Technical Description of Methods: LS_factor_from_DEM_v2 ArcGIS Tool

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What the Tool Does:

This tool will create a Universal Soil Loss Equation (USLE) Topographic factor (LS) raster dataset from

1) a digital elevation model (DEM), and
2) a project area polygon feature class.

The tool also calculates a mean LS value within specified "zone(s)". If the project area polygon feature class only contains one feature, the resulting table will include a mean value for the entire project area. If the project area polygon feature class contains multiple features, the resulting table will include a mean value for each feature (e.g. a separate mean LS value each land cover class in you project area).

Requirements for Tool Use:

The input DEM must have a spatial reference system with units of feet or meters AND the same vertical units. Two separate tools were created: one for data in units of feet, and one for data in units of meters. Be sure to use the appropriate tool to get an appropriate output.

As is standard best practice in all geospatial analyses, the DEM and the project area polygon feature class should be in the same spatial reference system.

Because hillslopes located outside of a project area that slope into the project area, would appropriately influencing the slope length of raster cells within the project area, the input DEM should have a spatial extent that extends beyond all sides of the project area polygon feature class by at least a few hundred feet. To avoid unnecessarily high processing times, prior to raster processing, the tool clips the input DEM to a polygon feature class that results from buffering the project area polygon feature class by 1000-feet.

An ArcGIS Spatial Analyst extension is required.

Methods & Rational:

The Unit Stream Power method (Moore & Wilson, 1992) is used. Consistent with the principles proposed by Desmet & Grovers, 1996, LS calculations utilize the following methods:

- "unit contributing area" is calculated using the D-infinity flow accumulation method to incorporate flow divergence;
- variable "contour widths" are calculated based on the aspect at which flow leaves a cell; and
- the slope length factor (L) is multiplied by an "(m+1)" term to integrate over each raster cell (see Griffin et al., 1988).

This tool was developed for use in multiple geographic contexts. Because the m and n exponents, associated with the L and S factors respectively, would be expected to vary significantly over this region, the RUSLE slope-based method of estimating m (Agriculture Handbook 703) is used for the L-factor and the Nearing equation (Nearing, 1997), which does not utilize n, was used to calculate S-factor. The Nearing equation has the added benefit of being calibrated to slopes >22% (in addition to more gentle slopes).

Finally, to avoid slope lengths from being calculated within concentrated flow paths (because the USLE only models sheet/rill erosion), a concentrated flow network is generated and the corresponding cells of the resulting LS-factor raster dataset are set to NULL. For this, the user must input a *maximum slope length*. The flow accumulation threshold that removes cells from the LS calculation analysis (due to assumed concentrated flow) is assumed equal to the area of a semi-circle with a radius of the *maximum slope length*.

When selecting a *maximum slope length* parameter to input into the tool, the user may consider the following guidance from the Revised Universal Soil Loss Equation Version 2 (RUSLE2) Handbook (2001): "Slope lengths on many landscapes generally are less than 200 ft., and usually do not exceed 400 ft.". Additionally, in a personal communication, the NRCS Ohio State Soil Scientist, said that, in Ohio, slope lengths rarely exceed 150-feet (2022).

Citations:

Agriculture Handbook 703: Renard et al. "Prediction soil erosion by water: A Guide to Conservation Planning with the Revised Universal Soil Loss Equation (RUSLE)". 1997.

Desmet, P.J.J.; Govers, G. “A GIS procedure for automatically calculating the USLE LS factor on topographically complex landscape units”. Journal of Soil and Water Conservation, 1996. 51: 427–433.

Griffin, M.L.; Beasley, D.B.; Fletcher, J.J.; Foster, G.R. “Estimating soil loss on topographically nonuniform field and farm units”. Journal of Soil and Water Conservation, 1988. 43: 326-331.

Moore, I.D.; Wilson, J.P. “Length-slope factors for Revised Universal Soil Loss Equation (RUSLE): simplified method of estimation”. Journal of Soil and Water Conservation, 1992. 47: (5)423-428.

Nearing, M.A. "A Single Continuous Functions for Slope Steepness Influence on Soil Loss". Soil Science Society of America Journal, 1997.

"Revised Universal Soil Loss Equation Version 2 (RUSLE2) Handbook". Prepared by USDA RULSE Development Team. March 2001.