



Long-term Monitoring of Stream Ecological Integrity in Rocky Mountain National Park

The Rocky Mountain Inventory and Monitoring Network (ROMN) will begin long-term monitoring of stream ecological integrity (SEI) in Rocky Mountain National Park (ROMO) in 2014. Fifty randomly selected streams and rivers will be visited every ten years, with a smaller number of sites sampled annually. Crews will collect data on water and sediment chemistry, stream flow, macroinvertebrates, diatoms, and several aspects of in-channel and riparian physical habitat. Stream monitoring complements efforts led by the ROMN and other partners, such as extensive wetland monitoring, and vegetation and climate response in alpine areas.

SEI monitoring will generate powerful data for the management and interpretation of flowing waters in ROMO. It is the first statistically rigorous sample of all of the park's streams and will provide unbiased estimates of the condition of the park's waters and long-term trends at select individual sites and eventually for all the flowing waters in the park. The SEI protocol includes developing park-specific reference conditions that can be used along with existing criteria to assess or interpret data.

SEI monitoring will help park resource management understand issues such as climate change-induced shifts in stream temperature, nutrient and sediment regimes, the biological response to stressors within and outside the park, detection of invasive riparian plants and aquatic invaders like New Zealand mud snails or *Didymosphenia geminata* ("rock snot"), and stream and riparian system restoration—especially at large scales, such as the Grand Ditch project or the park's response to the flooding of 2013.

Monitoring Objectives

The goals for long-term ecological monitoring of streams and rivers in ROMO focus on documenting the status and trend in condition or ecological integrity, understanding the causes of change in condition, and assisting in the application of results to park resource management. Specific objectives are to:

1. Determine the condition (status) every 10 years of all the parks streams and rivers using bioassessment (of macroinvertebrate and diatom assemblages), physical habitat and water physiochemistry.



The field crew prepares to collect water samples.

2. Determine the long-term trend in the condition of select sentinel sites and with sufficient data for all of the parks waters.
3. Assess these responses as follows:
 - Compare to existing and published assessment points, including any regulatory criteria, ecological thresholds or ecoregion assessment points that are relevant to the streams of ROMO and their management.
 - Compare to ecoregion assessment points derived from distributions of reference site data from the park and its surrounding ecoregion.
 - Compare to baselines derived from partner or auxiliary data or, with sufficient monitoring, SEI data.
4. Relate any spatial or temporal patterns (including trend when possible) in select responses to important ecological and anthropogenic drivers. Models will depend on scale-appropriate covariate SEI and auxiliary data, requiring clear (and often causal) connections to stream condition and will, therefore, be done as possible.



Stream monitoring crew measures bank angles on the Colorado River, 2013.

Methods

SEI monitoring focuses on the *ecological integrity* of streams. Ecological integrity is the capacity to support and maintain a balanced, integrated, and adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitats of the region. Ecological integrity is a complex, multidimensional concept and usually a single indicator or vital sign is insufficient to characterize it. Therefore, we monitor an integrated set of response measures, such as community-level composition of macroinvertebrates and diatoms, stream habitat (including hydrology), and water chemistry.

Most sites are randomly selected using a probability *survey* design. The 50 survey sites are distributed across all the park's accessible waters, from high-elevation alpine streams to the larger rivers near the park's boundaries. This unique aspect of the work allows unbiased statistical estimates of stream condition. Figure 1 includes the most likely survey sites (though they will need field confirmation).

Approximately four *sentinel sites* will be sampled annually. A sentinel site on the Colorado River (above and below the main Grand Ditch restoration area) is already being sampled (starting in 2010). Other new sentinel sites will be based on the following criteria:

- Natural perennial streams.
- Important or useful places to understand long-term trends in stream condition, especially with a long-term management or research application. Good examples might include Icy Brook in Loch Vale.

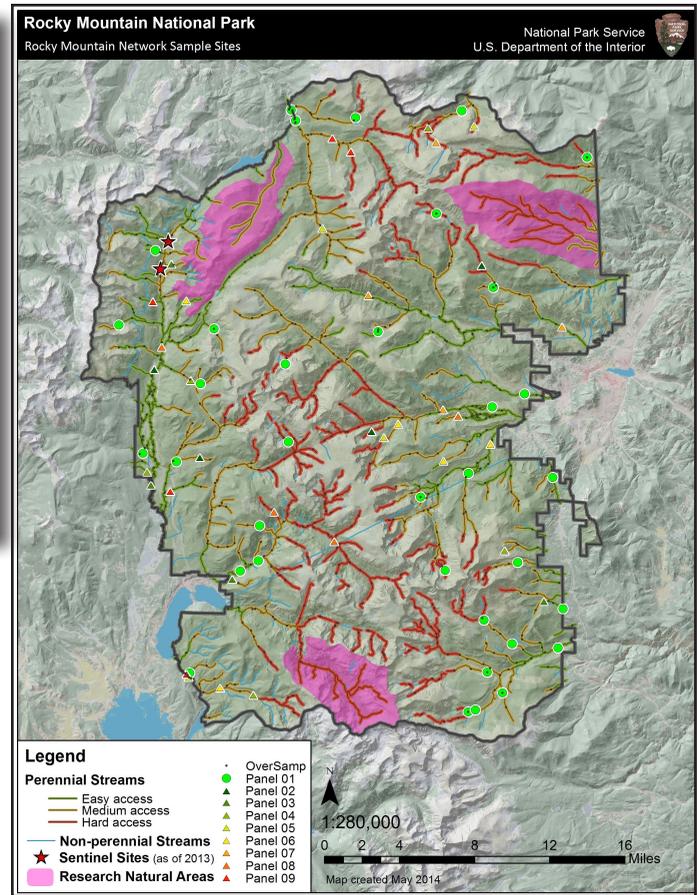


Figure 1. A map of possible sampling sites within ROMO. These will need to be investigated in the field to determine feasibility based on access and safety.

- Co-located with existing, complementary monitoring or research sites (especially a USGS or gauge, such as on the Big Thompson in Moraine Park or the Colorado River at Baker Gulch).
- Easy and safe to access (can be accessed and sampled in a single day).

Approximately ten *gradient sites* will be sampled once or twice during the main survey. Gradient sites are:

- Natural perennial streams.
- Modified or disturbed streams, likely to be in non-reference condition. Disturbances can include current or past land use, hydrologic modification, or other natural or anthropogenic events. Good examples might include the Fall River at the alluvial fan.
- High-quality, pristine streams likely to be in reference condition, with minimal or no impacts from anthropogenic uses. Good examples might include upper Ouzel Creek near the Continental Divide.

- Interesting or useful to inform models or analysis/ interpretation of data from other stream monitoring sites, due to a gradient in nutrients, sediment, water temperature, hydrologic regime, or a similar conditions.
- Co-located with existing, complementary monitoring or research sites, so that sampling the site connects SEI monitoring with past or ongoing work being conducted at the site.

A full sample event takes a crew of three to four people from four to six hours on site. Sampling includes:

- Macroinvertebrates and diatoms (algae) collected at base flow once per year. These are later identified to species as possible.
- Over 60 water and sediment physiochemistry parameters, such as nutrients, major ions, and metals. Sentinel sites are sampled for these four times a year on the limbs of the site's hydrograph. Chemistry samples are analyzed at labs with low detection limits appropriate for ROMO.
- Water *in situ* parameters, such as temperature, pH, and conductivity. At some sites, instruments that collect these continuously are installed each summer. We are adding several long-term continuous temperature loggers to the growing array of temperature sensors in the park.
- Detailed physical habitat, including human and natural disturbances, riparian composition, in-stream geomorphology, detailed sediment and bed form characterization, and stream flow.

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

Crews are trained in all methods by the ROMN. Safety is a paramount concern, as is compliance with conducting research in wilderness and other related concerns. Most sites have no infrastructure and what instrumentation is used is invisible to park visitors and deployed temporarily. ROMN crews will be identified with NPS logos and welcome questions from park staff and visitors. We especially like dedicated volunteers; please contact us if this is something you'd like to do.

Reporting Results

There is a large body of long-term work in ROMO related to aquatic resources and issues that will help inform the SEI long-term monitoring. Likewise, we believe the monitoring data and results will be a resource for ROMO resource managers, researchers working in and around the park, stakeholders, and partners.

As ROMO and the ROMN implement the SEI monitoring over the next few years, we will continue to engage ROMO managers and researchers, and other technical partners in sharing data and information as we begin to analyze and interpret the data.



Photo documentation of sampling sites is an important part of data collection.

Regulatory Issues

All waters in ROMO are Class 1 “Outstanding Resource Waters,” meaning they are of the highest quality, are designated for cold water aquatic life, and governed by anti-degradation policies. We recognize, however, that there may be possible impairments (especially near the edges of the park), such as metals (copper, cadmium, zinc), low dissolved oxygen, nutrient deposition, and possible mercury in fish. We are focusing attention on the possible Clean Water Act listing by the state of the Big Thompson watershed for copper. Work with the state and EPA will likely generate a watershed-specific criteria for this metal that accommodates the natural levels that occur in the mineral belt of the Southern Rocky Mountains.

The NPS Organic Act, Code of Federal Regulations, and NPS Management Policies broadly require park management to maintain, rehabilitate, and perpetuate the inherent integrity of aquatic resources and processes in ROMO. NPS does not have the ultimate authority under the Clean Water Act over the waters in the park, including the ability to evaluate or designate beneficial uses. It is the responsibility of the state (or EPA) to implement the Clean Water Act and evaluate or designate beneficial uses. NPS policies direct park managers to work with the appropriate partners (such as the Colorado Department of Public Health and Environment and the EPA) to obtain and maintain the highest possible condition of park waters and to restore water quality where needed.

SEI assessment is conducted for informational purposes, outside of any regulatory context, to provide the park and its stakeholders with data and interpretation regarding the condition of the park’s waters. Any comparisons we make using state or federal criteria do not include an official statement as to whether a beneficial designated use was attained.



Field crews collect benthos samples as part of stream ecological integrity monitoring.

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and refer to the full protocol and SOPs listed below

Britten, M., E. W. Schweiger, B. Frakes, D. Manier, and D. Pillmore. 2007. Rocky Mountain Network vital signs monitoring plan. Natural Resource Report NPS/ROMN/ NRR-2007/010. Fort Collins, Colorado.

Schweiger, E. W., L. O’Gan, M. Britten, and D. Shorrock. 2014. Rocky Mountain Network stream ecological integrity monitoring protocol: Narrative, version 1.0. Natural Resource Report NPS/ROMN/NRR—2014/XXX. National Park Service, Fort Collins, Colorado.

Schweiger, E. W., L. O’Gan, M. Britten, and D. Shorrock. 2014. Rocky Mountain Network stream ecological integrity monitoring protocol: Standard operating procedures, version 1.0. Natural Resource Report NPS/ROMN/NRR—2014/XXX. National Park Service, Fort Collins, Colorado.