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Validation of the FS WEPP Interfaces for Forest Roads and Disturbances

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Abstract. *We have developed Internet interfaces for forest applications (FSWEPP) of the Water Erosion Prediction Project (WEPP) model. We compared predicted erosion rates and sediment plume lengths from forest roads and other forest conditions with published field observations. Generally the interfaces predicted values similar to the observed values. Exceptions included low-use older roads, roads with channelized runoff and other channel effects, and sites where landslides were a major source of sediment.*

Keywords. Soil Erosion, WEPP, Forest Roads, Forest engineering, Fires,

Introduction

Prediction of soil erosion by water is a common practice for natural resource managers for evaluating impacts of upland erosion on soil productivity and offsite water quality. Erosion prediction methods are used to evaluate different management practices and control techniques. One of the prediction tools recently developed is the Water Erosion Prediction Project (WEPP; Flanagan and Livingston 1995). WEPP is a physically-based soil erosion model, and so is particularly suited to modeling the conditions common in forests. Forest templates were developed for the model (Elliot and Hall, 1997) and later, a user-friendly suite of Internet interfaces called FSWEPP (Elliot et al. 2000). Included with these interfaces is a database of typical forest soil and vegetation conditions. These databases were populated with values determined from rainfall simulation and natural rainfall field research by scientists within our organization and elsewhere.

The WEPP model has been validated by numerous scientists over the past ten years, and the model has been updated in response to these validation results. The purpose of this paper is to validate the database that we have developed for our interfaces.

Forest Erosion Processes

In forests, the majority of sediment comes from forest roads, and in some cases, from harvested or burned areas. Soil erodibility properties depend on both the surface cover and the soil texture (Elliot and Hall 1997). A soil that has been altered to become a road has different erodibility properties than does a forest soil regardless of disturbance, and the soil erodibility following a wild fire is much greater than in an undisturbed forest.

Following a fire, forests are highly susceptible to erosion in the following year. They do, however, recover quickly as vegetation regrowth is rapid when smaller plants do not have to compete with trees for sunlight, nutrients, and water.

Erosion in forests is highly variable, driven by a few extreme events each decade. Field data collected during years without events are likely to be well below "average annual" erosion rates, and data collected during a year with an event are likely to be well above the "average annual" rate. On carefully controlled field experiments, variability within a treatment is high, and the best that can be expected is a coefficient of variation of about 30 percent (Elliot et al. 1989; Robichaud 1996; Wasniewski 1994). In practice this means that at best, the 90 percent confidence limit on an individual field observation is about plus or minus two times the mean, and about one third the mean from a study with 4 replications (Mac Berthouex and Brown 1994). Any comparison of field data with a predicted value must consider this level of confidence in both the observed and predicted values.

Description of WEPP

The WEPP model is a complex computer program that describes the processes that lead to erosion. These processes include infiltration and runoff; soil detachment, transport, and deposition; and plant growth, senescence, and residue decomposition. For each simulation day, the model calculates the soil water content in multiple layers, plant growth, and residue decomposition. The effects of tillage processes and soil consolidation are also modeled.

The hillslope can have a complex shape, and can include numerous soils and plant types along the hillslope. Each unique combination of soil and vegetation is called an overland flow element (OFE) (Figure 1).

Input Files

The hillslope option requires four input files. (1) The daily climate file includes the description of daily precipitation, temperatures, radiation and wind. (2) The slope file contains two or more sets of points describing the slope at intervals along the profile. (3) The soil file can contain up to 10 layers of soil describing the texture and other properties of the soil. The most critical inputs are the erodibility and hydraulic conductivity of the surface layer. (4) The management file contains descriptions of the vegetation conditions.

FS WEPP Interfaces

Two Internet interfaces have been developed for WEPP for forest conditions (Elliot et al. 2000). One is for a number of road scenarios (WEPP:Road), and the other for disturbed forest conditions (Disturbed WEPP).

A complementary interface (Rock Clime) assists the user in selecting an appropriate climate from a large climate database, or to customize the mean monthly precipitation amounts, number of wet days per month, and monthly mean maximum and minimum temperatures (Scheele et al. 2001).

WEPP:Road. Figure 2 is a diagram of the three OFEs that are assumed in the WEPP:Road interface. The user is aided in selecting a climate and a soil from one of four textures. Four road design options are available: Insloped rocked or vegetated ditch; Insloped bare ditch; Outsloped unrutted; and Outsloped rutted. The road surface choices are native, graveled, or paved. The road and buffer topographic features allow the user to specify the length and steepness of both the road segment and the buffer, and the road width. WEPP:Road assumes that the road is in a newly constructed, or recently maintained condition since most of the database values are from experiments carried out under these conditions. WEPP:Road is likely to overpredict runoff and erosion from roads with little traffic, no recent maintenance, or vegetation on the surface.

The output from WEPP:Road presents not only the amount of sediment delivered from the forest buffer to a stream, but also the average precipitation, the runoff, and the amount of sediment leaving the eroding portion of the road prism. If the user requests an extended output,

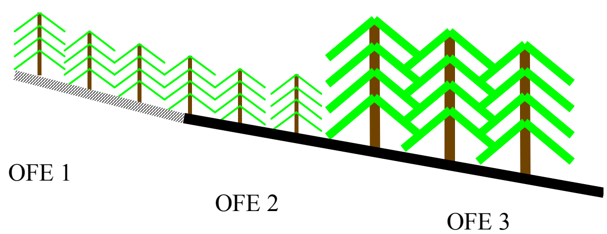

Figure 1. Overland flow elements (OFEs). OFE 1 has soil 1 and management 1, OFE 2 has soil 2 and management 1, and OFE 3 has soil 2 and management 2.

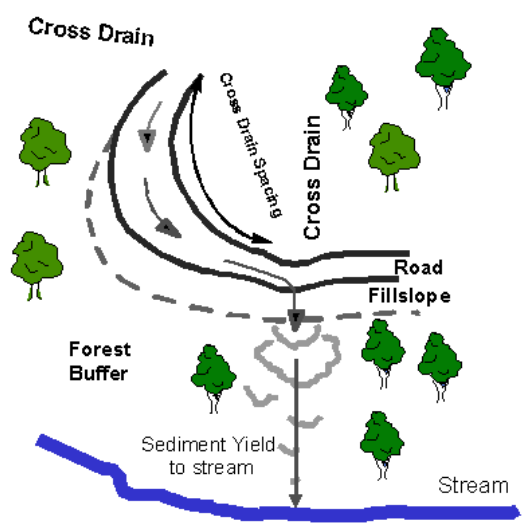

Figure 2. Template for the WEPP:Road interface.

then the WEPP Annual Abbreviated hillslope output is presented, allowing the user to determine the extent of a sediment plume in the forest. The results from a series of runs of WEPP:Road can be saved in a log file.

Disturbed WEPP. We are developing Disturbed WEPP for forest conditions including prescribed fires, wild fires, and young and mature forest. Options are also available for range conditions including good and poor grass and shrubs. Disturbed WEPP has two OFEs (Figure 1) so that users can study numerous combinations of uphill and downhill disturbances, such as a harvest area above a buffer zone.

The user can select the climate and soil, the vegetation type and surface cover on the two OFEs, and the topography for each OFE. The ouput presents the probability associated with years with exceptionally high runoff and erosion as well as a mean annual erosion rate that would occur in a year with an "average" climate.

Cover is one of the most important factors in determining soil erosion rate. The WEPP model does not have a cover value for an input, but instead calculates the amount of cover each day as a function of numerous plant growth and residue decomposition values and the climate. To aid users in ensuring the desired amount of cover, Disturbed WEPP has a calibration feature that allows the user to alter a cover input variable, and determine if the resulting modeled cover is adequate. Calibration may require several runs before the desired cover is achieved.

Validation Results and Discussion

For validation, we used a mix of references. Some references had been used to develop the current database (e.g. Elliot et al. 1996; Foltz 1996; Robichaud 1996). Some observations were data we collected, but have not yet published or used to develop the database (e.g. Foltz and Elliot 2001; Robichaud 1998). We also used a number of published erosion rates. As a general approach, we used the Rock:Clime interface to describe a climate as close to the reported weather as we could. In some cases, the reference provided the erosion results from several months only, and in these cases, we attempted to alter the climate to ensure similar levels of precipitation distribution and amount. We used as much soil and topographic data as we could determine from each reference. As a method for comparing observations with predictions, we assumed that the 90 percent confidence interval is about equal to the mean for both the observed and the predicted value for a single observation or prediction, or 0.3 times the mean for a replicated study. If the confidence intervals of the observed values and predicted values overlap, then we assumed that the prediction is a reasonable approximation of the observed value.

WEPP:Road

We carried out two different validation studies for WEPP:Road. We looked at the amount of sediment leaving the road, and the observed or predicted sediment travel distances. We only had one study that had measured sediment delivery amounts across a buffer (Kahklen 2001).

Road Erosion. The road erosion results are presented in Table 1. From the nine references, WEPP:Road appears to have overpredicted erosion rates on three studies (Beasley et al. 1984; Kahklen 2001; and Luce and Black 2001), underpredicted on one study (Swift 1984b), and been well within confidence limits on five studies.

The study of Beasley et al. (1984) was on roads that were at least ten years old, which may have armored, thus producing less sediment that WEPP:Road would predict for a newly constructed road. They also reported that road runoff exceeded precipitation by factors of 2 to 12, although this did not appear to cause excessive erosion on these older roads. Foltz and

Elliot (2001) hypothesized that the erodibility of armored roads is about a third that of freshly disturbed roads, which may explain most of the differences between the observed and predicted values, as the WEPP:Road database is mainly from newly constructed or recently disturbed roads.

Foltz (1996) reported that the difference in erosion rates between high and low quality aggregate was mainly due to the runoff flow paths. On a road surface treated with marginal quality aggregate with traffic, the marginal quality aggregated was more likely to rut. To model these two conditions, an outsloped section with ruts was used to describe the marginal quality treatment, and an outsloped road without ruts, the good quality treatment. Table 1 shows that in both cases, the confidence limits of the WEPP:Road predictions overlapped with the observed interval of confidence.

The observations for Kahklen (2001) are well below the predicted values, and are also well below observed erosion from the drier Oregon studies (Foltz 1996; Luce and Black 1999). The reasons for these low rates are not apparent in the document. We may have not interpreted his data correctly, or his observations may not have been for a full year. It is possible that the roads had limited traffic, so that they were armored, reducing the availability of erodible sediments (Foltz and Elliot 2001).

The predictions for both Kochenderfer (1987) and Luce and Black (1999) were similar to the observed values. With Kochenderfer's data, it appears the WEPP:Road was able to predict the differences between native and gravel roads. The Luce and Black (1999) comparisons showed that the vegetated ditch impacts are reasonable well predicted by FS:WEPP. It is not clear why Luce and Black (2001) observed such low road erosion rates. The values are well below those of their earlier study as well as the values observed by Foltz (1996) in a similar climate.

Megahan and Kidd (1972) predicted sedimentation from both landslides and surface erosion. The WEPP:Road predictions, for surface erosion only, were less than those observed when considering both forms of erosion, although within the confidence limits on the steeper grades.

Swift (1984a) found that erosion rates dropped considerable when grass was allowed to grow on roads. WEPP:Road predicted a similar erosion rate for the native surface condition, was not able to predict erosion when the road was covered with grass. WEPP:Road underpredicted the observed erosion rates from Swift (1984b). Swift's high rates occurred because the highest rainfall in 47 years occurred during the study. This underlines the importance of careful interpretation of natural rainfall precipitation to make sure that either unusually wet, or unusually dry years during studies do not lead to incorrect conclusions about "average annual" erosion rates.

Sediment Plume Lengths. The output from the WEPP model includes a table of erosion rates for 100 points for each overland flow element. In the WEPP:Road scenario (Figure 2) this means that there are 100 values for erosion or deposition rates in the buffer. Figure 3 shows a typical WEPP road erosion and buffer deposition prediction. We assumed that when the deposition value was less than about 1 kg m^{-2} per year, then the depth of deposition was less than 1 mm, and the researcher would assume that there was no identifiable sediment plume. The published results on plume length are summarized in Table 2, along with our predicted values.

Grace (1998) observed sediment plumes 50 to 60 m long below 55-m long road segments in Alabama. Using our criteria, the predicted sediment plume lengths were almost identical, 44 to 62 m long.

Ketcheson and Megahan (1996) reported the results of a large study of roads in central Idaho. They observed a wide variation in lengths, but most plumes were between 11 and 84 m from

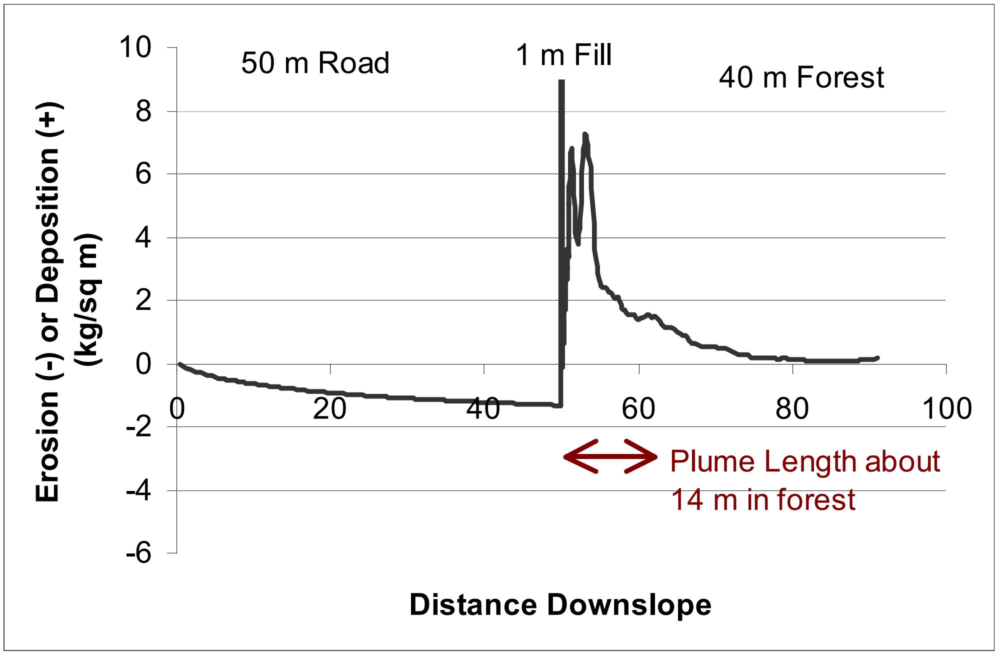

Figure 3. WEPP:Road-predicted distribution of erosion (negative values) and deposition (positive values) for a 50-m road segment on a loam soil, near Deadwood Dam, ID.

roads with cross drains (Figure 2). For this configuration, WEPP:Road predicted a similar range of plume lengths (19-41 m). WEPP:Road assumes the sediment is transported by overland flow, and is not channelized. If the sediment is channelized, it is likely to be carried much further (Elliot and Tysdal 1999), which may account for the larger observed values in Ketcheson and Megahan (1996). Kahklen (2001) also reported that most sediment that was detached on a road was transported to the bottom of a hill if the runoff was channelized. Ketcheson and Megahan (1996) also reported sediment plume lengths from outsloped roads. Their range was from 0.4 to 66 m, with an average length of 3.8 m. If we assumed the road was outsloped, WEPP:Road predicted sediment plume lengths from 0.05 to 0.3 m if the roads were not rutted, whereas if the outsloped roads were rutted, then the predicted plume length for an average of their conditions was 15 m. This large range of observed and predicted values emphasizes the importance of understanding the role of road geometry and runoff pathways on sediment delivery as emphasized by Foltz (1996) and Elliot and Tysdal (1999).

McNulty et al. (1995) developed a relationship for sediment plume delivery to aid in his development of a GIS tool to analyze road impacts. His relationship was

$$L = 5.1 + 0.00197\,M \qquad (1)$$

where L is the sediment transport distance from a given GIS cell (m), and M is the amount of sediment (kg) leaving the cell. Using the erosion rates predicted by WEPP:Road in equation 1 gives to the 25 to 50 m predicted sediment plume lengths in Table 2. The predicted sediment plume lengths are lower than the WEPP:Road predictions. McNulty et al. (1995) stated that equation was intended to be used within a 30-m GIS grid cell. Applying this assumption to the greater concentration of runoff and sediment as assumed by WEPP:Road may not be appropriate.

The observed plume lengths in Wasniewski (1994) in central Idaho are similar to the predicted sediment plume lengths. Wasniewski observed longer plume lengths on granitic soils than on gneiss/schist soils, whereas WEPP:Road predicted shorter lengths on granitics. The reasons for this difference are not clear. Wasniewski (1994) suggested the reasons for these observations could be that the gneiss/schist soils were more cohesive or that the granitics were not as different from the gneiss/schist soils as in other studies because of the proximatey of the granitic sites in his study to the gneiss/schist sites. It is also possible that the lighter-colored granitic sediments were easier to track further down the hill.

Many observers assume that the end of the measured sediment plume is the extent of sediment transport down the slope. The WEPP model, however, does not support this assumption. Sediment may be deposited beyond the observed plume in amounts too small to measure, or easily obscured by vegetation. WEPP results show that each storm has a sediment plume, depending on the runoff leaving the road. For most storms, this runoff is sufficient to carry water some distance into the observed sediment plume. Extreme events, however, may have little deposition, carrying all of the entrained sediment past the sediment plume and into the stream channel. In some cases, there may even be erosion on the hillslope, particularly in wetter climates, below the observed sediment plume.

Disturbed WEPP

The Disturbed WEPP interface was developed to predict soil erosion following forest fires and other forest disturbances. Forest vegetation regenerates rapidly following a fire, so the likelihood of severe erosion occurring depends on the severity of the weather the year following the fire. Disturbed WEPP was developed to provide both the erosion estimate from an "average" year, the runoff and erosion probabilities for years with highly erosive weather, and the probabilities that there will be no runoff and erosion in the year following the disturbance. Field observations are highly dependent on the weather during the year of observation, so careful interpretation is necessary of all field observations.

Erosion After Fire. Table 3 summarizes studies on hillslope erosion rates following fire. Elliot et al. (1996) reported an erosion rate between 0.5 and 1 Mg ha^{-1} following a prescribed fire in central Idaho. The site had experienced a low severity prescribed fire and had a skid trail at the bottom of the slope. It appeared that most of the sediment was generated from this short width of skid trail. We assumed a tall grass plant scenario for most of the hill with a skid trail at the bottom and predicted an erosion rate well within the confidence intervals.

On a prescribed fire study in Montana, Robichaud (1998) observed very low erosion rates the year following the prescribed fire, but a greater rate the second and third years. The first year (1995) was a year of low snowfall, likely the reason for the low erosion rate. The second year was a particularly wet year, resulting in increased erosion even though the vegetation had recovered. The third year, the effects of increased vegetation were apparent with the decreasing erosion rate. After specifying the cover in Disturbed WEPP for a different vegetation class and increased cover, it predicted values similar to the observed values in years 2 and 3. In year 1, it predicted a 34 percent chance that there would be no erosion, so the observed value was within the predicted erosion rate for this site.

The predicted erosion rates following wild fire reported in Robichaud and Brown (1999) were within the confidence limits of a replicated study of 0.3 times the mean. The reason that lower erosion rates were predicted on the 30 percent slope plots was that the plots were only half the length of the plots on the other treatments. A nearby climate station recorded below average precipitation for the year of the study, which is likely the reason for the overprediction based on an "average" climate for the area. Although not shown in Table 3, the predictions in the years of recovery were similar to the observed values as well. The predicted erosion rates for the wild fire in Robichaud (2000) were also with the observed confidence interval for a single observation.

Wohlgemuth (2000) reported very low erosion rates following a fire in southern California. He reported that rainfall during the year following the fire was 348 mm, well below the average of about 550 mm. Even though the precipitation in Disturbed WEPP was decreased so it was similar to the observed precipitation, Disturbed WEPP still predicted much greater erosion rates than were observed. It may be that the erodibility of these steep young sandy soils is less than that observed on the more weathered granitic sandy soil in central Idaho from which the erodibility values for Disturbed WEPP were developed.

Nonfire Erosion Rates. Disturbed WEPP is capable of modeling any non-tilled vegetation condition if users select the appropriate input values for vegetation type and cover. Most publications present watershed erosion rates which include erosion from both roads and other forest disturbances. Table 4 provides three of these studies. Patric (1976) provided a literature review from eleven southeastern U.S. states. The range of predicted erosion rates for typical hillslope lengths and southeastern climates is similar to the observed erosion rates. Because much of Patric's (1976) data came from watersheds where channel deposition may have been a factor, the higher predicted rates are to be expected. The predicted values, however, are within the 90 percent confidence interval of the observed values.

Rice (1979) presented a number of erosion rates for disturbed watersheds in northern California. His erosion rates included some landslide sediment and the movement of some legacy sediment in the stream channel, so his observed values are greater than predicted values.

Yoho (1980) reported watershed erosion rates from a number of studies. There were insufficient data to make detailed comparisons with reported values. We tried to match the climates based on the assumed locations of the cited studies in his report. Generally, erosion rates measured on a watershed scale are smaller than hillslope rates (unless the channel is severely disturbed), because the channel is a site of deposition in all but the very wettest years.

Elliot (2001) showed that the Disturbed WEPP interface was a better predictor of rangeland soil erosion rates than either RUSLE or the WEPP rangeland templates distributed with the WEPP MS DOS interface (Table 5). The data were from small watersheds, so there was likely some channel deposition of the eroded sediments that the hillslope assumptions in Disturbed WEPP would not predict.

Summary

Internet interfaces (FSWEPP) were developed to run the WEPP erosion model and CLIGEN weather generator for forest land managers. The predictive capabilities of these interfaces for roads, disturbed forests, and rangeland were evaluated by comparing them to observed erosion values. In most cases, the predicted values were similar to the observed values. It appears that the areas where FSWEPP did not perform well were:

- Older Roads
- Closed or revegetating roads
- Sites where road runoff is channelized
- Sites where landslides were a major sediment source
- Sites where there is sediment deposition or erosion in channels

Some of these limitations to the FSWEPP interfaces can be addressed in future interfaces. In some cases, research data are required that are not associated with abnormally dry or wet years.

Conclusions

From these analyses we conclude that in most cases, with reasonable parameterization, the FSWEPP interfaces provide a predicted erosion rate within an acceptable margin of error. Several studies demonstrated the need to develop additional capabilities to the FS WEPP interfaces.

References

Beasley, R. S., E. L. Miller, and S. C. Gough. 1984. Forest road erosion in the Ouachita Mountains. Proceedings of the Mountain Logging Symposium, 203-213.

Elliot, W. J. 2001. Comparing RUSLE to WEPP Cropland and Rangeland Formats. In: Ascough, II, J. S., and D. C. Flanagan (eds.). Soil Erosion Research for the 21st Century, Proceedings from the International Symposium on Soil Erosion Research for the 21st Century. Honolulu, HA. 3-5 Jan. St. Joseph, MI.: ASAE: 388-391.

Elliot, W. J., A. M. Liebenow, J. M. Laflen and K. D. Kohl. 1989. A compendium of soil erodibility data from WEPP cropland soil field erodibility experiments 1987 & 88. Report No. 3. USDA-ARS, National Soil Erosion Research Laboratory, W. Lafayette, IN. 316 p.

Elliot, W. J., and D. E. Hall. 1997. Water Erosion Prediction Project (WEPP) forest applications. General Technical Report INT-GTR-365. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station. 11 p.

Elliot, W. J., D. E. Hall and S. R. Graves. 1999. Predicting sedimentation from forest roads. *Journal of Forestry* 97(8): 23-29.

Elliot, W. J., D. L. Scheele, and D. E. Hall. 2000. The Forest Service WEPP interfaces. Paper No. 005021. St. Joseph, MI.: ASAE. 9 p.

Elliot, W. J. and L. M. Tysdal: 1999. Understanding and reducing erosion from insloping roads. *Journal of Forestry*. 97(8): 30-34.

Flanagan, D. C., and S. J. Livingston (eds.). 1995. *WEPP User Summary*. NSERL Report No. 11, W. Lafayette, IN.: National Soil Erosion Research Laboratory. 131 pp.

Foltz, R. B. 1996. Traffic and No-Traffic on an Aggregate Surfaced Road: Sediment Production Differences. Proceedings of the Food and Agriculture Organization (FAO) seminar on "Environmentally Sound Forest Road and Wood Transport" Sinaia, Romania, 17-22 June. Rome: FAO. 195-204.

Foltz, R. B., and W. J. Elliot. 2001. An approach to modeling sediment armoring and recovery on forest roads. Under Review. Moscow, ID: USDA Forest Service Rocky Mountain Research Station. 21 p.

Grace III, J.M. 1998. Sediment Export from Forest Road Turn-outs: A Study Design and Preliminary Results, Paper No. 987026. St. Joseph, MI.: ASAE.

Kahklen, K. 2001. A Method for Measuring Sediment Production from Forest Roads. Research Note PNW-RN-529. Portland, OR.: USDA Forest Service, Pacific Northwest Research Station. 17 p.

Ketcheson, G. L., and W. F. Megahan. 1996. Sediment Production and Downslope Sediment Transport from Forest Roads in Granitic Watersheds. Research Paper INT-RP-486. Ogden, UT.: USDA Forest Service Intermountain Research Station. 11 p.

Kochenderfer, J. N., and J. D. Helvey. 1987. Using gravel to reduce soil losses from minimum-standard forest roads. *Journal of Soil and Water Conservation* 42(1): 46-50.

Luce, C. H., and T. A. Black. 1999. Sediment production from forest roads in western Oregon. *Water Resources Research* 35(8): 2561-2570.

Luce, C. H. and T. A. Black. 2001. Effects of traffic and ditch maintenance on forest road sediment production. Proceedings of the Seventh Federal Interagency Sedimentation Conference, Reno, Nevada, 25-29 March. V: 67-74.

Mac Berthouex, P., and L. C. Brown. 1994. *Statistics for Environmental Engineers*. Boca Raton Fl.: CRC Press. 61-62.

McNulty, S., L. Swift, Jr., J. Hays and A. Clingenpeel. 1995. Predicting watershed erosion production and over-land sediment transport using a GIS. In: Carrying the Torch for Erosion Control: An Olympic Task. Proceedings: International Erosion Control Association: 397-406.

Megahan, W. F., and W. J. Kidd. 1972. Effects of logging and logging roads on erosion and sediment deposition from steep terrain. *Journal of Forestry* 70(3):136-141.

Patric, J. H. 1976. Soil Erosion in the Eastern Forest. *Journal of Forestry* 74:671-677.

Rice, R. M., F. B. Tilley, and P. A. Datzman. 1979. A Watershed's Response to Logging and Roads: South Fork of Caspar Creek, California, 1967-1976 Research Paper PSW-146. Berkley, CA.: USDA Forest Service Pacific SW Forest and Range Exp. Station. 12 p.

Robichaud, P. R. 1996. Spatially-varied erosion potential from harvested hillslopes after prescribed fire in the interior northwest. PhD dissertation. Univ. of ID, Moscow 219 p.

Robichaud, P.R. 1998. Slate Point Field Site, Bitterroot N.F. West Fork R.D. Internal progress report. Moscow, ID:USDA Forest Service Rocky Mountain Research Station. 1 p.

Robichaud, P. R. 2000. Fire and erosion: Evaluating the effectiveness of a post-fire rehabilitation treatment, contour-felled logs. IN Flug, M., and D. Frevert (eds.). Watershed Management & Operations Management 2000. Fort Collins, CO. 20-24 June. Reston, VA: ASCE. 9 p.

Robichaud, P. R. and R. E. Brown. 1999. What happened after the smoke cleared: Onsite erosion rates after a wildfire in Eastern Oregon. Revised (November 2000) In: Olsen, D. S., and J. P. Potyondy (eds.). Proceedings AWRA Specialty Conference: Wildland Hydrology, Bozeman, Montana. 419-426.

Scheele, D. L., W. J. Elliot and D. E. Hall. 2001. Enhancements to the CLIGEN weather generator for mountainous or custom applications. IN Ascough, II, J.C., and D. C. Flanagan. Proceedings of the International Symposium on Soil Erosion Research for the 21st Century. Honolulu, HA. 3-5 Jan. St. Joseph, MI: ASAE. 392-395.

Swift, Jr., L. W. 1984a. Soil Losses from Roadbeds and Cut and Fill Slopes in the Southern Appalachian Mountains. *Southern Journal of Applied Forestry* 8(4): 209-215.

Swift, Jr., L. W. 1984b. Gravel and Grass Surfacing Reduces soil Loss from Mountain Roads. *Forest Science* 30(3): 657-670.

Wasniewski, L. W. 1994. Hillslope Sediment Routing Below New Forest Roads in Central Idaho. Masters Paper, Oregon State University, Corvallis, OR. 105 p.

Wohlgemuth, P.M. 2000. Mixing Fire LEB Assessment Project First Annual Report. Riverside CA.: USDA Forest Service Pacific Southwest Research Station. 11 p.

Yoho, N. S. 1980. Forest Management and Sediment Production in the South – A Review. *Southern Journal of Applied Forestry* 4(1):27-36.

Table 1. Comparison of WEPP :Road-predicted road surface erosion rates with observed road erosion rates.

Reference	Comments	Observed sediment ($Mg\ ha^{-1}$)	WEPP prediction ($Mg\ ha^{-1}$)	Comments for WEPP	Prediction
Beasley, 1984	Alum Cr AR, ditch, shows rainfall exceeding runoff	16 for 1%, 44 for 4%, 76 for 7%	75-167 on 1%, 113-287 on 4%, 155-281 on 7%	Considered all four road designs	Overpredicted
Foltz, 1996	Lowell OR aggregate outslope	18 for good aggregate 132 for marginal	42 for good aggregate 98 for marginal	Climate adjusted to precip level	Similar values
Kahklen, 2001	SE Alaska, ditch	3	87 gravel, 108 native	Short seasons, not a full yr	Overpredicted
Kochenderfer, 1987	Fernow, WV, loam, rock and native, min standard and high standard design	103-144 native, 11-19 outslope gravel, 11-24 rock 3%	107 native, 47 outslope gravel, 29 rock 3%		Similar values
Luce and Black, 1999	Eugene OR, rock	30-99	50-148 bare ditch, 32-95 veg ditch	Elkton, OR climate adjusted	Similar values
Luce and Black, 2001	Eugene OR, ditch maintenance	.05-4.8	55	Elkton, OR climate adjusted	Overpredicted
Megahan and Kidd, 1972	Idaho batholith, sandy loam soils, 67% slopes, landslides	18.3	5 on 2%, 12 on 5%, 16 on 7%	Deadwood Dam, ID climate, outslope, rutted, 2%, 5%, 7% road grade	Similar values
Swift, 1984a	Coweeta 35% slope, outslope, 7m wide	167 on 7% bare, 32 with grass; 196 on 5% bare 30 on 5% with grass	145 on 7% bare, 105 with grass; 110 on 5% bare, 79 on 5% with grass	Outslope, rutted, bare & veg ditch on 7%,	Similar values
Swift, 1984b	Coweeta, outslope, sandy loam Two severe storm events during study.	720 bare, 175 clay loam rock 5%, 15 sandy loam rock 5%, 250 sandy loam rock 10%, 150 clay loam rock 8%	108 bare, 67 clay loam rock 5%, 77 sandy loam rock 5%, 135 sandy loam rock 10%, 103 clay loam rock 8%	Outslope, rutted	Underpredicted

Table 2. Comparison of WEPP:Road-predicted sediment plume lengths to observed lengths.

Reference	Comments	Observed (meters)	WEPP prediction (meters)	Comments
Grace, 1998	Tuskegee AL	50-60	44-62	
Ketcheson and Megahan, 1996	Silver Cr in Idaho batholith,	11-84 m ave 50m from cross drains,	19-41 for cross drains,	Deadwood Dam ID, sandy loam
	Slopes 15-40%	.4 to 66 ave 3.8 from fills	0.05 to 0.3 if unrutted 15 if rutted	Outsloped Unrutted Outslope Rutted
McNulty, 1995	NC adaptation of USLE for GIS. Equation: L=5.1+M*.00197	6.4-10	25-50	Predictions for Bare Ditch and Rutted Roads
Wasniewski, 1994	Central Idaho, granitic and gneiss/schist, inslope with ditch	13-81, ave 22 on granitics, 2-64 ave 18 on gneiss/schist	2-45 on granitics, 39-80 on gneiss/schist	

Table 3. Comparison of observed erosion rates and predictions from the Disturbed WEPP interface following fire.

Reference	Comments	Observed Sediment ($Mg\ ha^{-1}$)	WEPP prediction ($Mg\ ha^{-1}$)	Comments for WEPP
Elliot, Luce and Robichaud, 1996	Payette plot harvest and burn, skid road at bottom, 45% slope, sediment trap overflowed	Estimated 0.5 to 1.0	1.2	Warren, ID climate, Tall grass on slope with skid trail at bottom
Robichaud, 1998	Slate Pt on Bitterroot NF 50% slope, 70% cover low severity soil	.004 yr 1, .04 yr 2, .03 yr 3	.66 yr 1, .05 yr 2, .01 yr 3	Adjusted Stevensville, MT climate, Separate run yr 2 with 87% cover
Robichaud and Brown, 1999	Twin Lakes in eastern OR, loam soil, 28% cover first year, 82% yr 2	1.1 on 20% slope; 2.2 on 30%, 2.5 on 60%	1.6 on 20%, .82 on 30%, 4.01 on 60%	Adjusted Wallowa climate for elevation, 30% plots were half the slope length of other plots
Robichaud, 2000	Chelan WA, sandy loam, 40% high severity, Year 1 veg cover 50%, Year 2 veg cover 75%	.75 to 1.1 yr 1; 0 - yr 2	.76 to 1.5 yr 1; .01 to .02 yr 2	20% slope at bottom, 60% slope, 50% cover
Wohlgemuth, 2000	Mixing fire, San Bernardino, CA, 14 and 20% slopes, loamy sand soil, precip only 348mm, 81% bare ground	1.2 from 21-m hillslope plots	7 - 10 from hillslope plots	Used 4 x 21m plots 14 and 20 % steepness calibrated to 20% cover

Table 4. Comparison of observed erosion rates and Disturbed WEPP predictions following forest operations or other vegetation conditions.

Reference	Comments	Observed Sediment ($Mg\ ha^{-1}$)	WEPP prediction ($Mg\ ha^{-1}$)	Comments for WEPP
Patric, 1976	Literature review of SE US forested areas	.01-.3	.03 - .62	
Rice, 1979	Caspar Cr nr Ft Bragg, CA, 31% slope on partial cuts, 39% on tractor, numerous landslides	1.7-13.9, avg 8.3	.66 to .86 on partial cuts, 1.96 to 2.06 tractor, 1.4 in drainage	Adjusted for climate and cover
Yoho, 1980	Lit review of practices in South	0.74 -17.6 annual burn,	3.7 prescribed burn.	Careless clearcut with 40% disturbance, careful with 8%
	"Careless" clearcut: "Careful" clearcut:	3.03 0.13 - 0.38	0.93 careless and 0.08 careful clearcut	

Table 5. Results comparing the observed erosion rates ($Mg\ ha^{-1}$) on some rangeland sites in Colorado to rates predicted by RUSLE, the Rangeland Templates in the MS DOS WEPP interface, and the Disturbed WEPP interface (Elliot 2001).

Watershed	Observed	RUSLE	WEPP rangeland	Disturbed WEPP
1	0.13	0.20	0	0.05
7	5.97	6.52	1.08	5.34
27	2.57	7.64	0.50	4.79
38	0.98	0.92	0	0.63
45	2.75	4.94	0.50	4.49
Mean	2.48	4.04	0.42	3.06
Error SS		30.87	34.2	8.5

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