

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

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SWAT Conference
Purdue University
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Overview

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



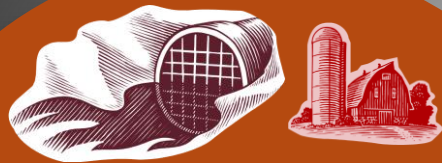
Water Quality in Wisconsin

- ▶ 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



Impaired Waters

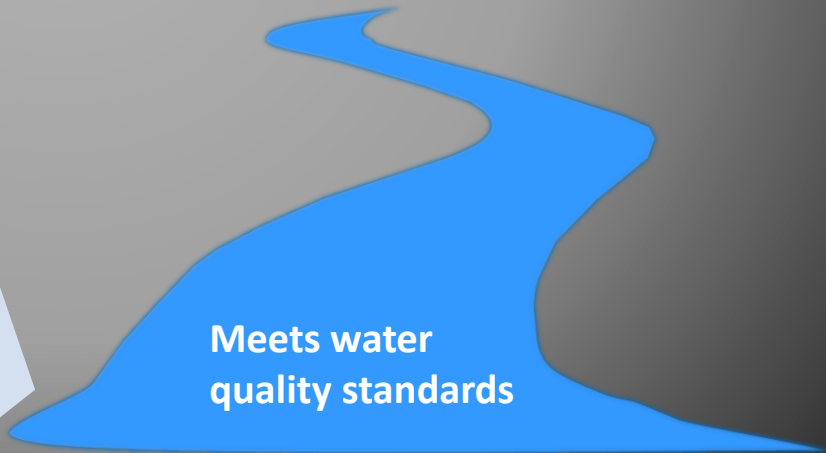
TMDL Purpose



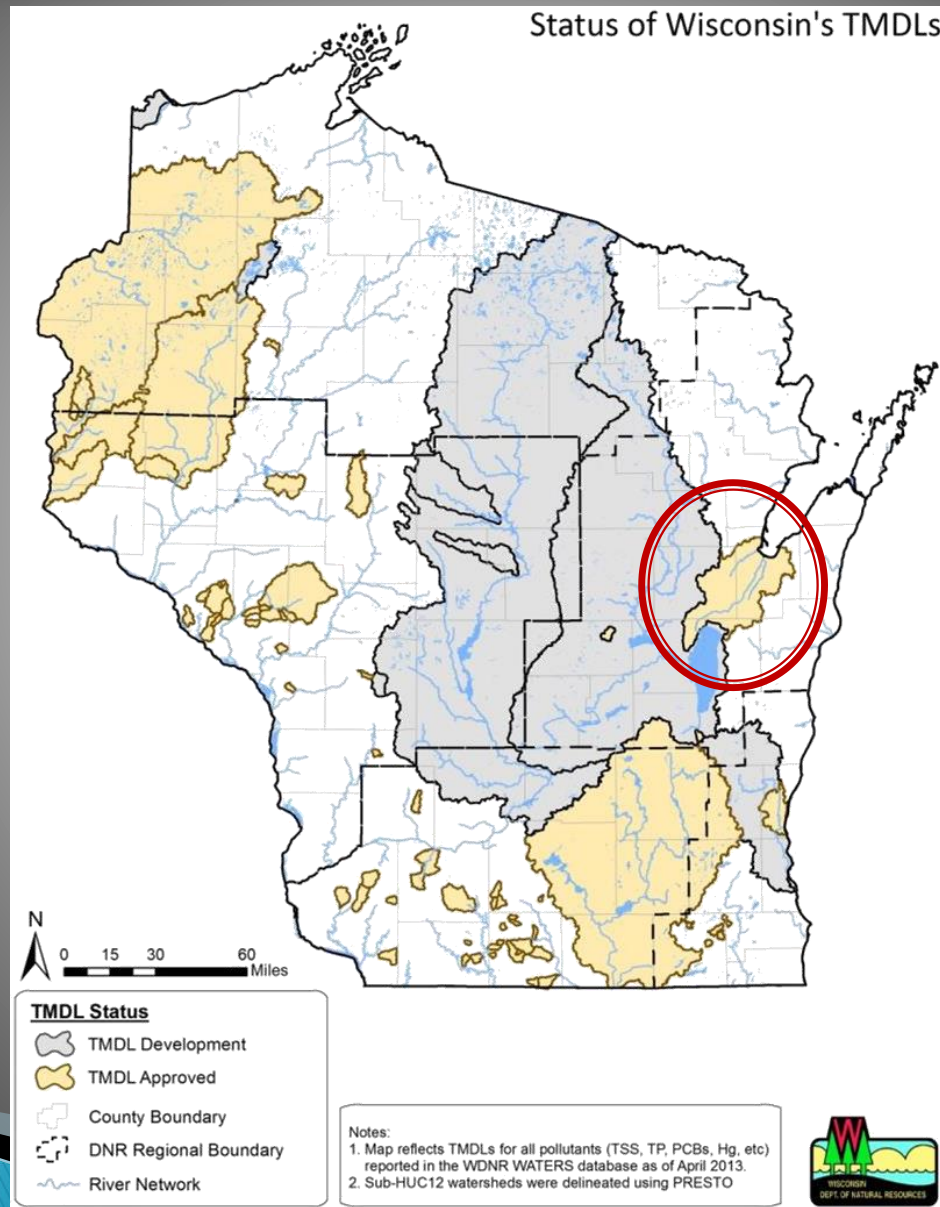
Current
Pollutant
Load



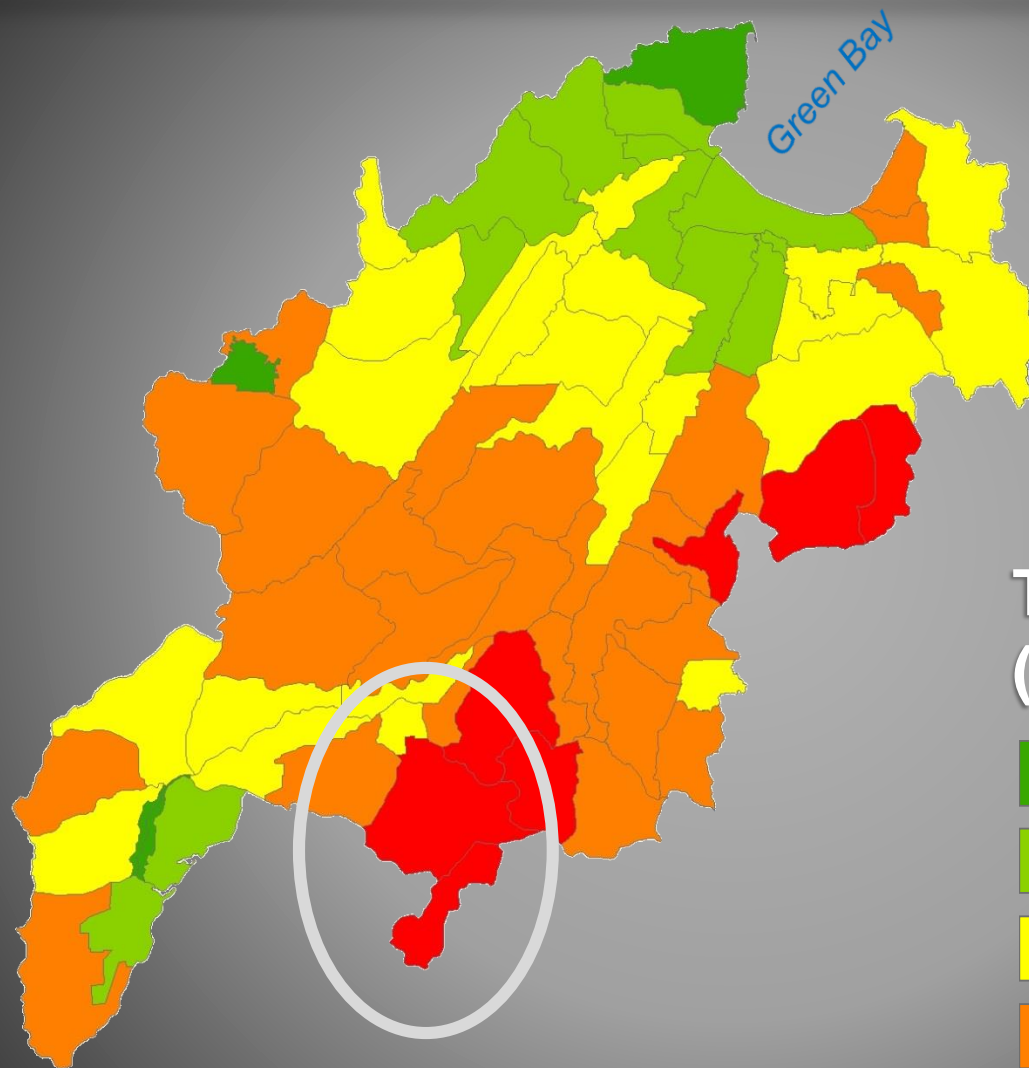
Meets water
quality standards



TMDLs Statewide



TMDL Results



**Total Phosphorus
(lbs/acre/year)**

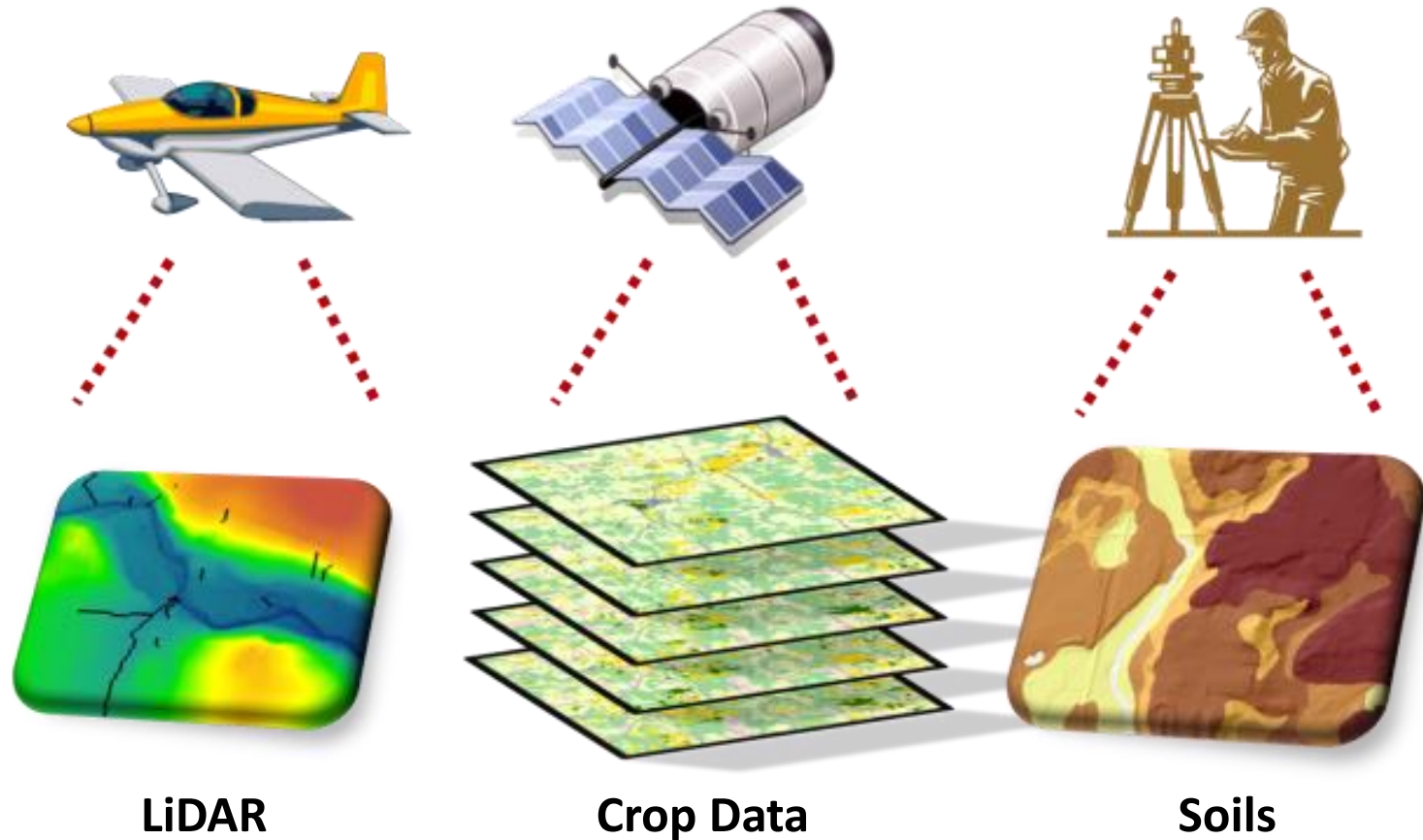


Kankapot Creek Watershed



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

Available Datasets



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



= E  AAL

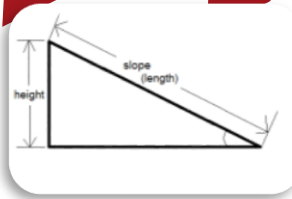
**Erosion Vulnerability Assessment
for Agricultural Lands**

Universal Soil Loss Equation

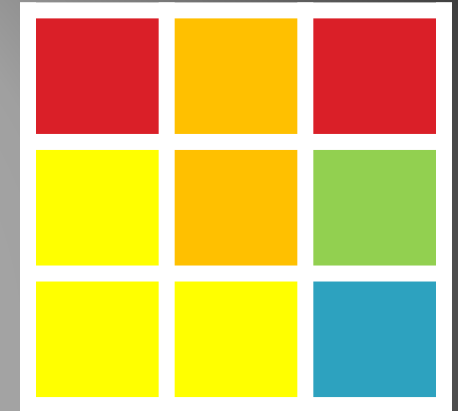
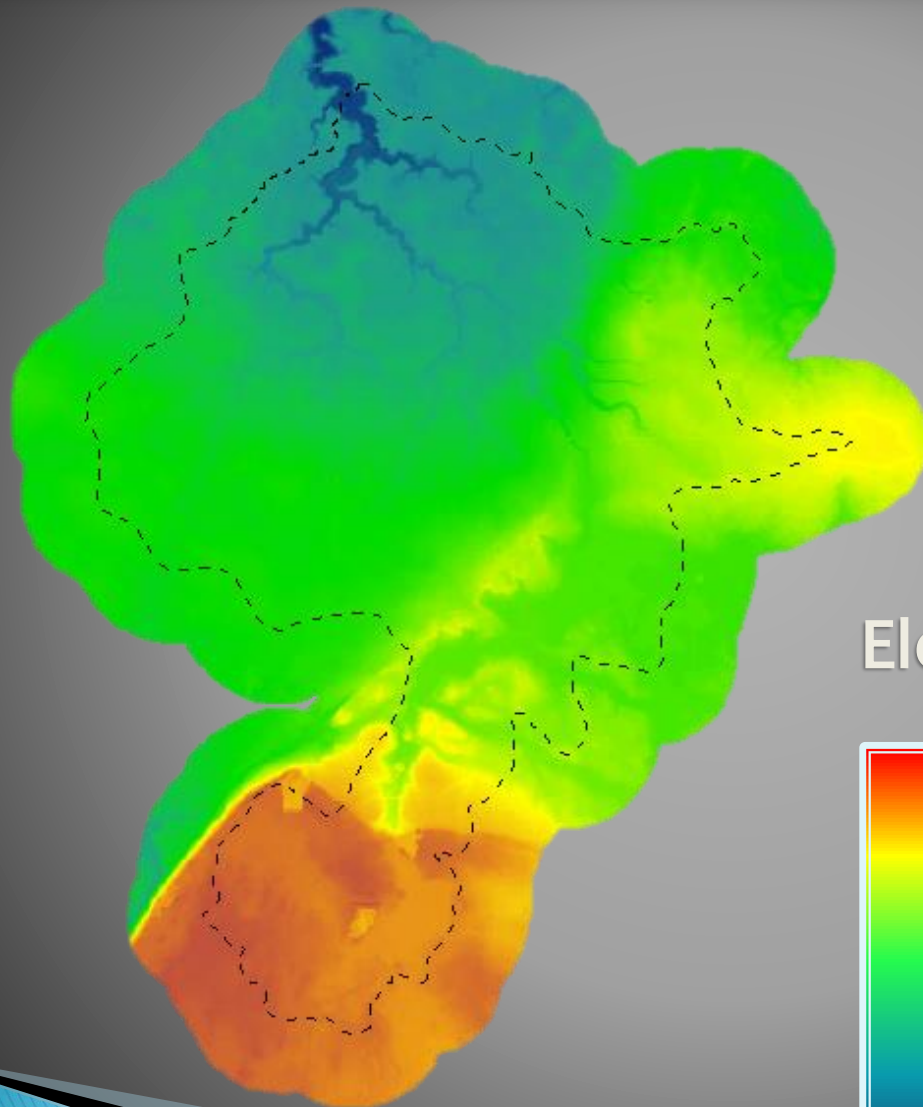
▶ Sheet and rill erosion

$$A = RK(LS)CP$$

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



LiDAR Data



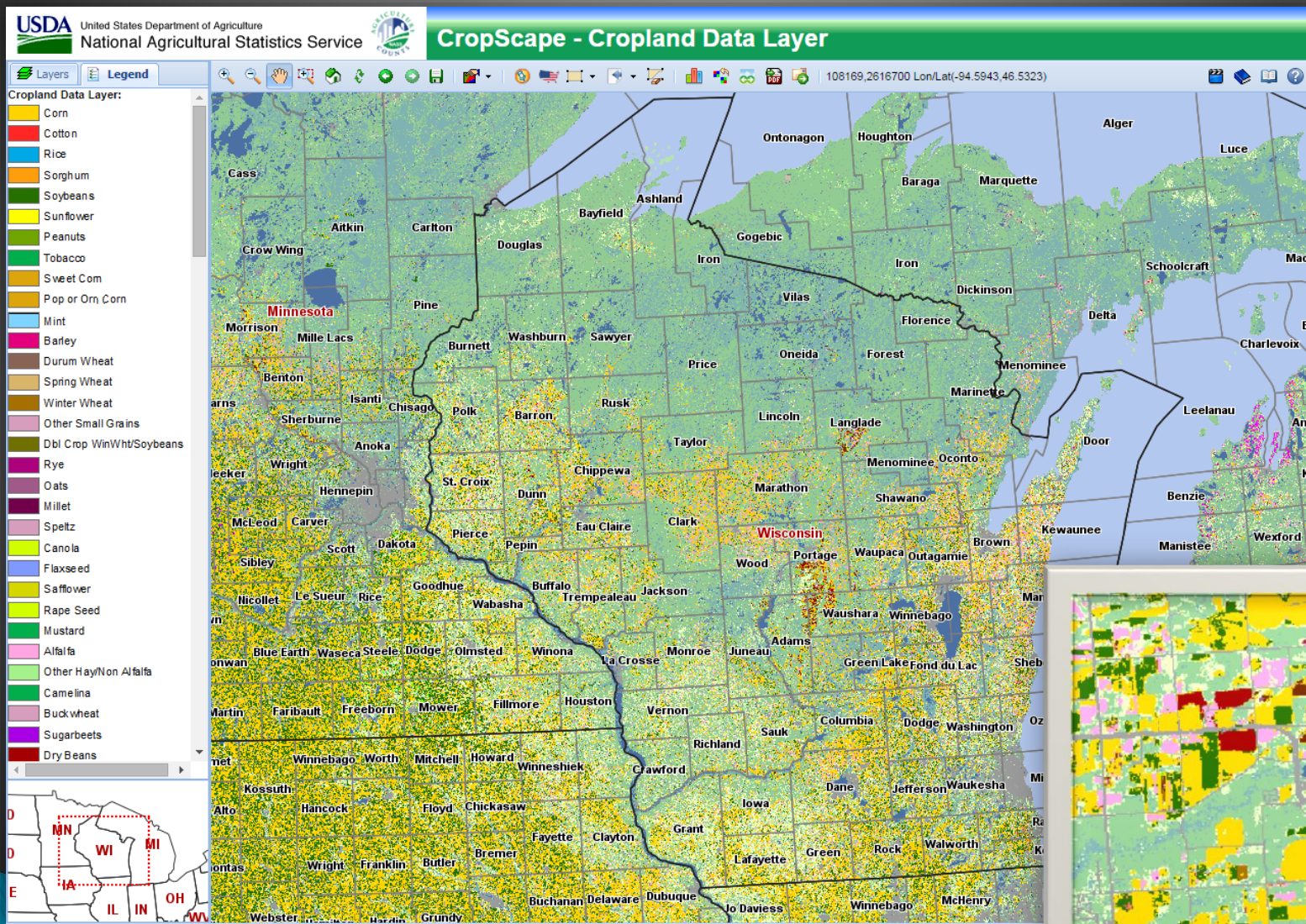
Elevation (feet)



1000

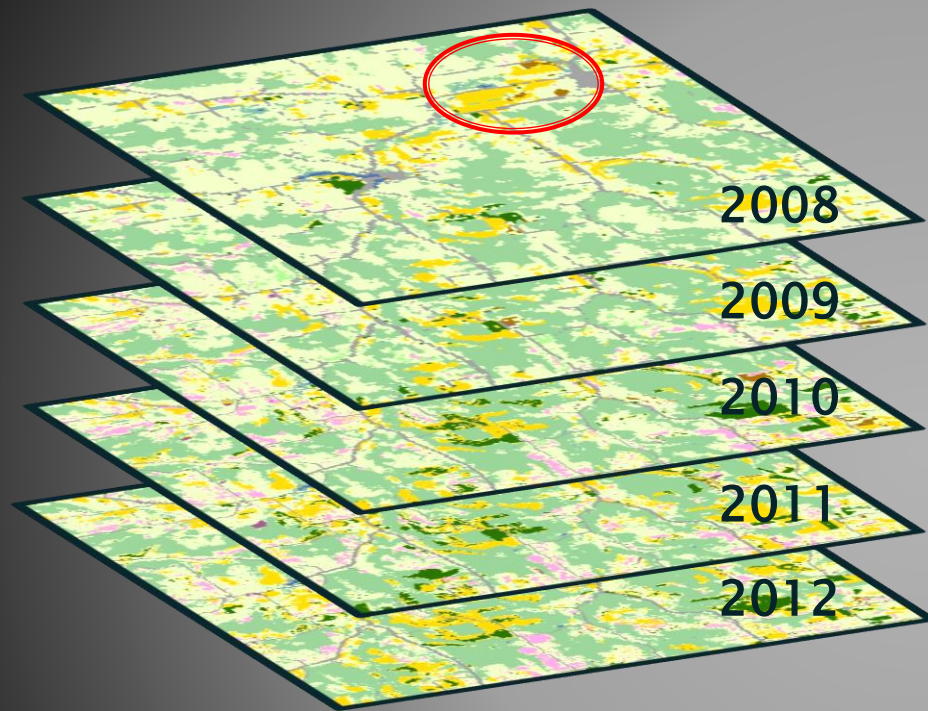
650

Crop Data



<http://nassgeodata.gmu.edu/CropScape/>

Crop Rotations



Corn

Soybean

Corn

Corn

Soybean

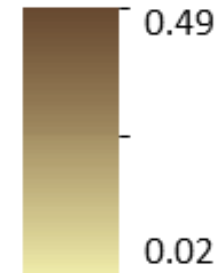
C-C-S-C-C, C-S-C-S-C, S-C-C-S-C, C-C-C-C-S, S-S-S-S-C
= Cash Grain Rotation

RUSLE2 → Rotational C Factor

Soils – gSSURGO



Soil Erodibility



10 meter resolution

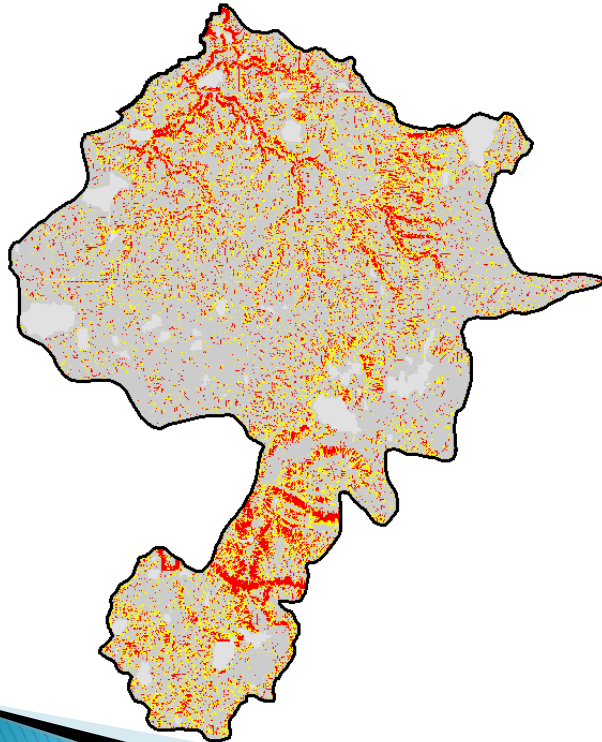


<http://datagateway.nrcs.usda.gov/>

Stream Power Index

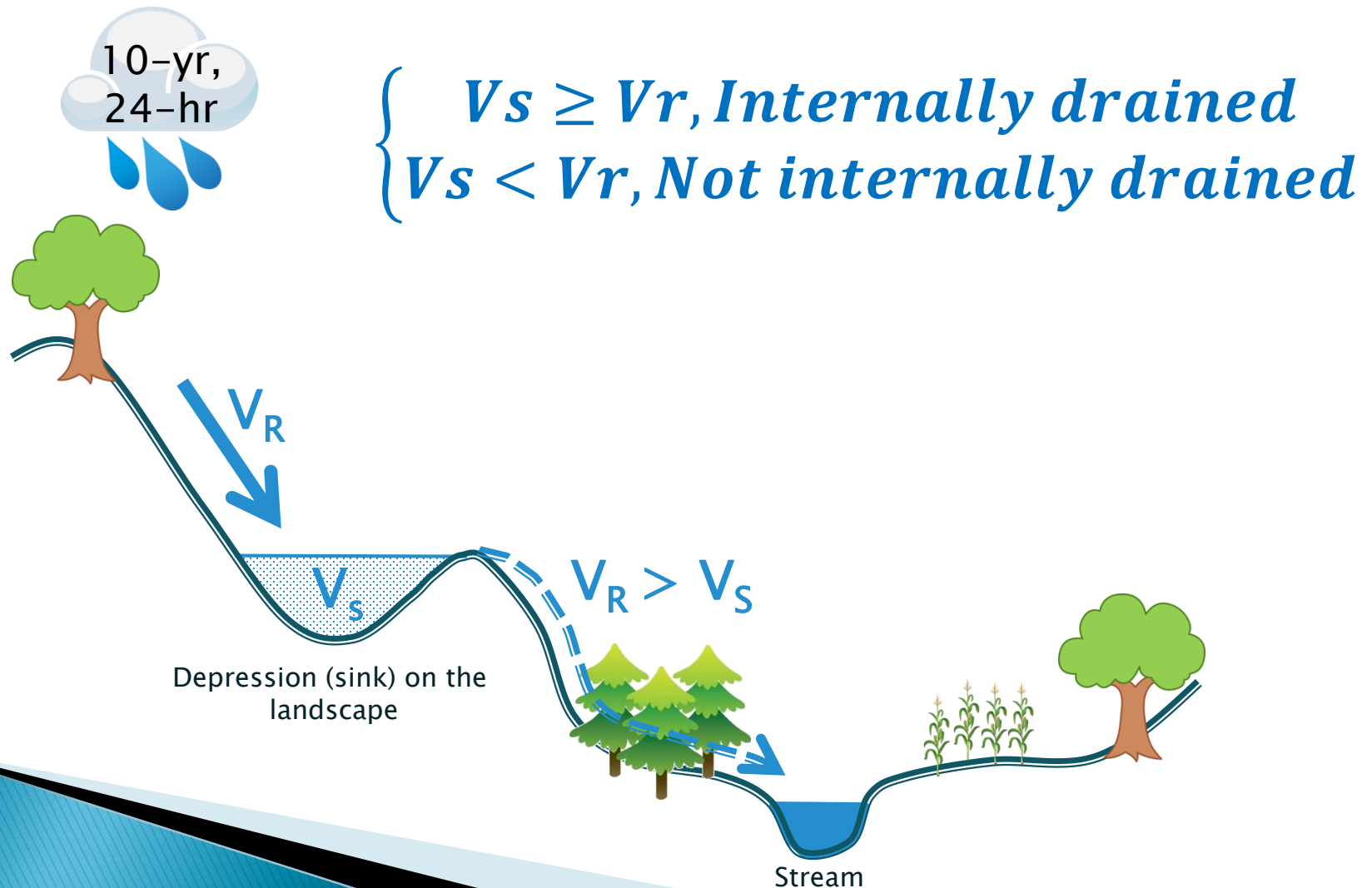
- ▶ Potential for gully erosion

$$SPI = f(\text{slope, catchment area})$$



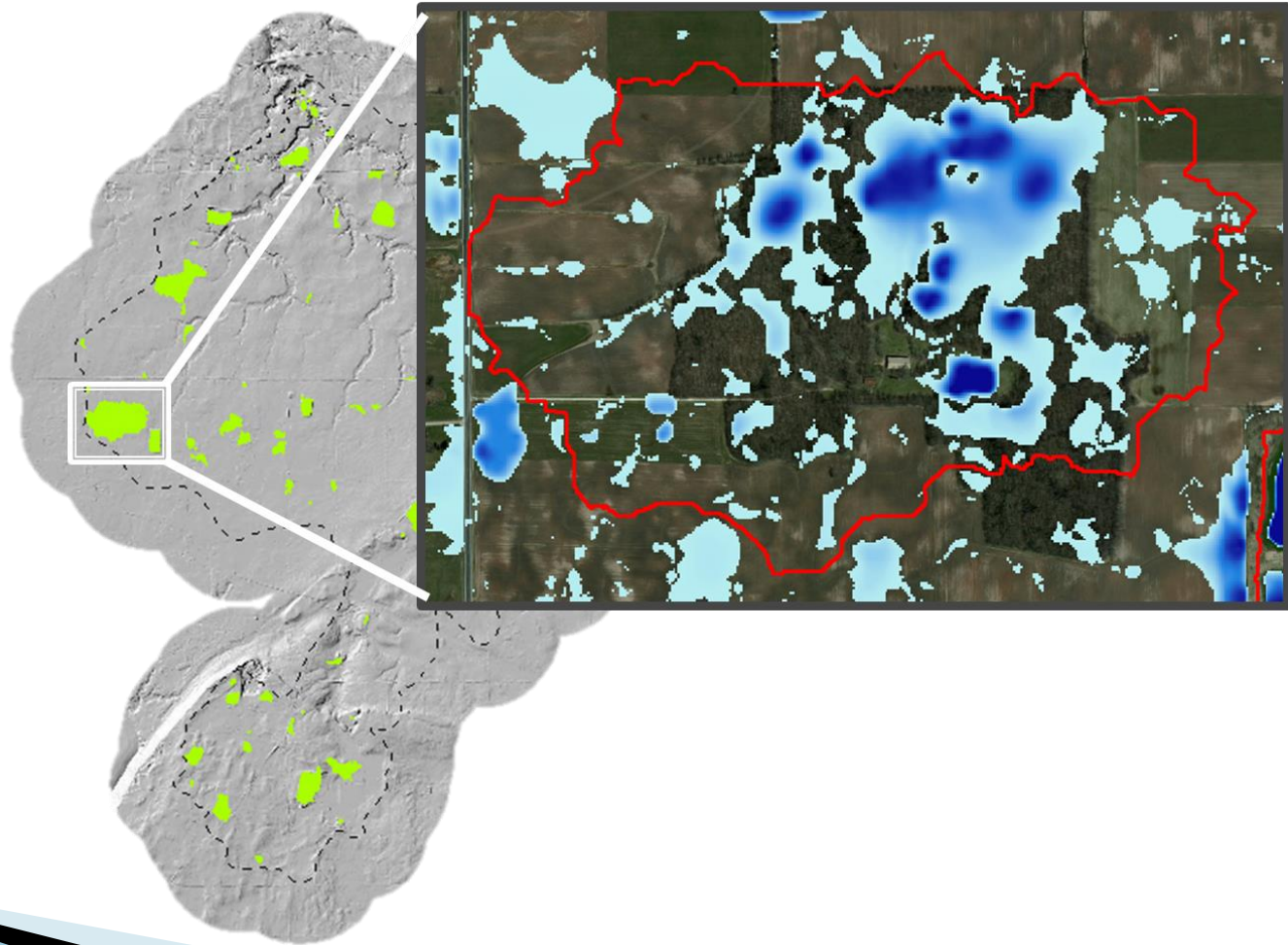
Internally Draining Areas

- ▶ Areas that do not contribute to surface waters



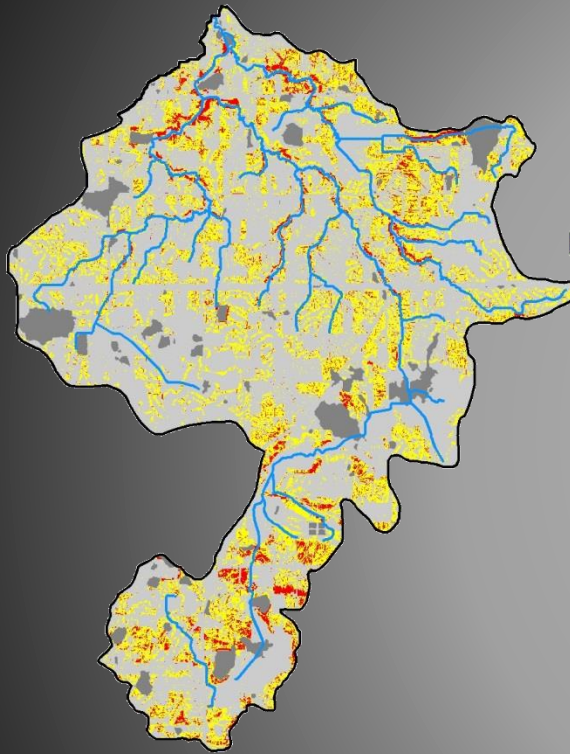
Internally Draining Areas

- ▶ Areas that do not contribute to surface waters

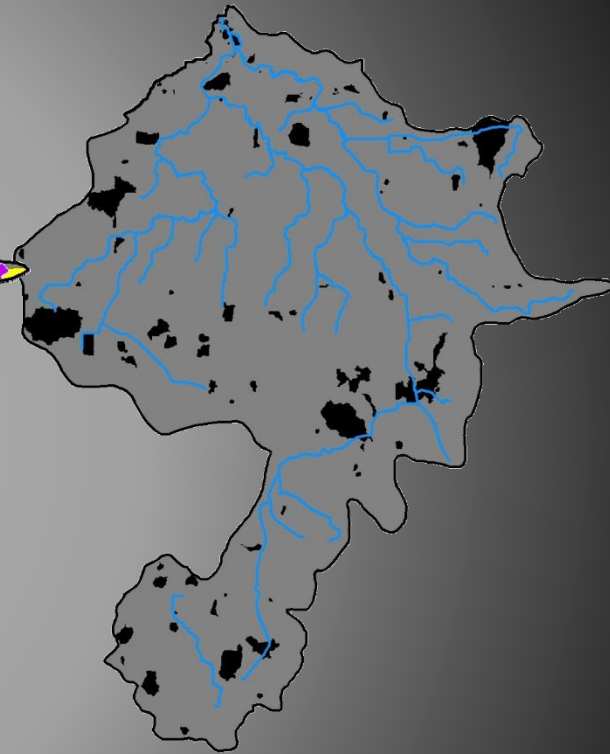


Results

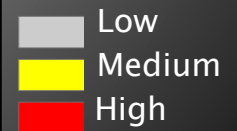
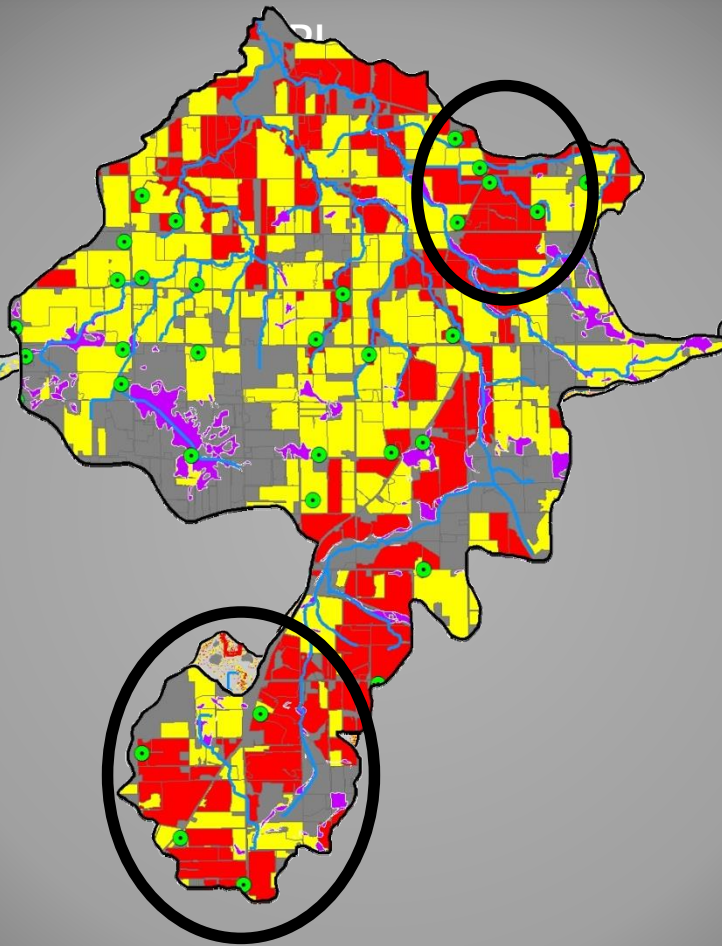
USLE



NC Areas

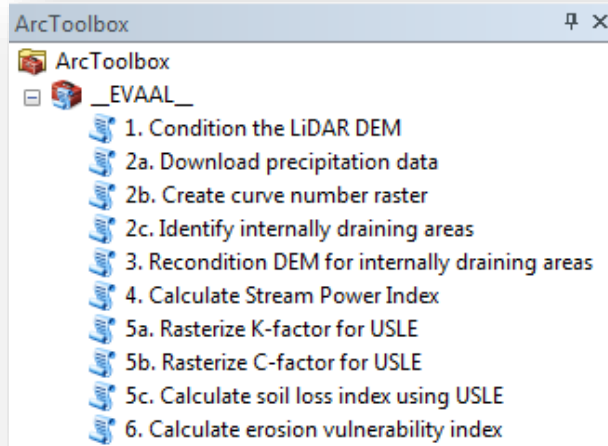


Episodic Vulnerability



EVAAL Website

- ▶ Documents
- ▶ Tutorial Data
- ▶ ArcToolbox



Agricultural NPS pollution

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) toolset to assist watershed managers in prioritizing areas within a watershed which may be vulnerable to water erosion (and thus increased nutrient export) and thus may 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 deprioritizing 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 \(zipped\)](#)
- [EVAAL Tutorial Data \(FTP site, ZIP file format\)](#)

Contact information

For questions or information about this model, please contact:

[Theresa M. Possley Nelson, P.E.](#)
TMDL modeling engineer
Project manager

Last revised: Friday September 26 2014

Nonpoint source pollution

Agricultural nonpoint source pollution
Learn more about agricultural nonpoint source pollution

Urban nonpoint source pollution
Learn more about urban nonpoint source pollution

What you can do
Learn more about controlling nonpoint source pollution in your area

TMDL implementation
Learn more about what the DNR is doing to control nonpoint source pollution

Related links

- [Environmental impacts](#)
- [Wisconsin Runoff Rules: What Farmers Need to Know \(PDF\)](#)
- [NR 151 implementation strategy](#)
- [Agricultural technical standards & assistance](#)
- [Financial assistance](#)
- [Discharges, complaints & assistance](#)
- [Notices of discharge](#)
- [Nonpoint program contacts](#)

<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

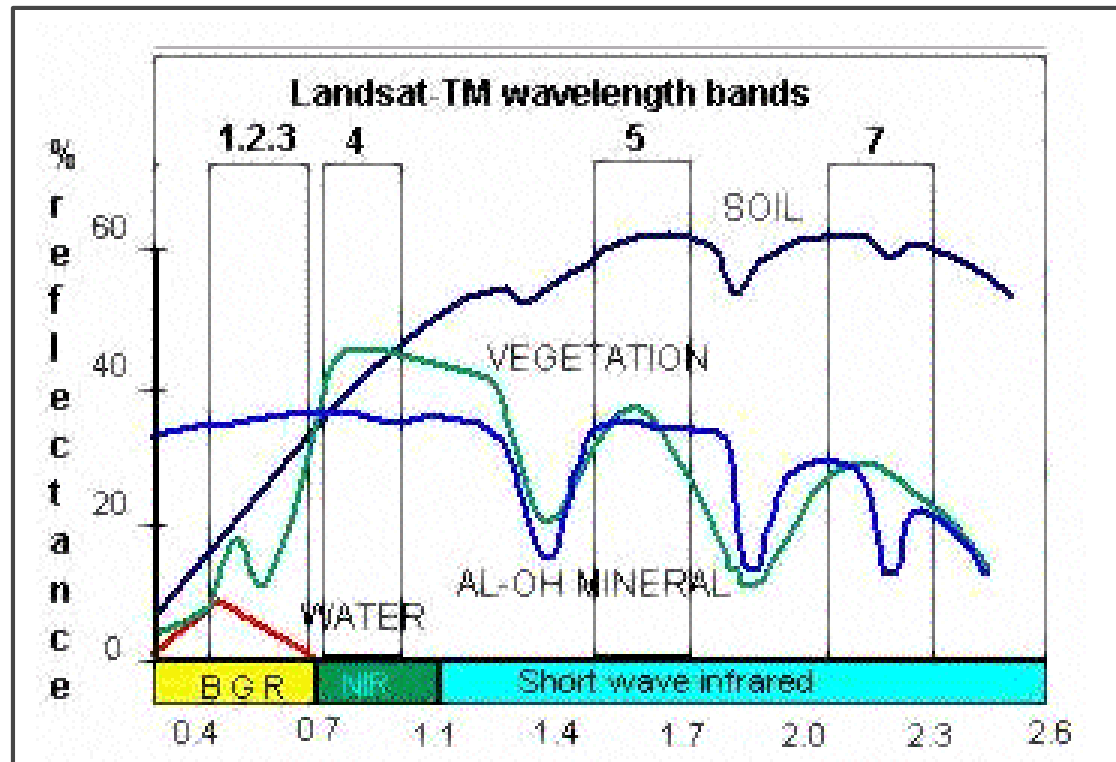
- ▶ We can't model what we don't know
 - Tillage
 - Manure application
 - Soil P
 - BMPs
- ▶ Erosion must be driving factor
- ▶ Does not account for delivery factors or tile drainage
- ▶ Cannot “target”, rather “prioritize”

Tillage – Overview

- ▶ 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

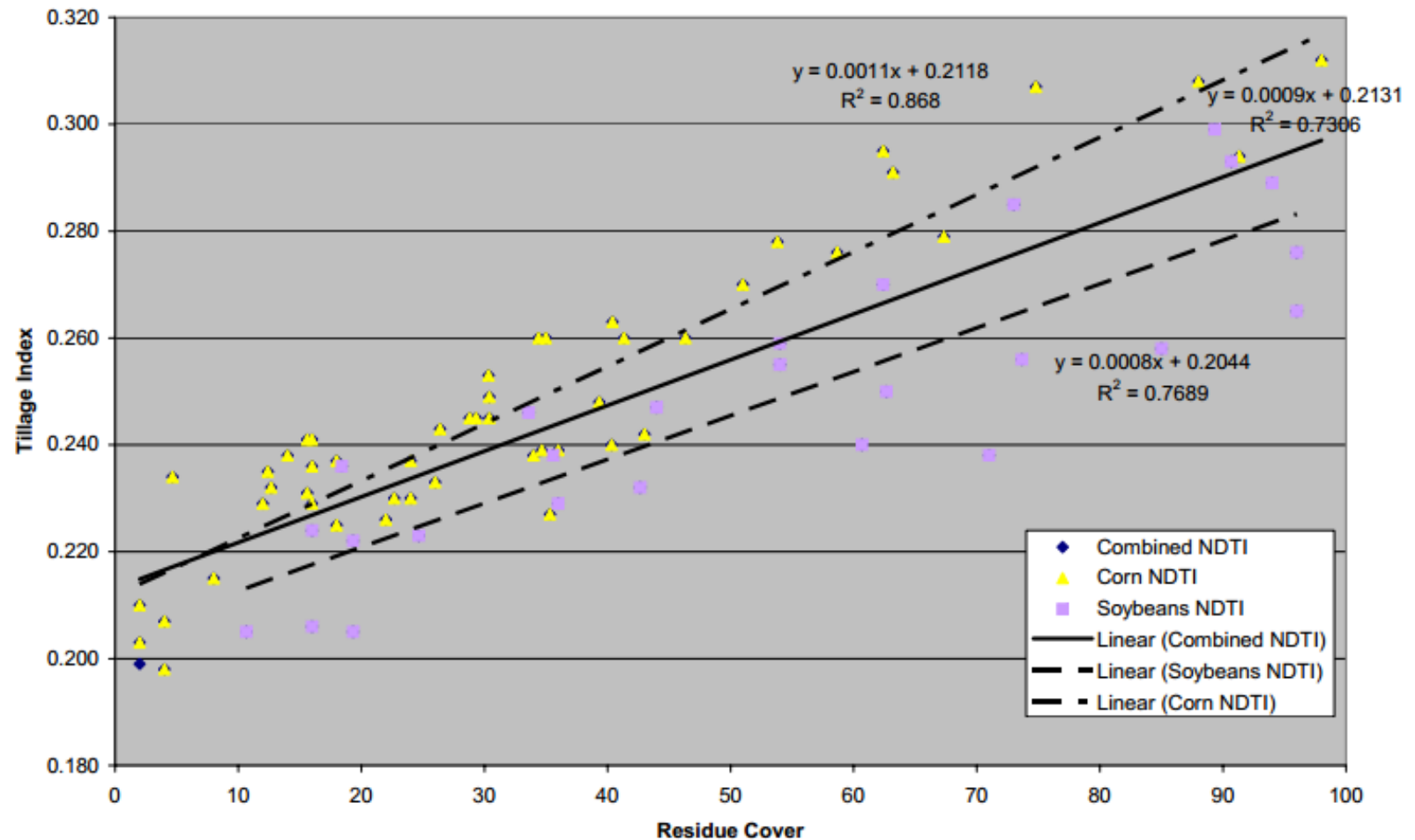
Satellite Imagery Analysis

- ▶ Landsat 7 & 8
- ▶ Normalized Difference Tillage Index
- ▶ $NDTI = (band5 - band7) / (band5 + band7)$

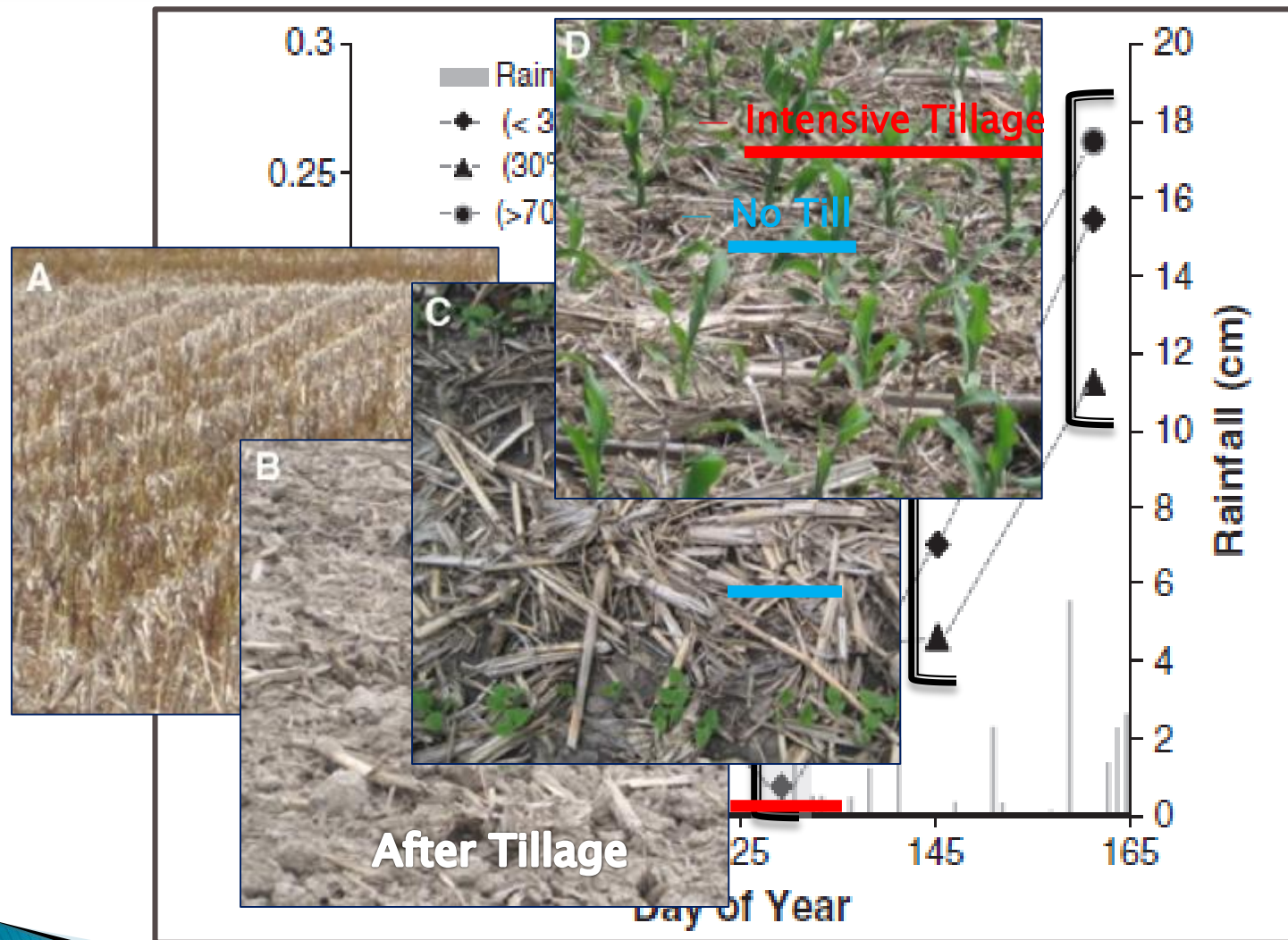


NDTI and Crop Residue Cover

- ▶ NDTI is positively correlated with crop residue cover and green vegetation



NDTI Changes with Time



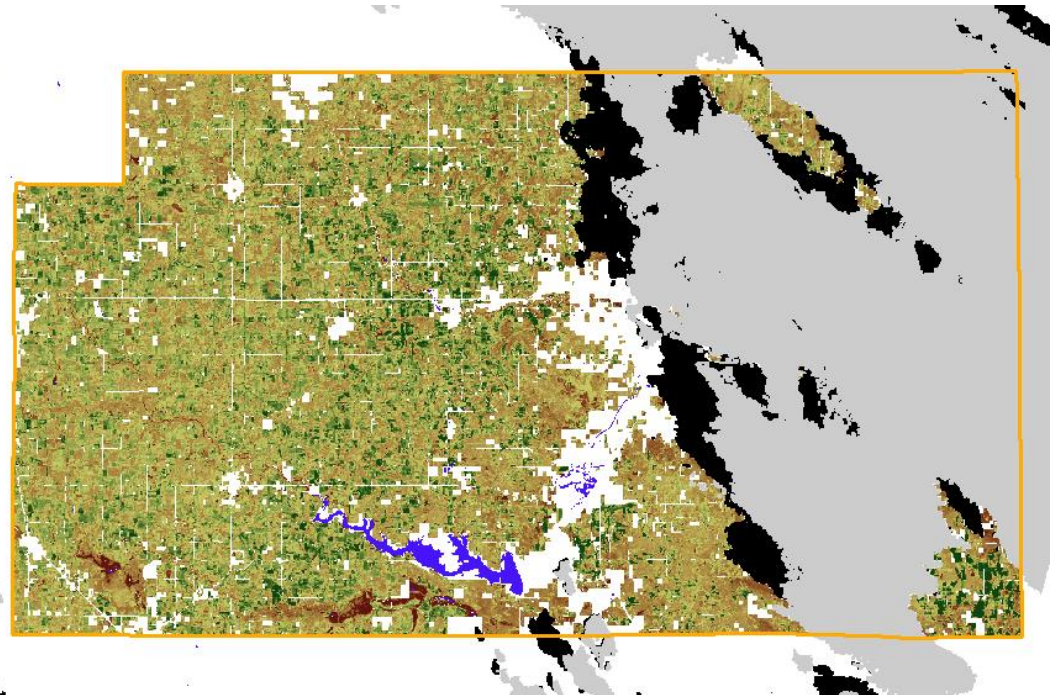
"Remote Sensing Of Crop Residue Cover Using Multi-temporal Landsat Imagery"
B. Zheng - 2012

Methods

- ▶ Obtain imagery throughout spring planting season
- ▶ Preprocessing: remove obscured pixels
- ▶ Calculate minNDTI

Obscured Pixels

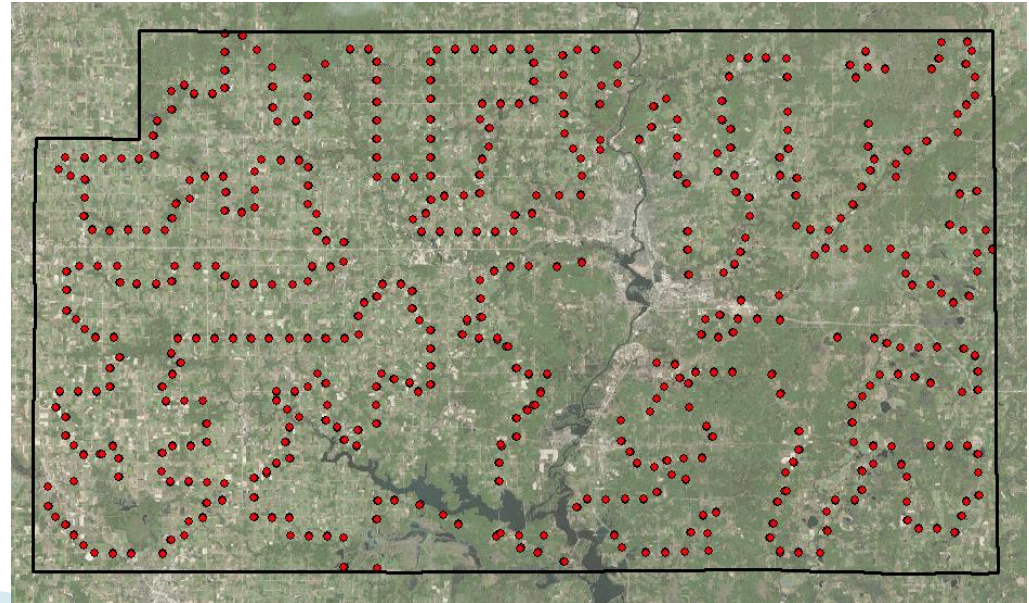
- Clear - No Color
- Water
- Shadow
- Ice/Snow
- Cloud



Transect Data

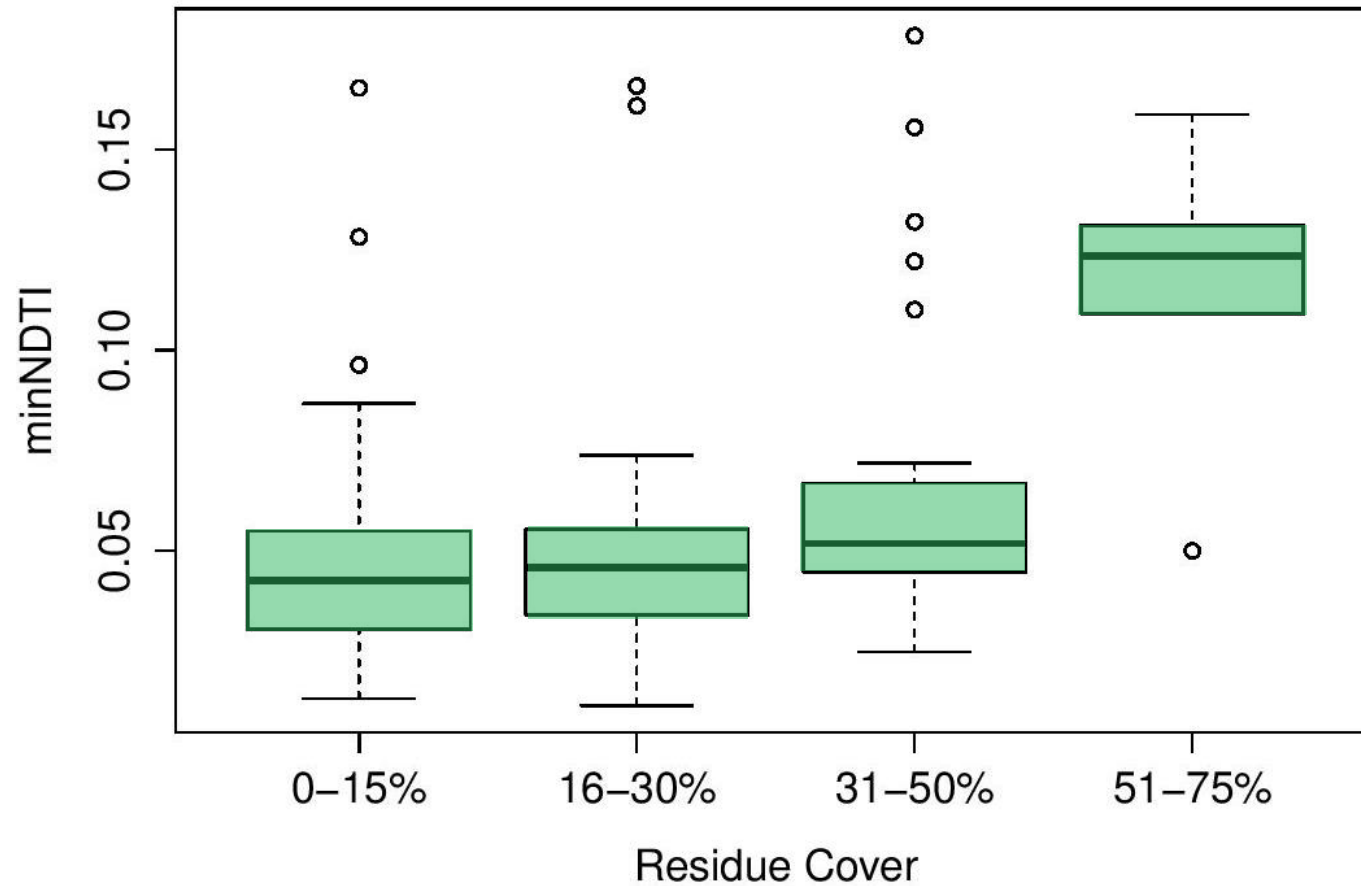
- ▶ Link known tillage practices and crop residue percentages to spectral signatures
- ▶ Annual data collection
- ▶ Includes
 - Crop type
 - Tillage type
 - Percent residue

Transect_Stops

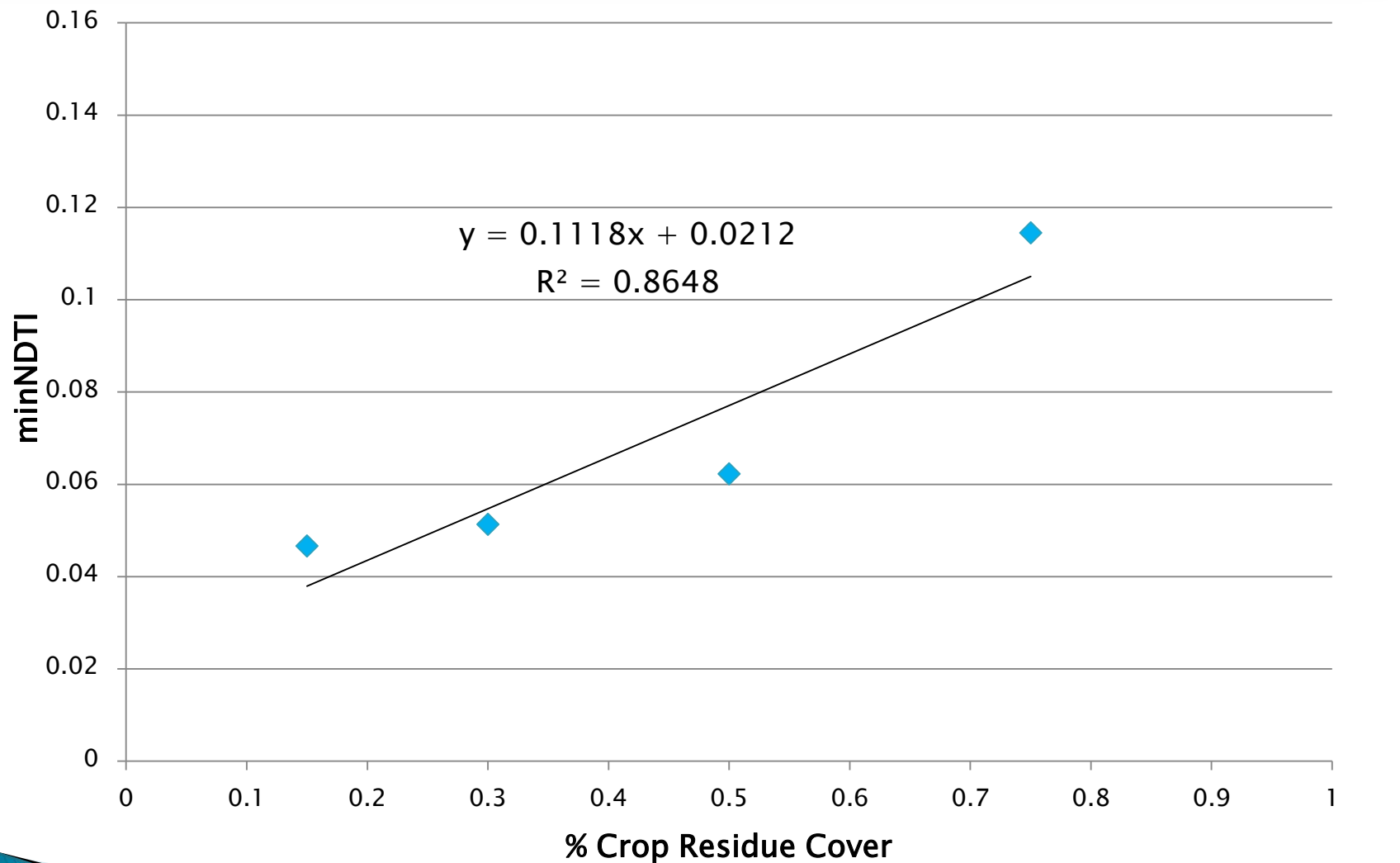


Reported Residue Cover and minNDTI

2012

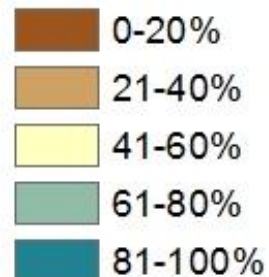
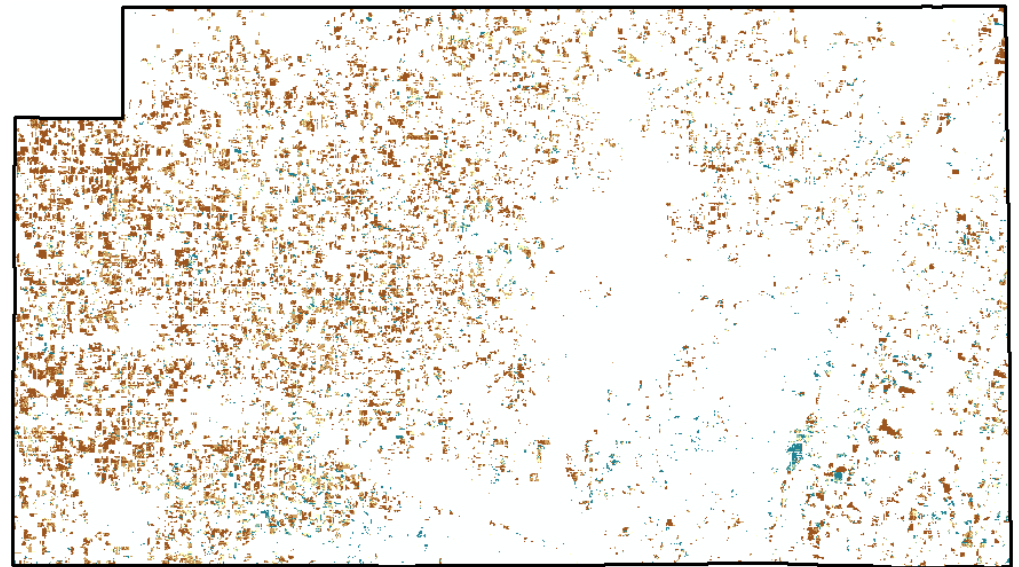
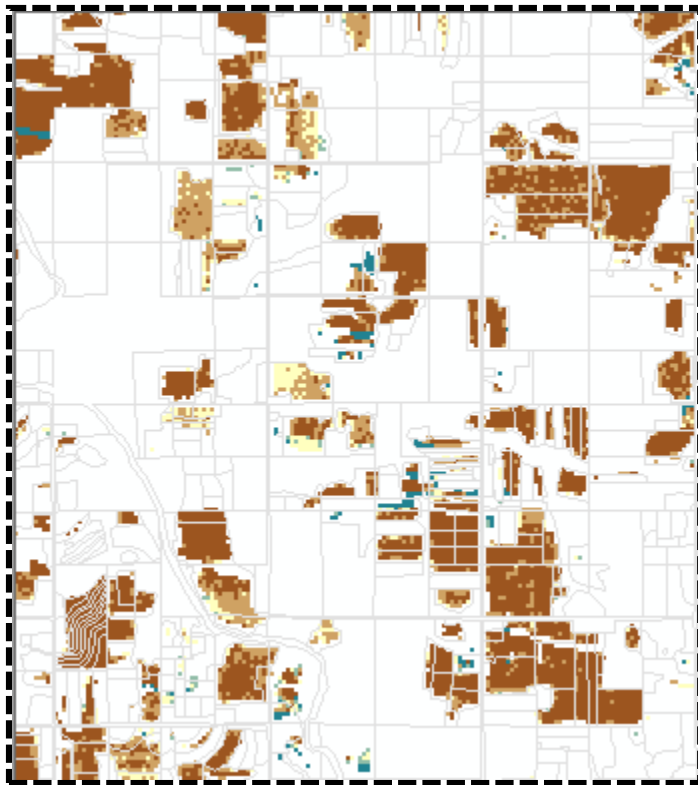


Relating Residue Cover and minNDTI

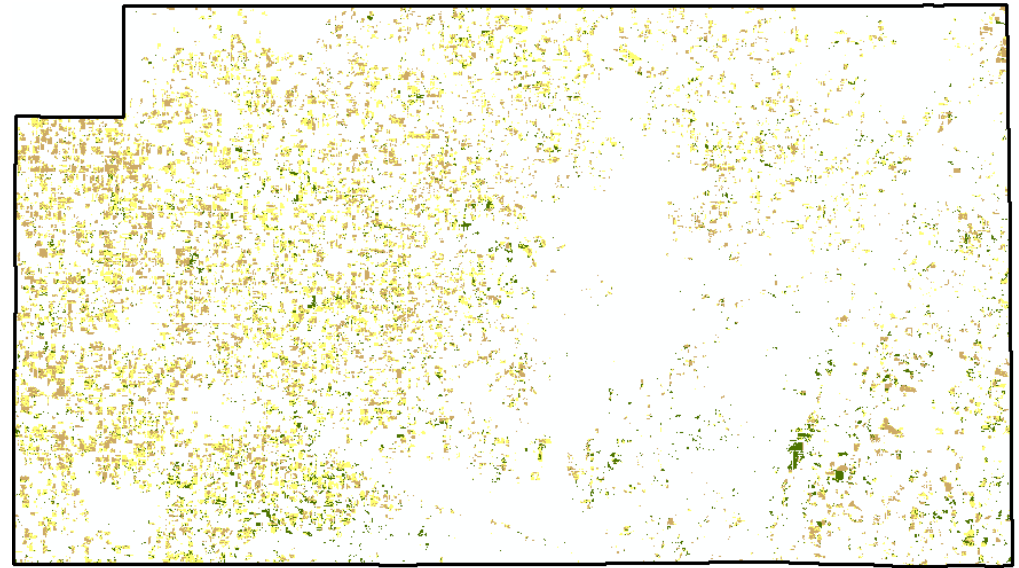
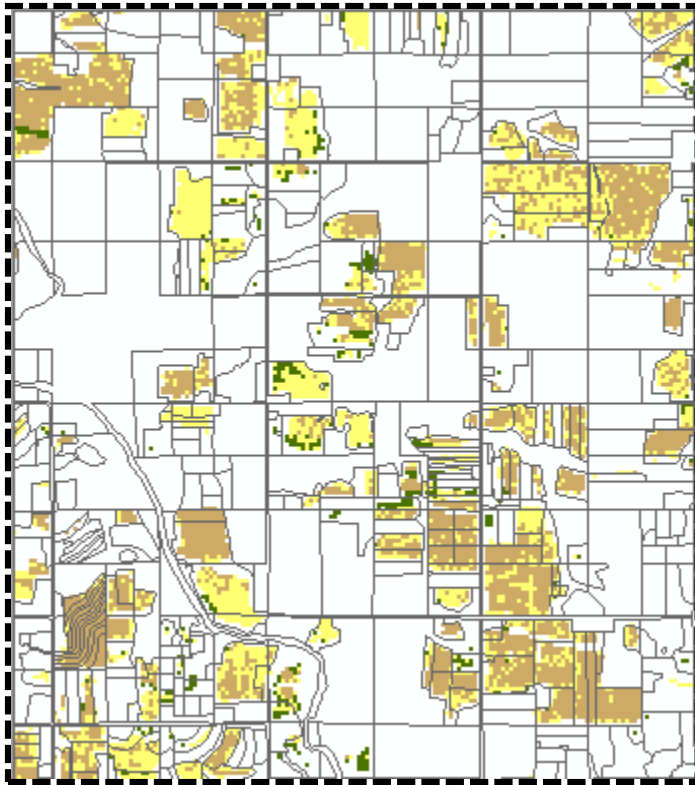


◆ Marathon County minNDTI 2012 — Linear (Marathon County minNDTI 2012)

Marathon County Crop Residue Cover



Relating minNDTI to Tillage Type



Tillage Type (%CRC)

Moldboard (0-15%)

(16-75%)

No Till (76-100%)



2012 minNDTI

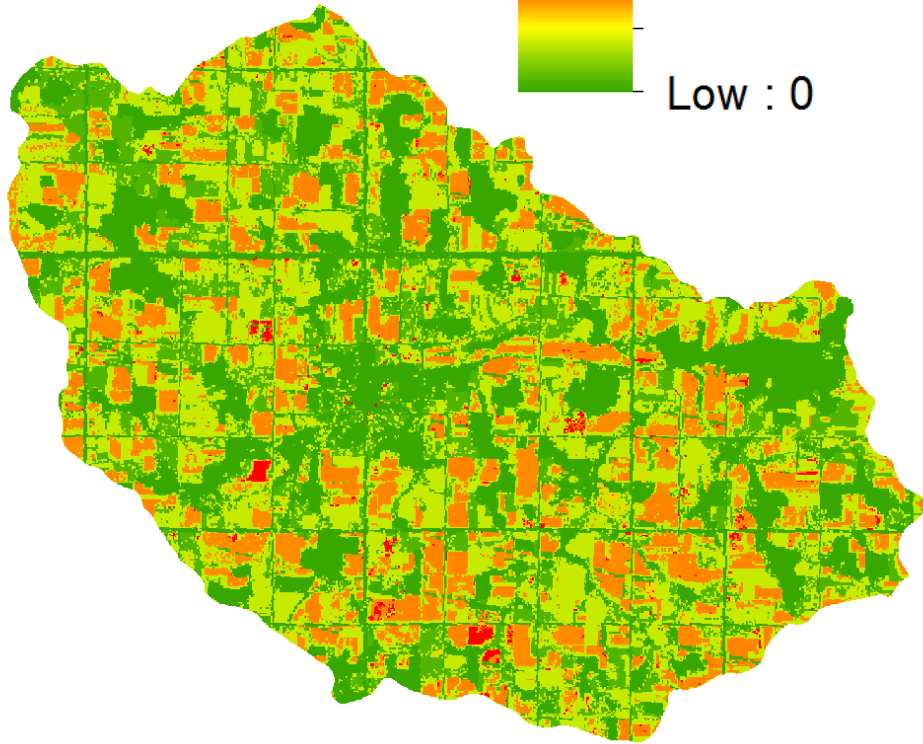
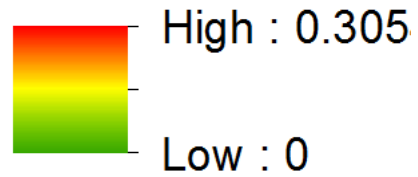
0.0001 – 0.0380

0.0380 – 0.0771

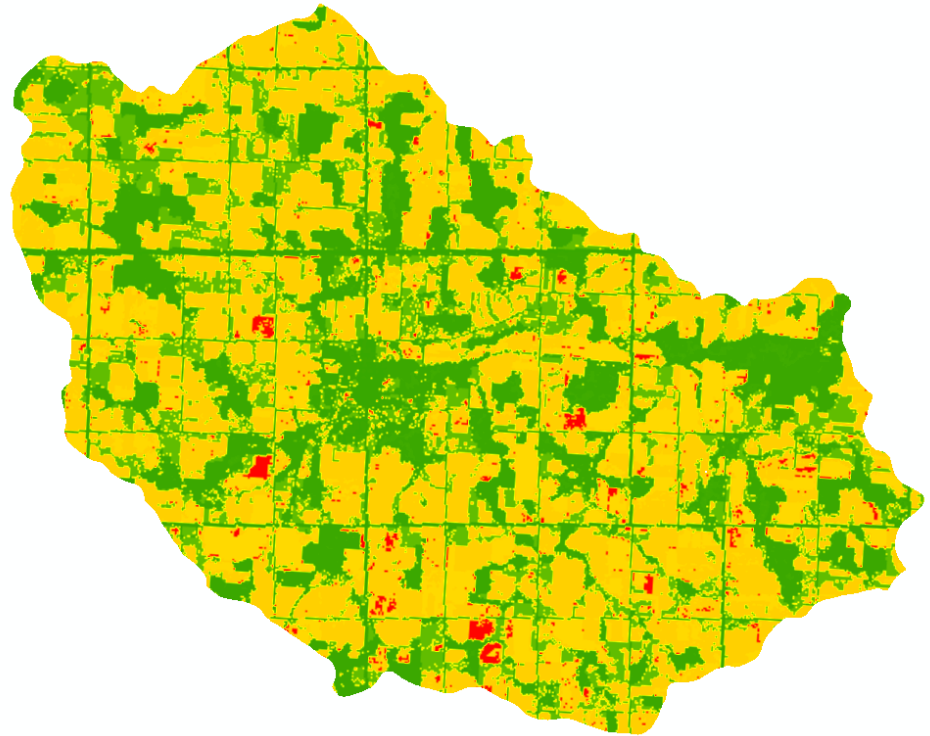
0.0771 – 0.2999

USLE C Factor

C Factor

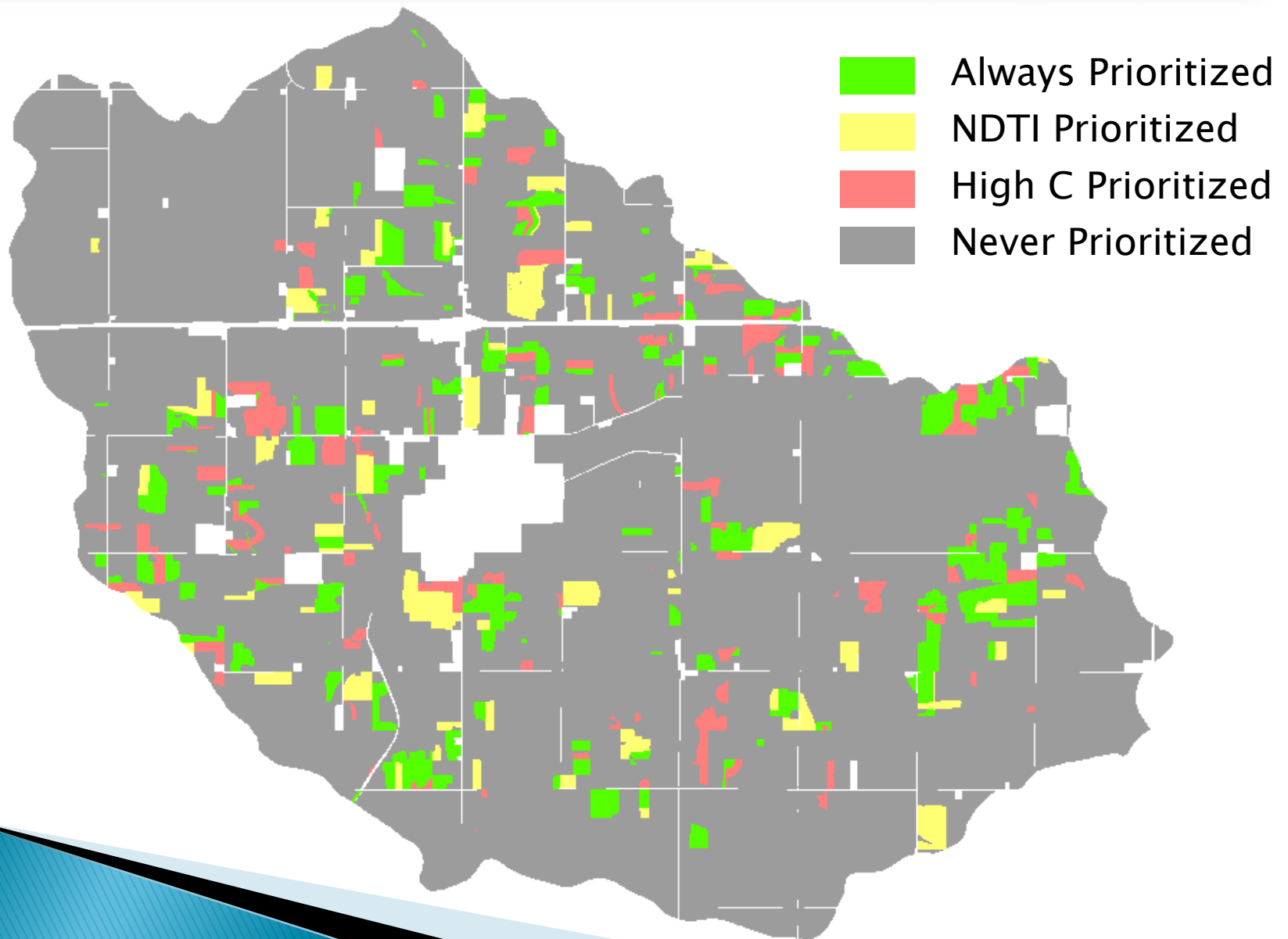


NDTI C factor



High C factor

Change in USLE top 10% prioritization



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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