Measuring Carbon Co-Benefits of Agricultural Conservation Policies: In-stream vs. Edge-of-Field Assessments of Water Quality.

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Carbon and Conservation Programs

- Nascent carbon markets and pilot sequestration projects
  - Chicago Climate Exchange
  - Iowa Farm Bureau
- Major Conservation Policies that Sequester Carbon
  - Land retirement (CRP) $1.6 billion/yr, about 4.5 MMTC
  - 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 in the interaction of carbon and conservation programs.

This Work

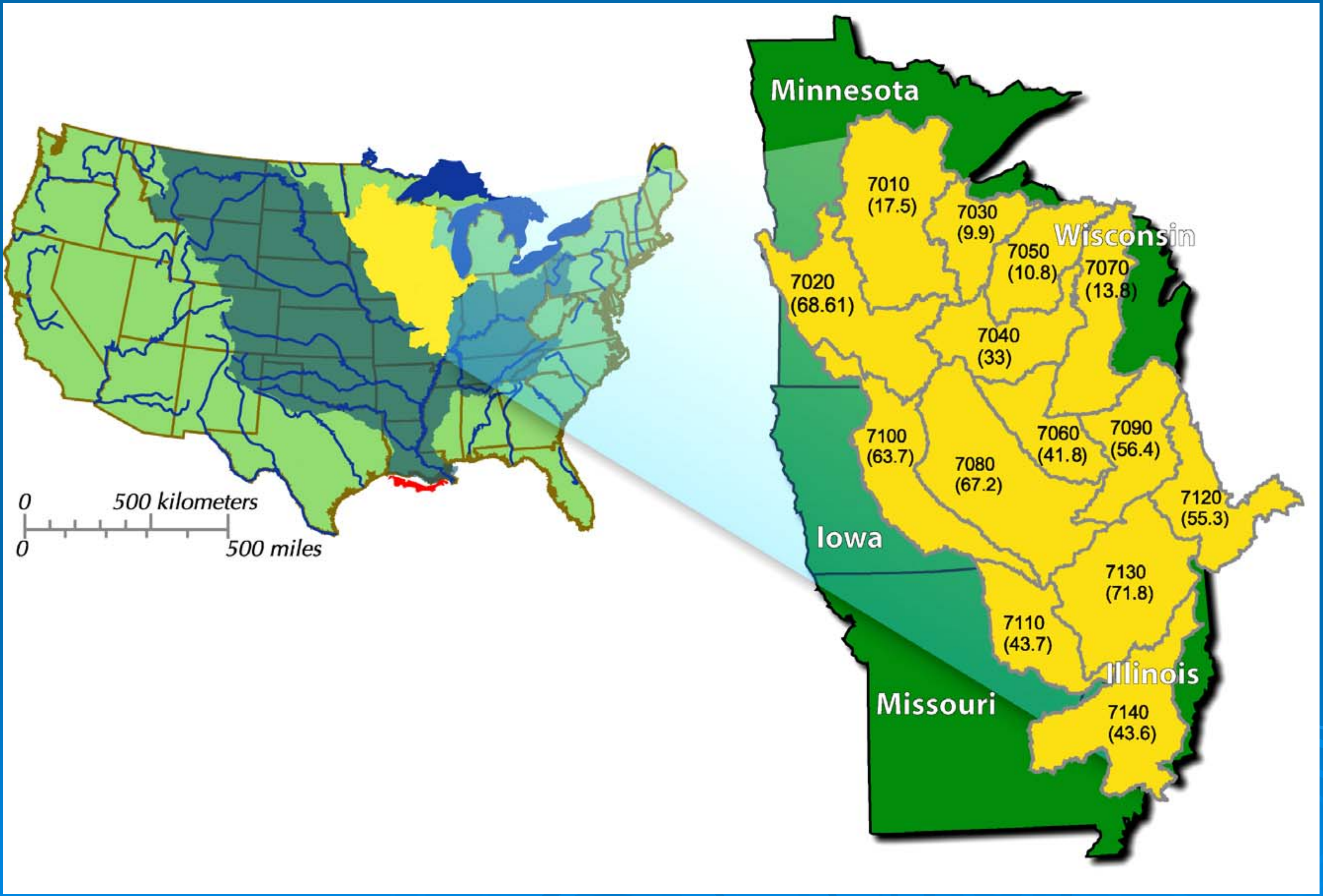
- Estimate Carbon and co-benefits from conservation policy in large region

- 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,
- has more than 1200 stream segments and lakes on EPA's impaired waters list, highest concentrations of phosphorous found in the world,
- 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 the cost of conservation tillage
- Specification, Estimation, and Prediction Samples

  1. Specification search by 4-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 in regional analyses and small-scale studies.

- Key differences:
  - EPIC is field scale: predicts changes at the edge of field

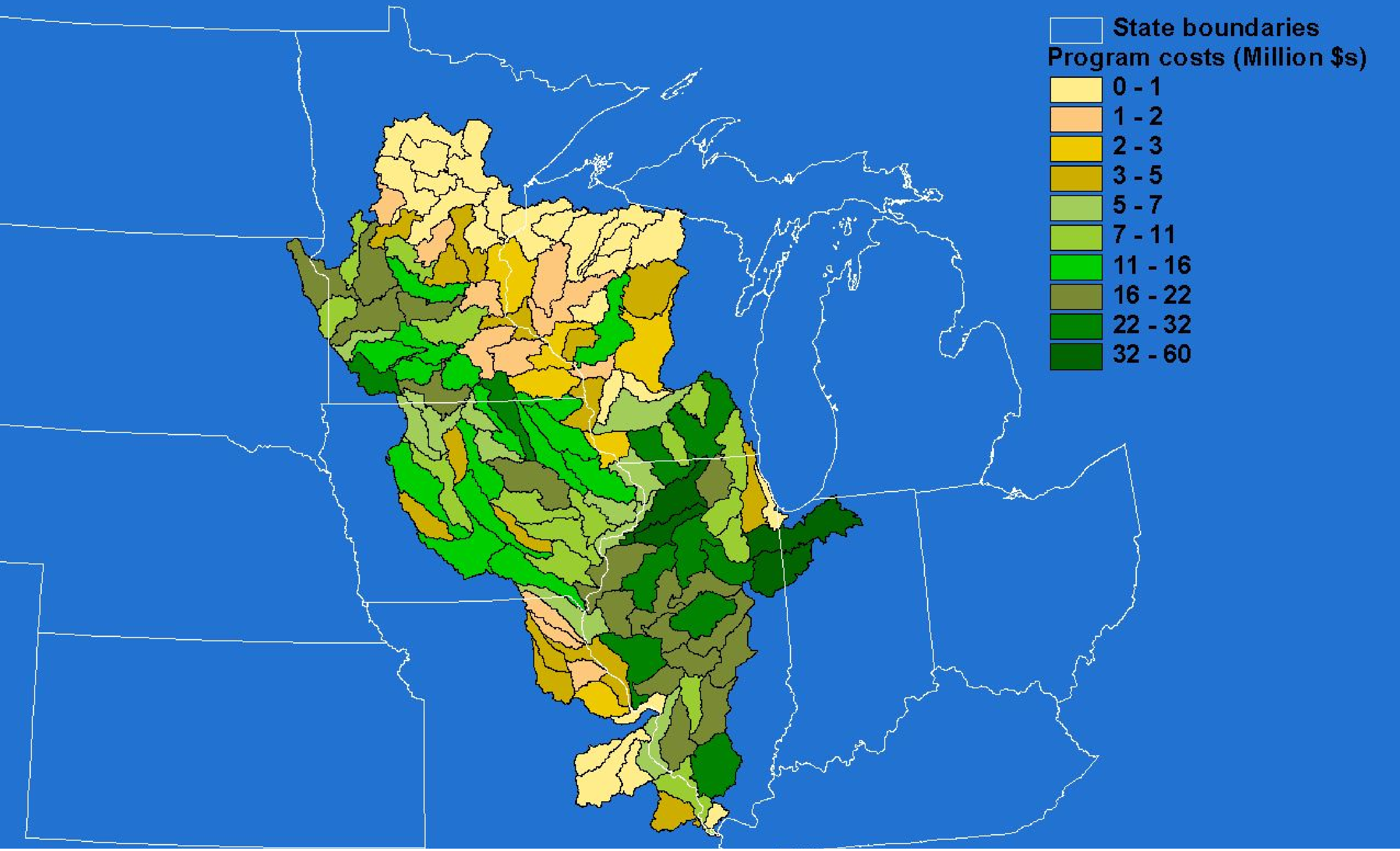
  - SWAT is watershed based: predicts changes in environmental quality at watershed outlets.

Conservation policy assessed

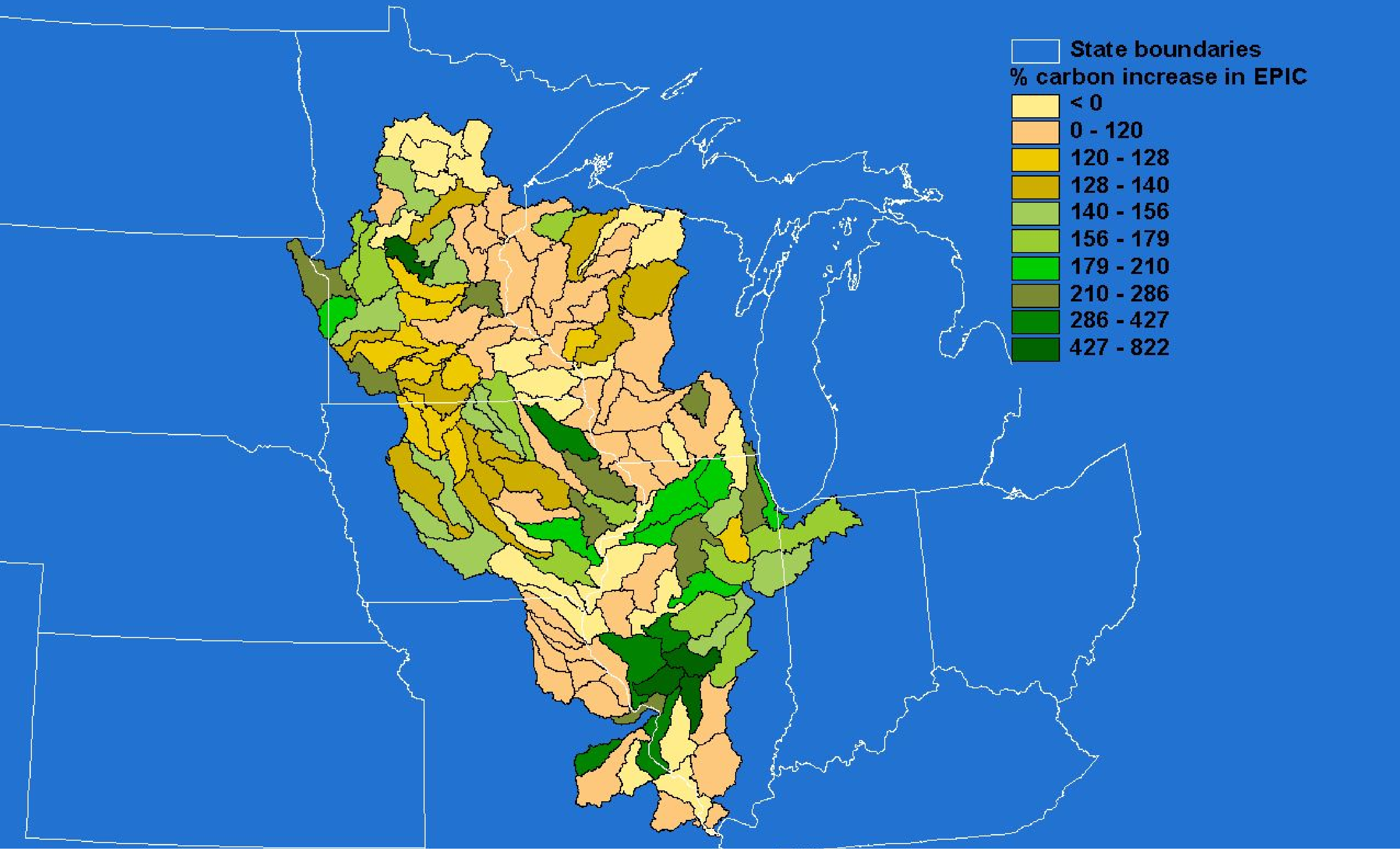
- CRP and CSP-type program
- Subsidy rates differ by USGS 4-digit watersheds
- Land retirement payment: 20th percentile of LR costs in watershed
- Conservation tillage payment: median conservation tillage adoption costs
- Transfer=payment –cost; for any field, the practice (LR or CT) with higher transfer is chosen if the transfer is positive.

HUC	Program costs ($m)	Transfer for CRP ($m)	Transfer for cons. till ($m)	Aver transfer rate	Cons. till rate	Base cons. till rate	CRP rate	Transfer CRP aver ($/a)	Transfer cons. till aver ($/a)
701	61.46	1.20	37.58	0.63	0.59	0.17	0.10	10.6	54.5
702	160.43	9.83	67.47	0.48	0.54	0.15	0.11	16.4	23.3
703	3.50	0.12	1.47	0.46	0.51	0.15	0.15	2.9	10.7
704	34.12	8.56	4.44	0.38	0.52	0.39	0.25	21.1	5.2
705	4.50	0.10	1.87	0.44	0.57	0.18	0.13	1.7	7.1
706	53.55	3.85	29.42	0.62	0.86	0.78	0.10	18.5	16.0
707	15.38	0.86	8.15	0.59	0.62	0.35	0.22	6.9	22.9
708	188.63	15.15	94.29	0.58	0.81	0.69	0.08	19.5	11.8
709	196.62	2.59	161.98	0.84	0.80	0.60	0.05	16.3	64.2
710	98.54	8.81	34.07	0.44	0.70	0.50	0.10	14.9	8.5
711	27.95	0.28	18.23	0.66	0.71	0.48	0.06	2.3	12.9
712	114.00	2.00	84.66	0.76	0.74	0.51	0.05	13.2	35.6
713	270.07	7.00	176.54	0.68	0.71	0.45	0.06	14.1	31.3
714	111.75	1.14	92.47	0.84	0.71	0.44	0.04	10.9	47.0
UMRB	1,340.51	61.50	812.64	0.65	0.71	0.49	0.09	15.6	24.7

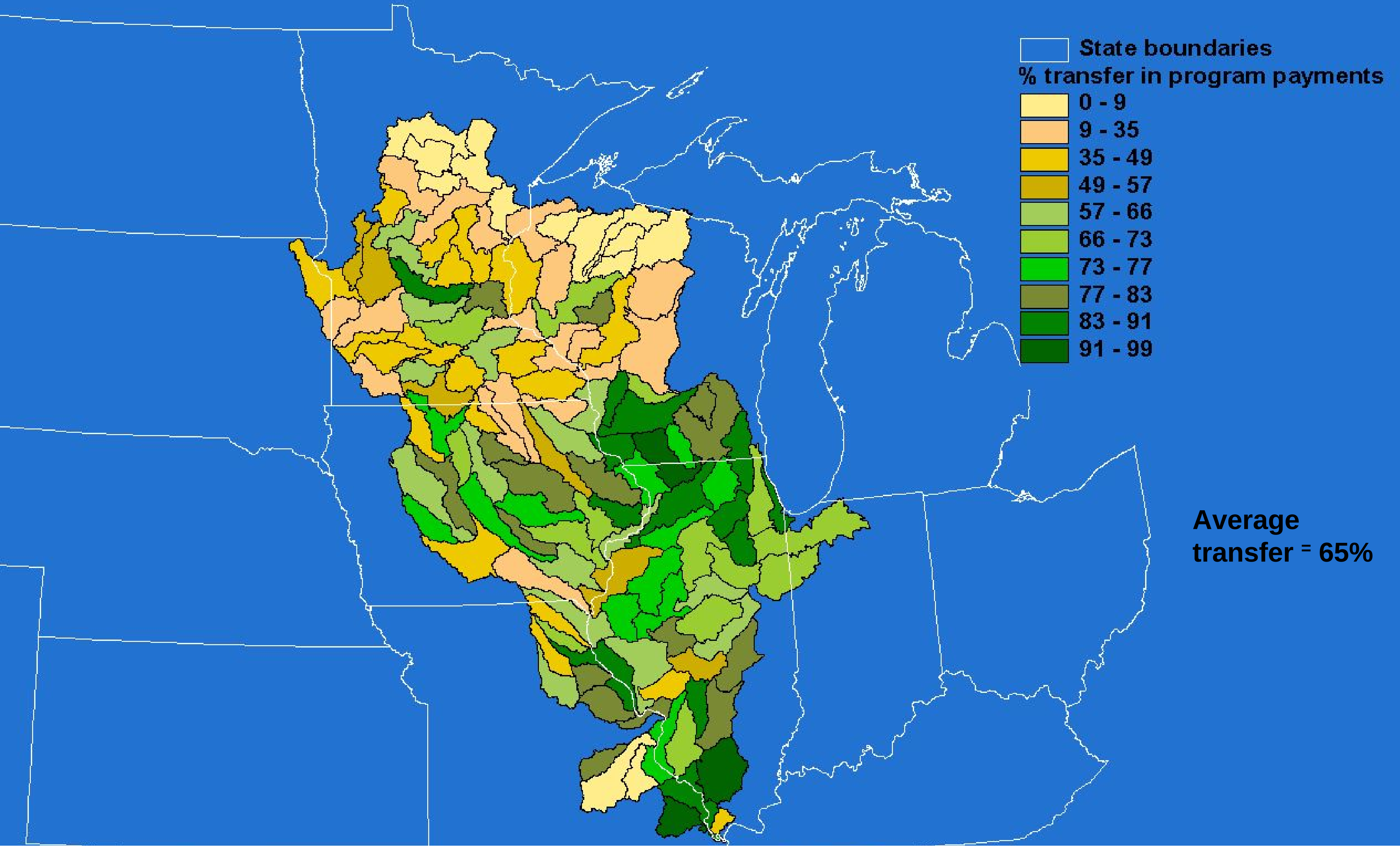
Predicted Program Costs: $1.3 Billion



Predicted Carbon Gains (EPIC): 9 million tons annually



Predicted Percentage Transfer Payments

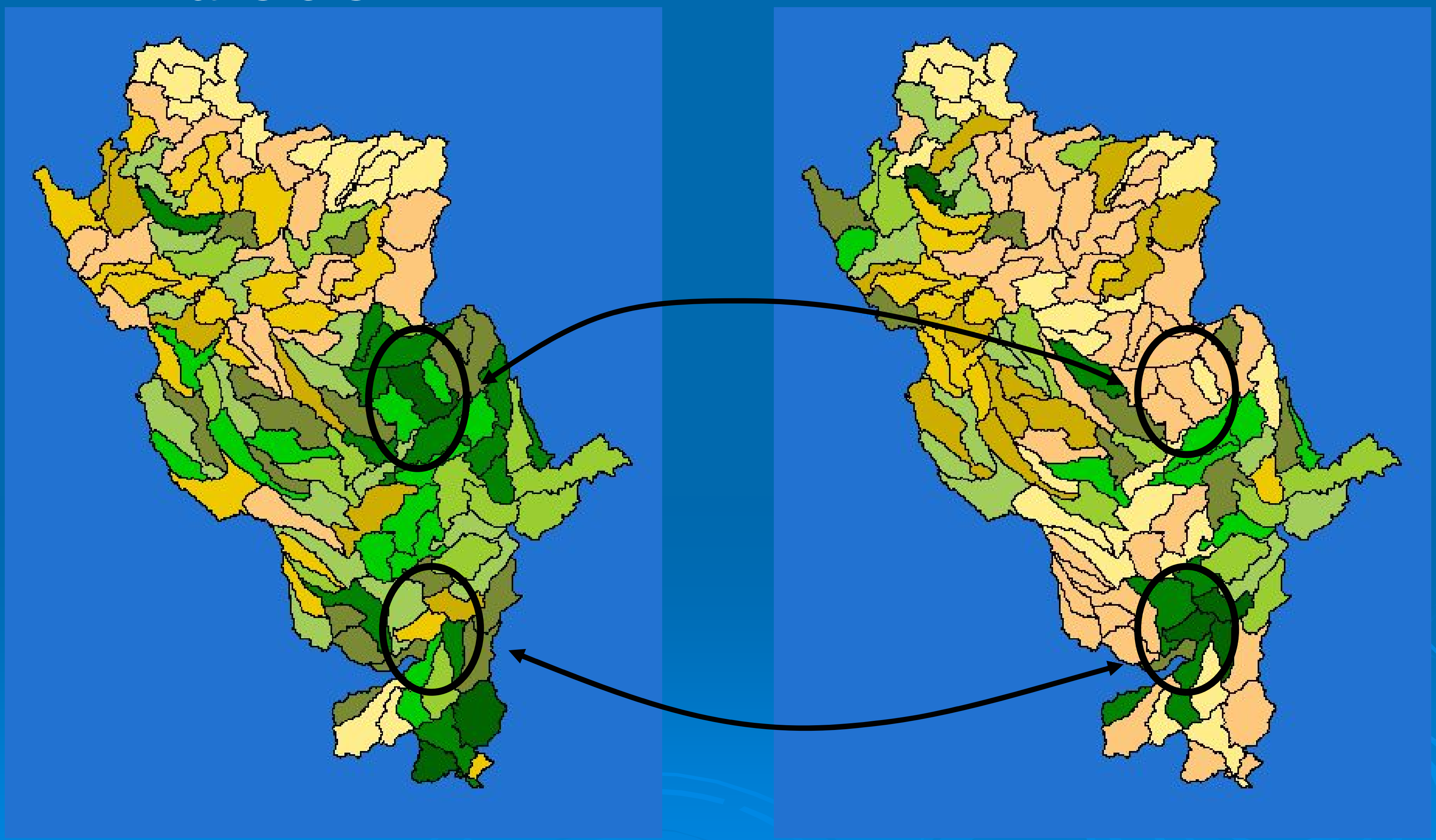


Average transfer = 65%

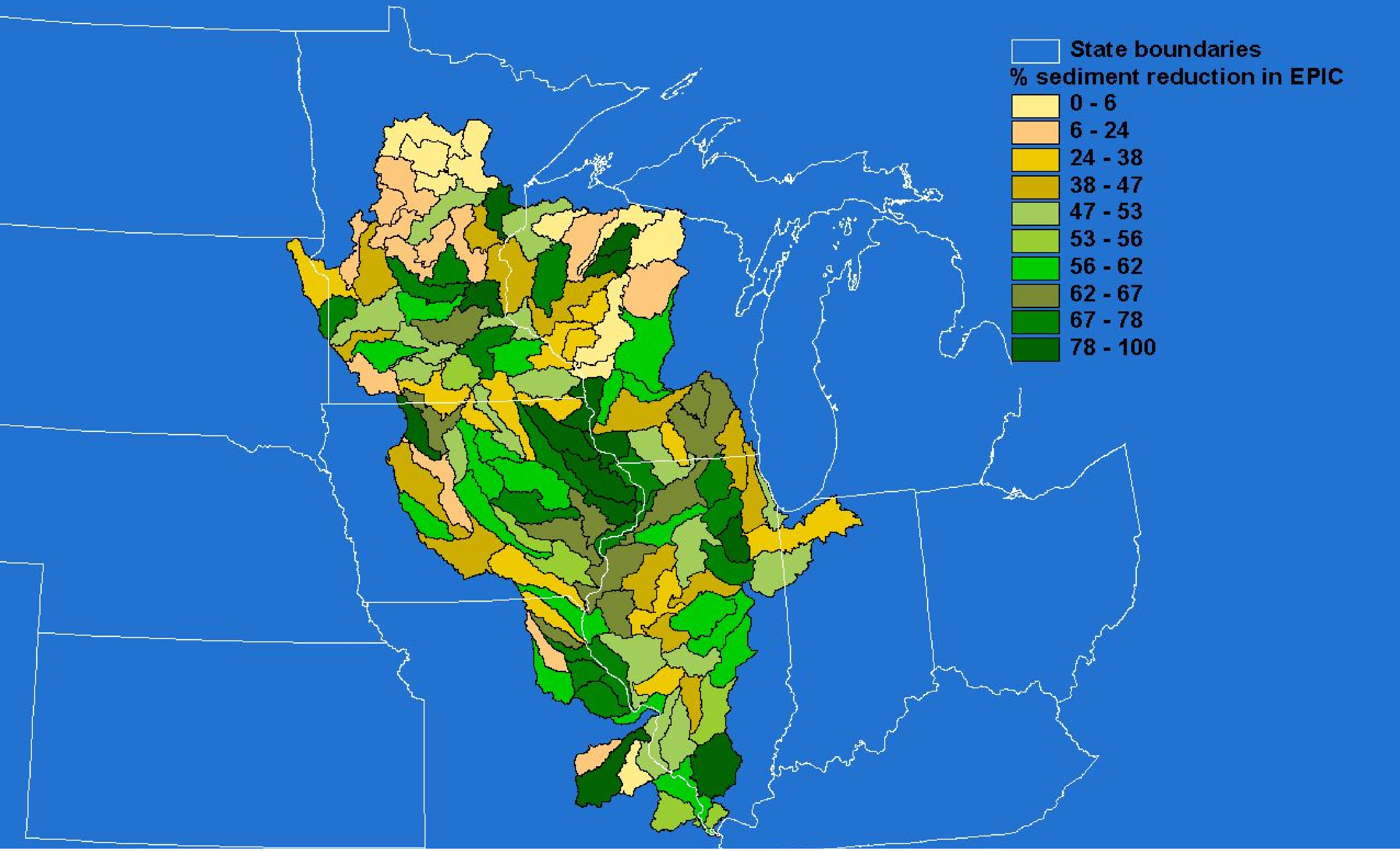
Environmental Gains vs. Transfers

Transfers

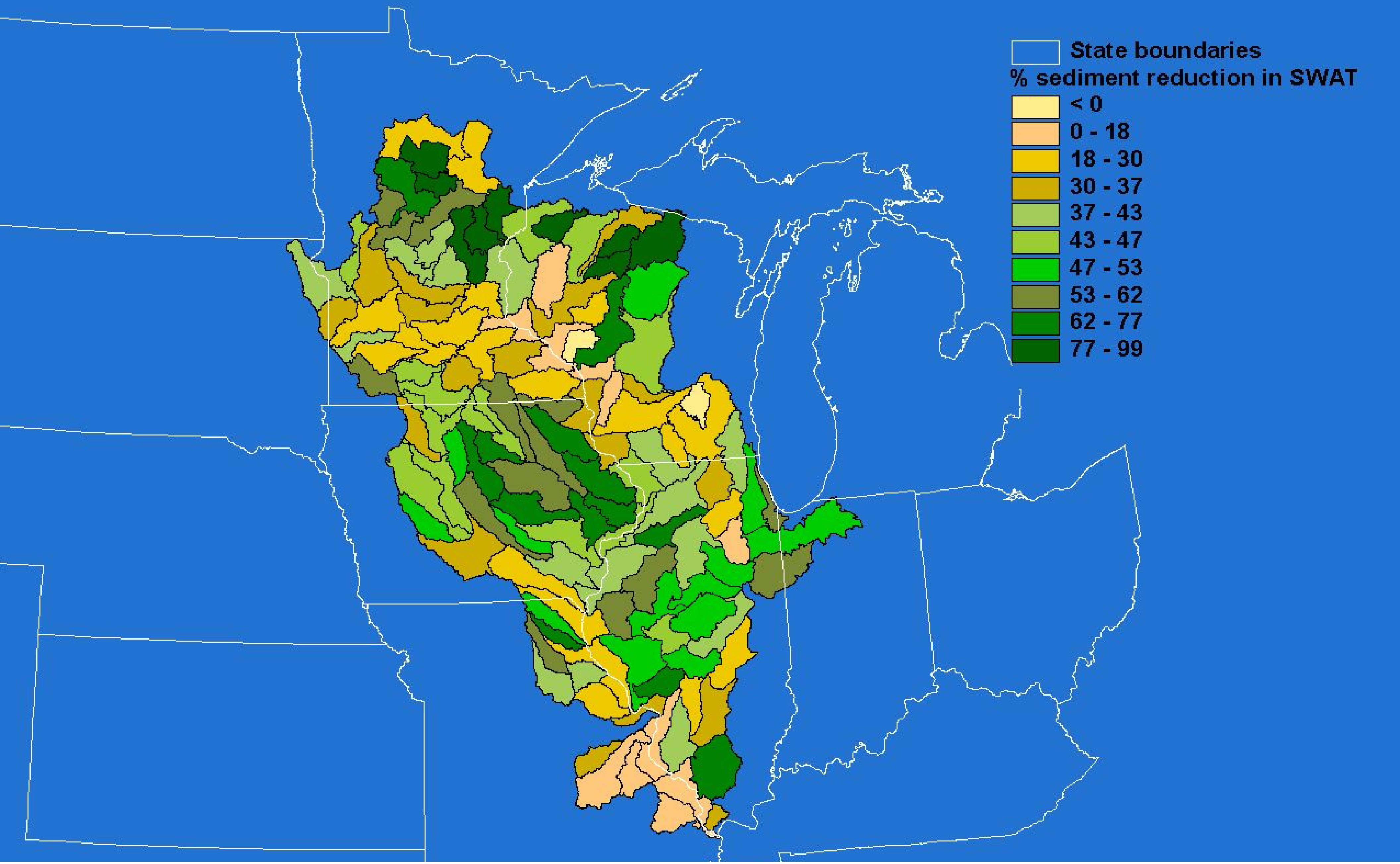
Carbon



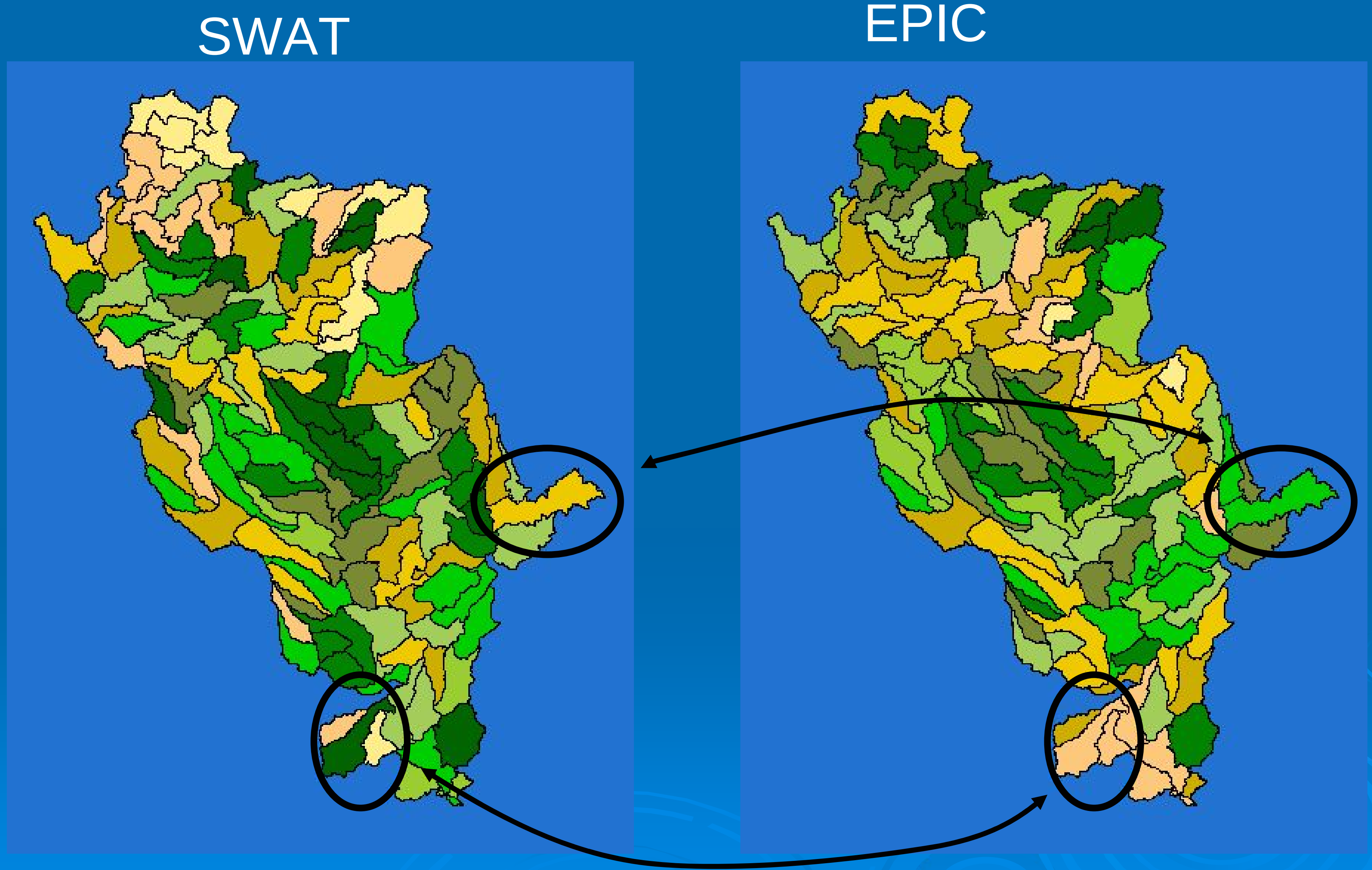
Predicted Sediment Reductions (EPIC)



Predicted Reduction in Sediment at 8-digit Watershed Outlets



Sediment Predictions: SWAT vs 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