Measurement and Modeling of Erosion from an Established Forest Road in the Ouachita Mountains of Oklahoma

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Background

Sediment is usually the major non-point source pollutant resulting from forest management.
Roads have often been identified as the single greatest long-term source of sediment. Despite this, few road erosion measurement studies have been performed in the south-central and southeastern US.

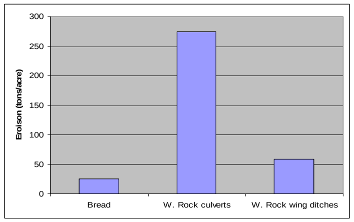
Past Studies in the Ouachita Mountains

Two road erosion studies have been conducted in the Ouachita's:
- White Rock Creek, OK – 2 yr old industrial road, 3 years of data (Vowell, 1984 and Turton and Vowell, 2000).
- Bread Creek, AR – established USFS road, 1 year of data (Miller, Beasley and Covert, 1984).

Both studies were located in similar soils (associations) and topography and measured erosion from cross-drain culverts. Erosion was measured from 2 wing ditches in the White Rock study as well. Segment slopes and lengths ranged from 8 to 1 % and 330 – 150 ft respectively.

Figure 1: H flume and Coshocton wheel sampler used in the White Rock Creek study.

Figure 2: Rates of erosion measured in the Bread and White Rock Creek studies in tons/acre of road prism.



Objectives

This work is part of a broad goal to develop sediment budgets for large forested basins. Sediment from roads is one part of the budget. Our objectives include the following steps:

1. Measure erosion from representative road segments.
2. Use measured data to validate erosion models such as WEPP.
3. Use erosion models to estimate basin wide road erosion.
4. Measure sediment delivery and determine the factors that control sediment delivery to streams.

This information will to provide information and assist in water quality planning and in the development of realistic TMDL's and solutions to water quality problems.

Road Erosion Methods

Two mid-slope road segments on an industrial forest road in the Bluff Creek watershed near Battiest, OK were instrumented. The road segments were typical of mid-slope roads in the Ouachita Mountains of southeastern Oklahoma.

Figure 3: Site 1 of the Bluff Creek road study. (length = 367 ft, slope = 4%, area = 0.2 ac)

Figure 4: Site 2 of the Buff Creek road study (length = 335 ft, slope = 6%, area = 0.2 ac)

Flow from each culvert was routed into a collection trough that contained screened baskets that trapped coarse sediment. Each trough flowed into an approach section and 1.5 ft H-flume. Discrete water samples were obtained from the flumes using automatic

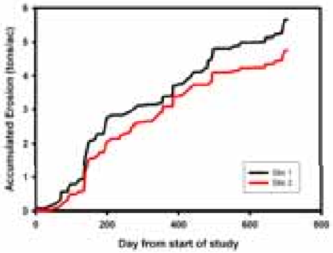
Figure 5: H-flume and approach section used at both road erosion sites.

pumping samplers. Each sample was analyzed for total suspended sediment in a lab. Sediment and flow data and trapped coarse sediment were used to calculate total erosion for each storm. A siphoning recording rain gage was located at the sites for calculation of rainfall amounts and intensities.

Road Erosion Results

Data from 100 storms has been collected from January 2003 to December 2004. Total erosion from Site 1 and Site 2 was 5.7 and 4.8 tons/ac respectively for the 2 year study period. Erosion was somewhat correlated (r's about 0.7) to each storm's rainfall amount and intensity. About 40% of the total erosion was produced by the 6 largest storms of the study.

Figure 6: Graph of accumulated storm erosion from site 1 and 2 of the Bluff Creek study.



Erosion Modeling Methods

Erosion was modeled using the WEPP watershed version Windows interface (USDA ARS NSERL, 2002). Sediment yield and flow were predicted for each storm. Measured rainfall was used for input data. Measured soil properties were used to estimate some, but not all soil parameters. The "effective length" of erosion was calculated as the diagonal flow path across the road surface. The road prism was broken (Figure 7) into 2 planes, the road surface and cutslope and one channel, the ditch. WEPP calculated erosion and flow from each component.

Figure 7: Road Site 1 broken into its flow components for modeling with WEPP. All field measurements of erosion were from the same 4 components.

WEPP Erosion Modeling Results

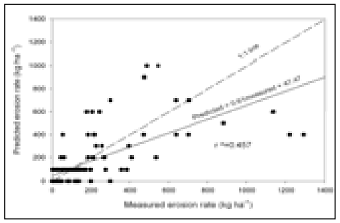
Table 1: Comparison of measured and predicted total accumulated erosion for the first 72 storms.

Site	Measured (tons/ac)	Predicted (tons/ac)	Difference (%)
Upper	3.4	2.9	14
Lower	2.9	2.9	0

Table 2: Statistical comparison of measured vs. predicted erosion for the first 72 storms.

Segment	r^2	Significance	Relative Error (%)	Nash-Sutcliffe Efficiency
Upper and Lower	0.42	< 0.001	- 9	0.24
Upper	0.42	< 0.001	-14	0.15
Lower	0.45	< 0.001	0	0.33

Figure 8: Validation comparison of measured vs. predicted storm erosion Sites 1 and 2 combined. WEPP tended to under predict erosion for the largest storms.



Conclusions and Discussion

1. Erosion rates on established roads are lower than on new roads.
The average erosion from the new mid-slope road segments on White Rock Creek were 52 times greater than the erosion from the Bluff Creek road segments. Differences in rainfall may account for some of the differences. Rainfall during the Bluff Creek study was slightly below normal, but above normal for 1 year of the White Rock study.

2. WEPP did a reasonable job predicting total erosion over the study period, but tended to under-predict storm erosion.
WEPP's prediction for total erosion was well within 50% of the measured value. The largest of the individual storms were under-predicted. Models like WEPP were designed for long-range planning, not particularly for predicting individual storms. Therefore, it's not surprising some deviation between the measured and predicted values storms was observed. On the other hand, if WEPP continually under predicts erosion from large storms, this error will carry over into long-term predictions.

Acknowledgements

- Oklahoma Agricultural Experiment Station
- Weyerhaeuser Company Southern Forestry Research Center
- Elaine Stebler and Randy Holeman, OSU Sr. Research Specialists
- Kiamichi Forestry Research Station
- William Elliot, USDA USFS Moscow, Idaho