Resilience to Extreme Events in Social Ecological Systems of the Lake Champlain Basin

(Basin Resilience to Extreme Events, BREE)

BREE IAM Status and Development Plans

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BREE Overarching Research Question

What are properties within the Lake Champlain Basin that drive hydrologic and nutrient responses to extreme events, and what are strategies for increasing resilience to protect water quality in the social ecological system?

WORKING HYPOTHESIS

The structure and state of systems can either dampen or amplify the cascading impacts of extreme events as their effects flow through the Social Ecological System of the Basin

FOCAL EXTREME EVENTS

- We define “extreme events” as “meteorological phenomena such as high temperature and precipitation with consequent events that are system responses, such as floods or droughts (Field et al. 2012)”.

- Following specific extreme events are being investigated by the BREE team in the hydro-meteorological context of the Lake Champlain Basin:

  (1) heavy and persistent precipitation and resulting floods;

  (2) intra-annual and inter-annual droughts;

  (3) heat waves;

  (4) cold snaps; and

  (5) extreme changes in the distribution of precipitation form (snow to rain).

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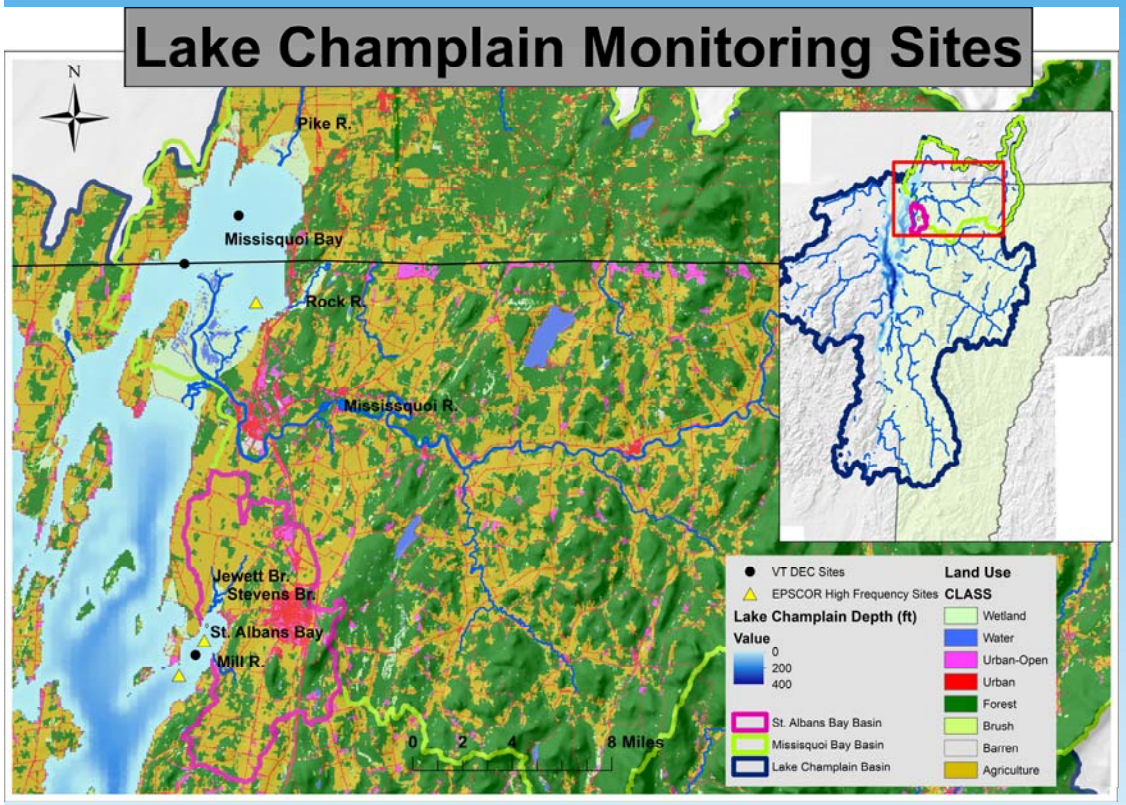
IAM Research Question: What strategies for resilience can be implemented to manage the risk from extreme events and what are the trade-offs for prioritizing public sector investments?

Extreme hydro-climatic event

Risk from change of state in the bay: mesotrophic to eutrophic

IAM Focal SES: Missisquoi & St. Albans



Shallow eutrophic systems that differ in terrestrial and open water connectivity

Adaptive Management Approach to Identify Resilient Strategies

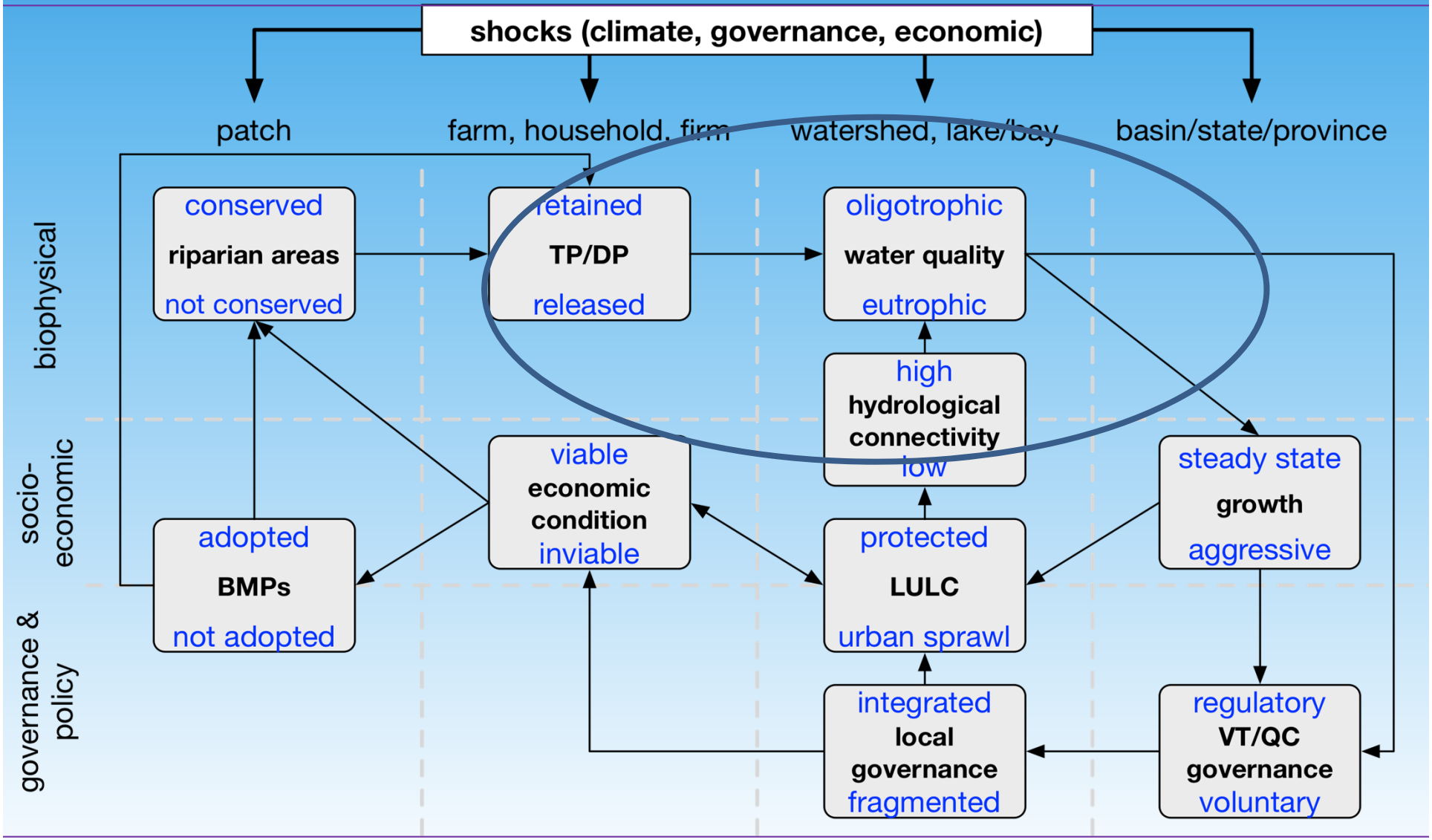
BREE IAM Policy & Technical Advisory Committee (PTAC) consensus on two definitions of resilience:

1: "The Lake Champlain Basin system should maintain critical functions after an event without significant post-event inputs" [Ex-Secretary, Agency of Agriculture]

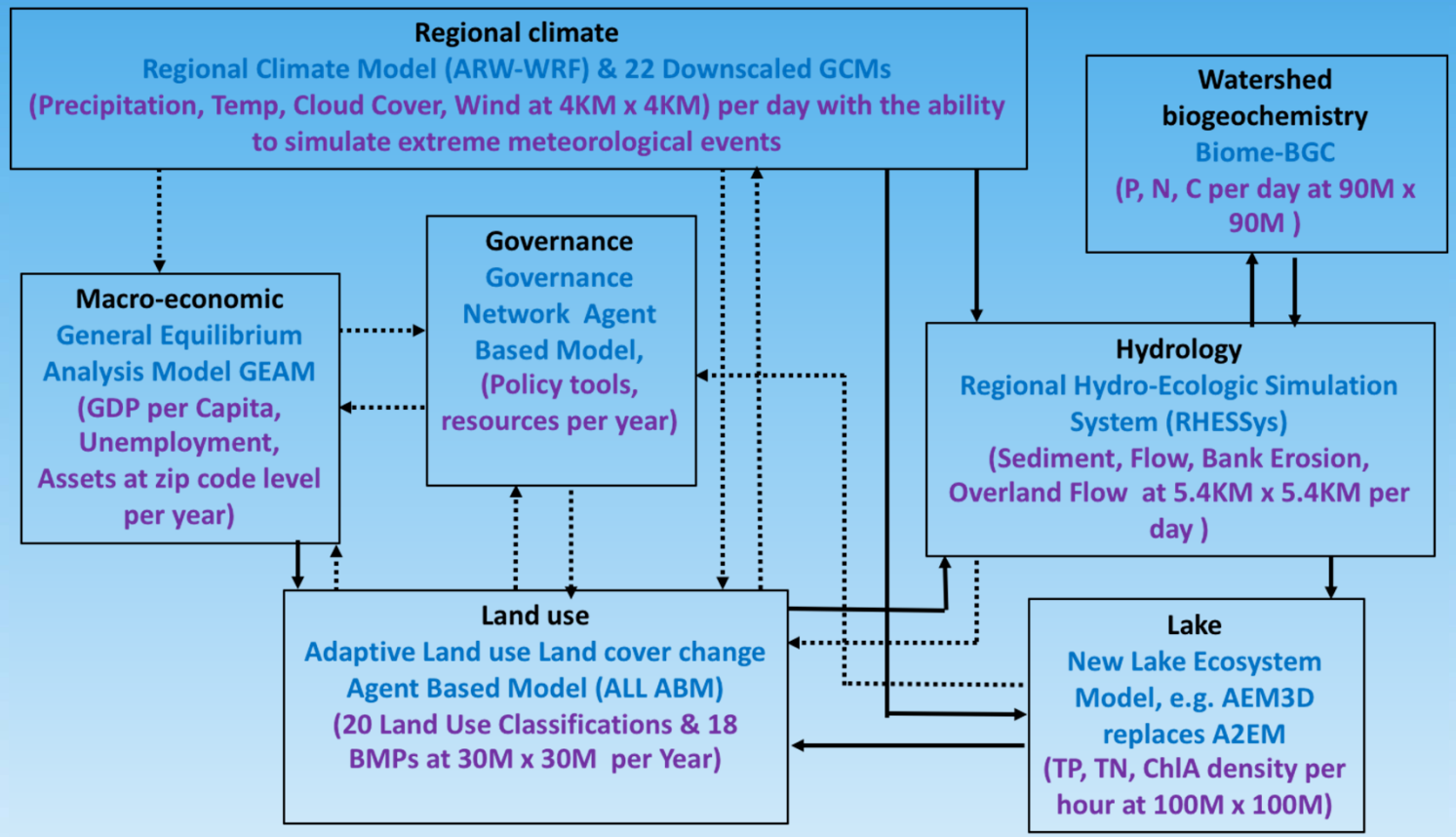
2: Ability to provide for public safety and property for as many people as possible affordably [Town Manager, St. Albans]

Identification of resilient strategies thus requires shared understanding BY ALL STAKEHHOLDERS of "desirable" alternate states in focal SES that maintain critical functions and maximize public interest

Hypothesized alternate states in the focal SES



BREE IAM V2.0: A modular, multi-scalar approach to test SES behavior in a computational IAM



Feedforward IAM can explore "baseline" SES behavior under various extreme event scenarios. Feedbacks and couplings will enable comparisons

→ Integration is enabled in BREE IAM

⇢ Integration is being tested/planned in BREE IAM

Papers in development from the current IAM configuration

1. **Zia et al. (in submission) Climate change-legacy phosphorus synergy hinders lake response to aggressive water policy targets**

2. Zia et al. (in preparation) Understanding lags, thresholds and cross Scale Dynamics in Social Ecological Systems: Cascading impacts of climatic, land and nutrient management changes on Missisiquoi Bay, 2000-2060

3. Zia et al. (forthcoming) Anticipatory governance of regime shifts in social ecological systems: Building resilience to climate change in transboundary Lake Champlain. *Annual conference of Earth System Governance,* November 2019.

4. Hecht et al. (in preparation) quadratic vs weighted vs threshold based regressions for simulating nutrient loading in IAM

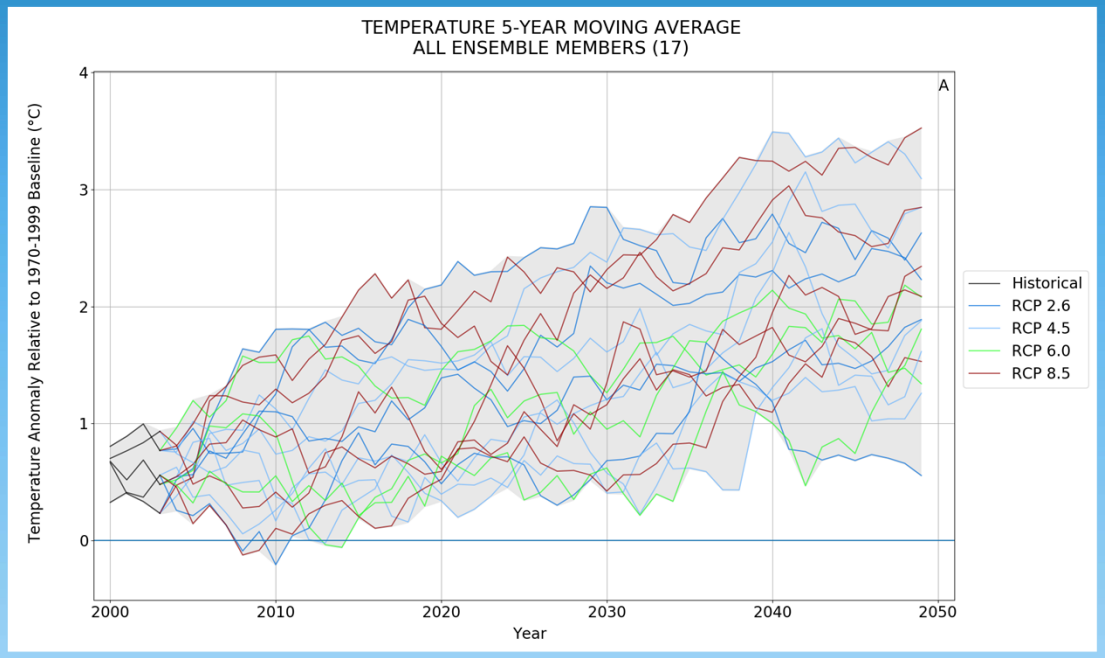
5. Hecht et al. (in preparation) Sensitivity of HABs to changing variance in temperature and precipitation

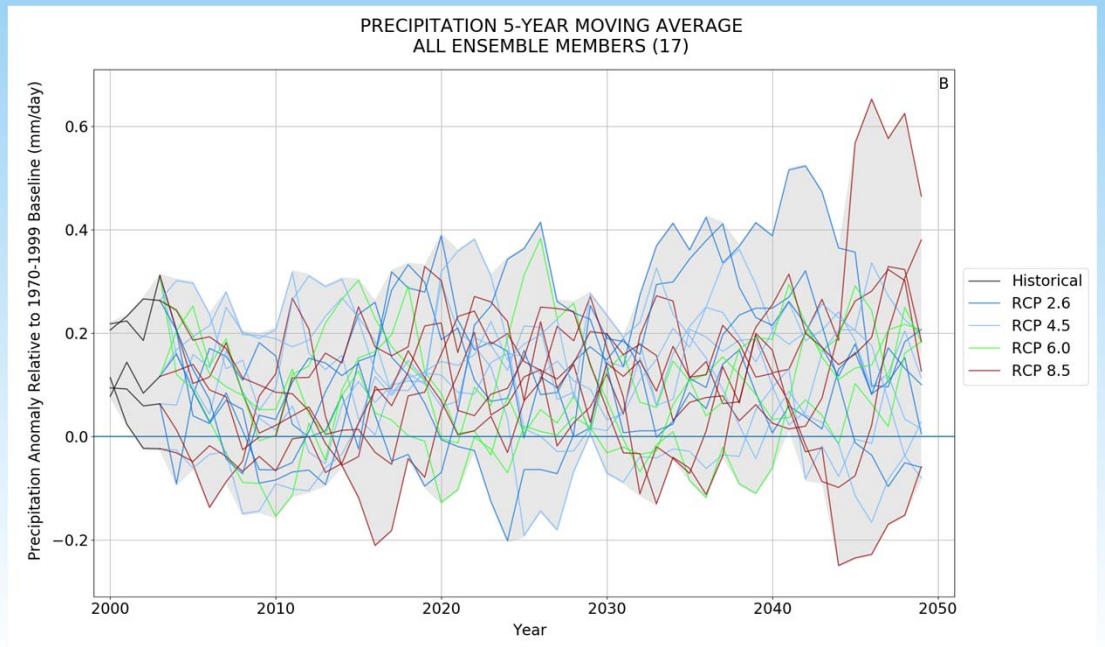
6. Doran et al. (in preparation) Farmer BMP adoption and P load reduction cascades in IAM

Zia et al. (in submission) Climate change-legacy phosphorus synergy hinders lake response to aggressive water policy targets

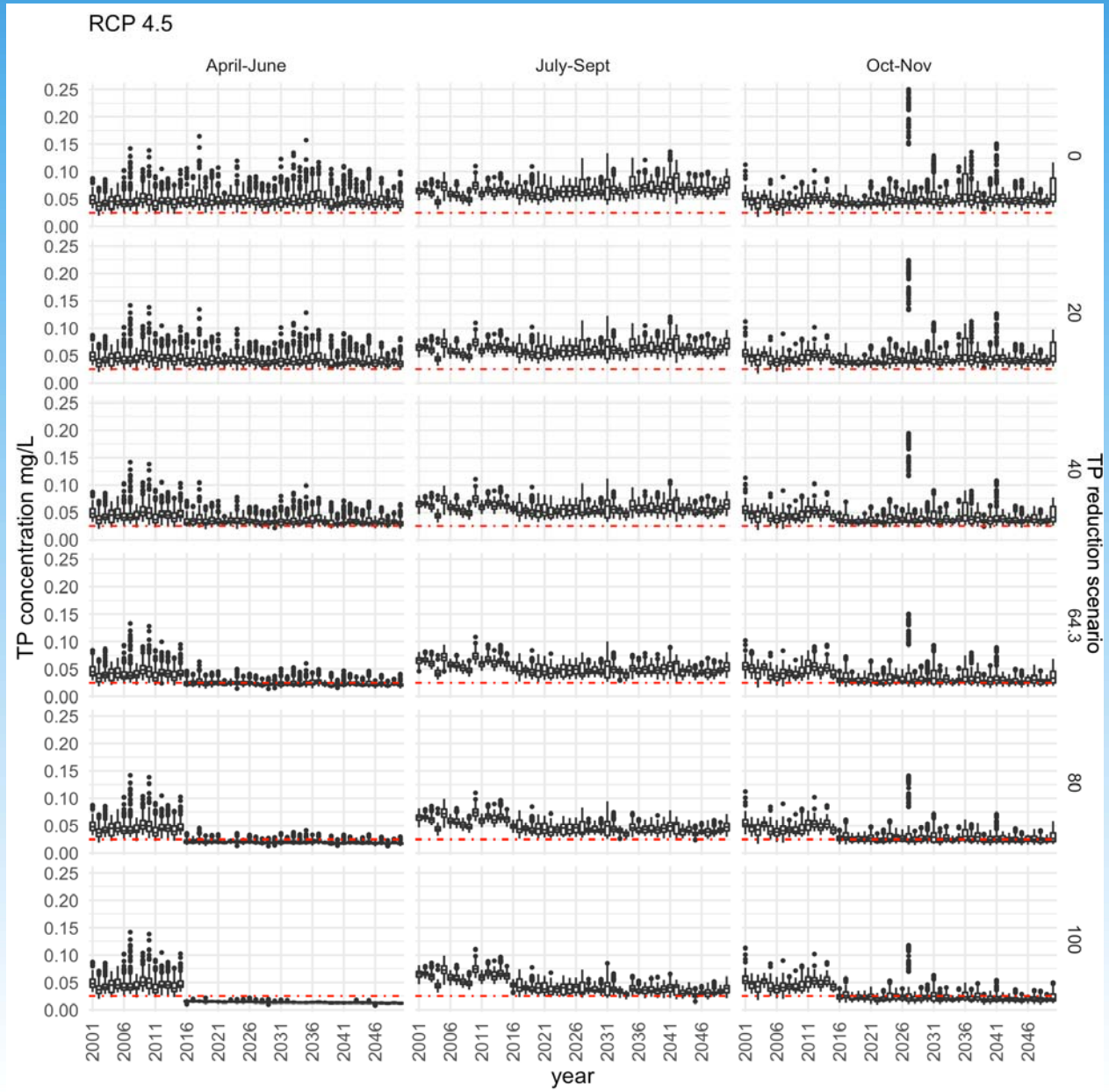
- **Four Climate Scenarios**: RCP 2.6, RCP 4.5; RCP 6.0 and RCP 8.5
  - Ensemble of five GCMs that are among the best to reproduce late 20th centruy North-Eastern US climatic conditions identified by Thibeault, J.M. and Seth, A., 2015. **Toward the credibility of Northeast United States summer precipitation projections in CMIP5 and NARCCAP simulations**. *Journal of Geophysical Research: Atmospheres*, *120*(19).
- **LULCC ABM Scenario**: Business As Usual
- **Hypothetical TP reduction scenarios for BAU LULCC ABM**
  - 100% TP reduction from 2016-2050 scenario (PTAC scenario)
  - 90%, 85%, 80%, **64.3%**...0% TP reduction scenario runs
- **Remaining settings are similar to IAM Version 1.0** (e.g. no additional changes in model settings and calibration as reported in Zia et al. 2016)

GCM Ensemble Projections, 2000-2050

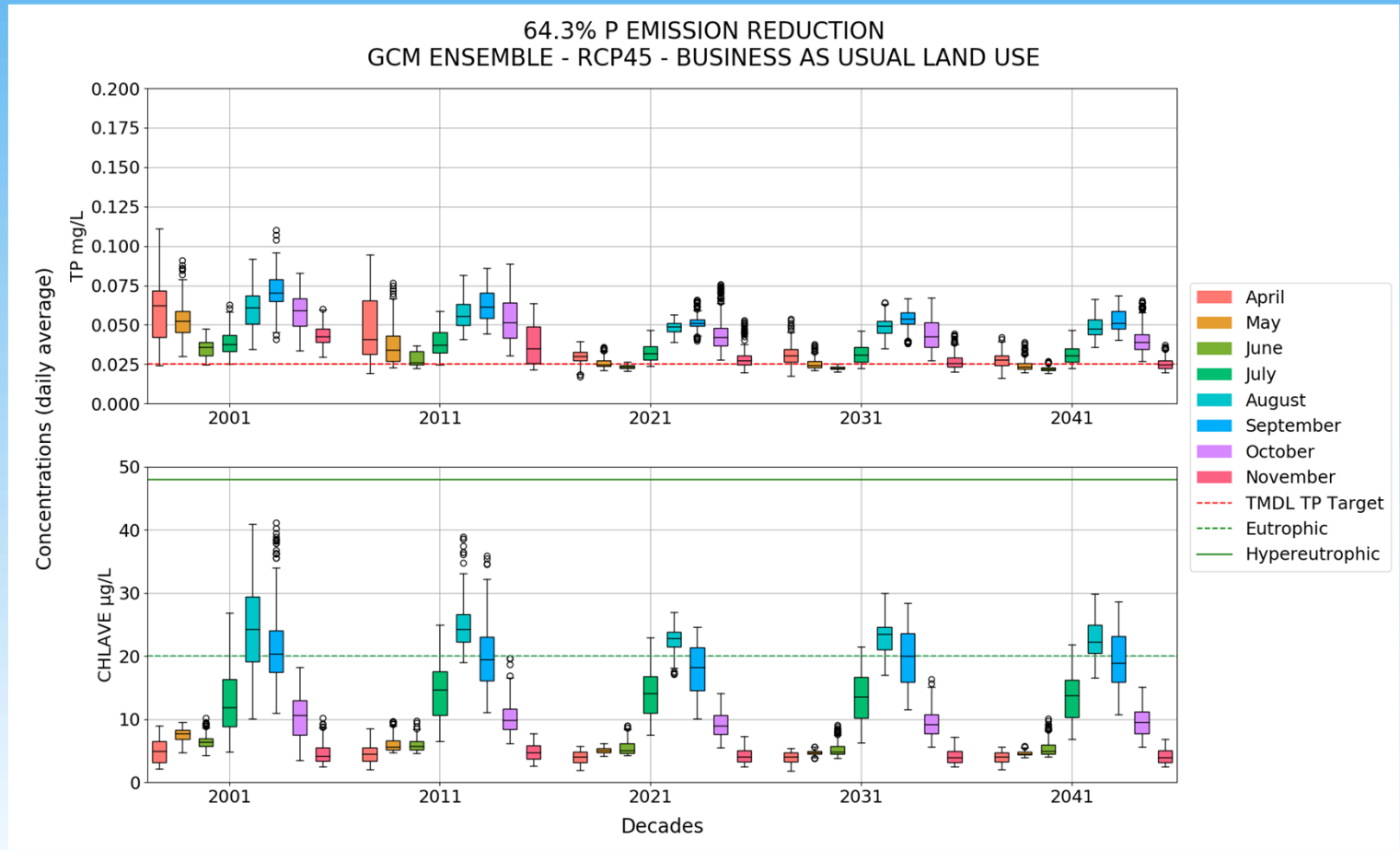




IAM projected TP concentrations for Missisquoi Bay under GCC stabilization RCP45 scenario for 0%, 20%, 40%, 64.3%, 80% and 100% TP loading reductions, compared with TMDL target of 0.025mg/L

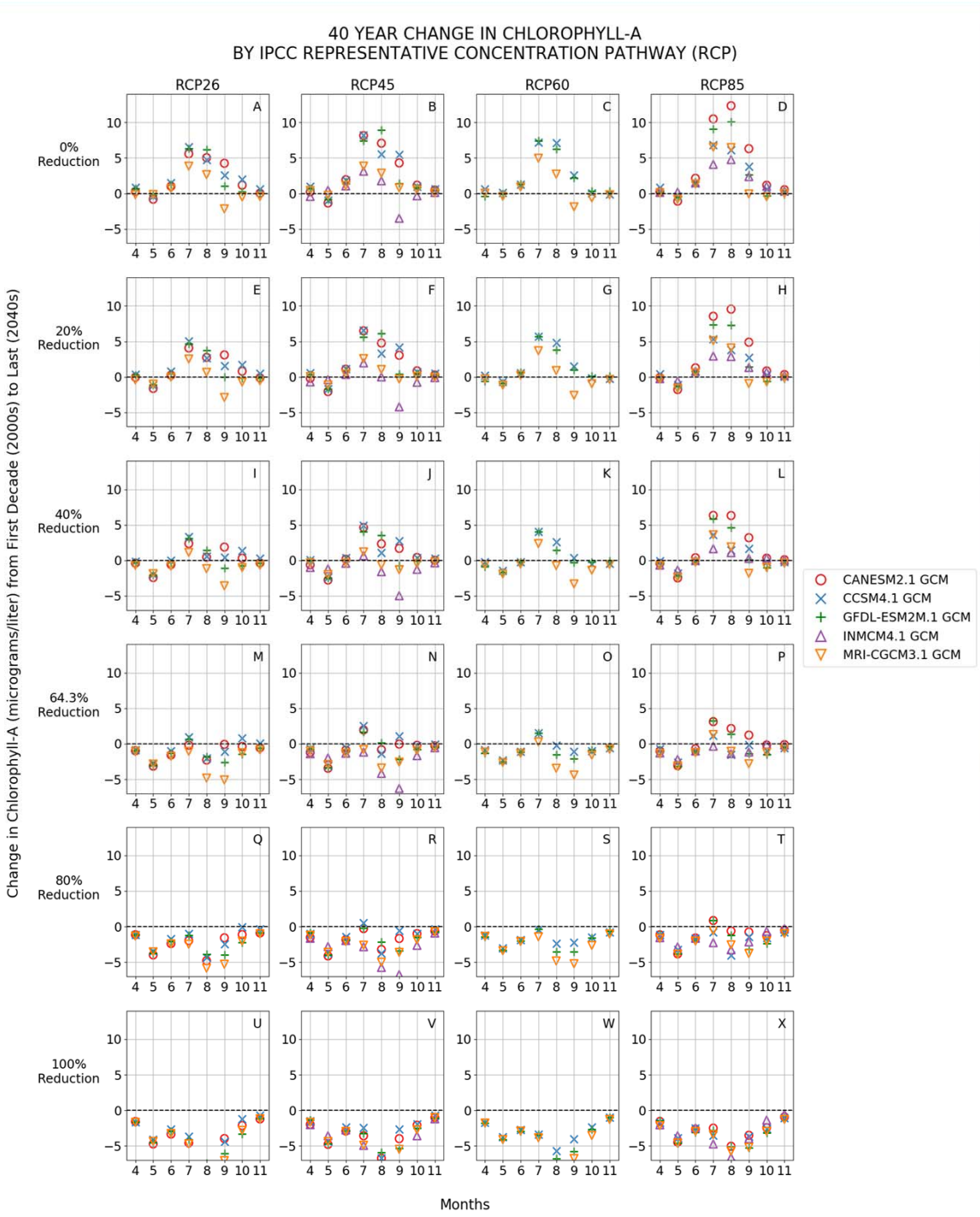


Testing Policy Feedbacks: What if 64.3% TP reductions (EPA TMDL 2015) are implemented in 2016 and Paris Treaty goals are met (RCP4.5)?



Lags and inertia in switching back to mesotrophic state

Projected changes in ChlA mg/L from the baseline first decade 2000s to mid-century 2040s under four GCC scenarios for 0% to 100% TP load reduction scenarios



BREE IAM DEVELOPMENT PLAN: SCENARIO DEVELOPMENT AND EVALUATION

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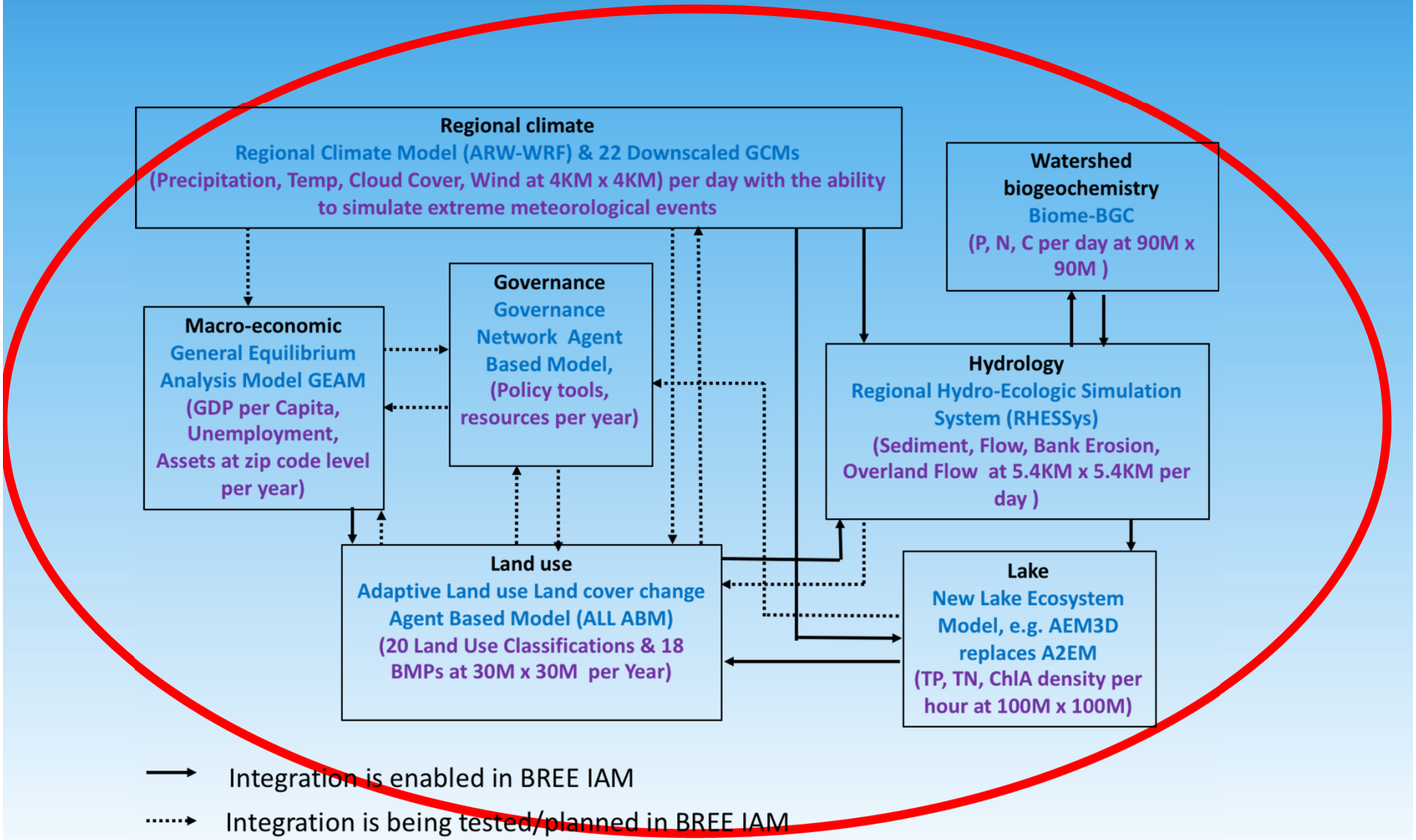


Thank you!