Impact of Rapid Land-Use Change in the Northern Great Plains: Integrated Modeling of Land-Use Patterns, Biophysical Responses, Sustainability, and Economic and Environmental Consequences
Objective:
Given two major drivers in the Northern Great Plains, **climate change** and production of **biomass for energy**, model alternative landscape trajectories to test whether land-use patterns driven largely by economic considerations are sustainable.
Team:
USGS Earth Resources Observation and Science (EROS) Center
Shuguang Liu (biogeochemical and hydrologic modeling)
Terry Sohl (landscape forecasting)
Alisa Gallant (landscape forecasting, risk analysis for wildlife)

University of Minnesota
Stephen Polasky (environmental economics)

USGS Northern Prairie Wildlife Research Center
Chip Euliss (ecosystem services, wildlife habitat)
David Mushet (wildlife habitat)

USGS Upper Midwest Environmental Science Center
Walt Sadinski (wildlife habitat)

PLUS – a large extended family
Alternative biofuels

“First generation” biofuels: food-based biofuels that are currently commercially available:
  – Corn-grain ethanol
  – Soybean biodiesel
  – Sugar cane ethanol
  – Palm oil biodiesel

“Second generation” biofuels: cellulosic biofuels
  – Switchgrass
  – Diverse prairie biomass
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Forecasting alternative landscapes

**A** Climate change scenarios
- Climate
- Soils
- Terrain
- Other factors

**B** Economic & policy drivers
- Land-use history

**C** Land cover
- Climate
- Soils
- Terrain
- Other factors

**D** Regional flux tower data extrapolation
- Fertilizer database

**E** Crop yield
- Estimated biomass
- Est. greenhouse gas emissions
- Biogeochemical assessments
- Estimated erosion rates
- Estimated nutrient input to surface/groundwater
- Wildlife habitat

**F** Ag. profitability
- Energy budget
- Climate-change pollutants
- Ecosystem quality and sustainability
  - Total C account
  - Soil productivity
  - Air quality
  - Water quality
  - Habitat

**Input data/info.**
- Models
- Outputs
- Env./econ. assessment

**Models**
- BASINS distributed hydrologic analysis system
- GEMS

**Output data**
- Production costs
- Crop prices

**Refined NLCD (base landscape)**
- Refined land-use history data
Forecasting alternative landscapes

- **A1b**: “business as usual”
- **A2**: IPCC high-change scenario
- **B1**: IPCC low-change scenario

**Environmental**

- Climate change scenarios
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- Other factors

**Economic & policy drivers**

- Land-use history
- Crop prices
- Production costs
- Ecosystem quality and sustainability

**Total C account**

- Soil productivity
- Air quality
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- A1b: “business as usual”
- A2: IPCC high-change scenario
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Forecasting alternative landscapes

**Basis for prescription (incentive) for annual land-use change**
- External demand
- External prices
- Estimated supply

**Query landscape capability to respond to demand**
Example ingredients used by FORE-SCE

- IPCC climate change predictions
- Policy/program requirements and incentives
- Contemporary land-conversion characteristics

**Modified 1992 NLCD**
- Soils - STATSGO
- Proximity to Transportation
- Population Data

**Climate Data (DAYMET)**
- County-based Socioeconomic Data
- Agricultural Census
- Distance to Urban Centers
FORE-SCE

Regression-based probability surfaces developed for each land-cover type
Forecasting alternative landscapes

- Demand module
- Fore-SCE
- Spatial allocation module
- BASINS distributed hydrologic analysis system
- Annual landscape information

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Soils
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Other factors

USGS
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-USGS-
Services through time

- Water Quality
  - Relative Ann. Discharge
  - Dissolved Phosphorus

- Potential Soil Conservation
  - Rate of Soil Erosion in
  - Metric Tons

- Carbon Sequestration
  - Metric Tons

- Biodiversity
  - Countryside SAR

- Storm Peak Management
  - Unitless

- Market Value
  - Constant Year
  - 2008 Dollars

Legend:
- **Plan Trend**
- **Development**
- **Conservation**
The model predicts that this catchment provided adequate habitat in 1991 to support 1 breeding pair of blue-winged teal.

The model graphs actual precipitation and estimates associated water level and evapotranspiration for the selected catchment for a specified time interval.
Future Midwestern Landscapes
U.S. EPA

- Improve society’s ability to incorporate ecosystem services into decision-making
- Address concerns about biofuels
- Facilitate development of ecosystem service markets
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