Hydro-geomorphic classification of Washington State rivers as a foundation for developing flow-ecology response relationships

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Project Abstract:
As demand for fresh water increases in tandem with human population growth, the need to understand ecological tradeoffs of flow regulation gain greater importance. Hydrologic classification is a first step towards quantifying these tradeoffs by creating the necessary framework for analyzing effects of flow on riverine biota via the characterization of streamflow variability. Here we present a spatially explicit hydro-geomorphic classification of streams and rivers in Washington State, U.S.A., with an investigation of how projected climate change is likely to affect flow regimes in the future. We calculated 101 hydrologic indices from 15 years of continuous streamflow data for 64 gages with negligible upstream impact throughout the state, which were fed into a Bayesian mixture model to classify the flow regimes into seven major classes described by their dominant flow source: groundwater (GW), rainfall (RF), rain-with-snow (RS), snow-and-rain (S&R), snow-with-rain (SR), snowmelt (SM), and ultra-snowmelt (US). The largest class sizes were represented by the transitional RS and S&R classes (14 and 12 gages, respectively), which are highly ubiquitous in temperate, mountainous landscapes found in Washington. Next, we used a recursive partitioning algorithm and Random Forests to predict flow class based on a suite of environmental and climate variables. Overall classification success was 85%, and the model was used to predict naturalized flow classes at the reach-scale for the entire state (see attached figure). Lastly, a geomorphic classification was developed using a Digital Elevation Model and climatic data to assign stream segments as either dominantly confined or floodplain, which was cross tabulated with the flow types to produce a 14-tier hydro-geomorphic classification. The hydro-geomorphic classification produced here provides a framework upon which empirical flow alteration-ecological response relationships can subsequently be developed (in progress) by facilitating the use of ecological information collected throughout the region.

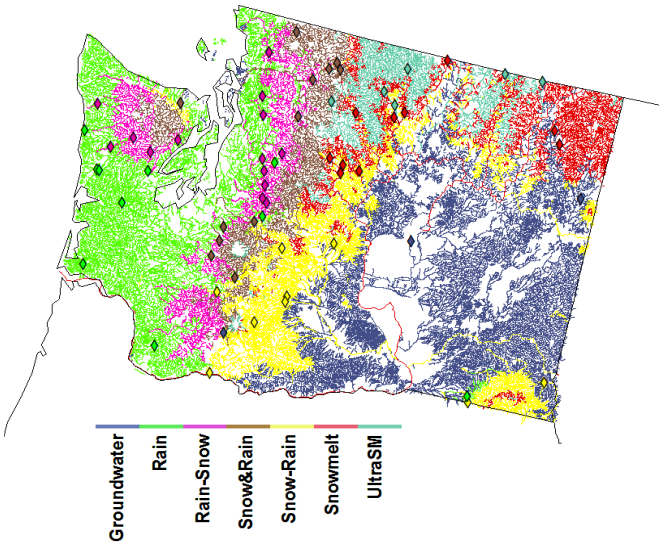

Figure: Map of flow class as modeled using a recursive partitioning algorithm and Random Forests. Diamonds represent the 64 reference gages and are colored according to flow class as determined by the Bayesian mixture model.

Use of NHDPlus:

We used NHDPlus Region 17 hydrography as our base data for all analyses with the exception of geomorphic modeling in the Columbia River Basin. In addition to relying on the NHDPlus hydrography as a principal underlying dataset, two particular tasks were made possible by NHD Plus tools which otherwise would have required significant programming and time beyond our project scope. These were:

1. Delineation of upstream catchments for 385 gages throughout Washington State (Basin Delineator Tool). All subsequent basin-scale metrics were dependent on this (e.g., identification of reference gages based on upstream impacts).
2. Allocation and accumulation of over ***200*** raster datasets (climatic, physiographic, environmental) for every NHDPlus flow line in Washington State (>55,000) (Flow Accumulation Tool). This allowed us to model hydrologic and geomorphic class for every flow line in the state based on upstream data (see attached figure).

These two tasks were critical to the success of our project, and we acknowledge the incredible time and energy put forth by Cindy McKay at Horizon Systems in helping us get these tools running with our data.

Partners:

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