# HUBBARD BROOK WATERSHED REPORT 2022

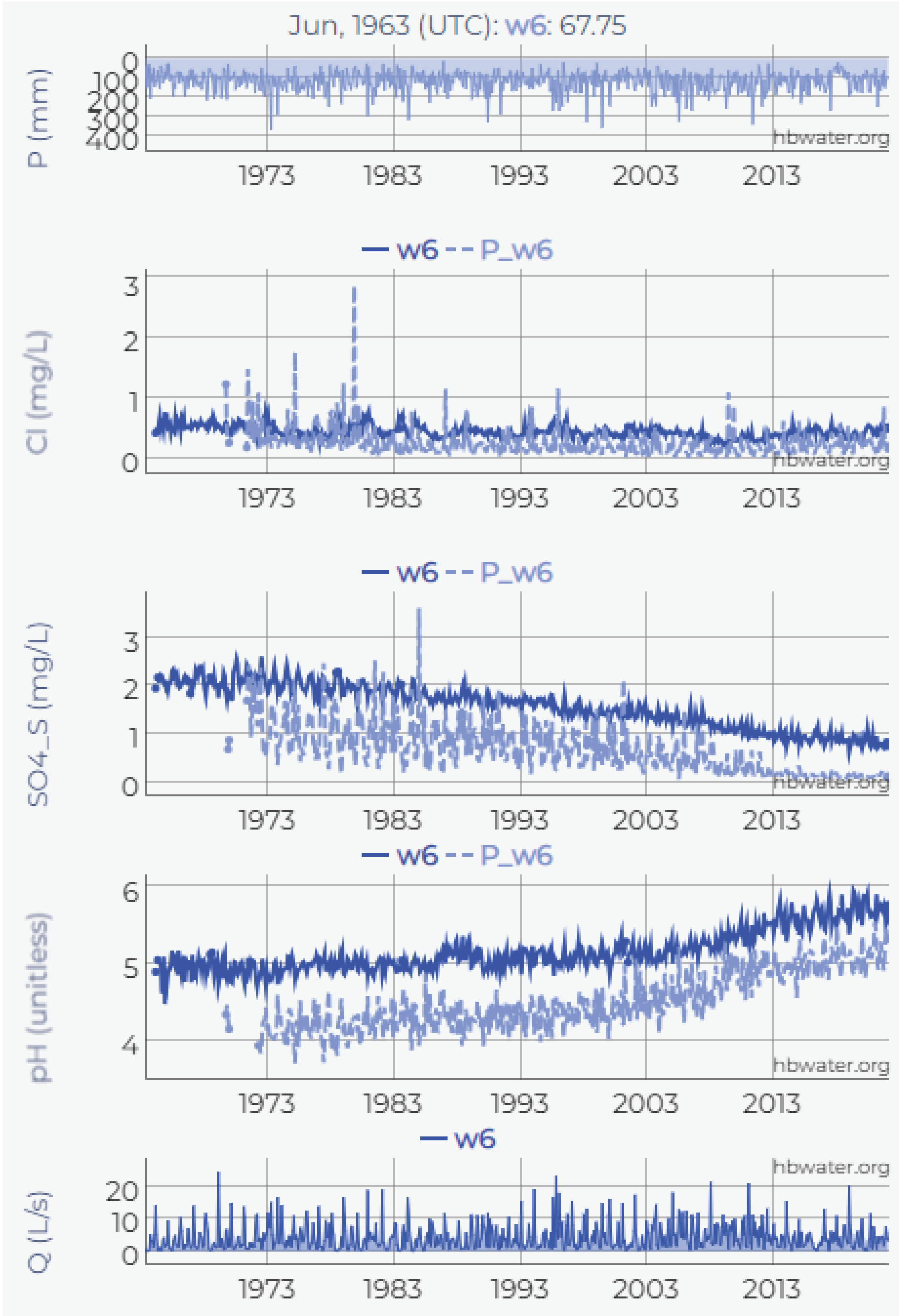
## WHAT IS HBWATER?

The Hubbard Brook Watershed Ecosystem Record 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 watershed, into which each small stream drains, and three long-term precipitation collection sites. The supporting LTREB funding for the HBWaTER data collection and analysis has been renewed for the next 5 years and was well received by the review committee.

Thank you for your support of this community endeavour!

## 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 the effectiveness of federal clean air legislation in reducing coal-fired power plant emissions was documented (see 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.




**Solute and Flow Timeseries exported from HbWater.org** These graphs show us (1) the amount of weekly precipitation as rain or snow; (2) Chloride in the precipitation (light blue) and streamwater (navy); (3) the concentration of sulfates in streamwater (navy) and precipitation (light blue); (4) the pH of streamwater (navy) and precipitation (light blue); (5) the average streamflow every week since July 1963 in watershed 6. Notice that precipitation and streamwater have become less acidic and lower in sulfates over time.

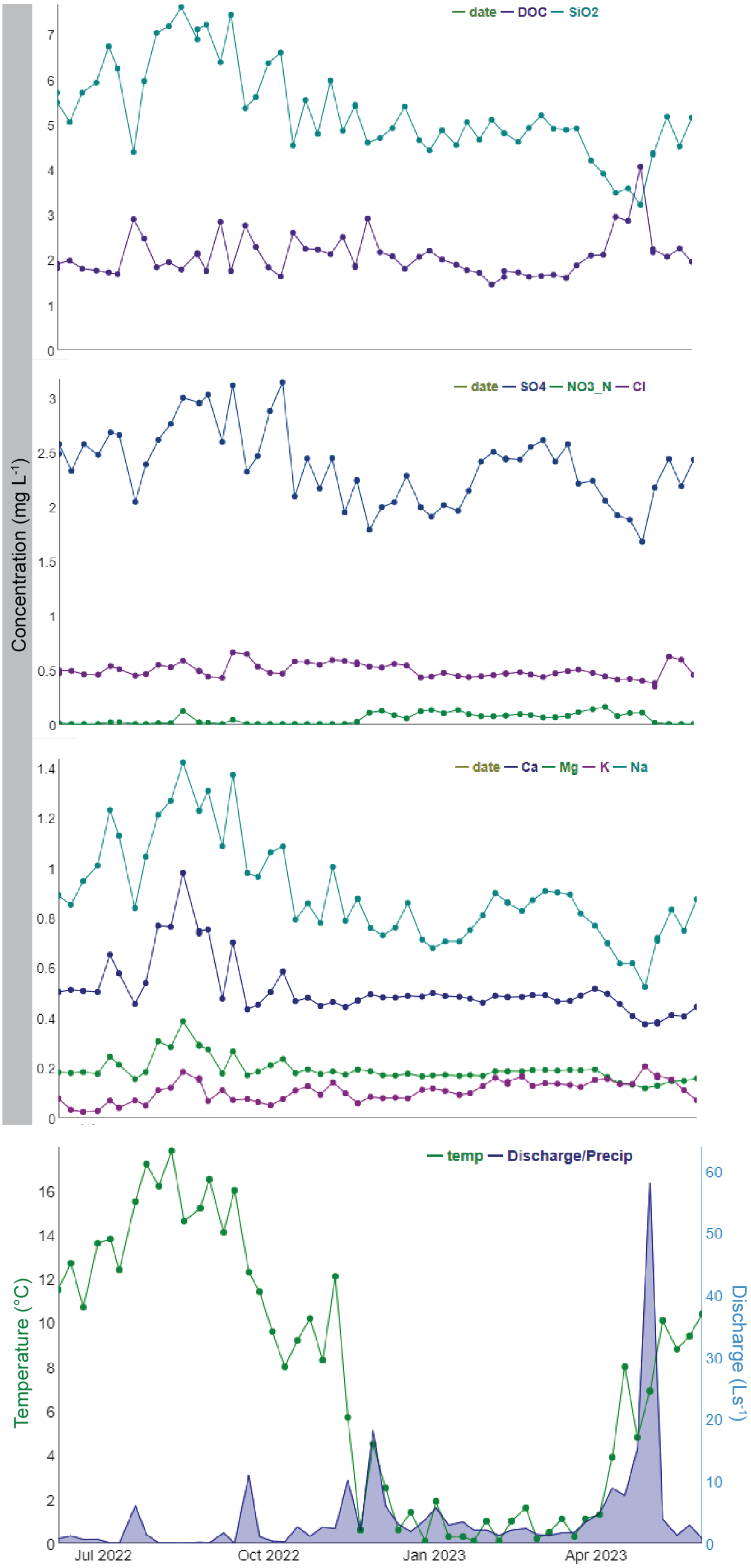
**EXPLORE THE HBWATER AT HBWATER.ORG**

# 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. Flow is an important factor in controlling solute patterns so comparing the solute patterns to the discharge records are an important method of evaluting processes that occur within the watershed ecosystem. The final graph in this series shows us the temperature of stream water every Monday throughout the 2022 water year and the rate of streamflow measured on each sampling date.

In the top graph, note the opposing patterns of Silica (Si) and Dissolved Organic Carbon (DOC). Si 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 from tea leaves or coffee grounds in water). Note that DOC goes up and Si goes down whenever stream flows are high. 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. Therfore, we can learn where water is coming from at any given time because of its different chemical signals.

Other solutes, like Sulfate (SO4) and Sodium (Na) , are also lower in concentration whenever there are high flows. In contrast, Chloride (Cl-), Calcium (Ca) and Magnesium (Mg) concentrations stay the same no matter what the flow. Check out that spike in Potassium (K) that occurs in late Autumn. This is common in most years of the record and it's the result of K ions being leached from all the leaves that fall from the trees into and alongside the stream each Autumn.

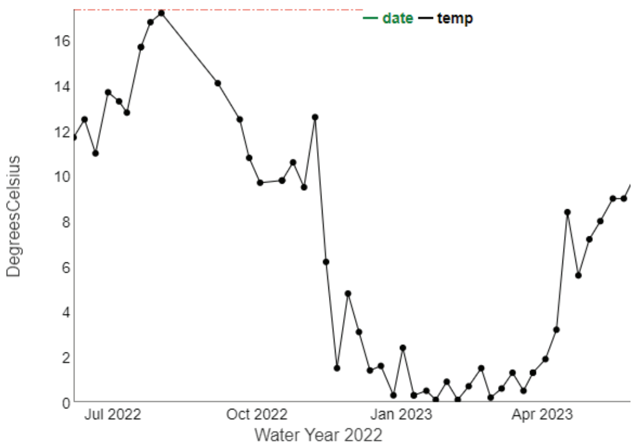



Solute and flow water year 2022 exported from HbWater.org. These graphs show us patterns of solutes over the year, which can facilitate the recognition of patterns and anomalies.

## NEW INVESTIGATOR

Heili Lowman joins the HBWaTER team as a postdoctoral associate at Duke University and will focus on elucidating patterns within the insect emergence data, considering the drivers of these patterns with a keen eye on antecedent stream conditions. She joined the team from the University of Nevada Reno, where she was a postdoctoral researcher in the lab of Dr. Joanna Blaszczak, focusing on quantifying riverine algal recovery following flood disturbance as well as watershed-lake connections following variable winter conditions. Previously, she received her Ecology, Evolution, and Marine Biology Doctorate from the University of California, Santa Barbara, where she has studied aquatic ecosystem response to watershed disturbances in the Santa Barbara Coastal LTER.

# *WATERSHED YEAR '22 CURIOSITIES*

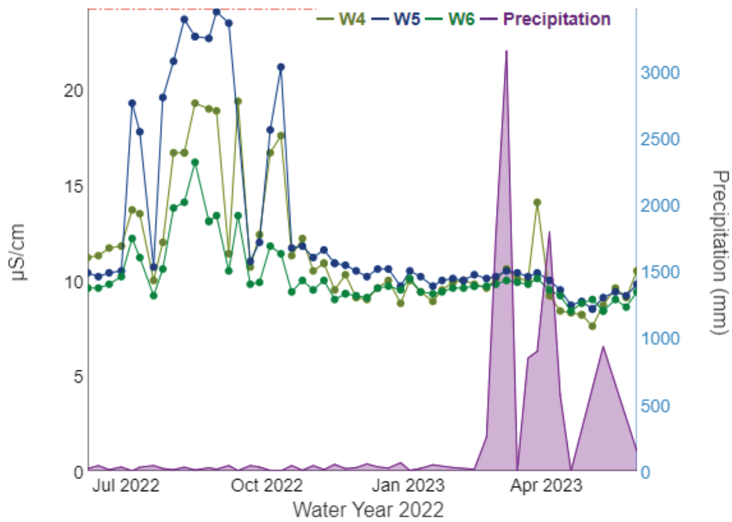


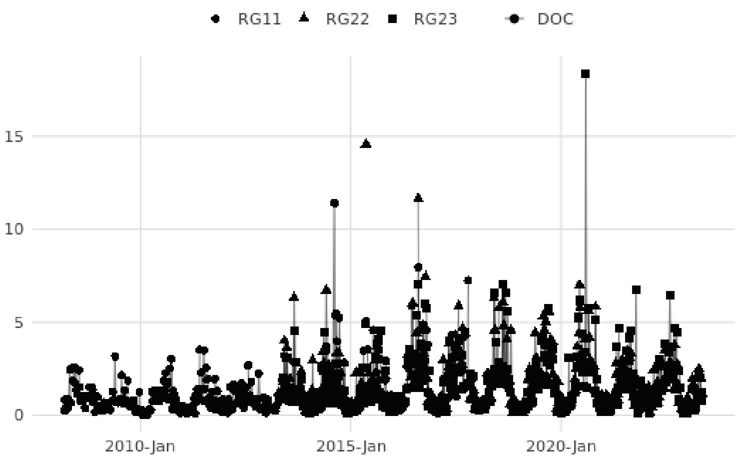

### Episodic spikes of in-stream temperature

The hottest ever weekly Hubbard Brook main stream temperatures were recorded, reaching 22˚C. This stream temperature encroaches on an important physiological threshold for some cold-water fishes, such as Brook trout (Salvelinus fontinalis), which exhibits thermal tolerance limits at 22-24˚C (Wehrly et al. 2007). Also seasonally important heat pulses and variability were recorded, notably on November 7th the wateshed 1 site reached 11.9˚C, and then two weeks latter recorded 1.5˚C.

### Prolonged Summer Dryness

The low precipitation between June and October/November 2022 forced many of the streams to experience periods of no flow in places. During these drought conditions, some streams appear to have stronger sustained flow which can offer insight into the landscape -aquatic connections and groundwater connectivity, which elevates specfic conductance µS/cm).



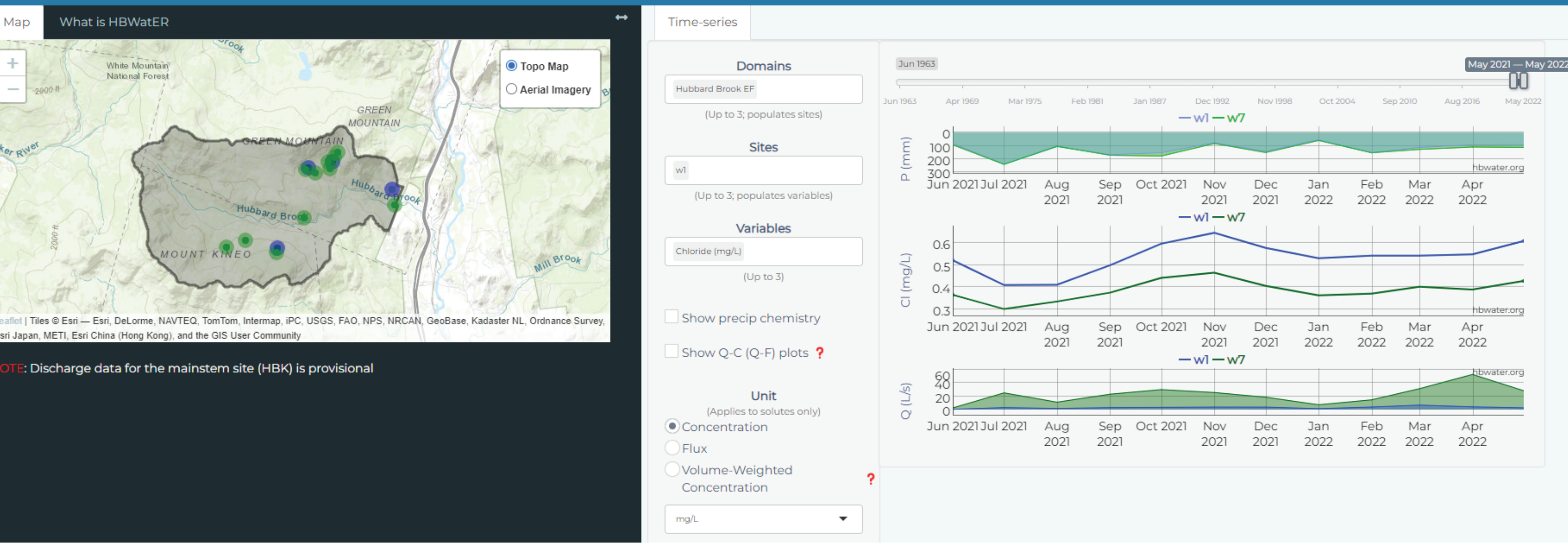




### Increasing DOC in Precipitation

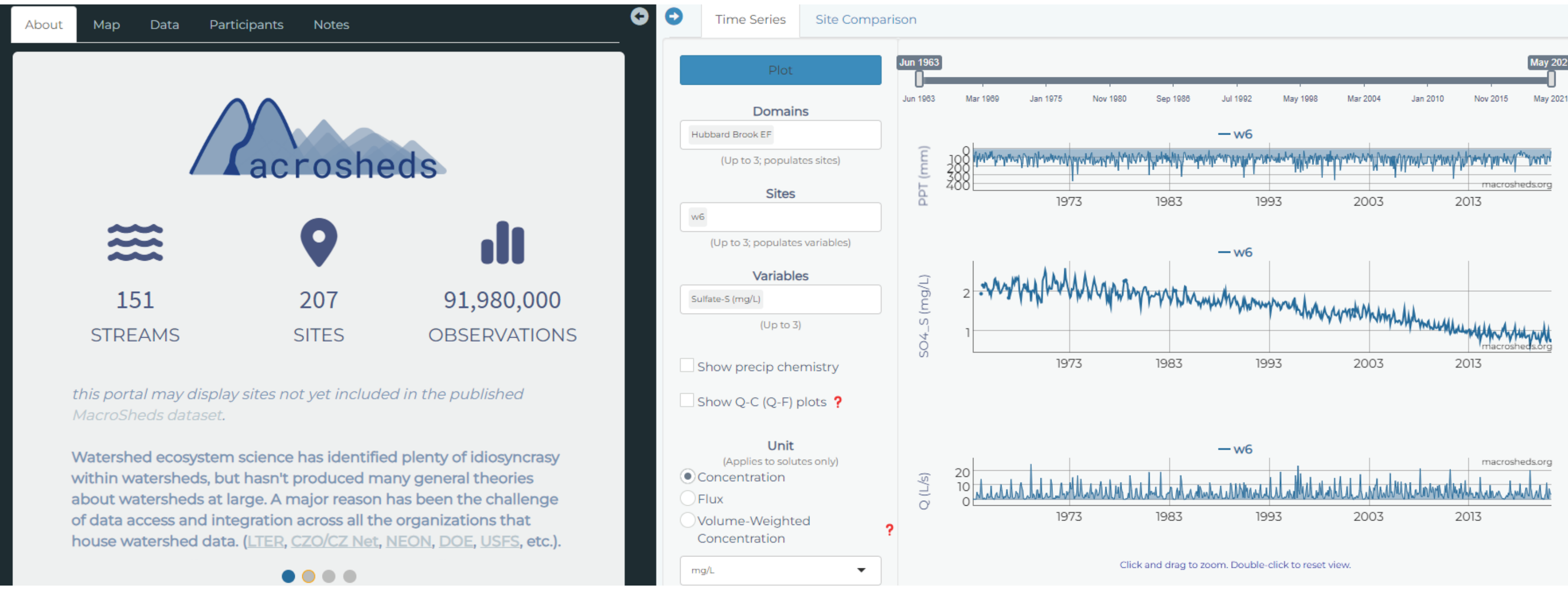
By supplementing the historical DOC precipitation dataset (beginning in 1995) with WY2022, there is supporting evidence that the elevated DOC of WY2021 and WY2020 represents a systematic increase, not merely anomalous peaks. PI John Campbell and colleagues have been investigating the potential cause of this increase, examining the potential for changing sources due to climatic changes, forest emissions, and/or shifts in atmospheric chemistry

# 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.




Screenshot from HBWatER.org public portal




Screenshot from macrosheds.org public portal

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: Chris Solomon (Cary IES) and Emily Bernhardt (Duke); Senior Personnel: 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