



BREE Social Systems Team Overview

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Social and Policy Modeling Group: Who we are...



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Software Developer

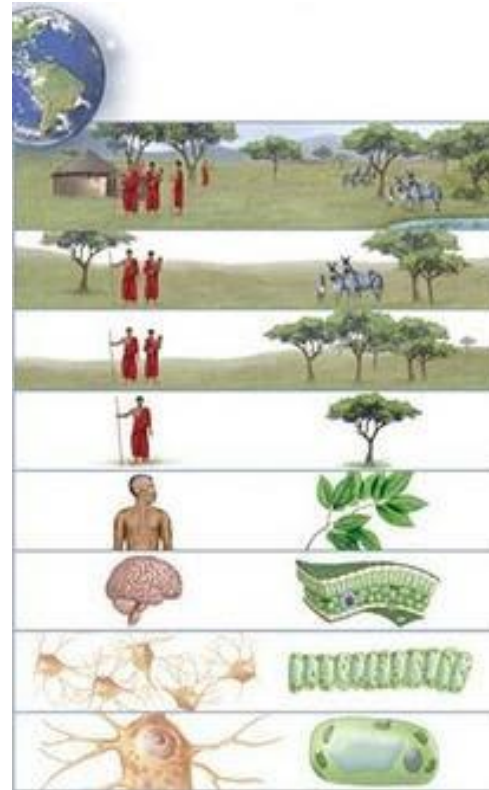
Elizabeth Dolan
Post Doc

Patrick Bitterman
Post Doc

Kevin Andrew
Post Doc

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.

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?*
- The Stockholm Resilience Centre has laid out two grand challenges for the study of adaptive governance:
 - What are the important multiscale processes in Social Ecological Systems governance that lead to more or less resilient outcomes on the ground?
 - What are the tradeoffs between management priorities and Social Ecological Systems for long-term sustainable futures and how do these play out over different scales?

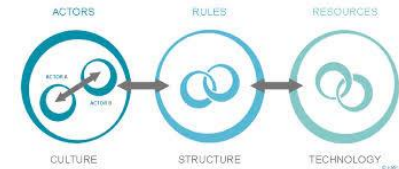
Social Systems Broad Overview:

Key concepts:

- **Agents** (farmers, urban residents, rural/forest land owners, town managers, watershed managers, policy makers, governments, nonprofits, firms) (consumers, citizens, owners...)
- Agent **behaviors** (rational, boundedly rational, non-rational)
- Agent **ties** (to each other, to the land, to markets, etc.)

Critical elements of social systems focus:

- **Governance & policy design** (H_1 : Governance failure)
- **Agent cognition & learning** (H_2 : Risk perception (environmental and economic)– land user and policy makers)
- **Stakeholder engagement for Adaptive Management**



Methods employed:

- **Surveys** (Farmers; Municipalities; Households; Institutions)
- **Focus Groups** (Tactical Basin Planning; State Agency Resource Allocation)
- **Field Experiments** (Stakeholder objective functions)
- **Network Analysis** (Governance)
- **Crowdsourcing Delphi** (Best practices; optimization)
- **Agent-based Modeling** (Economics; Land use; Governance)

EPA US Environmental Protection Agency

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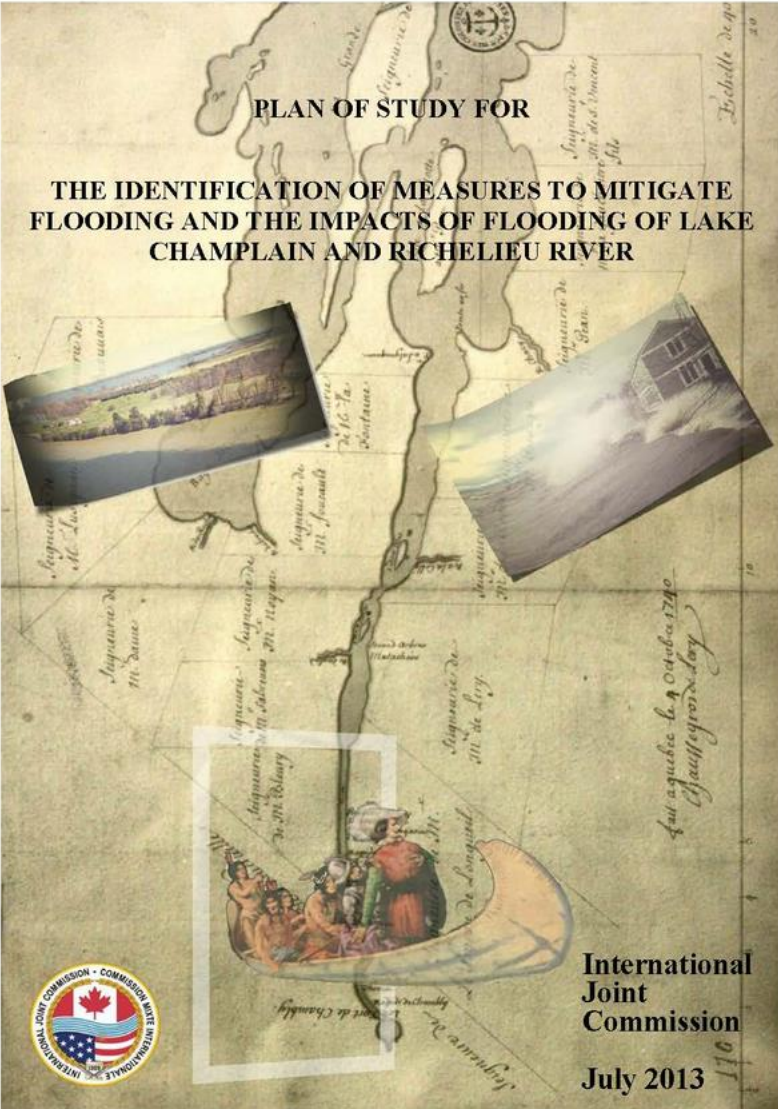

You are here: [EPA Home](#) » [Impaired Waters and TMDLs](#) » [Lake Champlain Phosphorous TMDL: A Commitment to Clean Water](#)

Lake Champlain Phosphorous TMDL: A Commitment to Clean Water



Excess phosphorous from a variety of sources has impaired the water quality of Lake Champlain. In 2002, Vermont prepared a plan to reduce phosphorous loadings by developing a Total Maximum Daily Load (TMDL). A TMDL places a cap on the maximum amount of phosphorous that is allowed to enter the Lake and still meet Vermont's water quality standards. EPA disapproved the Vermont 2002 Lake Champlain Phosphorous TMDL in 2011. EPA has prepared new TMDLs (see link below) in collaboration with the Vermont Department of Environmental Conservation and Agency of Agriculture, Food and Markets.

PLAN OF STUDY FOR THE IDENTIFICATION OF MEASURES TO MITIGATE FLOODING AND THE IMPACTS OF FLOODING OF LAKE CHAMPLAIN AND RICHELIEU RIVER

**International
Joint
Commission**

July 2013

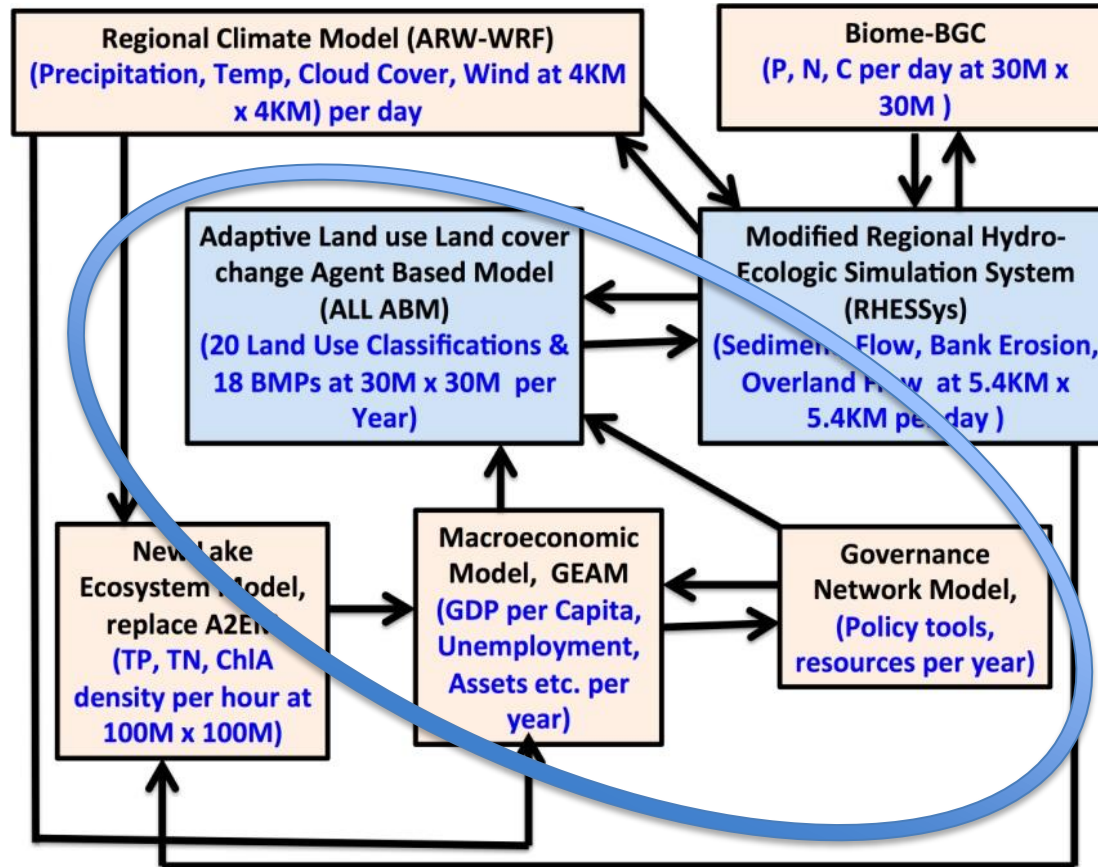
Policy and Technical Advisory Committee (PTAC)



- Provides **technical advice** regarding model development, calibration and validation, including possible access to datasets that may be used in the process.
- Provides input regarding the **communication of research findings** and uncertainty associated with them.
- Provides **advice about possible scenarios** to be generated and tested from the BREE Integrated Assessment Model (IAM), as well as the land use, hydrology, climate, governance and economic models that are to be wrapped into it.
- Provides advice about the **development of actionable, decision-support tools to inform water quality** in the face of changing frequencies and intensities of extreme events in the study areas.



Social Systems Models

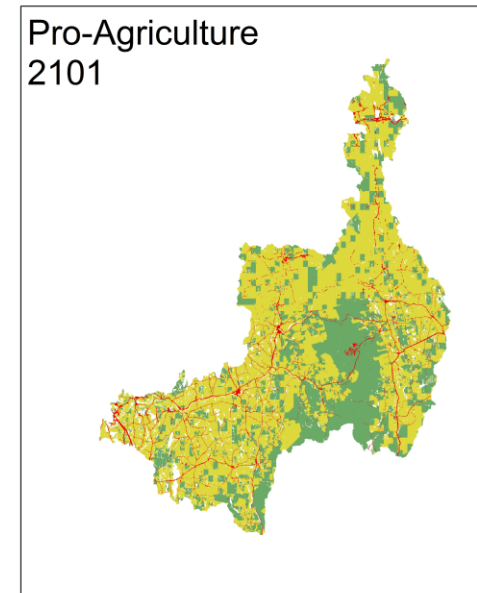
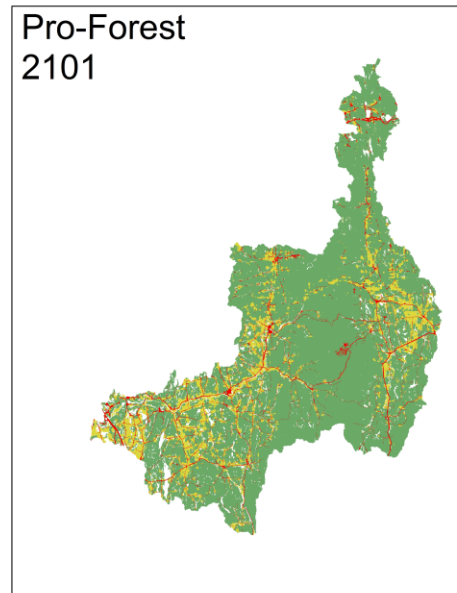
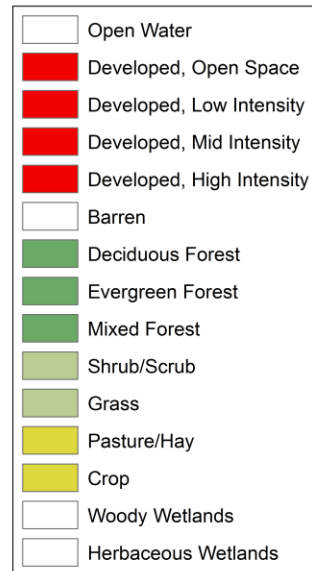
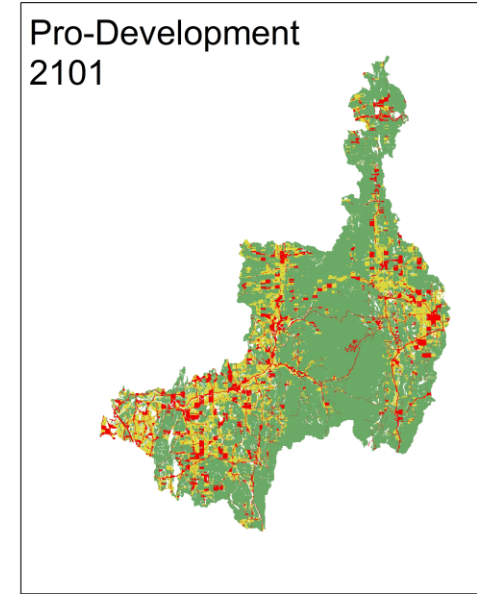
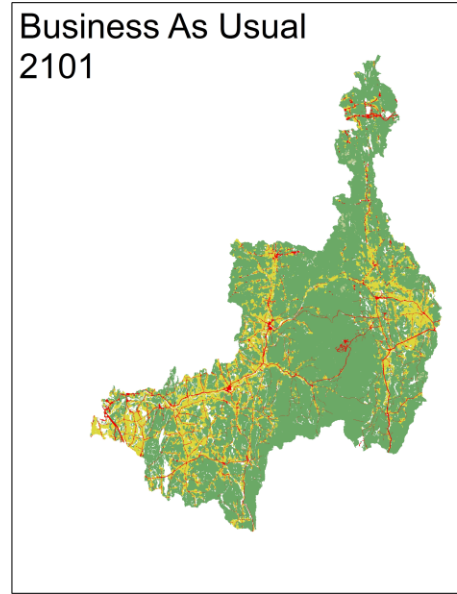
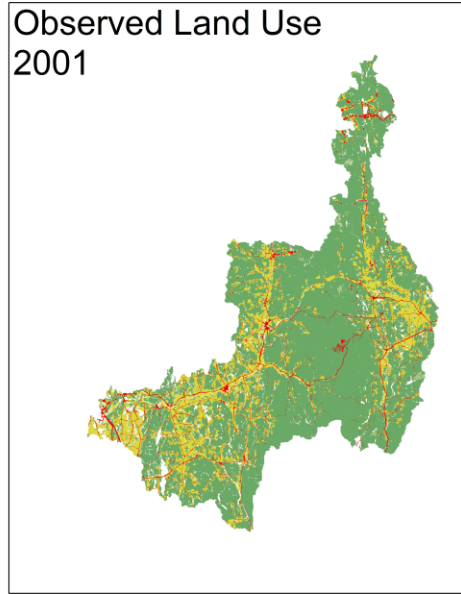


Adaptive Landuse and Land Cover Transition Model (ALL ABM)

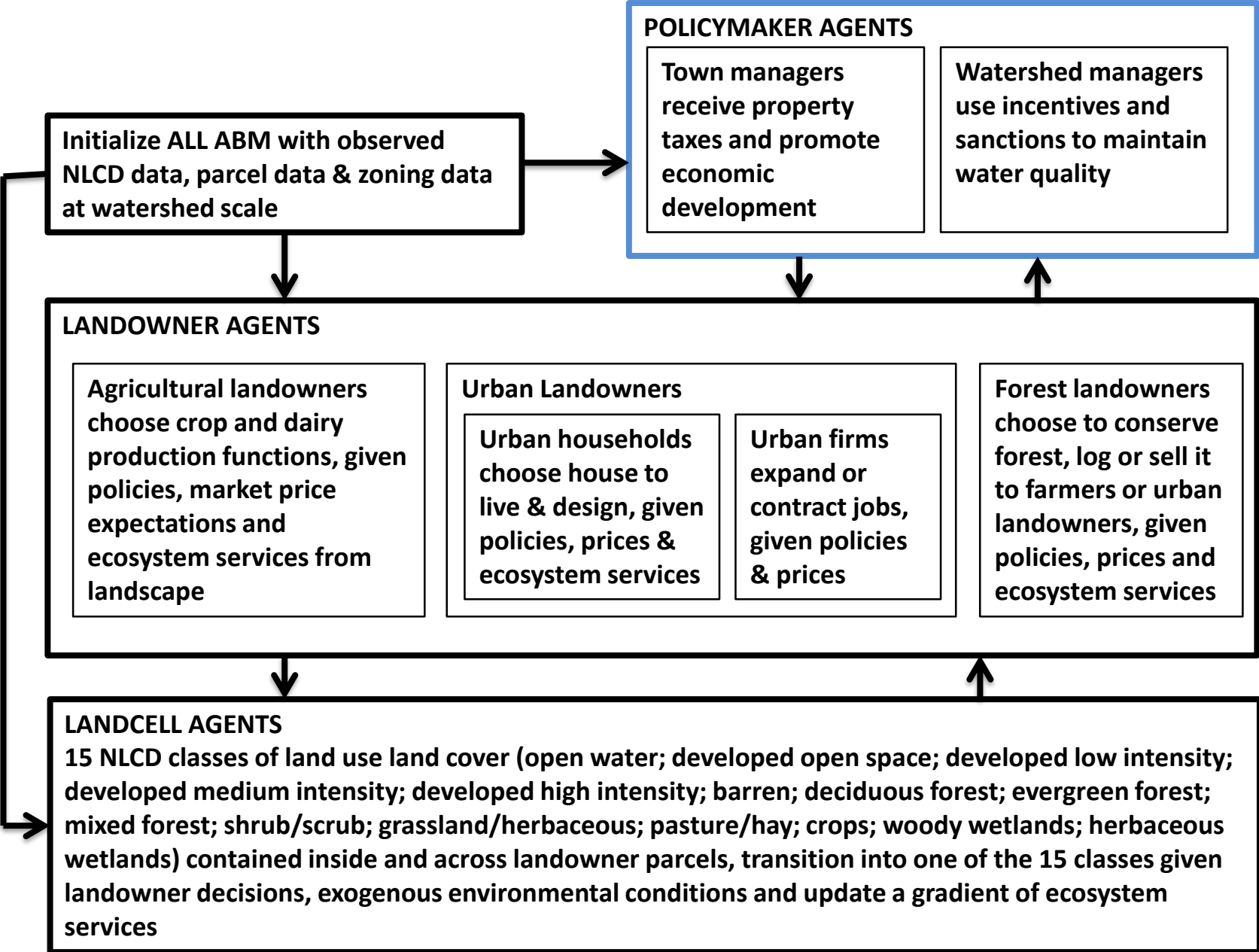
- **Purpose:** Simulation of land user behavior lies at the center of the IAM.
- Model calibrated using household and municipal surveys and farmer panel data; high resolution sub-meter panchromatic image satellite photography of the 10 population centers of over 6,000 to monitor BMP adoption
- **Model Calibration:** NLCD data; farmer, household, municipal government surveys; field experiments.
- **New Features:**
 - Expanding to St. Albans Bay catchment
 - Integrating agent learning
 - Expanding model to “urban” stormwater BMPs
 - Build capacity to run “green infrastructure” scenarios

Adaptive Land Use Land Cover Change (ALL) Agent Based Model (ABM) can generate high resolution (30M x 30M) scenarios consistent with National Land Cover Dataset

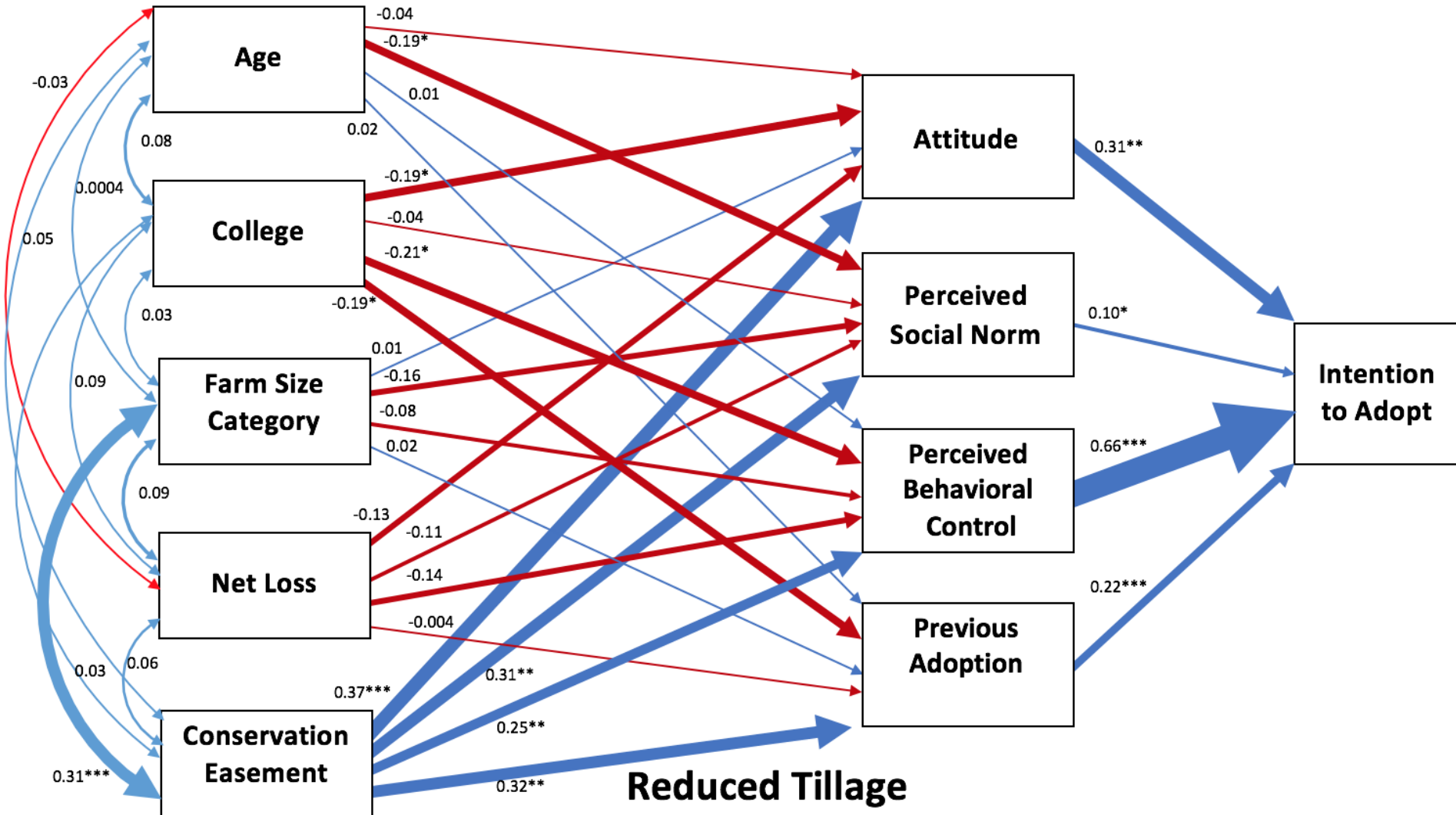
Projections of 4 “refined” Land Use Change scenarios developed for Missisquoi (2000-2101) and coupled with IAM for testing the effects of land use change on hydrological and lake systems. Many additional scenarios will be developed with stakeholders and tested as the BREE project evolves.



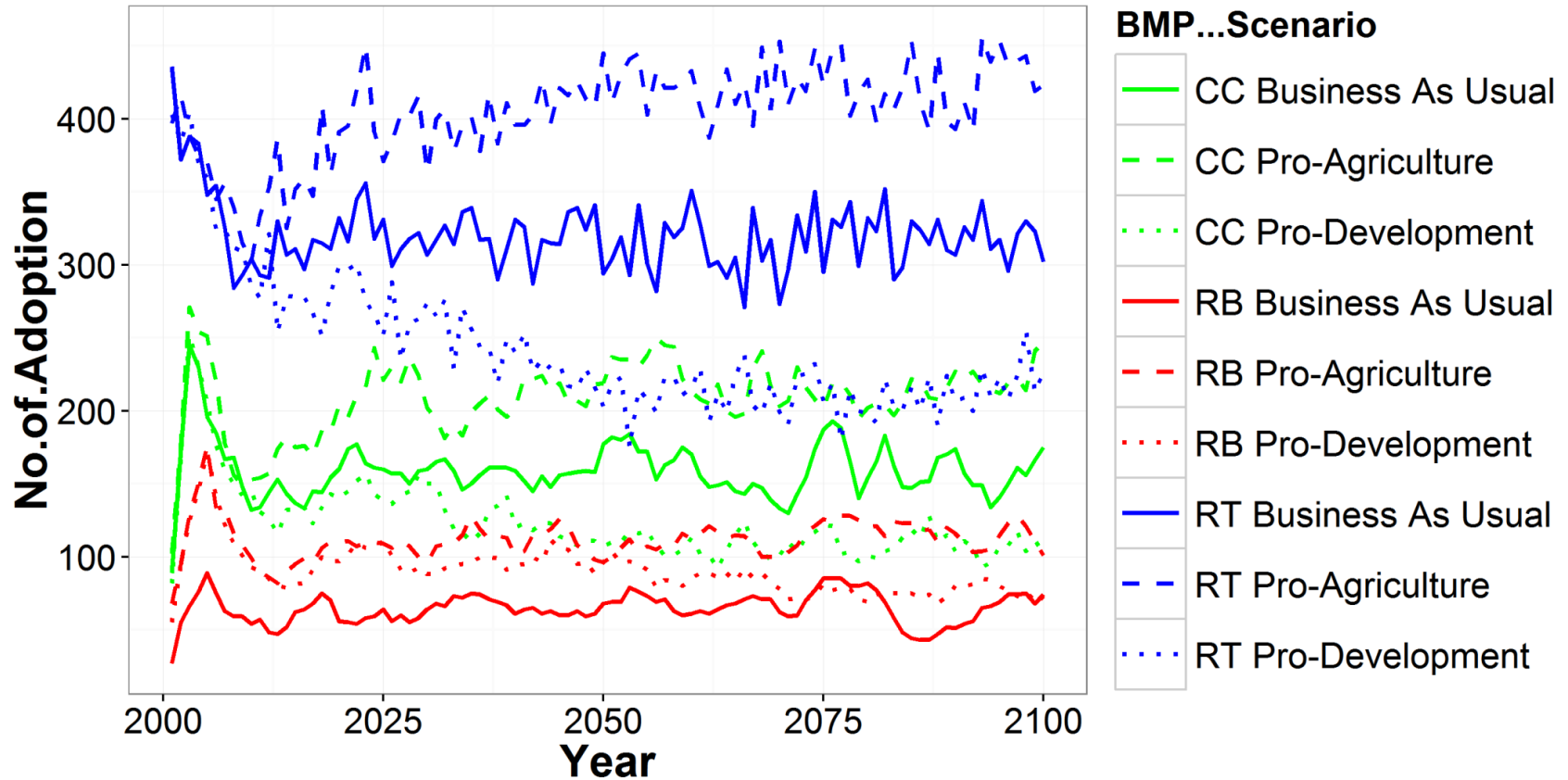
An overview of endogenous behaviors and environments of multiple agent classes (Landcells, Landowners and Policymakers) and their interactions in ALL ABM (Zia et al. 2016)



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.



ALL ABM calibration and testing is in progress to predict the timing and location of farms adopting BMPs under different land use change scenarios



CC = Cover Crops; RB = Riparian Buffers; RT = Reduced Tillage

Governance Network Model (GovABM)

- **Purpose:** To ascertain how financial resources flow through the technical assistance, financial aid and regulatory system, and how these systems are influenced by economic and environmental changes.
- ABM is useful here because we can model observed network ties and institutional rule structures.
- **Model Calibration:** longitudinal network survey data, focus groups, databases to further design and calibrate model.
- **Features:**
 - Major action arenas: LCBP TAC; Tactical Basin Planning; Regional Planning, VT Climate Cabinet, etc.
 - Outputting financial resources available for reg. and BMPs into ALL ABM.
 - Inputting economic forecasts from GEAM.
 - Decision criteria of action arenas to build in learning capacity.

Nested
Hierarchies
governance
networks

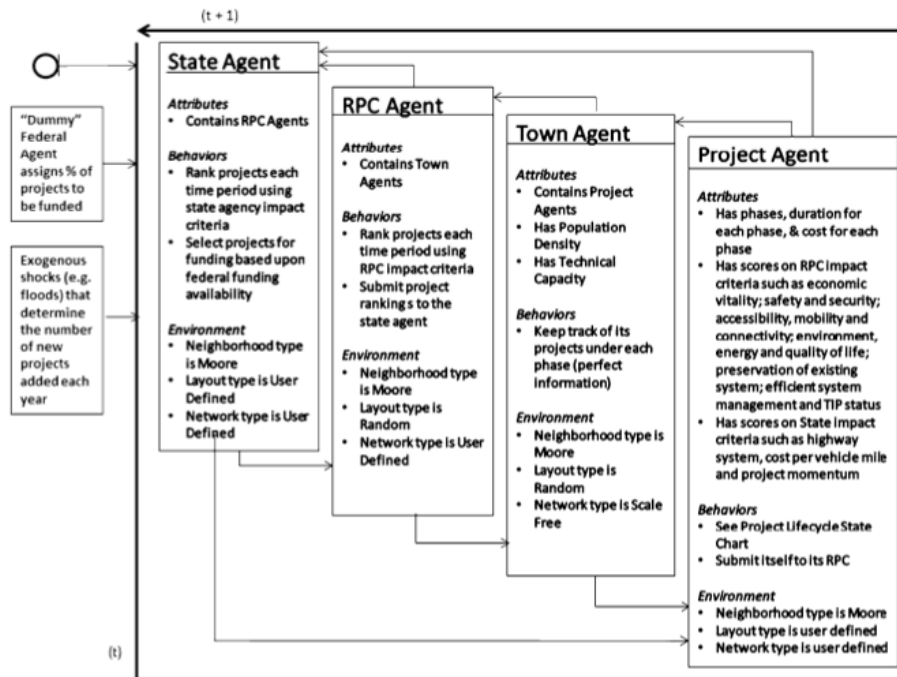
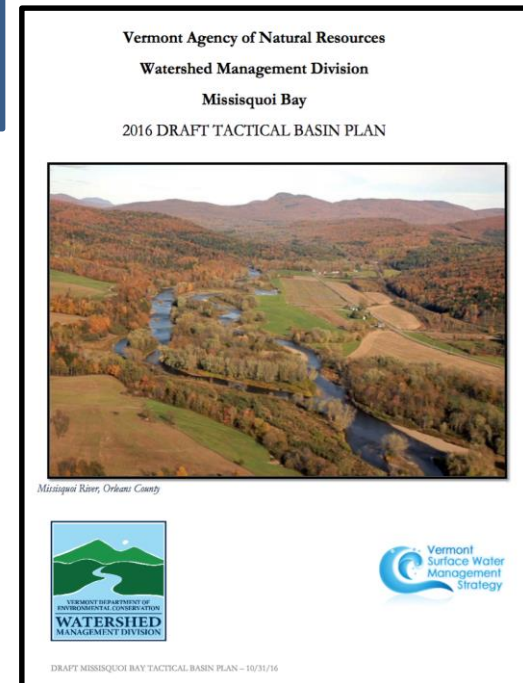


Fig. 2 The internal structure of the stochastic ABM showing attributes, behaviors, and the environment of four agent classes—state agency, regional planning commissions, local towns, and projects

Lake Champlain Water Quality Management “Action Arenas”

ACTION ARENA	DESCRIPTION
Tactical Basin Planning	Actors participate in tactical basin planning meetings to develop water quality management plans for specific watershed and rivers. Priority is given to projects with higher return on investments relative to water quality. Each tactical basin planning meetings take place on a cyclical pattern, usually producing annual plans for the management of water quality across a geographic (watershed) region.
Governor's Climate Cabinet	Comprised of the governor of Vermont’s cabinet or their surrogates. Responsive for coordinated state agency response to climate change mitigation and adaptation.
Lake Champlain Basin Program Technical Advisory Board	Actors participate in the review and production of research on Lake Champlain and wider basin through the creation of “opportunities for Action” strategic plans every five years, State of the Lake Reports, and the use of grants and contracts to complete critical research on the LCB.
Regional Land Use Planning	The State of Vermont has very weak regional and county government structures, with zoning and land use planning decentralized to local municipalities. Regional planning processes are in place and undertaken on a cyclical basis (every five years). These plans are used to provide advice to local town planners who must revise and update local town land use plans every 5 years (staggered) as well.
Agricultural Technical Assistance Provision Coordination	Actors involved in agricultural technical assistance provision meet regularly to coordinate actions around achieving common water quality goals. Agricultural TA working groups are loosely coordinated and meet episodically.
Municipal Stormwater Technical Assistance Provision	Based largely as an intergovernmental collaboration and groups of technical assistance government officials and private consultants, the municipal stormwater technical assistance provision action arena provides technical assistance and supports the pursuit of loans, bonds and technical assistance grants for stormwater improvements at the municipal level.
Roadway Stormwater Technical Assistance Provision	Actors involved in this action arena provide technical assistance to town and state level transportation engineers and road crews with a goal of mitigating stormwater runoff, and water-related transportation infrastructure degradation.
Green Infrastructure Roundtable	This group of actors serve on the Green Infrastructure Roundtable and play the role of an advocacy coalition focused on the promulgation of green infrastructure design. Provision of technical assistance, seeking funding for green infrastructure projects, and advocating for green infrastructure projects at the state, municipal, residential and commercial levels.

The Mechanism in Place to Allocate Resources: Reporting and Financing Interagency / Clean Water Fund Tactical Basin Planning



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

Vermont Tactical Basin Planning

[] Has your municipality been designated as a concentrated stormwater discharge area?

Please choose only one of the following:

- Yes
- No
- Uncertain

[] To what extent are you aware of the Agency of Natural Resources' Tactical Basin Planning process?

Please choose only one of the following:

- Very aware
- Somewhat aware
- Not too aware
- Not aware at all

[] Has your municipality completed a Road Erosion Control Inventory?

Please choose only one of the following:

- Yes, it is completed
- It is in progress
- It is not yet started, but we will start it soon
- It is not completed, in process, or planned
- Uncertain

[] Have you personally attended any Agency of Natural Resources Tactical Basin Planning meetings?

Please choose only one of the following:

- Yes
- No
- Uncertain

[] How many of these meetings have you attended?

Only numbers may be entered in this field.

Please write your answer here:

[] Has your municipality used data and models found in tactical basin plans or ANR models or dashboards?

Please choose only one of the following:

- Yes
- No
- Uncertain

[] In your opinion, what are the major challenges and opportunities to using data and/or models?

Please write your answer here:

Questions from Municipal Survey

Table 2. Status of rivers, streams, lakes, ponds in Middle Lamoille.

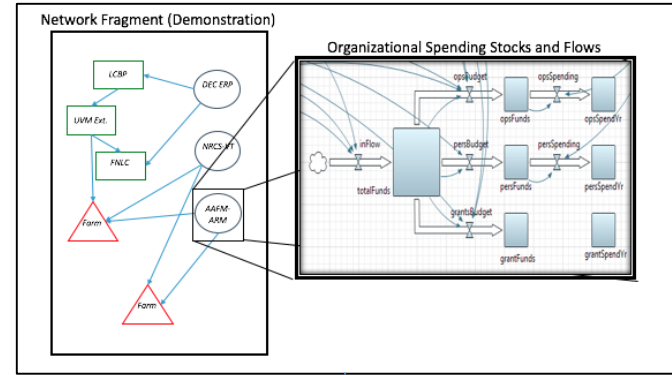
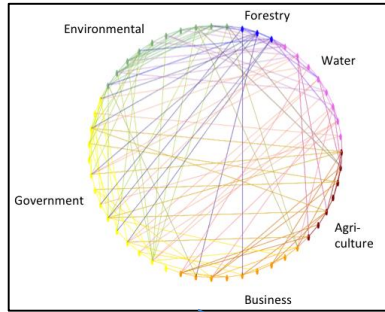
Stream or lake segment	Town	Mileage & status	Pollutant(s)	Primary Stressor	Use Impairment	Problem/Source
MIDDLE LAMOILLE						
Impaired						
Rodman Brook, from mouth to RM 0.6	Morristown	0.6 miles <i>Impaired</i> 303(d) List Part A	Iron		AES, ALS	Lamoille landfill leachate
Hutchins Brook, from RM 2.0 to RM 3.0	Eden	1.0 miles <i>Impaired</i> 303(d) List Part A	Sediment	asbest		
Hutchins Brook, Tributary 4, mouth to RM 0.3	Eden	0.3 miles <i>Impaired</i> 303(d) List Part A	Sediment	asbest		
Tributary #10 to Brewster River	Cambridge	1.0 miles <i>Impaired</i> 303(d) List Part A	Iron			
Lake of the Clouds	Cambridge	1 acres <i>Impaired</i> Part D list	pH			

Table D1. Biological sampling results for Basin 7 sites from 2010 to 2015.

WBID	Stream or River	Town	River Mile	Date	Macroinvertebrate Assessment	Fish Assessment
UPPER LAMOILLE						
VT07-22	Sawmill Brook	Greensboro	1.8	09/13/2011	Excellent – very good	----
VT07-22	Sawmill Brook	Greensboro	1.8	09/26/2013	Excellent	----
VT07-22	Stannard	Stannard	0.3	09/26/2013	Good to fair	----
VT07-22	Lamoille River	Greensboro	80.8	09/26/2013	Very good	----
WBID	Stream or River	Town	River Mile	Date	Macroinvertebrate Assessment	Fish Assessment
MIDDLE LAMOILLE						
VT07-04	Lamoille River	Johnson	45.0	09/19/2011	Excellent	
VT07-04	Lamoille River	Morristown	53.6	09/18/2013	Very good	
VT07-06	Foote Brook	Johnson	2.6	09/10/2013	Excellent	
VT07-06	Waterman Brook	Johnson	1.2	09/18/2013	Excellent	
VT07-06	Jacob Brook	Morristown	0.6	09/19/2011	Excellent	
VT07-06	Jacob Brook	Morristown	0.6	09/16/2013	Very good	
VT07-06	Smith Brook	Johnson	0.9	09/18/2013	Very good	
VT07-08	Rodman Brook	Morristown	0.6	09/20/2013	Very good	
VT07-08	Rodman Brook	Morristown	0.6	10/02/2014	Excellent	
VT07-08	Rodman Brook	Morristown	1.1	10/02/2014	Excellent	
VT07-13	Brewster River	Cambridge	4.2	09/19/2014	Very good	
VT07-13	Brewster River	Cambridge	4.5	09/19/2014	Very good	

Lake or Pond	Town	Lakes Scorecard				Best Lakes Rating	Sentinel Research Site
		WQ	AIS	Shore	Atmos		
Little Elmore	Elmore	NA				5%	
Elmore							
Big Muddy	Eden	NA	NA				
Ritterbush		NA					
Long				NA			
South							
Bean		NA	NA		NA		
Eden	Hyde Park					10%	
Green River						10%	
Schofield**						10%	
Zack Woods**						10%	
Mud		NA	NA				
Lake-of-the-Clouds	Cambridge	NA	NA	NA			
Wolcott	Wolcott					25%	
Wapanacki							
Lamoille*	Morristown	NA		NA			

- Interorganizational Network and Sub-network Configurations
- Sectoral, Jurisdictional, Size, Scale and Function of Network Actors
- Resources Available (endogenous/exogenous)



Formal:

- Public Policies
- Program Rules
- Regulations & Laws

Informal:

- Outside pressure/feedback
- Norms of authority (principal-agent/peer)

