EVALUATION OF WEPP AND ITS COMPARISON WITH USLE AND RUSLE

A. K. Tiwari, L. M. Risse, M. A. Nearing

ABSTRACT. *The USDA-Water Erosion Prediction Project (WEPP) demonstrates a new generation of water erosion prediction technology for use in soil and water conservation planning and assessment. The WEPP computer model is based on various interacting natural processes in hydrology, plant sciences, soil physics, and erosion mechanics. The model offers several advantages over existing erosion prediction technology and has the capability of accommodating spatial and temporal variability in topography, soil properties, cropping and management, and sediment detachment and deposition. The model has a wider range of applicability as it accounts for most of the variables affecting runoff and erosion processes. However, considerable validation is required to assess the reliability of predictions obtained from the model. Sixteen-hundred plot years of natural runoff plot data were used for verification and validation of WEPP, including most of data used to develop Universal Soil Loss Equation (USLE). WEPP predictions of soil loss from natural runoff plots at 20 different locations were compared to measured data and existing technology (i.e., USLE and RUSLE). WEPP recorded a model efficiency of 0.71 compared to 0.80 and 0.72 for the USLE and RUSLE respectively. While the USLE and RUSLE did exhibit better model efficiency than WEPP this could be attributed to availability of more refined and site specific input parameters for the empirical models.*
Keywords. *Soil erosion, Modeling, Validation, WEPP, USLE, RUSLE.*

Soil erosion models are the mathematical descriptors used to represent the erosion process. They have utility for design of impoundments, erosion control structures, evaluation of land-use management practices and environmental planning and assessment. Empirical methods have been quite commonly used in the past for sediment yield estimation (Walling, 1988). However, process based soil erosion models have a wider range of applicability and the capability to accommodate the spatial and temporal variability in the ongoing natural process, which cannot be achieved through empirical models.

The universal soil loss equation (USLE) is the most widely used of all soil erosion models. Wischmeier and Smith (1965) developed the following equation that estimates average annual soil loss using rainfall, soil, topographic, and management data:

$$A = R \times K \times LS \times C \times P \qquad (1)$$

where A is the computed long-term average annual soil loss per unit area, R is the rainfall and runoff factor, K is the soil erodibility factor, LS is the topographic factor, C is the cover and management factor, and P is the support practice factor. Each of these factors is designed to account for critical processes that can affect soil loss on a given slope. The rainfall and runoff factor (R-value) is designed to quantify the raindrop impact effect and provide relative information on the amount and rate of runoff likely to be associated with the rain. The soil erodibility factor (K) is used to represent the differences in natural susceptibilities of soils to erosion. The slope length (L) and slope steepness (S) factors represent the topography of the land. They are designed to account for topographic factors that can affect the rate of energy dissipation. The cropping and management factor (C) is the ratio of soil loss from land cropped under specific conditions to the corresponding loss from tilled, continuous fallow conditions. The effect of cultural practices like crop rotation and conservation tillage are also described by the C factor. The support practice factor (P) is intended to represent effects of supporting practices such as contour farming, terraces, and strip cropping. By definition, P is the ratio of soil loss with a specific support practice to the corresponding loss with conventional up-and-down slope tillage.

The USLE has been widely used all over the world either in the same or modified forms. Many scientists have conducted studies to quantify the accuracy of soil loss estimates from this model (Wischmeier, 1972; Onstad et al., 1976; Risse et al., 1993). Modification of the LS and C factor and a more deterministic approach to P factor calculation were incorporated in the Revised Universal Soil Loss Equation, RUSLE (Yoder et al., 1992). Rapp (1994) showed that these revisions had little effect on model efficiency for predictions from RUSLE and USLE using natural runoff plot data. Since then, modern theory on erosion processes of detachment, transport and deposition of soil particles by raindrop impact and surface runoff has been used to derive and refine some of the relationships in RUSLE. Since empirical models do not

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account for deposition and considerable time and effort are needed to derive different parameters, there has been a trend to develop process-based simulation models (Nearing et al., 1990).

In 1985, the USDA initiated the Water Erosion Prediction Project (WEPP) to "develop a new generation of water erosion prediction technology . . ." (Nearing et al., 1989). WEPP is a continuous simulation computer model that predicts soil loss and deposition rather than average net soil loss. This new process-based model offers several advantages over existing erosion prediction technology. It has capabilities of predicting spatial and temporal distributions of net soil loss or net soil loss or gain for the entire hillslope for any period of time. It also has a wider range of applicability as it contains its own process-based hydrology, water balance, plant growth, residue decomposition, and soil consolidation models as well as a climate generator and many other components that broaden its range of usefulness. In WEPP, weather and climate data are read from a "climate" file. CLIGEN, a stochastic weather generator, is usually used to construct these files. Infiltration is calculated using a solution of the Green-Ampt equation for unsteady rainfall developed by Chu (1978). The difference between rainfall and infiltration and storage is considered runoff and it is routed over the land surface using the kinematic wave equations.

As with most other process based models, the erosion component of WEPP is based firmly on a steady state continuity equation, of the form:

$$dG/dx = D_f + D_i \tag{2}$$

where x represent distance downslope, G is sediment load, D_i is the interrill erosion rate, and D_f is rill erosion rate. WEPP calculates erosion from the rill and interill areas on a per rill area basis. Interrill erosion, D_i, is considered to be independent of distance which means that interill erosion occurs at a constant rate down the slope. Rill erosion, D_f, is positive for detachment and negative for deposition. Each of these parameters is calculated on a per rill area basis, thus the sediment load is solved as soil loss per unit rill area. One difference between WEPP and most other models is that the sediment continuity equation is applied within rills rather than using uniform flow hydraulics. Interill detachment in WEPP is given by:

$$D_i = K_i\, I_e \sigma_{ir}\, SDR_{rr}\, F_{nozzle}(R_s/W) \tag{3}$$

where K_i is the interill erodibility, I_e is the effective rainfall intensity, σ_{ir} is the interrill runoff rate, SDR_{rr} is the sediment delivery ratio, F_{nozzle} is an adjustment factor to account for sprinkler irrigation nozzle impact energy variation, and R_s and w are the rill spacing and width. Interill erosion is conceptualized as a process in which detachment in the interill area is delivered to the concentrated flow channels or rills. Sediment delivery from the interill area may then be either transported down the hillslope or deposited in the rill. Rill detachment capacity in WEPP is calculated when the hydraulic shear stress of the flow exceeds the critical shear stress of the soil and is expressed as:

$$D_c = K_r\,(\tau_f - \tau_c) \tag{4}$$

where D_c is detachment capacity of the rill flow, K_r is rill erodibility of the soil, τ_f is flow shear stress acting on soil particles, and τ_c is rill detachment threshold parameter or critical shear stress of the soil. Rill detachment is zero if the shear stress of flow is less than the critical shear stress of the soil. If transport capacity is greater than the sediment load then detachment in the rills will be predicted using:

$$D_f = D_c\,(1 - G/T_c) \tag{5}$$

where D_f is the net rill detachment, and T_c is the transport capacity of flow in the rill. Otherwise, if the sediment load is greater than the transport capacity, then deposition will occur. The four hydrologic variables that drive the erosion model are the peak runoff rate, the effective runoff duration, and the effective rainfall intensity and duration. Comprehensive details of the model and its components may be found in Flanagan and Nearing (1995).

Validation of WEPP has suggested several refinements and modifications. Several researchers have conducted sensitivity analysis on WEPP (Nearing et al., 1990; Chaves and Nearing, 1991). The results of these sensitivity analyses are in general agreement that the rainfall parameters (depth, duration, and intensity) and the infiltration parameters (surface cover and hydraulic conductivity) have the most impact on the runoff predictions while the generated hydrologic characteristics, the surface cover, and the erodibility parameters have the most influence on soil loss. Others conducted validation studies and identified the rainfall disaggregation and parameter estimation routines as the major sources of error (Kramer and Alberts, 1992; Risse et al., 1994). These findings resulted in research that led to improved methods of estimating both the infiltration and erosion parameters (Risse, 1994; Zhang et al., 1994). As the WEPP project approaches its delivery to the user agency, considerable validation needs to be conducted to insure that the model produces reliable results. This validation must be conducted under a wide variety of conditions and locations and was the major goal of this study.

Methods

Rainfall, runoff, and soil loss data from natural runoff plots at 20 locations (table 1) in the United States were used for this validation work. More than 1,600 plot-years of data at these locations were used in the study. The sites were selected based on the availability of complete data sets as well as to conform to previous studies. The sites selected display wide heterogeneity in soil, slope length and steepness, climate, and management. The raw data was transformed to WEPP input format. The input included construction of climate, soil, management, and topographic files based on the recorded data.

All the files were put in a format to run with WEPP version 98.4 in the continuous simulation mode. Since previous studies determined that the model was sensitive to rainfall parameters, the climate files were generated by the stochastic generator and then modified to correct the rainfall amounts, the duration of rainstorm and corresponding ratio of peak and average intensity based on observed data. In most cases the maximum and minimum temperatures were also corrected to the measured data.

Table 1. Sites selected for WEPP validation to measured data

Site	Soil	Years	Slope (%)	Management (Crops/Crops in rotation)
Bethany, Mo.	Shelby sil	1931-40	8	Fallow, Corn, Alfalfa, Meadow, Bluegrass
Castana, Iowa	Monona Sil	1960-71	14	Fallow, Corn, Oats, Meadow
Clarinda, Iowa	Marshall Sicl	1932-43	8-9	Corn, Oat, Meadow, Alfalfa, Bluegrass
Clemson, S.C.	Cecil sl	1940-42	7	Fallow
Dixon Springs, Ill.	Grantburg sl	1940-45	5-10	Wheat, Meadow Corn
Geneva, N.Y.	Ontario l	1937-46	8	Fallow, Soybeans, Rye, Clover, Meadow
Guthrie, Okla.	Stephensville sl	1940-56	8	Fallow, Cotton, Oat, Alfalfa
Hayes, Kans.	Colby sl	1931-46	5-7	Wheat, Meadow
Hollysprings, Miss.	Providence sil	1961-68	5	Fallow, Corn, Meadow
Ithaca, N.Y.	Bath Flaggy sil	1935-40	18-21	Fallow, Corn, Meadow , Oat, Hay, Potato
Lacrosse, Wis.	Fayette sil	1933-46	3-16	Fallow, Corn, Barley, Hay, Meadow, Bluegrass
Madison, S Dak.	Egan sicl	1961-70	6	Fallow, Corn
Marcellus, N.Y.	Honeoye sil	1940-63	4-19	Fallow, Corn, Meadow
Morris, Minn.	Barnes l	1961-71	6	Fallow, Corn, Oat, Hay
Presque Isle, Maine	Caribou grsil	1961-69	8	Fallow, Potato
Raleigh, N.C.	Appling, sl	1944-48	4	Tobacco, Rye
Statesville, N.C	Cecil scl	1931-38	10	Fallow, Corn, Cotton, Wheat, Meadow
Temple, Tex.	Austin sil	1931-45	4	Corn, Oat, Cotton, Meadow
Tifton, Ga.	Tifton sl	1959-66	3	Fallow, Corn, Potato, Meadow
Watkinsville, Ga.	Cecil scl	1961-66	7	Fallow, Corn, Cotton, Meadow

Slope files were built in the required format, based on the topographic information. All sites had single overland flow elements except for Guthrie where eight overland flow elements were used to represent strip cropping. All the plots had a uniform slope and width. Management files included many different land uses including fallow, meadow, single crop or crop rotations at twenty locations on 190 individual plots. The information on plant growth, residue decay and management practices, initial conditions, and tillage sequences, etc., were incorporated in the management file based on the recorded data available and the WEPP crop input information. Information on dates and types of tillage were taken from recorded data. Initial conditions were generated using the warm-up option given in WEPP for locations where they were not available. The tillage database included in WEPP documentation was used to obtain tillage parameters including the depth, roughness, intensity, ridge height and ridge spacing. While management and tillage information probably introduced some error (since crop parameters and tillage implements have changed significantly over the last 60 years), previous sensitivity analysis has indicated that runoff and soil loss in WEPP is not affected by small changes in these inputs.

The information for the soil profile input file for WEPP was also obtained from measured data. The soil parameters were not calibrated and they were based on the best information available. On all plots, the texture data, the organic matter and usually the percent rock content were available in the measured data set. Other soil parameters were taken from experiment station bulletins or the NRCS Soils database. Rill and interrill erodibility, critical shear stress and saturated hydraulic conductivity were calculated based on the equation developed in Risse et al., (1994) and listed in the WEPP user's manual (Flanagan, 1994).

WEPP predictions were derived for each plot on both annual and average annual basis, and were compared to the measured record of the plot. Nash Sutcliffe model efficiency (Nash and Sutcliffe, 1970) was calculated as follows:

$$R^2 = 1 - \frac{\sum_{i=1}^{n} (Q_{mi} - Q_{ci})^2}{\sum_{i=1}^{n} (Q_{mi} - Q_m)^2}$$

where R^2 is the efficiency of the model, Q_{mi} represents the measured value of event i, Q_{ci} is the computed value of event i, and Q_m is the mean of measured values. In this method, a value of one indicates a perfect model, a value of zero indicates the model results are no better than the mean measured value, and a value less than zero indicates that using model predictions would be worse than using the mean.

One of the main user requirements for the WEPP model was that it, "produce quantitative results that are at least as good with respect to measured data as those from the USLE" (Foster and Lane, 1987). To assess this requirement, model predictions were compared to the results of USLE and RUSLE. USLE estimates of soil loss were obtained from Risse et al. (1993) and RUSLE predictions were taken from Rapp (1994). Since the data sets were not exactly the same, some modifications were made. However, all of the parameters for USLE and RUSLE were calculated as outlined in the procedures of these articles. Essentially this resulted in using measured values of rainfall erodibility, K and C values derived from information supplied by local NRCS field offices, and calculated LS values.

Results and Discussion

Table 2 gives the statistics for the analysis based on average annual values of soil loss predicted by USLE, RUSLE, and WEPP. The average predicted soil loss values were found to be close to average measured soil loss. Model efficiencies (R^2) for the three models were more than 0.70, hence all the three models performed well at predicting average annual soil loss. When analyzed based on annual predictions (each year taken as an independent observation) and compared with the annual observed

Table 2. Summary statistics for average annual values of soil loss predicted by USLE, RUSLE, and WEPP

Parameter	USLE	RUSLE	WEPP
Soil loss			
Avg. measured soil loss (kg/m^2)	3.68	3.68	3.69
Avg. predicted soil loss (kg/m^2)	3.76	3.29	3.63
Avg. magnitude of error (kg/m^2)	1.41	1.23	2.01
Regression results			
Slope	0.87	0.64	0.78
Intercept	0.55	0.95	0.84
Correlation coefficient	0.80	0.75	0.72
Model efficiency	0.80	0.72	0.71

Table 3. Summary statistics for annual values of soil loss predicted by USLE, RUSLE, and WEPP

Parameter	USLE	RUSLE	WEPP
Soil loss			
Avg. measured soil loss (kg/m^2)	3.51	3.51	3.51
Avg. predicted soil loss (kg/m^2)	3.22	3.22	3.29
Avg. magnitude of error (kg/m^2)	2.13	2.00	2.73
Regression results			
Slope	0.59	0.51	0.53
Intercept	1.16	1.45	1.42
Correlation coefficient	0.58	0.62	0.43
Model efficiency	0.58	0.60	0.40

values (table 3) the model efficiencies were found to be lower. WEPP displayed higher model efficiencies for the average annual values (0.71), than yearly soil loss values (0.40). This would be expected since the annual observations inherently display more variability. The average magnitude of error, taken as the average of the absolute value of the errors, was low (2.01 kg/m^2) in case of average annual prediction as compared to 2.73 kg/m^2 in case of annual predictions.

Figures 1 and 2 present plots of measured and WEPP estimated values of soil loss. In both figures it is apparent that WEPP overestimates soil loss for the small values. The plot of error against the measured soil loss (fig. 3) and the regression statistics in tables 2 and 3 confirm that WEPP overestimates low values and underestimates a majority of high values. This is consistent with previous studies using USLE and RUSLE that have shown overestimation on plots with relatively low erosion rates and underestimation

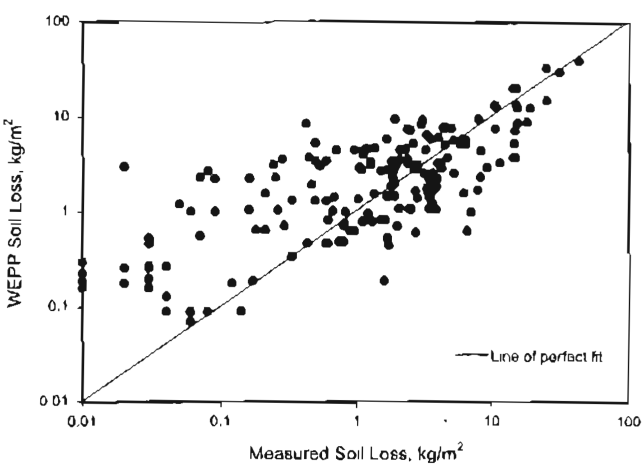

Figure 1–Soil loss on average annual basis measured and predicted by WEPP.

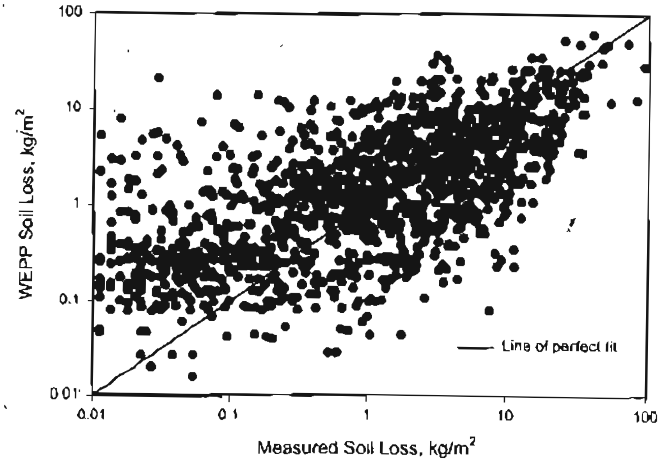

Figure 2–Measured and WEPP predicted values of annual soil loss.

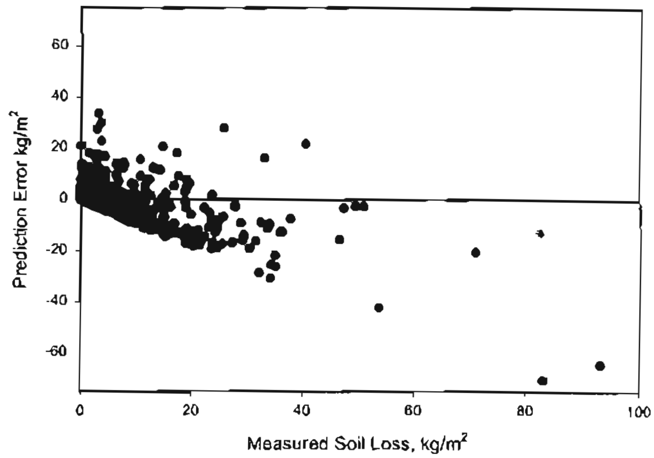

Figure 3–Measured annual soil loss plotted against the difference between the measured and WEPP predicted values.

with high erosion rates. While the phenomenon of erosion models overestimating small events and underestimating large events is inherent to all erosion models (Nearing, 1998), it appears that WEPP may display this characteristic even more than most models. The fact that the model efficiency and correlation coefficient are relatively close for annual as well as average annual values also indicates that WEPP is not consistently over or under predicting.

When comparing USLE and RUSLE with WEPP, the analysis shows that in case of USLE, the Nash and Sutcliffe model efficiency was highest (0.80) followed by 0.72 for RUSLE and 0.71 for WEPP. This indicates that USLE performed slightly better than the two later developments in soil erosion prediction technology for this dataset. The magnitude of error was higher for WEPP (2.01 kg/m^2) than RUSLE (1.23 kg/m^2) or the USLE (1.41 kg/m^2). Table 3 presents similar statistics for annual soil loss predicted by the above models. The comparative higher values of model efficiency of 0.58 in the case of USLE and 0.60 for RUSLE and also the lower magnitude of error being 2.00 to 2.13 kg/m^2 further confirms that the USLE and RUSLE models predicted soil loss better than WEPP for this data. The results seem logical as the analysis involves uniform plots similar to those on which USLE parameters have been developed. The USLE should be very accurate for these conditions. The USLE and RUSLE also used locally derived empirical erodibility parameters as opposed to the erodibility parameters calculated based on soil properties that were used in the WEPP model. A better comparison may have been to use K values in the USLE and RUSLE from the nomograph presented in Wischmeier and Smith (1965). This may have lowered the accuracy of these two models. However, the purpose of our work was to compare the models under conditions similar to how we would expect them to be used in the field. As the WEPP model evolves, these parameters will surely be refined and improved resulting in better predictions. Even under current conditions, when results were compared for individual sites WEPP was found to provide better predictions at some of the sites.

Table 4 presents the average annual soil loss predicted by the USLE, RUSLE, and WEPP for each site. In the case of the USLE, the average magnitude of error varied from 0.04 to 6.93 kg/m^2, for RUSLE it was between 0.02 to 3.76 kg/m^2, and for WEPP it ranged from 0.07 to 3.98 kg/m^2. Out of 20 sites, USLE was found to predict the average value of soil loss over all treatments better at four sites, RUSLE did better at 10 sites, and WEPP was found to be closest on six sites. The Nash and Sutcliffe model efficiency gave almost the same picture as WEPP was found to do better on 40% of the sites when compared individually with USLE.

Table 5 shows the Nash and Sutcliffe model efficiencies for the annual soil loss for all the three models. This had a low variation in the case of RUSLE from −2.88 to 0.82, followed by USLE (−10.54 to 0.85), and in the case of WEPP it varied from −18.05 to 0.94. Thus WEPP exhibited both the worst and best model efficiency. USLE was found to predict soil loss better at nine sites and RUSLE and WEPP predicted best for six and five sites, respectively. No single model was found to predict best at even half of the locations. This comparison has been done irrespective of the land use, crop or crop rotations; however, from the tables, it appears that the sites with low average soil loss resulted in comparatively low model efficiencies. The sites with high average soil loss show some improved prediction.

Figure 4 shows predicted average annual soil loss along with measured average annual soil loss for all three models. The regression lines for USLE and WEPP are much closer to the line of perfect fit than RUSLE. There was no significant difference in the predictive accuracy of the models for the low values of soil loss. However, for the higher values of soil loss, RUSLE deviates much farther from the line of perfect fit. Thus RUSLE, which has a better model efficiency than WEPP, did not produce better results at higher rates of soil loss. This was verified from the magnified view at low values in figure 5. It shows that the regression line for RUSLE meets the line of perfect fit at a value of 2.5 kg/m^2 signifying that RUSLE is over predicting under this value and under predicting over it. For WEPP the regression line meets the line of perfect fit at 4 kg/m^2 and for the USLE the lines meet slightly higher than 4 kg/m^2. This figure shows that there is not much

Table 4. Average annual soil loss predicted by USLE, RUSLE, and WEPP at different sites

Sites	Plot Years	Av. Soil Loss (kg/m^2)	USLE Soil Loss (kg/m^2)	RUSLE Soil Loss (kg/m^2)	WEPP Soil Loss (kg/m^2)
Bethany	90	5.77	**2.38***	2.01	**2.38**
Castana	44	7.65	14.58	**10.23**	11.63
Clarinda	117	5.50	4.72	**6.01**	4.17
Clemson	6	5.79	8.18	8.36	**5.72**
Dixon Springs	96	2.09	**2.05**	2.18	4.03
Geneva	57	2.29	2.08	**2.20**	0.84
Guthrie	153	2.26	2.85	**2.02**	3.45
Hayes	88	0.31	0.67	0.47	**0.46**
Hollyspring	24	8.88	10.97	11.49	**6.98**
Ithaca	79	0.65	0.91	**0.67**	4.10
Lacrosse	234	6.60	5.44	4.68	**5.65**
Madison	72	1.71	1.20	**1.29**	1.10
Marcellus	79	2.40	3.23	**1.72**	1.22
Morris	40	1.80	**1.88**	1.91	1.03
Presque	45	1.99	1.50	**1.85**	3.10
Raleigh	10	0.71	2.50	1.47	**0.79**
Statesville	72	5.41	11.99	**7.25**	1.65
Temple	105	2.88	2.62	3.14	**2.65**
Tifton	64	0.36	0.76	**0.54**	1.80
Watkinsville	119	3.21	**2.88**	1.30	5.64

* Value in bold indicates predicted value closest to the observed value.

Table 5. Nash and Sutcliffe Model efficiencies for annual soil loss for USLE, RUSLE, and WEPP at different sites

Sites	Plot Years	Av. Soil Loss (kg/m^2)	USLE Model Efficiency	RUSLE Model Efficiency	WEPP Model Efficiency
Bethany	90	5.77	0.73	0.73	0.40
Castana	44	7.65	0.30	0.77	0.23
Clarinda	117	5.50	0.30	0.48	0.28
Clemson	6	5.79	0.81	0.76	0.94
Dixon Springs	96	2.09	0.10	0.34	−10.58
Geneva	57	2.29	0.69	0.65	0.16
Guthrie	153	2.26	0.32	0.31	0.14
Hayes	88	0.31	0.28	0.39	−0.95
HollySprings	24	8.88	0.85	0.82	0.47
Ithaca	79	0.65	0.48	0.30	−37.74
Lacrosse	234	6.60	0.66	0.60	0.68
Madison	72	1.71	0.38	0.33	0.54
Marcellus	79	2.40	0.80	0.64	0.37
Morris	40	1.80	0.73	0.56	0.45
Presque	45	1.99	−0.50	0.48	−0.42
Raleigh	10	0.71	−10.54	−2.88	−0.004
Statesville	72	5.41	0.19	0.25	−0.21
Temple	105	2.88	0.39	0.44	0.38
Tifton	64	0.36	−0.31	−0.82	−18.05
Watkinsville	119	3.21	−1.53	−0.54	0.15

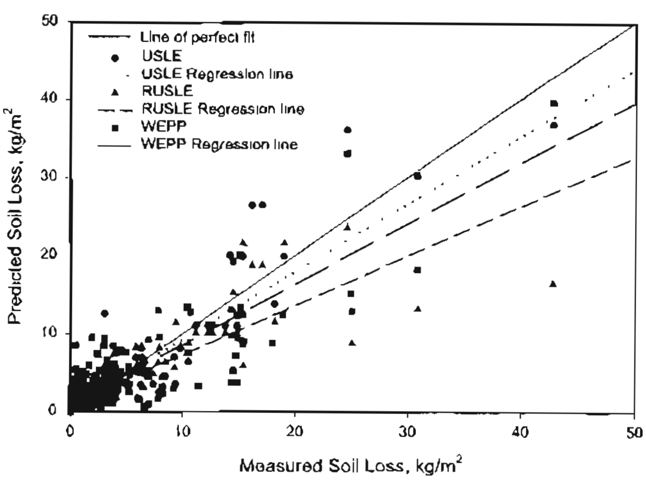

Figure 4–Average annual soil loss comparison of measured and predicted values from USLE, RUSLE, and WEPP.

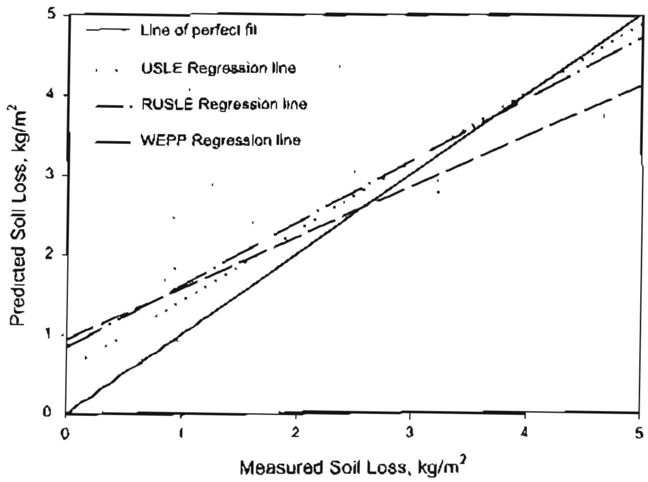

Figure 5–Average annual soil loss comparison of regression results from three models for low values of annual soil loss.

difference in predictive accuracy for the lower values of soil loss in all three models, however, for the higher values USLE and WEPP tend to produce better predictions. A similar trend was found when the data was analyzed on an annual basis for all plots.

In investigating the sources of error in WEPP, we found that for 85% of sites the model predicted well (model efficiency > 0.77). While WEPP tended to overpredict erosion on all plots, it significantly overpredicted soil loss at Tifton, Dixon Springs, and Ithaca. Figure 6 shows the measured and predicted soil loss at Tifton. It is apparent that the model overpredicted soil loss; however, predicted values follow a trend nearly parallel to the line of perfect fit. This seems to indicate that refining the procedures to estimate the WEPP parameters such as the erodibilities and hydraulic conductivity could improve model predictions. At Castana, an attempt was made to change the single parameter of hydraulic conductivity from 1.31 to 2.62 and it was found that the model efficiency rose from 0.34 to 0.95. This shows the sensitivity of WEPP to these parameters and the need for their further refinements or calibration.

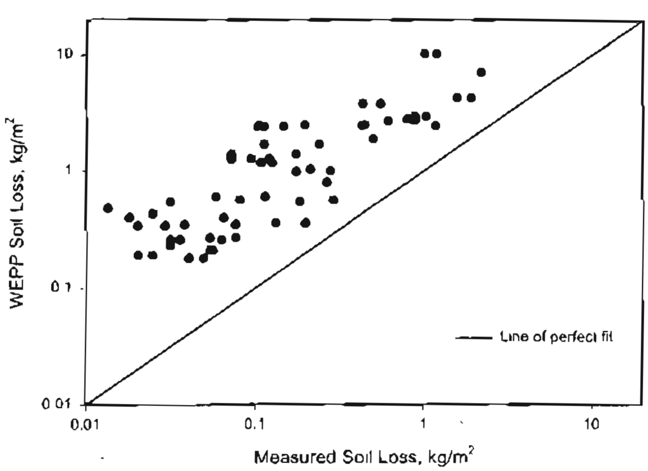

Figure 6–Measured and WEPP predicted values of annual soil loss at Tifton, Georgia.

Conclusions

The WEPP model predictions were compared with the measured natural runoff plot data. The WEPP model recorded a model efficiency of 0.71 in terms of average annual soil loss with average magnitude of error 2.01 kg/m^2. On an annual basis the model efficiency was 0.40 with an average magnitude of error of 2.73 kg/m^2. The phenomenon of overestimating the low values of measured soil loss and underpredicting the high values is inherent to all erosion models and these results show that WEPP is no exception to it. The model was compared with previous results from the USLE and RUSLE and it was found to be comparable to them. When WEPP was compared to USLE predictions on an average annual basis, it was found to improve the results at 40% of the selected sites. In general, the model efficiencies were low at sites with low average soil loss; whereas, the sites with high average soil loss showed some improved prediction. All of the models performed similarly at the low values of soil loss. However, USLE and WEPP were more suitable in the higher ranges.

While overall WEPP did not perform as well as the USLE, it did perform as good or better at 85% of the sites. This should be viewed as success considering the data set was biased toward the USLE (all uniform natural runoff plots), the parameters used in the USLE have undergone more refinement, and the WEPP model was not calibrated at all. WEPP represents a new generation of technology that needs further refinements and modification in deriving the basic input parameters. The WEPP model derives its strength from being a process based model and has the capability to predict spatial and temporal distribution of soil loss and deposition. It provides explicit estimates of when and where erosion is occurring so that conservation measures can be designed to most effectively control the sediment yield. This is the real advantage of this process based erosion model. Nevertheless, this study indicates that the model performs nearly as well as traditional empirical methods without calibration of any parameters.

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