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

U.S. Department of the Interior
U.S. Geological Survey

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.

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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

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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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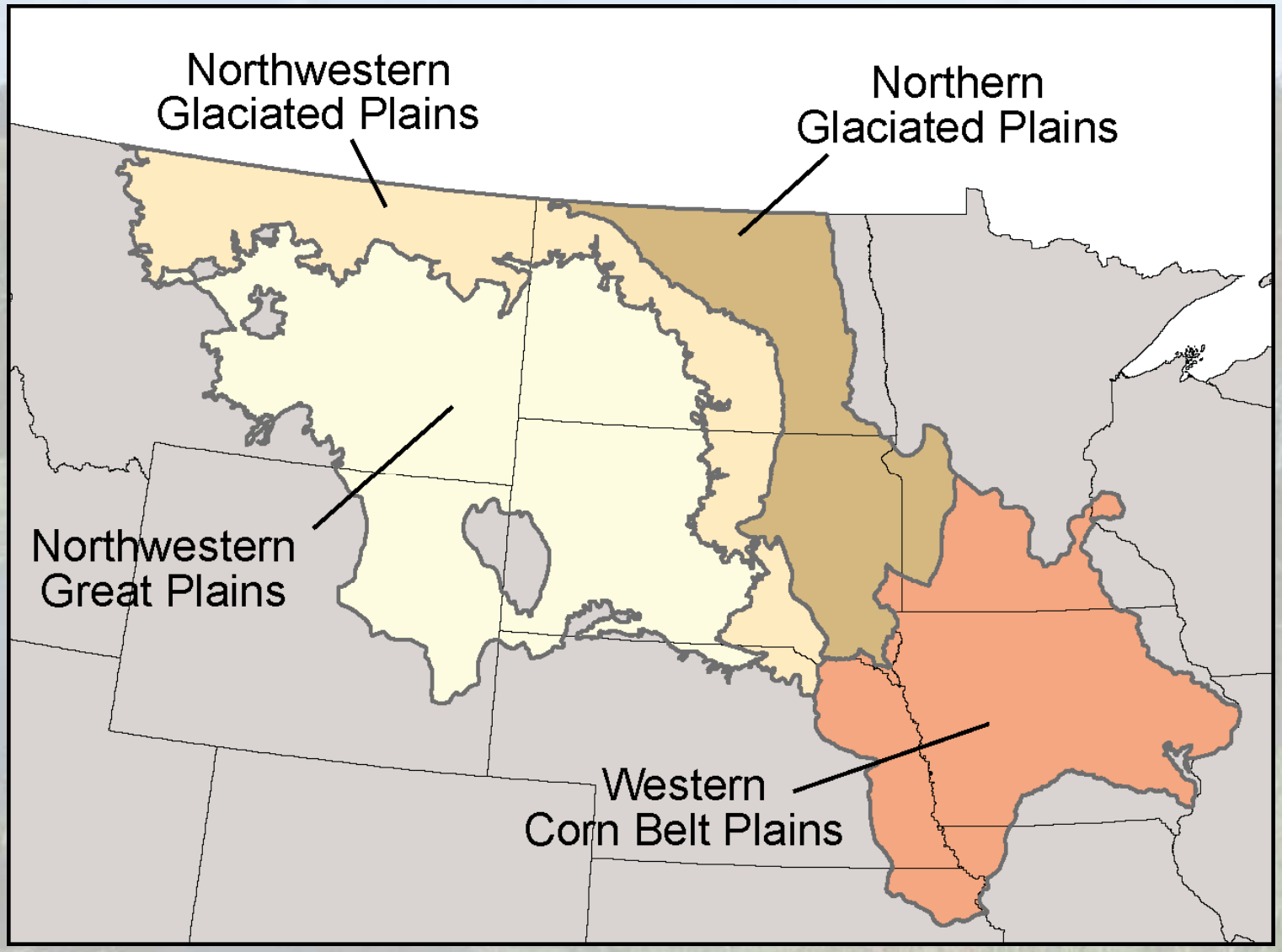
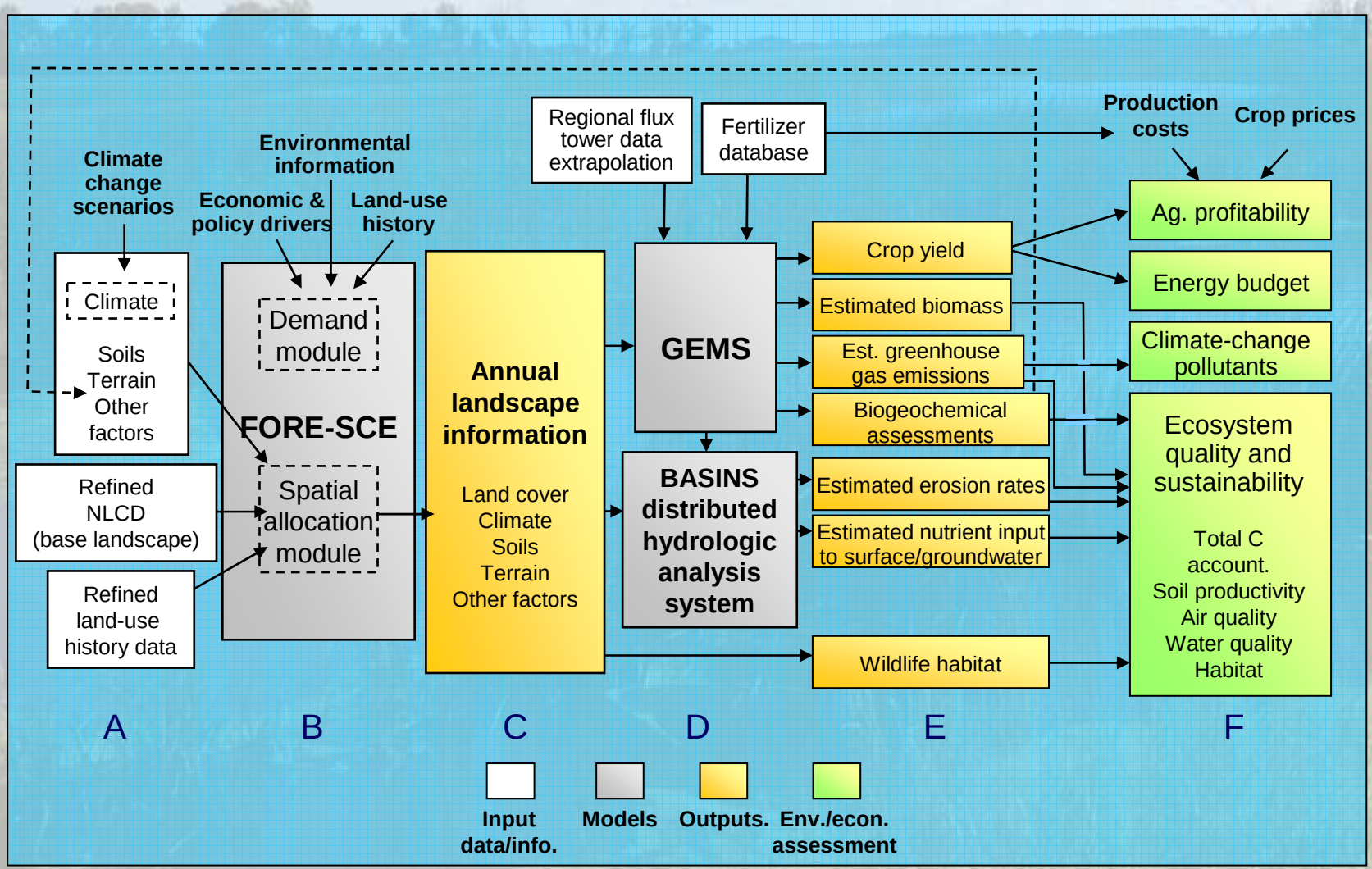

Northwestern
Glaciated Plains
Northern
Glaciated Plains
Northwestern
Great Plains
Western
Corn Belt Plains

USGS

Forecasting alternative landscapes



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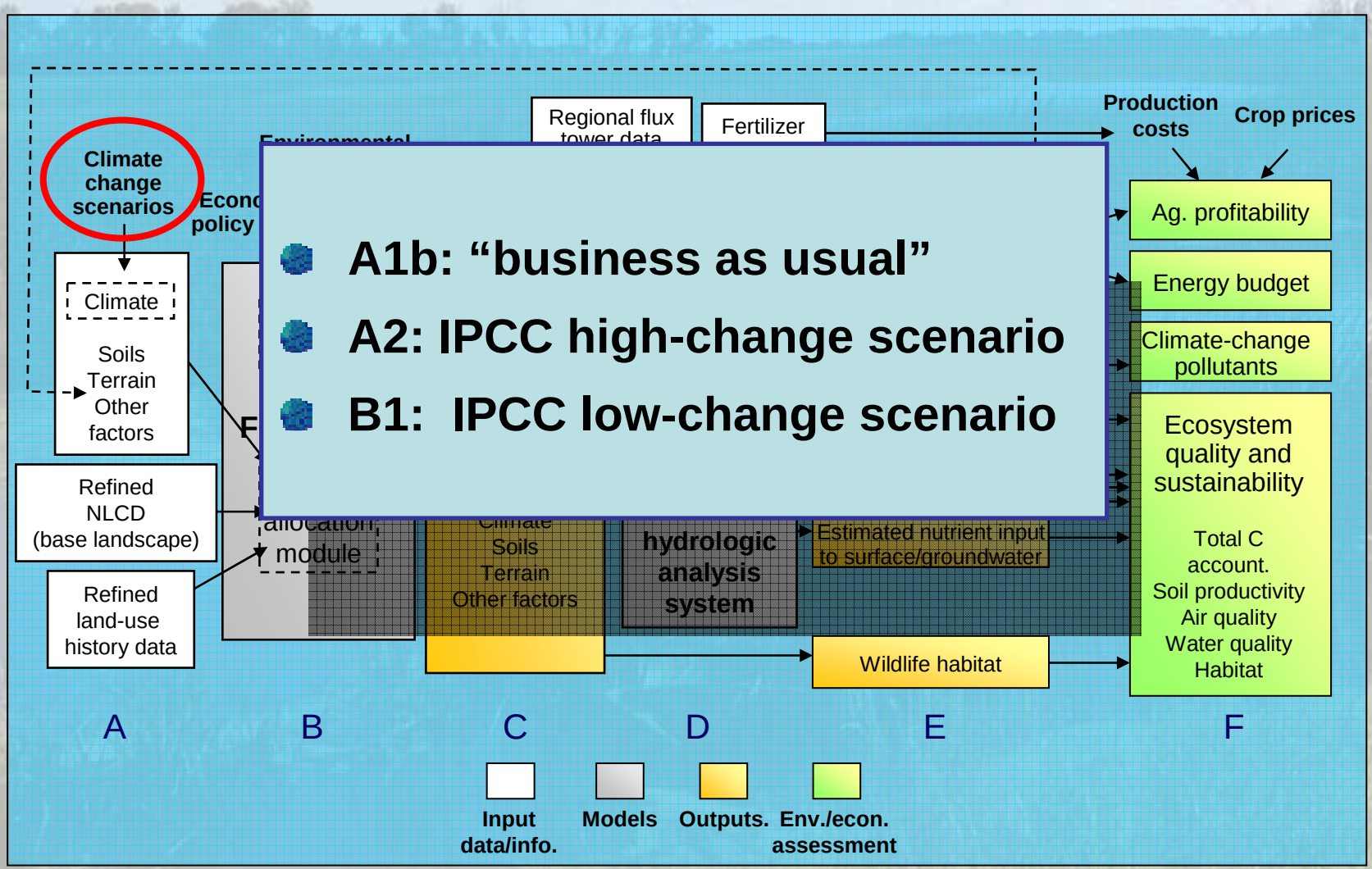

- **A1b: "business as usual"**
- **A2: IPCC high-change scenario**
- **B1: IPCC low-change scenario**

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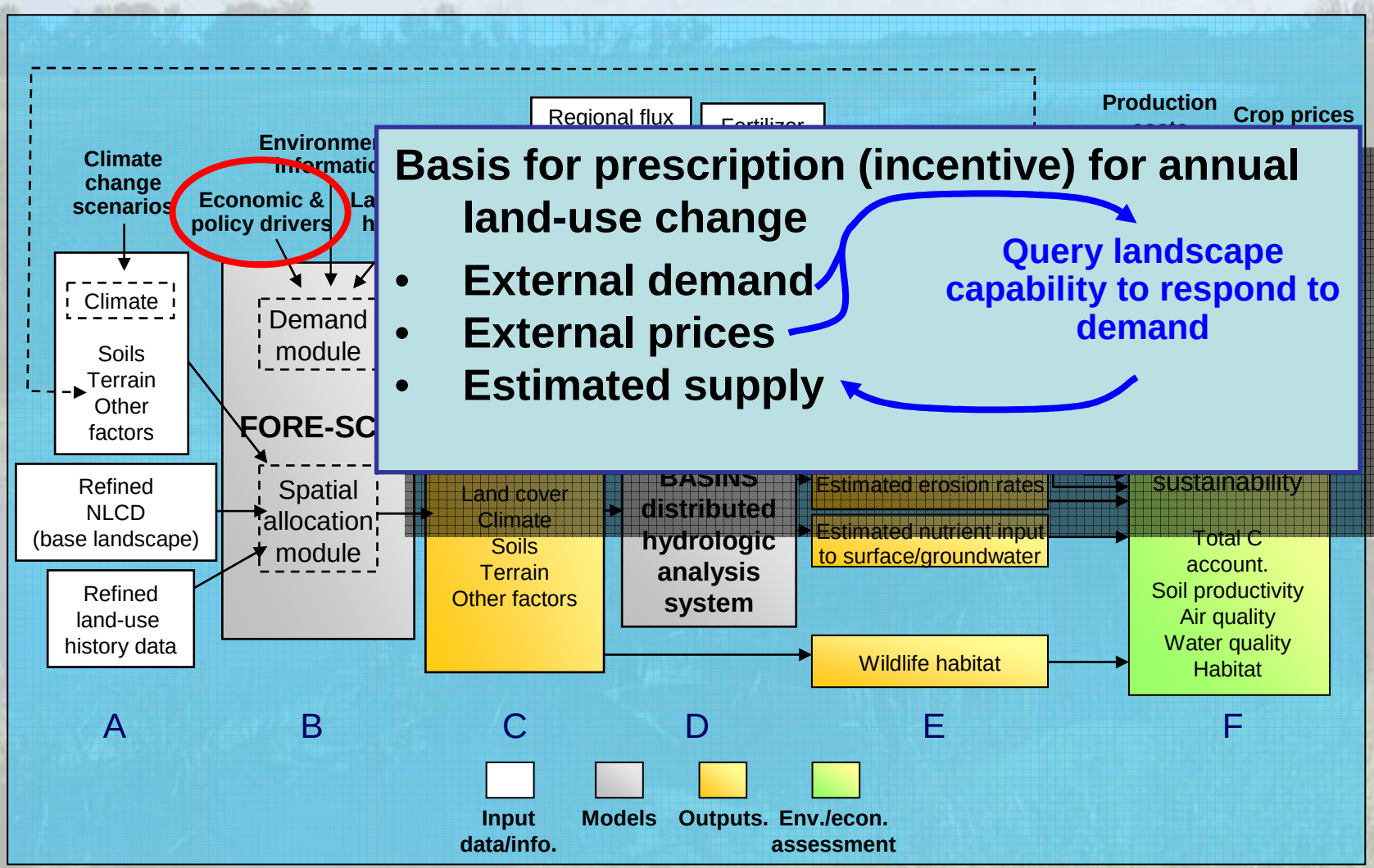
Forecasting alternative landscapes



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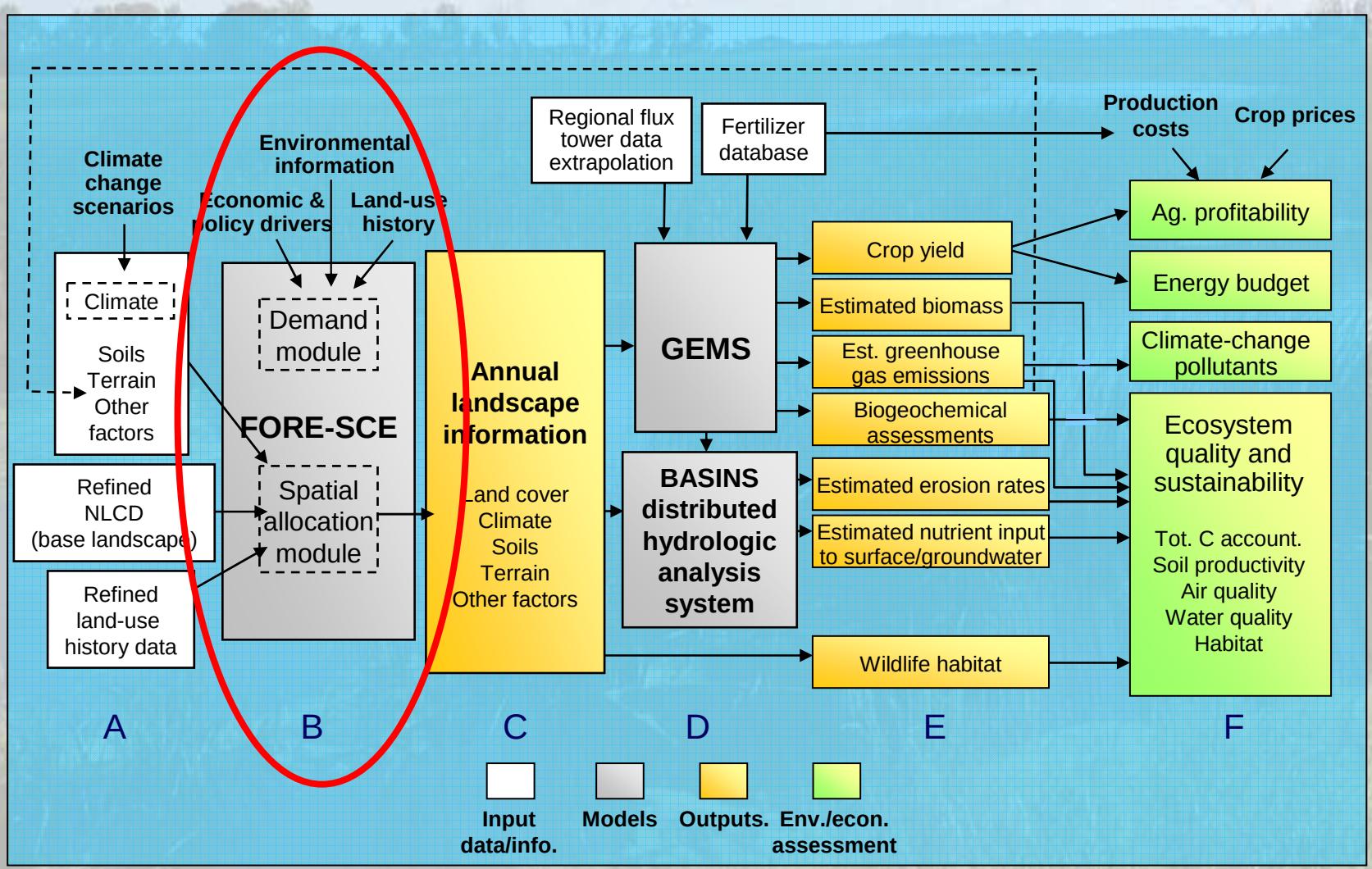
Climate change scenarios
Environmental information
Economic & policy drivers
Land-use history
Regional flux tower data extrapolation
Fertilizer database
Production costs
Crop prices
Climate
Soils
Terrain
Other factors
Demand module
FORE-SCE
Spatial allocation module
Refined NLCD (base landscape)
Refined land-use history data
Annual landscape information
Land cover
Climate
Soils
Terrain
Other factors
GEMS
BASINS distributed hydrologic analysis system
Crop yield
Estimated biomass
Est. greenhouse gas emissions
Biogeochemical assessments
Estimated erosion rates
Estimated nutrient input to surface/groundwater
Wildlife habitat
Ag. profitability
Energy budget
Climate-change pollutants
Ecosystem quality and sustainability
Tot. C account.
Soil productivity
Air quality
Water quality
Habitat
A
B
C
D
E
F
Input data/info.
Models
Outputs.
Env./econ. assessment

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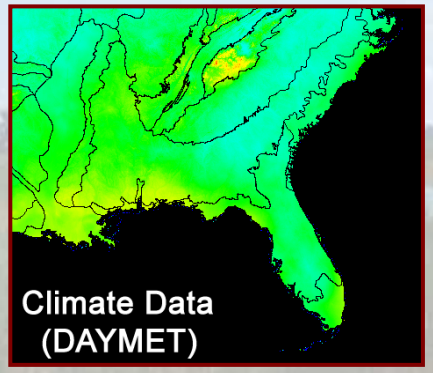
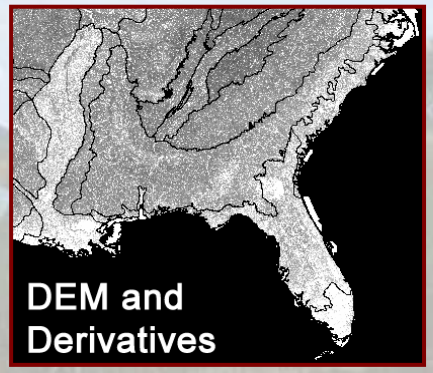
Example ingredients used by FORE-SCE

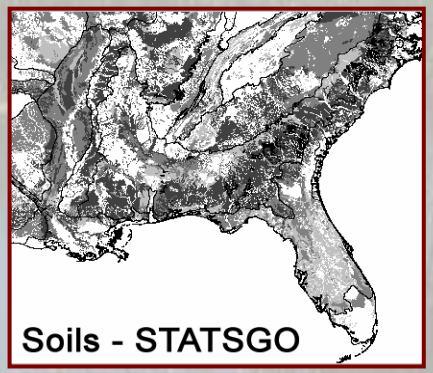
IPCC climate change predictions

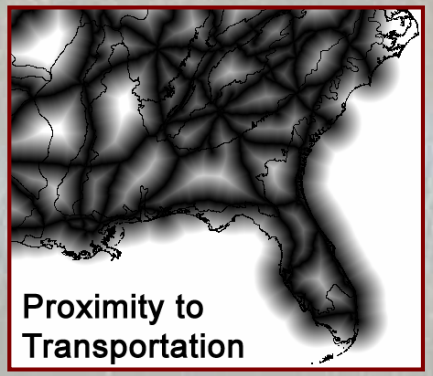
Policy/program requirements and incentives

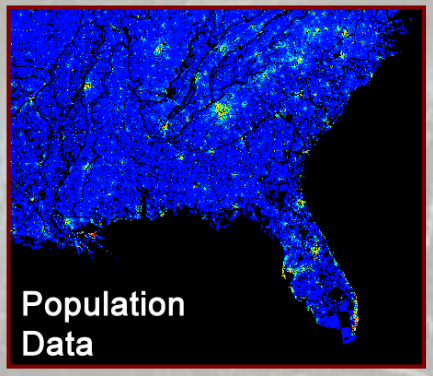
Contemporary land-conversion characteristics

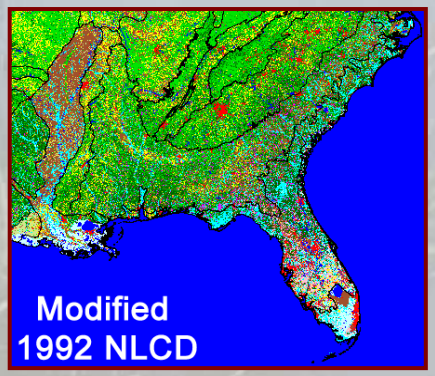


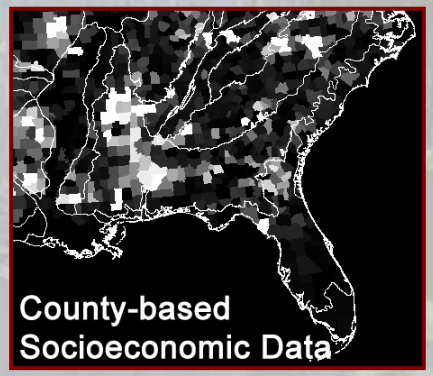


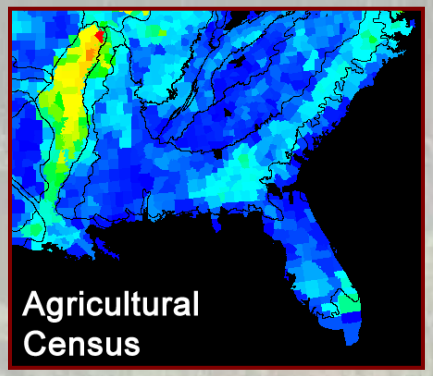


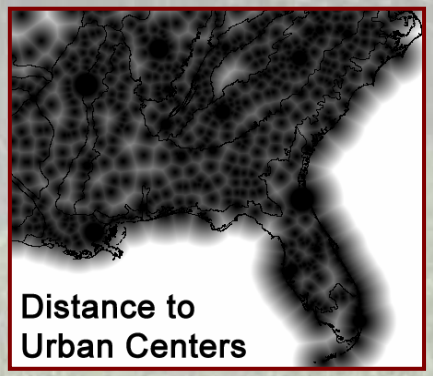












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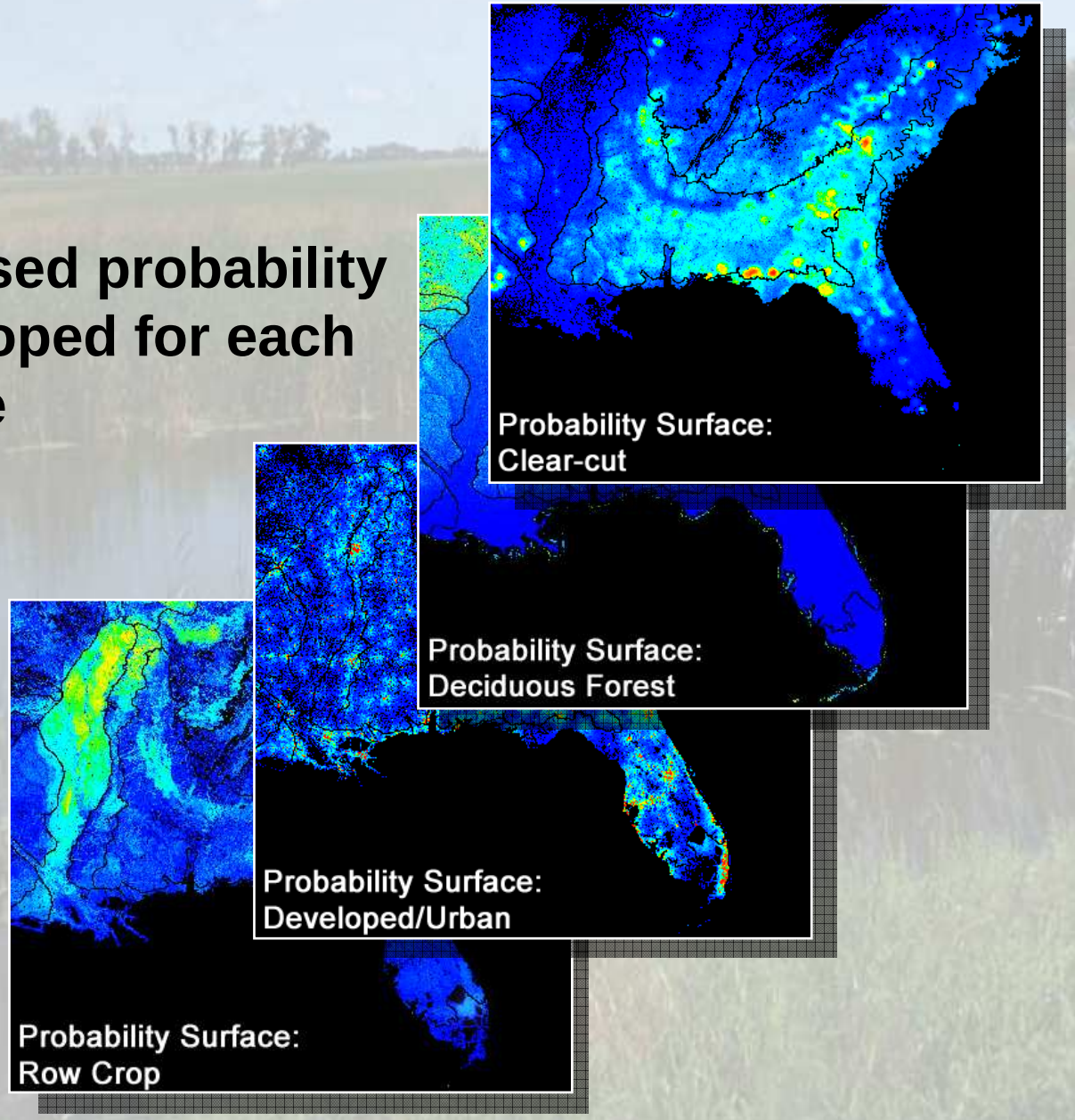
FORE-SCE

Regression-based probability surfaces developed for each land-cover type



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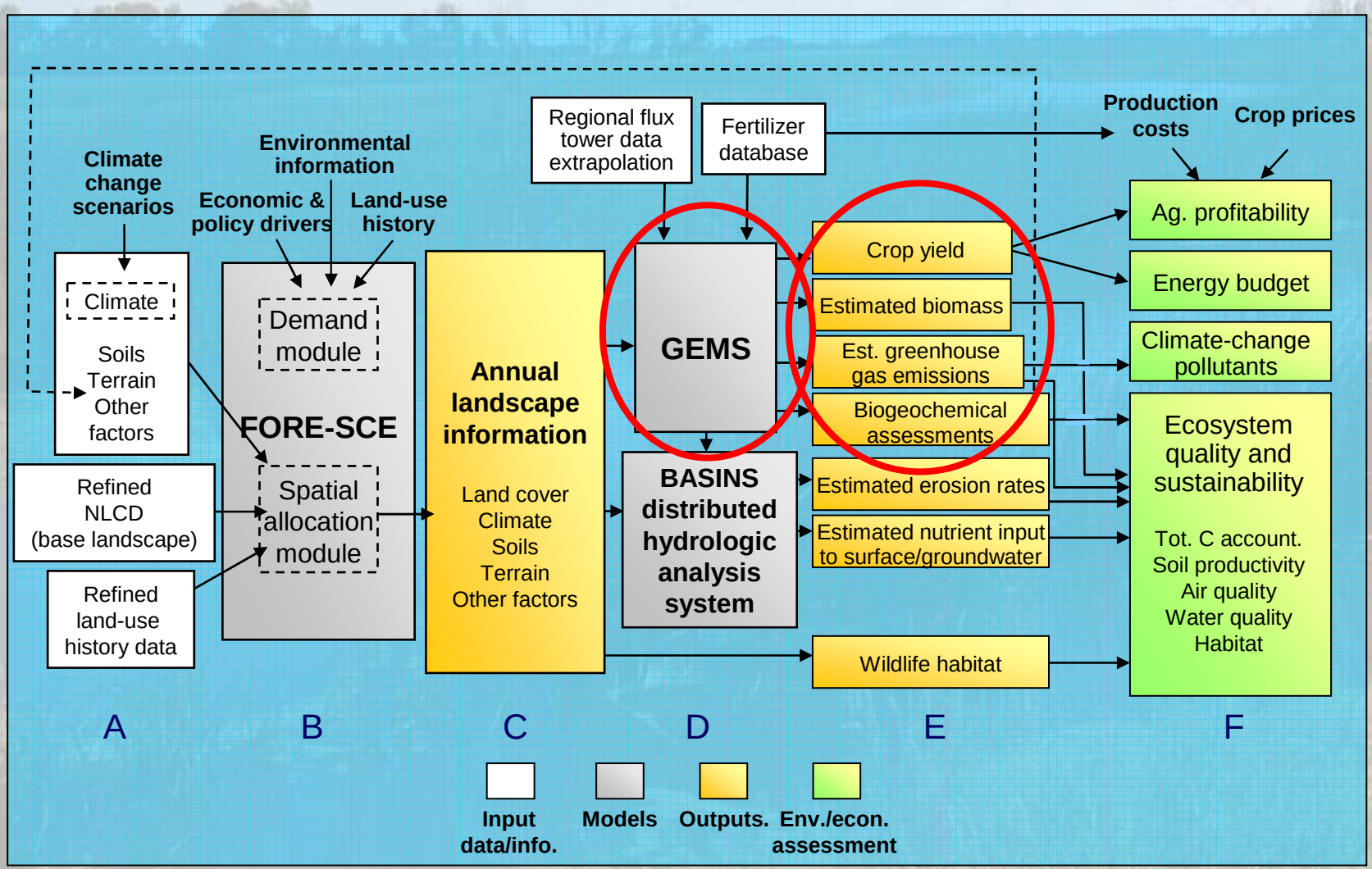
Forecasting alternative landscapes



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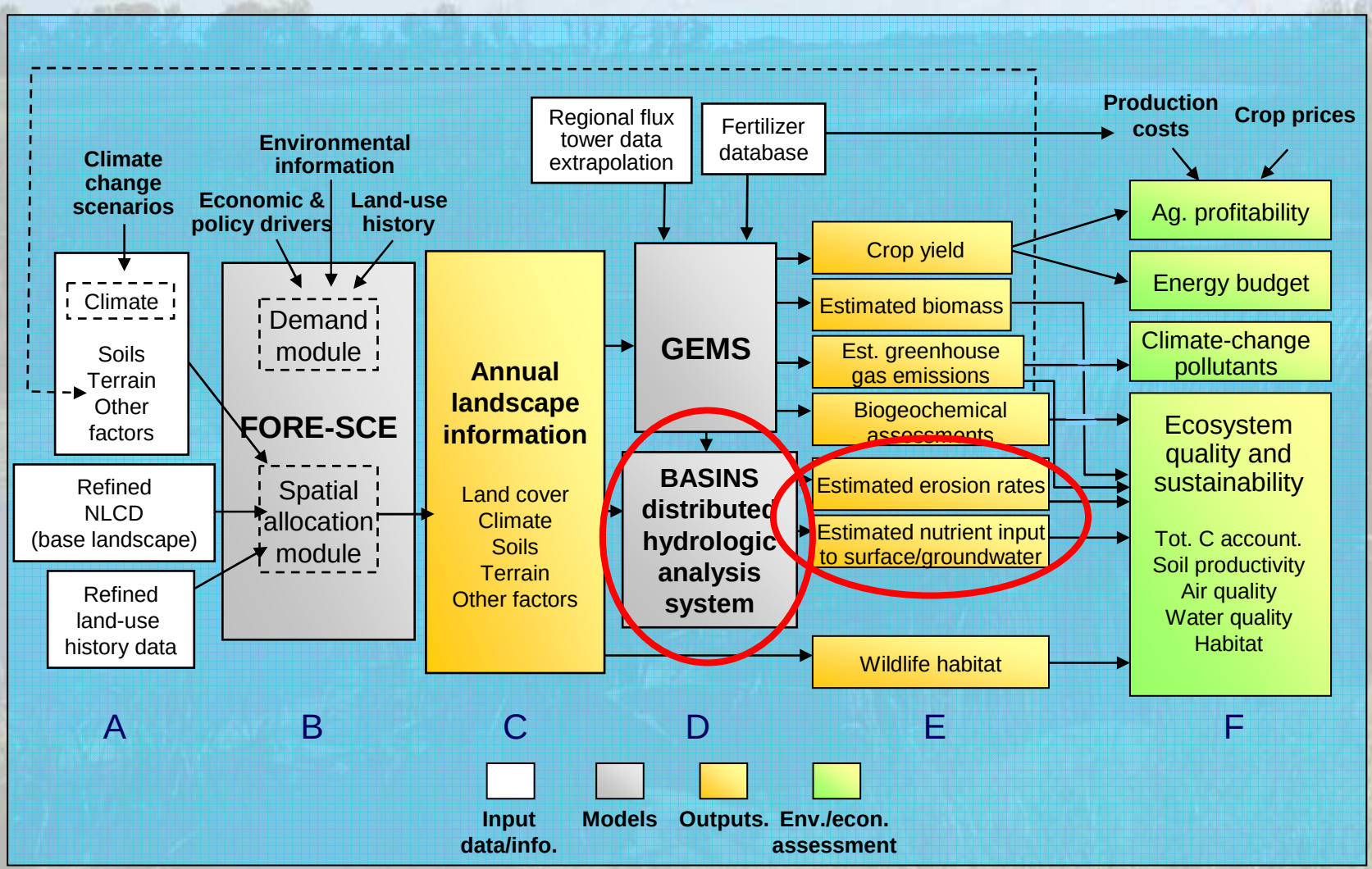

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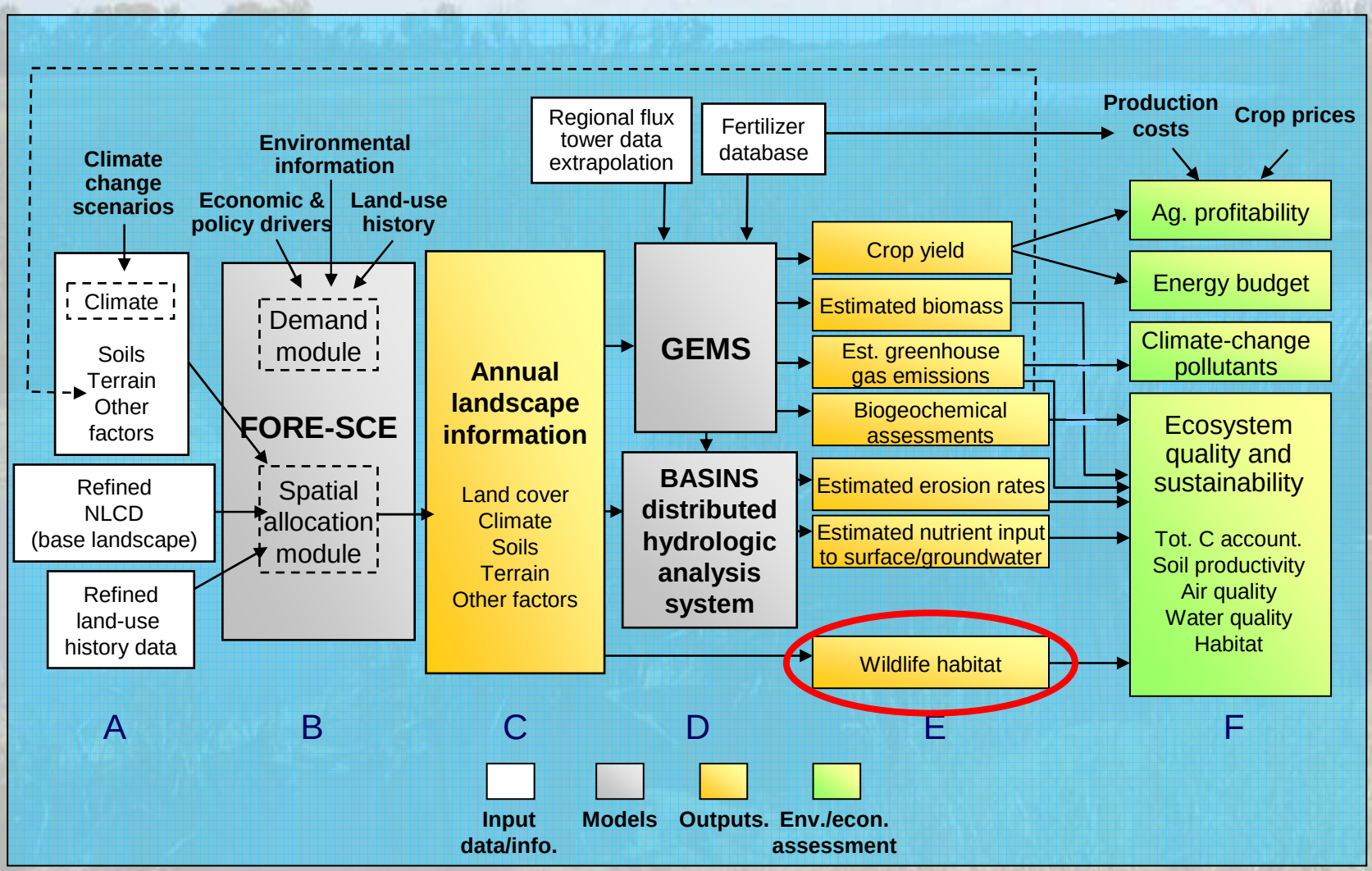
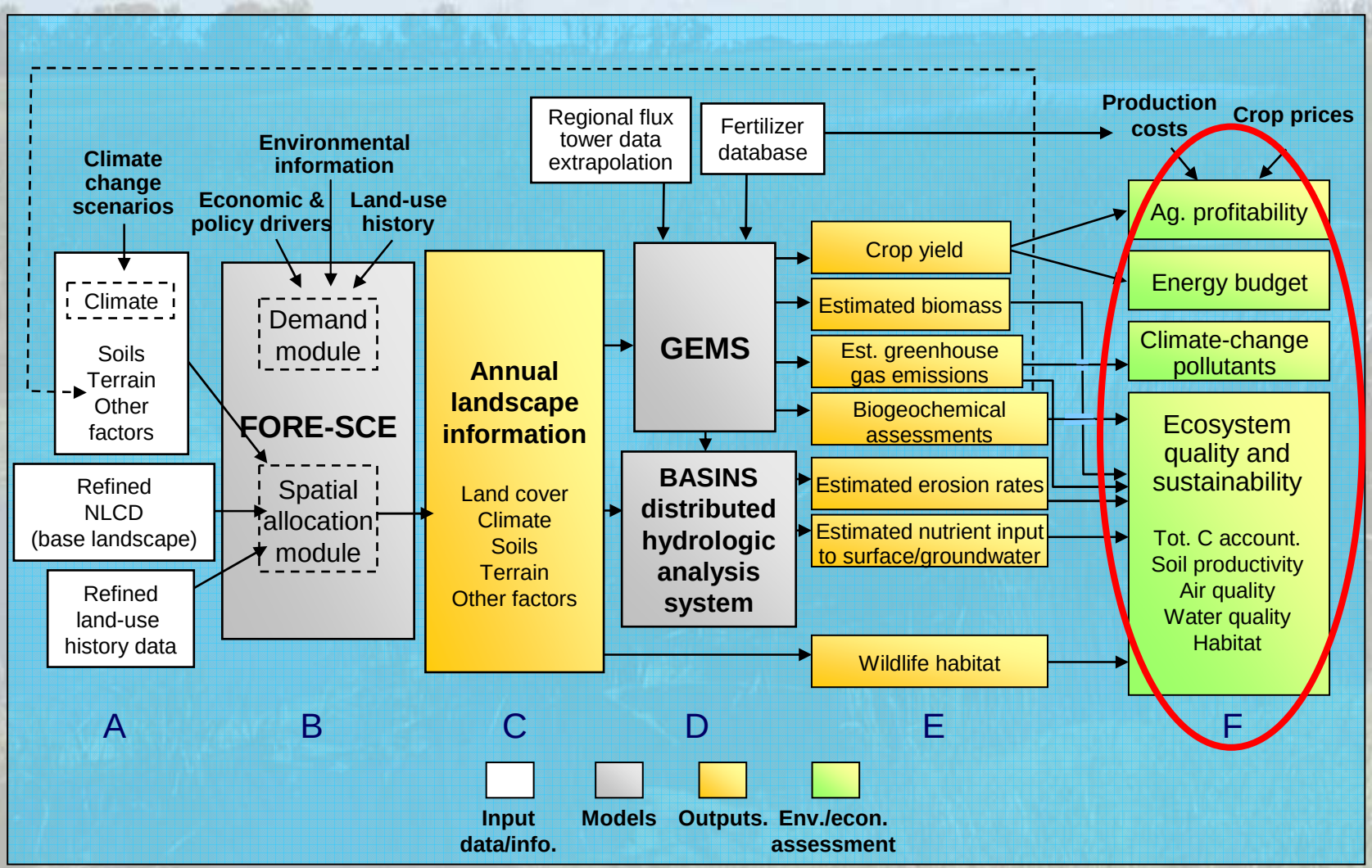


USGS

Forecasting alternative landscapes



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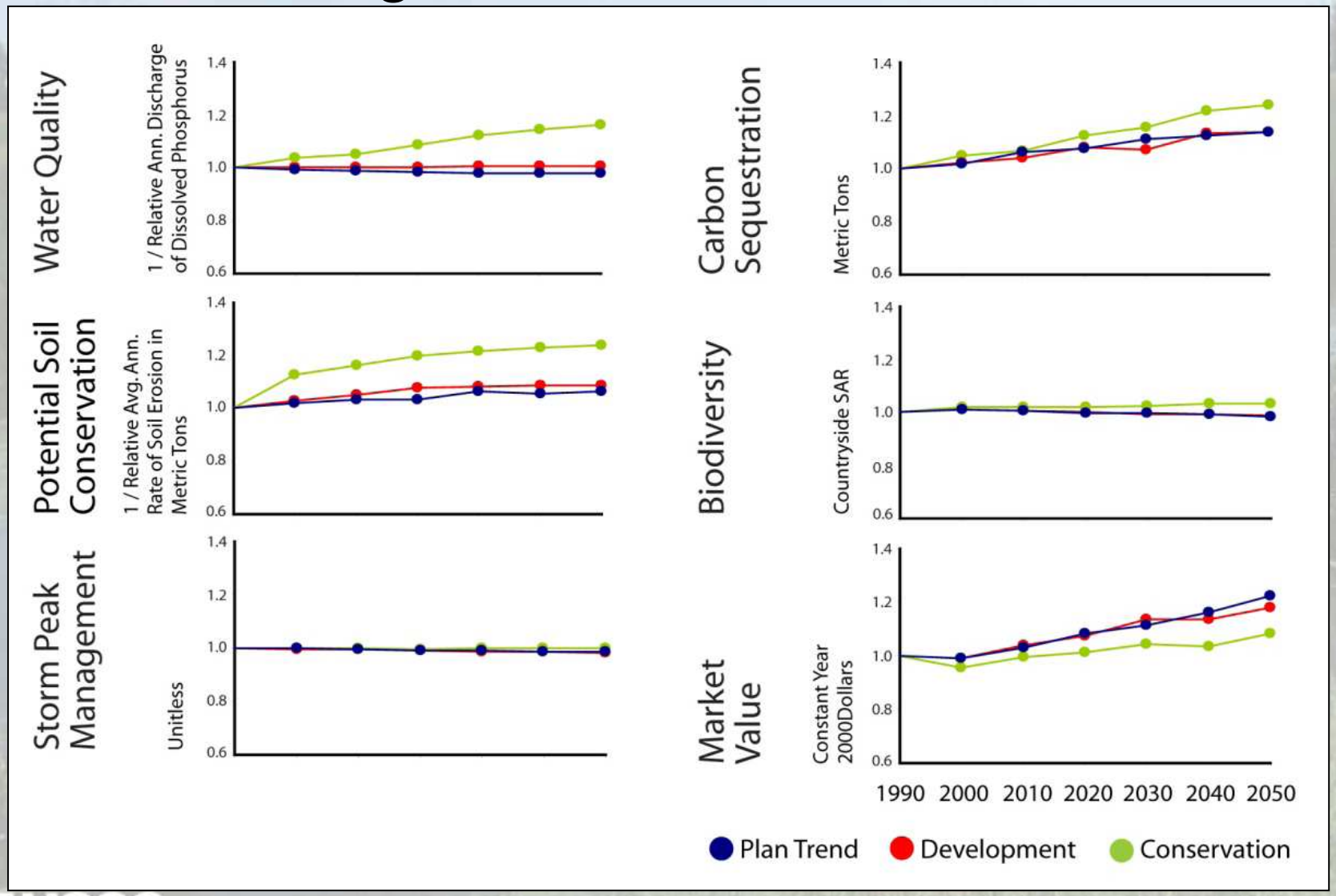
Services through time



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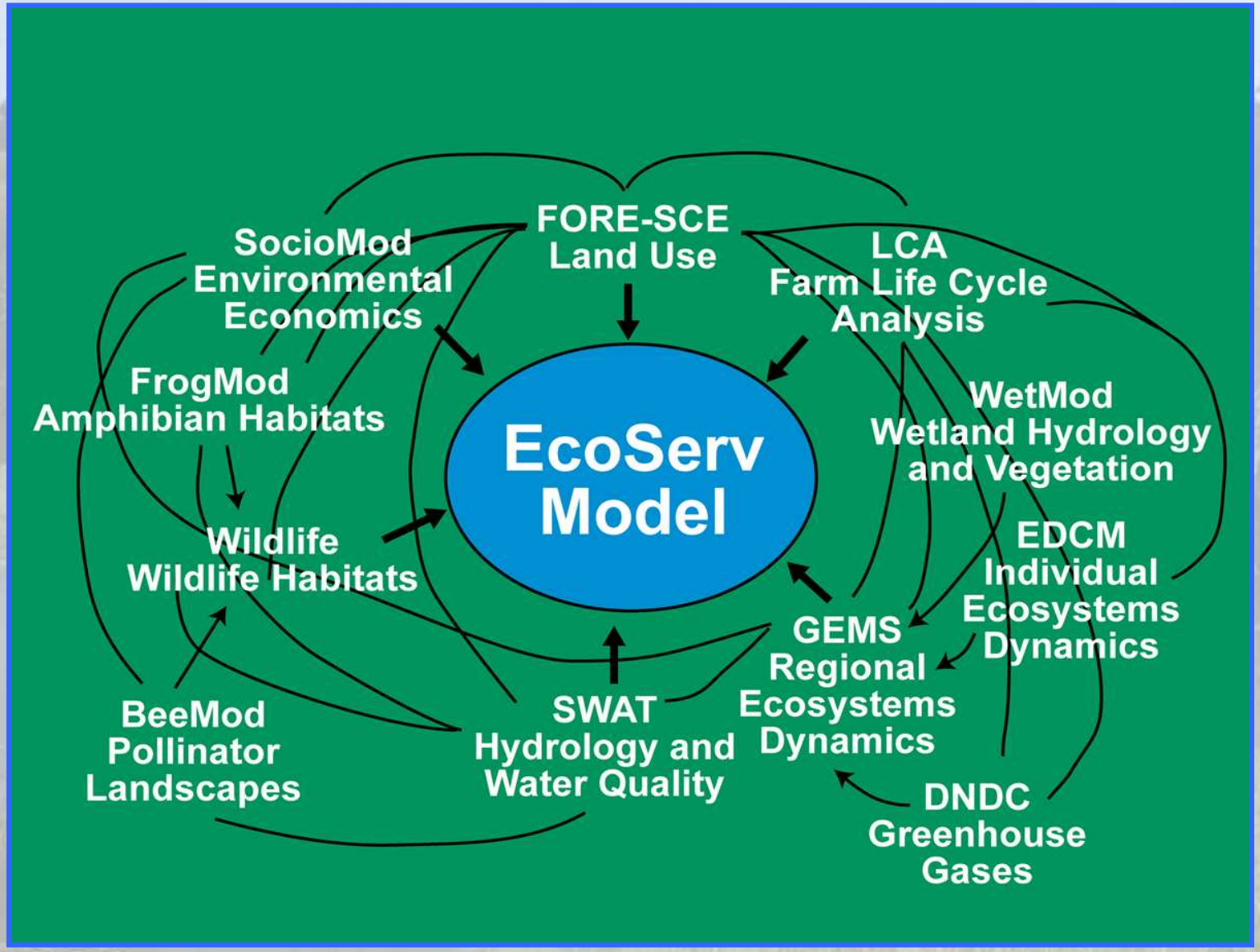
FORE-SCE
Land Use
SocioMod
Environmental
Economics
LCA
Farm Life Cycle
Analysis
FrogMod
Amphibian Habitats
EcoServ
Model
WetMod
Wetland Hydrology
and Vegetation
Wildlife
Wildlife Habitats
EDCM
Individual
Ecosystems
Dynamics
GEMS
Regional
Ecosystems
Dynamics
BeeMod
Pollinator
Landscapes
SWAT
Hydrology and
Water Quality
DNDC
Greenhouse
Gases

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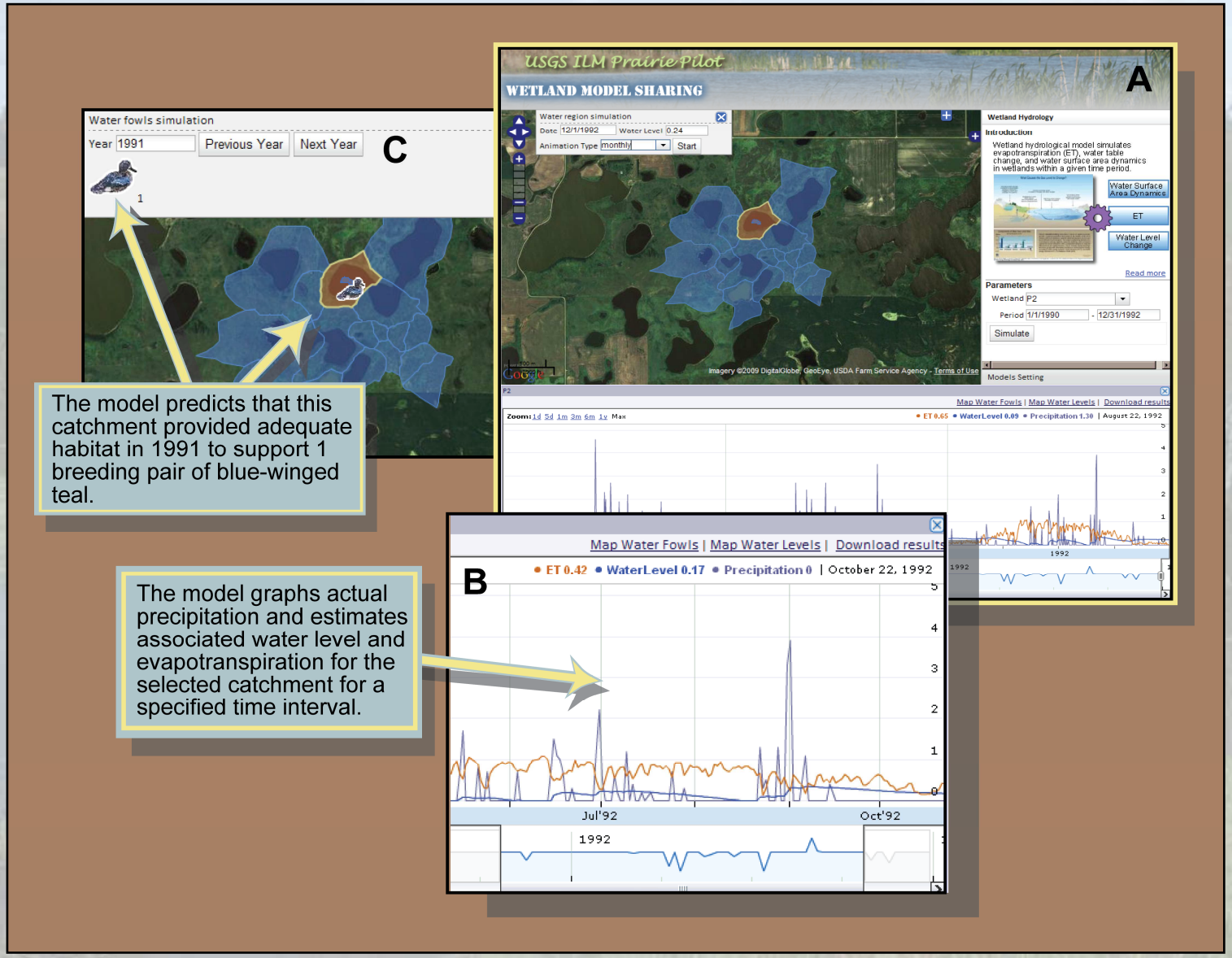
USGS ILM Prairie Pilot
WETLAND MODEL SHARING
A
Water region simulation
Date 12/1/1992 Water Level 0.24
Animation Type monthly Start
Wetland Hydrology
Introduction
Wetland hydrological model simulates evapotranspiration (ET), water table change, and water surface area dynamics in wetlands within a given time period.
Water Surface Area Dynamics
ET
Water Level Change
Read more
Parameters
Wetland P2
Period 1/1/1990 - 12/31/1992
Simulate
Models Setting
Imagery ©2009 DigitalGlobe, GeoEye, USDA Farm Service Agency - Terms of Use
Map Water Fowls | Map Water Levels | Download results
Zoom: 1d 5d 1m 3m 6m 1y Max
ET 0.65 WaterLevel 0.09 Precipitation 1.30 | August 22, 1992
1992
Water fowls simulation
Year 1991
Previous Year
Next Year
C
1
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.
Map Water Fowls | Map Water Levels | Download results
B
ET 0.42 WaterLevel 0.17 Precipitation 0 | October 22, 1992
5
4
3
2
1
0
Jul'92
Oct'92
1992

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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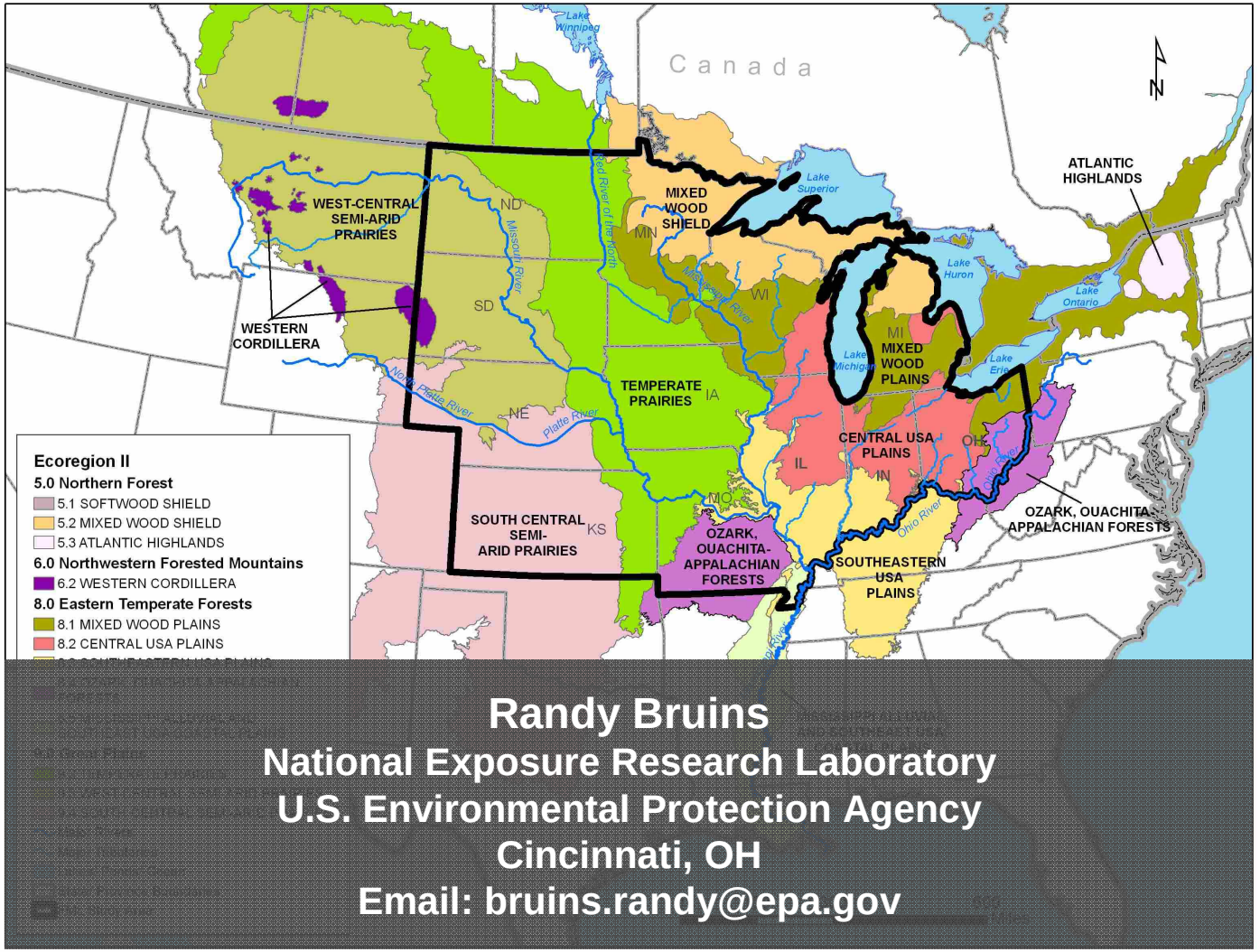

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