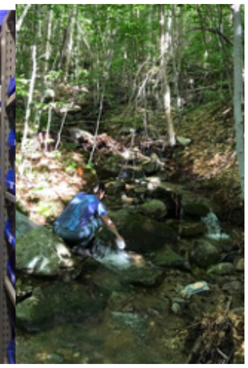
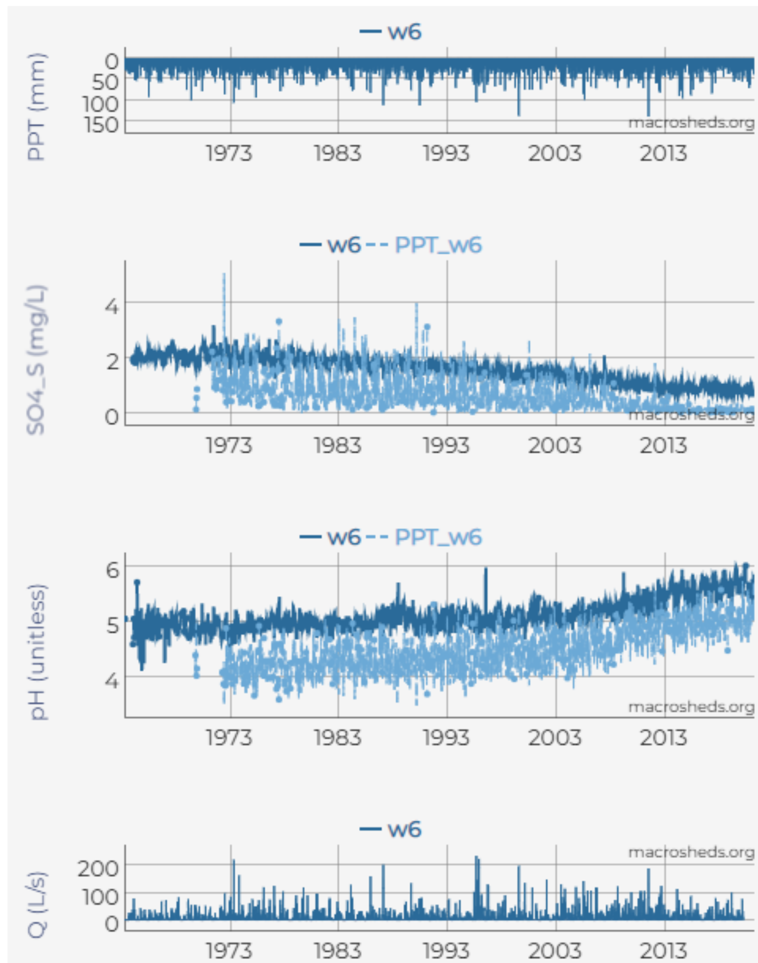
# Hubbard Brook Watershed Report - 2020



**What is HBWatER?** The **H**ubbard **B**rook **Wat**ershed **E**cosystem **R**ecord is a dataset of chemical concentration data for precipitation and streamwater samples that have been collected weekly since the summer of 1963 from streams and precipitation gauges throughout the Hubbard Brook Experimental Forest, a research forest in the White Mountains of New Hampshire. HBWatER currently collects weekly samples from nine gauged watersheds, the mainstem of the Hubbard Brook into which each small stream drains, and three long-term precipitation collection sites.

**A brief history:** In 1963, 4 visionary scientists (Gene E. Likens, F. Herbert Bormann, Robert S. Pierce, and Noye M. Johnson) began collecting and analyzing stream water and precipitation (rain and snow) at a Forest Service property in the White Mountains of New Hampshire. They had a simple idea, that by comparing watershed inputs in rain and snow to watershed outputs from streams, they could measure the behavior of entire ecosystems in response to atmospheric pollution or forestry practices. The record they began in 1963 has been added to every week up to the present day. Insights gained from studying this long-term chemical record led to the discovery of acid rain in North America and documented the effectiveness of federal clean air legislation in reducing coal-fired power plant emissions **see the Figure on the right**. This long-term record has become one of the most iconic and influential environmental data sets, featured in hundreds of scientific and popular press articles.



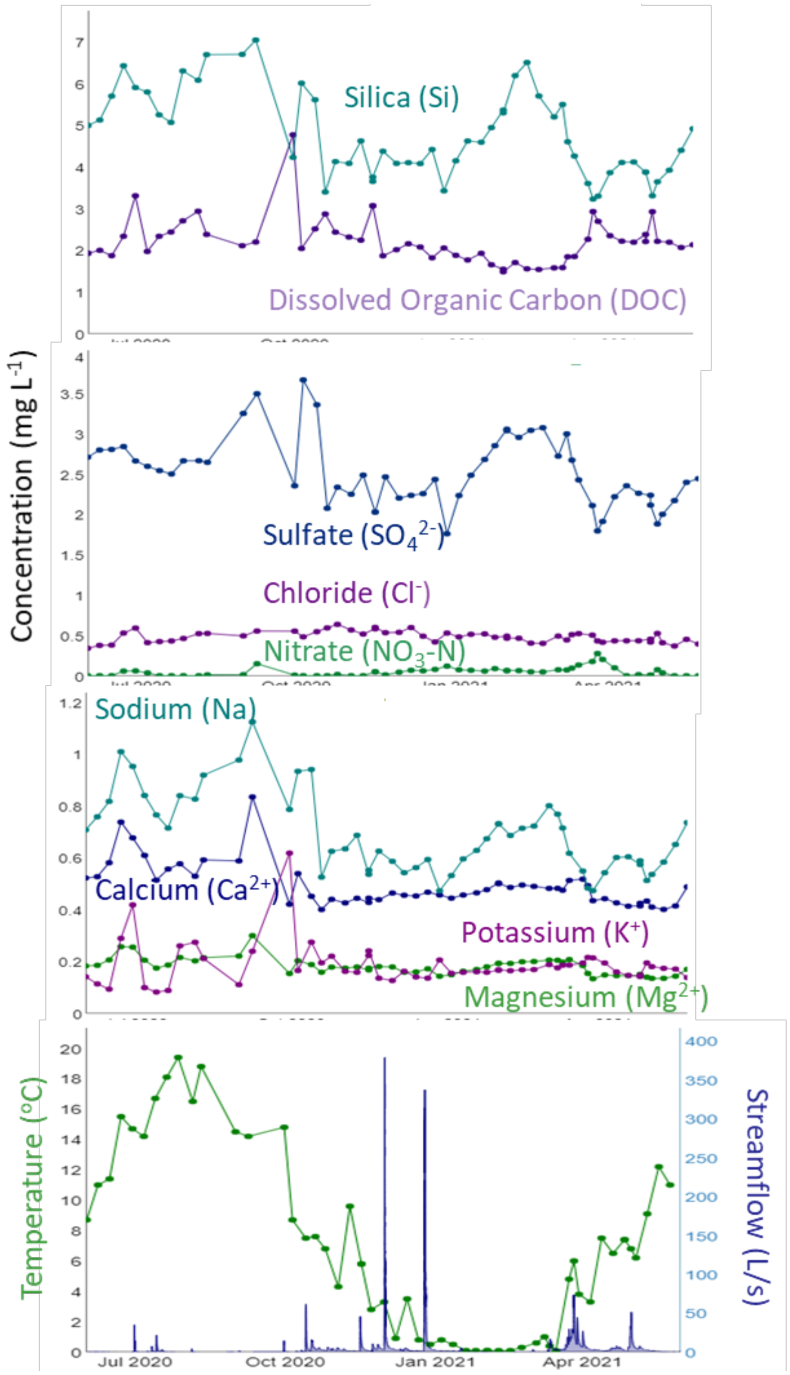

**These graphs show us: (1) the amount of weekly precipitation as rain or snow; (2) the concentration of sulfates in streamwater (navy) and precipitation (blue); (3) the pH of streamwater (navy) and precipitation (blue); and (4) the total streamflow every week for the last 54 years. Notice that precipitation and streamwater has become less acidic and lower in sulfates over time.**

**The collection and analysis of HBWatER samples is currently sustained by Tammy Wooster (Cary IES) and Jeff Merriam (USFS) and the dataset is curated and maintained by a team of researchers: Emma Rosi (Cary IES), Emily Bernhardt (Duke), Lindsey Rustad (USFS), John Campbell (USFS), Bill McDowell (UNH), Charley Driscoll (Syracuse U.), Mark Green (Case Western), Scott Bailey (USFS). Current Financial Support for HBWatER is provided by NSF LTREB # 1907683 and the USDA Forest Service Northern Research Station.**

**What can we learn from measuring the chemistry of a river?** The graphs on the right side of the page show how the chemistry of one stream at Hubbard Brook changes over the course of a full year. First, check out the bottom axis. Our 'water year' begins on June 1, and is determined as the twelve-month period with the most consistent relationship between precipitation and streamflow across years. We use this water year because it minimizes variation due to catchment water storage (including water stored as snow) and evapotranspiration, and is therefore more hydrologically relevant than the calendar year.

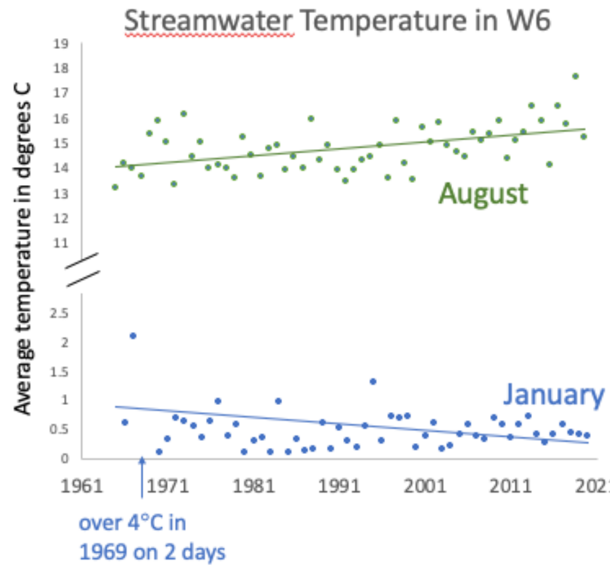
In the top graph, note the opposing patterns of Silicon (Si) and Dissolved Organic Carbon (DOC). Silica is slowly released from granitic bedrock wherever rock is in contact with water. DOC is organic matter that is leached out of soil and leaves into soil solution (much like the flavor and color that leaches out when you put tea leaves or coffee grounds in water). Note that DOC goes up and Si goes down whenever stream flows are high (check navy line in the bottom graph). This graph shows us that at low flows, water in the stream is dominated by groundwater that has been in contact with rocks deeper in the soil. In contrast, during storms, more water is coming from the organic rich surface soils where leaves and roots accumulate. We can learn where water is coming from at any given time because of its different chemical signals.

Now that you have noticed this, you can see that some other solutes, like Sulfate and Sodium, are also lower in concentration whenever there are high flows. In contrast, Chloride, Calcium and Magnesium concentrations stay the same no matter what the flow. Check out that spike in Potassium that occurs in late Autumn. This is common in most years of the record and it's the result of Potassium ions being leached from all the leaves that fall from the trees into and alongside the stream.

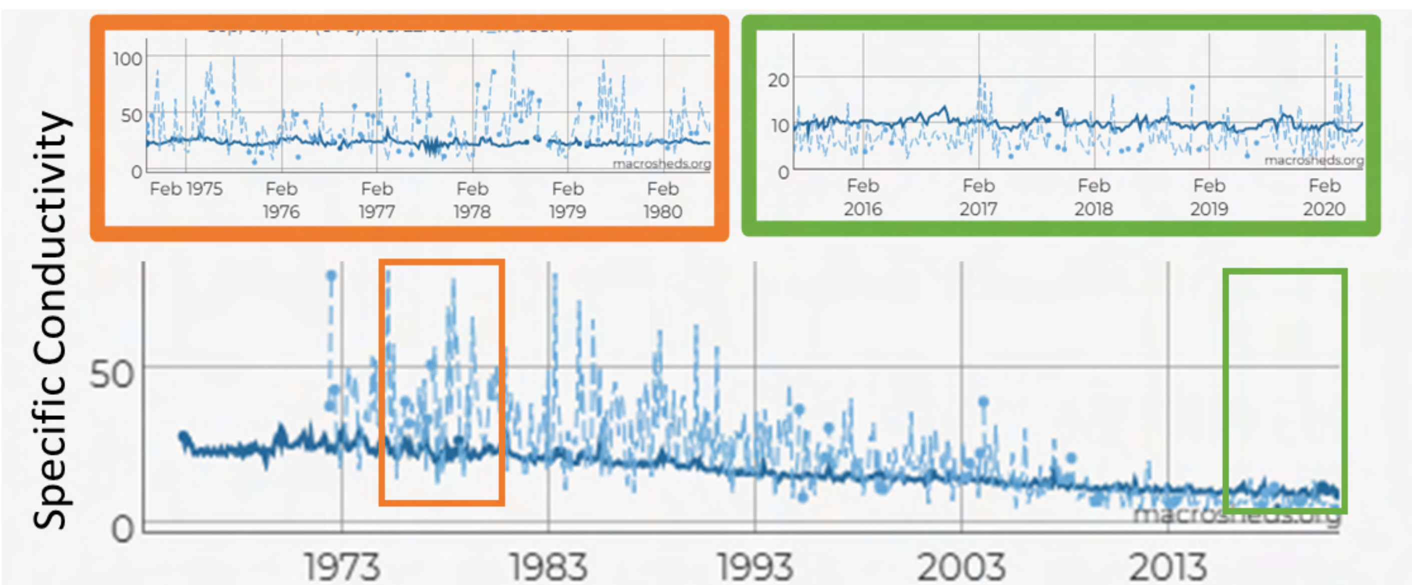



The final graph in this series shows us the temperature of stream water every Monday throughout the 2020 water year and the continuous rate of streamflow. You won't be surprised to see that these streams are warmer in the summer and colder in the winter. You can see the highest flow occurring as the stream warms up in April, that's the peak of snowmelt, as precipitation received throughout the winter melts and exits the watershed as streamflow. In WY2020, we also had a couple of big floods during the winter. That's a phenomenon that doesn't happen every year in these New England mountain streams, but one that may become more common as the climate of Northeastern forests warms.

**Hotter summers, colder winters.** Every week since 1965, when we collect chemistry samples we measure the temperature of the streams. Long-term stream temperature data illustrates how stream conditions are changing in the northeastern US. During August, (green data and line) the water temperature in the reference watershed (W6) has increased over time, but in January (blue data and line), the opposite is the case. Streams are getting actually colder in winter, likely due to less insulation from snow and ice. The effects of climate change on stream water temperature may have myriad consequences for life in HB streams. Hotter summer temperatures and colder winter temperatures increase the extremes throughout the year to which stream biota must adjust.

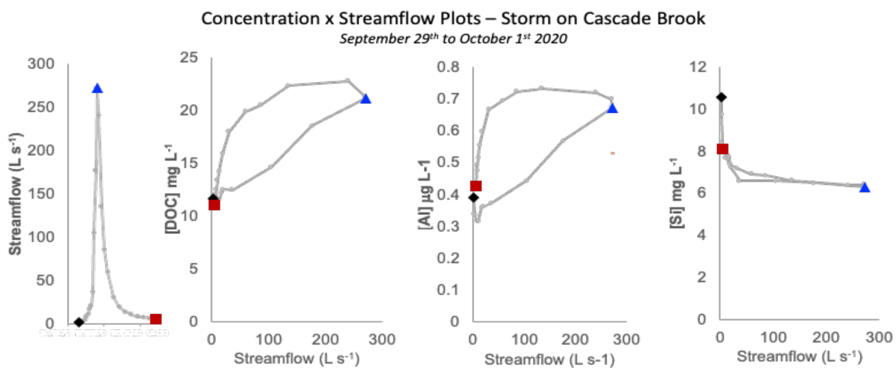


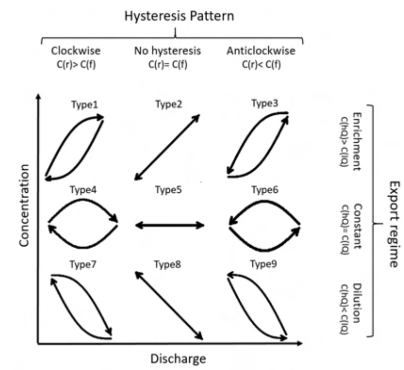

**DILUTIFICATION!** The amount of solutes being delivered to Hubbard Brook in precipitation, and exported from HBEF watersheds in streamwater has declined precipitously over time. In the lower graph below, the light blue line shows the conductivity, or abundance of charged ions, in precipitation samples over the record. In the first two decades of the record, precipitation almost always had much higher concentrations of ions (orange box) than streamwater. Declines in precipitation conductivity have been much steeper than the much discussed dilution of streamwater, so much so that in the most recent decade (green box) the very dilute HBEF streams have higher conductivity than rainwater. Note the difference in the magnitude of variation of both precipitation and streamwater conductivity between the **late 1970's** vs. the **late 2010's.**

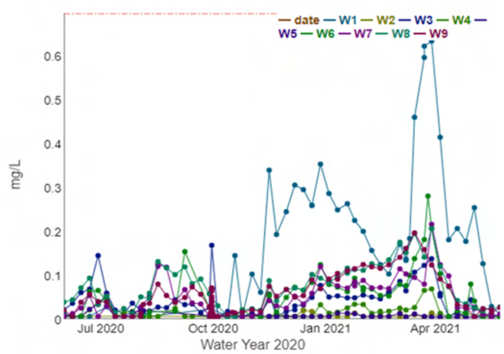


**Watershed Year Curiosities:** This final page of fun graphs, notes and photos is for the true watershed science junkies. Here are a few interesting observations from the 2020 water year dataset. We hope they will inspire your curiosity!

**Looking at hysteresis in storm discharge-concentration relationships.** In WY2020, we captured a September storm in Cascade Brook (Watershed 9). An automated sampler began collecting water samples at 7:30 pm on September 29th (**black** diamonds) and collected samples until 10:30 in the morning on October 1st (**red** squares). Over the course of those 39 hours, streamflow rose to a peak of ~270 liters per second (**blue** triangles). During the storm, both Dissolved Organic Carbon (DOC) and Aluminum (Al) concentrations increased as the streamflow was rising, but the patterns are different. For DOC the concentrations are higher on the rising limb of the storm than the falling limb (clockwise hysteresis). In contrast Al concentrations continued to increase as flow declined (counterclockwise hysteresis). Both of these patterns suggest that hydrologic transport limits the export of these solutes. In contrast, Silica, a product of rock weathering, declines in concentration with higher flows, providing evidence of source limitation. By reading the differential patterns of solute export during storms, we can gain valuable insights about the sources of solute exports.




**Which Watershed Is Worst at Holding onto its Nitrogen?** When we compare the seasonal nitrate concentrations across all 9 of our headwater sites for WY2020, Watershed 1 continues to have the highest peak nitrate concentrations.

***Field Notes Highlights:*** The dry summer of 2020 also reduced the streams to a trickle, and some completely dried up for many weeks. Beginning in mid-July, a caterpillar outbreak caused valley-wide defoliation. The dry channels were loaded with insect frass (poop) and munched leaves, which stagnated in pocket pools until a late September flush occurred.

Ice cover in Hubbard Brook streams is very dynamic. Here we show the anchor ice forming on the mainstem of Hubbard Brook, which occurs when surface waters become supercooled. By late December, the mainstem was almost completely covered in ice, but a mid-winter warming and rainstorm reversed this process and the whole channel became ice-free.

Ice dynamics on the Hubbard Brook Mainstem

Leaves and frass in HB streams

**To explore all of these data (and so much more) using our HB WatER online data visualization dashboard**

# Visit http://hbwater.org:3838/watershed_exploration/

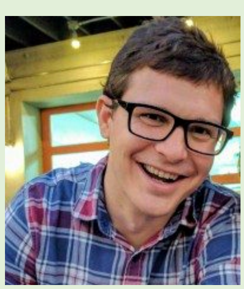

We welcome collaborators and we encourage you to use the HBWatER dataset. The entire record is available for download We only ask that you credit the source of the data by citing the record.

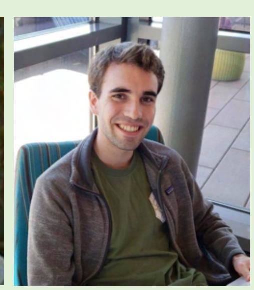
**Hubbard Brook Watershed Ecosystem Record (HBWatER). 2021. Continuous precipitation and stream chemistry data, Hubbard Brook Ecosystem Study, 1963 – present. ver 4. Environmental Data Initiative.**
https://doi.org/10.6073/pasta/0e79917db6bc3d70aa625f45f8bb226c

We encourage you to use figures straight from our data platform in talks and presentations, but, if you do, please credit HBWatER and the MacroSHEDS project.

Feel free to let us know what would make it easier for you to make use of the dataset in your research, your classrooms and your own independent learning.





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