A Long View:
Integrating Stories, Art, and Biophysical Models to Explore Long-term Change in the Yahara Watershed, Wisconsin

Photo: Jeff Miller, UW News Service

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Shifting Shorelines, Virginia Coast Reserve & North Temperate Lakes

History in Tree Rings, Harvard Forest

Wildfire, Bonanza Creek

Black Grama to Creosote Bush, Jornada

Long-Term Perspective:

Today's ecosystems are shaped by changes over many time frames in the past.

The future will be shaped by historical legacies as well as future events.

Historic legacies shaped the present

Current events will shape the future

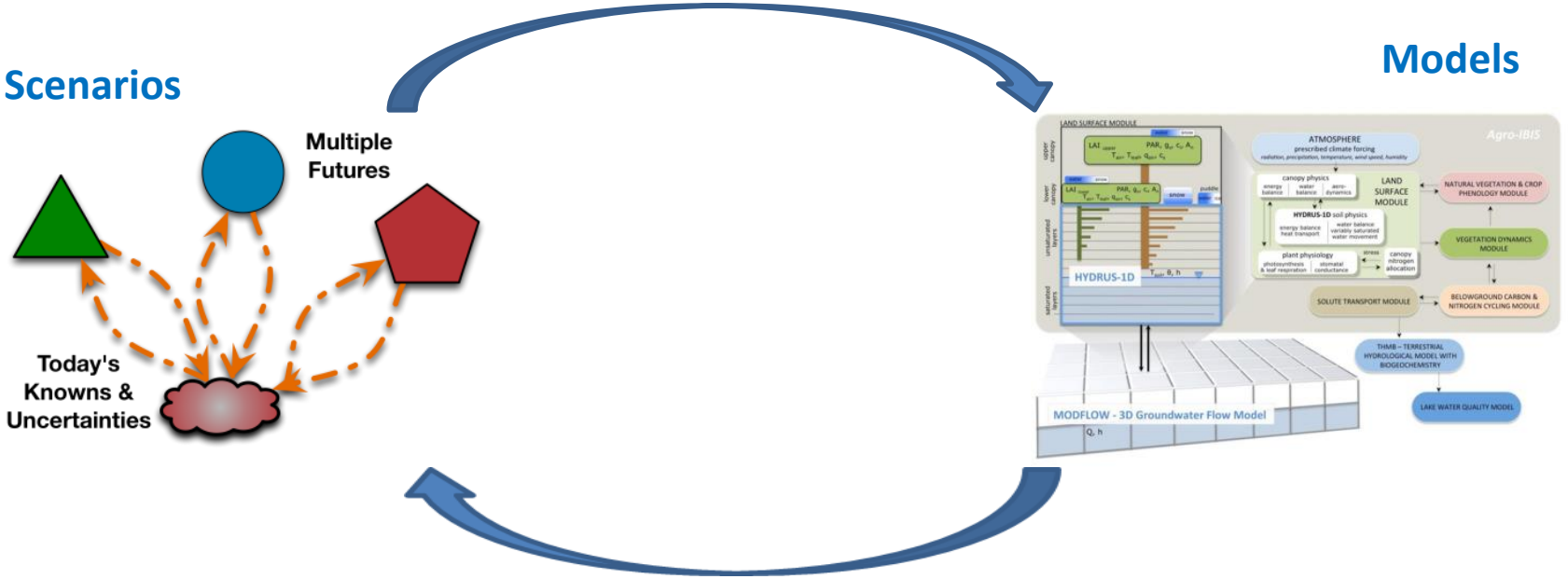
time

Scenarios and Models are complementary tools in long-term research:

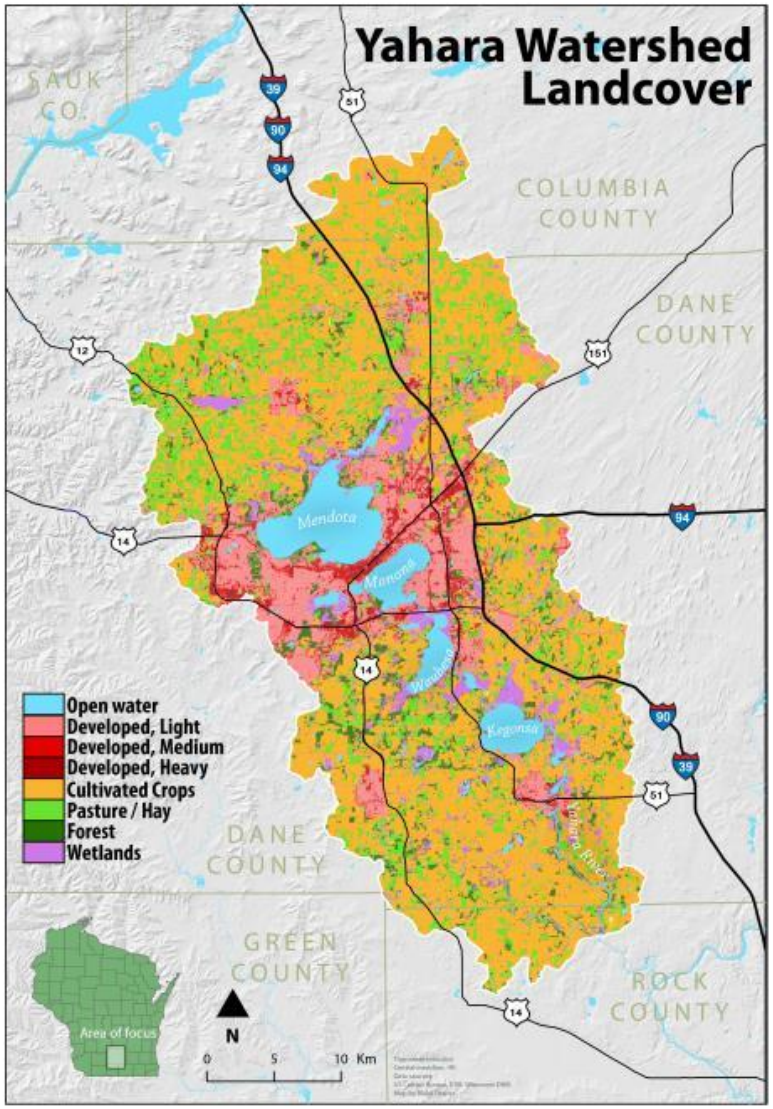
Scenarios frame uncertainties and goals for model analyses

Models are grounded in long-term data and process studies

Together they help create questions and goals for the next steps in long-term research



Assessing the Future of the Yahara Watershed (Madison Wisconsin)



1389 km^2, 372,000 people; 5 lakes

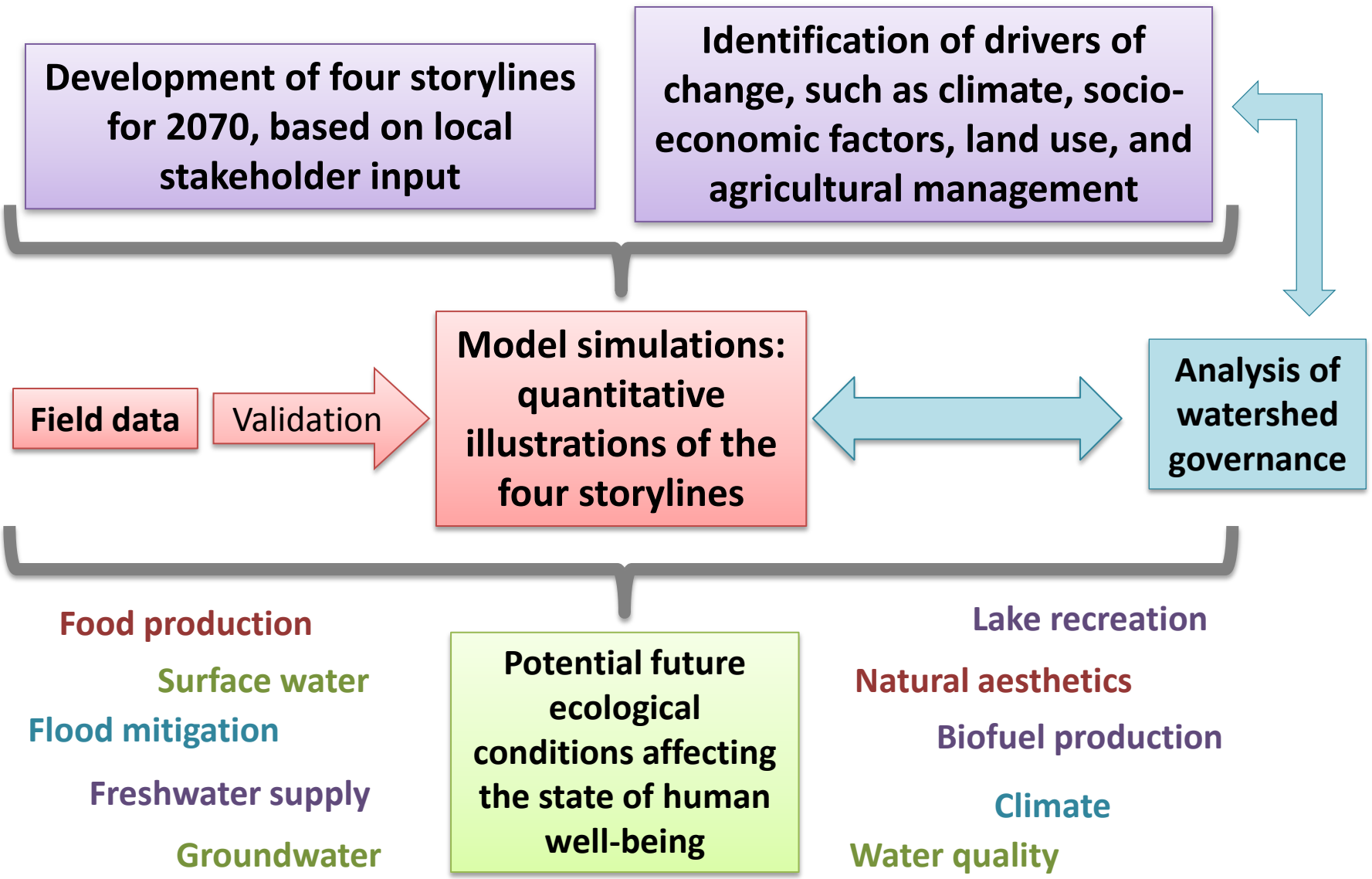
NTL-LTER site since 1994; lake data since 1875

Urbanizing agricultural region

Challenges to resilience:

- **More variable precipitation, warming**
- **Phosphorus pollution of soils and waters**
- **Toxic algae blooms**
- **More frequent flooding**
- **Rising demand for land and water resources**

Research Process

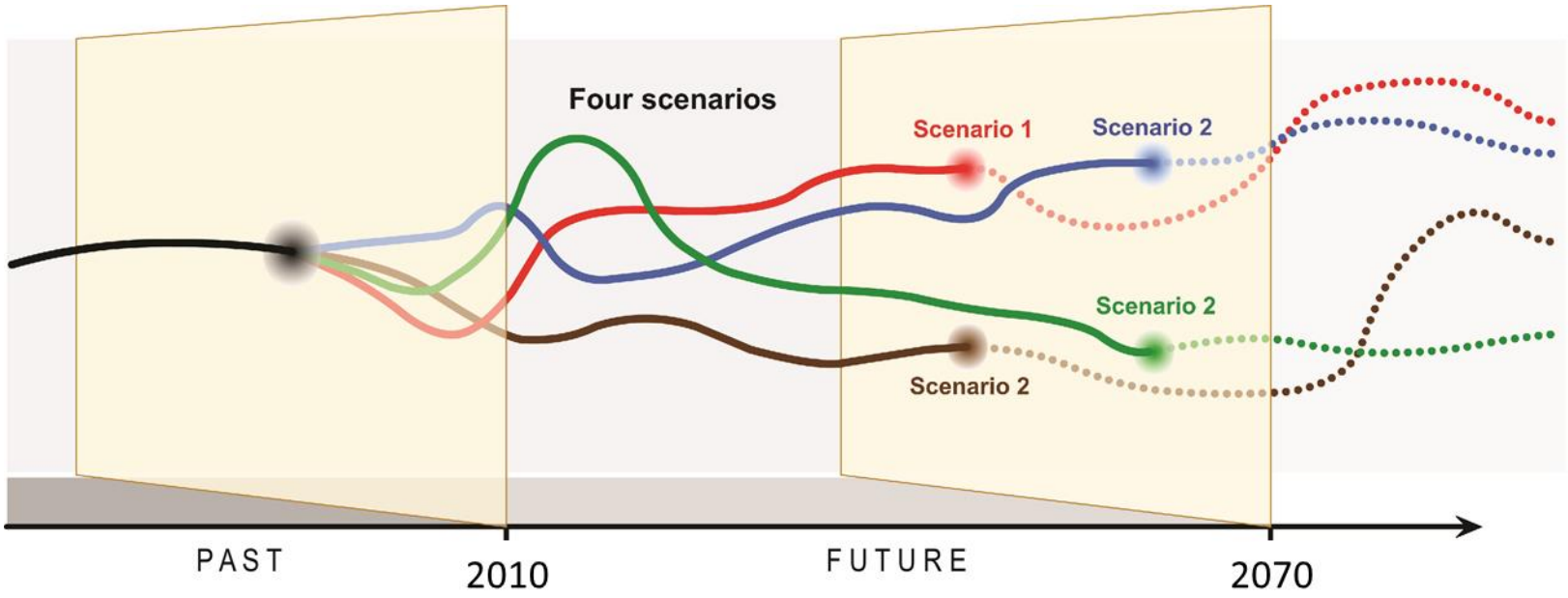


Scenario Narratives

Based on interviews and workshops with regional leaders, and the international scenarios literature

Four clusters of beliefs about pathways for the watershed to 2070

Each narrative is a story about one of these pathways.



based on Carpenter et al. 2005

Scenario Storylines

Tentative Name:	Nested Watersheds	Abandonment & Renewal	Accelerated Innovation	Connected Communities
Dynamics:	Adaptation	Transformation	Adaptation	Transformation
Key Factor in Change:	Government	Inaction	Technology	Values
Nutshell:	Government intervention maintains nature's benefits	Disaster decreases population, leads to reorganization	Massive growth in technology businesses, including green tech	Global shift in values toward sustainability

Nested Watersheds

In Nested Watersheds, rigorous centralized management is employed at the watershed scale to adapt to severe variations in the climate. Clean and sufficient water is the overarching goal.

Illustration draft by John Miller

Abandonment and Renewal

The Abandonment and Renewal images depict the aftermath of an environmental catastrophe that wipes out or drives away most of the population.

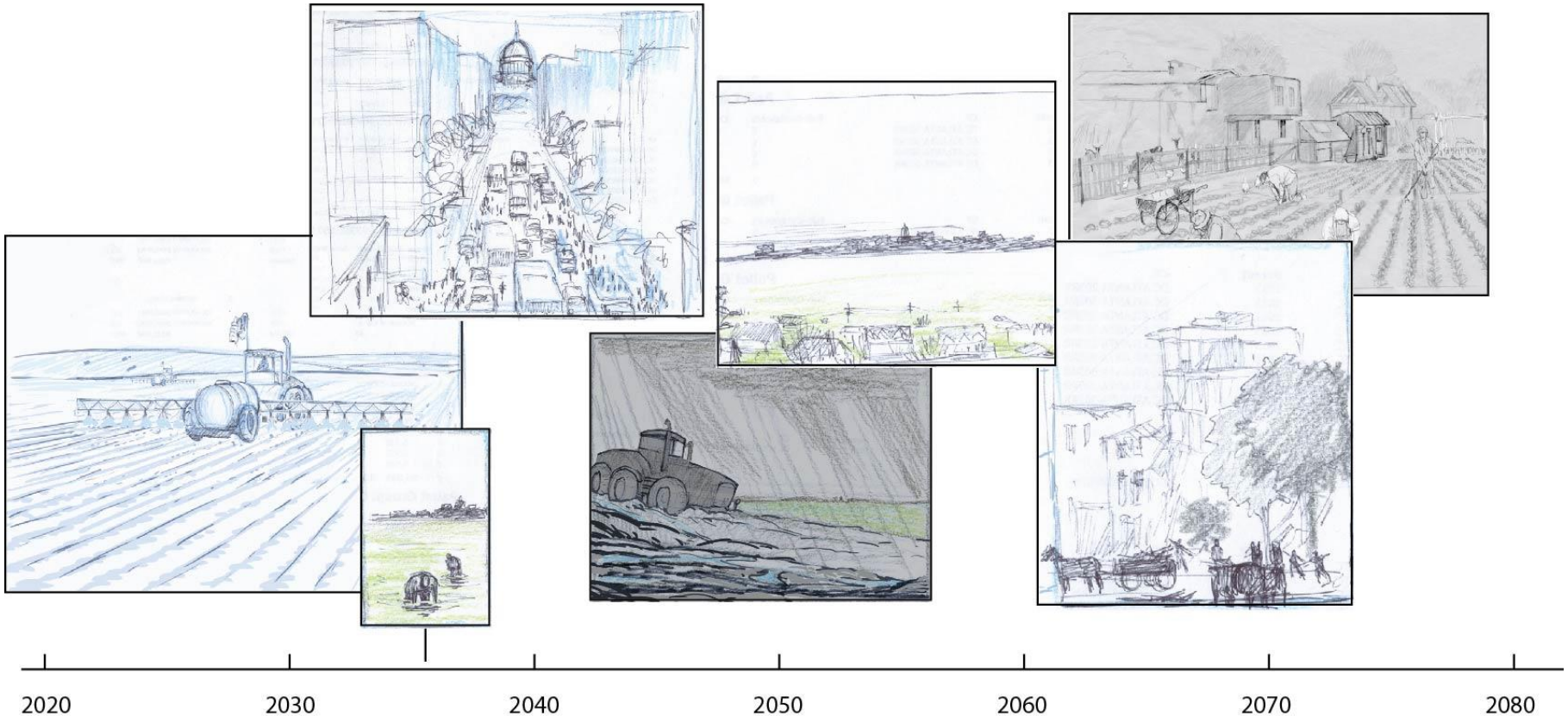


Illustration draft by John Miller

Accelerated Innovation

Accelerated Innovation is characterized by big investments in technological advancement.
The landscape is highly engineered for managing ecosystem services,
the built environment is high-tech, and high-density development is the paradigm.

Illustration by John Miller

Connected Communities

In Connected Communities, the landscape is managed according to principles that center on long-term viability of communities and the living systems on which they depend. The landscape evokes the collective shift in human values toward connection, sustainability, qualitative well-being, and fairness.

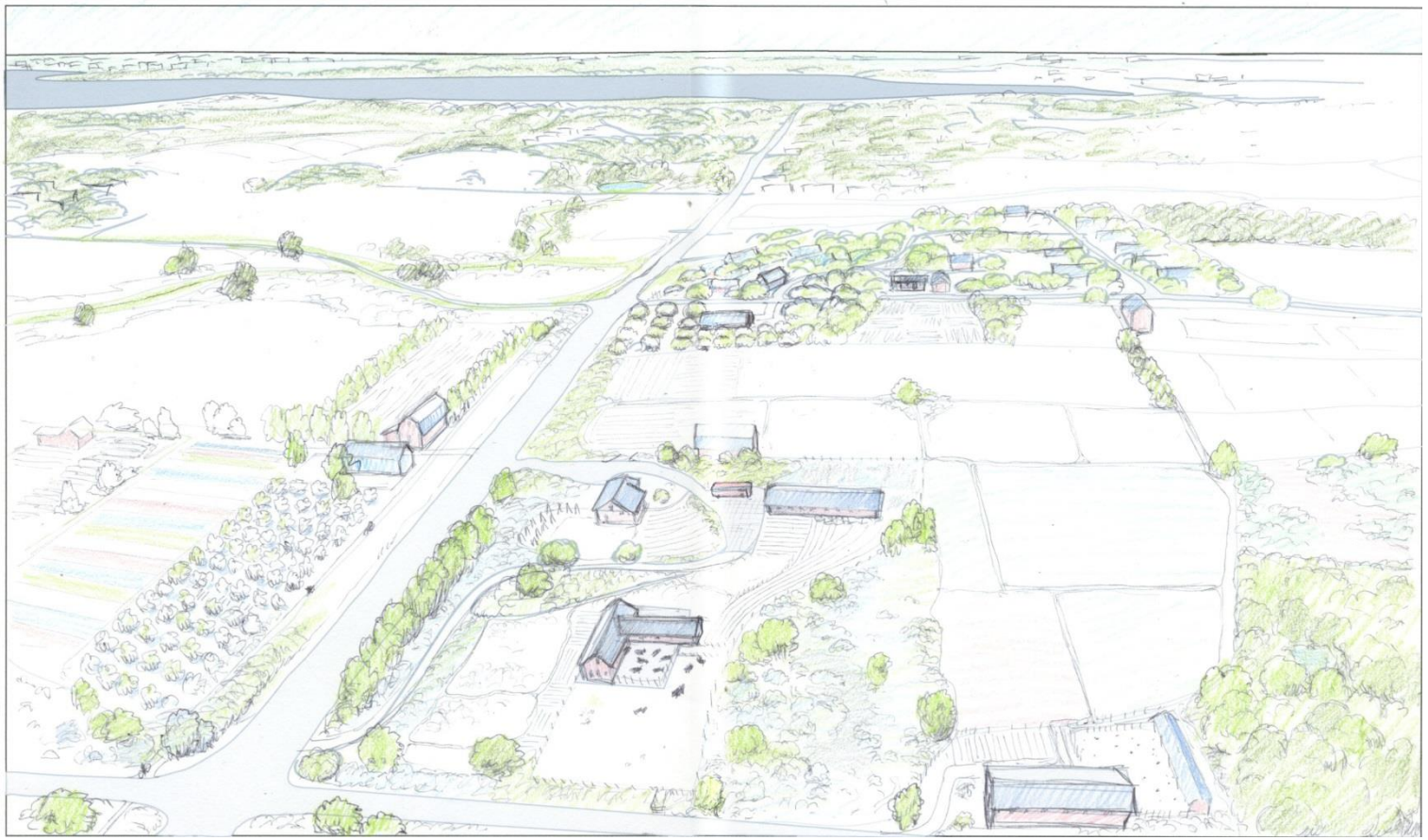
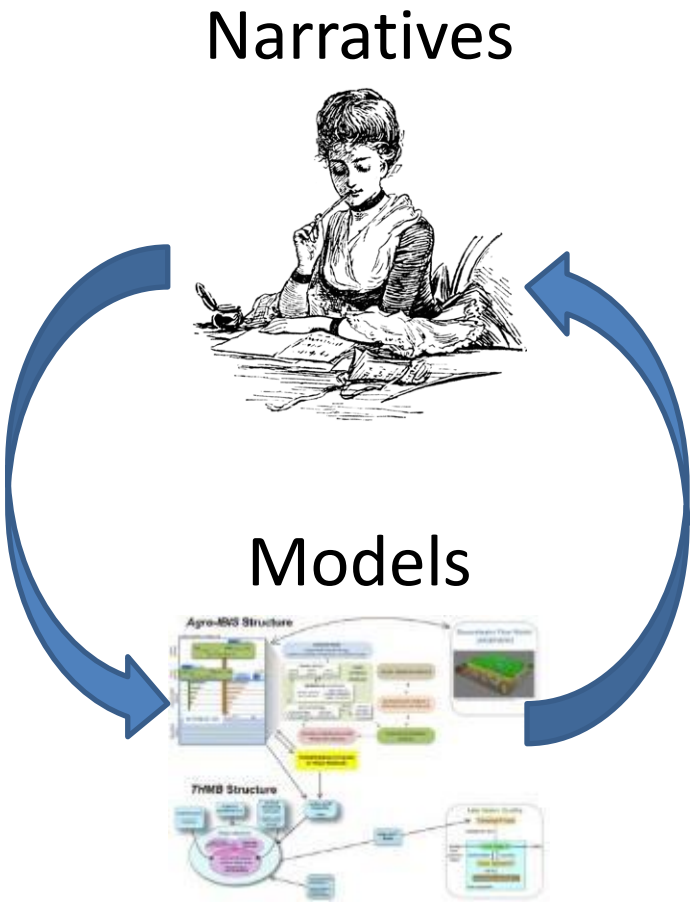


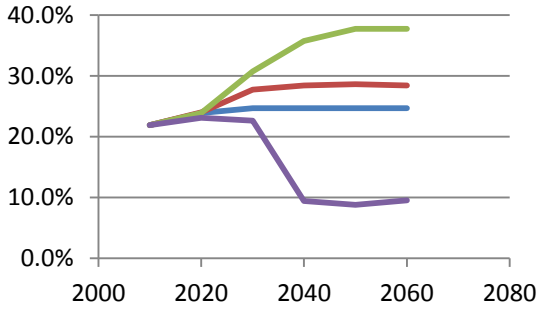
Illustration draft by John Miller

Translating Narratives Into Model Inputs

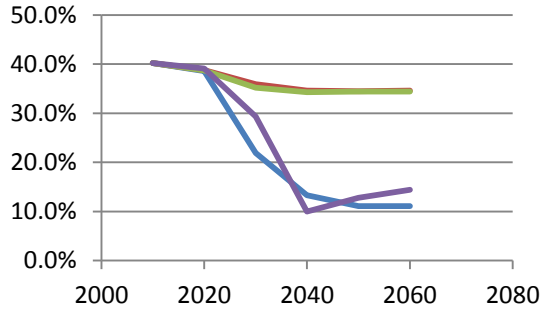
- Step 1
  - Determine broad climate model drivers
  - Determine broad land-use model drivers
- Step 2
  - Spatially distribute land-use changes (rule-based transitions)
- Step 3
  - Determine more specific management practices (e.g., nutrient management, tillage, small-scale water management)
- Step 4
  - Create model input files



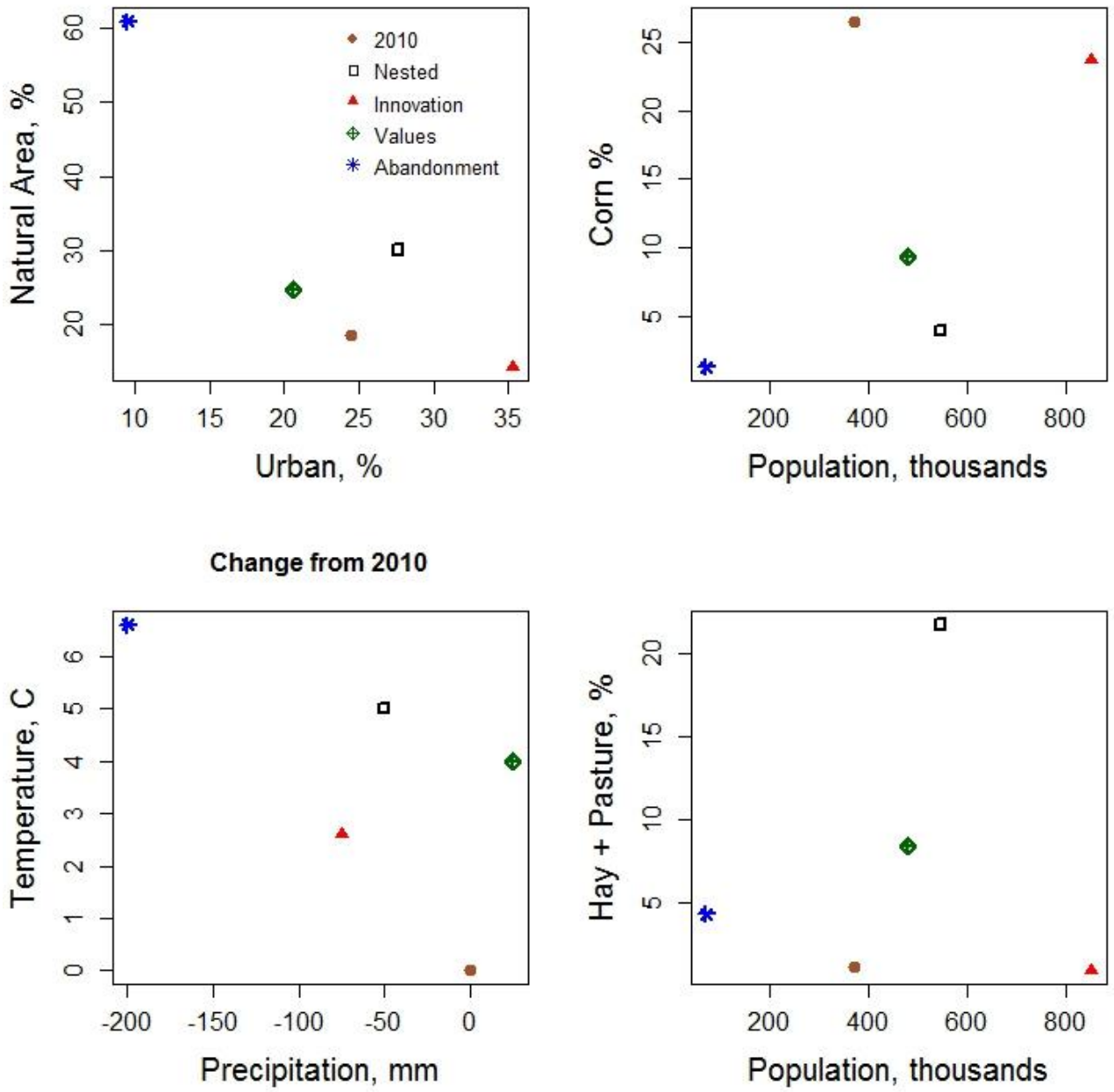
% urbanization



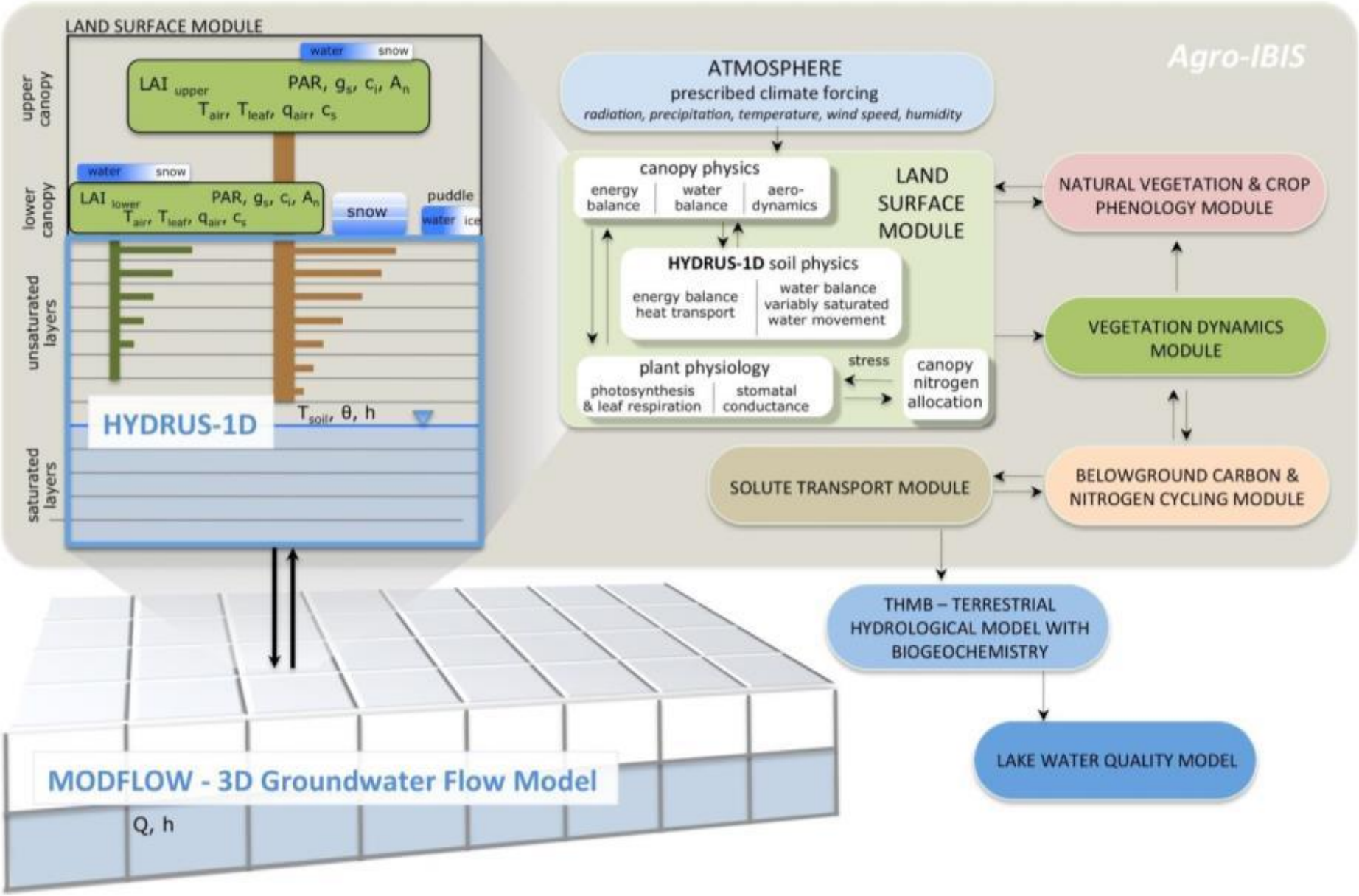
% agriculture



Driver Values Differ Widely by the Last Decade of the Scenarios



Quantitative Modeling



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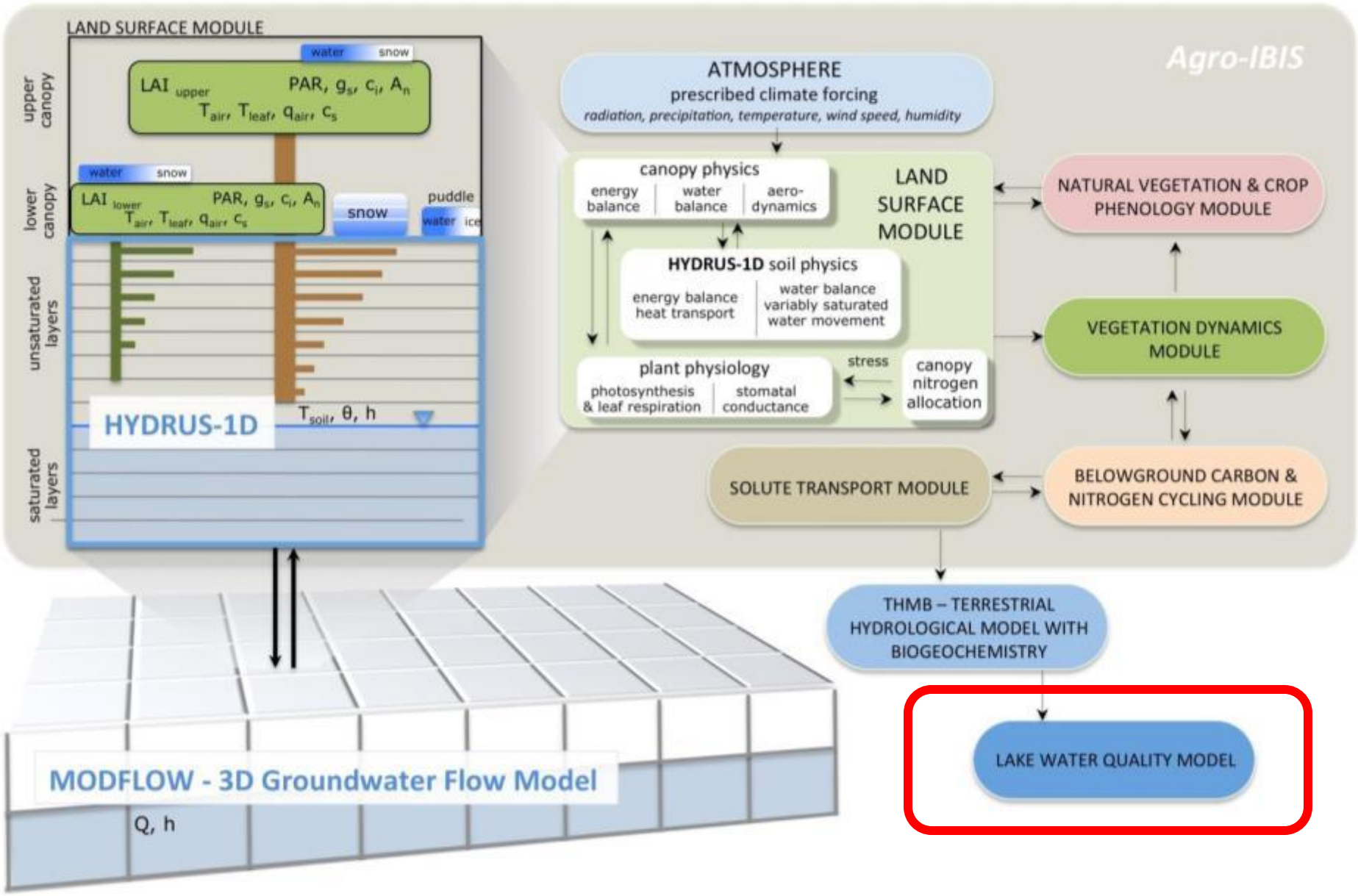
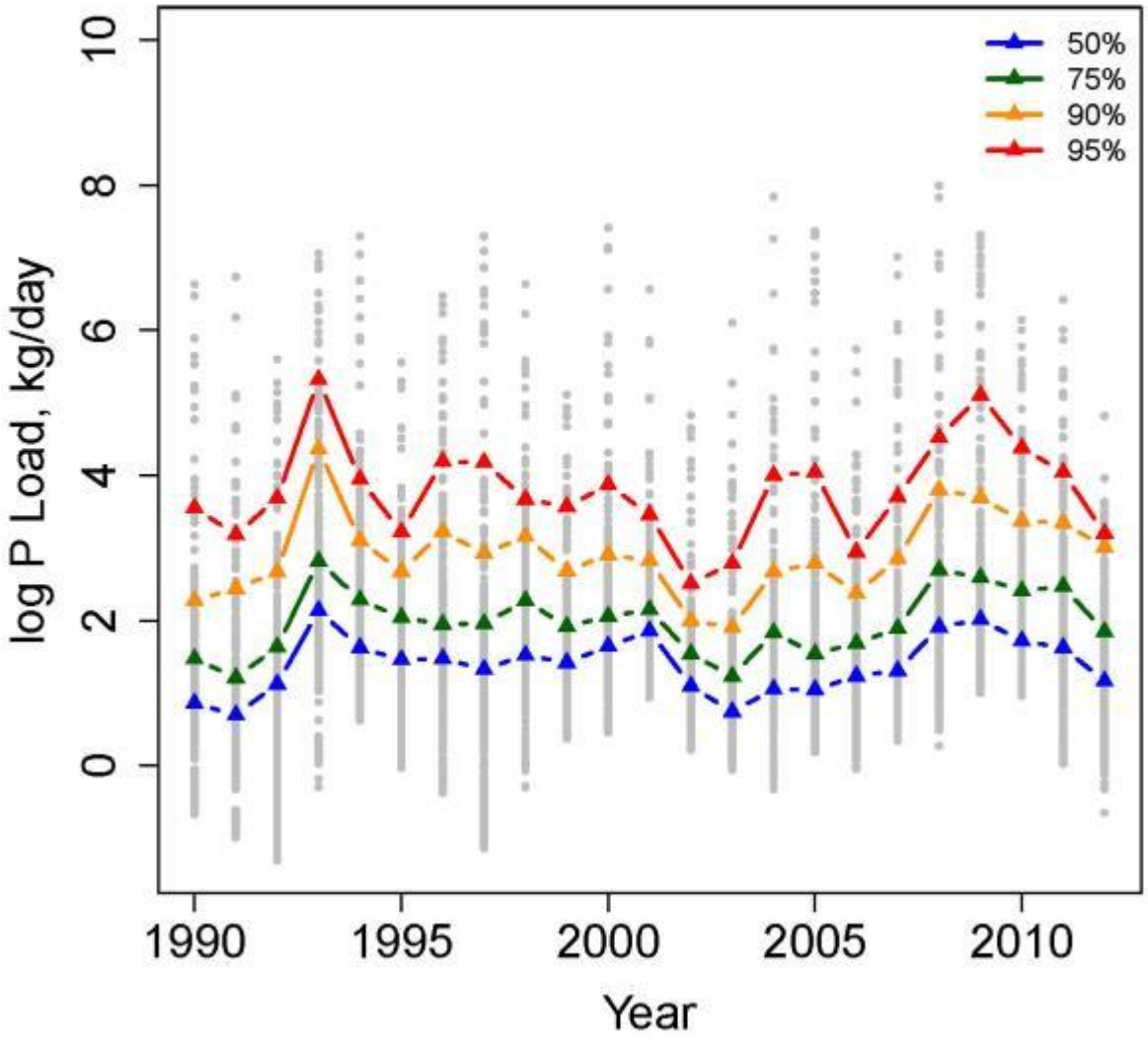
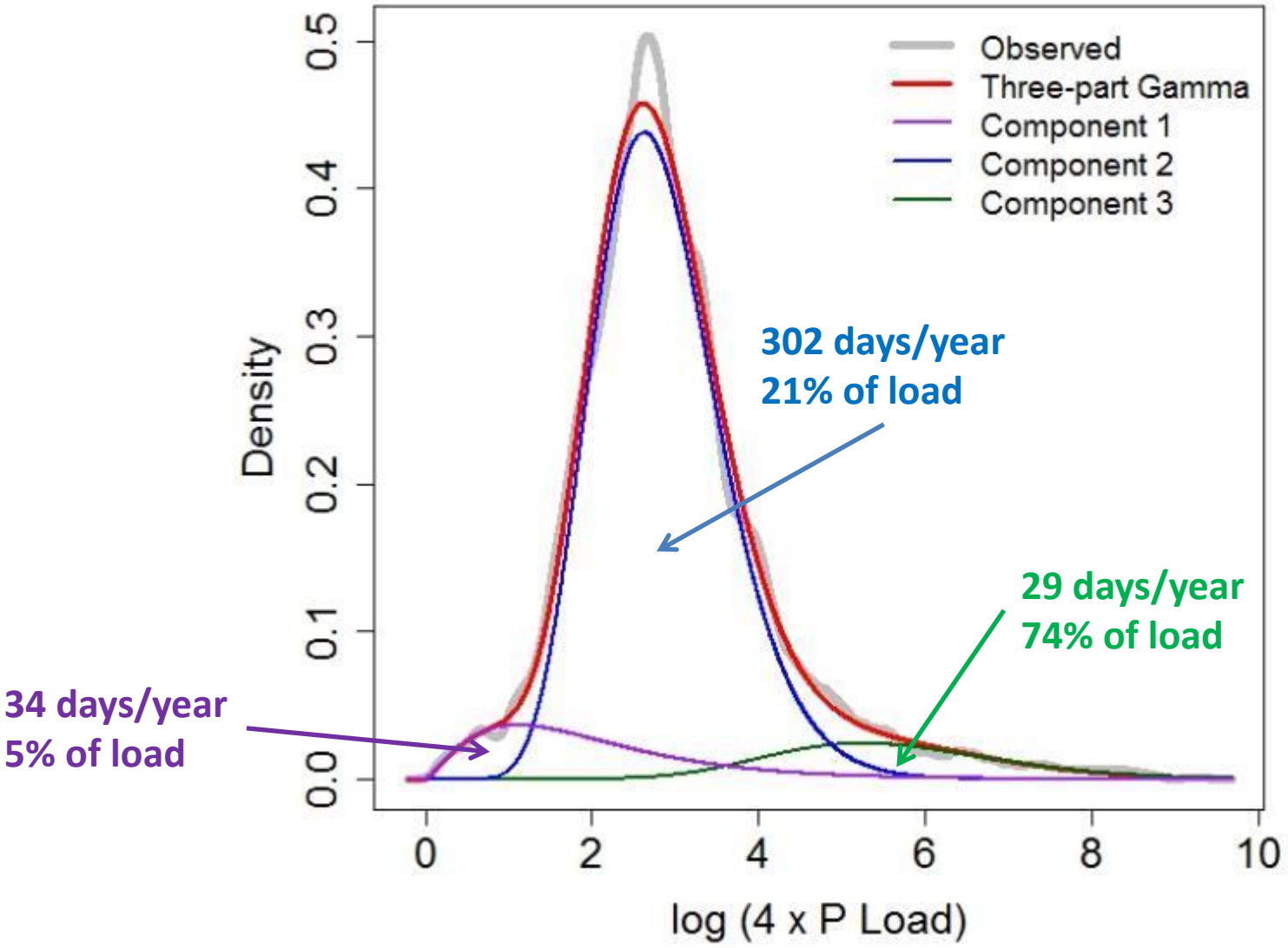


23 Years of Daily P Load Data to Lake Mendota From the Yahara River



Three-part Gamma Distribution Fit to Observed Daily Load Data



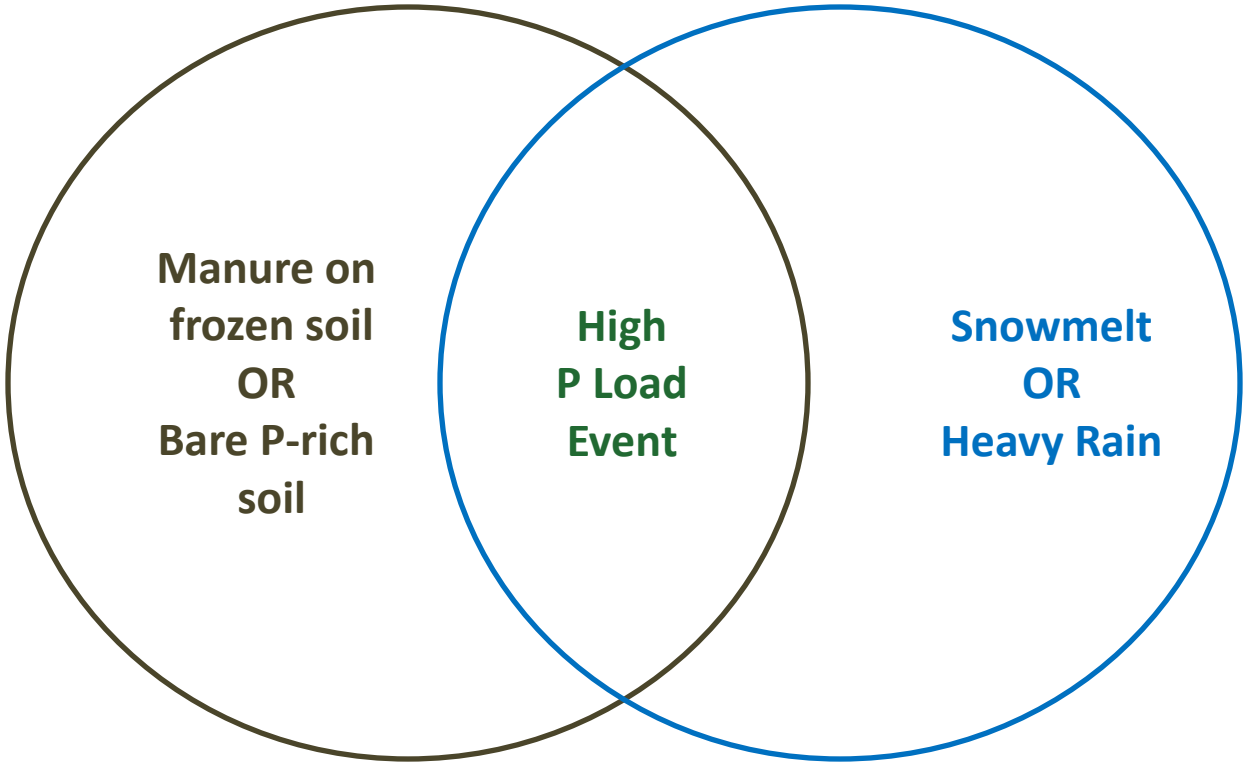
Causes of High-P-Load Events

Phosphorus pool in soil + manure >>> Annual flux to the lakes

Mendota watershed:

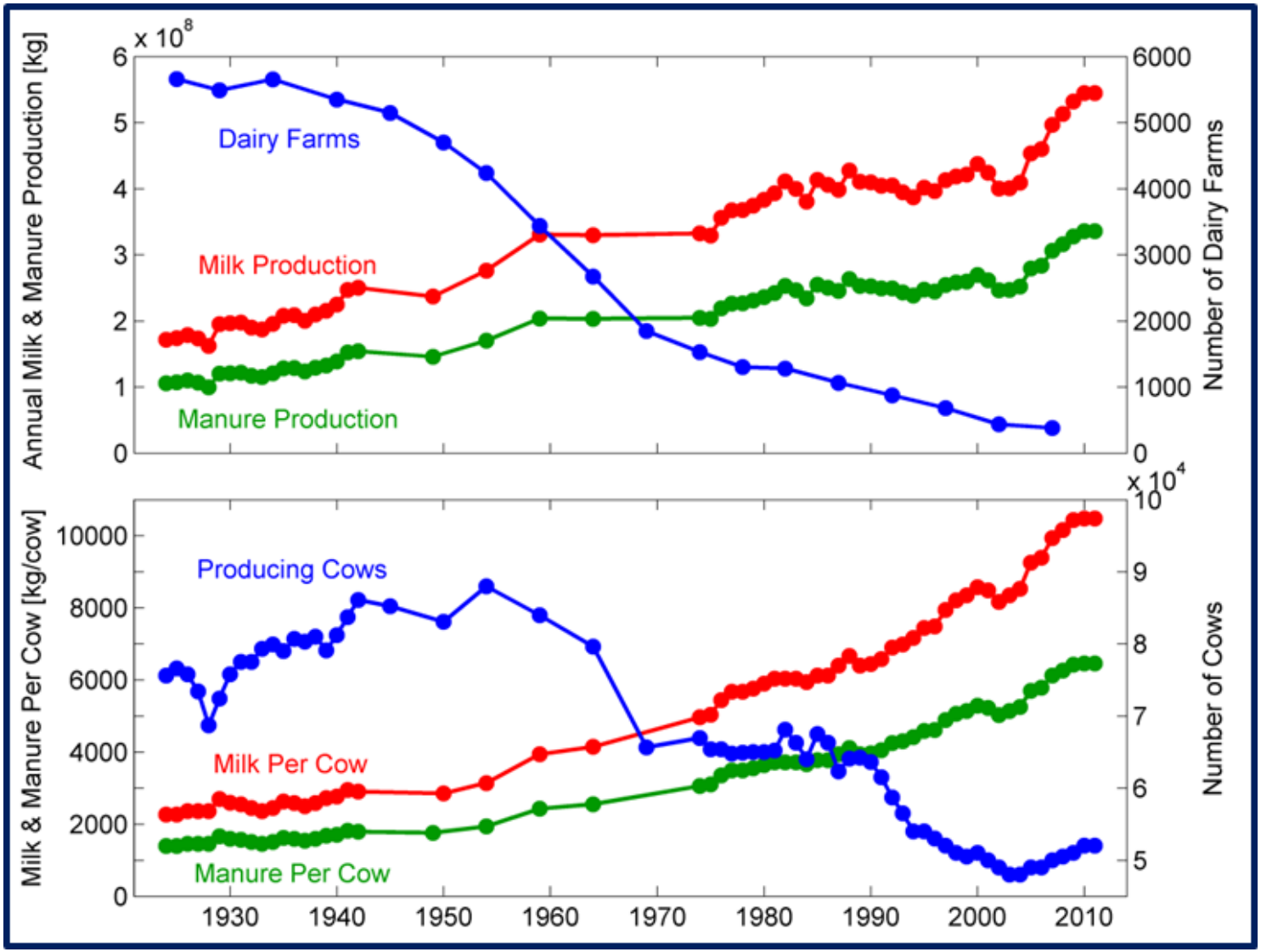
Annual net P addition to soil = 302 tonnes / year

Annual P load to lake = 12.4 to 78.4 tonnes / year



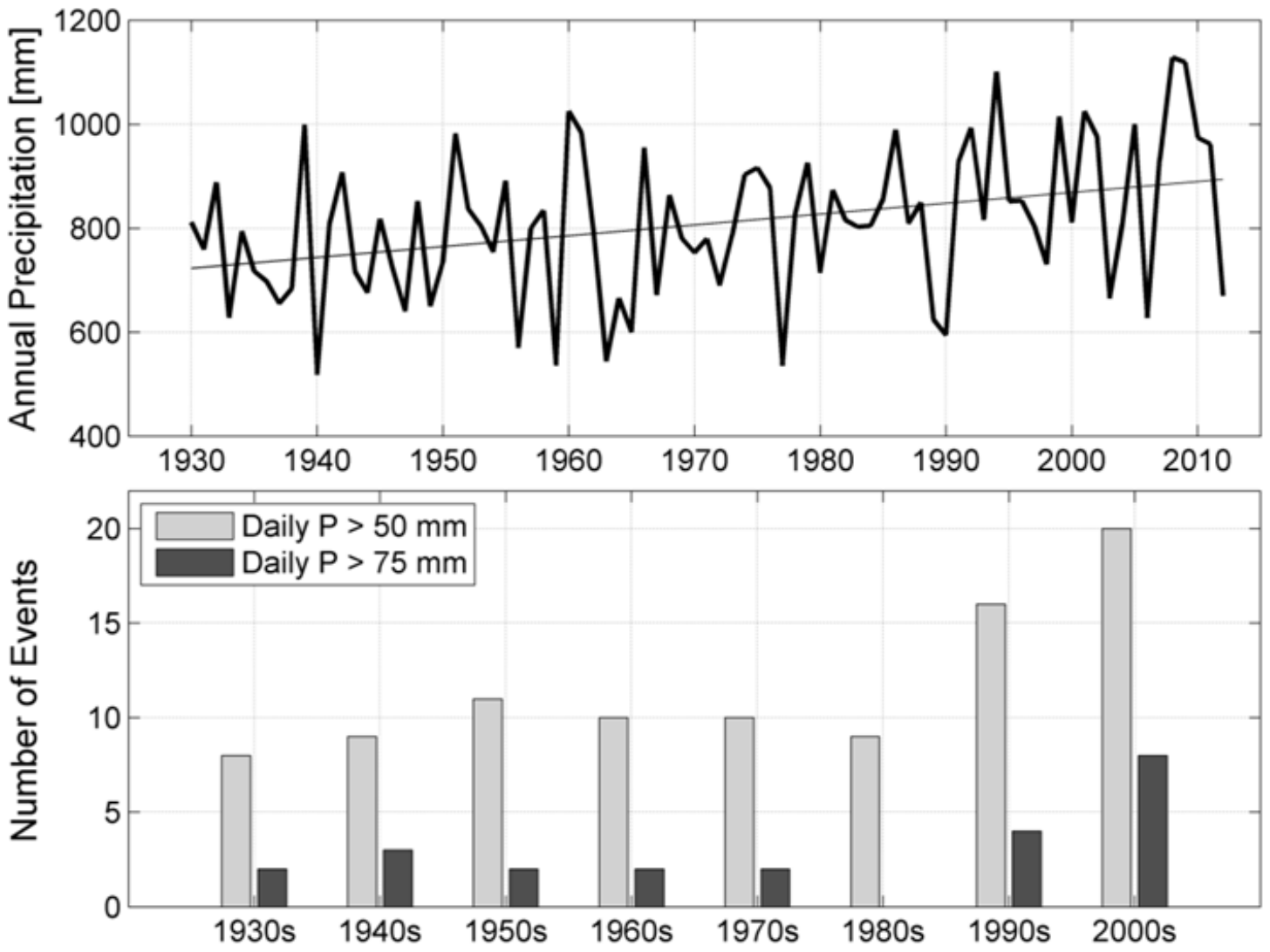
Bennett et al. Ecosystems 1999; Kara et al. Aquatic Sciences 2011; Lathrop & Carpenter Inland Waters 2014

Bullish outlook for manure . . ..



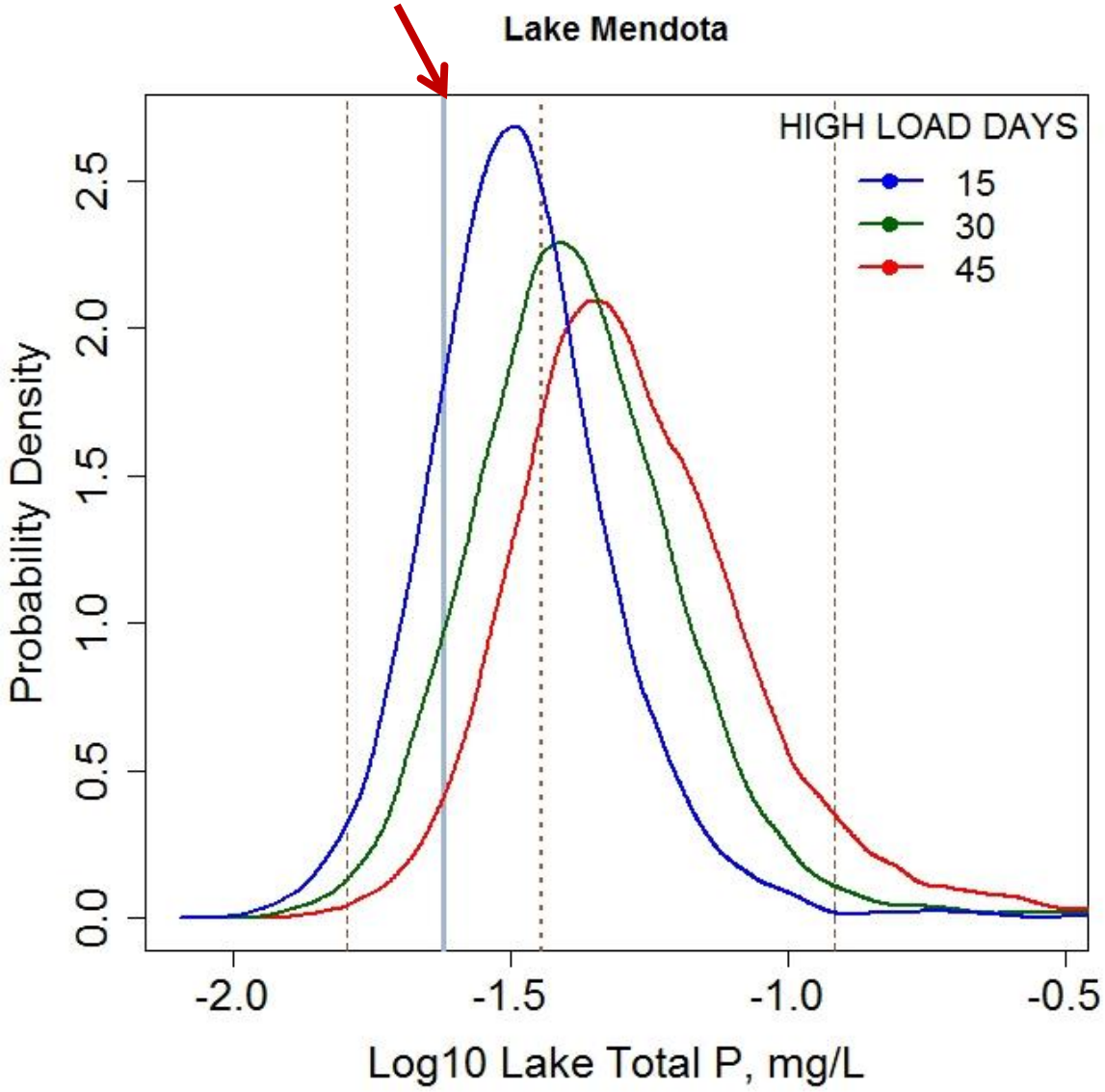
Eric Booth and others, unpublished

More precipitation, and more big storms:



Eric Booth and others, unpublished

With more high load days in a year, it is harder to reach water quality targets



Main Points (1):

Starting from the observed range of beliefs about the future, four scenarios were built to span a wide range of plausible futures.

Narrative stories + art → Models and quantitative analyses

Extreme events will drive lake responses.

Modeling extreme events is a current challenge.

Main Points (2):

Long term thinking is needed to understand & manage ecosystems.

Scenarios make the future concrete, accessible, and human.

Scenarios evoke discussion of options and logical consequence without advocating.

Scenarios are well-suited to education and outreach.

Scenarios challenge our current models.

Scenarios generate hypotheses for long-term research.

Long-Term Ecological Research:

Historic legacies shaped the present

Current events will shape the future

time

now

Long-term observations
Long-term experiments
Cross-system comparisons
Models and Theories

Scenarios
Models
Theories

LTER

University of Wisconsin
Center for Limnology

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