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The Knowledge Stream
Research Update

Quickly Determining Pools and Riffles Stability in Gravel-Bed Rivers

Evaluating the use of a rapid assessment tool that could help design sustainable pool-riffle habitat

Bottom Line

This research project evaluated simple measurements representing a ratio of averaged cross section flow velocities at a pool and riffle sequence. These measurements may be an indicator that determines the self-sustainability of pools and riffles—even with changes in annual streamflows from climate change, anthropogenic uses, or watershed disturbances.

Better, Faster, Cheaper

This rapid assessment tool may be a cost-effective way to determine if a pool and riffle will be self-sustaining with further field evaluation. This could help identify and develop self-sustaining habitat features and minimize maintenance costs in retaining these features, as well as ascertain where more detailed analyses are warranted. This can save project dollars in both design and maintenance.

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Problem

Gravel-bed rivers are an important habitat for salmonids. Pools and riffles in gravel-bed rivers are particularly critical for spawning and other life stages. Pool-riffle sequences comprise two distinct features. Pools are streambed depressions that occupy the main portion of the channel with a near horizontal water surface slope and lower velocities than riffles under low flow conditions. Riffles usually have steeper water surface slopes and higher velocities at low flow conditions.

The goal for many restoration projects is to create habitat features that will behave like natural systems, with as little intrusive maintenance as possible. This involves balancing natural stream dynamics—the combination of water flows and the available range of sediment sizes. Typically, designing sustainable pools in a restoration project requires either empirical analyses or full three-dimensional hydrodynamic and sediment transport models. But few projects have the budget to conduct a thorough modeling approach.

However, using simple measurements of physical conditions and respective ratios may provide a rapid assessment tool. This tool builds on the hypothesis of "velocity reversal" when the cross section averaged velocity becomes greater within the pool with respect to the riffle. This then assumes that sediment from the pool will scour and settle on the riffle, thus maintaining these sustainable pools and riffles without outside intervention. This tool is a simple one-dimensional criterion used to determine whether sustainable pools and riffles will be retained over time.

If river restoration designers use this tool, they could then determine which pools and riffles are likely to be stable, build features with the self-sustaining ratio properties, and focus efforts on those reaches where additional engineering design may be necessary to protect infrastructure and property.

Collecting data on the Red River Wildlife Management Area, Idaho.

Solution and Results

This Reclamation Science and Technology Program research project evaluated this simple set of measurements to find out if this rapid assessment would predict the stability of pools and riffles. These simple measurements can easily be collected in the field (using a tape for measuring channel widths and survey rod for measuring bottom depths) to determine whether a particular feature within a restoration reach should be left untouched, so efforts can focus on features that may require engineered features to create stable conditions. This information could supplement or replace more detailed numerical modeling used to design habitat restoration projects.

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First, the hypothesis was tested using the one-dimensional criterion by collecting and analyzing field measurements at the Red River Wildlife Management Area. The Idaho Department of Fish and Game manages this area, which is in the Lower Red River Meadow near Elk City, Idaho. Based on work to date:

- Field data support the hypothesis that velocity reversal may be a mechanism for the long-term sustainability of unforced pools.
- This measurement appears to be a reasonable indicator of whether pool-riffle sequences will persist.

Constructed large wood jam on the Trinity River. Ground photograph (left) compared to Light Detection and Ranging (LiDAR) scan (right).

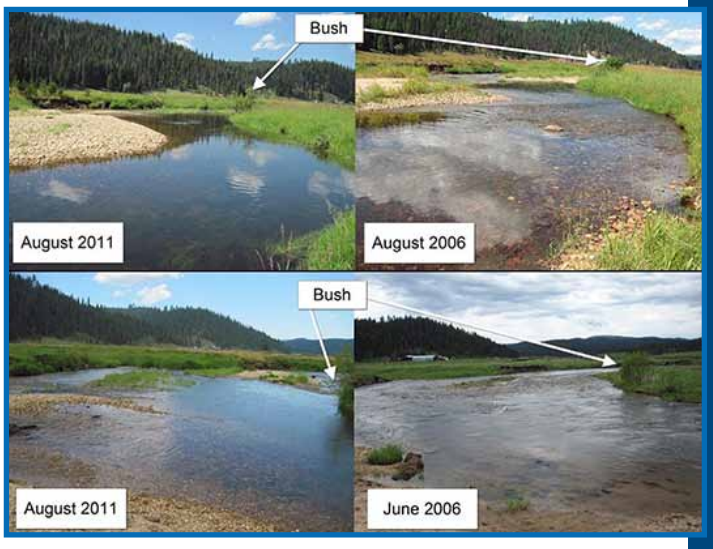
Next, to further understand how sediment transport influences how pools and riffles can be sustainable, laboratory experiments were conducted to replicate field conditions that are typically too dangerous and technically difficult to conduct safely in the field. Examinations of sediment transport processes found that while this rapid assessment tool is a cost-effective approach, it is a simplistic representation of complex hydraulic, sediment transport processes. For example, sediment overload of the pool may restrict self-recovery.

Future Plans

Using this rapid assessment tool means that simple measurements can easily be collected in the field and results have shown the usefulness of the approach in rapidly assessing the vulnerability of pool habitat for the Red River in north-central Idaho.

More testing is needed to:

- Determine the effectiveness of this rapid assessment tool over long periods of time and in other rivers. Monitoring the features in the Red River as the features evolve and move over time in natural systems should also continue.
- Determine how this tool is limited by sediment processes. Further plans are to collect pool-riffle dimensions in Reclamation's ongoing and proposed restoration projects. In addition, these will be applied to other restoration efforts to determine if this predictor can be modified and applied in other ways based on other sediment, hydrologic, or other physical reach conditions (for example, slope gradient).



Before and after—a dual pool-riffle sequence became a single pool-riffle sequence on the Red River Wildlife Management Area, Idaho.

"These physical measurements can be easily collected in the field and may be used in the monitoring and design of sustainable pool-riffle habitat features in gravel-bed rivers. These study results and guidelines could be applicable to instream habitat restoration projects throughout Reclamation."

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Collaborators

- **Reclamation:**
  - ◊ **Pacific Northwest Regional Office**
  - ◊ **Pacific Northwest Region's Columbia/Snake River Salmon Recovery Office**
- **University of Idaho, Center for Ecohydraulics Research**
- **State of Idaho Experimental Program to Stimulate Competitive Research**
- **National Science Foundation**

More Information

www.usbr.gov/research/projects/detail.cfm?id=4362