Biofuels and Water Quality in the Midwest: Corn vs. Switchgrass

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Rapid Expansion of Ethanol

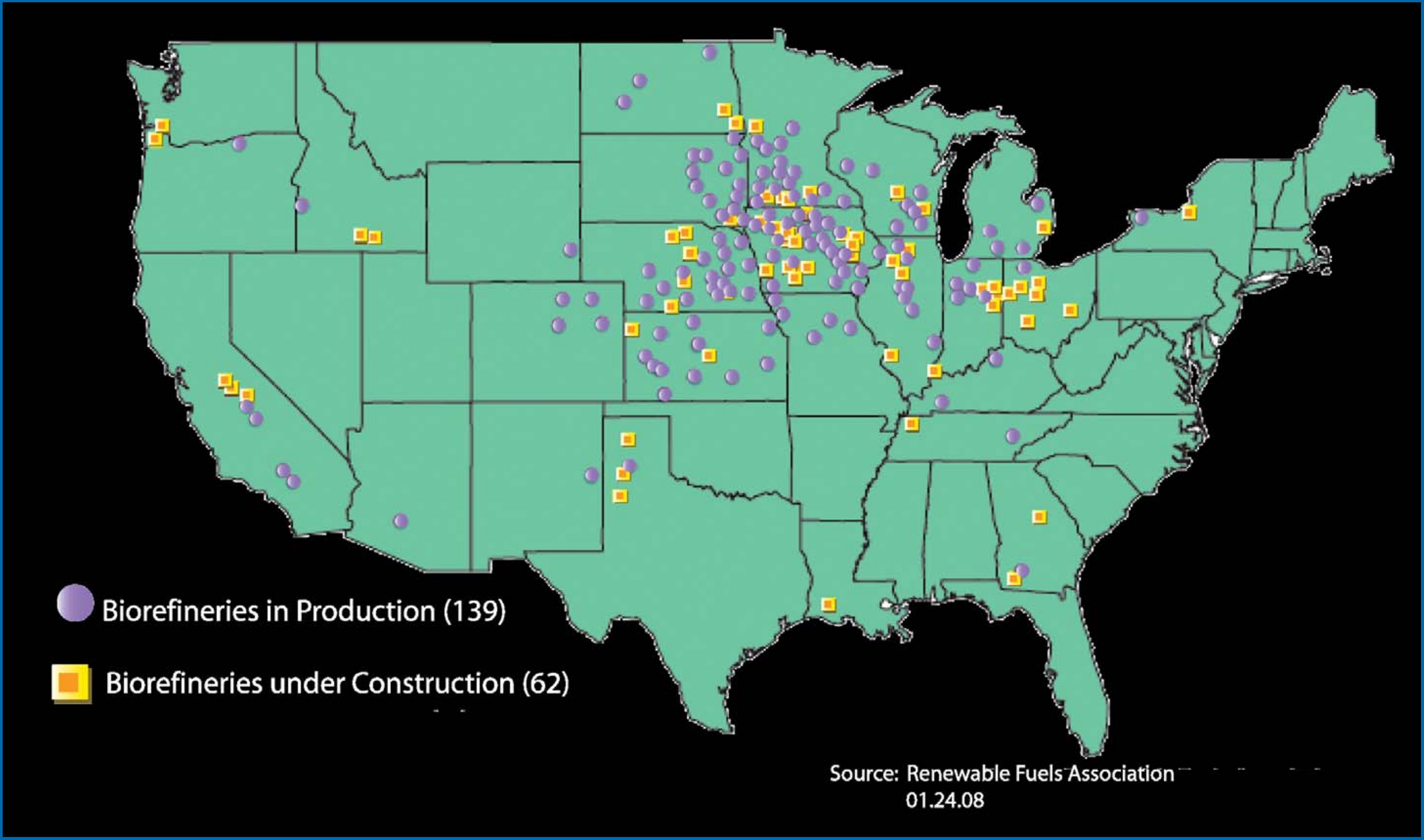
- U.S. production: 7 billion gallons of ethanol today, 2 billion gallons in 2002
- Corn: Acreage, 78 mil acres in 2006, 90 mil in 2007 (NASS)

  Prices, historically $2.5-$3/bushel, over $5 now
- Biorefineries: 139 in production, 62 under construction (RFA, Jan. 2008)
- Energy Bill: mandates 36 gallons from biofuels by 2022, 20 billion from advanced biofuels (EISA)

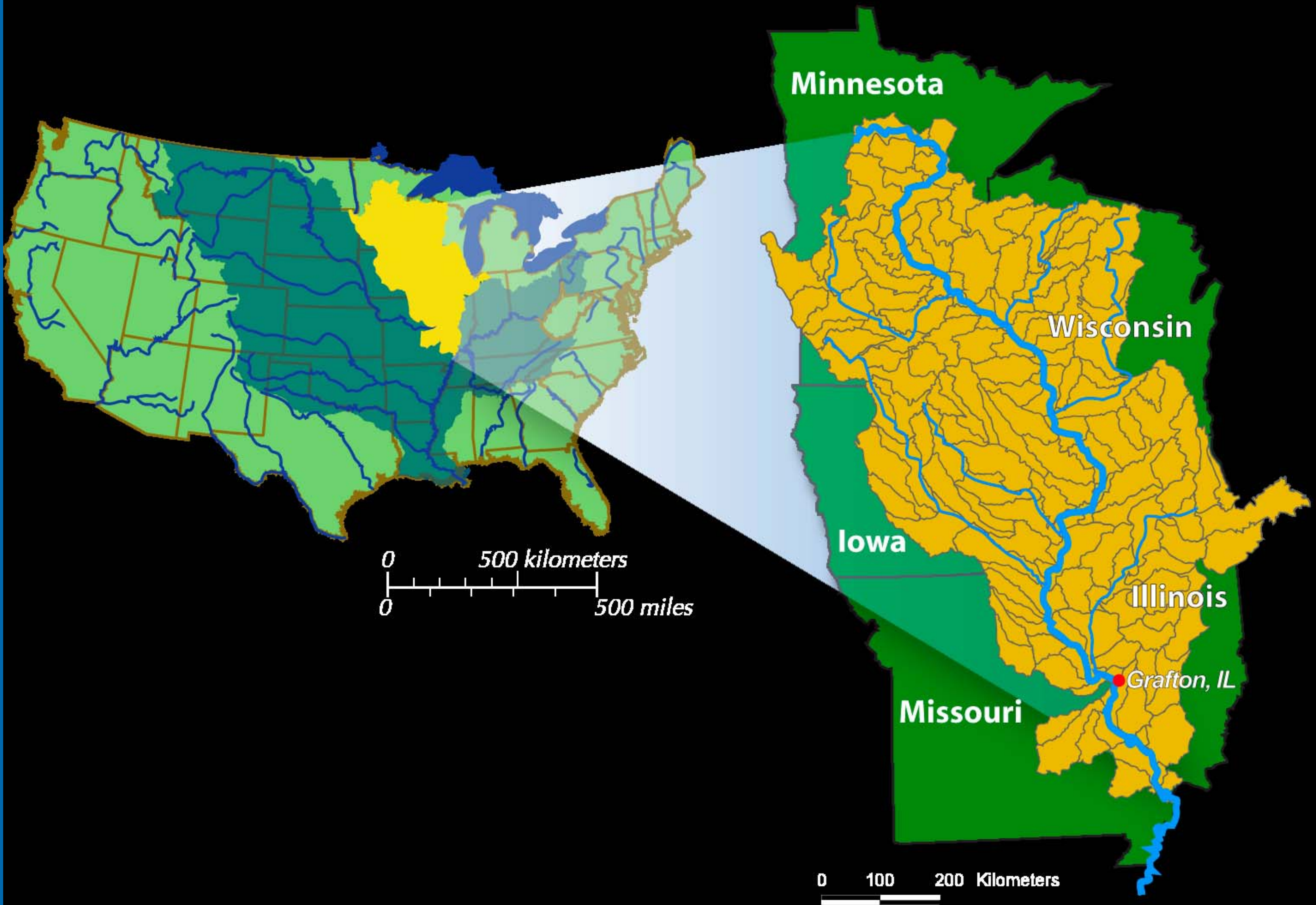
Some Key Policy Drivers of Economics Behind Ethanol Expansion

1975	Lead phase-out begins	Ethanol becomes attractive as octane booster
1978	Energy Tax Act	A $0.40 subsidy per gallon of ethanol blended into gasoline introduced
1980-1984	Energy Security Act, Crude Windfall Tax Act, Surface Transportation Act, Tax Reform Act	Insured loans for small ethanol producers, tariffs on foreign produced ethanol, ethanol subsidy increased to $0.50 and then $.60
1992	Clean Air Act Amendments	Mandated oxygenates in many locations, MTBEs major oxygenate in use
1985-2003	Various Acts	Subsidy reduced gradually to $0.52/gallon Various states banned MTBE's
2005	Energy Policy Act	Phased out MTBEs as oxygenate thereby increasing demand for ethanol
2007	Energy Bill	Biofuels mandate for 36 billion gallons by 2022

U.S. Ethanol Biorefinery Locations



The Upper Mississippi River Basin



Debate Concerning Benefits Continues

- Energy independence
- Carbon/GHG gains?
- Water quality/ environmental effects
  - how and where it is produced
  - Feedstock, corn? switchgrass?

Our Focus

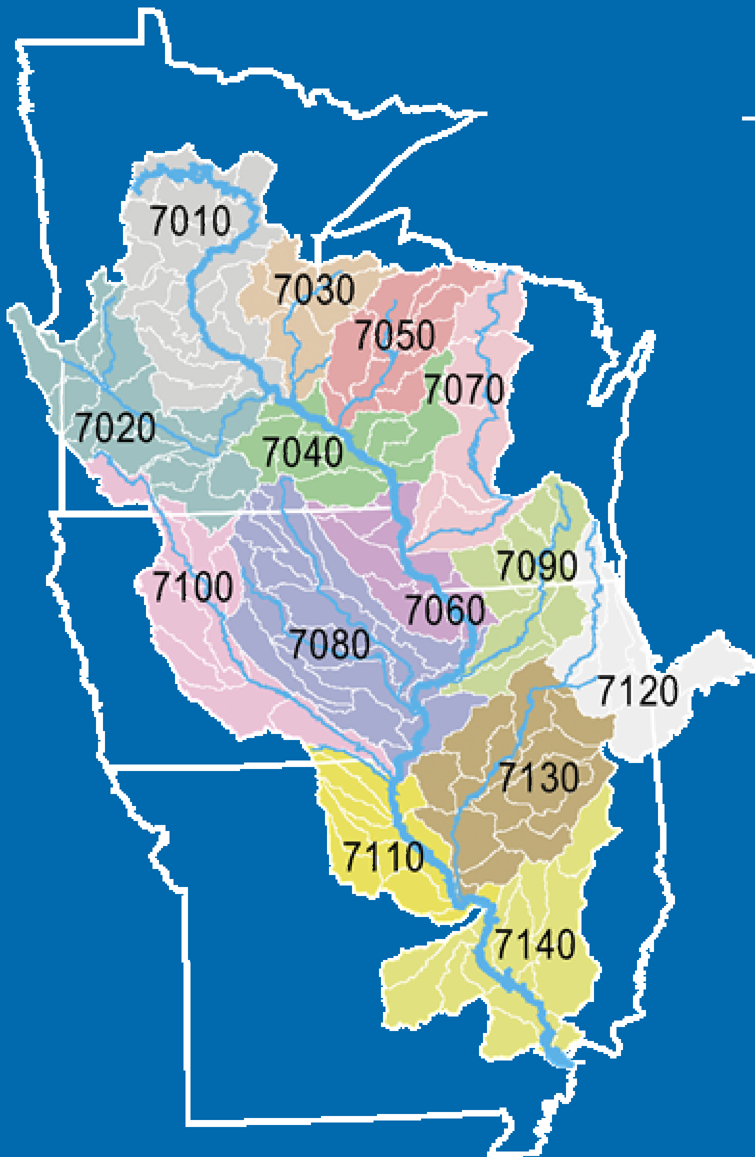
- Water quality consequences of corn ethanol vs ethanol from switchgrass

- Policy scenarios: If economic incentives were right to induce adoption of SG in the Upper Miss. River Basin:
  - Where might switchgrass be produced?
  - How much higher would returns to producing SG need to be to induce these changes?
  - What would the water quality consequences be?

Our Approach

- **Combine:**
  - Economic decision making models (highest profit opportunities) with,
  - Watershed based water quality model (SWAT).
- **To:**
  - Project how changes in economic drivers affect land use,
  - Water quality.
- **Examine:**
  - Sensitivity to switchgrass profitability (subsidy) assumptions
  - Sensitivity to targetting (place only highly erodible lands)
  - Sensitivity to baseline land use.

Watershed Schematic



	# of NRI points	# HRUs	Area km^2	% cropped
7010	8954	139	51,266	20.61
7020	7797	373	43,557	72.02
7030	4113	27	19,950	12.84
7040	6495	119	27,743	45.41
7050	3847	52	24,606	19.11
7060	5930	105	22,124	53.35
7070	5141	49	30,797	21.84
7080	14965	495	59,021	72.71
7090	7167	183	28,168	67.93
7100	8375	283	37,189	70.09
7110	5883	118	25,895	49.19
7120	7661	151	28,045	59.74
7130	9745	433	46,163	74.45
7140	7776	203	43,947	38.75
Total		2,730	488,471	51.04

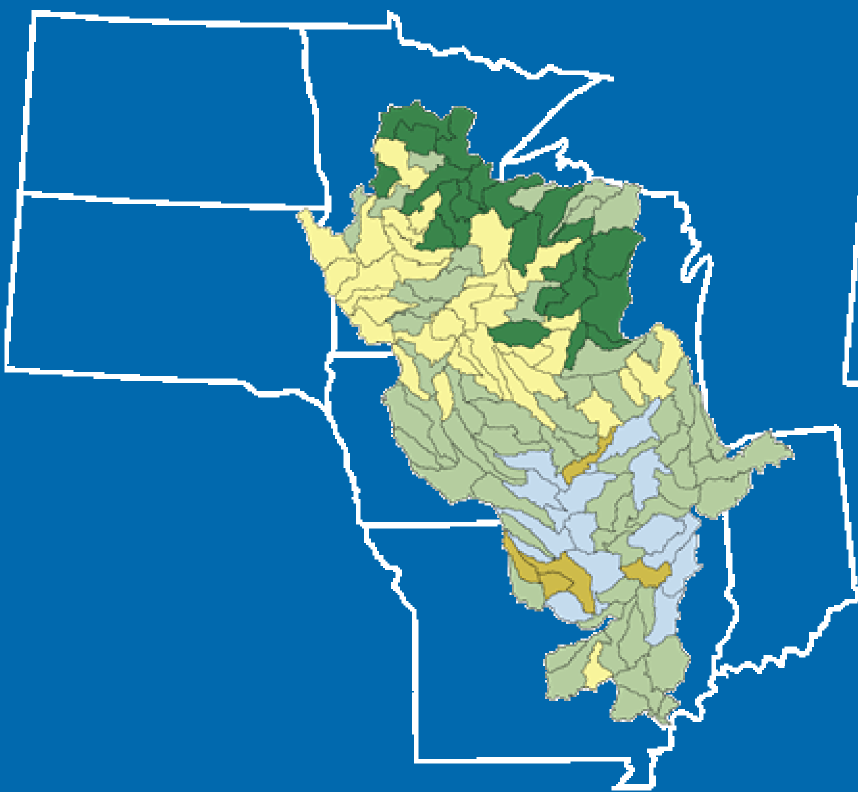
Some Specifics

- Baseline land use data we have is 1997 NRI, but fundamentally different price regime exists now
- Use current prices and revised tillage assumptions to predict crop placement to represent “current baseline”
- Switch grass scenarios: Place switchgrass on landscape where it is most profitable (assuming various SG payments)
- Examine sensitivity to fertilization rates for commercially growing switch grass: “low” vs. “high”

Switchgrass Data and Assumptions

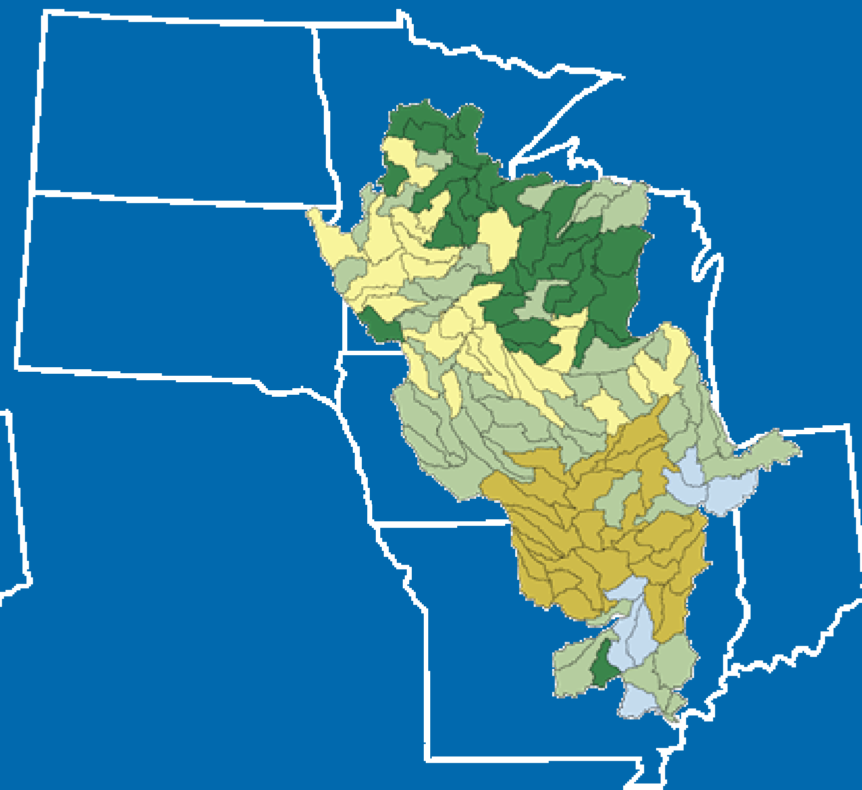
- Cost of SG per metric ton - given a yield of 15.38 tons/ha is $34.6 (based on M. Duffy's budgets- ISU)
- Average SG yields for UMRB = 9.74 tons/ha, of land chosen in most profitable scenario = 15.38 tons/ha
- Assume, no storage or transportation costs for farmers
- Alamo variety (parameters adjusted for Iowa performance) used everywhere with same management
- Two fertilization rates = 157 kg/ha and 100 kg/ha (Heggenstaller, (ISU Agronomy))

Switchgrass Fertilization



Net returns with N 100 kg/ha

- -635 - -471
- -471 - -328
- -328 - 0
- 0 - 44
- 44 - 166



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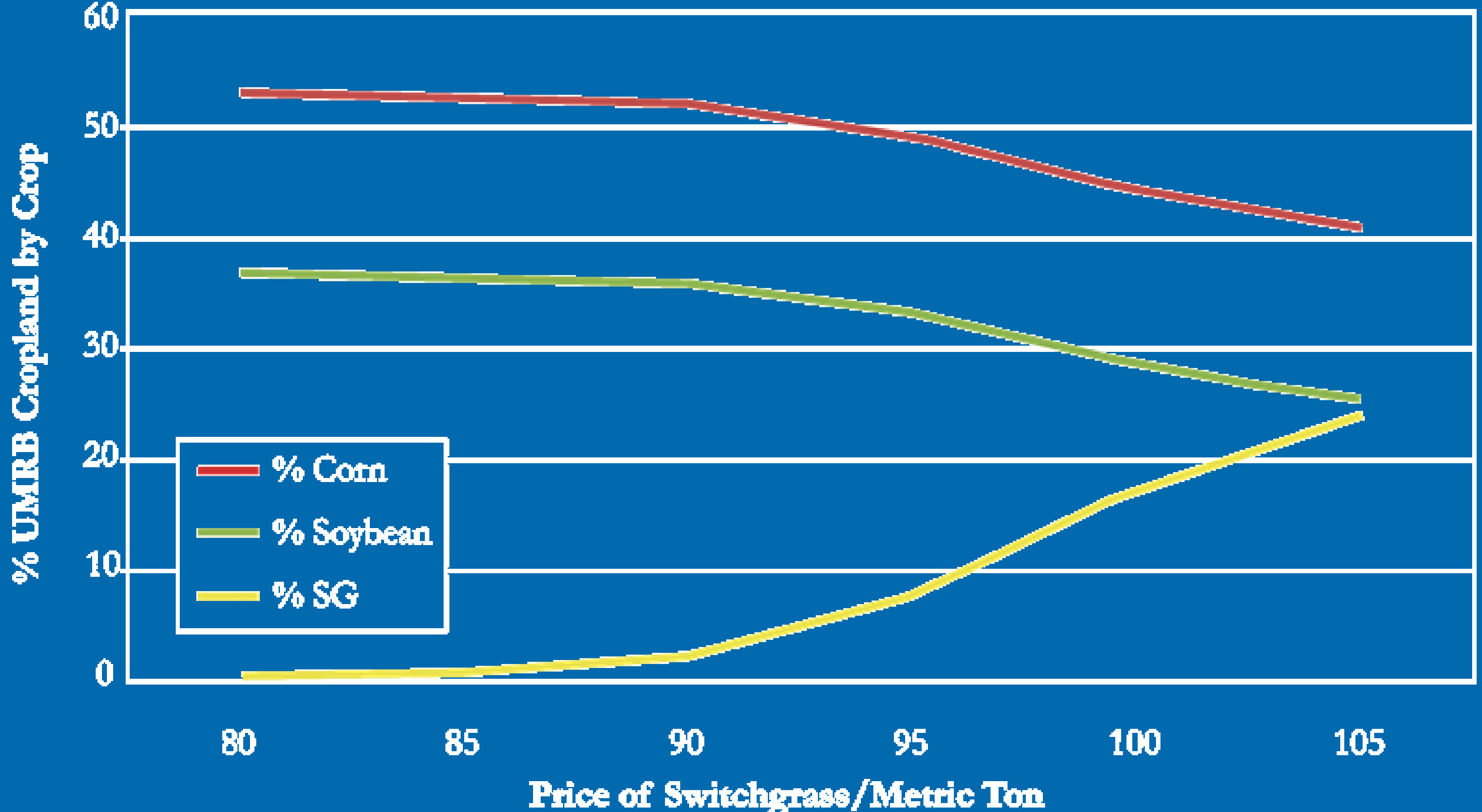
Acreage Responses to Switchgrass Prices/Metric Ton



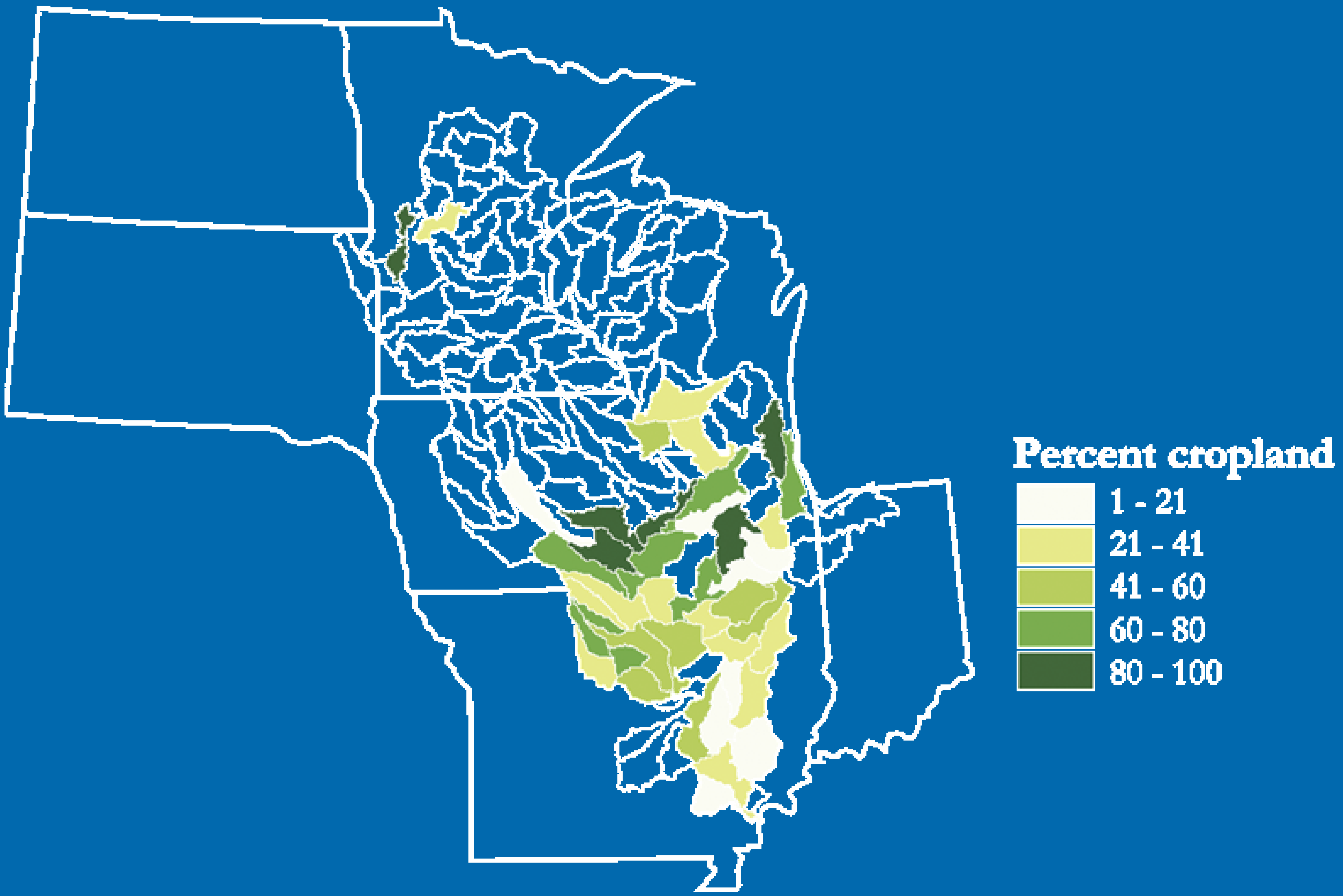
Land Use Projected

	Current Baseline**	Switchgrass Scenario ($100/ton)
Continuous Corn	20,000	20,000
Corn, Soybean	158,000	119,000
Corn, Corn, Soybean	29,000	26,000
Corn, Alfalfa	60,000	55,000
Switchgrass		46,000

*Other cropland and CRP total about 29,000 in the 1997 baseline, this land is allocated to cropland in the current baseline and/or switchgrass in the scenario

**Baseline projected using current corn prices and N fertilizer prices and current information on tillage (CTIC)

Switchgrass Locations Predicted at Payment of $100/ton



Implications for EISA 2007

- At $100/ ton UMRB could supply 70 million tons of switchgrass
- Assuming an ethanol conversion efficiency of 0.3 liters/kg, 26% of the 21 billion gallon cellulosic ethanol Energy Bill goal could be accomplished.
- The 25x25 (U Tenn.) study estimated switchgrass prices in the range of $ 44-88/metric ton; therefore to produce the switchgrass levels in our scenarios, subsidies would have to range from almost $800 million to over $4 billion.

Water Quality Predicted by SWAT at Grafton (exit of UMRB)

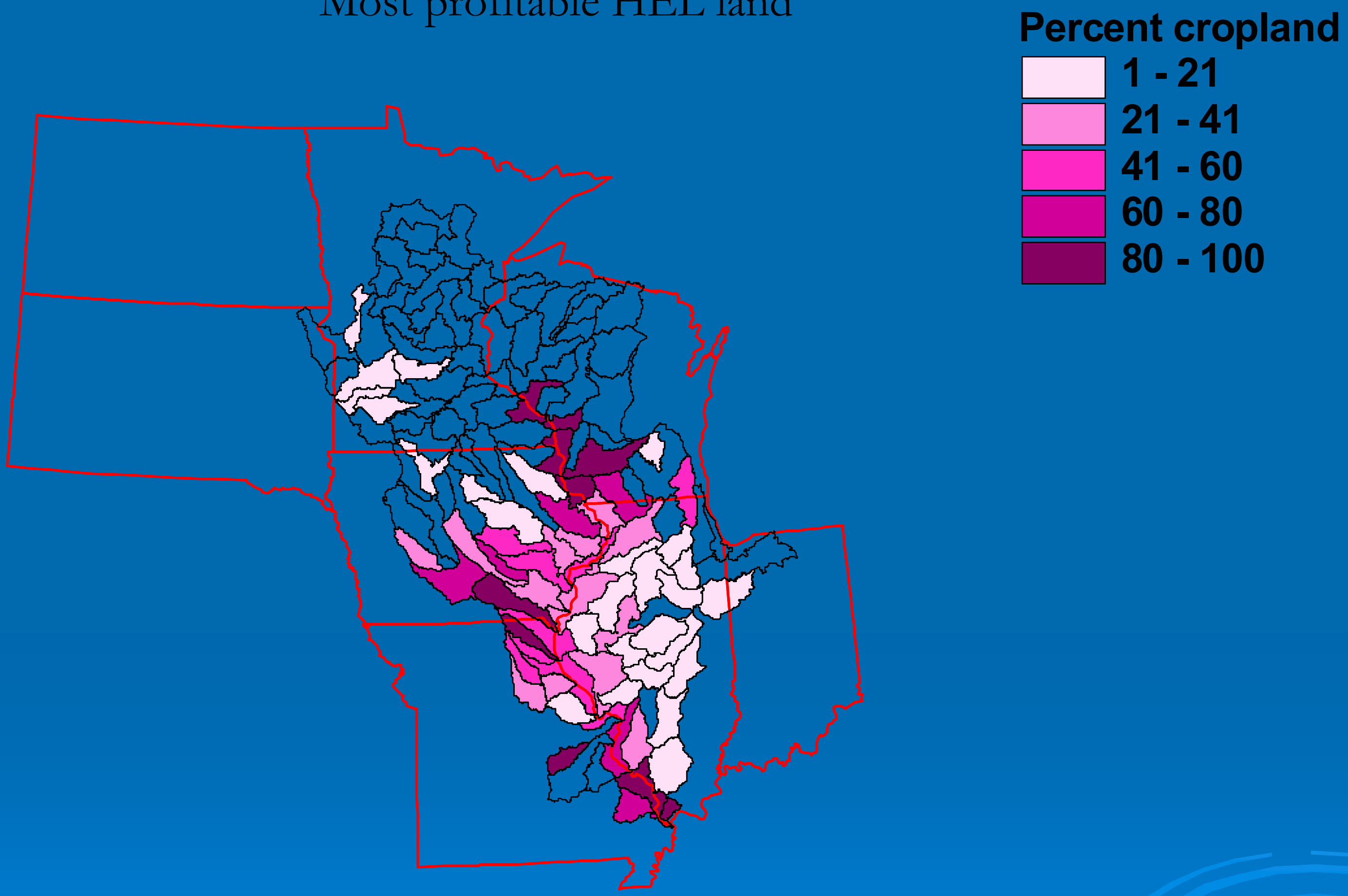
	Current Baseline	**Switchgrass Scenario**
Sediment (mmt)	22.5	17.8
Total N (million kgs)	390.4	384.6
Nitrate (million kgs)	369	366
Total Phosphorous (million kgs)	24.7	21.2

Can we have our cake and eat it too?

- Could we target conservation spending programs so that we place switchgrass in locations that are less profitable, but yield greater water quality benefits?
- Undertook scenarios that yielded the same SG acreage, but targeted
  - Highly erodible land (HEL)
  - Most profitable HEL , and
  - Highest yielding SG land

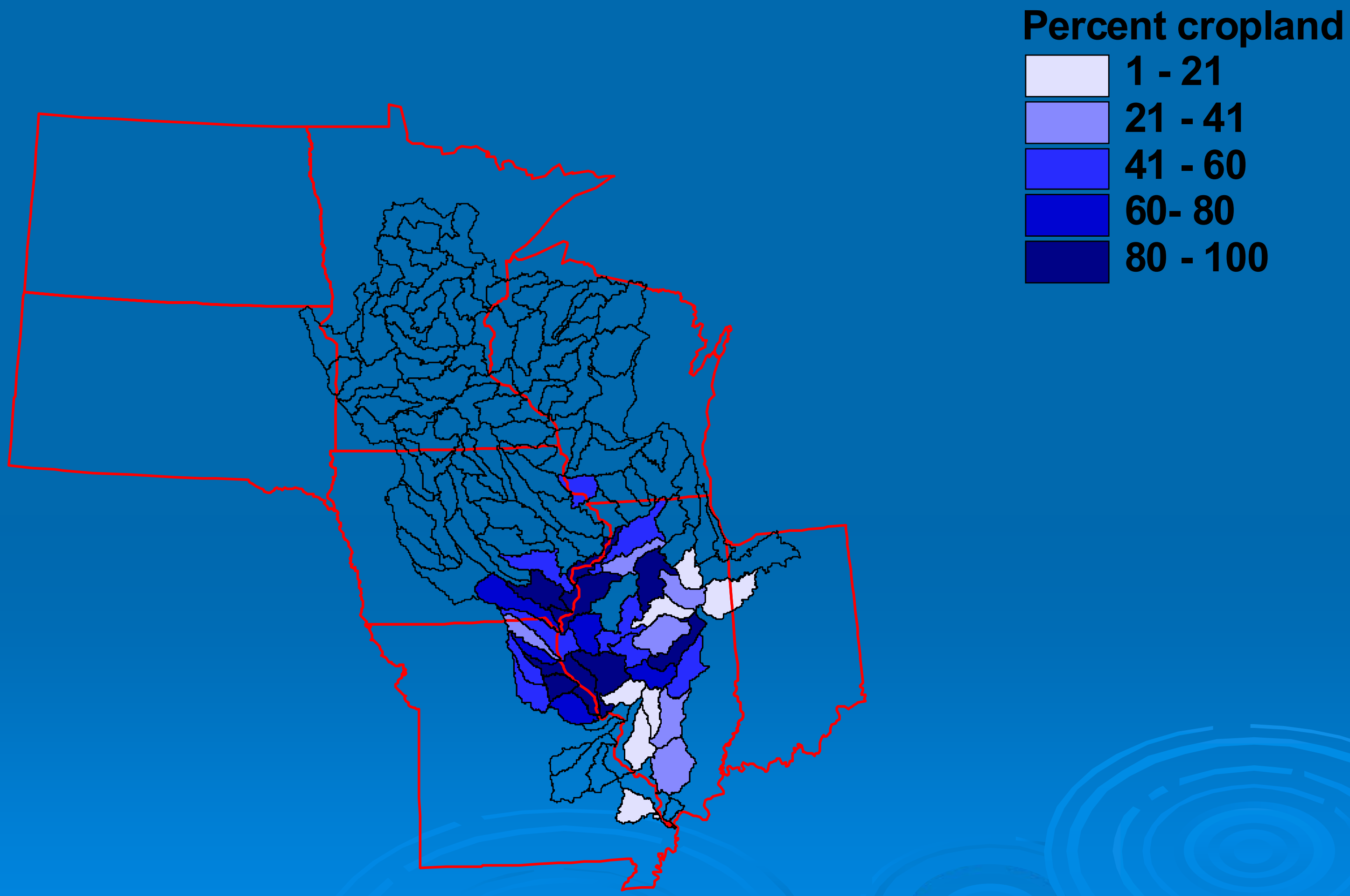
Switchgrass

Most profitable HEL land



Highest yield acreage

Switchgrass



Water Quality Predicted by SWAT at Grafton (exit of UMRB)

	SG Scenario	SG Scenario - yield
Sediment (mmt)	17.8	17.5
Total N (million kgs)	384.6	380.7
Nitrate (million kgs)	366	362.4
Total Phos. (million kgs)	21.2	21.1

- **Water quality improves (at base of UMRB)**
- **Switchgrass yield rises by ~2.6 million tons**
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- **Additional subsidies of about $1 billion required**
- **Water quality upstream may change more dramatically**

Take home messages?

- Much is unknown regarding development of markets for cellulosic feedstocks
  - Different feedstocks in different locations; woody biomass in northern UMRB, miscanthus and switchgrass elsewhere?
  - Transportation, technological progress huge unknowns
- Scenarios based on landscape scale modeling systems can help us understand consequences of alternative policies
- SG appears promising for biomass production, but needs subsidies and/or tech. advance to be large scale viable

Caveats (assumptions that might be particularly important in results)

- Analysis includes cropland in production in 1997 only (no CRP)
- Model under predicts corn yields (1997-2006)
  - Corn under estimated on average by 12%
  - Beans by 4.4%
- No yield drag for rotations
- Ignores risk premia farmers might require to plant new crop, if so understates costs
- Provides for no tech. advance, picture could change completely
- Climate change?... Etc.