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Evaluation of the RUSLE Soil Erosion Model[1]

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Abstract

As part of a broader effort to provide more information on hydrologic and water quality models, this paper presents an overview and evaluation of the Revised Universal Soil Loss Equation (RUSLE). It briefly discusses the background of RUSLE as it evolved from the USLE, and the basic changes involved in the revision. The validation of RUSLE is discussed, though limited data restrict the analysis for all except the standard cropping and management situations.

The evaluation examines the new situations to which RUSLE can be applied, including those requiring estimates of sediment delivery and representing significantly different land uses. The changes in RUSLE make it useful for estimating erosion and sediment yield not only from agronomic settings, but also for situations involving construction, mine spoils, and land reclamation.

The analysis then examines the strengths and weaknesses of the current RUSLE layout and computer interface and the changes being included in the new RUSLE2 program. Finally, the overview includes a listing of sources for the program and supporting documentation.

Keywords: Revised Universal Soil Loss Equation, USLE, RUSLE, soil erosion, erosion prediction

Introduction

Many recent research efforts have focused on a better understanding of wind and moving water and their impacts on water quality and on resource conservation. These efforts often resulted in models to predict contaminant movement or for conservation planning, and the models have most often been presented as computer programs designed to handle the tedious task of repetitive or complicated calculations.

Too often, users treat such models as automatic and infallible solutions to their problems, not realizing the models' limitations. Such use has led to significant problems with unrealistic results, leading in turn to disillusionment with the specific models, or with models in general. The results of a survey of groundwater flow and transport models conducted by the National Research Council [1990] give an example of this disillusionment, as they conclude that "...enough has been learned about the weaknesses of such models to justify the significant amount of skepticism that has also developed, both in the scientific community and in the regulatory arena (p. 253)."

This paper is part of an effort to provide additional background information on the usefulness of specific hydrologic and water-quality models, and to give users a better sense of the model that best fits their needs. This paper presents such information for the Revised Universal Soil Loss Equation (RUSLE) model. The evaluation begins with background information on RUSLE's development and intended use, and on limitations to that use. The paper also covers RUSLE validation efforts and the general experiences of users with RUSLE, and finally discusses the availability of the RUSLE computer program and of associated documentation.

Using RUSLE: Who, What, Where, and Why

The Universal Soil Loss Equation (USLE) was the result of an enormous data collection and analysis effort extending from the 1930s through the 1970s and culminating in Agriculture Handbook 282 (Wischmeier and Smith, 1965) and finally in Agriculture Handbook 537 (Wischmeier and Smith, 1978). It is represented by the simple equation

$$A = R \cdot K \cdot KS \cdot C \cdot P$$

where A is the long-term average annual soil loss (usually expressed in ton _ acre-1 _ yr-1), R is rainfall erosivity in [(hundreds of ft-ton) _ in. _ acre-1 _ hr-1 _ yr-1], K is the soil erodibility in [ton _ acre-1 _ (hundreds of ft-ton)-1 _ in.-1 _ acre _ hr], LS is the dimensionless impact of slope length and steepness, and C and P represent the dimensionless impacts of cropping and management systems and of erosion control practices. [Conversion of the USLE to SI units is described by Foster et al. (1981)]. All dimensionless parameters are normalized relative to the Unit Plot conditions, as described in Ag. Handbook 537. Over the years the USLE became the standard tool for predicting soil erosion by water not only in the US, but throughout the world (Meyer, 1984).

RUSLE was developed as an update to the USLE, with development work beginning in the late 1980s. The need for a USLE update became apparent as users demanded more flexibility in modeling erosion for new conditions, which clearly did not work well within the standard USLE (Wischmeier, 1976). In addition, new research and analysis provided scientists with the power to improve the USLE's performance for both new and old land management schemes (Renard et al., 1991; Renard et al., 1994; Renard et al., 1997). Specific improvements are listed in these references, and they include significant advancements in every one of the five USLE factors.

RUSLE is a combination of empirical and process-based routines designed to make optimum use of the database on which the USLE was anchored. The RUSLE factors are broken down into finer subfactors to permit more flexibility in calculating soil losses for situations not represented by significant erosion data. For situations simply not covered by those data, RUSLE uses basic process-based erosion science to complement the empirical basis, for example allowing estimation of deposition through basic sediment transport relationships.

Target Audience

Though an update, RUSLE is still intended primarily to meet the needs of the USLE user, concentrating on predicting long-term annual average erosion by water on disturbed slopes. As with the USLE, the core audience for RUSLE is resource conservationists, concentrating especially on field-office staff in the USDA Natural Resources Conservation Service (NRCS), formerly known as the Soil Conservation Service (SCS). These field-level personnel generally bring strong skills to their tasks, including good customer-relation abilities, a well-developed sense of what will work in the field, a basic background in natural resource sciences, and access to technical experts within the agency. The RUSLE effort followed the lead of the USLE in realizing that these users are not specifically erosion-science experts, and emphasized making both the model use and the logic behind the calculations accessible to these users.

In recent years other field-level personnel have also begun to use RUSLE for conservation planning, including efforts for erosion control on construction sites, mine reclamation areas, landfill covers, and even military training grounds. Later versions of the RUSLE model have expanded the technology to include the special needs of these users, including deposition calculations to allow for prediction of sediment yield. Even in these expansions, however, in order to ensure proper use of the model every effort has been made to keep the science and the interface easy to use and understand.

Throughout the effort, one of the primary commitments of RUSLE developers has been to expand and perfect the erosion-prediction technology without leaving the end-user behind. Balancing the power and sophistication of advanced complex science with the need for the user to understand and feel comfortable with the model has only been possible through the combined efforts of science and user agencies, including not only USDA-ARS and USDA-NRCS, but also USDI Bureau of Land Management (BLM) and USDI Office of Surface Mining (OSM).

Intended Use

As the list of RUSLE users has expanded, so has the list of potential uses. The core use is still the estimation of long-term sheet-and-rill erosion on disturbed hillslopes. As such, RUSLE still does not provide estimates of ephemeral or classical gully erosion, of streambank erosion, of mass soil failure, nor of erosion in undisturbed forests. RUSLE does not provide specific information on the sediment yield from watersheds, though RUSLE technology could be used to replace USLE factors in the MUSLE model designed for that purpose (Williams and Brendt, 1972; Williams, 1977). RUSLE may also replace the USLE factors used to estimate erosion in such models as ANAGNPS and EPIC.

RUSLE has been expanded, however, to include estimates of the impact of slope shape and land use changes along the slope on sediment deposition. The model now provides estimates of deposition on the toe-slope areas of concave slopes or complex slopes, and of the decreased sediment transport in other depositional areas such as those behind buffer strips, filter strips, silt fences, etc. In addition, the model includes routines to estimate the sediment-catching capabilities of terraces and sedimentation basins. This means that in addition to the estimates of long-term average annual soil loss on the slope, RUSLE now also provides estimates of the long-term average annual sediment yield from complex slope shapes and land uses, which should provide increased information on potential water-quality impacts. The deposition information currently provides no particle-size breakdown of the delivered sediment, though this will likely be included in future development.

Though it is not part of the RUSLE model itself, the RUSLE technology may still be used to predict the soil erosion caused by a single design storm using the method developed by Cooley (1980). When used with RUSLE rather than the USLE, this technique would also yield a design-storm sediment yield, under the assumption of similar relationships of single-storm erosion and sediment yield to long-term annual averages.

Whether used for a single storm or for long-term averages, and whether for estimating erosion or sediment yield, the primary goal of RUSLE is to provide a convenient planning tool. RUSLE is best used for comparing management alternatives and land-use scenarios. The simplicity of RUSLE allows the conservationist to not only determine soil loss or sediment yield estimates for the producer/operator, but RUSLE can also serve as a valuable conservation teaching tool in explaining why the alternatives differ.

RUSLE erosion predictions for specific land uses and physiographic regions. Since most of the data supporting the USLE and RUSLE were collected for standard agronomic cropping in the eastern half of the US, the most accurate RUSLE predictions of erosion will still be for that land use and area. Much of the effort in moving from the USLE to RUSLE, however, was geared toward extending those ranges of applicability.

RUSLE includes significant new routines to estimate erosion in the Northwest Wheat and Range Region (NWRR) in the Pacific Northwest, and in the entire surrounding area which experiences similar erosion from rainfall and snowmelt on frozen and thawing soils. This expanded region includes the eastern portions of Washington and Oregon, the northeast section of California, most of Idaho, the western part of Montana and Wyoming, the northern part of Utah, and the western portion of Colorado. In these areas, much of the erosion by water occurs not due to high-intensity rainfall, but rather due to a unique combination of conditions in which low-intensity rainfall or snowmelt occur on soils which are very erodible due to freezing and/or thawing. RUSLE attempts to deal with these unique conditions through use of an "equivalent R", which represents the combination of rainfall characteristics and the likelihood that the rainfall will occur on highly-erodible soils. RUSLE also includes minor changes representing other factors that may control erosion during those special events.

The USLE was also weak when used in any of the western portion of the US, much of which is rangeland, and much of which experiences drier conditions than those found in the database locations. RUSLE tackles this problem first by providing much finer climate resolution in the West. In fact, the climate information for the western US in RUSLE is probably of better quality than is that for the eastern half, though an NRCS-sponsored study is underway to upgrade the climate information for the eastern US. In addition to improving the climate information, RUSLE provides routines specifically to model erosion on rangeland sites, including descriptions of rangeland vegetative communities and of range improvement field operations. Finally, RUSLE provides the possibility of modeling various grazing schemes on rangeland or pastures.

In the eastern US, RUSLE was modified to improve its modeling of nonstandard cropping practices, and of practices not covered well in the USLE. Examples of these improvements include easier modeling of "sustainable agriculture" systems, of crops cut for hay or silage, of sod-based rotations, and of vegetable production. RUSLE allowed for these by making it much easier to handle longer rotations, by more closely tracking the impact of soil organic matter, and by making it far easier to model the impact of various field operations.

Finally, as was mentioned earlier, RUSLE represents a significant improvement over USLE technology for the modeling of erosion on sites undergoing construction, mining, and land reclamation activities. The changes allow not only for modeling of erosion on those sites, but also for reasonable estimates of the corresponding sediment delivery.

These results indicate that RUSLE can be used almost without limit to model sheet-and-rill erosion on disturbed lands. The extensive use of the USLE overseas and initial response to RUSLE indicates that RUSLE will also serve as a useful modeling tool internationally, though without additional data it is difficult to know what degree of confidence to assign to the results.

Where Has RUSLE Been Used and How Well Has It Worked?

Specific RUSLE validation efforts. Though RUSLE has been calibrated against the large USLE database, very little effort has actually been put into model validation. One comprehensive analysis of how well the USLE fits plot data produced a value of R2 = 0.75 for average annual erosion results (Risse et al., 1993). This value is very acceptable, especially given that the same data showed an annual erosion variability of 35% between replicated plots, which should have produced very similar erosion values. These data were collected for plots and cropping situations relatively similar to those used in the original USLE effort, including primarily row crops concentrated in the Midwestern and Southeastern US, with limited numbers from the Northeastern and Northwestern states. The typical length of record for these plots was less than 10 years, which could cause a few very erosive or non-erosive years to skew the results.

Because RUSLE was developed from the basic USLE primarily to extend its usefulness rather than specifically to increase predictive accuracy in these "normal" cropping situations, RUSLE was expected to provide about the same degree of fit to these data as provided by the USLE. A later study relying heavily on the work by Risse et al.(1993) and extending it to RUSLE bears that out (Rapp, 1994).

General RUSLE use and validity. Because of the RUSLE emphasis on extension of the technology, what was more important to the RUSLE effort was how well the model would predict erosion for conservation tillage and “sustainable agriculture" systems, for vegetable cropping systems, for erosion on steep slopes in the tropics, for construction sites and reclaimed mine spoils, and for other non-traditional settings.

Unfortunately, scientists have collected very few data characterizing erosion in these non-traditional settings, and what few data exist are for very short periods and reflect very localized conditions. In addition, the long-term nature of RUSLE increases the difficulty of collecting sufficient data. Because of these problems, there has been great difficulty in gathering enough information to drive an adequate validation of RUSLE when used in these settings, but this could be said of any erosion-prediction models. Since a rigorous validation is nearly impossible, all that can be said is that RUSLE use by experienced practitioners generally yielded results with which they feel comfortable, both with respect to the values generated by the models and with respect to the trends resulting from changing parameter values.

Perhaps the largest such effort has been the use of RUSLE by the NRCS to calculate an entire new series of C-factor values for regions across the US. This included a large number of crops and crop yields in a wide variety of cropping sequences, requiring a calculation of roughly 100,000 different scenarios by some 50 experienced agronomists over a four-year period. These calculations yielded very few surprising results. Although C factors generally were slightly lower with RUSLE than with the USLE, the RUSLE soil loss estimates were very similar to the USLE values for the same management schemes. In general, RUSLE is Providing the conservationists with what they consider to be reasonable answers. Since previous tests have shown RUSLE to be most sensitive to C-factor inputs (Renard and Ferreira, 1993; Ferreira et al., 1995), the stability of these results bodes well for the overall model stability.

Another recent major effort in using RUSLE has been concentrated on practitioners in the construction, mine spoil, and mine reclamation arenas. This effort was supported by the USDI Office of Surface Mining (OSM) through the University of Denver Department of Geology and Geography, and has resulted in the release of a manual for the use of RUSLE to predict erosion and sediment yield for these land uses (Toy and Foster, 1998). This effort tested RUSLE severely, and also did not find any major inconsistencies with RUSLE results for these situations, though admittedly the practitioners had far less background data on which to base such judgements.

Finally, RUSLE has been finding surprising support in overseas research predicting erosion on very steep slopes and under very different management practices. An example of such efforts can be found in Taiwan, where strong fundamental research into erosion processes on very steep slopes and with very different cropping systems is yielding results very much in keeping with RUSLE predictions (Fan, 1995; Wu, 1995).

Validation of recent RUSLE changes. As will be described in more detail below, earlier versions of the RUSLE program underwent peer review by a committee set up by the Soil and Water Conservation Society. More recent changes to the sediment deposition routines have undergone even more severe testing, this time by scientists and practitioners within ARS, NRCS, OSM, and the Univ. of Denver. As described above, the very limited data available for such situations limits the degree of true scientific validation that can be accomplished, and requires settling for this general verification of "reasonableness."

Expected Goodness of Fit

The experience of users and modelers and the forms of the relationships used in the calculations allow us to draw some inferences regarding the degree of confidence a user can expect assign to the RUSLE results. These are shown in Table 1. Note that these are often relative degrees of confidence rather than resulting from a strict statistical analysis, but are based on Risse et al. (1993), on Rapp (1994), and on substantial scientific experience and expertise.

Ease of Use

General layout and format. The current version of RUSLE (1.06) is available as a DOS-based computer program, and can be downloaded from the official RUSLE website at www.sedlab.olemiss.edu/rusle. This version is designed to reflect a "paper" use of RUSLE, going through calculation of each of the factors individually. This makes the general layout and format of the calculation very comfortable for the field user, but unnecessarily complex and cumbersome for those without previous USLE or RUSLE experience.

A Windows®-based version of RUSLE has been developed and is currently undergoing evaluation. This version includes some modifications in the RUSLE science as well, and allows users to vary soils and land uses on a hillslope. The new version should be available to the general public in April 2001 at the RUSLE website listed above.

Interface usability. Though the interface is somewhat dated by being text-based rather than graphical, users have in general responded to it very favorably. A section below includes discussion of a new graphical interface being developed for RUSLE, which does away with this "paper" layout of the current version and which appears to be far more intuitive for most users.

RUSLE makes no special attempts to allow for inputs derived from or stored in other sources. For example, there is no mechanism within RUSLE to accept inputs from a GIS package, nor is there a specific capability to extract information from some standard external database. There have been, and are, several attempts underway to insert the RUSLE calculations as an optional tool within a GIS package, but these have yet to yield a widely-usable result, nor has there been any significant request from users for this ability.

Input sets. RUSLE requires users to provide a complete description of their site and of their management scenario in order to perform the calculations. The program eases the formation of these input sets, however, in that users can save logical "chunks" of information into databases, from where they can be extracted for later reuse. RUSLE specifically allows users to save the climate information associated with a particular location under a specific location identifier (in this case a number), it allows all the growth and residue information for a specific vegetation to be saved under the vegetation name, and it allows all the information associated with a specific field operation to be stored under the operation name. Finally, RUSLE allows a complete slope and management scenario to be saved for later use, allowing users the option of making minor management changes and saving results.

Much of the work of creating and saving these "chunks" of information for RUSLE has already been done by the NRCS (McCool et al., 1994). As part of their implementation of RUSLE, NRCS agronomists and field personnel have created and saved literally hundreds of climate, vegetation, and field operation descriptions, and thousands of management scenarios. The descriptions have been based on an extensive review of the literature as well as on field measurements of many of the vegetation parameters. The scenarios have been set up to represent all major and many minor management schemes for most areas of the country. In short, much of the work of developing the RUSLE input descriptions for cropland in the US has been completed by the NRCS, and these are available for public use. Sample input sets for construction and land reclamation scenarios have also been developed for the OSM RUSLE Manual (Toy and Foster, 1998), and these input sets may be available through that office. Readers interested in pursuing the availability of either of these input sets are encouraged to visit the official RUSLE website, which is located at www.sedlab.olemiss.edu/rusle.

Because of all these efforts, users will rarely need to build their own descriptions or scenarios from scratch, but they can rather weave together existing pieces to create their own description or scenario. Once users build their own descriptions or scenarios, those pieces can serve as templates to save, modify, and even share with others. Rarely should users be required to collect field data other than those needed to define the slope topography and to determine soil type. Collecting new data describing climate parameters is as easy as looking through existing weather information, but collecting new data on soil or vegetative or field operation parameters is extremely difficult and time-consuming.

Outputs. RUSLE provides a wide range of outputs, ranging from very sparse information for some factors to very detailed values for other factors. The outputs include single values for R, for the slope segment and overall slope LS, and for the different P subfactors (for contouring, strips and slope changes, and terracing or basins). In addition, the outputs provide time-varying information on soil erodibility (how K changes with time), and on the C subfactors throughout the management scheme. This time-varying option for several of the outputs allows users to see how erosivity, erodibility, and erosion match up throughout a rotation. The data cannot be viewed graphically, which is a significant drawback.

RUSLE Availability

Any use of RUSLE should begin with Agriculture Handbook 703 (Renard et al., 1997), which provides the theoretical background and supporting materials for the RUSLE model, as well as providing extensive practical information describing RUSLE's use. This source is available through the National Technical Information Service (www.ntis.gov), or through the US Government Printing Office (www.access.gpo.gov).

There are also other printed supporting materials available describing specific RUSLE uses. The NRCS has a handbook providing background and describing use of the model within that agency for cropland erosion calculations. The OSM also has a Manual emphasizing use of RUSLE for construction sites, mine spoils, and land reclamation activities (Toy and Foster, 1998). Availability of these documents should be discussed with the NRCS and OSM representatives listed on the RUSLE website.

The RUSLE executable program and a relatively extensive supporting database set are available as a download at the RUSLE Official website (at www.sedlab.olemiss.edu/rusle), located at the USDA-ARS National Sedimentation Laboratory in Oxford, MS. This site also provides additional background information on RUSLE. It should be clear that the RUSLE program available at the website is the most recent version (version 1.06) and that it has undergone substantial review and has the confidence of the RUSLE development team, but that it is a research version and may undergo periodic changes.

The version of RUSLE available from the website is compiled to run on DOS® and Windows®-based operating systems. In the past the source code has been compiled to operate on UNIX-based machines, but this was done specifically for older carryover systems used years ago by NRCS, and has not been tried recently. As was described above, the Windows®-based RUSLE2 should be available on the website in April 2001.

The source code for RUSLE is not available from the website. Users with specific reasons to request the code should discuss this need with the USDA-ARS contact listed on the website. Several notes of caution should be clear before considering trying to manipulate this code. These cautions include: 1) the code is written for the Microsoft7 C compiler, and newer compilers don't recognize some of the older library functions without some reworking; 2) as is, the RUSLE program uses almost all of the 640K lower memory and makes no use of extended memory management, so code changes can easily result in exceeding this limit; 3) the current code is not modular, making it very difficult to separate the calculations from the I/O routines.

Most of the RUSLE training to date has been carried out by USDA-ARS, and has been specifically for USDA-NRCS personnel, and to a lesser extent for other federal agencies. Much of the training effort envisioned within the next two years with RUSLE2 will likely follow the same pattern, but the USDA-ARS RUSLE Development Team is also making an effort to involve other resources in carrying out training. This group envisions that experts outside of ARS could develop training materials and courses independently, perhaps with specific needs in mind (e.g., landfills, mine reclamation, etc.). The Development Team would provide guidance and feedback for such efforts, but would not be directly involved in these short-courses, workshops, or commercial sessions. Exactly how this will be carried out remains to be decided.

Continuing RUSLE Efforts

The current DOS®-based version of RUSLE has several weaknesses, due to the complexity of the "paper" layout, due to the memory-handling within the operating system, and due to the text-based interface technology. These weaknesses result in limits on the science, as the individual factor calculations in the "paper" layout prevent complete integration of interdependent effects. For example, RUSLE1.06 allows calculation of a time-varying erodibility (K), a time-varying C, and a time-varying P. Unfortunately, the "paper" version throws much of this information away, as it uses the time-varying numbers to calculate an average annual value for each factor, and then multiplies together these averages.

These weaknesses are being addressed by a new version of RUSLE, known as RUSLE2. This program is designed to be run in the Windows95/98/NT® operating environment, and is meant to provide users with a far more intuitive and visual means of describing their situations and of viewing results (Yoder and Lown, 1995). In addition, this version provides better information on the interactions between the RUSLE factors over the course of a simulation, providing better and clearer results. RUSLE2 is undergoing preliminary testing, and should be available for more general release this year. Changes to the erosion science in RUSLE2 are listed in Foster et al. (2000), while the interface development is more fully described in Lown et al. (2000).

In addition, the RUSLE2 work has become intertwined with a larger effort within ARS, known as the MOSES project (Modular Soil Erosion System). This is an effort to include two of the primary ARS erosion prediction models (RUSLE for water, WEPS for wind) under a single graphical user interface, and involves some 20+ scientists at nine locations throughout the US, representing ARS, NRCS, USDA Forest Service, and The University of Tennessee. This project is making good progress, and was released in an initial trial version in October 2000. It should be ready for release tot he public in late 2001.

Summary

RUSLE has been adopted by the NRCS as the standard tool for erosion prediction on disturbed lands. Because of NRCS' historical leading role in erosion prediction, many other technical-support and regulatory agencies involved in erosion prediction are likely to follow suit. Since this means that many RUSLE users will likely have limited erosion science background or training, simplicity and ease of use of both the science and the computer program are of great importance. In addition, this requires that the model be flexible enough to model a wide variety of field situations, and robust enough to provide reasonable answers in all those cases. Accuracies of the results are still important, but the complexity of the science required to fine-tune the results for some peculiar situation is less important than providing good answers for most situations and a reasonable answer for that peculiar one.

In general, RUSLE does a good job of meeting this need for users familiar with the USLE, and substantial documentation and sample input sets are available. RUSLE represents a significant improvement in science over that in the USLE, but though the entries and calculations are computerized, RUSLE still does not make it easy for novices to calculate reasonable erosion values. A new RUSLE2 effort currently underway should improve this capability.

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Table 1: Expected accuracy of the RUSLE factors and results.

Factor	Conditions	Expected Accuracy	Comments
A	< 1 T A-1 Yr-1	50%	
	1-3 T A-1 Yr-1	35%	
	3-20 T A-1 Yr-1	25%	
	>20 T A-1 Yr-1	35%	
R			The most accurate of RUSLE inputs. Best for regularly-occurring rainfall > 20 in. Yr-1. May be inaccurate in mountainous regions.
K			Best for medium-textured soils, mod. accurate for fine-textured, acceptable for coarse-textured, inaccurate for organic soils. Impact of rock fragments, seasonal variability, and soil consolidation in the West may need more specification.
L	0 - 50 ft	moderate	
	50 - 300 ft	best	most experimental plot data were within this range
	300 - 600 ft	acceptable	
	600 - 1000 ft	poor	
	1000+ ft	not allowed	rarely if ever occurs in nature
S	0 - 3%	moderate	
	3 - 20%	best	
	20 - 35%	moderate	
	>35%	acceptable	may result in soil mass movement, which is not predicted by RUSLE

C	< 0.01	great uncertainty	data have extreme variability
	0.01 - 0.05	moderate	RUSLE soil loss estimates are mostly strongly affected by this factor, and RUSLE data included a wide variety of surface conditions. Users need to be very careful in specifying factors which affect surface cover
	0.05 - 0.4	best	
	0.4 - 0.7	good	
	0.7 - 1.0+	good	
P	< 0.5	70%	The most uncertain of the RUSLE factors, since site-specific conditions contribute to great variability in the erosion data, especially as related to severe storms.
	0.5 - 1.0	35%	

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[2] Yoder and Lown are with the University of Tennessee, Foster and Renard are retired from USDA-ARS, McCool is with USDA-ARS in Pullman, WA; and Weesies is with USDA-NRCS in W. Lafayette, IN.

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