STAC Workshop
Climate Change Modeling 2.0

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WQGIT

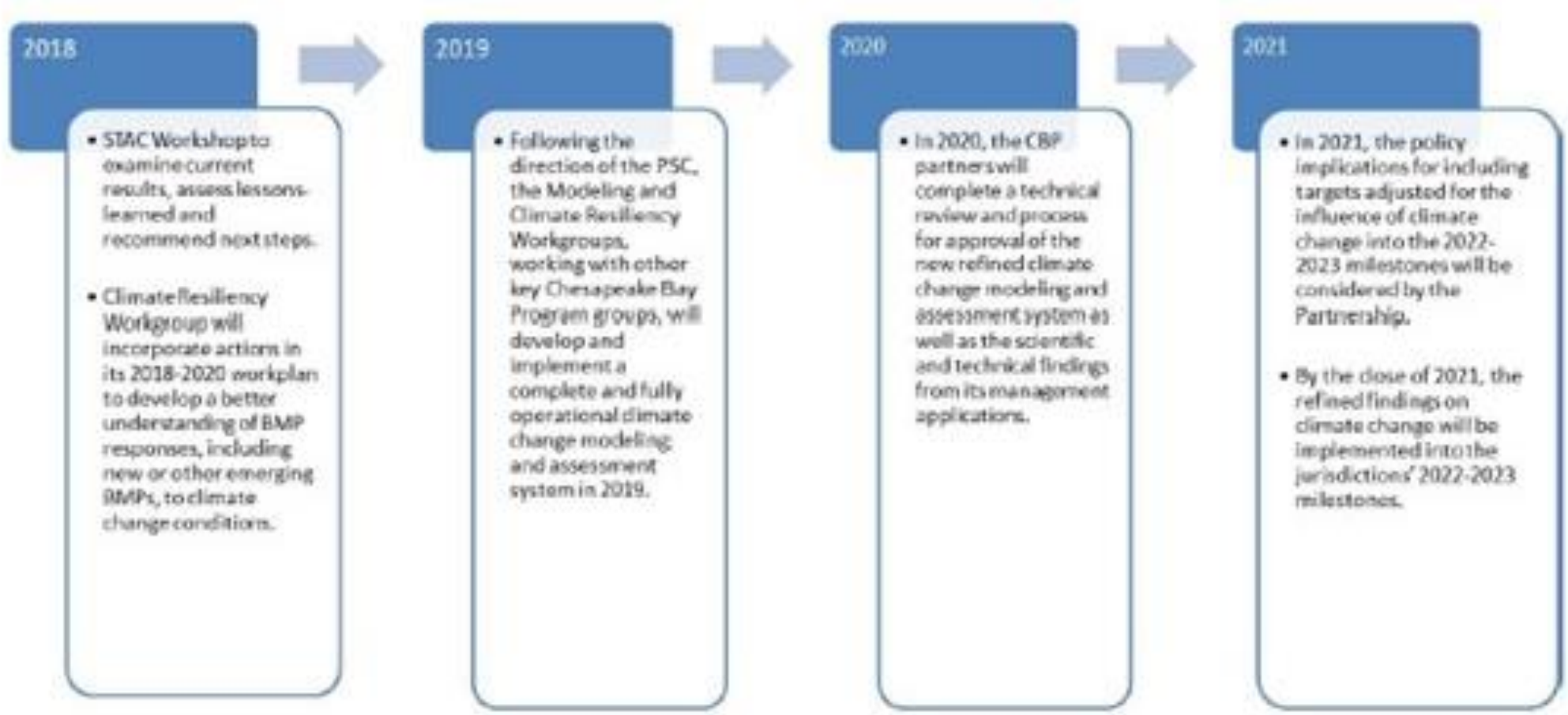
September 27, 2021

STAC Climate Change Modeling 2.0

- Workshop held in 2018 in response to PSC decision in 2017 to take a longer look at climate change as part of the Midpoint Assessment
- Purpose: Guidance on the models and assessment framework used to assess the effect of climate change on the TMDL

Workshop Steering Committee:
Co-Chair: Mark Bennett (USGS)
Co-Chair: Lewis Linker (EPA CBPO)
Don Boesch (UMCES)
Lee Currey (MD Dept. of Environment)
Marjorie Friedrichs (VIMS)
Maria Herrmann (Penn State) *
Raleigh Hood (UMCES)
Tom Johnson (USEPA)*
Andy Miller (UMBC)*
Dave Montali (Tetra Tech)
STAC Staff:
Rachel Dixon, Chesapeake Research Consortium
Annabelle Harvey, Chesapeake Research Consortium

Why is it coming out now?

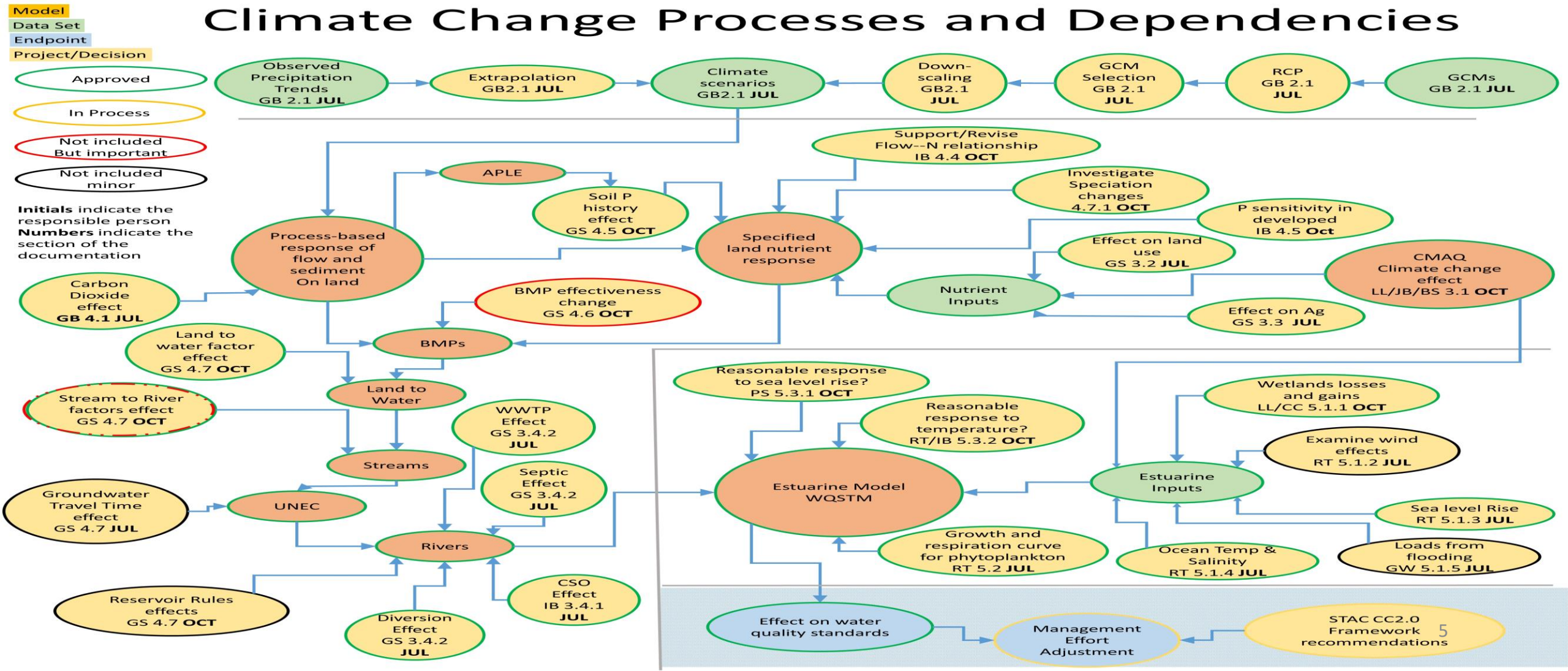


Too busy implementing recommendations!

Near Term Recommendations (by 2021)

- Introduce the estimation of **uncertainty** into the decision process.
- Closely **examine** all climate-related sensitivities in the watershed and estuarine models and characterize the relative importance of these effects on dissolved oxygen.
- With the knowledge gained from sensitivity analyses of recommendation #2, prioritize **improvements** and enhanced quantification of uncertainties in model inputs.
- Compare **multiple** existing estuarine **model** simulations, including the CBP's Water Quality and Sediment Transport Model, from 1985 through recent wet years.

Near term: Closely examine sensitivities and make improvements



Near term: Closely examine sensitivities and make improvements- watershed

- ✓ Spatially vary the relationship between nitrogen and flow
- ✓ Developed area sensitivity to Phosphorus
- ✓ Investigate potential changes to wastewater overflows
- ✓ Change the nitrogen and phosphorus speciation methods
- Incorporate the effects of climate change into the BMP effectiveness estimates

Climate change documentation:
https://cast.chesapeakebay.net/FileBrowser/GetFile?fileName=P6ModelDocumentation%2FClimateChangeDocumentation.pdf

Near term: Closely examine sensitivities - watershed

- Incorporate the effects of climate change into the BMP effectiveness estimates
  - Virginia Tech scientists are producing a comprehensive literature survey on the effects of climate change on nutrient cycling and BMP effectiveness.
  - WQGIT-funded project produced updated intensity-duration-frequency curves for all counties in the watershed will supply necessary estimates of climate effects.

Near term: Closely examine sensitivities - estuarine

- ✓ Resolve the effect of sea-level rise
- ✓ Increase phytoplankton growth at high temperatures.
- ✓ Include a temperature dependent mortality or grazing rate in the model.
- ✓ Re-examine the outer boundary conditions
- ✓ Investigate downscaled future wind products.

Near Term: Compare Multiple Water Quality Models

- VIMS-led CHAMP project
  - Multiple climate models
  - Multiple watershed models
  - Multiple estuarine models

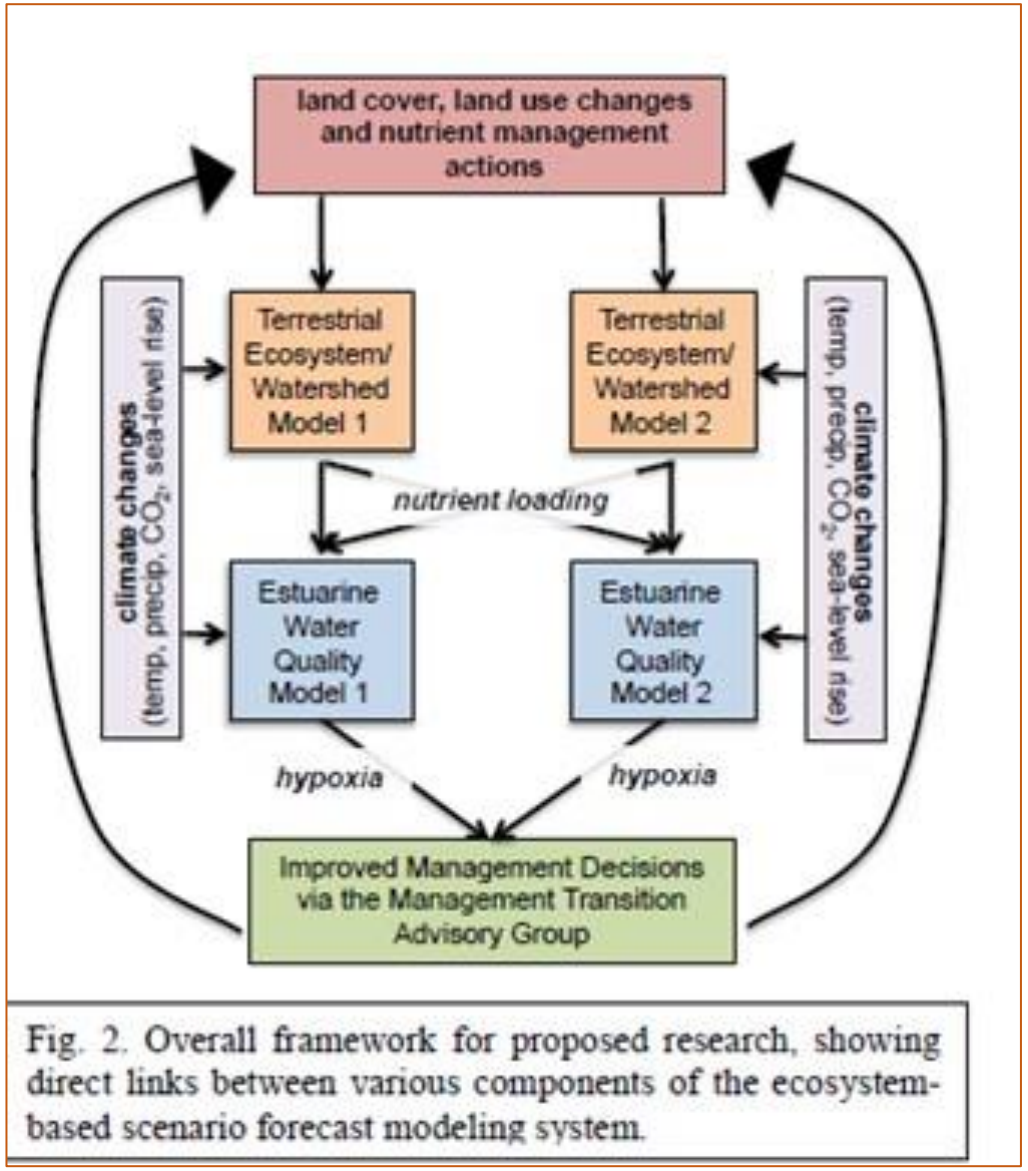


Fig. 2. Overall framework for proposed research, showing direct links between various components of the ecosystem-based scenario forecast modeling system.

Near Term Recommendations (by 2021)

- Introduce the estimation of **uncertainty** into the decision process.

- Closely **examine** all climate-related sensitivities in the watershed and estuarine models and characterize the relative importance of these effects on dissolved oxygen.

- With the knowledge gained from sensitivity analyses of recommendation #2, prioritize **improvements** and enhanced quantification of uncertainties in model inputs.

- Compare **multiple** existing estuarine **model** simulations, including the CBP's Water Quality and Sediment Transport Model, from 1985 through recent wet years.

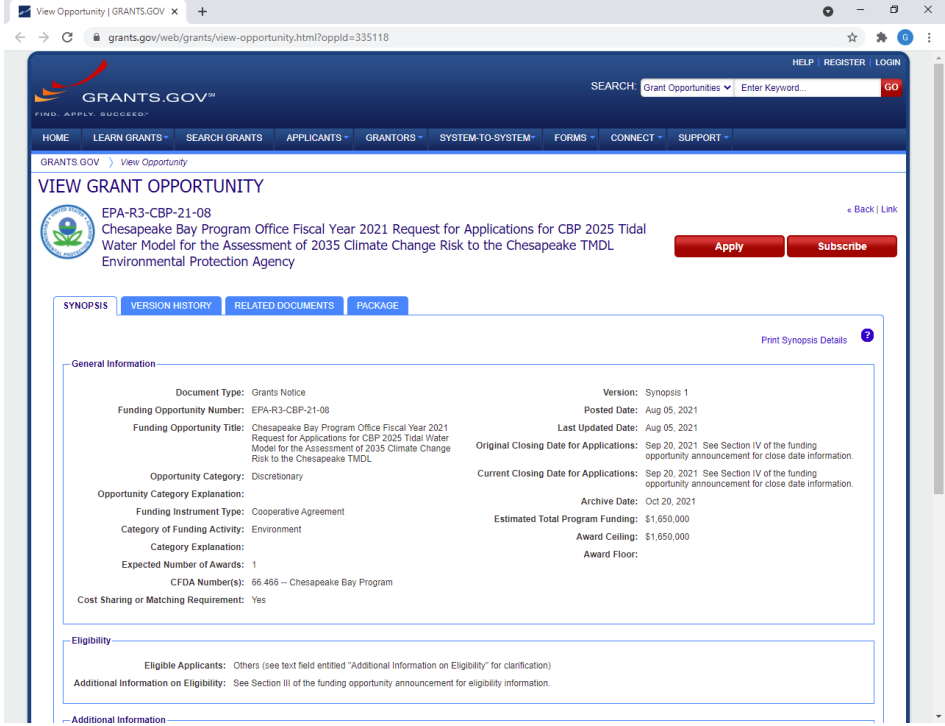
In the longer term (by 2025)

- Develop a **new estuarine model**
- **Continue development** of climate-related watershed model capabilities with particular attention to BMP effectiveness.
- Create a more **sophisticated evaluation framework** that incorporates various sources of uncertainty:

Long Term: Develop a new estuarine model

- Use an unstructured grid
- Simulate wetting and drying
- Develop a spectral wave model
- Extend the boundary onto the coastal shelf
- Improve biogeochemical parameterizations
- Improve model forcing

Long Term:
Estuarine model RFA



- Unstructured Grid
- May be part of new model
  - Simulate wetting and drying
  - Develop a spectral wave model
  - Extend the boundary onto the coastal shelf
  - Improve biogeochemical parameterizations
  - Improve model forcing

Long Term: Watershed model

- Continue watershed model refinement with particular attention to BMP effectiveness

- Modeling team working on scale issues
- Waiting on prioritization from WQGIT and other partners

Long term: framework

- Climate inputs
  - Use models rather than trend
  - Evaluate multiple RCPs (now SSPs)
  - Use climate models at a finer spatial scale
- Develop improved suite of mechanistic models
- Interact with similar efforts world-wide
- Create a climate research strategy
- Re-evaluate goals relative to climate change
- Use uncertainty in the decision process

Long term: framework

- Climate inputs
  - Use climate models rather than observed trend
  - Evaluate multiple RCPs (now SSPs)
  - Use climate models at a finer spatial scale
- CBP will consider these in 2024-2025
- Develop improved suite of mechanistic models
- Yes for estuarine model: No for watershed model
- Interact with similar efforts world-wide
- Yes for scientists; ??? for managers

Long term: framework

- Create a climate research strategy
  - the CBP should consider developing, supporting, and periodically updating a Strategic Research Framework that identifies ongoing activities and priority knowledge gaps.

Long term: framework

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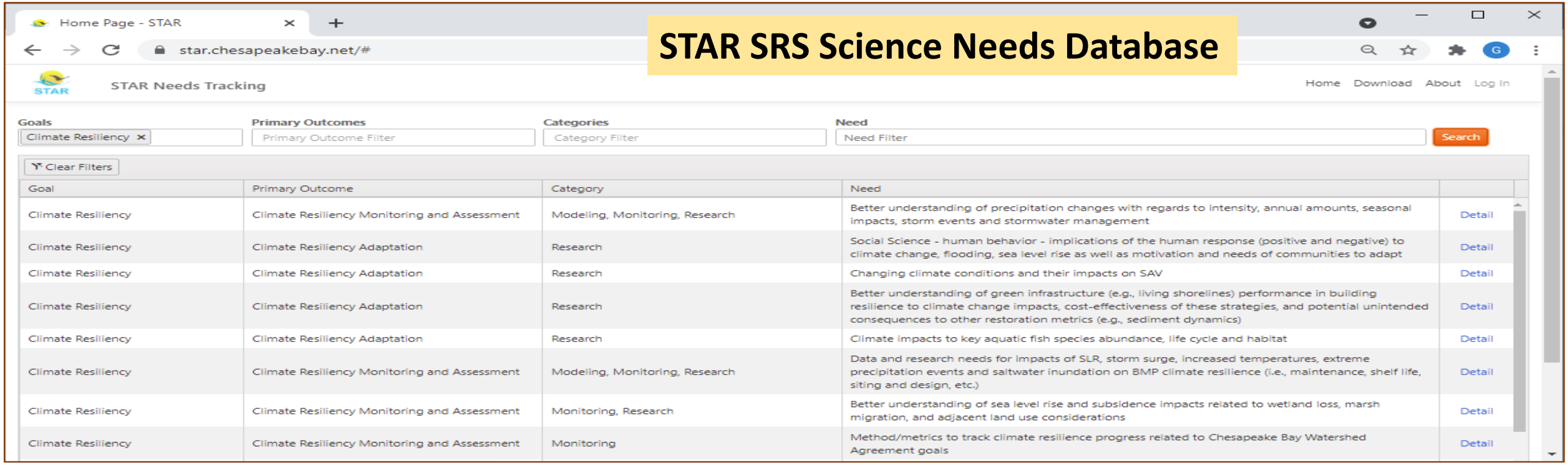
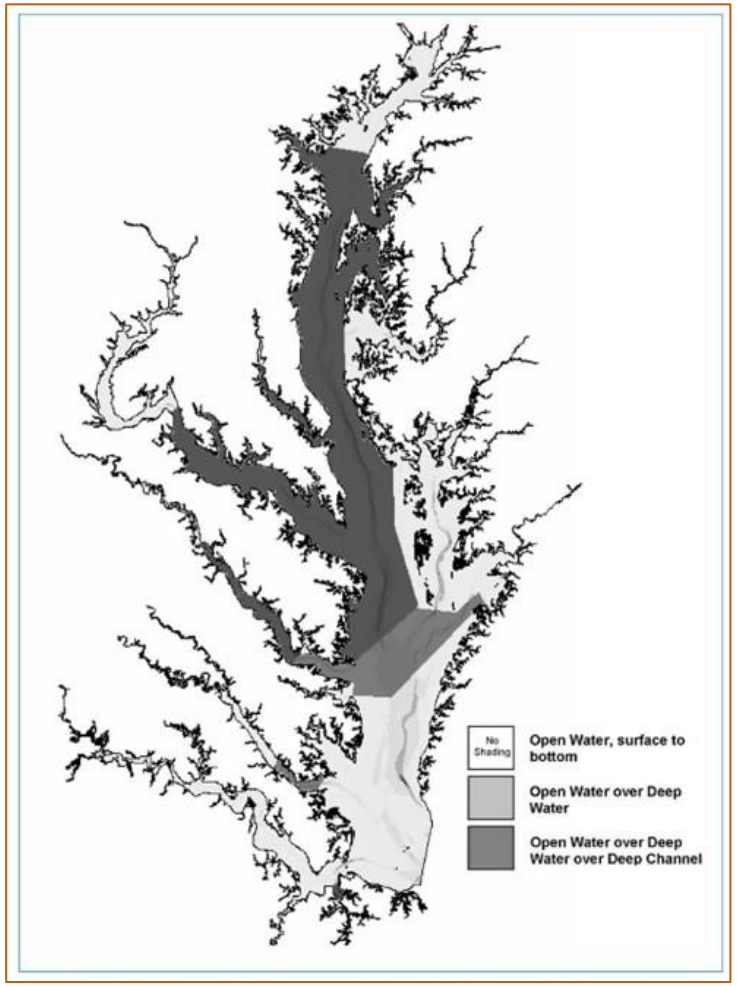
  - the CBP should consider developing, supporting, and periodically updating a Strategic Research Framework that identifies ongoing activities and priority knowledge gaps.

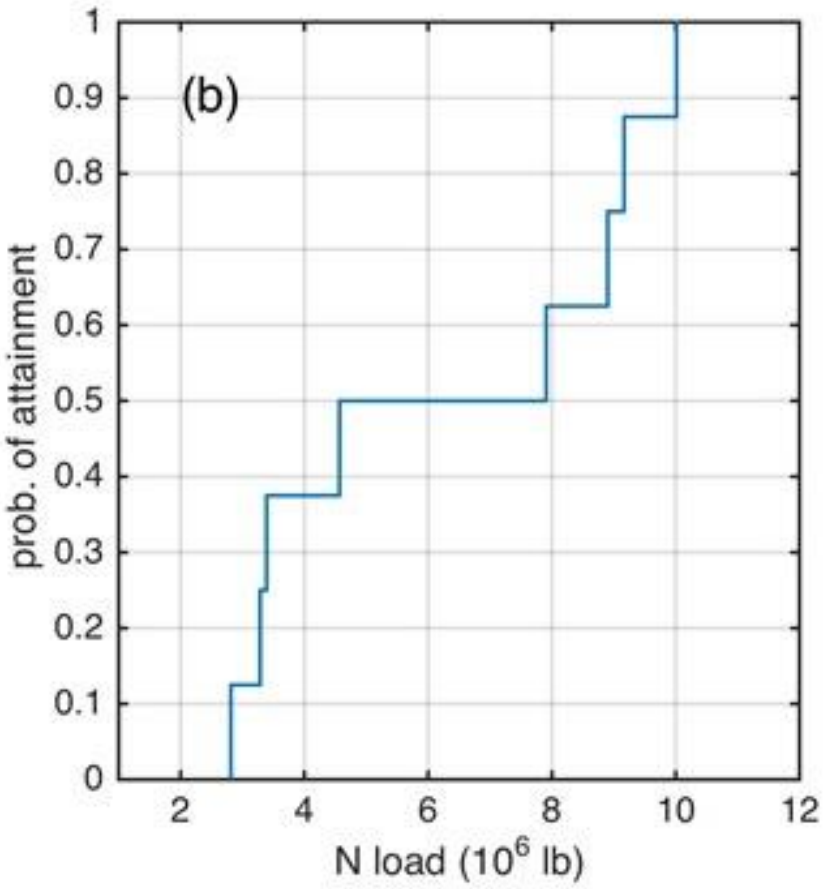


Long term: framework

- Re-evaluate goals relative to climate change
  - CBP noted issues with the Open Water designated uses under climate change and declined to base reductions on Open Water
  - Criteria Assessment Protocols Workgroup looking at changing Open Water boundaries.
  - Potential issues will arise with assessment short-duration Water Quality Standards



Use of uncertainty in Decision Process



- Workshop Suggestion: Use of multiple scenarios to define a probability of attainment for a particular load reduction goal.
- CBP could consider in 2024-2025

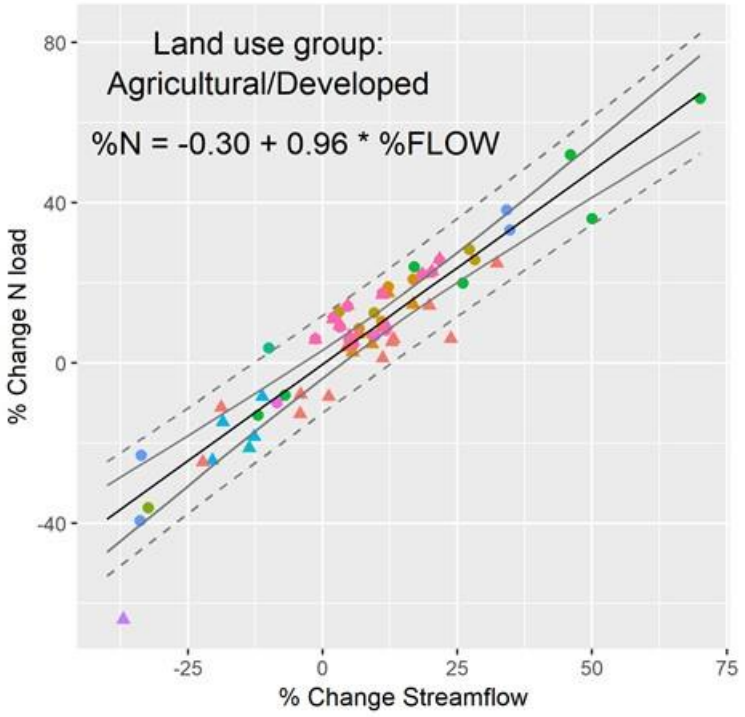
Summary

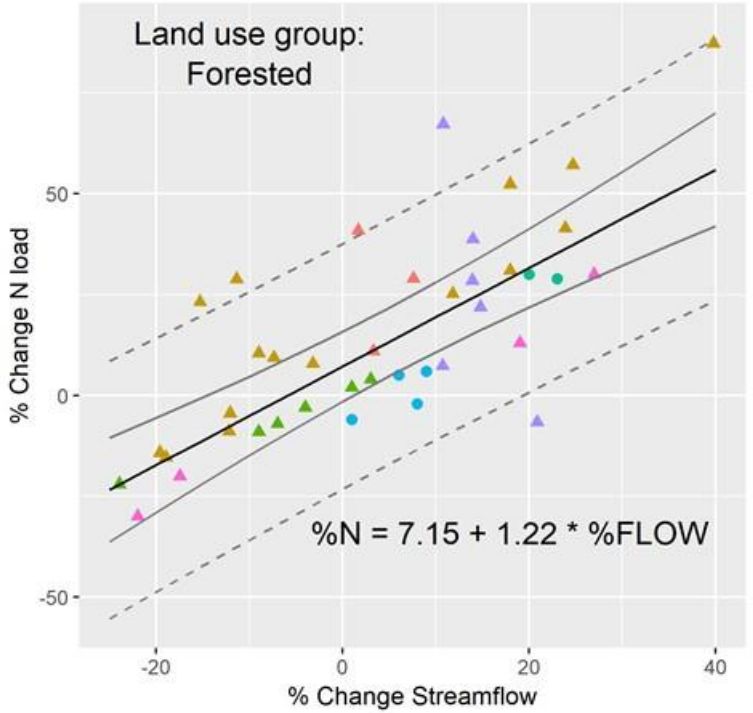
- Watershed modeling
  - Significant advances incorporated into 2020 climate decision
  - Little additional work specified
- Estuarine modeling
  - Significant advances incorporated into 2020 climate decision
  - Progress being made toward wholesale changes recommended for the future
- Overall framework
  - Challenge to incorporate uncertainty in decision-making
  - Re-examine climate assumptions
  - Re-examine environmental endpoints

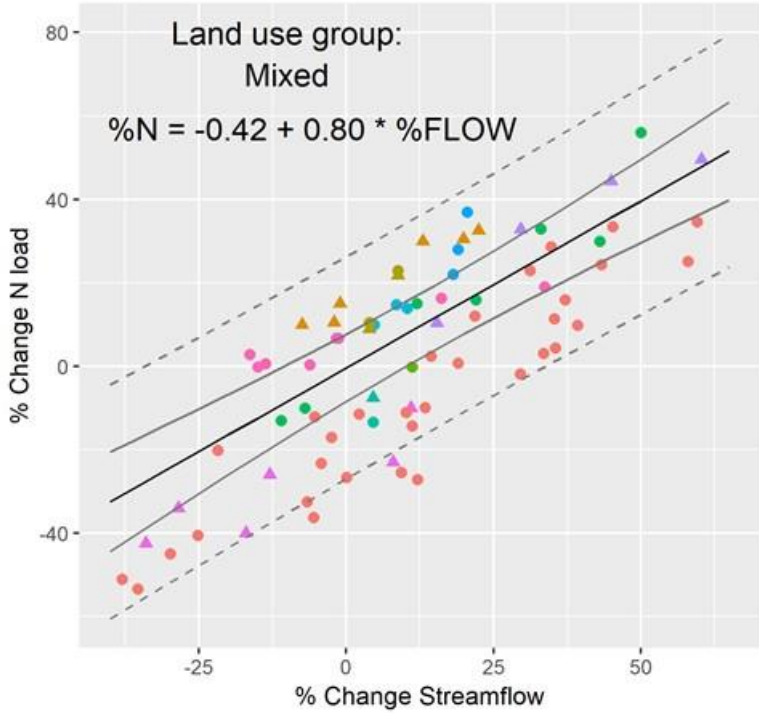
Extra Slides

Near term: Closely examine sensitivities - watershed

- Spatially vary the relationship between nitrogen and flow





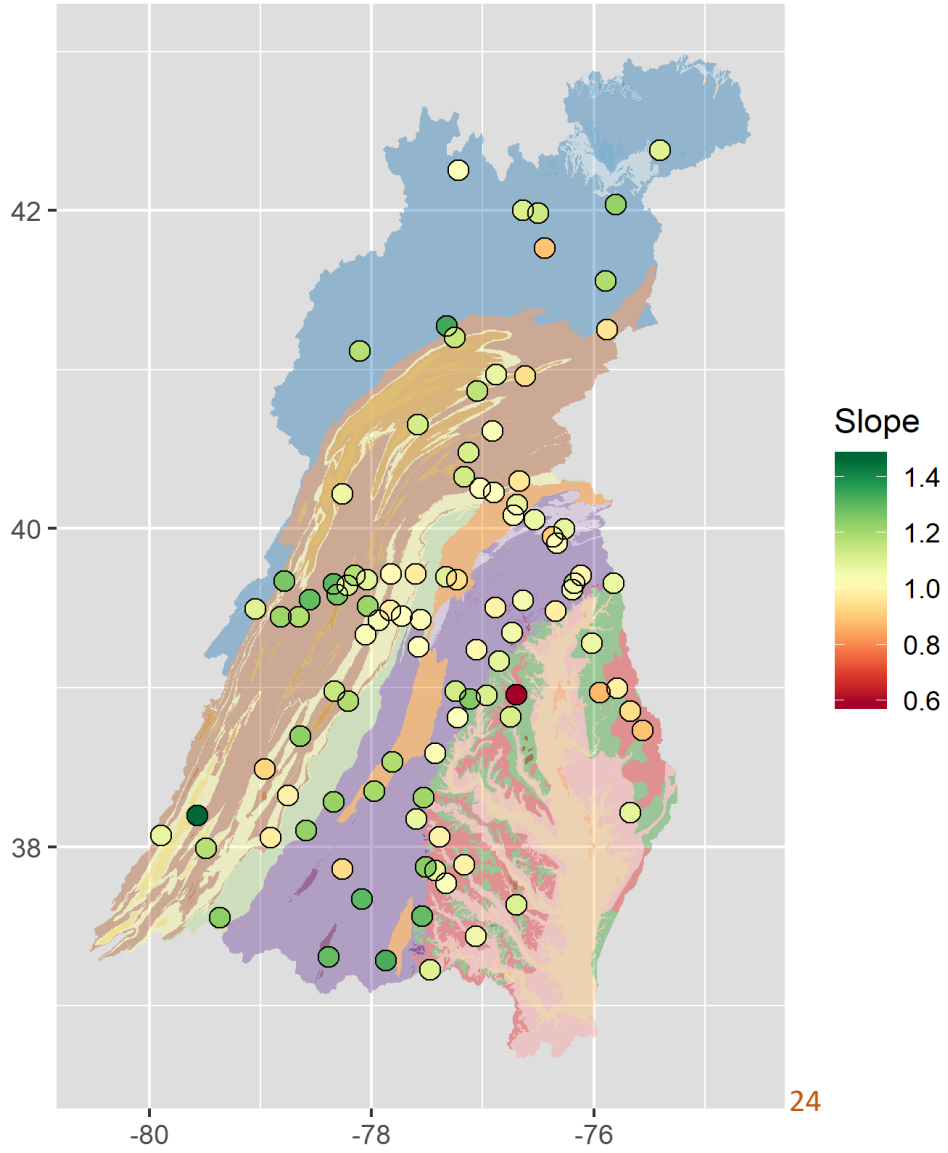


- No consistent relationship to land use found

Bertani

Near term: Closely examine sensitivities - watershed

- Spatially vary the relationship between nitrogen and flow
- Using monitoring data, a slightly higher than a 1:1 relationship between flow change and TN change found in lower loading areas, but not a strong enough relationship to include.

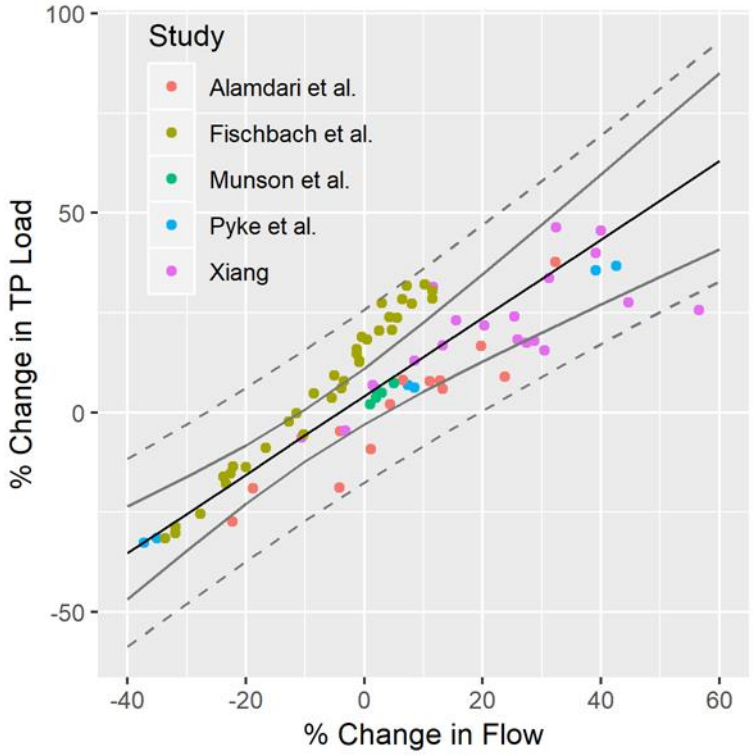


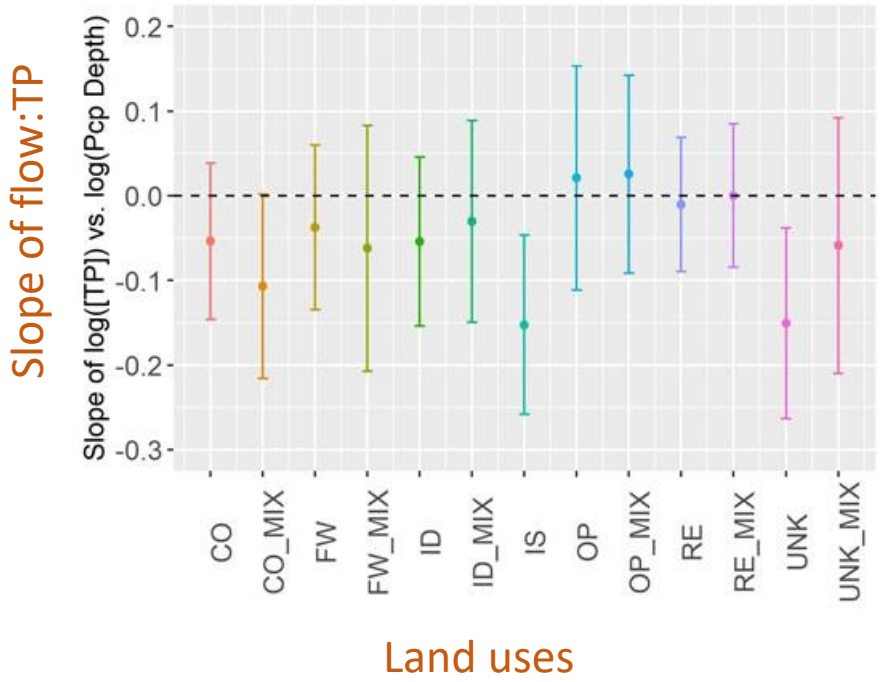
Bertani

Near term: Closely examine sensitivities - watershed

- Developed area sensitivity to Phosphorus

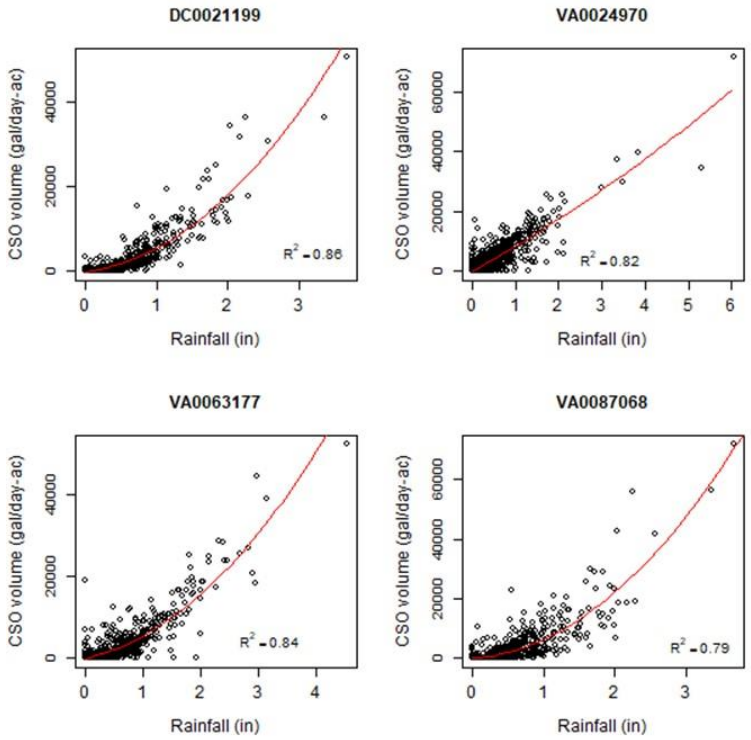
Literature review shows 1:1 relationship to flow





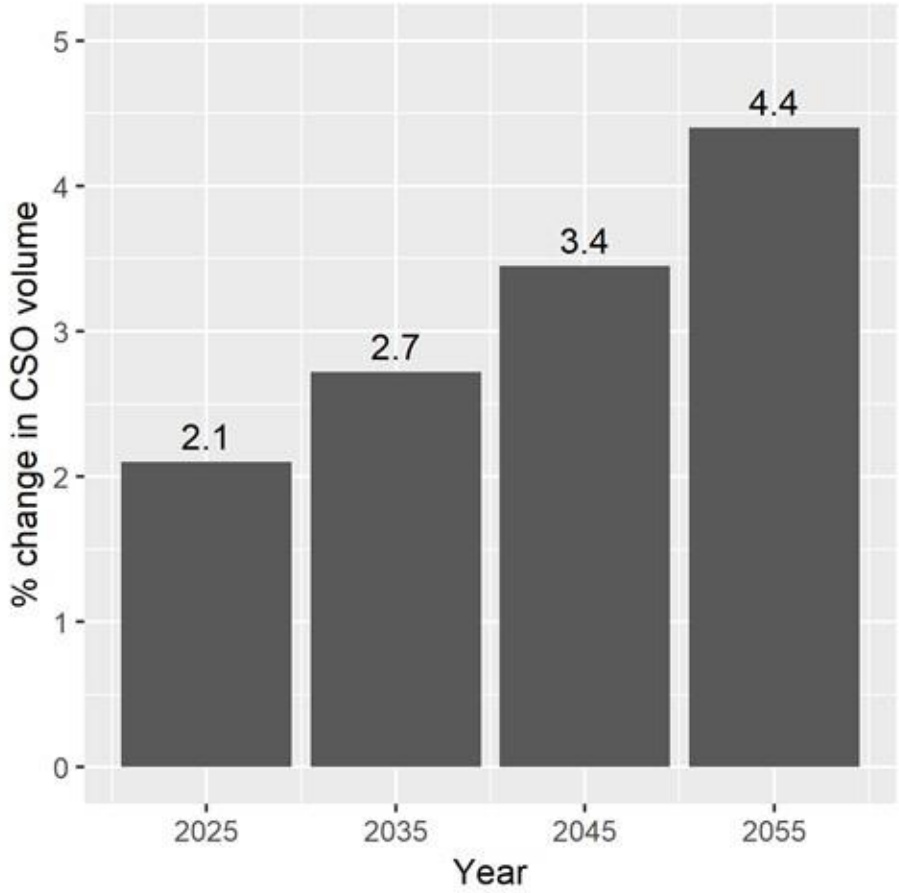
Near term: Closely examine sensitivities - watershed

- Investigate potential changes to wastewater overflows



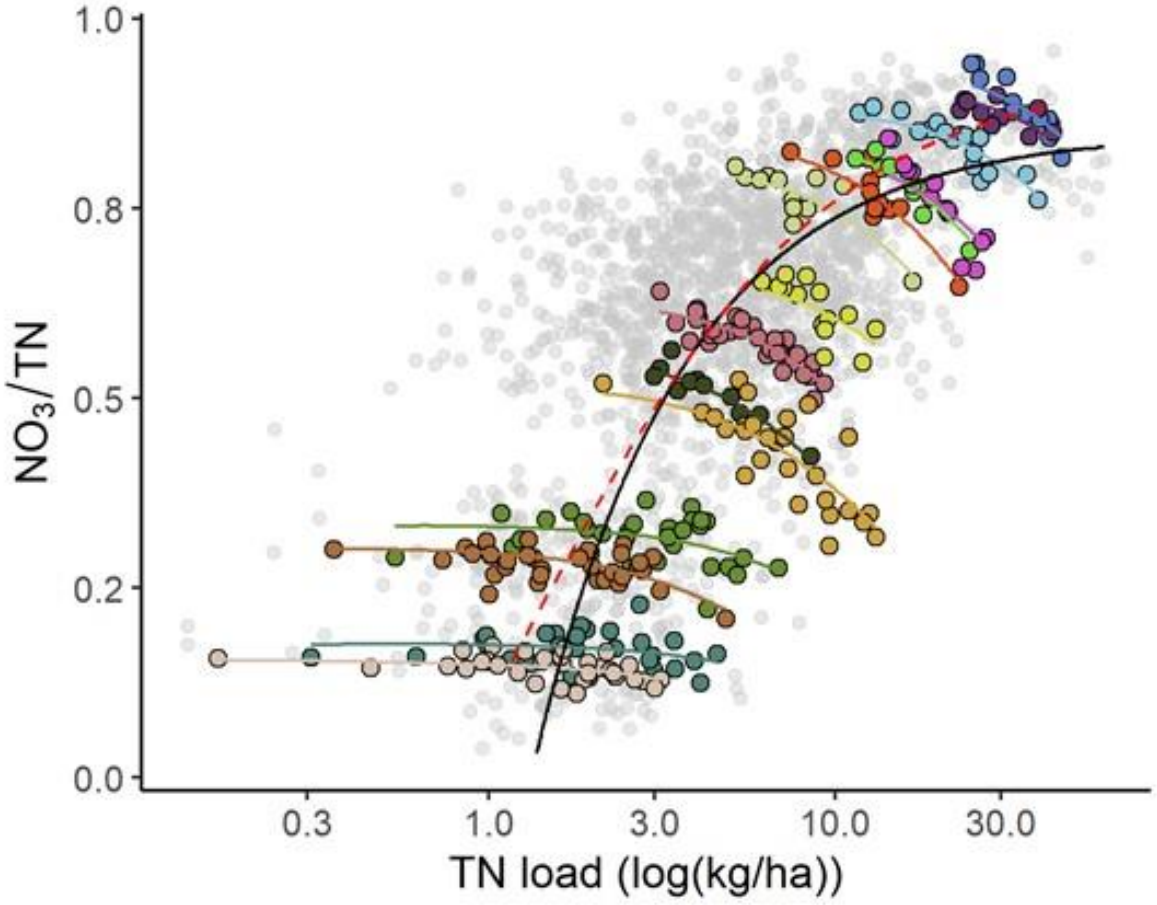
CSO volume

Rain



Near term: Closely examine sensitivities - watershed

- Change the nitrogen and phosphorus speciation methods

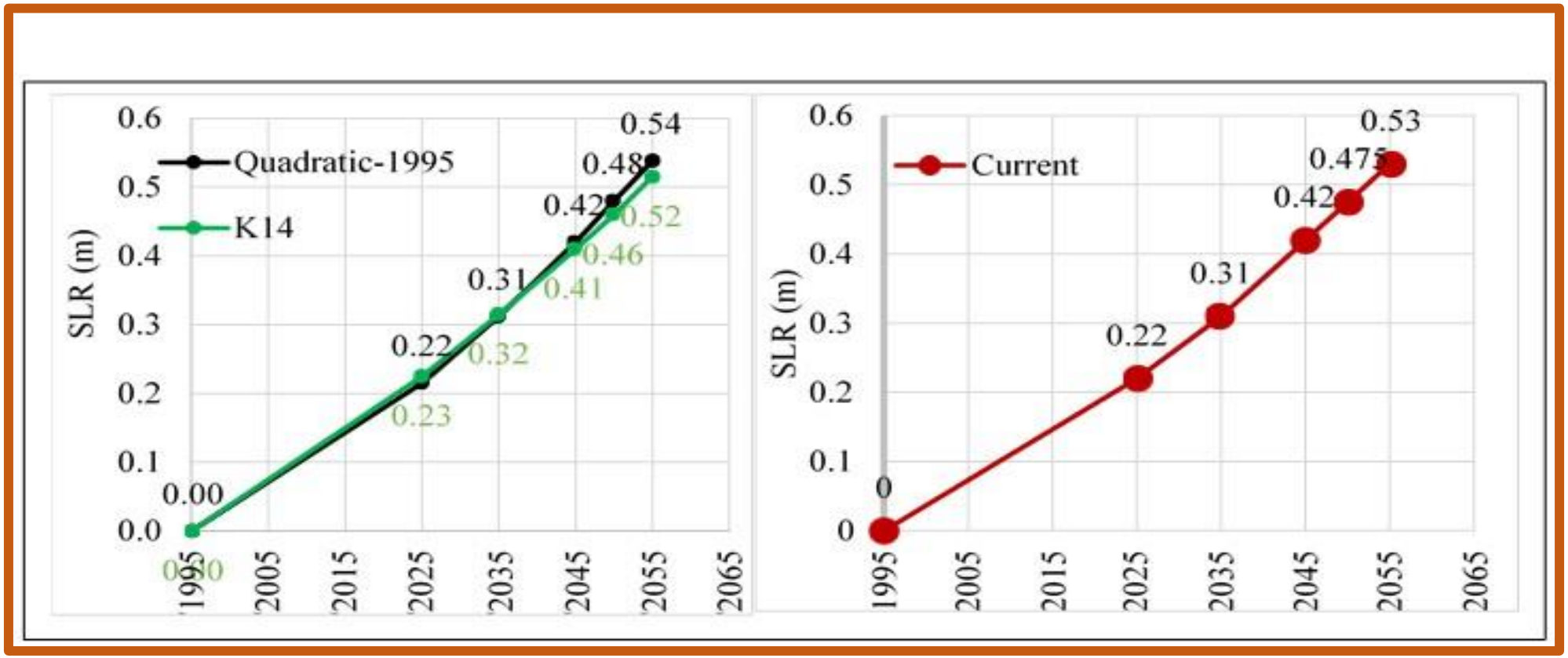


- Nitrate fraction increases with more load across space
- Nitrate fraction decreases with more load at a single station.

Bertani, I., Bhatt, G., Shenk, G.W. and Linker, L.C., 2021. Quantifying the Response of Nitrogen Speciation to Hydrology in the Chesapeake Bay Watershed Using a Multilevel Modeling Approach. JAWRA Journal of the American Water Resources Association.

Near term: Closely examine sensitivities - estuarine

- Resolve the effect of sea-level rise



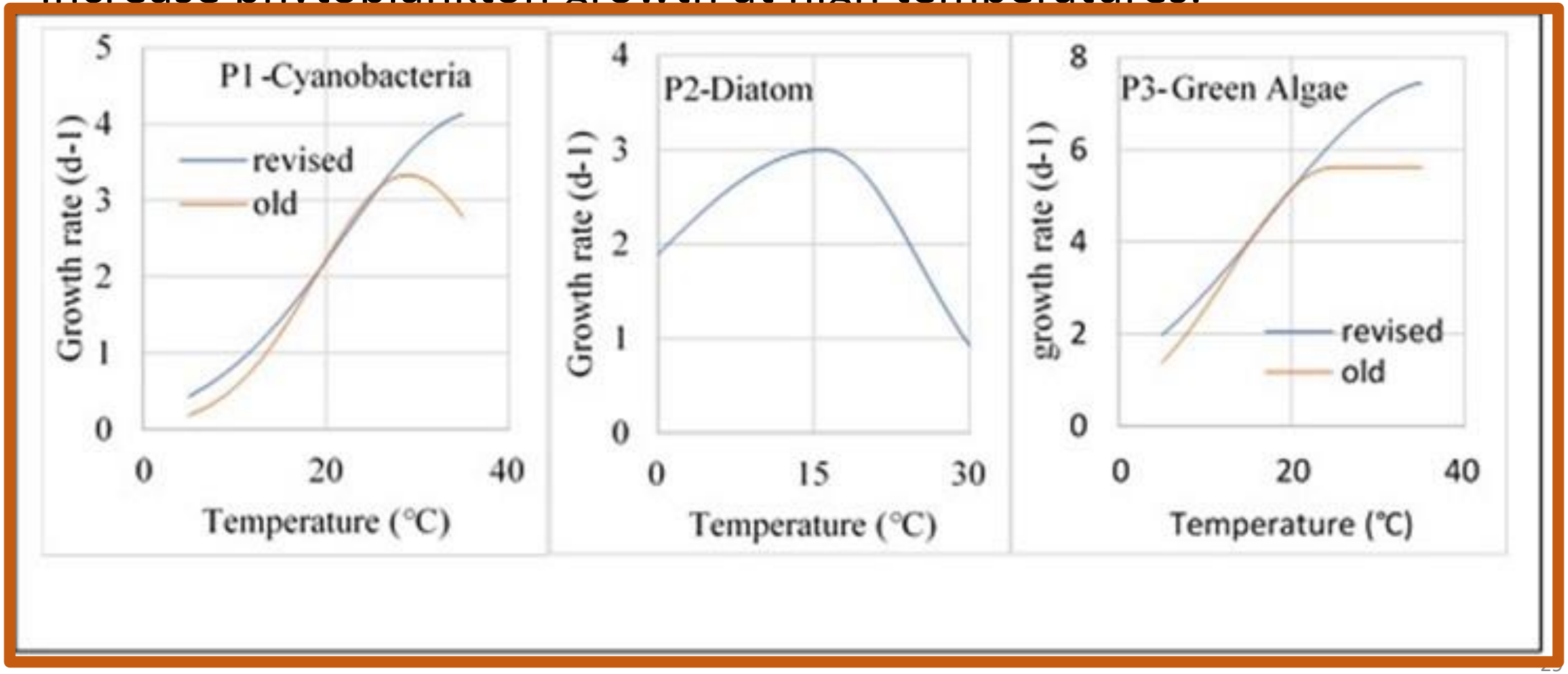
Two separate models

Average – used in CBP model

Tian

Near term: Closely examine sensitivities - estuarine

- Increase phytoplankton growth at high temperatures.



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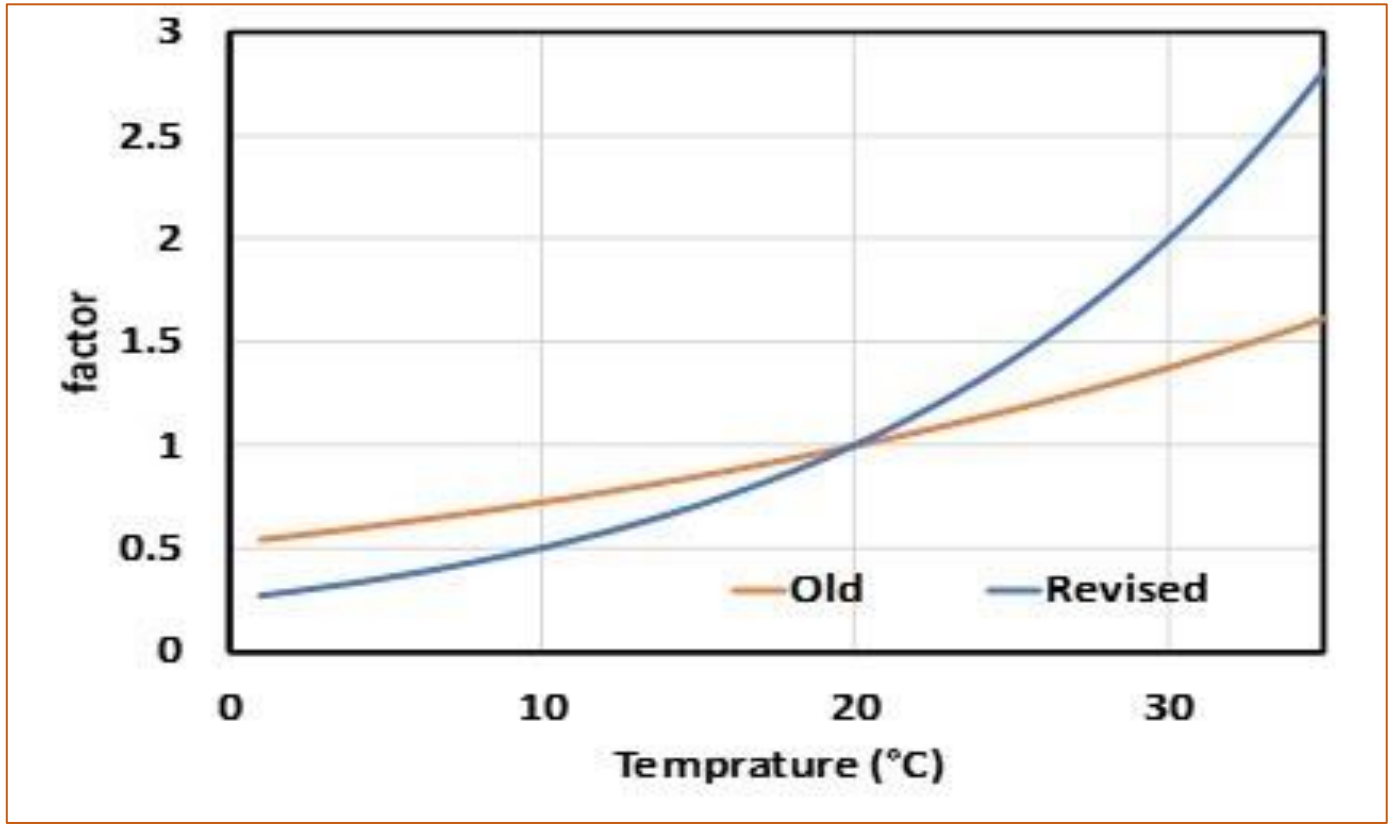
Near term: Closely examine sensitivities - estuarine

- Include a temperature dependent mortality or grazing rate in the model.

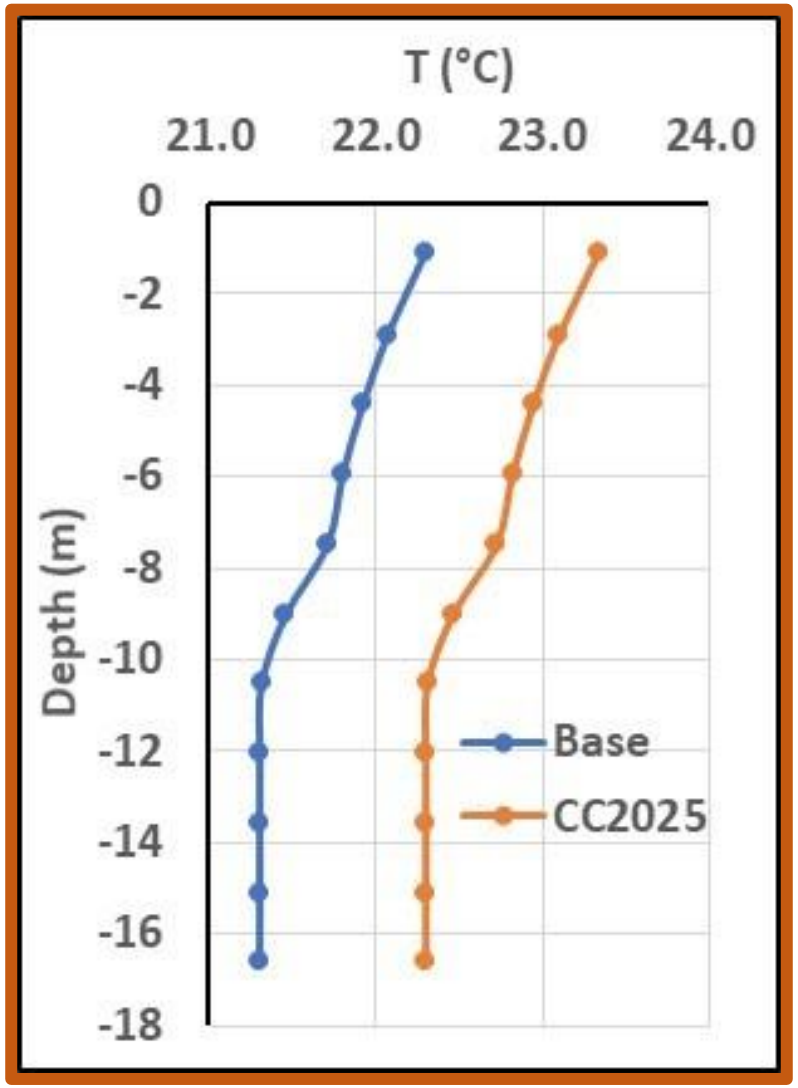


- More recent and local literature used to modify respiration curve

Tian

Near term: Closely examine sensitivities - estuarine

- Re-examine the outer boundary conditions
- Change in surface temperature is 90% of the air temperature change
- Change in temperature at depth is the surface change times the ratio of initial temperatures – colder, deeper water changes less



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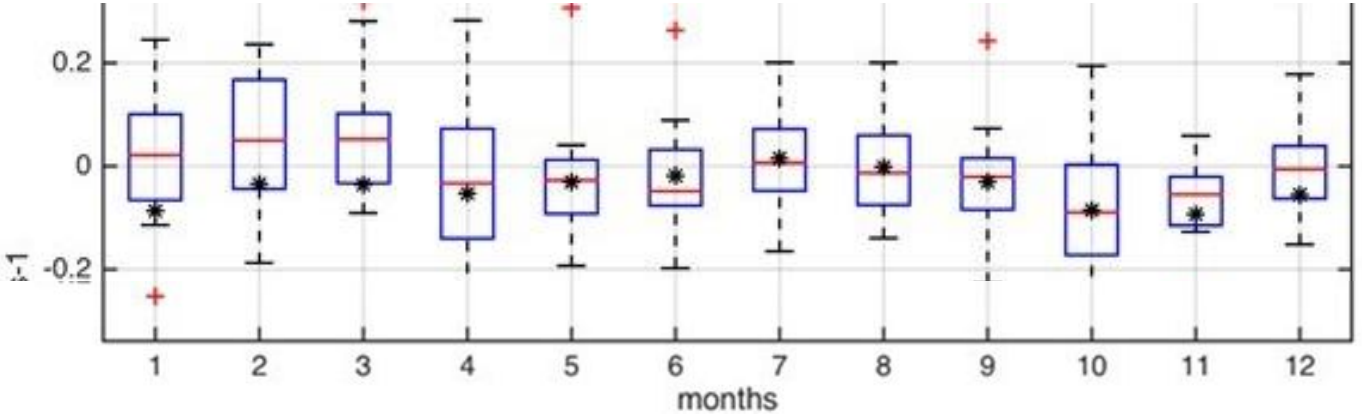
Near term: Closely examine sensitivities - estuarine

- Investigate downscaled future wind products.



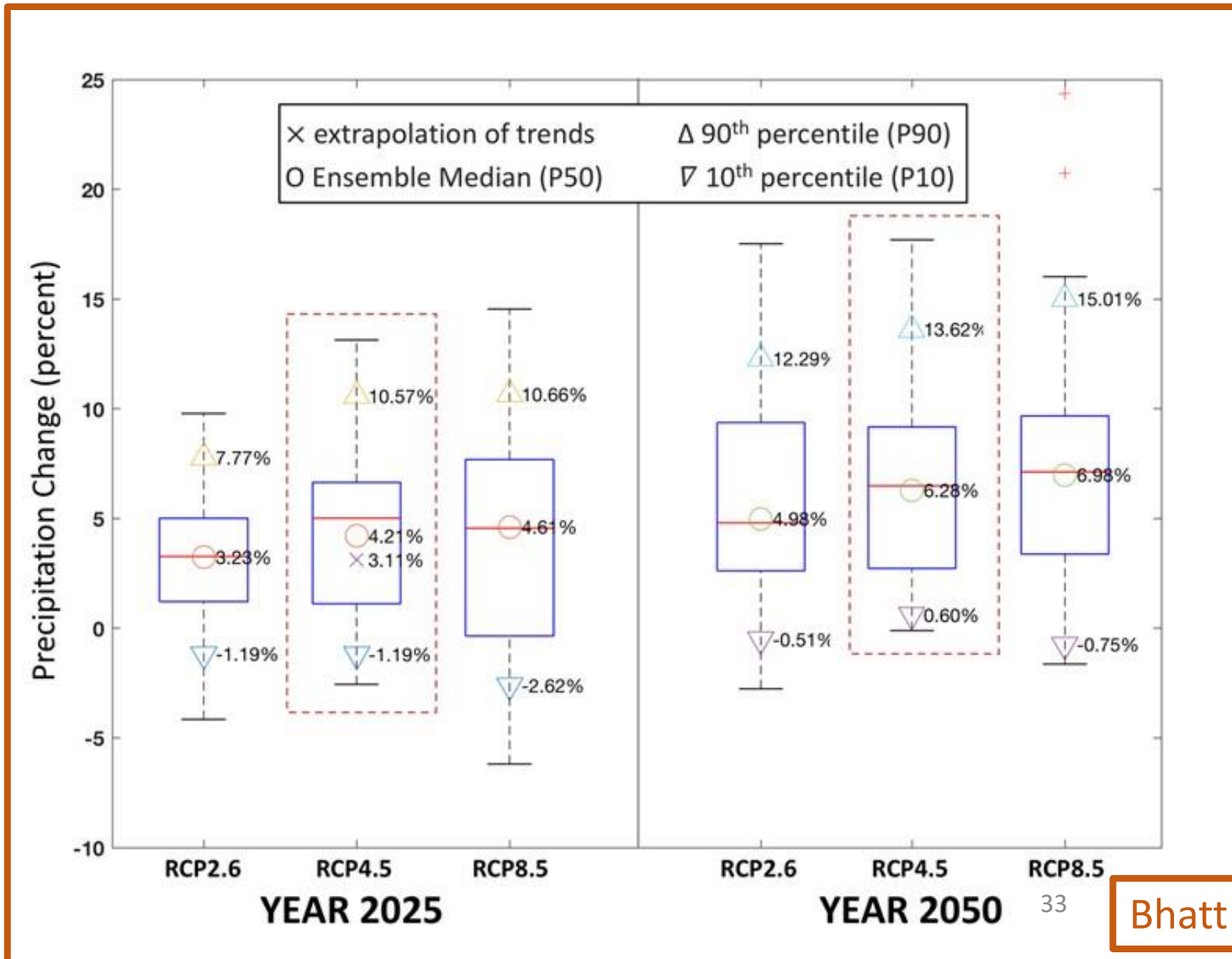
- Change in wind speed on the order of 0.1 meters per second

- Need around 4 meters per second to make a significant difference

Tian

Near term: Uncertainty

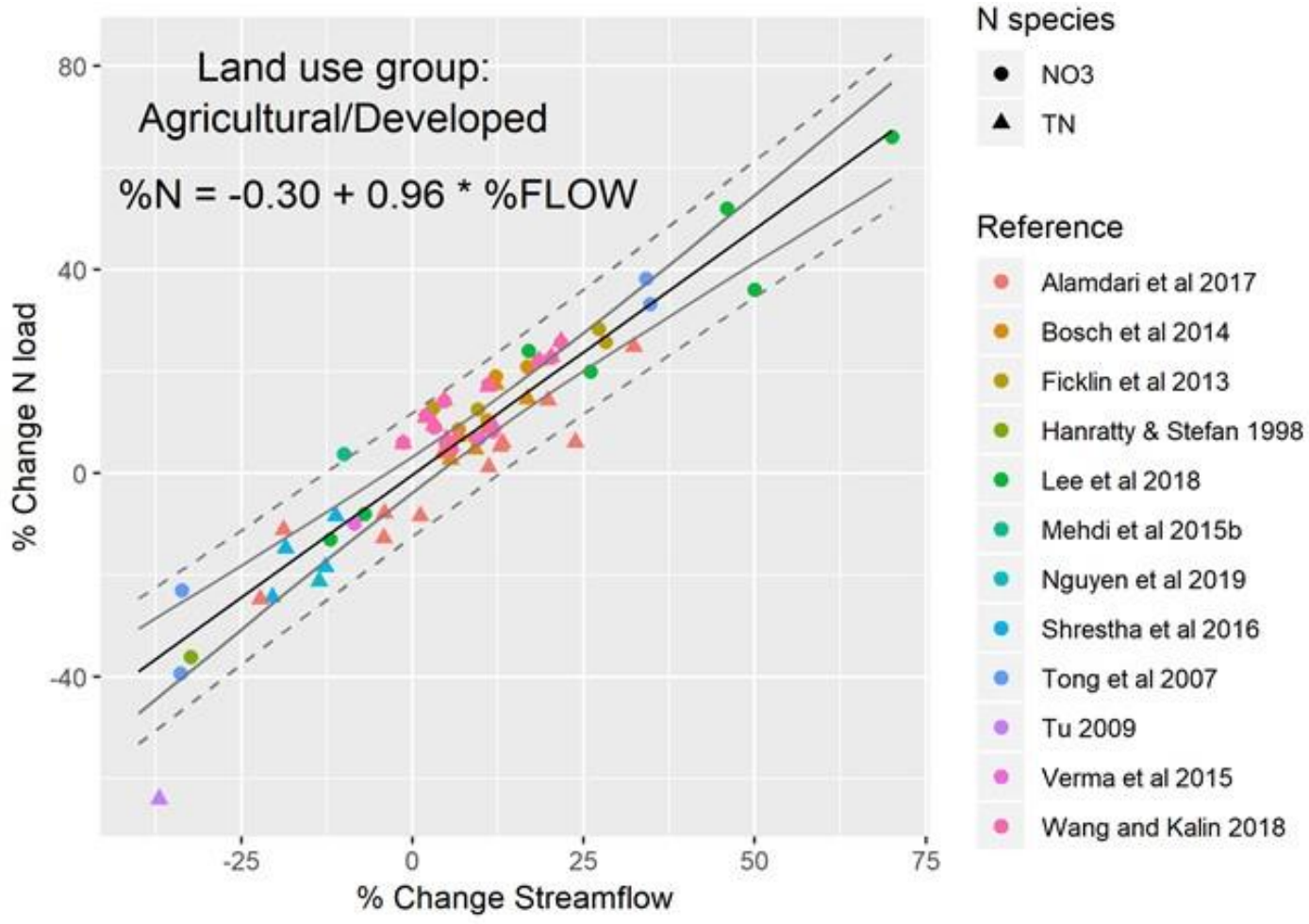
- Evaluated uncertainty of rainfall and temperature extrapolations



Bhatt

Near term: Uncertainty

- Evaluated uncertainty of individual components
- But did not put it all together to estimate overall uncertainty



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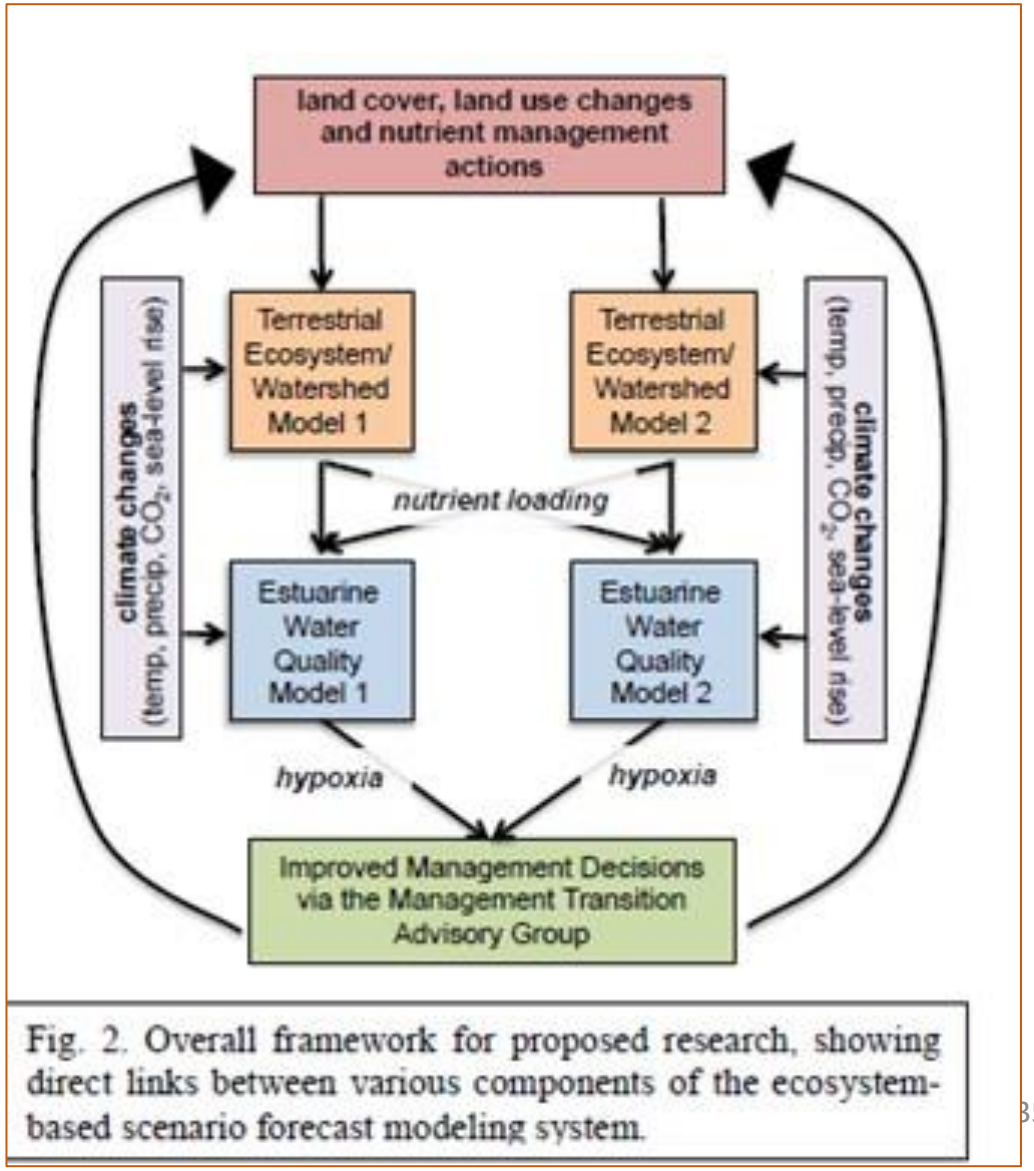

Fig. 2. Overall framework for proposed research, showing direct links between various components of the ecosystem-based scenario forecast modeling system.