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Regional Differences of Climate Change in Maine: Flow rates, Precipitation, and Snowpack

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Introduction

- Maine winters are changing rapidly, associated with changes in climate.
- These climate-linked changes are implicated in flooding, changes in snowpack, and changes in flow regimes in Maine. [1]
- In this study, four different regions in Maine were analyzed to evaluate changes over time in snowpack, river ice, fall-through-spring precipitation, and river flow. [2]

Methods

- Maine was separated into four regions:
  - **Saco Region:** this watershed was chosen to represent southern regions
  - **Sandy Region:** this watershed was chosen to represent western regions
  - **St. John Region:** this watershed was chosen to reflect northern regions
  - **Piscataquis Region:** this watershed was chosen to reflect central regions.
- Daily water year (starting Oct 1) flow and ice cover data were collected from USGS[3]
- Weekly precipitation data were collected from CoCoRaHS[4] and NOAA[5]
- Monthly snowpack data were collected from MGS[6]
- Data were analyzed in RStudio[7]
  - Quantile regression was used on snowpack, precipitation, and flow datasets to determine whether significant trends existed in the median (50^{th} quantile) or extreme (99^{th} quantile) data values
  - Snowpack was also plotted with local regression lines to visually evaluate any sub-decadal trends

Results

February Snowpack water equivalent

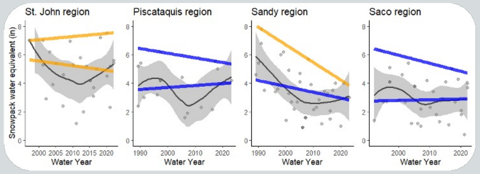

Figure 1: Regression trend lines for the 99th and 50th quantiles (straight lines) and the local regression (smooth line) of the February snowpack in each region by year. Significant trends are depicted in orange.

- The St. John and Sandy regions had significant trends in snowpack, but these did not exist in the Piscataquis or Saco regions
- Both increasing and decreasing trends were observed, depending on the region

March Snowpack water equivalent

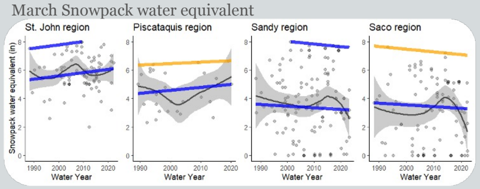

Figure 2: Regression trend lines for the 99th and 50th quantiles (straight lines) and the local regression (smooth line) of the March snowpack in each region by year. Significant trends are depicted in orange.

- March snowpack trends were significant at the 99th percentile for the Piscataquis and Saco regions, but trends had differing directions
- A steep decline in March snowpack was observed in the Sandy and Saco regions in recent years

Ice Cover Dates per Water Year

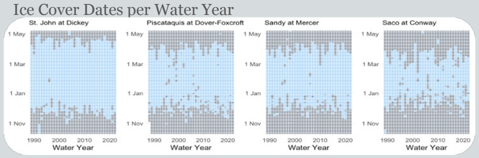

Figure 3: Ice cover (in blue) from November to May across 20 water years (1990-2020).

- **St John at Dickey** had the most time with ice cover.
- **The Piscataquis at Dover-Foxcroft** and **Sandy at Mercer** had similar durations of ice cover.
- The **Saco at Conway** had the least amount of time with ice cover.

Weekly precipitation for 1 Oct-1 May

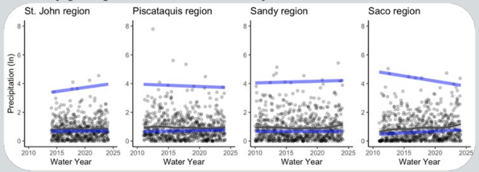

Figure 4: Quantile regression (50^{th} and 99^{th}) for precipitation in each region by year (October through May).

- No significant trends were observed in precipitation patterns. However, available datasets were <20 years in duration.

Flow Discharge per Water Year

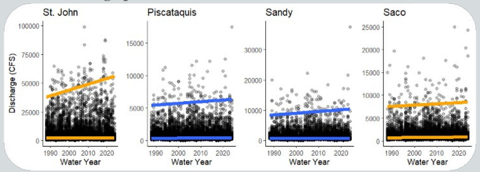

Figure 5: Regression trend lines for the 99th and 50th quantiles for discharge (CFS) per water year in each region.

- **St John Region:** There was a significant positive trend found in both the 99th and the 50th percentile.
- **Piscataquis Region:** There was no significant trend found.
- **Sandy Region:** There was no significant trend found.
- **Saco Region:** There was a significant positive trend found in both the 99th and 50th percentile.

Discussion

The Saco and Sandy regions are continuing to experience less snowpack during the end of winter and beginning of spring than in past years. The snowpack in February also exhibited a negative yearly local regression trend in **The Saco, St. John, and Sandy regions.** In addition to the negative trend found in **The Saco and Sandy regions**, there is an increasing amount of variability in the snow water equivalent.

There is also a noteworthy change in ice coverage dates in recent years for these rivers, most notably in **The Saco, Sandy, and Piscataquis rivers.** The river ice is forming later and melting earlier than previously observed.

While none of the quantile regression trends in precipitation were significant, our data set was limited in duration, and precipitation is predicted to change significantly with climate change, with likely implications for river flow[1].

The 99th percentile of discharge in each of the selected rivers only showed significant trends in the **The Saco** and **St. John** regions; these are the most northerly and southerly regions in our dataset. Median flows are generally increasing, and peak flow variability is increasing. This corresponds to the trends found in both snowpack as well as precipitation.

The observed trends support our hypothesis that there would be significant changes in snowpack, precipitation, and flow rate. However, we importantly find that these changes are not occurring equally across the select four regions of Maine.

These observed trends have implications for many aspects of life in Maine.[8]

Figure 6: Maine Map[9] showing locations of data sources for each region.

Resources

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