Appendix D

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Appendix D - Sediment Model Methodology

Background

Components of the R1-R4 erosion model (Potyondy, 1991) were used to estimate the current sediment yield from the Tower analysis area and to predict accelerated average annual levels resulting from existing management activities, the Tower fire and proposed ground disturbing management activities. The R1-R4 erosion model was incorporated into the WATSED model (USDA-FS, Region 1) developed in Region 1 to predict the effects of land management activities on water quantity and timing, and sedimentation. Direct application of the WATSED model to the Tower EIS analysis area was not possible because erosion response curves and land type databases required for the model have not been developed for the Blue Mountain Province. Also, the model has not be calibrated or validated with measured runoff and sediment data, though Gill (1994) tested WWSED, also a derivation of R1-R4 model developed by the Wallowa-Whitman NF.

The WWSED model is identical to the R1-R4 model, except that WWSED incorporates a filter strip concept, which assumes that all sediment generated more than 200 feet from a stream does not reach the channel. Sediment yield was predicted for a 1,300-acre timber sale that required 25.6 miles of new road construction on the Starkey Experimental Forest approximately 20 miles northeast of the Tower analysis area. WWSED predicted that 32.95, 25.06 and 24.92 tons/mi^2/yr would be produced in 1991, 1992 and 1993, respectively. Sediment measurements made during the three years after implementing the timber sale were used to validate the model predictions sediment yields. Measured values for the same period were 0.37, 0.07 and 0.74 tons/mi^2/yr, respectively. During the 3-year duration of the study model predictions were 70 times greater that the measured sediment yield, indicating that the average annual sediment yield approach to modeling does not account for the spatial and temporal variability in sediment movement.

Soil detachment and sediment transport are two components used by the R1-R4 model to predict sediment yield from a watershed. Soil detachment component, or soil erosion, predicts how much soil is moved from its original location. The distance that the detached sediment moves downhill or downstream is predicted by sediment transport component. Predicted soil erosion curves for management activities (see Table A.1) were obtained from the WATSED model documentation. Erosion curves for activities that were not documented in WATSED were estimated from activities having similar effect on erosion.

The distance that sediment gets transported before getting deposited depends upon numerous characteristics including slope gradient, surface roughness, vegetation and litter cover. Delivery ratios predict the ratio of detached sediment that actually leaves a particular watershed. Sediment delivery ratios in WATSED were based upon land type and slope position and the values varied from 1% on ridge tops to 80% on stream bottoms. Land type databases have not be developed on the Umatilla NF, so an alternative method using existing data was developed to estimate sediment yield based upon the distance of the disturbance to the nearest stream channel.

Table A.1: Erosion Response Curves for Tower EIS non-point sources.

Proposed Activity	Predicted Soil Loss (tons/mile^2/year)						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Road Construct. (granitics)	67,500	18,000	5,000	5,000	5,000	5,000	5,000
Road Construct. (non-granitics)	12,750	9,817	8,160	6,875	5,100	4,450	4,080
Logging (tractor)	352	187	144	92	89	21	0
Logging (harvester/ forward)	176	94	72	46	44	10	0
Logging (helicopter)	35	0	0	0	0	0	0
Wildfire (high intensity)	550	468	275	138	83	44	17
Wildfire (moderate intensity)*	225	234	138	69	42	22	8
Wildfire (low intensity)*	55	20	0	0	0	0	0
Road Obliteration*	12,750	6,375	0	0	0	0	0
Trail Construction*	4,080	1,020	64	64	64	64	64
Tree planting (16” scalp)*	10	0	0	0	0	0	0
Fuel Break Construction*	125	25	0	0	0	0	0
Subsoiling*	525	278	137	0	0	0	0

* estimated values

Studies that showed specific delivery ratios based upon the distance to the nearest stream channel were available, but the relationship relating the delivery ratio to drainage area was commonly described by negative power functions (Bunte and MacDonald 1998). In a study by Megahan (1984) d 88% of the sediment from surface erosion of a newly constructed road was deposited on the hill slope below the road and only 7% of the sediment appeared at the downstream monitoring site. The author also found that delivery ratios for landslides initiated by road construction were between 33% and 67%. No cut/fill road construction projects that have a high probability for landslide initiation were planned with the Tower EIS, so delivery ratios would be lower than these values. Broderson (1973 in USDA, 1993) showed that 200 foot buffers adjacent to streams in undisturbed forest in western Washington would effectively remove sediment derived from off site sources. In effect the delivery ratio beyond 200 feet was zero. Conditions in the Tower burn area were markedly different than those studied by Broderson, so delivery ratios should be higher. As drainage area increases the sediment delivery ratio decreases. For the Tower EIS the change in sediment delivery with respect to the distance from the disturbance to the nearest stream channel, was estimated with a linear relationship (see Table A.2).

Table A.2: Estimated Sediment Delivery Ratios.

Distance from Stream Channel (meters)	Delivery ratio (%)
0 - 50	30
51 - 100	20
101 - 150	10
> 150	1

Thirty percent of the soil erosion that occurs within 50 meters of a stream channel would be transported to the channel and the remaining 70% would get redeposited on the hill slope and would not contribute to sediment yield from the drainage. All sediment that entered stream channels was assumed to continue downstream to the watershed outlet. Sediment often gets detained within the channel network, such as behind woody debris, until a high flow event flushes the sediment downstream. No attempt was made to simulate the routing of sediment through the channel network, so the predicted sediment yield at the watershed scale is the hypothetical maximum.

Sediment yield numbers were converted to percent increase above background level, to provide a more meaningful comparison between alternatives. Measurements of background sediment yield have not been made within the analysis area, so a value was obtained from High Ridge Watershed 3, which is the nearest instrumented watershed. Although the High Ridge watersheds receive more rainfall and have deeper soils and higher vegetation density than the watersheds within the Tower analysis area, they provide the closest match to “pre-management” background conditions. During the period between 1984 and 1995 sediment yield from the untreated watershed 3 was 18.1 tons/mi^2 (Helvey and Fowler, 1997). Sediment yield estimates were divided by this number to derive the percent increase above background levels.

Modeling Procedures

Step 1. Use the buffer command in ARC-INFO to create the sediment transport zone coverage. This coverage stratifies the watershed into areas based upon the distance to the nearest stream channel.

Step 2. Intersect the sediment transport zone coverage with the subwatershed coverage, to add subwatershed data to the sediment transport info table.

Step 3. Intersect the sediment transport coverage with the coverage of the particular ground disturbing activity being analyzed.

Step 4. Export the resulting info table as text files and convert it into Excel format, import as table in Access database.

Step 5. Summarize the activity database into three columns:

1 - Subwatershed

2 - sediment transport zone

3 - Total area of ground disturbance by zone (mi^2)

There will be 4 rows for each subwatershed, one for each transport zone.

Step 6. Export the summarized database as a Excel spread sheet.

Step 7. For each subwatershed and each transport zone, multiply the area of disturbance type by its corresponding erosion response curve and sediment transport ratio. The resulting table contains a row for each sediment transport zone and a column for each year analyzed.

Step 8. For each year add the amount of sediment from each of the four zones to compute the total tons of sediment from the entire subwatershed.

Step 9. Repeat the procedure for each activity and each alternative.

Step 10. Add sediment yield estimates for each ground disturbing activity to determine the total amount of sediment expected from implementation of each alternative. Divide the result by the background sediment yield, to compute the percent increase in sediment yield.

Step 11. Compare the predicted sediment yield for each alternative.

References

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