Impact of episodic acidification events on brook trout in Shenandoah National Park

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INTRODUCTION

From 1996 to 2009, trends in Brook trout (Salvelinus fontinalis) abundance in Shenandoah National Park (SNP) varied significantly by stream (n = 33 streams), with a strong correlation to the underlying stream bedrock. While the population within the park as a whole is considered to be stable, the inter-annual variability in both adult and young-of-the-year (YOY) abundance is high. Brook trout abundance is strongly linked to stream chemistry and hydrology. However, applied analyses of stream chemistry to Brook trout studies have been widely limited to base flow data despite the acknowledgement that episodic events (i.e. acute acidification) are the main concern.

Salvelinus fontinalis . . .The Brook Trout

Brook trout are members of the char subgroup of the salmon family *(Salmonidae)*. The are found in cold, headwater streams in Virginia, range from 6 – 13 inches in length, and spawn during October and November with eggs hatching in January.

MAJOR THREATS TO BROOK TROUT POPULATIONS

- Flood/droughts can affect within population variance
- Changes in water chemistry from acidification
- Over-harvesting
- Disease and predation
- Elevated stream temperatures

OUR STUDY SITE

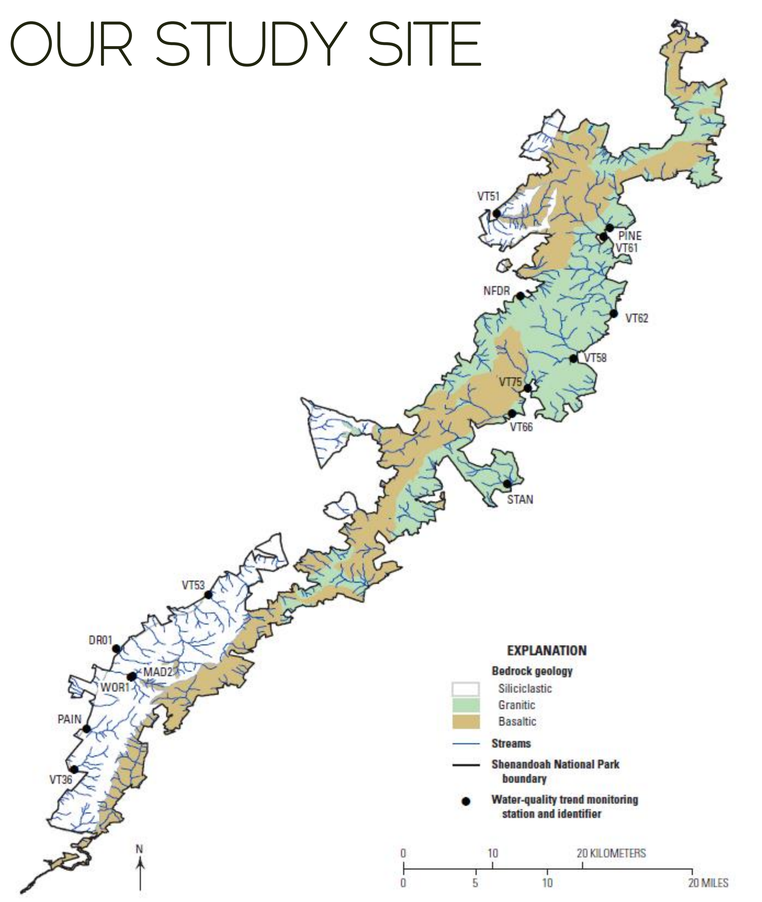


Figure 1. Map of Shenandoah National Park indicating sampling points. Bedrock classifications are indicated in the legend. (Jastram et al. 2013)

Paine Run
- bedrock: siliciclastic
- pH and ANC: relatively low
- soil base saturation: about 5%
- fish species: 3

Staunton River
- bedrock: granitic
- pH and ANC: intermediate
- soil base saturation: about 15%
- fish species: 5

Piney River
- bedrock: basaltic
- pH and ANC: relatively high
- soil base saturation: about 40%
- fish species: 12

DEPOSITION, BEDROCK, AND STREAM CHEMISTRY

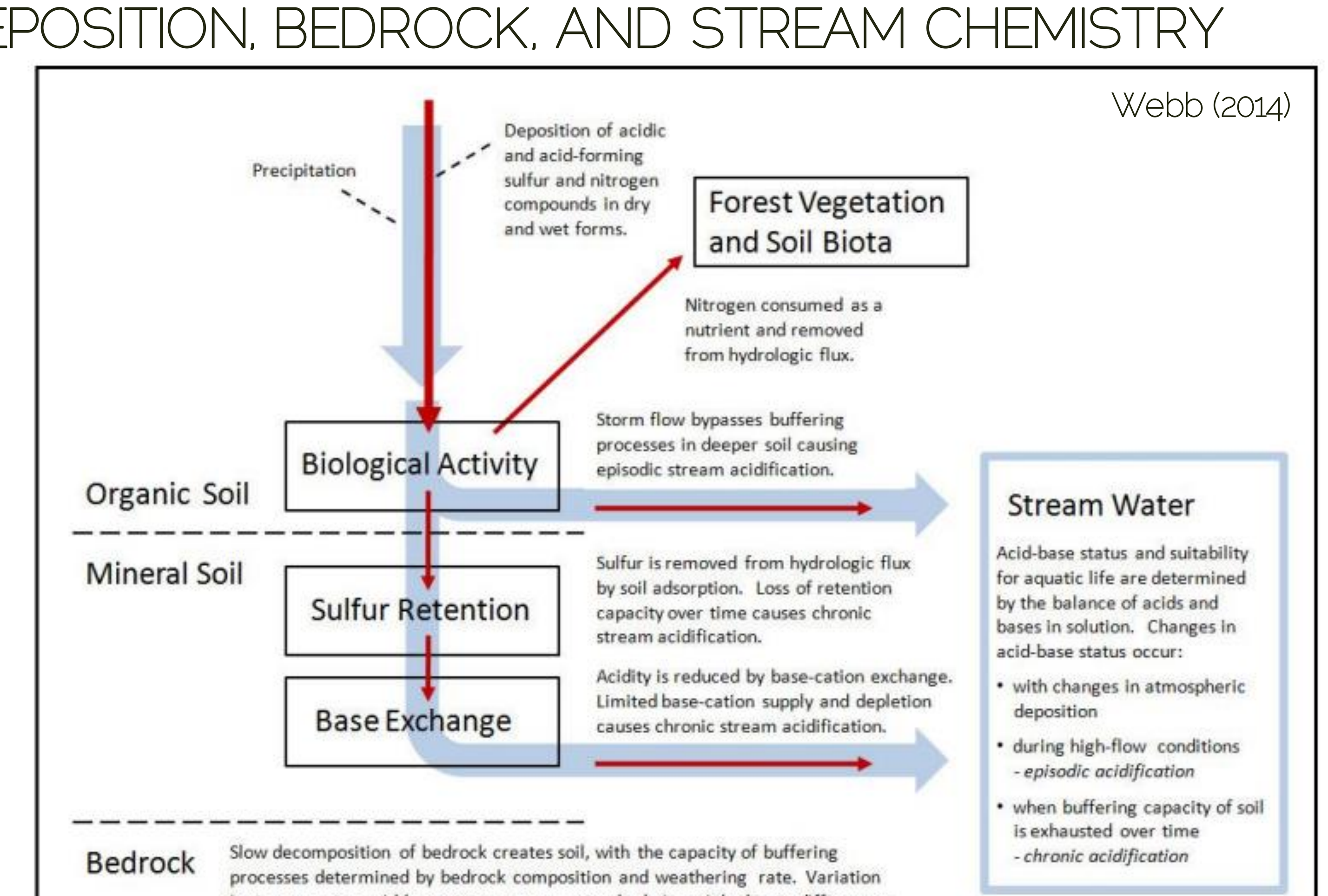


Figure 2. Conceptual diagram of the environmental processes occurring with each watershed.

COMBINING DATA SOURCES FOR NEW INSIGHTS

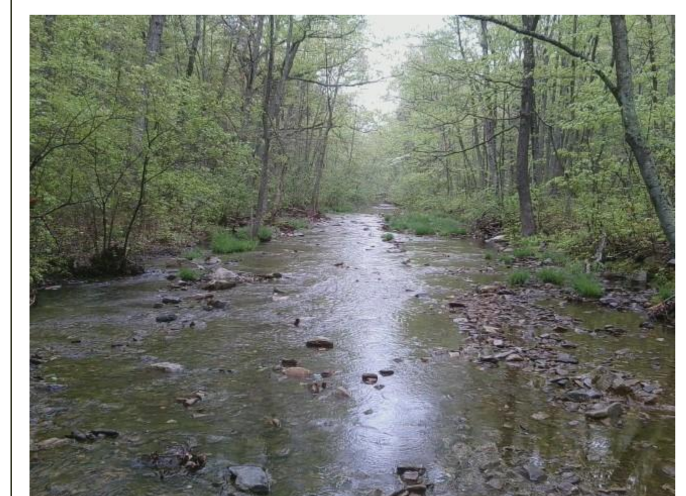
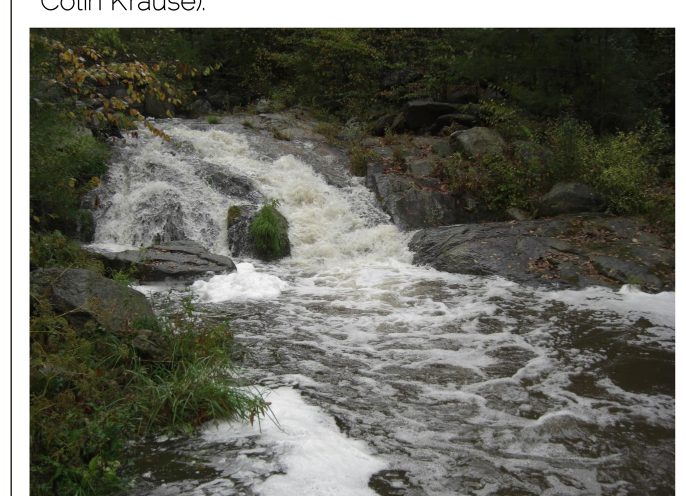


Figure 3. Paine Run, located north of Waynesboro, VA.

Figure 4. Electrofishing in Staunton River. (Photo by Colin Krause).



Fish data for this study were obtained from Shenandoah National Park. Park personnel have collected fish data since 1982, providing a rich and indispensable dataset for analysis.

Fish were sampled using three-pass electrofishing backpack techniques within standardized 100 m reaches. Sampling was completed between June and August each year (Jastram et al. 2013).

We have used a subset of available data (1996-2012) focusing on three streams (PAIN – Paine Run, PINE – Piney River, and STAN – Staunton River) that coincide with intensive and episodic sampling as part of the SWAS-VTSSS program (Shenandoah Watershed Study-Virginia Trout Stream Sensitivity Study).

Hydrology and stream chemistry data were obtained from the SWAS-VTSSS archive—which houses hourly hydrology data paired with stream chemistry data gathered from weekly water grab samples since 1992 for all three streams.

Unique to this analysis, is the employment of episodic data collected during periods of peak flow (>95%) when stream ANC (acid-neutralization capacity) declines resulting in acute acidification events. Episodic data were collected with ISCO autosamplers that sampled every two hours during an event. Samples were taken for a consecutive 48 hours, or until the stage height fell below the 95% threshold.

Analyses were completed in R. Fish abundances were calculated using the FSA package (Fisheries Stock Assessment (github.com/droglenc/FSA).

Figure 5. Staunton River here at flood stage (>95%) during the summer of 2011.

GENERAL TRENDS IN BROOK TROUT ABUNDANCE

Overall brook trout abundance is increasing in both Staunton and Piney Rivers, but declining in Paine Run, our siliciclastic, low-ANC stream. Yet the variability in the data merits further consideration.

Baseflow hydrology is strongly influenced by inter-annual climate.

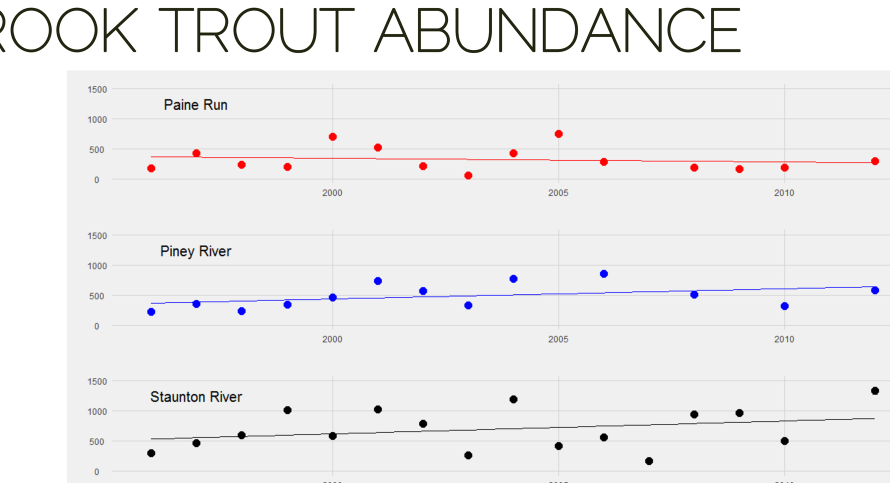


Figure 6. Total brook trout abundance by year for each stream.

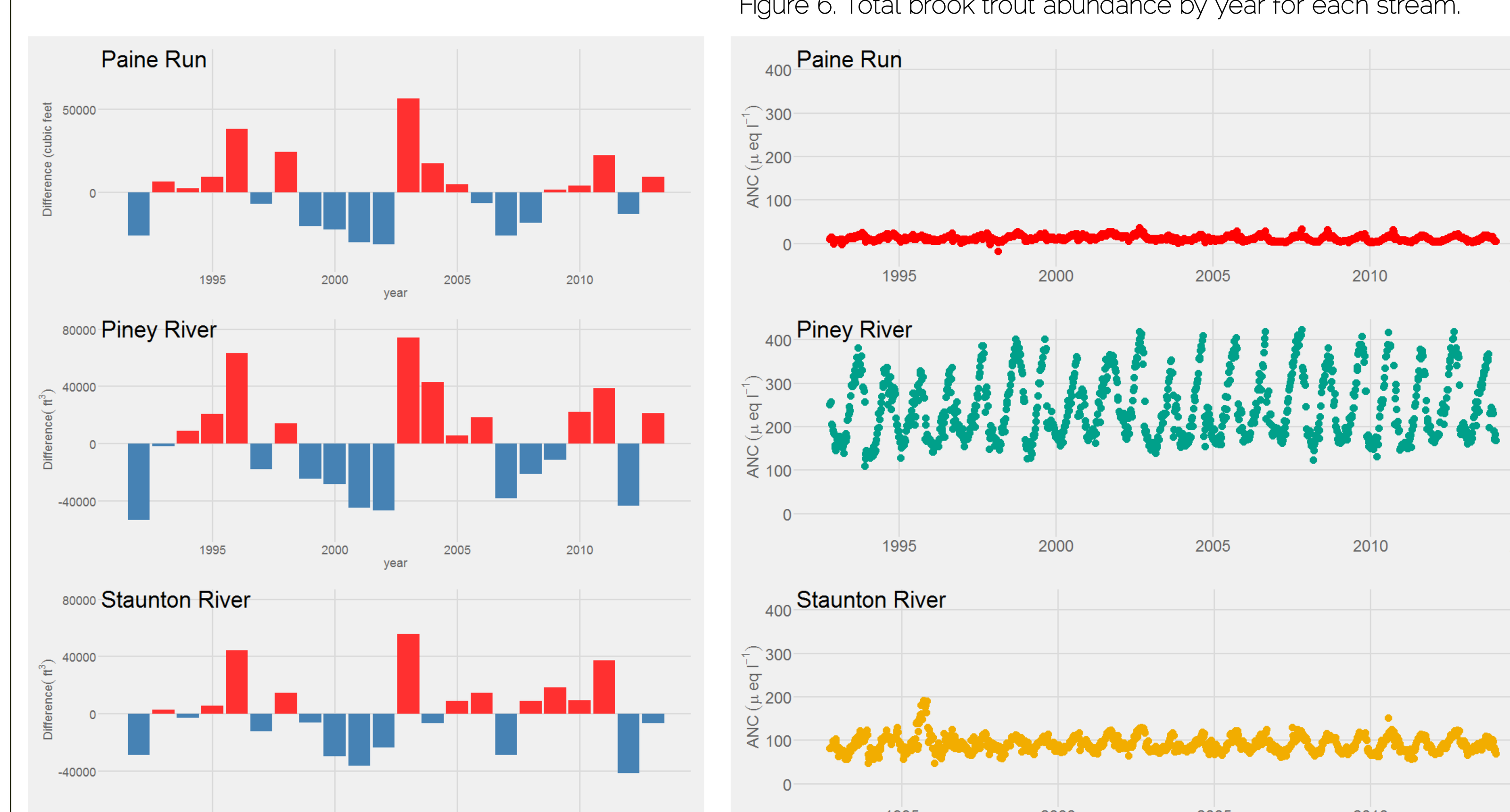


Figure 7. At left, discharge anomaly graph showing the fluctuations in annual discharge (ft³) from the mean (1992-2012) for each stream. At right, ANC at baseflow for our three target streams. Note, Paine is consistently lower, while Piney is much higher. Both Piney River and Staunton River demonstrate notable seasonal variation.

Initial analysis shows no significant correlation between brook trout abundance and either max/min flow, or max temperature in the three study streams (figure 9 at right). Of consideration here is further study into duration of these stressors, particularly stream temperature. How long does a stream need to be above 25° to impact brook trout significantly?

Figure 8. Panel graph showing brook trout against MIN DISCHARGE (left), MAX DISCHARGE (middle), and MAX STREAM TEMPERATURE (right).

THE ROLE OF EPISODIC EVENTS

An episodic event is characterized as an isolated event where discharge in the stream exceeds the 95% level. The events are of research interest because stream chemistry can dramatically alter during an event. Stream ANC and pH can drop significantly during periods of high flow. In siliciclastic systems, like Paine Run, lowered ANC and acute acidification can result in the mobilization of aluminum (Al⁻) in the system. Aluminum can be lethal to biota, particularly the typically acid-tolerant brook trout.

Our initial analysis focused on isolating storm events in the park that occurred between February and June. Within that data range, we focused on assessing effects on discharge, ANC, and TMAL (total monomeric aluminum). After isolating events of interest, then we began to look at brook trout abundance split by adult and YOY (young-of-the-year) age classification.

June 4 – 6, 1997

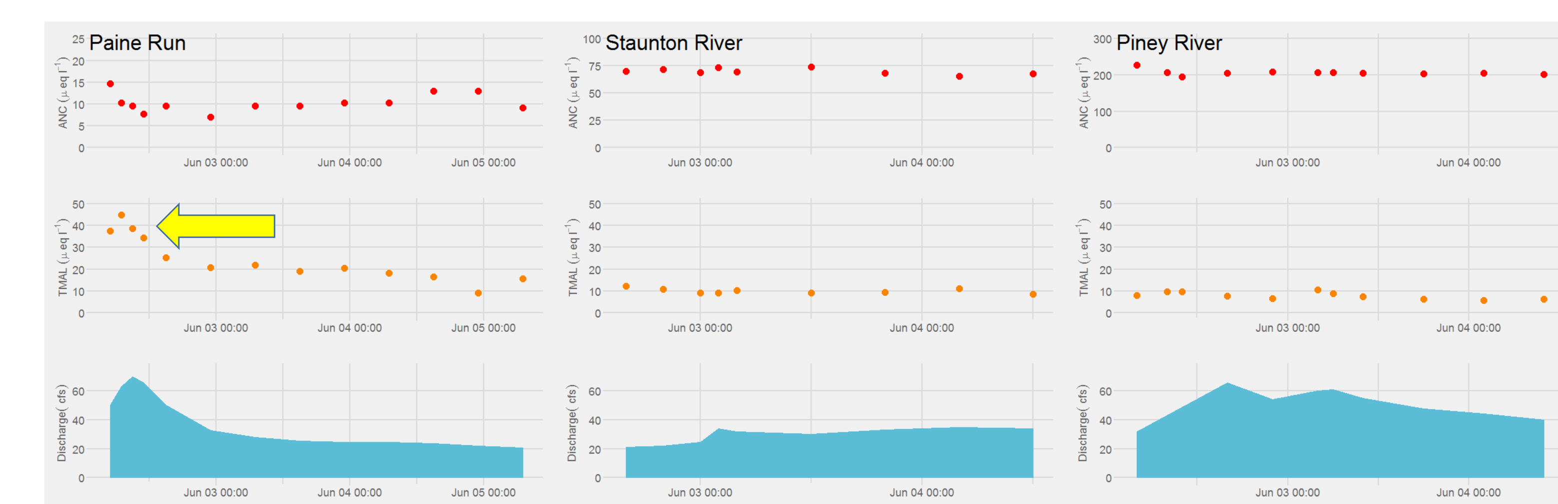
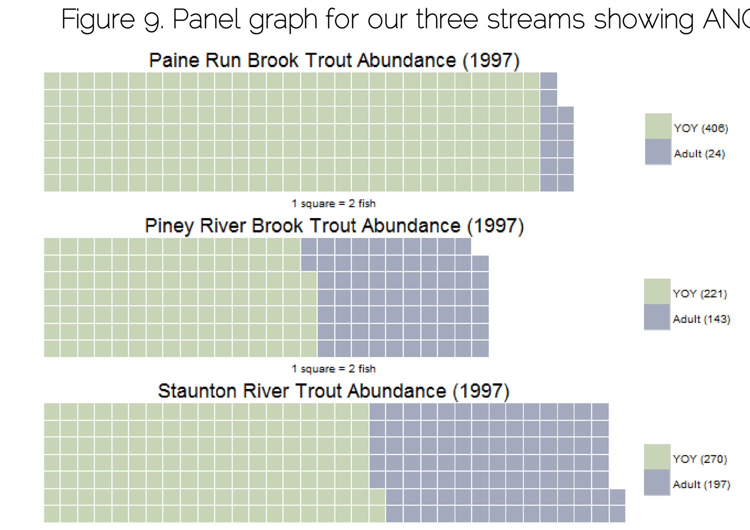


Figure 9. Panel graph for our three streams showing ANC, TMAL and discharge during a flood event (June 4-6, 1997).



During a episodic event across SNP in 1997, we can see a concurrent drop in ANC and rise in TMAL at Paine Run. Analysis over time has shown that of the three rivers in the SWAS-VTSSS episodic monitoring system, only Paine Run experiences increases in TMAL during episodic events of concern, thus measurement of TMAL was halted for other streams.

Figure 10. Brook trout abundance (1997 collection) by stream and age class.

April 9 - 12, 2003

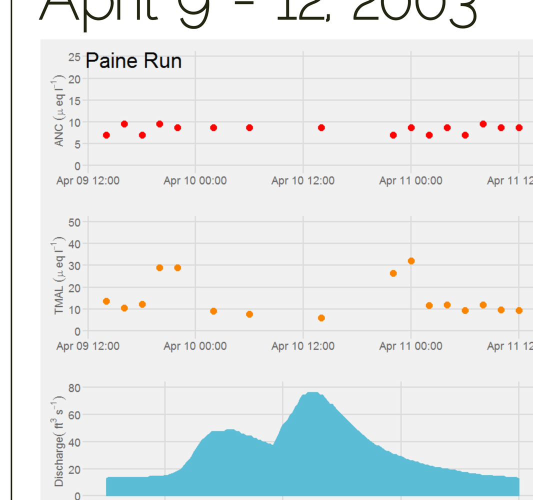


Figure 11. Panel graph showing ANC, TMAL and discharge for April 9 – 12, 2003 in Paine Run.

A flood in April, 2003, showed two different phases of Al⁻ mobilization. This year is of unique interest as it represents the lowest mean streamflow in our record following a prolonged drought (figure 7).

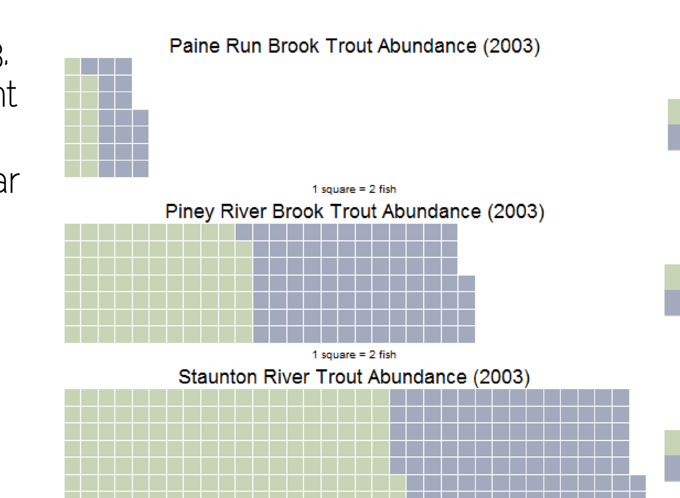


Figure 12. Brook trout abundance (2003) collection) by stream and age class.

FUTURE DIRECTIONS

This poster represents early findings and considerations of this project. It is unclear if brook trout response in the system is dependent on acute exposure of elevated levels of TMAL or if there is a cumulative effect to episodic exposure. Further analysis must consider inclusions of the additive effects of other stressors in the system (low flow, high temperatures, etc.) Streams in SNP have shown evidence of increasing temperatures and are forecasted to continue to do so. Given the regional importance of brook trout, it is important to understand population dynamics.