WATERSHED EROSION PREDICTION PROJECT (WEPP) SOIL EROSION RATES for FIA/FHM PHASE 3 PLOTS in IDAHO

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Introduction:

•Rates of soil erosion are an important indicator of forest soil health.
•The Revised Universal Soil Loss Equation (RUSLE) was initially selected to assess soil erosion potential on FIA/FHM P3 plots and data collection methods were developed accordingly.
•The Watershed Erosion Prediction Project (WEPP) model for assessing soil erosion potential can also be applied to P3 plot soil data. This model has many advantages including use of climate station data, calculation of soil erosion potential for ranges of precipitation return periods, and calculation of soil erosion potential for different forest disturbances.

Objective:

•Demonstrate how the WEPP model can be used to calculate soil erosion potentials using 1999 P3 plot data from Idaho as an example.

Table 1. Soil erosion data collected from P3 plots and input data needed for the RUSLE and Disturbed WEPP models.

Field data	RUSLE inputs[1]	Disturbed WEPP inputs
None	Precipitation erosivity factor (R)	Climate station data
Soil texture	Soil erodibility factor (K)	Soil texture
% bare soil, % litter cover, % plant cover, litter thickness, plant canopy height	Cover factor (C)	Total soil cover = 100 - % bare soil[2]
% Slope	Slope factor (LS)	% Slope
Slope length		Slope length
None	Cultural practice factor (P)	Not applicable
Forest condition class and ancillary data	Not applicable	Forest or disturbance type[3]

[1] A = RKLSCP
where A is the predicted soil loss, R is the precipitation erosivity factor, K is the soil erodibility factor, L is slope length, S is slope gradient, C is the cover and management factor, and P is the erosion control practice factor.
[2] Only % bare soil is needed to run WEPP, the other cover values, litter thickness, and plant canopy height data are needed for RUSLE, but not for WEPP.
[3] Choices are 20-year old forest (mature forest), 5-year old forest (young forest), low-severity fire, high-severity fire, or skid trails.

Table 2. Example of a data input table for the Disturbed WEPP model.

Location[1]	Paradise Dam				
Soil texture[2]	Loam				
Element[3]	Treatment[4]	Gradient[5] (%)	Length[6] (ft)	Area[7] (acres)	Cover[8] (%)
Upper	20-year old forest	35	112	1.33	99
		35			
Lower	20-year old forest	35	112		99
		35			

[1]Select from climate station database. Use climate station with similar elevation nearest to plot location.
[2]Choices are sandy loam, silt loam, clay loam, and loam. Since slightly different soil textures are collected in the field, use the soil texture conversion table to match the soil textures collected in the field to those used by WEPP.
[3]WEPP divides a hillslope into upper and lower areas or elements, but it can be applied to portions of a hillslope (e.g., plot area). Apply the WEPP model to a rectangular area surrounding the four subplots (fig. 1). Divide the area into two halves with equal slope lengths (e.g., 112 + 112 = 224 ft). Also, you may want to consider the orientation of the plot on the hillslope when selecting slope lengths since the area surrounding all four subplots is a rectangle and not a square.
[4]Choose a forest or disturbance type. Choices for forest type are 20-year old forest (mature forest) or 5-year forest (young forest). Choices for disturbance type are low-severity fires, high-severity fires, or skid trails.
[5]Use the mean of the slopes for all four subplots in the WEPP input table. Normally, the 1st slope of the upper element is the top of the hillslope (0%) and the 2nd is the slope at the midpoint of the upper element. The 1st slope of the lower element is the midpoint of the lower element and the 2nd slope is the bottom of the hillslope. Since WEPP is being applied to an area the size of the whole plot, which may be less than the whole hillslope area, use the same value for all four inputs.
[6]Divide the whole plot area into upper and lower elements of equal slope length (e.g., 112 + 112 = 224 ft).
[7]Corresponds to a rectangular area surrounding all four subplots (fig. 1).
[8]Soil cover = 100 - % bare soil. Use mean for all four subplots.

Table 3. Soil textures used by WEPP that correspond to soil textures collected from P3 plots.

Soil textures in FIA field guide	Soil textures used by WEPP
Coarse sand	Sandy loam
Sand	Sandy loam
Loam	Loam
Clay	Clay loam

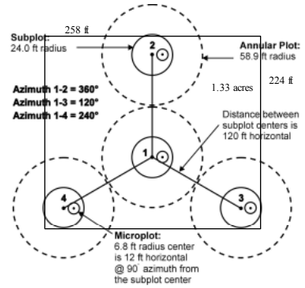

Fig. 1. FIA/FHM P3 plot diagram. The rectangular area shows the proposed soil erosion plot area for determining slope gradient and slope length for soil erosion modeling. The mean of the soil cover values from the four subplots was used as the input soil cover value for Disturbed WEPP.

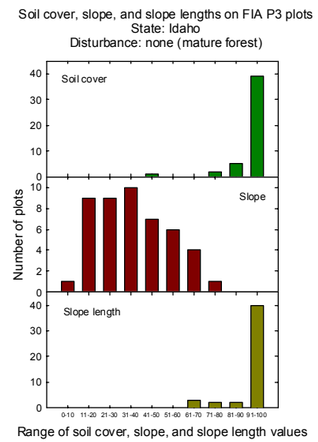

Fig. 2. Histograms showing the number of plots found in each range of soil cover (top), slope (center), and slope length (bottom) values for FIA/FHM P3 plots in Idaho

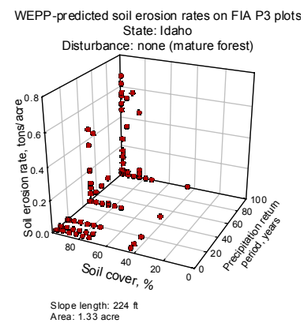

Fig. 3. Three-dimensional scatter plot of WEPP-predicted soil erosion rates vs. soil cover and precipitation return period for all FIA/FHM P3 plots in Idaho assuming mature forest conditions (no disturbances).

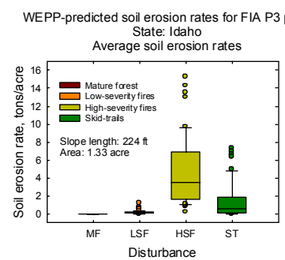

Fig. 6. Box plots of WEPP-predicted soil erosion rates for all FIA/FHM P3 plots in Idaho as a function of disturbance type assuming average (2-year return period) precipitation levels. The 25th and 75th percentiles are shown as a box centered about the median, the 10th and 90th percentiles are shown as error bars, and the 5th and 95th percentiles and outliers are shown as points. MF = mature forest, LSF = low-severity fires, HSF = high-severity fires, ST = skid trails

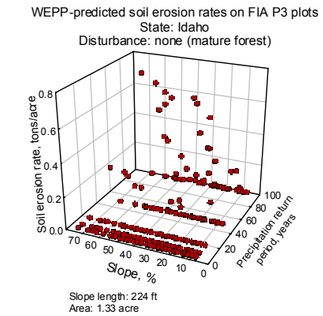

Fig. 4. Three-dimensional scatter plot of WEPP-predicted soil erosion rates vs. slope and precipitation return period for all FIA/FHM P3 plots in Idaho assuming mature forest conditions (no disturbances).

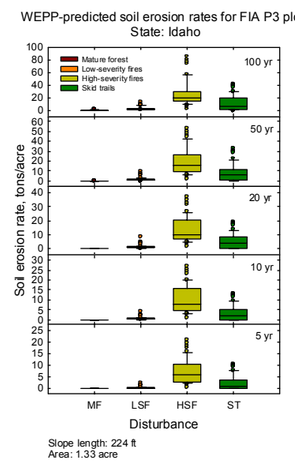

Fig. 7. Box plots of WEPP-predicted soil erosion rates for all FIA/FHM P3 plots in Idaho as a function of disturbance type and precipitation return period.

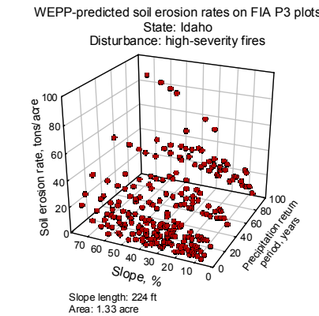

Fig. 5. Three-dimensional scatter plot of WEPP-predicted soil erosion rates vs. slope and precipitation return period for all FIA/FHM P3 plots in Idaho assuming high-severity fire disturbances.

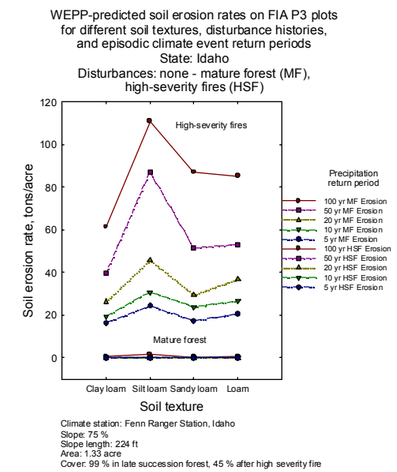

Fig. 8. WEPP-predicted soil erosion rates for an FIA/FHM P3 plot near the Fenn climate station as a function of soil texture and precipitation return period assuming mature forest and high-severity fire conditions.

Results:

•P3 plot slope values tend to be normally distributed, while soil cover and slope lengths are skewed (Fig. 2).
•WEPP-predicted soil erosion rates for P3 plots in mature forest (median cover = 99%) are negligibly small (Fig. 3) even on steep slopes (median slope = 35 %), although rates increase with slope steepness and precipitation return period (Fig. 4). Median soil erosion rate for an average precipitation year = 0 tons/acre. Maximum soil erosion rate for a 100-year return period precipitation year = 0.7 tons/acre.
•Disturbances greatly increase potential soil erosion rates (Fig. 5, 6 & 7), especially high-severity fires on steep slopes during wet years (Fig. 5). High-severity fires produce the greatest soil erosion potential followed by skid trails followed by low-severity fires. The maximum predicted soil erosion rates for a 100-year return period precipitation year on Idaho P3 plots disturbed by high-severity fires, skid trails, and low-severity fires are 85, 41, and 13 tons/acre, respectively for plots on the steepest slopes.
•Soil erosion potentials are not sensitive to soil texture for undisturbed areas (Fig. 8). Silt loam soils have the highest soil erosion potential under high-severity fire conditions (Fig. 8).

Summary and Conclusions:

•The WEPP model can be used to calculate soil erosion potentials on FIA/FHM P3 plots. WEPP offers several advantages including use of climate station databases and calculation of soil erosion rates for a range of precipitation return periods and disturbance scenarios. Recommendations are presented for using the WEPP model with P3 plot data.
•Preserving soil cover is the key to soil conservation. Since it is not possible to predict when high return period episodic precipitation events will occur, managing forest resource use to minimize disturbance impacts to soil cover is the best way to forestall catastrophic soil erosion events. Prompt post-disturbance implementation of effective rehabilitation practices will minimize the time bare soils are exposed to erosive events.

Recommendations:

•Apply the WEPP model to the entire plot area (fig. 1) instead of to each subplot area individually. Divide the whole plot area into equal halves for the slope lengths for the upper and lower elements in the WEPP input table. Additional enhancement: Consider the orientation of the rectangular area surrounding the whole plot area on the hillslope for selecting slope lengths. Note: A new slope length protocol is being developed for a future version of the field guide.
•Discontinue collecting the litter cover and plant cover estimates as part of the soil erosion indicator. These data are not needed for WEPP and can be obtained from field data collected as part of the vegetation indicator for use in RUSLE. Note: This recommendation was included in the change proposal for version 1.5 of the field guide.
•Delete the 4-ft radius soil erosion miniplots from the soil indicator. The litter thickness and plant canopy height data collected from these mini-plots are not needed for WEPP and can be derived from data collected by the down woody debris and vegetation indicators for use in RUSLE. Note: This recommendation was included in the change proposal for version 1.5 of the field guide.
•Develop a procedure to automatically match the location of each P3 plot to the nearest climate station with an elevation similar to the plot.
•Change soil texture designations in FIA field guide to match those used by WEPP.

References:

Renard, K.G., G.R. Foster, G.A. Weesies and others. 1991. RUSLE: Revised universal soil loss equation. J. Soil Water Conserv. 46:30-33.

Elliot, W.J., D.E. Hall, D.L. Scheele. 2000. Disturbed WEPP: WEPP interface for disturbed forest and range runoff, erosion, and sediment delivery. http://forest.moscowfsl.wsu.edu/fswepp/docs/distwepp.doc.html.