Water Quality Impacts from an ORV Trail Stream Crossing in the Talladega National Forest, Alabama, USA[1]

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Abstract

Off-Road Vehicles (ORVs) are one of the most damaging forms of recreation utilized in our National Forests. Erosion from ORV trails can be a major source of water quality impact. In 2003, a study was initiated in the Talladega National Forest to quantify water quality impacts of an ORV trail crossing a local stream. Automated samplers were installed upstream and downstream from an ORV trail stream crossing to collect suspended sediment (SS) samples. Storm-event SS samples were collected over a 9-month period and trail conditions were monitored. Three different operational conditions - closed, maintenance, and open - were observed during the sampling period. During the trail closed condition, four storm events, which included a 49 mm storm, contributed a total of 109.3 kg of SS load. Subsequent to this, two storm events during the trail maintenance period contributed a total of 4.1kg of SS to the stream. The trail was then opened to ORV traffic. During the trail open period, eight storms contributed a SS load of 6.5 kg. Since most of the observed storms had return periods of less than one year, the SS loads contributed by the ORV stream crossing were small. The measured data and the observations, however, suggest that the ORV stream crossing can contribute large SS loads during storm events with return periods of one year or more.

Key words: erosion, Off-Road Vehicles, ORV, runoff, stream crossing, suspended sediment, water quality

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Introduction

Water quality is a major concern for many countries around the world. Research has been conducted in many areas to assess impairment of waterways by agriculture, urban development, wildlife, and recreational activities. Water is a finite resource that needs to be monitored and protected to ensure its longevity. In the United States, legislation has been enacted for the protection of water quality. In response to the Clean Water Act of 1977, and the Water Quality Act of 1987, improved guidelines and management practices have been implemented in each state.

Sources of pollution originally defined as "point" and "non-point" sources have more recently been viewed as encompassing too narrow a spectrum. Non-point sources are now more commonly referred to as "diffuse sources" and include the characterization "discharges [that] enter the receiving surface waters in a diffuse manner at intermittent intervals that are related mostly to the occurrence of meteorological events" (Novotny and Olem, 1993). Diffuse sources are a rising concern and are addressed by several agencies in Alabama.

Alabama Forestry Best Management Practices (BMPs) published by the Alabama Forestry Commission list sediment as "one of the most important considerations related to silvicultural activity" (Alabama, 1990). It also acknowledges that "many operations have the potential to increase sediment rates" (Alabama, 1990). Federal and state BMPs have been established and implemented to address the problem of increased sediment loads in waterways due to stream and wetland crossings.

The threat of sedimentation created by ORV trails is a growing concern for many recreational areas including our National Forests. The trail systems set up for ORVs contain steep climbs, banked turns, and ruts or crevices that sustain high volumes of riders. The nature of ORV use for recreation includes quick stops, fast accelerations, and high speed turns. This type of activity leads to miles of exposed soil surfaces. During storm events, these trail systems become a contributor of sediment into the nearby streams.

Objective

The impact of ORV use on nearby streams is a new area of interest and limited scientific data are available to address the growing concern. The objective of this study was to quantify sediment loads generated by an ORV trail stream crossing under three different trail operational conditions (closed, maintenance, and open).

Methods

Site description

The study area was located in the Talladega National Forest, Talladega County, Alabama within the Alabama Valley and Ridge Province. Elevation in the vicinity of the study site ranges between 300 and 580 m. Average annual precipitation is approximately 1330 mm while average annual temperatures range between 7.2 in January and 26 degrees C in August. Topography features of this area include short, steep slopes, narrow ridge tops, and rock and shale outcrops with slopes that range between 15 and 45 percent. Soils within this area have been identified as belonging to the Tallapoosa-Tatum association that developed from weathered slate or phyllite. Surface soil layers are composed of silt loam underlain by silty clay loam (Cotton et al.).

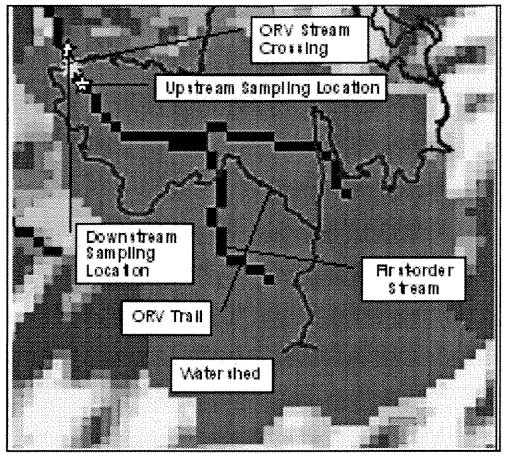

Figure 1 - Kentuck ORV trail and stream crossings. Spatial representation of the 113 ha

Permission was granted by the United States Department of Agriculture (USDA) Forest Service, Talladega Ranger District to conduct this study on their trail system. While the entire trail system is 30 miles long, a 2-mile looped portion of the trail was selected for this study. Before the data collection process could begin, certain criteria were established for selecting a suitable stream crossing to sample for SS loads: it had to be perennial, it needed to intersect the trail system, an ORV with a trailer had to be able to access it, it needed to have high enough flow rates to meet the data logger requirements, and there needed to be a sufficient stream bank for the installation of the data collection equipment. After this was completed, both a Geographic Information System (GIS) and a Global Positioning System (GPS) were used to identify and locate several streams within the trail system. The streams were assessed according to the set criteria, and a suitable stream was selected that had a bridge. The watershed area (113 ha) upstream from the stream crossing was delineated using GIS (Figure 1). The slopes of the trail approaching the stream from the left decreased from 18 percent to 1 percent slope and increased to 3 percent on the right side of the stream (Figure 2).

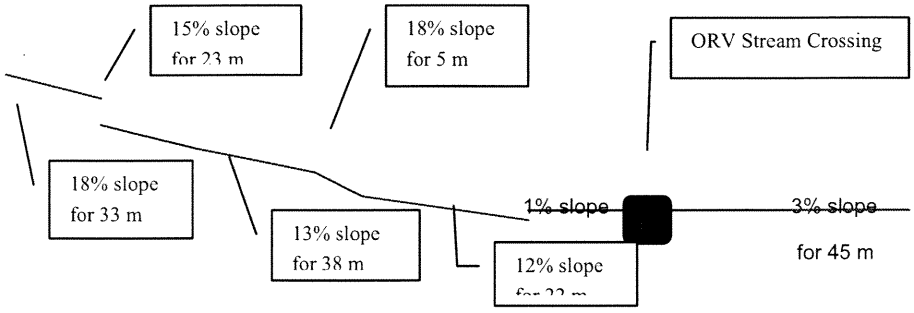

Figure 2 – Profile view of the ORV stream crossing

During the maintenance period (March 1, 2004 – March 16, 2004), a crawler tractor was used to remediate trail areas that contained standing water. The trail was then allowed to dry for several days. A crawler tractor was then used to smooth the trail. All of the soil that was removed from the trail surface during the "smoothing/blading" process was pushed to the center of the trail and compacted with repeated passes of the tractor. This process took approximately two weeks to complete and was dependent upon the weather.

Data collection

The equipment utilized for this study consisted of an 6700 water sampler, two ISCO tipping bucket rain gauges, and a StarFlow ultra sonic doppler flow meter. The upstream sampler was placed in the stream far enough above the stream crossing so that any runoff from the trail into the stream would not be sampled by the intake hose. The distance from the stream crossing to the upstream sampler was approximately 60 m. The location of the downstream sampler was selected by following the sediment plumes that were being deposited into the stream from the ORV trail turnouts. The sampler was installed just downstream from the sediment plume entry point - at approximately 16 m from the stream crossing. Both the upstream and downstream samplers were connected to their own ISCO tipping bucket rain gauge.

Several parameters and procedures were set and followed for the collection of the field data. When rainfall intensity reached 2.6 mm/hr, both the upstream and downstream samplers started collecting water samples from the stream at a rate of 250 ml every fifteen minutes. Four samples were composited into each bottle. Each 1000-ml collection bottle inside the ISCO water sampler represented one hour of a storm event. Data were collected for a full 24-hour period after the sampling began.

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[4] Reference herein to any specific commercial products, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government.

Laboratory analysis of the water samples was conducted to determine the amount of suspended sediment (SS) in each 1000-mL collection bottle. These measurements were obtained by following standardized procedures (APHA – AWWA – WPCF, 1958), and the SS loads were calculated.

Results

Rainfall intensity and quantity has a direct affect on sediment loads contributed by ORV trail and stream crossings. The amount of exposed soil and the condition of the trail are also key factors that influence soil loss and resulting impairment of receiving streams. The following section presents sediment load contributed by the OVR trail stream crossing from the storm events that occurred during three trail conditions: closed, maintenance, and open. Sediment loads were calculated for both the upstream and downstream collection points using suspended sediment (SS) concentrations and stream flow rates.

When the data collection began (December 16, 2003) the trail was open for a short time. Soon after that, the trail was closed due to a highly degraded state. The trail remained closed until the end of February 2004. The trail had areas of exposed soil that had accumulated when the trail was open to ORV traffic. During trail closure, four storm events were recorded. These storm events included a 49 mm storm that occurred on February 6, 2004 (Figure 3).

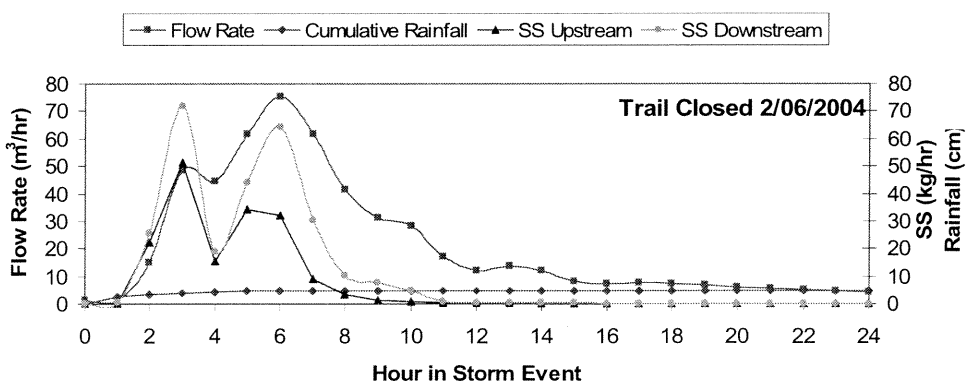

Figure 3 – Flow rate, cumulative rainfall, and suspended sediment loads from a 49 mm storm event that occurred on February 6, 2004 during trail closed condition.

The ORV trail stream crossing contributed 109 kg of sediment during this storm event, which constitutes about 39 percent of the load contributed by the 113 ha watershed (Table 1). Sediment loading to the stream reached its peak (75 kg/hr) during the 3rd hour due to the intense nature of the previous hour of rainfall. After this

event, the sediment load declined both above and below the stream crossing because of the decrease in rainfall intensity. The rainfall intensity increased again during the 5th and 6th hours and contributed a large sediment load from the ORV stream crossing. The ORV trail stream crossing contributed little sediment load from other storm events that occurred during trail closed condition (Table 1). It should be noted that these storm events had a return period of less than one year.

Table 5-Individual storm events and the SS loads contributed by the ORV stream crossing.

Trail Condition	*Date*	*Cumul-ative Rainfall*	*SS Up-stream*	*SS Down-stream*	*SS Load Contrib-uted by Stream Crossing*	*% of Load Contri-buted by Stream Crossing*
		(mm)	(kg)	(kg)	(kg)	(kg)
Trail Closed	01/25/2004	22	0.8	0.9	0.1	11.1
	02/06/2004	49	171.3	280.3	109.0	38.9
	02/12/2004	20	4.8	4.9	0.1	2.0
	02/25/2004	11	0.7	0.8	0.1	12.5
Maintenance	03/06/2004	20	26.7	30.7	4.0	13.0
	03/16/2004	5	0.1	0.2	0.1	50.0
Trail Open	12/16/2003	10	0.4	0.6	0.2	33.3
	03/20/2004	9	1.3	1.7	0.4	23.5
	03/29/2004	20	2.1	2.2	0.1	4.5
	04/11/2004	13	1.2	1.7	0.5	29.4
	04/26/2004	18	0.5	0.8	0.3	37.5
	04/30/2004	22	18.2	20.4	2.2	10.8
	05/16/2004	36	7.3	9.3	2.0	21.5
	06/22/2004	10	0.3	0.9	0.6	66.7
	07/02/2004	16	1.6	1.8	0.2	11.1

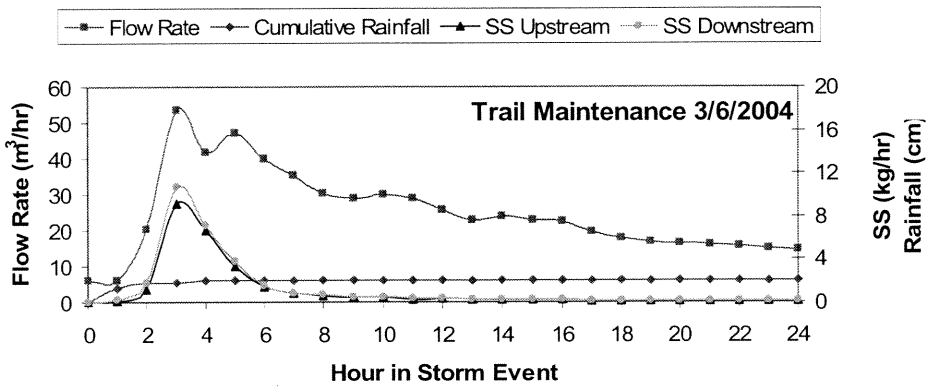

Figure 4 – Flow rate, cumulative rainfall, and suspended sediment loads from a 20 mm storm event that occurred on March 6, 2004 during trail maintenance condition.

Two similar storms, (January 25th and February 12th) which occurred during trail closure, contributed quite different sediment loads from the watershed (February 12th load being higher than the January 25th load). This could be due to a lack of rainfall prior to January 25th. While a large storm (49 mm) occurred a few days before the February 12th storm. The ground was already wet when the February 12th storm occurred resulting in more runoff and sediment load.

As mentioned earlier, during the trail maintenance period (March 1, 2004 – March 16, 2004), a crawler tractor was used to remediate trail areas that contained standing water. Even though all of the soil that was removed from the trail surface during the "smoothing/blading" process was pushed to the center of the trail and compacted with repeated passes of the tractor, this process left loose soil on the trail when a 20 mm storm occurred on March 6, 2004. During the March 6th storm event there was a steady increase in rainfall during the first few hours. As a result, stream flow rate (57 m^3/hr) and sediment load (30 kg/hr) measured by the downstream sampler reached their maximum values during the same hour (3rd), and slowly declined as the rainfall event ended (Figure 4). Two similar storm events occurring on January 25th and February 12th during the trail closed condition did not contribute nearly as much sediment as was contributed by this storm event (Table 1).

Shortly after the completion of the trail maintenance period, the trail was re-opened on March 20th to ORV use. The use of ORVs on a trail results in ruts, crevices, and the accumulation of loose soil that is spun off of the tires during fast accelerations and turns. Eight storm events after March 20, 2004 were recorded for this period. A 22 mm storm event (on April 30th) during this period resulted in 2.2 kg of sediment from the ORV trail stream crossing. The sediment load from this storm

event is slightly lower than the loads generated by a similar storm event that occurred on March 6th (Table 1). This 22 mm storm occurred after an 18 mm storm on April 26th. Since the soil was already wet, this storm event contributed large runoff and sediment loads. As shown in Figure 5, the rainfall during the April 30th storm peaked during a short time (during 2nd and 3rd hour) and resulted in a high intensity storm. A larger storm (36 mm) occurred on May 16th and did not contribute nearly as much sediment load due to a lack of rainfall prior to this storm event. The ground was fairly dry and did not result in much runoff and sediment load. In general, it was observed that when storm events occurred in succession there was an increase in the SS loads contributed by the ORV stream crossing.

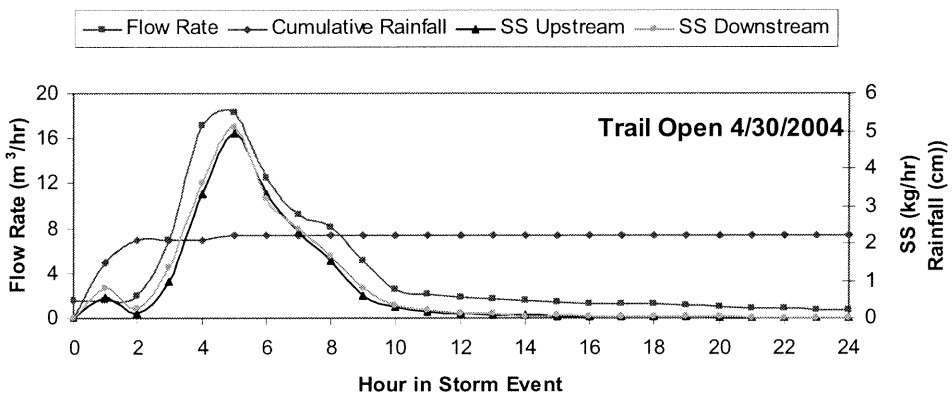

Figure 5 – Flow rate, cumulative rainfall, and suspended sediment loads from a 22 mm storm event that occurred on April 30, 2004 during trail open condition.

Conclusion

In this study, sediment loads contributed by an Off-Road-Vehicle (ORV) trail stream crossing were measured using automated samplers. Sediment loads contributed by stream crossings depend on rainfall intensity, rainfall frequency, topography, soil type, and trail condition. Data from this study suggests that back-to-back rainfall events tend to increase sediment loads from the watershed and the ORV trail stream crossing. However, isolated storm events of similar size do not contribute as much sediment load. The most significant sediment contribution into the stream occurred during an intense storm that lasted for several hours. This rainfall event had an approximate return interval of 1 year. The ORV trail did not contribute large sediment loads during other smaller events. This study suggests that ORV trail stream crossings have the potential to contribute large sediment loads from storm events that have a return interval of one year or higher. However, since data was collected for only one such event, more long-term data needs to be collected to better quantify

sediment loads contributed by ORV trail stream crossings. In addition to collecting additional data from larger storms, modeling studies need to be conducted to better assess potential loads contributed by ORV trails and ORV trail stream crossings. Future plans for this study include calibrating the WEPP (Water Erosion Prediction Project) model using the collected data and quantifying long-term sediment loads contributed by ORV trails and ORV trail stream crossings. A modeling study will also help identify management practices that can be used to minimize water quality impacts of ORV trails.

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