Platform for Regional Integrated Modeling and Analysis (PRIMA)*

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*Previously the integrated Regional Earth System Model (iRESM)
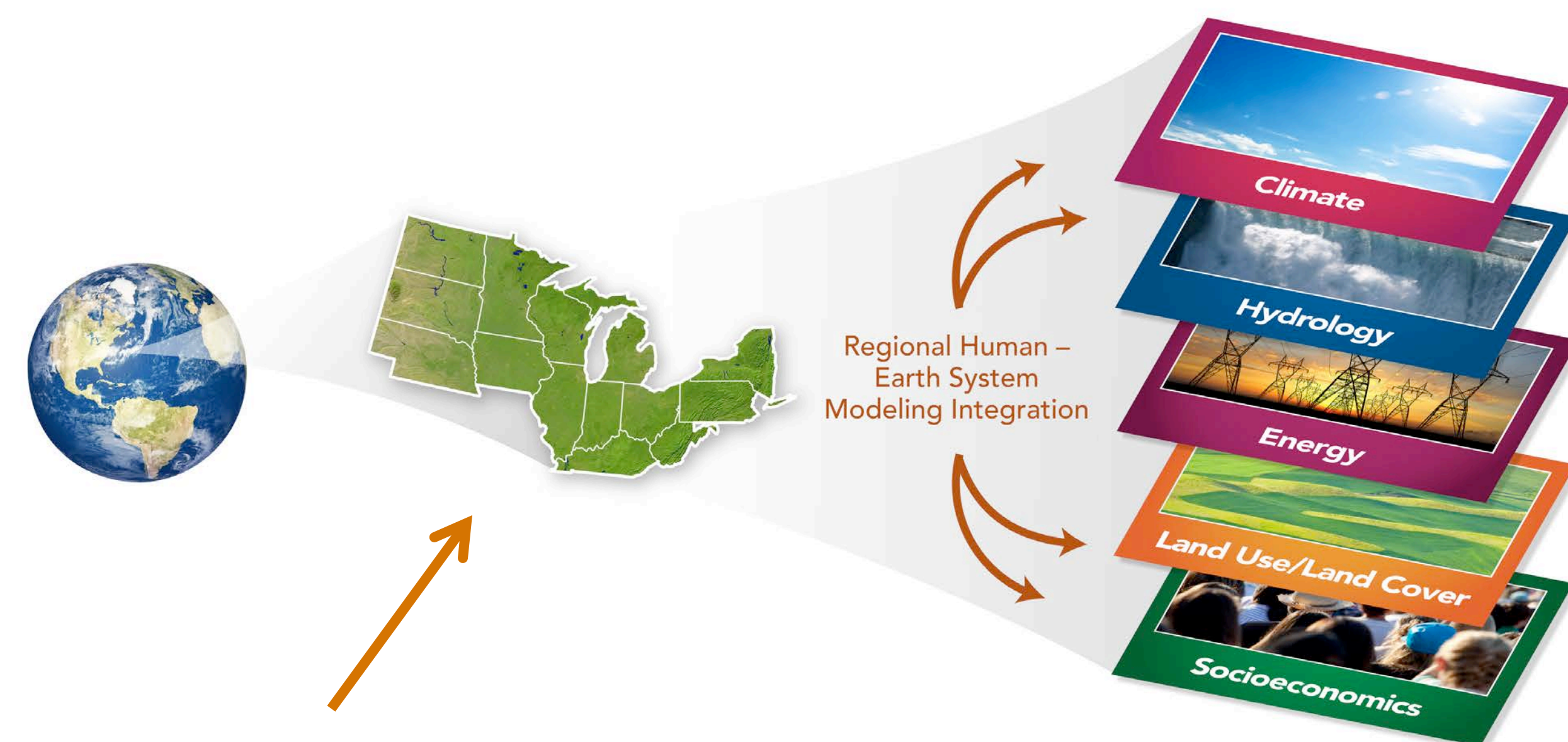
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Motivation and Overview

Global climate and integrated assessment models can address questions related to interactions among human and natural systems at large scales, but they cannot resolve the regional-scale interactions that are critical for many decisions, such as those related to climate change mitigation and adaptation.

PNNL's Platform for Regional Integrated Modeling and Analysis (PRIMA) fills this gap by providing a flexible, stakeholder-driven framework for simulating key human and natural system processes at regional scales.

The ultimate goal of PRIMA is to improve scientific understanding and support effective decision making related to regional interactions among climate, energy, hydrology, land use, and socioeconomics.

Regional Human – Earth System Modeling Integration

Climate
Hydrology
Energy
Land Use/Land Cover
Socioeconomics

Upper Midwest Pilot Region:

Strong gradients in population density, land use/land cover, power generation resources, socioeconomic factors, etc.
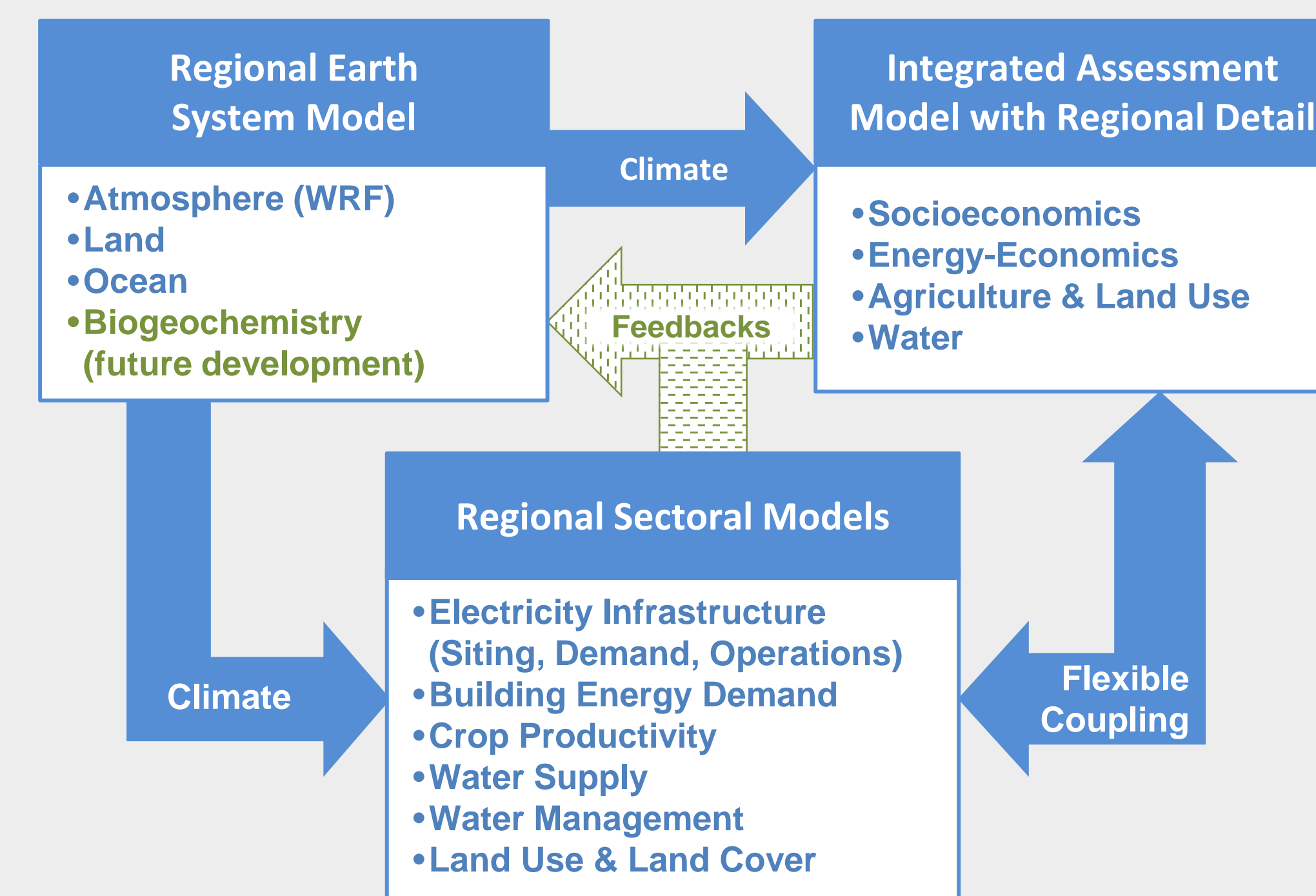
Stakeholder Interests: Mitigation

- Regional carbon tax
- Renewable energy investments (especially biofuels and wind)
- Improve building codes & standards
- Agriculture/forestry management

Stakeholder Interests: Adaptation

- Dry-cooling for thermal plants
- Grid reliability/resilience
- Improve building codes & standards
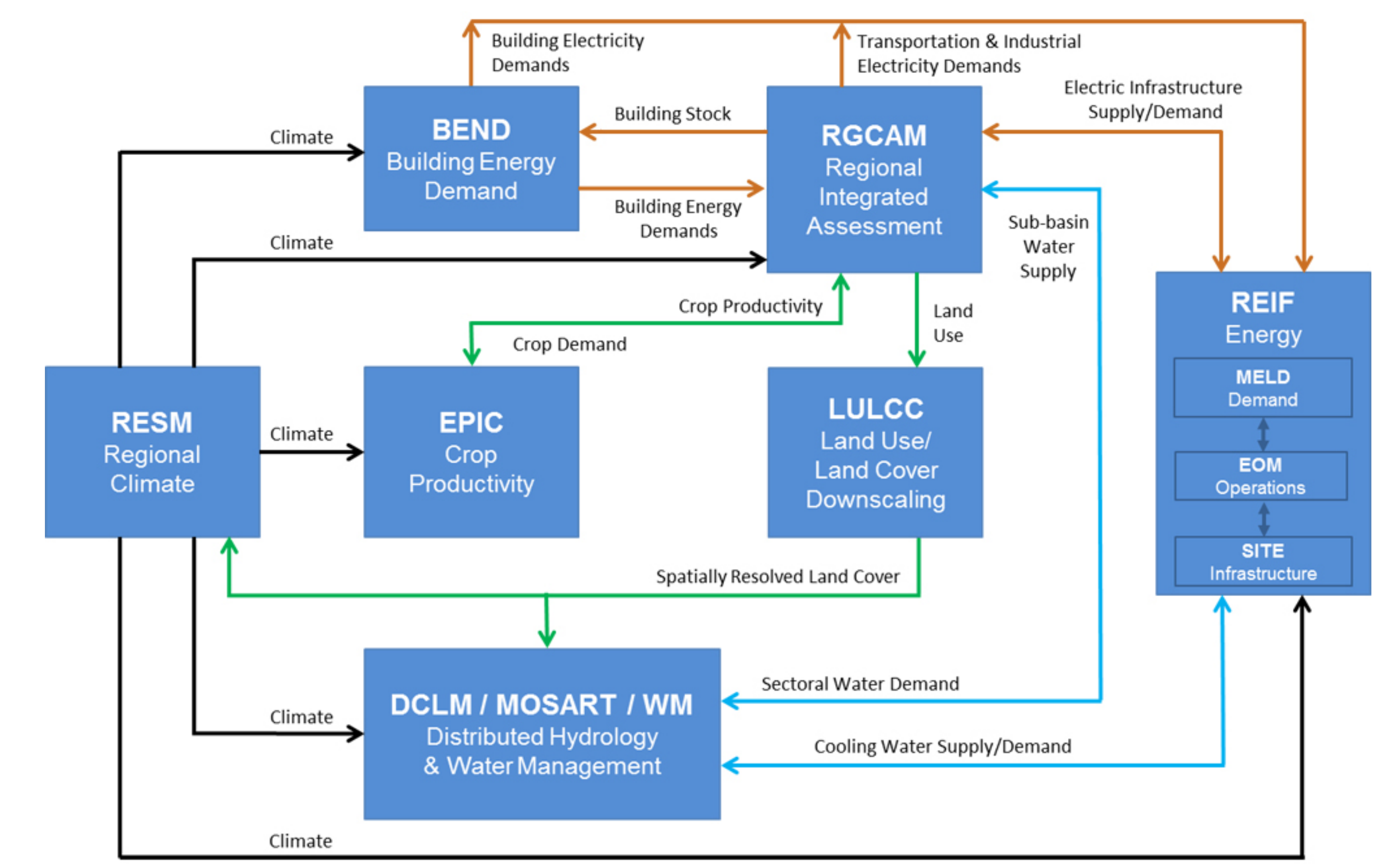- Modified reservoir releases
- Drought-resistant crops

Modeling Framework

Regional Earth System Model
- Atmosphere (WRF)
- Land
- Ocean
- Biogeochemistry (future development)

Climate

Integrated Assessment Model with Regional Detail
- Socioeconomics
- Energy-Economics
- Agriculture & Land Use
- Water

Feedbacks

Regional Sectoral Models
- Electricity Infrastructure (Siting, Demand, Operations)
- Building Energy Demand
- Crop Productivity
- Water Supply
- Water Management
- Land Use & Land Cover

Climate

Flexible Coupling

Key Attributes

- Open-Source Component Models
- Consistent with Global Boundary Conditions
- Portable and Modular, with Initial Focus on Energy-Water-Land Interactions in the Upper Midwest
- Flexible Model Coupling with Velo Software Platform
- Stakeholder-Driven Numerical Experiments and Uncertainty Characterization
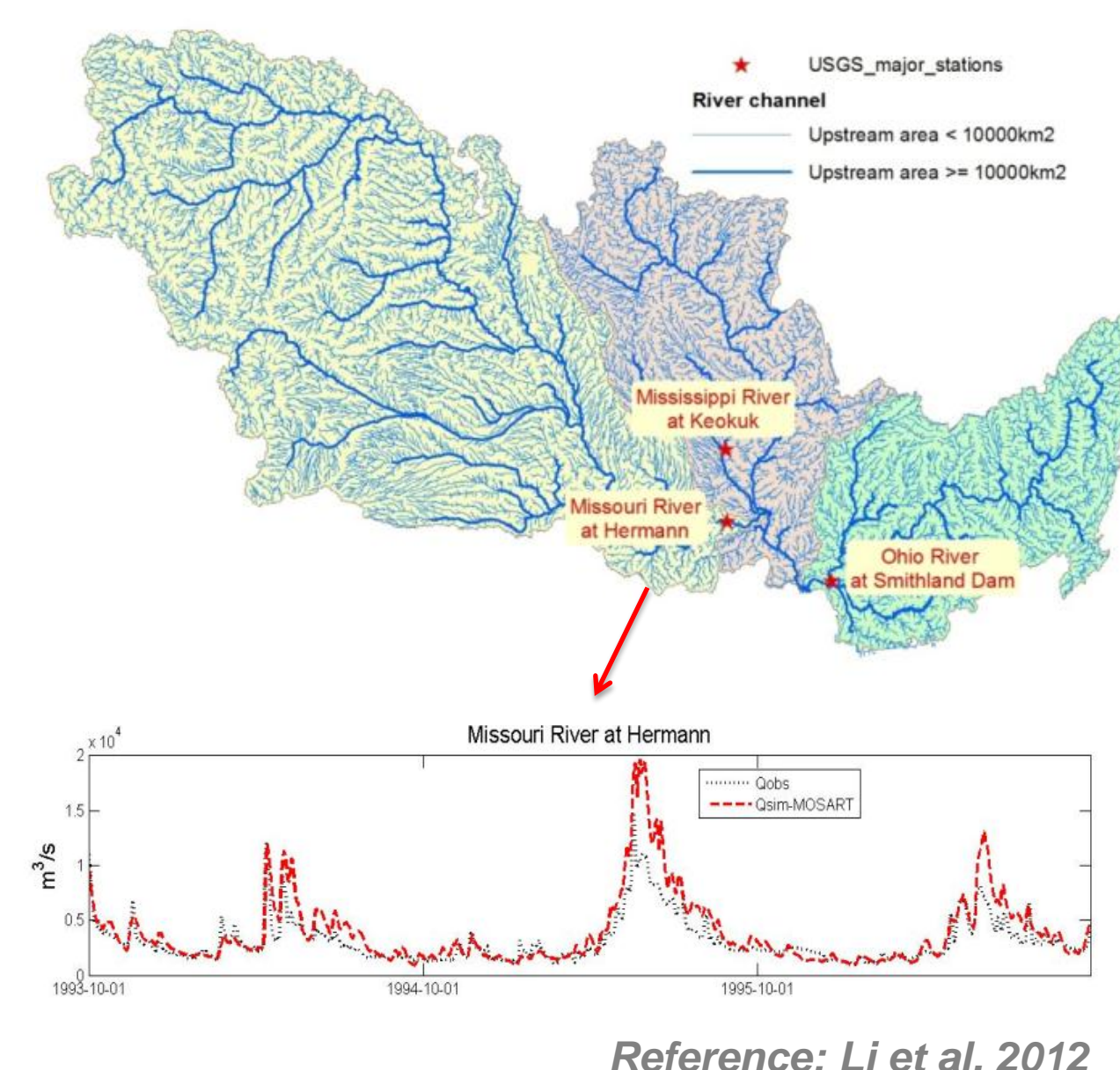
Component Models and Coupling Options

Building Electricity Demands
Transportation & Industrial Electricity Demands
Electric Infrastructure Supply/Demand

BEND
Building Energy Demand

RGCAM
Regional Integrated Assessment

REIF
Energy

MELD
Demand

EOM
Operations

SITE
Infrastructure

Building Stock
Building Energy Demands
Climate
Sub-basin Water Supply
Land Use

RESM
Regional Climate

EPIC
Crop Productivity

LULCC
Land Use/ Land Cover Downscaling

Crop Productivity
Crop Demand

Spatially Resolved Land Cover

DCLM / MOSART / WM
Distributed Hydrology & Water Management

Sectoral Water Demand
Cooling Water Supply/Demand

Climate

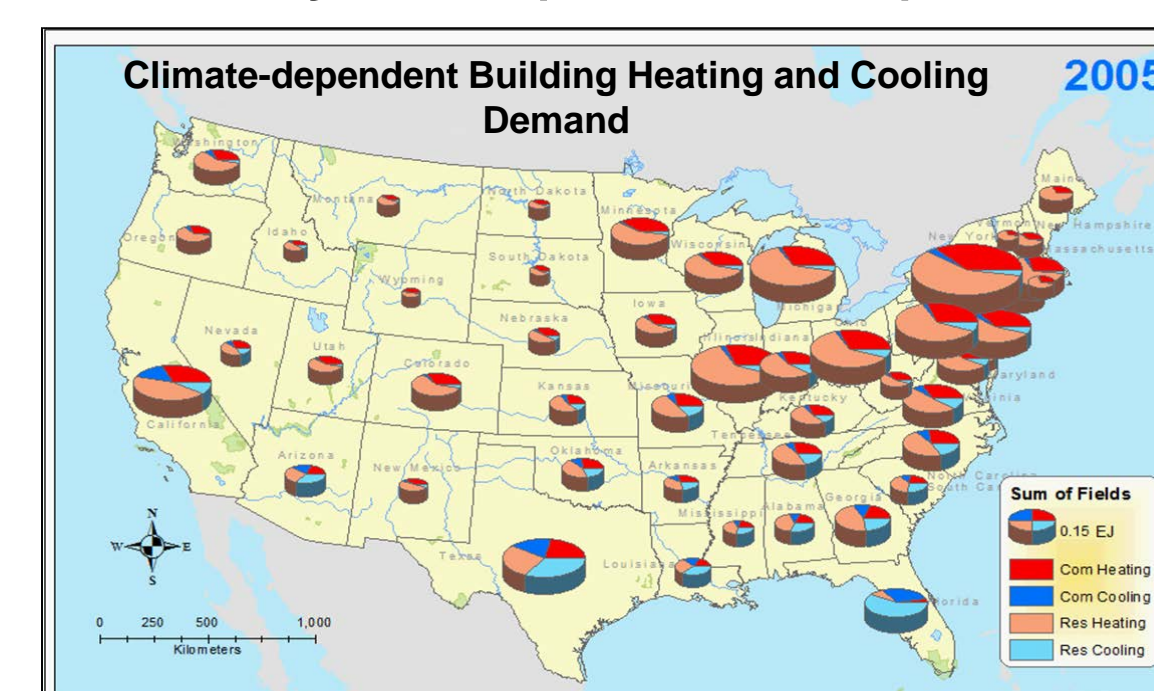|	
BEND	Building ENergy Demand model
RGCAM	Regionalized Global Change Assessment Model (GCAM-USA = GCAM with 50-state resolution)
RESM	Regional Earth System Model:
	▪ WRF Weather Research and Forecasting model
	▪ ROMS Regional Ocean Modeling System
	▪ CLM Community Land Model
EPIC	Environmental Policy Integrated Climate (cropping model)
LULCC	Land Use and Land Cover Change Downscaling
REIF	Regional Energy Infrastructure Framework:
	▪ MELD Model of ELectricity Demand
	▪ EOM Electricity Operation Model
	▪ SITE Electricity generation siting model
DCLM	Distributed Community Land Model
MOSART	MOdel for Scale-Adaptive River Transport
WM	Water resources Management model

Preliminary Results / Model Evaluation

Water Availability:

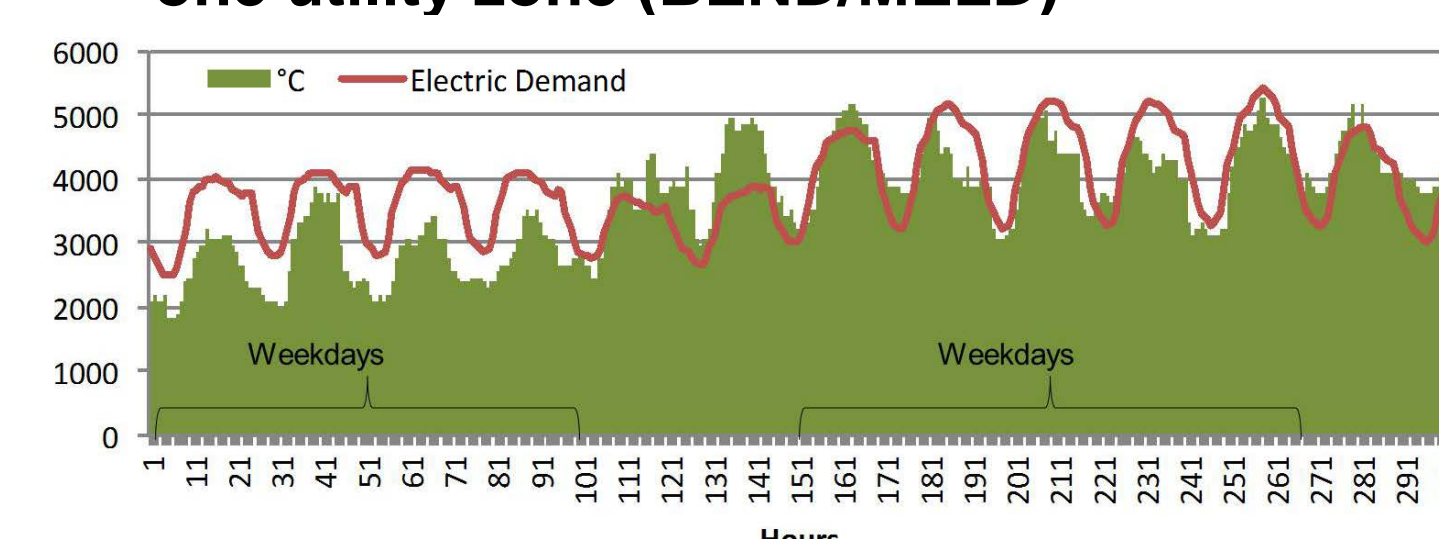**Distributed Hydrology (DCLM) and Streamflow (MOSART) for the upper Mississippi basin**

USGS_major_stations
River channel
Upstream area < 10000km2
Upstream area >= 10000km2

Mississippi River at Keokuk
Missouri River at Hermann
Ohio River at Smithland Dam

Missouri River at Hermann

Reference: Li et al. 2012

Building Energy Demands:

Decadal-scale building energy trends by state (GCAM-USA)

Climate-dependent Building Heating and Cooling Demand — 2005

Sum of Fields
Coil Heating
Coil Cooling
Gas Heating
Gas Cooling

Hourly building energy demand for one utility zone (BEND/MELD)

°C — Electric Demand

Weekdays Weekdays

Hours

Power Plant Siting:

Actual Power Plant Sitings Compared with Suitability Criteria (from SITE Model)

Legend
• New power plants, 2000–2010 – Suitable area
• New power plants, 2000–2010 – Unsuitable area
Suitable area
Unsuitable area – 1 or more violations
Pilot Region
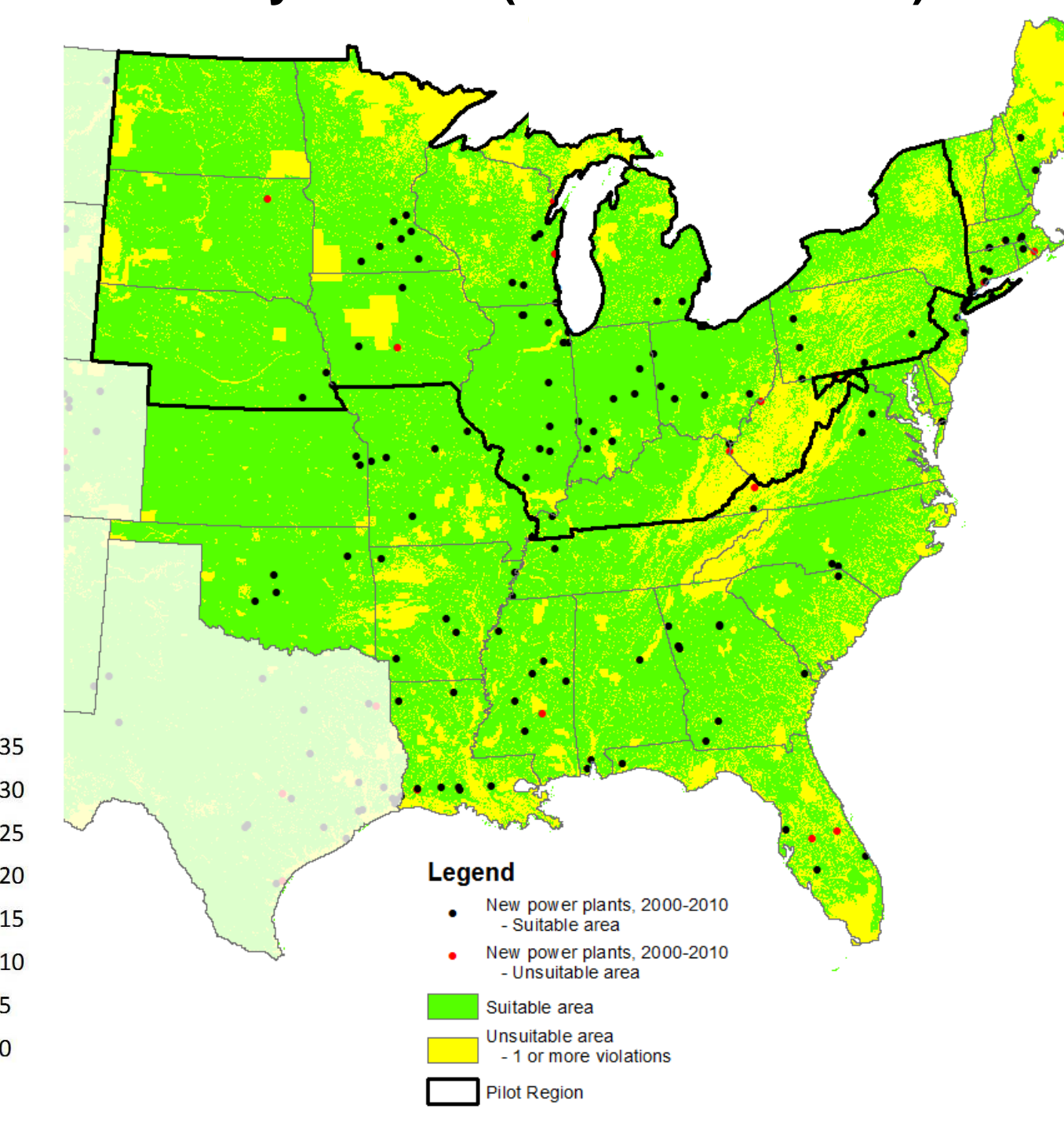
Stakeholder-Driven Uncertainty Characterization

Characterize Stakeholder Decision Support Needs
- Alternatives for Analysis
- Decision Criteria
- Preferences

Identify Uncertainty Sources
- Input Quantification
- Model Skill
- Model Completeness
- Integration and Implementation

Apply Flexible Architecture
- Relevant Models
- Coupling Strategies
- Surrogate Models

Select Uncertainty Characterization Methods
- Qualitative or Quantitative
- Uncertainty Ranges for Sensitivity Analysis
- UC Propagation Algorithms

Perform Sensitivity Analysis

Characterize Uncertainty in Sensitive Parameters

Perform Uncertainty Propagation

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