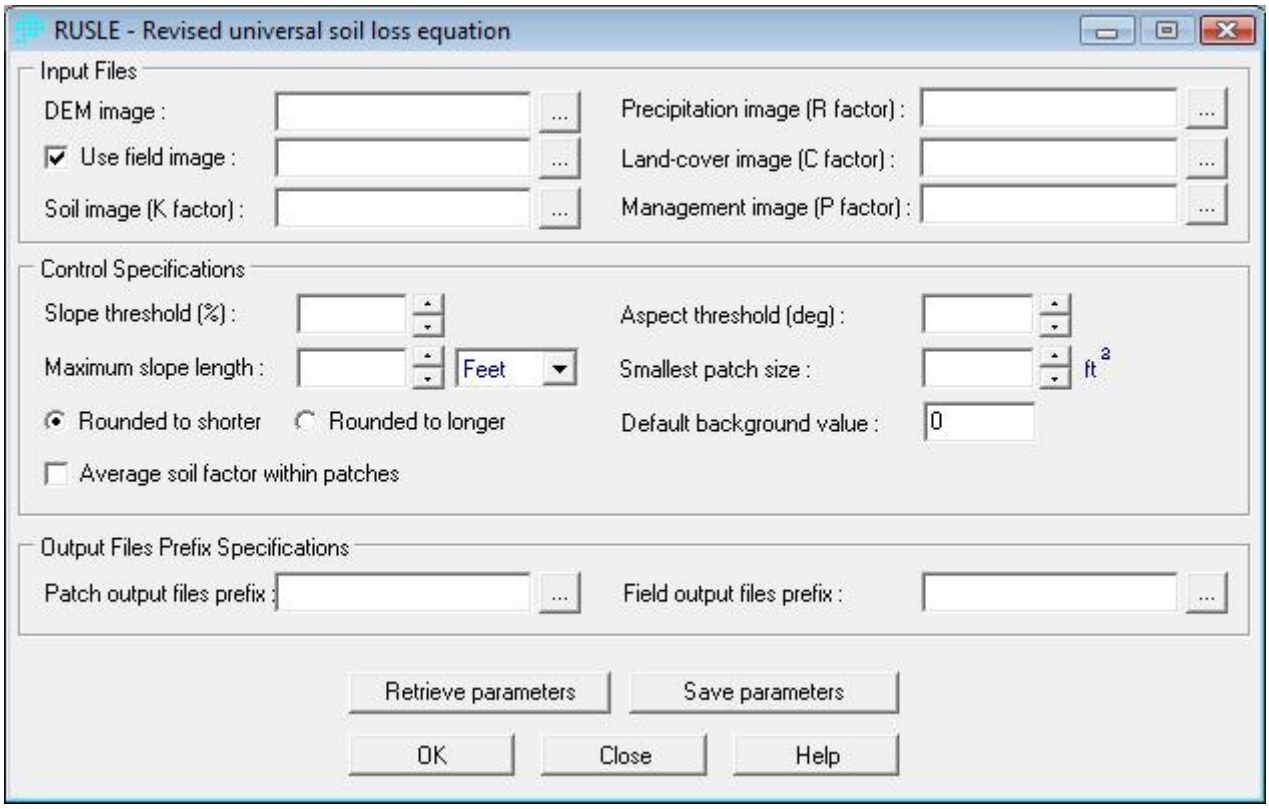
RUSLE

RUSLE evaluates farmland and rangeland nonchannelized soil loss by water. It is an implementation of the Revised Universal Soil Loss Equation (RUSLE) described in the USDA Agricultural Handbook, Number 703.

The RUSLE module allows the user not only to estimate average annual soil loss for existing conditions, it permits one to simulate how land use change, climate change, and/or changes in conservation/management practices, will affect soil loss. Using the RUSLE module, it is possible to estimate soil loss for individual farm fields, river basins, or other appropriate areal units. In addition, the RUSLE module output allows the user to determine the spatial pattern of soil loss. This permits the user to identify the critical areas within fields or catchments that are contributing major amounts of soil loss.

Related Modules: SEDIMENTATION



RUSLE Operation

1. Specify a DEM, a precipitation factor (R) image, a soil factor (K) image, a land cover factor (C) image, and a management factor (P) image. A farm field image is optional, but is strongly recommended since the average and total soil loss are generated for each farm field when the farm field image is provided. -- Input images must have reference units in meters or feet.

2. Indicate the thresholds for slope, aspect, slope length, and smallest patch size.

-- The slope and aspect thresholds are used for partitioning the topographic surface into homogeneous patches.

-- The maximum slope length threshold should be the distance water can flow as a sheet before becoming concentrated. (RUSLE documentation *usually* recommends 400 feet (121.92 meters) or less.) You must also specify whether this number is in feet or meters. Choosing feet or meters will have implications for the units for the R and K factors and the output units for the output images. Choosing feet requires that the value units (attribute units) for the R and K factors be in U.S. Customary units. Output units for all output images will also be in U.S. Customary units. Choosing meters requires that the value units for the R and K factors be in SI (metric) units. The output units for the output images will also be in SI units. Conversion is necessary if the value units do not match between the Maximum Slope Length unit and the R and K factors layers do not match. See Note 1 for details.

-- The smallest patch size threshold merges patches below the threshold to larger patches (see Note 4 for results that have patch sizes smaller than the threshold).

3. Specify how to implement the maximum slope length used in the calculation, either rounded to shorter or rounded to longer than the actual slope length allowed.

-- The difference is due to the fixed nature of the pixel width. The difference cannot be greater than the diagonal of the pixel.

4. Indicate whether to average the soil factor (K) within patches.

5. Specify a uniform background value found in all the input images.

-- The default is zero.

-- Alternatively, you can specify a background value for each image using Metadata and the Flag Value option. RUSLE will use the value specified in the form if no Flag Value is given.

6. Enter an output prefix for the patch outputs. If you have selected to use a field image, you will also need to specify an output prefix for the field output files.

-- An ASCII text file and image files for patches are created as outputs. A patch image is created which retains the ID values of each patch. A text file for patch soil loss is created, and the parameters utilized in the evaluation of soil loss are listed in the text file. A raster image for total soil loss per patch and a raster image for average soil loss are also produced in image files named by adding the suffix "total" and "average" to the patch filename respectively. If a farm field image is provided, an ASCII text file is created which contains the soil loss information for farm fields. Also, an average and a total soil loss image are created. The per field total soil loss image is created by adding the suffix "total" to the average soil loss image.

7. Click Save parameters to save the parameters to a file that can be retrieved later.

8. Click OK.

Macro Command

RUSLE Notes

1. The reference units of the input images must have units in either meters or feet. The value units for the R and K factors should match the unit chosen for the value unit of the Maximum Slope Length parameter, i.e., if feet is chosen as the unit for Maximum Slope Length, the R and K should be in U.S. (English) Customary units, if meters is chosen, the R and K should be in SI (Metric) units. The following, as quoted from Renard et. al., Appendix A (pp. 326-327), give the U.S. Customary and SI units and conversions for both R and K factors:

K (U.S.) = ((ton)(acre)(hour))/((hundreds of acre)(foot)(ton)(inch))

K (SI) = ((metric ton)(hectare)(hour))/((hectare)(mega joule)(millimeter))

R (U.S.) = ((hundreds of foot)(tons)(inch))/((acre)(hour)(year))

R (SI) = ((mega joule)(millimeter))/((Hectare)(hour)(year))

To convert from U.S. to SI units of the K value, multiply U.S. by 0.1317.

To convert from U.S. to SI units of the R value, multiply U.S. by 17.02.

You may use Image Calculator to facilitate this conversion before running RUSLE.

2. The RUSLE module requires six factors and is represented by the following formula:

A = R * K * L * S * C * P (1)

Where:

- A is the computed soil loss per unit area, usually in tons per acre per year; (if meters are chosen in the module, output is in tons/hectare/year)
- R, the rainfall and runoff factor, is the number of rainfall erosion index units;
- K, the soil erodibility factor, is the soil loss rate per erosion index unit for a specified soil as measured on a unit plot, which is defined as a 72.6-ft length of uniform 9% slope continuously in clean tilled fallow;
- L, the slope-length factor, is the ratio of soil loss from the field slope length to that from a 72.6-ft length under identical conditions;
- S, the slope-steepness factor, is the ratio of soil loss from the field slope gradient to that from a 9% slope under otherwise identical conditions;
- C, the cover and management factor, is the ratio of soil loss from an area with specified cover and management to that from an identical area in tilled continuous fallow; and
- P, the support practice factor, is the ratio of soil loss with a support practice like contouring, stripcropping, or terracing to that with straight-row farming up and down the slope.

The following procedures are taken in the calculation of the L and S factors.

The L factor calculation:

$$L = (\lambda / 72.6)^m$$

where 72.6 feet is the unit plot length in feet (Wishmeier and Smith, 1978), λ is the horizontal projection of slope length, *m* is a variable slope-length exponent. The *m* is defined by the following equation (Foster et al., 1997)

$$m = \beta/(1+\beta)$$

where β is the ratio of rill erosion caused by flow to interrill erosion which is principally caused by raindrop impact.

Values for the ratio β of rill to interrill erosion for condition when the soil is moderately susceptible to both rill and interrill erosion were computed from (McCool et al., 1989)

$$\beta = (\sin\theta/0.0896)/[3.0(\sin\theta)^{0.8} + 0.56]$$

where θ is the slope angle.

According to the explanation in the handbook, the ratio β of rill to interrill erosion is doubled when the land is bare or recently disturbed; it is halved when the ground is covered with complete ground cover. In the implementation of this criteria, the cover-management factor, C, is referenced to indicate the two extreme conditions. When C=1.0, then β is doubled before calculating the slope-length exponent *m*. When C is small enough, e.g., $c \le 0.004$, then β is halved. The steepness is not considered in the adjustment of β.

The S factor calculation:

The slope steepness factor (S) is evaluated (McCool et al., 1987) using the following two equations for the two steepness categories.

$$S = 10.8\sin\theta + 0.03 \text{ when } steepness < 9\%$$

$$S = 10.8\sin\theta - 0.50 \text{ when } steepness \ge 9\%$$

Since the above equations are applicable to slopes greater than 15 feet, the following equation is used to evaluate S when the slope length is shorter than 15 feet (McCool et al.):

$$S = 3.0(\sin\theta)^{0.8} + 0.56$$

3. Evaluation of soil loss by water using RUSLE

After all of the six parameters are ready for each patch, the soil loss per patch can be evaluated using equation (1). The output of equation (1) is the unit soil loss, the total soil loss is evaluated by multiplying the area.

Patch's Total Soil Loss =

$$A \times Area$$

where *A* is the soil loss of the patch which comes from evaluation of equation (1).

Since the number of patches and sub patches are known within a farm field, the total soil loss for each farm field is obtained by summing each field.

Farm Field's Total Soil Loss =

$$\sum_{i=1}^{n} A_i \times Area_i$$

where *n* is the number of patches in a field. And the average soil loss for a field is obtained.

Farm Field's Average Soil Loss =

$$(Total\_Loss) / \sum_{i=1}^{n} Area_i$$

where *n* is the number of patches in a field.

4. Since the number of patches has a limitation of 32,000, the threshold for slope and aspect should be chosen carefully. If they are given too small, the number of patches might be greater than 32,000, which is not allowed. If you insist on the thresholds given, a work around is to split the DEM into subsets and run each of them separately.

5. Patch size may be smaller than the threshold because the minimum size refers to each layer. Since each patch must be homogenous with regard to each layer (slope, aspect, C value, R value, P value, K value,) usually the patch size will be less than the minimum for each layer.

6. RUSLE calls several other modules during its analysis. They are PITREMOVAL, to remove pits from a DEM; SURFACE, to generate slope and aspect image; FACET, to partition the slope and aspect image into homogeneous patches; GENERALIZATION, to generalize small patches into the neighboring patches; GROUP, to assign a patch with an ordinal number to assist the overlay process among layers; and FLOW, to generate flow directions to assist the calculation of slope length.

7. The RUSLE module is computationally intensive and thus will not run on images larger than 32,000 rows and columns.

8. You may find more information from the following references:

Renard, K.G., G.R. Foster, G.A. Weesies, D.K. McCool, and D.C. Yoder, 1997, Predicting Soil Erosion by Water: A Guide to Conservation Planning With the Revised Universal Soil Loss Equation (RUSLE), Agricultural Handbook, 703. U.S. Government Printing Office, Washington, D.C. 404 pp.

Wischmeier, W.H. 1976, Use and misuse of the universal soil loss equation, Journal of Soil and Water Conservation. 31(1): 5-9.

Wischmeier, W.H., and Smith, D.D., 1965, Predicting rainfall-erosion losses from cropland east of the Rocky Mountains: U.S. Department of Agricultural Handbook 282: Washington, D.C., U.S. Government Printing Office, 47 pp.