RESOURCE NOTES

NO. 46 DATE 04/18/01

SOILS/GEOLOGY

# *Regional Sheet and Rill Soil Erosion Prediction with the Revised Universal Soil Loss Equation (RUSLE) – GIS Interface*

*by Jacek Blaszczynski*
*Physical Scientist, National Science and Technology Center*

## Background

An ecological issue of great importance to the United States and the world is degradation of rangelands, the major symptom of which is increase in the rate of water-caused soil erosion. Livestock grazing and drought can combine to reduce the grass cover, compact the soil causing increases in runoff and erosion, and create a patchy distribution of water and nutrients. Intensified grazing during periods of moderate drought can lead to a decrease in grass cover that normally supports a uniform distribution of moisture and nutrients throughout the soil profile. Bare patches, which may have developed during the drought, become more pronounced. Topsoil compacted by trampling allows less rainfall to infiltrate the topsoil, leading to greater surface runoff and related sheet and rill erosion. The problem of erosion is further exacerbated by loss of organic matter in the topsoil that tends to hold the soil particles together. If overgrazing and drought continue, the bare patches expand, and erosion becomes a significant problem as rain and nutrients are carried away from the patches to be deposited in nearby surface depressions. Creosote and mesquite shrubs begin to appear in these areas of concentrated soil, water, and nutrients. As soil around the grasses loses its depth, nutrients, and moisture through erosion and leaching, it can no longer sustain the grasses, limiting their ability to regenerate. To avoid this downward spiral, management of rangeland soil resources has to be performed in a way that does not deplete the resource and results in loss of soil productivity. Technologies to estimate, manage, and contain soil erosion are needed to help prescribe management practices that maintain existing rangelands in an ecologically healthy state and, if possible, to return degraded rangelands to a more pristine condition.

For most of the world's regions, accurate estimates of soil erosion are not available. An examination by experts of the available figures including a review carried out for the United Nations Food and Agriculture Organization (UNFAO) concluded that these estimates have little scientific merit. The overwhelming share of land reported to the United Nations Environment Program (UNEP) as under danger from soil erosion and related desertification processes is rangeland. If global climate warming proves actual, leading to an increase in mean surface temperature, the rates of desertification in various regions may sharply increase. Since a significant portion of the public lands managed by the Bureau of Land Management (BLM) consists of rangelands, BLM has a vested interest in issues related to rangeland soil erosion. Development and application of soil erosion prediction methodologies is therefore of utmost importance. The Revised Universal Soil Loss Equation (RUSLE)/Geographic Information System interface provides such a methodology for regional level analysis of soil erosion. While it is likely that application of more complex models than RUSLE can provide more accurate estimates of soil erosion for specific sites, the data requirements of these models make them difficult to use on a regional scale. By comparison, data for utilization of RUSLE/GIS interface can be relatively easy to obtain.

## Methodology

The RUSLE/GIS methodology permits calculation of potential soil loss from sheet and rill erosion for rangelands. The RUSLE equation calculates potential erosion (A) as follows:

$$A = R * K * L * S * C * P$$

Where R is the rainfall and runoff factor; K is the soil erodibility factor; L is the slope-length factor; S is the slope-steepness factor; C is the cover and management factor; and P is the erosion control practice factor. In the modeling procedure, the values for the different RUSLE factors are assigned to their respective mapping units (i.e., a soil unit map, a vegetation class map, and a digital elevation model).

Values for the factors can be obtained from reference sources or calculated from mapped or field collected data about the project location. To facilitate calculation of RUSLE factors, the user can input relevant information into a PC program, such as the RUSLE program prepared by BLM in 1987 upon which RUSLE/GIS interface is based. The rainfall and runoff factor R value is calculated from latitude and longitude and 2yr-6hr precipitation of the study area. The soil erodibility K factor values are obtained from soil surveys or calculated from field information that includes percentage of silt and very fine sand in the soil, percentage of clay, percentage of organic matter, soil structure, and permeability code. The slope gradient S and slope length L factors are calculated from digital elevation data using GIS hydrologic terrain analysis capabilities and map algebra. The C factor values are calculated using field survey information on percent and average height of vegetation cover, the root mass in the top four inches of soil, percent of rock, gravel, litter, and vegetation on the ground surface. In calculation of the C factor, the RUSLE program also provides a table of surface roughness values from which one can pick the appropriate roughness number. The erosion control P factor values are obtained from a table provided by the designers of the RUSLE. After the factor values have been assigned or calculated for each of the mapping units, the factor maps are overlaid to produce a visualization of soil erosion potential.

There has been much controversy over the accuracy of the Universal Soil Loss Equation and its close cousin, the Revised Universal Soil Loss Equation. However, even if we regard the resultant soil-erosion potential map purely as a relative evaluation based on known interactions and influence of rainfall, soil cohesion, terrain shape, surface vegetation cover, and erosion control practices, such a map still provides us with useful information. A preliminary run of the procedure based on existing data should provide us with a rapid reconnaissance level evaluation as to where we can expect low, medium, high, and very high erosion rates based on environmental parameters expressed by the RUSLE factors. Although the RUSLE model oversimplifies the complexity of erosion processes, its estimates can be improved to by refining the quality of input data.

The RUSLE/GIS interface can be used to model various possible management and ecological health scenarios by changing the values for various environmental factors to simulate different conditions, such as seasonal change, change in precipitation, vegetation cover, terrain and management practice.

## Automated Calculation of Terrain Factor from Digital Elevation Models (DEMs)

At the National Science and Technology Center, we developed automated tools to make the RUSLE/GIS procedure easier to perform. LSFACTOR.AML provides three methods of calculation of the RUSLE terrain factor from DEM data. The products are three terrain factor maps that represent various methodologies.

## Benefits and Uses

Interfacing GIS geographic analysis capabilities with the Revised Universal Soil Loss Erosion provides the resource specialist with a tool to quickly visualize the likely sheet and rill soil erosion potential (soil detachment potential but not transport and deposition) based on several major environmental parameters for large areas. This permits regional scale studies by quickly processing large amounts of information from data sources that are easy to obtain from various government agencies.

The interface also permits modeling of various management alternatives and changing environmental conditions in space and time. This allows for evaluation of the possible effects of each management practice on the stability of the soil resource. Because the procedure relies on standardized methodology, it also allows for comparison of different geographic areas. Furthermore, it provides maps of various resolutions depending on the resolution of the input data. The RUSLE/GIS interface can serve as core methodology for further GIS hydrologic and geomorphologic applications such as analysis of watershed condition, sediment loading of streams and rivers, non-point source pollution, and the effects of hazardous wastes in soils on water quality, etc.

## Contact

Jacek Blaszczynski
National Science and Technology Center, BLM
Denver Federal Center
Building 50, PO Box 25047
Denver, CO, 80225-0047
phone (303) 236-5263
fax (303) 236-3508
email: Jacek_Blaszczynski@blm.gov