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COMPUTERIZED CALCULATIONS FOR CONSERVATION PLANNING

Revisions to the universal soil loss equation improve descriptions of conditions in modern farming systems

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Editor's Note: Soil and wind erosion are complex processes to model. This article discusses the revisions to the first model developed to predict soil erosion. Following this article, two others will discuss new models — the Water Erosion Prediction Project (WEPP), page 18, and the Wind Erosion Prediction System (WEPS), page 20. Finally, ASAE member Richard Johnson offers some insights on developing these models, page 22.

The Universal Soil Loss Equation (USLE) has been used for conservation planning activities in the United States and internationally for several decades. Despite the criticisms that have been directed at it, the technology continues to have considerable utility.

In 1985, USDA engineers and academic cooperators agreed that the USLE technology needed to be updated. Research completed after the 1978 USLE handbook (AH-537), which appeared in various literature sources, has been incorporated with other modifications into the Revised Universal Soil Loss Equation (RUSLE).

RUSLE is computerized to facilitate rapid calculation. Calculations not possible with charts and graphs from the the 1978 USLE handbook now can be made rapidly, permitting a more faithful description of the conditions encountered in modern farming systems. What follows is a synopsis of the major changes and improvements to the six RUSLE factors.

R-factor

The R-factor represents the hydrologic (weather) input that drives the sheet and rill erosion process. Differences in R-values represent differences in erosivity of the climate. One of the major improvements in RUSLE is a better isoerodent map of the Western United States. Data from more than 1,000 locations have been analyzed to prepare the new map.

Another change is to lower R-values where flat slopes occur in regions of intense thunderstorms, since ponded water on the soil surface reduces the erosivity of raindrop impact. The correction used relates annual R to land slope. Finally, an R-equivalent approach has been developed to replace the customary R-value in the Pacific Northwest. This factor considers the combined effect on erosion of thawing soil, and rain on snow or partially frozen soil.

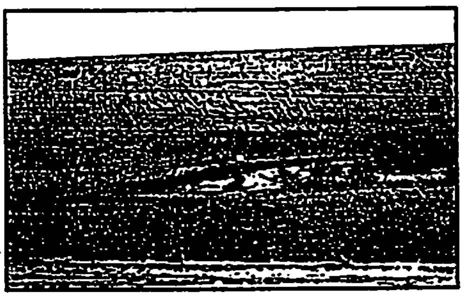

Fig. 1. The parallel rill erosion pattern produces high soil loss values for this winter wheat field.

Fig. 2. The rill erosion from this winter wheat field in the Pacific Northwest is deposited in the flat area in foreground.

K-factor

The K-factor is a measure of the inherent erodibility of a given soil with the standard condition of a unit plot maintained in continuous fallow. The erodibility nomograph remains the most commonly used tool for estimating K-values. K-values for the volcanic soils of Hawaii are estimated with an alternative algorithm.

Experimental data suggest that K varies with season, being highest in the spring following soil fluffing freeze-thaw actions and lowest in fall and winter following rainfall soil compaction or when the soil is frozen. This seasonal variability is addressed using relationships relating the short-term erodibility to the annual R-factor and the frost-free period. The short-term estimate of K is weighted in proportion to percent of annual R for bimonthly intervals.

L- and S-factors

RUSLE uses three separate L-factors for length and S-factors for slope. They include a function of slope steepness, and a function of susceptibility to rill relative to interrill erosion. RUSLE has a nearly linear slope steepness relationship. Experimental data do not support the quadratic relationship used previously. A specific slope length relationship was developed for the Palouse region of the Pacific Northwest.

In most practical applications, a slope profile previously represented as a single plane or uniform slope can be a poor topographical representation. Complex slopes can be described readily in RUSLE to provide an improved topographic representation.

C-factor

The cover-management factor, C, is perhaps the most important RUSLE factor because it represents conditions that can be managed to reduce erosion. Values for C are a weighted average of soil loss ratios (SLRs) that represent the soil loss for a given condition at a given time to that of the unit plot. Thus, SLRs vary during the year as soil and cover conditions change. To compute C, SLRs are weighted according to the distribution of erosivity during a year.

The RUSLE subfactor relationship is given by

$$C = PLU \bullet CC \bullet SC \bullet SR \bullet SM$$

where PLU is the prior land-use subfactor, CC is the canopy subfactor, SC is the surface cover subfactor, SR is the surface roughness subfactor, and SM is a soil moisture subfactor used in the Pacific Northwest small-grain farming areas.

One reason for the subfactor approach in RUSLE is for applications where SLR values are not available. For example, no experimental erosion data exist for many vegetable and fruit crops. Developing SLR values using the subfactor method in RUSLE is easier and more accurate than making comparisons with values in the 1978 handbook.

The RUSLE computer program includes data files for many tillage operations and crops. In other instances, the user must input new data reflecting the residue incorporated by a tillage operation and the surface random roughness following tillage.

For crops not available in the computer program, data are needed to reflect canopy characteristics, residue and root mass in the upper 4 inches of the soil profile and crop yield and residue characteristics. Finally, users must specify the crops in a rotation and the dates of operations such as tillage and harvest. The RUSLE computer program calculates SLRs and average annual C-factor.

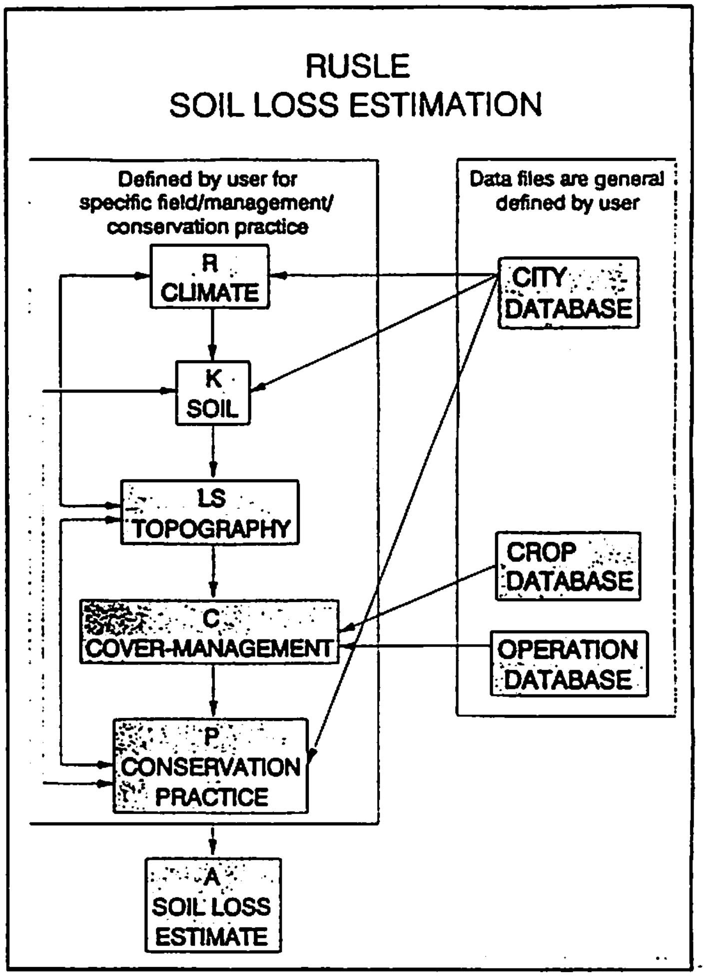

Fig. 3. RUSLE soil loss estimation.

Table 1. RUSLE and USLE comparison for a corn-soybean rotation on a silt loam soil near Indianapolis, Ind.

Factor	RUSLE	USLE
R	180	180
K	0.28	0.32
LS[1]	0.715	0.61
C	0.269	0.335
P[2]	0.86	1.0
A[3]	8.3	11.8

[1]Used three segments in RUSLE of 5% for 125 ft., 3.5% for 100 ft. and 3% for 125 ft. USLE was 3.6% for 350 ft.
[2]Used the contouring routine with a 2% grade for a moderate ridge height. USLE does not permit this credit.
[3]Some of the difference in predicted soil loss results from the P-factor. In other applications the individual factors will differ between RUSLE and USLE in opposite directions from this illustration.

P-factor

P-factor values, the least reliable of the RUSLE factors, represent how surface conditions affect flow paths, flow hydraulics, and thus erosion. For example, with contouring, tillage marks are credited with directing runoff around the slope at reduced grades. However, slight changes in grade can change runoff erosivity greatly. In experimental field studies, small changes in such features as row grade and their effect on erosion are difficult to document, leading to appreciable scatter in measured data. Thus, P-factor values represent broad, general effects of such practices as contouring and stripcropping.

In RUSLE, extensive data have been analyzed and the results interpreted to give factor values for contouring and cross-slope farming as a function of ridge height, furrow grade, and climactic erosivity. P-factor values for terracing account for grade along the terrace, while a broader array of stripcropping and buffer strip conditions are considered in RUSLE. Finally, P-factors have been developed to reflect conservation practices on rangeland. The practices require estimates of surface roughness and runoff reduction.

Credits

Numerous ASAE members and associates have been involved in the development of RUSLE. K.G. Renard, G.R. Foster, G.A. Weesies, D.K. McCool and D.C. Yoder have served as coordinators of the effort. Other contributors are J.M. Bradford, K.R. Cooley, S.A. El-Swaify, J.D. Istok, A.J. Ketchum, J.M. Laflen, L.D. Meyer, C.K. Mutchler, J.W.A. Poesen, J.P. Porter, M.J.M. Römkens, J.R. Simanton, D.A. Whittemore, and R.A. Young. ■

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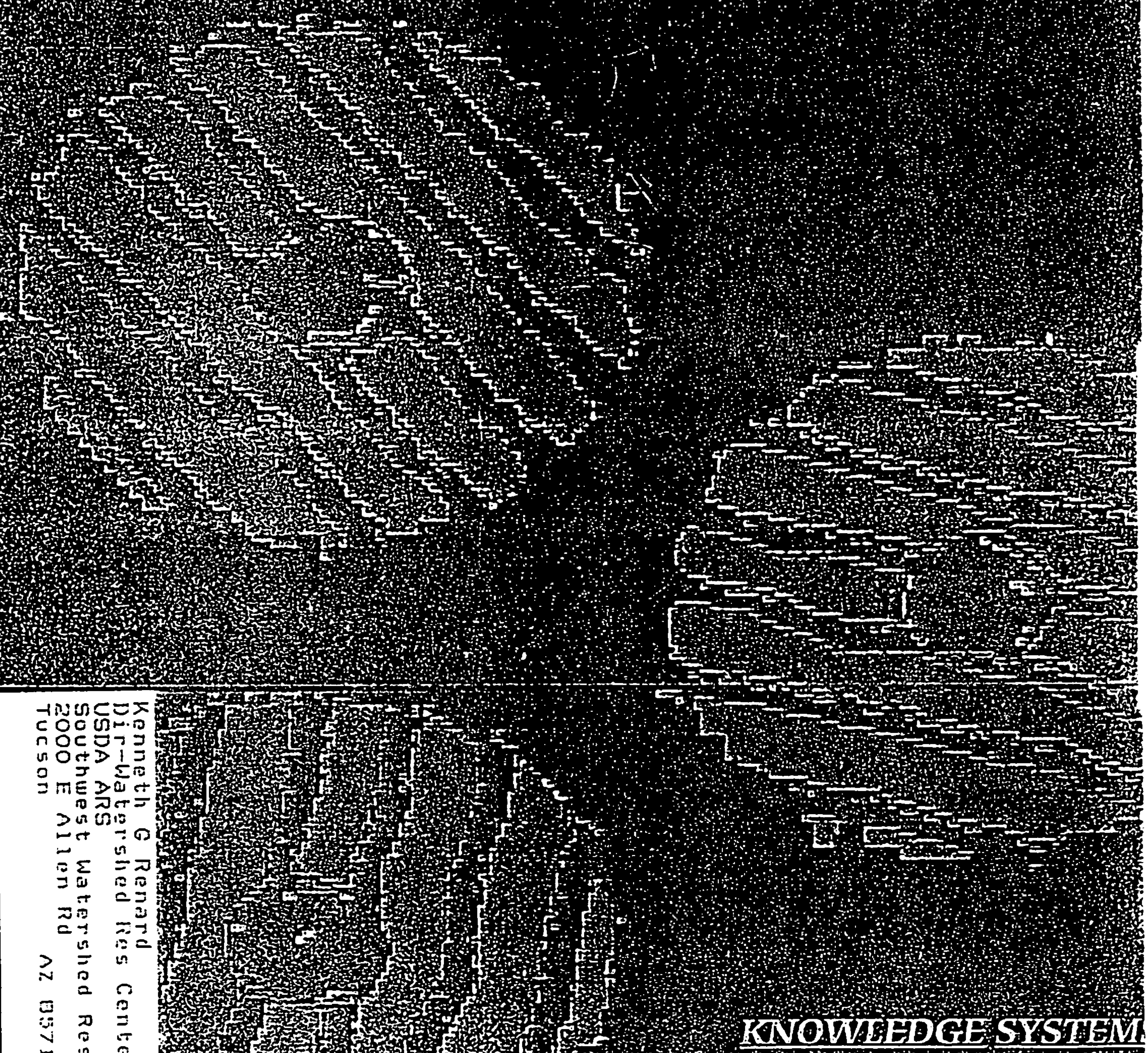

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