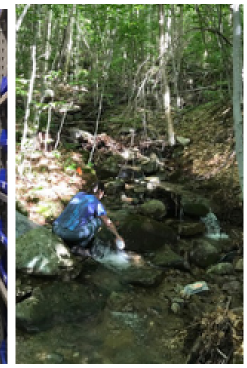
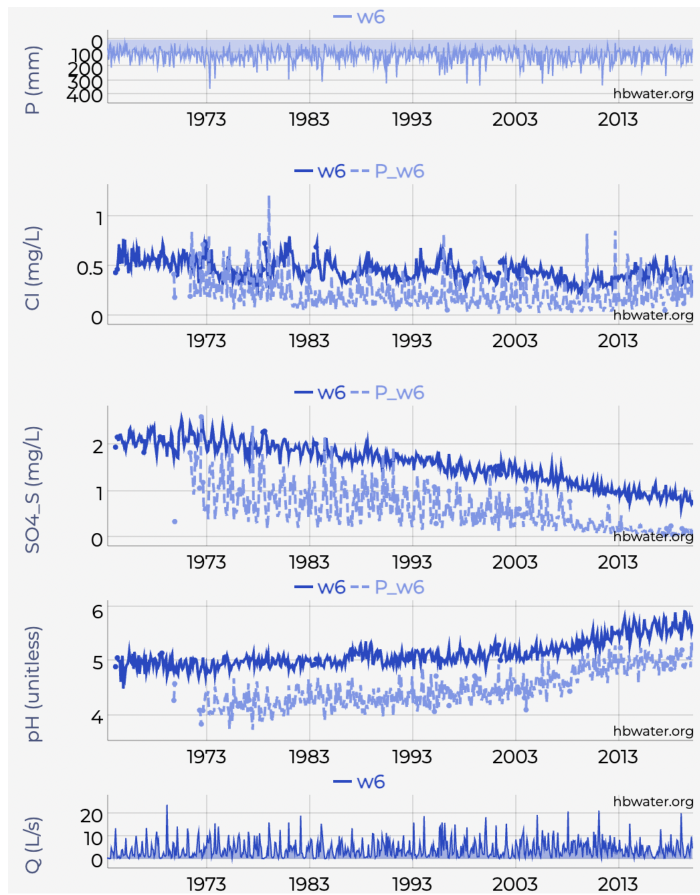
Hubbard Brook Watershed Report - 2021



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 since July 1963. Notice that precipitation and streamwater has become less acidic and lower in sulfates over time.

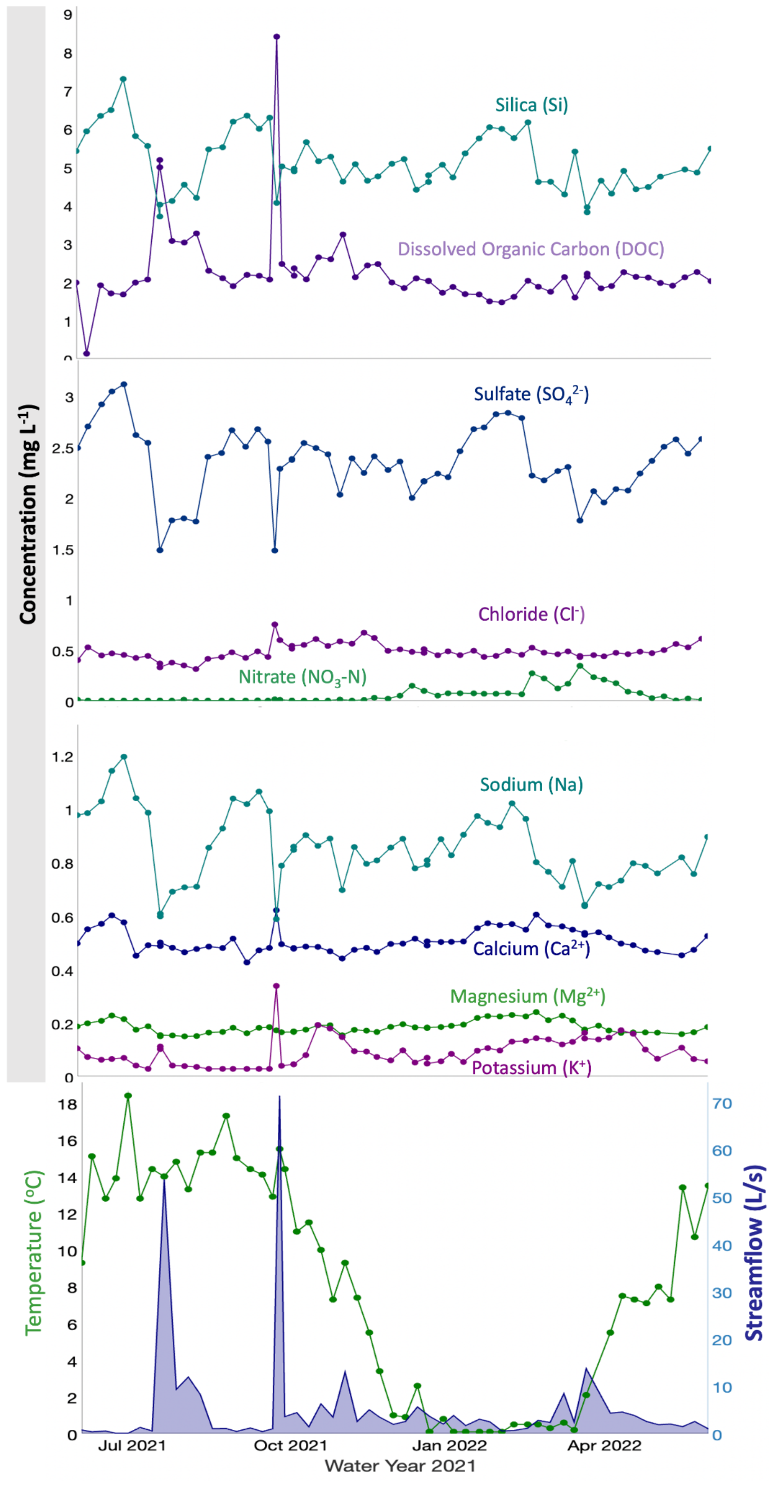
Explore the HBWatER at hbwater.org

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 and Chris Solomon (Cary IES), Emily Bernhardt (Duke), 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 this 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 enters the steam after flowing through 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 each Autumn.



The final graph in this series shows us the temperature of stream water every Monday throughout the 2021 water year and the rate of streamflow measured on each sampling date. In 2021 we captured large storms in late July and October that interrupted very low flows during both Summer and Fall. Follow the October storm peak from the bottom graph up through the solute graphs to see how chemistry shifts between low flow and peak flow.

New Investigators in the HBWatER Team!

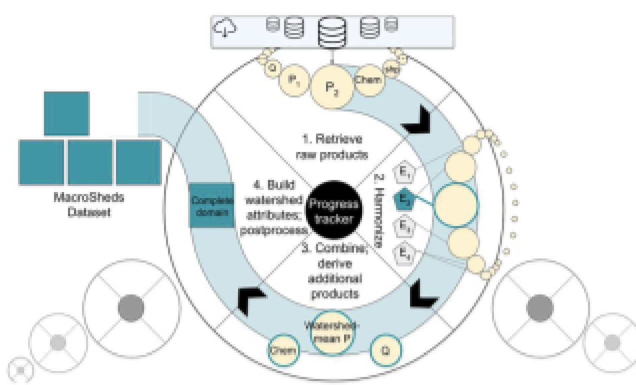
Chris Solomon joined HBWatER as a new PI in summer 2022. Chris is an ecosystem ecologist at the Cary Institute who has studied the effects of DOC on ecosystem metabolism and food web productivity, social-ecological dynamics in recreational fisheries, and other topics. Chris says: "I'm excited and humbled to be joining the research community at Hubbard Brook, and to be learning about watershed biogeochemistry from such an amazing group of scientists!" Chris' initial work with the HBWatER team and broader HB community is focusing on how patterns of DOC export from the HB watersheds are changing in response to deacidification, changing winters, and other factors.

Danielle Hare is joining the HBWatER team in September 2023 as a postdoctoral scholar at the Cary Institute. Danielle brings her expertise in groundwater-surface water exchange and stream temperature from the Connecticut River Watershed uphill to these headwater streams. "*I am very excited and eager to contribute to the current work in revealing the ecosystem processes and patterns that are contained within the vast HBWatER Database. I look forward to learning from, collaborating with, and building on the profound knowledge of the Hubbard Brook community!*" Danielle's work will focus on deconstructing the spatiotemporal biogeochemical variability across the Hubbard Brook Basin, and will initially examine how storm and winter hydrologic events contribute to the phenological patterns and magnitudes of carbon and nutrient exports, as well as explore how climate change has/may modify these event-driven fluxes.

Compare the 10 HBWatER watersheds with 169+ other small watershed ecosystem studies!

We are proud to announce the publication of v1.0 of the Macrosheds dataset that allows you to directly compare watershed attributes, climate, hydrology, solute concentrations from small watershed ecosystem studies from across North America. You can play with the data directly, or rapidly explore the dataset on our data visualization platform macrosheds.org

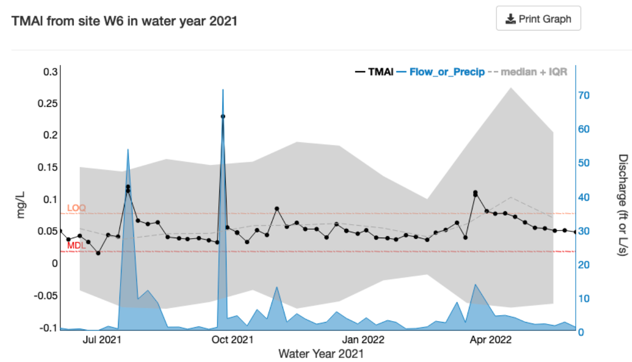
Read all about the dataset at *Vlah, M. J., S. Rhea, and E. S. Bernhardt. 2022. MacroSheds: A synthesis of long-term biogeochemical, hydroclimatic, and geospatial data from small watershed ecosystem studies. Limnology and Oceanography 8:419-252* [doi: 10.1002/lol2.10325](https://doi.org/10.1002/lol2.10325)



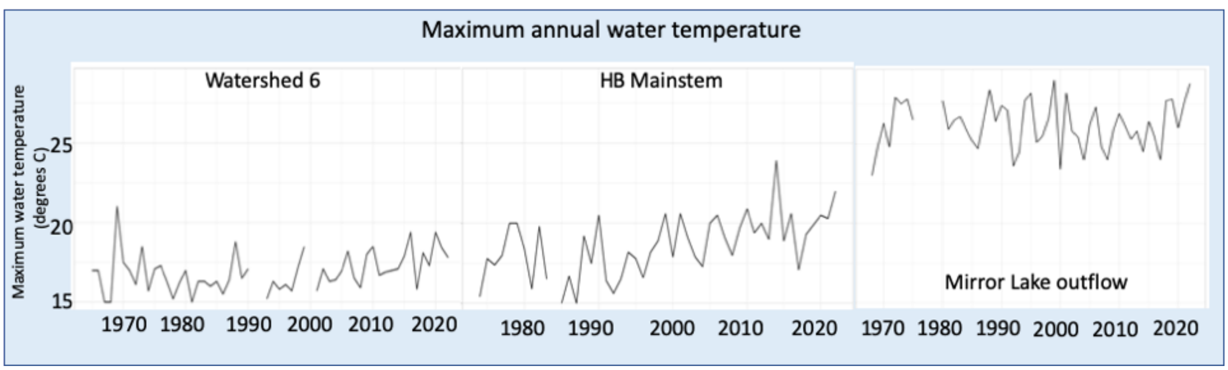
The data processing and derivation pipeline for Macrosheds.

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 2021 water year dataset. We hope they will inspire your curiosity!

Storms are where the action is: ***It has always been the case that storms export the majority of solutes over the course of the year, but a***s HBEF streams continue to get more and more dilute nearly all solute fluxes are occurring during high flows. This has consequences not only for our watershed budgets, but for the organisms living in streams. In WY2021, Tammy Wooster sampled W6 a number of times where the discharge was high. These high flow samples were the only instances in which total monomeric aluminum concentrations were above the limit of quantification (LOQ). Moreover, on Sept. 24, 2021, this measurement was higher than ~~any~~ the median and interquartile range (median+IQR, Figure X, gray band) of all of the measurements of TMAI in the HB WatER record and was the 3rd highest measurement on record (we began measuring TMAI in 2005).

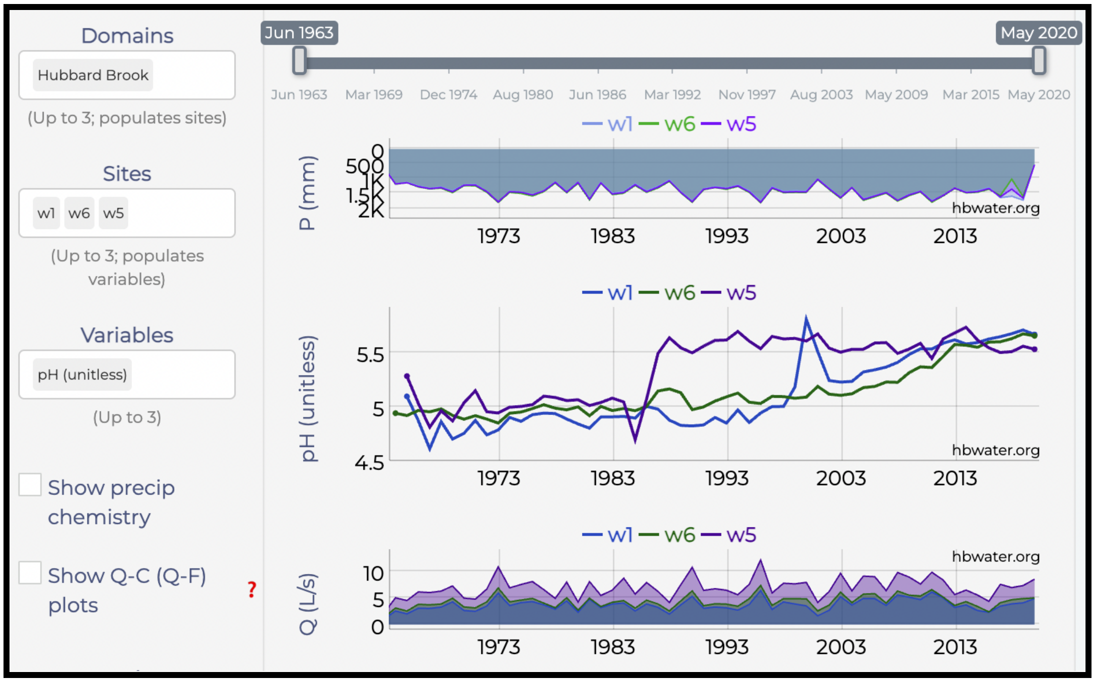


Rising water temperatures in Hubbard Brook aquatic ecosystems: The effects of climate change on Hubbard Brook ecosystems is becoming apparent in numerous ways. In last year's watershed report, we reported on the warming that is occurring during the winter. Within the mainstem of the Hubbard Brook (Figure X, center panel), the maximum annual water temperature observed has been apparently rising over time, the maximum annual water temperature in Watershed 6 and the Mirror Lake are not obviously increasing, but we will continue to report on these measurements. The maximum annual water temperature may have an influence on aquatic organisms who may be sensitive to higher water temperatures, even those that last only a short amount of time. Higher water temperatures are known to cause stress to aquatic animals such as macroinvertebrates, salamanders and fishes.



Field Notes Highlight: *Jan 2022 was EXTREMELY cold which caused heavy ice accretion on all of the streams. The ice shelving on the main Hubbard was up to 3 feet thick in places which made for some tricky sampling. In the photo below, I had to squeeze between shelving on my belly to access this open water hole. At Least there was no chopping involved which wasn't the case in the second photo of the W8 sample site. That one took a bit more effort!*

Visit & Explore hbwater.org and macrosheds.org



Visit both of these platforms to play with the data in simple interactive windows. On hbwater.org you can read and use curated data stories and explore the full record of precipitation and streamwater chemistry and fluxes. On macrosheds.org you can make the same comparisons for HBEF alongside 160 additional watershed ecosystem studies - and you can easily access hydroclimatic and geospatial data for each of these watersheds.

We welcome collaborators and we encourage you to use the HBWatER dataset and visualization platform. The entire record is available for download. We only ask that you credit the source of the data by citing the record so that we can celebrate its use by others (and tell our funders about it).

Hubbard Brook Watershed Ecosystem Record (HBWatER). 2023. Continuous precipitation and stream chemistry data, Hubbard Brook Ecosystem Study, 1963 – ongoing. ver 9. Environmental Data Initiative. https://doi.org/10.6073/pasta/f2fb8b6542106c6db534fab76decdcec

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

HBWatER LTREB Team: CoPIs: Emma Rosi & Chris Solomon (Cary IES) and Emily Bernhardt (Duke); Senior Personnel: Scott Bailey (USFS), John Campbell (USFS), Charley Driscoll (Syracuse U), Mark Green (Case Western), Bill McDowell (UNH); Field Operations: Tammy Wooster; Analytical Chemistry: Jeff Merriam (USFS).

Macrosheds Data Team: Emily Bernhardt, Duke and Matt Ross, CSU(CoPIs); Mike Vlah - data scientist