Large-Scale Biofuel Water Quality and Water Resource Assessment for the U.S. Billion Ton Scenarios

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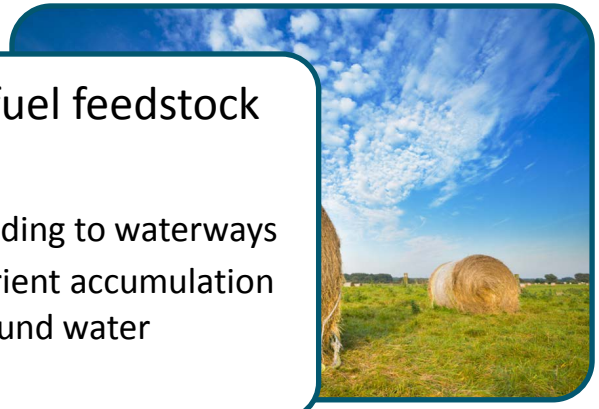
Water Quality and Quantity Impacts Must be Addressed at Regional Level



Large scale biofuel feedstock production

- Environmental loading to waterways
- Chemical and nutrient accumulation in surface and ground water

Compounding effect on water body

- Hypoxia zone expansion
- Aquatic ecosystem degradation

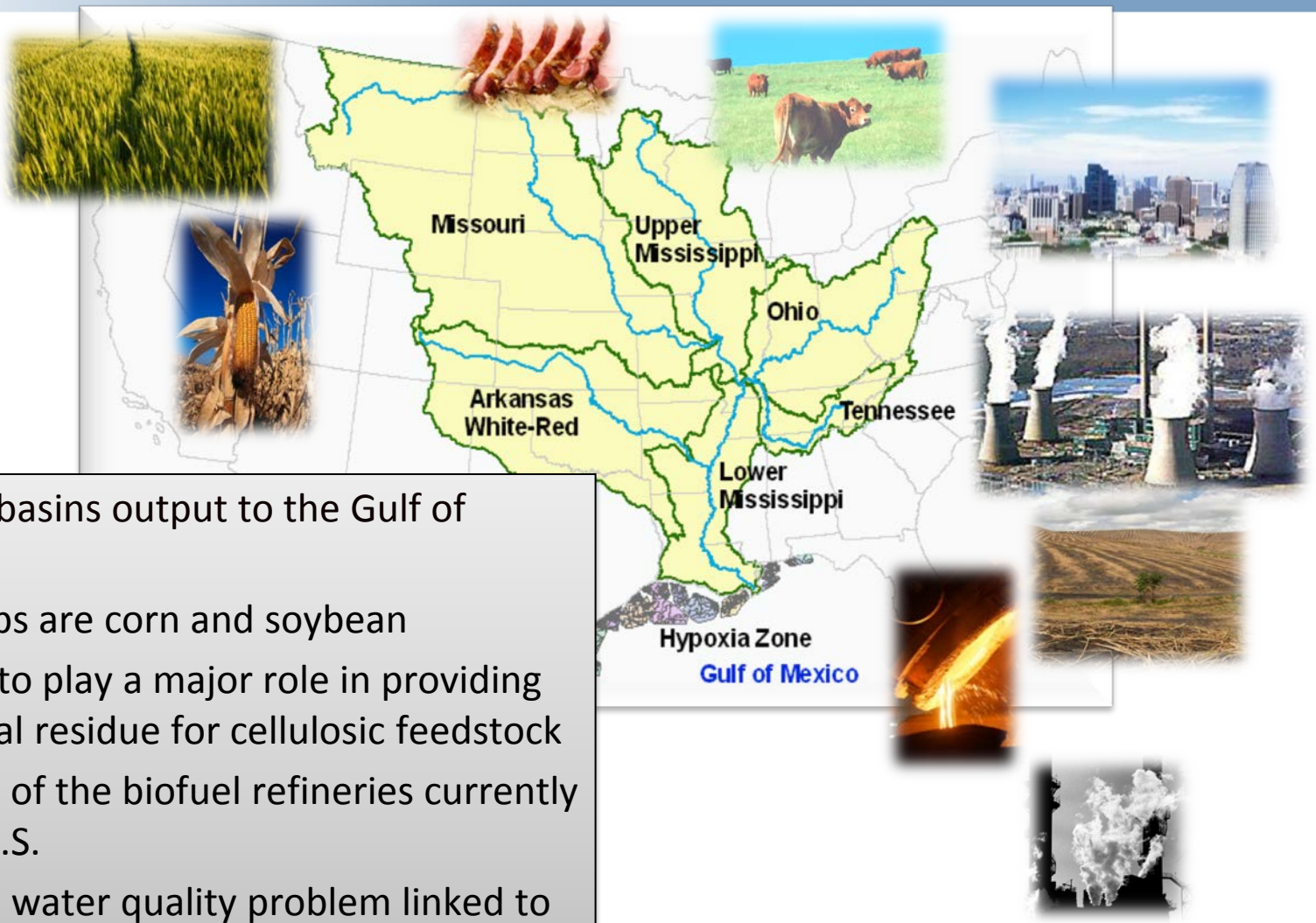
Competing water use from multiple sectors and projects

- Power
- Biofuel
- Agricultural
- Urban development



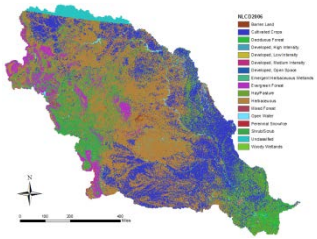


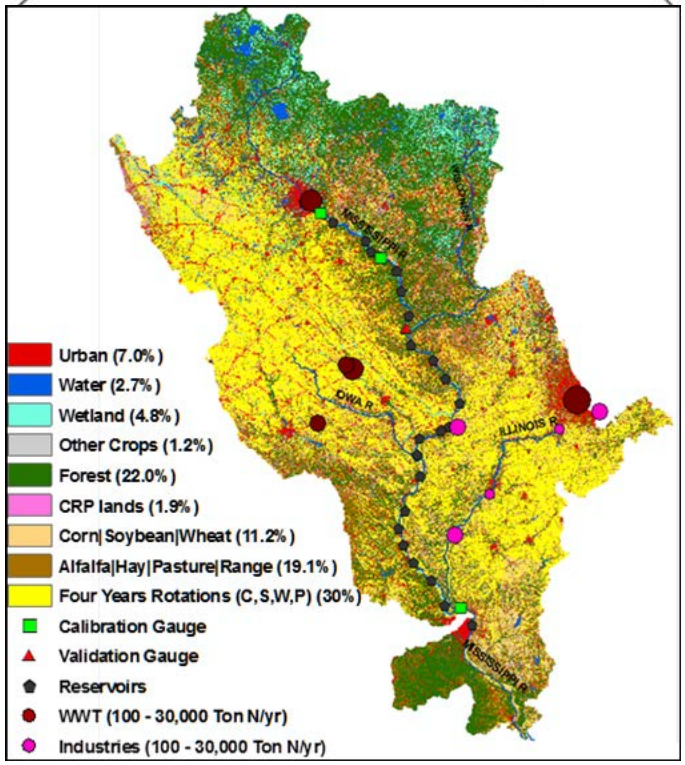

Great Mississippi River Basin: Multiple Inputs and Burdens



- Five tributary basins output to the Gulf of Mexico
- Dominant crops are corn and soybean
  - Expected to play a major role in providing agricultural residue for cellulosic feedstock
- Home for 90% of the biofuel refineries currently operating in U.S.
- Severe stream water quality problem linked to hypoxia problem in Gulf of Mexico

Watershed Modeling for Mississippi River Basin

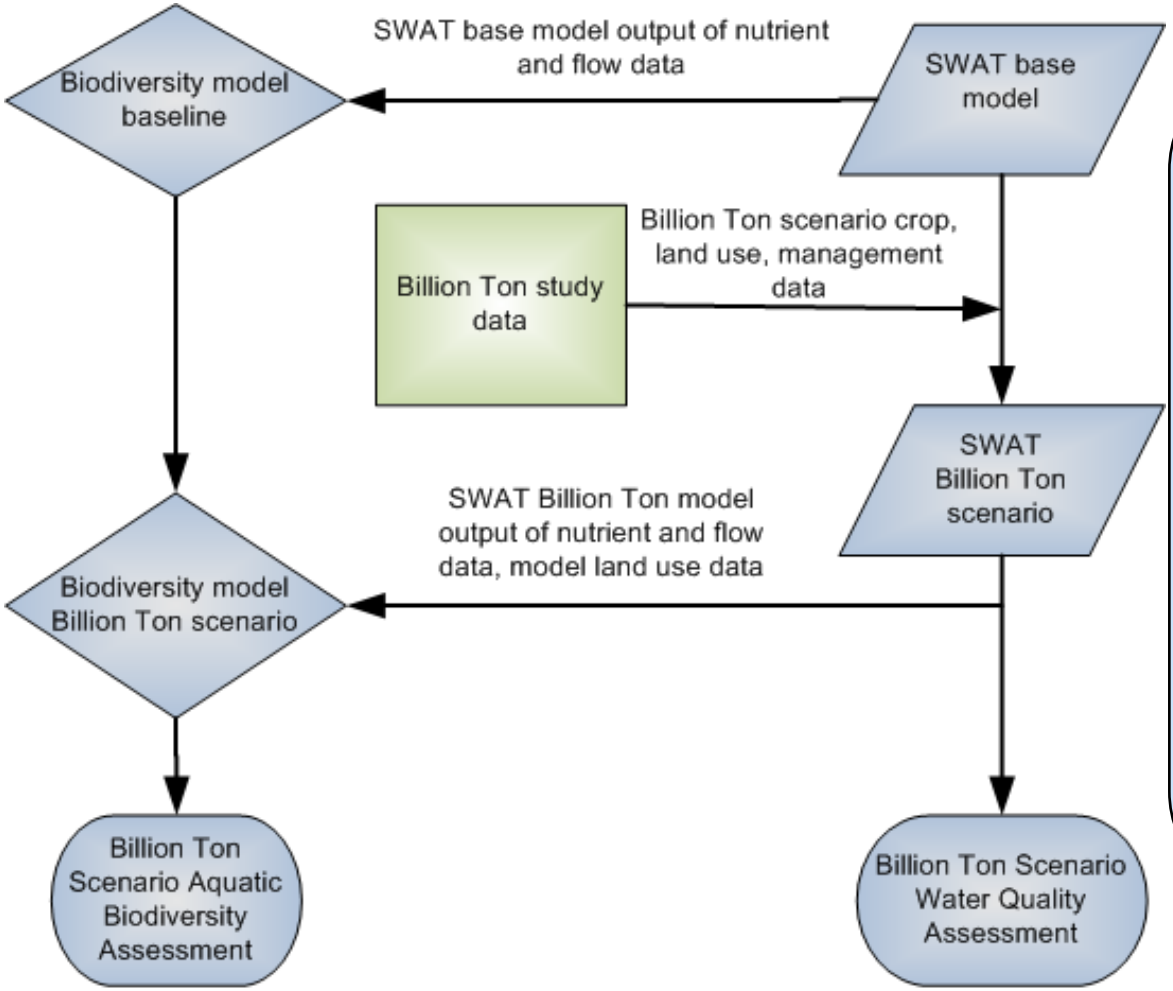


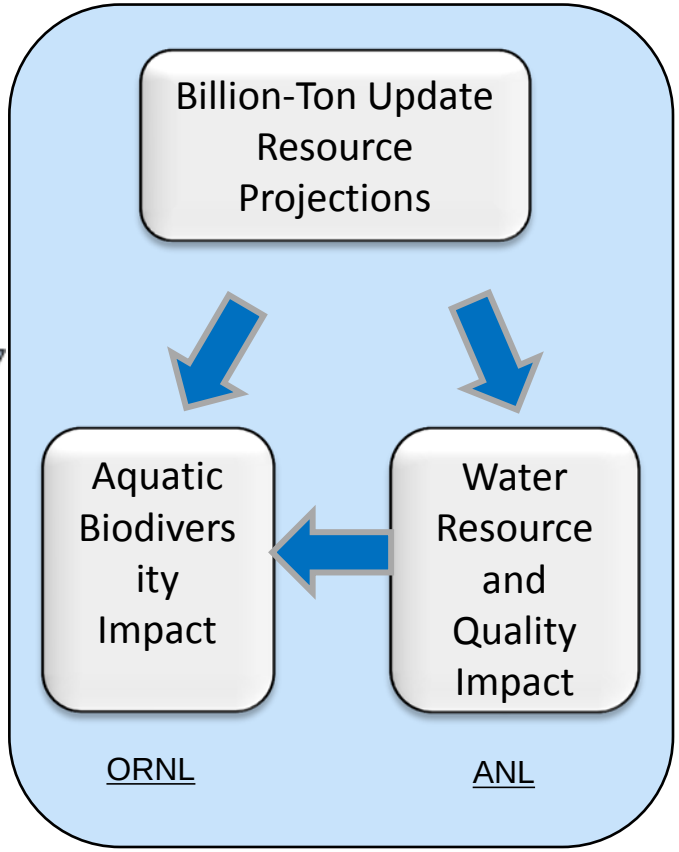


- Advance understanding of the relation of increased feedstock production to natural processes that affect spatial variations in
  - ***Water quality***
  - ***Water resource availability***
- Assist in a variety of management decisions and protection strategies to meet regulatory limit and sustainability criteria

U.S. DEPARTMENT OF ENERGY

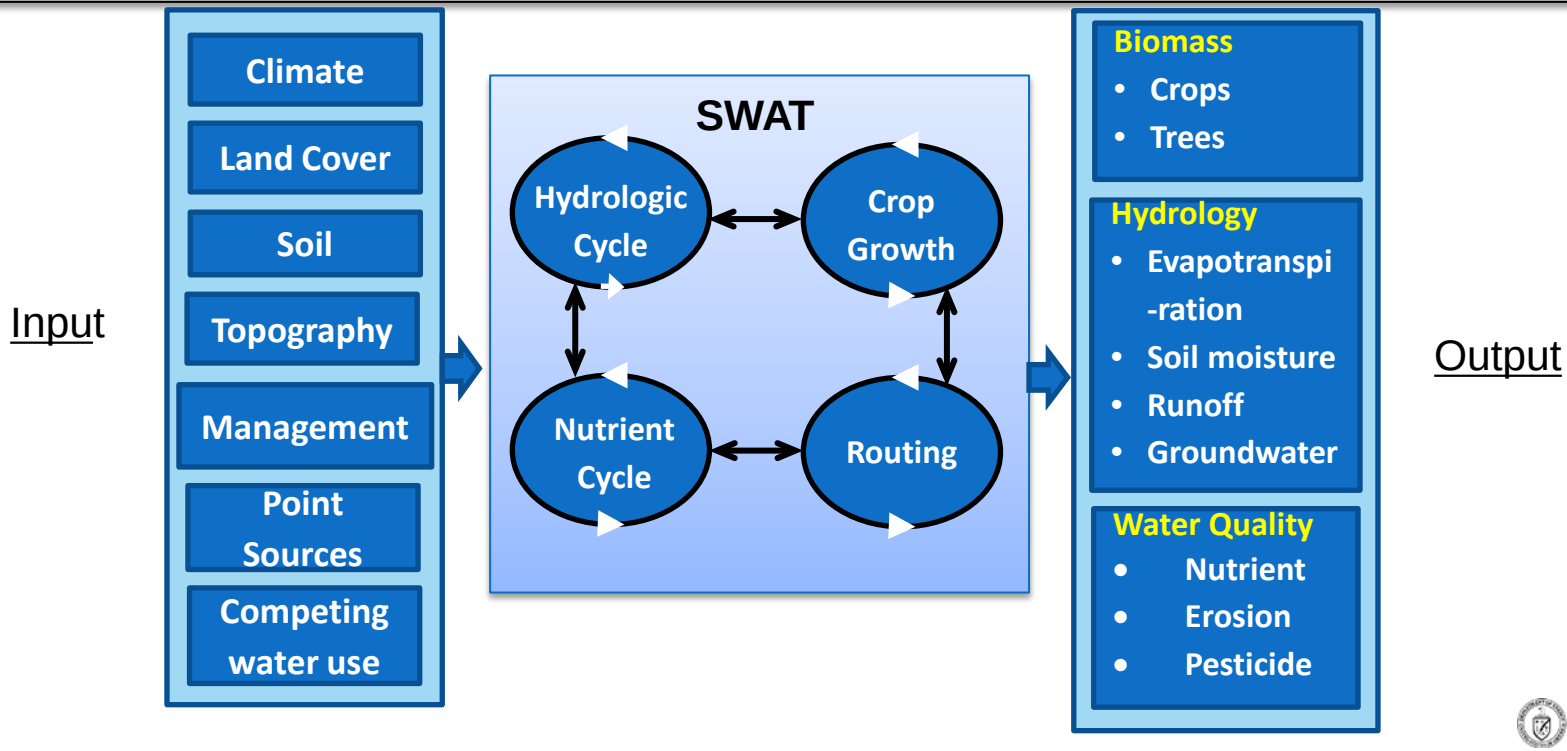
ANL-ORNL Integrated Analysis





SWAT Model (Soil Water Assessment Tool)

- Open-access, multi-scale hydrologic model coupled with crop growth and agricultural management processes
- Feature spatial and temporal distributions of soil, land use and hydrologic elements
- Simulate watershed scale water quality (contaminant, sediment, nitrogen, phosphorus) and project response to future scenarios including land use change, increased production, and climate change

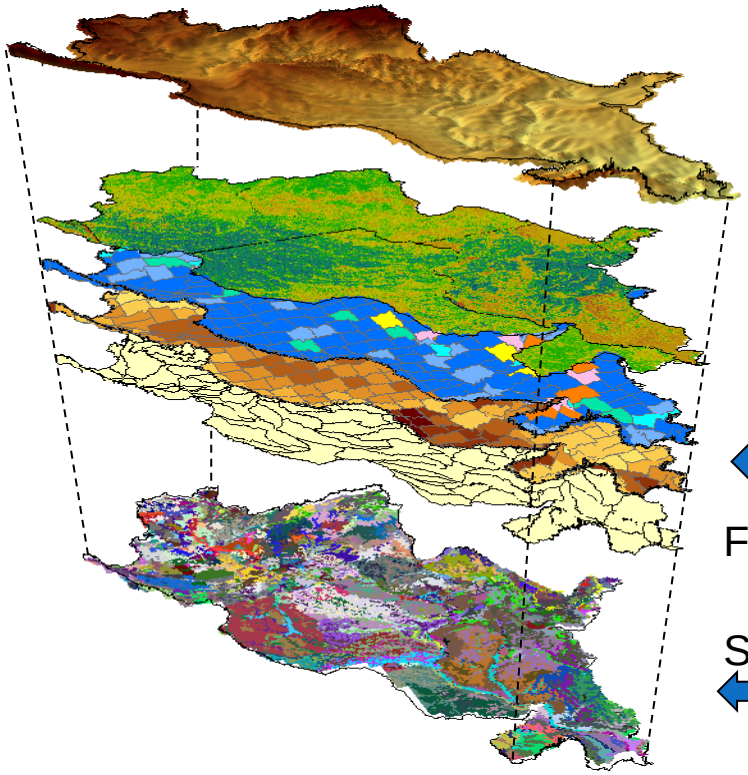


Developed A SWAT Base Model for Upper Mississippi River Basin

Ground surface topography

Water use

Sub basin



Land use, crop rotation

Fertilizer

Soil type

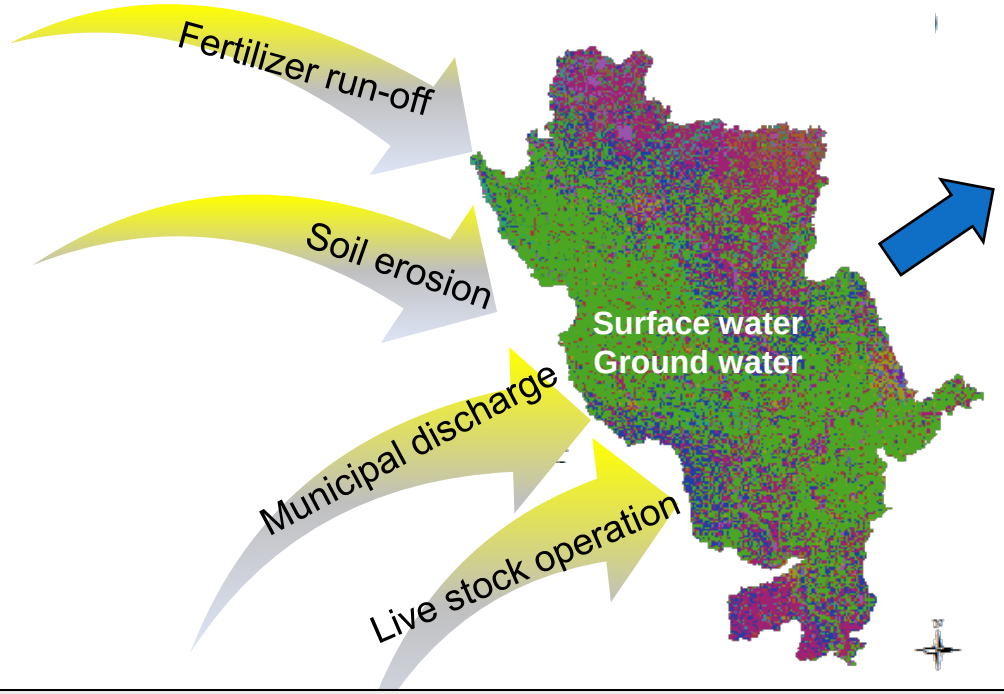
Others:

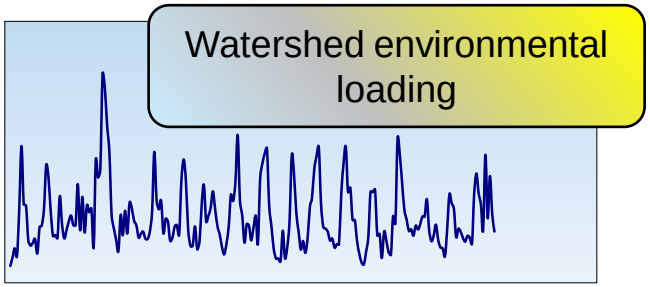
- Climate
- Tile drainage
- Tillage
- Irrigation
- Point source
- Reservoirs

The UMRB SWAT base model water quality results provide a baseline for aquatic biodiversity modeling at ORNL

- 20 year climate hydrologic data downscaling
- Four-yr. crop rotations based on CDL: total 16 combinations
- Calibrated flow, nitrogen, phosphorus, sediment for 17 yrs. Validated for three yrs.
- Corn and soybean yield calibration
- Crop land validation.

Implement Billion Ton Scenario to the UMRB SWAT Model





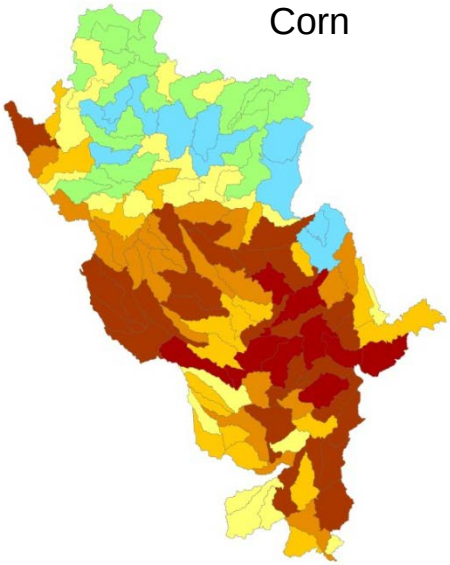
- Converted county data to HUC-8 digit sub basins
- Incorporated land use change projected by the BT2 scenario from 2009 to 2022 to each of 131 sub basins
- Applied land balance for each sub basin each year
- Developed fertilizer application rate based on historical trend, NUE improvement, and BAU.

Billion Ton Update

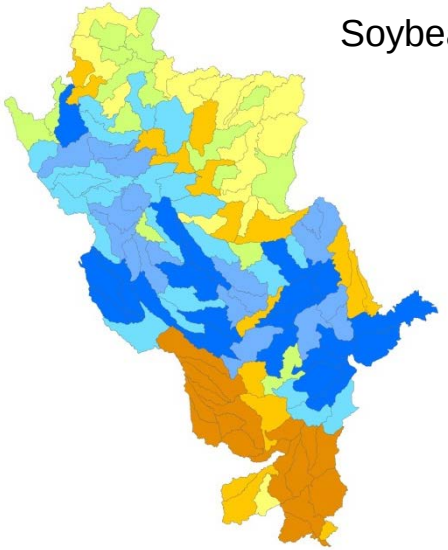
- USDA baseline scenario
- 1% yield increase for corn per year from 2009 to 2030
- Partial corn stover harvest
- Significant land management changes
- Limited SWG production and forest wood residue harvest – not included in this simulation

Billion Ton Scenario: USDA Baseline Major Crop Acreage

Corn



Soybean



Land Area Change

Corn by 2022 (acres)

- -77,147 - -15,000
- -14,999 - 0
- 1 - 15,000
- 15,001 - 30,000
- 30,001 - 60,000
- 60,001 - 90,000
- 90,001 - 142,671

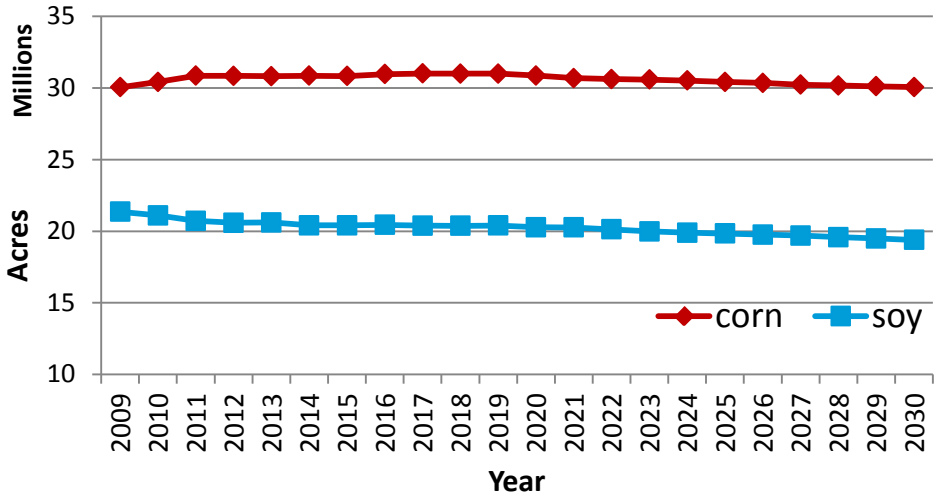
Land Area Change

Soybean by 2022 (acres)

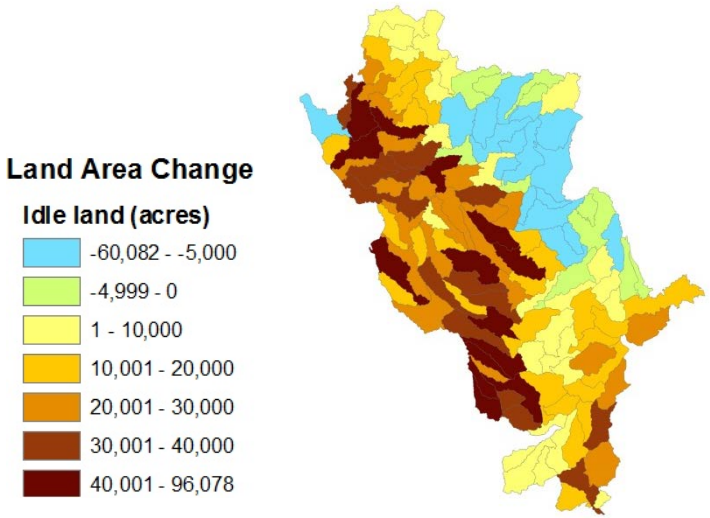
- -112,965 - -50,000
- -49,999 - -30,000
- -29,999 - -10,000
- -9,999 - 0
- 1 - 5,000
- 5,001 - 30,000
- 30,001 - 97,484

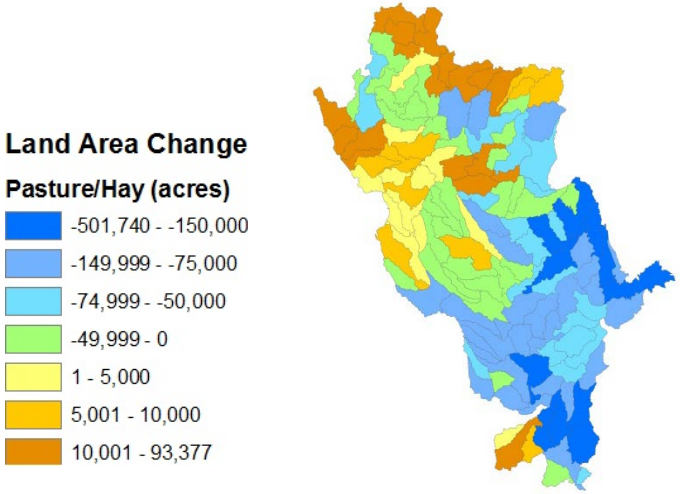
Corn and Soybean acreage change from 2006 to 2022

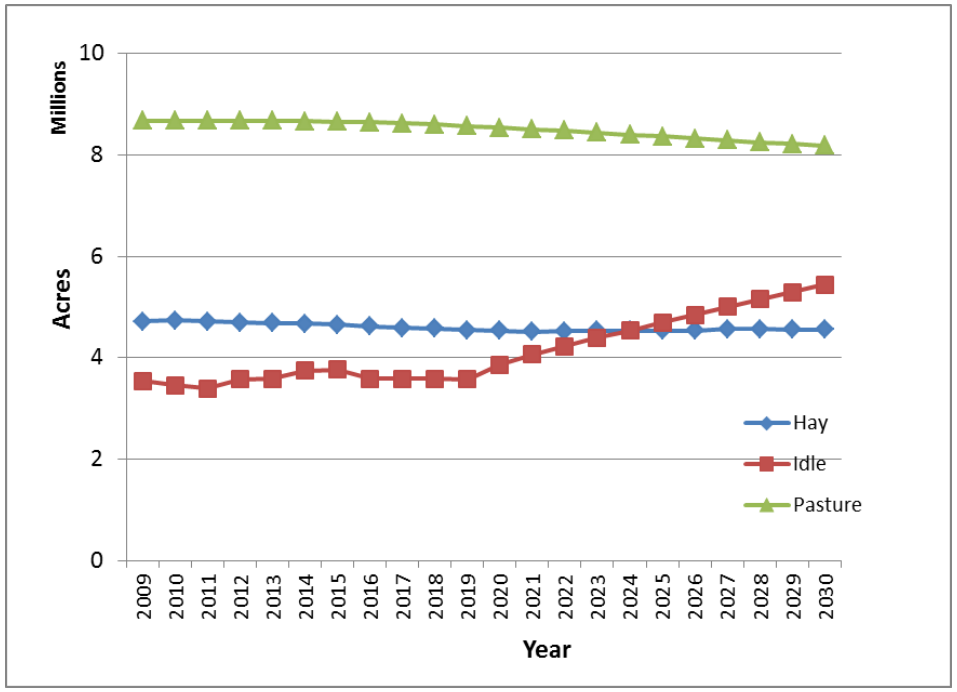
- Central sub basins experience large increase in corn and decrease in soybean.
- Corn acreage reaches peak at 2015 then declines slightly
- Corn: 3.8 million acre increase
- Soybean: 1.2 million acre decrease



Billion Ton Scenario: USDA Baseline Idle, Hay, and Pasture Land



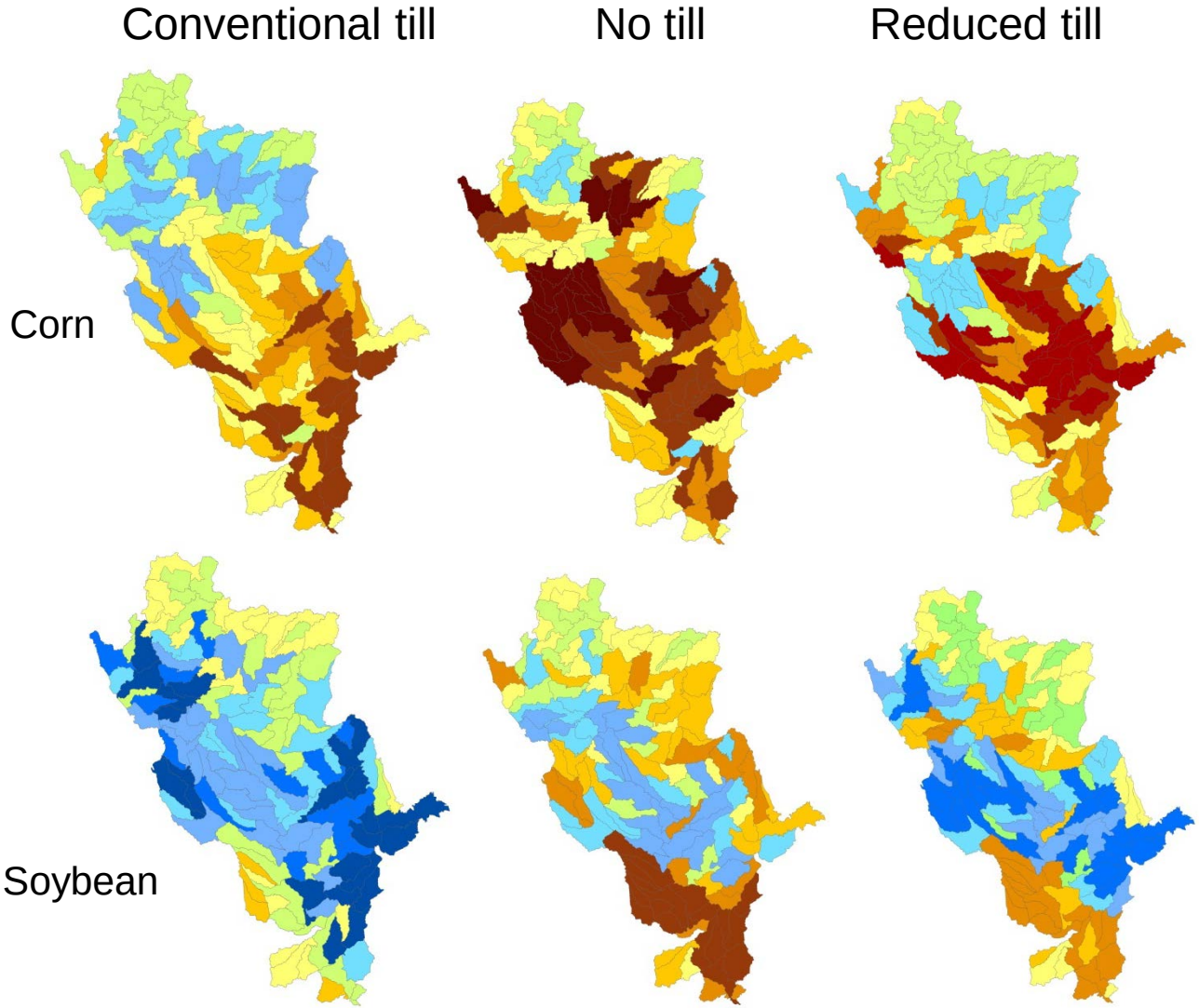




Change from 2006 to 2022

- 1.5 million acre increase in idle land.
- 4.8 million decrease in pasture and hay.

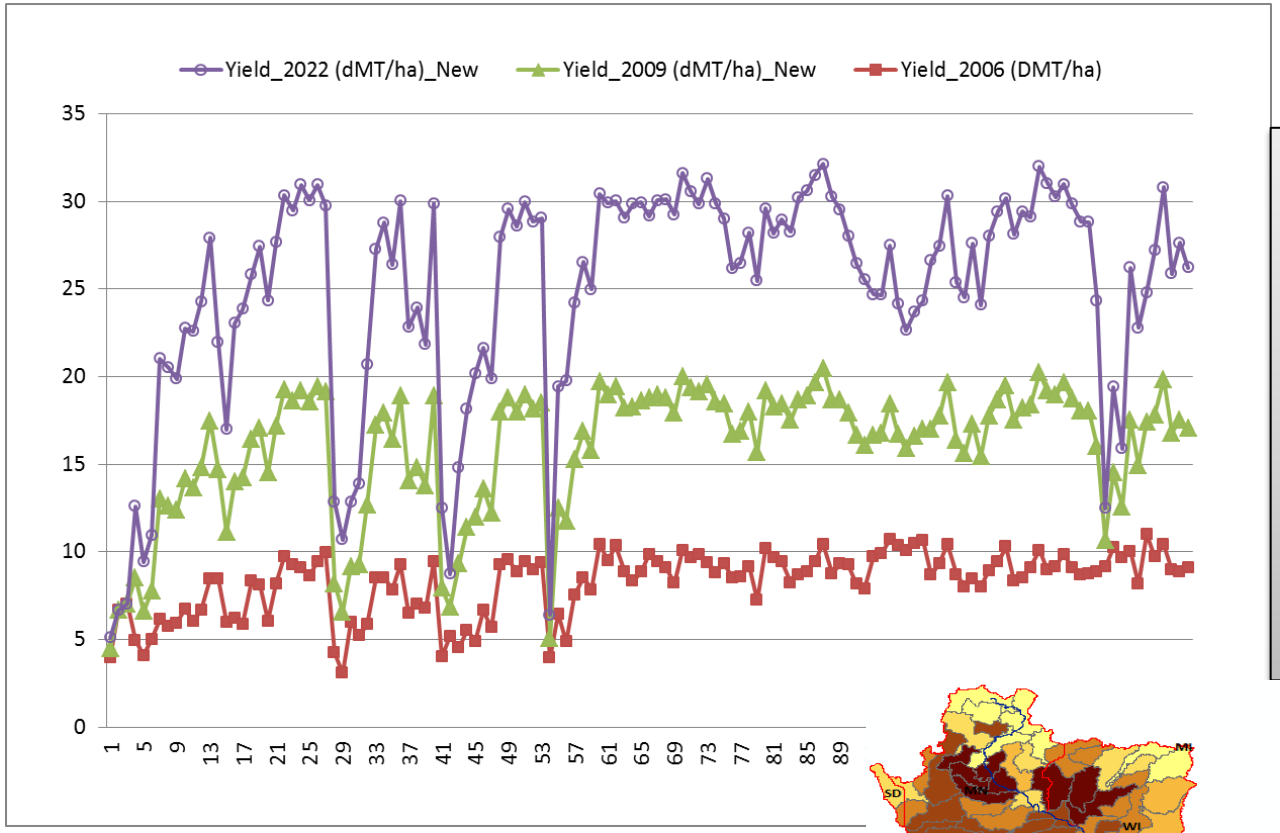
Billion Ton Scenario: USDA Baseline: Land Management



Change from 2006-2022 (Corn and soybean)

- No till increases 3.9 million acres
- Conventional and reduced till decrease 1.3 million acres

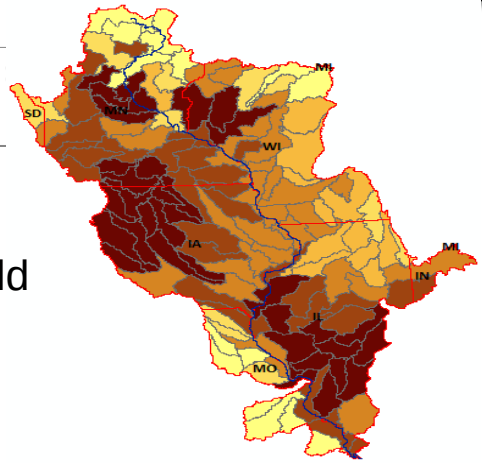
Billion Ton Scenario: USDA Baseline Corn Yield



Corn yield

- Similar trend with significant variations
- Several sub basins may experience large reductions
- Land conversion occurs in low productivity land

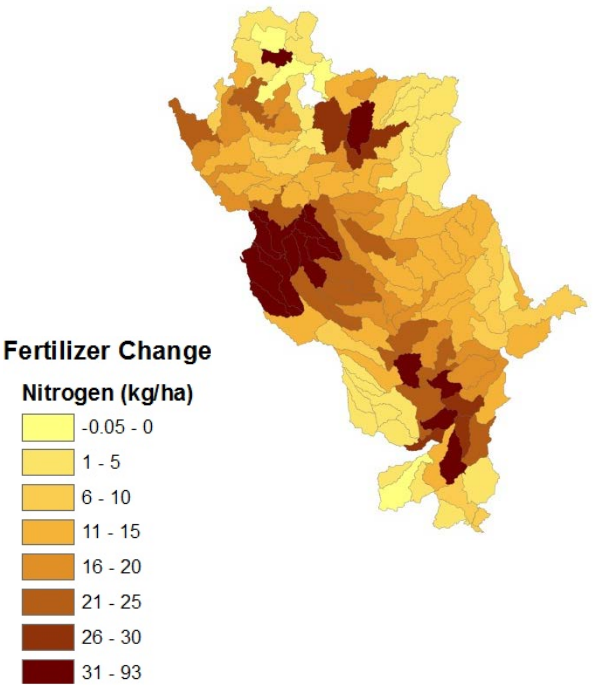
Change in corn yield from 2006 to 2022



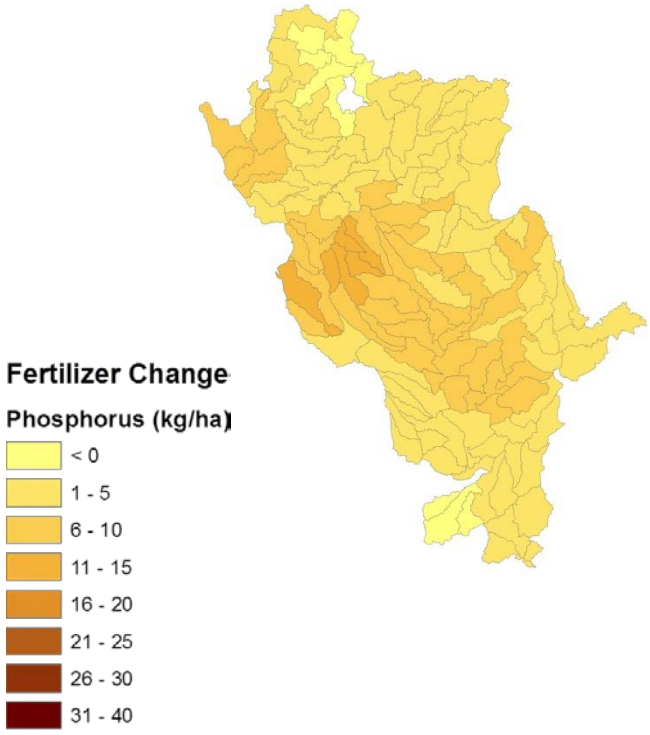
Billion Ton Scenario: USDA Baseline Fertilizer Input

Change from 2006 to 2022

Nitrogen

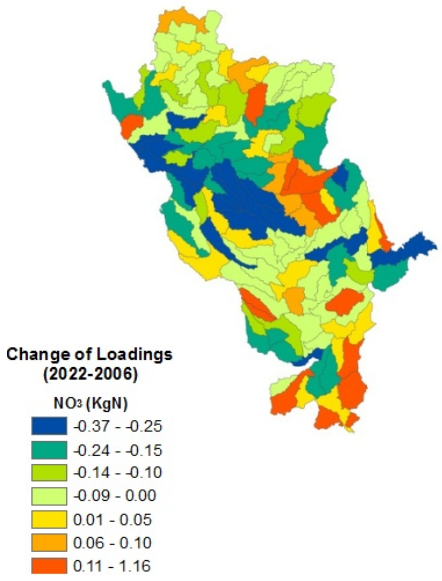


Phosphorus

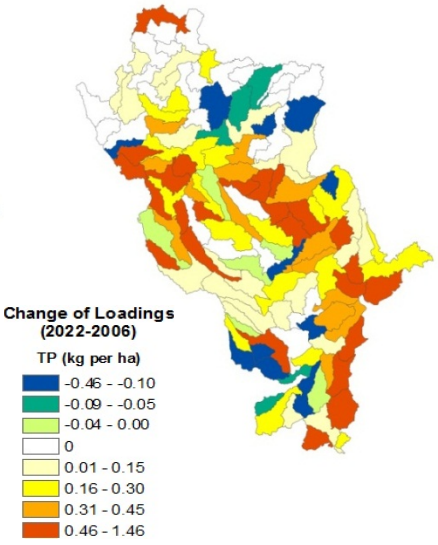


Water Quality and Quantity Changes under the Selected Billion Ton Scenario

Nitrate



Phosphorus



Nitrogen, Phosphorus ↓↑

Sediment ↑↓ Flow ↓

Evapotranspiration ↑

Soil moisture content ↓

Concluding Remarks and Outstanding Issues

- Results mixed for the USDA baseline scenario of billion ton assessment at UMRB
  - Land management plays a key role in water quality
  - Converting low productivity land from corn to idle land appears beneficial
- Further analysis is on-going to refine the model and assumptions
  - NUE assumption
  - Modeling improvement
- Impact assessment: what level of change is acceptable?

Thank you

Acknowledgement

Alison Goss Eng DOE EERE Office of Biomass Program

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