Putting the Social in Social-Ecological Systems….

Chris Koliba
Professor and Social Systems Team Leader

BREE All Hands Meeting
June 12, 2018

EPS 1101317

Lake Champlain Basin Socio-Ecological Systems

Scientific Domain	Frameworks	Theories
Systems Science	Computation; Feedback; Feedforward;	**Social Ecological Systems**
Natural Science	Water; Soils; Biogeochemistry	
Behavioral and Decision Science	Incentives; Practices; Choices	
Policy Science	Policy & Governance	

Young OR, Berkhout F, Gallopin GC, Janssen MA, Ostrom E, and Leeuw SVD. (2006). The globalization of socio-ecological systems: An agenda for scientific research. *Global Environmental Change* 2006;16(3):304-316.

What is the future alternative state of Lake Champlain?

It’s 2035….

THE CHAMPLAIN SEVEN-DIGGER-TIMES INDEPENDENT DAILY

Your only remaining consolidated news source for Lake Champlain Valley

FREE WEEKLY NEWS PRESS .NET

$10

All proceeds to rescuing Elon Musk from Mars
Bring him home!

Today: mostly sunny 81/58, Tomorrow: snow flurries 34/22

May 24, 2040

Write your headline here

1. Does the conceptual map need to change to fit your storyline? If so, how?

2. What are the primary factors that led to your storyline?

Construction of Winooski dome remains on schedule despite tragic accident

THE CHAMPLAIN SEVEN-DIGGER-TIMES INDEPENDENT DAILY
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All proceeds to rescuing Elon Musk from Mars
Bring him home!
Today: mostly sunny 81/58, Tomorrow: snow flurries 34/22
May 24, 2040

Like Champ Cyanobacteria is a Rare Sighting

Write your headline here

1. Does the conceptual map need to change to fit your storyline? If so, how?	2. What are the primary factors that led to your storyline?	*Construction of Winooski dome remains on schedule despite tragic accident*

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All proceeds to rescuing Elon Musk from Mars
Bring him home!

Today: mostly sunny 81/58, Tomorrow: snow flurries 34/22

May 24, 2040

Population Increases Brings Problems for Water Quality

Write your headline here

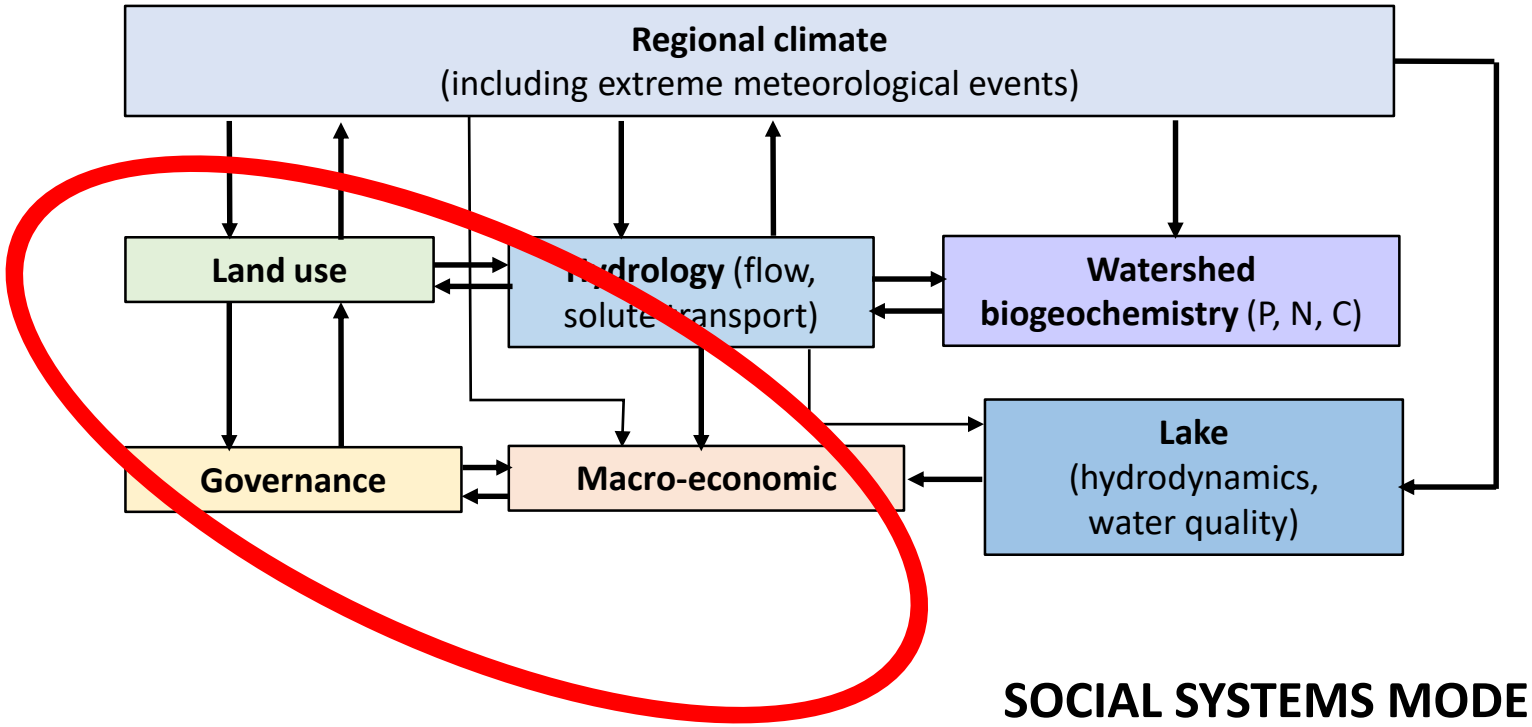
1. Does the conceptual map need to change to fit your storyline? If so, how?

2. What are the primary factors that led to your storyline?

Construction of Winooski dome remains on schedule despite tragic accident

Social Systems:

Major features



SOCIAL SYSTEMS MODELS

BREE
Basin Resilience to Extreme Events
in the Lake Champlain Basin

Overarching Research Question for Social Systems:

- *How do governance networks, institutional rules, macro-economic indices and resource allocation decisions respond to extreme events, and how can this knowledge be used to design public policies and governance networks that enhance resilience across the Lake Champlain Basin?*

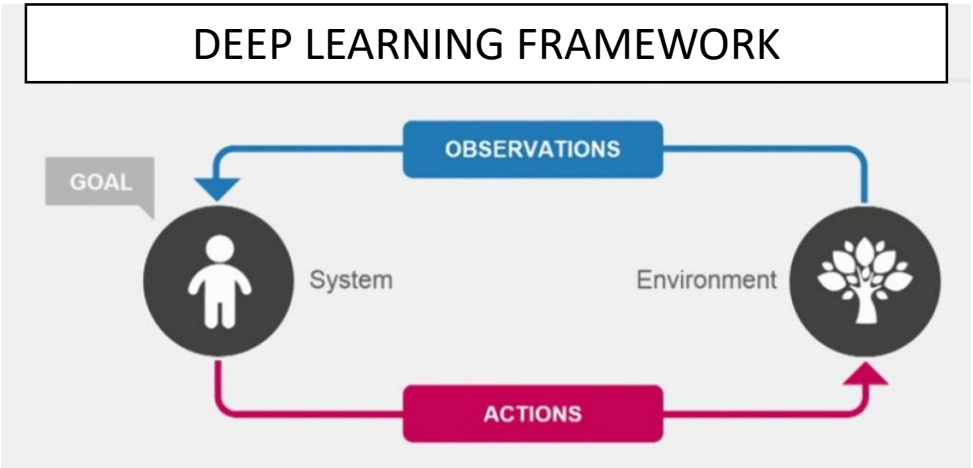
BREE Social Systems Key Concepts:

- **Agents**
  - LAND USERS: farmers, urban residents, rural/forest land owners,
  - GOVERNANCE ACTORS: town managers, watershed managers, policy makers, governments, nonprofits, firms
  - ECONOMIC ACTORS: consumers, owners…
- Agent **rules & behaviors**
  - Rational -> boundedly rational-> non-rational
- Agent **ties**
  - to each other
  - to the land
  - to markets

THE MICRO / MACRO CHALLENGE OF THE GOVERNANCE OF COLLECTIVE RISK IN SOCIAL ECOLOGICAL SYSTEMS

- ***KEY CHALLENGE: To understand the relationship that individual human behavior at the micro scale has to the development of aggregated patterns at the macro scale of larger systems-level phenomena.***

- ***KEY OPPORTUNITY: The more aware that individual and institutional social actors are of the collective consequences of their actions, the more likely they are to behave in ways that protect the security of collective interests*.**



http://visteon.bg/2017/03/02/machine-learning-algorithms-autonomous-cars/

Major Objectives of BREE Social System Team

1.) To collect relevant **social science data** to inform the **design and calibration** of land use, governance and economic agent-based models.

2.) To build and eventually calibrate a **governance ABM** for the Vermont portion of the Lake Champlain Basin.

3.) To extend the **ALL ABM** to include household and forester agents, to integrate reinforcement learning into all agent cognition, and to build in capacity to include water quality best management practices.

4.) To build and calibrate a **Macroeconomic General Equilibrium Model (GEAM)** for the State of Vermont.

Objective 1: Building datasets about individual, stakeholder and institutional response to extreme events

- **Focus Groups** (Tactical Basin Planning; State Agency Resource Allocation)
- **Surveys** (Farmers; Municipalities; Households; Institutions)
- **Network Analysis** (Governance)
- **Digital Field Experiments** (Stakeholder objective functions)

“Action Arena” Focus Groups

- Franklin County Regional Planning Commission

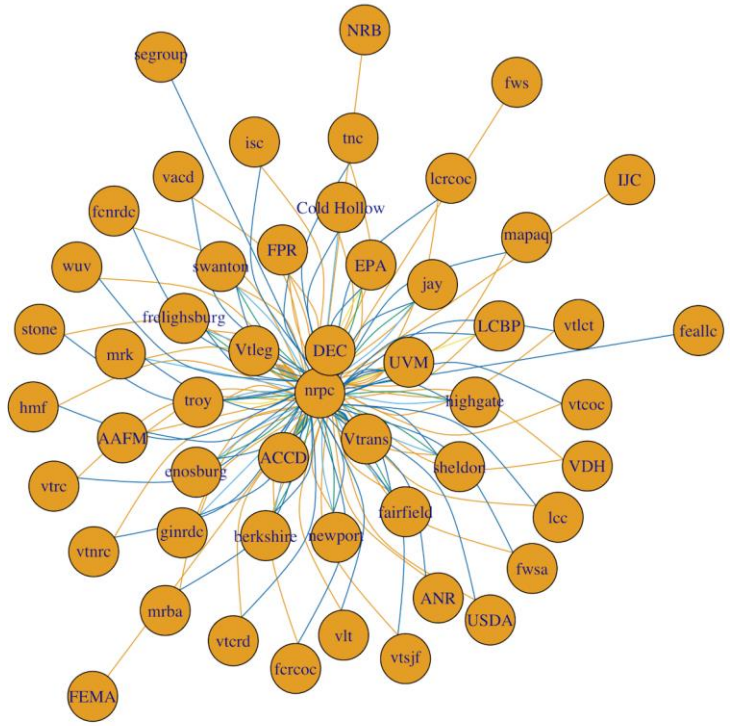


Photo: CWAC focus group: 1/25/18

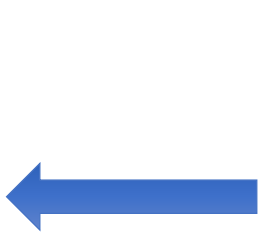
Governance

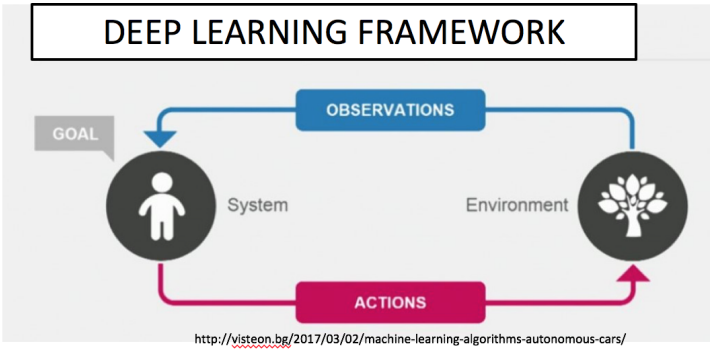
Surveys

- Objectives:
  - To use surveys to validate and calibration ALL and Governance ABMs
  - Design and execute several **surveys of households (1x), farmers (1x), municipalities (2x), institutions (2x)** over the course of the five years of the grant.
    - Data from these surveys will be analyzed and published in stand alone articles.

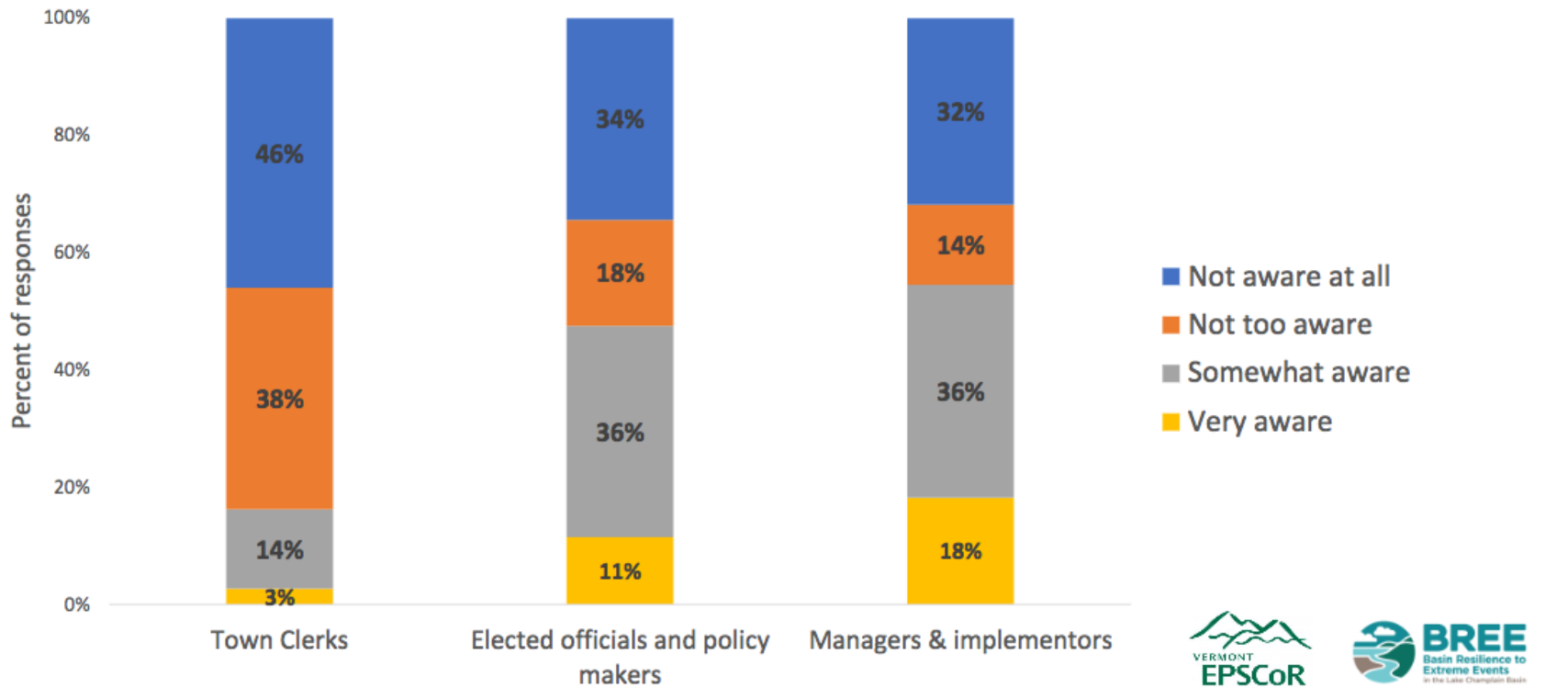
Land use

Governance





Awareness of ANR's Tactical Basin Planning Process



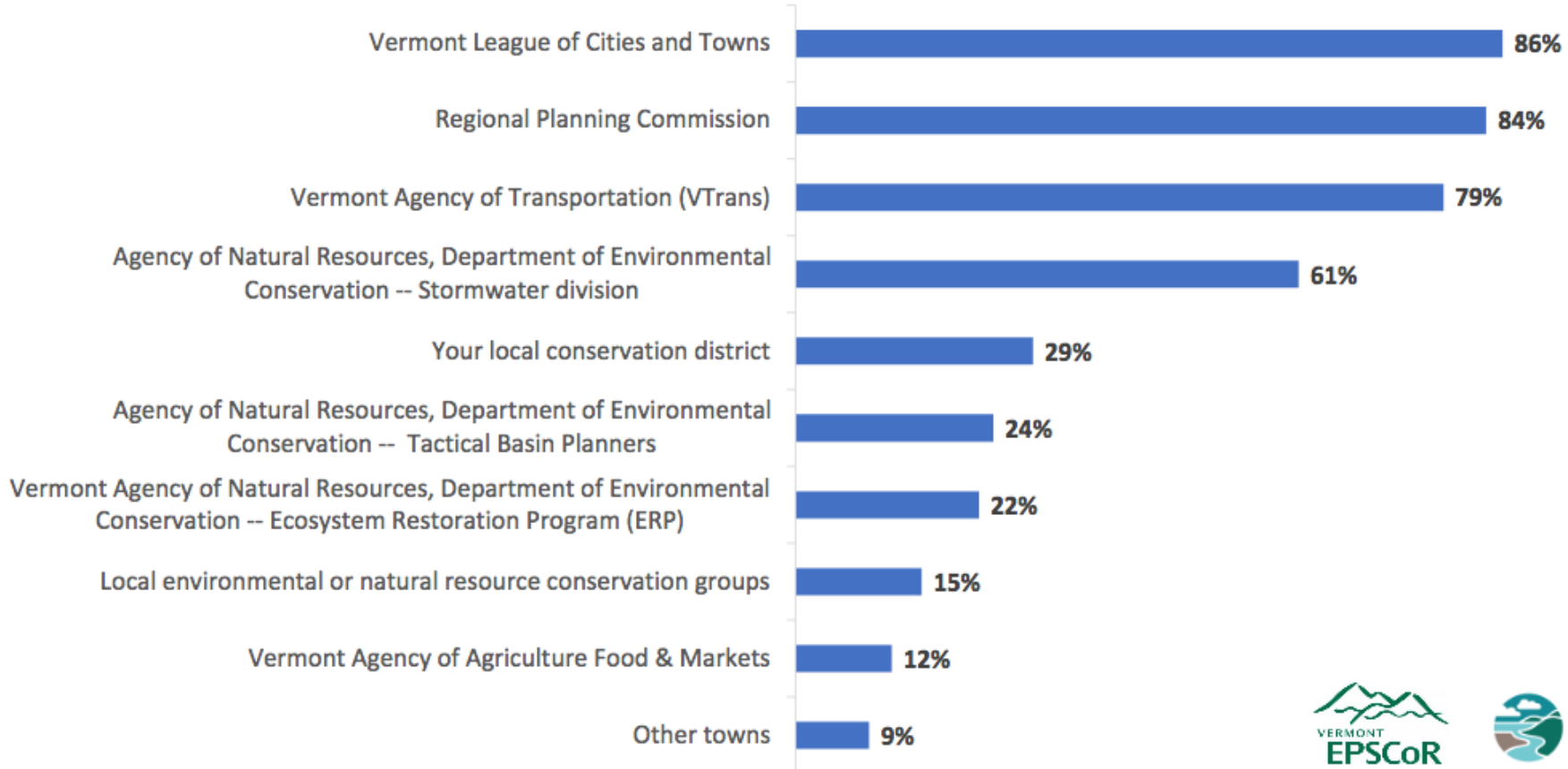
VERMONT EPSCoR

BREE Basin Resilience to Extreme Events in the Lake Champlain Basin

Castleton Polling Institute

The University of Vermont

From whom does the municipality receive technical assistance?



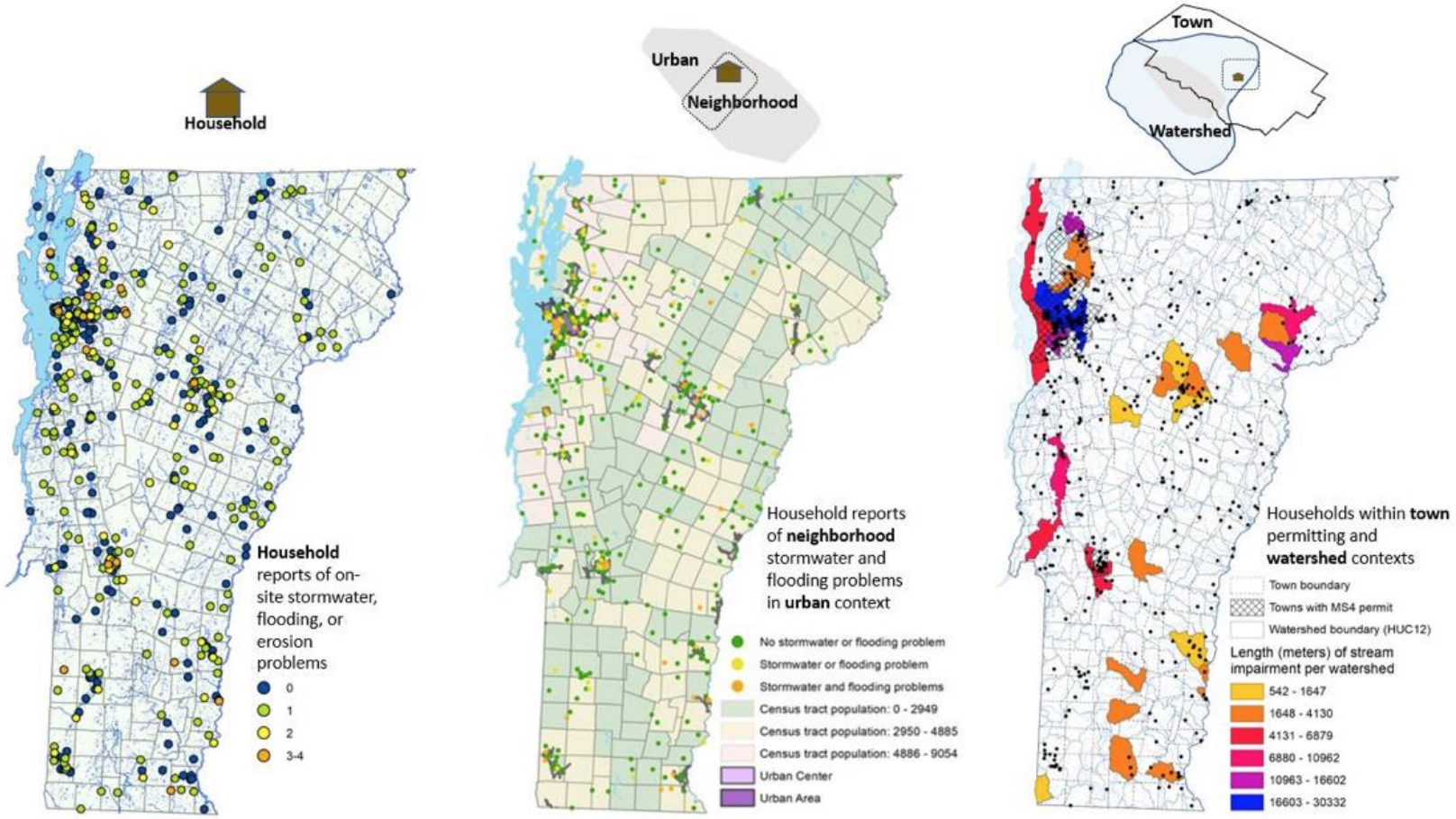
VERMONT EPSCoR

BREE Basin Resilience to Extreme Events in the Lake Champlain Basin

Castleton Polling Institute

The University of Vermont

Household Green Stormwater Infrastructure Survey



“Visualizing bioretention to understand maintenance capacities of Vermont towns and aesthetic preferences of Vermont’s municipal officials”

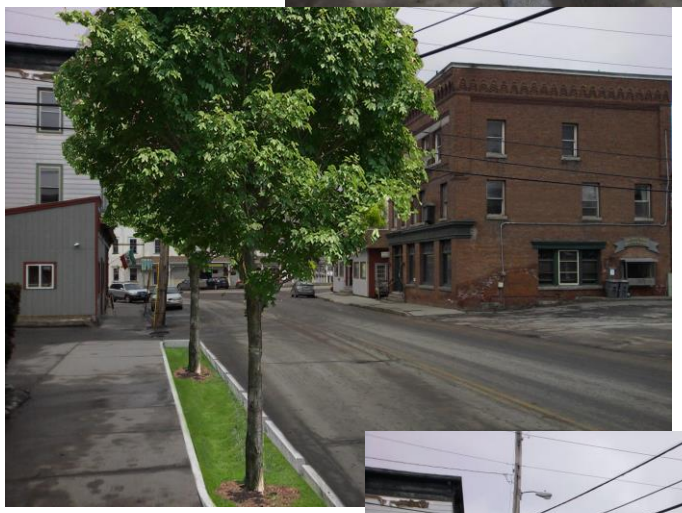
Municipal responders Rate the image pairs displayed as to their…

Visual Appeal

3. Very appealing
2. Appealing
1. Somewhat appealing
0. Neutral
-1. Somewhat unappealing
-2. Unappealing
-3. Very Unappealing
x. I don’t know

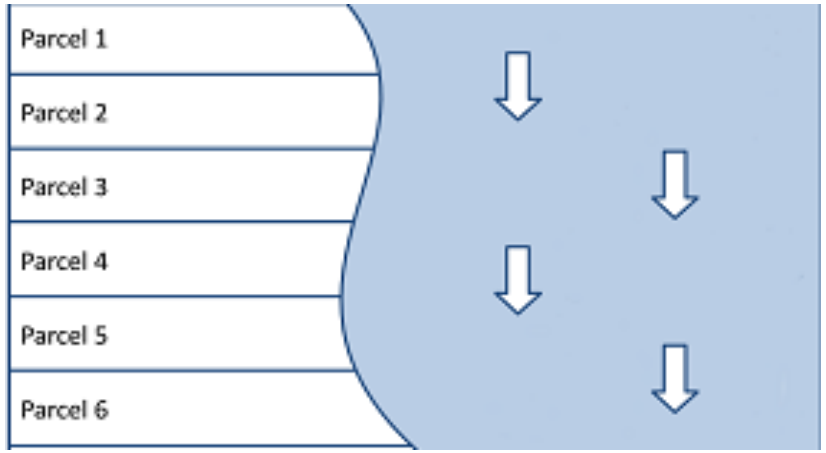
Ability of Town to Maintain

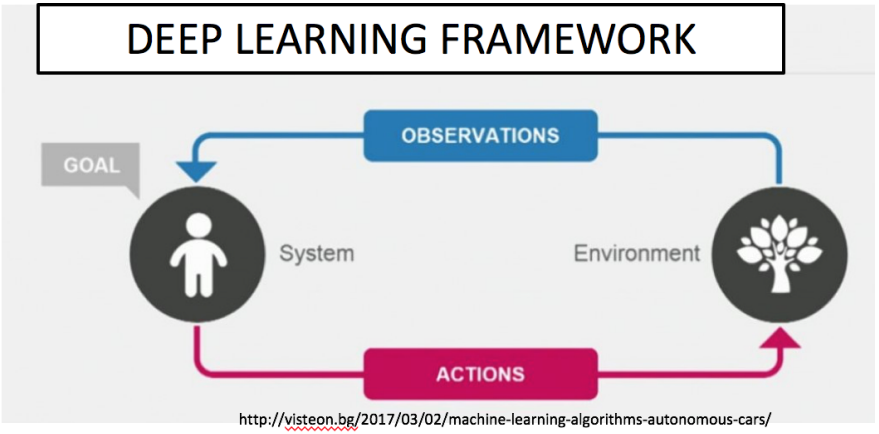
3. Very able to maintain
2. Able to maintain
1. Somewhat able to maintain
0. Neutral
-1. Somewhat unable to maintain
-2. unable to maintain
-3. Very unable to maintain
x. I don’t know



Digital Field Experiments

- Objectives:
  - To use digital field experiments to validate **deep learning** capacity that shape land owners, land use managers and policy makers decisions relative to water quality and extreme events.
  - To use results to calibrate reinforcement learning of ALL and Governance Network ABM agents
  - To published results of field experiments



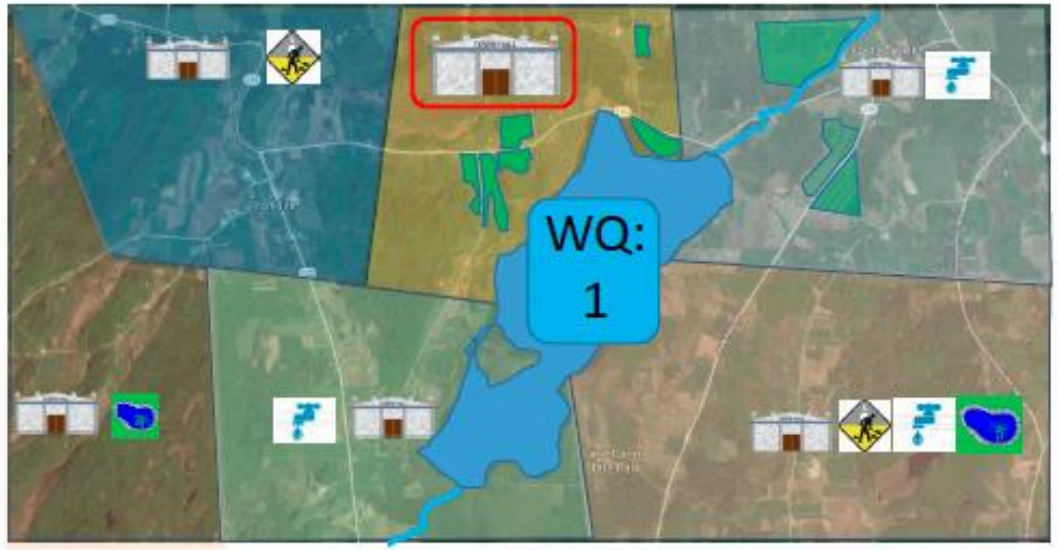


http://visteon.bg/2017/03/02/machine-learning-algorithms-autonomous-cars/

Taxable base 5,000,000*Quality of Life	$500,000
Tax rate	2.00% + -
Tax revenue	$100,000
Fixed costs	$80,000
Subsidies	$20,000
Discretionary Funds (Tax revenue-Fixed costs + Subsidies)	$40,000
Bank account	$125,000

Quality of life
DistanceToLake*(1/water Q)*1/tax base*(1/OpportunityCosts)
(Click for details)

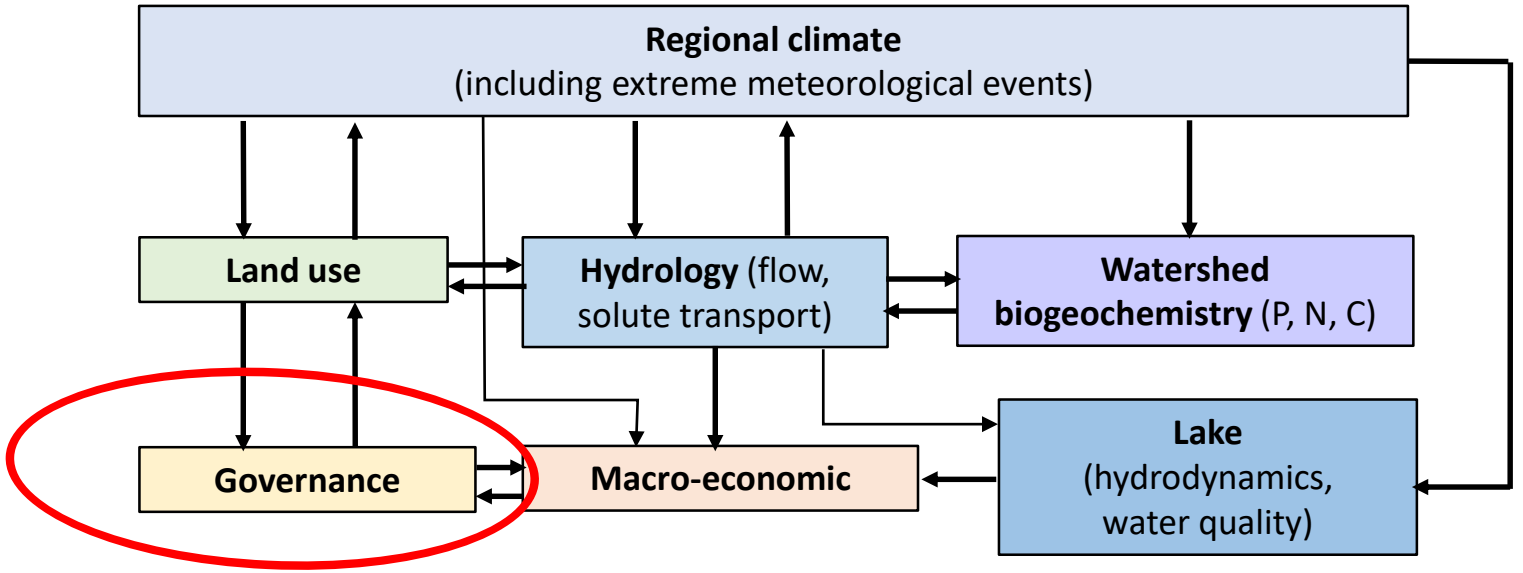
1.0



Project	Upfront cost	Annual cost	Impact	
Road Maintenance	$120,000	$20,000	10% reduction	+
Stormwater	$90,000	$30,000	10% reduction	+
Retention pond	$75,000	$2000	2% reduction	+

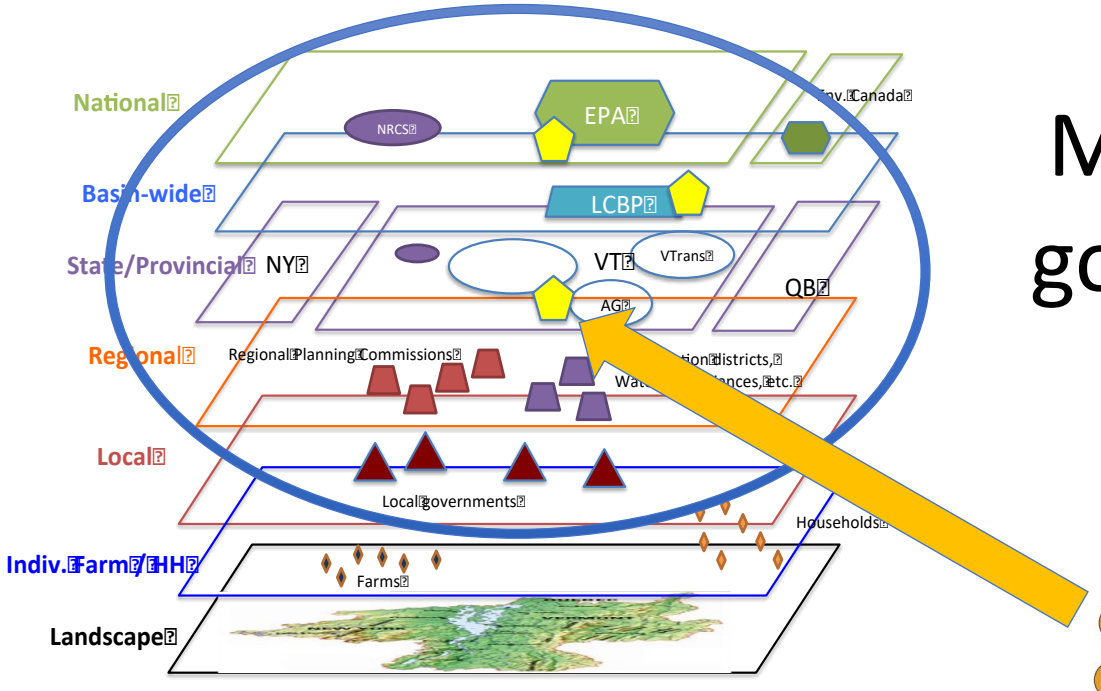
BREE Integrated Assessment Model:

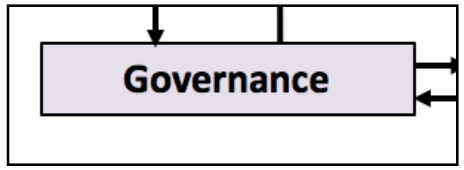
Major features



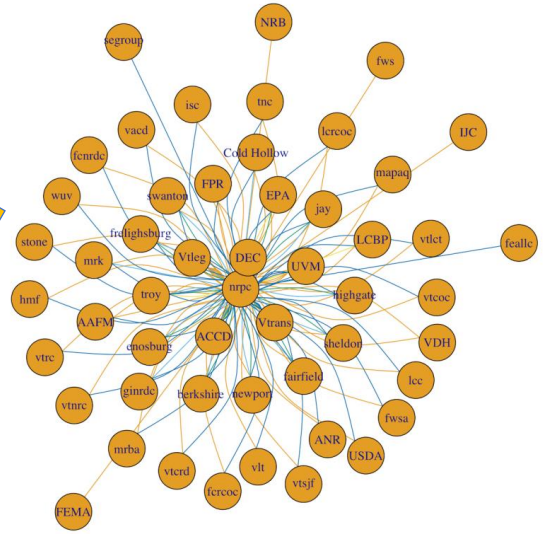
SOCIAL SYSTEMS MODELS

Objective 2: Construct, calibrate, and integrate a novel BREE **governance agent based model** that accounts for policy learning resource and political scenarios





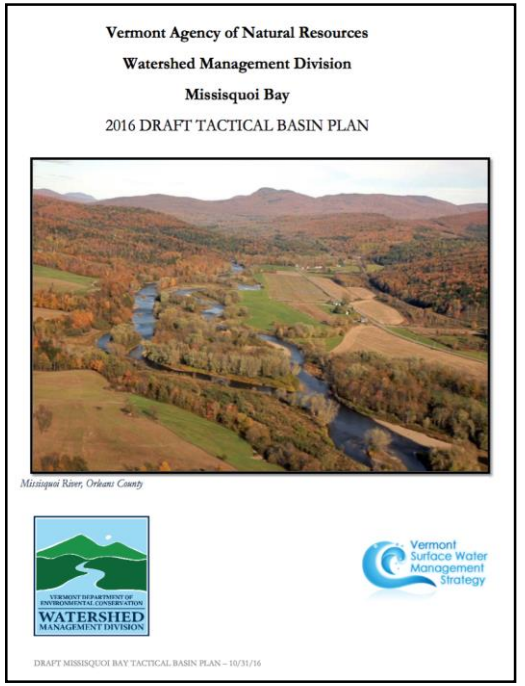
Multi-level governance



The Mechanism in Place to Allocate Resources:

Reporting and Financing Interagency / Clean Water Fund Tactical Basin Planning

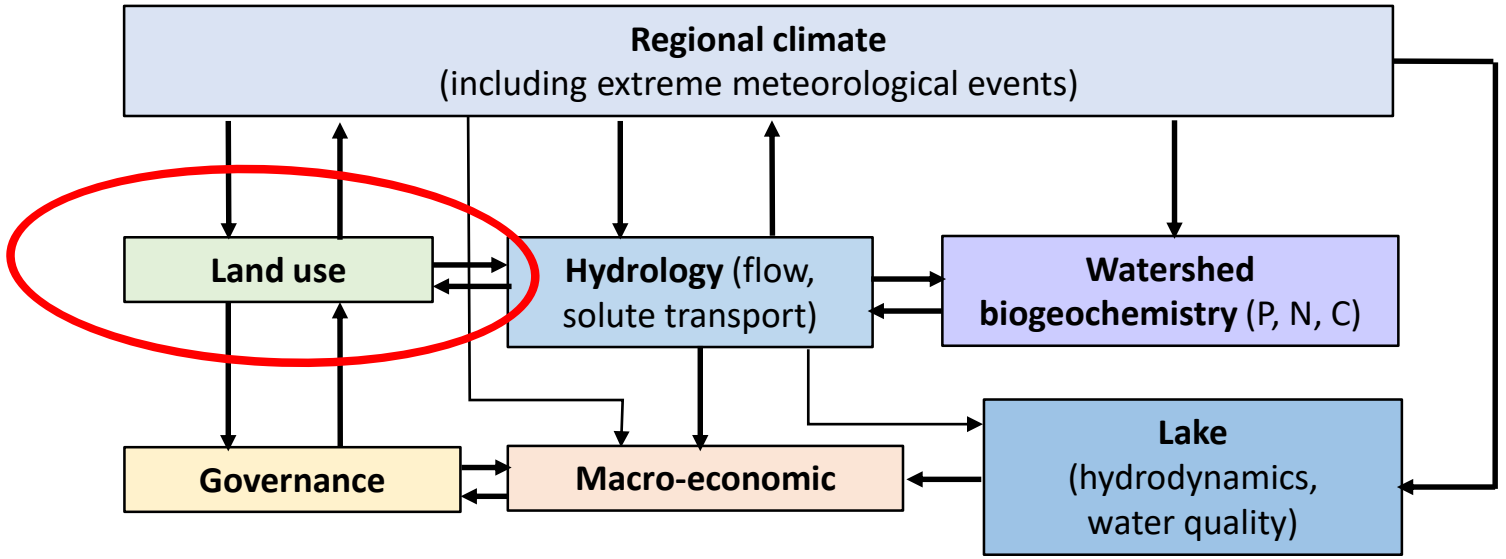
Need | Project | Project Design | Owner Consent | Funding



These “Action Arenas” will be integrated into governance ABM and optimization models.

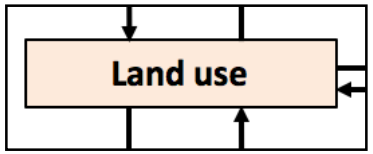
BREE Integrated Assessment Model:

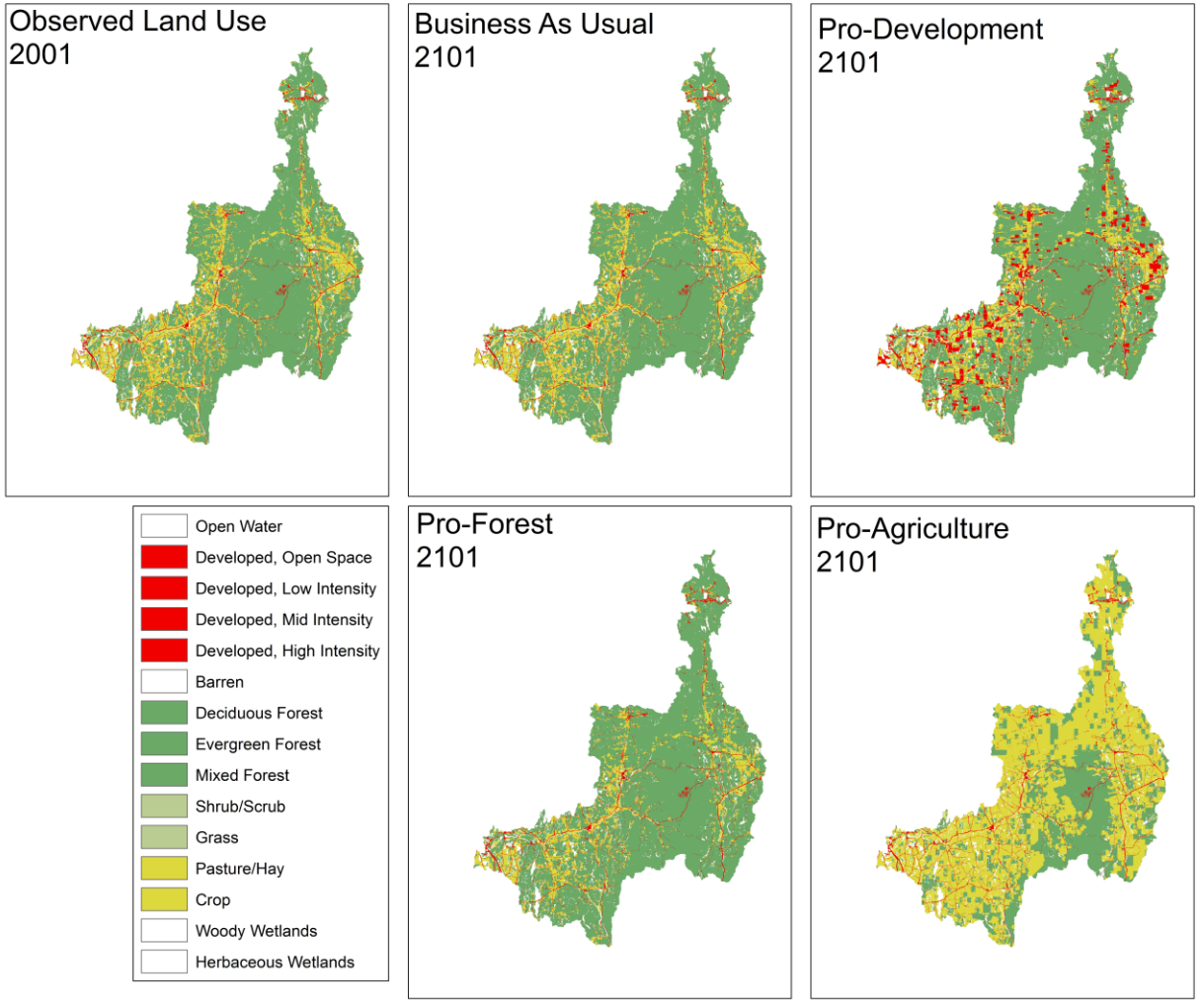
Major features



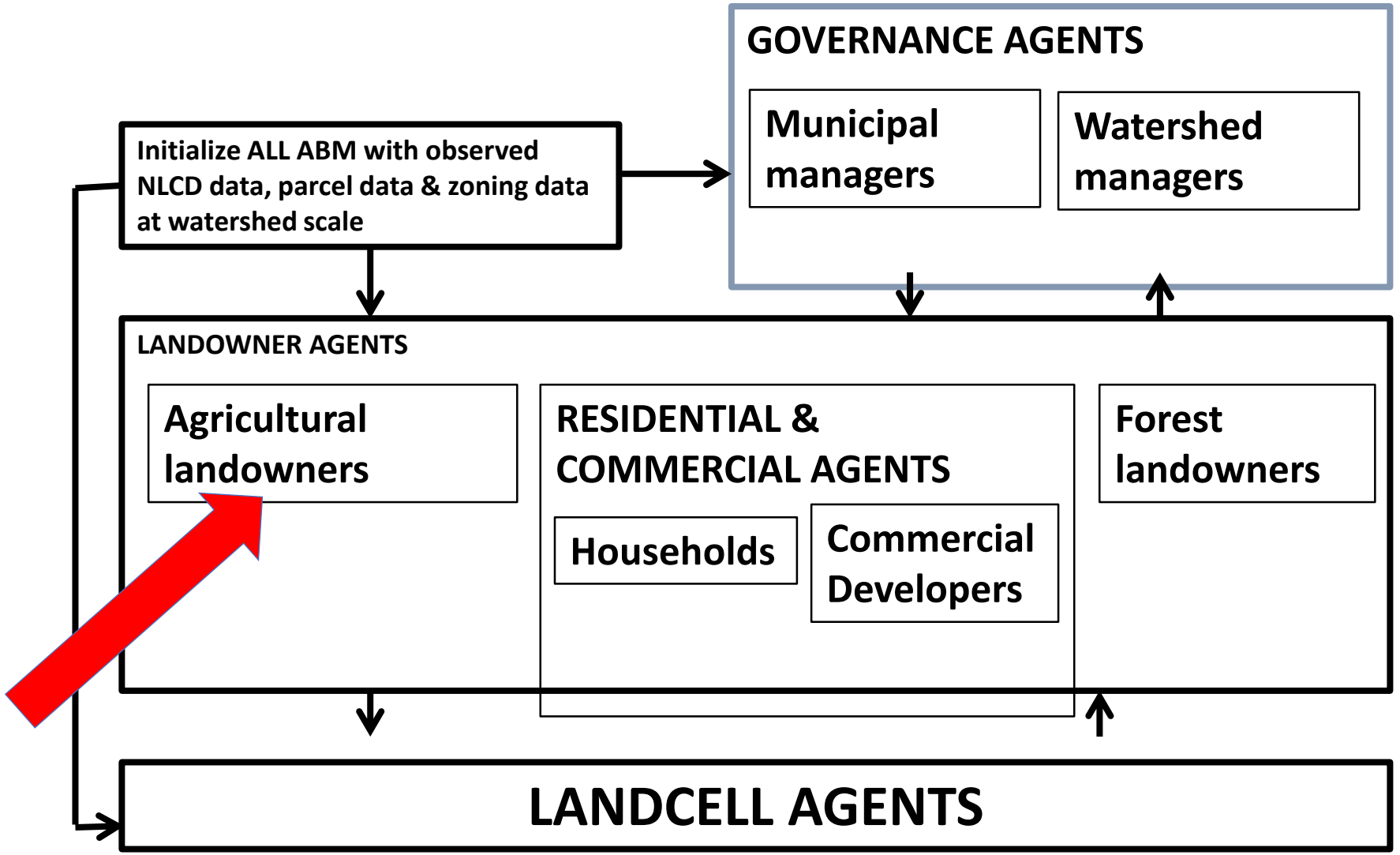
Objective 3: Calibrate and integrate deep learning into farmer, household, and municipal agents, expand the **ALL ABM** into the St Albans watershed, and build in urban stormwater management capacity.

Projections of 4 “refined” Land Use Change scenarios developed for Missisquoi Watershed (2000-2101)



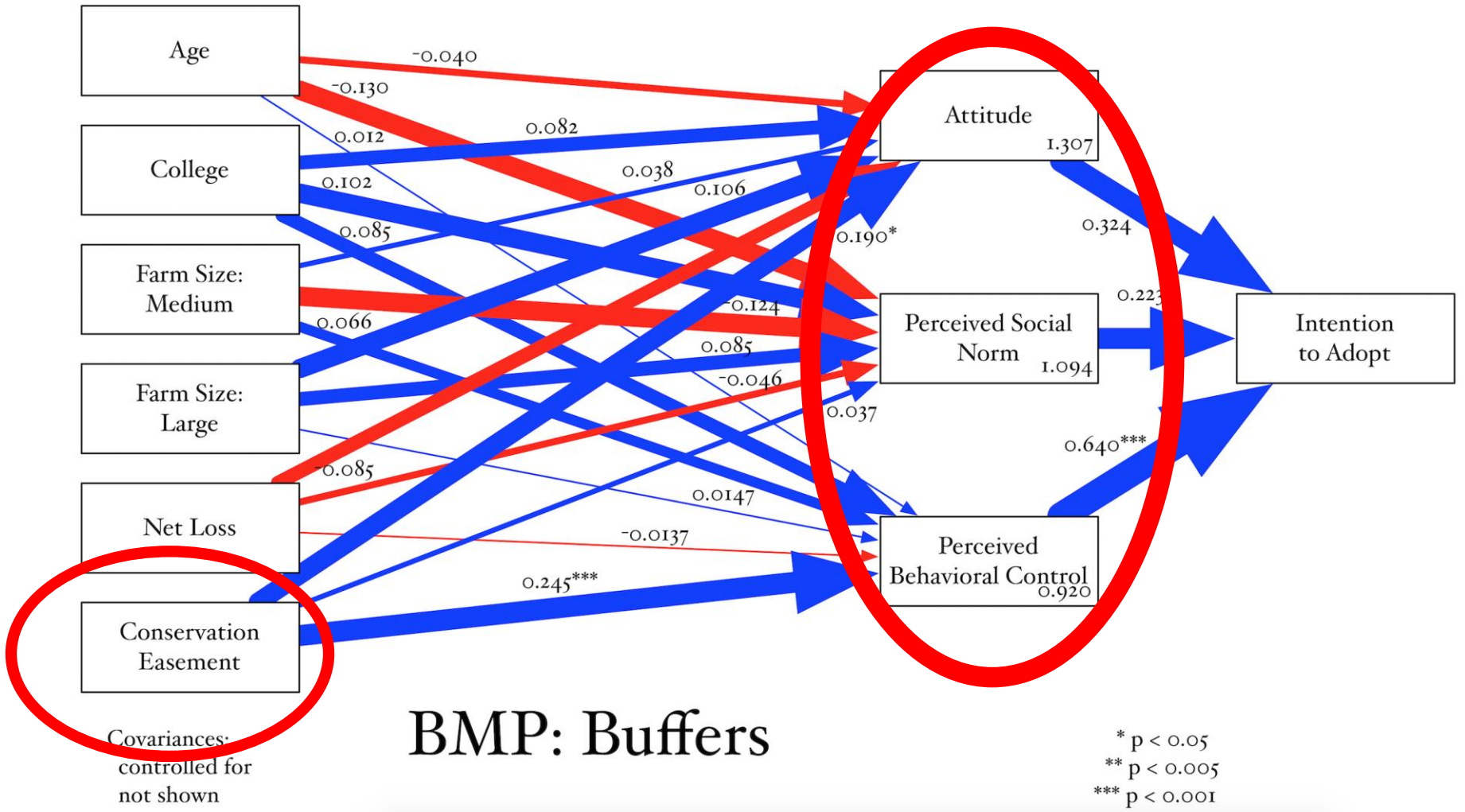


An overview of endogenous behaviors and environments of multiple agent classes (Landcells, Landowners and Policymakers) and their interactions in ALL ABM (Zia et al. 2016)



SEM:

Farmer agents in ALL ABM can adopt three Nutrient Management Practices using Structural Equation Models estimated from farmer survey. Behavioral change is premised on the theory of planned behavior that was used to frame survey questions.



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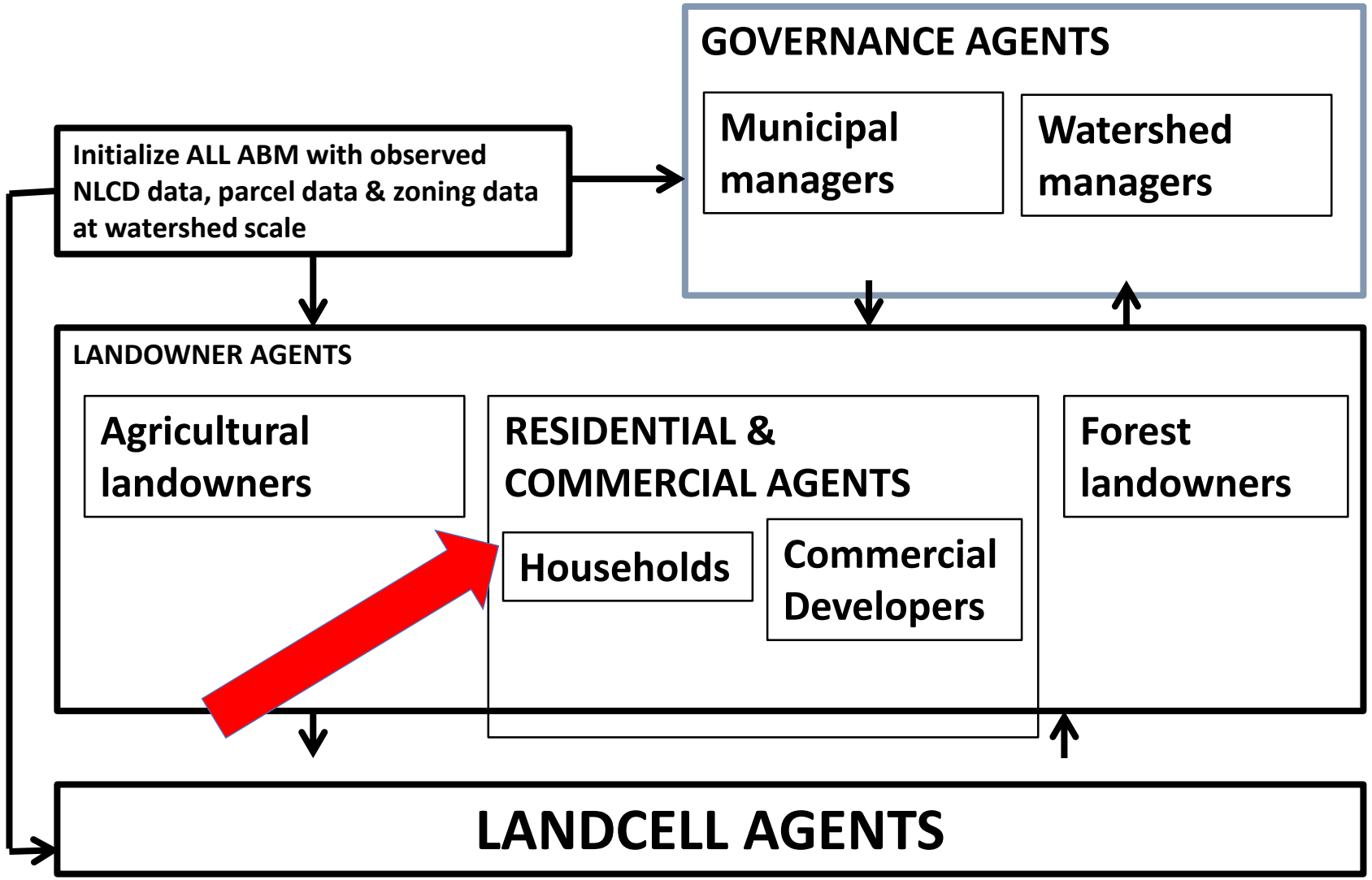
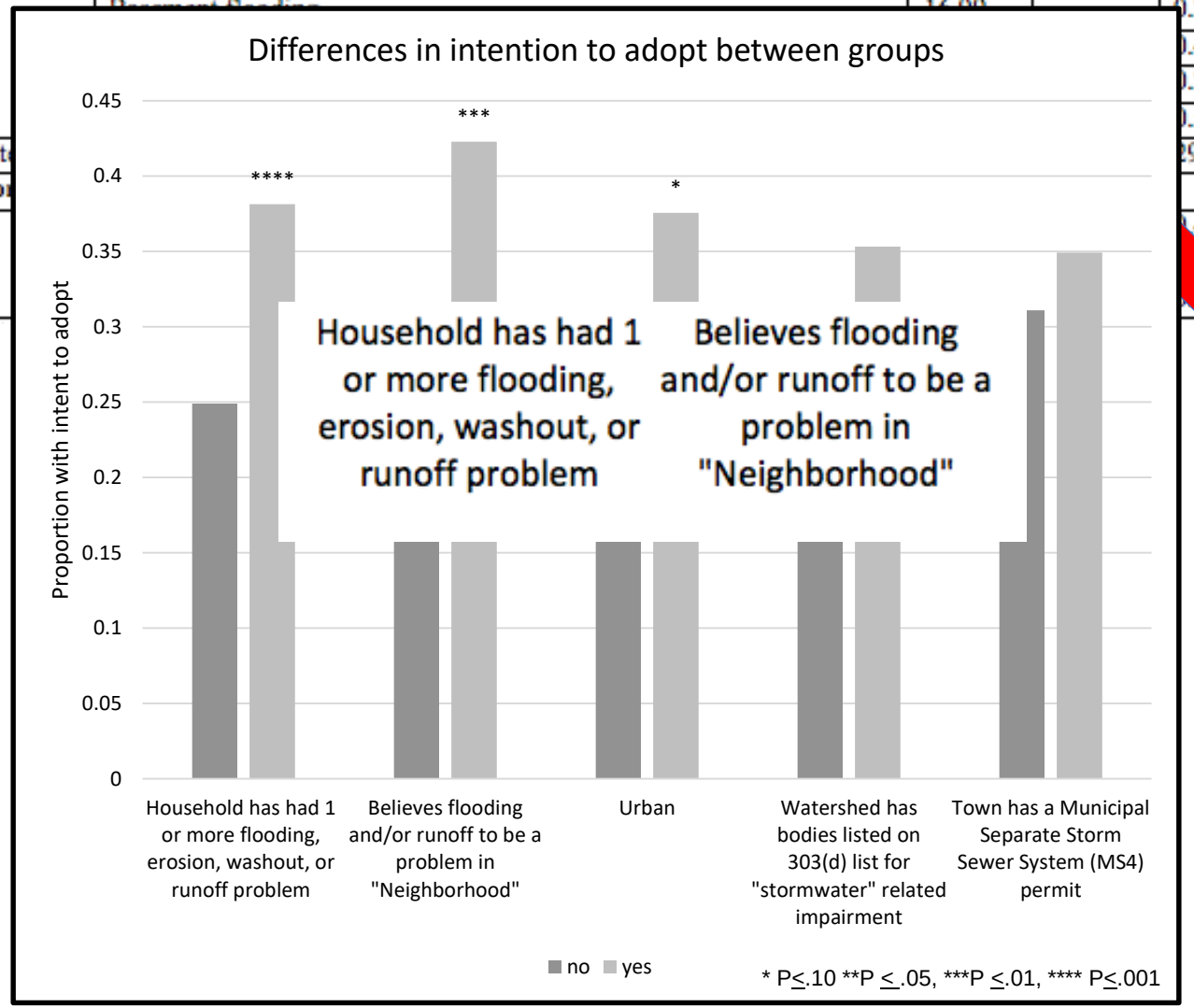
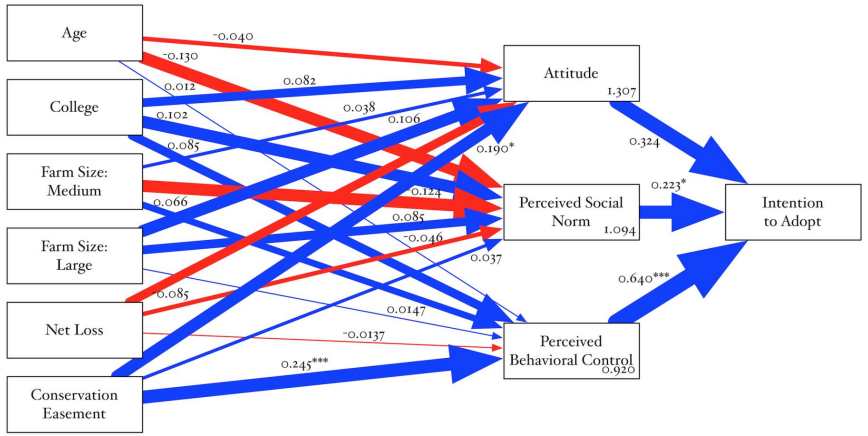


Table 1: Descriptive Statistics for the variables related to stormwater challenges at different spatial levels.

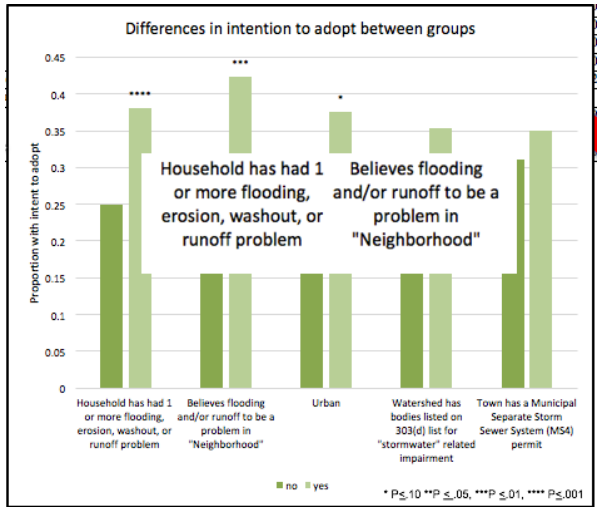
	Spatial Variables	Percent%	Mean	Std. Dev
Household				
Survey	Flooding on property	9.91		0.30
				0.38
				0.47
				0.32
				0.50
Geolocat				291.50
Neighbo				
Survey				0.40

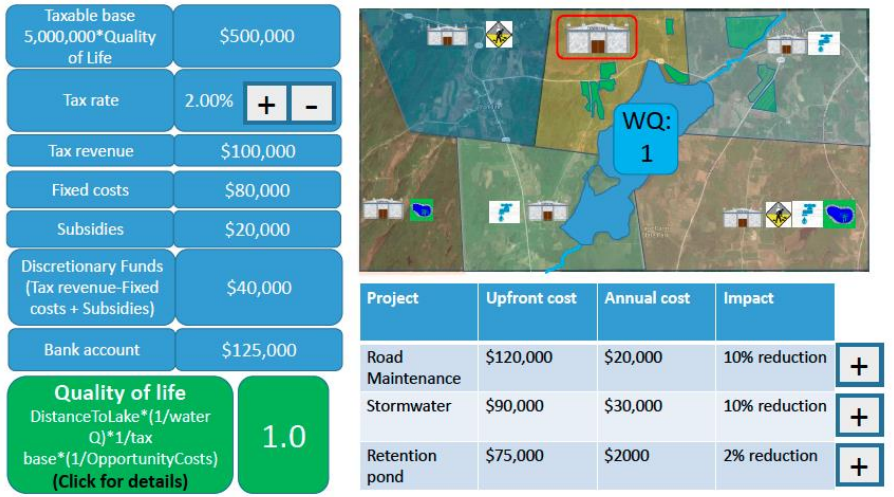


Calibration of ALL ABM's Deep Learning capacity:



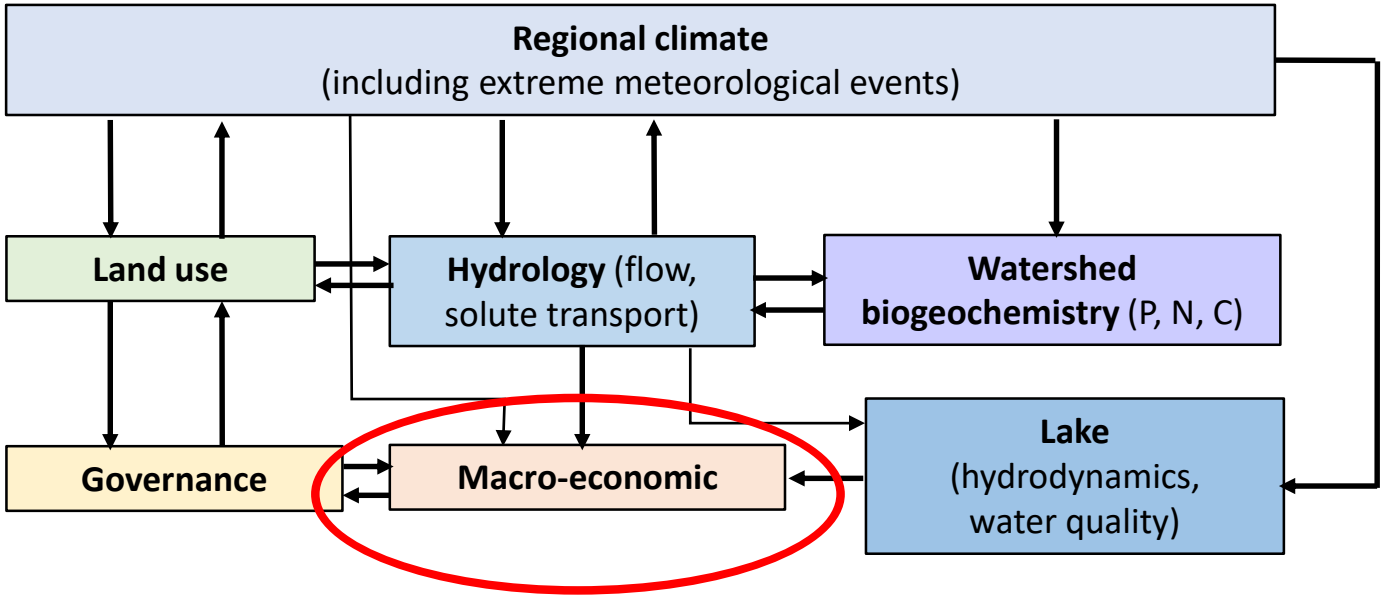
Survey and Digital Experiment Results





BREE Integrated Assessment Model:

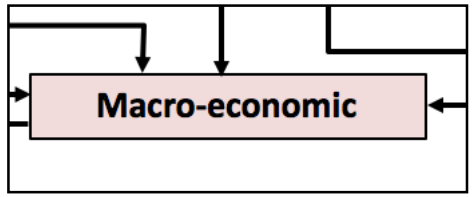
Major features



Objective 4. Build, calibrate, and integrate a regional General Equilibrium Analysis Model (GEAM).

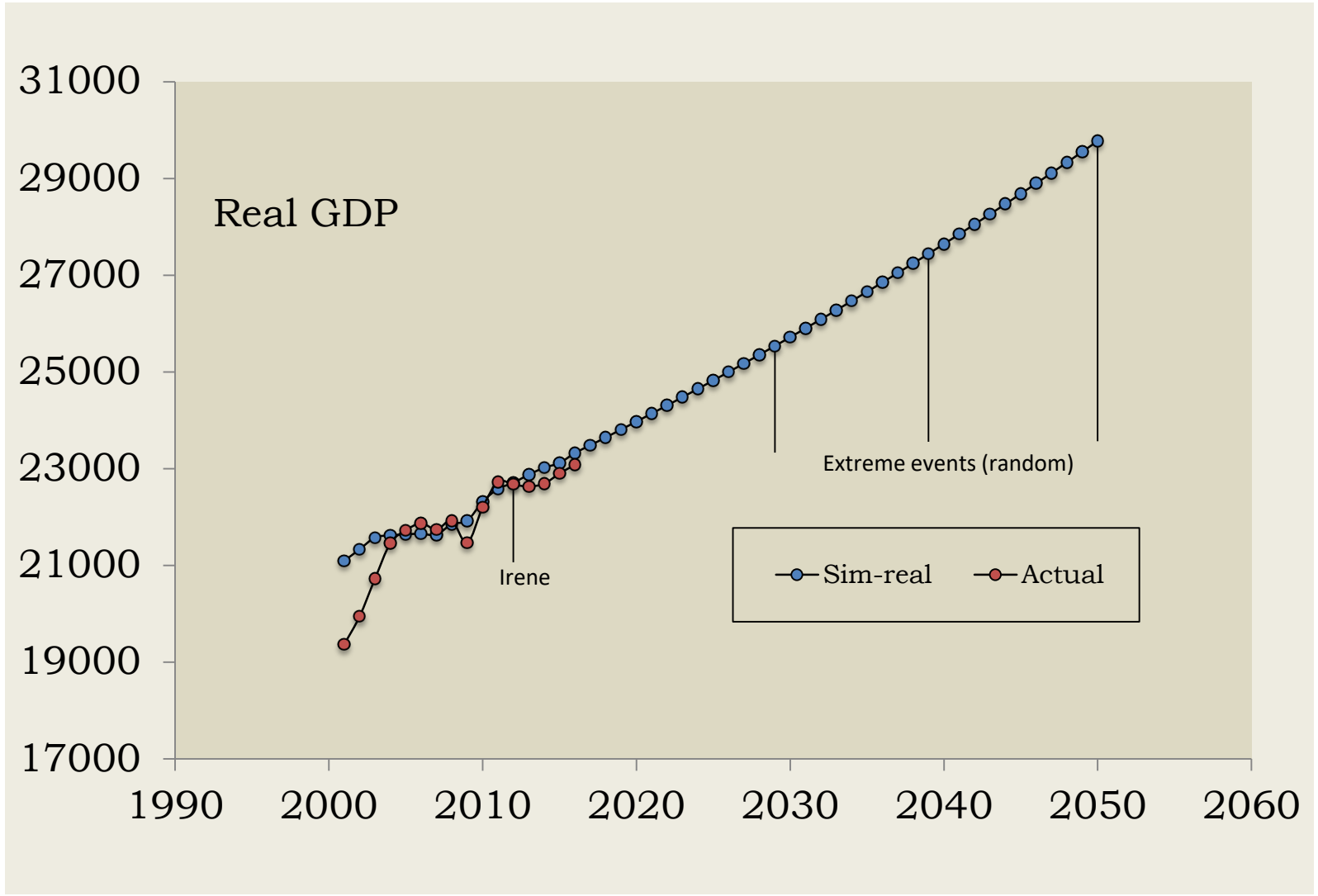
- **Tax revenues** as inputs into governance models

- **Economic utility/production functions** of farmers, developers
  - Indirect impacts on policy makers



Real GDP per capita in Vermont- in terms of 2001 $

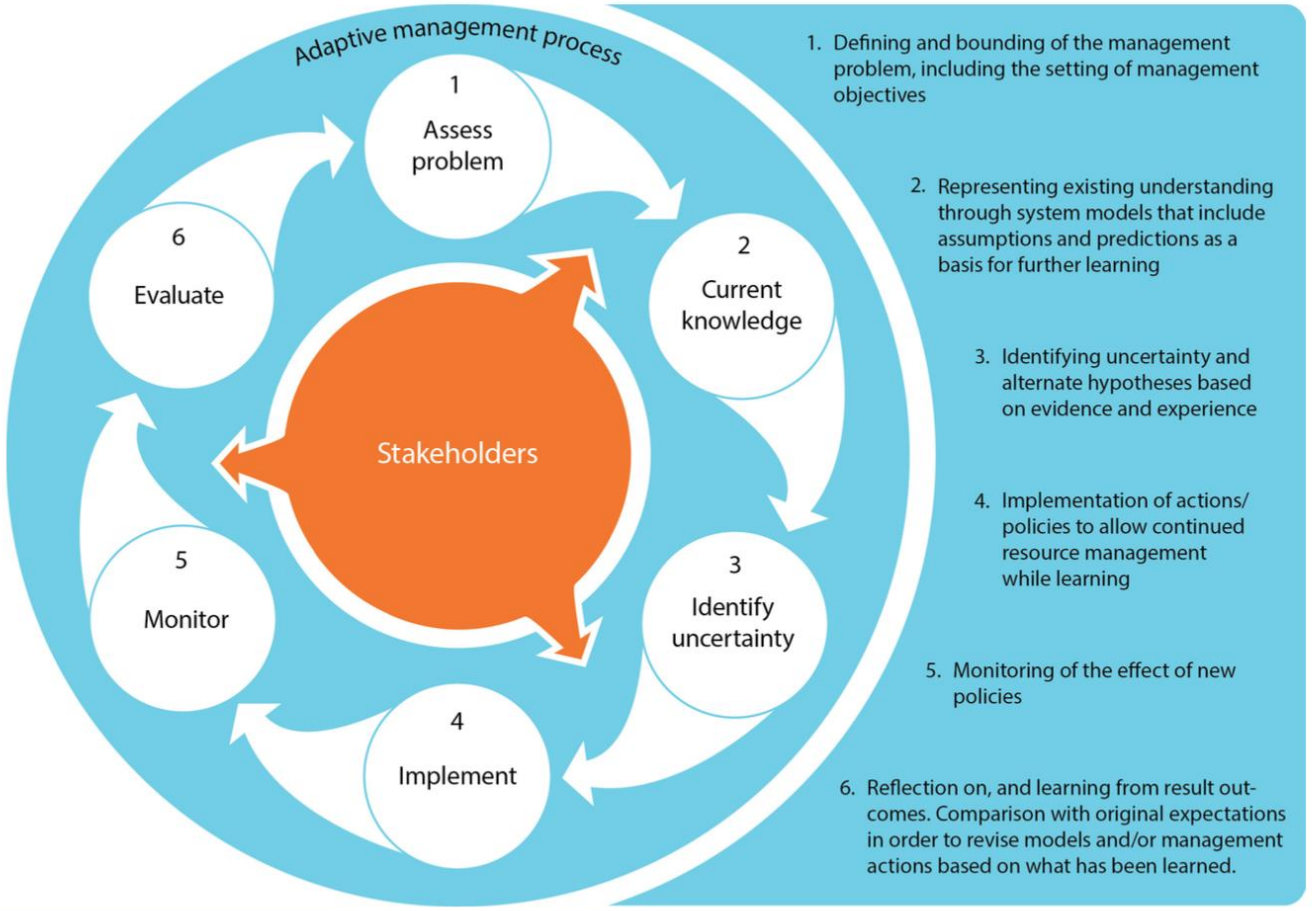
MUSD



RESULT: GEAM is calibrated.

Thrust 2; Goal 2.1; Objective 2.1d
Activity 1 : Prototype GEAM

Adaptive Management Process: Using science to manage and govern segments of society.



Rist, L., A. Felton, L. Samuelsson, C. Sandström, and O. Rosvall. 2013. A new paradigm for adaptive management. *Ecology and Society* **18**(4): 63. http://dx.doi.org/10.5751/ES-06183-180463

"Vermont EPSCoR provides important leadership in organizing stakeholders in the Lake Champlain Basin around the issues of climate change, extreme events and resilience, in both the near- and long-term. Their research efforts have provided critical data that are allowing us to better understand the causes and intensity of algal blooms, the long-term commitment needed to achieve our water quality and resilience goals for the Lake and Basin, and the engagement of stakeholders that is necessary for success. In particular, the Integrated Assessment Model is a welcome and unique resource for Vermont as it tackles implementation of the Total Maximum Daily Load (TMDL) and sustainable funding for clean water initiatives. Vermont EPSCoR provides real and significant value to agencies of state government, including the Agency of Natural Resources."

VERMONT
AGENCY OF NATURAL RESOURCES

Julia S. Moore, P.E.
Secretary
Vermont Agency of
Natural Resources

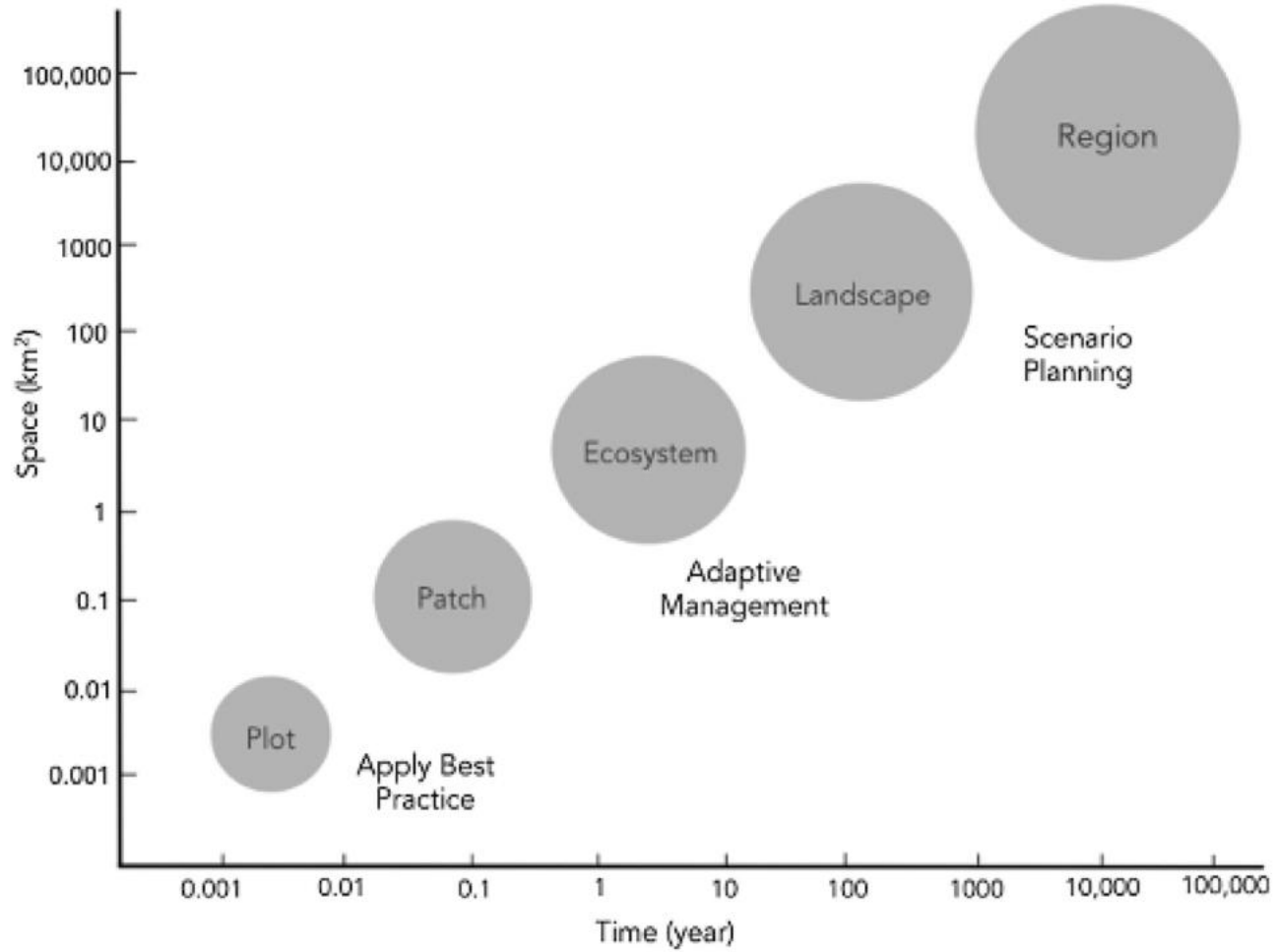


Fig. 6. A framework of thresholds for five spatiotemporal scales, with indications of appropriate management strategies.

Adaptive management for ecosystem services

Birge, H.E., Allen, C. R., Garmestani, A.S. (2016). Adaptive management for ecosystem services. *Journal of Environmental Management,* Volume 183, Part 2, pp. 343-352

Policy and Technical Advisory Committee (PTAC) Roles

BREE
Basin Resilience to Extreme Events
in the Lake Champlain Basin

VERMONT
AGENCY OF AGRICULTURE, FOOD & MARKETS

Lake Champlain Basin Program

VERMONT
AGENCY OF NATURAL RESOURCES
Department of Environmental Conservation

NRCS
Natural Resources Conservation Service

ECHO LAKE AQUARIUM AND SCIENCE CENTER

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

FRIENDS OF NORTHERN LAKE CHAMPLAIN

LAKE CHAMPLAIN COMMITTEE

- **Technical advice and access to data**
- Input regarding the **communication of research findings** and uncertainty associated with them.
- Advice about **possible scenarios** to be generated and tested from the BREE Integrated Assessment Model (IAM)
- Advice about the **development of actionable, decision-support tools to inform water quality**

Policy and Technical Advisory Committee (PTAC) Roles

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Basin Resilience to Extreme Events
in the Lake Champlain Basin

VERMONT
AGENCY OF AGRICULTURE, FOOD & MARKETS

Lake Champlain Basin Program

VERMONT
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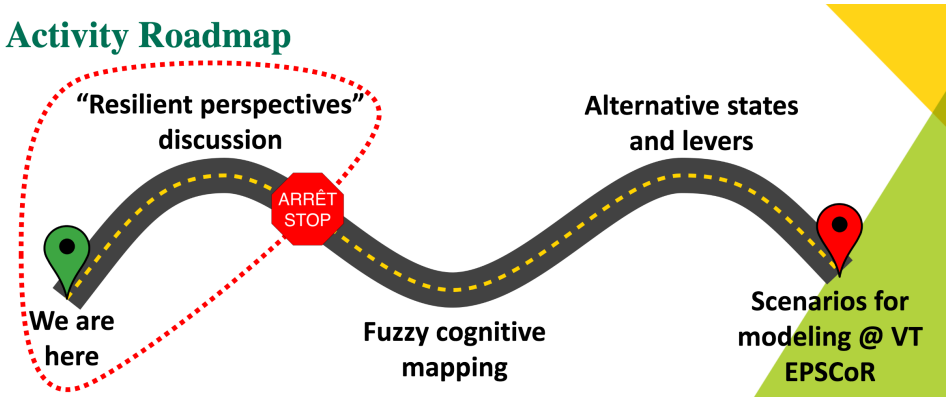
LAKE CHAMPLAIN COMMITTEE



EPA

BREE Science Leader

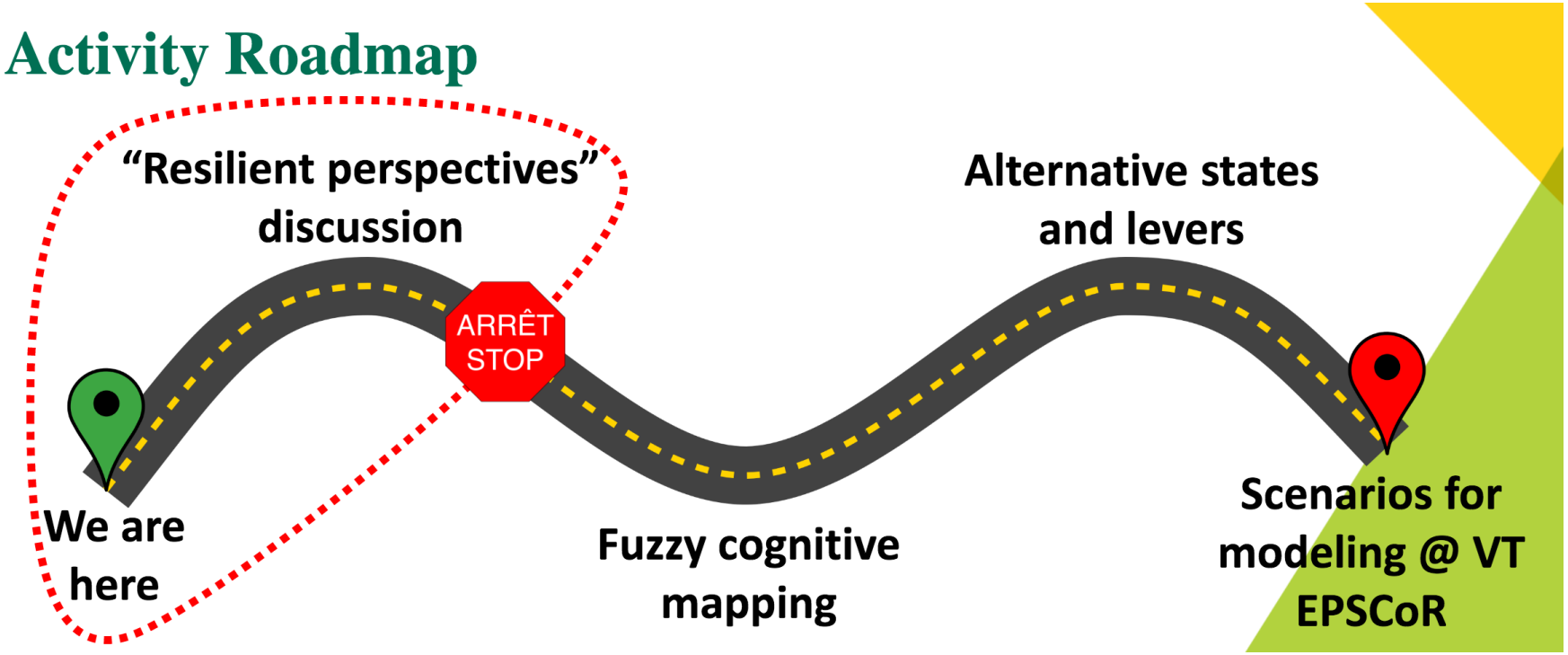
Lake Champlain Basin Program

BREE Post Doc

Quebec Government

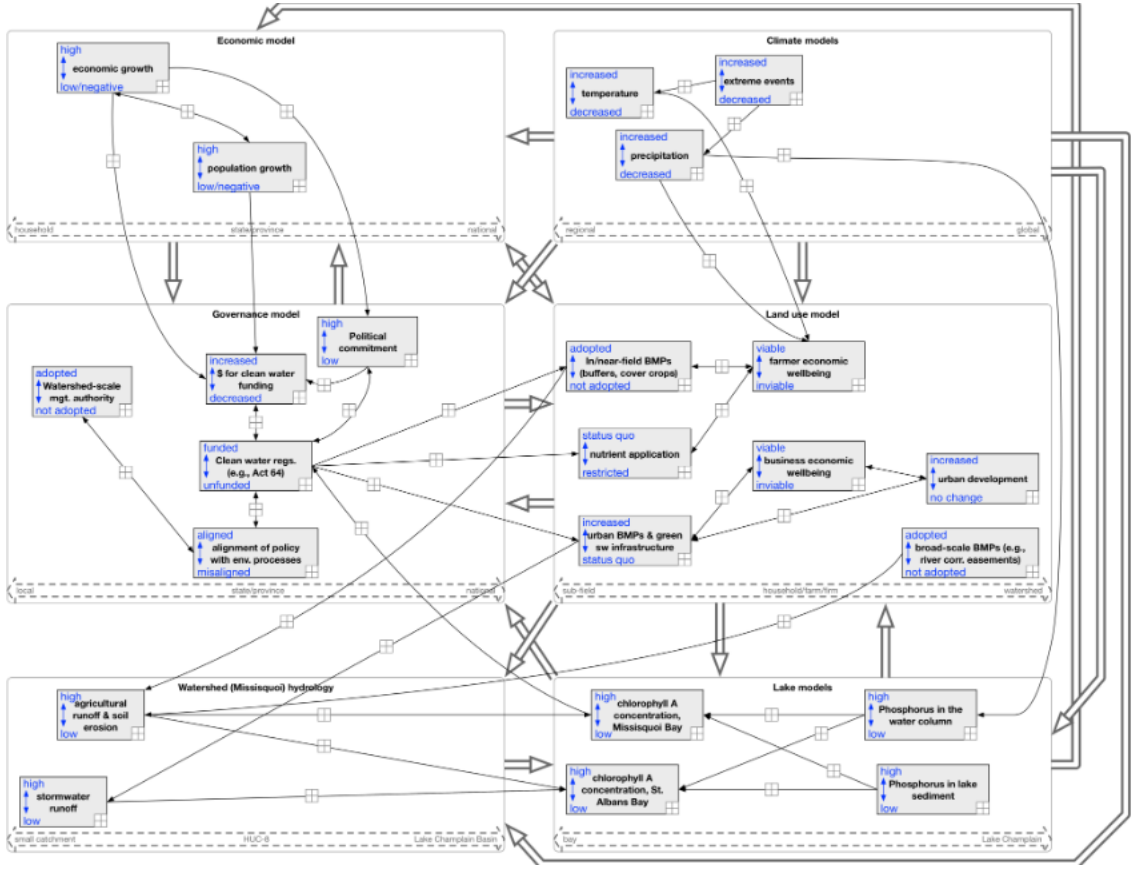
PTAC Meeting,
November 28, 2017

Activity Roadmap



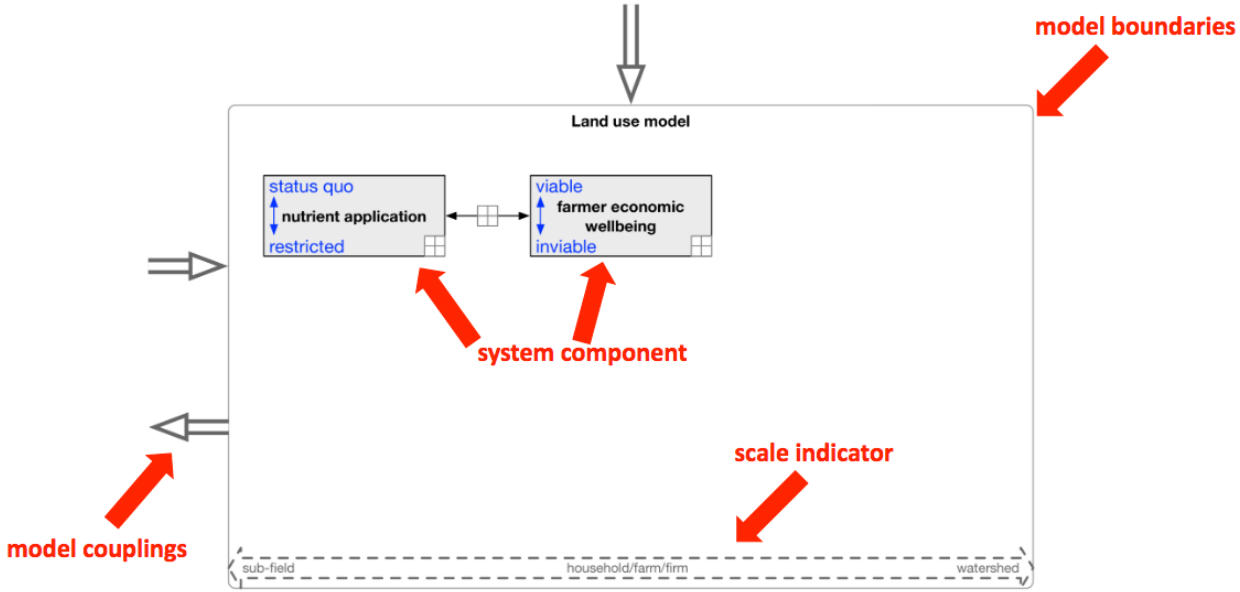
Meeting	Meeting Date	Activity Description
1	May 2017	BREE Overview; PTAC Scope and purpose; Paper findings; data acquisition needs
2	November 2017	Resilience perspectives: identification of perspectives, priorities, and constraints of key decision-makers and interest groups in the LCB; increase PTAC member buy-in to BREE
3	Summer 2018	Fuzzy cognitive mapping: link key processes in the system to external drivers of change
4	Fall/Winter 2018	Levers and scenarios: identification & exploration of alternative levers and states that might shift system trajectory; translate into actionable scenarios for modeling

PTAC Cognitive Mapping and Scenario Development

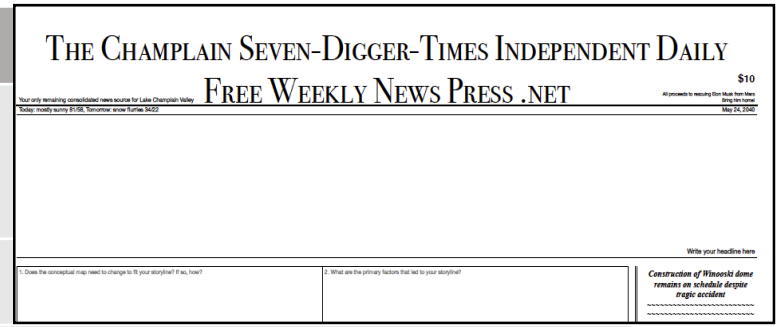


Evaluate and edit

- What is missing? (add it)
- What is wrong? (change it)
- What is important? (mark it)



Headlines


THE CHAMPLAIN SEVEN-DIGGER-TIMES INDEPENDENT DAILY

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"Water Q efforts continue but citizens wondering when benefits will be seen. P loads down but historical storage proving hard to shake. Loss of snow pack inhibits efforts"

International Joint Commission (IJC)

IJC Updates on its Flooding and Water Quality References

VT EPSCoR BREE PTAC Meeting
24 May 2018

Presenters: Glenn Benoy (IJC-Ottawa)
and Michael Laitta (IJC-Washington)

IJC-BREE PTAC Experts Workshop

- Following completion of reports by the basin organizations, the IJC plans to hold a binational workshop with technical and policy experts in the region
  - Compilation, analysis and synthesis of the research, policies and programs on nutrient loading and HABs in the basin, including key findings
  - Preliminary recommendations to reinforce effective government efforts and perhaps to offer a longer term approach or strategy to address the problem
- Given the composition of the BREE PTAC group, joint sponsorship between it, the LCBP and the IJC may be the most effective option for ensuring that the best recommendations possible are forwarded to governments
- Ideal time and location: Spring 2019 at UVM?

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Crowdsourced Delphis: Designing solutions to complex environmental problems with broad stakeholder participation

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ABSTRACT

There is a well-established need for increased stakeholder participation in the generation of adaptive management approaches and specific solutions to complex environmental problems. However, integrating participant feedback into current science, research, and decision-making processes is challenging. This paper presents a novel approach that marries a rigorous Delphi method, borrowed from policy and organizational sciences, with contemporary "crowdsourcing" to address the complex problems of water pollution exacerbated by climate change in the Lake Champlain Basin. In an online Delphi forum that occurred over a six-week period during the Spring of 2014, fifty-three participants proposed and commented on adaptive solutions to address water quality in the context of climate change. In a follow up Multi-Stakeholder workshop, thirty-eight stakeholders participated in refining and synthesizing the results from the forum. To inform modeling and policy dialogue, the resulting list of interventions was analyzed by time horizon, domain, type of adaptation action, and priority level. The interventions suggested by stakeholders within the crowdsourcing forum have contributed to the current policy dialogue in Vermont including legislation to address phosphorus loading to Lake Champlain. This stakeholder approach strengthens traditional modeling scenario development to include solutions and priorities that have been collectively refined and vetted.