RECLAMATION Managing Water in the West

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The Knowledge Stream
Research Update

# Assessing the Ecological Costs of Streamflow Regulation

*Measuring the biological health of ecosystems in streams with altered flows*

## Bottom Line

**This study assessed macroinvertebrates (stream animals without backbones, such as crayfish) to determine the effects of streamflow alterations on stream ecosystems. Examinations of 25 mountain streams showed that winter flow depletions strongly and negatively affected biological conditions.**

## Better, Faster, Cheaper

**Understanding how alterations of natural streamflows affect ecosystems is critical to managing water resources.**

## Principal Investigator

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## Collaborators

- **U.S. Geological Survey National Water Quality Assessment Program**
- **Central Utah Water Conservancy District**
- **Utah Division of Water Quality**

## Problem

Changing natural streamflows (that is, changing the frequency, duration, amount, and timing of various streamflows) can alter the ecosystems and biological communities associated with these streams and rivers. Increasingly, riverflows are being managed to balance the needs of ecosystems and society. A key question is: How much can natural hydrology be altered before there are measurable declines in biological integrity (as measured by how the community composition and native species richness in a particular stream segment differ from regional reference conditions)?

Unfortunately, the range of flows that protect biological communities are largely unknown beyond a few case studies. Understanding the relationships between biological integrity and hydrological alteration at regional scales is necessary to establish water management goals that balance ecosystem and society's needs.

## Study and Results

This Science and Technology Program research project, in conjunction with the U.S. Geological Survey's (USGS) National Water Quality Assessment Program, evaluated the relationship between the severity of hydrological changes and biological integrity. We conducted biological assessments of macroinvertebrate communities (such as aquatic insects) in 25 rivers with varying degrees of hydrological alteration with the Wasatch-Uinta Mountain Ecoregion in northeastern Utah and southwestern Wyoming.

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*S. Mark Nelson, Reclamation; Ken Eng, USGS; and Ben Holcomb, Utah Division of Water Quality—taking samples at Currant Creek, Utah.*

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**Streamflow Alterations.** We quantified the severity of alteration of monthly mean streamflows by comparing observed flows to flows expected in the absence of human activities (natural streamflows). Monthly flows represent the seasonal dynamics of runoff, summer recession, and base flow, which are important for many species to signal the next phase in their lives, such as metamorphosis.

Streamflow changes varied widely among sites and, as expected from known water management operations, seasonal streamflow alterations differed between reservoirs and diversions. Diversions appeared to deplete flows throughout the year, while reservoirs tended to inflate flows in summer and substantially deplete flows in spring, fall, and winter. Streams appeared to experience unique patterns of monthly streamflow alteration during spring runoff (May and June) and fall (October).

**Biological Integrity.** We used the quantity and diversity of aquatic invertebrates and analyzed how the observed levels differed from what would be expected in a natural stream as indicators for biological integrity. To compare the biological integrity of the 25 study sites to reference streams, we used recently developed models from the Utah Division of Water Quality.

These results yielded quantitative relations between the severity of streamflow alteration and the degree of biological impairment. Results suggest that water management that reduces streamflows during winter months is likely to have negative effects on biological communities at the bottom of Utah mountain streams, as well as reservoirs downstream.

## Future Plans

Although the exact mechanisms remain unclear, these relationships are still a useful guide to decisions about the tradeoff between flow depletion and stream health. The ability to generalize this relationship to other Rocky Mountain streams also remains unclear and needs corroboration by similar studies in other subregions.

As the streamflow and biological factors that were measured provided little information on community makeup, further research is needed to determine the possible ways altered streamflows could influence macroinvertebrate communities. Analyzing how macroinvertebrate interact with the environment and other species could provide this evidence.

We are currently analyzing an additional dataset collected from streams in California to determine the role that altered temperatures, in conjunction with hydrological alteration, may play in controlling macroinvertebrate communities.

*Caddisfly larvae—one of the many macroinvertebrates that live in the bottom of Utah mountain streams.*

***"Our study yielded quantitative relations between the severity of streamflow alteration and the degree of biological impairment and suggests that water management that reduces streamflows during winter months is likely to have negative effects on downstream benthic communities in Utah mountain streams."***

**D.M. Carlisle, et al. 2012.**

## More Information

**Carlisle, D.M., S.M. Nelson, K. Eng. *"Macroinvertebrate Community Condition Associated With the Severity of Streamflow Alteration."* River Research and Applications, 2012.**

**Science and Technology Program Research Project: www.usbr.gov/research/projects/detail.cfm?id=6188**

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