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

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Presentation Outline

- Project Background and Role in GLWESS
- Tiffin Watershed
- Enhanced, Fine-Scale SWAT Model (TRSWAT)
- Targeted Land Management Practices

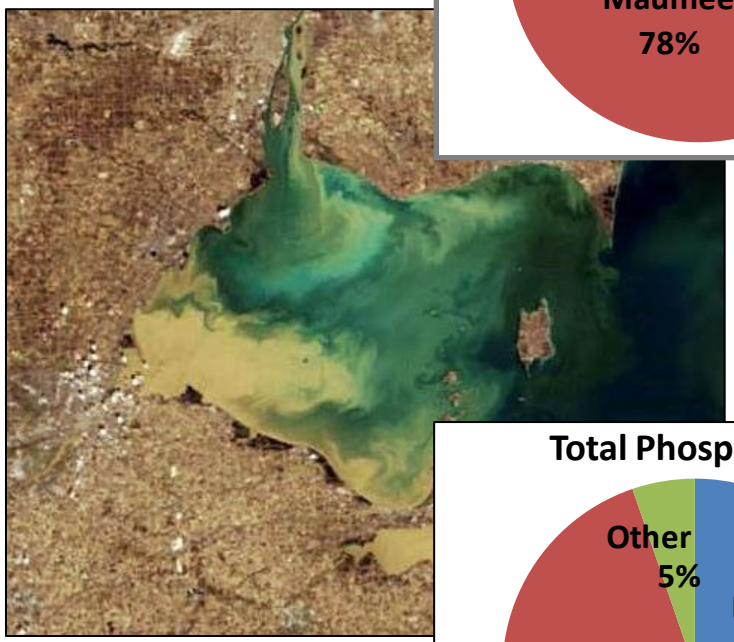
Project Background

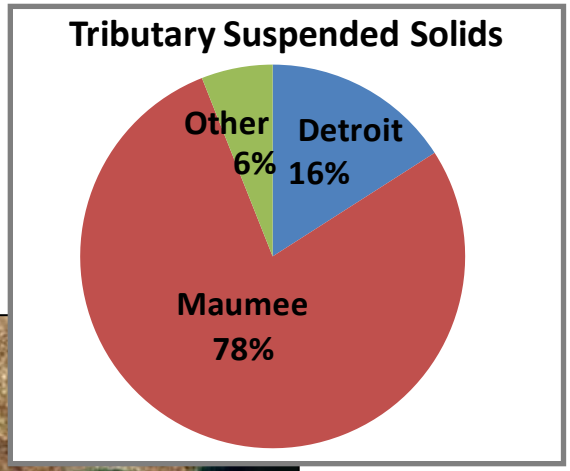
Great Lakes Tributary Modeling Program

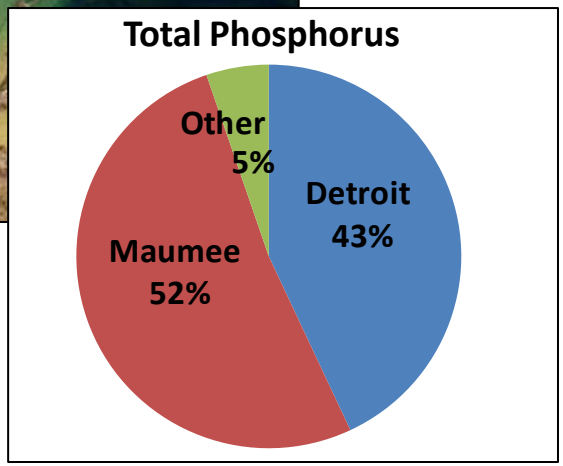
- Objective: “develop a tool for watershed planning that is usable and will be used by stakeholders who make decisions about soil conservation and NPS pollution prevention measures…” (*http://glc.org/tributary/*)
- Funded by the USACE-Buffalo District under 516(e)
- TRSWAT used to determine sediment 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

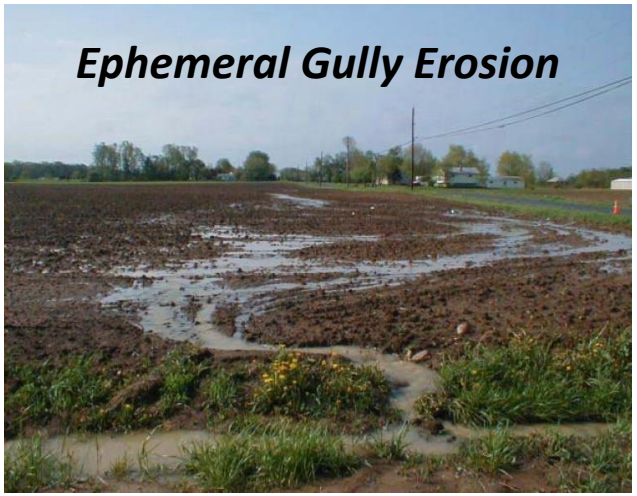






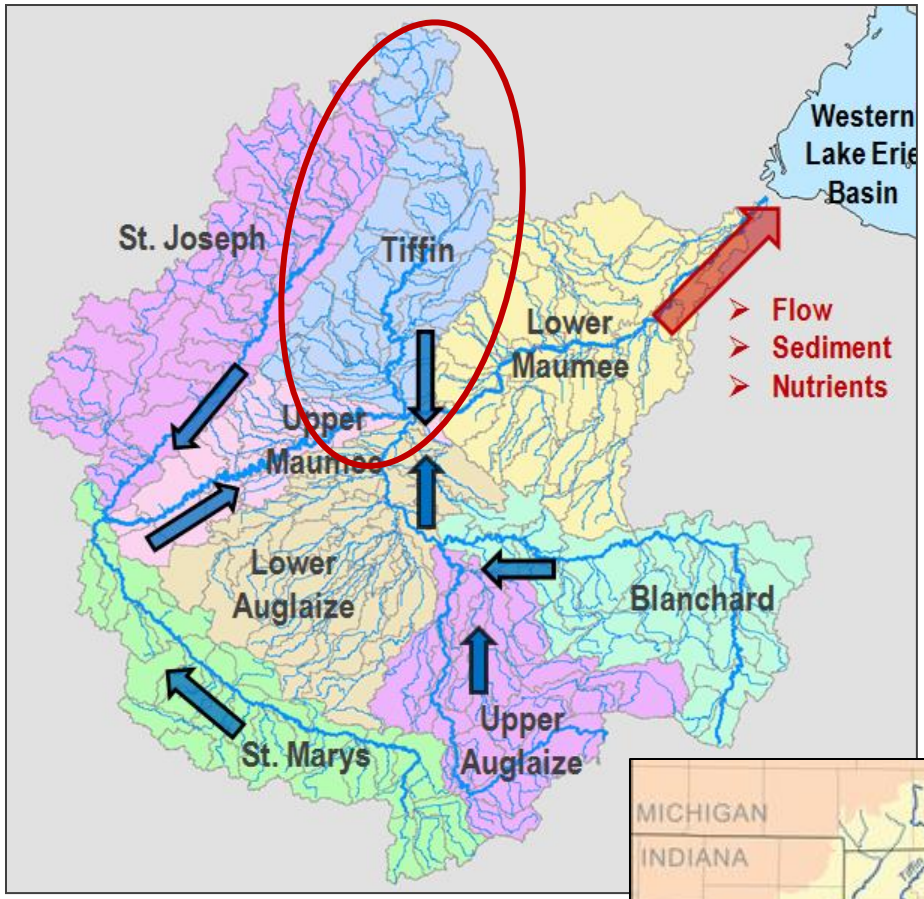
Great Lakes Watershed Ecological Sustainability Strategy (GLWESS)

- 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

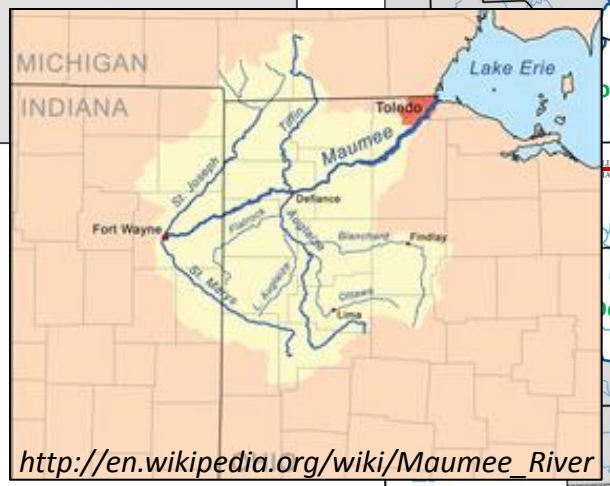


Tiffin River Watershed

Tiffin River Watershed



Maumee River Basin (6,300 mi²)



http://en.wikipedia.org/wiki/Maumee_River

Tiffin River Watershed (778 mi²)

Michigan

Ohio

Hillsdale County

Lenawee County

Fulton County

Henry County

Defiance County

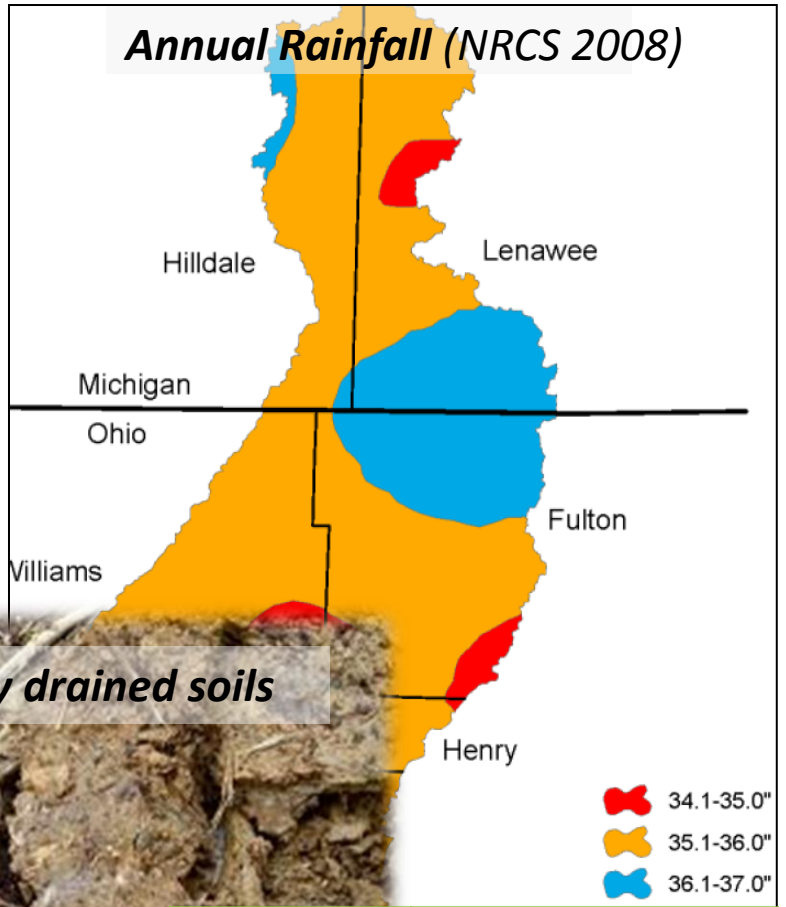
04184500 Bean Creek at Powers OH

04185000 Tiffin River at Stryker OH

04192500 Maumee River near Defiance OH

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

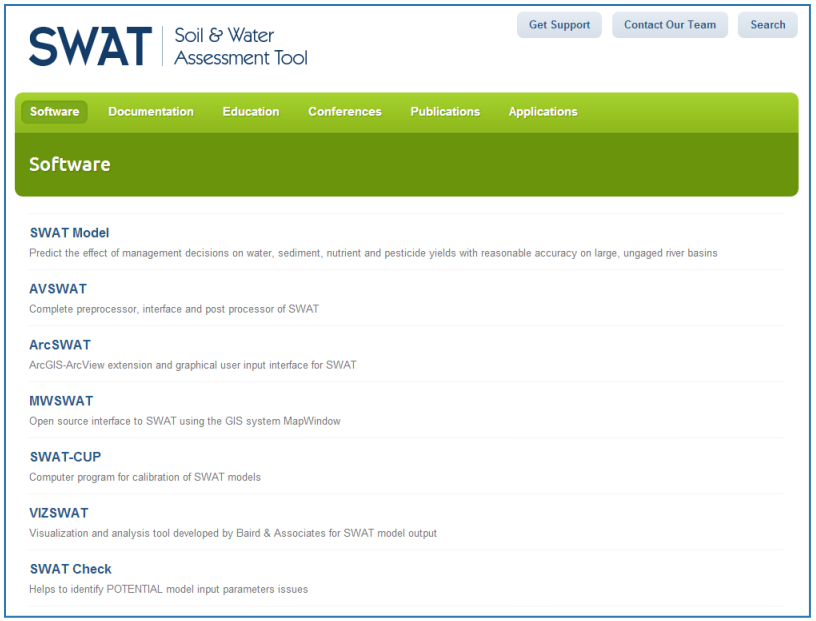


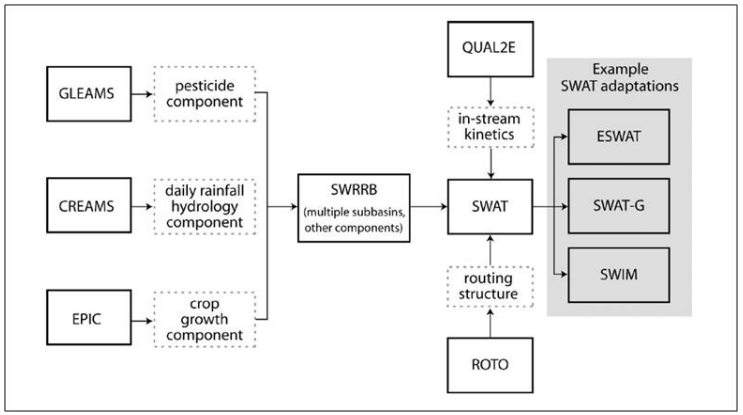
Land Use	Percent of Area
Cropland	51.7%
Forest	19.1%
Pasture	10.3%
Urban	16.7%
Wetland	2.1%

Enhanced, Fine-Scale SWAT Model (TRSWAT)

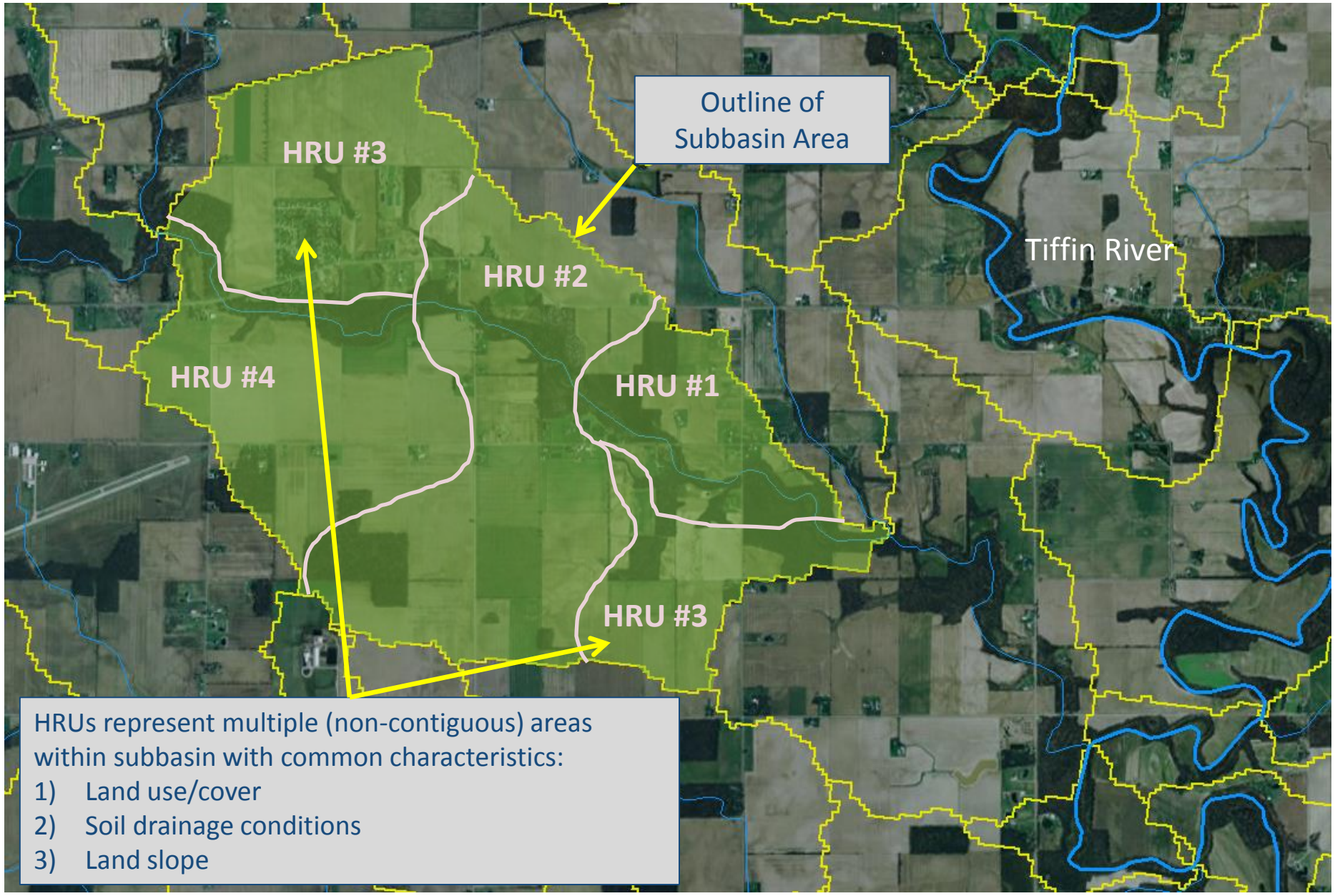
SWAT Background

- 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



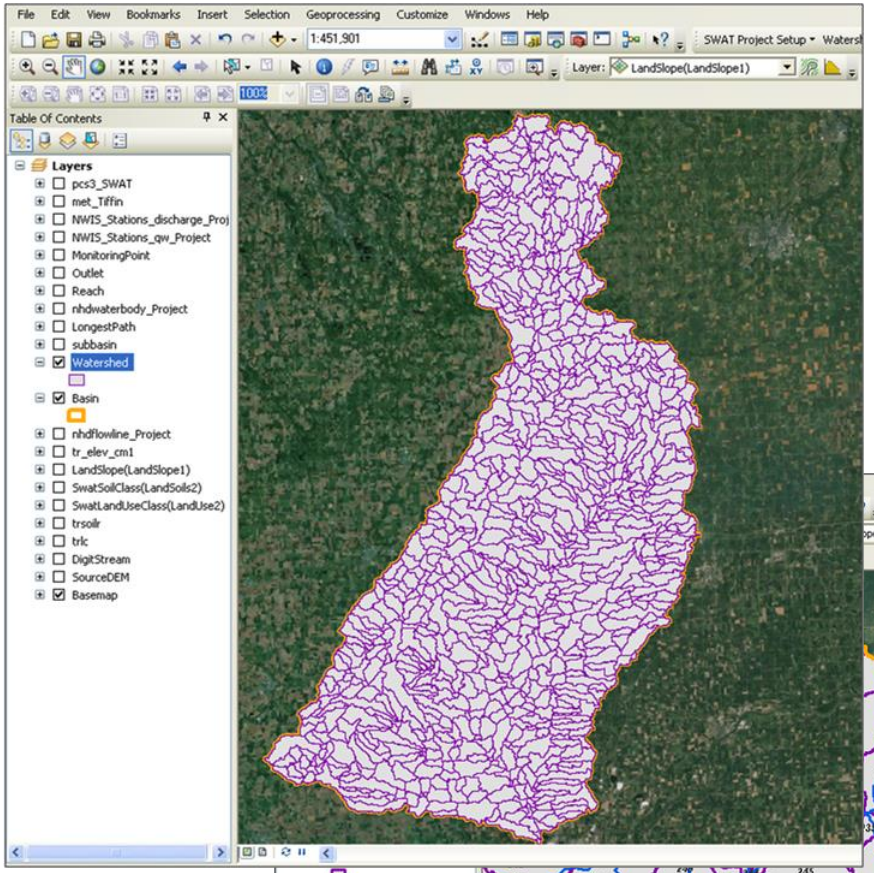


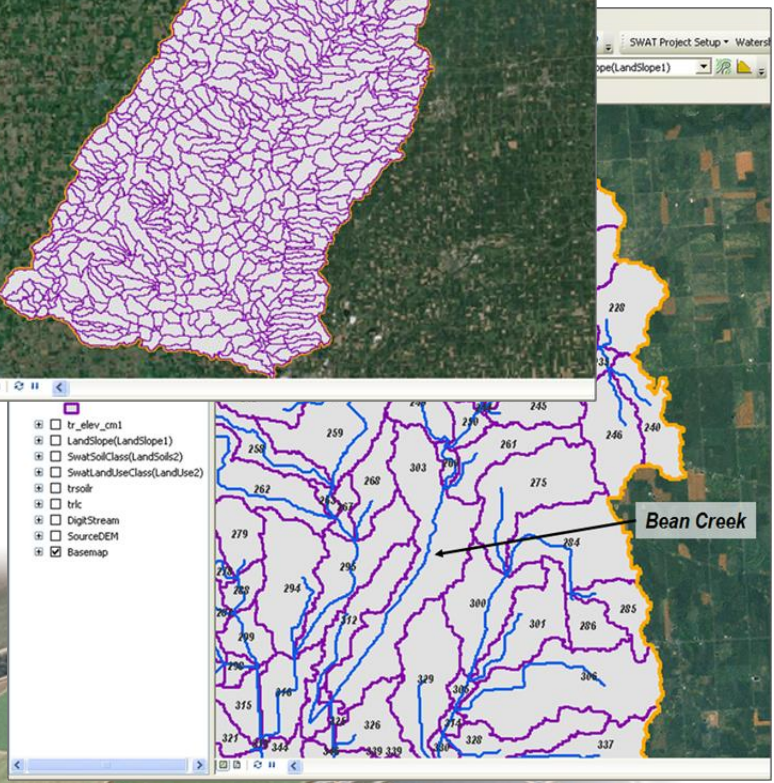
SWAT “Hydrologic Response Units” (HRUs)



Watershed & Subbasin Delineation

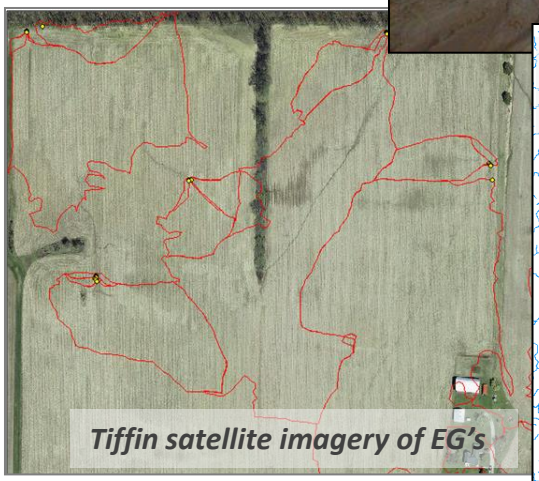
- Fine-scale SWAT model:
  - 907 subbasins
  - Average area of ~540 acres
  - >15,000 HRU's (LU/LC, soils, slope, and management)
- Based on NHDPlus DEM, stream network

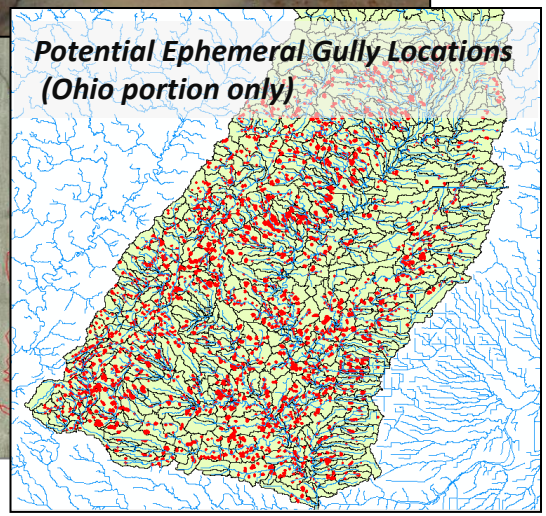




Ephemeral Gully (EG) Erosion

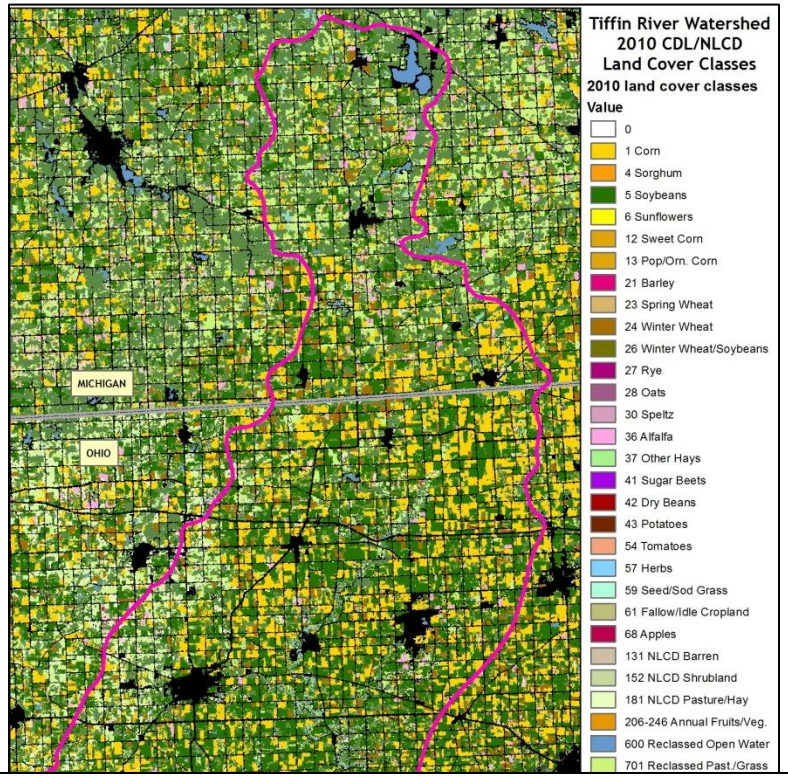
- Incorporate TI-EGEM algorithms into SWAT code
- Confirmation, testing, and diagnostics
- Identify PEG's based on high-resolution DEM, satellite imagery, CTI
- Implementation in TRSWAT

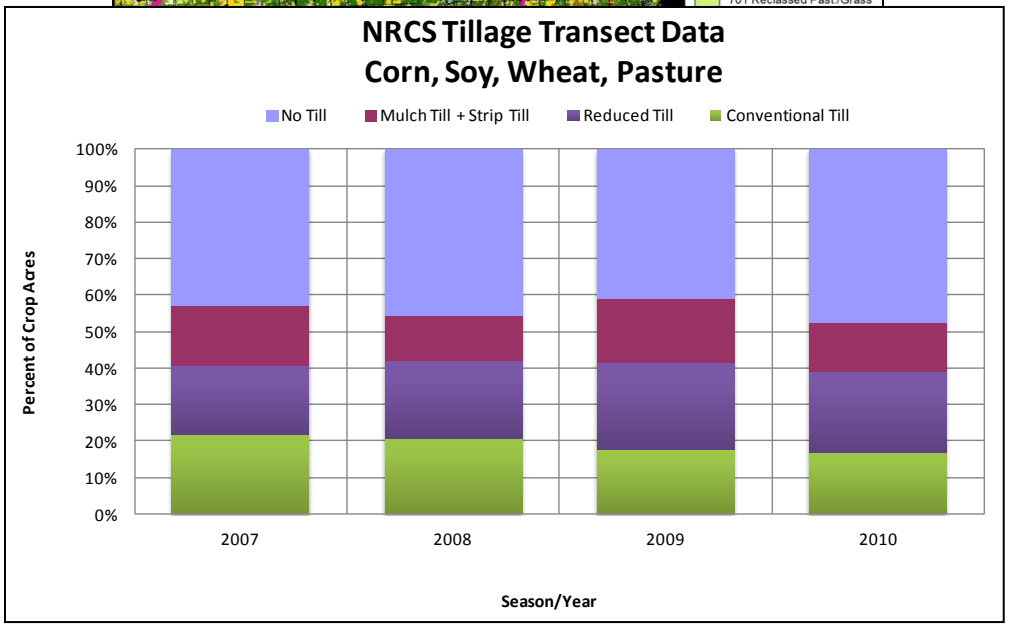




Crop and Tillage Rotations

- 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”

Sediment Source	% Source Contribution to Total Sediment Yield
Sheet and Rill	71%
Ephemeral Gully	29%

- Ephemeral gully erosion contribution varies significantly by HRU, contributing ~0 to 90% of the total sediment load

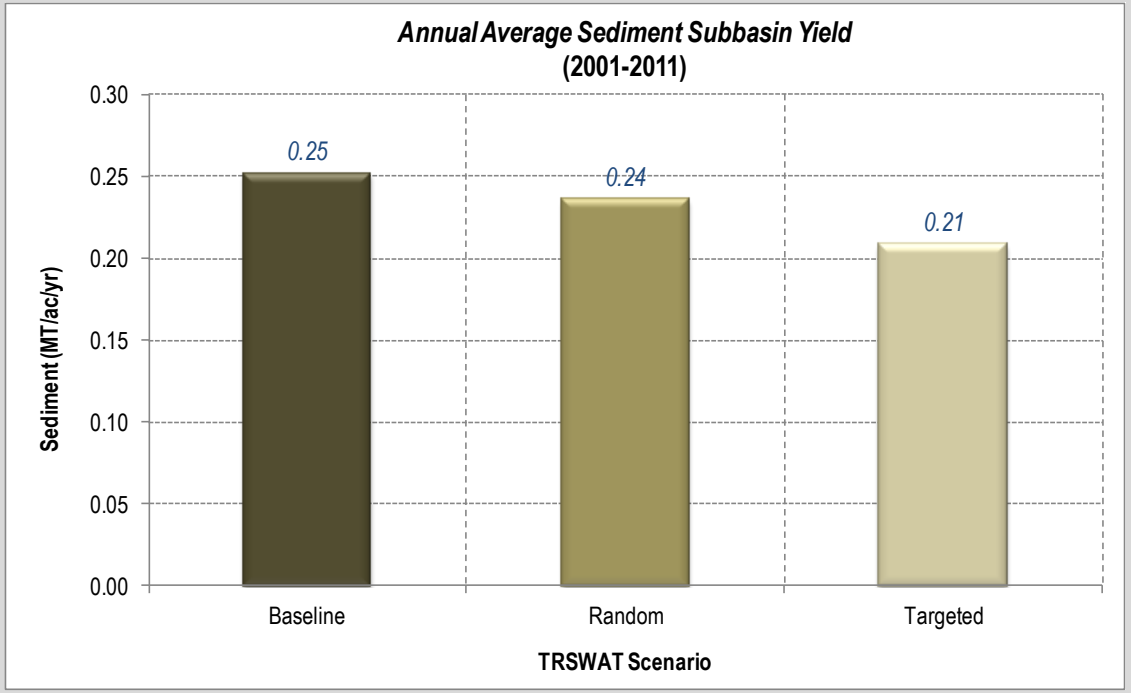
SWAT BMP Representation to Address Ephemeral Gully Erosion:

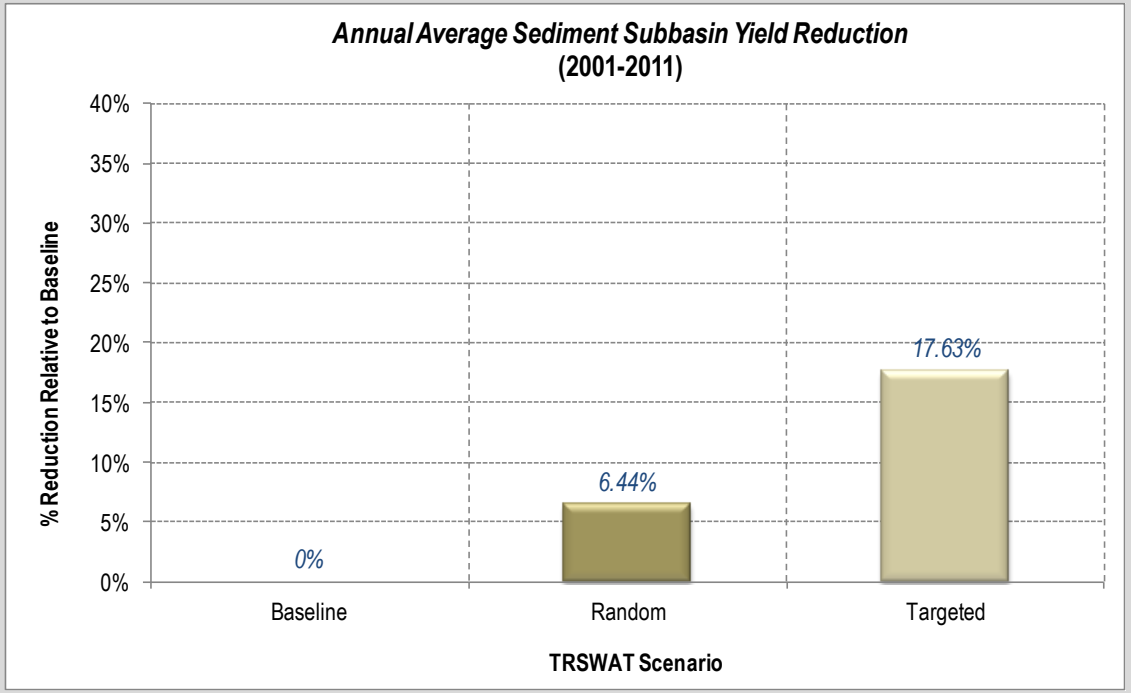
- **Grassed Waterways:**
  - Conceptual: reduce sediment/nutrient erosion from ephemeral gullies, first-order channels and ditches.
  - SWAT Representation: remove ephemeral gully locations from HRUs, incorporate grassed waterway (assumed 5 meter (~16 ft) width)

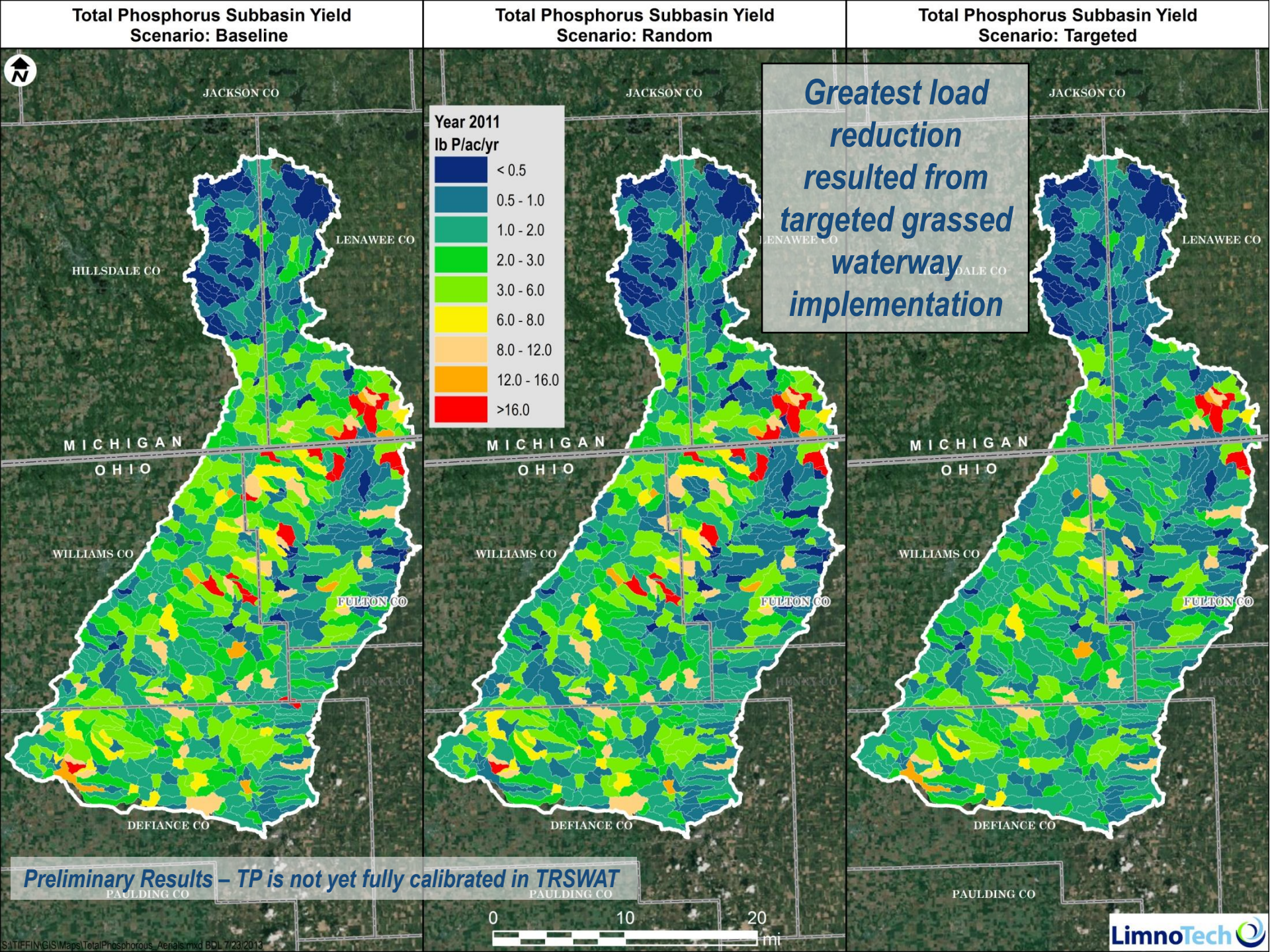
TRSWAT Scenarios:

- **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






Total Phosphorus Subbasin Yield
Scenario: Baseline
Total Phosphorus Subbasin Yield
Scenario: Random
Total Phosphorus Subbasin Yield
Scenario: Targeted
Year 2011
lb P/ac/yr
< 0.5
0.5 - 1.0
1.0 - 2.0
2.0 - 3.0
3.0 - 6.0
6.0 - 8.0
8.0 - 12.0
12.0 - 16.0
>16.0
Greatest load reduction resulted from targeted grassed waterway implementation
JACKSON CO
LENAWEE CO
HILLSDALE CO
MICHIGAN
OHIO
WILLIAMS CO
FULTON CO
HENRY CO
DEFIANCE CO
PAULDING CO
Preliminary Results – TP is not yet fully calibrated in TRSWAT
0
10
20
mi
S:\TIFFIN\GIS\Maps\TotalPhosphorous_Aerials.mxd BDL 7/23/2013
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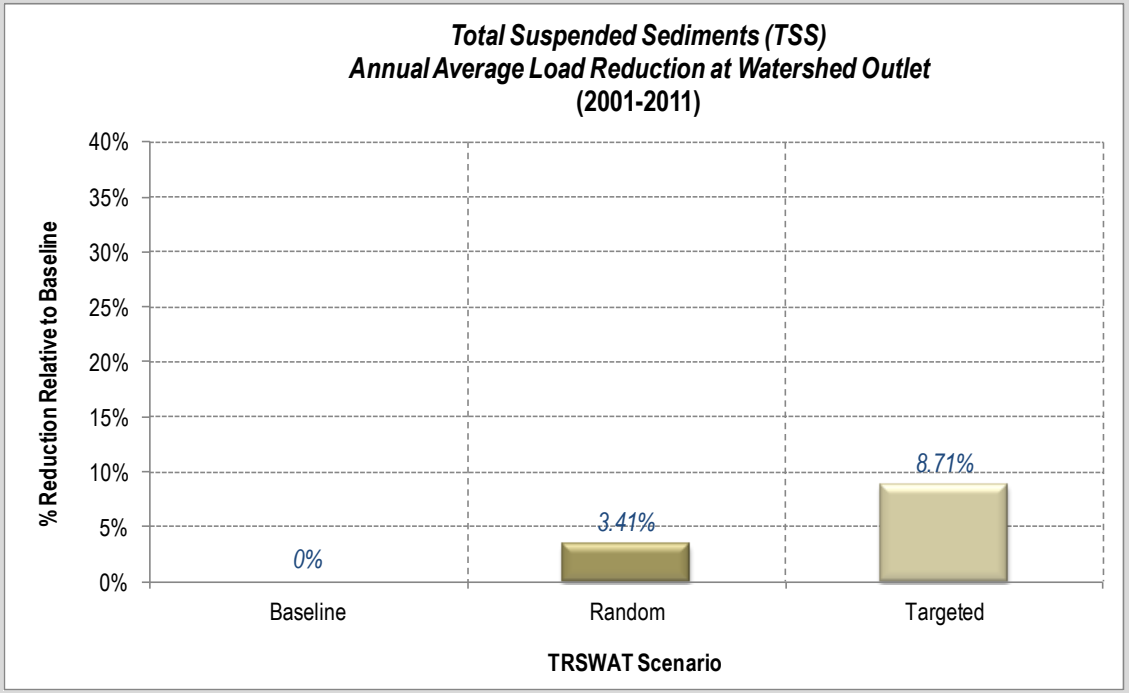
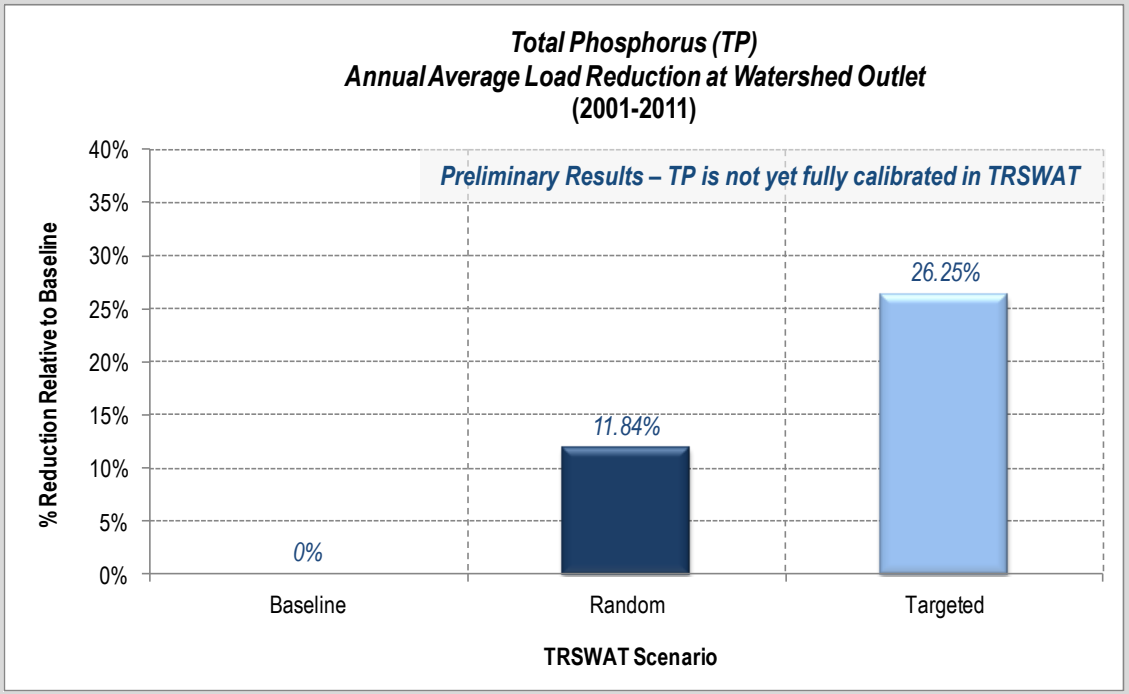
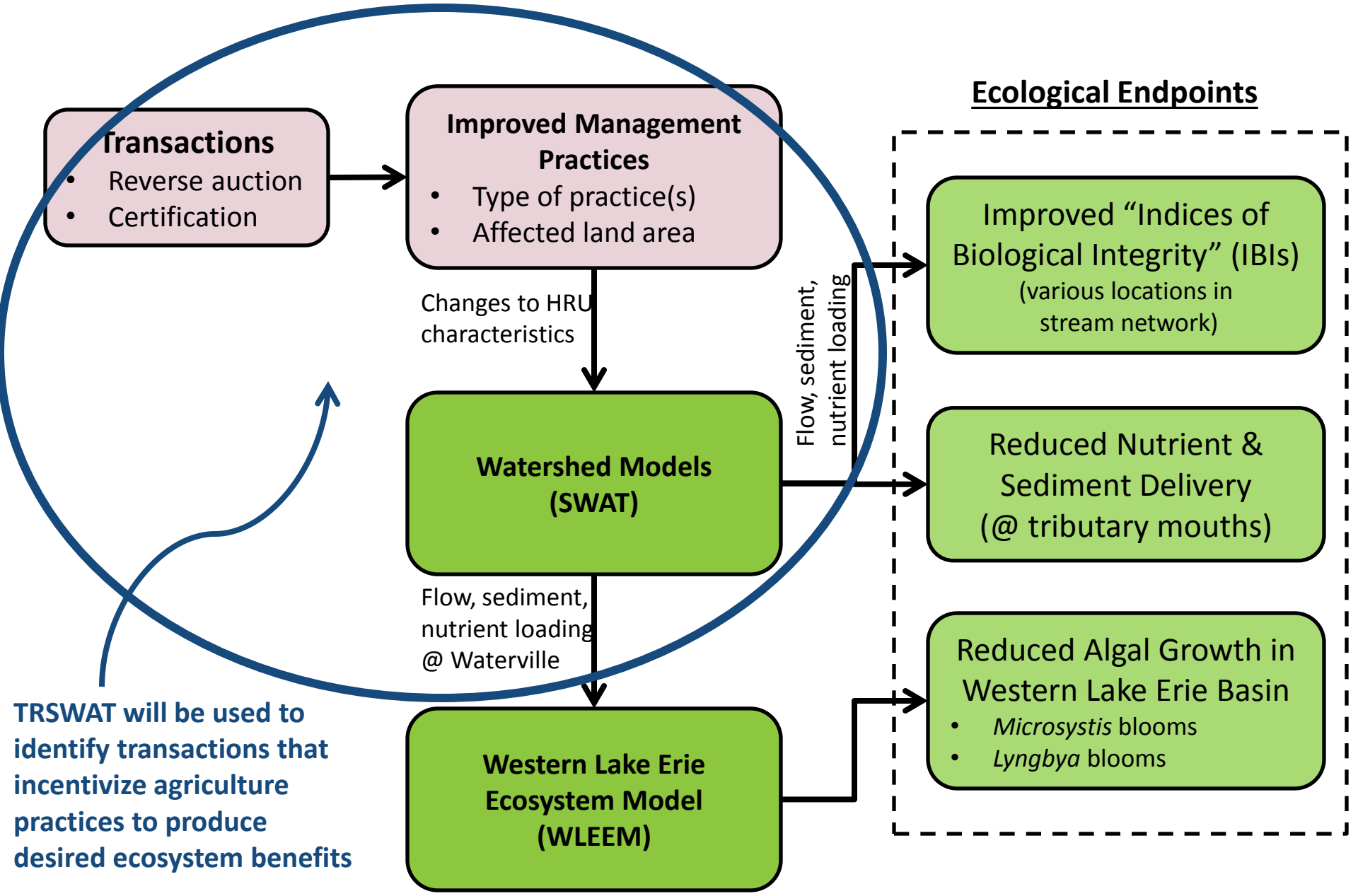
TRSWAT results indicate a **+5% reduction** in **TSS** load and **+14% reduction** in **TP** load at the watershed outlet for **targeted** grassed waterway implementation compared to random implementation





Transactions → Ecological Endpoints



Questions?

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