The WEPP Watershed Model: III. Comparisons to Measured Data from Small Watersheds

B. Y. Liu, M. A. Nearing, C. Baffaut, J. C. Ascough II

Abstract. *The Water Erosion Prediction Project (WEPP) watershed scale model was developed by the USDA for purposes of erosion assessment and conservation planning. The purpose of this study was to evaluate the WEPP watershed model applicability and prediction accuracy for small watersheds (0.34-5.14 ha) under different climate, topography, soil, and management regimes. No calibration was conducted to obtain the results. Only default model parameters were used. Data from 15 watersheds in six U.S. locations were compared to runoff and sediment yield estimates using WEPP95. The r^2 values between measured and predicted total runoff and sediment yield for the 15 watersheds were 0.86 and 0.91, respectively. The r^2 between measured and predicted event data for individual watersheds ranged from 0.01 to 0.85 for runoff and from 0.02 to 0.90 for sediment. Cumulative frequency distributions for predicted values of event runoff and sediment matched those for measured values with some exceptions. Improvements in the WEPP model are suggested where limitations were observed.*

Keywords. *Hydrology, Modeling, Runoff, Soil erosion, Watersheds, WEPP.*

The Water Erosion Prediction Project (WEPP) model is process-based erosion prediction technology designed to assess environmental and anthropogenic impacts on soil erosion by water (Lane and Nearing, 1989; Nearing et al., 1989; Flanagan and Nearing, 1995). The watershed version of WEPP simulates a series of processes, including the following: erosion on hillslopes; soil detachment, transport and deposition in channels; sediment deposition in impoundments; and watershed runoff and sediment yield under different land use and environmental conditions (Ascough et al., 1997).

Model evaluation is an important step in developing a model. The evaluation process may include several steps, including the sensitivity of model response to perturbations of input values; evaluation of confidence limits, and comparison of model predictions to measured data. Several sensitivity analyses and evaluation studies have completed on the WEPP hillslope version (Nearing et al., 1990; Chaves and Nearing, 1991; Flanagan and Nearing, 1991; Tiscareno-Lopez et al., 1993; Deer-Ascough, 1995). For watershed applications, Tiscareno-Lopez et al. (1994) conducted a study for rangeland conditions and Baffaut et al. (1997) conducted sensitivity tests for cropland applications. Zhang et al. (1996) presented comparisons between model results and measured soil loss data for hillslope applications, and several studies have been conducted to compare hillslope runoff predictions to measured plot runoff data (Risse et al., 1994, 1995a,b; Zhang et al., 1995a,b; Nearing et al., 1996). Only limited efforts (Savabi et al., 1996; Nearing and Nicks, 1997), however, have been made to evaluate the accuracy of WEPP watershed model predictions by comparing predicted results to measured data.

The objective of this study was to evaluate the WEPP watershed model predictions of runoff and sediment yields relative to measured small watershed data using default equations for soil infiltration and erodibility parameter estimation. Comparisons between measured and predicted runoff and sediment yield were made for: (1) total amounts for each watershed; (2) individual storm events; and (3) storm event distributions.

Materials and Methods

Input Files

Fifteen small watersheds ranging in size from 0.34 to 5.14 ha from six locations were used in this study (table 1). Land uses for these watersheds included conventionally managed row crop rotations, no-till corn, and meadow. To run the WEPP watershed model, information was needed on weather, soils, management, topography, channel geometry, and channel outlet structures. Each watershed was divided into hillslope and channel elements with uniform soil, management, and general over-land flow direction. All of this information was compiled into six to eight input files, including weather, soil, management, slope, channel, irrigation, and watershed structure files. Because the watersheds were not large, we used a single weather file for each watershed. All the input files were set up for WEPP95 format, which was described by Ascough et al. (1997) and evaluated by Baffaut et al. (1997).

Weather Input Files. WEPP weather input files contain values for 10 daily parameters. The four precipitation parameters are precipitation amount and duration, peak 5-min rainfall intensity, and time to peak intensity, which

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The authors are **Bao Y. Liu**, Scientist, **Mark A. Nearing,** ***ASAE Member Engineer***, Scientist, and **Claire Baffaut**, Scientist, National Soil Erosion Research Laboratory, USDA-ARS, West Lafayette, Ind.; and **James C. Ascough II,** ***ASAE Member Engineer***, Agricultural Engineer, Great Plains Systems Research Units, USDA-ARS, Fort Collins, Colo. **Corresponding author:** Mark A. Nearing, NSERL, USDA-ARS-MWA, 1196 Soil Building, West Lafayette, IN 47907-1196; tel.: (765) 494-8697; fax: (765) 494-5948; e-mail: <nearing@ecn.purdue.edu>.

Table 1. Watersheds selected for WEPP watershed model validation

Watershed	Area (ha)	Site*	Years	Slope (%)	Management
C-5	5.14	Chickasha, Okla.	1971-74	0.5 - 1	Winter wheat
109	0.68	Coshocton, Ohio	1979-89	9 - 15.6	Corn, soybean, wheat, meadow†
191	0.49	Coshocton, Ohio	1979-89	4 - 16	No-till corn†
130	0.66	Coshocton, Ohio	1987-93	15.8 - 29.0	Meadow
1	1.57	Holly Springs, Miss.	1970-77	5.1 - 14.2	Soybean, meadow
2	0.59	Holly Springs, Miss.	1970-77	6.2 - 10.9	Corn, wheat, soybean
3	0.65	Holly Springs, Miss.	1970-77	4.9 - 9.8	Corn, wheat, soybean
W-12	4.01	Riesel, Tex.	1987-92	1 - 2.7	Wheat, corn, sorghum†
W-13	4.57	Riesel, Tex.	1987-92	1.3	Wheat, corn, sorghum†
SW-12	1.20	Riesel, Tex.	1987-92	2.7 - 3.8	Bermuda grass
Z	0.34	Tifton, Ga.	1969-86	3.6	Corn, oats, peanuts, soybeans, rye
P-1	2.70	Watkinsville, Ga.	1972-82	2 - 7	Wheat, sorghum, barley, soybeans, clover
P-2	1.29	Watkinsville, Ga.	1973-75	1.6 - 4.5	Corn, bermuda grass
P-3	1.26	Watkinsville, Ga.	1972-82	3	Sorghum, barley, soybeans, rye
P-4	1.40	Watkinsville, Ga.	1973-82	3	Barley, soybeans, rye, corn, wheat

* Soils on these six sites were:
Chickasha: McLain silty clay loam, silt loam and Reinach silt loam.
Coshocton: Berks shaly silt loam, Rayne silt loam.
Holly Springs: Grenada silt loam.
Riesel: Heiden silty clay.
Tifton: Cowarts sandy loam.
Watkinsville: Cecil sandy loam and sandy clay loam.
† Contoured (other watersheds were not contoured).

were calculated using break point precipitation data for all watersheds except the P3 and P4 watersheds at Watkinsville, Georgia. Precipitation amount was available, but break point data were not available for these two watersheds. In this case we used the total daily precipitation and duration for P3 and P4, and used data from the P1 watershed for peak rainfall intensity and time to peak intensity. Watersheds P3 and P4 were located approximately 3.5 km from the P1 watershed.

The other six daily weather parameters (i.e., maximum and minimum temperatures, solar radiation, wind velocity and direction, and dew point temperature) were generated by the WEPP weather generator, CLIGEN (Nicks et al., 1995). In addition, the rainfall data for the watershed in Tifton, Georgia, were recorded every 5 min in 2.54 mm (0.1 in.) increments. Thus, the accuracy of total storm duration and maximum 5-min intensities for each storm were not as precise as for the other locations.

Slope Input Files. Topographic maps from location publications were used to develop slope input files for hillslopes and channels.

Management Input Files. Tillage and crop management information were entered into the plant/management files according to the field operation notes. These data included tillage equipment and date of use, planting date, type of crop, harvest date, residue management, etc. Most of the plant specific parameters used were WEPP default values at the medium (average) productivity level. The WEPP95 model contained default data for wheat, corn, soybeans, alfalfa (meadow), sorghum, rye, and peanuts. Parameters for barley and Bermuda grass were derived using the Crop Parameter Intelligent Database System (Deer-Ascough et al., 1995) and by modifying data from the WEPP database for wheat and rye grass, respectively. All of the plant growth output of the model was checked to be sure that the model was growing appropriate biomass and yields for the crops at their respective locations. Experience in this exercise indicated that minor adjustments to the biomass conversion factor was necessary in some cases for the model to generate appropriate production levels. In other words, the plant growth parameters were somewhat location dependent.

Soil Input Files. Soil characteristics, including percent of sand, clay, organic matter, rock fragment fraction, and cation exchange capacity were obtained from measured data in location records. Three baseline soil erodibility parameters (interrill, rill, and critical shear stress) and the Green and Ampt (1911) effective hydraulic infiltration values of the soils were estimated using the WEPP default estimation procedures (Flanagan and Nearing, 1995). An exception was the Grenada silt loam soil in Holly Springs, Mississippi, for which previous studies showed that the estimated infiltration parameter did not produce reasonable results for fallow field plot data (Risse et al., 1995a). We used the optimized value of 0.70 mm/h resulting from those plot scale studies.

Channel Input Files. Channel parameters varied from watershed to watershed, and from channel to channel. WEPP has an option for peak runoff calculation, and we used the method from EPIC (Ascough et al., 1997), which is the preferred option for small watersheds. We also used the WEPP option of setting friction slope equal to channel bed slope (Ascough et al., 1997). The channel erodibility and critical shear stress values used were WEPP default estimated values, which are derived in the same way as the WEPP erodibility values. The bare soil and total Manning roughness coefficients were taken from Table II-28 of the CREAMS document (Foster et al., 1980).

Irrigation Input File. Only the Z watershed at Tifton, Georgia, was irrigated. The actual dates and irrigation amounts were entered in WEPP "Fixed-Date Irrigation Scheduling" format.

Structure Input Files. Structure files provide the water and sediment routing linkages for the WEPP watershed components. The watershed structure files were created based upon topographic maps according to how the watershed was divided into hillslope and channel elements, and the direction of runoff between elements.

Analyses

Analyses were conducted on selected storm events for each watershed. Every storm result from the data set was used unless the predicted event occurred during winter when no measured data were collected. Three types of analyses were made on the results of the study, and they were based on: (1) total runoff and sediment yield for the selected events; (2) event-by-event comparisons; and (3) cumulative frequency distributions for event runoffs and sediment yields. Total sediment values are important in terms of erosion prediction for such purposes as understanding long term effects of erosion on soil loss and sedimentation on the site, sedimentation and filling of reservoirs and stream channels, and long-term erosion inventories. Event-by-event comparisons may be important if the user is interested in the predictions for individual storms. Perhaps more important for model usage than the event-by-event comparisons is whether the sequence of event predictions is statistically representative of natural events for a watershed. WEPP may be used for either representing historical conditions or for future predictions.

When the model is used for future prediction purposes, the expected mode of application is the use of CLIGEN to create weather sequences which are statistically representative of historical data at a location. In this mode of application, event-by-event predictions of runoff and erosion are not relevant because the individual storms are synthetically generated. But the probability distributions of event runoff and erosion are certainly relevant and interesting for conservation planning purposes.

With regard to comparisons of both total and event-by-event runoff and sediment yields, we plotted predicted vs. measured runoff and sediment yield and calculated the best-fit regression line as an indicator of fit. Total values were first normalized to the number of selected events for each watershed, since the number of events per site was quite variable. The slope and intercept of the regression line indicate potential bias for the model predictions, while the coefficient of determination, r^2, of the regression analysis is an indicator of variance about the best-fit line.

Predicted and measured event distributions were compared statistically and visually. Mean, variance, and skewness values were computed and tabulated for both measured and predicted values at each site. Predicted and measured mean values were compared using the student t-test, a Duncan test, and a Tukey test. Equivalence of variance was also evaluated with the t-test.

For visual comparisons, we sorted the runoff and sediment yield values from small to large, then assigned a rank to each event beginning from one. In other words, we used a cumulative frequency curve of predicted and measured values. In each case, only events greater than zero were used in the rankings for the measured data. We then divided the ranking number by total event number to normalize ranks. Normalized ranks were plotted on the y-axis and either runoff or sediment yield on the x-axis.

Table 2. Total runoff and sediment yields

Watershed	Runoff (mm) Measured	Runoff (mm) Predicted	Sediment Yield (t/ha) Measured	Sediment Yield (t/ha) Predicted	Number of Years of Record	Total No. of Selected Events
Chickasha C5, Okla.	320	309	4.27	3.81	4	34
Coshocton 109, Ohio	25	26	1.99	1.02	11	4
Coshocton 130, Ohio	49	30	0.036	1.11	7	6
Coshocton 191, Ohio	20	20	0.055	0.035	11	3
Holly Springs 1, Miss.	3409	2820	64.7	153.7	8	237
Holly Springs 2, Miss.	3576	2658	65.9	121.8	8	241
Holly Springs 3, Miss.	2858	2600	94.0	141.6	8	241
Riesel SW-12, Tex.	1086	940	--	3.88	6	57*
Riesel W-12, Tex.	833	860	15.77	9.61	6	117
Riesel W-13, Tex.	879	920	10.38	8.05	6	83
Tifton Z, Ga.	403	332	6.67	8.31	8	46
Watkinsville P-1, Ga.	596	567	53.9	67.6	11	33
Watkinsville P-2, Ga.	377	359	17.40	18.18	3	21
Watkinsville P-3, Ga.	518	614	9.74	8.51	11	35
Watkinsville P-4, Ga.	529	541	5.96	7.50	10	36

* Sediment data were not available for the SW-12 watershed.

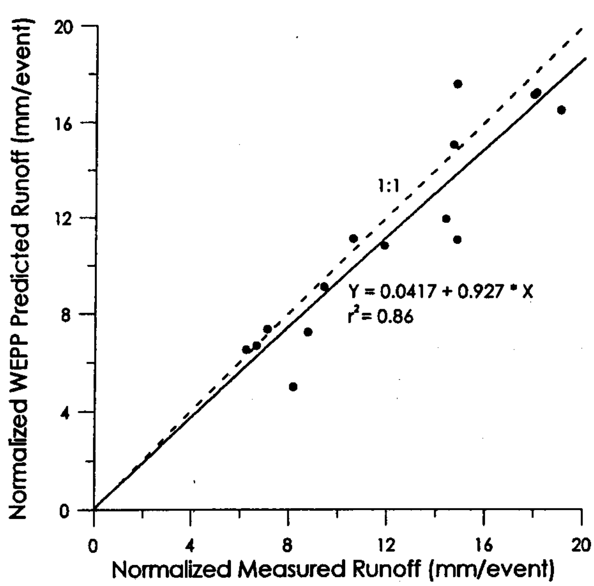


Figure 1–Measured vs WEPP-predicted normalized total runoff for the 15 watersheds. Total runoff values were the sum of the values for the selected events, and totals were normalized to the number of storm events (table 2).

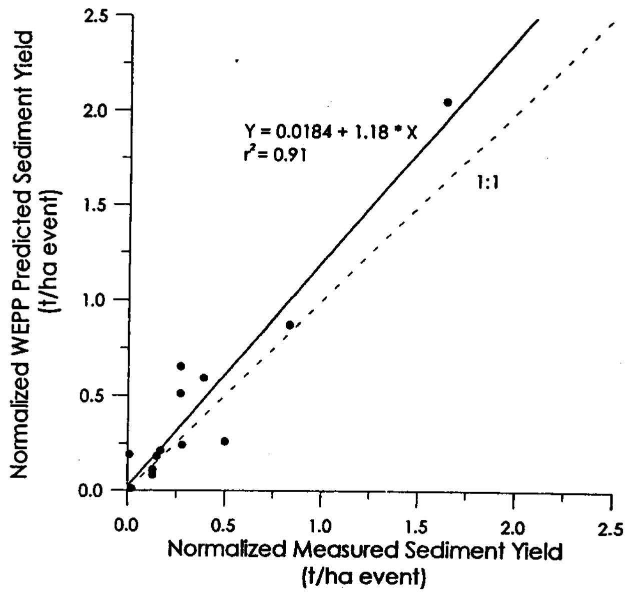


Figure 2–Measured vs WEPP-predicted normalized total sediment yield for the 15 watersheds. Total sediment yield values were the sum of the values for the selected events, and totals were normalized to the number of storm events (table 2).

Table 3. Results for regression between measured and predicted event values of runoff and sediment yield

Watershed	Runoff r^2	Runoff Intercept	Runoff Slope	Sediment Yield r^2	Sediment Yield Intercept	Sediment Yield Slope	No. of Events
Chickasha C5, Okla.	0.54	1.67	0.79	0.81	0.00	0.90	34
Coshocton 109, Ohio	0.14	4.71	0.27	0.09	0.24	0.03	4
Coshocton 130, Ohio	0.01	3.70	0.17	0.20	0.08	17.61	6
Coshocton 191, Ohio	0.11	9.14	–0.36	0.88	0.02	–0.50	3
Holly Springs 1, Miss.	0.78	1.37	0.73	0.74	0.38	0.98	237
Holly Springs 2, Miss.	0.80	1.25	0.66	0.78	0.30	0.75	241
Holly Springs 3, Miss.	0.79	1.74	0.76	0.73	0.27	0.81	241
Riesel SW-12, Tex.	0.68	1.98	0.76	NA	NA	NA	57*
Riesel W-12, Tex.	0.69	2.34	0.70	0.02	0.07	0.09	117
Riesel W-13, Tex.	0.65	1.54	0.90	0.14	0.05	0.39	83
Tifton Z, Ga.	0.41	4.24	0.34	0.14	0.16	0.17	46
Watkinsville P-1, Ga.	0.71	5.03	0.67	0.49	0.88	0.72	33
Watkinsville P-2, Ga.	0.85	3.50	0.84	0.89	0.35	0.62	21
Watkinsville P-3, Ga.	0.75	0.96	1.12	0.64	0.09	0.57	35
Watkinsville P-4, Ga.	0.75	1.39	0.93	0.90	0.05	0.93	36
Combined data	0.74	1.91	0.73	0.71	0.23	0.82	1194 (1137)*

* Sediment data was not available for the SW-12 watershed.

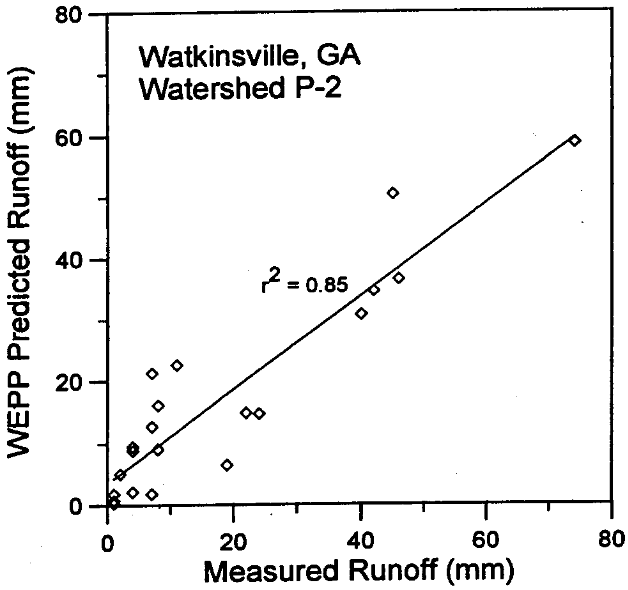
Results and Discussion

Total Runoff and Sediment Yield Predictions

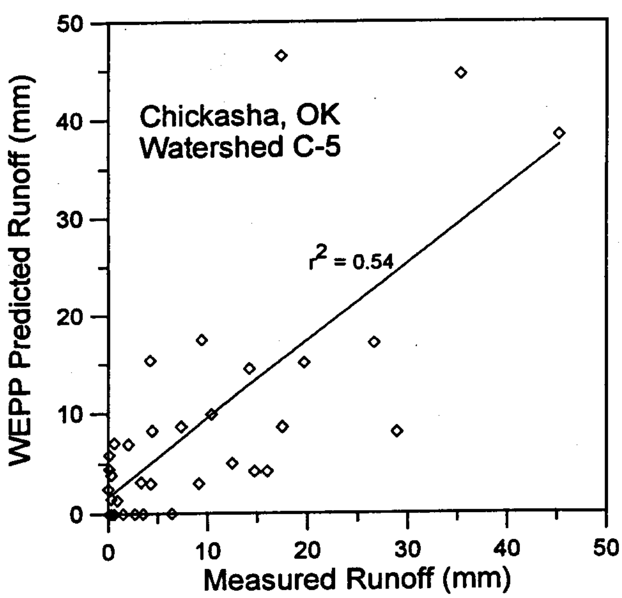
Table 2 shows the comparison of measured and WEPP predicted total runoff and sediment yields. Measured versus WEPP-predicted normalized total runoff and sediment yield for the 15 watersheds are plotted in figures 1 and 2, respectively. Total runoff and sediment yield values were the sum of the values for the selected events, and totals were normalized to the number of storm events (table 2). The major problems for the model in terms of total sediment yield appeared to be for the three Holly Springs watersheds and watershed 130 at Coshocton, where sediment was overpredicted, and for watershed 109 at Coshocton, where sediment was significantly underpredicted. This result was exhibited in both total sediment (table 2) and in normalized sediment results (fig. 2). WEPP predicted greater than 0.5 t/ha event for normalized sediment yield for the three Holly Springs watersheds, whereas measured data was less than 0.5 t/ha event for all three. The Coshocton 130 watershed had a normalized sediment yield of 0.006 t/ha event, whereas the predicted value was 0.19 t/ha event. The Coshocton 109 watershed, which had a normalized sediment yield of 0.50 t/ha event, was underpredicted by approximately 50%.

WEPP overpredicted sediment yield by a factor of approximately two for the Holly Springs watersheds. This may be due to the fact that at Holly Springs in several years the corn was cut for silage. When the silage option in WEPP is used the model assumes a 95% biomass removal, whereas the actual removal rates were much lower at Holly Springs (Keith McGregor, personal communication). Also, weed growth after harvest at Holly Springs was substantial, and WEPP does not have a specific weed growth option. Another possibility for the prediction bias for the Holly Springs application could be a problem with erodibility parameterization. However, the results from the study of Zhang et al. (1996), which included the application of WEPP to plot data from Holly Springs, do not bear this out. In that study, the fallow plot had a measured erosion rate of 170 kg/ha year, and WEPP predicted 161 kg/ha year. The row cropped plots from Holly Springs, however, were overpredicted by a factor of 2 to 4 (Zhang, personal communication). These results would indicate a problem with the WEPP application at Holly Springs associated with cropping routines rather than soil parameters. The evaluations at Holly Springs point to a need for model improvement for both weed growth and silage options.

The Coshocton watersheds produced small amounts of sediment. In general, experience has shown that other erosion models including the USLE (Risse et al., 1993), RUSLE (Rapp, 1995), and WEPP hillslope (Zhang et al., 1996; Nearing and Nicks, 1997) tend to produce large errors on a percentage basis for low erosion rates. The



(a)



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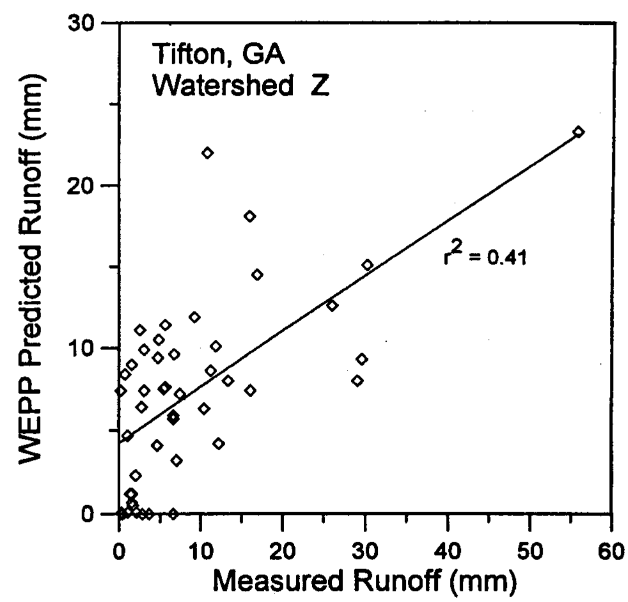


(c)

Figure 3–Measured vs WEPP-predicted storm-by storm runoff: (a) Watkinsville, Ga., P-2; (b) Chickasha, Okla., C-5; (c) Tifton, Ga., Z.

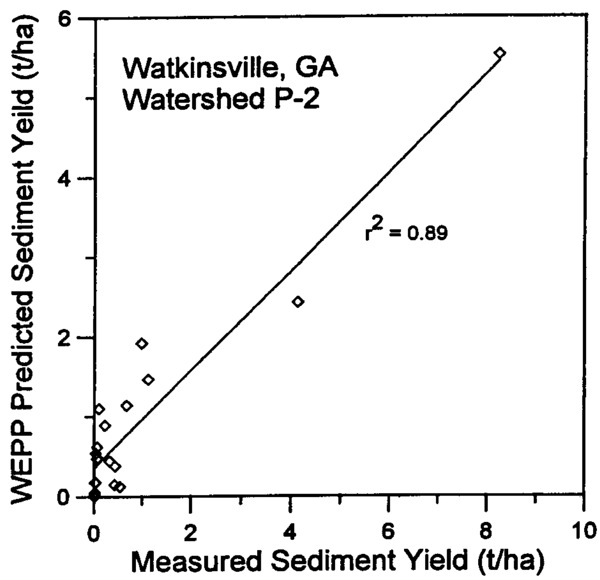
reason for this is that there tend to be fewer events measured at such sites and that there is more natural variability in terms of relative amounts for small events. The Coshocton watersheds had only three to six measured runoff events for the three watersheds. The absolute values of the errors for these two watersheds are within the range of absolute errors for the remainder of the watersheds, and the total erosion for the three Coshocton watersheds are the least of all the watersheds for both the measured and predicted case. We conclude that WEPP performed as well as could be expected for the Coshocton site, given the nature and quantity of the data used.

Event by Event Predictions

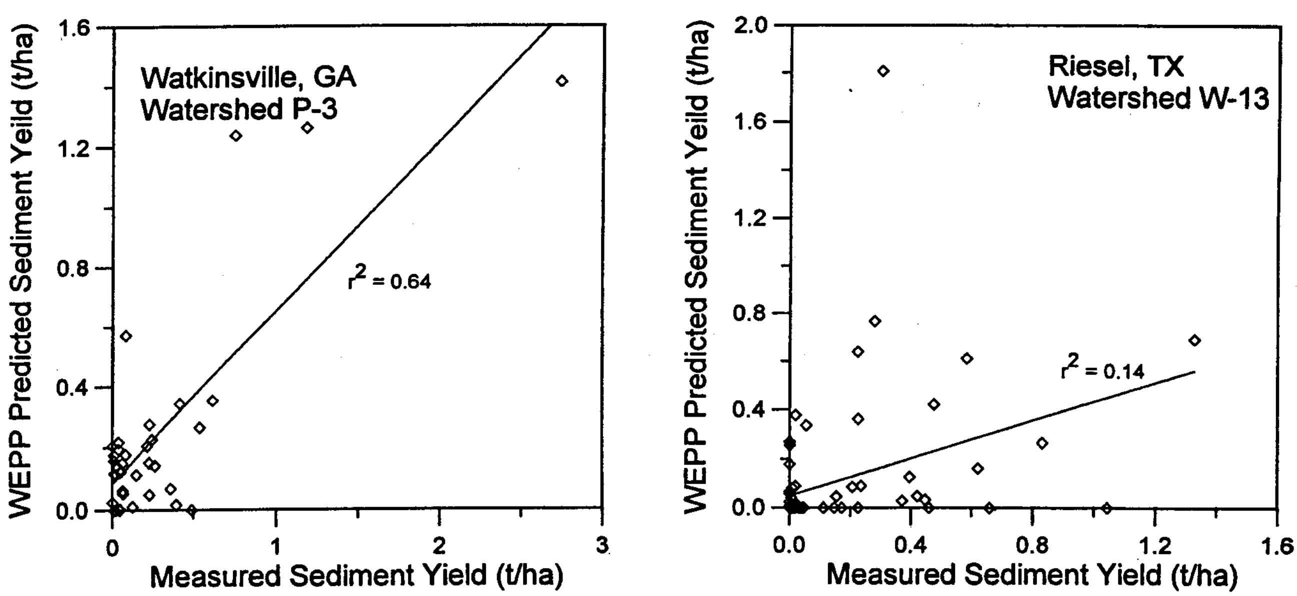
Regression results for the analyses of predicted versus measured event runoff and soil loss values are presented in the table 3. Selected graphs of measured vs. predicted runoff and sediment yield are shown in figures 3 and 4, respectively. The three examples shown represent good ($r^2 > 0.7$), medium ($0.5 < r^2 < 0.7$), and low ($r^2 < 0.5$) cases of predictions for both runoff and sediment yield. For all event data points combined, WEPP predicted an r^2 of 0.74 and 0.71 for runoff and sediment yield, respectively (table 3).

There were five watersheds for which the fit between measured and predicted sediment yield was very poor ($r^2 \leq 0.2$). One was the Tifton Z watershed. This lack of fit might be due to the poor definition of rainfall intensity information for that site, as discussed above in the methods section. Three of the other four watersheds, including Coshocton 109 and Riesel W-12 and W-13, were contoured. The linkage between hillslope sediment routing and channel sediment routing routines in WEPP, including overtopping of contours, could be a factor in these results, and should be further studied.

It is interesting to note that even though the total sediment yield for all three watersheds at Holly Springs, Mississippi, was overpredicted, the regression line between measured and predicted event sediment yield for events did not exceed unity for any of the three. This would indicate that the overprediction at Holly Springs was due to an overprediction bias for low magnitude erosion events, which is supported by the log-log graph of measured versus predicted sediment yield for Watershed 1 at Holly Springs, Mississippi (fig. 5). This result is further indication that there may be a problem with the model's ability to represent the plant and cover relationships at the Holly Springs site. Calibration of the model via the adjustment of erodibility parameters would lower the value for average erosion at the Holly Springs watersheds, but



(a)



(b) (c)

Figure 4–Measured vs WEPP-predicted storm-by-storm sediment yield: (a) Watkinsville, Ga., P-2; (b) Watkinsville, Ga., P-3; (c) Riesel, Tex., W-13.

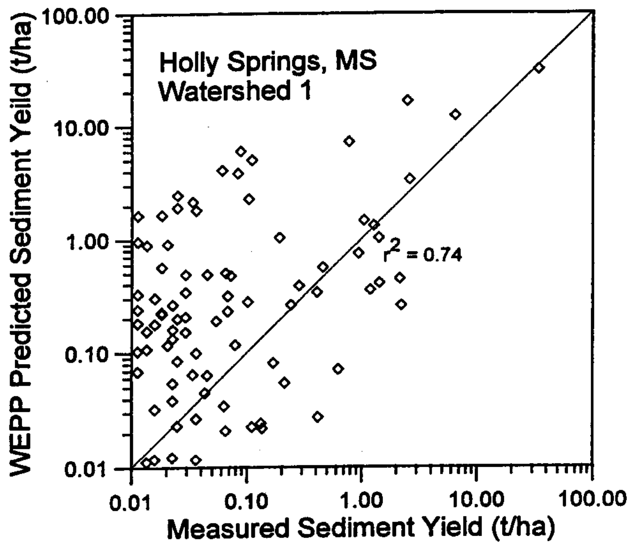


Figure 5–Measured vs predicted sediment yield on a log-log scale for Watershed 1 at Holly Springs, Mississippi.

would not alleviate the bias in sediment yield for the smaller events.

Overall results for measured versus predicted event runoff and sediment yield suggest caution in using the WEPP model for evaluating runoff or sediment yield for individual rainfalls. Prediction errors for individual storms are often quite large, and the fit between measured and predicted data are poor for certain watersheds. This is not to suggest that WEPP necessarily performs more poorly than do other models, but is rather a reinforcement of the knowledge that erosion predictions in general contain large factors of error. The error for individual storm predictions for this study are certainly not greater than errors shown for other models, such as the USLE (Risse et al., 1993), RUSLE (Rapp, 1995) or the WEPP hillslope model (Zhang et al., 1996; Nearing and Nicks, 1997).

Comparison of the Distributions

Means, standard deviations, and skewnesses for measured and predicted runoff and sediment yield for each watershed are presented in tables 4 and 5. In general, differences in mean values for event runoff and sediment yield between measured and predicted values were not detected in the data, with the exception of the runoff for watershed 2 at Holly Springs. The lack of statistical difference in the means was due to the large variances in the event data which mask differences in the means. The parameters reported here which describe the shape of the distributions are the standard deviation and skewness. For runoff, the WEPP distributions had a significantly different standard deviation for the Tifton Z watershed. There was also a large difference, 2.5 versus 0.8, for the skewness values between measured and predicted distributions for the Tifton data. For sediment yield, the WEPP predicted a standard deviation which was significantly less than for the measured data for the Riesel S-12 and Tifton Z watersheds. As for the case of runoff, the skewness difference at Tifton was also large: 5.7 for the measured and 0.9 for the predicted.

Table 4. Statistical parameters for event runoff data*

Watershed	Measured Data			WEPP Predicted Data		
	$\bar{x}$	SD	Skew	$\bar{x}$	SD	Skew
Chickasha C5, Okla.	9.40	11.17	1.6	9.09	11.99	2.2
Coshocton 109, Ohio	6.35	NA	NA	6.42	NA	NA
Coshocton 130, Ohio	8.17	NA	NA	5.07	NA	NA
Coshocton 191, Ohio	6.57	NA	NA	6.80	NA	NA
Holly Springs 1, Miss.	14.38	17.13	2.3	11.90	14.22	2.5
Holly Springs 2, Miss.	14.84†	18.74	2.7	11.03†	13.80	2.7
Holly Springs 3, Miss.	11.86	16.03	2.6	10.79	13.80	2.7
Riesel SW-12, Tex.	19.05	20.83	2.2	16.50	19.28	1.9
Riesel W-12, Tex.	7.12	11.79	2.7	7.35	9.94	2.2
Riesel W-13, Tex.	10.59	12.98	1.9	11.08	14.45	2.0
Tifton Z, Ga.	8.76	10.64†	2.5	7.22	5.65†	0.8
Watkinsville P-1, Ga.	18.06	17.42	1.9	17.17	13.86	1.1
Watkinsville P-2, Ga.	17.95	20.11	1.4	17.10	16.54	1.2
Watkinsville P-3, Ga.	14.80	12.62	1.2	17.53	16.34	1.3
Watkinsville P-4, Ga.	14.69	15.08	1.5	15.03	16.17	1.2

* Means were tested using student t-test, Duncan's, and Tukey's comparison of means, all of which gave the same decision results of hypothesis testing at $\alpha = 0.05$. Standard deviations were compared using the t-test. Measured and predicted means and standard deviations were not statistically different at the 95% confidence level unless otherwise marked. Standard deviations and skewness are not reported for data sets which numbered less than 10.

† Measured and predicted means or standard deviations were statistically different at the 95% confidence level.

Table 5. Statistical parameters for event sediment yield data*

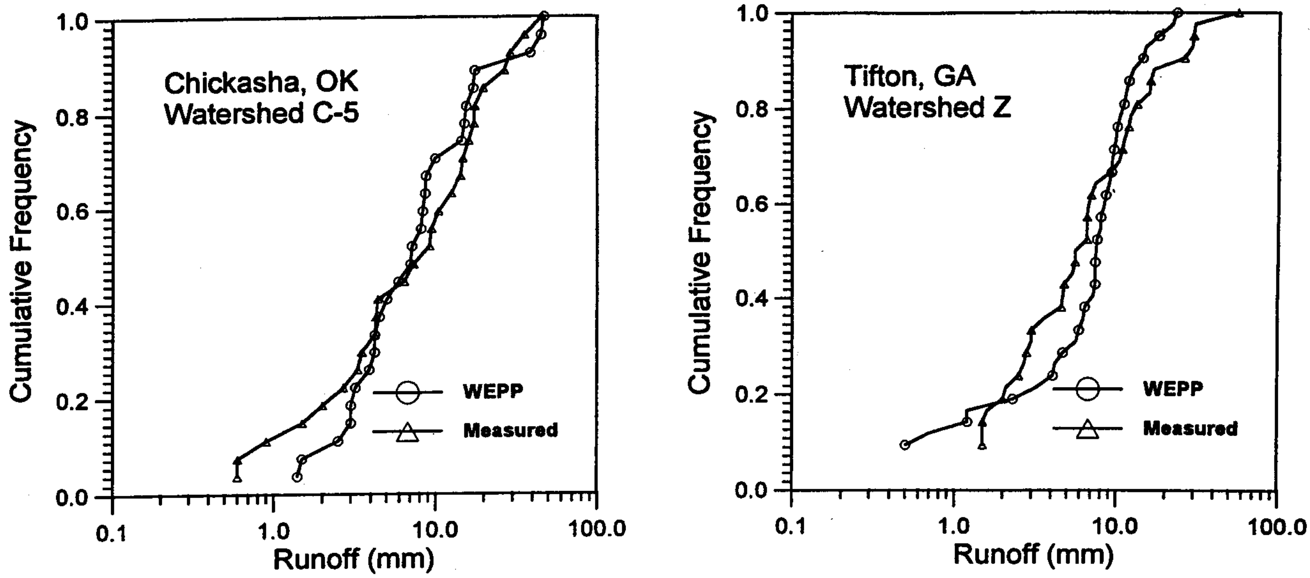
Watershed	Measured Data			WEPP Predicted Data		
	$\bar{x}$	SD	Skew	$\bar{x}$	SD	Skew
Chickasha C5, Okla.	0.125	0.325	4.4	0.112	0.327	4.6
Coshocton 109, Ohio	0.498	NA	NA	0.254	NA	NA
Coshocton 130, Ohio	0.006	NA	NA	0.184	NA	NA
Coshocton 191, Ohio	0.018	NA	NA	0.012	NA	NA
Holly Springs 1, Miss.	0.273	2.252	14.2	0.648	2.572	9.1
Holly Springs 2, Miss.	0.274	2.454	14.5	0.505	2.080	9.9
Holly Springs 3, Miss.	0.390	2.682	11.6	0.588	2.551	7.9
Riesel W-12, Tex.	0.135	0.413†	4.9	0.082	0.260†	5.3
Riesel W-13, Tex.	0.125	0.247	2.7	0.097	0.253	4.5
Tifton Z, Ga.	0.145	0.411†	5.7	0.181	0.154†	0.9
Watkinsville P-1, Ga.	1.634	3.781	3.4	2.049	3.856	2.8
Watkinsville P-2, Ga.	0.828	1.921	3:4	0.866	1.253	2.9
Watkinsville P-3, Ga.	0.278	0.500	3.9	0.243	0.353	2.5
Watkinsville P-4, Ga.	0.166	0.400	5.0	0.208	0.392	4.7

* Means were tested using student t-test, Duncan's, and Tukey's comparison of means, all of which gave the same decision results of hypothesis testing at $\alpha = 0.05$. Standard deviations were compared using the t-test. Measured and predicted means and standard deviations were not statistically different at the 95% confidence level unless otherwise marked. Standard deviations and skewness are not reported for data sets which numbered less than 10.

† Measured and predicted means or standard deviations were statistically different at the 95% confidence level.

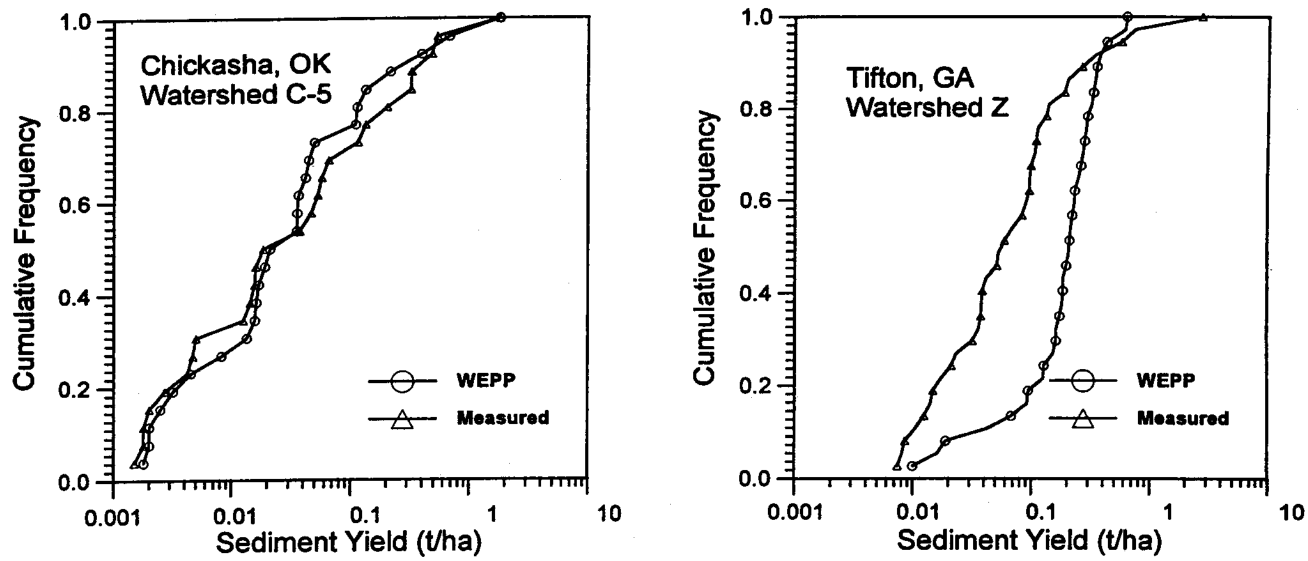
Perhaps the most notable characteristic of the Tifton Z watershed is the soil, which contains greater than 85% sand and less than 5% clay. It is highly porous, has a very high infiltration rate, a very low interrill erodibility, and low transportability. Also, the Tifton site is known to exhibit a significant amount of subsurface lateral flow. The facts that the Tifton soil tends toward the extreme of the WEPP soil parameterization data set (Elliot et al., 1989) and that the process of subsurface lateral flow can be a highly variable process may be the reasons why the variability and skewness of the data are underpredicted at the Tifton site. Adjustment of WEPP input parameters is useful for calibration of mean response, but would not likely bring the measured and predicted distributions closer for the Tifton site.

Cumulative distribution curves for the Chickasha C5 and Tifton Z watersheds are plotted in figures 6 and 7 for runoff and sediment yield, respectively. The Chickasha watershed had similar statistics for the measured and predicted distributions, while the Tifton site had significantly different standard deviation and skewness between measured and predicted data. The differences in the curves for the Tifton watershed, particularly for the sediment case, are evident in the separation of the two curves.



(a) (b)

Figure 6–Cumulative frequency distributions of measured and predicted runoff volumes: (a) Chickasha, Okla., C-5; and (b) Tifton, Ga., Z.



(a) (b)

Figure 7–Cumulative frequency distributions of measured and predicted sediment yield: (a) Chickasha, Okla., C-5; and (b) Tifton, Ga., Z.

Conclusions

The WEPP watershed model produced reasonable results when applied to many of the data sets used in this study. With the exception of the Holly Springs, Mississippi site, the model gave reasonable predictions for both total and event runoff and sediment yield. The results indicate that the default soil erodibility and infiltration parameter estimation procedures were effective for these data sets. The model correctly reflected the relative differences and rankings of runoff and sediment yield from the watersheds, which is important if WEPP is to be used for selecting management practices for soil conservation. The model also produced reasonable distributions of event runoff and sediment yield for the watersheds, with the exception of the Tifton, Georgia, Z watershed. This is a positive indication of the model's capacity to be used to evaluate long-term erosion patterns and event contributions to total sediment yield.

Problems were encountered with predictions for several of the watersheds, which point out several areas of improvement for the watershed model's performance. The total predictions for Holly Springs, Mississippi, were overpredicted, and it is suggested that the inclusion of better silage routines and a weed component in the plant growth and management model in WEPP might improve predictions where these factors play a role. Related to this issue, though not explicitly addressed in this study, is that in WEPP the user cannot represent inter-cropping, where a second crop is planted between the rows of a first crop prior to the harvest of the first crop.

Fit between measured and predicted individual event data was variable. Overall fit between measured and predicted data gave an r^2 of 0.74 for the runoff data and 0.71 for the sediment data. However, coefficients of determination between measured and predicted event runoff values for individual watersheds ranged from 0.01 for the Coshocton 130 watershed to 0.85 for the Watkinsville P-2 watershed. Coefficients of determination between measured and predicted event sediment yield values for individual watersheds ranged from 0.02 for the Riesel W-12 watershed to 0.90 for the Watkinsville P-4 watershed. Caution is suggested in using the WEPP model to assess runoff and erosion for individual storm events. Individual storm comparisons tended to be worse on contoured watersheds. Another apparent area of needed model improvement of the model is better linkage of the sediment from contoured hillslopes to the watershed channel system.

Cumulative frequency distributions for predicted event runoff and sediment yield for individual watersheds matched those for measured data with some exceptions. Both runoff and sediment distributions for the Tifton Z watershed were not matched by WEPP. The reason in this case might be due to unique soil conditions at that site. The good fit of WEPP distributions to measured distributions for the bulk of the watersheds bodes well for the use of WEPP in simulating long-term erosion rates from small watersheds.

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