



Long-term Monitoring of Stream Ecological Integrity in Glacier National Park

Streams are fundamental components of every park in the Rocky Mountain Network (ROMN). They support a broad spectrum of ecological services including hydrologic cycling, nutrient processing, and wildlife habitat as well as recreation, fisheries, and cultural context. Streams are sensitive to stresses such as excessive sediment and nutrient inputs, withdrawal for agricultural use, and climate change, making them ideal for long-term monitoring of ecological health. The general objectives of stream ecological integrity monitoring are to document the status and long-term trends in condition of streams and rivers in a park, and to use this information to help understand why stream conditions may have changed.

The Rocky Mountain Network (ROMN) began long-term monitoring of stream ecological integrity (SEI) in Glacier National Park (NP) in 2007. Between 2007 and 2014, the network established 49 permanent stream monitoring sites in the park and conducted 108 full sample events and 74 partial events at these locations (Figure 1). Most sites (39) were randomly selected and are visited every ten years, with a small number revisited several times during the survey. These data are used to statistically infer park-scale condition and create various models and numeric reference conditions specific to the park. A smaller number of hand-picked “sentinel” sites (4) are sampled annually (with 27 full and 68 partial samples as of 2014) to better understand site-specific stream condition, especially how biology, chemistry, habitat, and disturbance interact. Finally, six additional “gradient” sites that targeted streams in likely disturbed or pristine states are sampled during the surveys and episodically after that to assist in modeling. A full sample event at a site takes a crew of three to four people from four to six hours. Crews are trained in protocol methods and safety is a paramount concern as well as compliance with conducting research in wilderness and other related concerns.

The SEI protocol includes a broad spectrum of indicators to help evaluate the ecological integrity of the streams of Glacier. Core indicators include multiple measures of water and sediment physiochemistry (nutrients, metals, temperature); physical habitat (substrate composition, riparian cover, channel geomorphology); and community-level assays of two important biological assemblages: macroinvertebrates and algae. The latter provide an integrated aspect for assessing ecological integrity, because these organisms respond to environmental conditions over time and space. We include measures of drivers (or stressors) and ecological responses, so that we may better understand the linkages among them and help parks apply these results to resource management.



NPS, BILLY SCHWEIGER

Sampling a site on Reynolds Creek, 2009.

SEI methods are documented in a NPS ROMN protocol being published in 2014 and are largely derived from well-established and existing protocols developed by ROMN partners, including the Environmental Protection Agency, the U.S. Geological Survey (USGS), and the Montana Department of Environmental Quality. The application of standardized protocols across ROMN and partner stream monitoring sites facilitates the comparison of streams and rivers within an ecoregion.

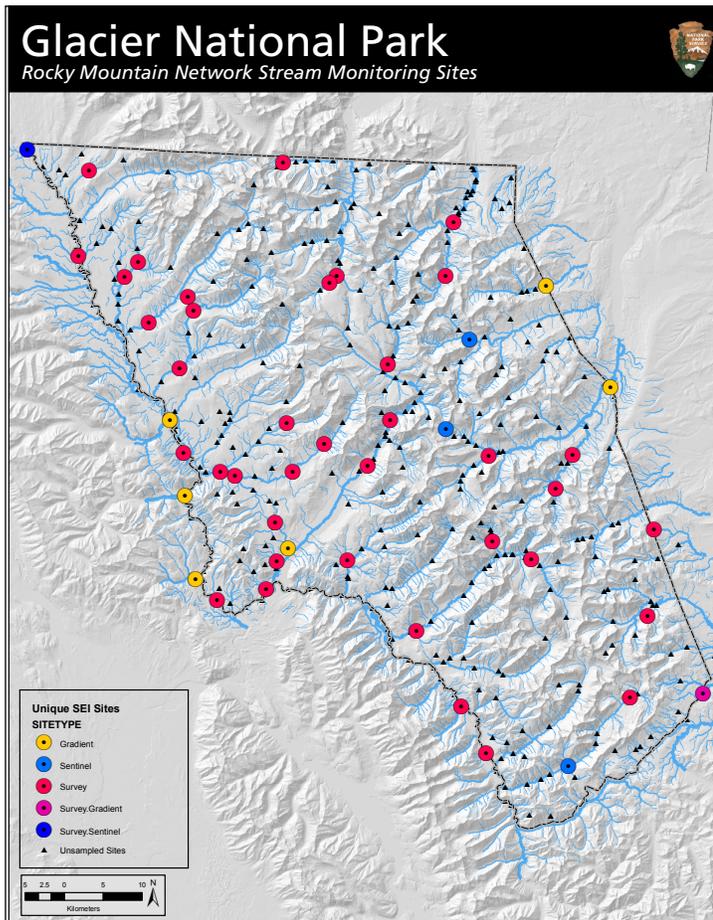


Figure 1. SEI monitoring sites in Glacier NP.

Monitoring Objectives

The goals for long-term ecological monitoring of streams in Glacier NP focus on documenting the status and trend in condition (ecological integrity), understanding the causes of change in integrity, and assisting in the application of results to park resource management.

Assessment

A key step in the reporting of SEI data in Glacier NP is interpreting the meaning behind a given result or set of results. Is a result suggestive of high quality or reference conditions, and why? Does a trend in a response suggest that condition is moving toward a non-reference state, and why? This understanding is a critical aspect of a mature long-term monitoring program and something the ROMN stresses. Generally, our approach is to compare SEI results to established or derived “assessment points” (see box) and evaluate responses based on these comparisons using Glacier NP resource management guidance, NPS Inventory & Monitoring Division guidance, NPS resource management policies, ecological theory, and collaborative work with ROMN partners.

Assessment Points

Assessment points occur along a continuum of condition states where scientists and park managers have agreed that assessment of the status or trend of a resource is warranted relative to program goals, natural variation, or potential concerns. Assessment points may take several forms:

- **Ecological thresholds** are boundaries at which a small change in external factors trigger a rapid or abrupt change in ecosystem condition. They are often difficult to estimate and in many cases are only approximations.
- **Ecoregion thresholds** are boundaries within distributions of a response as measured at reference sites within a park or broader ecoregion. They may be arbitrary (a percentile) or derived from modeling and attempt to connect ecological or management meaning to the boundary.
- **Criteria** are assessment points established for decisions that have an explicit connection to a regulatory policy. These are usually based on human health or environmental effects and generally represent the lower limits of the acceptable range in a condition gradient (or the boundary of non-reference). They are used by regulatory agencies to ensure that a resource does not become impaired.
- **Baseline assessment points** are summary statistics (a mean and its confidence interval) derived from a sufficient spatial or temporal data set for an indicator. They may estimate a natural range in variation if the sites or time period they are derived from are in a reference state.
- **Management assessment points** represent a point (or several points) for a response, defined by park management that triggers management action (including additional sampling or research). Management assessment points are often set to avoid undesirable ecosystem changes (e.g., ecological thresholds) and enable more proactive management responses. They can be estimated by modeling, but are often derived from informed professional judgment. Most other types of assessment points (e.g., baselines, criteria) may be adopted as management assessment points.

Select Results

SEI data were analyzed following well-established methods. Biological response was emphasized because the presence and health of populations of key taxa are indicative of overall stream health. Ongoing analyses of Glacier NP SEI data have provided several interesting results, some of these are described below.

A suite of integrated, synthetic stream multimetric (MMI) and multivariate (RIVPACS) models of macroinvertebrate and diatom communities were generated that provide synthetic estimates of stream condition at each site. These models can be analyzed using properties of the survey design to estimate stream condition park-wide. Using the macroinvertebrate MMI as an example, these results suggest that approximately 77% of the stream across the park is in reference condition in 2007-2009. MMI output may also be expressed at specific sites illustrating the difference in stream condition across the park (Figure 2). Currently, these models and assessment points are criteria and model forms required by the state. Future work will customize these to Glacier NP and use ecoregional or park-scaled assessment points.

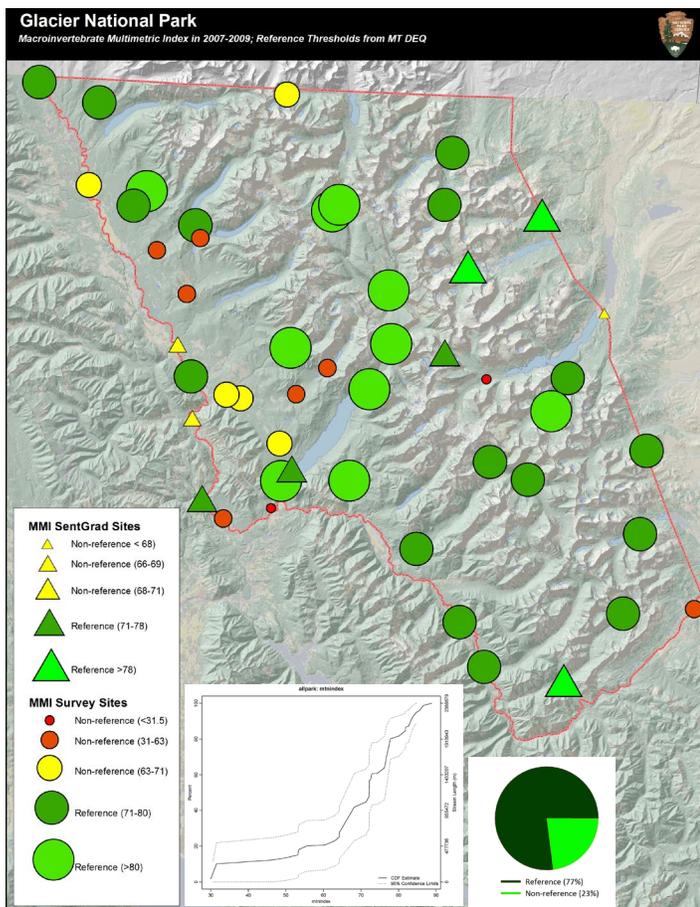


Figure 2. MMI at the site level, 2007-2009.

These models will take advantage of the measurable response to disturbance seen in results like the MMI. There appears to be a strong gradient in the macroinvertebrate community with human disturbance (Figure 3). These sorts of patterns allow construction of likely more precise MMI models specific to the park and estimation of assessment points from SEI data itself.

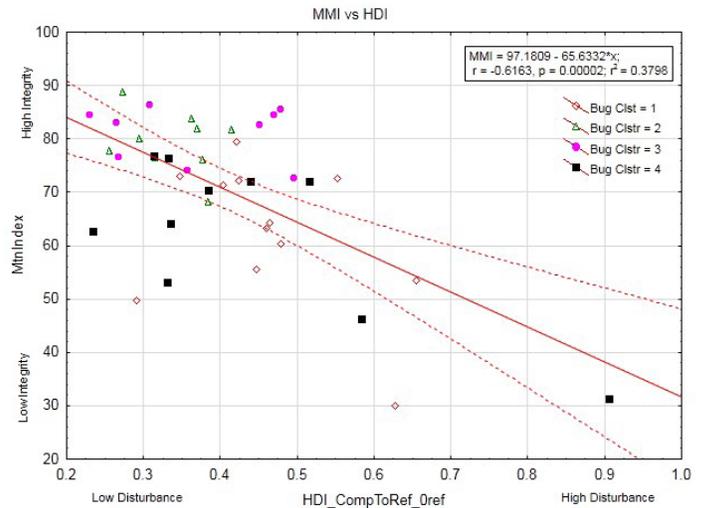


Figure 3. Macroinvertebrate MMI vs human disturbance, 2007-2009.

SEI sentinel sites include repeat sampling and are often instrumented, allowing estimates of temporal patterns. For example, water temperature at the sentinel site on the North Fork suggested the site was probably thermally suitable for bull trout rearing in mid-summer, but only marginal for spawning in early fall in both 2010 and 2011 (Figure 4).

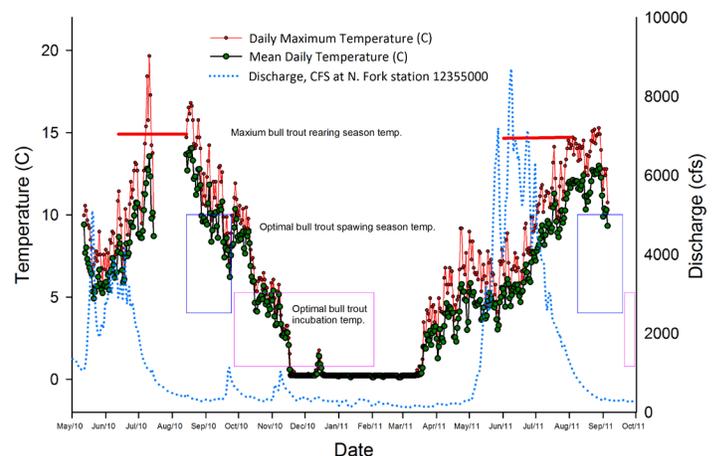


Figure 4. N. Fork of the Flathead temperature, 2010-2011.

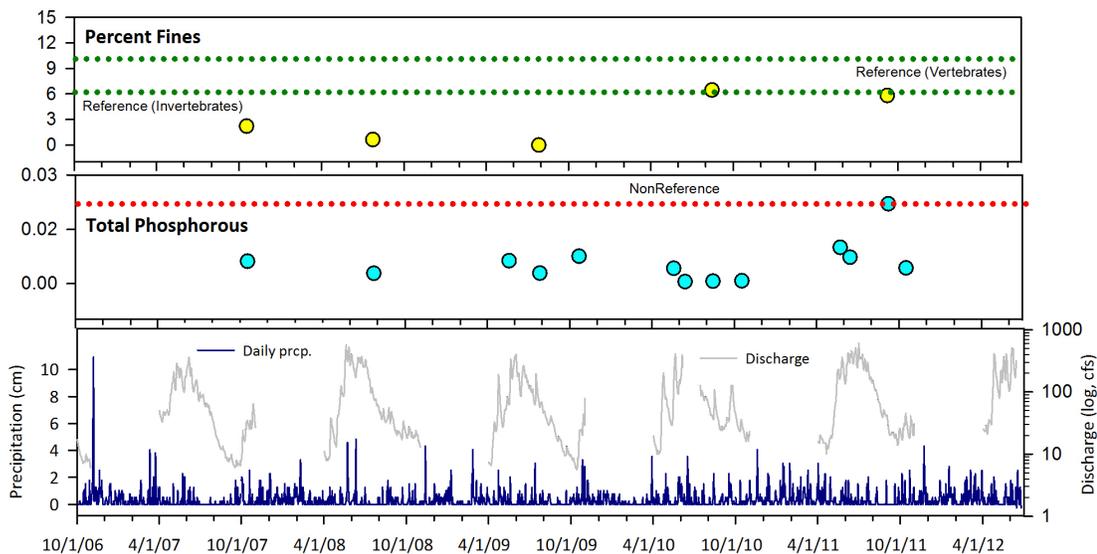


Figure 5. Percent fines, total phosphorous, precipitation and discharge between 2007 and 2011, Swiftcurrent.

Habitat and chemistry responses at the Swiftcurrent Creek sentinel site suggest that between 2007 and 2011, total phosphorous was almost always below the state water quality criteria, but later summer base-flow concentrations were sometimes elevated, perhaps due to increasing groundwater contributions (Figure 5). The percentage of bottom substrates that were fine at the site were also always within a reference range for vertebrates, and usually for invertebrates. There was a suggestion that an increasing percentage of fines was associated with increasing total phosphorous, perhaps because nutrients can be adsorbed to small sediments and thus be more persistent in the water column.

Application and Future Work

SEI monitoring has generated useful data for the management and interpretation of important stream habitat in Glacier NP. It is the first statistically rigorous sample of the park’s streams and provides unbiased estimates of stream condition across the park. Ongoing work will estimate long-term trend in condition at select sentinel streams, and when the survey is repeated, change and trend will be estimated for all the streams in the park. The SEI protocol also includes an emphasis on developing park-specific reference conditions that can be used along with existing criteria to assess or interpret data.

SEI monitoring is and will continue to help park resource managers understand issues such as the impacts of climate change on the park’s ecology, the biological response to stressors within and outside the park, and detection of invasive plants. The work can also assist in site-specific restoration by providing important context and tools for focused decisions and across large spatial and temporal scales. Monitoring of streams in Glacier NP complements other efforts being done by the ROMN and our partners such as extensive stream monitoring by the USGS.

References

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