RUSLE APPLICATIONS ON ARIZONA RANGELANDS

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INTRODUCTION

The Revised Universal Soil Loss Equation (RUSLE) is a standardized soil erosion prediction equation that can be used for many land use situations. The USDA Natural Resource Conservation Service is the primary user of RUSLE. Because of the variable nature of rangelands and their large size, there are limitations of the use of RUSLE on rangelands. With understanding of those limitations, RUSLE can still serve as an effective and easy tool to indicate average annual soil loss per acre.

Arizona ranchers and rangeland managers often find RUSLE useful to estimate, monitor, and predict soil loss. The tool is site specific, readily available, inexpensive, and fairly easy to use. Its most common application is to examine and address areas with known erosion problems.

Soil loss is important because there is a direct relationship between soil depth and plant growth. It is a valuable parameter to help gauge and determine potential range condition. Land use normally has more effect on soil loss than any other single factor. Of the major factors affecting soil loss, land use is generally the only one that can be changed to control soil loss. A decrease in soil loss over time would demonstrate that management practices being used are environmentally sound. Conversely, an increase may point to a need to address management practices and/or landscape vulnerability.

Efforts to create an equation to estimate soil erosion began in the 1930s (Cook, 1936). Subsequent research by various agencies of the U.S. Department of Agriculture and universities resulted in the Universal Soil Loss Equation, presented in *Agriculture Handbook No. 537* (Wischmeier and Smith, 1978). The revised equation, RUSLE, was made available in 1992 as a computer-based application that can now be accessed over the Internet. It can be found at

http://www.sedlab.olemiss.edu/rusle/

The program is updated on a regular basis and is available as a download at no charge. This website includes links for assistance, including rangeland specialists based out of Tucson, and other complimentary information. Two other resources necessary for using RUSLE are the assistance of the nearest USDA Natural Resources Conservation Service (NRCS) office and the *Agriculture Handbook No. 703,* "Predicting Soil Erosion by Water: A Guide to Conservation Planning with the Revised Universal Soil Loss Equation (RUSLE)" (Renard et al., 1997).

This paper is intended to provide a basic understanding of RUSLE, concerns for rangeland applications, and what land managers can do to implement RUSLE. Although there is debate about RUSLE's accuracy for rangeland applications (Weltz, Kidwell, and Fox, 1998), USDA scientists and researchers are continually improving the equation's utility. Other erosion simulation models, such as the Water Erosion Prediction Project (WEPP), are just too complex and/or cost prohibitive for most rangeland managers. At present, RUSLE is readily available, inexpensive, and fairly easy to execute. Its limitations for rangeland applications are identifiable and can be addresed to provide useful information. Until other erosion simulation models are developed for the general user, RUSLE continues to be the primary soil erosion prediction tool in use today.

THE EQUATION

Based on the 1978 Universal Soil Loss Equation (USLE), RUSLE is as follows:

$$A = R \cdot K \cdot L \cdot S \cdot C \cdot P$$

Where:

A = Average annual soil loss per unit area predicted by the model (tons/acre/year).

R = Rainfall-runoff erosivity factor—the rainfall erosion index.

K = Soil erodibility factor—the soil-loss rate per erosion index unit for a specified soil on a standard plot.*

L = Slope length factor—the ratio of soil loss from the field slope length to soil loss from a 72.6-ft length under identical conditions.

S = Slope steepness factor—the ratio of soil loss from the field slope gradient to soil loss from a 9% slope under otherwise identical conditions.

C = Cover-management factor—the ratio of soil loss from an area with specified cover and management to soil loss from an identical area in tilled continuous fallow.

P = Support practice factor—the ratio of soil loss with a support practice such as contouring, stripcropping, or terracing to soil loss with straight-row farming up and down the slope.

*The standard plot is defined as a 72.6-ft. length of uniform 9% slope in continuous clean-tilled fallow.

Like its predecessor USLE, RUSLE is a lumped empirical model in a simple linear equation, the product of the above six factors. In the equation, all the factors and subfactors are calculated together to give an estimated soil loss as an annual average. As revised, current knowledge of erosion science is incorporated into the subfactors that make up the factors used.

THE FACTORS

The following is a brief description of each factor (Renard et al., 1997):

Rainfall-Runoff Erosivity Factor (R): The R-factor quantifies the effect of raindrop impact and also reflects the amount and rate of runoff likely to be associated with precipitation events. The R-factor is calculated as total storm energy (E) times the maximum 30-minute intensity (I_{30}), or EI, and is expressed as the rainfall erosion index. Index maps are used to determine the local value used for R. The R-factor is estimated by a methodology that includes information gathered from over 1,000 National Weather Station rain gauges.

Soil erodibility factor (K): The K-factor is the rate of soil loss per rainfall erosion index unit as measured on a standard plot, as defined in the above section. It represents the average long-term response of a specific soil and its profile to the combined effects of rainfall, runoff, and infiltration. It is expressed as the change in the soil loss per unit of applied external force or energy.

Slope length factor (L): The L-factor incorporates the ratio of rill erosion (caused by flow) to interrill erosion (raindrop impact) to determine the loss of soil as compared to the standard plot length of 72.6 ft. Slope length is defined as the horizontal distance from the origin of overland flow to the point where deposition occurs (a flattened slope) or runoff concentrates into a defined channel, usually within 400 feet of surface flow. RUSLE is most accurate when slope lengths are considered in 1,000-ft. distances or less.

Slope steepness factor (S): The S-factor reflects the influence of slope gradient on erosion as compared to the standard plot steepness of 9%. The program is designed to account for non-uniform slopes and slopes greater than 20% as well. Slope steepness has a greater effect on soil loss than slope length. The factors L and S are evaluated together in RUSLE.

Cover-management factor (C): The C-factor is used to reflect the effect of management practices on erosion rates. The RUSLE program user can easily compare the relative impacts of management options by making changes in the C-factor to reflect grazing impact or burning. For rangeland applications, average annual values for the C-factor are usually used. The C-factor is determined using subfactors for prior land-use, canopy cover, soil cover, surface roughness, and soil moisture.

Support practice factor (P): The P-factor is the ratio of soil loss with a specific support practice to the corresponding loss with upslope and downslope tillage. Soil-disturbing practices such as ripping, root plowing, contour furrowing, and chaining that result in storage of moisture and reduction of runoff are considered the major rangeland support practices.

USING RUSLE

"The principal number that RUSLE computes is average annual soil loss, but it also displays a wide range of other values that provide insight into how conditions at the given site affect soil loss. For example, the amount of ground cover from the previous year's forage is one of those variables. Another important piece of output information is time in the vegetation growth cycle when the soil has reduced cover in relation to when erosive rains occur. If intense, erosive rains occur when the soil is relatively bare, and higher erosion rates can be expected. To control erosion means giving special attention to make sure that the ground has cover when the intense rains occurs."

—G. H. Foster & the RUSLE Development Team 1999

The RUSLE user's most important resource is the local NRCS office. The nearest office can be found in the phone book under the government listings. The District Conservationist and his/her staff are familiar with RUSLE's applications and the erosion science behind it, as well as with the strengths and weaknesses of both. They will be instrumental in helping the user to get the most meaningful information out of RUSLE. Once the local soil conservationist is contacted, he or she will visit the field site, meet with the land user, and discuss the needs and interests of the land user. The conservationist and the land user can develop a conservation plan together where site-specific conditions and the interests of the land user are given primary consideration (Foster et al., 1999).

The Agriculture Handbook No. 703, "Predicting Soil Erosion by Water: A Guide to Conservation Planning with the Revised Universal Soil Loss Equation (RUSLE)" (Renard et al., 1997), provides maps, graphs, tables, and explanations of each factor of the equation, and is necessary to use RUSLE effectively. It is available at no cost while supplies last. Contact the USDA Agricultural Research Service, Southwest Watershed Research Center, 2000 East Allen Road, Tucson, AZ 85719, to receive a copy. You may also request it through the website http://www.sedlab.olemiss.edu/rusle/ or local NRCS office.

The RUSLE program available at the website is currently version 1.06b. It is free and can be downloaded for use. The website also provides a tutorial for practice. At some time in the near future, a new version of the program will be available, RUSLE 2 (Yoder and Lown, 1995). This version will be Windows-based, making it more flexible and easier to use. RUSLE 2 will also be backward compatible, meaning that it will accept information from earlier versions of RUSLE.

CONCERNS FOR APPLICATION

As there is a direct relationship between soil depth and plant growth, better soil conservation should be a management goal for rangeland managers. Soil loss is a valuable parameter to help gauge range condition and potential.

It is important to remember that RUSLE is only a model of the natural erosion process. It attempts to account for as many variables as necessary to make it practical for a wide range of land uses. In the case of its use for rangelands, however, studies conducted to examine RUSLE's accuracy showed that the soil loss estimates were considerably less than methods RUSLE is evaluated against (Weltz et al., 1987; Renard and Simanton, 1990; Benkobi et al., 1993). Their method of evaluation, single storm simulations, may or may not reflect an annual average as RUSLE is designed to estimate (Renard, 1999).

When applied for rangeland purposes, RUSLE is limited in its ability to account for a very large area. The natural variability of vegetative cover, soil types, topography, precipitation events, and other influencing factors within that area is inherently complex. Weltz, Kidwell, and Fox (1998) point out that the "distribution and connectivity of the bare soil interspaces and vegetation patches are more important than the absolute amount of bare soil in determining potential runoff and soil erosion rates." Research is needed to address the spatial distribution of bare soil and should be incorporated in later versions of RUSLE.

For the Arizona rangeland manager, a great concern for using RUSLE should be the limitation of slope length. Allotments in the tens and hundreds of thousands of acres would require many subsets of slope lengths under 1000 ft. to assure that results are meaningful. This would require detailed and careful design in the selection of slope lengths to estimate annual soil loss over a large area. Use of RUSLE on identified problem erosion areas may be more practical.

The other erosion simulator model developed for rangeland soil loss prediction is the Water Erosion Prediction Project (WEPP) model. WEPP is a process-based erosion simulation model (Nearing et al., 1989), with a continuous simulation option to reflect erosion over time. It is used to estimate soil loss per event, as opposed to giving an annual average soil loss like RUSLE. WEPP separates factors that influence soil erosion and other factors that RUSLE lumps together to calculate. WEPP can be effective on a field size of over 1,975 acres. According to Weltz, Kidwell, and Fox (1998), studies have shown the WEPP model to give good results in predicting runoff volume and peak discharge (Stone et al., 1992; Tiscareno-Lopez, 1994; Kidwell, 1994). However, observations of sediment yields using WEPP have been less consistent (Weltz et al., 1997; Mokhothu 1996).

The greatest limitation of the WEPP model for the general user is its complexity of variables to be estimated and entered by the user. Like RUSLE, it too is limited by slope lengths. The user needs to gather a great deal more on-the-ground information to use the model effectively, which may require substantially more time and expert assistance. According to scientist K.G. Renard, the WEPP model has proven so complex in its application that RUSLE will remain the primary tool for estimating soil loss for the foreseeable future (1999).

Ongoing research and revision of RUSLE is conducted primarily by the USDA Agricultural Research Service, NRCS, and associated Land Grant universities. Limitations to its universal usage, such as in the case of rangelands, are identified and research is conducted to resolve the problem or at least incrementally improve the accuracy of the equation's results. These advances in soil erosion science are then incorporated into the program.

CONCLUSION

The technology behind RUSLE has been developed over decades of research and field-testing by U.S. federal agricultural agencies and universities. Although it has limitations when used for rangeland applications, they are recognizable and assistance is available to overcome and/or interpret results to make RUSLE's estimates useful. Research is ongoing to improve the utility of RUSLE and address limitations for rangeland applications.

Because the RUSLE program is easy to use and resources to apply it are readily available, many rangeland managers should find it worthwhile to estimate average annual soil loss. It can provide an inexpensive but useful parameter to examine how management practices influence range use and soil conservation.

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FROM:

Arizona Ranchers' Management Guide
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