New Hampshire’s Changing Climate, Land Cover, and Ecosystems

With thousands of miles of rivers and streams and hundreds of lakes and ponds, New Hampshire offers aquatic habitat that support a rich fish population. However, some of our fish habitat is deteriorating due to elevated chloride concentrations, warmer water temperatures, and low flows during summer months. Projected changes in climate and land cover will lead to changes in these environmental variables in ways that will likely reduce fish habitat in the future, with increasing stream temperatures as the predominant problem.

**WATER TEMPERATURES**

**WHAT HAVE WE SEEN SINCE 1995 FOR THE MERRIMACK RIVER?**
- 70 river miles (~1% of the total NH river aquatic habitat) exceed an average weekly temperature tolerated by common indigenous fish species (84.6°F)

**WHAT CAN WE EXPECT IN THE FUTURE?**
- Warmer air temperatures and increased surface runoff in New Hampshire will result in elevations in stream and river water temperatures
- By mid-century, river miles with temperature impairment are expected to increase 4 to 19%
- By late-century, river miles with temperature impairment are expected to increase 4 to 62% (higher impact under the high emissions and backyard amenities scenarios)

**LOW FLOW**

**WHAT HAVE WE SEEN SINCE 1995 FOR THE MERRIMACK RIVER?**
- 27 river miles (<1% of total NH river aquatic habitat network) experienced low flow (0.122 mm per day; described in methods on back)

**WHAT CAN WE EXPECT IN THE FUTURE?**
- Occurrences of low flow conditions are sensitive to both climate and land cover scenarios
- In a moderately warming climate (low emissions) with constant land cover, low flow occurrences decrease 40% by mid-century, but increase back to 30% of current values by late-century due to increased precipitation and maturing forest

**CHLORIDE CONCENTRATIONS**

**WHAT HAVE WE SEEN SINCE 1995 FOR THE MERRIMACK RIVER?**
- 27 river miles (<1% of total NH river aquatic habitat network) exceeds a chloride threshold of 140 mg chloride per litre that is protective of aquatic diversity

**WHAT CAN WE EXPECT IN THE FUTURE?**
- Given current land use, warmer winters could reduce impairment by 7 to 14% by mid-century or by 40% by late-century
- Increased impervious surfaces could increase chloride impairment up to 90% by the end of the century despite warmer winters
Watersheds with grid a resolution of 1.5 km². PnET-FrAMES represented the Merrimack and Piscataqua River water temperature, and chloride dynamics through watersheds that represents land cover and land use to simulate runoff, for Aquatic Modeling in the Earth System), is a gridded model water, carbon, and nitrogen dynamics. FrAMES (Framework EvapoTranspiration with Carbon and Nitrogen), simulates forest condition under different scenarios. PnET-CN (Photosynthetic models were coupled to provide estimates of environmental MODEL: Existing forest (PnET-CN) and river network (FrAMES) models were coupled to provide estimates of environmental condition under different scenarios. PnET-CN (Photosynthetic EvapoTranspiration with Carbon and Nitrogen), simulates forest water, carbon, and nitrogen dynamics. FrAMES (Framework for Aquatic Modeling in the Earth System), is a gridded model that represents land cover and land use to simulate runoff, water temperature, and chloride dynamics through watersheds. PnET-FrAMES represented the Merrimack and Piscataqua River Watersheds with grid a resolution of 1.5 km².

CONTEMPORARY VALIDATION: Testing of PnET-FrAMES under recent historical conditions used climate from NASA Modern Era-Retrospective Analysis for Research and Applications (MERRA) for the period of 1980-2014. Output corresponded well with station (gage) measurements for discharge (U.S. Geological Survey - USGS), specific conductance (Lotic Volunteers Temperature Electrical Conductance and Stage network – LoVoTECS; ddc-lovotec.sr.unh.edu), and water temperature (USGS/LoVoTECS).

LAND USE DATA: Two land cover scenarios encompass the widest divergence in land cover change: present-day land cover and Backyard Amenities, which prioritizes large building lots and increases impervious areas dramatically. More info at: ddc-landcover.sr.unh.edu.

FUTURE CLIMATE DATA: Future climate projections used statistically downscaled climate simulations derived from the Geophysical Fluid Dynamics Laboratory CM2.1 model (Hayhoe 2007). Two scenarios represent a wide range of potential future climate: lower emission (B1, 550 ppm CO₂ by 2100) and higher CO₂ emission (A1FI, 970 ppm CO₂ by 2100).

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