Amity Creek Restoration Initiative, Minnesota, USA:

Demonstration project to help restore and protect north shore Lake Superior Basin trout streams.

R. Axler, V. Brady, G. Host, L. Johnson , J. Henneck, E. Ruzycki, N. Will- U. of Minnesota-Duluth (NRRI);
J. Schomberg –MN Sea Grant; K. Gran, G. Neitzel, M. Wick, J. Geissler – U. of Minnesota-Duluth;
K. Anderson, R.C. Boheim, K. Kubiak -South St. Louis SWCD; J. Jasperson, J. Magner, D. Breneman, and B. Story - MN Pollution Control Agency (Duluth)

INTRODUCTION

There are an estimated 720 perennial and 127 intermittent streams that flow into ultra oligotrophic Lake Superior, including 309 trout streams and their tributaries along the Superior north shore and St. Louis River Estuary. Bedrock escarpments create a high density of stream corridors in forested watersheds with steep gradients, thin, erodible soils, typically low productivity, and "flashy" hydrology. These trout streams are especially sensitive to potential impacts from urbanization and rural development: rising water temperature, increasing water and sediment runoff, openings in riparian cover/canopy, impervious surfaces, road crossings, and construction runoff. Impacts from watershed disturbance would likely be exacerbated by concurrent trends in warming and increased frequency of severe storms, that climate change models predict will persist and worsen.

Amity Creek is a cold-water trout stream on the northeast side of Duluth, MN. The upper reaches of its watershed consist of thick glacial tills and glaciolacustrine deposits while the lower reaches flow over primarily bedrock before reaching Lake Superior. Its watershed is mostly undeveloped (~4 % rural-urban, 6 – 8% impervious surface), but faces increasing urban and rural development. The creek was listed as *Impaired* (303(b)) in 2004 due to excess turbidity from suspended sediment, and fish-Hg. Since then, an effort has been made by multiple agencies, organizations, individuals, and UM-Duluth to determine the source and solution to the turbidity problem.

In 2005, a private gift to NRRI-UMD spawned the *Weber Stream Restoration Initiative* (www.lakesuperiorstreams.org/weber) with a goal of restoring and protecting Superior Basin trout streams using the Amity Creek watershed as an ideal demonstration project for restoration, assessment, and extension education activities. Projects carried out by the Partnership from 2005-2011 included two stream bank/channel stabilizations, a neighborhood stormwater reduction experiment, comprehensive water, habitat, and biological monitoring and outreach programs, and developing GIS landscape stressor maps highlighting areas of higher environmental risk.

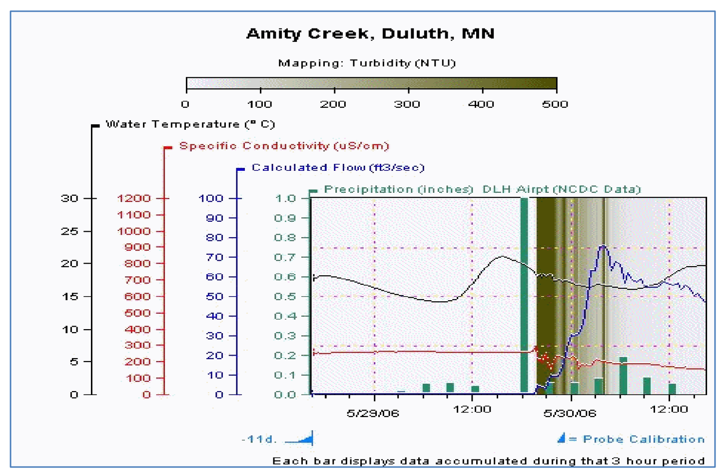
Additional efforts since 2011 have focused on:
1) Stream restoration using BMPs in critical areas; 2) Social tools to reduce erosion and stormwater runoff; 3) A regional ditch design and maintenance handbook; 4) Geomorphic assessment of banks and bluffs using aerial and ground-based Lidar scanning; 5) Assessing potential for increased groundwater storage to reduce flashiness; 5) Water quality, habitat, and biological assessments; 7) Outreach activities.

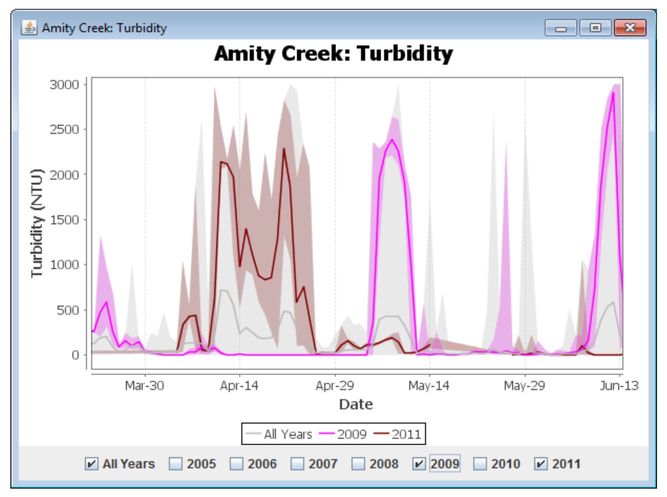
PROBLEM

- Excessive turbidity and suspended sediment in Amity Creek.



Sources of fine-grained sediment are thought to be from eroding stream banks, urban runoff, and increased peak flows. The *LakeSuperiorStreams.org* data viewer tool (left) shows the response of the creek to a rain event. Two days of rain (green bars) at the end of May 2006 led to very high flow (blue line) and turbid or muddy water (brown background). These data are from in-stream, continuous sensors that deliver data daily to the website. The figure on the right shows current stream turbidity data combined with the historical range bands to illustrate how the current data compares with the values from previous years for the same days.

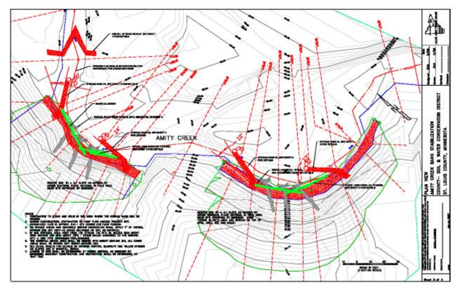




RESTORATION

- **Upper Amity Bank Stabilization**

Eroding banks were identified from NRRI surveys, and the South St. Louis Soil & Water Conservation District led an effort to mitigate two of the largest sediment sources and redirect high flows using J-vanes– the first such project on the Superior North Shore.


- **Graves Road Creek channel stabilization**

This intermittent tributary discharged a muddy plume during rainstorms and snowmelt runoff since a 1946 flood destroyed the road. The City of Duluth carried out a restoration including new culverts, flow rerouting, bank slope reductions, and sediment stabilization.



- **Lakeside Stormwater Runoff Reduction**

UMD scientists, city utilities staff, and local environmental engineers have teamed up with homeowners in Lakeside to determine the best ways to reduce stormwater runoff from a Duluth residential neighborhood. This project will investigate the techniques that reduce runoff the most and their ease of maintenance for homeowners. The ultimate goal is to use what works best to reduce runoff contributing to problems in Amity Creek and other sensitive streams in the region.



- **Tree planting throughout the watershed**

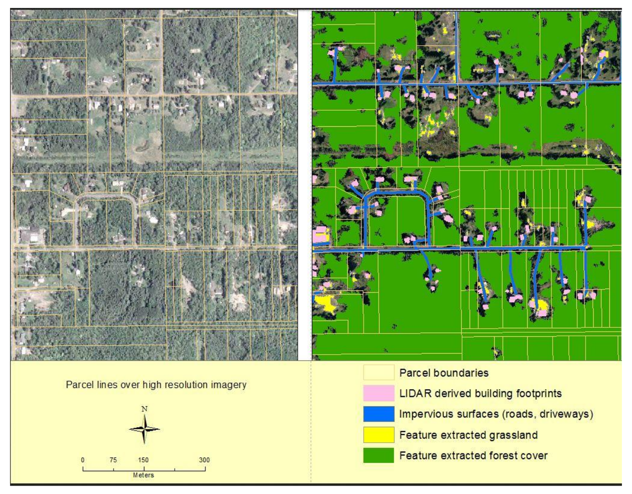
We know that planting trees along streams helps keep the water clean, but we don't know which trees are the best choices. As of 2013 over 2800 trees have been planted throughout the watershed. Amity Creek is also a the site for a study to determine which species can withstand animal browsing, competition from other plants, and are most cost-effective. Volunteers will plant white spruce, white cedar, white pine and tamarack, which will be assigned animal–browsing restraints and weed control treatments. NRRI researchers will monitor the trees monthly to determine their success rates, along with the expense associated with each species and treatment.



OUTREACH

- **Duluth Township Land Use Internet Map Server Tool**

We are using LiDAR imagery and object-oriented image analysis to classify land use within land ownership parcels in three north shore townships. The resulting data will provide inputs to decision tools such as the EPA National Stormwater Calculator and the MN PCA Minimal Impact Design Standards program. LakeSuperiorStreams.org will feature a user-friendly **Internet Map Server "tool"** that will allow landowners to easily generate working base maps of their property.



The goal is to allow easy access to base maps of property that contain multiple layers of the best existing data, such as aerial photographs, topography and wetlands. With this information, landowners can develop a stormwater management plan required by their township and do their part in keeping Lake Superior and its watersheds clean.

- **Duluth Rain Garden Workshops**

A rain garden workshop was held, complete with planting a rain garden that we constructed on a willing property owners yard just outside the study area. All workshop attendees participated in a walking tour of the rain gardens previously installed in 2009 in the study neighborhood, which looked very nice even after just one year of growth.



- **Roadside Ditch Maintenance Guidebook**

This manual will address issues in ditch design specifically for the clay soils in northern Minnesota.

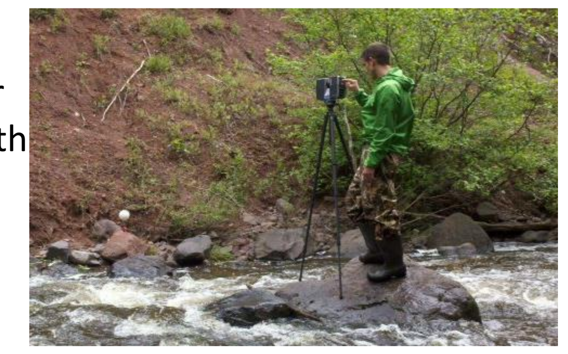

- **Lake Superior Streams Website**

LakeSuperiorStreams.org

Natural Resources Research Institute · University of Minnesota Duluth · Duluth · Sea Grant Minnesota · South St. Louis · University of Minnesota Extension · Minnesota DNR · Minnesota Department of Transportation · NRCS Natural Resources Conservation Service · WLSSD · Minnesota Pollution Control Agency

ASSESSMENTS

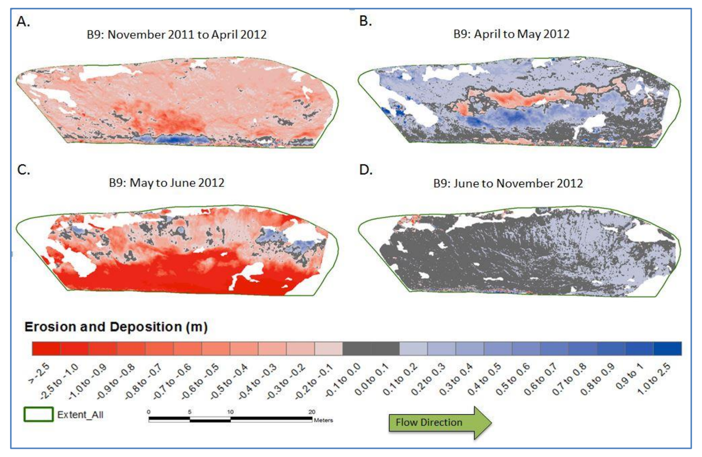
Measuring bluff erosion

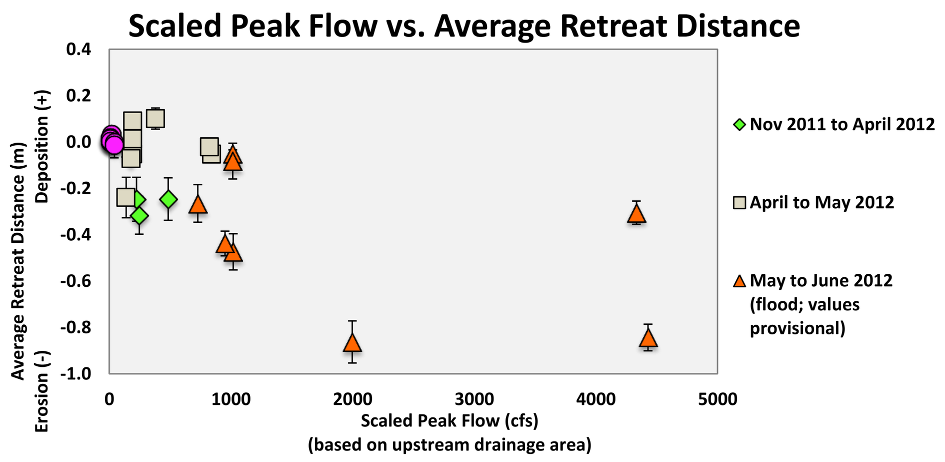


The loss of material from stream bluffs/banks was measured using portable terrestrial laser scanner that provided detailed characterization of erodable bluffs which are an abundant features of all north shore streams.

Data were collected for change detection over a range of time periods:

- Over-winter, low spring melt flood (Nov. 2011 – April 2012)
- Large flood in May 2012
- Flood of record in June 2012
- Low base-flow period (June- Nov. 2012)

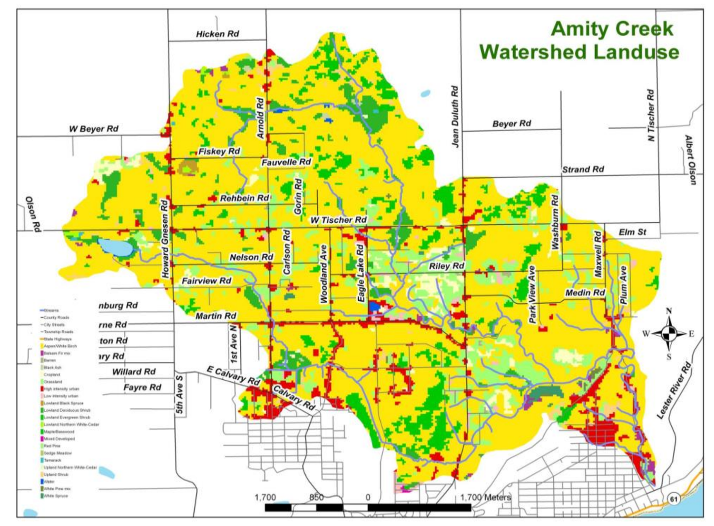


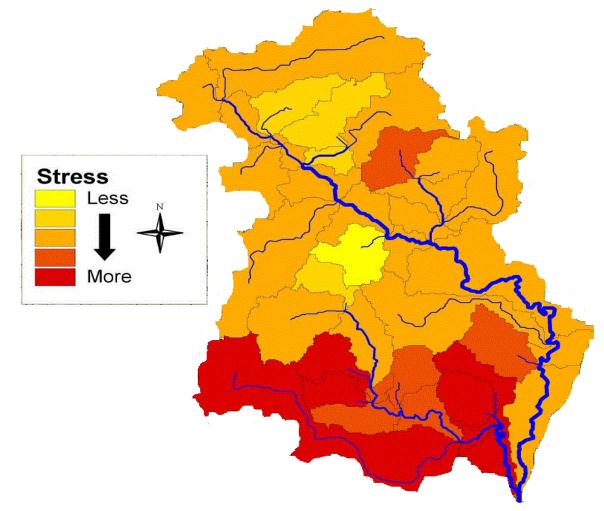


Conclusions: There is a relationship between peak flow between scans and average retreat distance of each bluff, with higher peak flows resulting in greater bluff erosion. Retreat distance was calculated as the volume of sediment eroded divided by the area of analysis on each bluff. This relationship is complicated in part by antecedent conditions and whether bank failure material is removed during the event (common in June event) or deposited at the base of the bluff (common in May event).

Mapping watershed stressors

A number of human activities within watersheds can affect stream health. GIS allows the mapping of those activities to assess their spatial distribution and extent. One method used to investigate how land cover/land use impact water quality is though the development of stressor gradients. These gradients can be based on as few as one component, e.g., percent impervious surface, to hundreds of components.





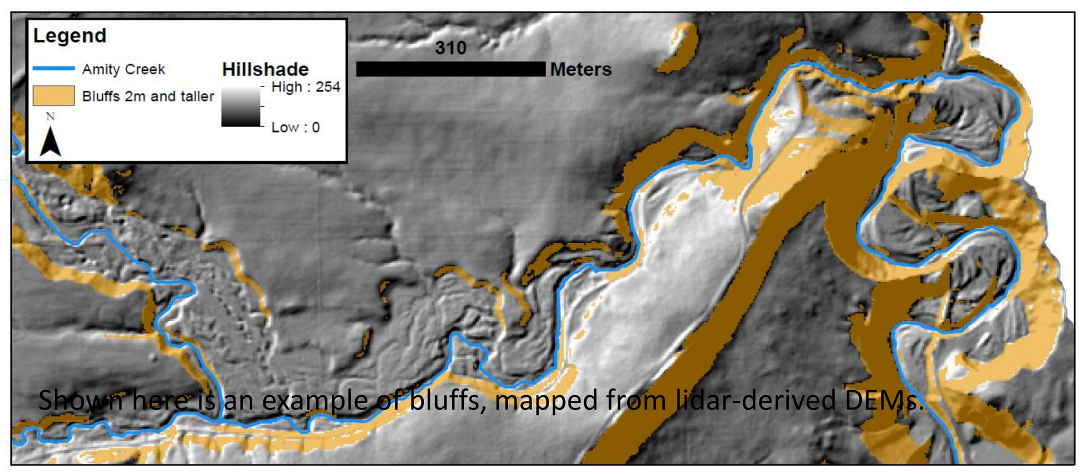
Red colors on the map indicate areas with the most potential to stress streams. The colors represent composite scores that represent population and road density in a given area and reflect conditions on the land both near and upstream of that area. They also suggest where stream stress-causers may accumulate as water flows from each sub-watershed into main streams and, ultimately, to the mouth of the Lester River on Lake Superior. The scores signal where streams may be stressed and help them decide where to focus their research in the watershed.

Predicting erosion hotspots

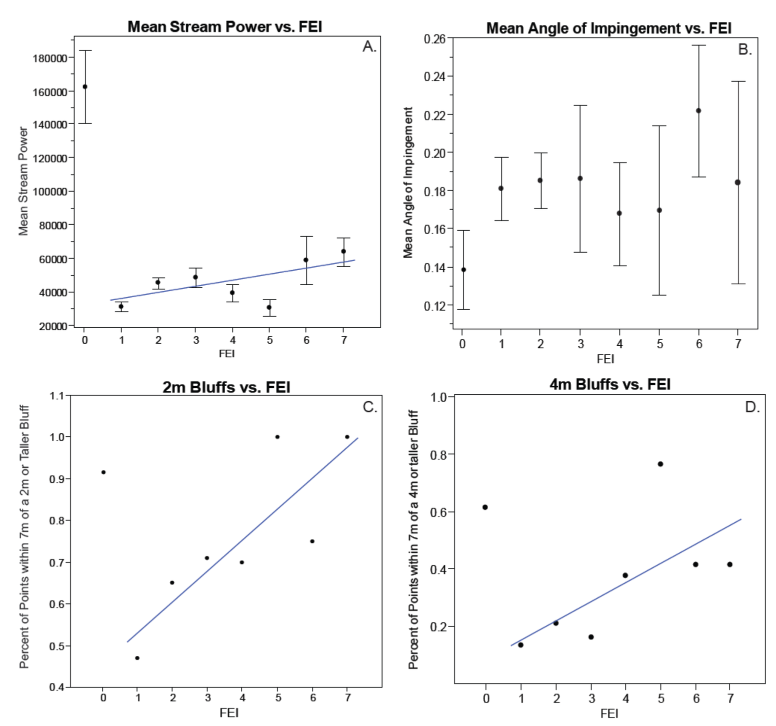
Erosion hotspots predictions utilized high-resolution Lidar DEM, soils (NRCS-SSURGO), and bedrock data. The predictor variables focused on:

- Driving forces: Stream power, Angle of impingement
- Resisting forces: bedrock and soils
- Sediment availability: proximity to high bluffs

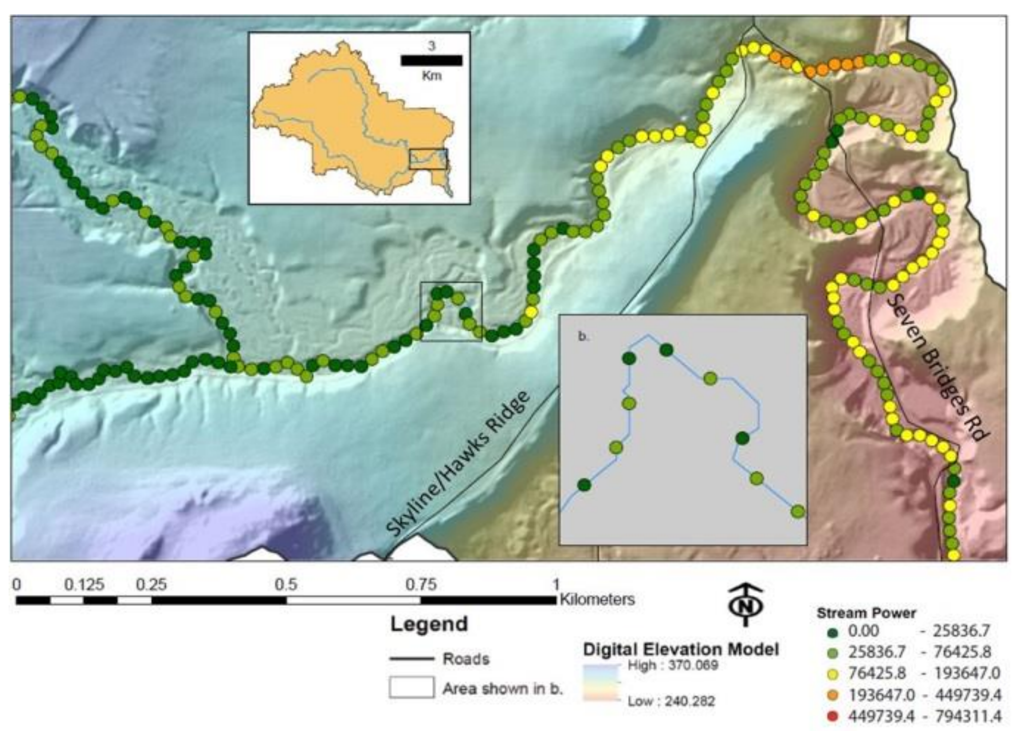
Erosion predictions were compared with erosion mapped after the flood of record in June 2012.



Shown here is an example of bluffs, mapped from lidar-derived DEMs.



Shown here is an example of unit stream power: $\omega = kA^{0.5}S$

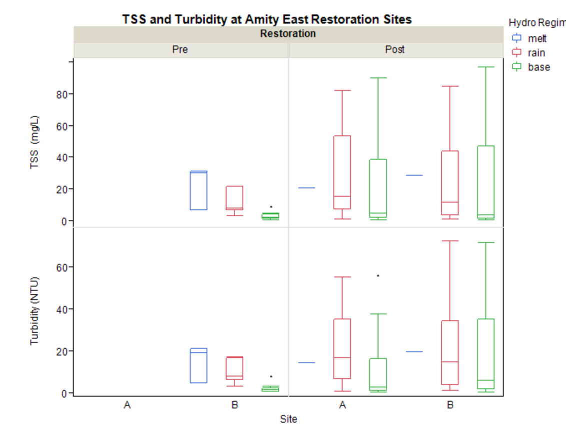


Conclusions: A threshold-based model, predicting erosion in locations with high stream power, bluffs in proximity, and no bedrock, was able to accurately predict erosion over 70% of the channel, while over predicting 10% of all hotspots.

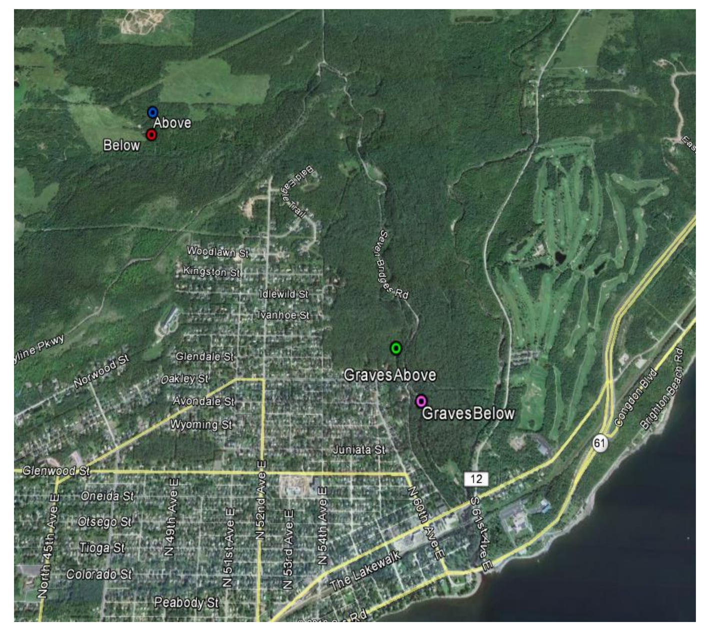
Without knowledge of where bedrock reaches are located, however, high stream power and bluff proximity alone cannot accurately predict erosion hotspots.

Water quality and biology

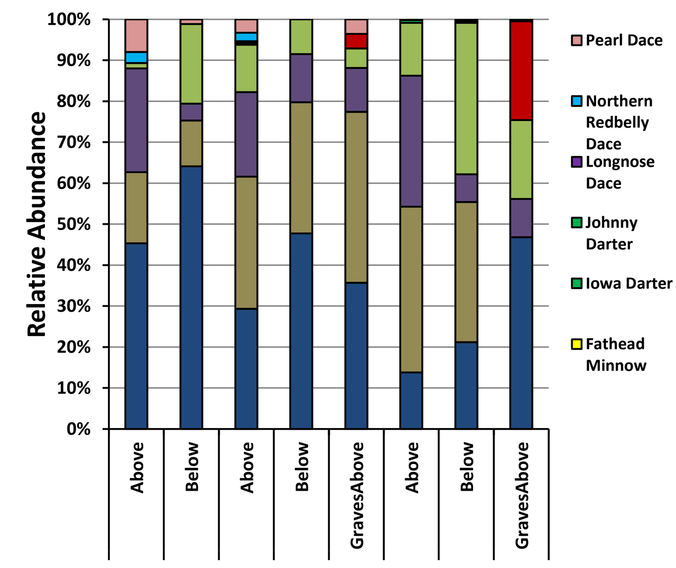
Fish, benthic macroinvertebrates, periphyton, and water quality surveys have been on-going since 2005. In addition, assessments have been made above (upstream) and below (downstream) of two restoration sites, bank stabilization project in the Upper Amity and the Graves Road Creek project in the lower reaches of Amity.



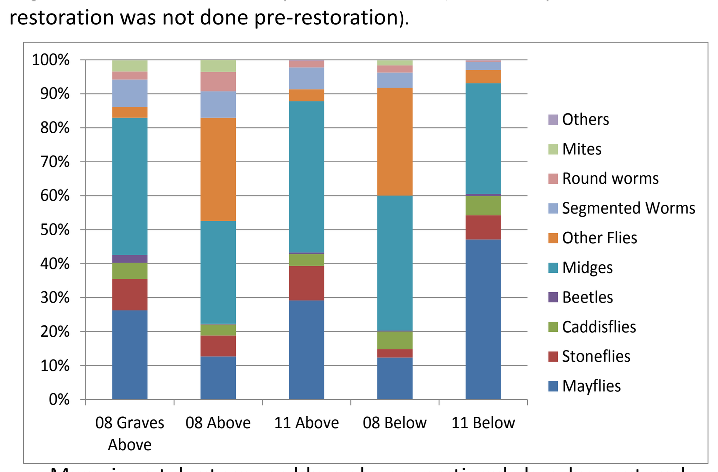
Turbidity and TSS at Amity East restoration sites during each precipitation regime. Pre-restoration and post-restoration (note Amity East Above restoration was not done pre-restoration).



Map showing the restoration sites and sampling locations.



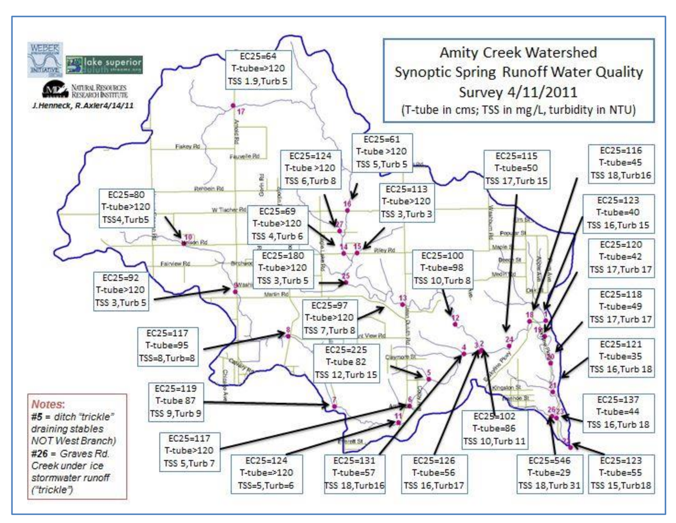
Relative abundances of captured taxa in each station by year standardized to fish/100 m.



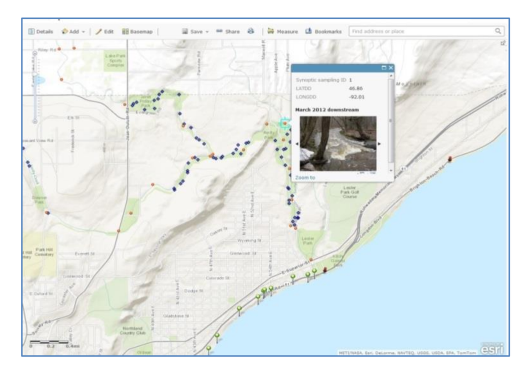
Macroinvertebrate assemblages by proportional abundance at each sampling station for both Before and After sampling periods.

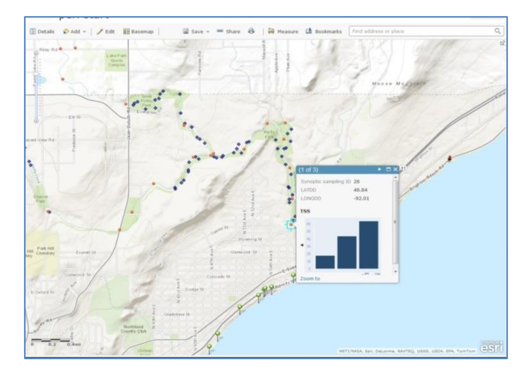
Conclusions: Comparisons of biological and water quality data above and below restoration sites so far is inconclusive. However, base line information has been collected and long-term monitoring will continue. Some observations include:

- The creek segments (stations) sampled above and below the bank restoration on the East Branch of Amity Creek were different from each other prior to the restoration work.
- The station downstream of the bank restoration had greater gains in sensitive invertebrates than did the upstream station, and this is the type of change that we would hope to see.
- No significant differences were seen in water quality measures above and below the sites.



Several stream-wide surveys have also been conducted to help better understand the differences in water quality throughout the watershed. The left figure shows results of a synoptic survey just following snow-melt in 2011. The maps to right allow a user to view both data and images at each of the sampling locations.





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