Prioritizing Water Quality Improvement Efforts on Agricultural Lands Using Readily Available GIS Data

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Overview

- Water quality in Wisconsin
- EVAAL
- Tillage estimations
Water Quality in Wisconsin

- TMDL = Total Maximum Daily Load
- Established under the Clean Water Act
- The maximum amount of a pollutant that a waterbody can receive and still safely meet water quality standards
TMDL Purpose

Current Pollutant Load

Meets water quality standards
TMDLs Statewide

Status of Wisconsin’s TMDLs

Notes:
1. Map reflects TMDLs for all pollutants (TSS, TP, PCBs, Hg, etc) reported in the WCNR Waters database as of April 2013.
2. Sub-HUC12 watersheds were delineated using PRESTO.
TMDL Results

Total Phosphorus (lbs/acre/year)

- 0.0-0.3
- 0.3-0.6
- 0.6-0.8
- 0.8-1.1
- 1.1-1.6

Green Bay
Kankapot Creek Watershed

- 23 square miles
- 187 farms
- 1,129 fields
Available Datasets

- LiDAR
- Crop Data
- Soils
EVAAL

- Erosion Vulnerability Assessment for Agricultural Lands
- GIS–based model
- Vulnerability to erosion and nutrient export
- Deprioritizes internally draining areas
Erosion Vulnerability Analysis

USLE + SPI - IDA

= EVAAL

Erosion Vulnerability Assessment for Agricultural Lands
Sheet and rill erosion

\[ A = RK(LS)CP \]

- Rainfall erosivity
- Soil erodibility
- Slope/Slope-Length
- Cover factor
- Practice Factor

SSURGO soils
DEM Cropland data
Crop Data

http://nassgeoddata.gmu.edu/CropScape/
Crop Rotations

RUSLE2 -> Rotational C Factor

= Cash Grain Rotation
Soils – gSSURGO

http://datagateway.nrcs.usda.gov/
Stream Power Index

- Potential for gully erosion

$$SPI = f \text{ (slope, catchment area)}$$
Area that do not contribute to surface waters:

\[ V_s \geq V_r, \text{ Internally drained} \]
\[ V_s < V_r, \text{ Not internally drained} \]
Internally Draining Areas

- Areas that do not contribute to surface waters
Results

USLE

Erosion Vulnerability

NC Areas

Legend:
- Low
- Medium
- High
EVAAL Website

- Documents
- Tutorial Data
- ArcToolbox

Erosion Vulnerability Assessment for Agricultural Lands (EVAAL)

The Wisconsin Department of Natural Resources (WDNR) Bureau of Water Quality has developed the Erosion Vulnerability Assessment for Agricultural Lands (EVAAL) tool to assist watershed managers in prioritizing areas within a watershed which may be vulnerable to water erosion (and thus increased nutrient export) and thus contribute to downstream surface water quality problems. It evaluates locations of relative vulnerability to sheet, rill and gully erosion using information about topography, soils, rainfall and land cover. This tool enables watershed managers to prioritize and focus field-scale data collection efforts, thus saving time and money while increasing the probability of locating fields with high sediment and nutrient export for implementation of best management practices (BMPs).

Erosion Vulnerability Index

EVAAL was designed to quickly identify areas vulnerable to erosion, and thus more likely to export nutrients like phosphorus, using readily available data and a user-friendly interface. This tool estimates vulnerability by separately assessing the risk for sheet and rill erosion (using the Universal Soil Loss Equation, USLE), and gully erosion (using the Stream Power Index, SPI), while deprecimating those areas that are not hydrologically connected to surface waters (also known as internally drained areas, IDA). These three pieces are combined to produce an erosion vulnerability index value that can be assessed at the grid scale or aggregated to areas, such as field boundaries.

EVAAL, Version 1.0 (August 2014)
- Fact Sheet (.pdf)
- Tutorial (.pdf)
  - Includes installation instructions to be read prior to downloading EVAAL model files
- Methods Documentation (.pdf)
- EVAAL Model Files (zip)
- EVAAL Tutorial (zip)

Contact Information
For questions or information about this model, please contact:

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http://dnr.wi.gov/topic/nonpoint/evaal.html
EVAAL Applications

- Counties, consultants, NGOs for watershed planning
  - > 15 counties
    - 9 key element & TMDL implementation plans
    - Land and water resource management plans
    - Lake management planning
    - Adaptive management/water quality trading
Limitations

- We can’t model what we don’t know
  - Tillage
  - Manure application
  - Soil P
  - BMPs

- Erosion must be driving factor

- Does not account for delivery factors or tile drainage

- Cannot “target”, rather “prioritize”
Currently assuming high or low C factor

Use Landsat satellite imagery

Calculate Normalized Difference Tillage Index (NDTI) values and correlate to residue cover and associated tillage type
Satellite Imagery Analysis

- Landsat 7 & 8
- Normalized Difference Tillage Index
- $\text{NDTI} = \frac{\text{band5} - \text{band7}}{\text{band5} + \text{band7}}$

“Remote Sensing Of Crop Residue Cover Using Multi–temporal Landsat Imagery”
B. Zheng – 2012
NDTI is positively correlated with crop residue cover and green vegetation.
NDTI Changes with Time

“Remote Sensing Of Crop Residue Cover Using Multi-temporal Landsat Imagery”
B. Zheng – 2012
Obtain imagery throughout spring planting season
Preprocessing: remove obscured pixels
Calculate minNDTI
Transect Data

- Link known tillage practices and crop residue percentages to spectral signatures
- Annual data collection
- Includes
  - Crop type
  - Tillage type
  - Percent residue
Relating Residue Cover and \text{minNDTI}

\begin{equation*}
y = 0.1118x + 0.0212
\end{equation*}

\[R^2 = 0.8648\]

\text{minNDTI} vs \% Crop Residue Cover

- \text{Marathon County minNDTI 2012}
- Linear (Marathon County minNDTI 2012)
Marathon County Crop Residue Cover

Legend:
- 0-20%
- 21-40%
- 41-60%
- 61-80%
- 81-100%
Relating minNDTI to Tillage Type

Tillage Type (%CRC) | 2012 minNDTI
--- | ---
Moldboard (0-15%) | 0.0001 – 0.0380
(16-75%) | 0.0380 – 0.0771
No Till (76-100%) | 0.0771 – 0.2999
Challenges

- Landsat
  - Data gaps
  - Clouds
  - Timing/availability
  - Soil moisture impacts

- Validation data

- Computing time/power
Conclusions

- EVAAL uses readily available data to assess erosion vulnerability; can be used to prioritize watershed efforts

- NDTI is positively correlated to crop residue coverage; can be used to infer tillage

- EVAAL results can be improved using satellite derived tillage information
Questions

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