Monitoring the effectiveness of large wood at maintaining deep pool habitat… through a 500-year flood event

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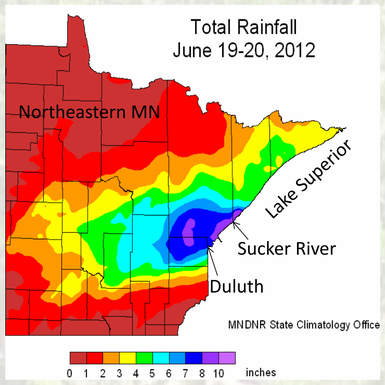
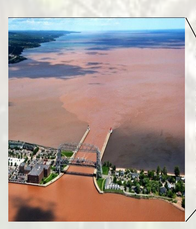
Abstract

Habitat improvement projects employ various techniques to corral flow, create hydrologic complexity, stabilize eroding banks, or improve specific types of stream habitat. Minnesota North Shore streams offer unique challenges with flashy flood peaks followed by low summer base flows, and it is unknown whether techniques used elsewhere will be successful here. We are monitoring the effectiveness of a habitat improvement project conducted by Minnesota Trout Unlimited on the Sucker River in NE Minnesota with the goal of improving deep pool habitat through a combination of installed large woody debris (LWD) jams and cross-vanes. This project is intended to be a test case to see if deep pool habitat can be created and maintained, and if the increase in habitat translates into improvements in local fish populations. Adding to the challenge, a 500-year flood event occurred on June 19-20th, 2012.

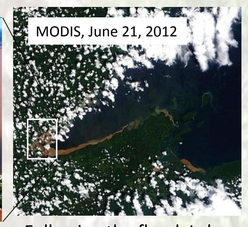
We established a monitoring framework being implemented by University of Minnesota Duluth students through class laboratory assignments. To date, we have conducted pre- and post-installation surveys on 16 transects, plus LWD and pool surveys throughout the entire reach. Results indicate that pool habitat (areas > 60 cm deep) in the 400 meter reach increased from 53 m^2 pre-installation, with 40% of that area in the largest pool, to 123 m^2 immediately post-installation, with 18% in the largest pool. Additional surveys in July and October 2011 found a continued increase in deep pool area, from 208 m^2 to 347 m^2. Wood quantities increased with the addition of installed wood and captured pieces. Conditions changed in the June 2012 flood. In the upstream reach, much of the installed wood was removed and thrown onto the floodplain. At the apex of a tight meander bend, an LWD installation caught at least 80 pieces of LWD. Many pools were filled in, leading to only 94 m^2 of remaining deep pool area, with <50% in one pool. While LWD quantity stayed the same, many installed structures were destroyed and logs moved downstream. Almost half of our transect stakes, both gages on the river, and one major bridge were destroyed.

The June 19-20th, 2012 Flood



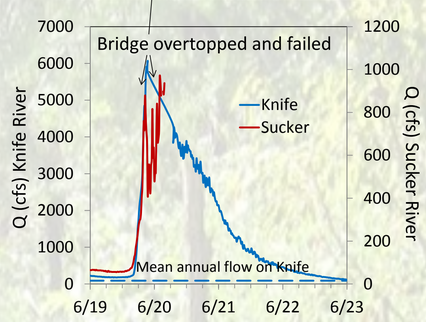


Duluth harbor – red with clay from flood.
(it's usually blue!)



Following the flood, Lake Superior turned red with clay, remaining off-color until it over-turned in early August.

Sucker River bridge, downstream from study site



The main gage on the Sucker River was destroyed when the bridge it was on washed out. The Knife River gage nearby shows the quick rise and fall of the floodwaters. Initial estimates put the flood at an ~500-year event.

Flood damage at nearby Jay Cooke State Park. A dam breach on a canal led to excavation of a new channel.

Looking downstream from breach

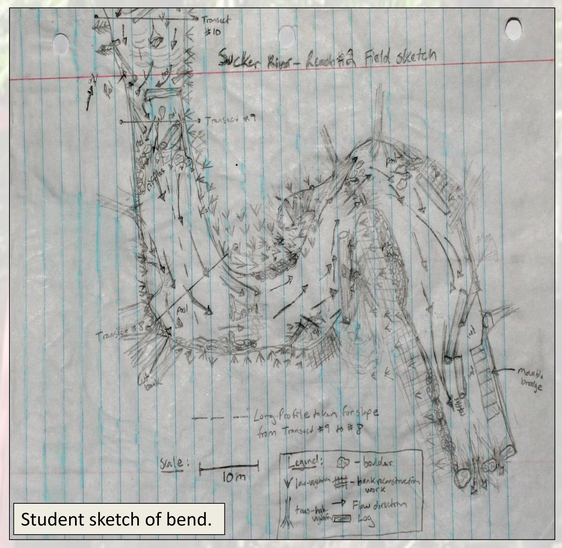
(Technically unrelated to Sucker River site – just very impressive.)

Looking upstream at breach

The students do it all!

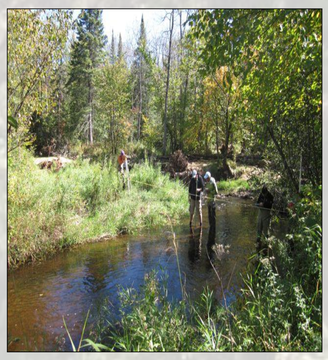
Although the habitat improvement project was initiated by Trout Unlimited and designed by a consulting firm, all of the monitoring is being done by students through class assignments.

Students in Fluvial Geomorphology visit the reach every other year, with additional data sets collected through class independent research projects. We are currently working on getting Stream Ecology students to set up a long-term monitoring program for macroinvertebrates.

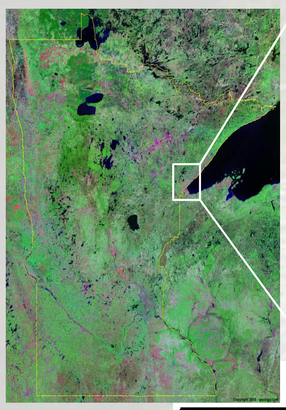


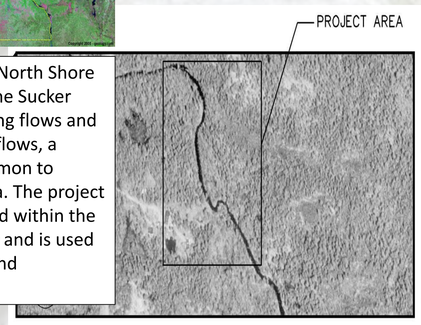
Student sketch of bend.

Students survey transects within their reach using a tripod, level, stadia rod, and tape. They measure velocity to calculate discharge, do Wolman pebble counts to determine grain size, and survey a water surface long profile through their portion of the reach. They calculate roughness and reach-averaged shear stress and analyze variations over the project area.



Project Location



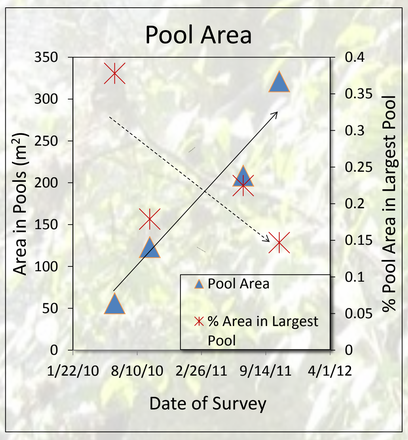


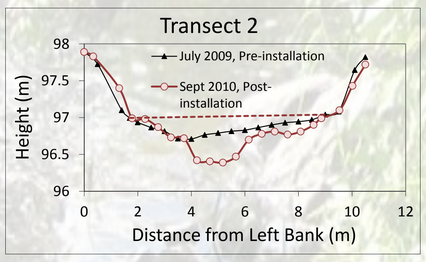
Located along the North Shore of Lake Superior, the Sucker River has high spring flows and low summer base flows, a characteristic common to streams in the area. The project area itself is located within the Haensel's property and is used as a trout fishing and educational area.

The river cuts primarily through clay-rich glacial tills in the upper reaches (project site) and turns into a steep, bedrock channel as it nears the lake.

Project Outcomes, Pre-Flood

Deep pool habitat was created, was being maintained, and was increasing through time.
LWD continued to increase with captured logs.



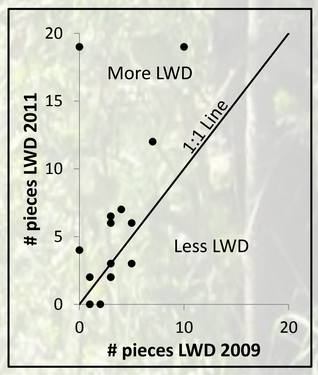


Area in pools (>0.6 m deep) increased from pre-project installation to post-project and has continued to increase over the last year. Care was taken to compare water depths between surveys with the 0.6 m cut-off shifted slightly to keep water depth for pools consistent.

The proportion of pool area found in the largest pool has also declined. There are now more pools with area in pools more evenly distributed.

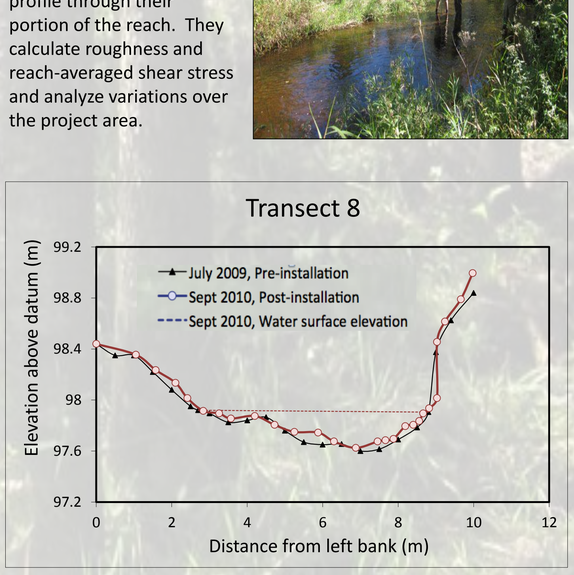
Example of one cross-section where a new pool was created between July 2009 and Sept. 2010.

Installed log jams, Fall 2010.



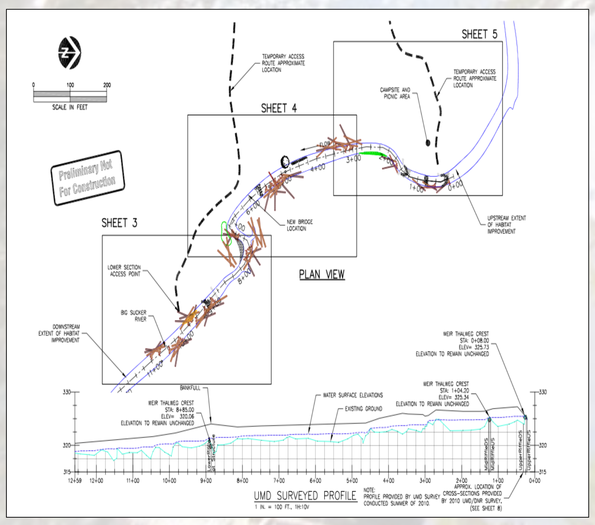
LWD pieces per 25m reach in 2009 (pre-project) and 2011 (post-installation). Most reaches showed an increase in the # of LWD pieces. Overall, the # of pieces almost doubled.

Total Pieces LWD:
2009: 50 (pre-installation)
2011: 91 (1 yr post-installation)

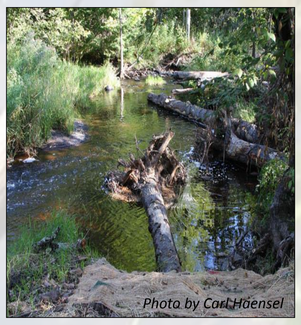


Student data are replicable and adequate for tracking changes along individual cross-sections. Students in multiple classes have assisted with pool and wood surveys for independent projects, too.

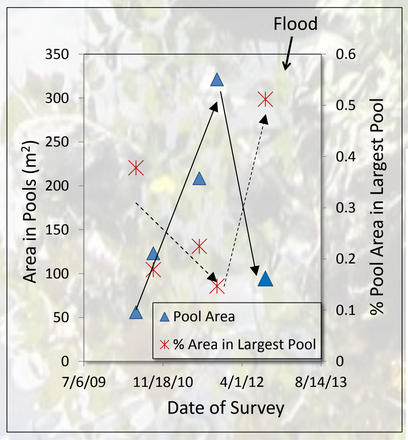
Project Plan



The Sucker River Habitat improvement plan created by Marty Melchior at Inter-Fluve had the overall goals of deepening existing pools, increasing the total number of pools located along the reach, and increasing overhead cover above pools with the ultimate goal of improving trout habitat. The plan relied heavily on installation of log jams, cross-vanes, and bank stabilization mats. All logs used in this project were salvaged from thinning of diseased white pines, and all boulders were sourced on-site.



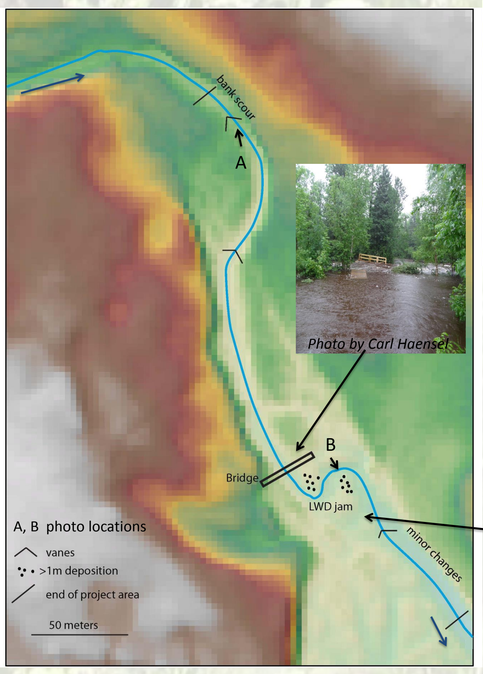
Project Outcomes, Post-Flood



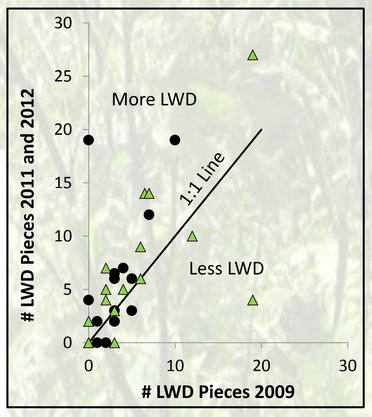
As a result of sediment transport during the flood, pools filled in, dropping the total area in pools to pre-project levels.

Over half of the pool area was found in a single large pool under a LWD jam that grew during the flood.

Steeper, upstream end had significant bank scour (1-2 meters, installed LWD was removed, and new trees fell into channel.



Low-gradient downstream end had only minor bank scour. Most installed LWD remained in place. Much of the flow here moved through the floodplain.

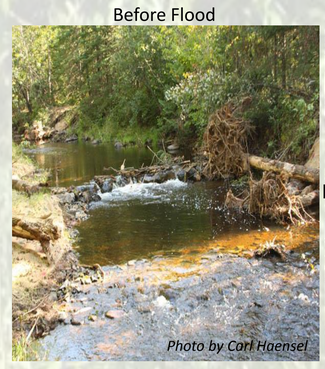


The amount of LWD stayed roughly the same. Many large, installed pieces were thrown into the floodplain and "lost" to the channel, but more LWD pieces were caught by existing jams.

Giant (for northern MN) LWD jam (>100 pieces)

Photo A

Before Flood



After Flood

Installed cross-vane and LWD jam. Channel shifted 1-2 meters towards left banks side (right side of photo), burying half of cross-vane and eroding bank. LWD jam was removed. The boulders in the cross-vane now direct flow into the bank rather than away from it, causing more bank erosion.

Photo B

Before Flood

After Flood

> 1 meter of sand and gravel deposition

On the downstream end of the second bend, looking downstream.
The downstream half of the reach experienced less erosion compared to upstream half, in part because much of the flow moved through the floodplain here.
In the tight bends, significant deposition occurred on point bars.

Many thanks to Minnesota Trout Unlimited, Inter-Fluve, and the Minnesota Department of Natural Resources for partnership in design and development of the project. Funding came from Minnesota's Lessard-Sams Outdoor Heritage Fund and UMD's Center for Community and Regional Research (CCRR).
A final thanks to all the students who helped with field data collection including Julia Halbur, Ehren Inkel, Kirsti Hakala, Vivian Leung, Grant Neitzel, Drew Solberg, Michael Strain, Jeremy Erickson, and all the students in Geology 5260.