



Stream Ecological Integrity, Glacier National Park

Streams are fundamental components of every park in the Rocky Mountain Network (ROMN), including Glacier National Park. 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 following is a summary of results from Stream Ecological Integrity (SEI) monitoring in Glacier National Park (NP) from 2007-2009.

Methods

Most SEI sites were randomly selected and are visited every ten years in a major survey effort. The 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 are sampled annually to better understand site-specific stream condition, especially how biology, chemistry, habitat, and disturbance interact. The SEI protocol includes a broad spectrum of indicators to help evaluate the ecological integrity of the streams in Glacier NP. 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.

SEI methods are documented in a 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, and the Montana Department of Environmental Quality (MT DEQ). The application of standardized protocols across ROMN and partner stream monitoring sites facilitates the comparison of streams and rivers within an ecoregion.

We interpret results using a variety of assessment points including regulatory criteria, ecoregional thresholds derived from state and federal monitoring reference sites in the surrounding ecoregion. Our approach is to compare SEI results to established or derived assessment points and evaluate responses based on these comparisons using Glacier



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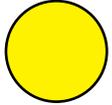
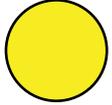
ROMN SEI field crew sampling a site on Hudson Creek, 2008.

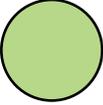
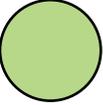
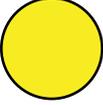
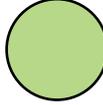
NP resource management guidance, other NPS guidance and policies, ecological theory, and collaborative work with ROMN partners.

Results

In general, the streams and river in Glacier NP are largely intact and high quality. A few minor areas of concern include a suggestion of rising water temperatures, a slightly elevated level of fine embedded substrates in a few of the park’s streams, and some indication of a biological response to temperature and nutrients. The majority of the other measures and metrics, however, including the synthetic biological indices of ecological condition, suggests that most aspects of the park’s streams were in a reference or near-reference state in 2007-2009. With these results, we determine the overall condition to be intact and of reference quality.

The following summary table describes each SEI indicator and measure and symbolizes the status, trend, and level of confidence. This information is a considerable simplification of the detail in the full report and should be used with caution.

Vital Sign (Example Indicators)	Summary Condition Table Description	Symbol
Overall stream ecological integrity (2007-2009)	Overall, the ecological integrity of the majority of the streams and rivers of Glacier NP was intact and of reference quality. Given our survey design approach, we have high confidence in applying this statement to the sampleable population of streams in the park. We do not yet have park-scale data to test for trend in the ecological integrity of the park.	
Water physiochemistry (nutrients)	A small percentage of the park's streams may have elevated nutrient concentrations. We expect this is mostly due to natural sources (i.e., groundwater in alluvial floodplains or nutrient-rich wetlands) or to shorter-term loading after fires. There is little evidence of any pervasive impact from nutrients on the base of the aquatic food chain (diatoms) or on macroinvertebrate communities that support important fish and other species in the park. There are also complex natural temporal patterns in nutrients as discussed in the SEI Sentinel Report. We have medium confidence in these data because our methods do not fully meet requirements from the state for nutrient assessment. We do not yet have park-scale data to test for trend in nutrient concentrations.	
Water physiochemistry (major ions)	The median concentrations of sulfate and chloride for the park's streams in 2007-2009 were lower than or close to a conservative reference threshold value derived from ecoregion reference sites. A small percentage of the park's streams had concentrations above a non-reference threshold. Data presented in a follow-up report for sentinel sites suggest that, at least at select sites in the park, chloride concentrations have declined over the last few decades. There are complex temporal patterns in these indicators, as discussed in the SEI Sentinel Report. We have high confidence in these data for this purpose. We do not yet have park-scale data to test for trend in the concentrations of important ions.	
In situ water physiochemistry (temperature)	Water temperature dynamics across the park are complex and will require continued research. There is some evidence for decreased biological integrity in streams with warmer water. Focused research on specific taxa also indicates that temperature plays a (or perhaps the) central role in the persistence of many species, especially in alpine ecosystems. Water temperature is driven by climate dynamics and will require careful monitoring into the future, especially in alpine areas. The SEI Sentinel Report presents additional details on water temperature temporal dynamics at select sites in the park. We have medium confidence in these data because our methods do not fully meet requirements from the state for temperature assessment. We do not yet have park-scale data to test for trends in water temperature, but will soon at select sentinel sites.	
In situ water physiochemistry (pH, conductivity, DO)	Higher water temperatures may alter water chemistry including dissolved oxygen. A small percentage of the park's waters do not always meet state standards for dissolved oxygen. Temporal dynamics in dissolved oxygen are complex, however, and we do not think there are more than isolated instances that pose any threat to aquatic biota. We have high confidence in these data. We do not yet have park-scale data to test for trends in <i>in situ</i> physiochemistry.	
Sediment chemistry (metals)	The SEI Sentinel Report presents results for sediment chemistry at select sites in the park, but they are not site specific, nor do we suspect park-wide issues with stream sediment chemistry.	
Habitat, in stream and riparian (general)	The physical habitat of Glacier NP's streams, rivers, and riparian systems was generally excellent, with nearly all metrics indicating that the majority of the park's streams were well above ecoregion reference thresholds. We have high confidence in these data. We do not yet have park-scale data to test for trend in any habitat response.	
Habitat, sediment (size, stability)	Select streams do have complex sediment dynamics, with some excessive fine sediment cover and embedding of larger substrate types relative to expectations for the channel form and watershed characteristics. This may be related to hydrologic changes driven by climate dynamics, runoff from fires, or isolated impacts from visitor facilities and transportation infrastructure. It can have important consequences. We have high confidence in these data. We do not yet have park-scale data to test for trend in any habitat response.	
Habitat, invasive plants (frequency)	Targeted invasive plants were found in riparian habitat at SEI sites; however, over 60% of the park's streams were completely "weed free." The more common species recorded (e.g., Canada thistle, <i>Cirsium arvense</i>) were likely not having important impacts on the streams. Isolated patches of more problematic species (e.g., spotted knapweed, <i>Centaurea maculosa</i>) were found in select sites that were near infrastructure. We have medium confidence in these data due to likely incomplete detection. We do not yet have park-scale data to test for trend in any habitat response.	

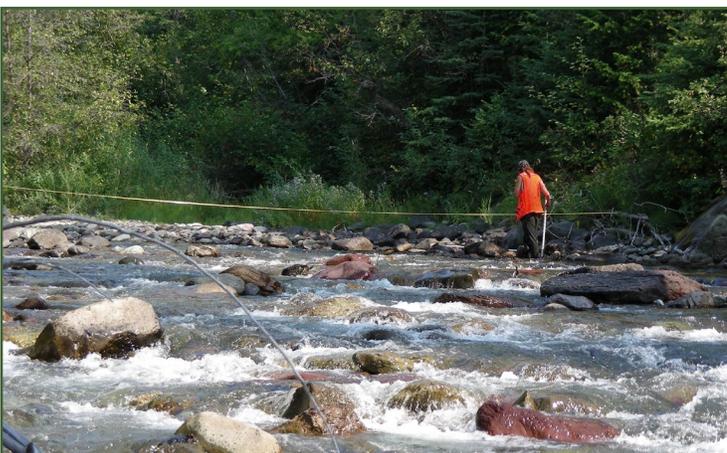
Vital Sign (Example Indicators)	Summary Condition Table Description	Symbol
Habitat, stream flow (amount and timing)	The SEI Sentinel Report presents results for stream flow at select sites in the park, but we do not suspect or have any evidence of site-specific or park-wide issues with stream flow.	
Biological communities, macroinvertebrates (MMI and RIVPACS metrics)	All macroinvertebrate metric median values were above MT DEQ impairment criteria (indicating no impairment if assessed by MT DEQ). Moreover, most of park's stream length was above ecoregion reference thresholds. This suggests that the macroinvertebrate communities are largely intact in the park. Given the synthetic nature of the macroinvertebrate metrics we used, we consider this the primary evidence for the general high integrity of the parks streams. However, the models used are not specific to the park, and until such tools are created, we have medium confidence in these results. We do not yet have park-scale data to test for trend in the overall condition of macroinvertebrate communities.	
Biological communities, macroinvertebrates (temperature and patterns with disturbance)	Metrics focused on macroinvertebrate response to water temperature and preliminary models of patterns between synthetic indices and water temperature may suggest that increasing water temperatures are impacting community structure. Only about a quarter of the park's streams were in a reference state regarding macroinvertebrate response to temperatures when compared to ecoregion reference sites. Ecological integrity also appears to degrade as water warms and this appears to be largely independent of other environmental gradients. We have medium confidence in these analyses. We do not yet have park-scale data to test for trend in the overall condition of macroinvertebrate communities.	
Biological communities, diatoms (increaser metrics)	Like macroinvertebrates, most diatom metrics were above MT DEQ thresholds with little indication of sediment, nutrient, or metal issues. Diatoms are the base of the food chain and the intact diatom community at Glacier NP may be one of the reasons why we also see fairly high-quality macroinvertebrate assemblages. We lack ecoregion reference thresholds for increaser metrics and there is some suggestion these models are not optimized for Glacier NP. We have high confidence in these data, but suspect there are some analytical issues with model appropriateness. We do not yet have park-scale data to test for trend in the overall condition of macroinvertebrate communities.	
Aquatic invasives (presence)	Aquatic invasive species may be a problem in Glacier NP. We do not include vertebrates in SEI monitoring, but there is ongoing research by the park and others on the implications of non-native fish. We found <i>Didymosphenia geminata</i> (rock snot) in a large portion of the parks streams, often in a bloom state. Research is ongoing on the implications of didymo on the park's streams. New Zealand Mud Snails (<i>Potamopyrgus antipodarum</i>) are in nearby watersheds and on the move. SEI monitoring will watch closely for these and other invasive species over the coming years. We have high confidence in these data. We do not yet have park-scale data to test for trend in any aquatic invasive taxa.	

Key

Red=significant concern/nonreference, Yellow=caution/intermediate, Green=good condition/reference

Thick border=high confidence, solid border=medium confidence, dashed border=low confidence

Arrows: up=improving trend, down=decreasing trend; flat=stable trend; empty=unknown trend due to insufficient data



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