# EVAAL Training

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Wisconsin Department of Natural Resources

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# Acknowledgements


- Aaron Ruesch
- Dave Evans
- Michelle Hu

# Overview

- Introductions
- EVAAL Overview
- EVAAL – How To
- Exercises

# EVAAL

- Overview

# EVAAL

- **E**rosion **V**ulnerability **A**ssessment for **A**gricultural **L**ands
- Developed by WDNR
- GIS-based model
- Vulnerability to erosion and nutrient export
- Deprioritizes internally draining areas

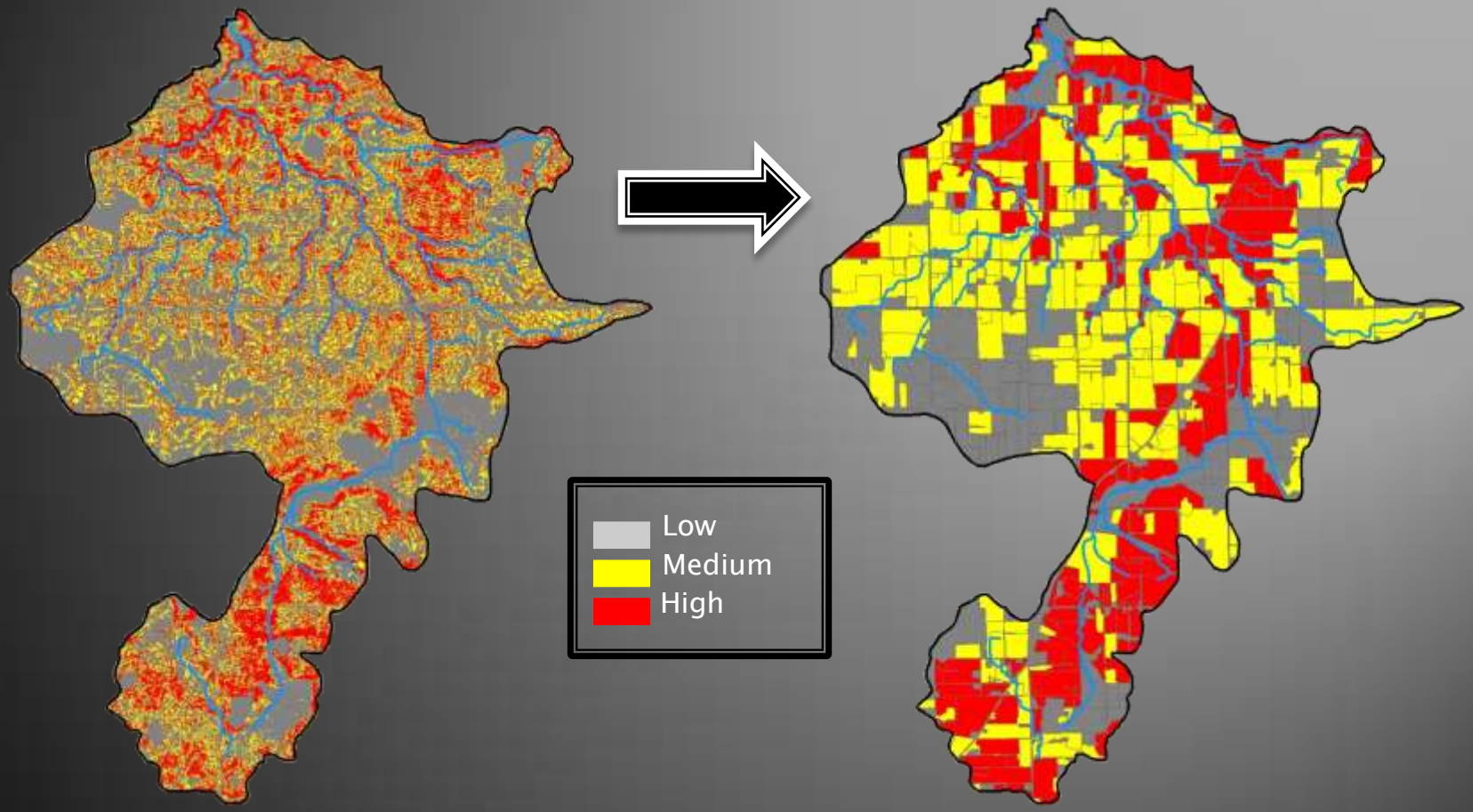
EVAAL

Erosion Vulnerability Assessment for Agricultural Lands

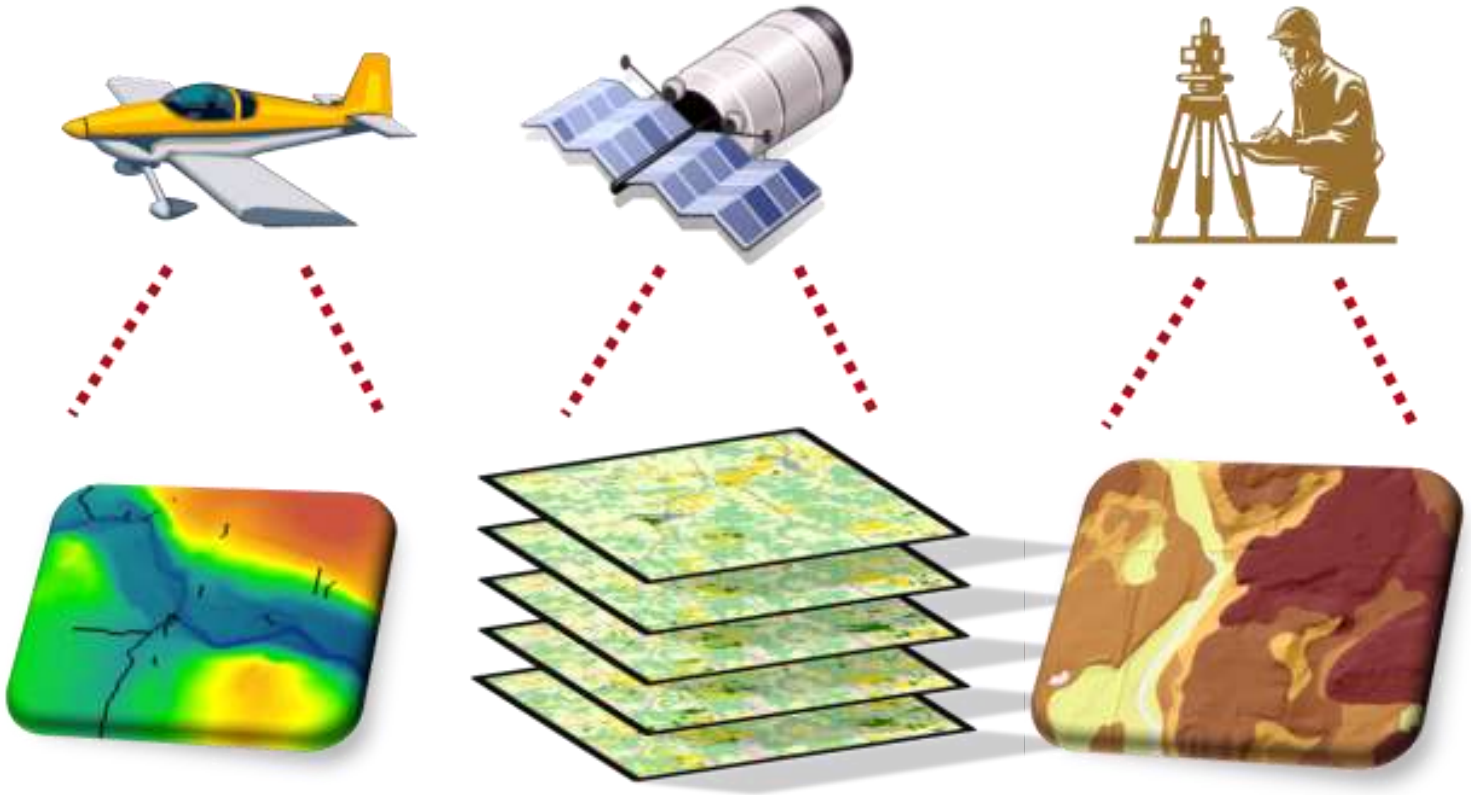
http://dnr.wi.gov/topic/nonpoint/evaal.htm

# EVAAL

## Erosion Vulnerability

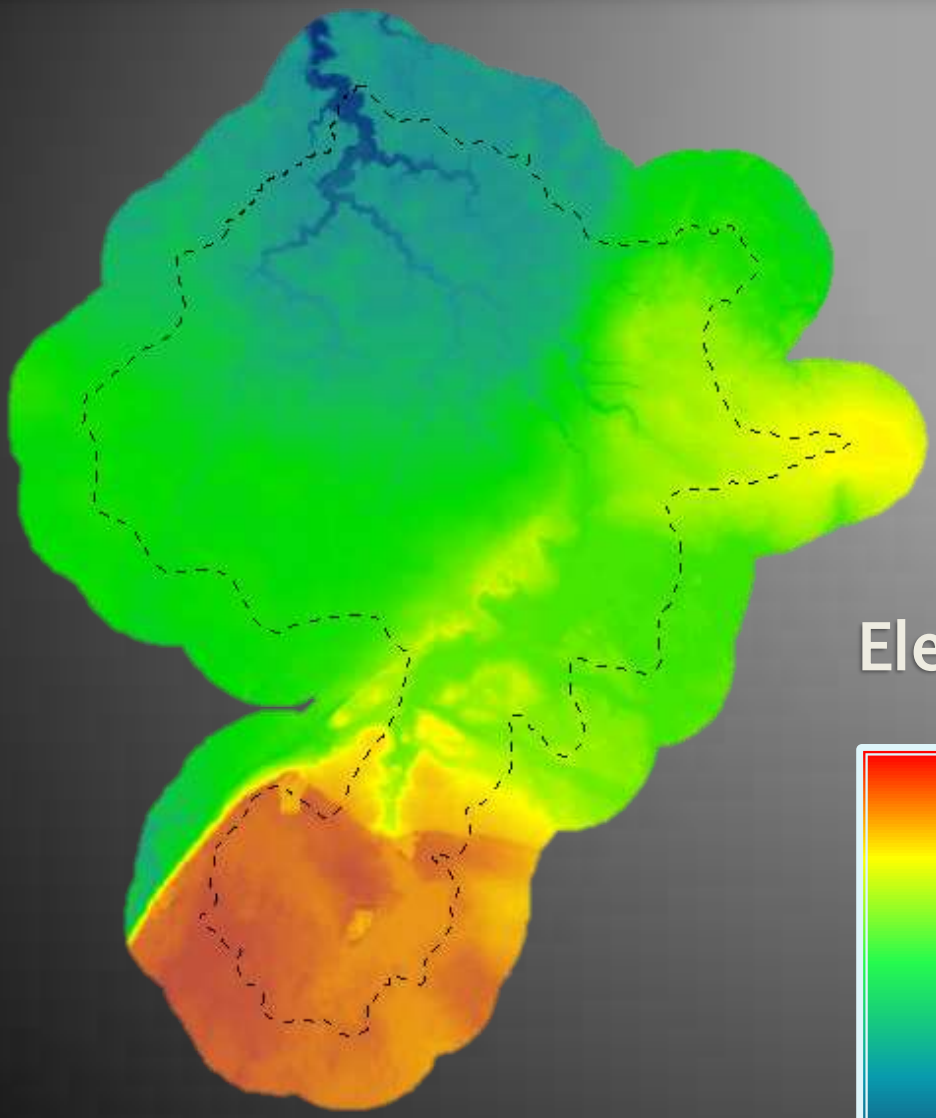


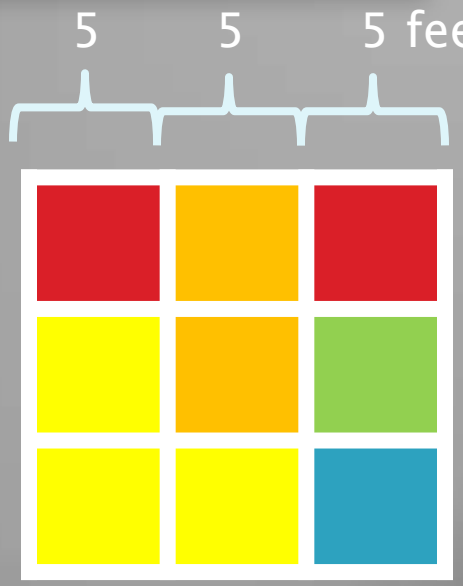
# Available Datasets



**LiDAR** **Crop Data** **Soils**

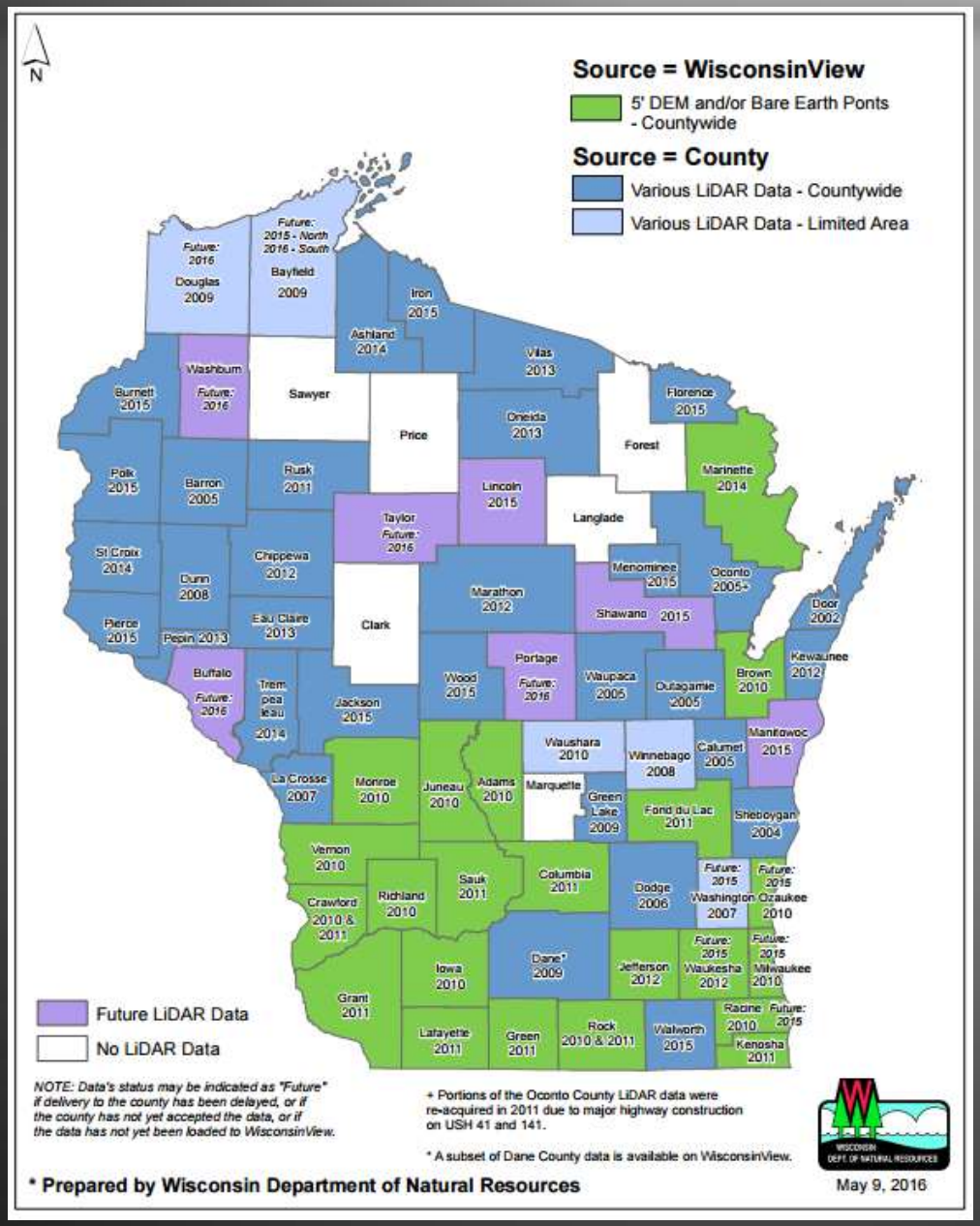
# LiDAR Data



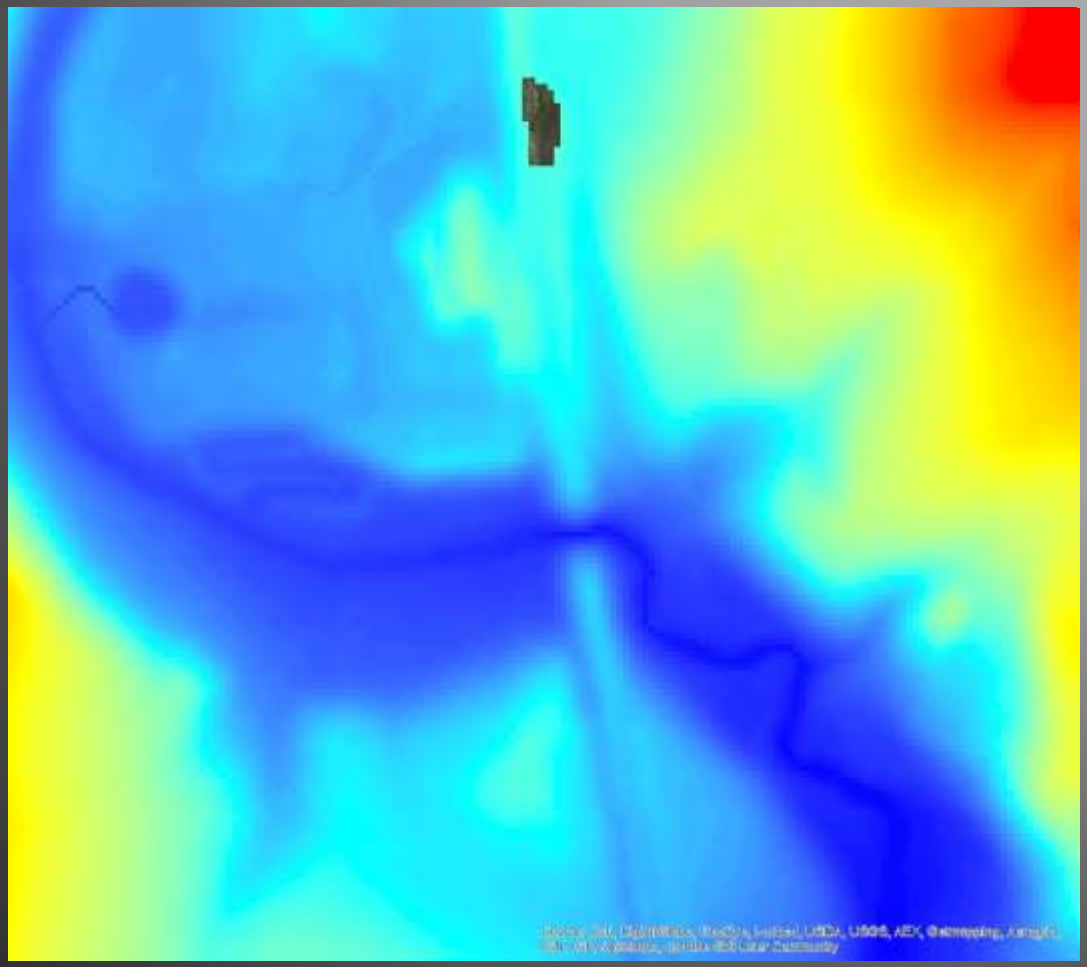



Elevation (feet)

# LiDAR Availability

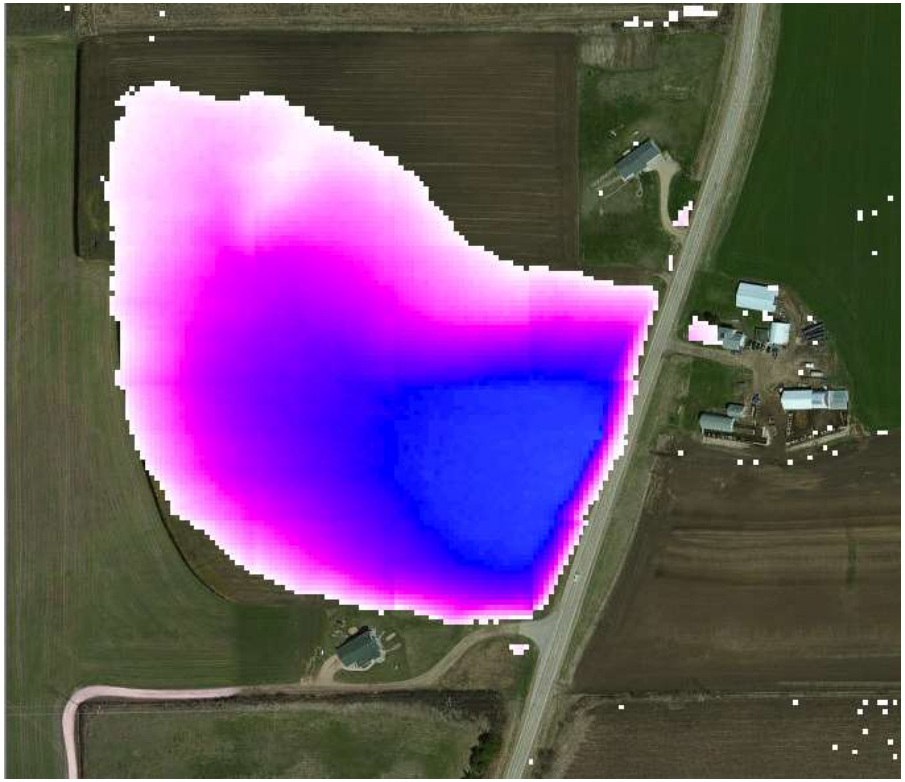


# Digital Dams



# Locate Depressions

- Differentiate between real and “fake” depressions



Classic case

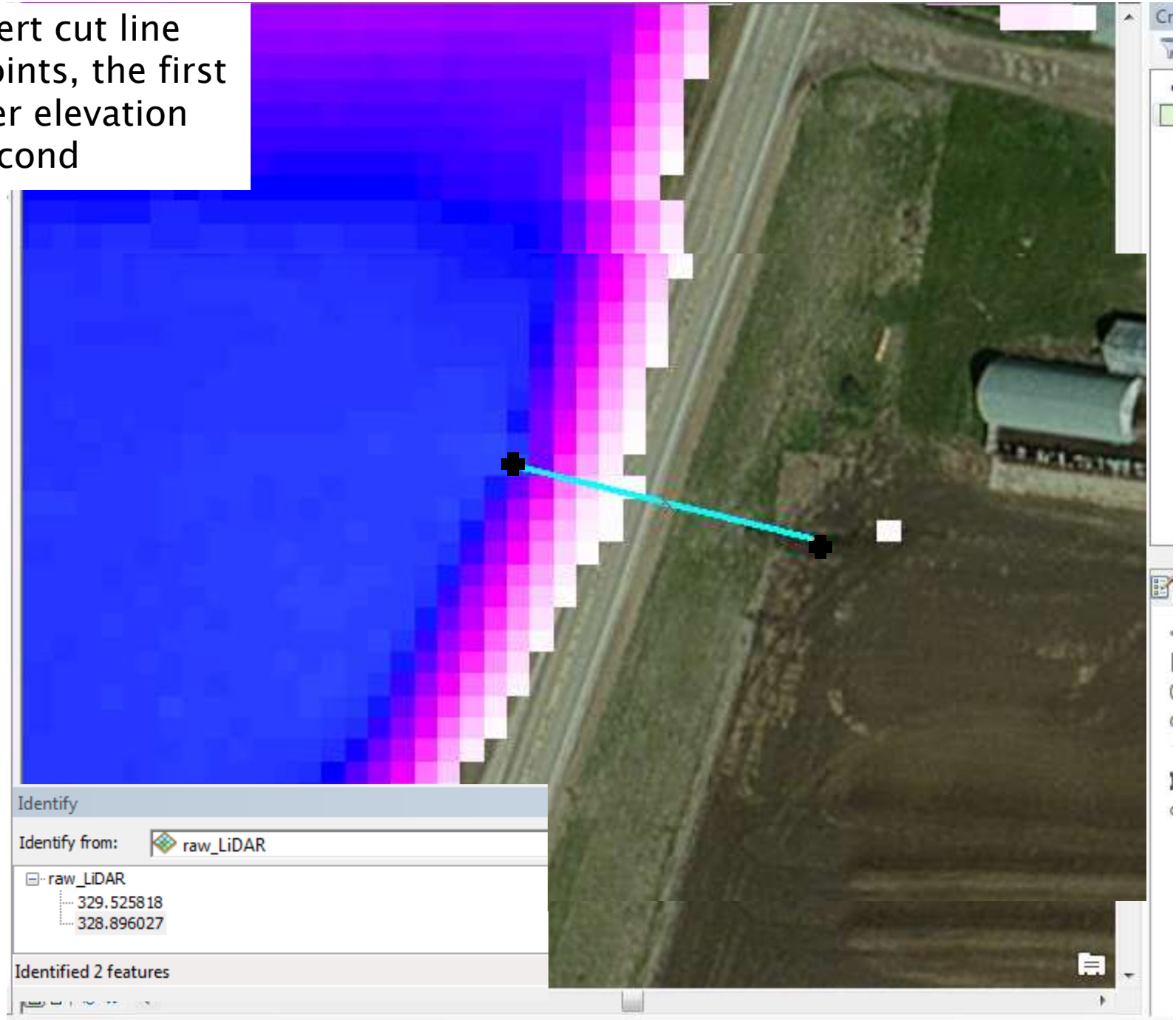
- Completely round…
- Don't bother trying to cut these

# Create Culverts

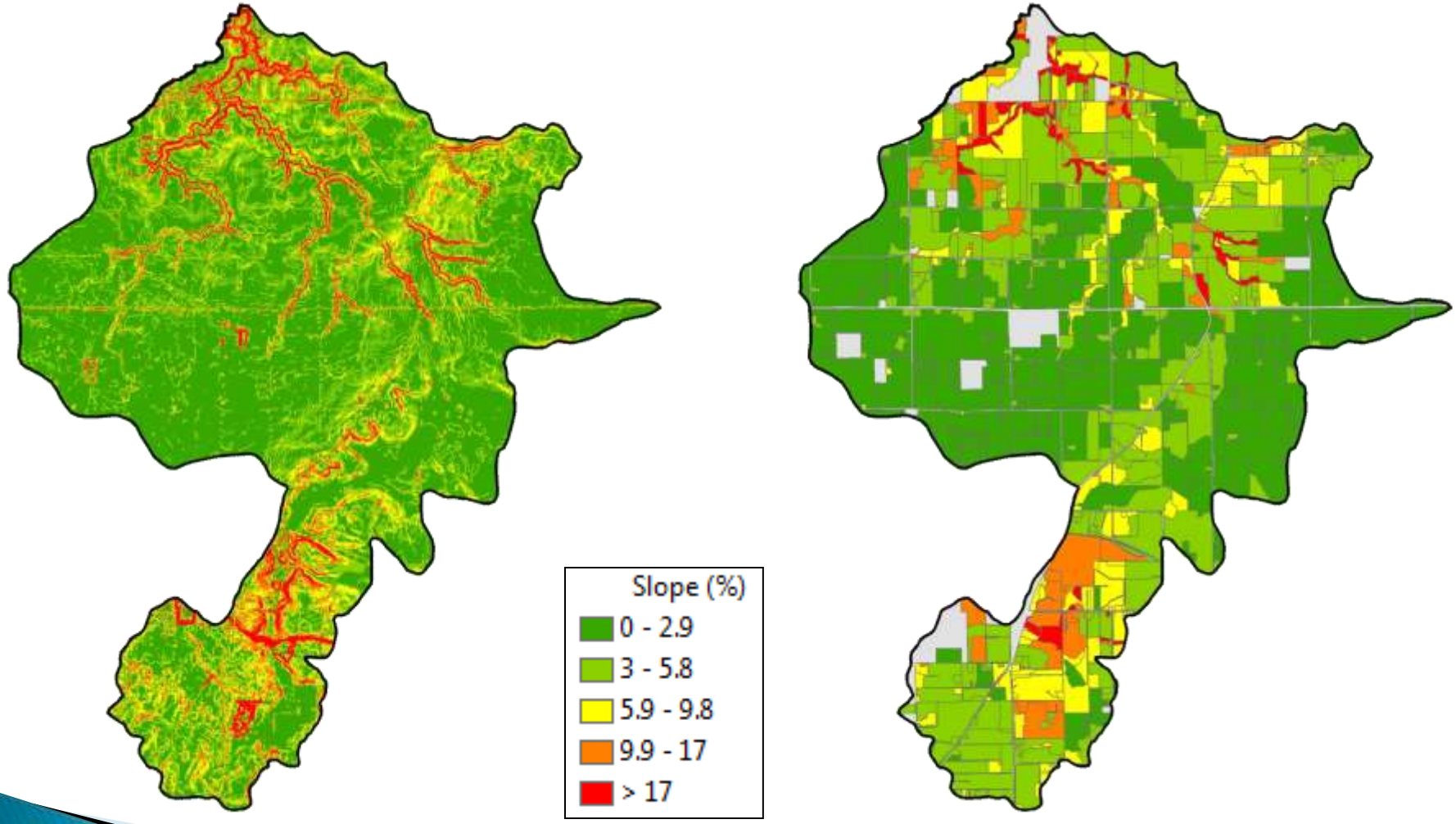
- Different approaches:
  - Geolocate culverts in your area of interest in the field, prior to digitizing
  - View aerial photos and base maps while creating the culvert layer
  - After creating a culverts layer, field verify questionable areas

# Google Street View

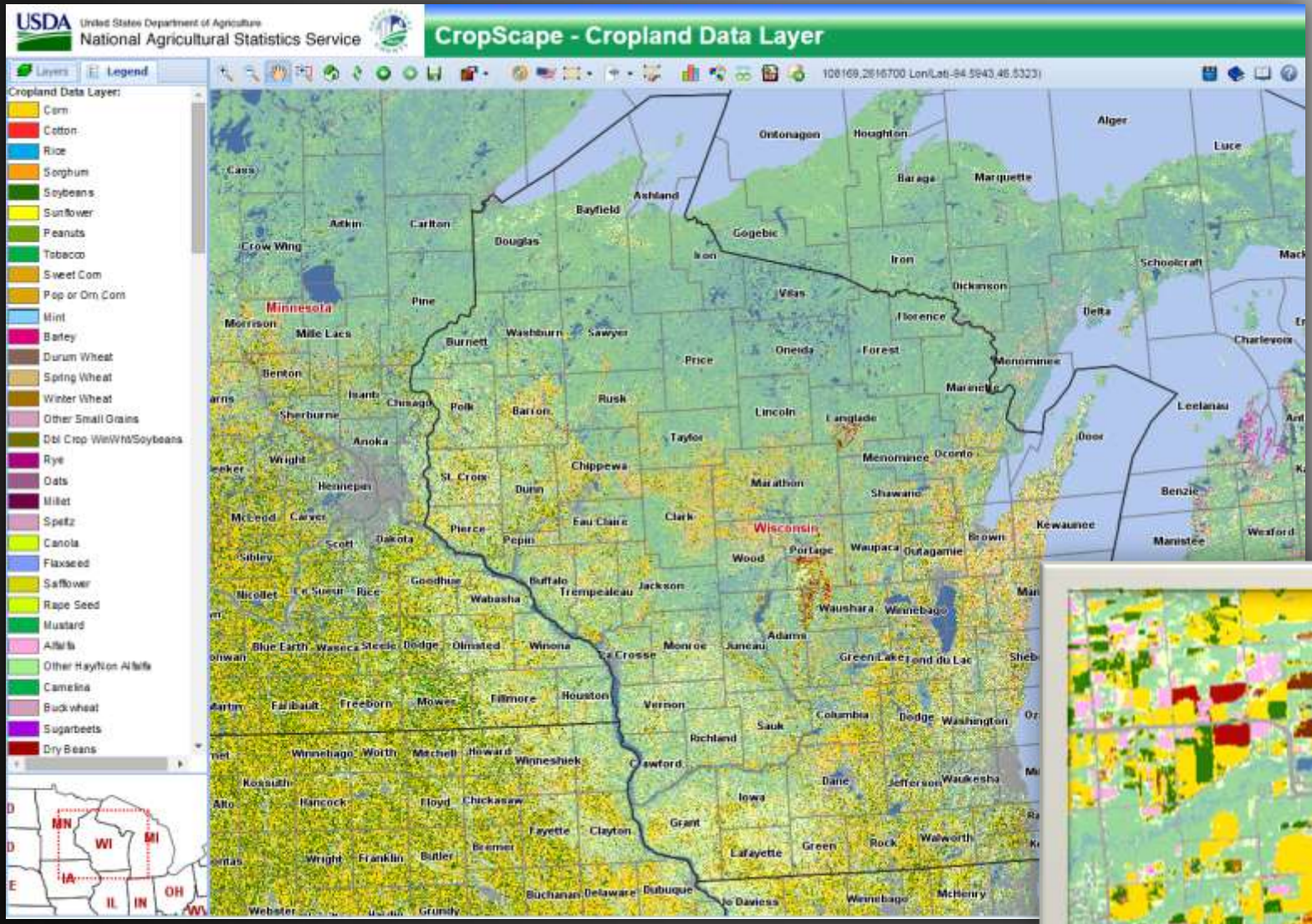
Create culvert cut line with two points, the first being higher elevation than the second



# Slope

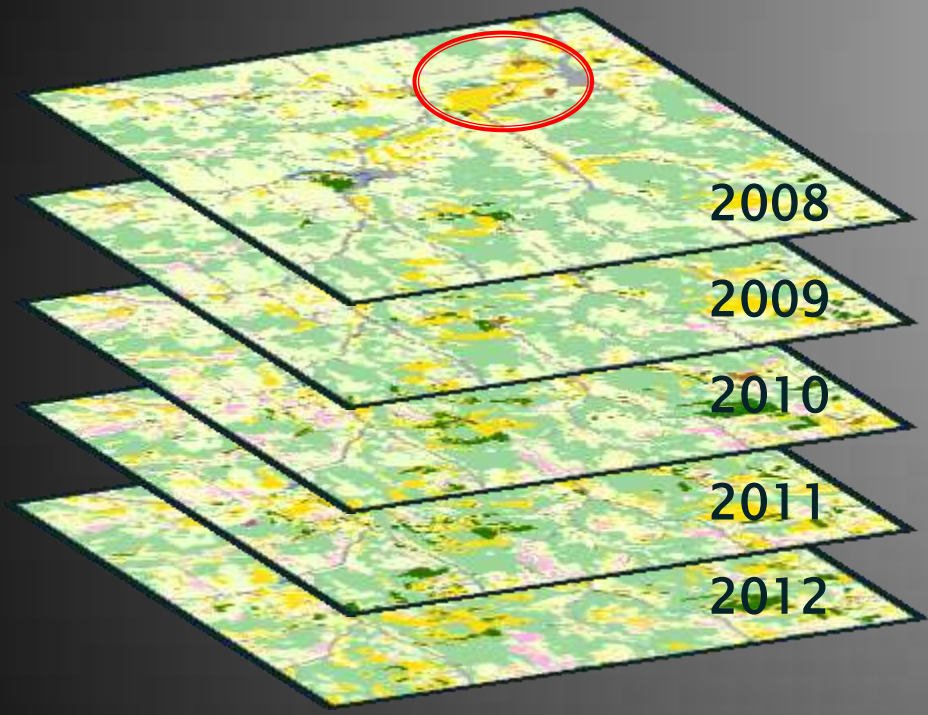


# Crop Data




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

# Crop Rotations




Corn

Soybean

Corn

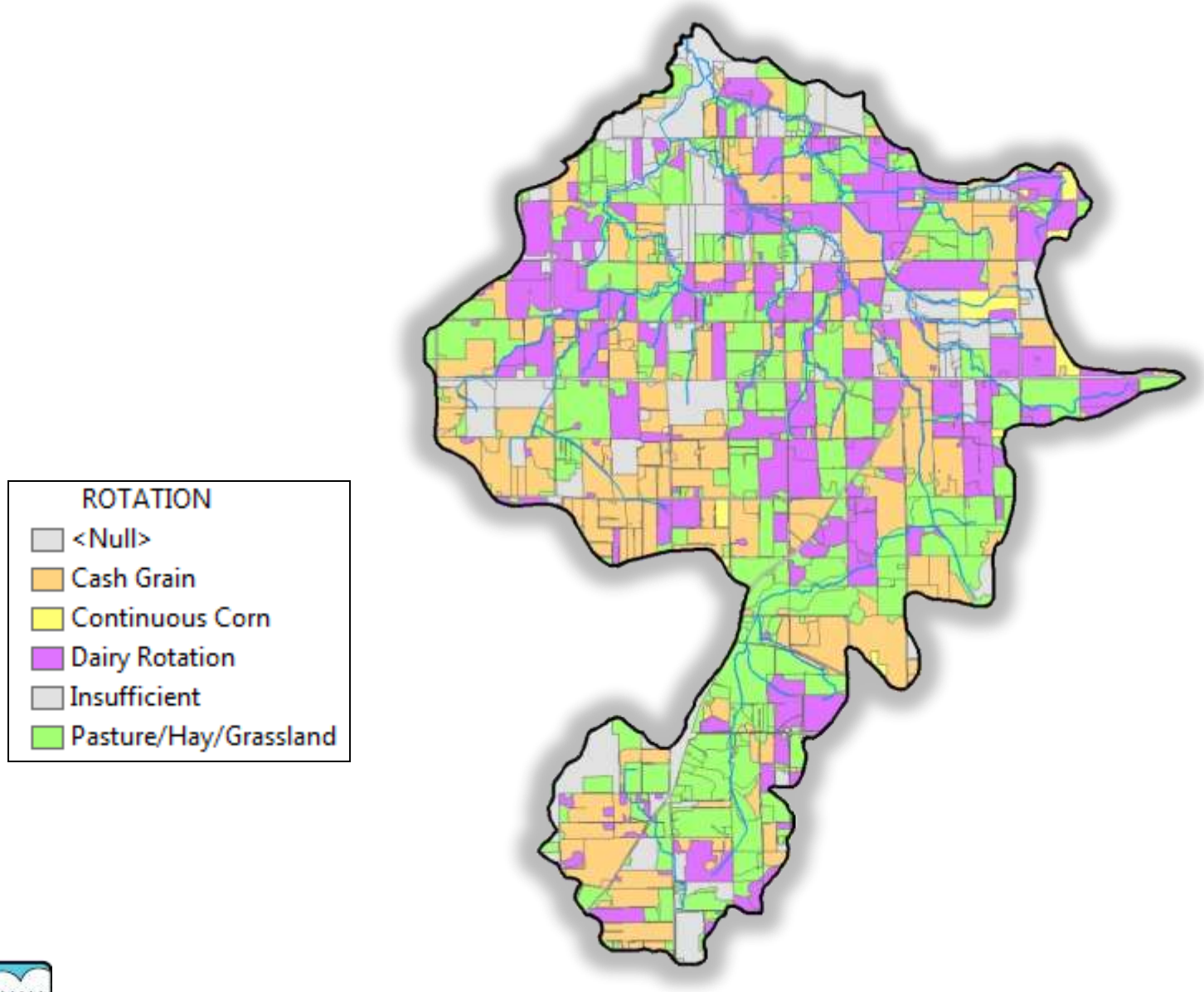
Corn

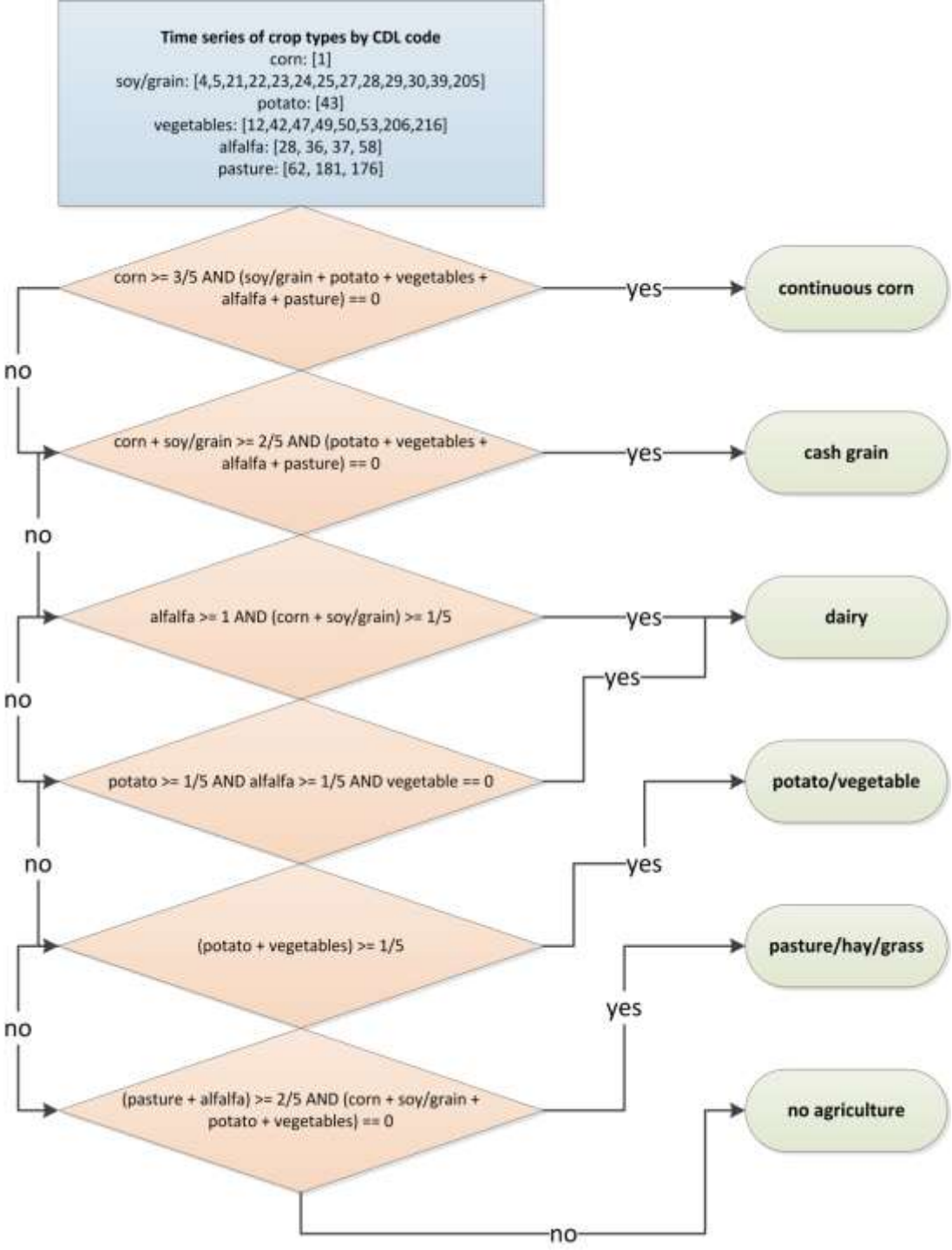
Soybean

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

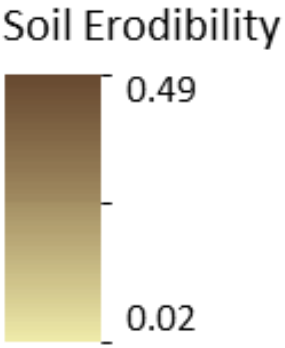
= **Cash Grain Rotation**

# Generalized Crop Rotations

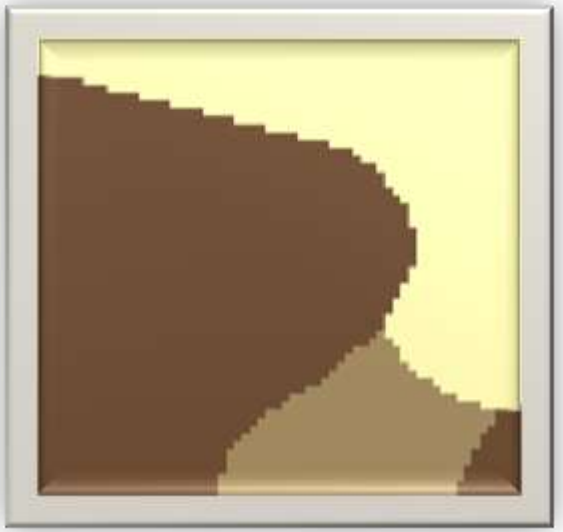



Time series of crop types by CDL code
corn: [1]
soy/grain: [4,5,21,22,23,24,25,27,28,29,30,39,205]
potato: [43]
vegetables: [12,42,47,49,50,53,206,216]
alfalfa: [28, 36, 37, 58]
pasture: [62, 181, 176]
corn >= 3/5 AND (soy/grain + potato + vegetables + alfalfa + pasture) == 0
yes
continuous corn
no
corn + soy/grain >= 2/5 AND (potato + vegetables + alfalfa + pasture) == 0
yes
cash grain
no
alfalfa >= 1 AND (corn + soy/grain) >= 1/5
yes
dairy
yes
no
potato >= 1/5 AND alfalfa >= 1/5 AND vegetable == 0
yes
potato/vegetable
no
(potato + vegetables) >= 1/5
yes
pasture/hay/grass
yes
no
(pasture + alfalfa) >= 2/5 AND (corn + soy/grain + potato + vegetables) == 0
yes
no agriculture
no

# Soils – gSSURGO



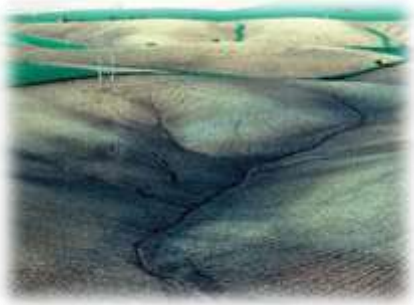

10 meter resolution



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

# Erosion Vulnerability Analysis

## USLE + SPI – IDA



= EVAAL

**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

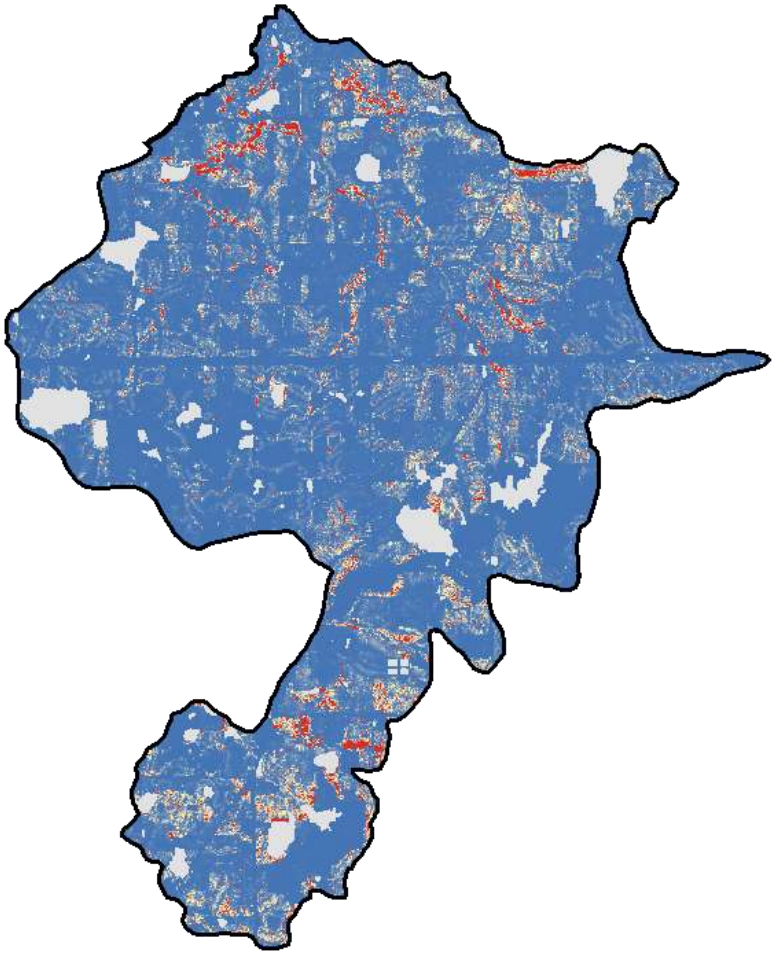
Constant Constant

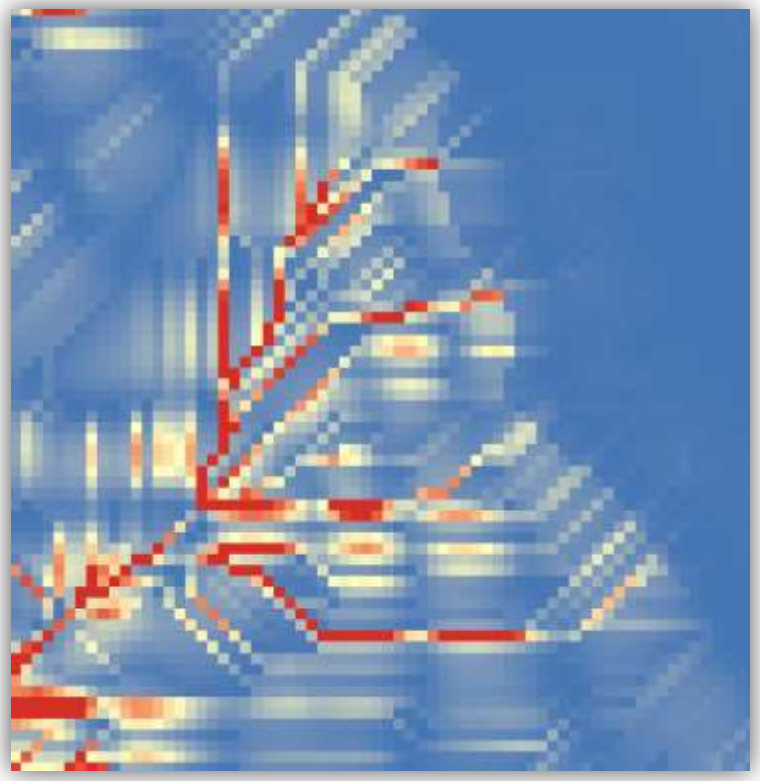
$$A = K(LS)C$$





# Universal Soil Loss Equation

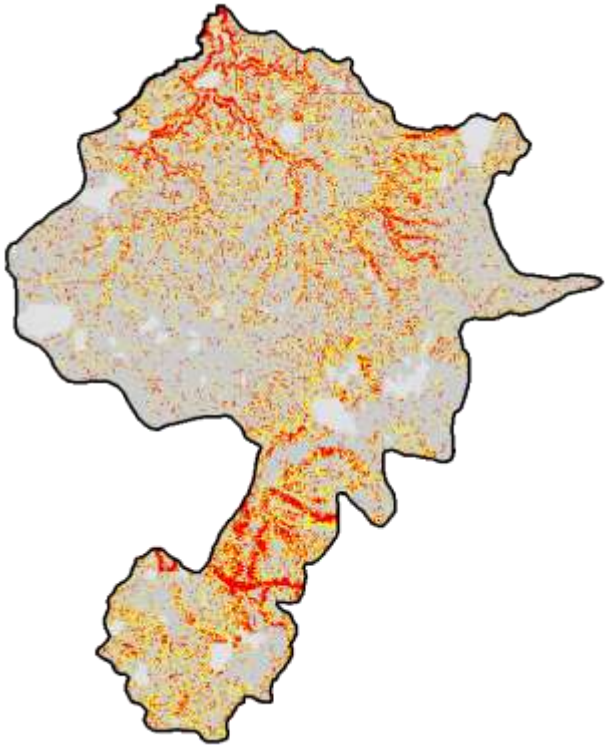




# Stream Power Index

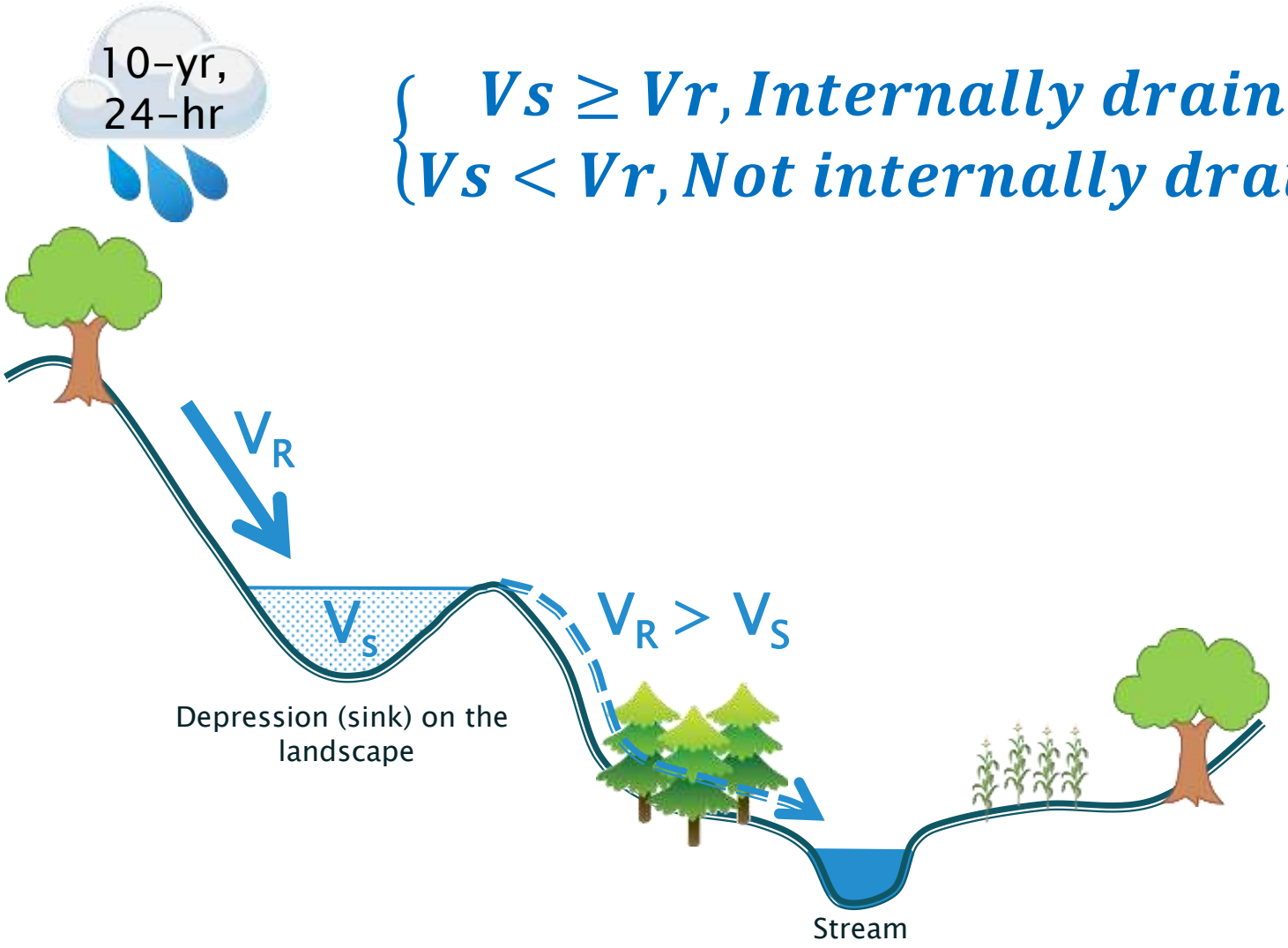
- Potential for gully erosion

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

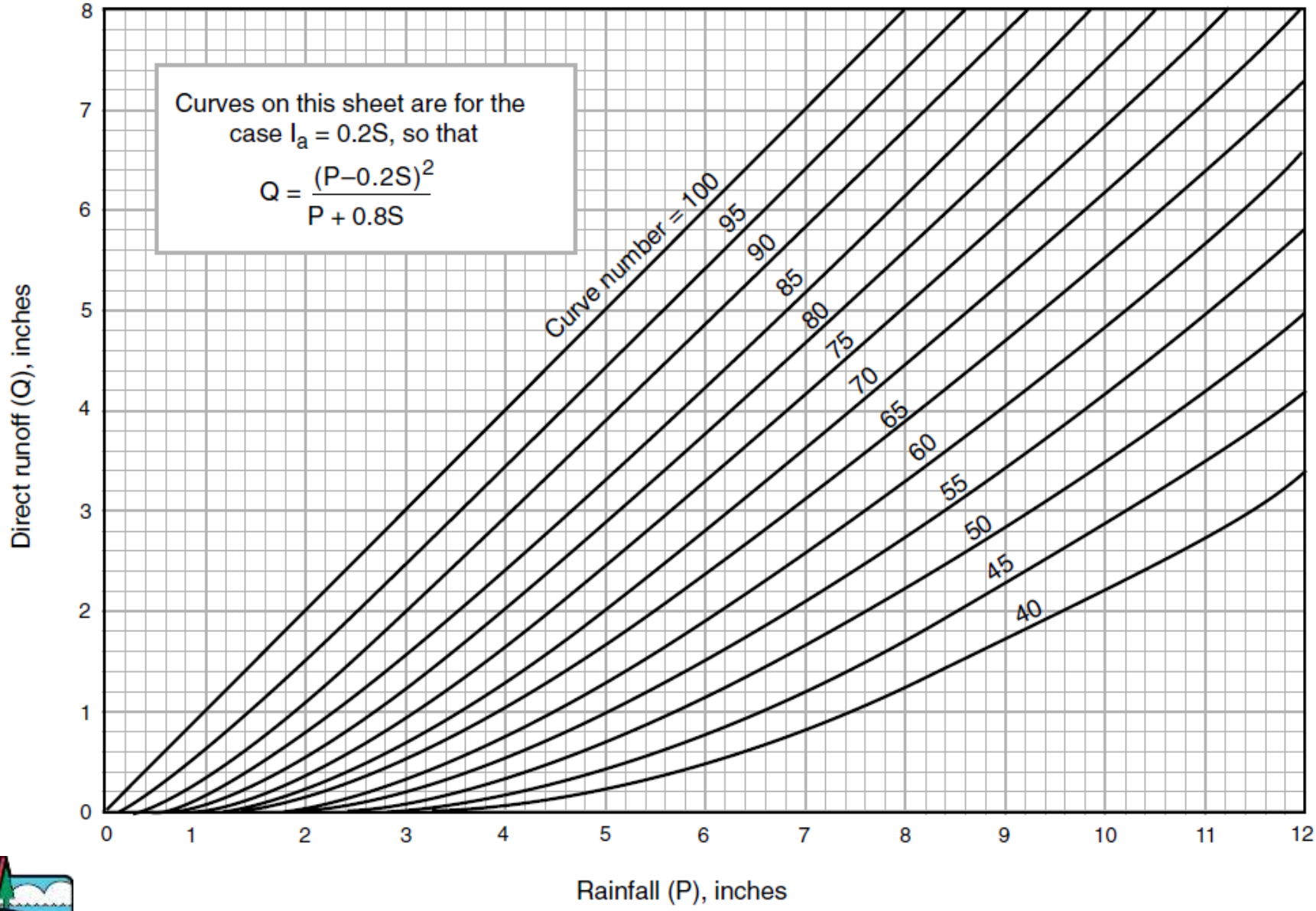


# Internally Draining Areas

- Areas that do not contribute to surface waters



# Runoff Calculation

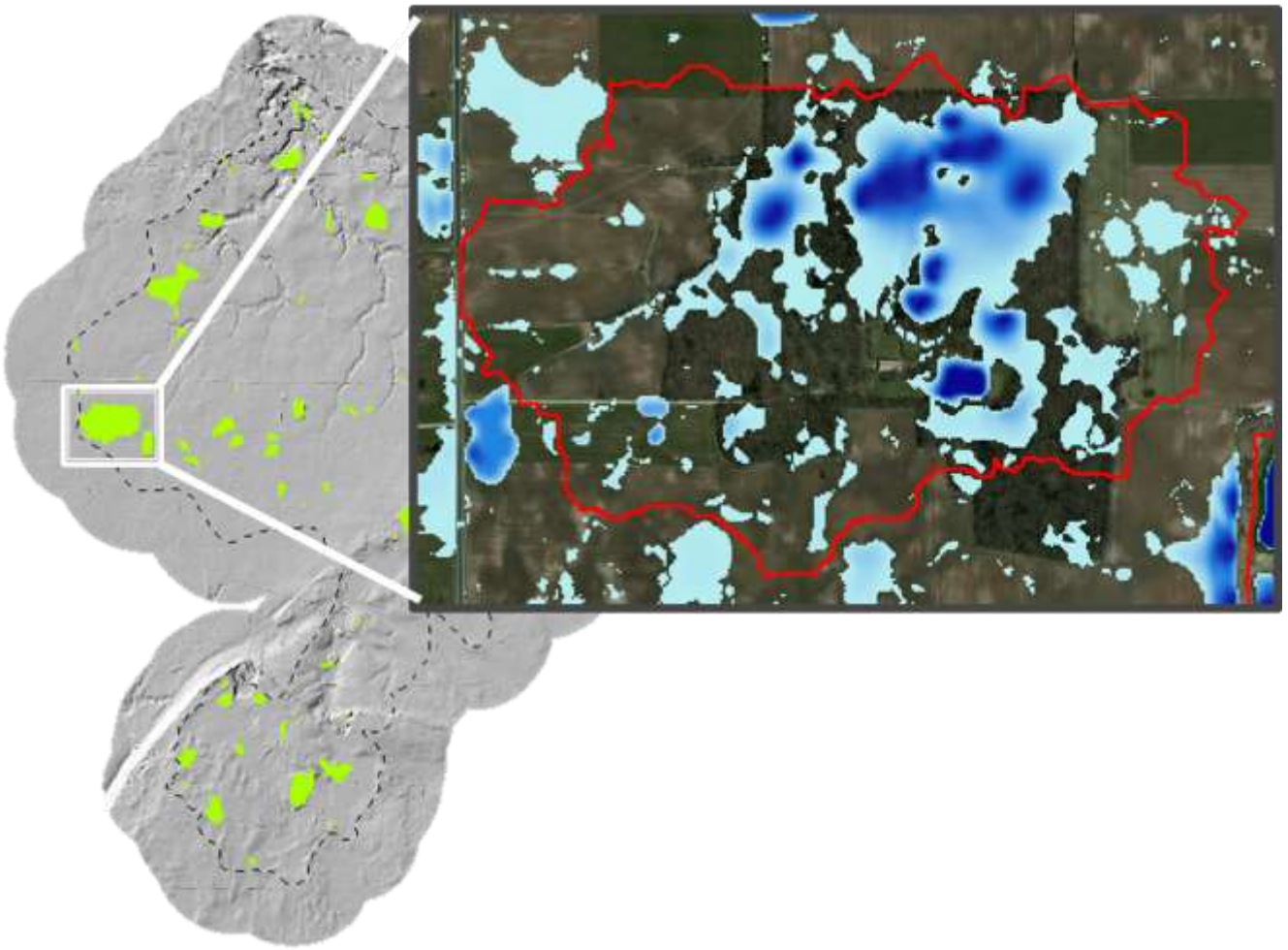


# Curve Numbers

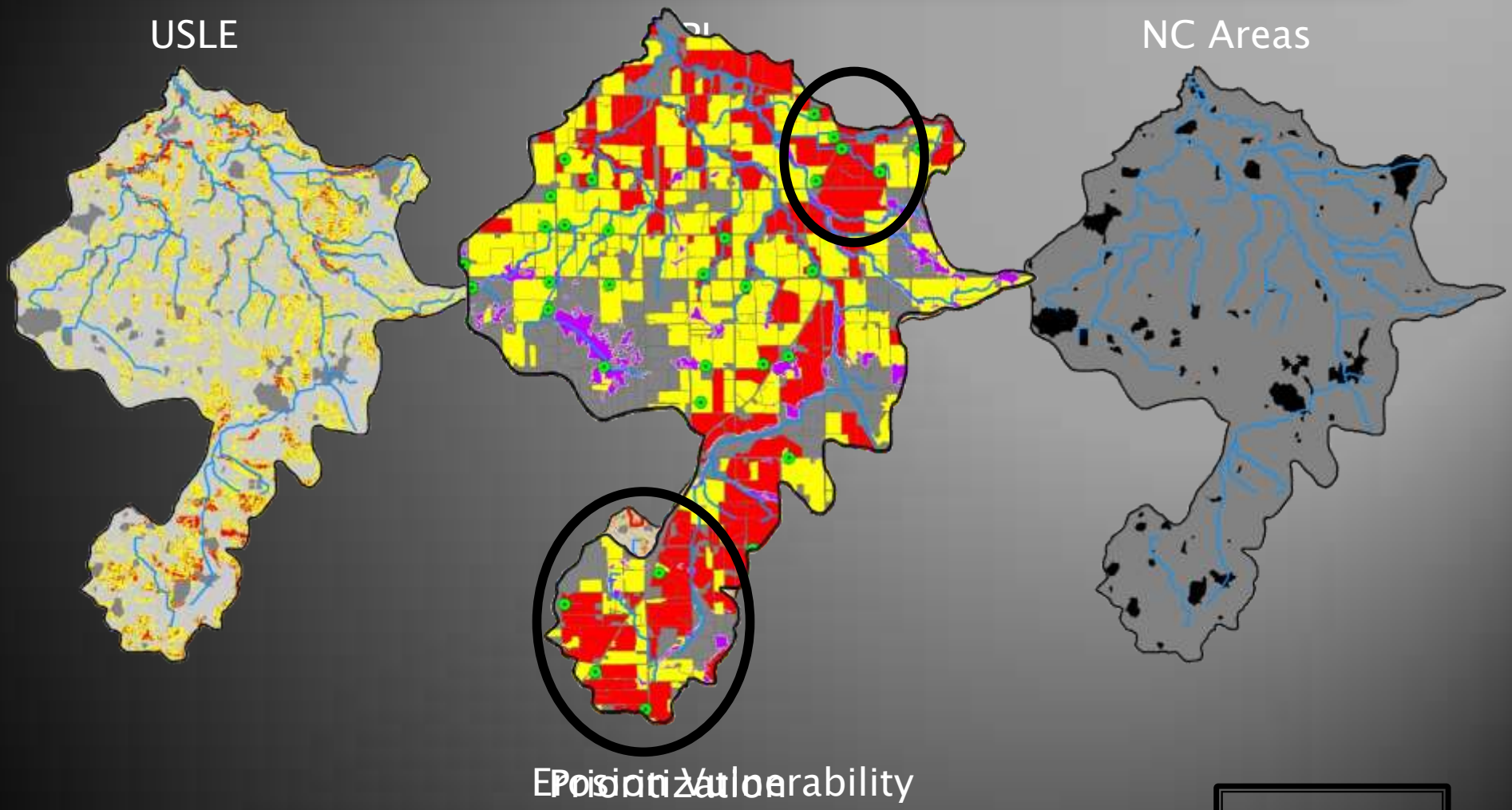
| Cover description | | | Curve numbers for hydrologic soil group | | | |
|---|---|---|---|---|---|---|
| Cover type | Treatment [2/] | Hydrologic condition [3/] | A | B | C | D |
| Fallow | Bare soil | — | 77 | 86 | 91 | 94 |
| | Crop residue cover (CR) | Poor | 76 | 85 | 90 | 93 |
| | | Good | 74 | 83 | 88 | 90 |
| Row crops | Straight row (SR) | Poor | 72 | 81 | 88 | 91 |
| | | Good | 67 | 78 | 85 | 89 |
| | SR + CR | Poor | 71 | 80 | 87 | 90 |
| | | Good | 64 | 75 | 82 | 85 |
| | Contoured (C) | Poor | 70 | 79 | 84 | 88 |
| | | Good | 65 | 75 | 82 | 86 |
| | C + CR | Poor | 69 | 78 | 83 | 87 |
| | | Good | 64 | 74 | 81 | 85 |
| | Contoured & terraced (C&T) | Poor | 66 | 74 | 80 | 82 |
| | | Good | 62 | 71 | 78 | 81 |
| | C&T+ CR | Poor | 65 | 73 | 79 | 81 |
| | | Good | 61 | 70 | 77 | 80 |
| Small grain | SR | Poor | 65 | 76 | 84 | 88 |
| | | Good | 63 | 75 | 83 | 87 |
| | SR + CR | Poor | 64 | 75 | 83 | 86 |
| | | Good | 60 | 72 | 80 | 84 |
| | C | Poor | 63 | 74 | 82 | 85 |
| | | Good | 61 | 73 | 81 | 84 |
| | C + CR | Poor | 62 | 73 | 81 | 84 |
| | | Good | 60 | 72 | 80 | 83 |
| | C&T | Poor | 61 | 72 | 79 | 82 |
| | | Good | 59 | 70 | 78 | 81 |
| | C&T+ CR | Poor | 60 | 71 | 78 | 81 |
| | | Good | 58 | 69 | 77 | 80 |
| Close-seeded or broadcast legumes or rotation meadow | SR | Poor | 66 | 77 | 85 | 89 |
| | | Good | 58 | 72 | 81 | 85 |
| | C | Poor | 64 | 75 | 83 | 85 |
| | | Good | 55 | 69 | 78 | 83 |
| | C&T | Poor | 63 | 73 | 80 | 83 |
| | | Good | 51 | 67 | 76 | 80 |

# Internally Draining Areas

- Areas that do not contribute to surface waters



# Results



# Mitigation Opportunity

$$A = K(LS)C$$

Cropland data layer

Crop Rotations

SNAP-Plus -> Rotation C Factor

Poor

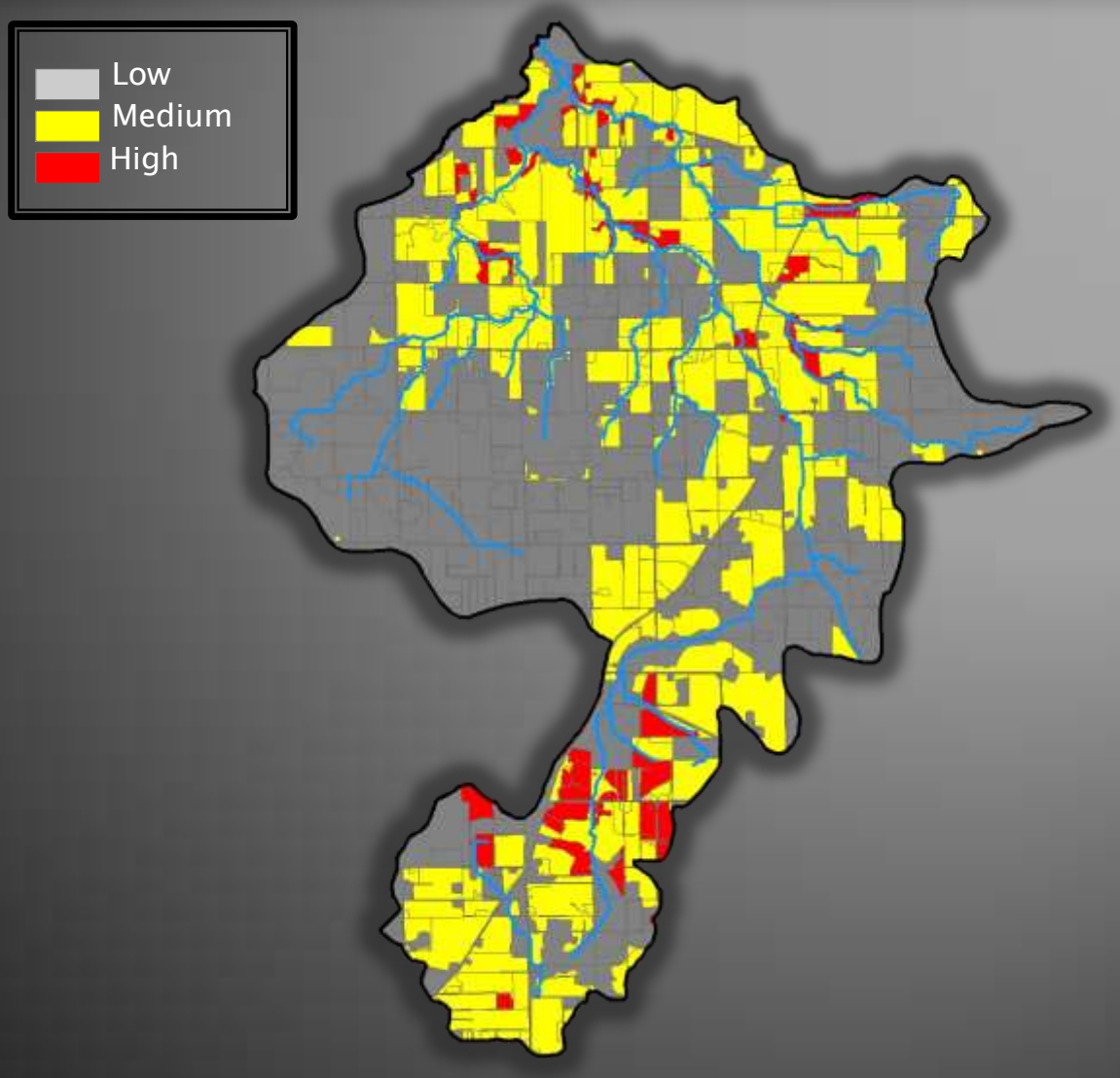
Good

# C Factor Adjustments

USLE w/ Low C Factor

USLE w/ High C Factor

# Mitigation Opportunity



# EVAAL Outputs

- Relative erosion vulnerability across watershed
  - Normalizes USLE & SPI prior to calculating vulnerability index
- What does this mean?
  - Cannot compare values from different watersheds
  - Look at relative values for one run
- How to compare across watersheds?
  - Merge USLE and SPI layers prior to running erosion vulnerability

# EVAAL System Requirements

- Windows operating system
- ArcGIS Desktop 10.x
- ArcGIS Spatial Analyst 10.x
- 1.5 GB RAM minimum

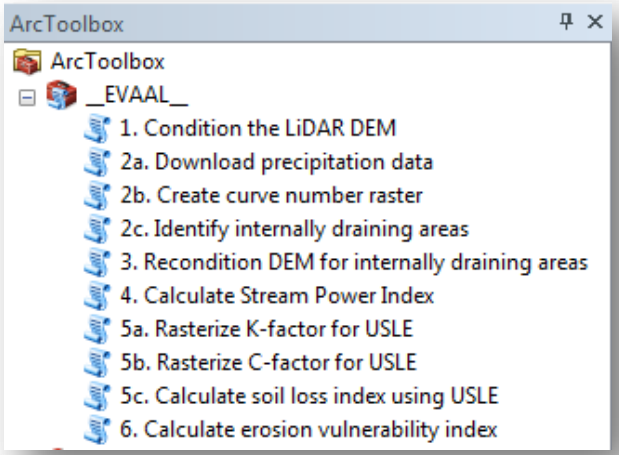
- Does not require any installation, but does need write access to file folder

# Limitations

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

# EVAAL Website

- Documents
- Tutorial Data
- ArcToolbox





http://dnr.wi.gov/topic/nonpoint/evaal.html

# EVAAL Applications

# EVAAL

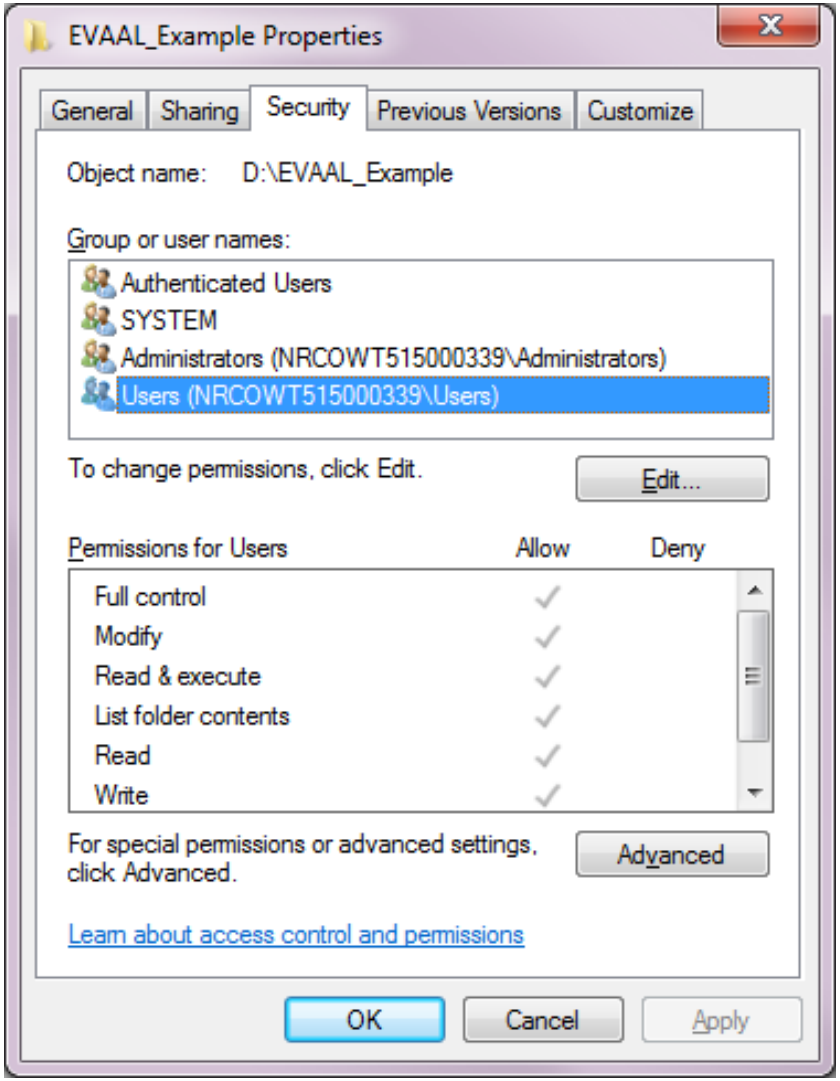
- How to use the model

# Model Setup

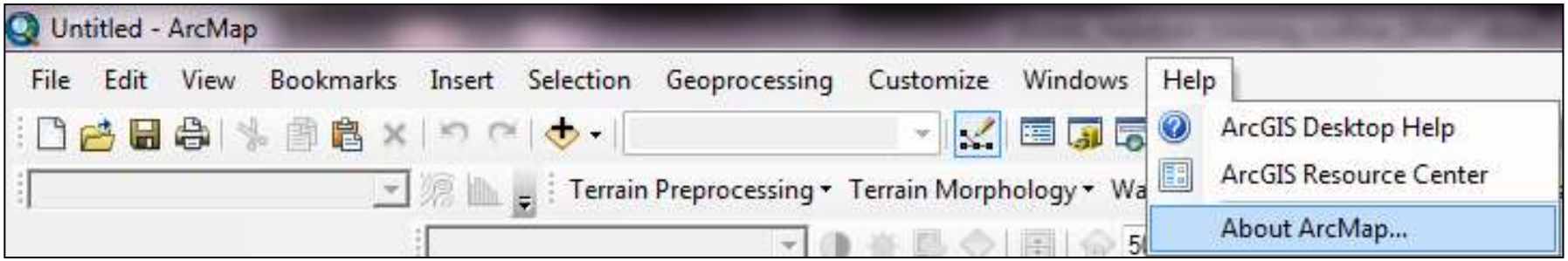
- Check folder permissions
- Check ArcMap versions
- Where to download EVAAL
- Load EVAAL toolbox and Spatial Analyst Extension in ArcMap

# Check Folder Permissions

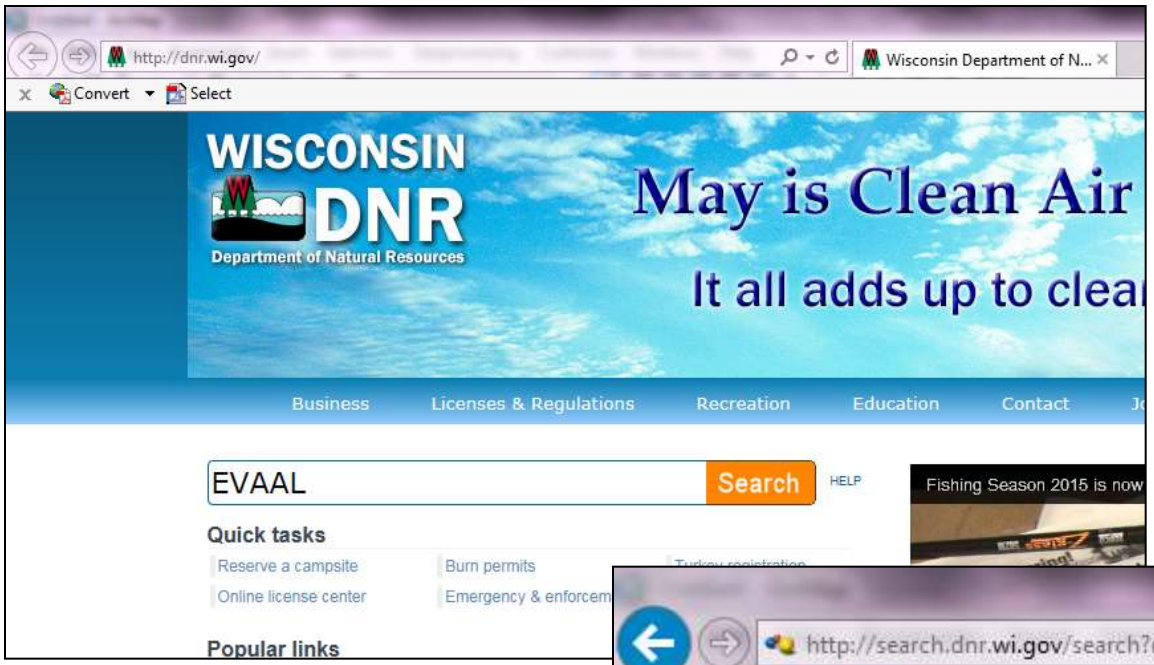
- Need permission to Read & Write

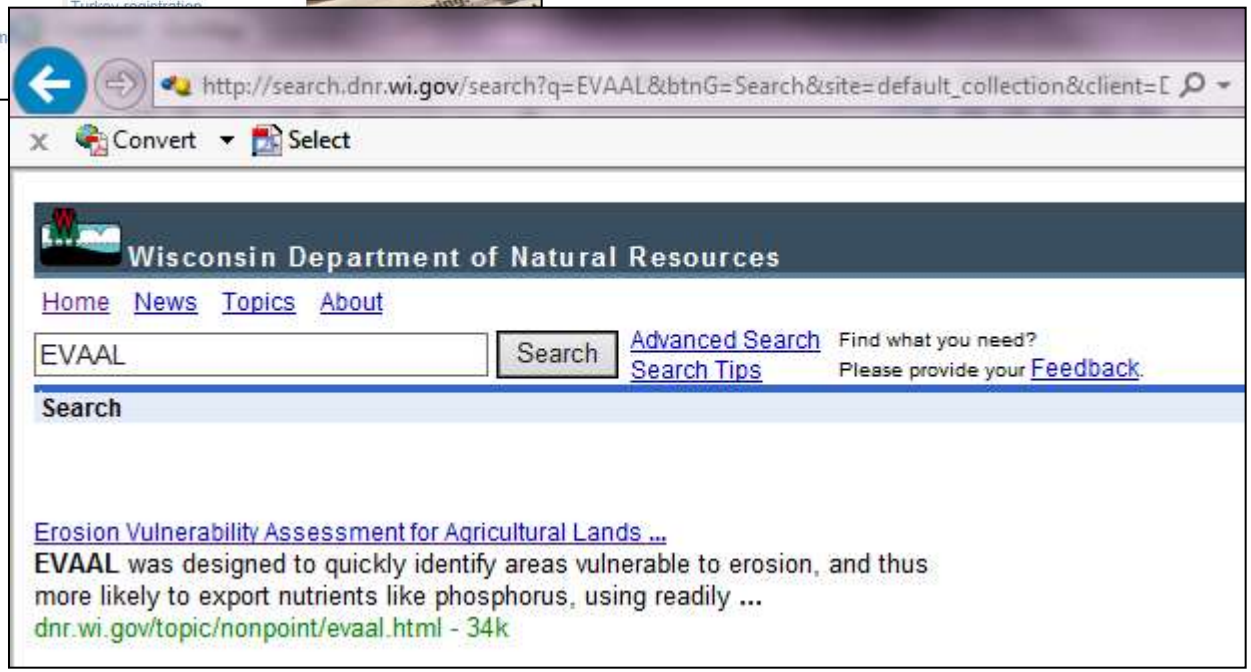


# Check ArcMap Version




# Download EVAAL




http://dnr.wi.gov/

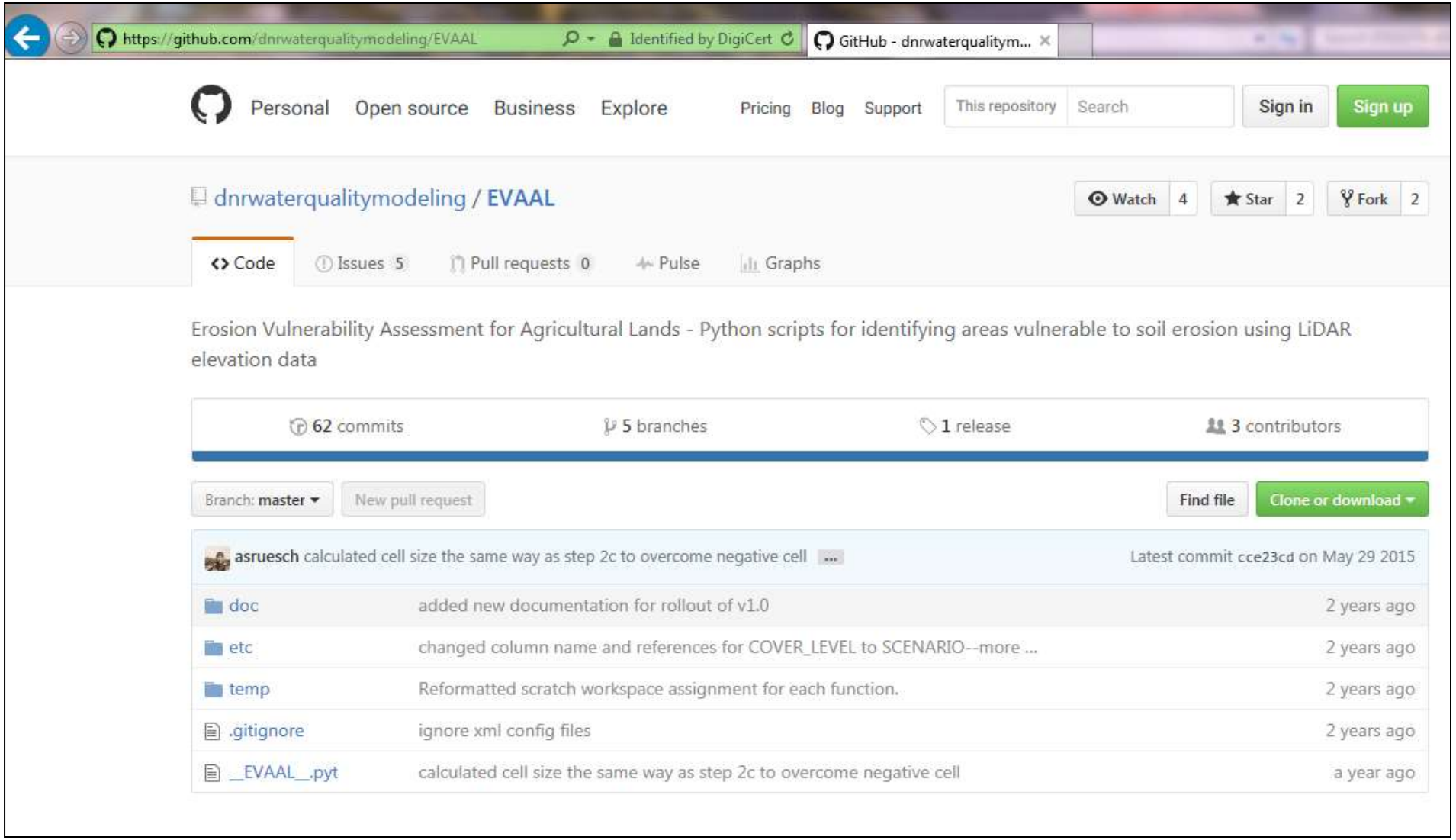
# Download EVAAL


## EVAAL, Version 1.0.1 (December 2015)

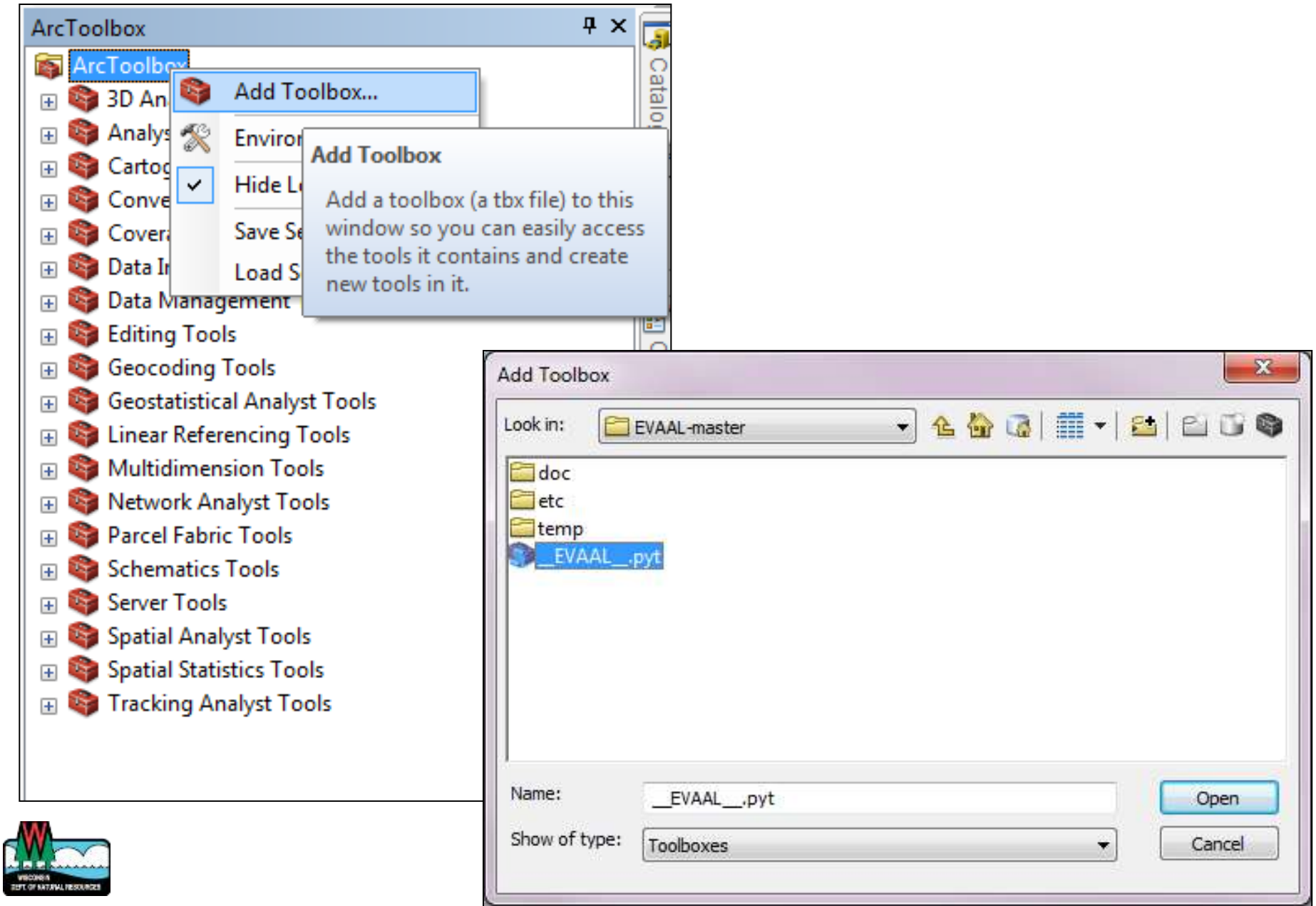
(Although updates to the model files were made in December, documentation remains the same.)

- Fact Sheet [PDF]
- Tutorial [PDF]
  (Includes installation instructions to be read prior to downloading EVAAL model files)
- Methods Documentation [PDF]
- EVAAL Model Files [exit DNR]
- EVAAL Tutorial Data [FTP site, ZIP file format] ~~(includes 2014 gSSURGO geodatabase)~~

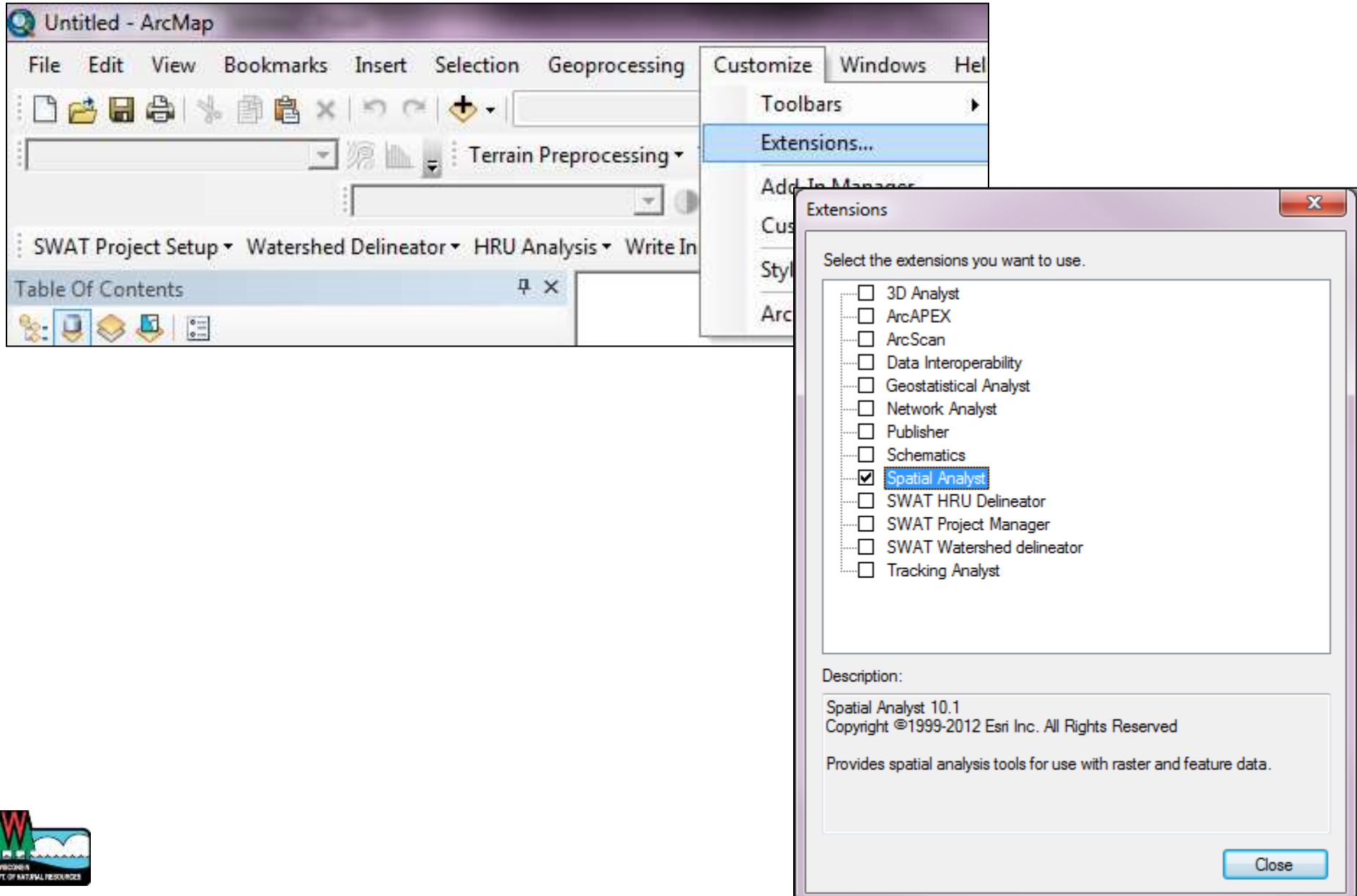
# Download EVAAL



# Load Toolbox



# Load Spatial Analyst Extension



# Inputs

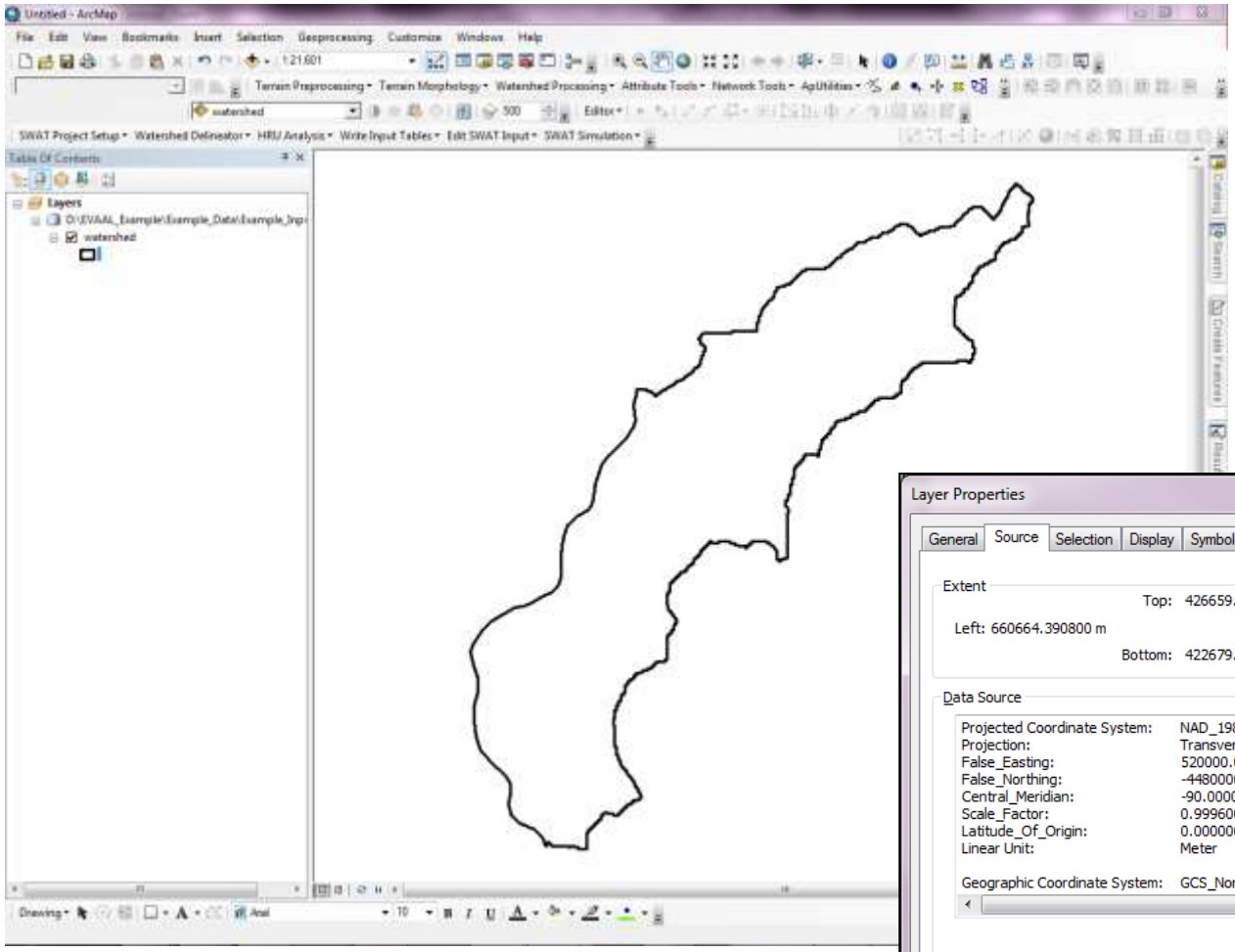
- Coordinate projection
- Watershed & buffered watershed
- DEM
- gSSURGO
- Culverts

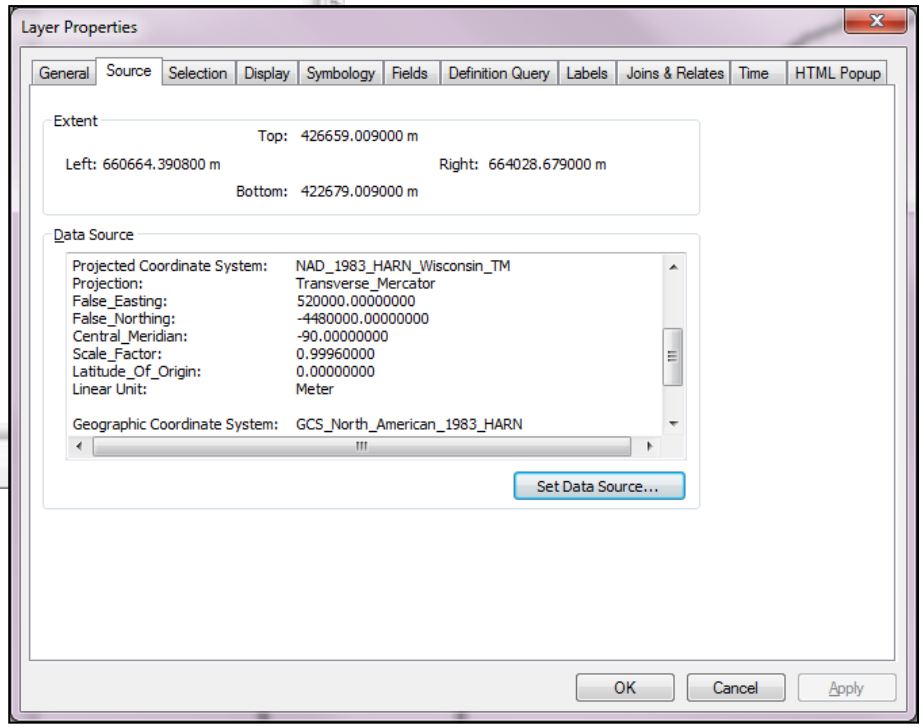
# Coordinate Projection

- EVAAL requires all datasets to be in Wisconsin Transverse Mercator projection (meters)
  - EPSG: 3071
  - NAD_1983_HARN_Wisconsin_TM
  - NAD_1983_HARN_Transverse_Mercator

  - ftp://dnrftp01.wi.gov/geodata/projection_file/

# Watershed boundary

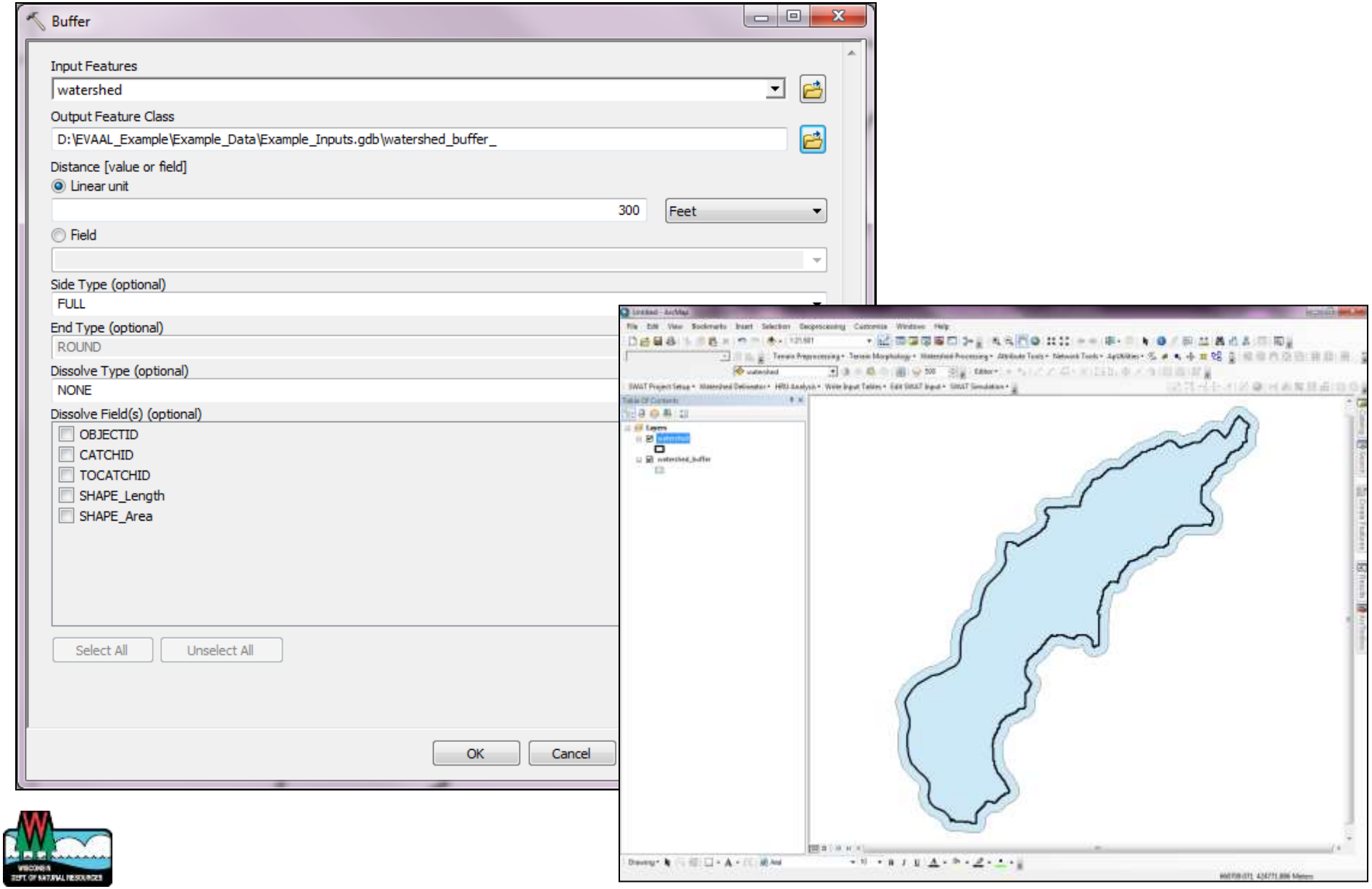


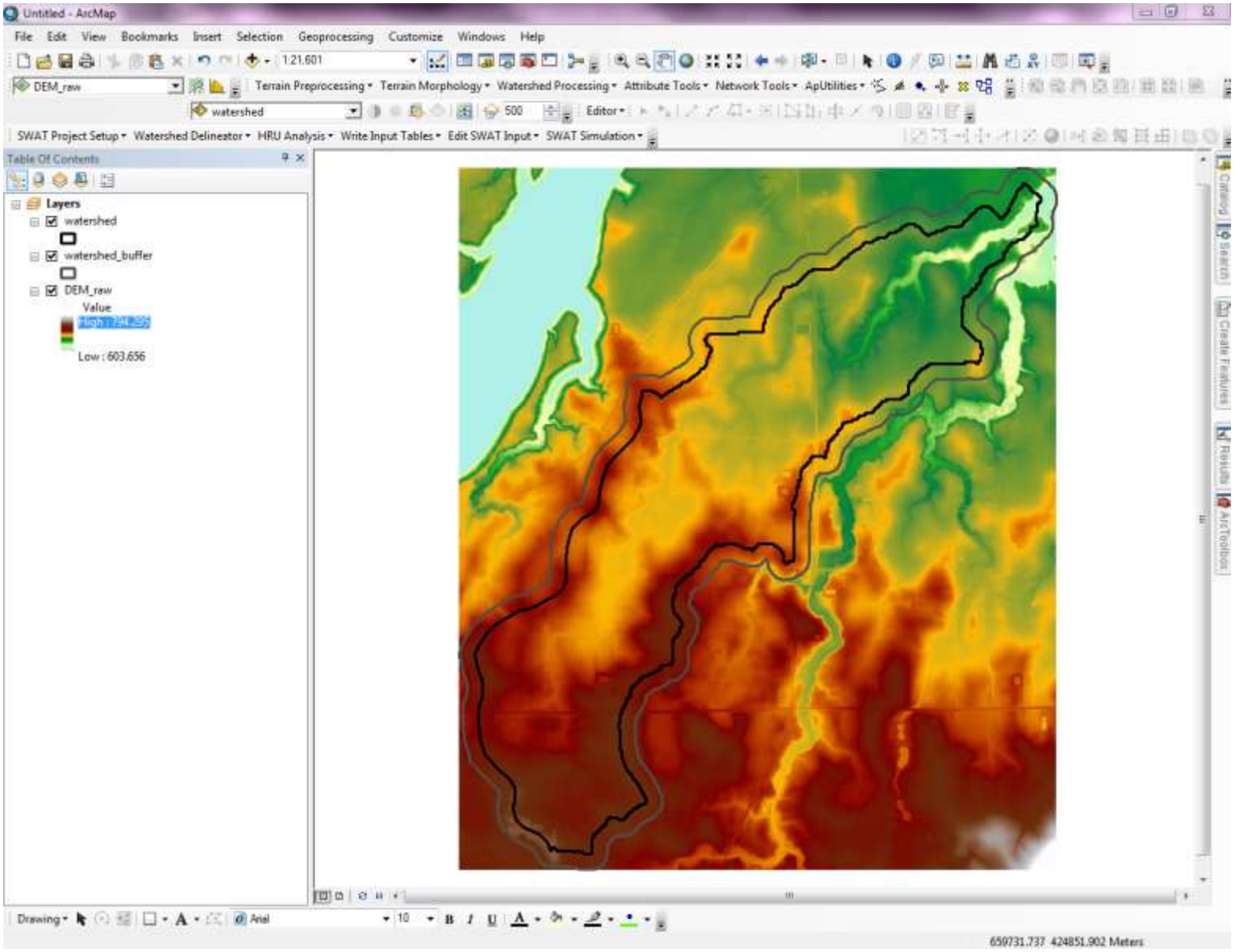
# Where to get watershed boundaries?

- HUCs: ftp://dnrftp01.wi.gov/geodata/WI_WBD_HUCs/
- WHD-plus: ftp://dnrftp01.wi.gov/geodata/hydro_va_24k/
- USGS: http://viewer.nationalmap.gov/viewer/
- USDA: https://gdg.sc.egov.usda.gov/

# Buffered Watershed

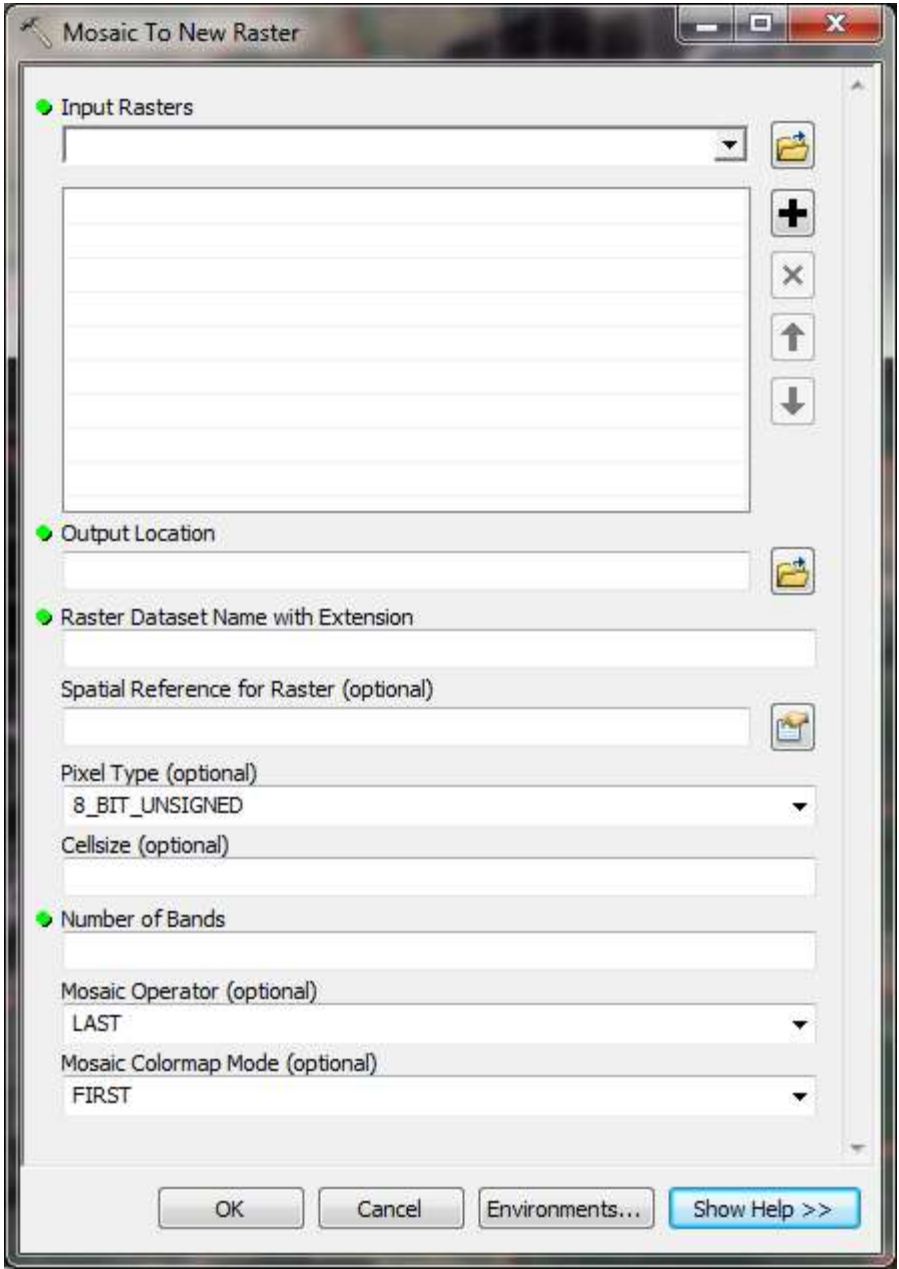


# DEM


Untitled - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
1:21,601
DEM_raw
Terrain Preprocessing Terrain Morphology Watershed Processing Attribute Tools Network Tools ApUtilities
watershed
500
Editor
SWAT Project Setup Watershed Delineator HRU Analysis Write Input Tables Edit SWAT Input SWAT Simulation
Table Of Contents
Layers
watershed
watershed_buffer
DEM_raw
Value
High : 841.395
Low : 603.656
Drawing
Arial
10
659731.737 424851.902 Meters

# Combine multiple rasters

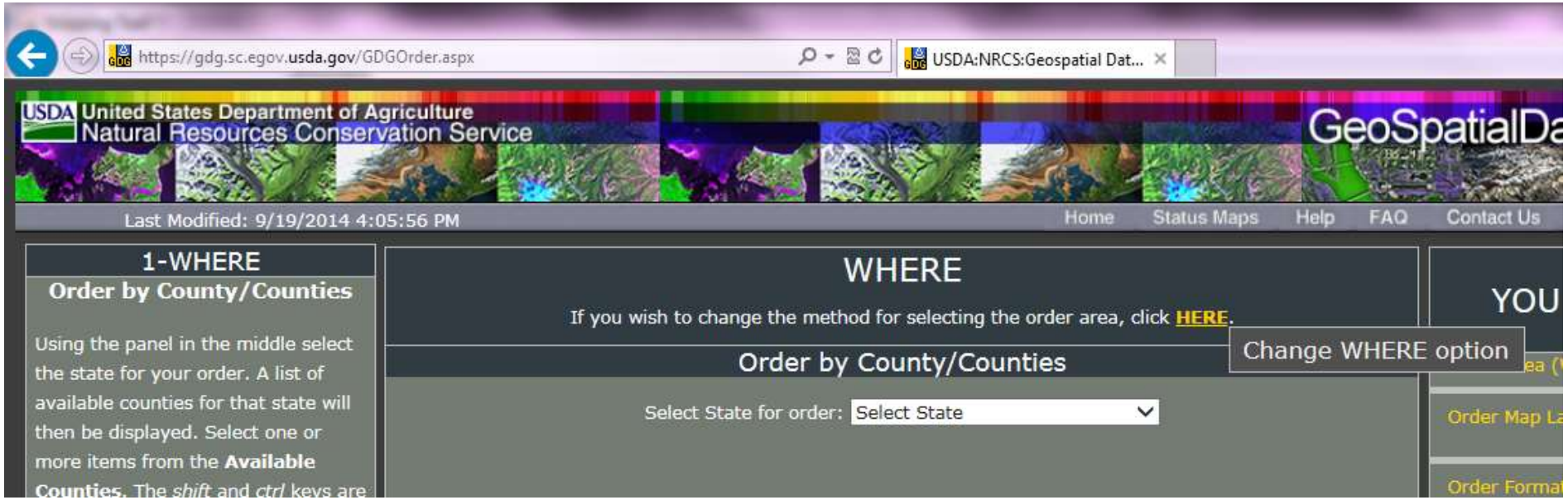
- Mosaic to New Raster Tool
  - Specify Pixel Type the same as input rasters



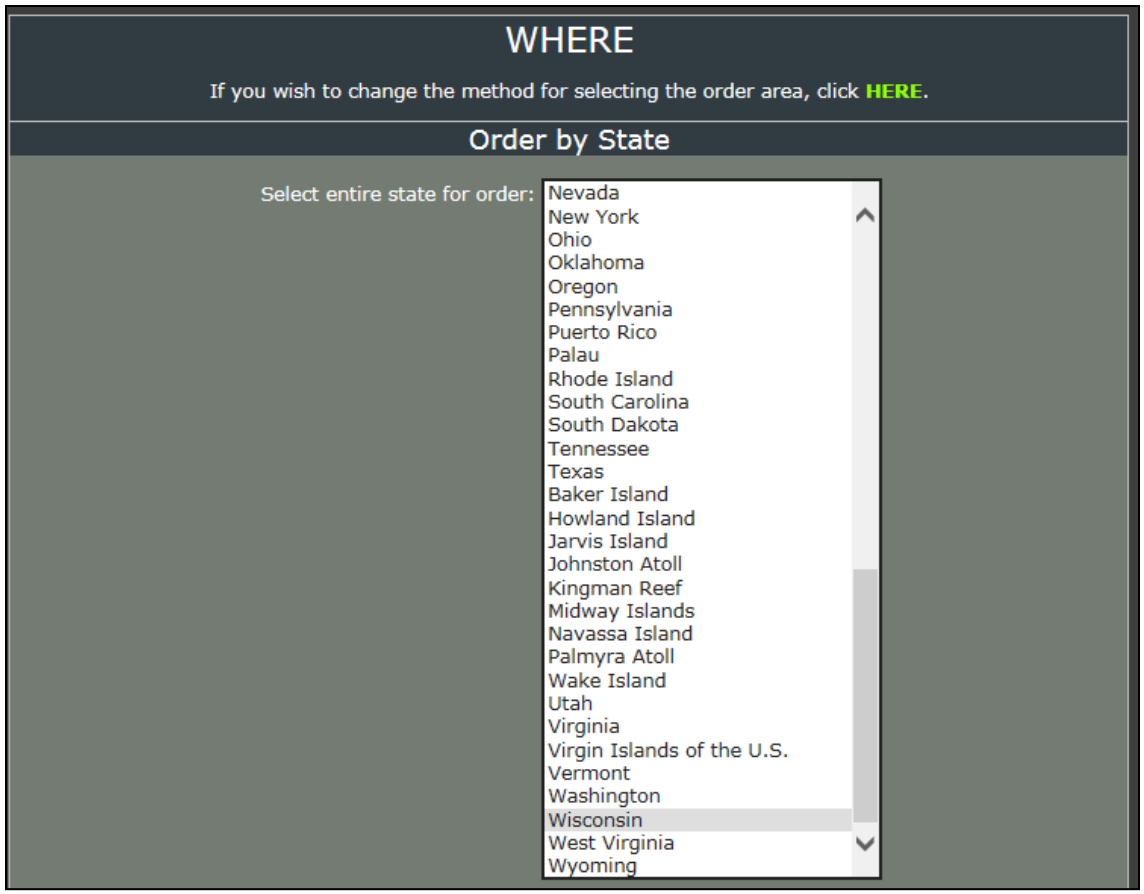
# gSSURGO

https://gdg.sc.egov.usda.gov/

# gSSURGO


https://gdg.sc.egov.usda.gov/GDGOrder.aspx
USDA:NRCS:Geospatial Dat...
USDA United States Department of Agriculture
Natural Resources Conservation Service
GeoSpatialDa
Last Modified: 9/19/2014 4:05:56 PM
Home
Status Maps
Help
FAQ
Contact Us
1-WHERE
Order by County/Counties
Using the panel in the middle select the state for your order. A list of available counties for that state will then be displayed. Select one or more items from the Available Counties. The shift and ctrl keys are
WHERE
If you wish to change the method for selecting the order area, click HERE.
Change WHERE option
Order by County/Counties
Select State for order:
Select State
YOU
Order Map La
Order Formal

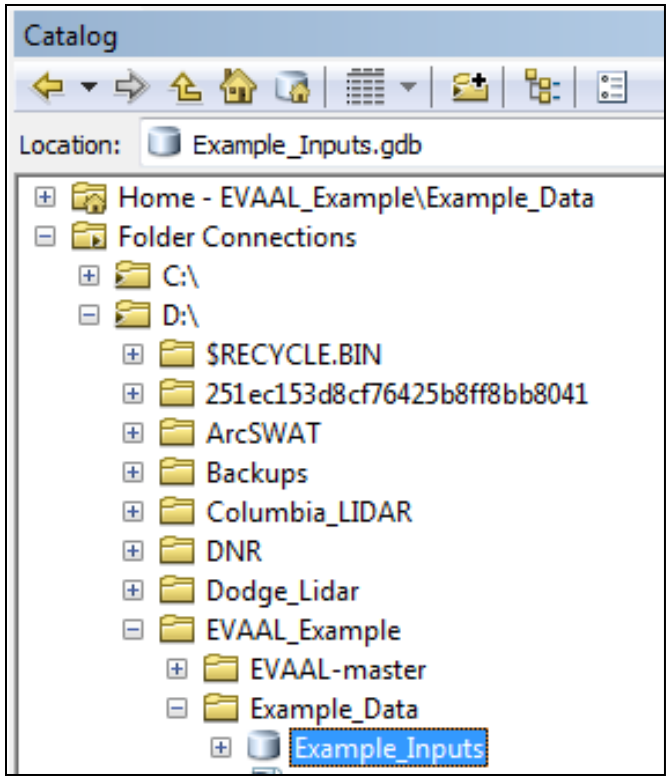
# gSSURGO

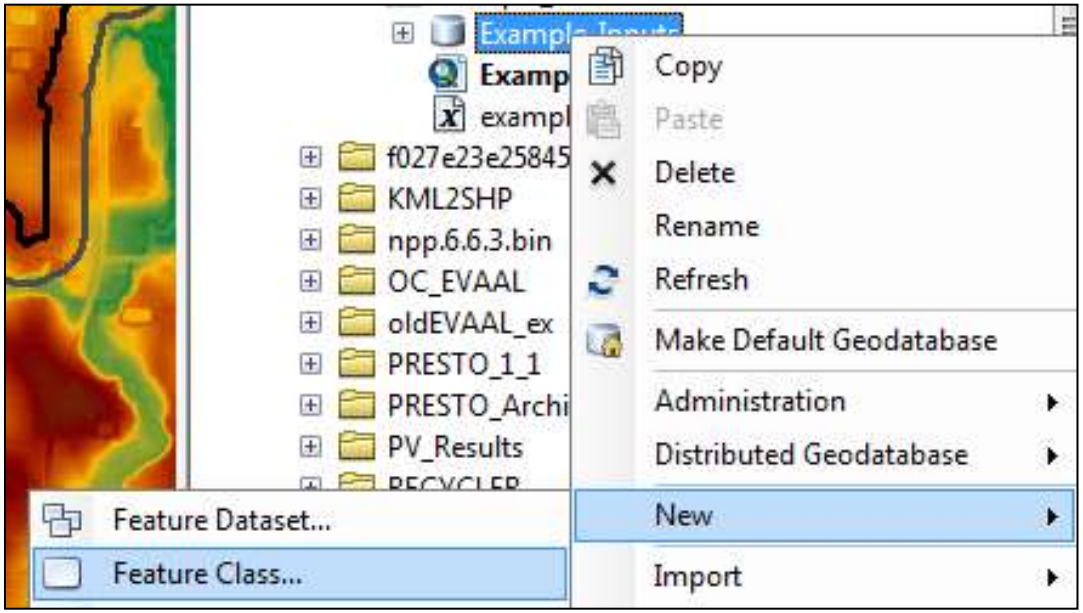

WHERE
If you wish to change the method for selecting the order area, click HERE.
Order by State
Select entire state for order:
Nevada
New York
Ohio
Oklahoma
Oregon
Pennsylvania
Puerto Rico
Palau
Rhode Island
South Carolina
South Dakota
Tennessee
Texas
Baker Island
Howland Island
Jarvis Island
Johnston Atoll
Kingman Reef
Midway Islands
Navassa Island
Palmyra Atoll
Wake Island
Utah
Virginia
Virgin Islands of the U.S.
Vermont
Washington
Wisconsin
West Virginia
Wyoming


Soils
Major Land Resource Areas by State, 1 map 2.616 MB
Common Resource Areas by State, 1 map 2.500 MB
Soil Survey Spatial and Tabular Data (SSURGO 2.2), 69 maps 2177.970 MB
U.S. General Soil Map (STATSGO2) by State, 1 map 5.363 MB
Gridded Soil Survey Geographic (gSSURGO) by State or Conterminous U.S., 1 map 1360.892 MB

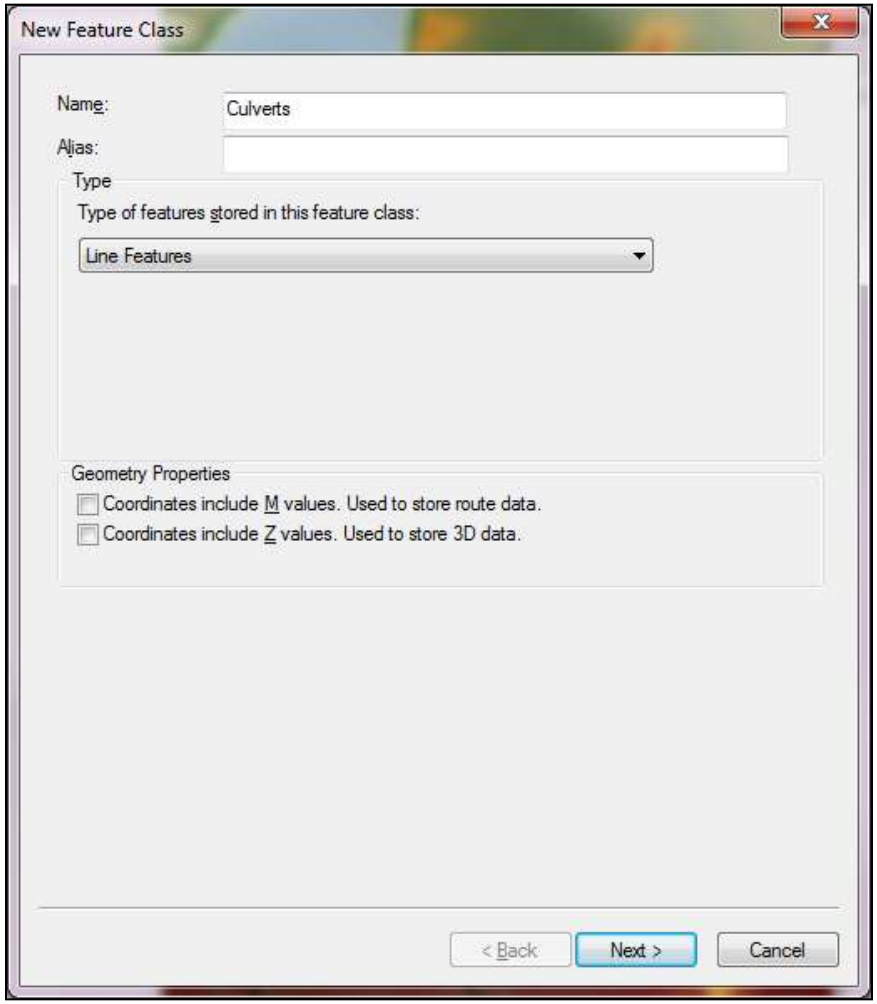
# Culverts

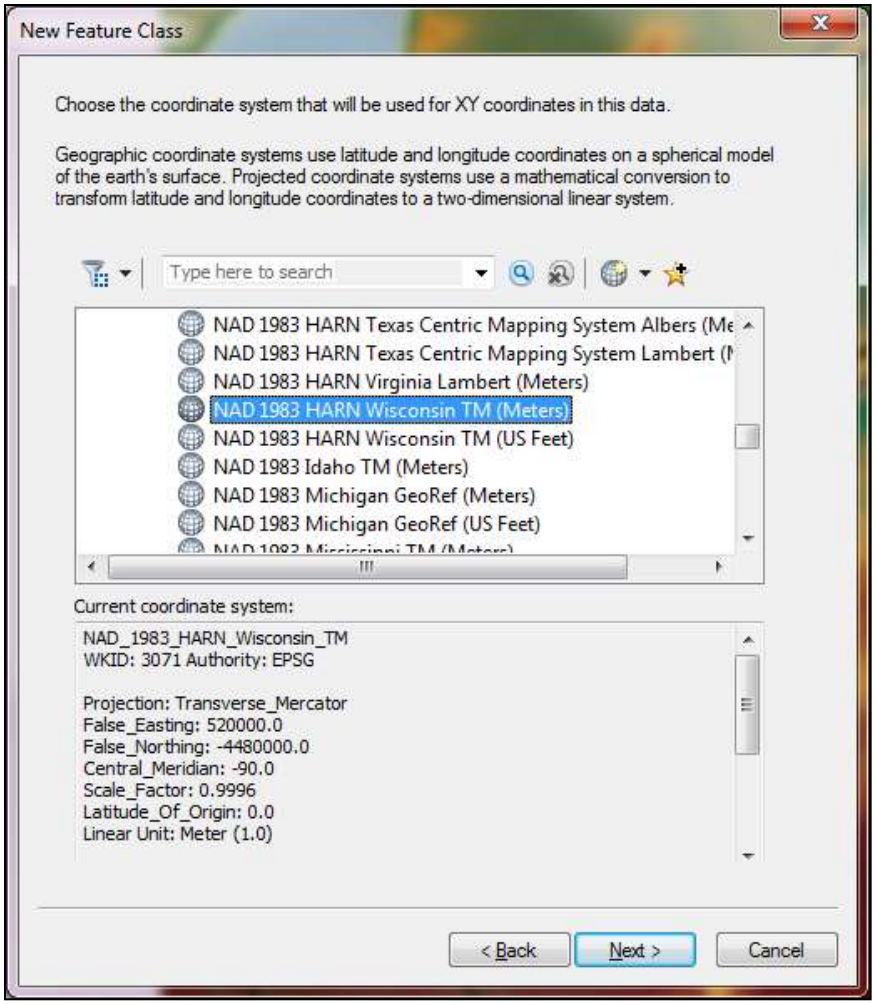
- Create empty feature class



# Culverts


New Feature Class
Name:
Culverts
Alias:
Type
Type of features stored in this feature class:
Line Features
Geometry Properties
Coordinates include M values. Used to store route data.
Coordinates include Z values. Used to store 3D data.
< Back
Next >
Cancel

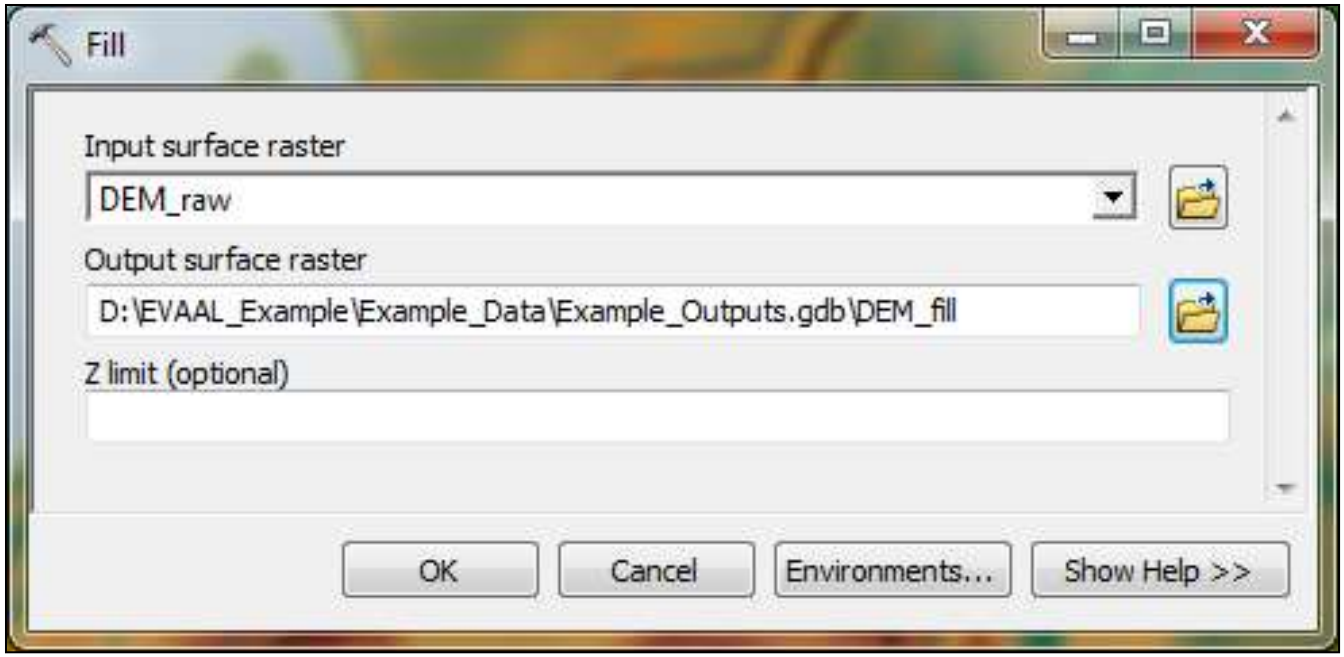

New Feature Class
Choose the coordinate system that will be used for XY coordinates in this data.
Geographic coordinate systems use latitude and longitude coordinates on a spherical model of the earth's surface. Projected coordinate systems use a mathematical conversion to transform latitude and longitude coordinates to a two-dimensional linear system.
Type here to search
NAD 1983 HARN Texas Centric Mapping System Albers (Me
NAD 1983 HARN Texas Centric Mapping System Lambert (
NAD 1983 HARN Virginia Lambert (Meters)
NAD 1983 HARN Wisconsin TM (Meters)
NAD 1983 HARN Wisconsin TM (US Feet)
NAD 1983 Idaho TM (Meters)
NAD 1983 Michigan GeoRef (Meters)
NAD 1983 Michigan GeoRef (US Feet)
Current coordinate system:
NAD_1983_HARN_Wisconsin_TM
WKID: 3071 Authority: EPSG
Projection: Transverse_Mercator
False_Easting: 520000.0
False_Northing: -4480000.0
Central_Meridian: -90.0
Scale_Factor: 0.9996
Latitude_Of_Origin: 0.0
Linear Unit: Meter (1.0)
< Back
Next >
Cancel

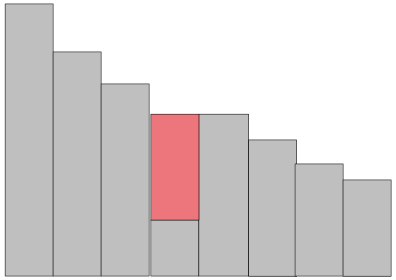
# Where to place culvert cut lines

- Create depression raster
- Add additional layers
- Draw culverts
- Run steps 1 thru 2c
  - Review internally draining areas
    - Add more culverts if necessary
      - Repeat steps 1 & 2c

# Create Depression Raster

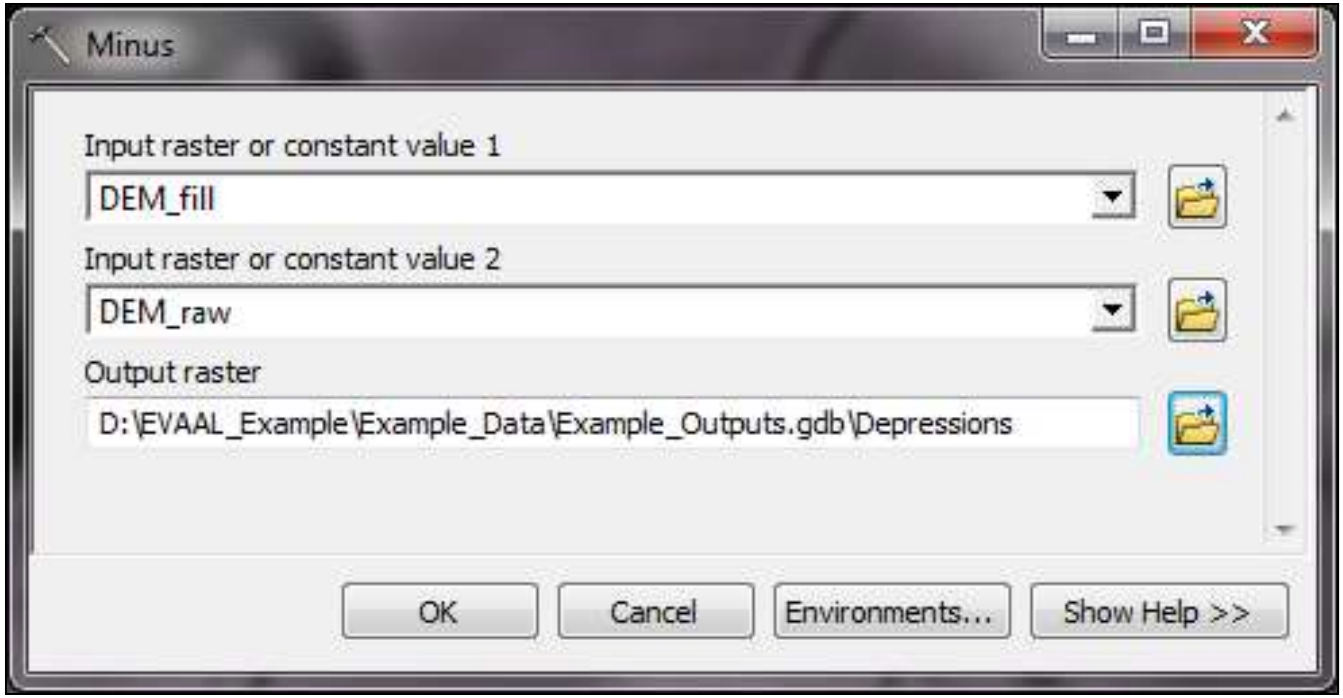
- Fill DEM

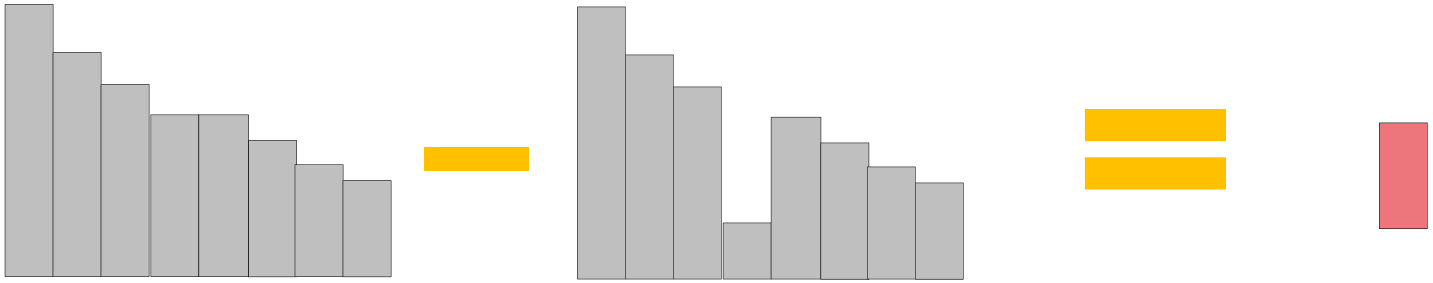


# Create Depression Raster

- Subtract filled DEM from raw DEM



# Add additional layers

- Aerial photo basemap
- Streams
- Roads

- Others
  - Wetlands
  - Lakes

# Create Culverts

- **Main idea**: input culverts to areas that are drained by culverts, bridges, etc.
  - Find sinks that are likely drained by culverts
  - Create a line that represents a culvert
  - Repeat

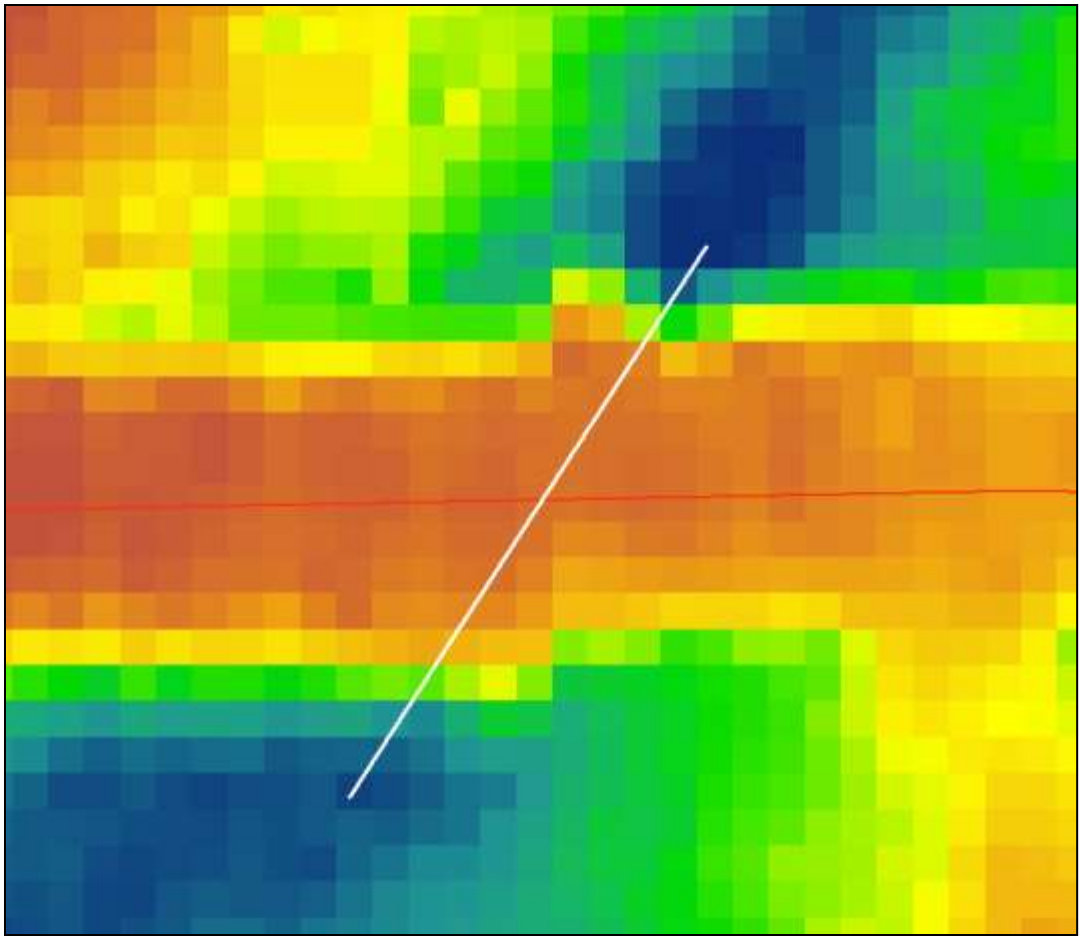
  - **NOTE**: this can be a difficult and iterative process. It will take some time to get right and will involve a number of judgment calls.

# Create Culverts

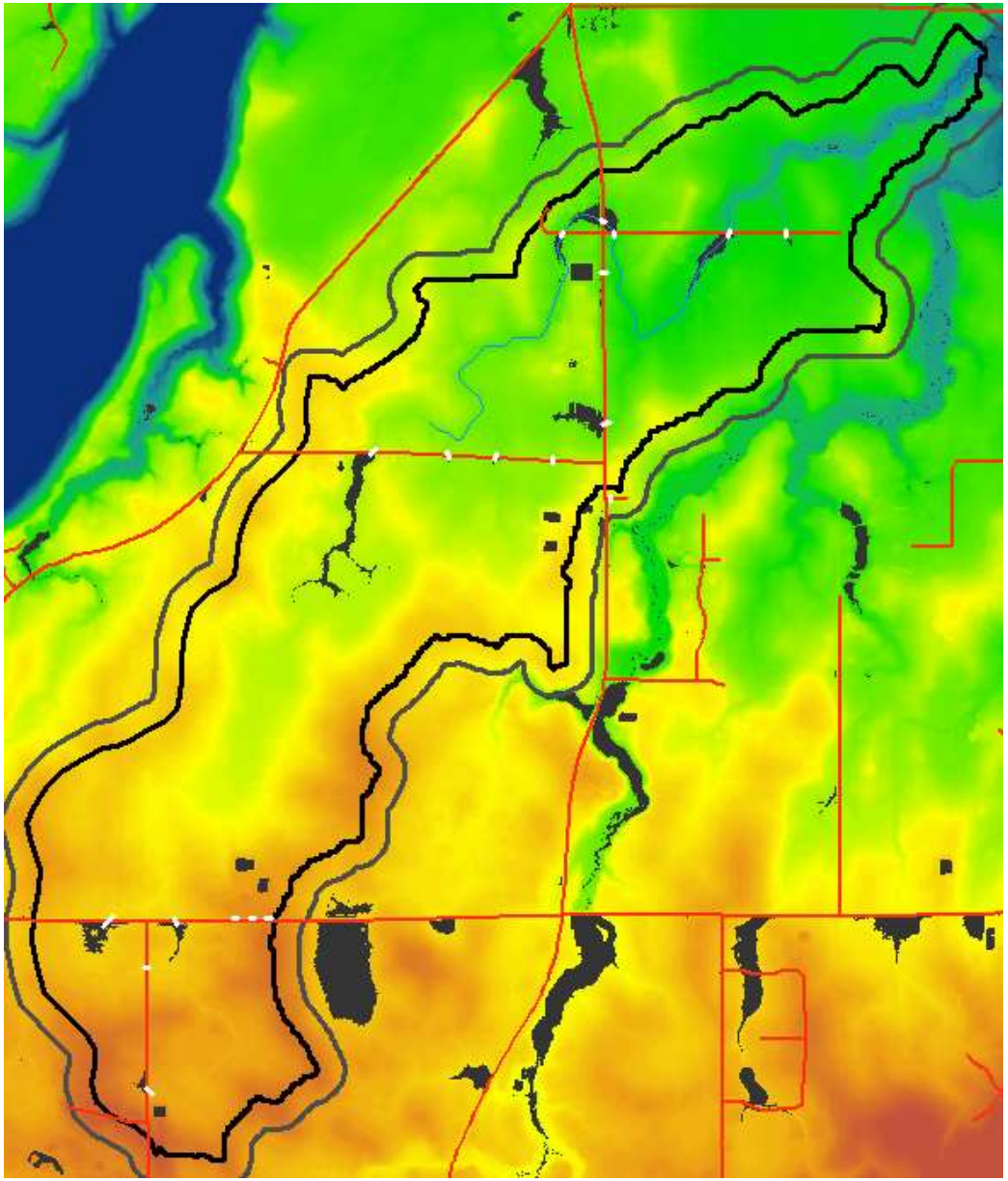
- Zoom in to depression area
- Look for evidence of channel/culvert

# Create Culverts

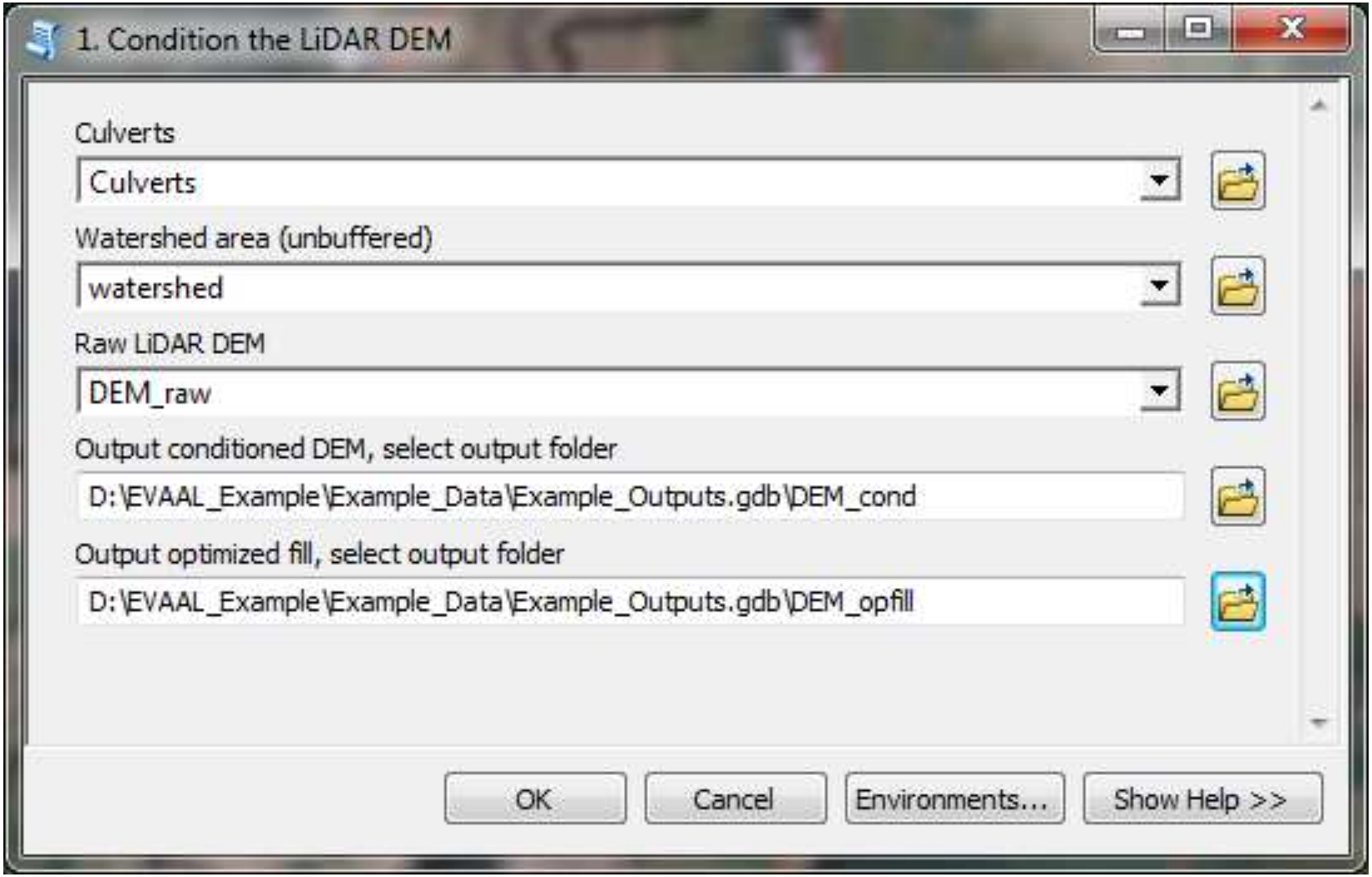
- Turn on raw DEM
- Draw culvert line
  - Upstream to downstream
  - First point of line must be higher elevation than second point

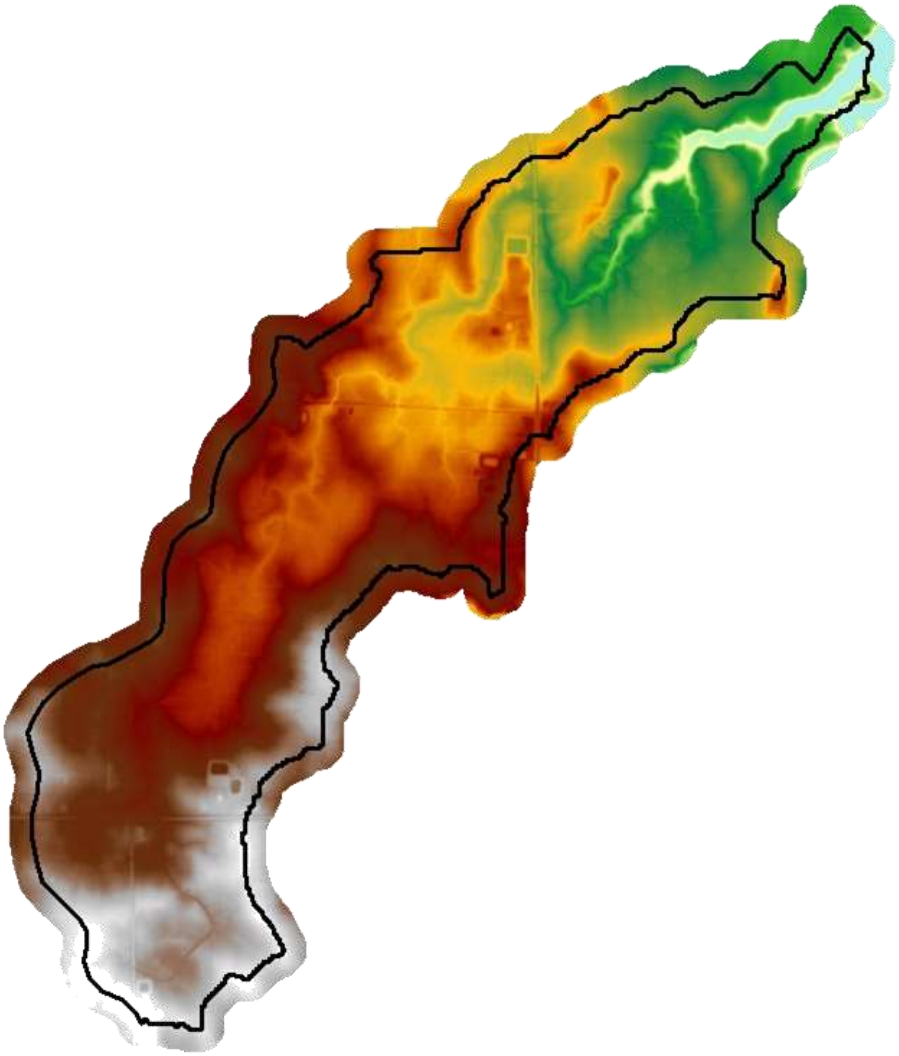


# Create Culverts

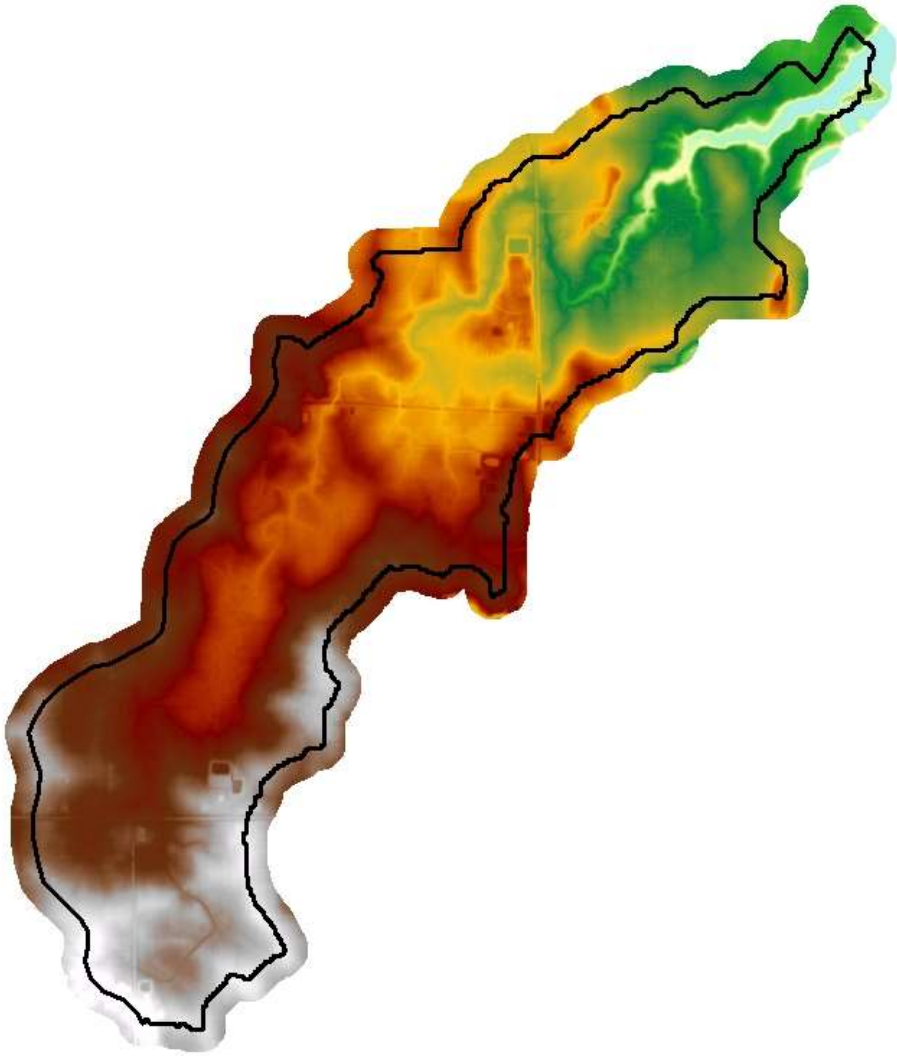


# Step 1: Condition DEM



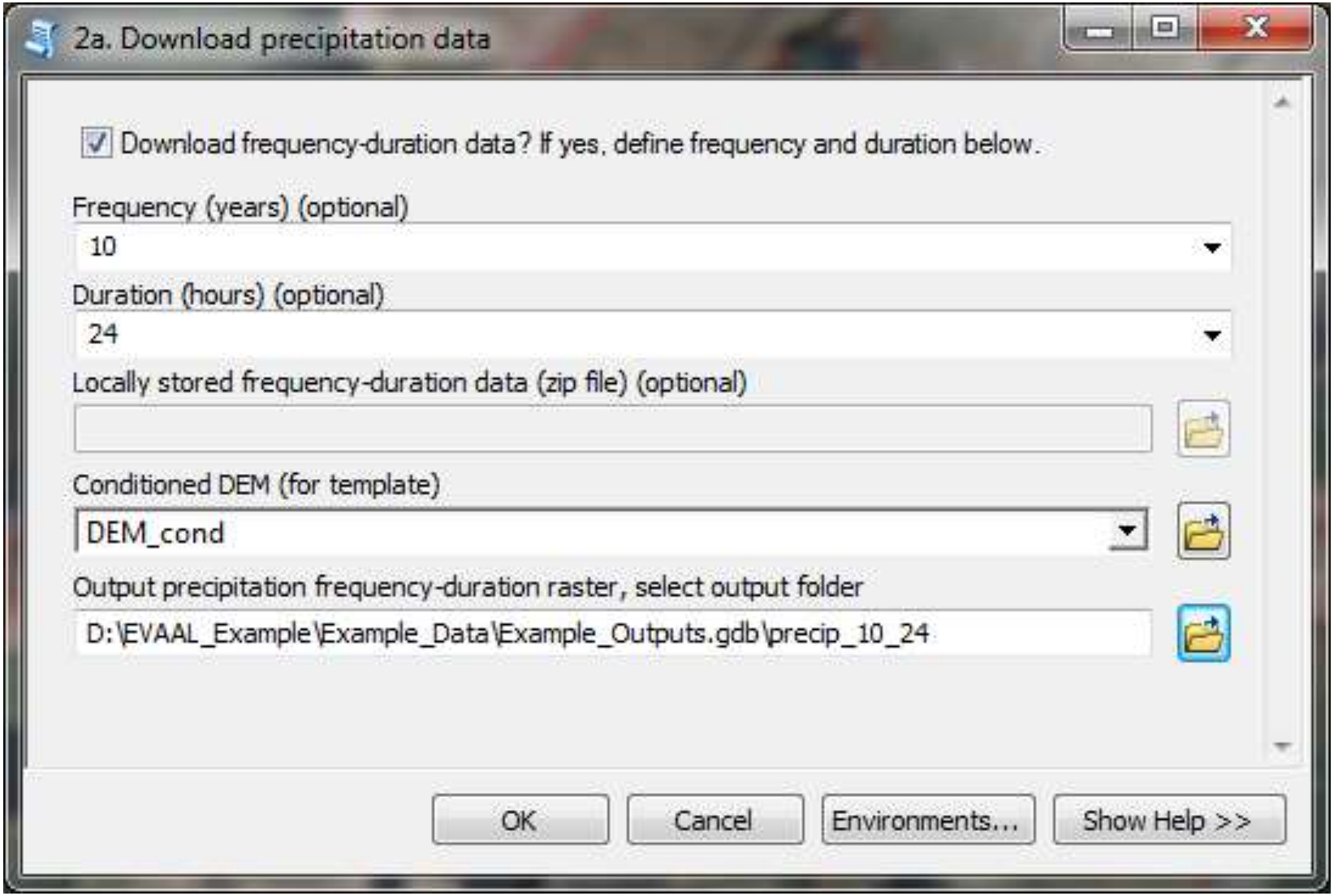


Conditioned DEM
"DEM_cond"

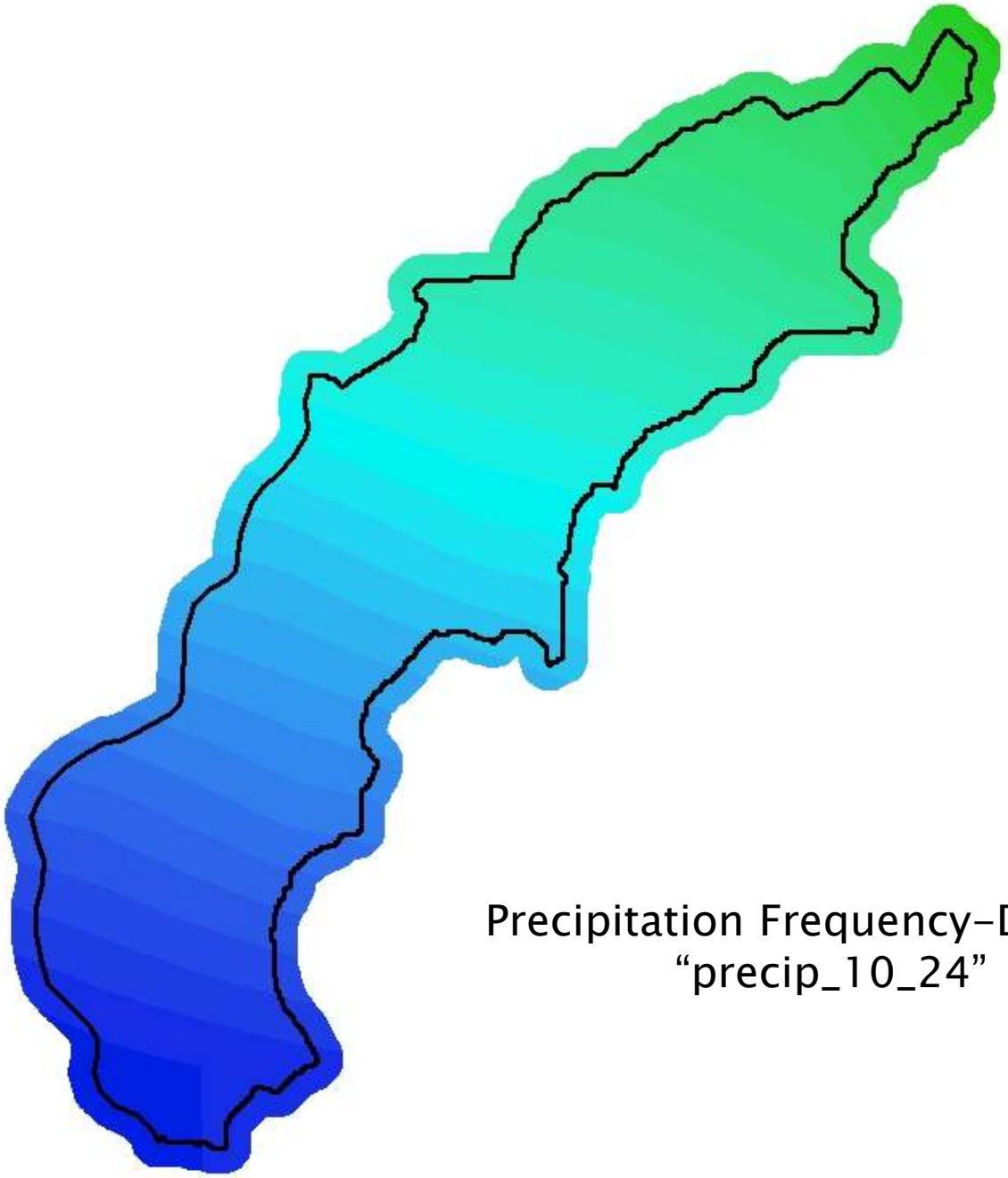


Optimized Filled DEM
"DEM_opfill"

# Step 2a: Download precip data

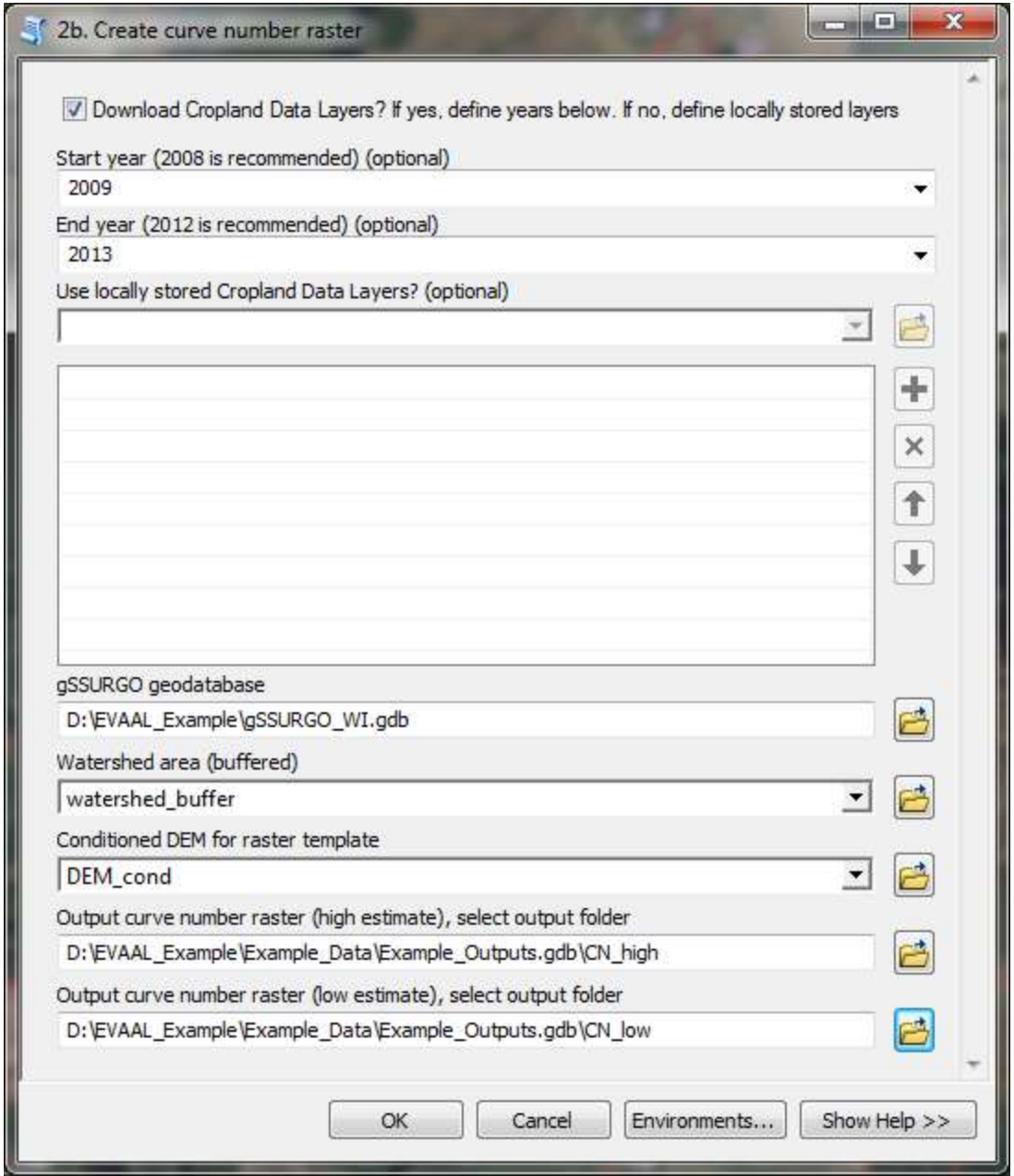


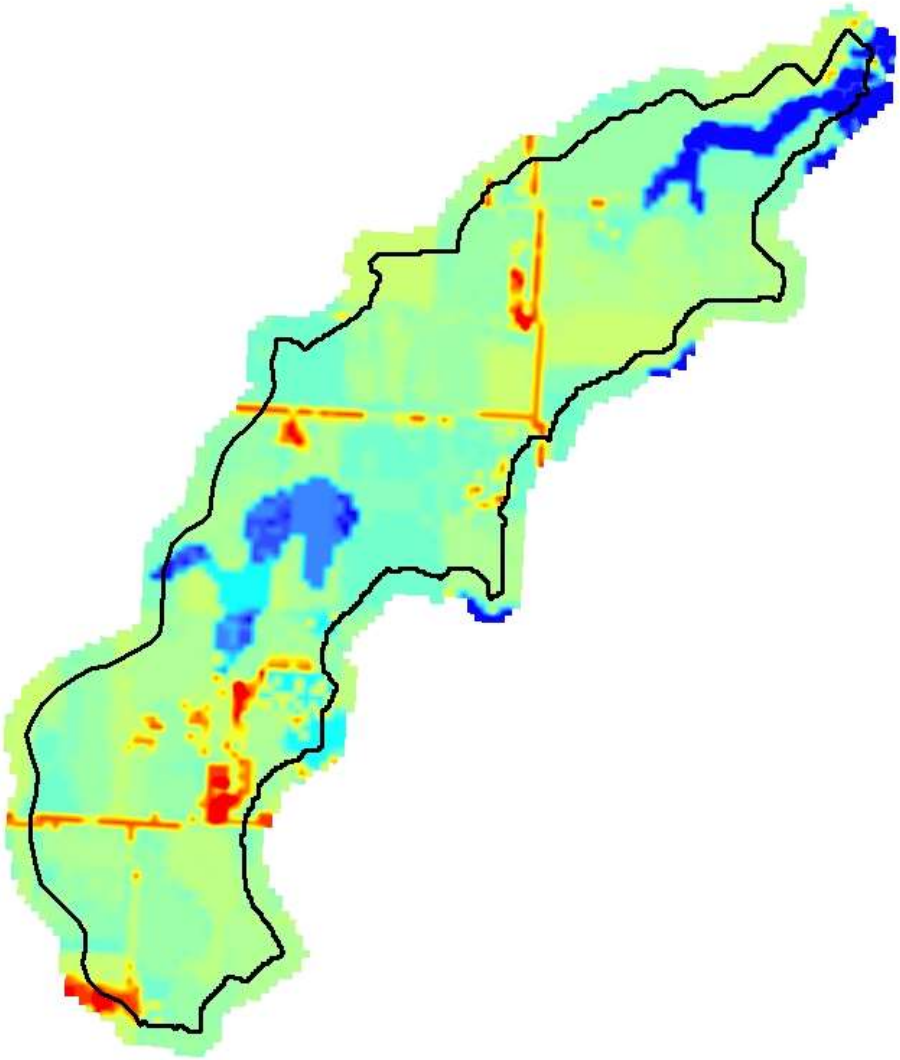

ftp://hdsc.nws.noaa.gov/pub/hdsc/data/mw/



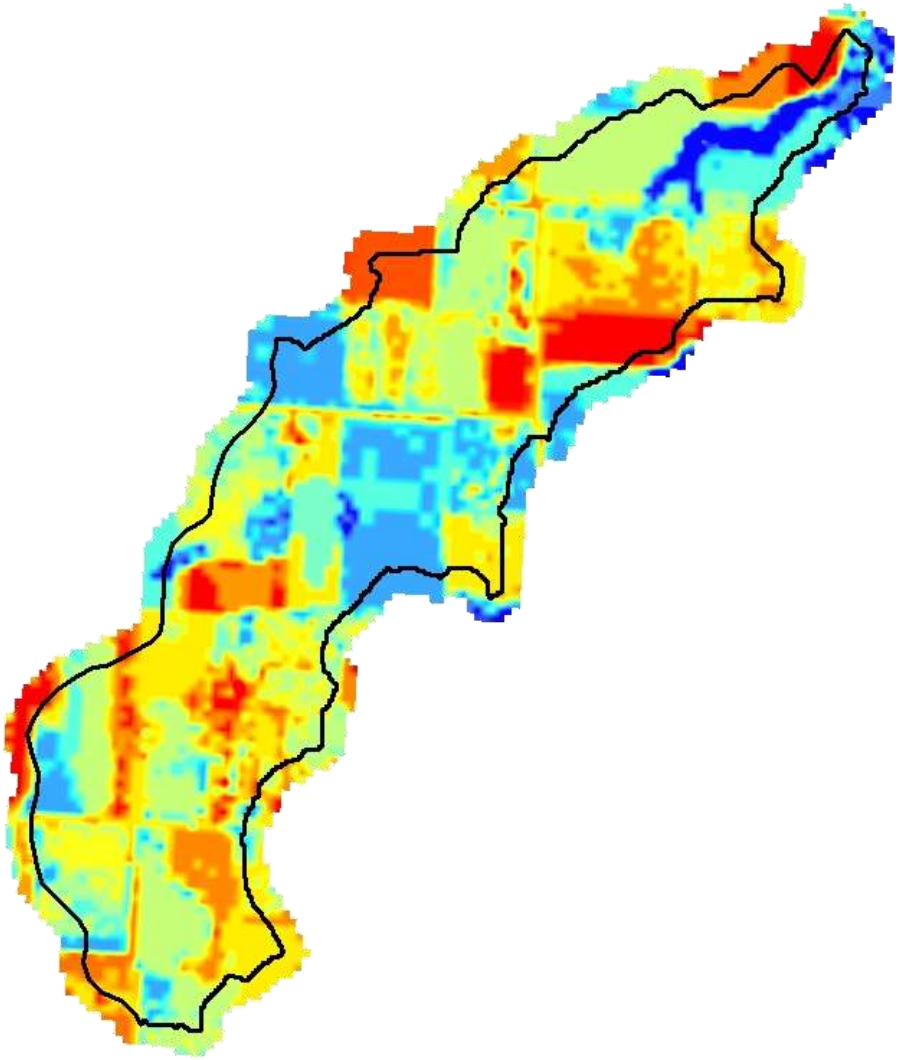
Precipitation Frequency-Duration
"precip_10_24"

# Step 2b: Create curve number raster



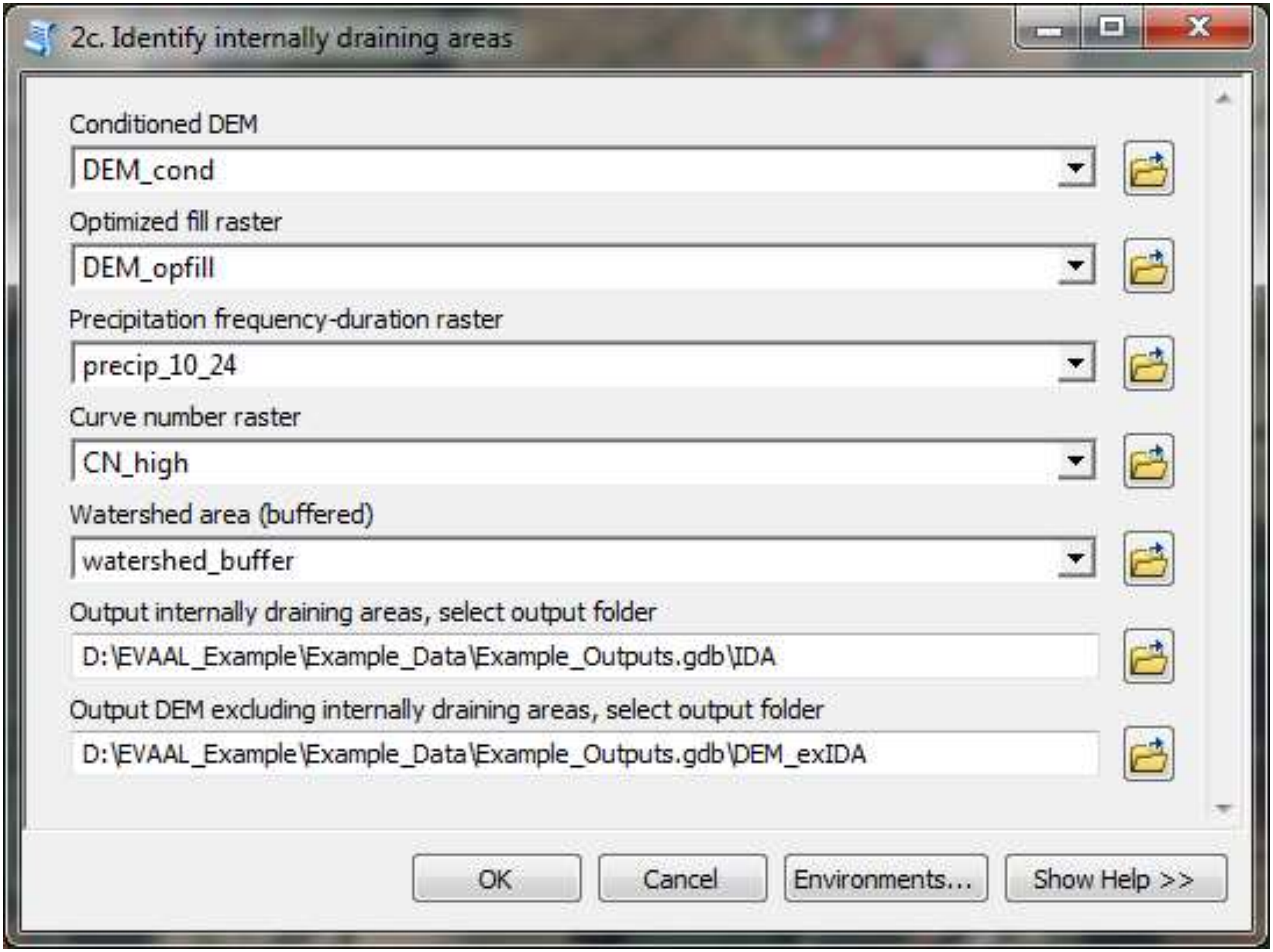


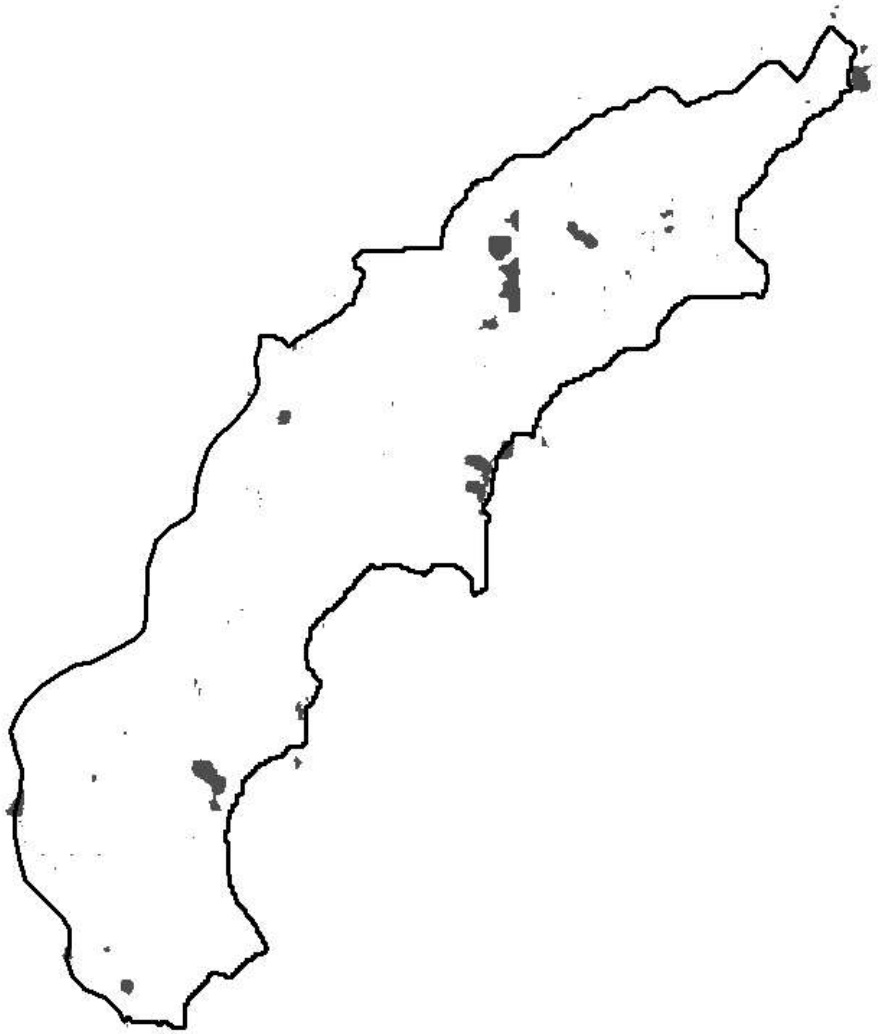
Curve Number (low estimate)
"CN_low"



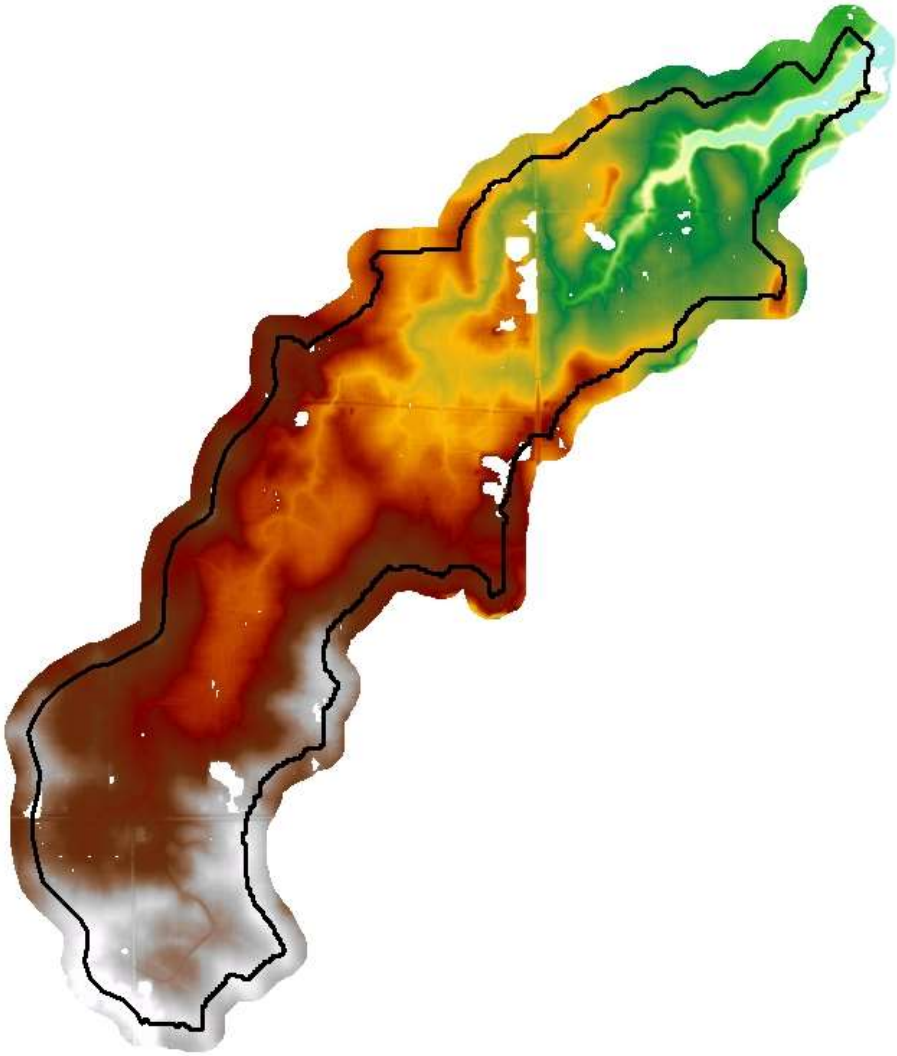
Curve Number (high estimate)
"CN_high"

# Step 2c: Identify internally draining areas



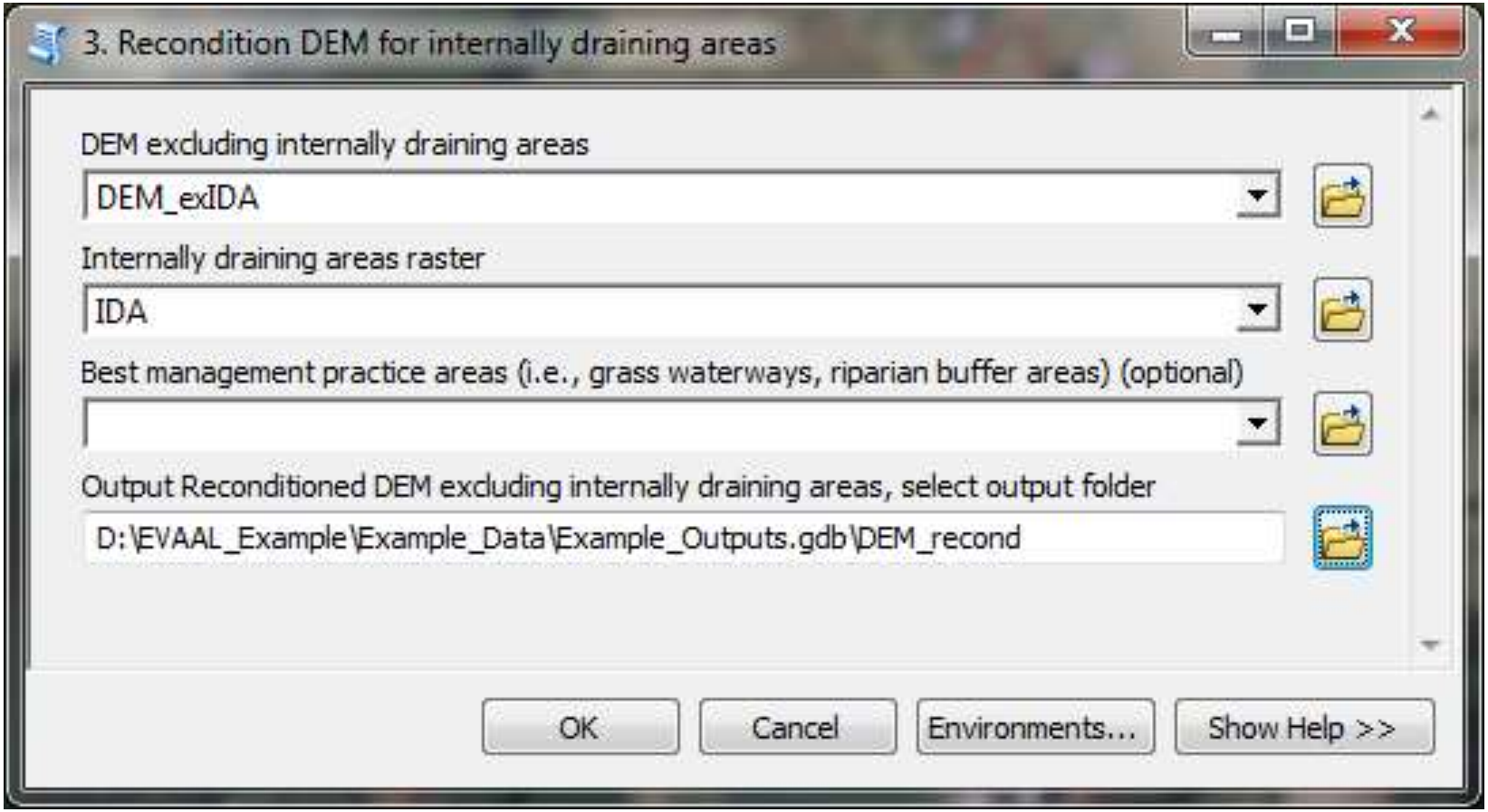


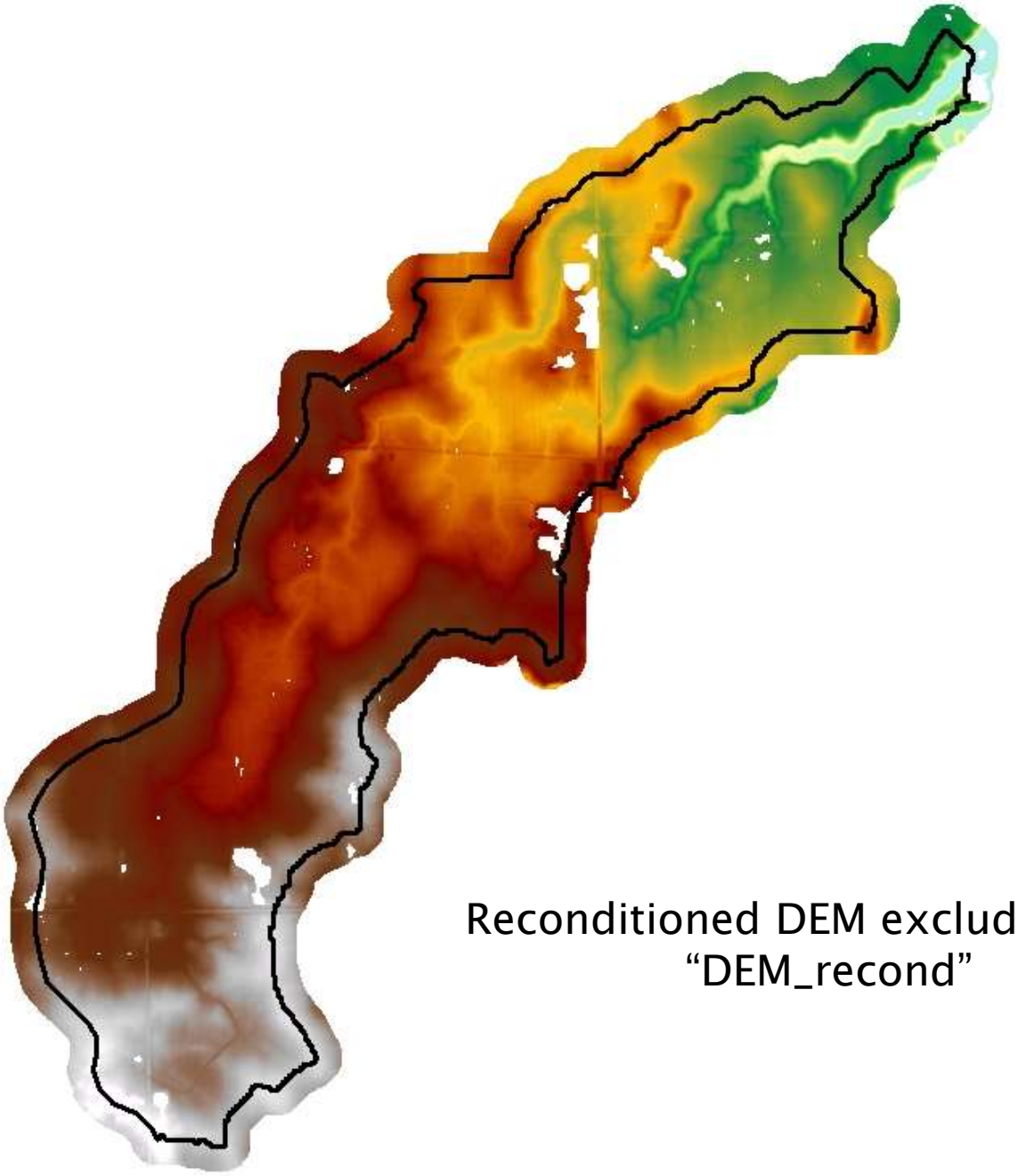
Internally Draining Areas
"IDA"



DEM excluding internally draining areas
"DEM_exIDA"

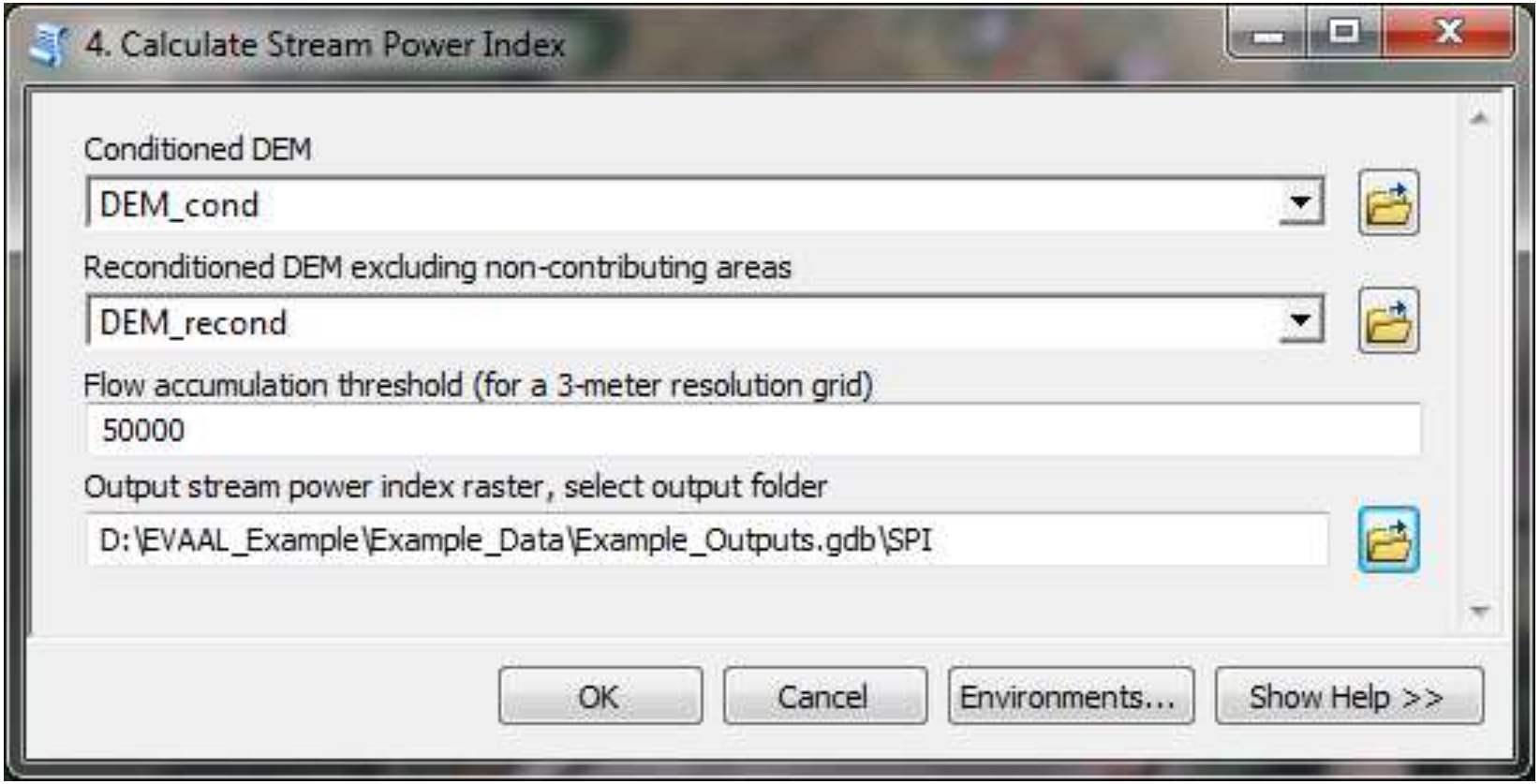
# Step 3: Recondition DEM

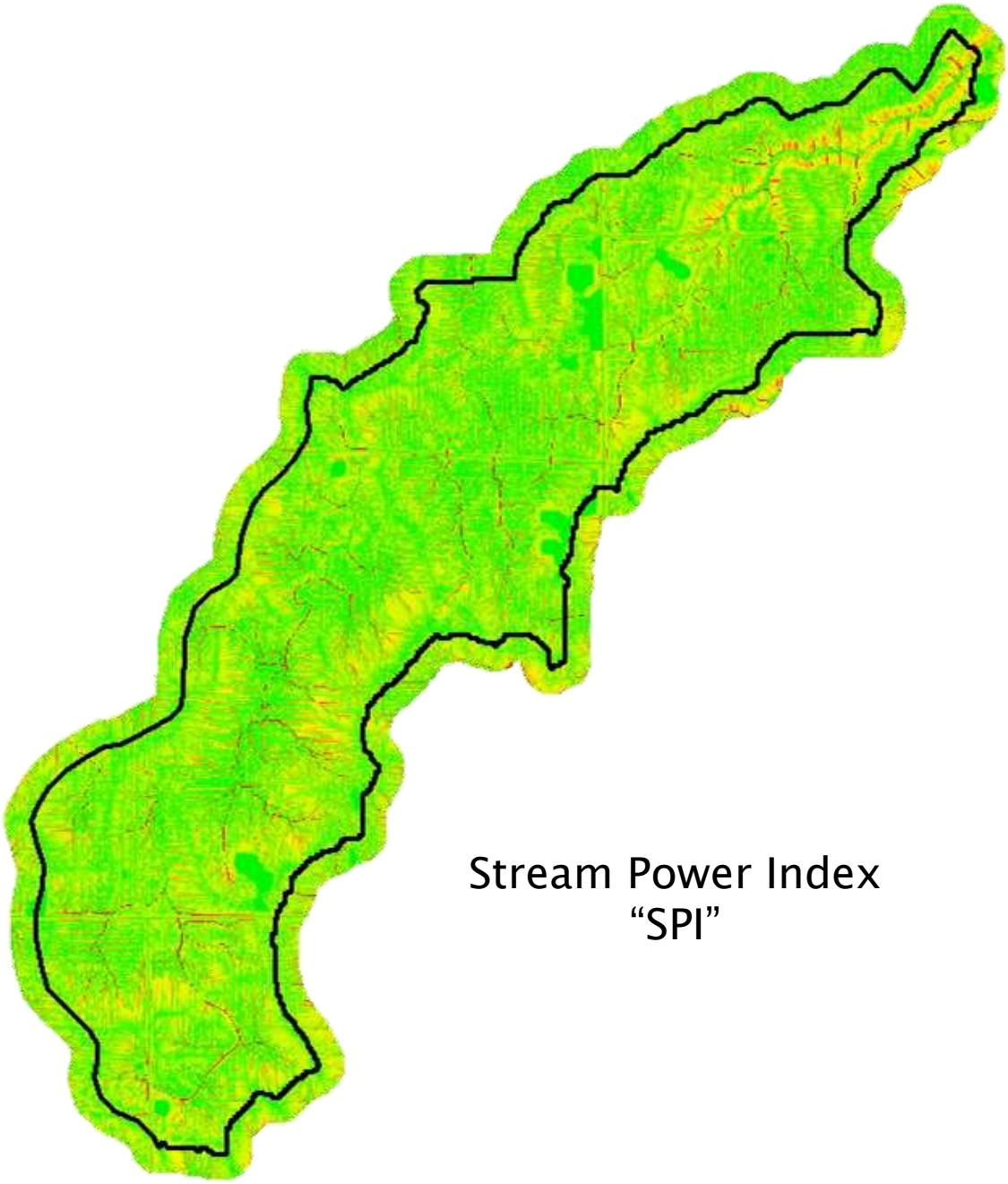




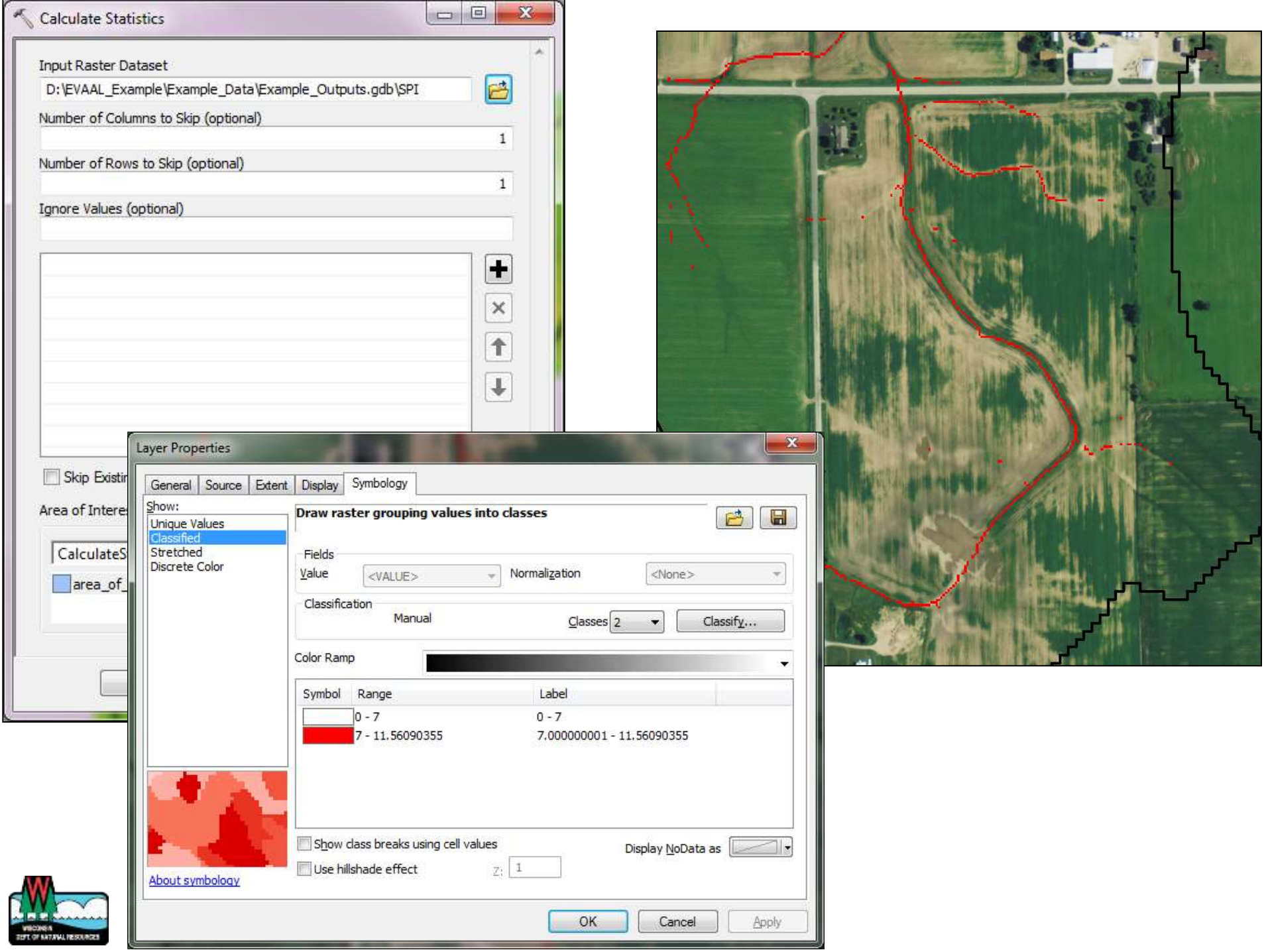
Reconditioned DEM excluding IDAs
"DEM_recond"

# Step 4: Calculate Stream Power Index

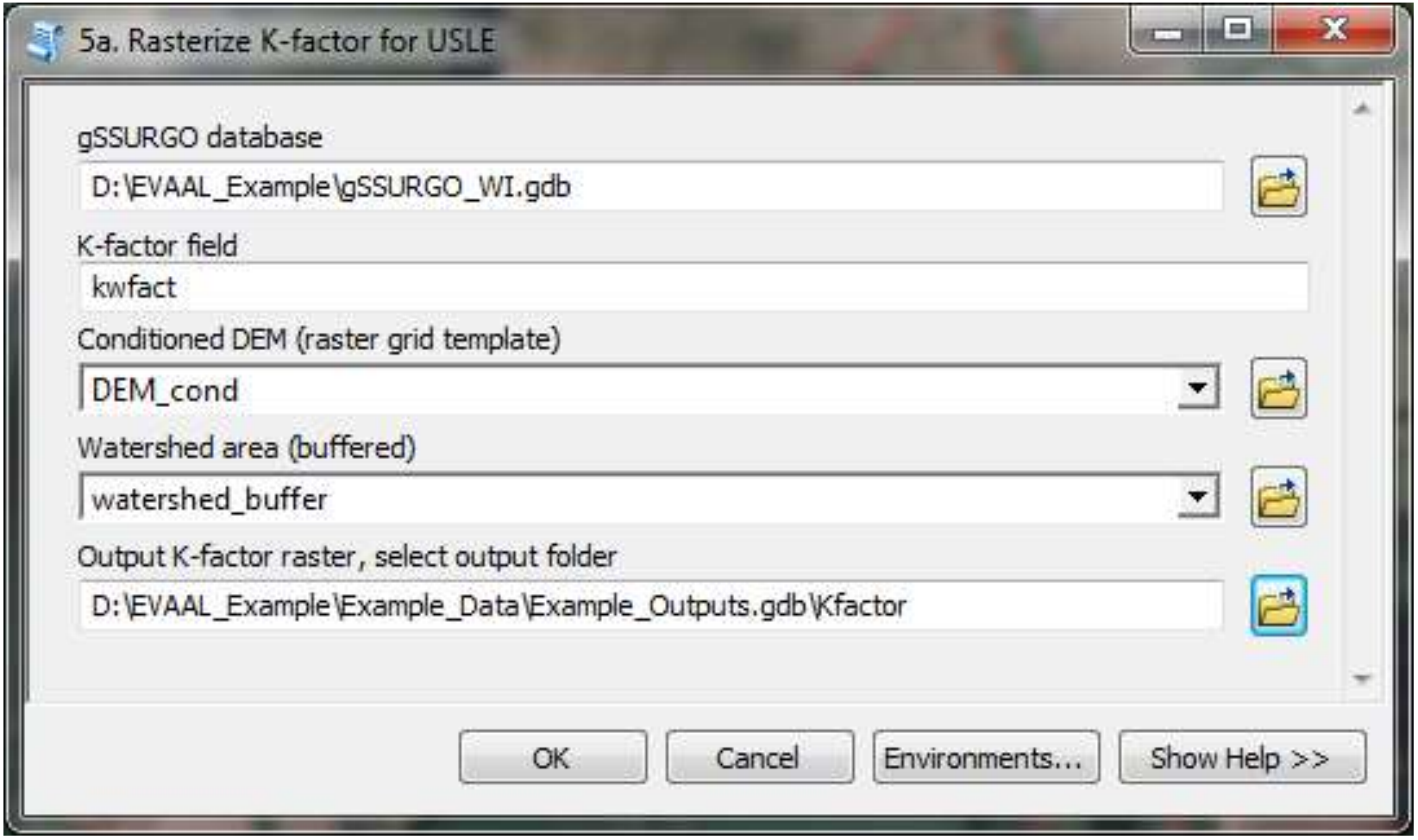


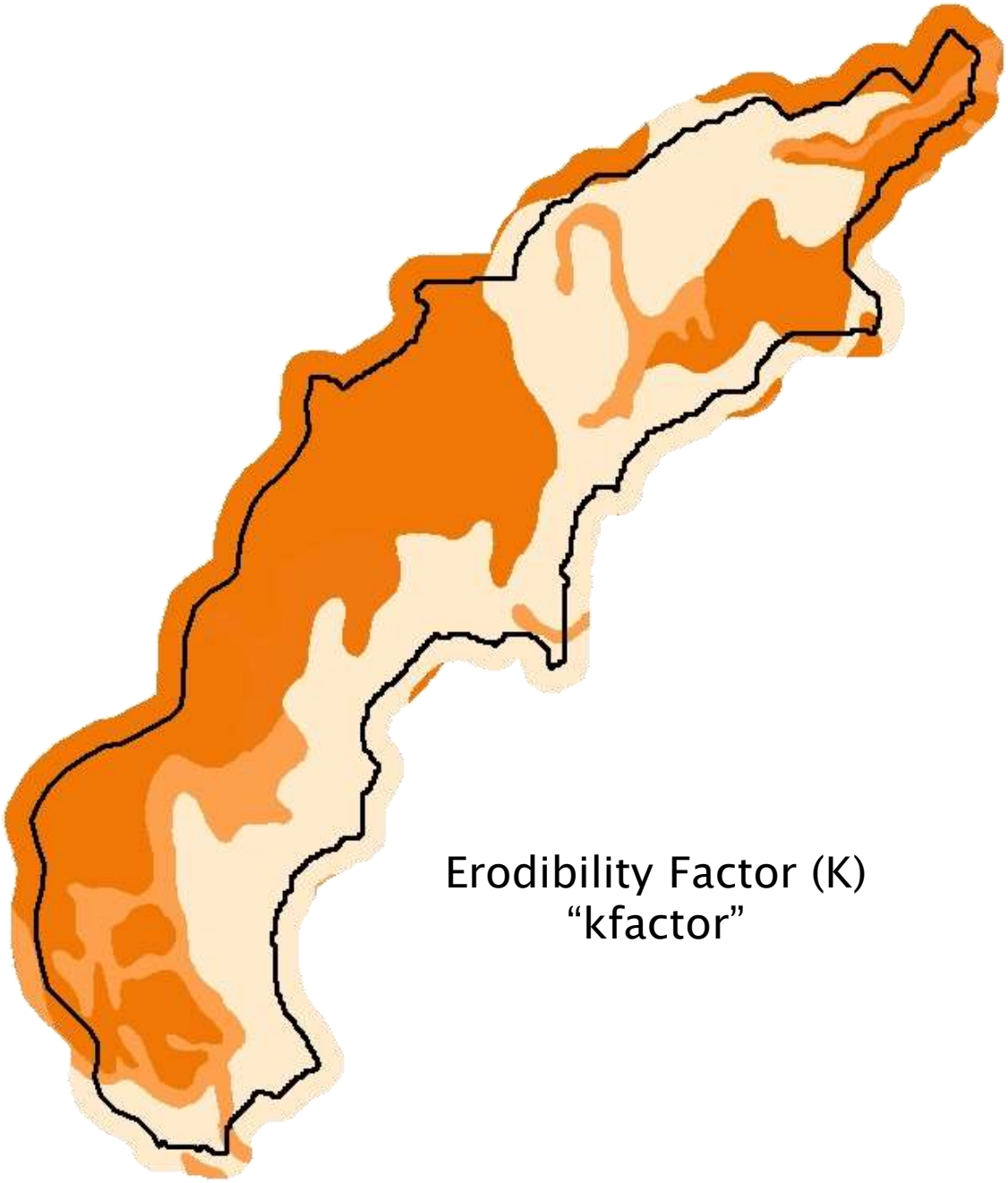


Stream Power Index
"SPI"


Calculate Statistics
Input Raster Dataset
D:\EVAAL_Example\Example_Data\Example_Outputs.gdb\SPI
Number of Columns to Skip (optional)
1
Number of Rows to Skip (optional)
1
Ignore Values (optional)
Skip Existin
Area of Intere
CalculateS
area_of_
Layer Properties
General
Source
Extent
Display
Symbology
Show:
Unique Values
Classified
Stretched
Discrete Color
Draw raster grouping values into classes
Fields
Value
<VALUE>
Normalization
<None>
Classification
Manual
Classes 2
Classify...
Color Ramp
Symbol
Range
Label
0 - 7
0 - 7
7 - 11.56090355
7.000000001 - 11.56090355
Show class breaks using cell values
Display NoData as
Use hillshade effect
Z: 1
About symbology
OK
Cancel
Apply

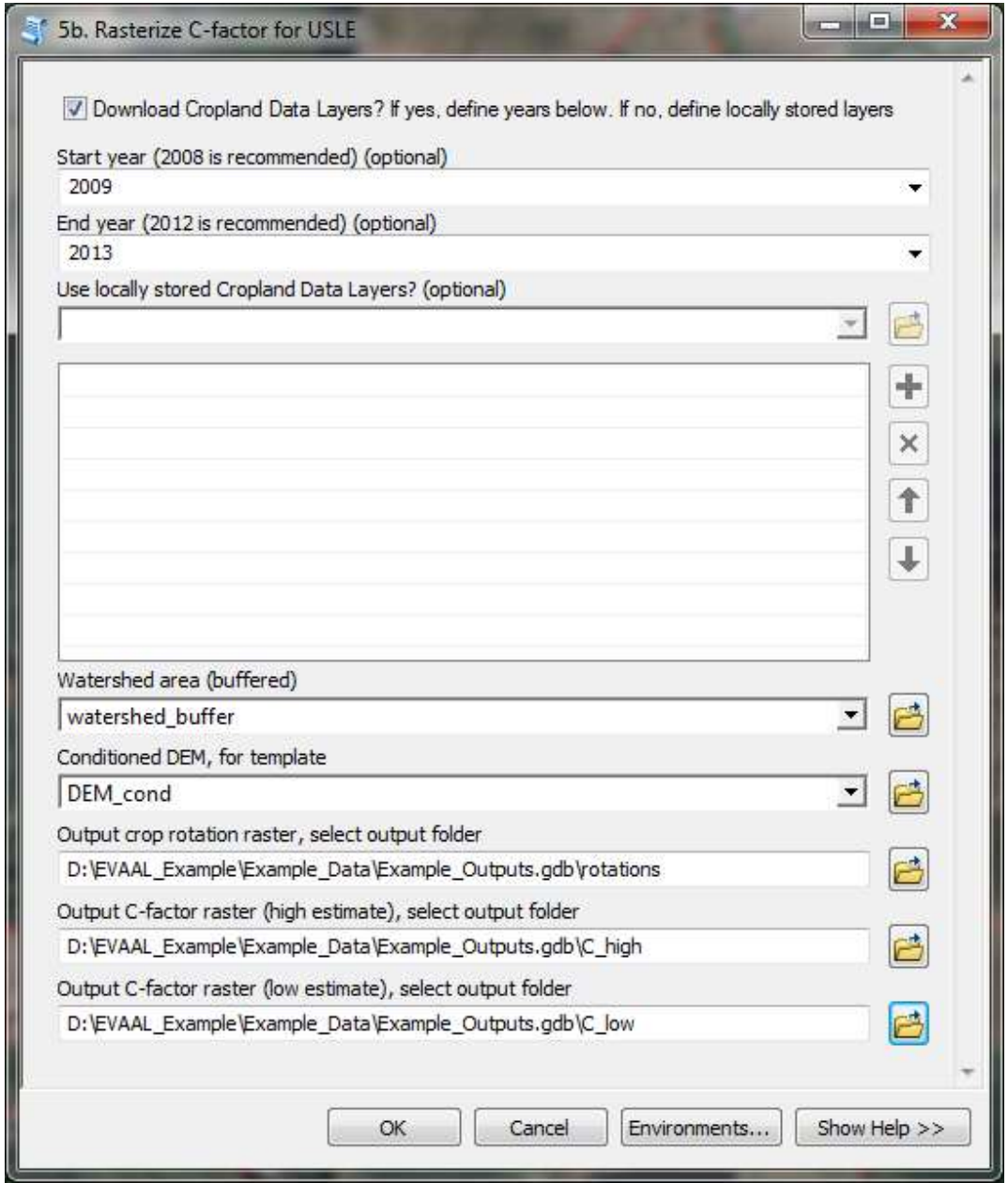
# Step 5a: Rasterize K-factor

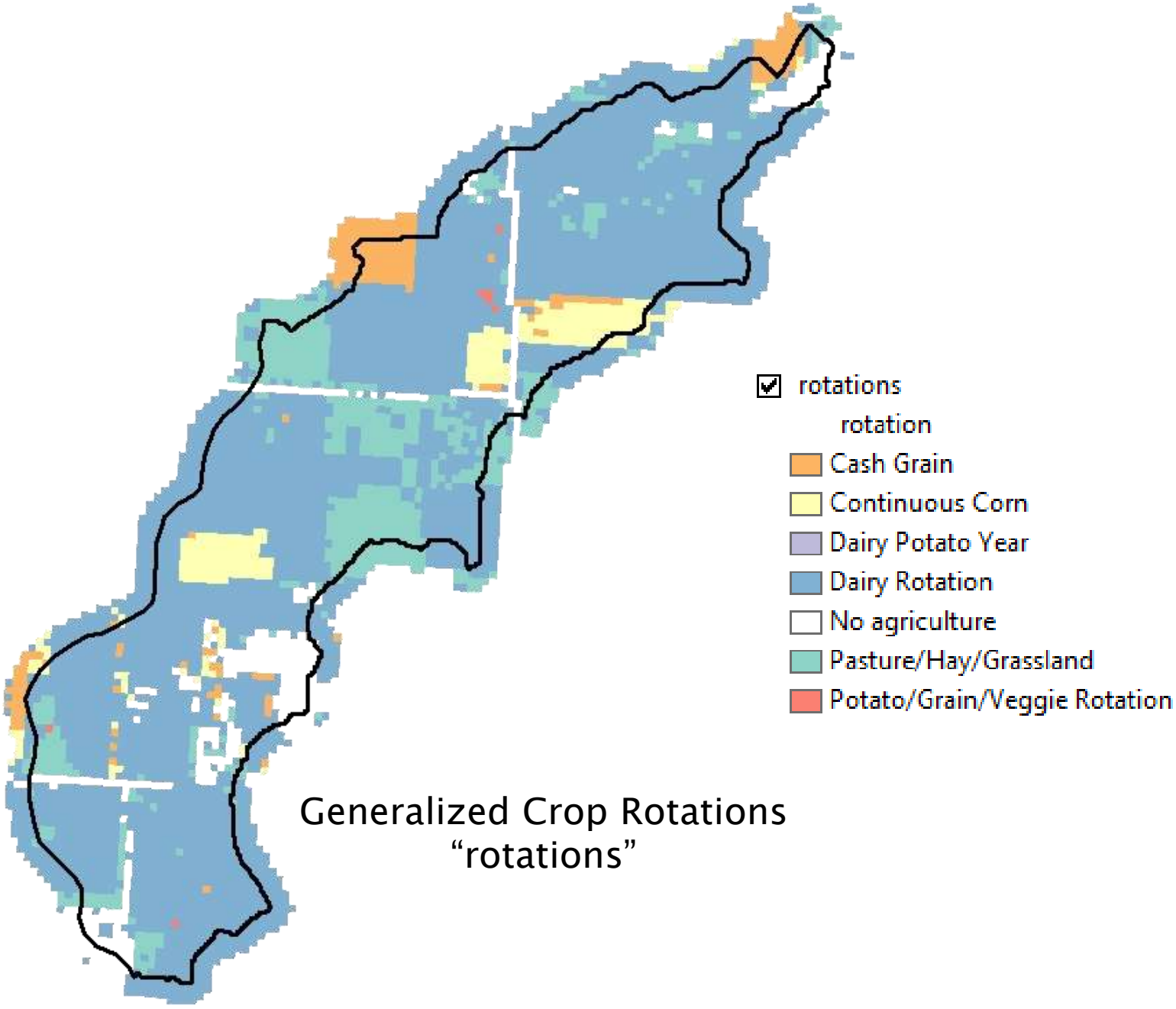




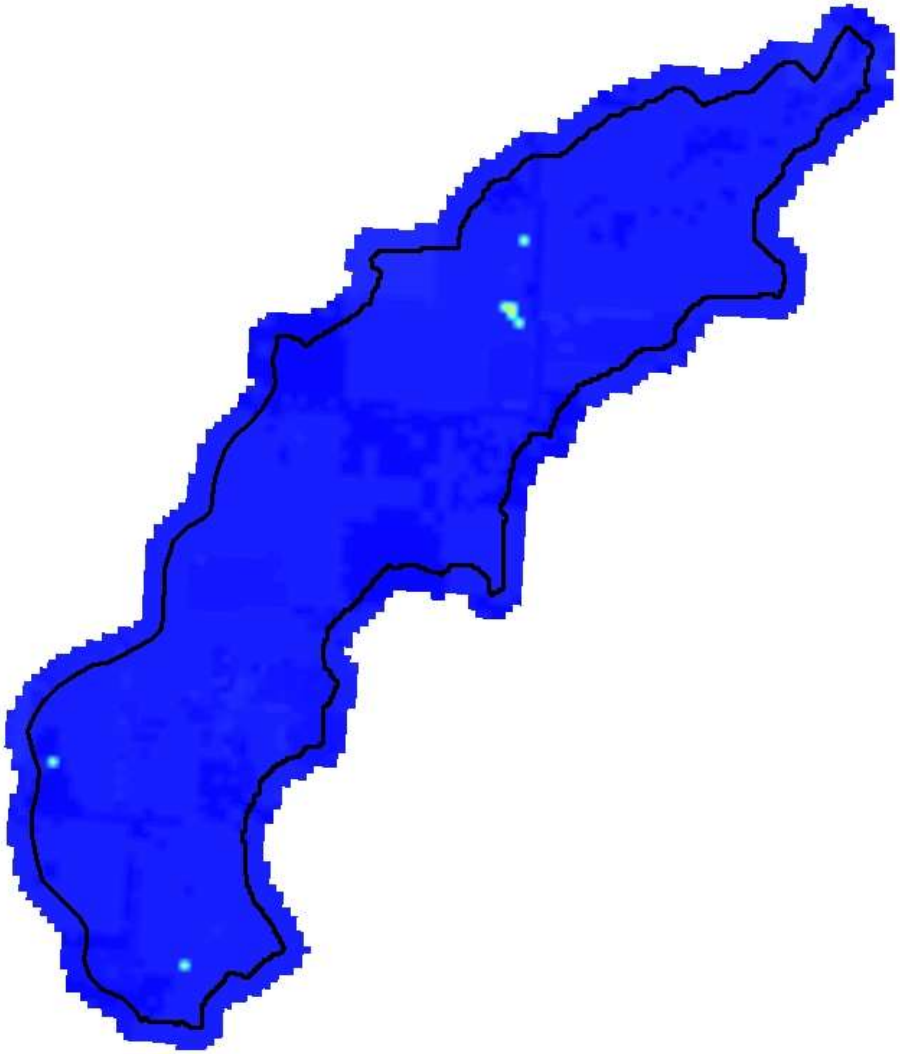
Erodibility Factor (K)
“kfactor”

# Step 5b: Rasterize C-factor

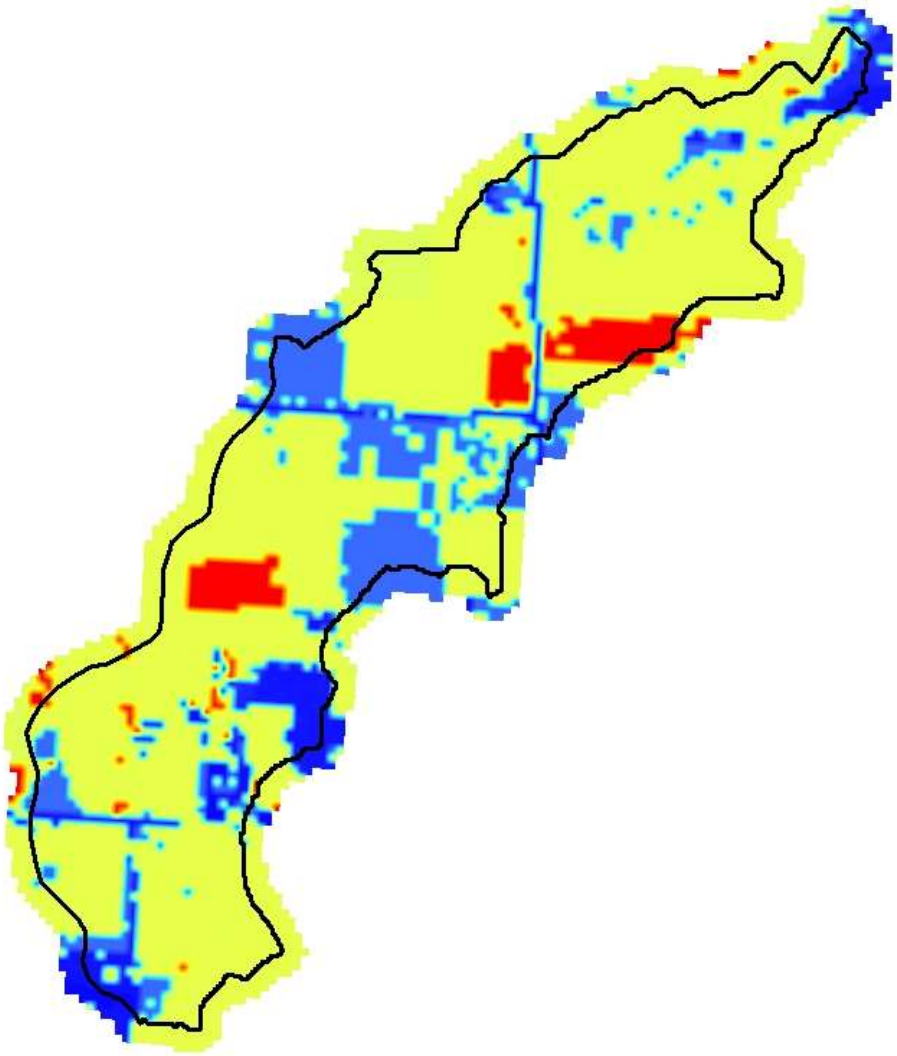





Generalized Crop Rotations
"rotations"

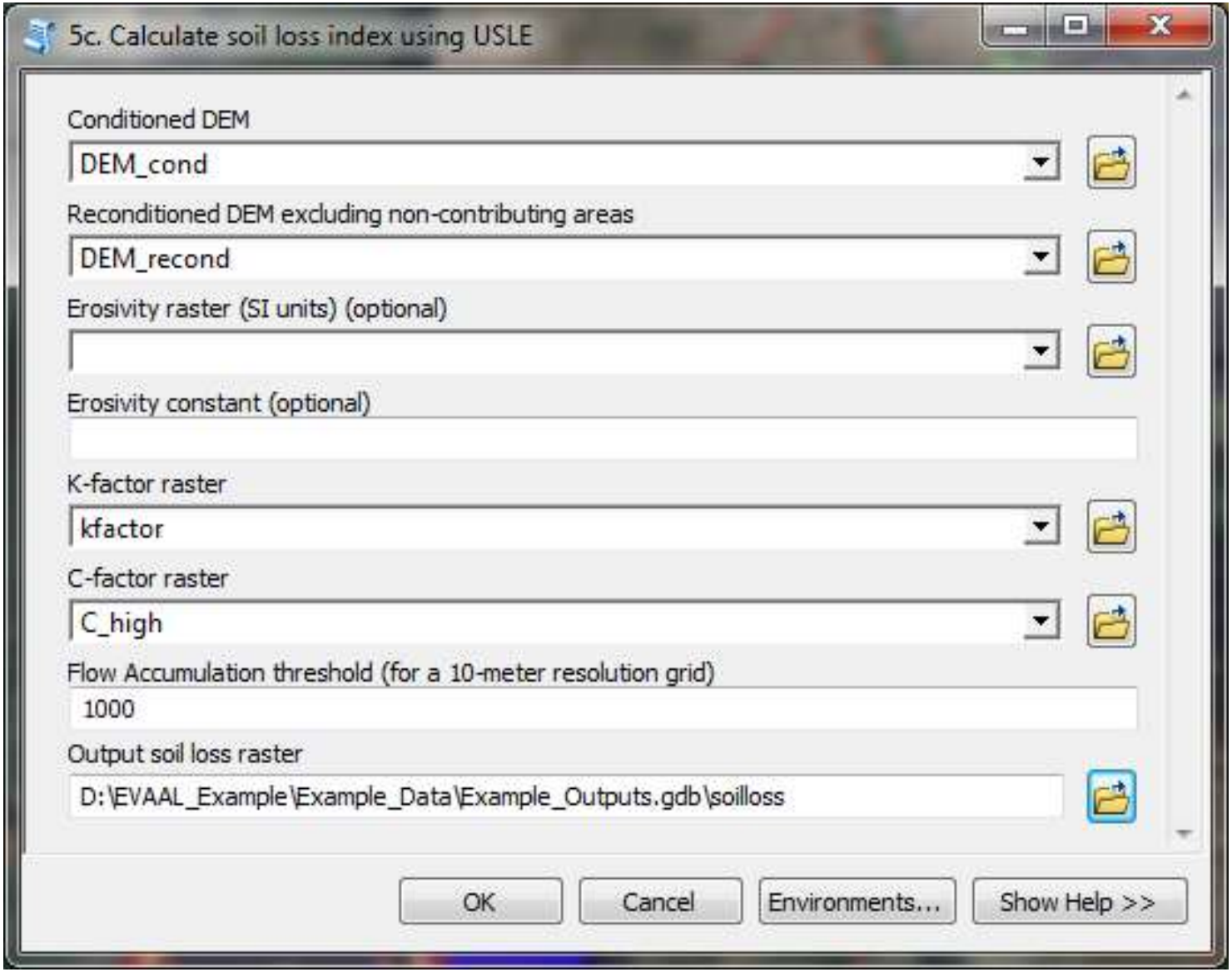


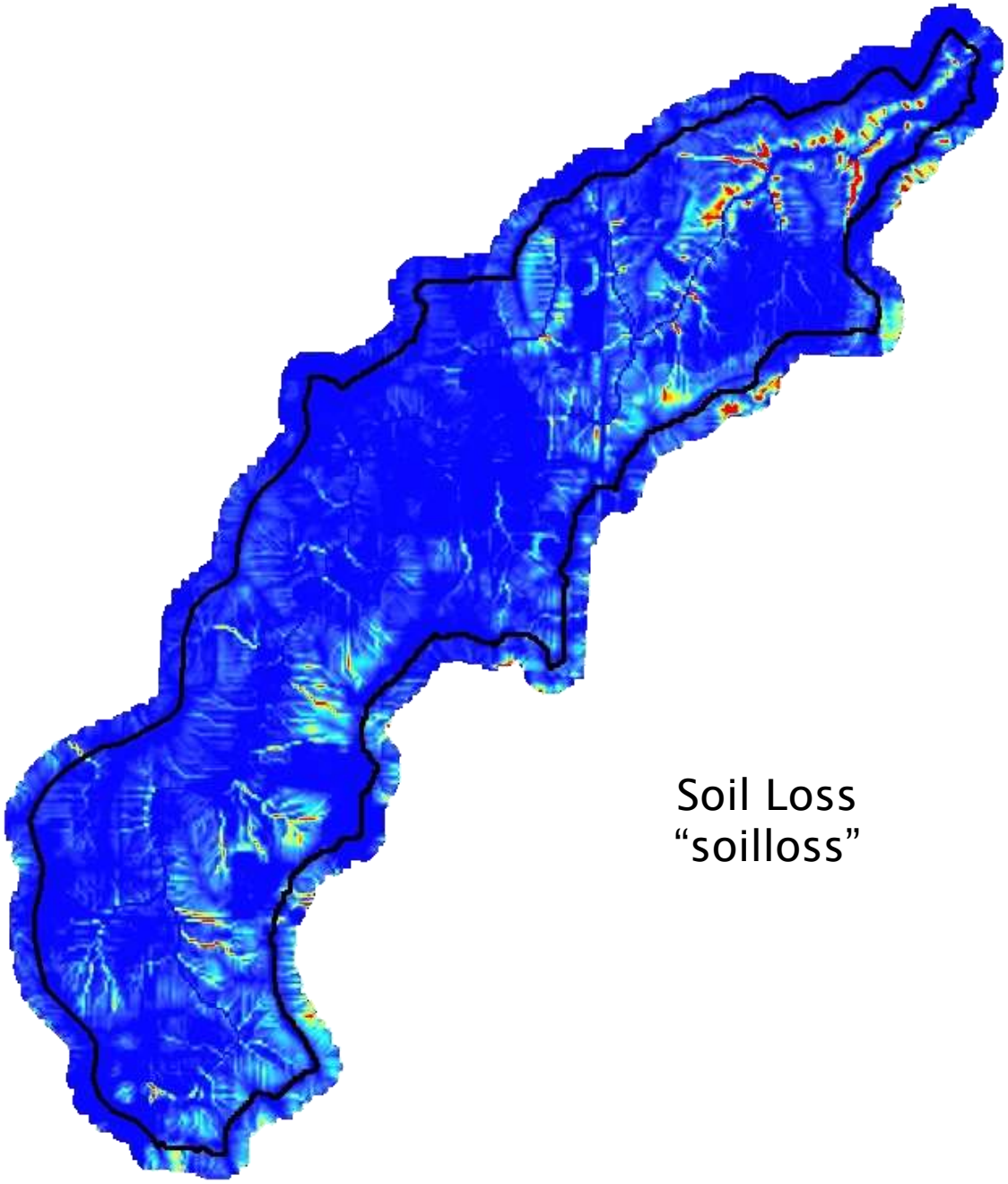
Cover Factor (C) – low estimate
"C_low"



Cover Factor (C) – high estimate
"C_high"

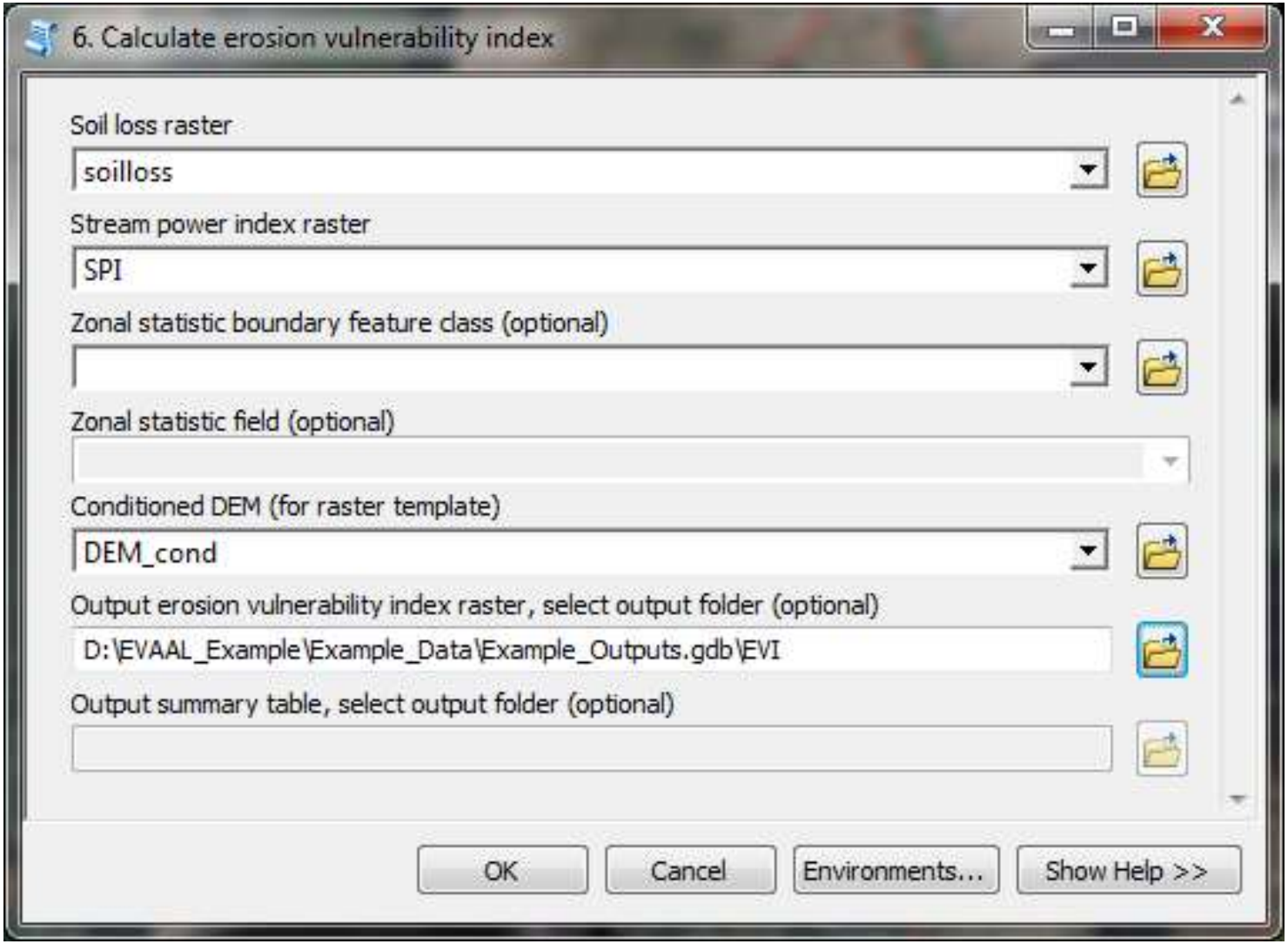
# Step 5c: Calculate soil loss index

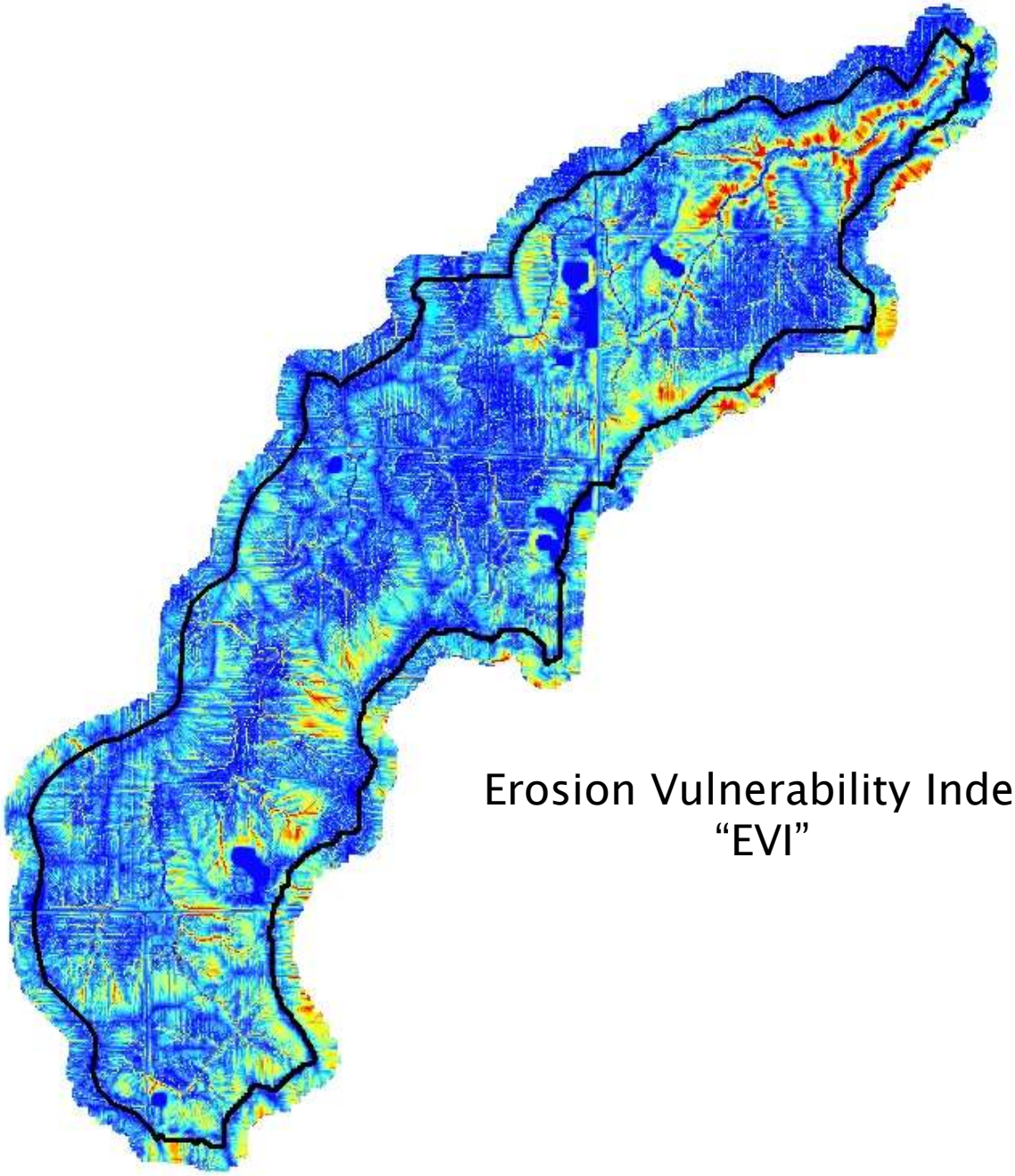




Soil Loss
“soilloss”

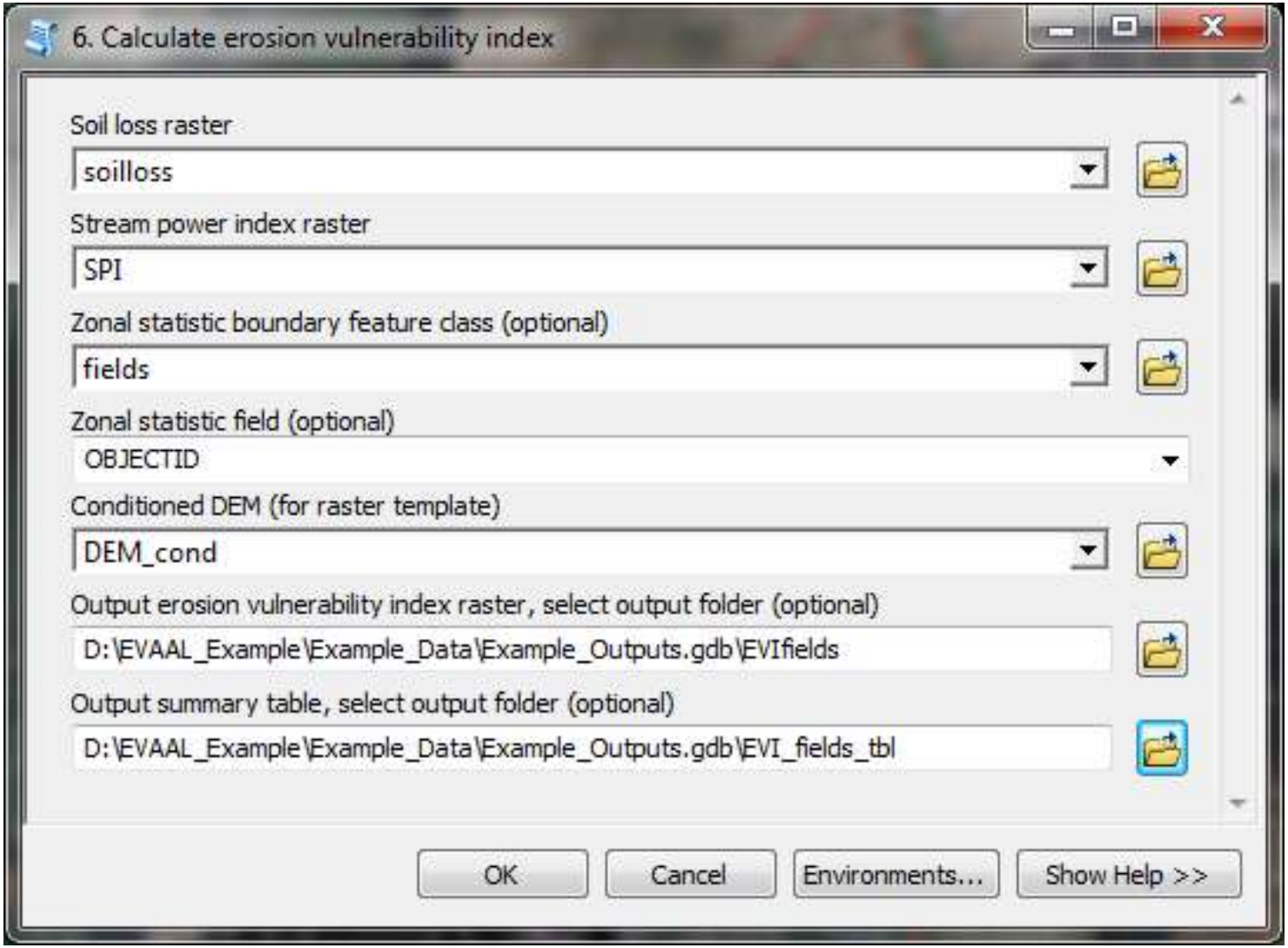
# Step 6: Calculate erosion vulnerability

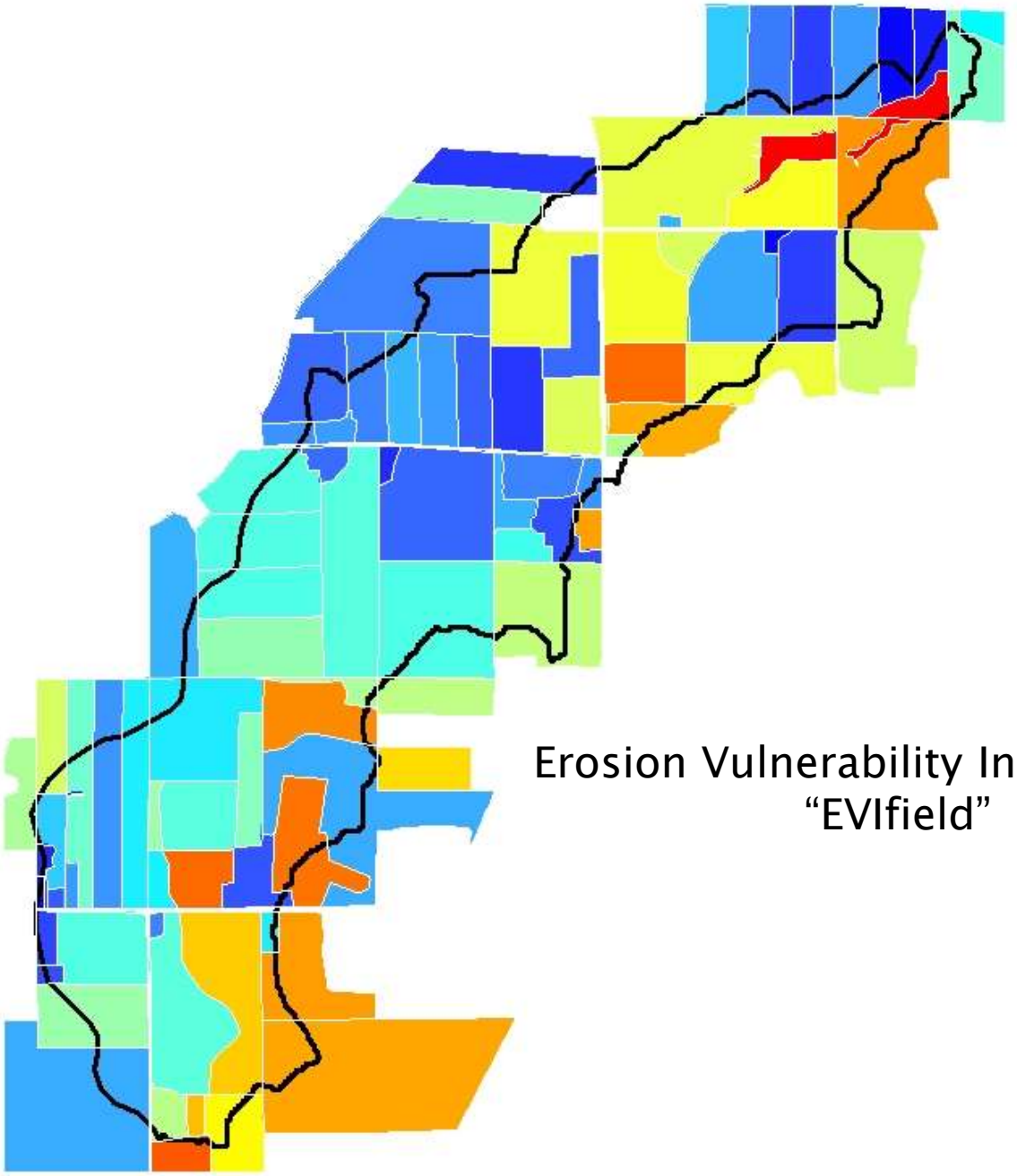




Erosion Vulnerability Index
"EVI"

# Step 6: Calculate erosion vulnerability





Erosion Vulnerability Index by field
"EVIfield"

# Common Problems

# Projection Issues

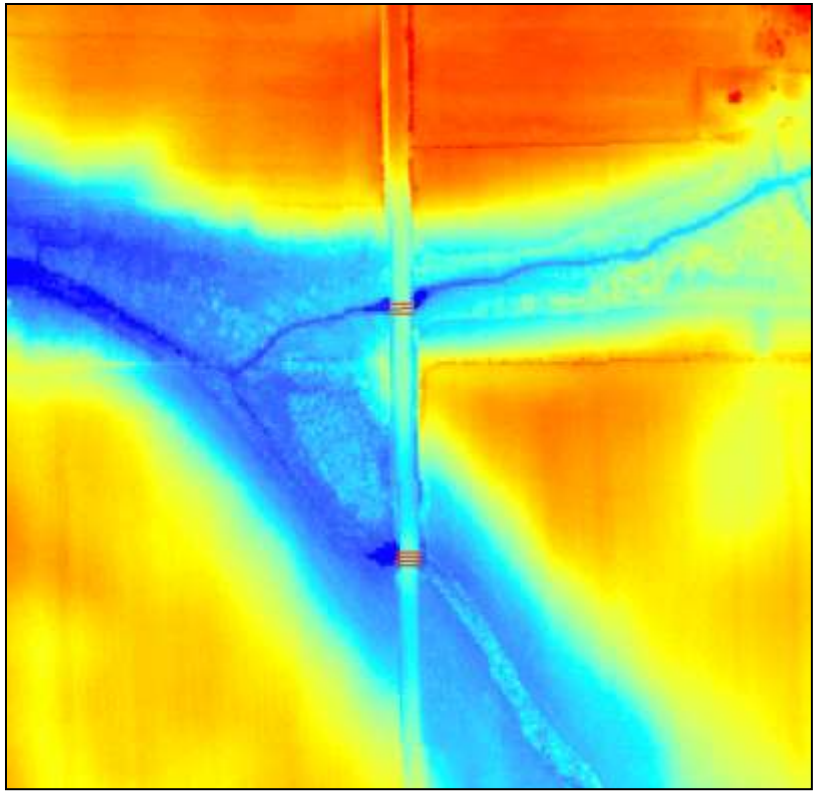
- Input data incorrectly projected

# Folder Permissions & Pathnames

- Must have “write” permission to EVAAL-master folder
  - Temp files are stored in scratch.gdb
- No special characters in path name (., &, /, etc.)
  - Better to also have no spaces

# Culverts!

- Unnecessary culverts
- Wrong orientation
- Need to have at least one in the watershed
- No culvert lines outside the watershed



# Watershed Too Big

- Limit is approximately 75 $km^2$ or 30 $mi^2$
  - Actual limit is number of grid cells in raster, so can run into problems with long narrow watershed, or irregular shaped watershed

# Watershed Boundaries

- Clipping upper parts of watershed at county line
- Not providing an actual watershed

# Missing soils data

- “holes” in outputs that are not internally draining areas
  - Kwfact is blank in soils database tables
  - Often “udorthents”

# Bugs

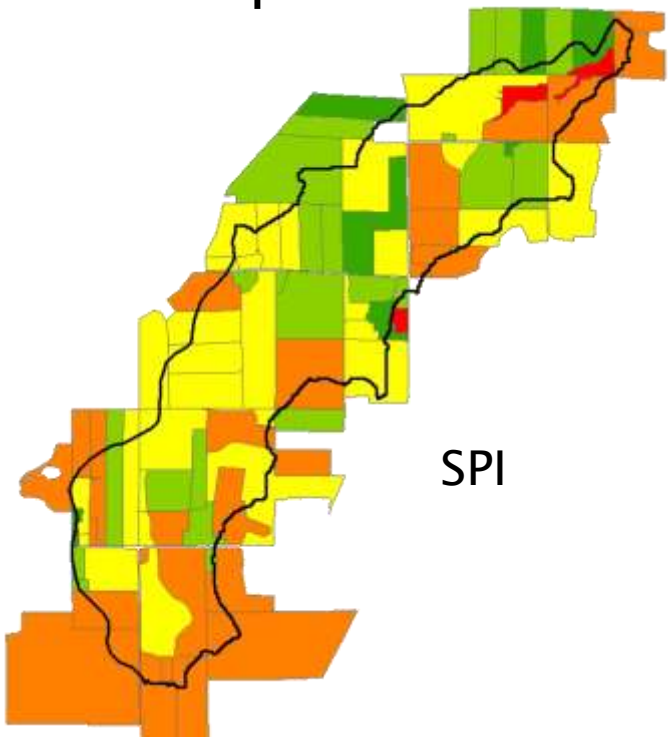
- If you get an error, try downloading and using the Development version
  - Bugs are fixed there first

# Exercises

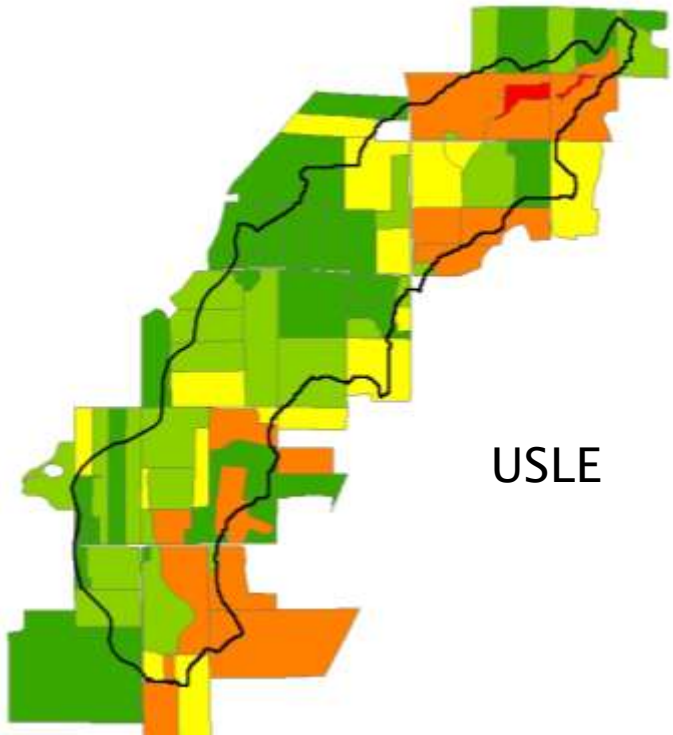
- On your own

# Exercise 1: Visualize by Field Boundaries

- Visualize results by field boundaries
  - Run Zonal Statistics on SPI and soil loss rasters using field boundaries as zones
  - Join resulting tables with field layer
  - Symbolize by mean value
  - Select top 10% of fields



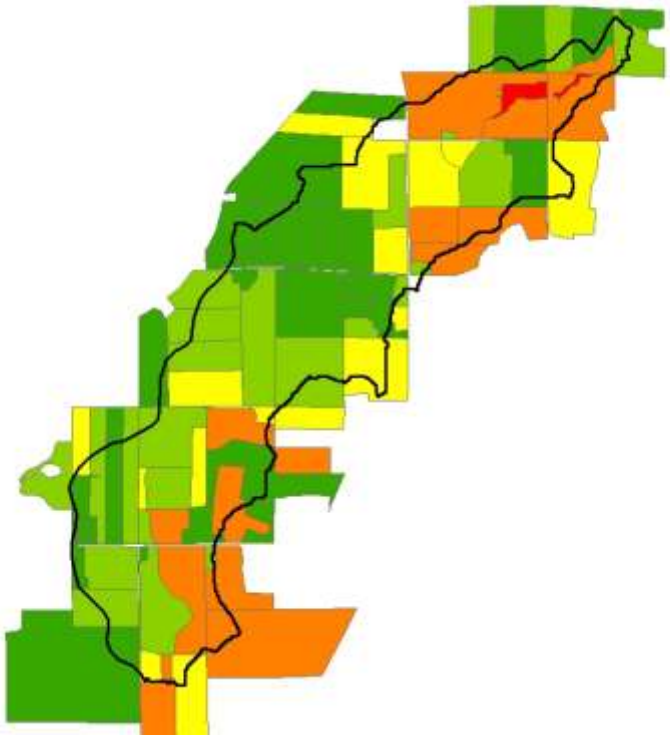
SPI



USLE

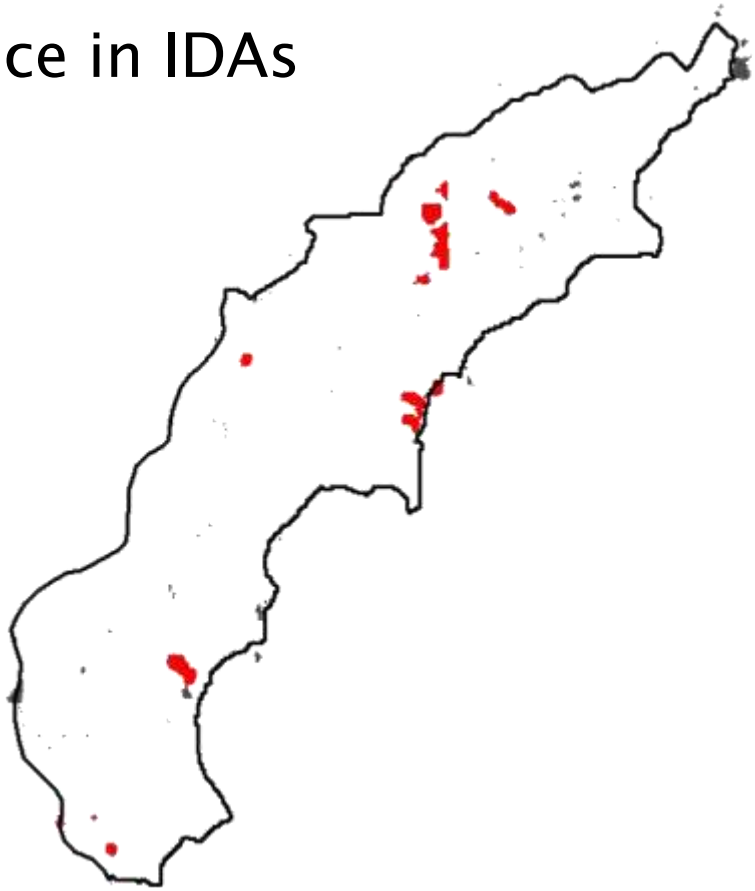
# Exercise 2: Mitigation Opportunity

- Mitigation Opportunity
  - Re-run soil loss with low C factor
  - Subtract soil loss (low) from soil loss (high)
  - Run Zonal statistics and join to field table to visualize by fields



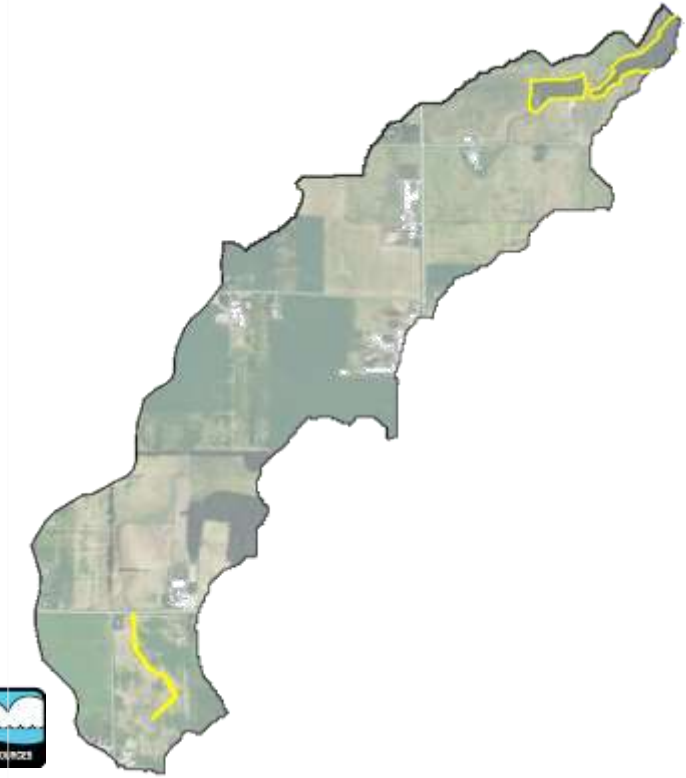
# Exercise 3: IDA sensitivity to precip

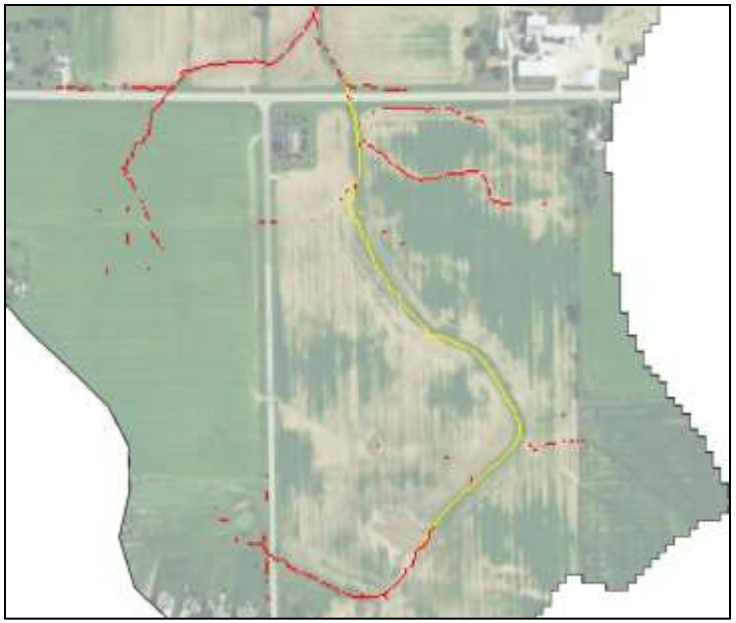
- Sensitivity of IDAs to precipitation
  - Re-run Step 2a using a different frequency and duration
    - How different is the precipitation amount?
  - Re-run Step 2c to see difference in IDAs
    - Do results make sense?



# Exercise 4:Create BMP layer

- Use BMP layer to deprioritize areas where practices are already in place
  - Create BMP layer (new polygon feature class)
  - Re-run Step 3 with BMP input
  - See how this changes SPI, soil loss, EVI results





# Contact Info

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dnrwaterqualitymodeling@wisconsin.gov