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Seasonal Variability in Peak Flow of Maine Rivers

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Introduction

Rivers are essential parts of the landscape that influence human infrastructure and the surrounding environment. They support important economic and recreational activities, and are essential habitat for many species. Maine is home to 31,752 miles of rivers and streams. These rivers experience fluctuations in their flow rates based on the changing environment including annual precipitation, evaporation, and runoff effects, some eventually leading to increased flooding (Brakeley and Ezor 2009). **With a changing climate, it is possible that river flow and the timing of peak flow are changing.** Previous studies found that during the 20th century, the seasonal peak flow of rivers in New England was moving to earlier in the year, and the variation of peak flow was increasing as well (Hodgkins et al. 2003).

Questions and Hypotheses

- How has the timing of peak flow changed over time?
 - Hypothesis: Peak flow has moved earlier in the spring due to a warming climate melting snow earlier.
- How has the variation of flow changed over time?
 - Hypothesis: Flow has grown more variable in more recent years due to an increase in more variable precipitation patterns, especially in the spring months.

Methods

In this study, we utilized:

- Historical data on flow rates from the USGS National Water Information System, which operates stations along rivers across the United States measuring discharge & height of the water.
 - We looked at the Sandy River at Mercer, Carrabassett River at Anson, Mousam River at Kennebunk, & Narraguagus River at Cherry Field.
- We calculated peak flow and flow CV by month and fit regression lines to evaluate trends over time in each month. We also fit regression lines to the date of peak flow in either the first or second half of the year, for each river. All analysis was conducted in R.

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Peak Flow and Flow CV by Month

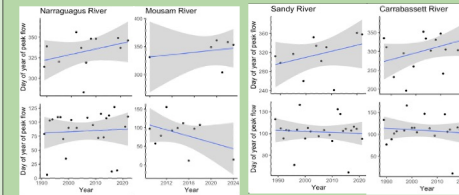


Figure 1: Graphs of the maximum flow in each month across years, and the coefficient of variance of flow in each month. Trend lines show regression model fit. Months outlined in red had trends where the model fit was significant ($p < 0.05$).

References

- Brakeley, S. and Ezor, Z., 2009. State of Rivers and Dams in Maine. State of Maine's Environment 2009, p.49.
- Hodgkins, G.A., Dudley, R.W. and Huntington, T.G., 2003. Changes in the timing of high river flows in New England over the 20th century. Journal of Hydrology, 278(1-4), pp.244-252.
- Martin, E.H., Kelleher, C. and Wagener, T., 2012. Has urbanization changed ecological streamflow characteristics in Maine (USA)? Hydrological sciences journal, 57(7), pp.1337-1354.

Timing of Peak Flow



Figures 2: The day of year when peak flow occurred, separated by the first (bottom) or second (top) half of the year. None of the regression trends were significant.

Daily Flow

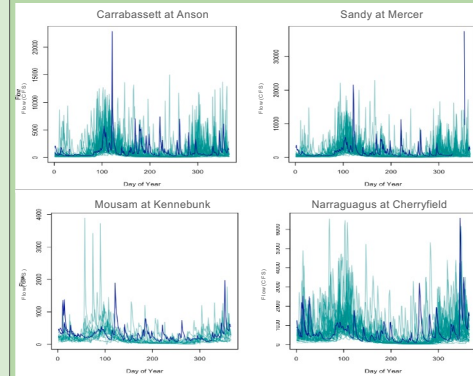


Figure 3: Annual flow in cubic feet per second, for the period of record shown in Figure 1. Each line is one year; past years are in light blue and the most recent year of data is in dark blue.

Map of River Areas

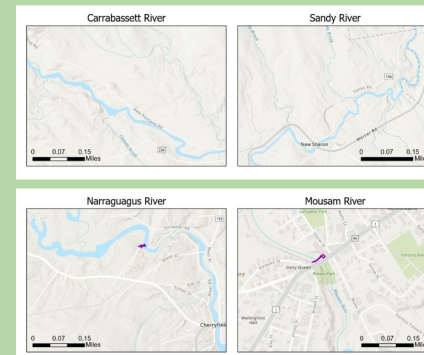


Figure 4: Maps of the rivers at the location where the USGS station takes measurements. Additionally, dams are marked in purple on the Narraguagus and Mousam Rivers.

Results

- Maximum flow pattern
 - All rivers have highest flows in April, but April trends in maximum flow varies by the river.
 - None of the rivers have significant trends in maximum flow in spring months
 - December maximum flows are increasing in all rivers, and this is significant in the Narraguagus.
- Flow Coefficient of Variation
 - Spring flow is becoming more stable in spring months in the Mousam and Carrabassett Rivers, but spring variability is increasing in the Narraguagus River.
 - October and December are increasing in flow variability over time in all rivers, with most trends significant.
- Timing of Peak Flow
 - Peak flow is occurring slightly earlier, or is stable, in the spring; peak flow is occurring later in the fall.
- Daily Flow
 - All four rivers show generally higher flows around late March to late April.
 - All four rivers also have higher flows in October through December.

Conclusions

- There seems to be an increase in flow variability in fall, specifically within the month of October.
 - Hypothesis: Summer and fall phenology is shifting, and larger storms may impact fall flow regimes.
- The Mousam and the Carrabassett rivers displayed a decrease in flow variation in March.
 - Hypothesis: Recent thinner snowpack may lead to less spring melt/runoff, leading to less variability in peak flow.
- In December the Narraguagus and the Sandy river displayed an increase in flow variance.
 - The Narraguagus displayed an increase in maximum flow during that month as well.
- The timing of peak flows appears to be shifting more in fall than in spring, though trends are not significant.
- Previous studies in Maine have noted that variability in flow of southern watersheds is higher than northern watersheds, and suggest variability in flow could be related to surrounding levels of urbanization (Martin et al 2013).
 - Both the Mousam and the Narraguagus rivers are coastal and have more notable human influences such as dams.

Acknowledgments

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