Application of an Enhanced, Fine-Scale SWAT Model to Target Land Management Practices for Maximizing Pollutant Reduction and Conservation Benefits

Amanda Flynn, Todd Redder, Joe DePinto, Derek Schlea Brian Lord, Laura Weintraub

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Presentation Outline

• Project Background and Role in GLWESS
• Tiffin Watershed
• Enhanced, Fine-Scale SWAT Model (TRSWAT)
• Targeted Land Management Practices
Project Background
Great Lakes Tributary Modeling Program

• Objective: “develop a tool for watershed planning that is usable and will be used by stakeholders who make decisions about soil conservation and NPS pollution prevention measures...” ([http://glc.org/tributary/](http://glc.org/tributary/))

• Funded by the USACE-Buffalo District under 516(e)

• TRSWAT used to determine sediment and nutrient:
  – Critical source areas
  – Key transport pathways
  – Effect of management practices on rates of delivery (i.e., load reduction) to watershed outlet
Overview of Ecological Concerns

• Impact of degraded stream habitat & water quality on fish/macroinvertebrate indicators

• Watershed export of sediment and nutrients:
  – Suspended solids
  – Phosphorus (P), especially soluble reactive P
  – Nitrogen (N)

• Eutrophication & sedimentation impacts in WLEB:
  – High sedimentation rates in Federal navigation channel
  – Harmful algal blooms (HABs)
  – Nuisance benthic algae
Great Lakes Watershed Ecological Sustainability Strategy (GLWESS)

- Link ecosystem improvement outcomes to type, placement and amount of BMPs applied in watershed
- Test transaction framework that will pay for water stewardship practices based on how well they reduce the release of sediment and nutrients from farmlands
- Models used to support transactions
  - SWAT watershed models
  - Western Lake Erie Ecosystem Model (WLEEM)
- Agricultural community will be ultimate end user
Tiffin River Watershed
Tiffin River Watershed

Maumee River Basin
(6,300 mi²)

http://en.wikipedia.org/wiki/Maumee_River
General Watershed Characteristics

- Topography of the watershed is flat to rolling:
  - 0-6% slope = 95% of drainage area
  - Max percent slope ~23%
- Annual average precipitation ranges from 34 –37 inches
- 90% of the soils are moderately poor to very poorly drained (HSG C/D)
- Land use is predominantly agriculture; extensively tile drained

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Percent of Area</th>
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<tbody>
<tr>
<td>Cropland</td>
<td>51.7%</td>
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<tr>
<td>Forest</td>
<td>19.1%</td>
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<tr>
<td>Pasture</td>
<td>10.3%</td>
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<tr>
<td>Urban</td>
<td>16.7%</td>
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<tr>
<td>Wetland</td>
<td>2.1%</td>
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Enhanced, Fine-Scale SWAT Model (TRSWAT)
SWAT Background

• Developed by USDA-ARS
• Models daily flow, TSS, and nutrients
• Accounts for land management practices

• Limitations
  – HRUs not spatially explicit within subbasin
  – No simulation of ephemeral gullies
HRUs represent multiple (non-contiguous) areas within subbasin with common characteristics:

1) Land use/cover
2) Soil drainage conditions
3) Land slope
Watershed & Subbasin Delineation

- Fine-scale SWAT model:
  - 907 subbasins
  - Average area of ~540 acres
  - >15,000 HRU’s (LU/LC, soils, slope, and management)

- Based on NHDPlus DEM, stream network
Ephemeral Gully (EG) Erosion

- Incorporate TI-EGEM algorithms into SWAT code
- Confirmation, testing, and diagnostics
- Identify PEG’s based on high-resolution DEM, satellite imagery, CTI
- Implementation in TRSWAT

Ephemeral gully in Upper Auglaize watershed (Bingner et al. 2005)
Tiffin satellite imagery of EG’s
Potential Ephemeral Gully Locations (Ohio portion only)
Crop and Tillage Rotations

- Develop a 4-year crop rotation/tillage operation sequence for each cropland HRU
- Crop data from USDA NASS cropland data layer
- Tillage data from NRCS transects, remote sensing
Targeted Land Management Practices
TRSWAT Model Application Approach

• **Goal:** Evaluate the impact of land “random” versus “targeted” management alternatives on sediment/nutrient export from the Tiffin River watershed

• **Approach:**
  – Evaluate appropriate BMP/land management alternatives for ephemeral gully erosion and nutrient export
  – Translate BMPs into modified SWAT inputs
  – Run the suite of BMP scenarios
  – Interpret results & report findings
Ephemeral Gully Contributions

- Relative proportions of erosion sources “watershed wide”

<table>
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<tr>
<th>Sediment Source</th>
<th>% Source Contribution to Total Sediment Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheet and Rill</td>
<td>71%</td>
</tr>
<tr>
<td>Ephemeral Gully</td>
<td>29%</td>
</tr>
</tbody>
</table>

- Ephemeral gully erosion contribution varies significantly by HRU, contributing ~0 to 90% of the total sediment load
SWAT BMP Representation to Address Ephemeral Gully Erosion:

• **Grassed Waterways:**
  - **Conceptual:** reduce sediment/nutrient erosion from ephemeral gullies, first-order channels and ditches.
  - **SWAT Representation:** remove ephemeral gully locations from HRUs, incorporate grassed waterway (assumed 5 meter (~16 ft) width)
TRSWAT Scenarios:

- **Baseline** = Historical conditions
- **Random** = EG removal/ grassed waterways implemented on 20% of the watershed area by random selection of subbasins
- **Targeted** = EG removal/ grassed waterways implemented on 20% of the watershed area based on highest sediment yield/most erodible subbasins
TRSWAT results indicate a +11\% reduction in sediment subbasin yield for targeted grassed waterway implementation compared to random implementation.
Preliminary Results – TP is not yet fully calibrated in TRSWAT.

Greatest load reduction resulted from targeted grassed waterway implementation.
TRSWAT results indicate a **+5% reduction** in TSS load and **+14% reduction** in TP load at the watershed outlet for **targeted** grassed waterway implementation compared to random implementation.
Transactions $\rightarrow$ Ecological Endpoints

Transactions
- Reverse auction
- Certification

Improved Management Practices
- Type of practice(s)
- Affected land area

Watershed Models (SWAT)

Western Lake Erie Ecosystem Model (WLEEM)

Ecological Endpoints

Improved “Indices of Biological Integrity” (IBIs)
(various locations in stream network)

Reduced Nutrient & Sediment Delivery (@ tributary mouths)

Reduced Algal Growth in Western Lake Erie Basin
- *Microsystis* blooms
- *Lyngbya* blooms

TRSWAT will be used to identify transactions that incentivize agriculture practices to produce desired ecosystem benefits
Questions?

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Contact Information:

Amanda Flynn, Project Scientist
501 Avis Drive, Ann Arbor, MI 48108
aflynn@limno.com