WISDM: Understanding Feedbacks Between Human and Natural Systems through Changes in the Institutions of Water Resource Management

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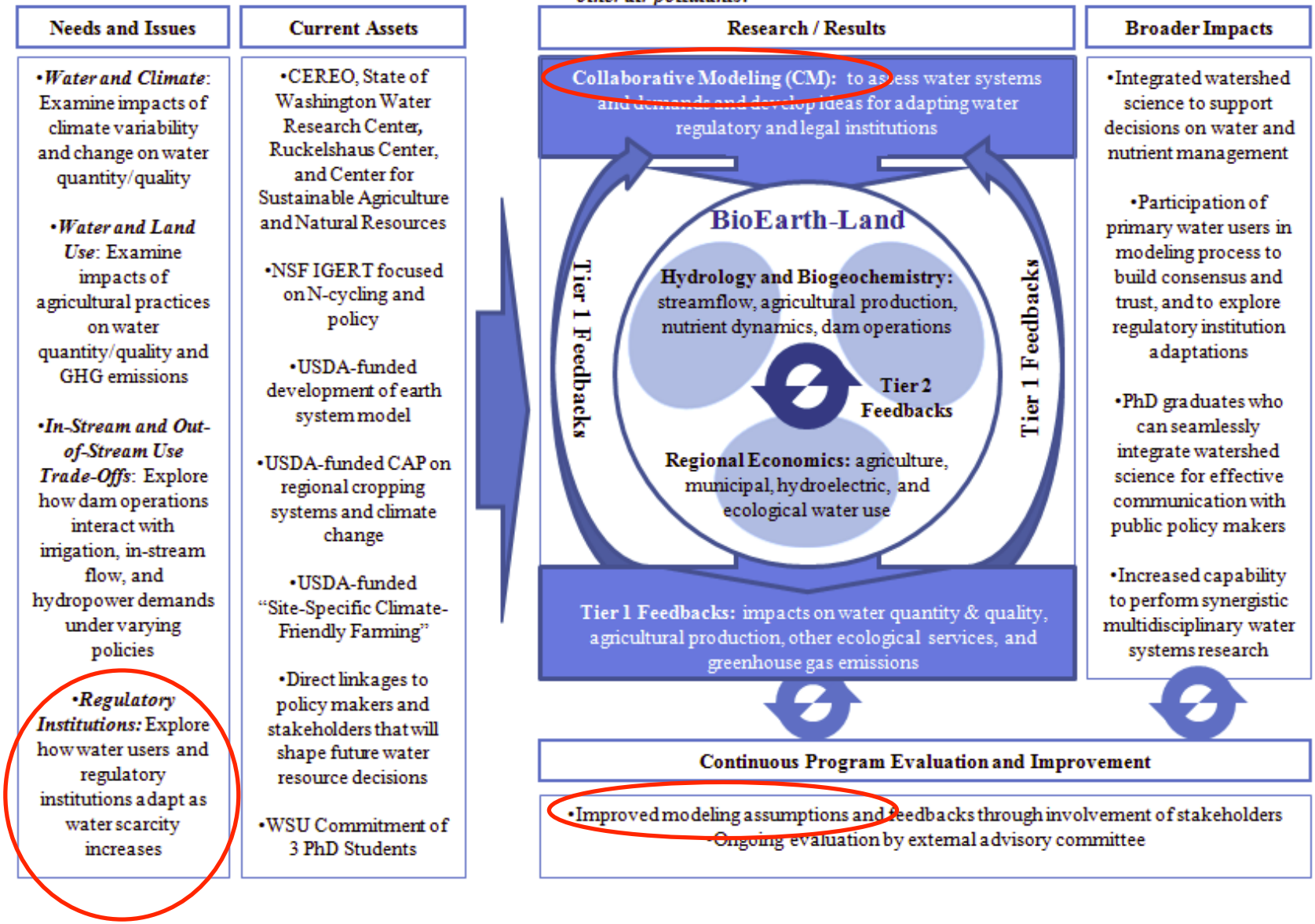
Watershed Integrated System Dynamics Modeling (WISDM) Overarching Question:
As Columbia River Basin (CRB) climate and land use change over the coming decades, how are biophysical and social systems likely to co-evolve to promote the sustainability of water quantity, water quality, and agricultural productivity, while minimizing greenhouse gas (GHG) emissions and other air pollutants?



Key motivation for WISDM

- Interdisciplinary group had experience in model development and integration in previous projects (BioEarth).
- WISDM does have a significant model development and integration component.
- However, WISDM focuses more on social science integration.
  - Management
  - Political action
  - Economics
  - Law
- Goal:
  - More empirical analysis to better understand bottom-up and top-down decision making.
- Result:
  - Improve the predictive ability of large integrated modeling efforts.
  - Identify key decision making characteristics that can simplify modeling.

Two difficult aspects to modeling human decision making

1. People are forward looking (even though that often doesn't seem to be the case).
   - Dynamic models with expectations are complicated.
   - Expectations incorporate public information but are ultimately subjective, which can make them even more complicated.
   - Do we get it right in the aggregate?

2. People have different preferences that shape priorities.
   - Must account for codetermined political and economic systems that feedback with the expression of individual preferences.
   - Used to be a discipline called "Political Economy".

Endogenous Institutional Change

- Want to avoid modeling changes in water management institutions in ad hoc way.

- For example:
  - "What if water markets develop?"
  - "What if there is a water rights adjudication?"
  - "What if there is water quality trading?"

- These "What ifs" could be modeled.

- However, without a greater ability to predictively model them happening in a probabilistic way problems arise.

- Barb Cosens' expertise in water law is a big part of this effort.

Endogenous Institutional Change

- Quantify the distribution of costs and benefits across stakeholders and model incentives present to seek to influence change.

- A preliminary question to modeling a water rights adjudication...
  - Ask, “Why was there a basin wide adjudication in the Yakima Basin initiated in the late 1970’s?”
  - Can answering this question help us predict when an adjudication may happen elsewhere?

- Adjudications clarify property rights over water which are a prerequisite for water market development.

- Now we can more realistically model the development of water markets.

Another example...

- The Kittitas moratorium on exempt wells was another instance of addressing an issue of incompletely defined water rights.
- Increased groundwater pumping with water rights imposed costs on senior water rights holders who sought to change water policy and management.
- How bad did it get before they acted?
- The answer to this helps us understand when incomplete property rights problems are addressed.
- Also, use water market development in Colorado, California, and Arizona to understand Washington's future.

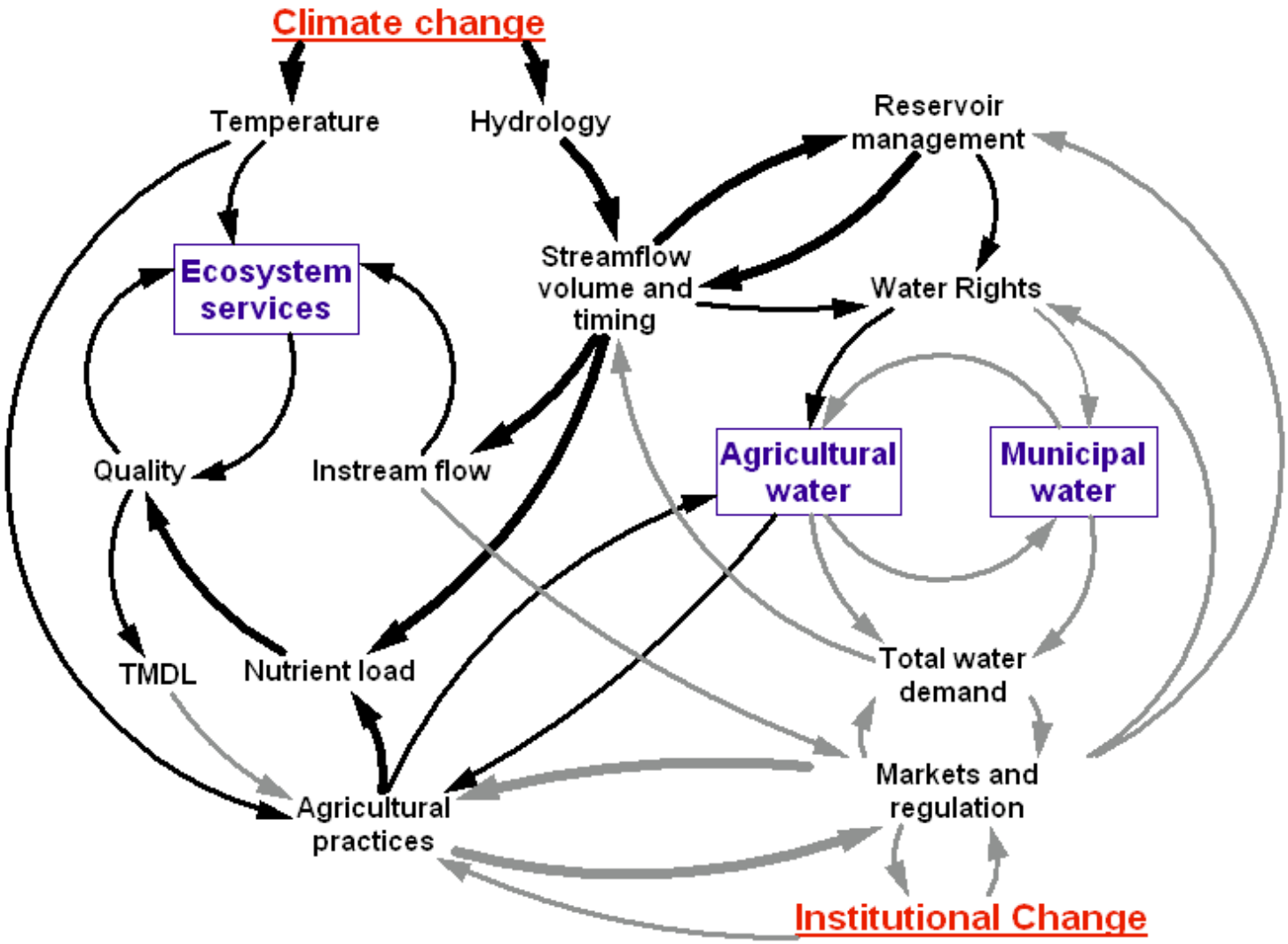
A final example...

- Water rights are based on diversions rather than consumptive use.
- Why? Likely due to transactions costs of monitoring.
- Will this change as information technologies develop?
- How is this affected by water market develop where transfers are over consumptive use?

Individual decision making

- Allyson Beall-King uses the approach of Participatory Modeling to achieve two goals:
  1. provide a system for stakeholders to better understand the functioning of the hydrological system.
  2. reveal important aspects of human comprehension, decision making, and preferences.

- The Holy Grail: can we identify decision making characteristics that allow for simplifying models AND improved predictive ability?


Climate change
Temperature
Hydrology
Reservoir management
Ecosystem services
Streamflow volume and timing
Water Rights
Quality
Instream flow
Agricultural water
Municipal water
TMDL
Nutrient load
Total water demand
Markets and regulation
Agricultural practices
Institutional Change

Participatory modeling reveals

- What information people focus on.
- Whether stances on preferred policy responses changes as understanding of the hydrological system improves.
- Preferences over costs and benefits of altering systems.

Empirical analysis

- Focus on identifying what are called “quasi- or natural experiments” in the econometrics literature to reveal decision making.
- Very complex dynamic stochastic economic models exist.
- However, we know farmers are
  - heterogeneous in a number of ways
  - use rules of thumb
  - form expectations of future conditions in different ways.
- Of course they do once one considers the opportunity cost of time.

Example

- Analyze irrigation technology choices on borders of irrigation districts that differ in the probability of drought but are very similar in all other ways.

- Finding: irrigators curtailed 50% 1 in 5 years are 5% more likely to invest in an efficient irrigation system.

Conclusion

- A critical component of understanding feedbacks is institutional change.

- Want this effort to shape scenario development.