Future Climate and Landcover Impacts to Ecosystem Services of the Great Bay Watershed

Wilfred M. Wollheim

Dept. of Natural Resources and the Environment

University of New Hampshire

E-mail: wil.wollheim@unh.edu

Twitter: @WilWollheim

N.H. Coastal Adaptation Working Group

2018-06-20

Greenland, NH

Acknowledgements

- **Shan Zuidema**
- Nihar Samal
- Zaixing Zhou
- Rob Stewart
- Cameron Wake
- Madeleine Mineau
- Tao Huang
- Kevin Gardner
- Mark Borsuk
- Georgia Mavrommati
- Dave Lutz
- Stanley Glidden
- Matt Huber

Samal, N., W.M. Wollheim, S. Zuidema, R. Stewart, M. Mineau, T. Huang, C. Wake, K. Gardner, M. Borsuk, G. Mavrommati, D. Lutz, Z. Zhou, S. Glidden, M. Huber. 2017. Projections of Coupled Terrestrial and Aquatic Ecosystem Change Relevant to Ecosystem Service Valuation at Regional Scales. **Ecology and Society** 22: 18. https://doi.org/10.5751/ES-09662-220418

Ecosystems and Society Project Goals

- Understand how aquatic ecosystem services are impacted by the interactions of climate, land use, and ecosystem function.
- Integrate terrestrial and aquatic ecosystem processes
  - Hydrologic cycle
  - N loading and retention
  - Water Temperature
  - Salt loading (road salt) and transport
- Future projections based on scenarios for how aquatic ecosystem services will change in the future
  - N flux, Flood Risk, Fish Habitat
  - Relative importance of climate and landuse.

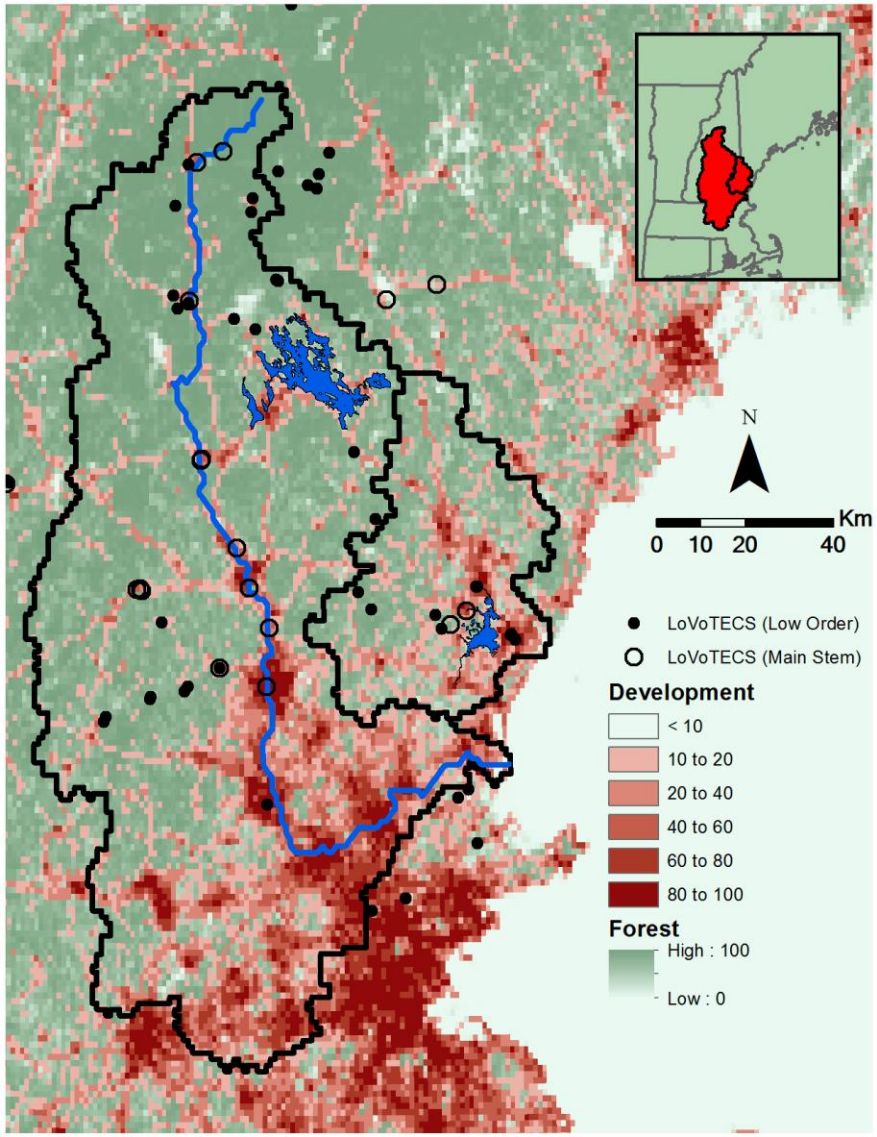
Scenario Design: LANDUSE x CLIMATE

	LOW	HIGH
	CMIP3, GFDL-2 Low Emissions (B1) (Statistically Downscaled)	**CMIP3 GFDL-2 High Emissions (A1Fi) (Statistically Downscaled)**
Backyard Amenities **BA**	**Similar climate** More People (2.2x) **Less Forest, More Residential, More Impervious**	**Warmer, Wetter** More People (2.2x) **Less Forest, More Residential, More Impervious**
Community Amenities **CA**	**Similar climate** More People (2.2x) **Same Forest, People in existing cites**	**Warmer, Wetter** More People (2.2x) **Same Forest, People in existing cites**

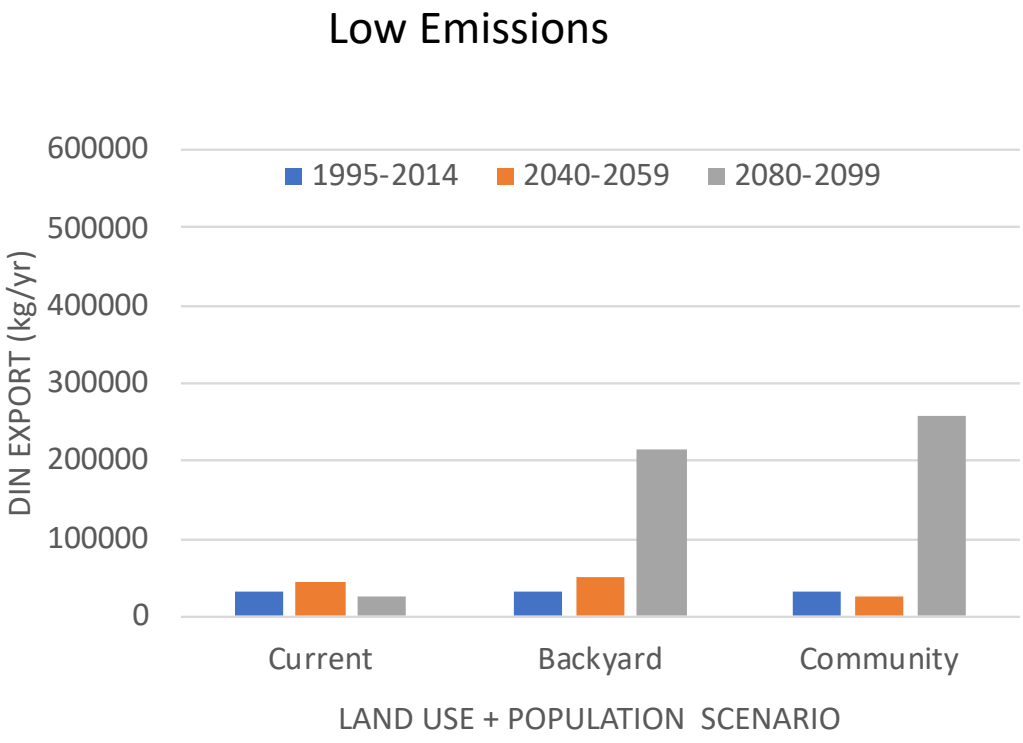
Model Domain

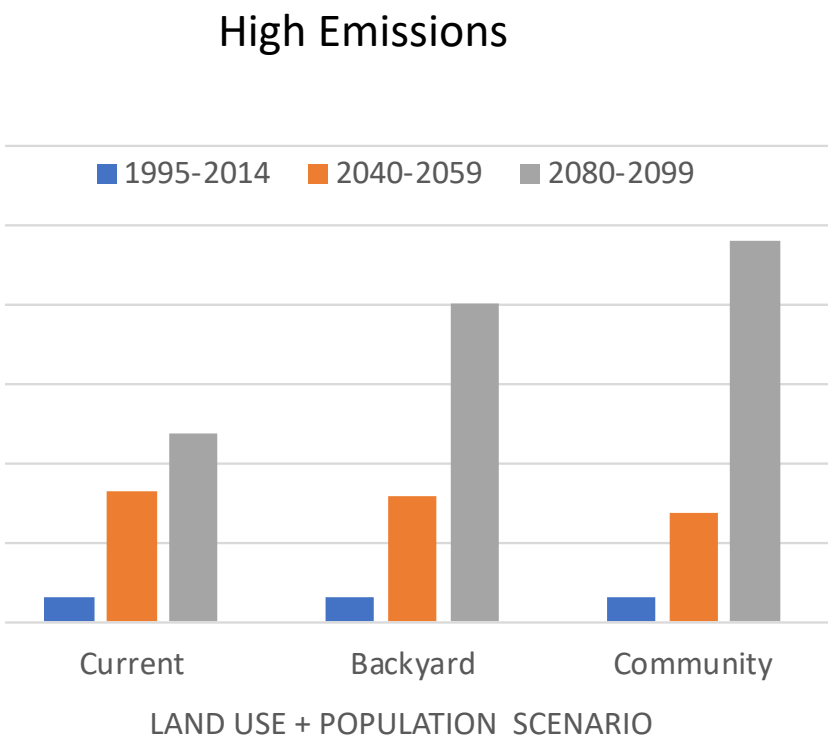
- Spatial Domain – Merrimack and Great Bay, New England, USA
  - Grid Resolution ~1.5 x 1.5km
- Temporal Domain – 1980-2100
  - Resolution – daily
  - AGGREGATED TO ANNUAL
- River network routes, mixes, and processes constituent inputs
  - Upstream influences downstream
  - Aquatic processes accumulate
- Quantify response at regional (watershed) scale
- Parameterized a priori, and tested with observations

Study Domain and Sensor Network



Future Scenarios: Watershed N export*



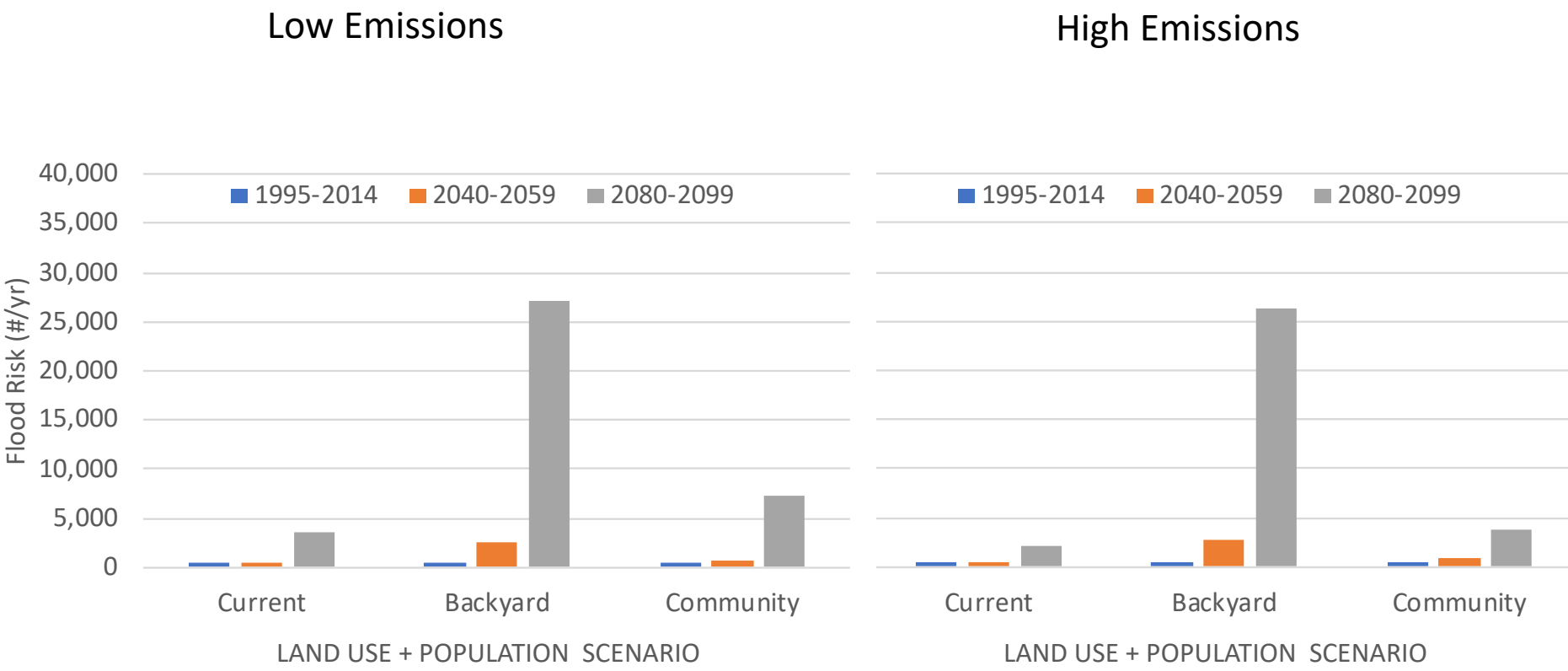


- N export will increase in future.

- Climate change and population/landuse change both contribute to future increases

* DIN export above critical Great Bay threshold

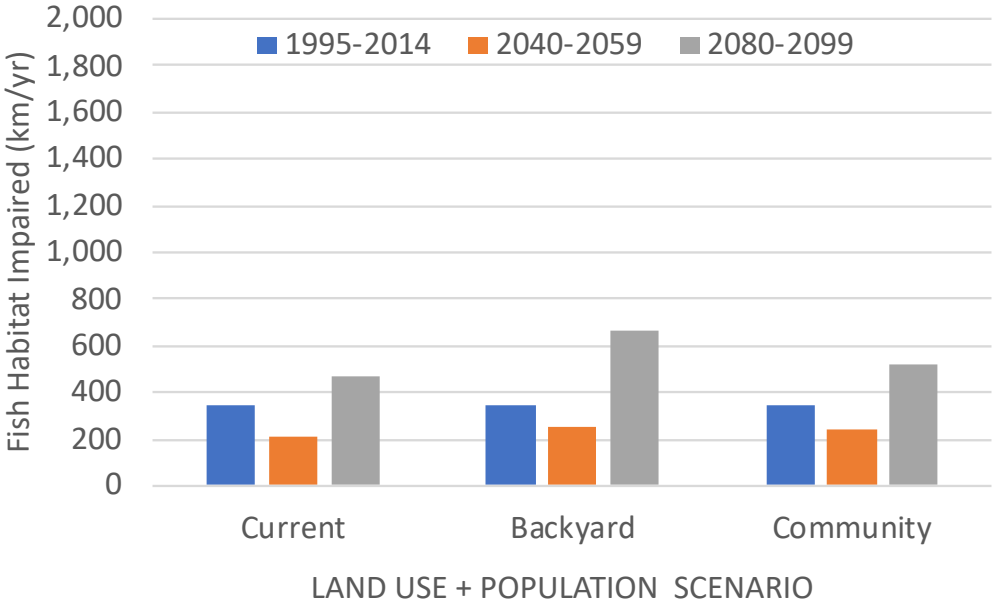
Future Scenarios: Watershed Flood Risk



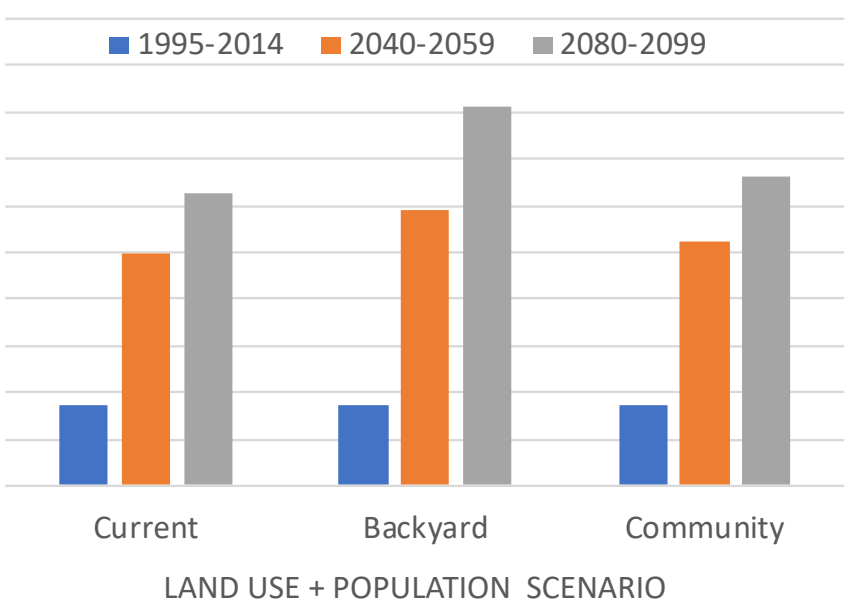
- Flood risk in the future will increase
    - due mostly to people moving into harms way and increased impervious surfaces
    - Climate effect much smaller p[opulation/land use effect.
- Conservative estimates of flood risk
    - GFDL predicts less climate variability than most other GCMs

Future Scenarios: Fish Habitat Impaired

Low Emissions



High Emissions

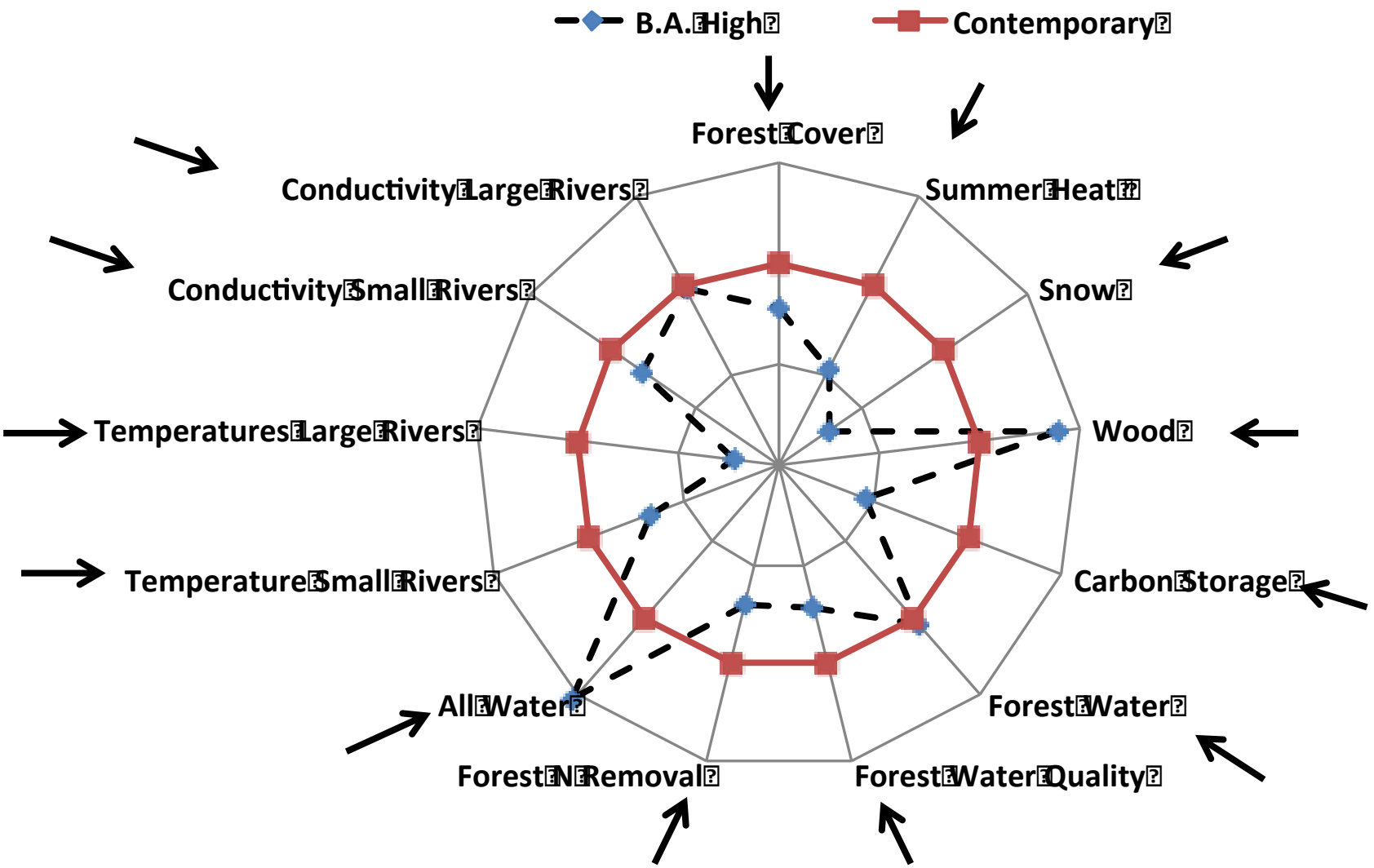


- More fish habitat impaired in future, due mostly to climate change (increased temperature).

Total Length of All Rivers in Great Bay Watershed = 2372 km

Coupled Responses

Backyard Amenities, High Emissions



Relevance

- Decline in ecosystem services will be noticeable by mid century, with steep declines by end century.

- Climate change projected to have a bigger impact than land use for N export and Fish Habitat.
  - But, population growth and land use more important for flood

- Dynamic models coupled to scenarios uncover complex response to both climate and land use change.
  - Use to explore tradeoffs among ecosystem services

- Many factors not considered in models
  - E.g. Possibility of dam removals and effect on N exports and flooding (ongoing work)

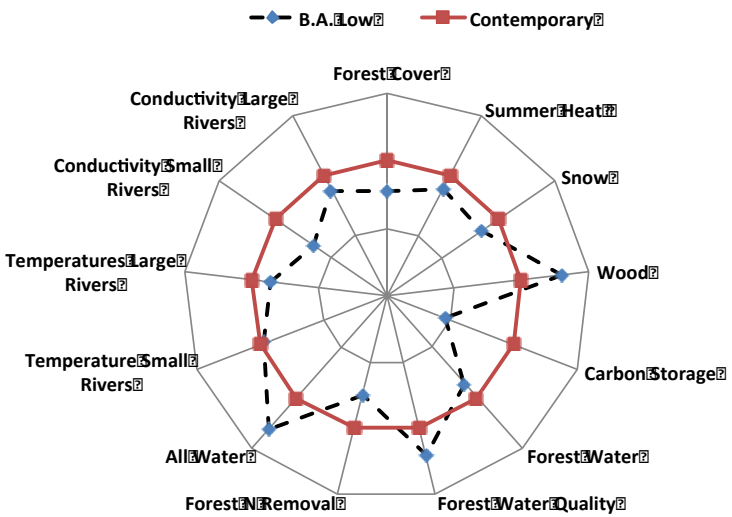

QUESTIONS?

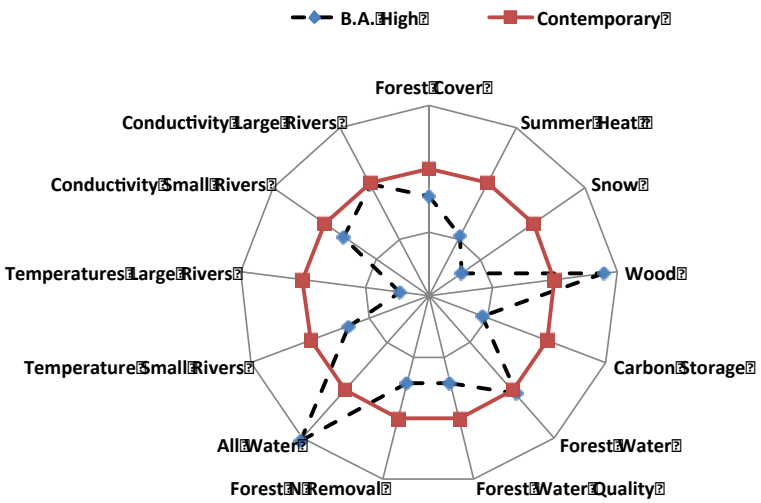
TRADEOFFS

LOW EMISSIONS

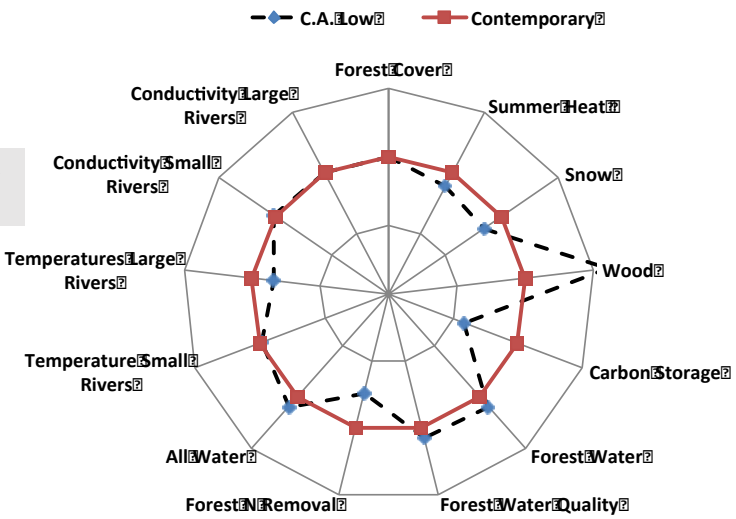
HIGH EMISSIONS

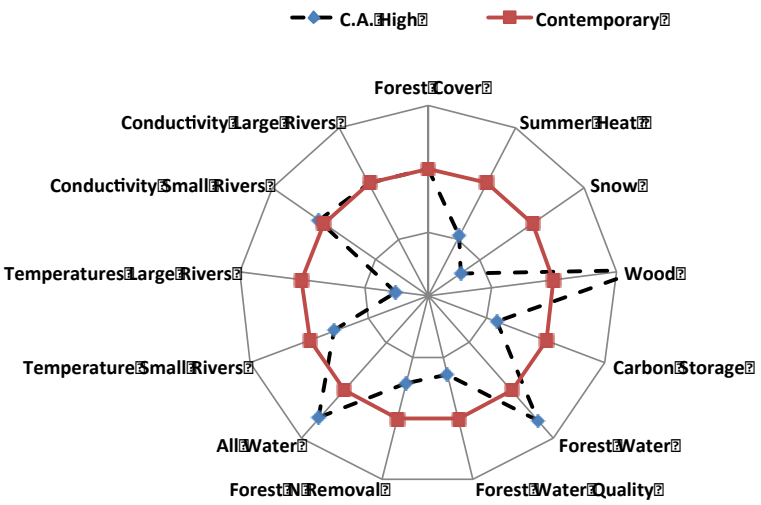
BACKYARD





COMMUNITY

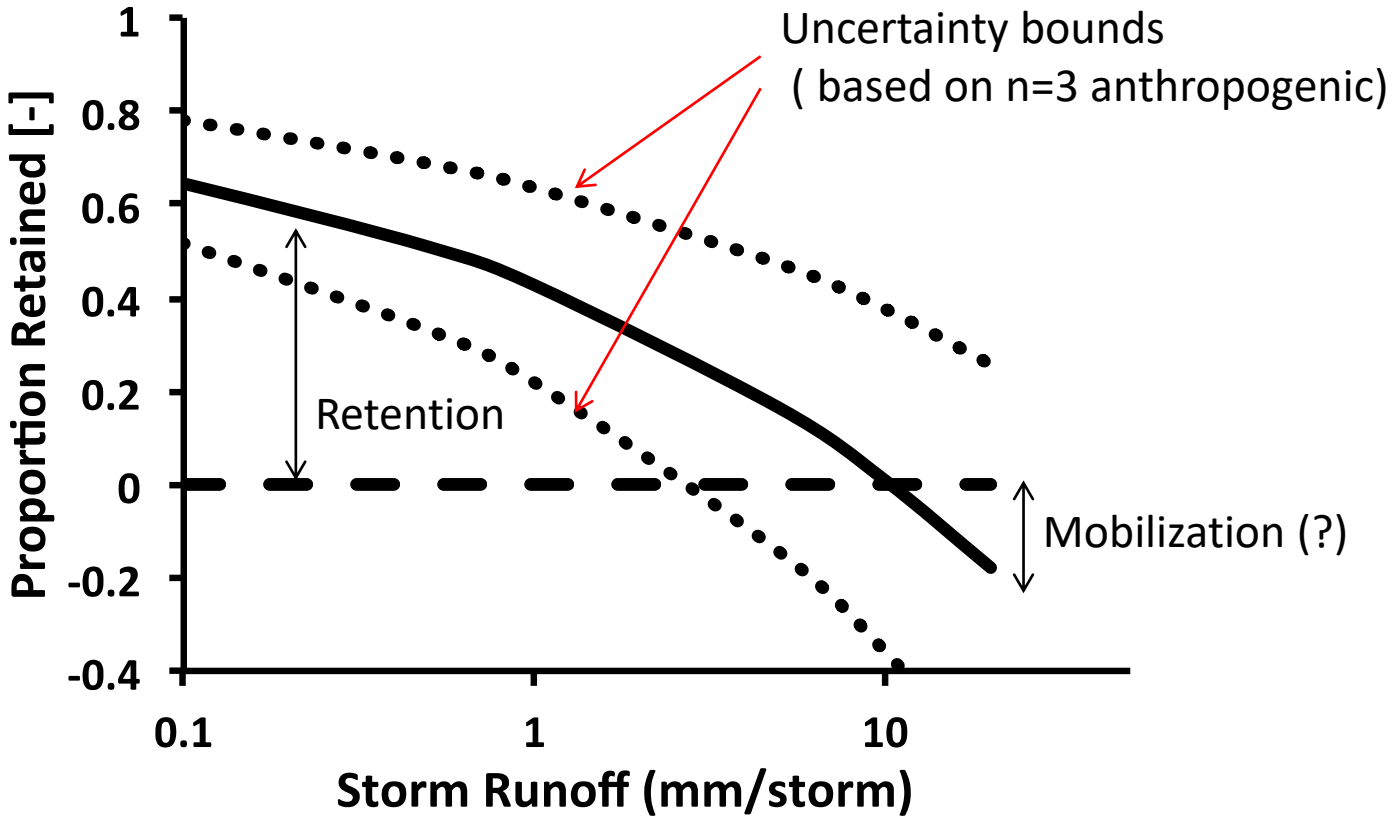




Climate impacts aquatic N retention:

Retention by river systems declines as flows go up.

- Predicted from Two Endmember Mixing Analysis



Wollheim et al. 2017.

United States Environmental Protection Agency

NH Seagrant
NH EPSCoR
UNH Hamel Center
NRCS
RealTech Inc.

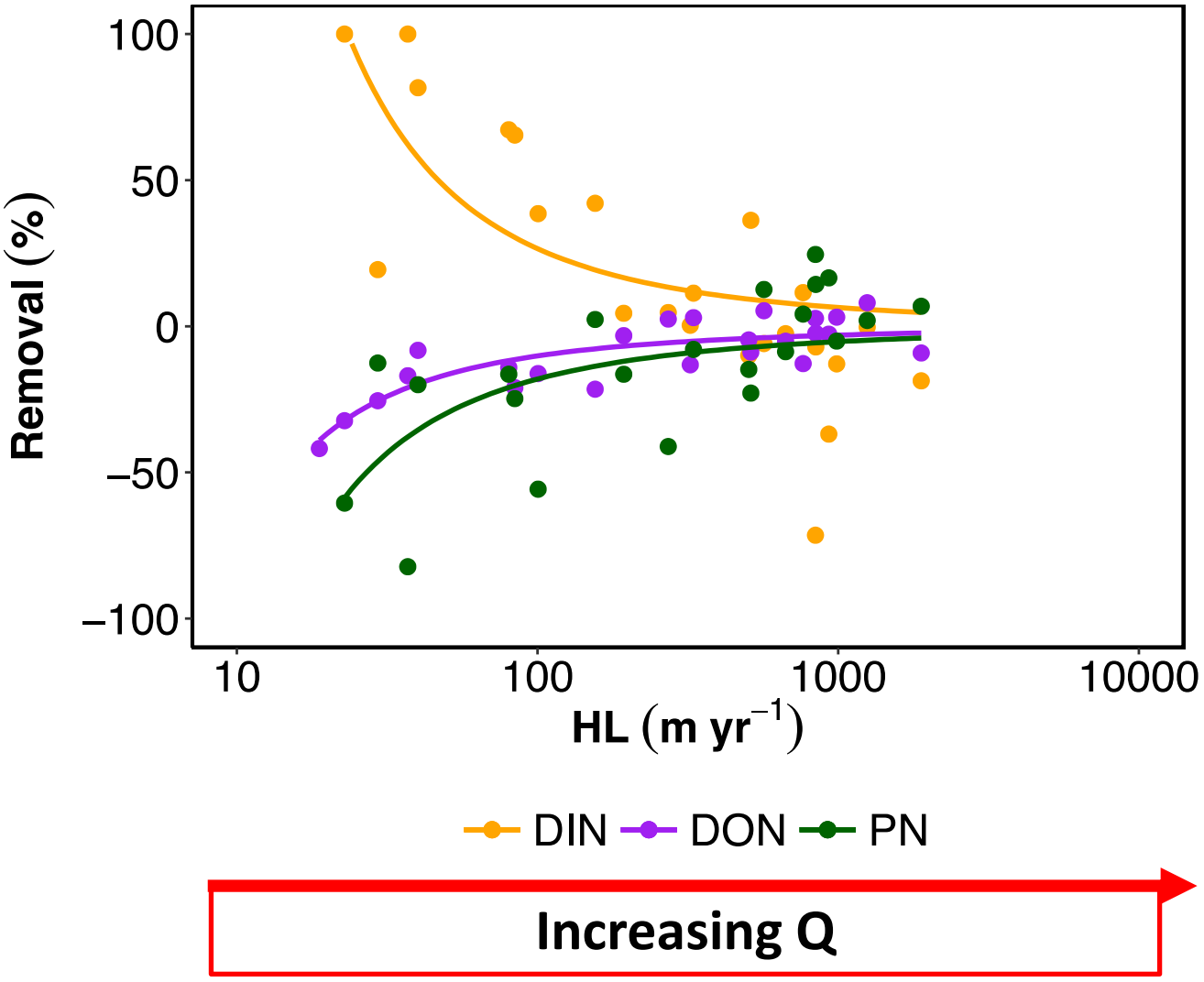
Quantifying the impact of dam removals on nitrate retention using low cost nitrate sensors.

Wilfred Wollheim - NREN
Kevin Gardner - CEE
Gopal Mulukutla - ESRC
Julia Peterson – NH Sea Grant

Reservoir impacts on nitrogen fluxes:

Reservoirs retain less inorganic N at higher flows

Reservoirs transform inorganic N To organic N

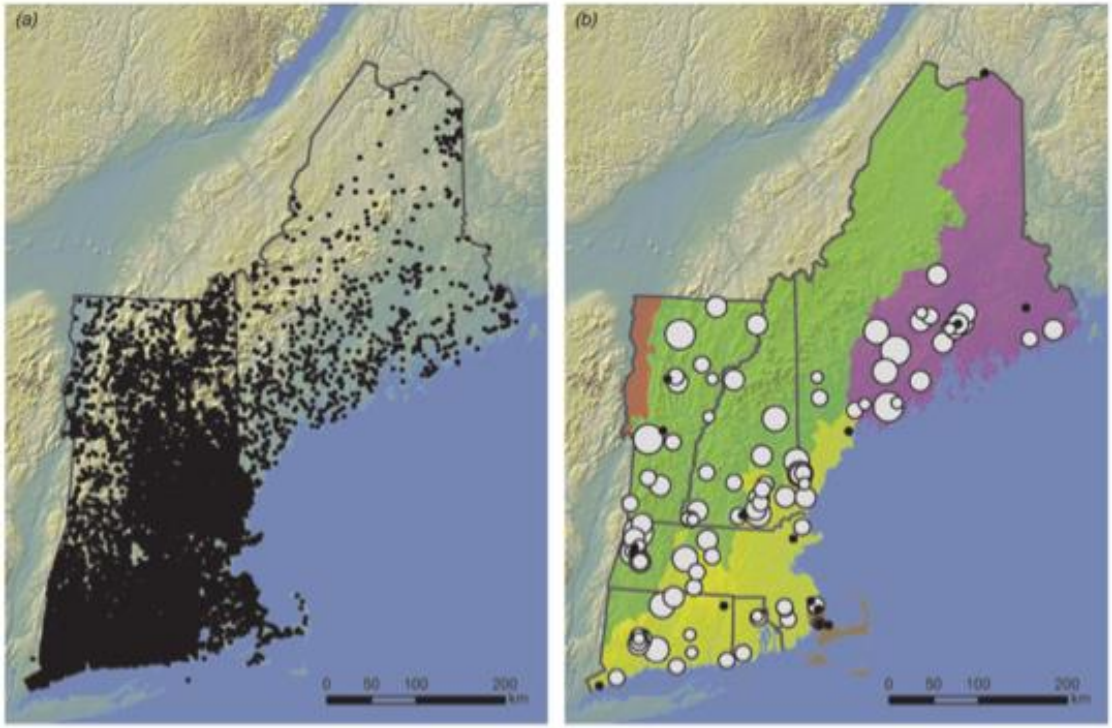


There are a lot of dams, and many are being removed:

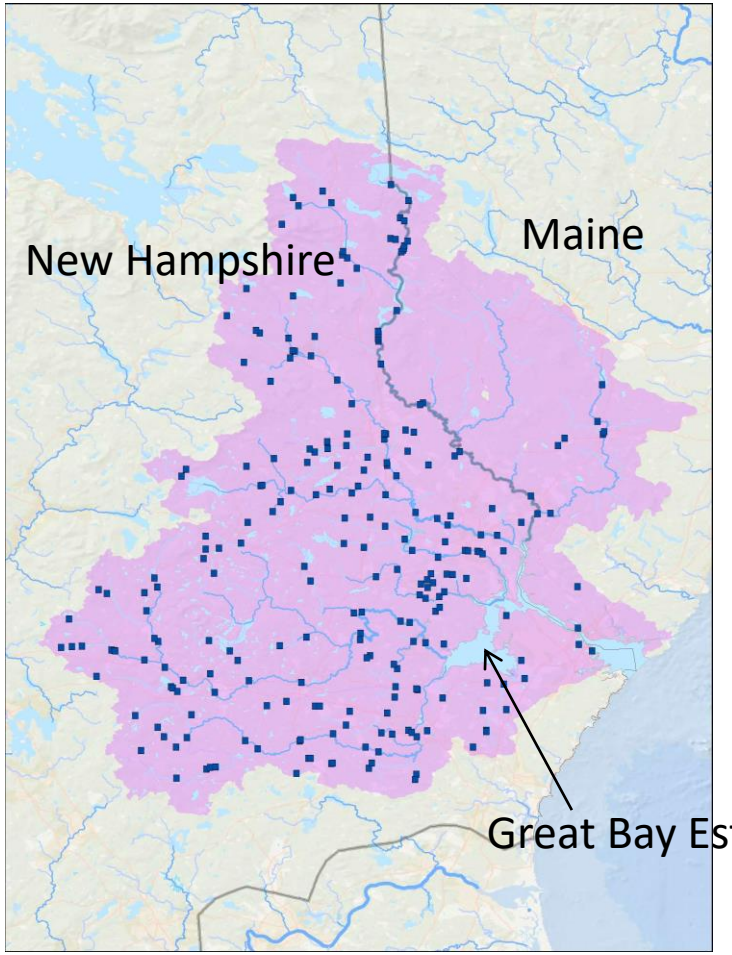
What will be coastal impact?

Current Dams

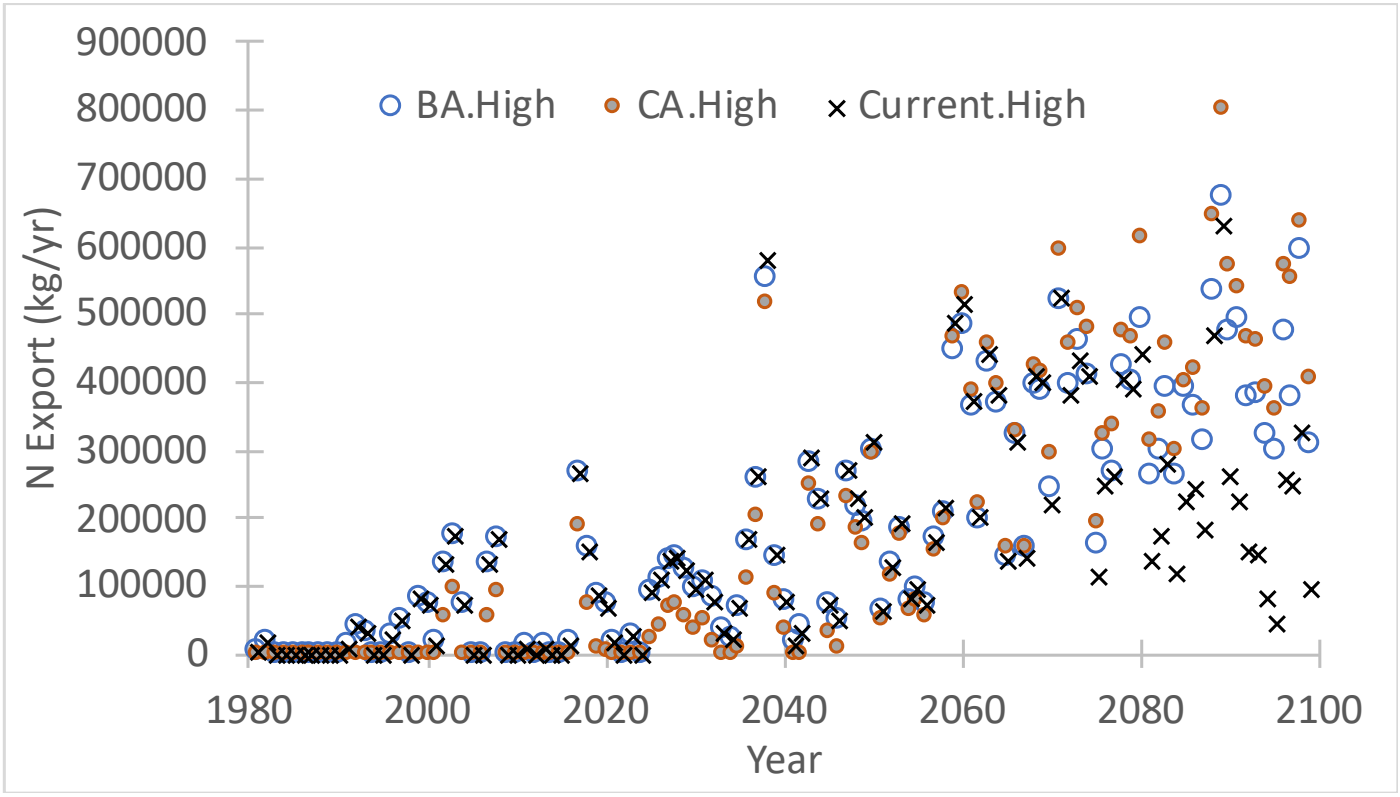
Dams Removed



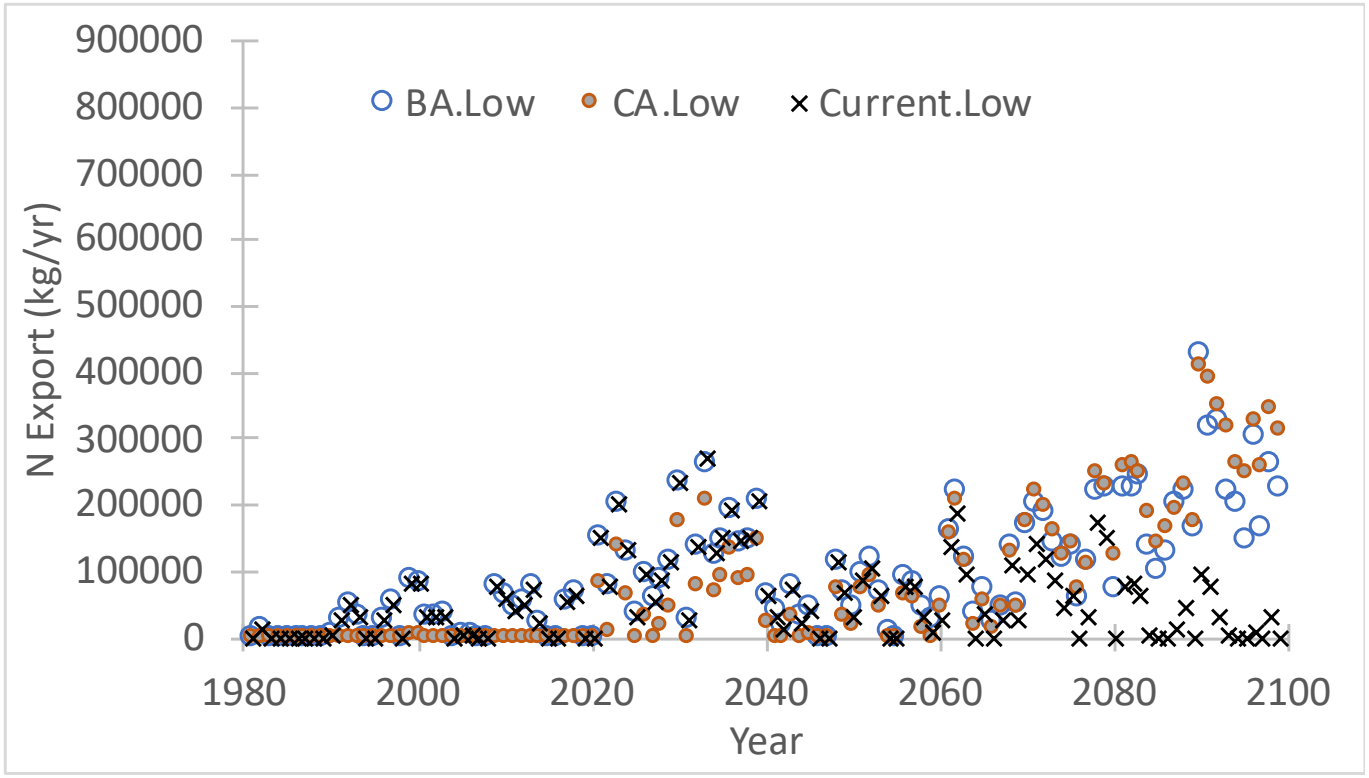
Magilligan et al. 2016



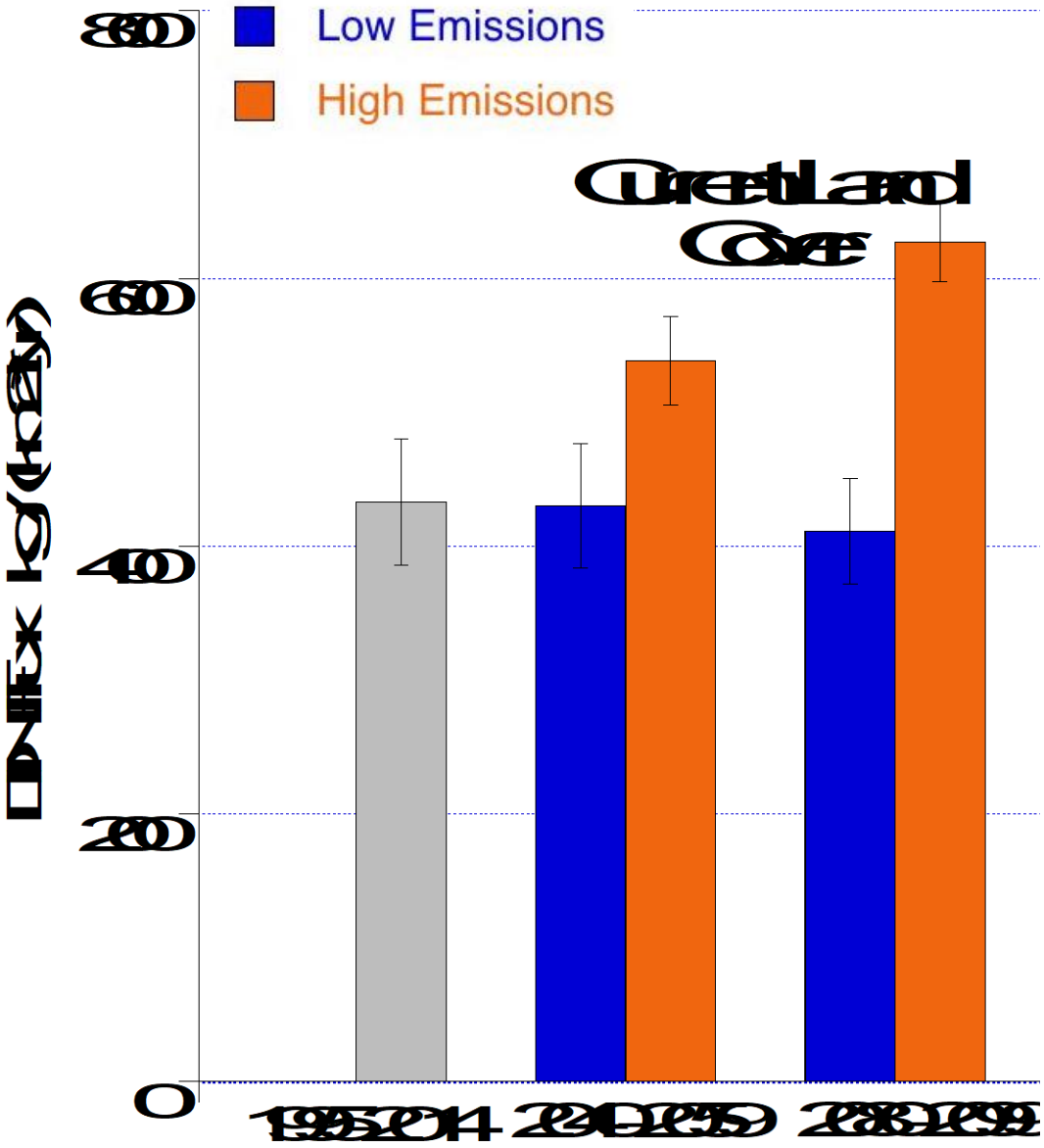
N export projected to increase in future due to climate change



N export above critical threshold Low Emissions

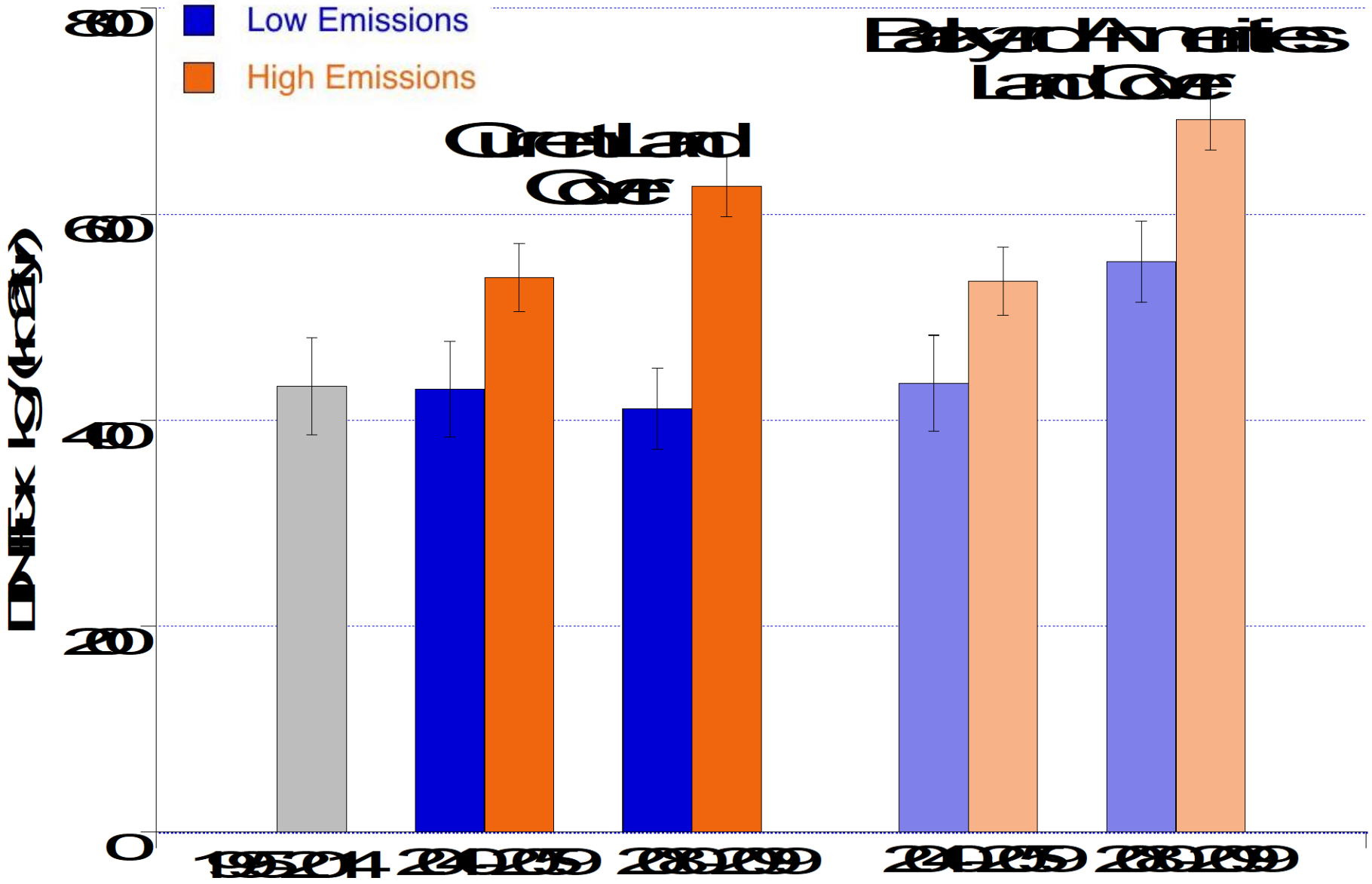


DIN Flux to Great Bay: Cocheco & Lamprey Rivers



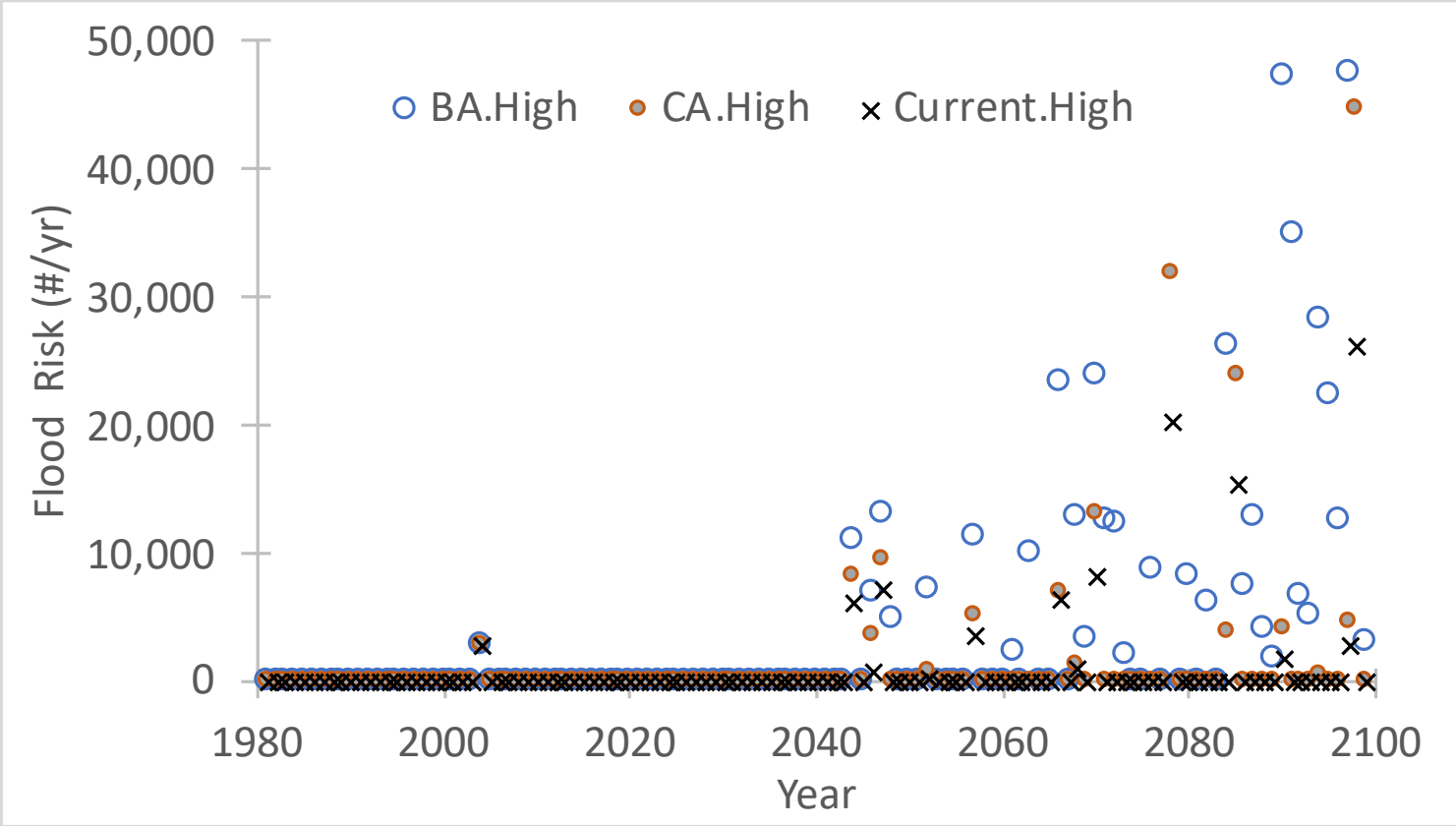
Whiskers represent interannual variability over 20 year period

DIN Flux to Great Bay: Cocheco & Lamprey Rivers

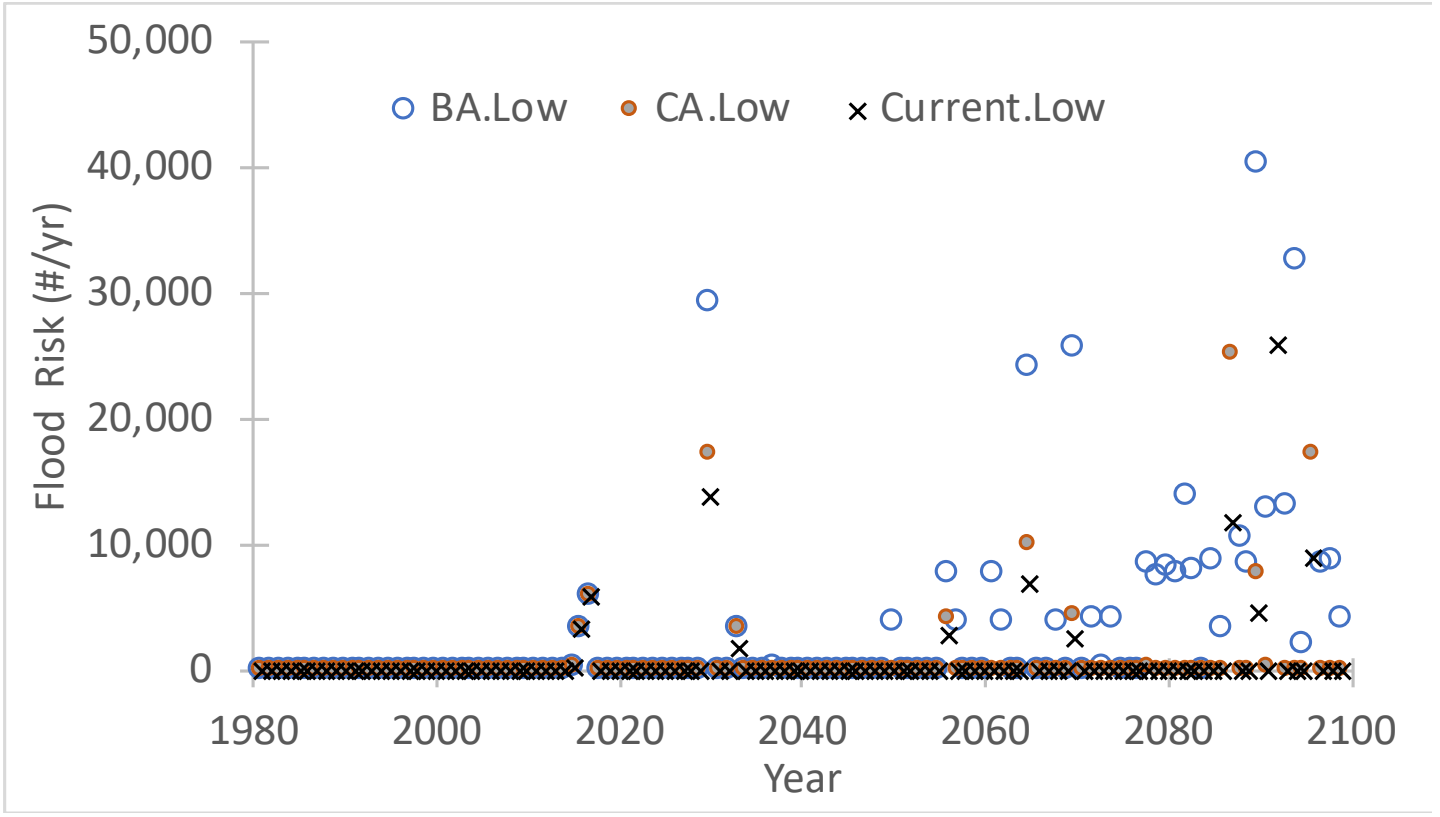


Whiskers represent interannual variability over 20 year period

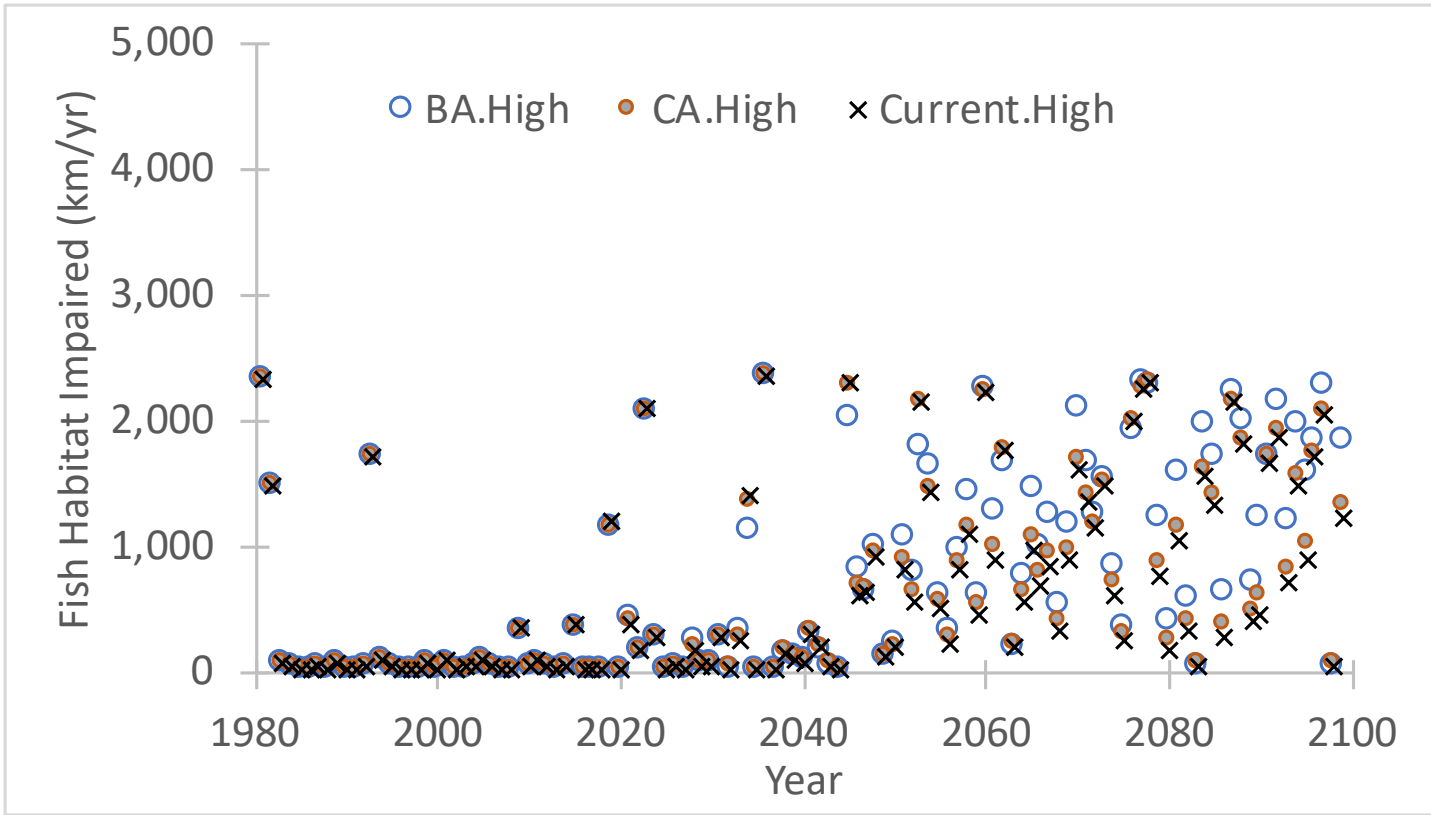
Flood Risk
High Emissions



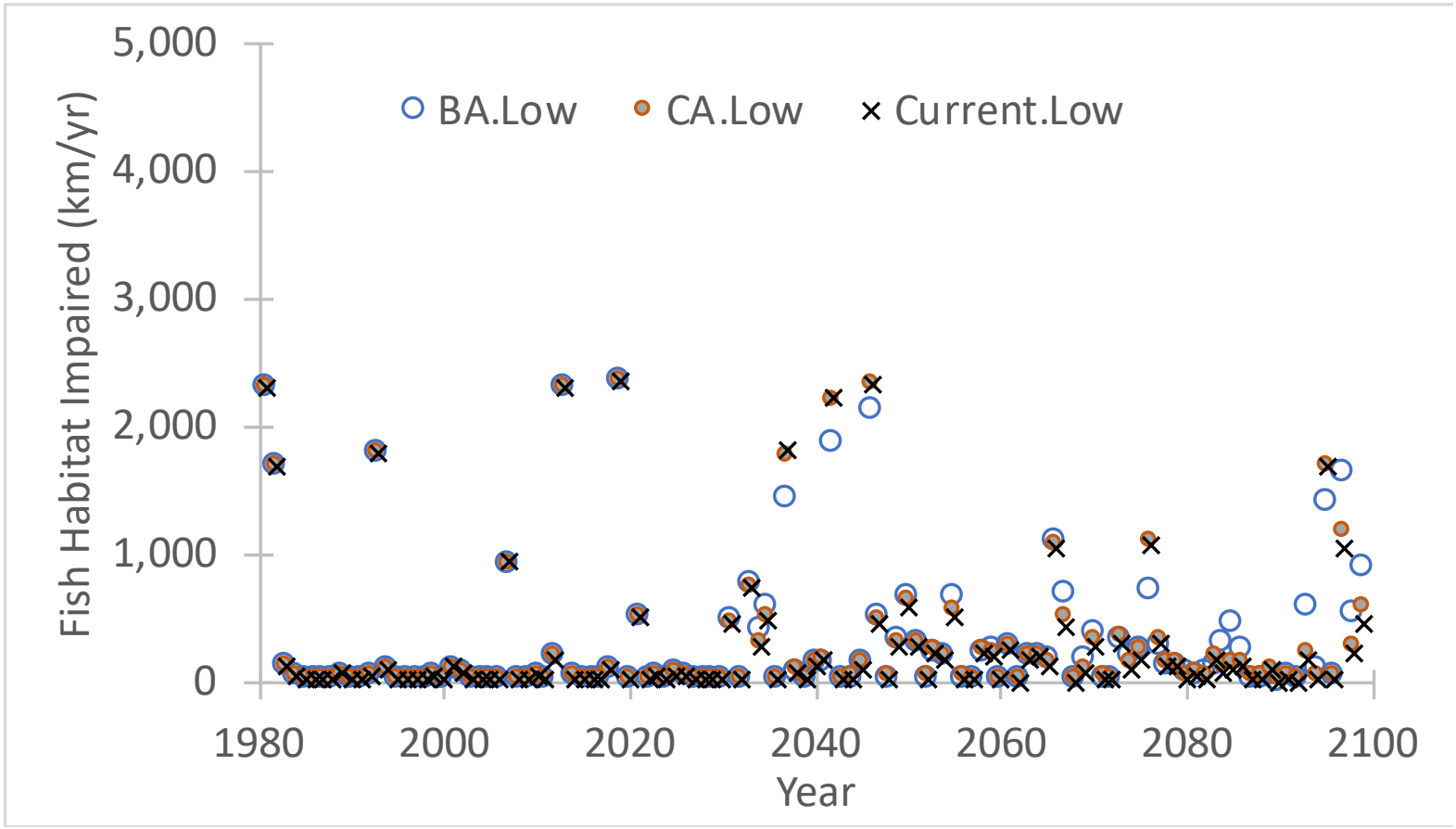
Flood Risk
Low Emissions



Fish Habitat Impaired
High Emissions



Fish Habitat Impaired
Low Emissions



Scenarios

Name	Population	Forest %	Urban%	NOTES
Current	387,000	[80]	[4.5]	
Backyard Amenities	2.4x	0.75x	5.8x	Dispersed Development
Community Amenities	2.4x	1x	1x	Concentrated Development

	Climate Low Emission	Climate High Emission
Land use - dispersed	BA.Low	BA.High
Land use - concentrated	CA.Low	CA.High