Optimizing Rural Best Management Practices to Improve Water Quality

Using advanced GIS technologies and approaches to target locations for soil and nutrient management

A water and sediment control basin constructed to keep soil on the field

High Level Results

- Spatial analytical techniques enabled the identification of nutrient and sediment source areas with a high degree of accuracy
- Maps of source areas were the catalyst for starting the discussion with the farming community
- Solid working relationships with the farming community underpinned the pilot's success

"*I'm impressed. These are the areas where we see erosion. I guess I should do something about this*."
Mr. Martin, Farmer
Wellesley, ON

Project Context

Non-point sources of nutrients and sediment remain the most challenging to manage or control for water quality improvement. Funding for best management practices is limited; nutrient and sediment source areas need to be first identified to maximize the benefits of limited funding and yield the greatest improvements in water quality..

This pilot demonstrates advanced GIS tools and an approach to identify nutrient and sediment source areas in the upper Nith River subwatershed – a high priority watershed for nutrient and sediment reduction efforts in the Grand River Watershed.

Challenge

Diffuse, or non-point sources of nutrients and sediment (Figure 1) remain the most challenging to manage or control for water quality improvement yet non-point sources remain the largest contributors to Lake Erie[1]. To address this challenge, areas on the landscape that contribute nutrients and sediments to streams need to be identified at the farm/field scale. These 'source areas' can then be targeted for the adoption of best management practices to realize downstream water quality improvements.

Figure 1. Runoff from a field carries valuable soil and also nutrients. Keeping soil and nutrients on the field is a win-win situation for farmers and the environment.

Project Goals

The Ontario Ministry of the Environment and Climate Change's Showcasing Water Innovation Program provided the opportunity to develop tools and/or approaches using a high resolution digital elevation model (DEM) and advanced GIS techniques to identify nutrient/ sediment source areas at the farm/field scale.

Priority subwatersheds in the Grand River watershed were identified by a synthesis of best available information and documented in a report titled "*Sources of nutrients and sediment in the Grand River Watershed*" (www.grandriver.ca). This work confirmed the upper Nith River subwatershed as a priority subbasin. Within the upper Nith, a small subwatershed was identified to pilot the use of terrain analysis tools and soil erosion models using a high resolution digital elevation model (DEM) (Figure 2).

Solution

The creation of a large-scale, three dimensional (3-D) vector hydrology layer provided the foundation for creating a high resolution DEM. These spatial data layers combined were essential for developing the approach used to identify nutrient and sediment priority areas for targeting best management practices.

[1] A Balanced Diet for Lake Erie. 2014. International Joint Commission. http://www.ijc.org/en_/leep

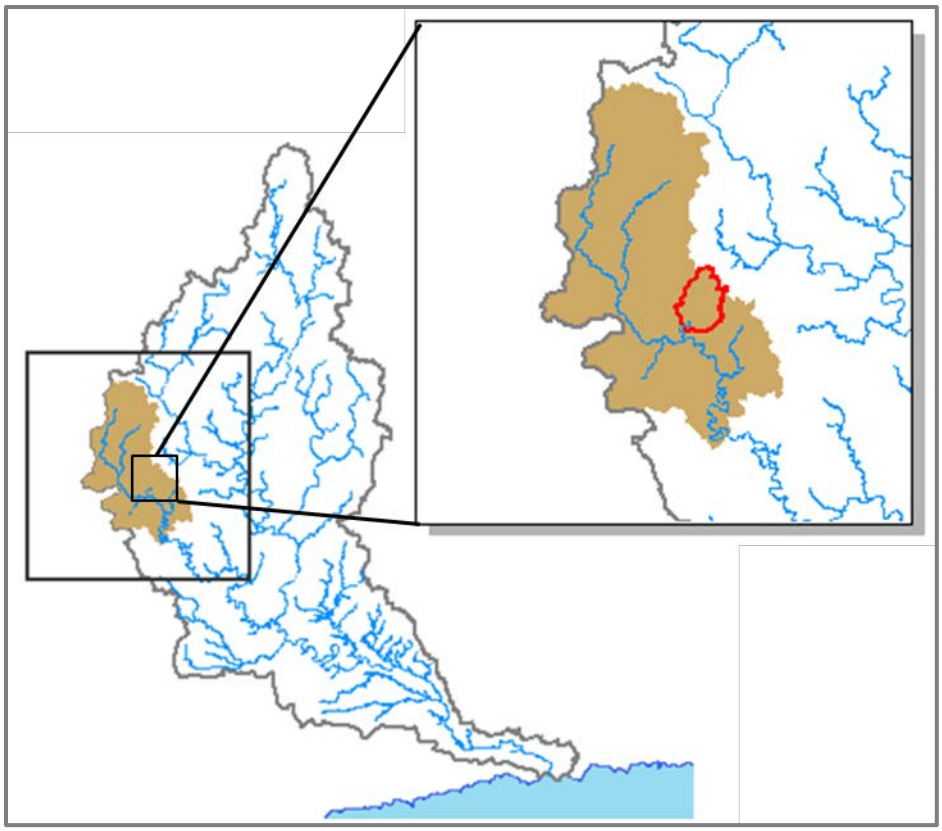

Figure 2. The Location of Firella Creek, outlined in red, in the Upper Nith River subwatershed, coloured in beige.

Two spatial analytical approaches were used to identify source areas - areas defined as susceptible to erosion and nonpoint source runoff. Approaches were developed to characterize two dominant erosion processes – (1) rill/gully; and (2) sheet erosion. Combined, the total soil and nutrient loss from rill/gully and sheet erosion from farm fields can be significant.

First, the terrain analysis approach was used to identify areas of concentrated overland flow that were hydrologically connected to digitized surface hydrology features. Slope and flow accumulation were combined to determine a 'stream power index' (SPI). This approach was used to identify areas with a high potential for gully erosion.

Second, the Revised Universal Soil Loss Equation for Application in Canada (RUSLE-FAC) was used to identify areas with a potential risk of sheet erosion.

Combining the first and second analytical approaches identified those areas that had the highest likelihood of contributing nutrients and sediment to streams (Figure 3).

Farm-scale maps generated from this approach were used by Conservation Specialists to start a discussion with local farmers about soil and nutrient loss. Conservation Specialists were able to offer technical and financial assistance to the farmers through the Rural Water Quality Program – a municipal, provincial and federal cost-share program administered by the Grand River Conservation Authority, to implement best management practices.

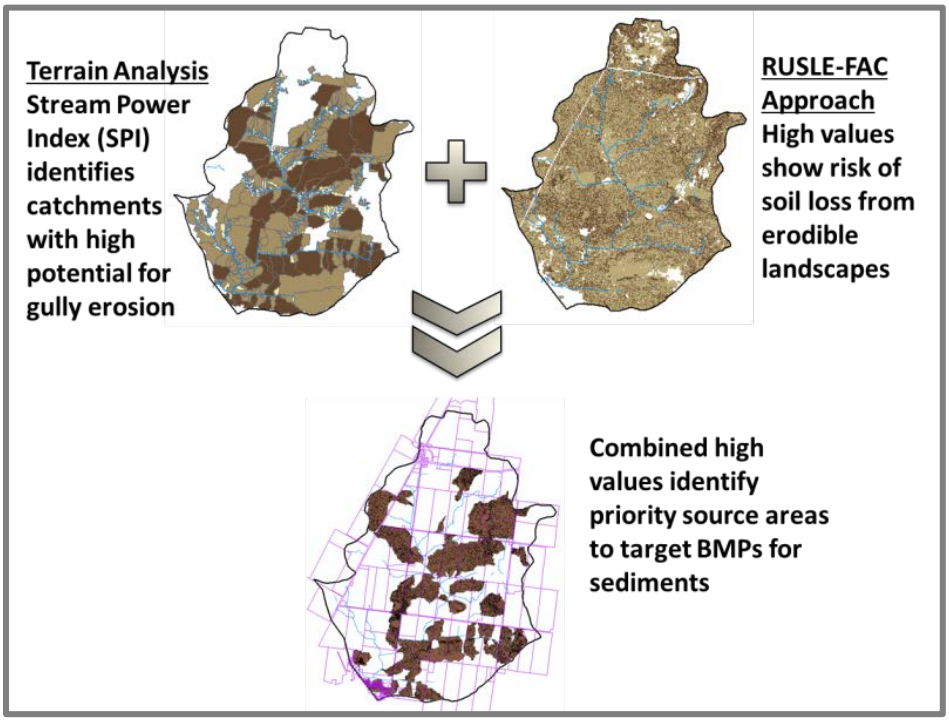

Figure 3. Nutrient and sediment source areas in Firella Creek subwatershed were identified by combining maps of gully (terrain analysis) and sheet (RUSLE-FAC) erosion.

Results

- The terrain analysis approach identified areas with a high likelihood of gully erosion with a high degree of accuracy (90%) when verified in the field.
- Characterization of sheet erosion was facilitated by high resolution soils data for the study area; cropping data were limited.
- The series of maps generated from this project proved to be a catalyst among soil, agronomists, and water experts to discuss and conceptualize nutrient and erosion processes at the subwatershed and farm/field scale.
- The approach proved to be very useful to identify farm/field scale areas that had a high likelihood of contributing sediment and nutrients to streams.
- Farm/field scale maps were catalysts for starting the discussion about sediment and nutrient source areas on the farm. One farmer consulted through this process confirmed the accuracy of the source area maps and requested assistance in designing an erosion control project to mitigate soil loss. Since the maps were useful to the farmers for learning about areas of potential nutrient loss, they were accepted with interest.

Lessons Learned

- The success of this pilot was entirely dependent on the long-standing relationships that have been built by staff at the Grand River Conservation Authority and the farming community over the past 18 years. An adequate long-term financial incentive and technical assistance program enabled this relationship to be built. The long-standing relationships helped to facilitate the vetting of the mapping and information developed by this pilot.
- Cropping information is required for evaluating seasonal or year-to-year variability of the nutrient/sediment source areas.

Next Steps

- The approach developed in this pilot will be critical for targeting best management practices that will yield the greatest potential for improving water quality and limiting soil loss. In essence, it will help find the best value solutions for addressing sediment and nutrient loading issues in the watershed and for Lake Erie.
- The mapping and information from this pilot will improve the ability to connect the land management issue to the appropriate Best Management Practices (BMPs). For example, the information generated by this mapping approach facilitates promoting erosion control structures to areas of highest risk for gully erosion, and promoting conservation practices such as cover crops for those areas with the highest risk of sheet erosion.
- The mapping products may be useful in determining areas that require higher incentives or specific BMPs to address erosion.
- The mapping products will be used by water experts to identify appropriate sites for monitoring water quality to evaluate the effectiveness of BMPs through research and monitoring projects.
- The high resolution DEM has multiple benefits to resource managers. For instance, the DEM will be used for the design of erosion control structures on-farm and mapping other watershed features such as floodplains; there is also interest in applying this approach to identify locations for erosion control measures in urban development sites.
- The tools and approach developed through this pilot will be further refined and applied to other areas of the Grand River watershed. The knowledge and tools will be transferred to the larger resource management community through continued financial support by the Ontario Ministry of Agriculture, Food and Rural Affairs.

Application for Ontario Communities

High-resolution Digital Elevation Models are essential tools for evaluating and solving many resource management challenges. The application of these advanced GIS technologies and tools can assist with identifying nutrient and sediment source areas throughout Ontario and Canada; however, the approach presented in this pilot should

be field verified and adapted to local topography and landscape characteristics. These tools also have great application for floodplain mapping and hydrologic modelling. Implementing best management practices in critical source areas will help to reduce nutrient and sediment loading to creeks and rivers but also to the Great Lakes – a key directive in the Great Lakes Water Quality Agreement.

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