



Using LIDAR and ^{137}Cs to measure soil erosion

Great Resources In Minnesota

- Access to LIDAR and DEMs
- Paired with soil measurements



Minnesota Geospatial Information Office

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How is LIDAR Data Used to Protect Water Quality in Minnesota?

High resolution elevation data collected using [LIDAR technology](#) has been available for parts of Minnesota for several years, much of it made possible by funding from the [Clean Water Fund of the Clean Water, Land, and Legacy Amendments](#). The following examples illustrate how LIDAR data is already being used to protect water quality in Minnesota. As the data becomes available for more areas of the state, the uses are expected to increase exponentially. [Click on any graphic to see it full size.](#)

- [Erosion analysis](#)
- [Water storage to reduce streambank erosion and improve water quality](#)
- [Siting and design of best management practices](#)
- [Wetland mapping, protection, and restoration](#)
- [Flood control and mapping](#)

Erosion Analysis

Estimating Soil Erosion Using LIDAR-derived Terrain Attributes and ¹³⁷Cs Concentrations in Soils

¹³⁷Cs is a radioactive isotope whose only source is nuclear fission. The isotope binds strongly to soils and "labels" the soil surface during aboveground nuclear testing in the 1950s and 1960s. Measuring the ¹³⁷Cs content of soil profiles serves as an effective tracer for soil movement on local scales. The picture is an example output from a regression model developed by researchers at the University of Minnesota. Based on digital terrain attributes, the model result shows localized areas of potentially high erosion rates while the overall average field erosion rate is 3 tons/acre/year. When applied to cultivated landscapes, the regression models create maps of predicted long-term rates of soil erosion or deposition. These maps will be useful to Board of Water and Soil Resources personnel, soil conservationists, and other local government unit personnel to help identify which portions of the landscape would benefit the most from potential vegetation conservation practices.

- [Modeling Soil Erosion with ¹³⁷Cs](#): Final report for this LCCMR-funded project.
- Soil erosion data:
 - [Download by county](#) in raster file geodatabase format.
 - See Appendix A in the final report above for help using the data to compare field-average erosion-deposition rates.



Model developed by University of Minnesota soil scientists

Modeling Soil Erosion with ^{137}Cs

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Executive Summary

In order to develop landscape-scale estimates of soil erosion in Minnesota's agricultural landscapes, we conducted a broad survey study of ^{137}Cs in cultivated fields and uncultivated grassland reference sites located across the southern third of Minnesota. Because the only source of ^{137}Cs is nuclear fission and it binds tightly to soils, landscapes were "labeled" with ^{137}Cs during aboveground testing of nuclear weapons in the 1950s and 1960s. As a result of this, ^{137}Cs inventories can serve as an effective tracer for soil movement on decadal timescales. A ^{137}Cs conversion model was used to determine soil erosion rates for 107 locations in cultivated sites. Measured soil erosion rates ranged from $49 \text{ t ha}^{-1} \text{ yr}^{-1}$ (erosion) to $-74 \text{ t ha}^{-1} \text{ yr}^{-1}$ (deposition). Based on these measured rates, regression models were developed with the goal of broadly predicting soil erosion rates based on topographic characteristics. Digital terrain attributes were calculated from LiDAR-derived (Light Detection And Ranging) digital elevation models and then used as predictor terms in regression model development. Resulting models showed that: (1) profile curvature, (2) platform curvature, and (3) slope steepness were significant model terms in predicting erosion rates for different Minnesota Major Land Resource Areas (MLRAs). The resulting regression models were able to explain 38% of the variability observed in measured soil erosion rates. When applied to cultivated landscapes, the regression models create maps of predicted long-term rates of soil erosion or deposition. These maps will be helpful to BWSR personnel, soil conservationists, and other local government unit personnel to help identify which portions of the landscape would benefit the most from perennial vegetation conservation practices. In a complementary manner, these maps may also be used to quantify the soil and water quality benefits of farmland enrollment into a conservation program (or, conversely, the environmental impact of converting perennially vegetated land for cultivation).



What is it?

Soils

BWSR works with partner agencies to increase the usefulness of current soils data, update soil surveys in the state, and provide technical support and training to local governments.

Soils data and resources

- [Minnesota Statutes Chapter 103F Soil Erosion Law: History, Perspectives and Recommendations](#)
This paper is intended to frame questions and comments in relation to Minnesota's present soil erosion law.
- [Soil Carbon & Long-term Land Use](#)
- [Web Soil Survey](#) (Updated crop yields and an index of soil productivity now available on the WEB Soil Survey. This project is a joint effort of the USDA Natural Resources Conservation Service, University of Minnesota and the Board of Water and Soil Resources. Financial support was provided by the Minnesota Environment and Natural Resources Trust Fund.)
- [Minnesota Geospatial Information Office](#) (Soils Information)
- [Minnesota Geospatial Information Office](#) (Crop Productivity Index)
- [Minnesota Geospatial Information Office](#) (Crop Equivalent Ratings)
- [Air Photo Information Page](#)
- [Model Ordinance for Agricultural Erosion Control](#) (see [M.S. 103F.411](#))
- [LCCMR Estimators Project: Soil Erosion Maps](#)
 - Download County Shapefile: 



- Raster Geodatabase
- 3m DEM
- Erosion rates



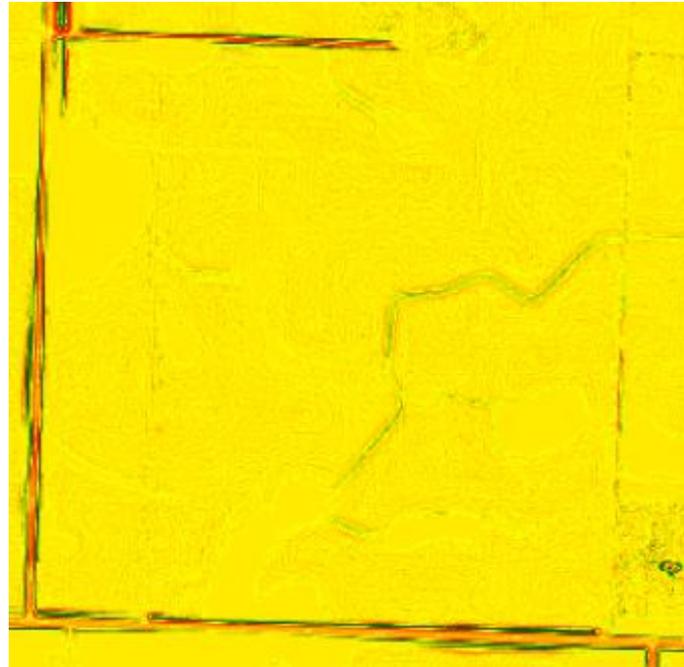
What you can use this for

- Precision conservation: targeting, prioritizing
- Estimate benefits of easements and other grass plantings
- Predict erosion due to landuse change (CRP to row crop)



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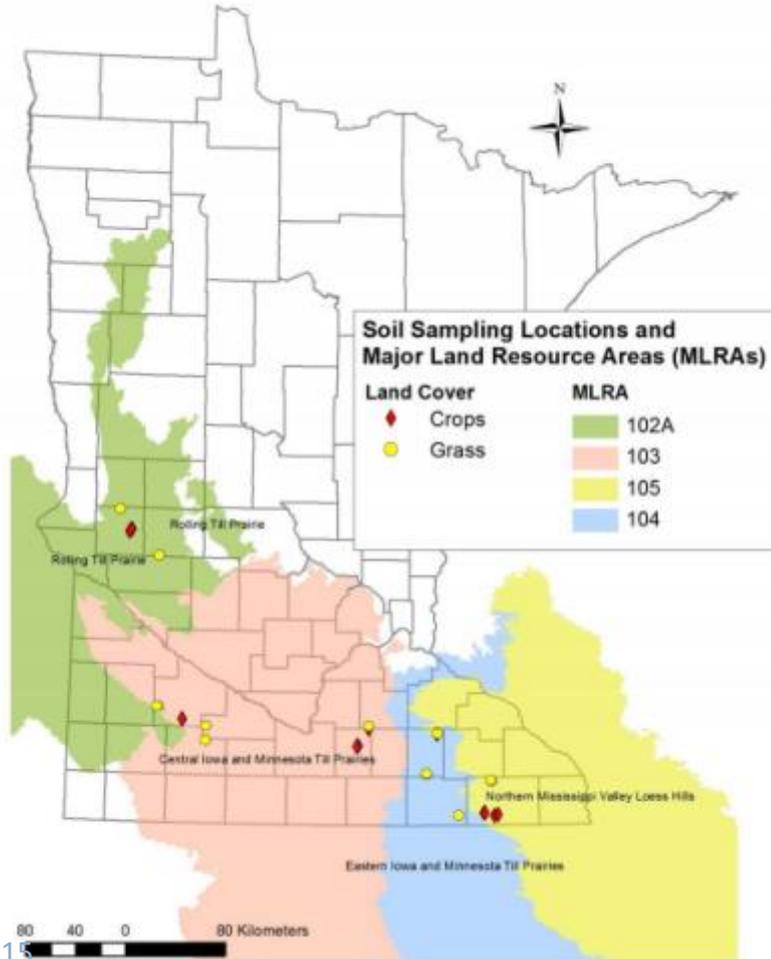


Goals of research

1. Measure long-term erosion rates across southern 1/3 of Minnesota
2. Develop empirical models based on digital terrain attributes
3. Produce maps of long-term erosion

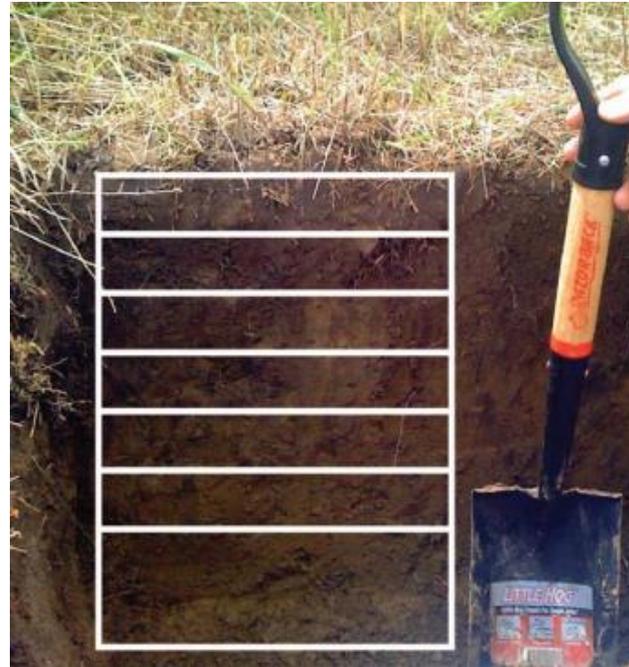


Areas sampled



^{137}Cs Inventory

- Sample collection in increments
- 150cm



Why is ^{137}Cs important?

- Radioactive isotope is human-made
- Uniform atmospheric deposition
- ^{137}Cs movement is a physical process
- Unique tracer for studying erosion and sedimentation

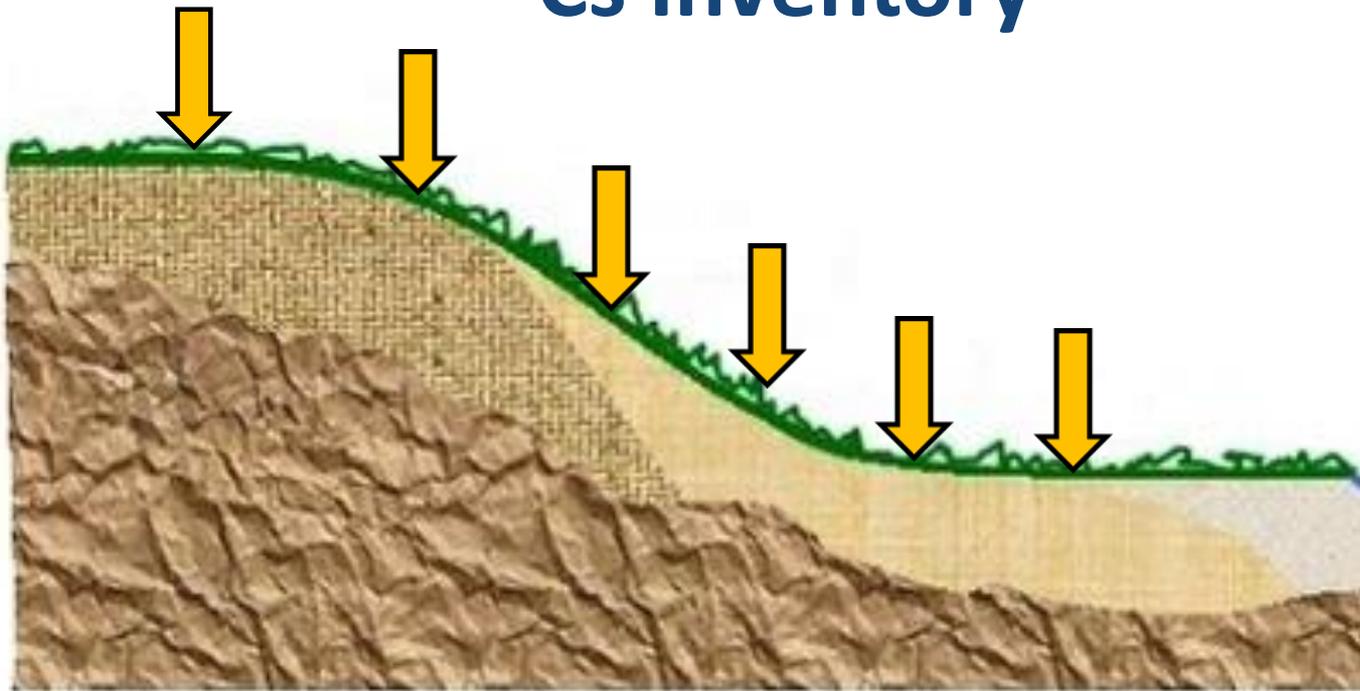


Using fallout isotopes

- Use of fallout isotopes is not new
- Combining isotope movement with DEM is new
- Allows for field-scale estimates of erosion and deposition



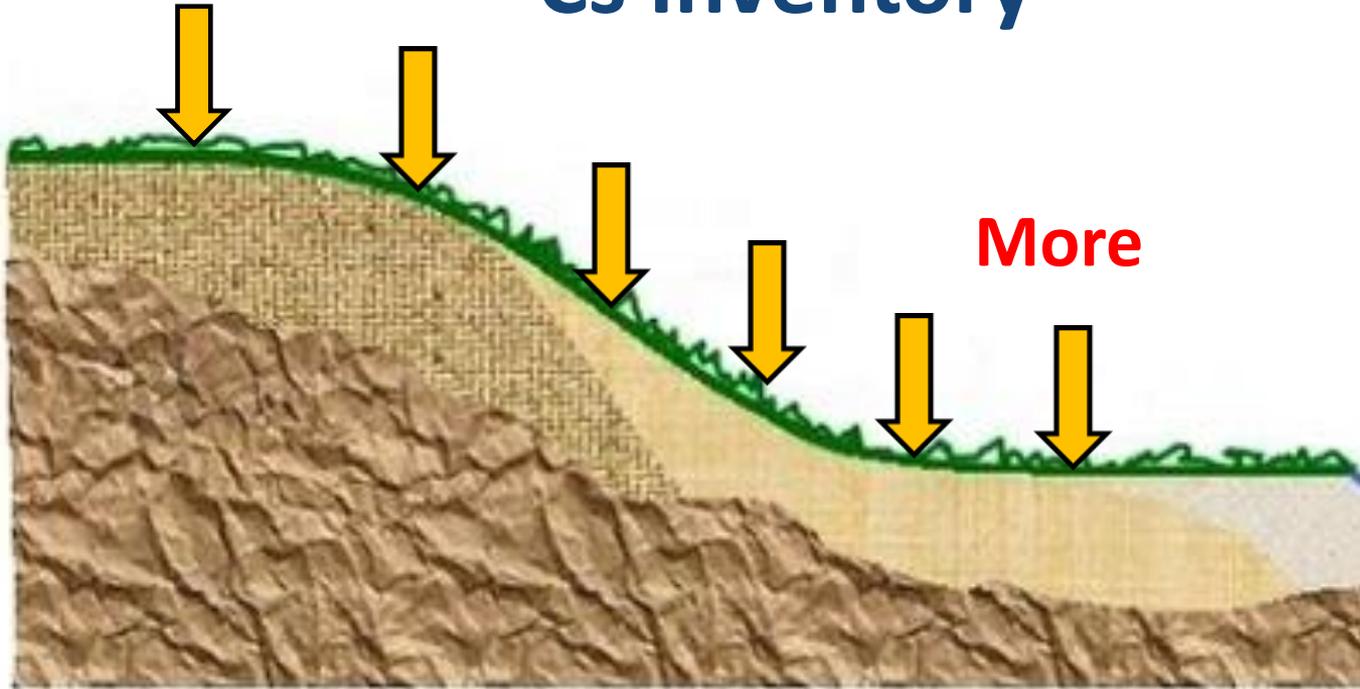
^{137}Cs Inventory



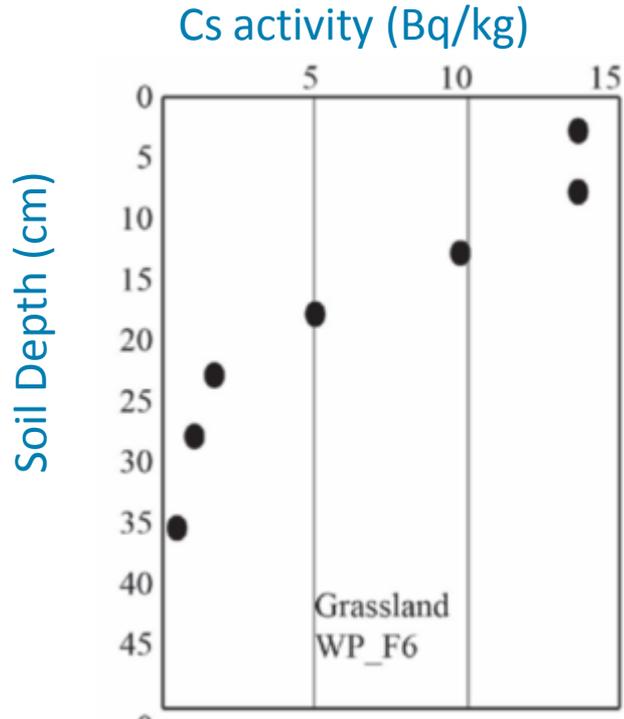
Less

^{137}Cs Inventory

More



137 Cs distribution with depth

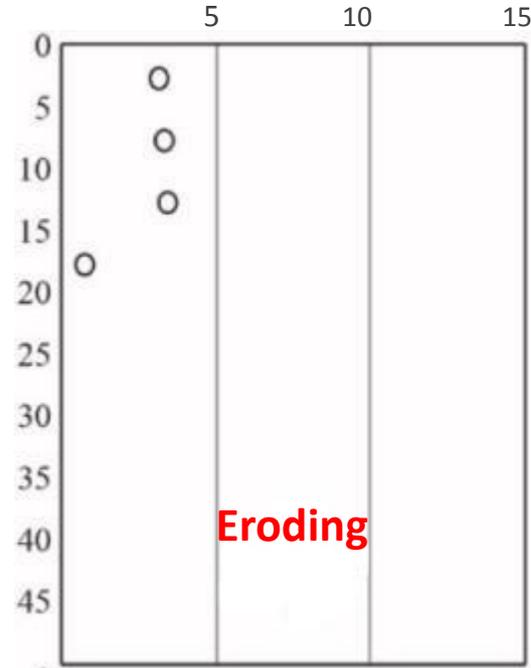
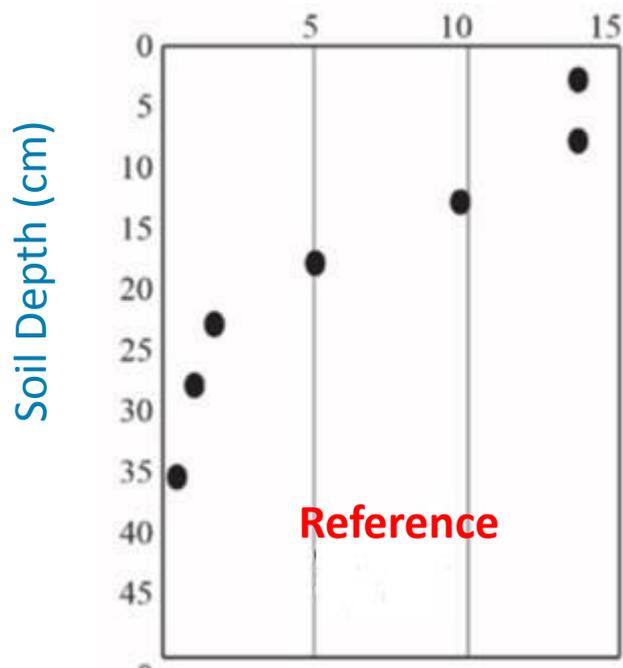


Reference Site -
grassland

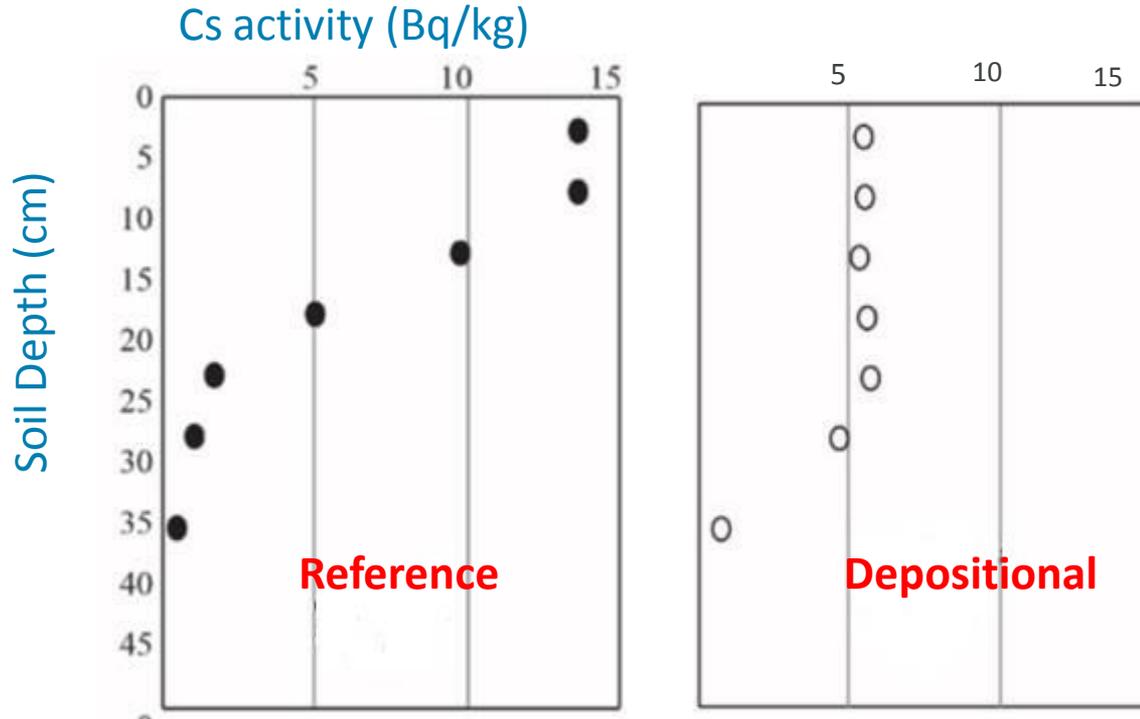


137 Cs distribution with depth

Cs activity (Bq/kg)

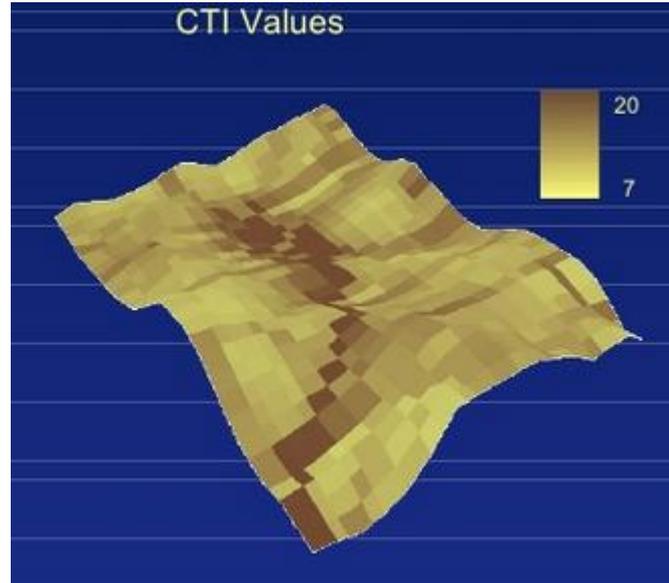


137 Cs distribution with depth



Landscape data

- Compound topographic Index
- Quantifies the position of a site in the local landscape



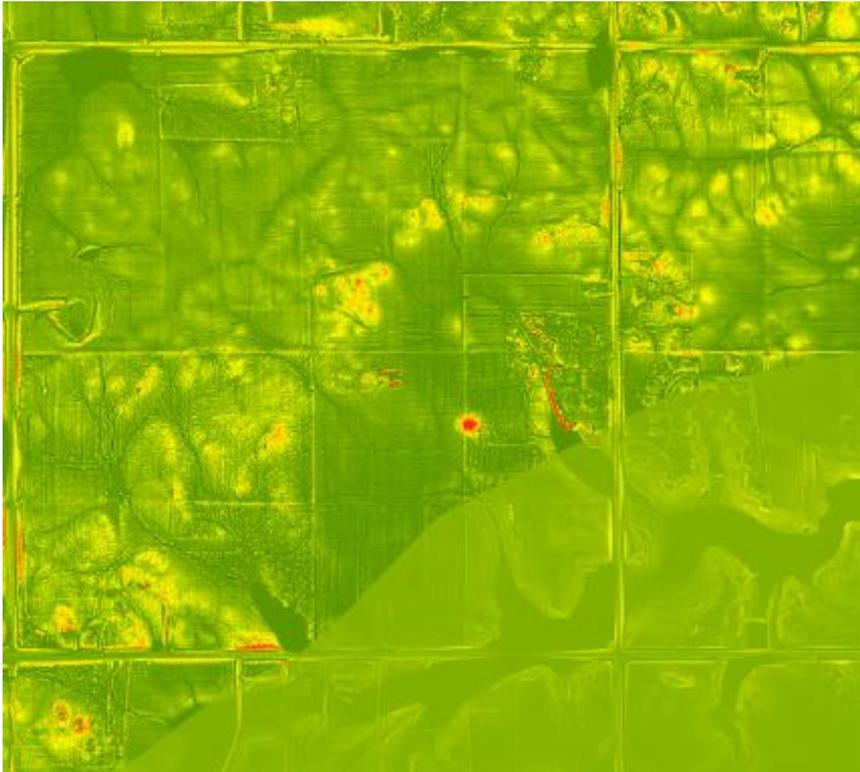
Putting all the pieces together

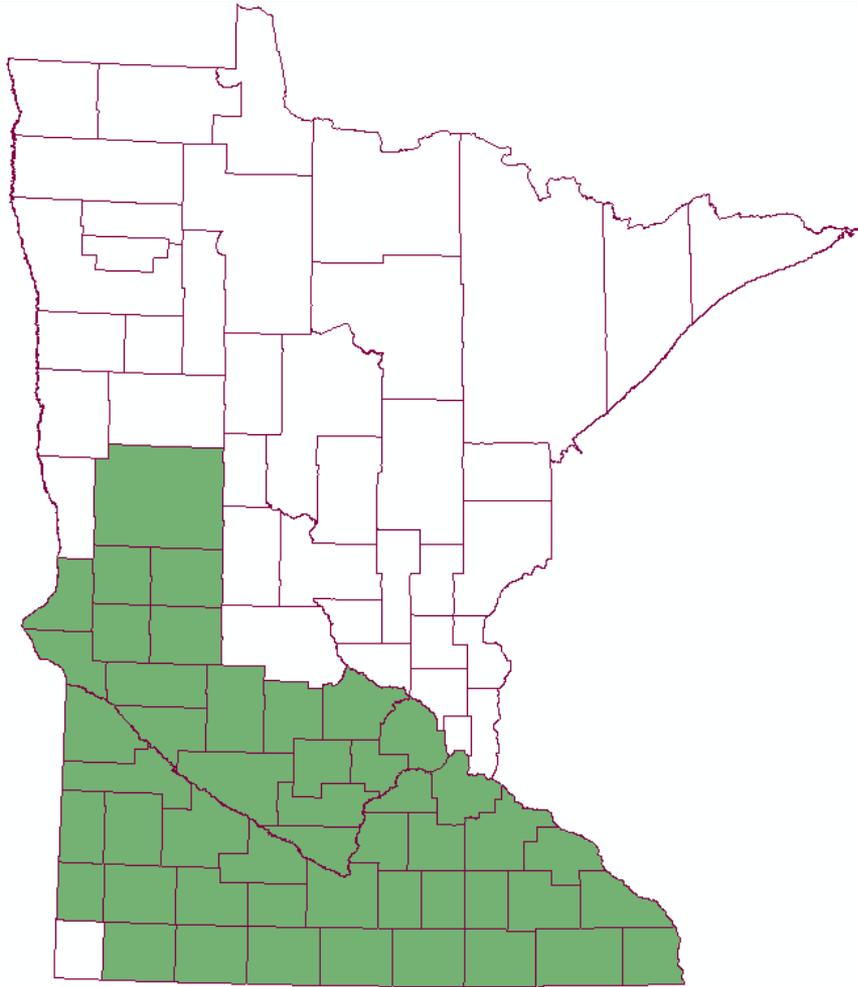
Predicting Soil Erosion

- Bulk density
- Depth of cultivation
- % reduction in ^{137}Cs relative to reference
- Time since onset of ^{137}Cs accumulation



Soil erosion rates in Geodatabase





Geodatabase availability



Determining field-average erosion/deposition

Inputs

- Geodatabase raster for your county of interest
- Air photo layer to help identify area of interest

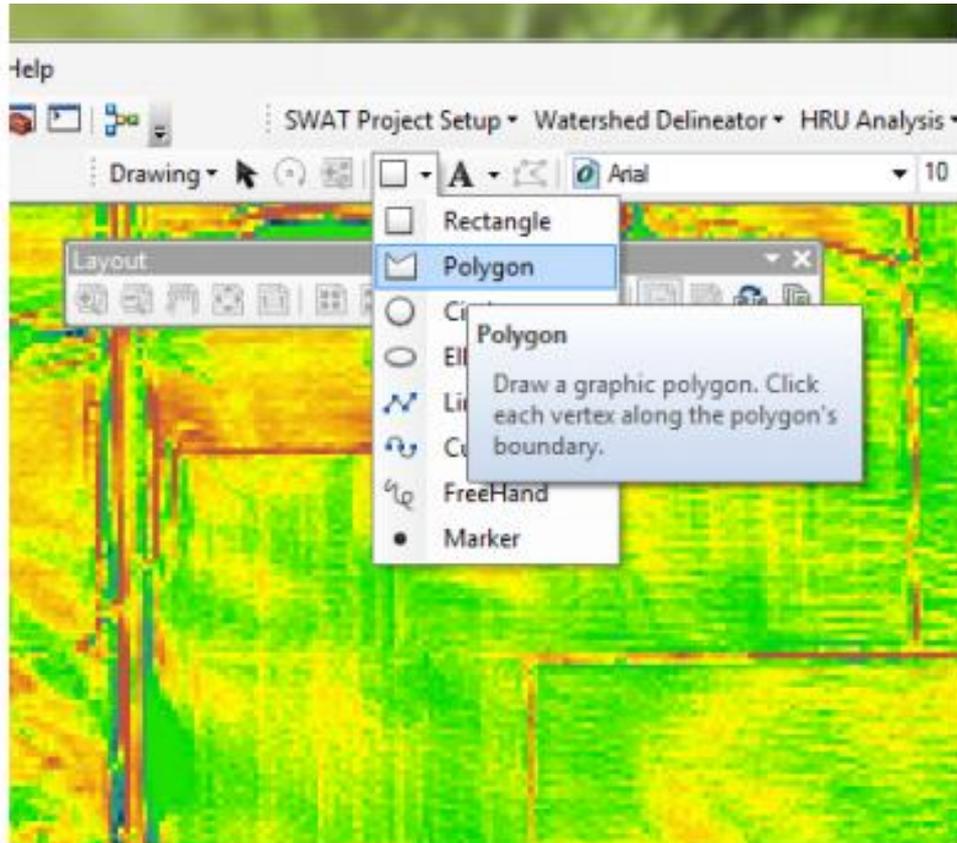
Outputs

- Shapefile of area of interest
- Raster showing the average predicted erosion/deposition rate for area of interest



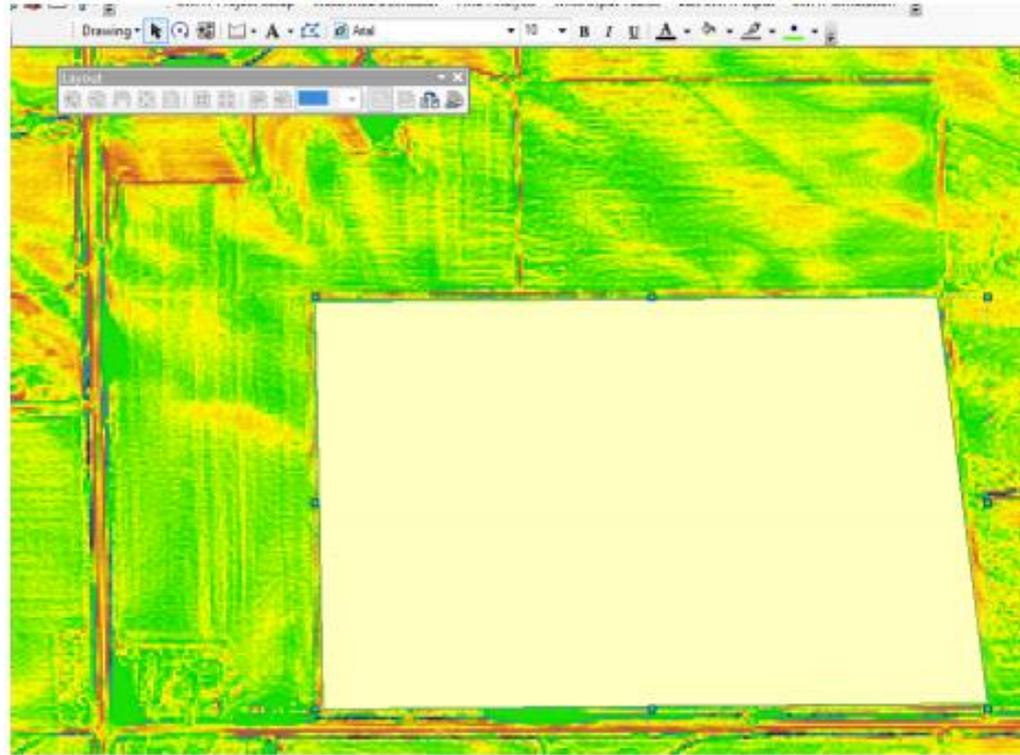
Step 1a

Manually delineate area of interest



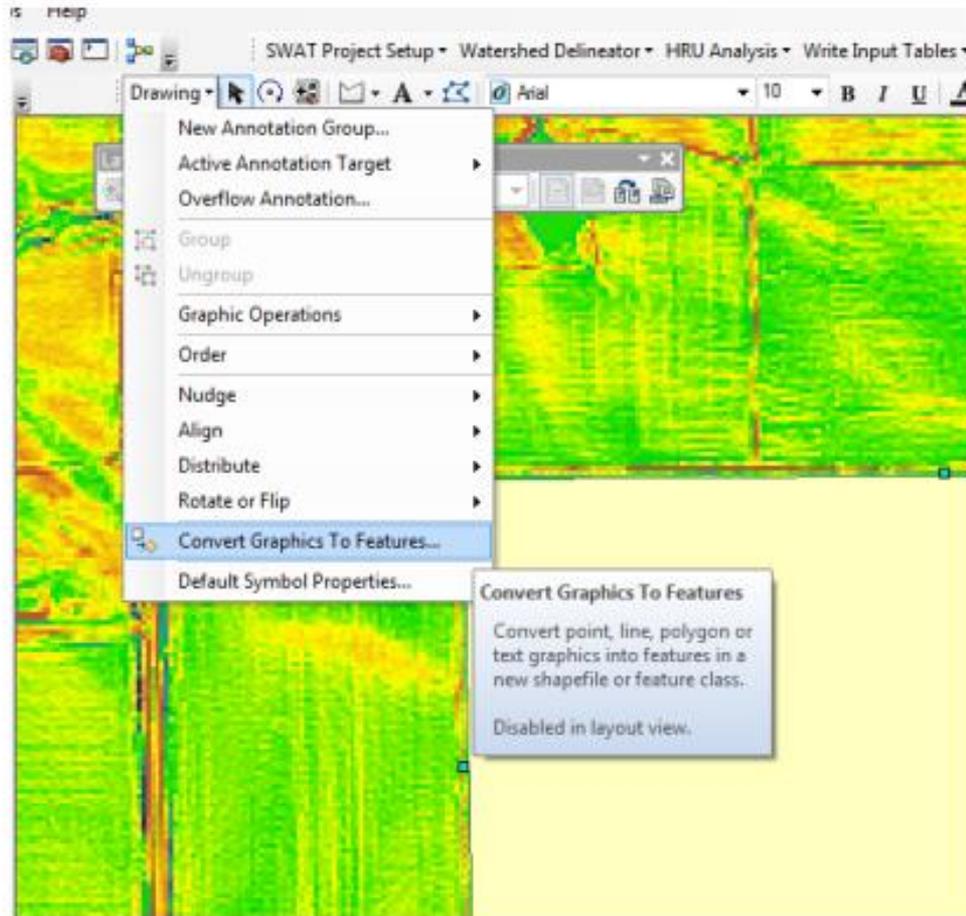
Step 1b

New polygon



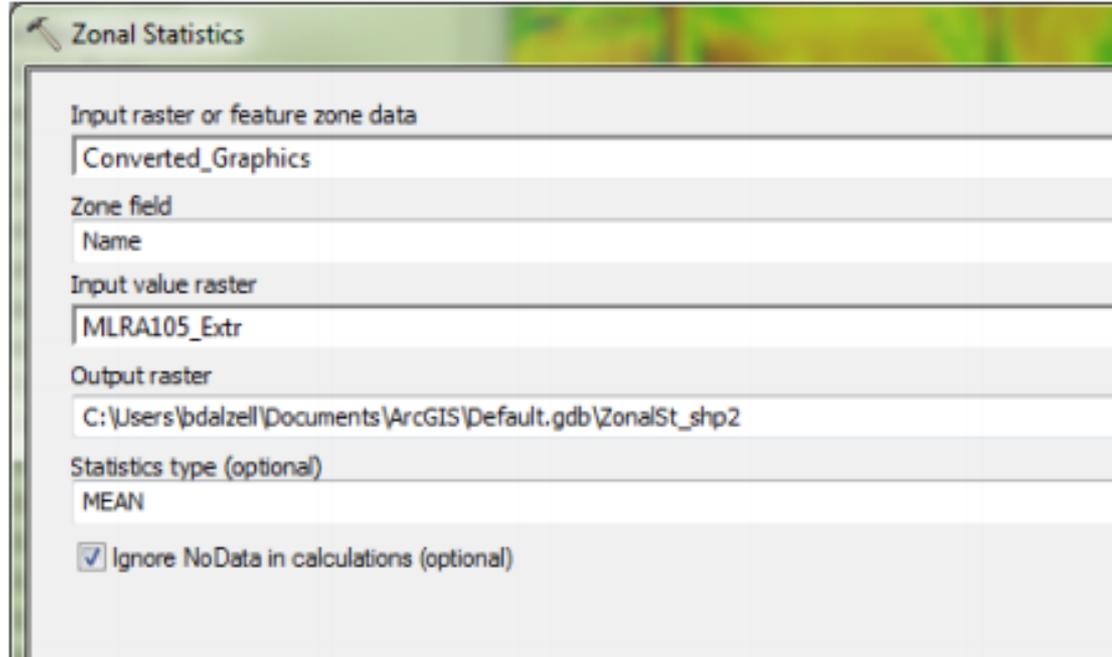
Step 2

Convert Graphics to Feature



Step 3

Perform Zonal Statistics



Zonal Statistics

Input raster or feature zone data
Converted_Graphics

Zone field
Name

Input value raster
MLRA105_Ext

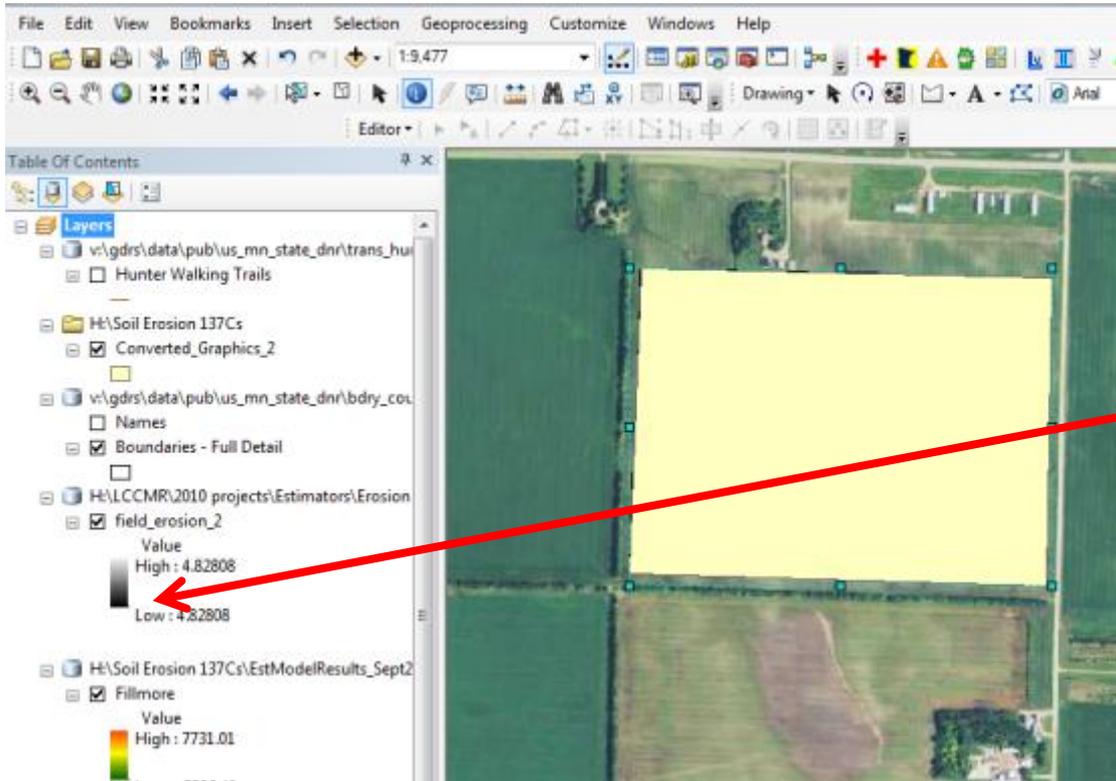
Output raster
C:\Users\bdalzell\Documents\ArcGIS\Default.gdb\ZonalSt_shp2

Statistics type (optional)
MEAN

Ignore NoData in calculations (optional)



Output Raster



Field Average
erosion (t/ha yr)



Keep in Mind

- Estimates of long-term average erosion
- Doesn't account for management practices
- Compare row crops to grassland



We want your feedback

Try it out, let us know what you think

www.bwsr.state.mn.us/soils

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