# Q3:Adaptive management of critical transitions in the Lake Champlain Basin

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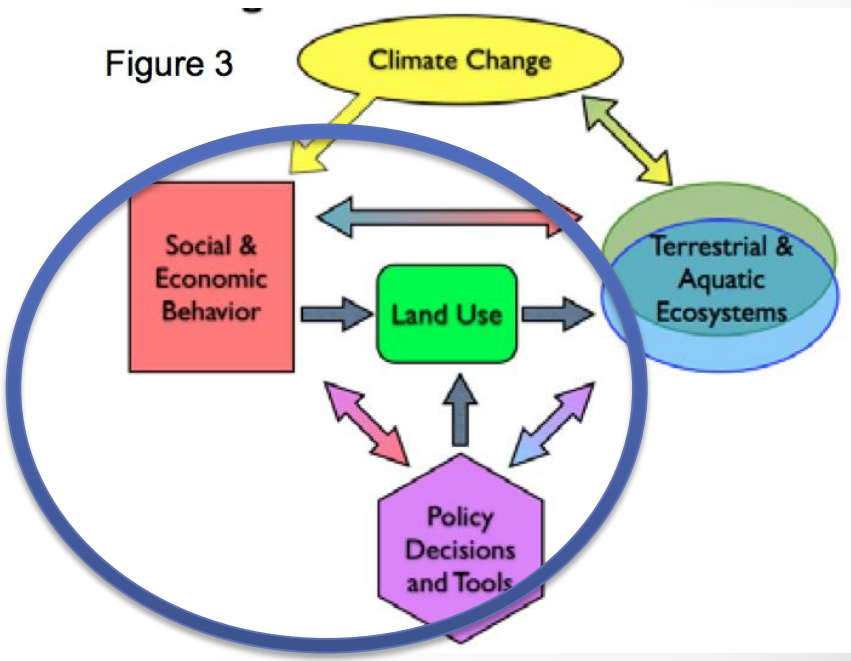
# Our agenda:

- Overarching question(s)/Publications / presentations of work to date/ Climate change adaptation scenarios (Koliba)
- Governance Agent-based Model (Scheinert)
- Land Use Transition Agent-based Model (Tsai)
- Theoretical and empirical dimensions of coupled human-natural systems modeling (Zia)

"Q3": Adaptive management of critical transitions in the Lake Champlain basin

Hypothesis: "Effective watershed governance networks may induce watershed to a stable state that is valued relatively higher by society and policy makers."

**In the face of uncertainties about climate change, land use and lake response scenarios, how can <u>adaptive management</u> interventions (e.g. regulation, incentives, treaties) be *designed*, valued and implemented in the multi-jurisdictional Lake Champlain Basin?**

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# Brief summary of Q3 data collection & outreach activities:

- Climate Change Adaptation Scenario Generation Workshop – Nov. 2012
- Presentations and participation in local and regional watershed-related conferences - VEC, NEIWPCC
- Participant observations at meetings, public hearing, legislative committees, etc.
- Focus groups – MRV community resiliency study
- Surveys – farmer, public opinion
- Interviews - over 30 logged so far with stakeholders
- Participation in national panel on infrastructure resiliency at Sandia National Labs

# Q3-related publications and presentations over the past year:

- Zia, A., Bombies, A., Koliba, C., Betts, A., and Beckage, B. (to be submitted). **Confounding Effects of Scale and Ideology in Communicating Uncertain Climate Risks: Findings from an Experimental Survey Pre- and Post-Tropical Storm Irene**
- Scheinert, S., Reynolds, A., Koliba, C., Zia, C. 2013. **Emerging Environmental Governance Networks: The Development of the Network in the Lake Champlain Basin Program's Opportunities for Action Plans**. Sunbelt XXXIII: Mechanisms of Change in Organizational Networks. Hamburg, Germany.
- Reynolds, A., Koliba, C., Scheinert, S., and Zia. A. 2013. **Isomorphic Properties of Network Governance: Comparing Two Watershed Governance Initiatives in the Lake Champlain Basin Using Institutional Network Analysis.** American Association of Public Administration. New Orleans, LA.
- Ricketson, J., Koliba, C., Zia, A., Hurley, S. 2013. **Boundary Objects, Brokers and Conversation Starters: the Role of Tactical Management Tools for Non-Point Phosphorus Mitigation in the Lake Champlain Basin.** National Ecological Economics Association. National Conference. Burlington, VT.
- Koliba, C. and Zia, A. (accepted for publication). Book chapter: **Governance Informatics: Using Computer Simulation Models to Deepen Situational Awareness and Governance Design Considerations**. DeSouza, K. and Johnston, E. editors. Policy Informatics. MIT Press: Cambridge, MA.
- Zia A, Koliba C. **Adaptive Management of Critical Transitions in the Social Ecological Systems: Governing Alternate Stable States in Multi-Jurisdictional Lake Champlain Basin.** In: The American Society for Public Administration, Section on Complexity and Network Studies (SCNS), and Erasmus University Rotterdam, research group Governance of Complex Systems (GOCS) Joint Conference on "Challenges of Making Public Administration and Com. The American Society for Public Administration, Section on Complexity and Network Studies (SCNS), and Erasmus University Rotterdam, research group Governance of Complex Systems (GOCS) Joint Conference on "Challenges of Making Public Administration and Com. La Verne, CA,; 2013.
- Koliba C, Zia A. **Complexity Friendly Meso-Level Public Administration and Policy Studies Frameworks for Modeling Complex Governance Systems: Challenges and Opportunities for a Meta-Theoretical Research Program.** In: COMPACT I: Public Administration in Complexity. COMPACT I: Public Administration in Complexity. Litchfield Park, AZ; 2013. p. 119-136.
- Zia A, Koliba C, Tian Y. **Governance Network Analysis: Experimental Simulations of Alternate Institutional Designs for Intergovernmental Project Prioritization Processes.** In: COMPACT I: Public Administration in Complexity. COMPACT I: Public Administration in Complexity. Litchfi eld Park, AZ; 2013. p. 144-165.
- Zia A, Koliba C. **How Multi-Level Institutional Mechanisms Generate Basins of Attraction in Infrastructure Investments.** In: International Research Society for Public Management (IRSPM) Annual Conference. International Research Society for Public Management (IRSPM) Annual Conference. Prague, Czech Republic; 2013. p. .
- Tsai Y, Zia A, Koliba C, Guilbert J, Bucini G, Beckage B. **Impacts of Land Managers' Decisions on Landuse Transition within Missisquoi Watershed Vermont: An Application of Agent-based Modeling System.** IEEE International Systems Conference. 2013.
- Beckage B, Kauffman S, Zia A, Koliba C, Gross LJ. **More complex complexity: exploring the nature of computational irreducibility across physical, biological, and human social systems.** In: Irreducibility and Computational Equivalence: Wolfram Science 10 Years After the Publication of A New Kind of Science. Vol. 2. Irreducibility and Computational Equivalence: Wolfram Science 10 Years After the Publication of A New Kind of Science. ; 2013. p. 79-88. Available from: http://link.springer.com/chapter/10.1007%2F978-3-642-35482-3_7#page-2
- Koliba C, Zia A. **The Resiliency Challenge for Social Ecological Systems: Overcoming Institutional Silos Through Mediated Modeling.** In: The American Society for Public Administration, Section on Complexity and Network Studies (SCNS), and Erasmus University Rotterdam, research group Governance of Complex Systems (GOCS) Joint Conference on "Challenges of Making Public Administration and Com. The American Society for Public Administration, Section on Complexity and Network Studies (SCNS), and Erasmus University Rotterdam, research group Governance of Complex Systems (GOCS) Joint Conference on "Challenges of Making Public Administration and Com. La Verne, CA; 2013.
- Koliba C, Zia A. **The Role of Governance Informatics in Promoting Accountability and Performance: Examples from Watershed Management.** In: International Research Society for Public Management (IRSPM) Annual Conference. International Research Society for Public Management (IRSPM) Annual Conference. Prague, Czech Republic; 2013.

## RIVER AND STREAM SCENARIOS

## SOIL DYNAMICS SCENARIOS

## LAKE HYDROLOGY SCENARIOS

### First Order Impacts
- Change in stream dynamics

### Second Order Impacts
- Increase in flooding
- Increase in effluent concentration
- Change in hydropower storage and potential

### Third Order Impacts
- Increase in property damage
- Increase in human risk: injury and loss of life
- Increase in sediment and nutrient loading
- Increase in mental health impacts
- Decrease in recreational activities
- Decrease in species range and viability
- Decrease in water quality
- Increase in Harmful Algae Blooms
- Change in costs
- Change in habitat
- Change in economic feasibility
- Change in water quality

### Adaptation Strategies
- Change in planning and zoning
- Change in infrastructure design requirements
- Increased emergency planning

Key:
- Environment
- Agriculture
- Economic
- Social/Recreation
- Infrastructure

CLIMATE DRIVERS

### First Order Impacts
- Decrease in soil moisture

### Second Order Impacts
- Increase in stressed vegetation: leaves
- Changes in root structure
- Increase in infiltration
- Uncertainty in surface and ground water availability
- Increase in vulnerability of seasonal pools/wetlands

### Third Order Impacts
- Decrease in tourism/recreation
- Increase in vulnerabilities, blowdowns
- Decrease in sugaring
- Increase in negative impacts on farming in general
- Decrease in flooding impacts
- Decrease in cost of infrastructure maintenance

### Adaptation Strategies
- Increase in irrigation
- Change in infrastructure design requirements
- Increase in need for soil Management: soil health and fertility (building soils)
- Maintain forest cover, maximize ground infiltration to maximize ground storage and maintain springs

Key:
- Environment
- Agriculture
- Economic
- Social/Recreation
- Infrastructure

CLIMATE DRIVERS

### First Order Impacts
- Change in Lake Champlain Basin Hydrology

### Second Order Impacts
- Increase in assimilative capacity
- Increase in flooding
- Increase in erosion
- Change in groundwater table elevation
- Change in animal composition and distribution
- Change in aquatic and riparian plant composition and distribution
- Change in temperatures
- Decrease in access to recreation

### Third Order Impacts
- Change in wetlands
- Increase in septic fails
- Increase in lake armoring
- Decrease in income from tourism

### Adaptation Strategies
- Change in planning and zoning
- Change in infrastructure design requirements
- Increased emergency planning
- Maintain forest cover, maximize ground infiltration to maximize ground storage and maintain springs

Key:
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CLIMATE DRIVERS

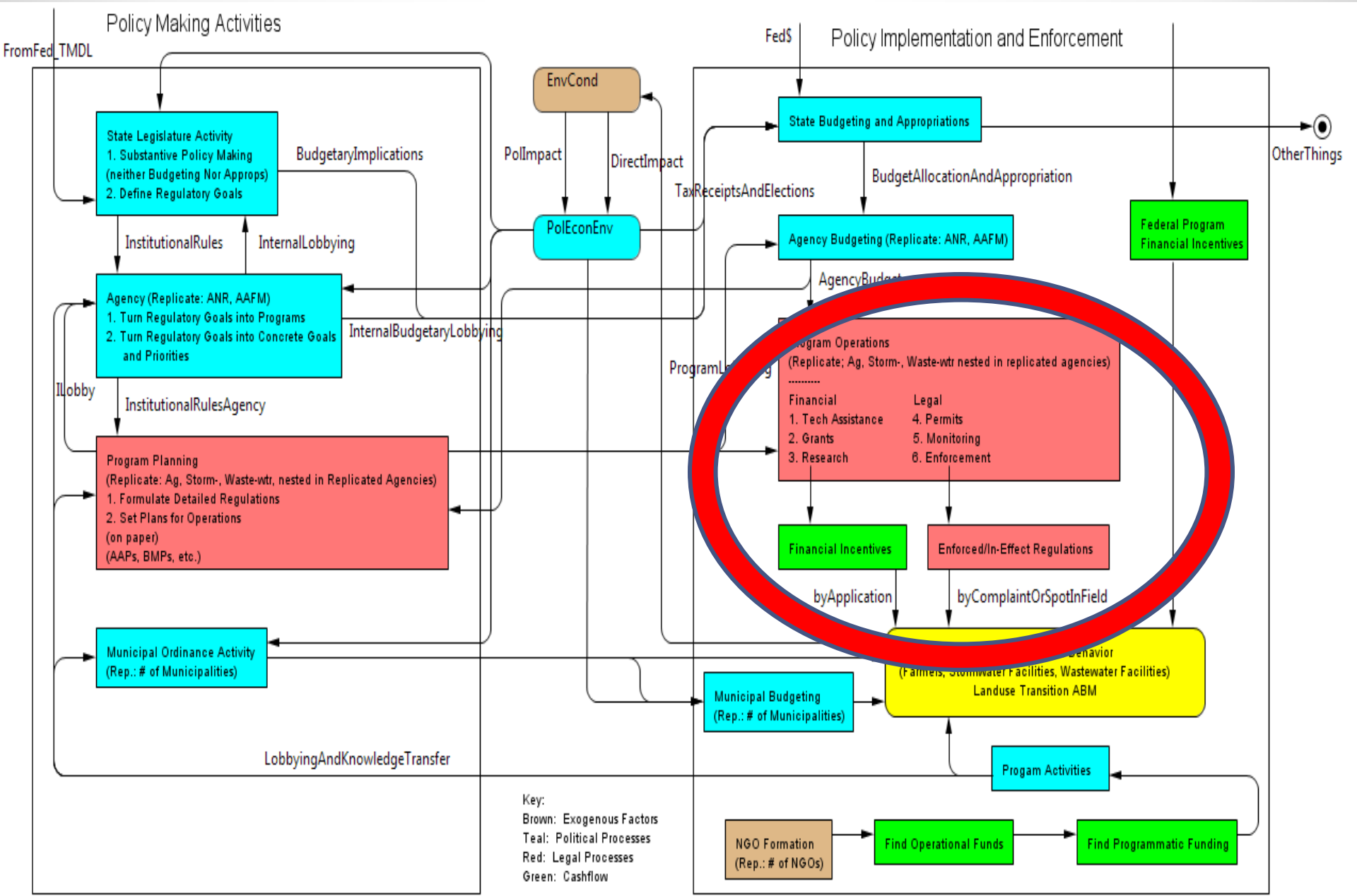
# Agent-Based Governance Model (GovABM)

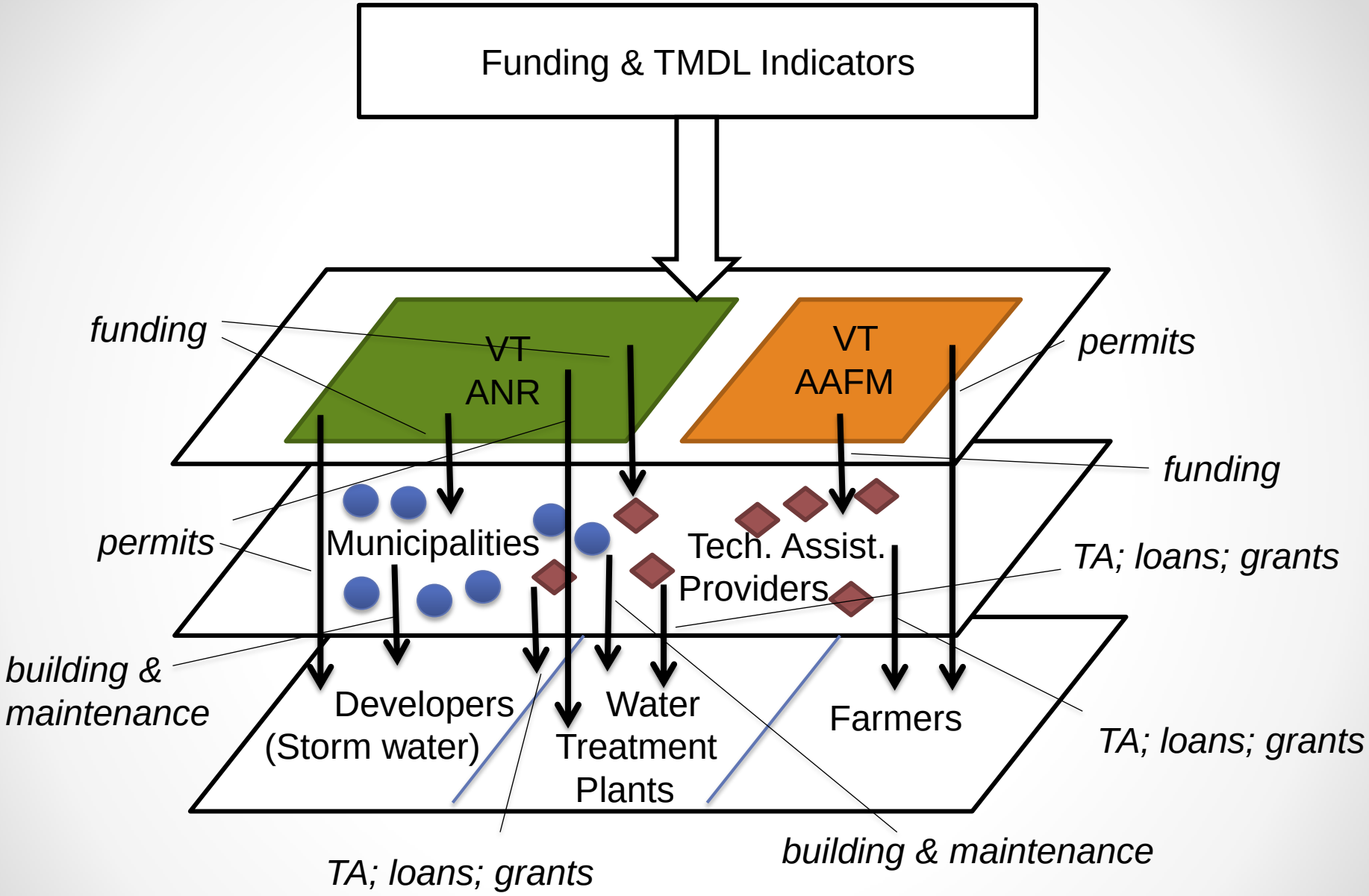
- Goal:  Test policy options to find a mix structural reforms and funding arrangements for improving water quality

- Models the operation of water-quality oriented state and federal programs in the context of a set of policy domain(s)

- Data Sources
  - Stakeholder interviews
  - Program data
    - Program structures
    - Program budgets
    - Program application records
  - Validation through stakeholder feedback

# Full System with Decision Mechanisms (GovABM v2)

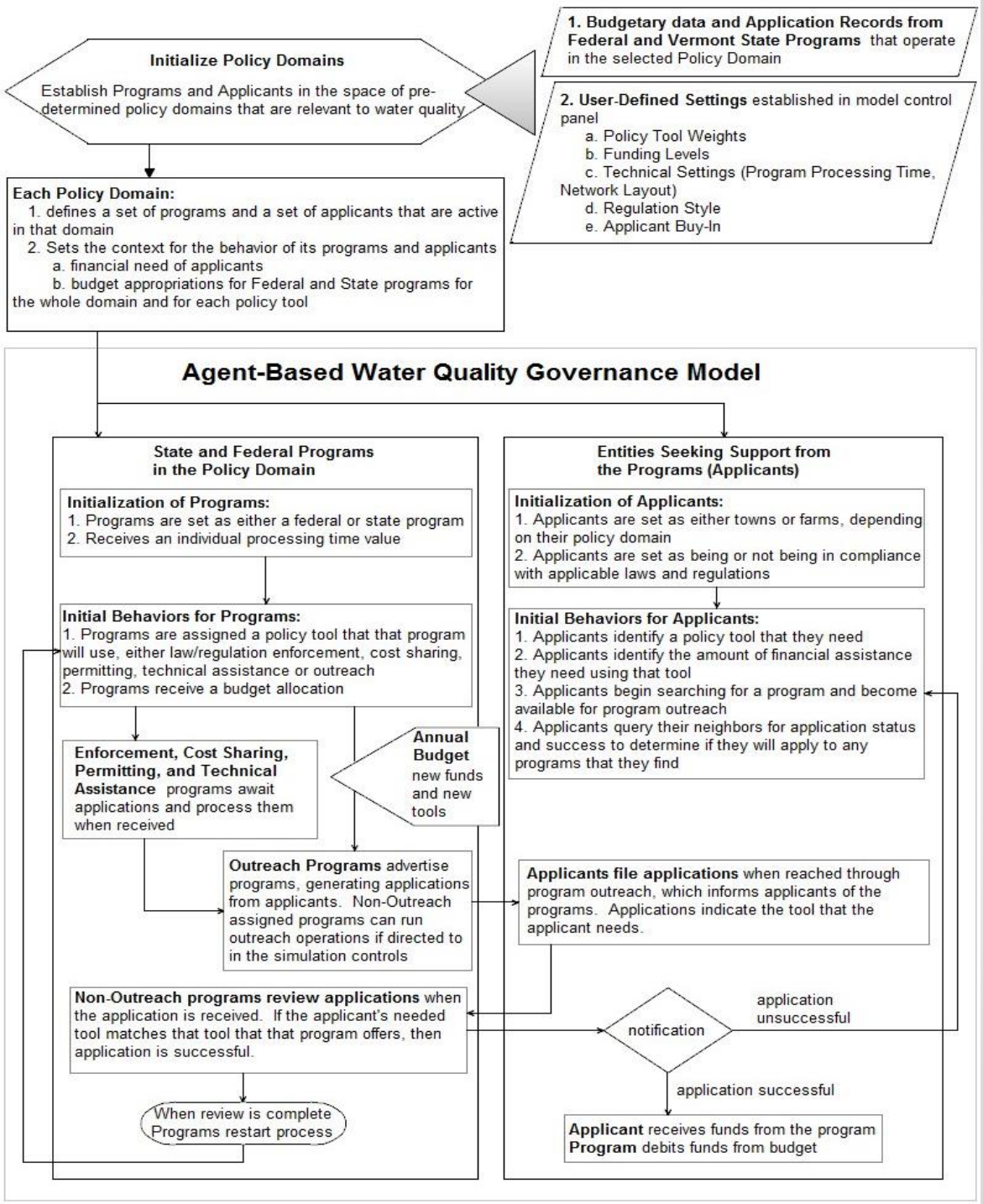



Funding & TMDL Indicators
funding
VT
ANR
VT
AAFM
permits
funding
permits
Municipalities
Tech. Assist.
Providers
TA; loans; grants
building &
maintenance
Developers
(Storm water)
Water
Treatment
Plants
Farmers
TA; loans; grants
TA; loans; grants
building & maintenance

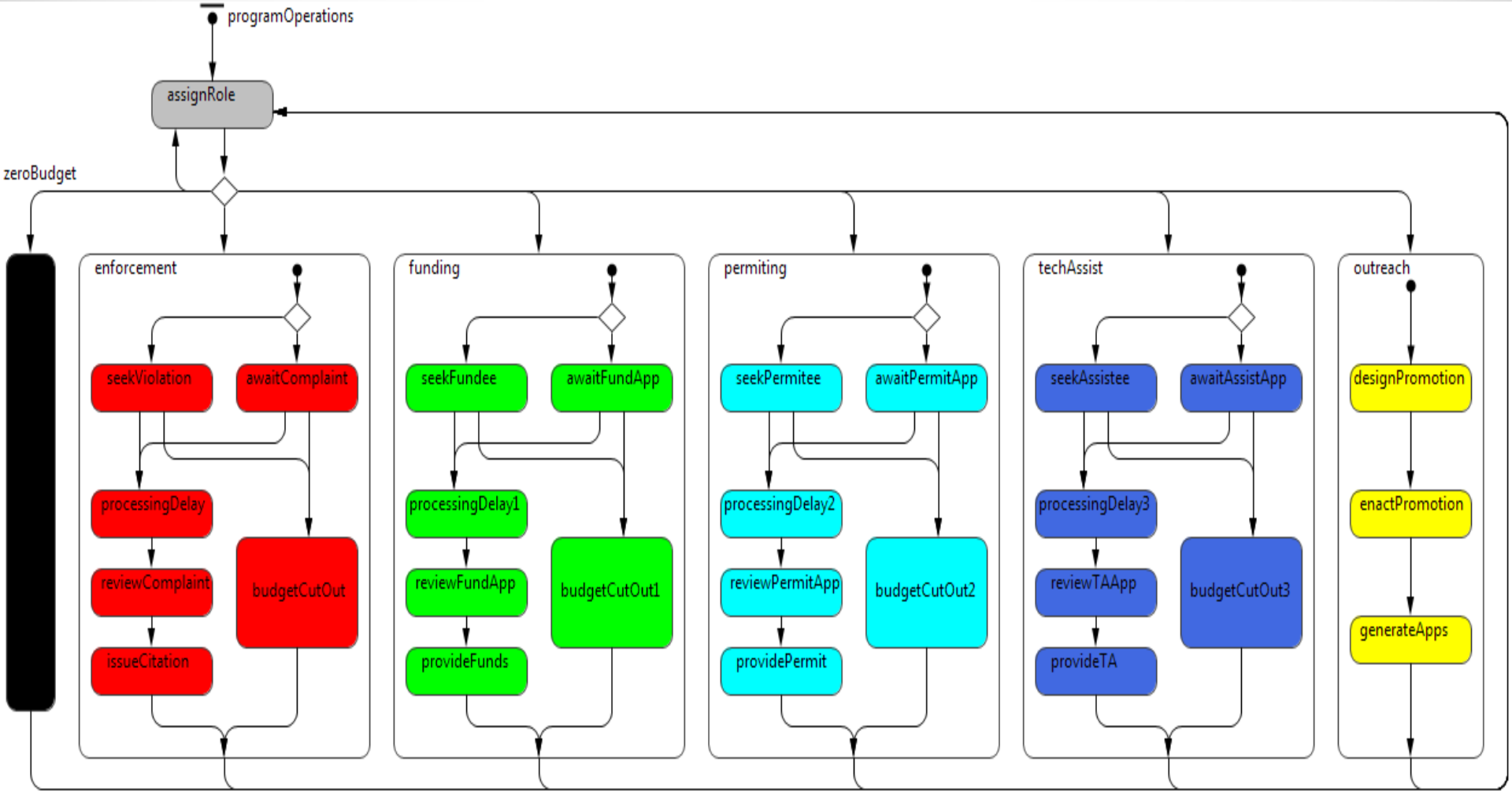
# Program Focuses

- Federal Programs
  - Environmental Quality Incentive Program (EQIP)
  - Conservation Reserve Enhancement Program (CREP)
  - Farm and Ranch Lands Protection Program (FRPP)
- VT State Programs
  - Agricultural water quality (VT AAFM)
  - Ecosystem Restoration Program (VT DEC)
- Program Data
  - Budgetary Data
    - Funding amounts
    - Funding sources
  - Staffing levels (FTE's)
  - Policy tool use patterns
  - Program operation rules
  - Application records
  - Financial disbursements

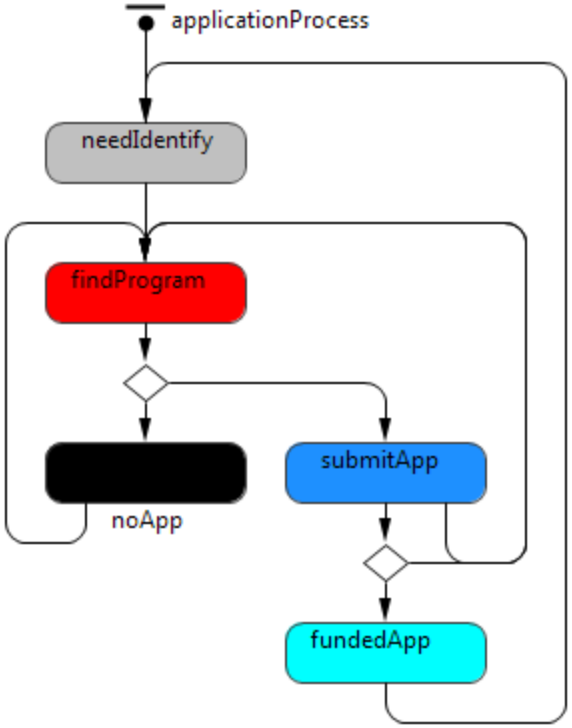
# Process Map: GovABM v3.2



# Program Operation Schematic (v3.2)



# Applicant Behavior Schematic (v3.2)



# Water Quality Governance v3.2

## Political Decision Parameters and Tool Weights Control Panel

### Policy Domains and Programs Setup

1) Number of Policy Domains

(•) 1 ( ) 2 ( ) 3 ( ) 4 ( ) 5 ( ) 6

2) Total Number of Programs

(•) 1 ( ) 2 ( ) 3 ( ) 4 ( ) 5 ( ) 6 ( ) 7 ( ) 8 ( ) 9 ( ) 10

3) Number of Federal Programs

(•) 0 ( ) 1 ( ) 2 ( ) 3 ( ) 4 ( ) 5 ( ) 6 ( ) 7 ( ) 8 ( ) 9 ( ) 10

### Percentage of Funding to be Used on Each Tool

1) Legal/Regulatory Enforcement

min value max

2) Cost Sharing

min value max

3) Permitting

min value max

4) Technical Assistance

min value max

5) Outreach

min value max

### Financial Settings

1) Federal Program Funding Level

min value max

2) State Program Funding Level

min value max

3) Non-Governmental Organization (NGO) Funding Level

min value max

Run the Model

**Authors: Steve Scheinert (Vermont EPSCoR: RACC)**
**Chris Koliba (University of Vermont)**
**Asim Zia (University of Vermont)**

Acknowledgement: Thank you to Yuan Tian (University of Saskatchawan) and Asim Zia (University of Vermont) for access to their Intergovernmental Project Prioritization (IPP) Model. Many of the simulation interface structures and functionality for this model were taken from the IPP Model and adapted to function in this model. For reference, see:

# Water Quality Governance v3.2

## Program and Applicant Behaviors

### Governance Approach

| Regulation Style | Low Priority Tools | Applicant Receptivity |
|---|---|---|
| (•) Reactive | (•) Contract Out | (•) Engaged |
| ( ) Proactive | ( ) Leave for NGOs | ( ) Reluctant |
| | ( ) Ignore | |

### Program Behaviors and Costs

1) Operational Cost

min value max

2) Outreach Cost

min value max

3) Average Number of Weeks Required for Program Actions (Program Delay Factor)

min value max

4) Variability in Program Response Times

min value max

### Regulatory Compliance Rate Settings

1) Farmer Compliance Compliance Rate

min value max

2) Municipality Regulatory Compliance Rate

min value max

# Why Landuse Transition Agent-based Model (LUT ABM)

Source: State of The Lake, LCBP, 2012

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# Conceptual Flow Chart of the LUT ABM

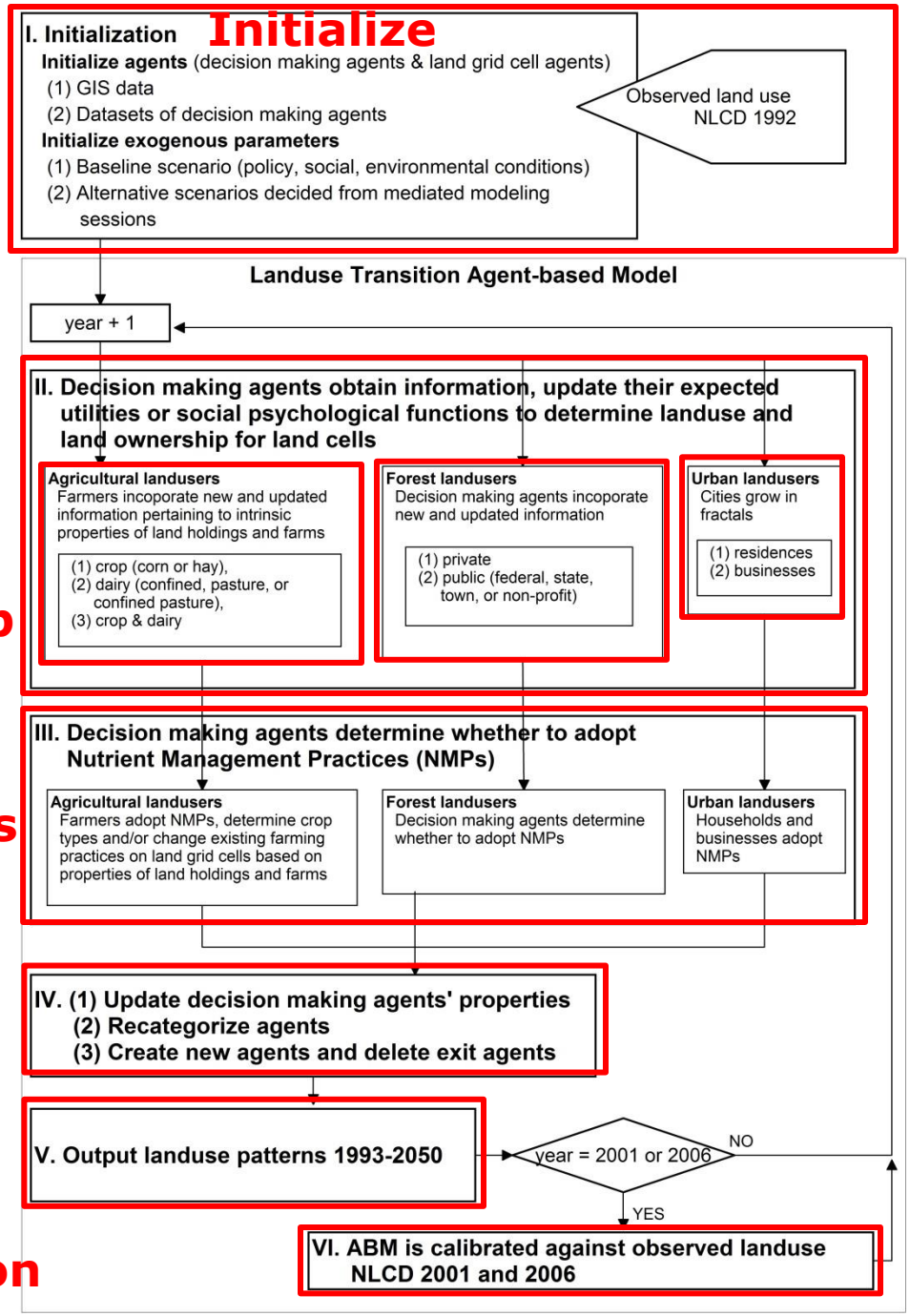
**Landuse & Land Ownership**

**Nutrient Management Practices**

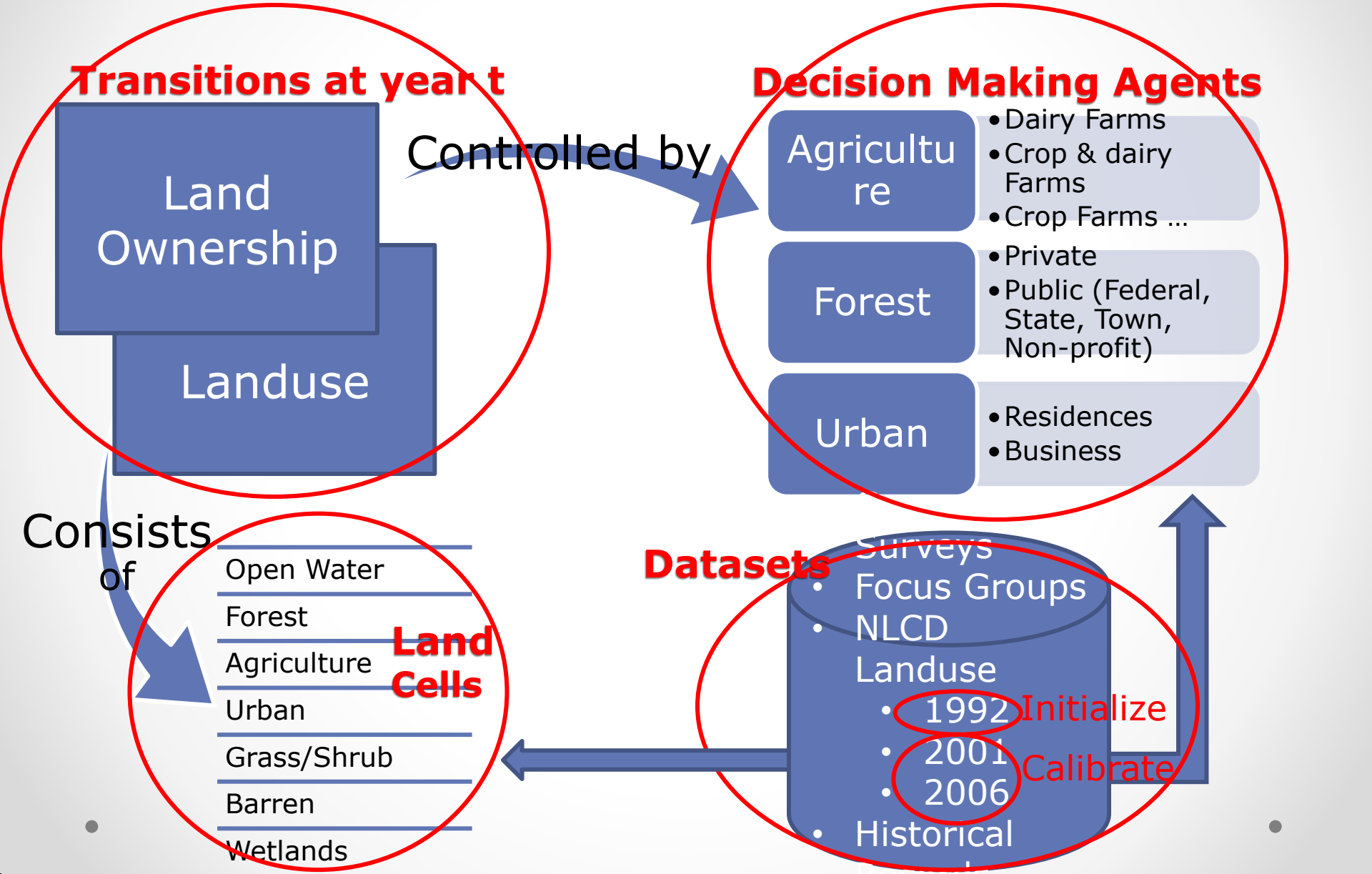
**Update**

**Output**

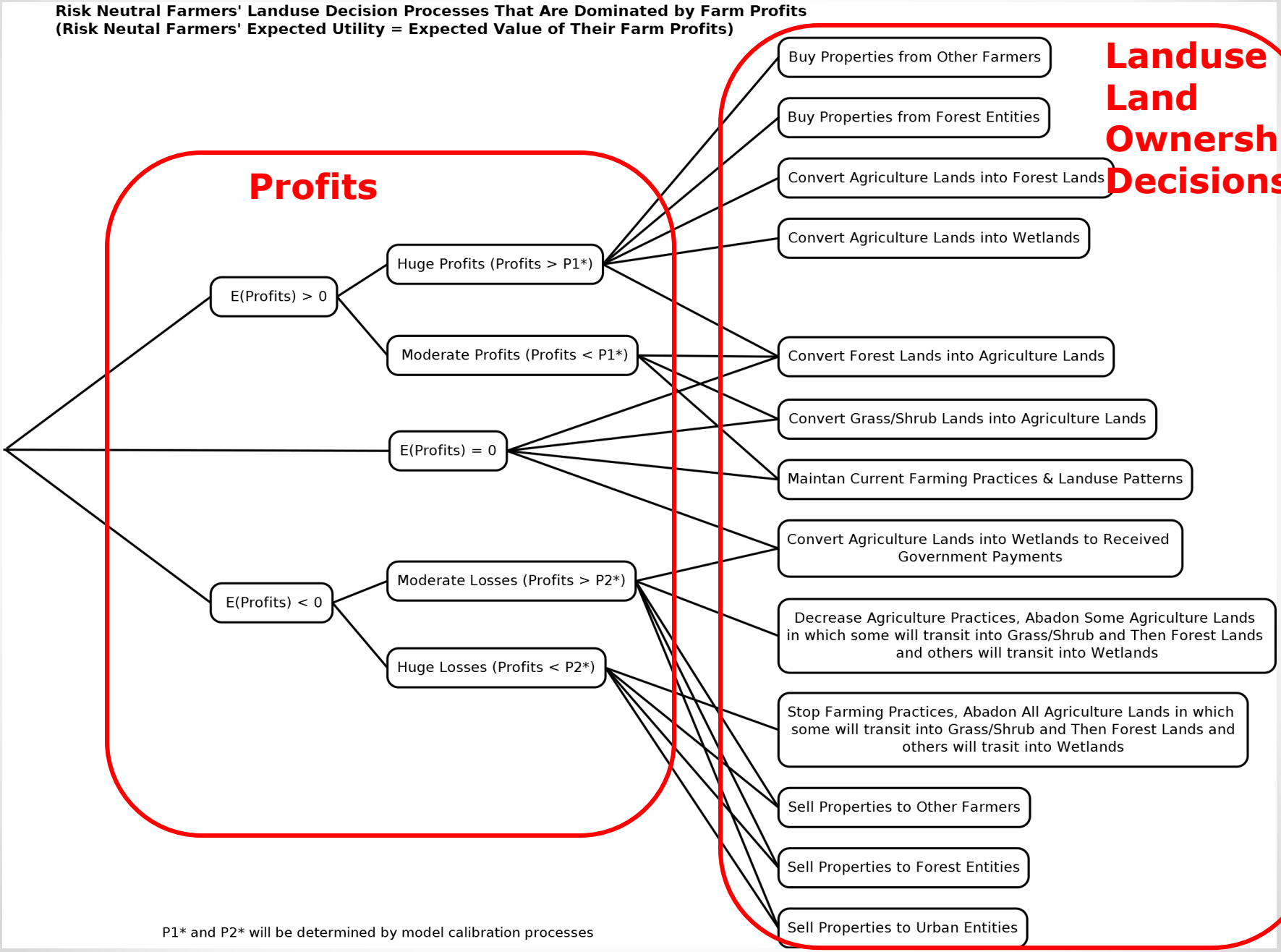
**Calibration**



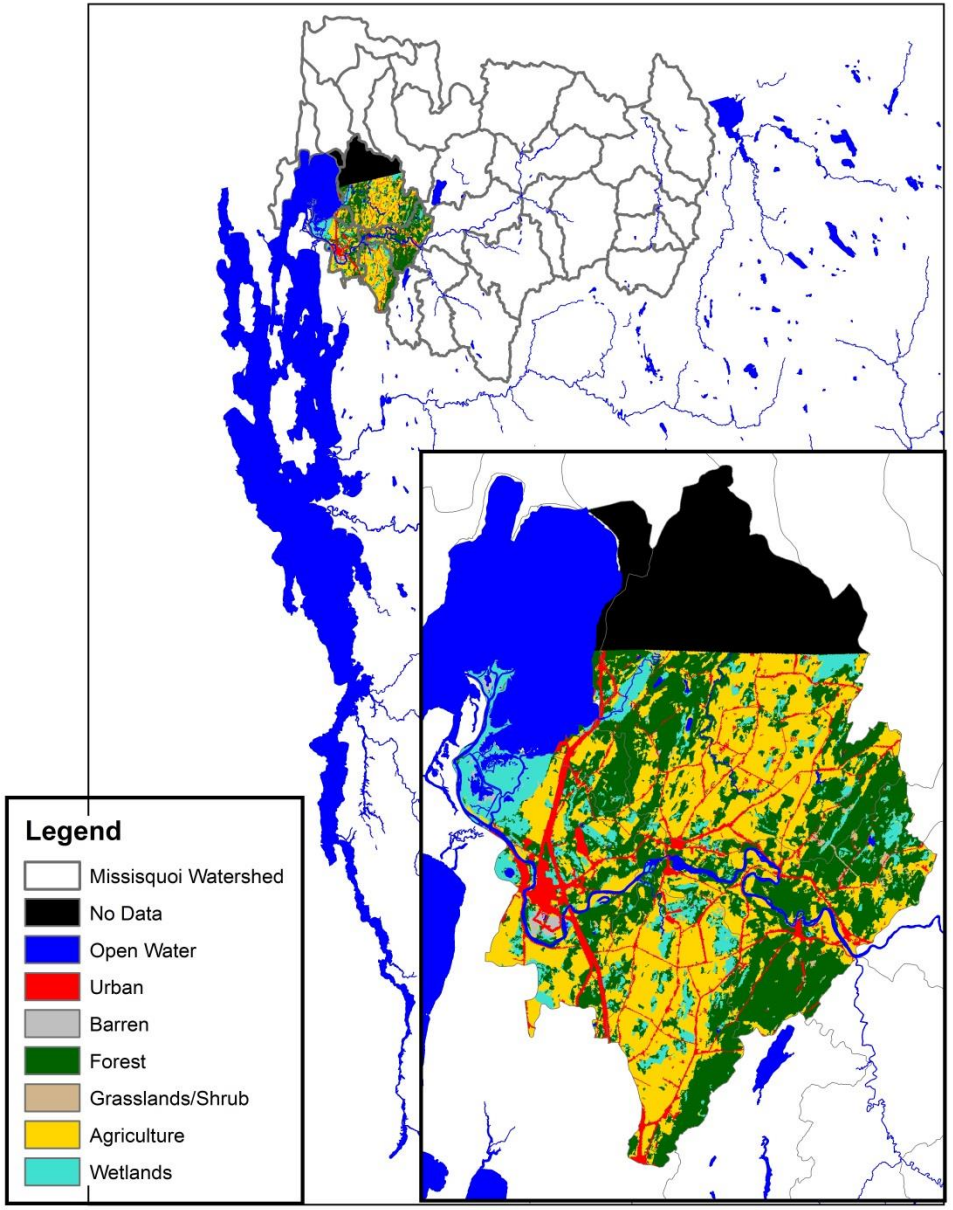
# Components of the LUT ABM



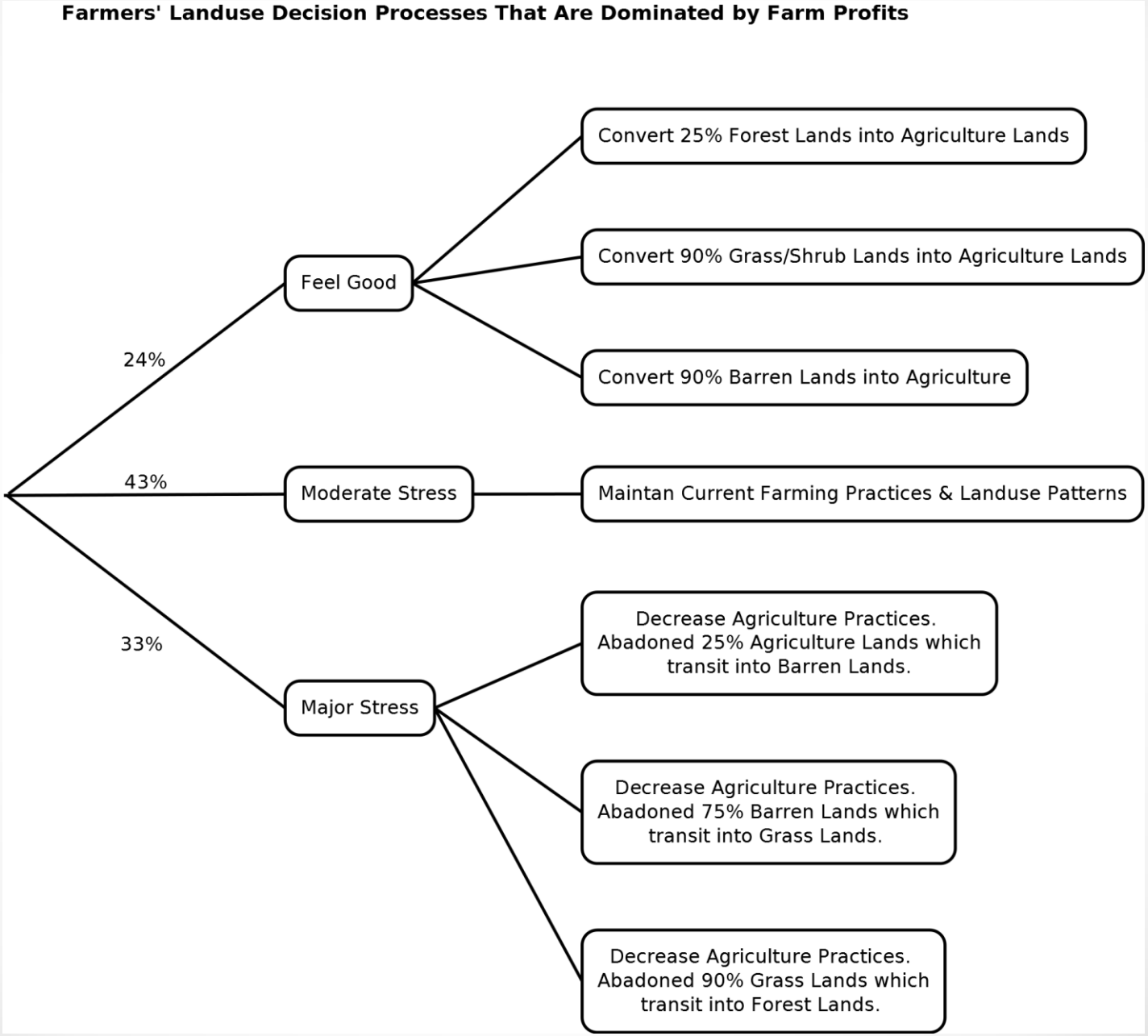
# Farmers' Landuse & Land Ownership Decisions



# Preliminary Simulation Study Area

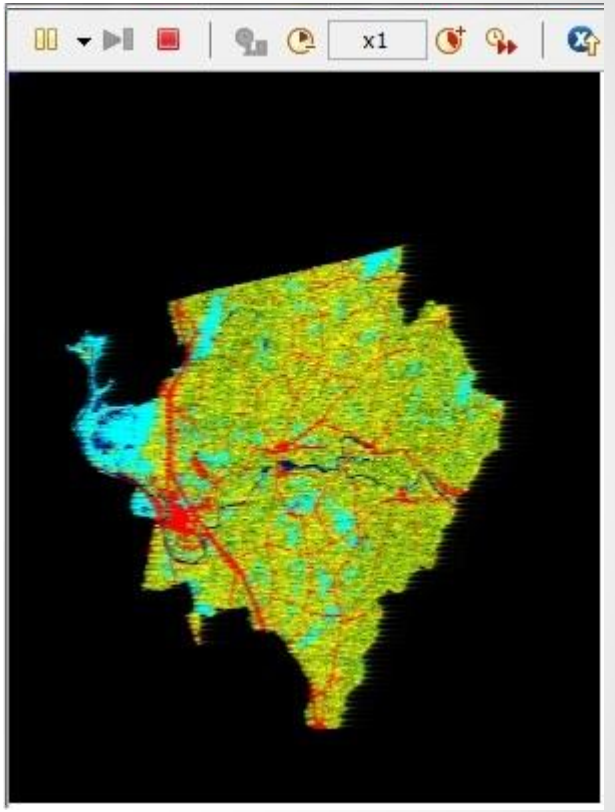


# Preliminary Simulation



# Preliminary Simulation

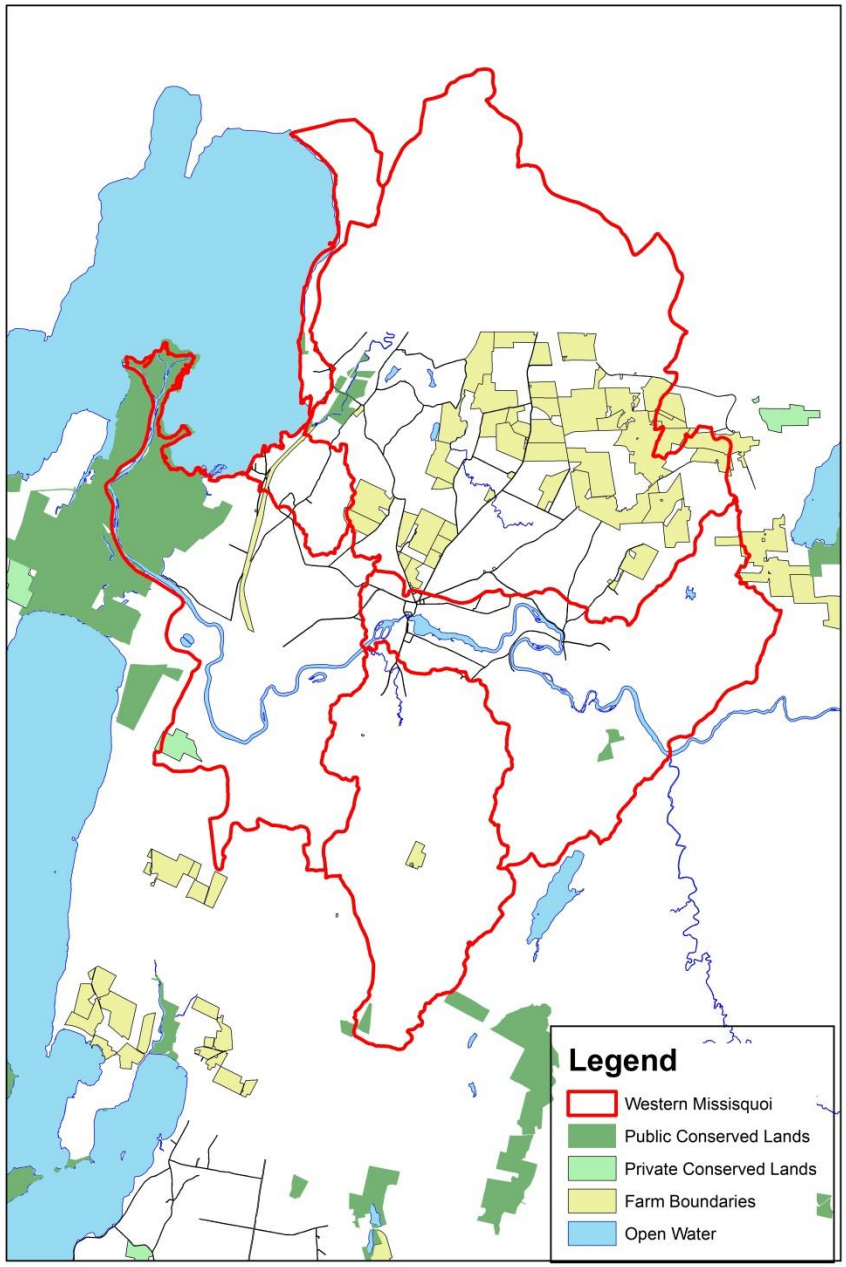
| Landuse transitions as percent of A land is turned into B land during one year time interval | | Three possible financial conditions for the farmers during a year (Probability that the financial condition occurs ) | | |
|---|---|---|---|---|
| A | B | Major Stress (33%) | Moderate Stress (43%) | Feel Good (24%) |
| Agriculture | Barren | 25% | 0% | 0% |
| Barren | Grass | 75% | 0% | 0% |
| Grass | Forest | 90% | 0% | 0% |
| Forest | Agriculture | 0% | 0% | 25% |
| Barren | Agriculture | 0% | 0% | 90% |
| Grass | Agriculture | 0% | 0% | 90% |




Year 2012

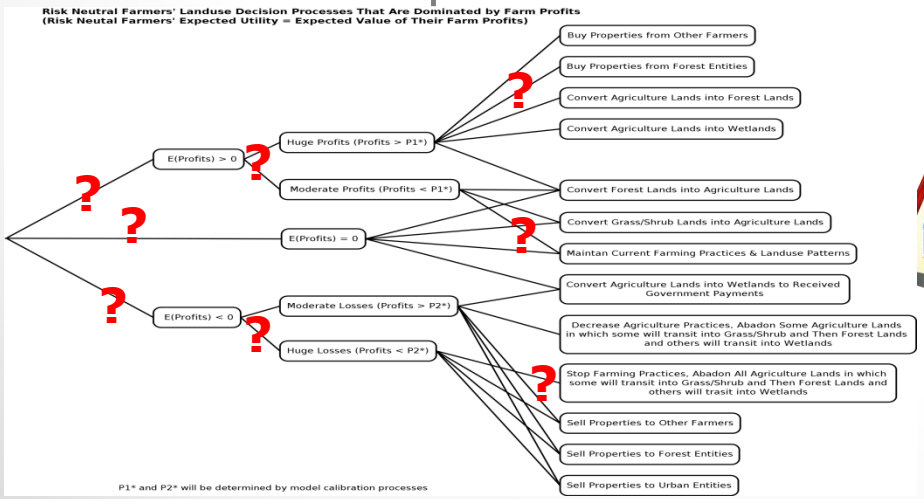
# Continuing Efforts

- Determine Land Ownership for initial year 1992 & consequent years
  - Common land unit (CLU) dataset
  - Public and private owned conservation lands GIS Layers
  - Vermont E911 (buildings) data
  - Census Data



# Continuing Efforts

- Determine Landuse Decision Rules of land owners of different types
  - Census, Past and current Surveys, Focus Groups
  - Stochastic processes

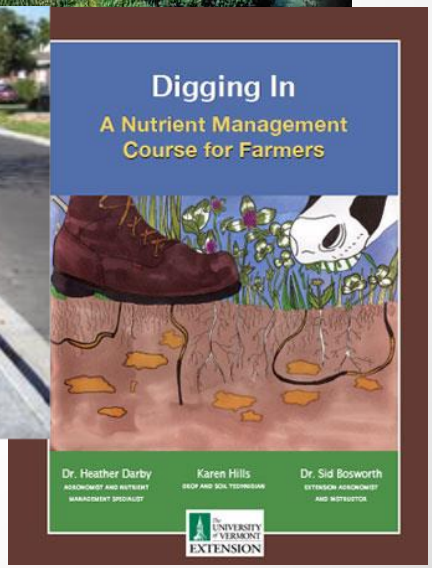



# Continuing Efforts

- Calibrate the LTABM to
  - Observed landuse data
- Impacts of Best Management Practices in reducing Phosphorous loads
  - Mata-analysis on past literature
- Expend to the whole Missisquoi Watershed
- Integrate with Governance Network, Hydrologic and In-lake Transport Models

Source: www.oh.nrcs.usda.gov

Source: www.kingston.vic.gov.au




Source: pss.uvm.edu