Long-term Biological Monitoring at Ranch Brook

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Sentinel Stream Monitoring

The Vermont Department of Environmental Conservation (VTDEC) is conducting long term monitoring of twelve "sentinel" streams in Vermont. These reference streams are widely variable in terms of size (4.6 -510 km^2), elevation (33m – 585m) and geographical separation. One of the longest running sentinel monitoring stations is at Ranch Brook in Stowe, VT. With a drainage area of 10 km^2 and an elevation of 378 m, it is one of the smallest and most pristine sentinel streams.

All twelve streams are currently being monitored on an annual basis for water chemistry, physical habitat, water temperature, and biology (fish and macroinvertebrate communities). Several sites are also being gaged for stream discharge. Through this monitoring, we hope to be able to gain an understanding of how climate change is affecting stream habitat and water quality, and how changes in these abiotic variables may cause long-term alterations in biological communities.

VTDEC collects macroinvertebrate community samples during an annual index period that runs from September 1st through mid-October. Samples are collected from riffle habitats, and sorted and identified in the laboratory. VTDEC biologists use population data, as well as a number of community variables (called metrics) to assess stream health. These metrics cover many aspects of community structure and function, including biodiversity, tolerance to pollution and ecological feeding habits. Metric values are used to determine a narrative assessment for community health, using a scale ranging from *Poor* to *Excellent*.

Habitat data collected includes water chemistry (pH, alkalinity, sulfate, earth metals, turbidity, chloride, and nutrients), riparian canopy, substrate particle size, and periphyton cover. With a continuously operated USGS gage and annual monitoring by VTDEC since 2000, Ranch Brook also has one of the best data sets in the state for pairing biological condition with stream hydrology. Continuous stream discharge data is available from the USGS gage, in addition to daily mean and annual peak discharge values.

2015 Monitoring in Summary

Figure 1 shows results for three of the eight metrics used to assess biological condition, as well as the overall assessment rating. **Macroinvertebrate density** at Ranch Brook was 659 individuals per square meter, higher than VTDEC's minimum biological criteria for a healthy stream. This is within the range of other reference streams and similar to the average of other small streams throughout the state. This is a significant recovery for Ranch Brook, which has shown a depressed density for several years following flood flows in 2010 and 2011. **Total species richness** (44) was very high in 2015 compared to DEC's minimum criteria (27), and similar to reference and statewide averages.

A "functional feeding group" refers to one of several types of ecological feeding types to which a species has evolved. Small forested streams like Ranch Brook typically have low algae growth but high quantities of leaf detritus, and populations in different functional feeding groups should reflect this. The ***PPCS-FFG* score** is based on a model that compares the distribution of functional feeding groups at a given site to what we would expect to find at a hypothetical site untouched by human activity. High scores at Ranch Brook indicate increased similarity to a typical reference stream.

High values for these three metrics, as well as the other metrics evaluated by DEC, caused Ranch Brook to get a rating of *Excellent* in 2015, the highest possible score. In addition to acknowledging the high ecological condition of Ranch Brook, it should also be noted that other reference sites and randomly chosen streams throughout Vermont also score very highly. This is a good sign for the overall quality of headwater streams in Vermont.

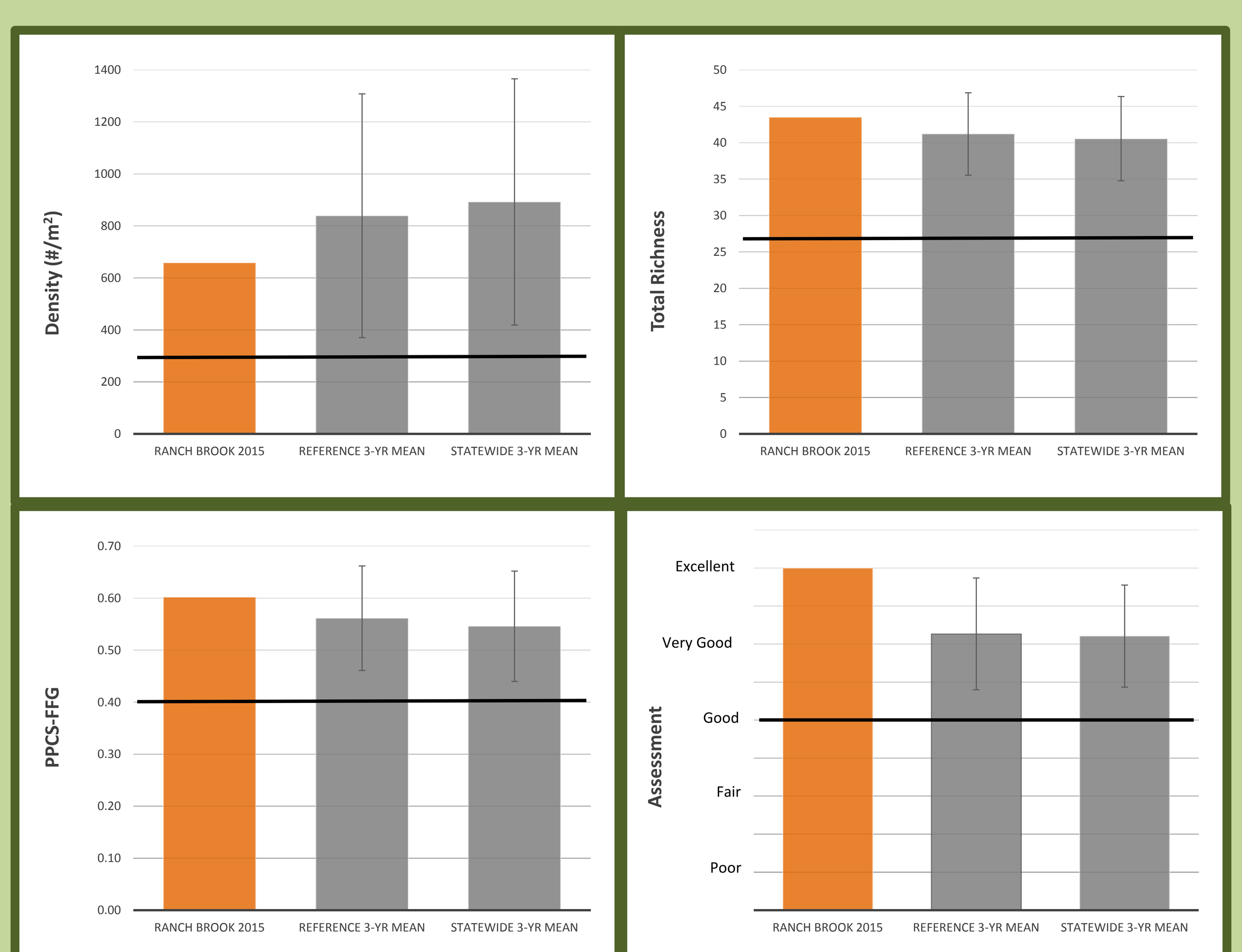

Figure 1: Scores for three biological metrics used to assess biological health, as well as overall assessment rating. The horizontal black bar represents DEC's minimum acceptable criteria.

Long-term Trends

Annual peak discharge during each water year (October – September) at Ranch Brook shows an interesting trend since 2010 when compared to earlier years of record. Four of the top five highest annual discharges have occurred since 2010. When this hydrological variability is plotted against macroinvertebrate density, it seems apparent that organism abundance is responding to recent high peak flows (**Figure 2**).

Most of the highest recorded densities were early in this period of record. Beginning around 2008, we see that densities are generally depressed in years when sampling followed a high annual peak discharge. The highest densities during this time period were recorded in 2009 and 2012, years with low peak discharges. Trendlines plotted through this data suggest an inverse relationship over time between these variables.

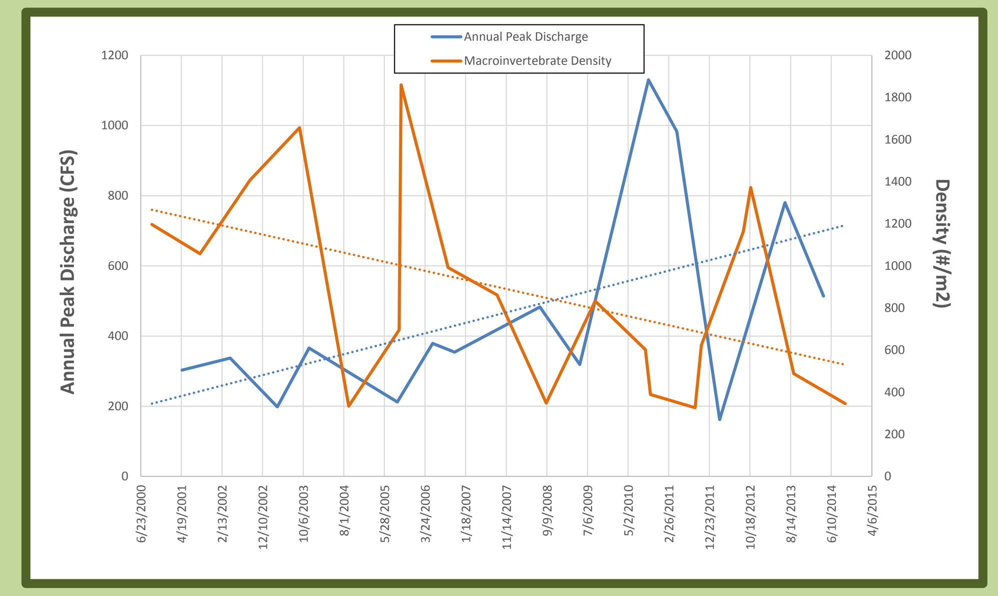

Figure 2: Comparison of annual peak flows at Ranch Brook with stream macroinvertebrate density.

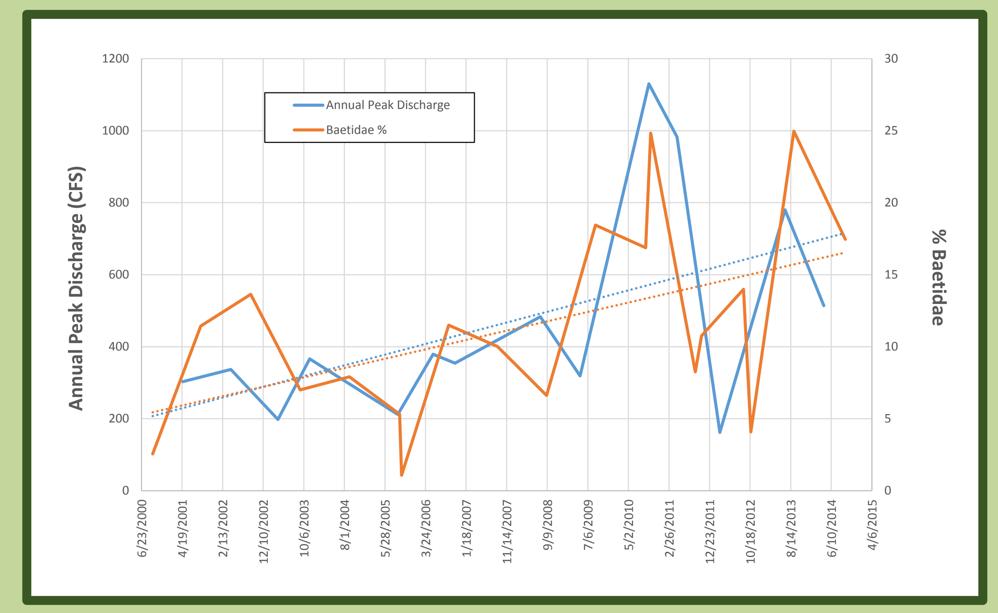

Figure 3: Comparison of annual peak flows with density of Baetidae populations.

High flows have affected individual taxa as well. Mayflies of the family Baetidae are early colonizers that often increase in abundance after disturbance events. The proportion of Baetidae in Ranch Brook has responded closely to recent peak flows **(Figure 3)**.

Overall macroinvertebrate richness has remained very stable over time (**Figure 4**). Ranch Brook is the only stream that DEC has frequently sampled twice during our index period; both in early September and again in mid/late October. This consistency in richness holds regardless of what time the sample was collected. High annual peak discharges have occurred over the last five years, and decreased densities have corresponded with lower than normal assessment ratings. It appears that biological condition may have finally rebounded fully after two relatively low flow years in 2015-2016

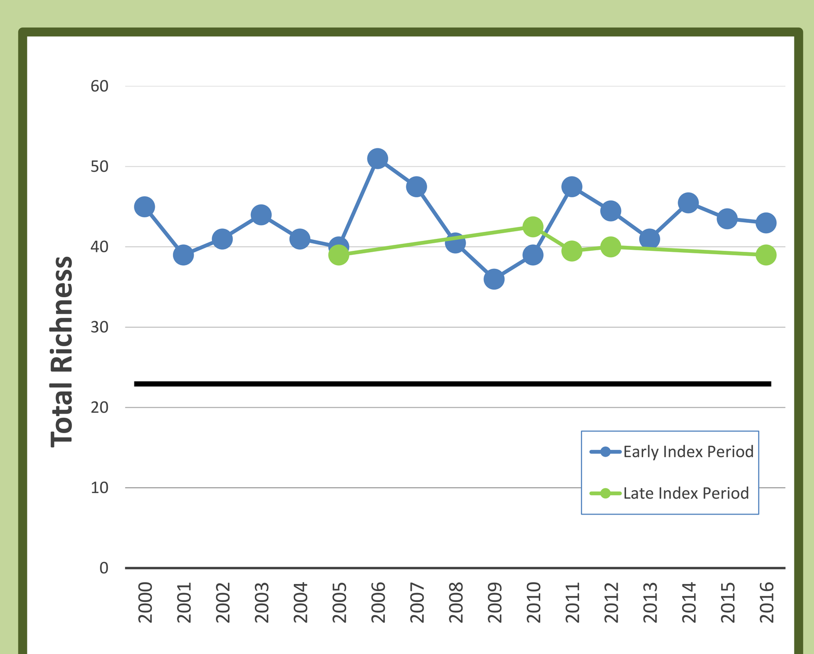

Figure 4: Total species richness from 2000 to 2016. The black bar represents DEC's minimum acceptable criteria for this metric.

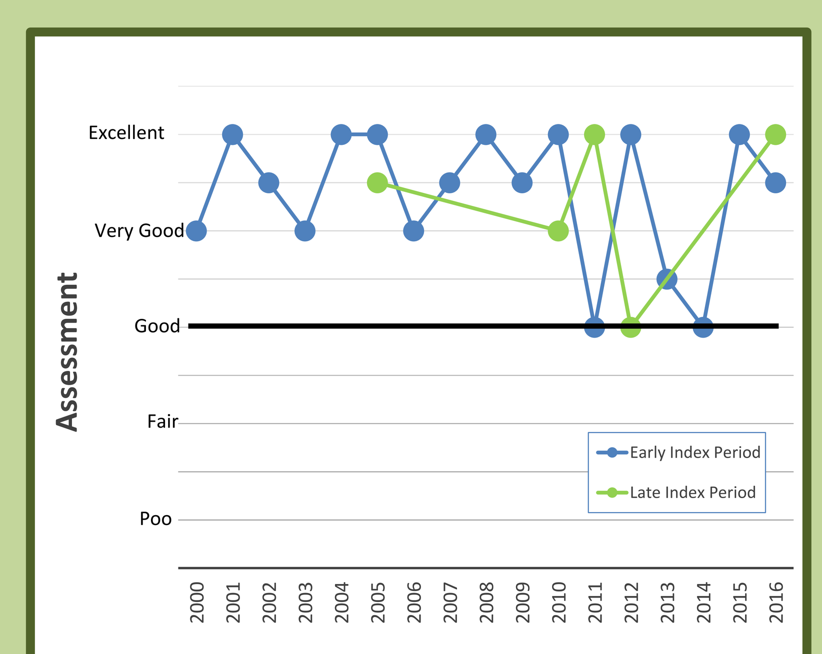

Figure 5: Overall site assessment rating from 2000 to 2016. The black bar represents DEC's minimum acceptable criteria for this metric.

Other Factors Shaping Stream Communities

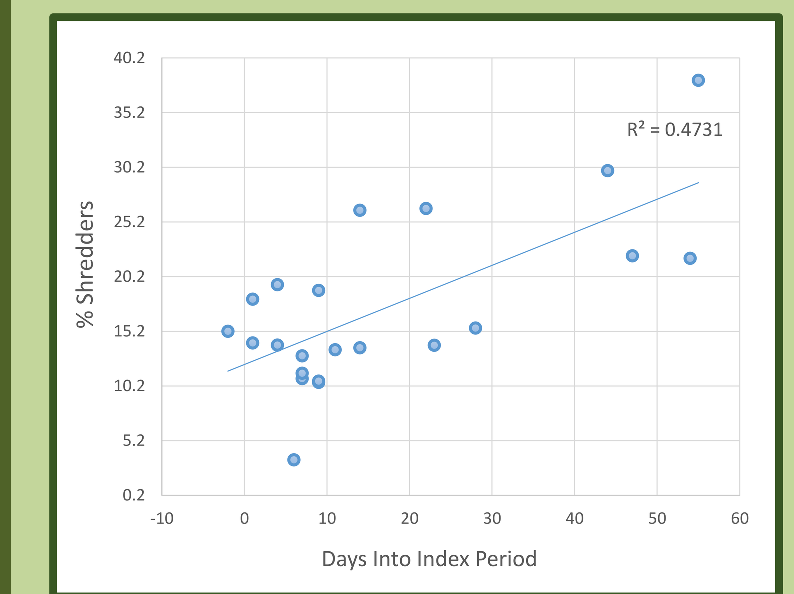

Figure 6: Relationship between % shredders and the number of days into DEC's fall index period that the biological sample was collected.

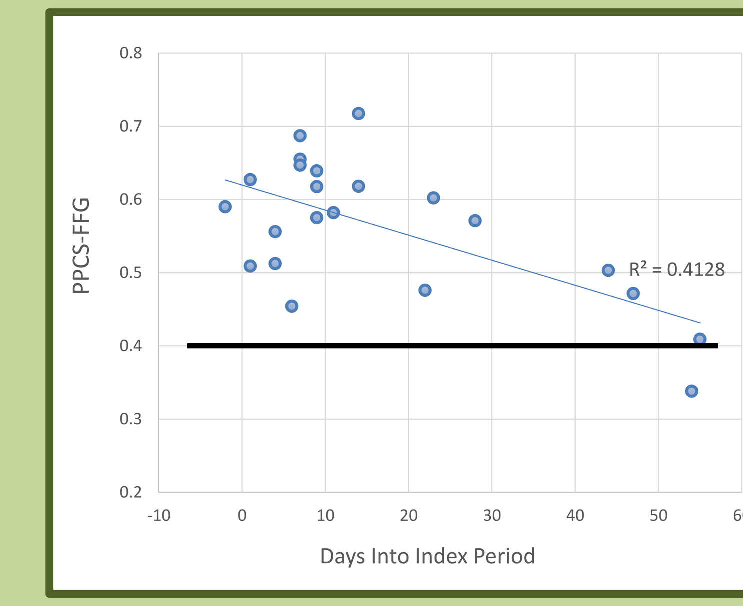

Figure 7: Relationship between PPCS-FFG score and the number of days into DEC's fall index period that the biological sample was collected.

Annual peak discharge and median discharge in the previous 30 days were found to be very important in influencing communities at Ranch Brook. However, of all other environmental variables the two strongest factors determining presence and densities of taxa were found to be **the number of days into the biomonitoring index period the sample was collected, and the quantity of coarse particulate organic matter (CPOM) present**.

DEC's index period begins in late summer and ends in late autumn. Shredder invertebrate taxa that feed on fallen leaves increase as autumn progresses (**Figure 6**) while the functional feeding group similarity metric decreases **(Figure 7)**. CPOM quantity is highly indicative of the amount of fallen leaves accumulating in the stream, which also tends to increase dramatically by late autumn (**Figure 8**).

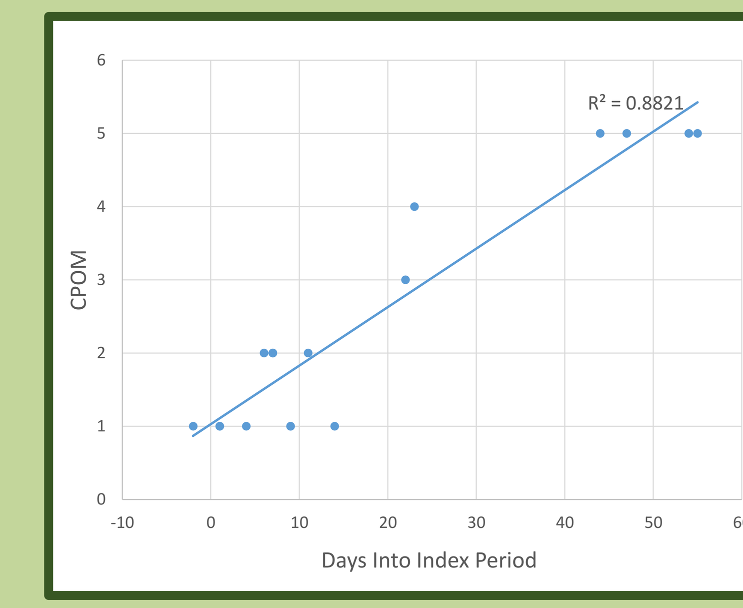

Figure 8: Relationship between CPOM and the number of days into DEC's fall index period that the biological sample was collected.

Climate Change Implications

High precipitation events like Tropical Storm Irene and other storms that have affected Ranch Brook in recent years are expected to become more common with our changing climate. These events will lead to more hydrological variability and higher annual peak flows, which in turn scours stream beds and decreases habitat stability.

Our data suggests that small, **low-productivity mountain streams like Ranch Brook may have a hard time recovering macroinvertebrate abundance in response to increased flood flows**. High flow events also seem to be affecting which invertebrate populations are dominating the stream community. Hydrologic instability could also have negative effects on the fish community, either as a direct result of high flow events, or through food web dynamics resulting from lower invertebrate abundance.

It is an important finding that the **timing of sampling is an important factor in the presence and abundance of taxa in these communities**, though perhaps not surprising. The mid to late October samples were collected after leaf fall. As autumn progresses, the resource base for macroinvertebrates at Ranch Brook shifts more heavily to a community based on breaking down leaf detritus. This kind of seasonal community shift could confound our ability to fully understand how taxon populations are changing over longer periods of time as a result of climate change. These results suggest that it is important to consistently collect biological samples at sentinel sites at roughly the same time every year. Collecting biological samples at sentinel sites at both the beginning and end of DEC's fall index period might provide even more valuable data on how macroinvertebrate populations are affected by climate change variations in flow and temperature.

Acknowledgements

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