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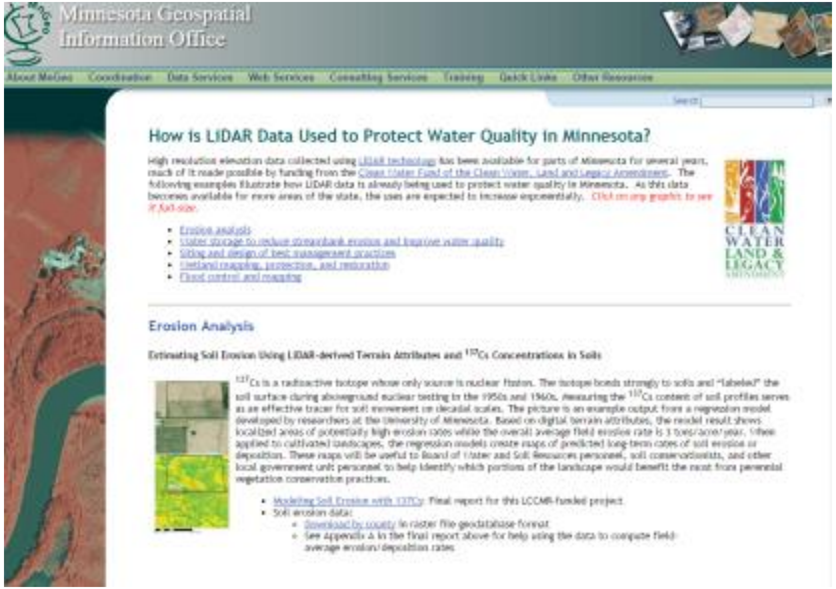
Using LIDAR and ^{137}Cs to measure soil erosion

Great Resources In Minnesota

- Access to LIDAR and DEMs
- Paired with soil measurements



Model developed by University of Minnesota soil scientists

Modeling Soil Erosion with ^{137}Cs

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ENVIRONMENT AND NATURAL RESOURCES TRUST FUND

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 t ha^{-1} yr^{-1} (erosion) to -74 t ha^{-1} 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) planform 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).

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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: Choose County

- Raster Geodatabase
- 3m DEM
- Erosion rates

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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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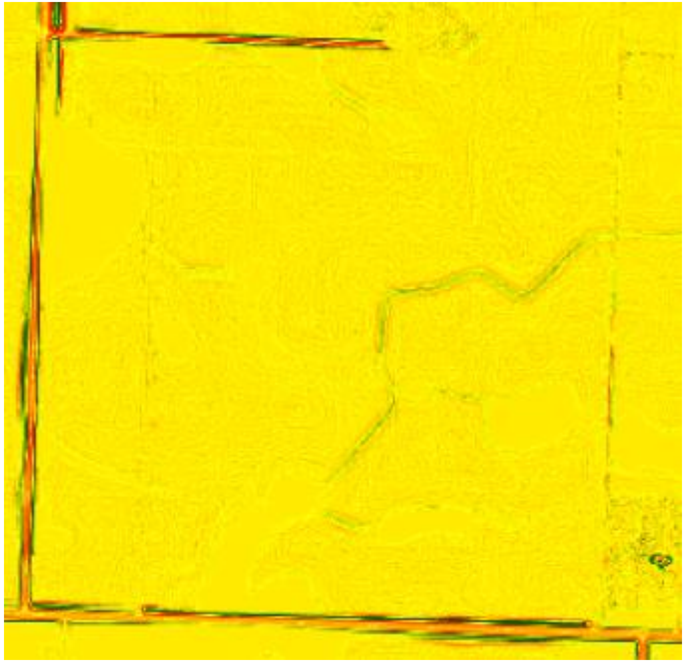

Goals of research

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

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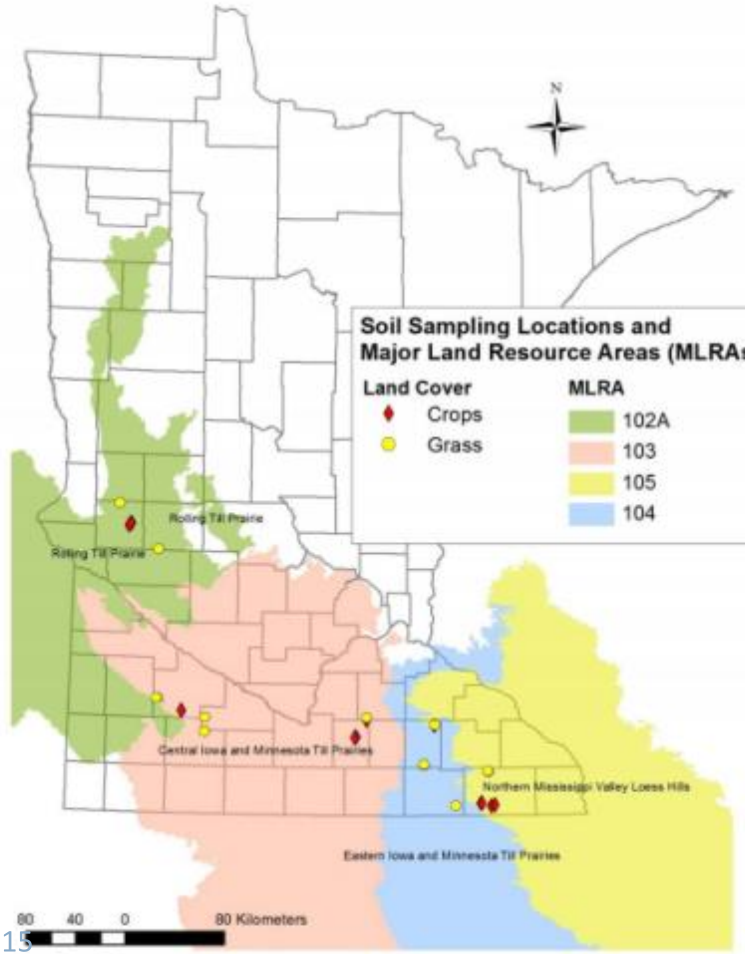
Areas sampled



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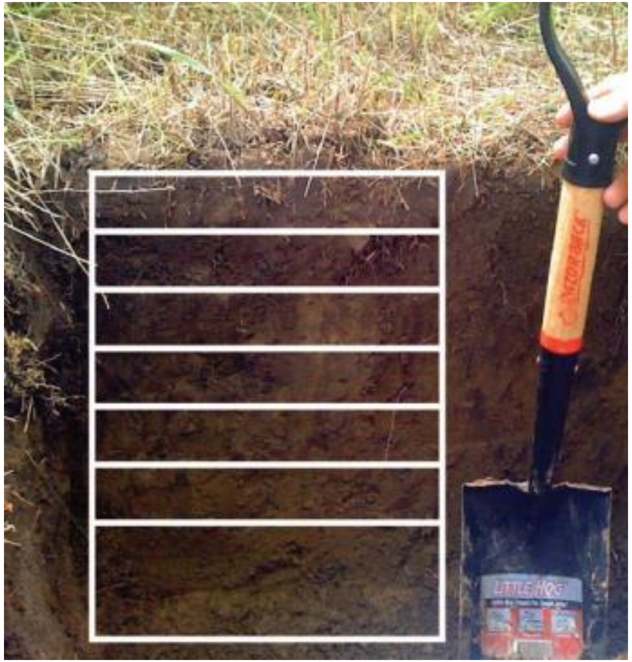
^{137}Cs Inventory

- 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

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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

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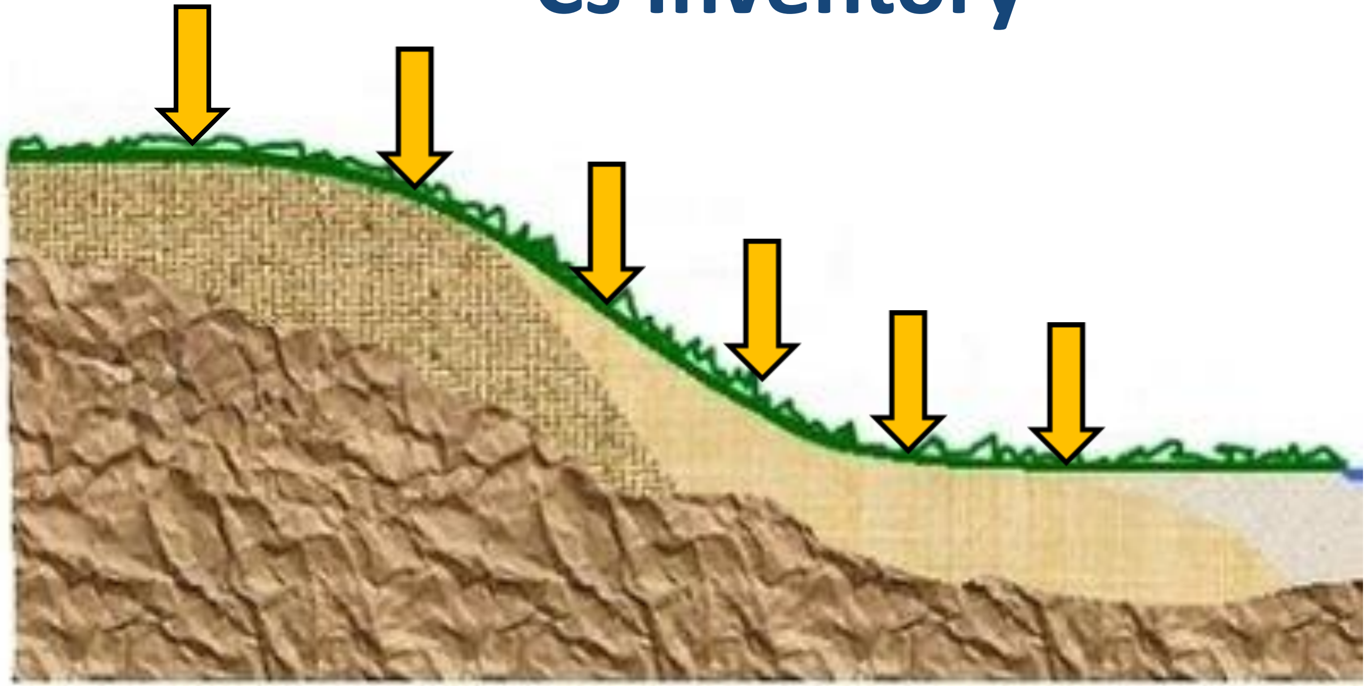
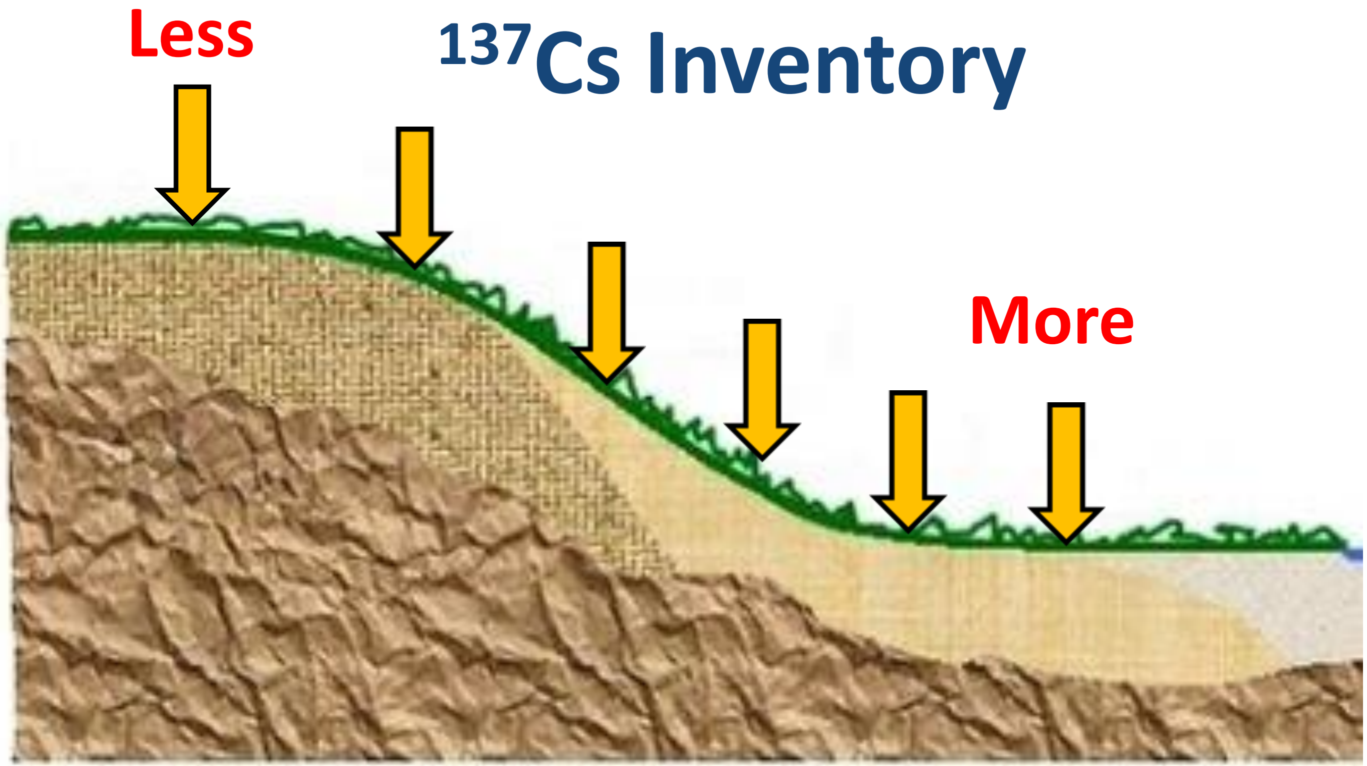
^{137}Cs Inventory



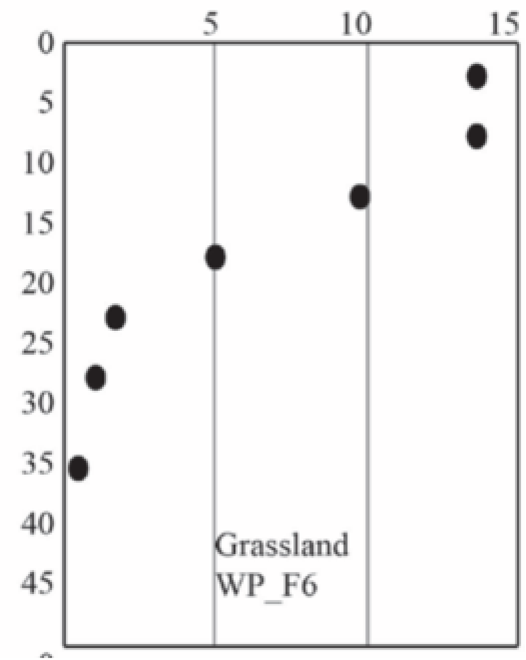
^{137}Cs Inventory



137 Cs distribution with depth

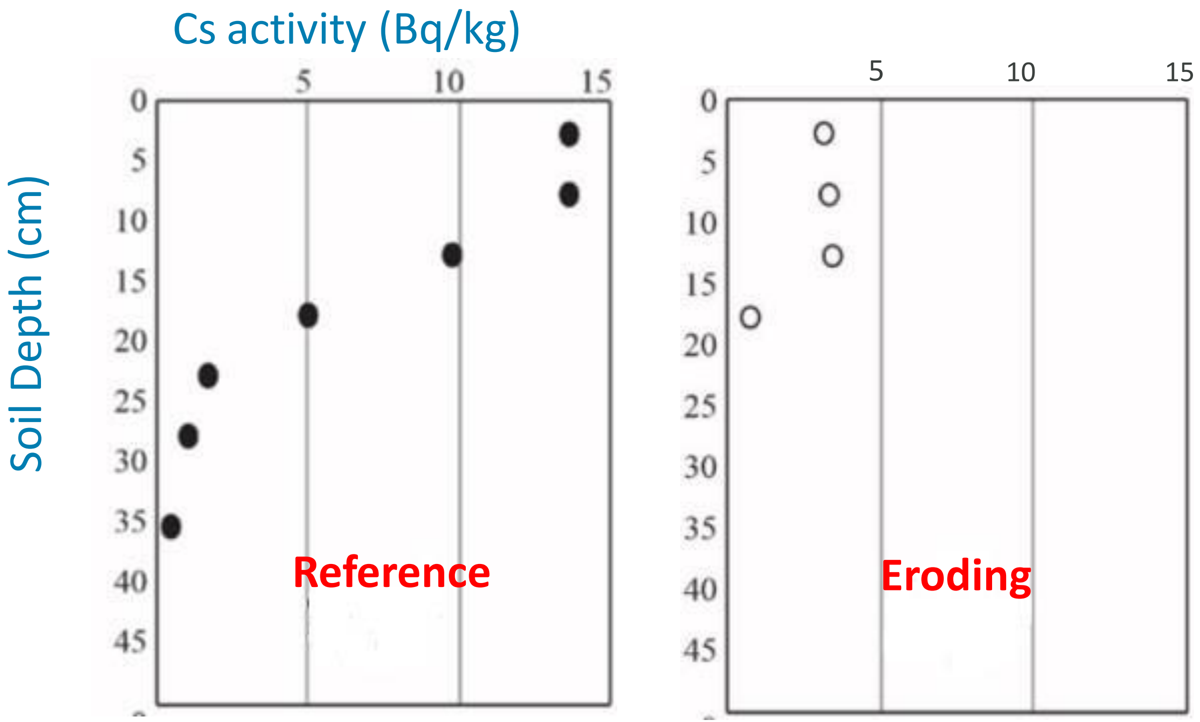
Cs activity (Bq/kg)

Soil Depth (cm)

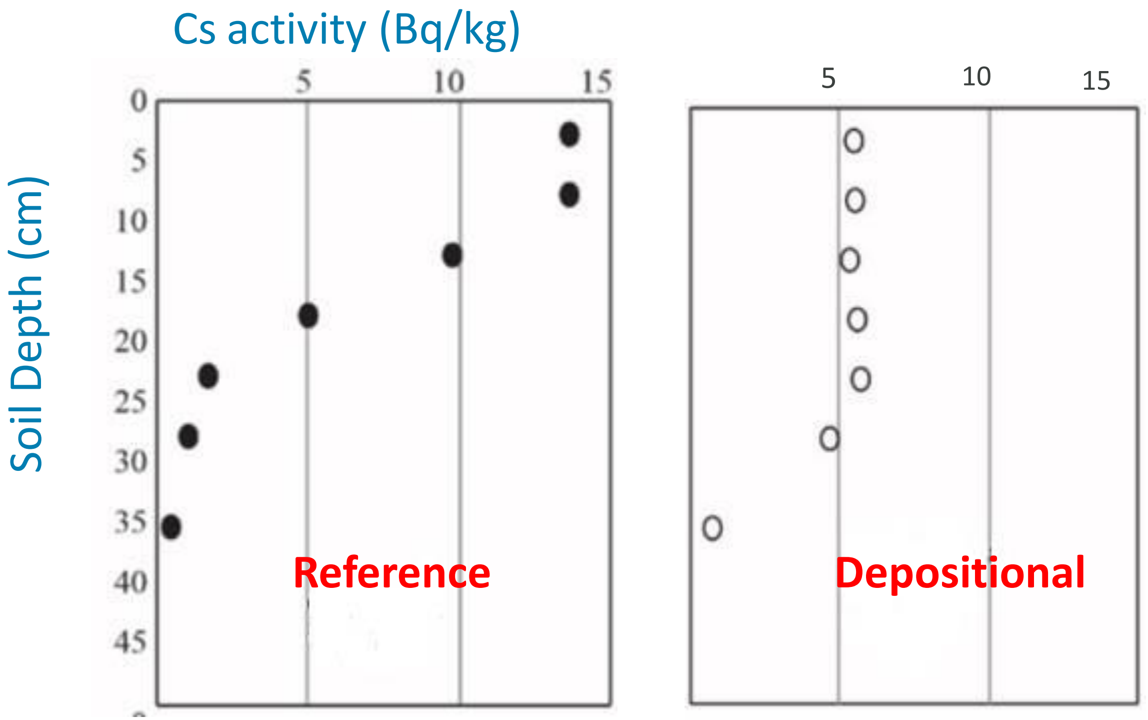


Reference Site - grassland

137 Cs distribution with depth

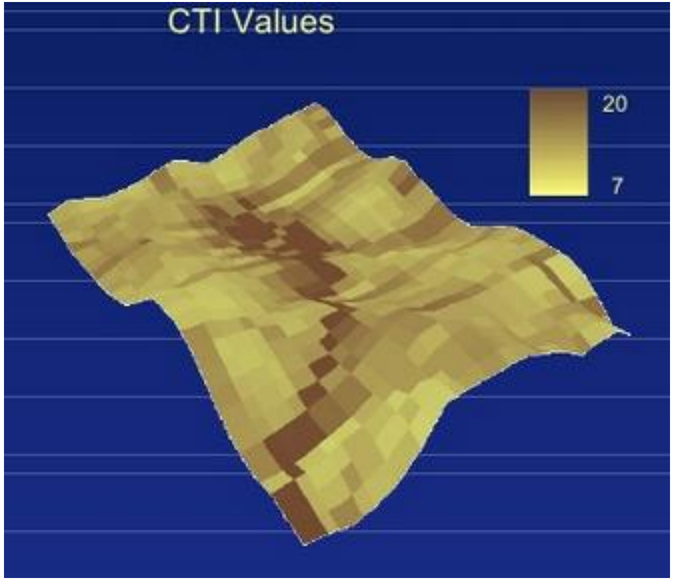


137 Cs distribution with depth



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

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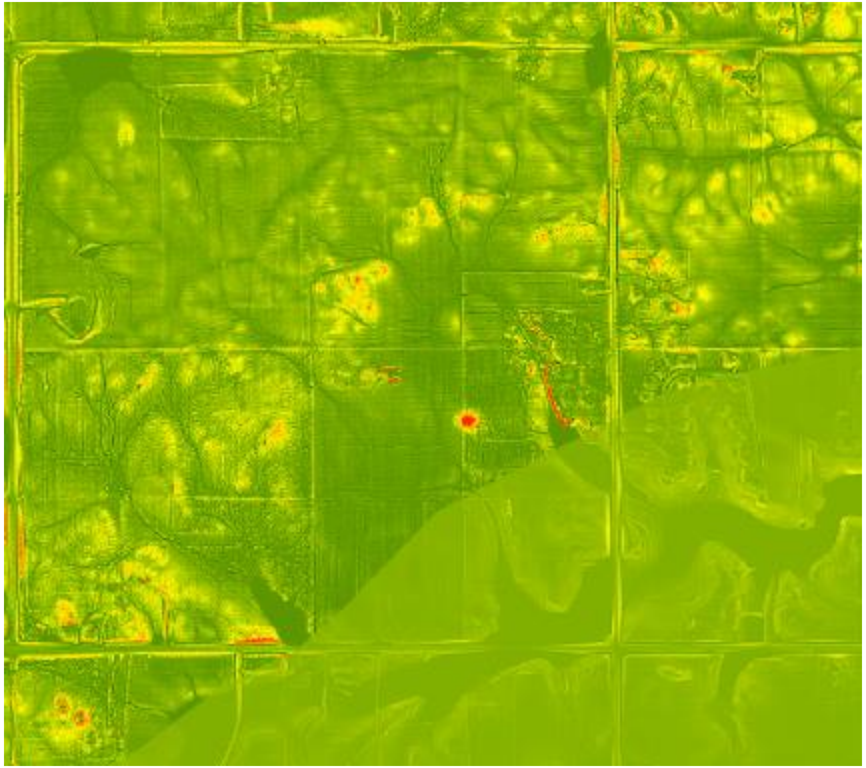
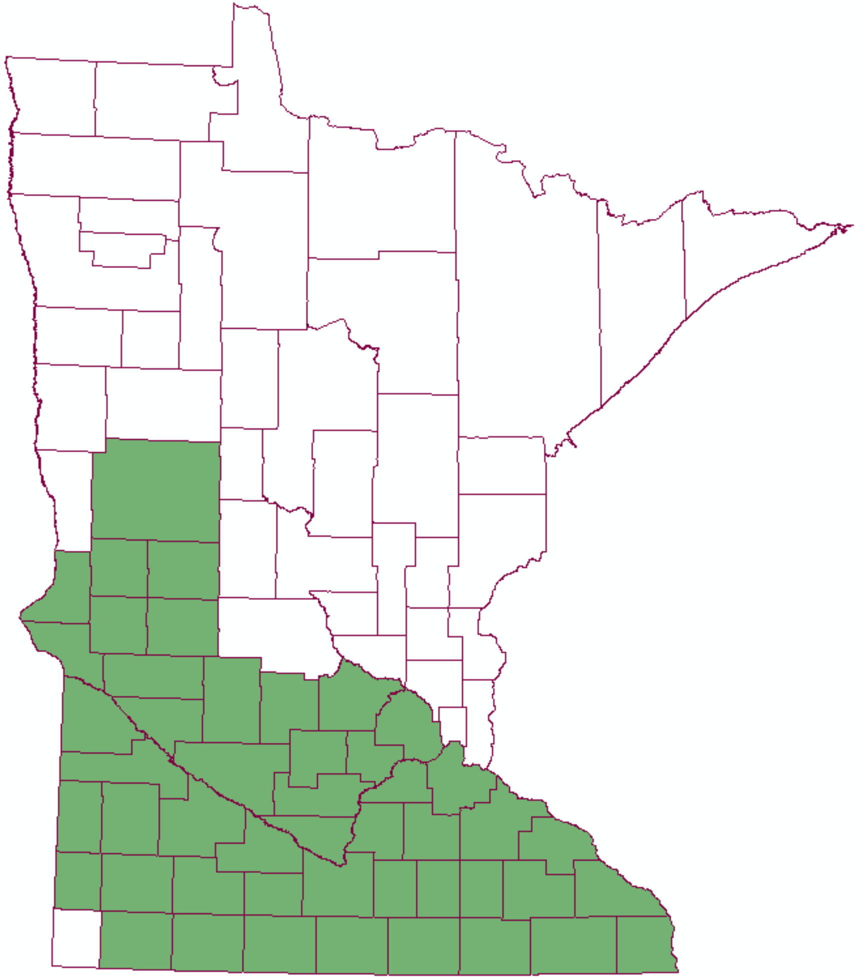
Soil erosion rates in Geodatabase





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

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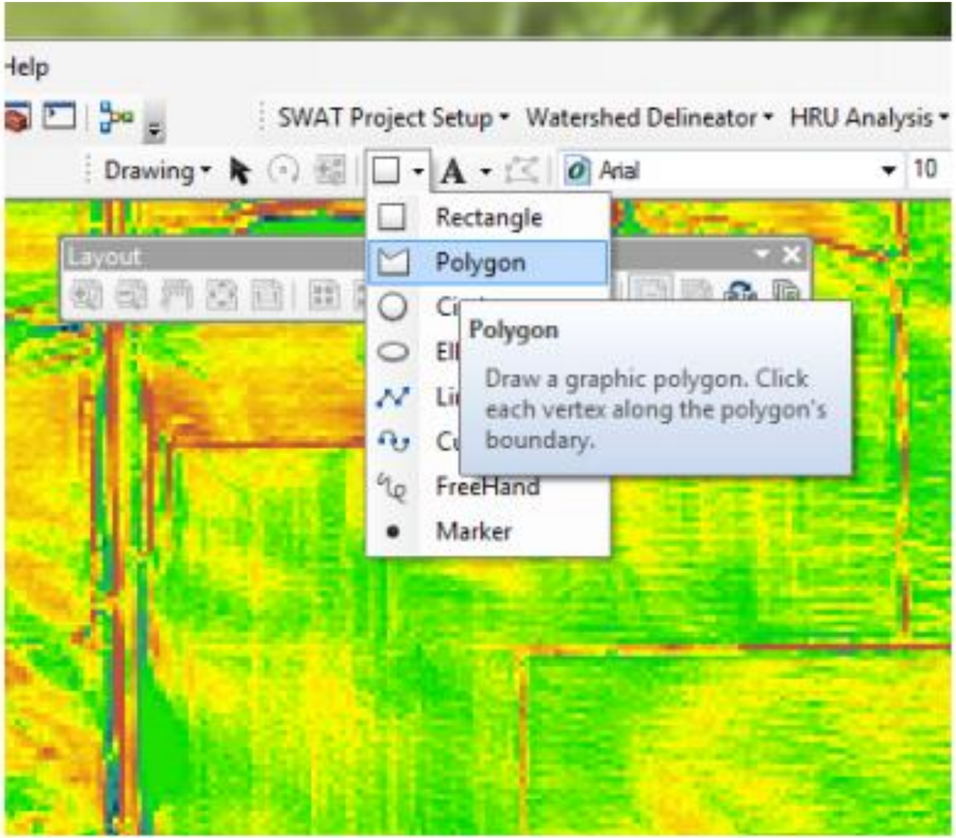
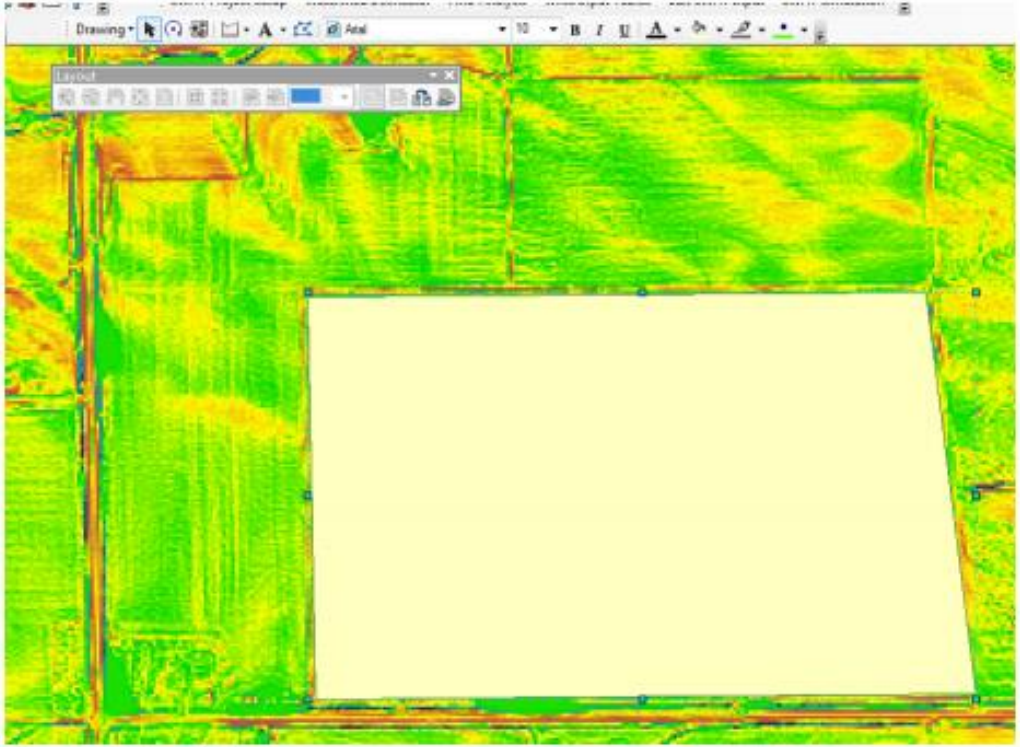
Step 1a

Manually delineate area of interest



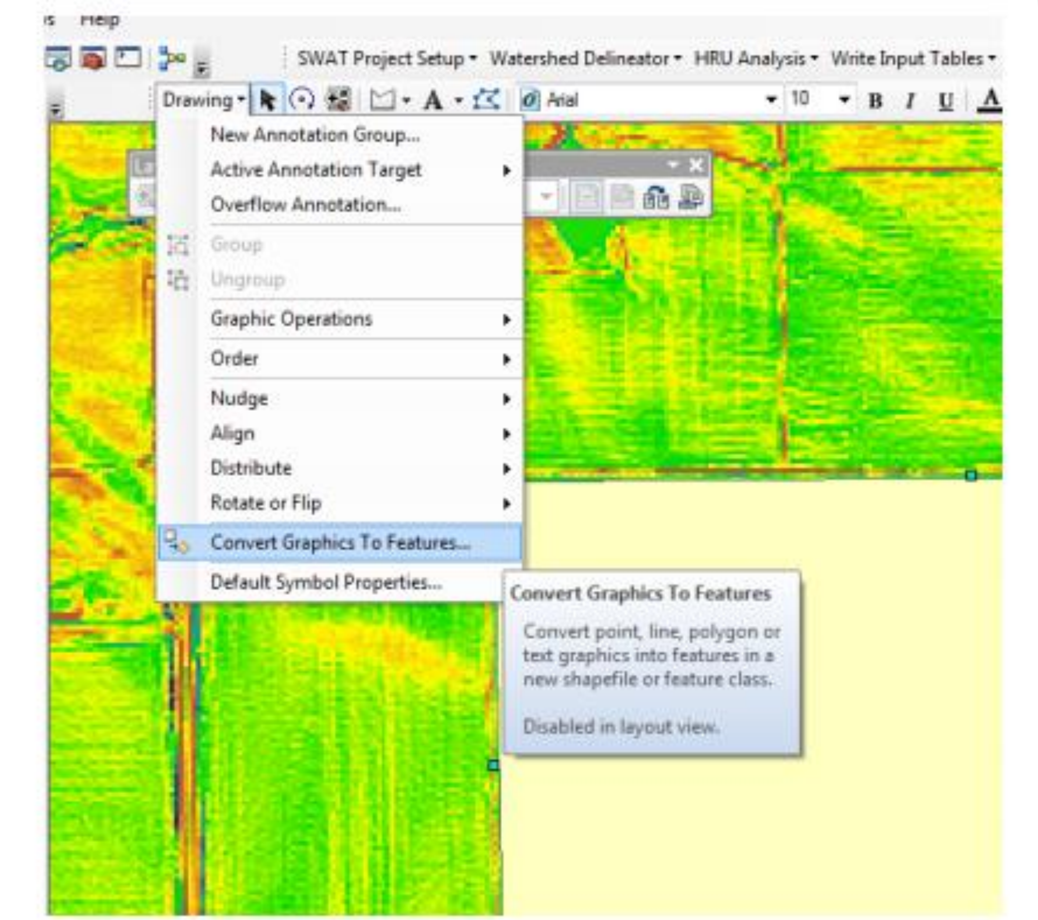
Step 1b

New polygon



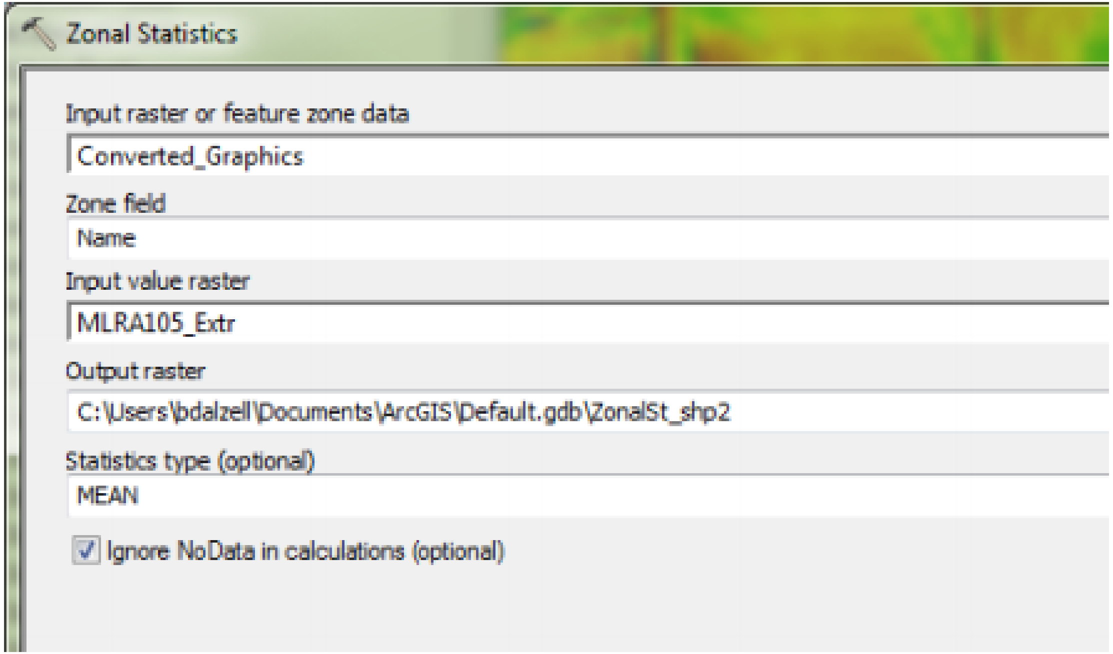
Step 2

Convert Graphics to Feature



Step 3

Perform Zonal Statistics



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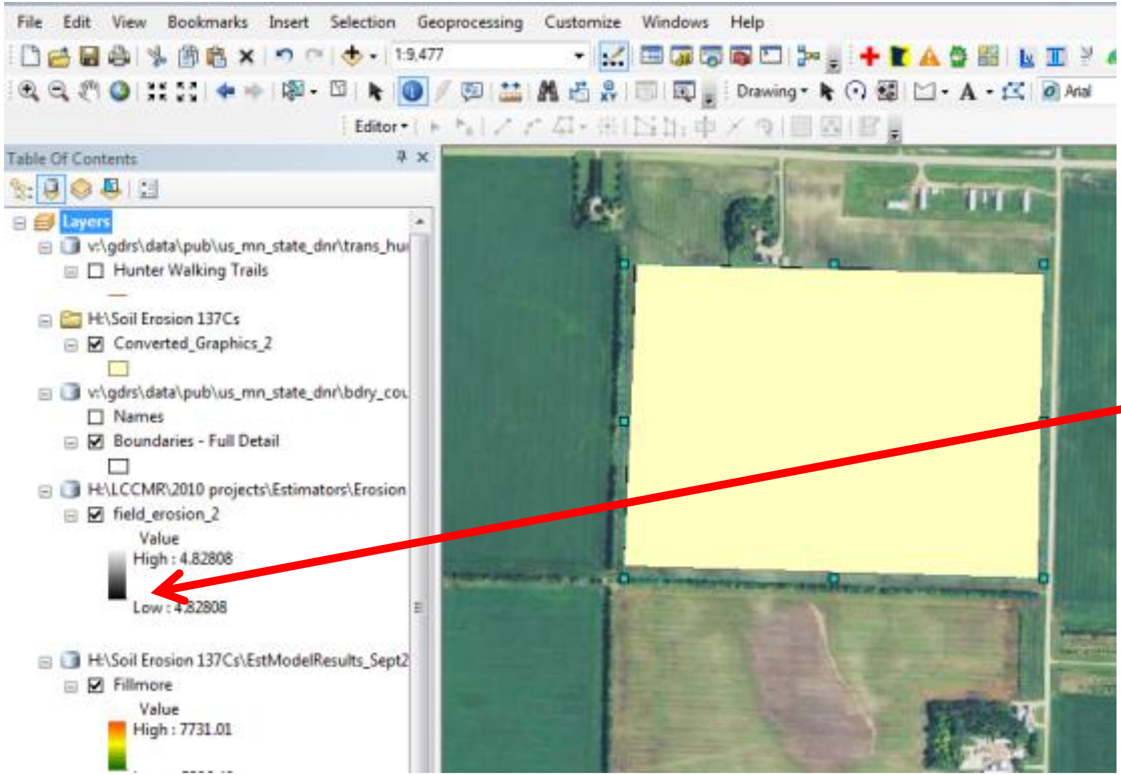
Output Raster



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

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We want your feedback

Try it out, let us know what you think

www.bwsr.state.mn.us/soils

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