Co-Benefits from Conservation Policies that Promote Carbon Sequestration in Agriculture: The Corn Belt

CARD, Iowa State University
Presented at the Forestry & Agriculture Greenhouse Gas Modeling Forum,
Shepherdstown, West Virginia, October, 2004

Hongli Feng, Luba Kurkalova, Philip Gassman, Catherine Kling, and Silvia Secchi

Carbon Markets Future, Conservation Programs Now

- ➢ Major Conservation Policies that Sequester Carbon
  - Land retirement (CRP) $1.6 billion/yr
 - Working land conservation (EQIP) $0.11 billion/yr

- ➢ Farm Bill (2002) increases focus on Working Lands
  - Land retirement (CRP,WRP) $11 billion/10yrs
  - Working land conservation (CSP, EQIP,…) $3 billion/10yrs

- ➢ Co-Benefits will be key to conservation policy

This Work

- Estimate Carbon and co-benefits from conservation policy in large region

- But, use "small" unit of analysis (110,000 NRI points in region) to preserve rich regional heterogeneity
  - in costs,
  - land and soil characteristics,
  - environmental changes

- Study two fundamentally different land uses:
  - Land Retirement
  - Working land

- Integrate two environmental models:
  - edge of field environmental benefits (EPIC)
  - and watershed effects (SWAT)

The Upper Mississippi River Basin
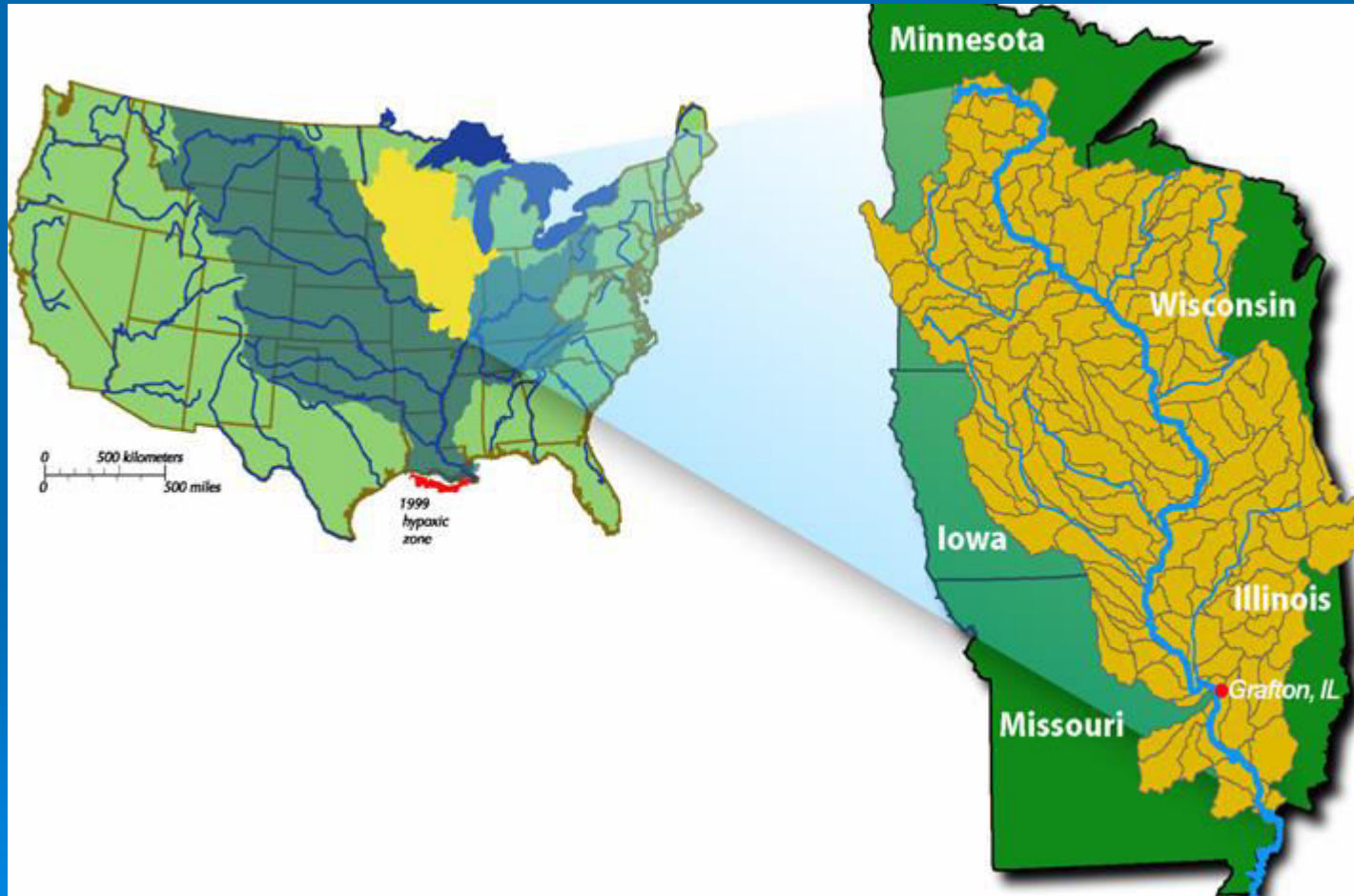
Some stats

THE UMRB:

➢ covers 189,000 square miles in seven states,

➢ is dominated by agriculture: cropland and pasture together account for nearly 67% of the total area (NAS),

➢ has more than 1200 stream segments and lakes on EPAs impaired waters list, highest concentrations of phosphorous found in the world (Downing),

➢ is estimated to be the source of nearly 40% of the Mississippi nitrate load discharged in the 1980- 1986 (Goolsby et al.),

➢ contains over 37,500 cropland NRI points

Two Major Conservation Programs: Land Retirement , Working Land Practices

➢ Land retirement

- Expensive

- Lots of C

- Many co-benefits

➢ Working land

- Cheaper

- Less C

- Fewer co-benefits?

Modeling Approach

➢ Pose Hypothetical Conservation Policy

➢ Predict farmer choices between working land-conventional tillage, working land-conservation tillage, and land retirement

- Economic model of working land
  - Returns to conventional tillage
  - Returns to conservation tillage
- Economic model of land retirement

➢ Predict environmental effects

- Field level changes in Carbon sequestration, erosion, phosphorous, nitrogen under each of the above three land uses
- Watershed level changes in sediment and nutrients (phosphorous and nitrogen), under combinations of the above three land uses

Empirical Economic Model

➢ Adoption model to estimate returns to conservation tillage

➢ Specification, Estimation, and Prediction Samples

1. Specification search by 8-digit HUC (14 models) in 1st sample

2. Estimate on 2nd sample to obtain clean estimate of coefficients and standard errors

3. Use prediction sample to assess model fit out of sample

➢ Cash rental rate as a function of yields to estimate opportunity cost of land retirement, vary by county and state

➢ Data Sources: 1992 and 1997 NRI data (soil and tillage), Census of Agriculture (farmer characteristics), Climate data of NCDA, Conservation tillage data from CTIC, Cropping Practices Surveys (budgets), cash rental rates

Environmental Models

- Two Models
  - Environmental Policy Integrated Climate (EPIC) Model
  - Soil and Water Assessment Tool (SWAT)

- Similarities: both
  - simulate a high level of spatial details,
  - operate on a daily time-step
  - can perform long-term simulations of hundreds of years, and
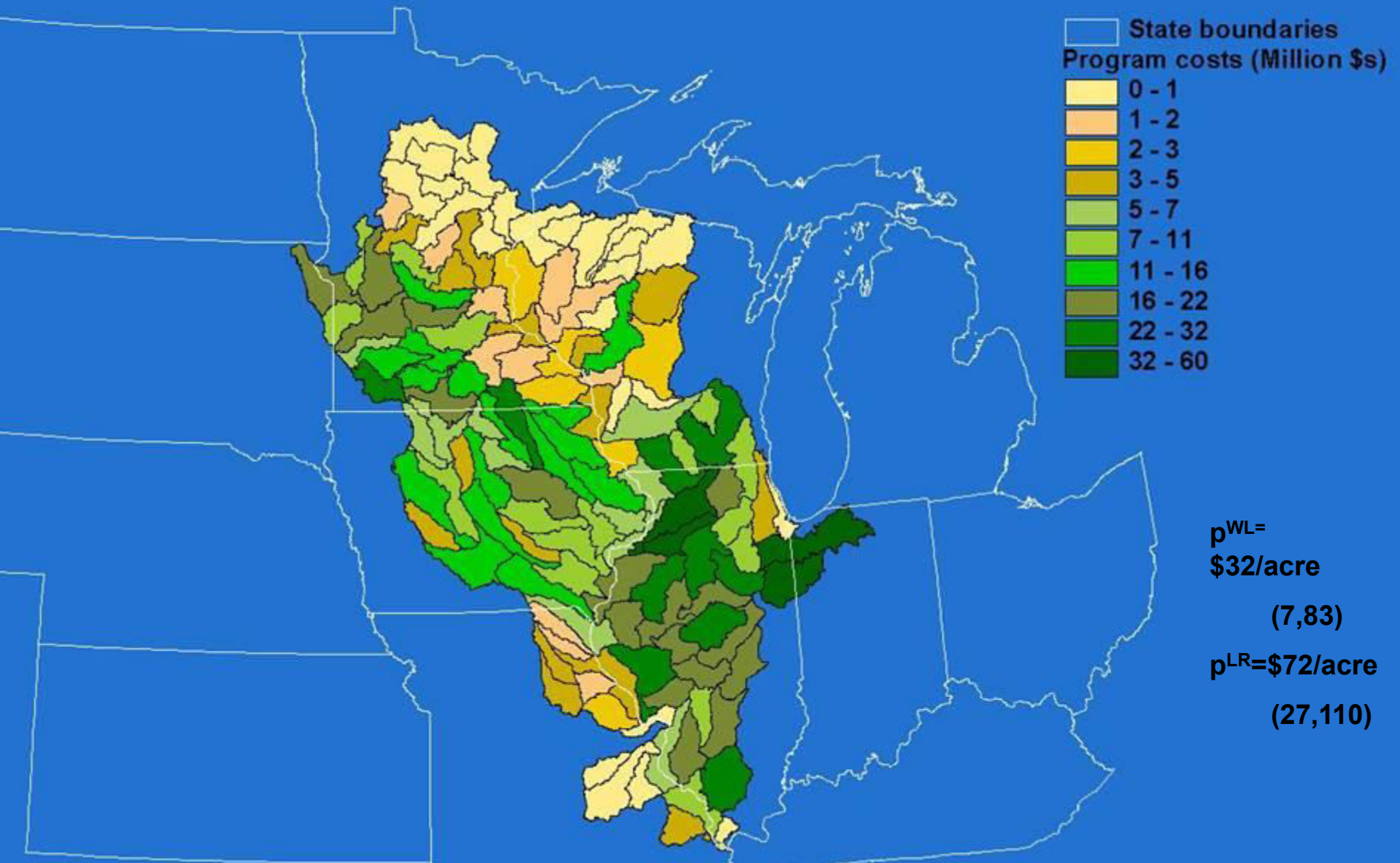 - can/have been used regional analyses and small-scale studies.

- Key differences:
  - EPIC is field scale: no interactions between fields, aggregate environmental indicators are simple sum of field level effects

  - SWAT is watershed based: predicts changes in environmental quality at watershed outlets, highly nonlinear between practices, land characteristics, soil types, and water quality
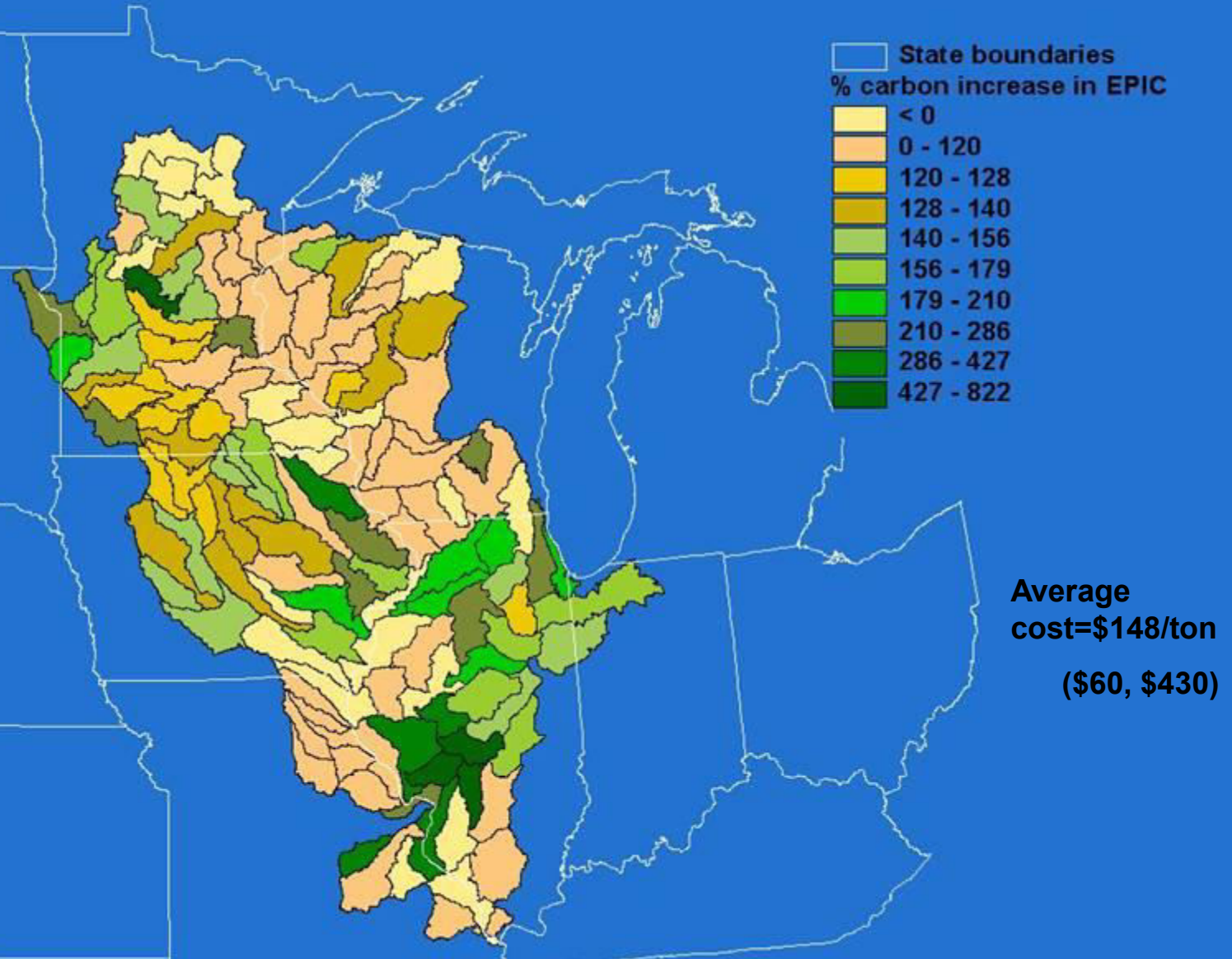
Now the fun! Conservation Policy

➢ CRP and CSP-type program

➢ Subsidy rates differ by USGS 4-digit watersheds

➢ Land retirement = p^{LR}

  20th percentile of LR costs in watershed

➢ Conservation tillage subsidy=p^{WL}

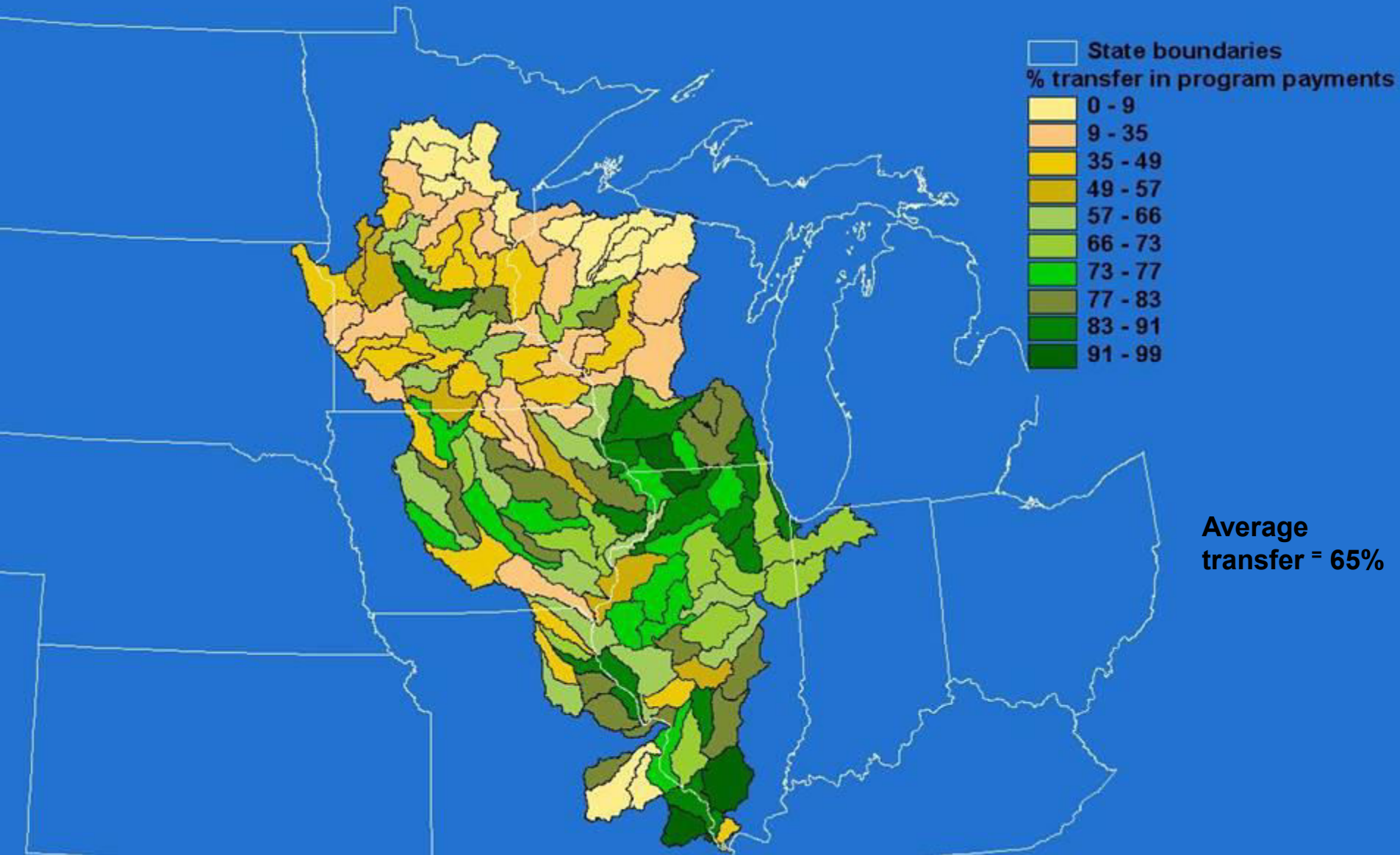 median conservation tillage adoption costs

Predicted Program Costs: $1.4 Billion

State boundaries
Program costs (Million $s)
- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 5
- 5 - 7
- 7 - 11
- 11 - 16
- 16 - 22
- 22 - 32
- 32 - 60

$p^{WL}=$ $32/acre

(7,83)

$p^{LR}=$$72/acre

(27,110)

Predicted Carbon Gains (EPIC): 9 million tons annually

State boundaries
% carbon increase in EPIC
- < 0
- 0 - 120
- 120 - 128
- 128 - 140
- 140 - 156
- 156 - 179
- 179 - 210
- 210 - 286
- 286 - 427
- 427 - 822

Average cost=$148/ton

($60, $430)

Predicted Percentage Transfer Payments in Sediment at 4-digit Watershed Outlets

State boundaries
% transfer in program payments
- 0 - 9
- 9 - 35
- 35 - 49
- 49 - 57
- 57 - 66
- 66 - 73
- 73 - 77
- 77 - 83
- 83 - 91
- 91 - 99

Average transfer = 65%

Environmental Gains vs. Transfers

Carbon

Transfers
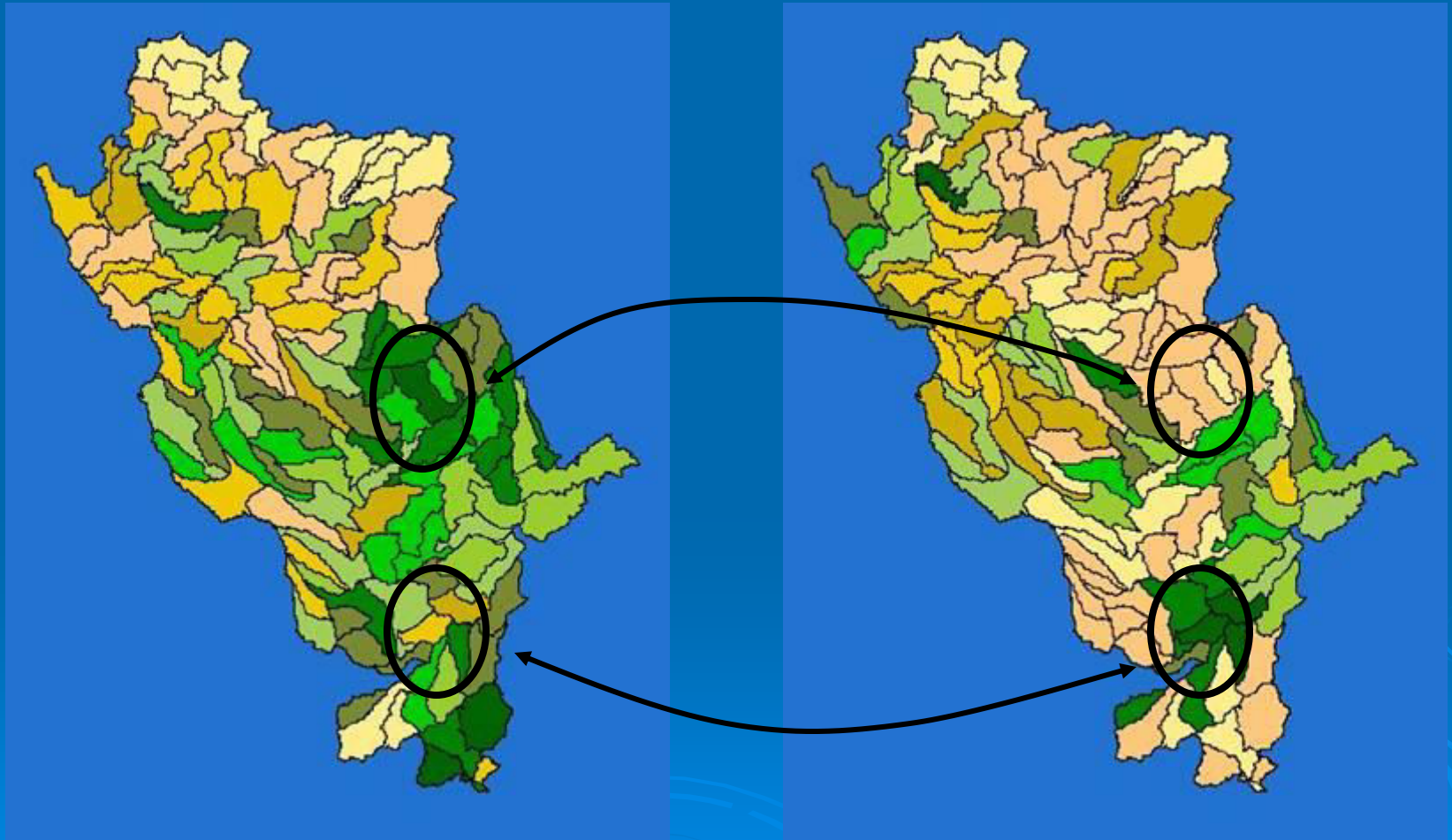
Predicted Sediment Reductions (EPIC)

State boundaries

% sediment reduction in EPIC
- 0 - 6
- 6 - 24
- 24 - 38
- 38 - 47
- 47 - 53
- 53 - 56
- 56 - 62
- 62 - 67
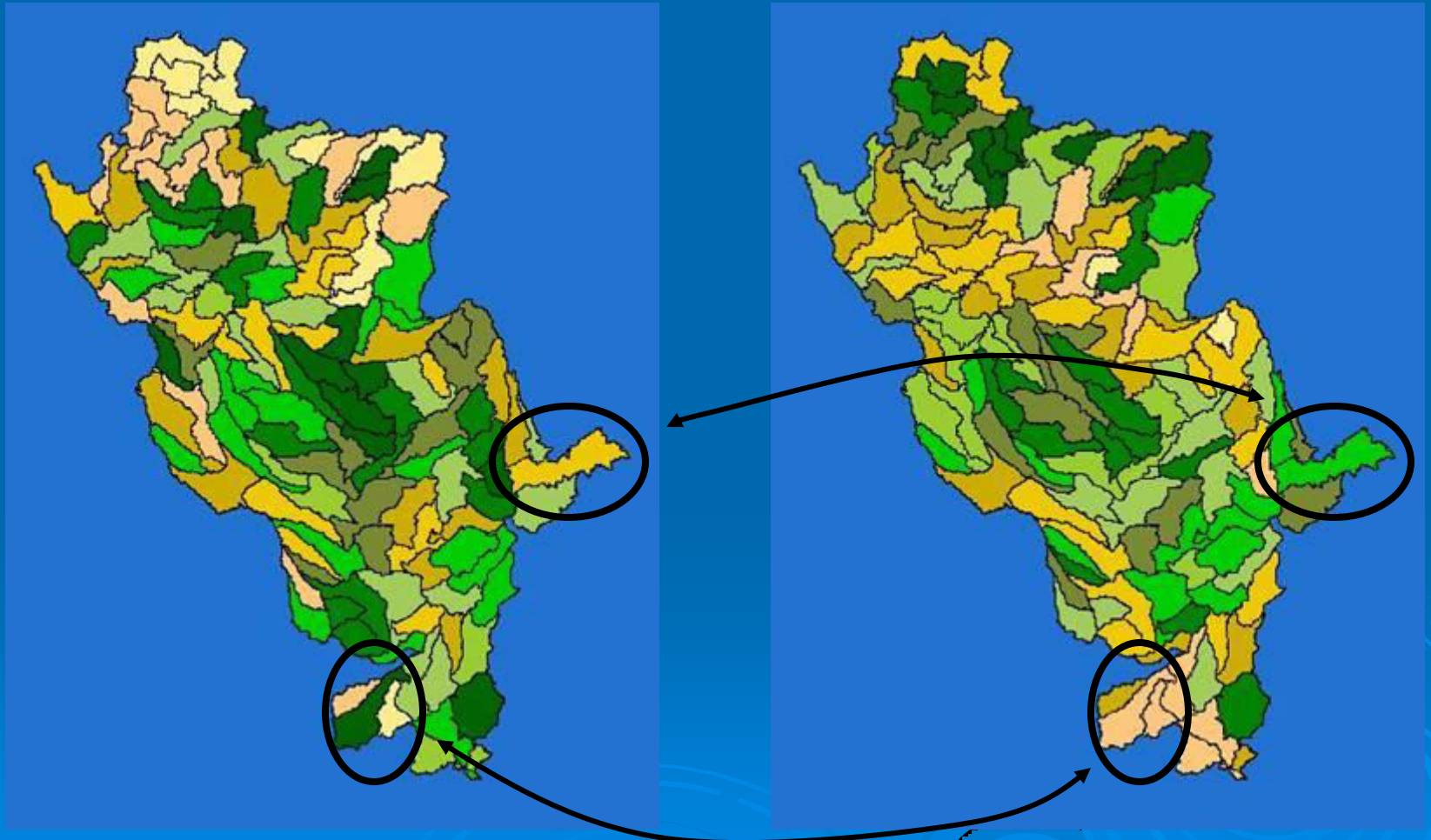- 67 - 78
- 78 - 100
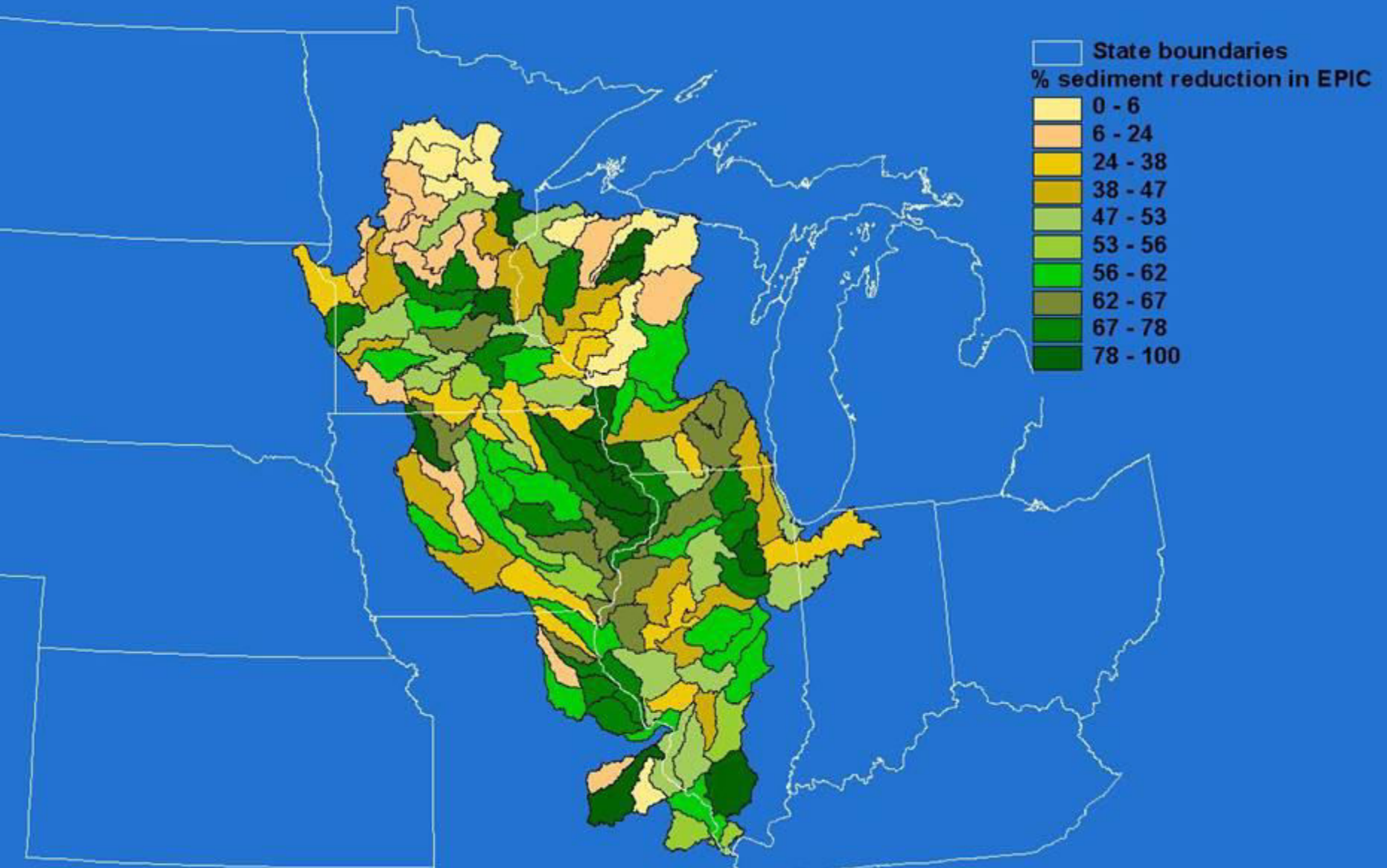
Predicted Reduction in Sediment at 8-digit Watershed Outlets
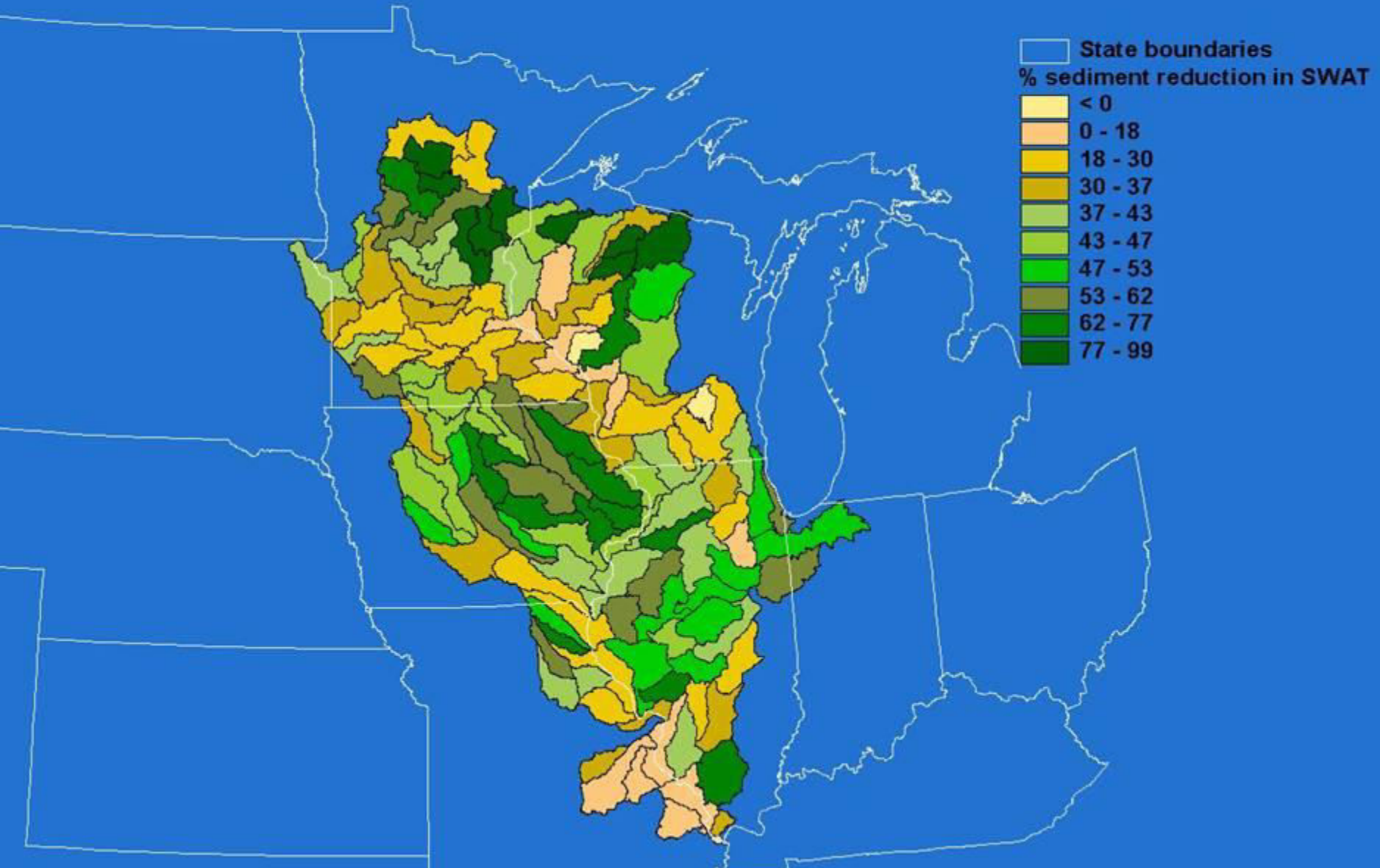
Sediment Predictions: SWAT vs EPIC

SWAT

EPIC

Final Remarks

1. Spatially rich model of large land area can be valuable tool

2. There is substantial heterogeneity in costs and environmental benefits across the UMRB

3. These differences have important efficiency and income distribution effects from conservation policies

4. The use of both an edge-of-field model (EPIC) and a watershed based model (SWAT) can increase our understanding of conservation policy efficiency as well as tradeoffs between equity and efficiency