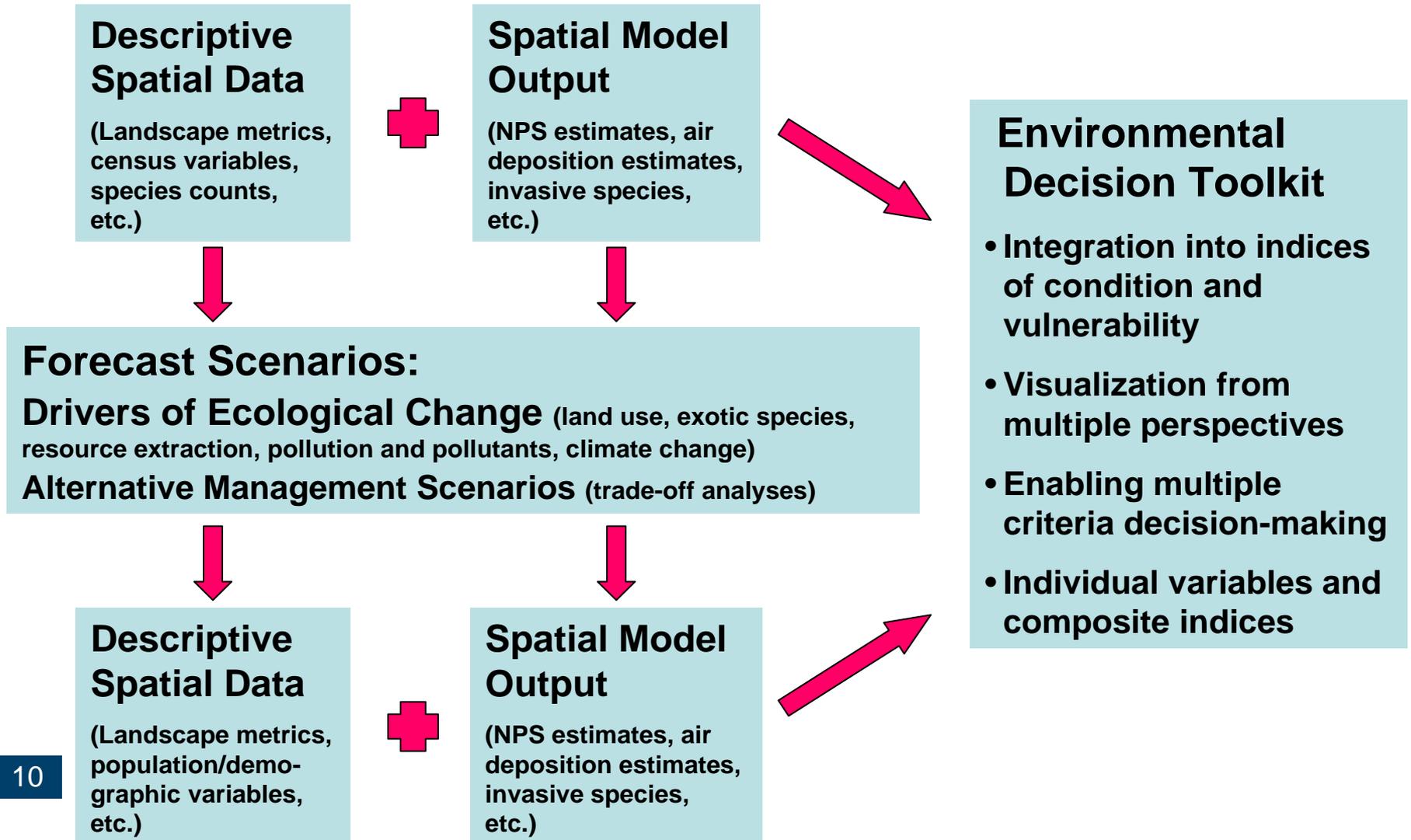
FML Study Area and Major Drainage Basins



Modeling approach options (given unique spatial scale of FML Study)

- Unified simulation environment (implies use of generalized, representative landscapes)
- Realistic, detailed landscapes (implies coupling of existing models)
 - Disadvantages
 - cobbled modeling system, hard to build and run
 - hard to characterize sensitivity across whole system
 - limited to examining few scenarios
 - Advantages
 - decision-makers relate well to actual landscapes
 - decision-makers may be familiar with models
 - models (individually) have been validated
 - EPA success using a detailed landscape approach , Regional Vulnerability Assessment (ReVA), to inform at large scales

Regional Vulnerability Assessment (ReVA) Process



Uses of ReVA's EDT to support environmental decisions

- EPA Region 3 used EDT to **prioritize watershed projects**
- Charlotte, NC area planners used EDT to compare watershed impacts of **alternative regional development approaches**
- EPA air regulators are using EDT as framework for studying the **vulnerability of human populations and ecological systems** in the Southeast to toxic air pollutants from multiple sources.
- Great Lakes National Program Office used for **state-of-the-lakes reporting**, and to **prioritize efforts to reduce impacts** to lakes

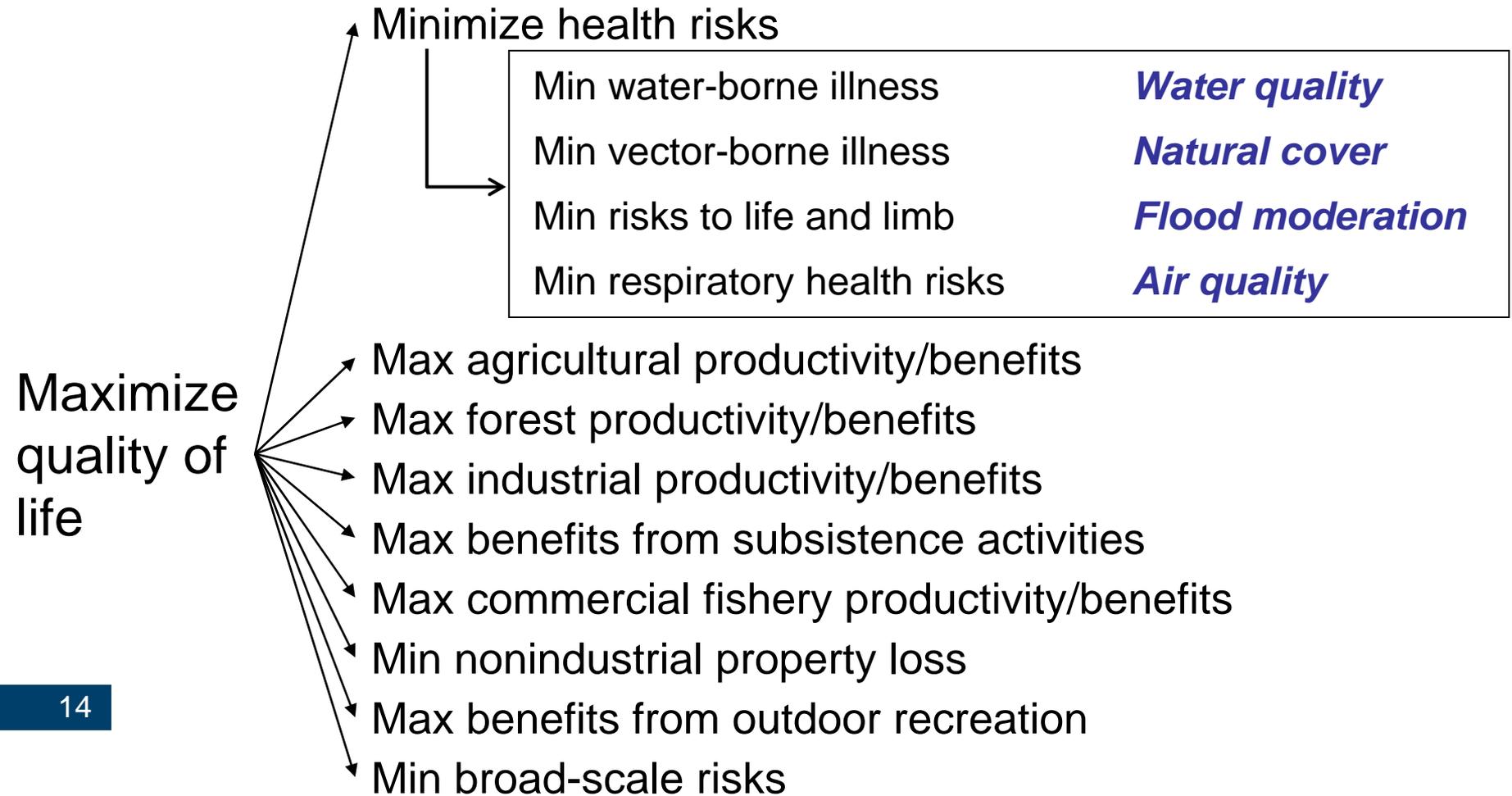
Decision: Use ReVA approach

- Combine existing data sets to produce detailed **Base Year (BY) landscape** ...
 - Land uses, crop rotations and land management practices existing in 2001
- Economic modeling approaches to project landscapes ...
 - expected in 2022, given current biofuel incentives
 - **Biofuel Targets (BT) Landscape**
 - expected in 2022, absent US biofuel incentives, and given a hypothetical Multiple Services Incentive Program
 - **Multiple Services (MS) Landscape**

Decision: Use ReVA approach

- Apply/adapt existing models of...
 - Air emissions, air quality and deposition
 - Hydrology, water quality and aquatic biota
 - Wildlife habitat suitability
- Involve decision-makers in development of an on-line Environmental Decision Toolkit (FML-EDT)

Hierarchy of objectives and *services*



Services of interest in FML Study (as defined within objectives hierarchy)

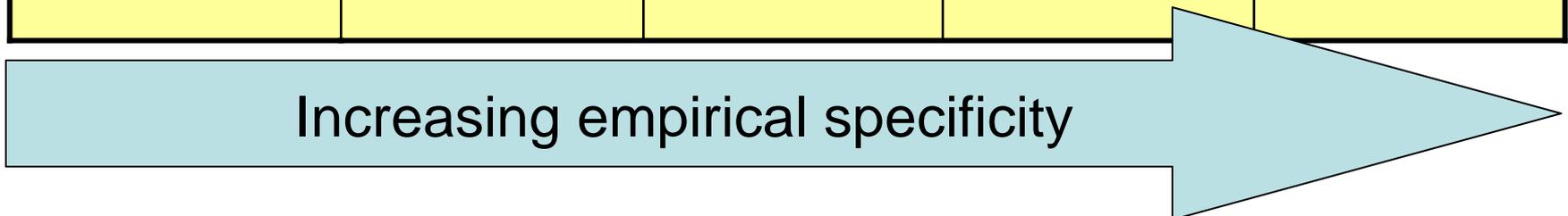
- ***Natural cover***
- ***Managed forest cover***
- ***Agricultural cover***
- ***Landscape heterogeneity***
- ***Soil quality***
- ***Carbon storage***
- ***Surface water storage***
- ***Groundwater storage***
- ***Flood moderation***
- ***Water quality***
- ***Biodiversity***
- ***Air quality***
- ***Food production***
- ***Biofuel feedstock production***

Production Function Methods Continuum

Lisa Wainger

Conceptual Models			Data-Derived Models	
Land Use Classification	Continuous Functions	Weighted Indicators	Simulation Models	Fitted Empirical Models

Increasing empirical specificity



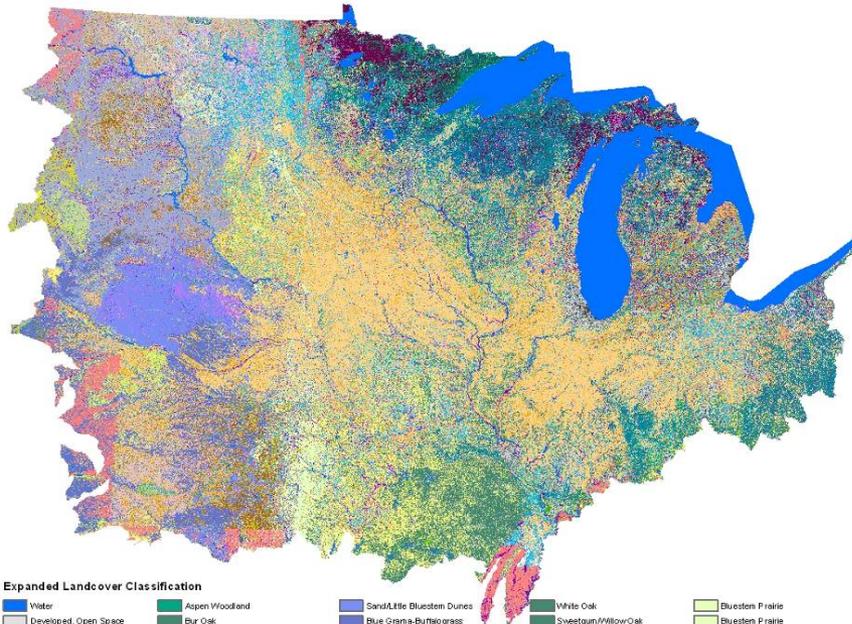
Presentation Outline

- Design decisions governing study structure and approach
 - Spatial & temporal scales, boundaries
 - Modeling approach
 - Future scenarios
 - Ecosystem services
- Progress to date
 - Efforts completed
 - Methodological issues addressed
 - Partnerships established
- Current efforts and challenges

Efforts completed

- Region 7 stakeholder workshop (Nov. 2007, Ames, Iowa)
- Pilot workshop for scientist and decision-maker values elicitation (Mar. 2009, RTP, NC)
- Base Year (2001) landscape coverage
- Biofuel Targets (2022) landscape coverage
- FML Environmental Decision Toolkit prototype online

FML Base Year Landscape



- 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

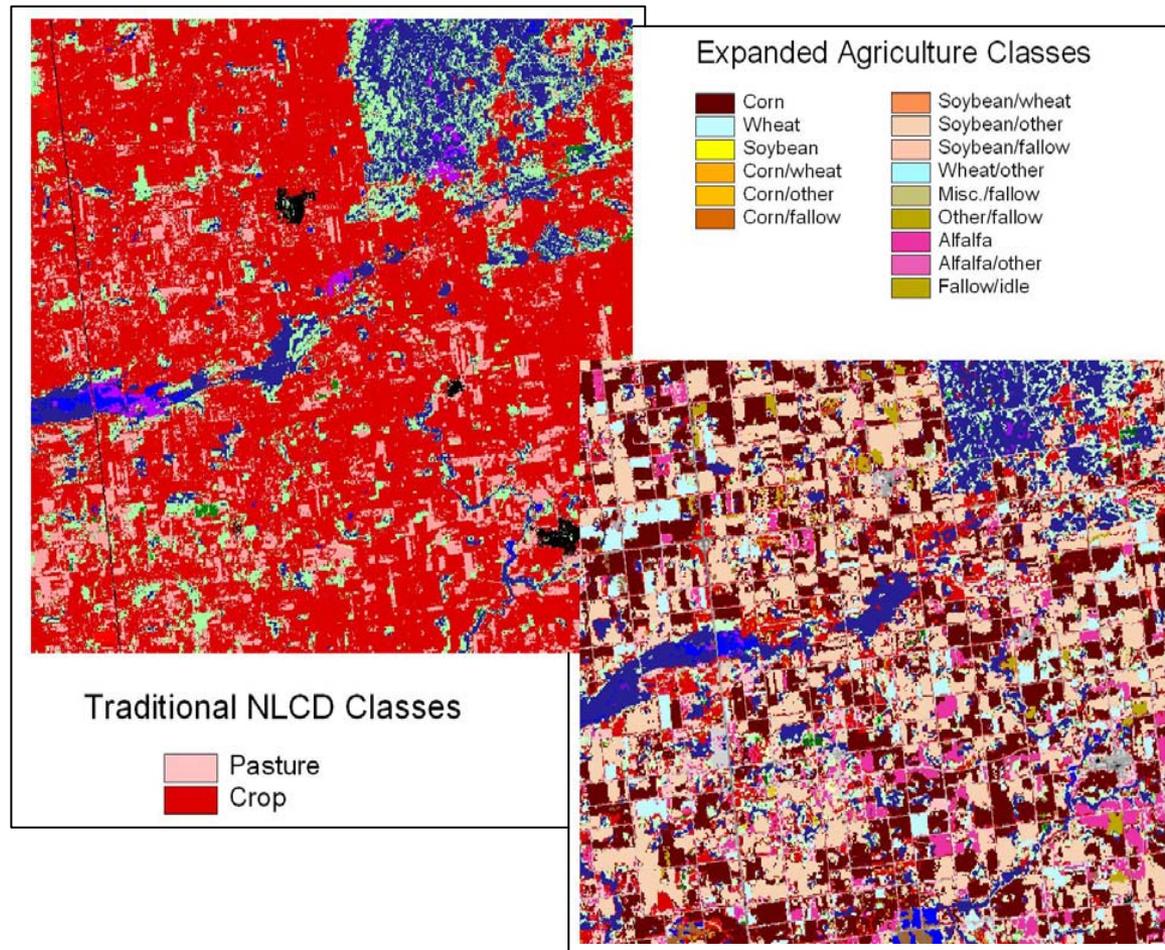
- Implications for better estimation of nutrients and pesticides loads/export

- Better assessment of crop yields

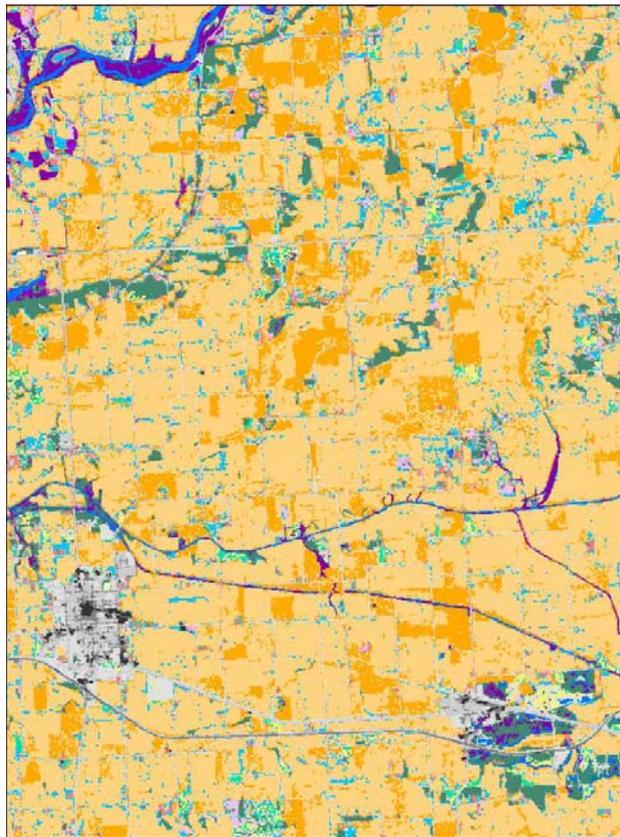
Expanded Landcover Classification

Water	Aspen Floodland	Sand/Little Bluestem Dunes	White Oak	Bluestem Prairie
Developed, Open Space	Bur Oak	Blue Grama/Buffgrass	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	Saltbush-Oreaseed	Deciduous Flatwood	Little Bluestem/Indiangrass/Wintergrass
Developed, High Intensity	Lambert Pine	Riparian Woodland	White Oak	Black Ash/Elm/Red Maple
Barren Land	Lodgepole Pine	Cottonwood/Willow	Swamp Chestnut/Cherrybark Oak	Willow/Water/Dian/Red Oak
Undefined Deciduous Forest	Douglas Fir	Riparian	Live Oak	Jack Pine Sedge
Undefined Evergreen Forest	Ponderosa Pine	Riparian	Aspen	Great Plains Riparian
Undefined Mixed Forest	Spruce/Sup/Alpine Fir	Douglas Fir	White/Black/Red Oak	Floodplain Riverbark/Sycamore
Undefined Shrub/Scrub	Bristlecone Pine	Shrubland	Grass/Shrub Balds	Riparian Riverbark/Sycamore
Undefined Grassland/Herb.	Juniper-Pinyon Pine	Ponderosa Pine	Jack Pine	Floodplain Sweetgum/Willow Oak
Undefined Pasture Hay	Aspen	Introduced Woody Wetland	Longleaf Pine	Floodplain Sweetgum/Willow Oak
Undefined Crop	Red Alder	Introduced Upland Herbaceous	Virginia Pine	Floodplain Black Ash/Elm/Maple
Undefined Woody/Wetland	Black Sagebrush	Introduced Upland Herbaceous	Willow/White/Dian/Red Oak	Black Spruce/Tamarack/Peastland
Undefined Herbaceous Wetland	Saltbush-Oreaseed	Introduced Upland Herbaceous	Red Pine	Swamp Riverbark/Sycamore
Moniculture Corn	Black Sagebrush	Introduced Herbaceous Wetland Riparian	Missouri Glades	Coastal Plain Swamp
Moniculture Soybean	Big Sagebrush	Introduced Upland Tree	Post/Black Oak	Black Ash/Elm/Maple Swamp/Bog
Moniculture Wheat	Salt Desert Shrub	Recently Logged	Balsam Fir	Prairie Pothole Wetland
Moniculture Cotton	Sagebrush/Grass	Recently Logged	Hemlock Yellow Birch	Wet Meadow/Prairie Marsh
Corn/Soy	Chokecherry-Serviceberry Rose	Ruderal Forest	Shortleaf Pine/Oak	Coastal Herbaceous Marsh
Corn/Wheat	Sandsage Prairie	Sand Shinnery Oak	Chestnut Oak	Appal. Shrub/Herbaceous Wetland
Corn/Other	Chokecherry-Serviceberry Rose	Big Sagebrush	Sugar Maple/Beech	Laurentian-Acadian Herbaceous Wetland
Corn/Fallow	Gambel Oak	Aspen	Loblolly Pine-Hardwood	Bluestem Depressional Wetland
Soybean/Wheat	Mesquite	Sugar Maple	Shortleaf Pine/Oak	Alkali Casaton-Tobosa Grass
Soybean/Other	Ponderosa Pine	White/Black/Red Oak	Chestnut Oak	Alkali Casaton-Tobosa Bottom land
Soybean/Fallow	Juniper-Pinyon Pine	White Oak	Post/Black Oak	White Oak
Wheat/Other Crop	Big Sagebrush/Buebunch/Wheatgrass	Oak	Deciduous Shrubland	Shortleaf Pine/Oak
Wheat/Fallow	Big Sagebrush	Oak-Hickory	Bur Oak	Sweetgum/Willow Oak/River Flatwoods
Cotton/Other	Big Sagebrush	White/Black/Red Oak	Pin Oak	Black Oak/Bluff/Grassland
Misc Grain/Fallow	Blue Gramma/Western Wheatgrass	Post/Black Oak	Grass/Shrub Bald	Pinoak/Sweetgum/Wet Flatwood
Other Crop/Fallow	Green Ash/Utly-Threes/wn	White/Black/Red Oak	Glade	Ruderal Shrub Forest
Alfalfa Hay	Green Ash/Oletha	Black Oak	Red Pine	Ruderal Mixed Forest
Alfalfa Hay/Other	Rough Fescue-Bluebunch/Wheatgrass	Post/Black Oak	White Cedar	Ruderal Mixed Forest
Fallow	Rough Fescue/Idaho Fescue	Sugar Maple/Beech/Yellow Birch	Lake Prairie	Managed Tree Plantation
Sparsely Vegetated	Wheatgrass/Bluestem-Neetgrass	Sugar Maple/Basswood	Bluestem Prairie	Managed Tree Plantation
Sparsely Vegetated	Tall Fescue	Chestnut Oak	Bluesgrass Savanna/Woodland	Introduced Wetland Vegetation
Sparsely Vegetated	Alpine Rangeland	Yellow Poplar/Hemlock	Little Bluestem/Post Oak	Modified/Managed Tallgrass
Aspen Forest/Parkland	Bluestem Gramin. Prairie	Sugar Maple/Beech	Karst Plain Prairie	Modified/Managed Tallgrass

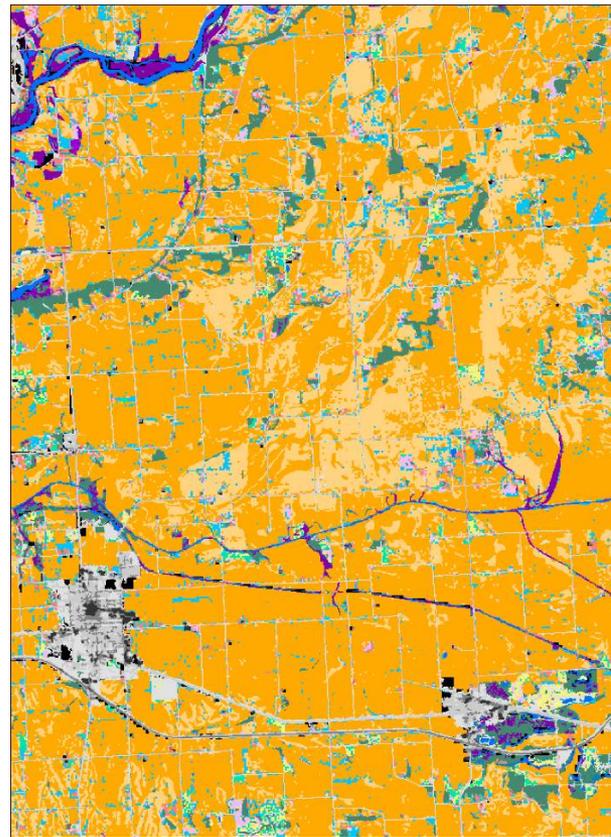
Comparison of Traditional and Expanded NLCD Agriculture Classes for FML Base Year Landscape – Enhanced NLCD 2001/2002



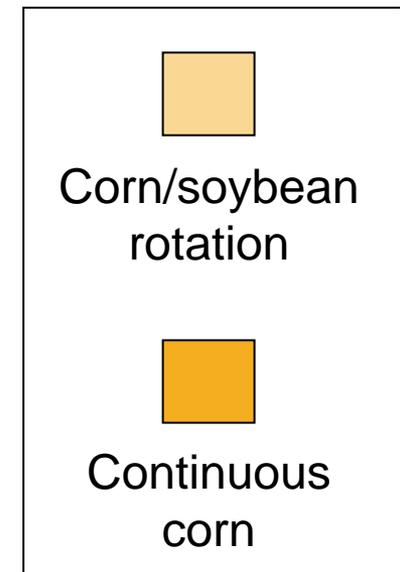
Detail comparison of Base Year (2001) and Biofuel Targets (2022) landscapes



Baseyear (2001)



“Biofuel targets” (2022)



Detail for Corn Belt area in Illinois

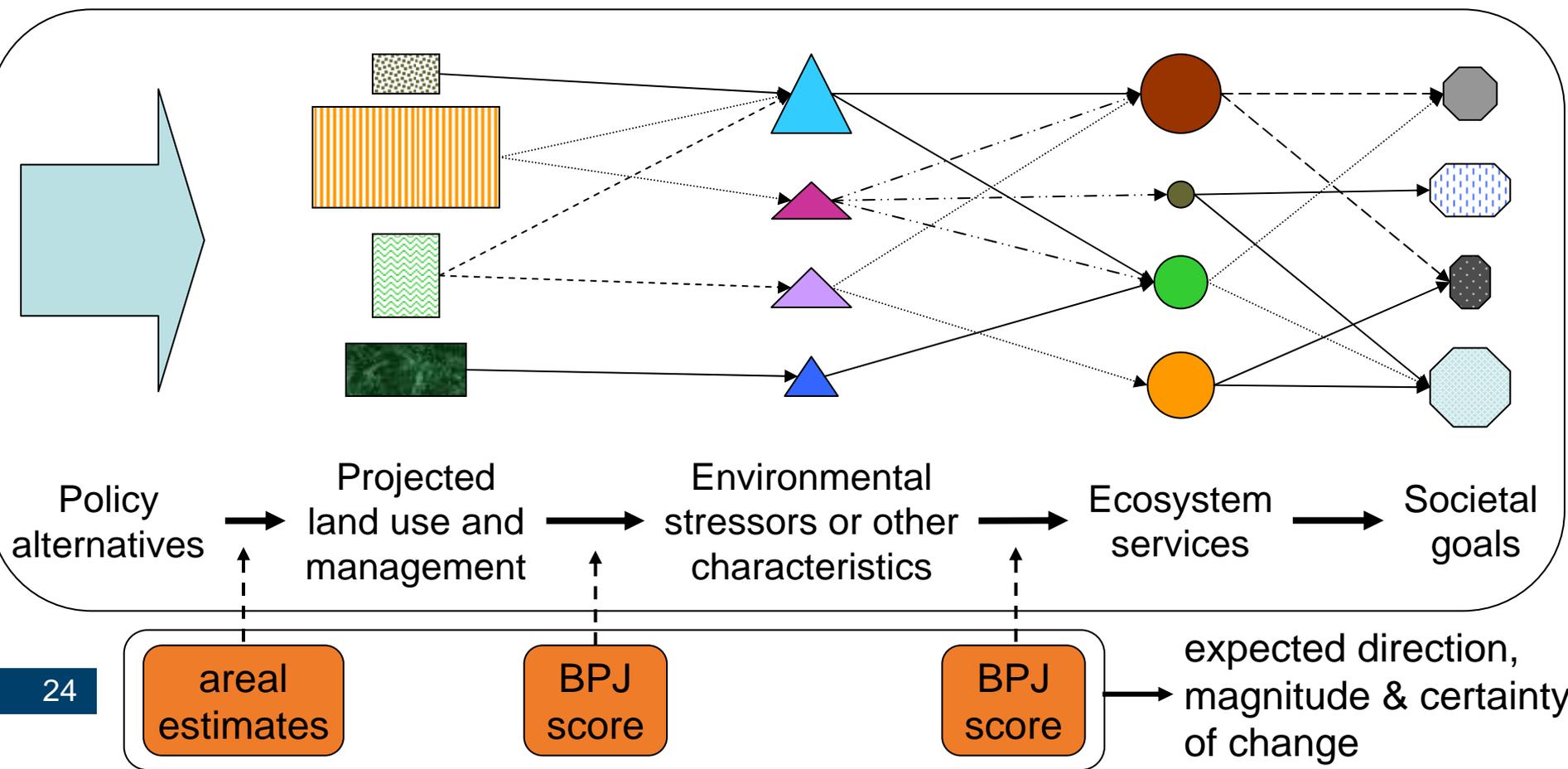
The Future Midwestern Landscapes Environmental Decision Toolkit (FML-EDT)

- Prototype system currently on-line
- Landscape statistics from Base Year and Biofuel Targets scenarios now being summarized for inclusion

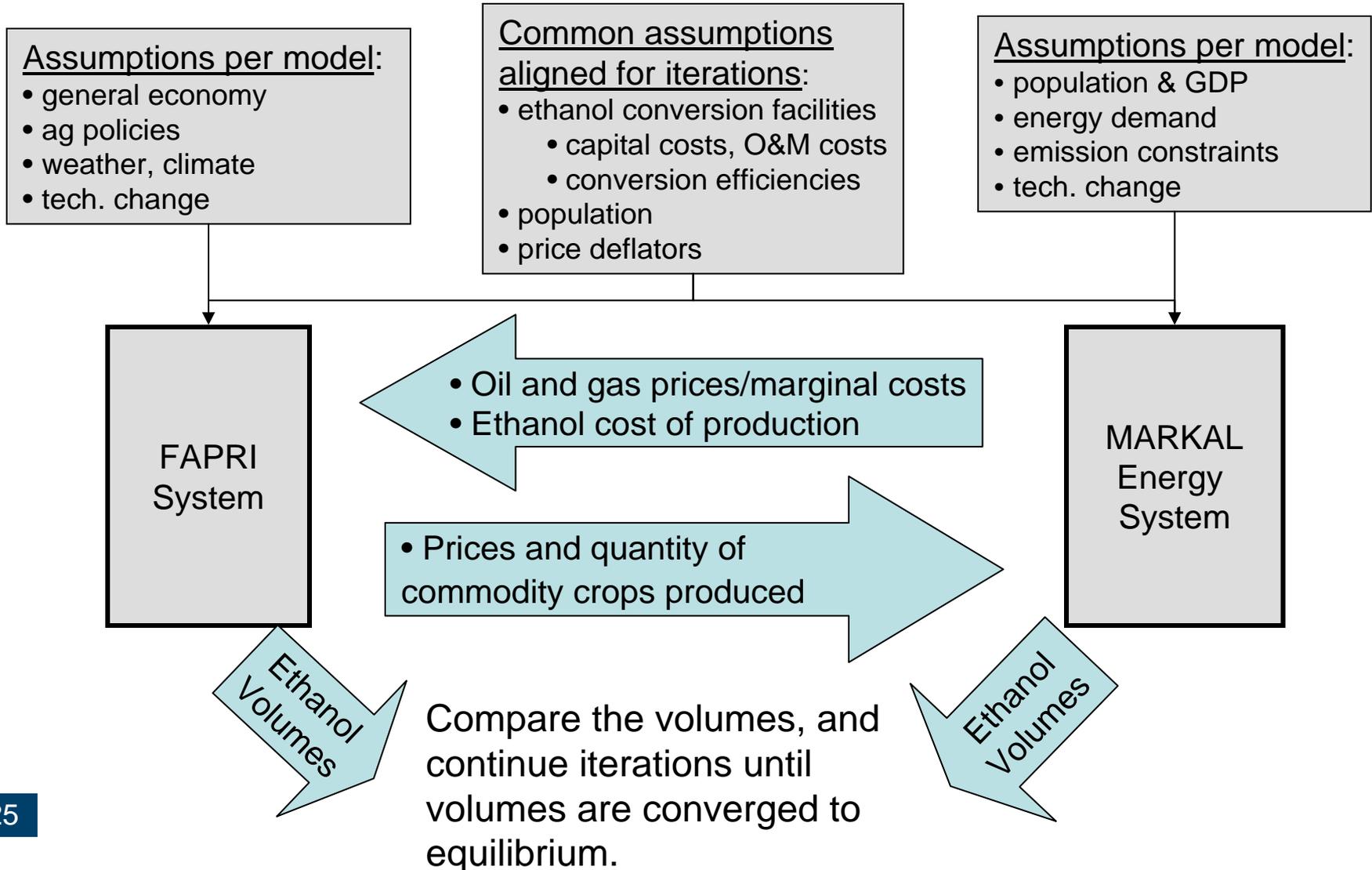
Methodological Progress (*partners*)

- Scoping analysis (*in-house*)
- Coupled analysis of US agricultural and energy systems (*Iowa State/CARD*)
- “Multiple Services” landscape design (*USDA Farm Service Agency*)
- Air quality response to land use & land cover change (*in-house*)
- Two-tier watershed modeling approach (*partners TBD*)

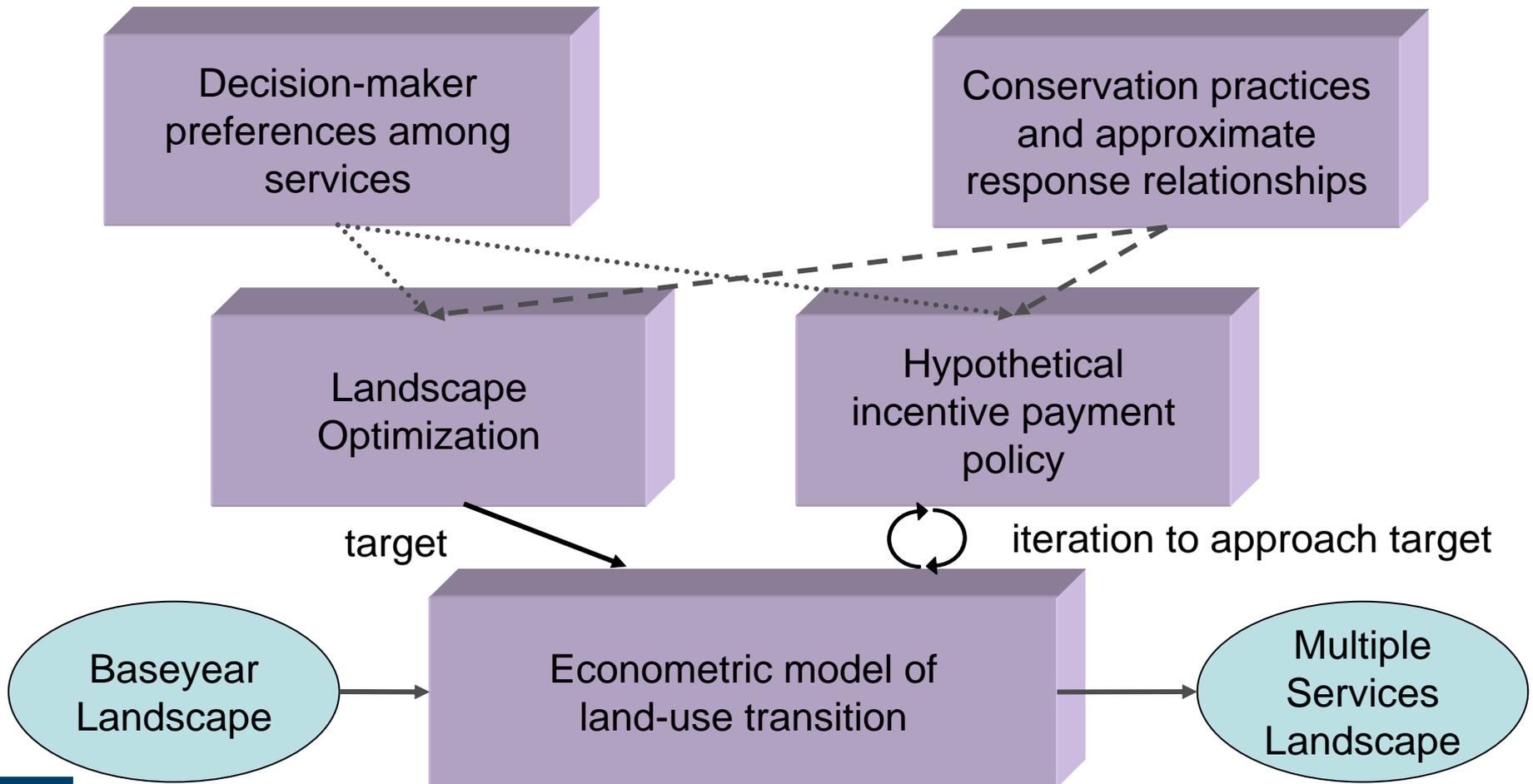
Forming hypotheses about scenario-driven changes in services



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



2022 Multiple Services Landscape



Air Quality Response to Land Use Change

- Modifications to Community Multiscale Air Quality model (CMAQ) – underway or complete
 - Modifying meteorological model and emissions processing to accept land use/land cover (LULC) classes
 - Link LULC to biogenic emissions data base
 - Incorporate bidirectional ammonia flux
 - Develop fertilizer input scenarios

Two-tier watershed modeling approach under development

- SPARROW (SPATIally Referenced Regressions On Watershed attributes)
 - accuracy at large basin scale
 - statistical bounds
 - use to calibrate process-based models for existing conditions
- Process-based model(s)
 - SWAT, AnnAGNPS
 - able to simulate many land management changes
 - employ at HUC-8 and smaller scales
 - use to develop revised SPARROW models for future scenarios
- Partners yet to be identified

Presentation Outline

- Design decisions governing study structure and approach
 - Spatial & temporal scales, boundaries
 - Modeling approach
 - Future scenarios
 - Ecosystem services
- Progress to date
 - Efforts completed
 - Methodological issues addressed
 - Partnerships established
- **Current efforts and challenges**

Current efforts and challenges

- Reaching out to additional *partners*
 - Wildlife habitat modeling (*US Fish and Wildlife Service*)
 - Flood plain modeling (*Corps of Engineers Institute for Water Resources*)
 - Collaboration on modeling ecosystem services in the Midwest (*US Geological Survey*)
 - New STAR grantees?

ESRP-funded STAR grant solicitation:

“Enhancing ecosystem services from agricultural lands.”

- Co-funded with USDA, total of \$4.5 M (\$1 M ESRP, \$3.5 M USDA)
- Released Feb. 2009 (now closed, awards pending)
- Grants *may* complement in-house FML study, and potentially enable cooperation with in-house scientists, and with EPA Regional staff.

Current efforts and challenges

- Expand FML approach in response to energy sustainability questions
 - include an additional region (e.g., Southeast)?
 - expand scenarios
 - examine other bioenergy/conservation policy combinations?
 - incorporate greater detail on bioenergy crops?

Contacts

Ecosystems Services Research Program

Rick Linthurst, National Program Director

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

Future Midwestern Landscapes Study

Randy Bruins, Study Co-Leader

513-569-7581; bruins.randy@epa.gov

Betsy Smith, Study Co-Leader

919-541-0620; smith.betsy@epa.gov