

Modifying Digital Elevation Models to Develop More Realistic Wetness Index Layers for Soil Survey Applications

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Background

Performing additional processes on Digital Elevation Models is a common practice. Several basic techniques are reviewed in the [May 2016](#) NCSS Newsletter (page 16). Hydrologically based covariates are grounded on the basis of watersheds and include:

- Flow accumulation
- Slope length
- Stream link
- Stream order
- Stream power index
- Upslope contributing area
- Watershed
- Wetness Index

Wetness Index (aka Compound Topographic Index, Topographic Wetness Index, or Topographic Index; Moore et al., 1988) is one of the most common and useful hydrologically based covariates used in soil survey applications (Gessler et al., 2000). Generally speaking, Wetness Index is the ratio of upslope contributing area and slope gradient. Manmade features like roads and railroads often confound the usefulness of this covariate by functioning as ridges or pits and creating micro-topographic noise. Figure 1 shows a northwest-to-southeast-trending linear feature that is a transportation right-of-way. The difference in cell values is apparent along the juncture of the right-of-way where artificial lows have been created (in the vicinity of “A”). Soil scientists ignore these minor features when creating polygon-based soil survey maps. When raster data is used for the mapping inputs and is the desired output format, the features may result in undesired anomalies. The Remove Linear Artifacts tool, available in ArcSIE, is one method described in the May 2016 NCSS Newsletter for minimizing the effect of the manmade features. This document describes another useful method.

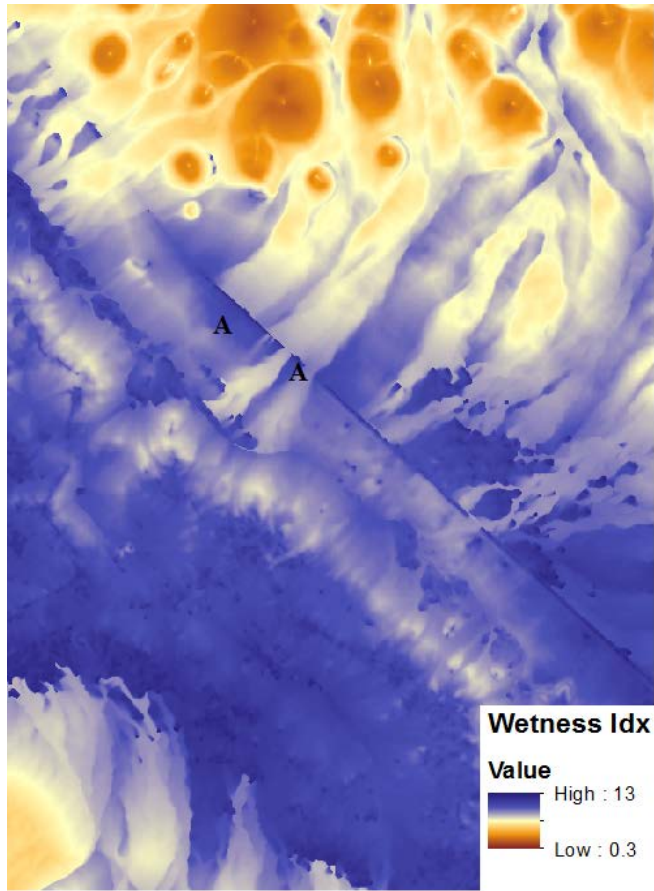


Figure 1.— A transportation feature bisecting a watershed.

Preprocessing Checklist

- 1) Verify the data source
- 2) Verify the projection parameters
- 3) Verify the horizontal **and** vertical units
- 4) Verify the resolution
- 5) Verify the extent in terms of rows and columns
- 6) Verify raster statistics
- 7) Set a snap raster
- 8) Buffer the project area
- 9) Use complete watershed extents for hydrologically based derivatives
- 10) Perform a qualitative check using a hillshade
- 11) Display transportation layer
- 12) Process data
- 13) Store output in a common folder

Display the transportation vector layer over the DEM and make an inventory of transportation segments that are likely to introduce problems. The presence of smaller, local roads is usually of minor consequence and typically can be ignored. Large, multi-lane roadways and railroads, however, can create problems with hydrologically based covariates.

Steps for Minimizing Anthropogenic Features

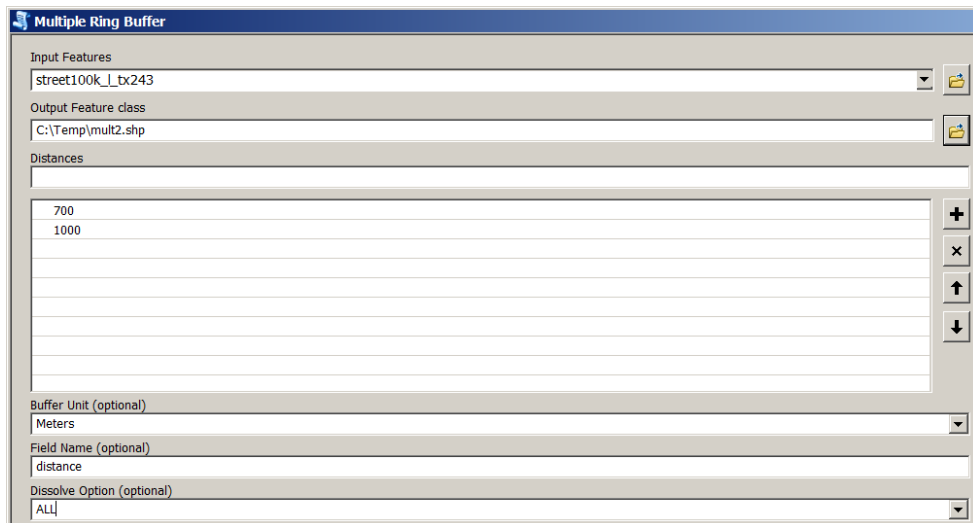
The example area, in the Basin and Range Province, indicates the presence of a U.S. highway with an adjacent railroad line (Figure 2). This feature, which bisects the watershed, will introduce anomalies that interrupt and confound the general landform trends, as revealed in Figure 1. The following process will remove the area represented by the transportation features, interpolate new elevations for a “roadless” DEM, and mosaic the “roadless” DEM back to the original DEM.



Figure 2. —U.S. highway highlighted with local roads (a), and a landscape image of the area (b).

- 1) Select the problem feature(s).
- 2) Create a buffer around selected feature(s) using the Multiple Ring Buffer tool:

- Analysis Tools
 - Extract
 - Overlay
 - Proximity
 - Buffer
 - Create Thiessen Polygons
 - Generate Near Table
 - Multiple Ring Buffer

The screenshot shows the Multiple Ring Buffer tool dialog box. The Input Features field contains 'street100k_1_tx243'. The Output Feature class field contains 'C:\Temp\mult2.shp'. The Distances list contains '700' and '1000'. The Buffer Unit (optional) is set to 'Meters'. The Field Name (optional) is 'distance'. The Dissolve Option (optional) is 'ALL'.

This tool creates a polygon resembling a donut (see Figure 3). Use buffer distances large enough to be free of the effects of the transportation features.

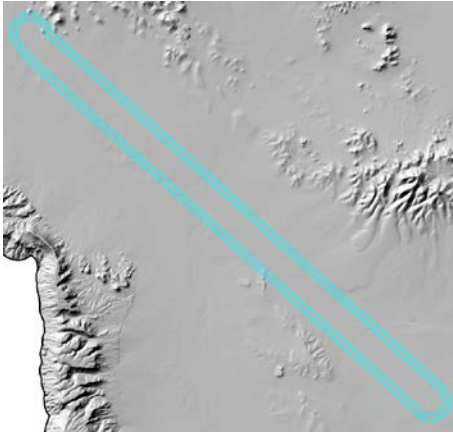
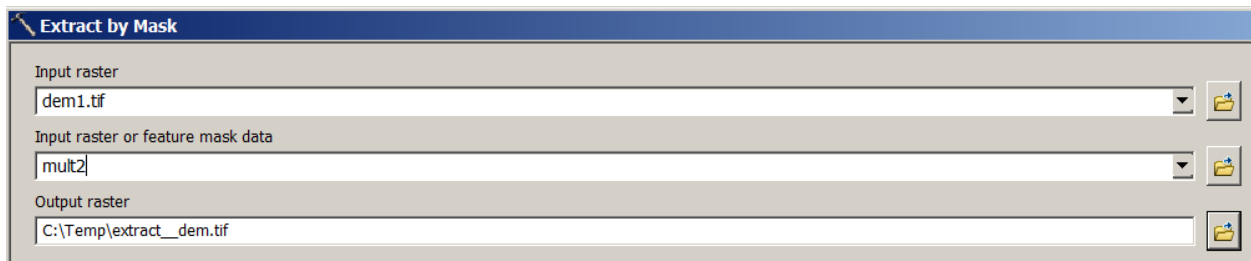
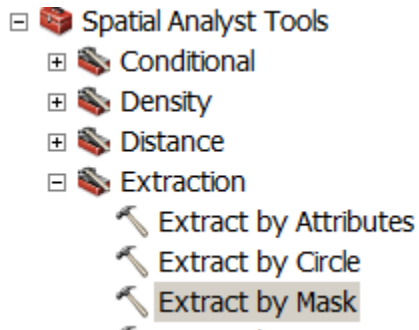
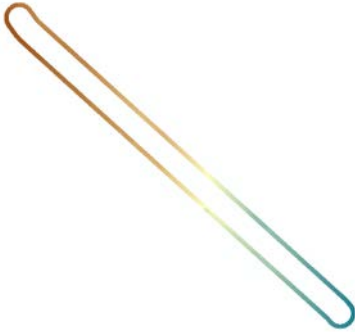


Figure 3. —Output of the Multiple Ring Buffer with outer ring selected.

- 3) Select the outer polygon ring.
- 4) Run Extract By MASK on your DEM of interest:



The result is a DEM representing the “donut” without the transportation features.



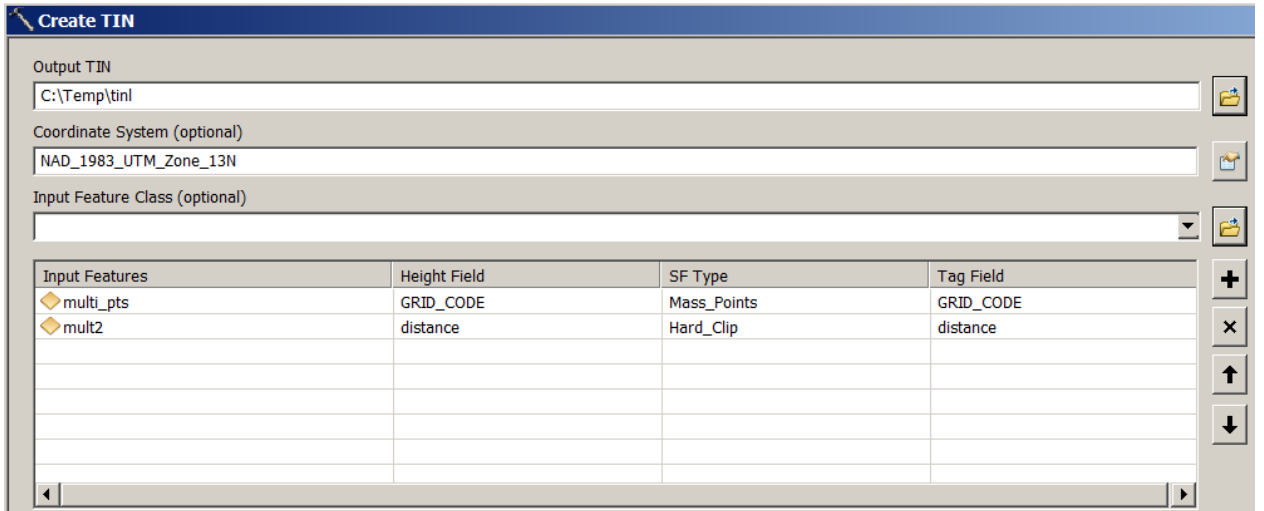
5) Convert this raster output to a point file using Raster to Point:

- [-] Conversion Tools
 - [+] Excel
 - [+] From GPS
 - [+] From KML
 - [-] From Raster
 - [+] Raster to ASCII
 - [+] Raster to Float
 - [+] Raster to Point

6) Create a TIN:

- [-] 3D Analyst Tools
 - [+] 3D Features
 - [+] CityEngine
 - [+] Conversion
 - [-] Data Management
 - [+] LAS Dataset
 - [+] Terrain Dataset
 - [-] TIN
 - [+] Copy TIN
 - [+] Create TIN

Use two input files to create the TIN: the point file from Step 5 as the Mass Points surface feature type and a polygon file representing the maximum buffer distance used in the Multiple Ring Buffer operation as the Harp Clip feature type.

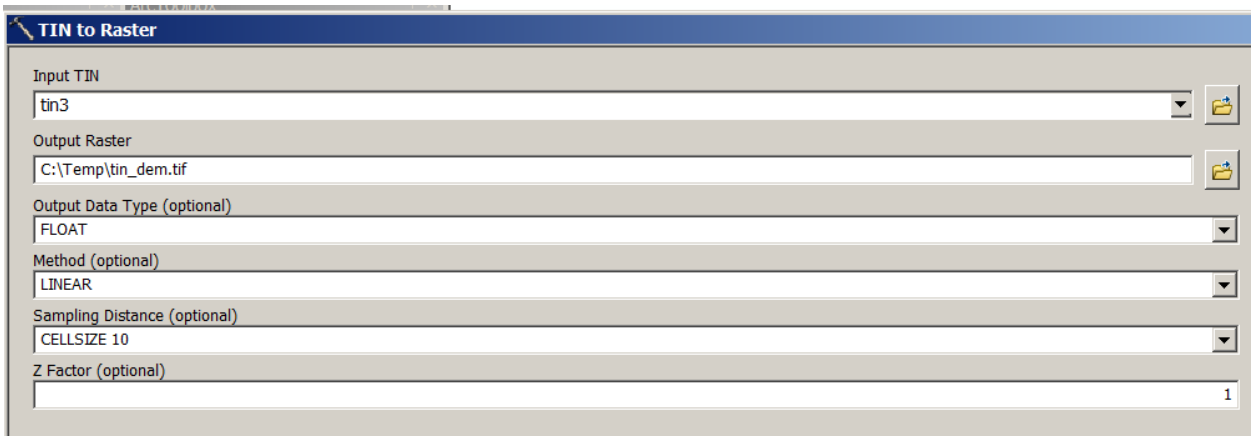


The output shows a TIN with the complete surface for the “donut” and “hole” constrained to the outer bounds of the polygon used for the Hard Clip.

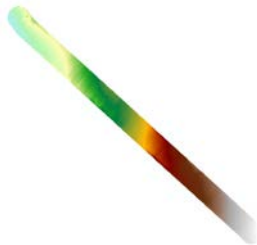


7) Convert TIN to Raster (be sure to specify correct cell resolution):

- [-] 3D Analyst Tools
 - [+] 3D Features
 - [+] CityEngine
 - [-] Conversion
 - [+] From Feature Class
 - [+] From File
 - [+] From LAS Dataset
 - [+] From Raster
 - [+] From Terrain
 - [-] From TIN
 - TIN Domain
 - TIN Edge
 - TIN Line
 - TIN Node
 - TIN Polygon Tag
 - TIN to Raster

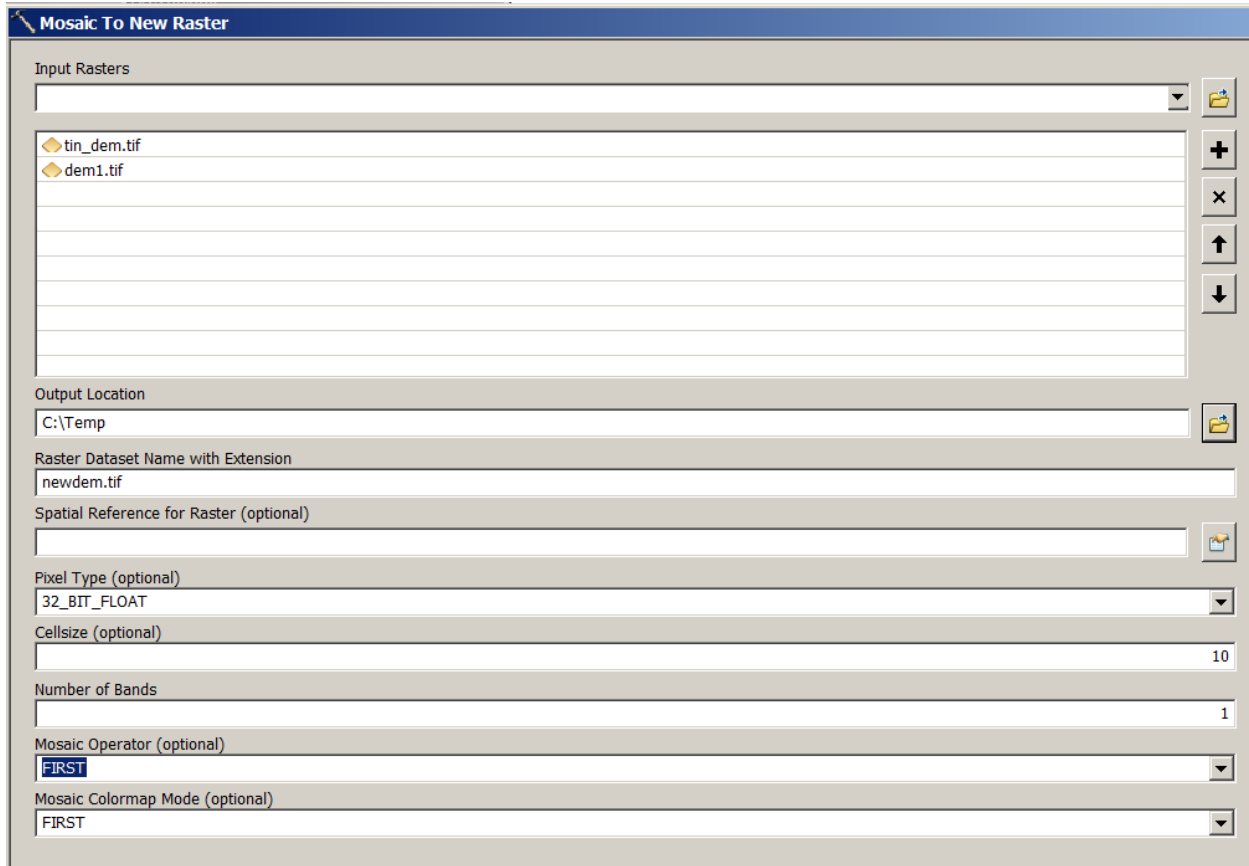


The output should be a 10 meter resolution raster file of the TIN from Step 6.



8) Mosaic the DEM from Step 7 back to the original DEM of interest with NO blending, using the Mosaic to New Raster tool in the Data Management Tool Box:

- [-] Raster
 - [+] Mosaic Dataset
 - [+] Raster Catalog
 - [-] Raster Dataset
 - Copy Raster
 - Create Random Raster
 - Create Raster Dataset
 - Download Rasters
 - Mosaic
 - Mosaic To New Raster



Selecting the FIRST Mosaic Operator ensures that cell values from the raster in Step 7 will be used for this overlapping area. The purpose of this modification is to create a DEM with transportation features eliminated or minimized.

Review Results

Wetness Index covariates were developed using the SAGA Wetness Index tool for the original and modified DEM. Viewing the area within the black ellipse in Figure 4, it is apparent that the fan deposits are interrupted by the transportation features on the original DEM in panel “a.” The modified DEM in panel “b” shows a more natural representation of the features and is more suitable for soil mapping purposes.

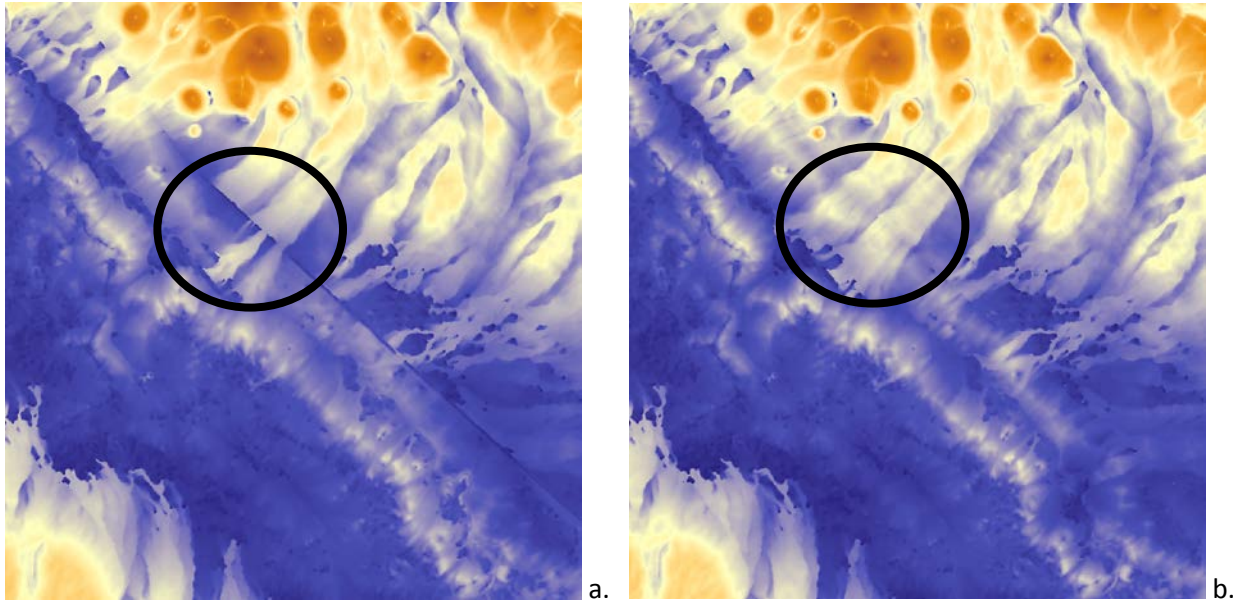


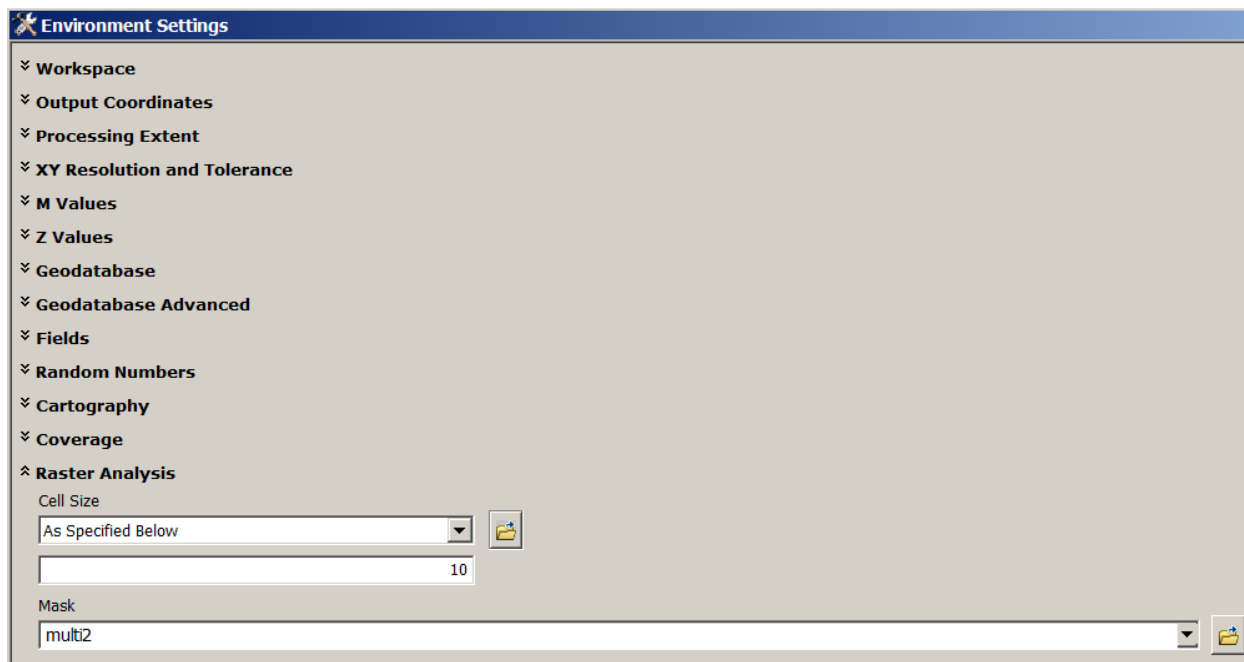
Figure 4. —Wetness Index from the original DEM (a) and modified DEM (b).

A desirable attribute of TINs is the direct relationship between point density and surface variability that may be established. TINs can have a higher resolution in areas with higher variability and a lower resolution in areas with lower variability. In this example, the assumption is a relatively uniform elevation surface within the created data “hole,” which the TIN accommodates well. Using a Terrain data model will yield results similar or identical to those of the TIN data model. Both TIN and Terrain data model functions require the 3D Analyst Extension.

Miscellaneous

Interpolation techniques like Inverse Distance Weighting, Trend, Spline, Kriging, Local Polynomial, Global Polynomial, and Radial Basis Functions have also been tested. They were found to yield less satisfactory results and often require longer processing time. These tools require the Spatial Analyst or Geostatistical Analyst Extensions.

To be complete, the Natural Neighbor interpolation method is available with Spatial Analyst and produces output similar to TINs with short processing times. This is related to the similarities of the interpolation [algorithms](#) used by these two methods. Using Natural Neighbor would eliminate Steps 6 and 7 described above. If you use Natural Neighbor, you need to set a MASK in the Raster Analysis section of the Geoprocessing Environment Settings to confine the interpolation to the bounding polygon of the “clip” file from Step 2.



Although this job aid focuses on watershed-based derivatives, anthropogenic features can have undesirable results on terrain-based derivatives, such as relative position (aka relative elevation or normalized slope height). Figure 5 shows the effect of anthropogenic features on relative position.

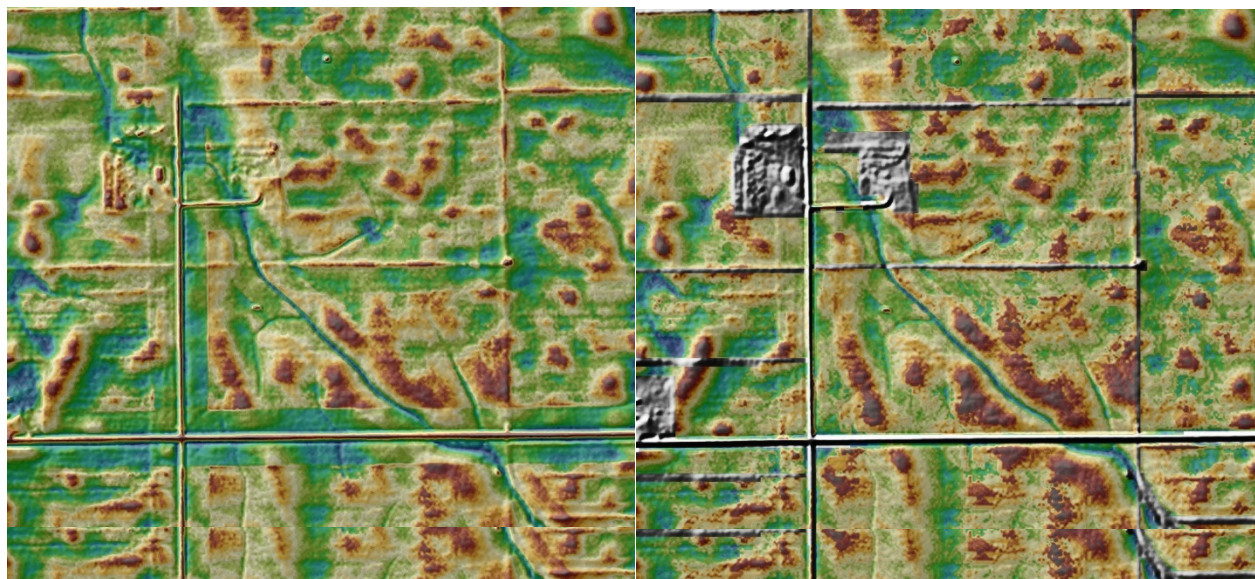


Figure 5. —Relative position calculated with (left) and without (right) anthropogenic features.

References

Gessler, P.E., O.A. Chadwick, F. Chamran, L. Althouse, and K. Holmes. 2000. Modeling soil–landscape and ecosystem properties using terrain attributes. *Soil Science Society of America Journal* 64:2046-2056.

Moore, I.D., G.J. Burch, and D.H. Mackenzie. 1988. Topographic effects on the distribution of surface soil water and the location of ephemeral gullies. *Transactions of the ASAE* 31(4):1098-1107.