EFFECTS OF FOREST HARVEST AND PLANTING ON HYDROLOGY AND SEDIMENT TRANSPORT IN HEADWATER BASINS DRAINING THE PELHAM ESCARPMENT

Scott B. Terrell[1], William B. Summer[2], C. Rhett Jackson[3]

AUTHORS: [1]Master of Science Candidate, Warnell School of Forest and Natural Resources, University of Georgia, Athens GA, 30602. [2]NPS Specialist, NC Division of Forest Resources, DENR, [3]Assistant Professor, Warnell School of Forest and Natural Resources, University of Georgia, Athens GA, 30602.
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Abstract. Timber harvesting practices are known to disturb soil and increase bare soil, increase overland flow and peakflow rates, all of which have the potential to increase sediment input to a stream and the erosional power of a stream. These potential water quality issues can have detrimental effects on riparian and aquatic species. Streamside management zones (SMZs) help to reduce the impacts of silvicultural practices. This study is designed to evaluate the hydrologic and sediment transport response during pre-harvest and post harvest periods using a paired watershed approach. Two reference watersheds and two treatment (harvested) watersheds of relatively the same size, shape, geology, and vegetation have been monitored since July 2001. The treatment watersheds will be harvested with the exception of the streamside management zones (SMZs). The SMZs in the will be divided up into upper and lower sections. The upper sections will remain intact and lower sections have undergone partial harvesting in accordance with Georgia forestry best management practices (BMPs). Our results show that there were significant increases in total yield of the treatment watersheds from the pre-harvest to the post harvest period. Peak flows increased slightly in the treatment watersheds after harvest.

INTRODUCTION

It is well documented that forestry practices are sources of non-point source pollution. Harvesting trees is known to disturb and increase bare soil, increase peak flow, surface runoff and the erosional power of the stream causing an increase in sedimentation (Beasley, 1976; NCASI, 1994; Yoho, 1980). The 2000 National Water Quality Inventory conducted by the EPA, found that over 40% streams, 45% of lakes and 50% of estuaries assessed are impaired. Sedimentation and nutrient loading were in the top five and top three leading causes of impairment for streams and lakes respectively. Common sources of stream degradation are hydrologic modifications (reductions in flow) and habitat modifications (removal of riparian areas) (USEPA 2002).

Best management practices (BMPs) are recommended by federal and state regulatory agencies to reduce the impacts of non-point source pollution. Many studies have been conducted and have shown that if BMPs are properly implemented, non-point source pollution is significantly reduced (Hutchens, 2004; Jackson and Olszewski, 2005; Wynn et al., 2000). A crucial part to forestry BMPs is the streamside management zone (SMZ). An SMZ is an area of intact vegetation acting to buffer a stream from adjacent forestry practices. SMZs help to stabilize stream banks, regulate temperature, input woody debris and organic litter into the stream, create habitat, and filter storm runoff that have the capabilities of transporting contaminants to a stream (Rivenbark and Jackson, 2004). A partial harvesting of the SMZ, up to 50% canopy cover or 11.5 square meters of the remaining basal area, took place in the lower sections of the treatment SMZs. Effects of partial harvesting an SMZ on habitat and stream water quality have not been well documented, leaving the efficiency of this BMP method, in reducing non-point source pollution, uncertain. The objective of this paper is to observe the hydrologic and sediment transport response during pre-harvest and post harvest periods, using a paired watershed approach.

METHODS

Site Description

The study site is located in the Upper Coastal Plain physiographic province of Georgia in Decatur County at International Paper's Southlands Forest (30°47'30"N and 84°37'30"W) (Figure 1). The precipitation in this area is dominated by high intensity, short duration storms in the summer and low intensity, long duration frontal systems in the winter and spring months. The longterm average annual precipitation range 1250 mm (International Paper Co., 1980).

Four watersheds (A, B, C, D) were chosen due to their relative size shape, geology, aspect and vegetation to conduct a paired watershed study design. They range from 26 to 48 hectares and consist of first order perennial streams, except in times of extreme drought. All flow into Dry Creek, a second order stream and a tributary of Lake Seminole, which is part of the Apalachicola-Chattahoochee-Flint river basin. Watershed pairs A (reference) and B (harvested) have gentle slopes with broad, flat riparian areas and meandering channels whereas, C (harvested) and D (reference) have steeper slopes and narrow often incised riparian area with well defined channels.

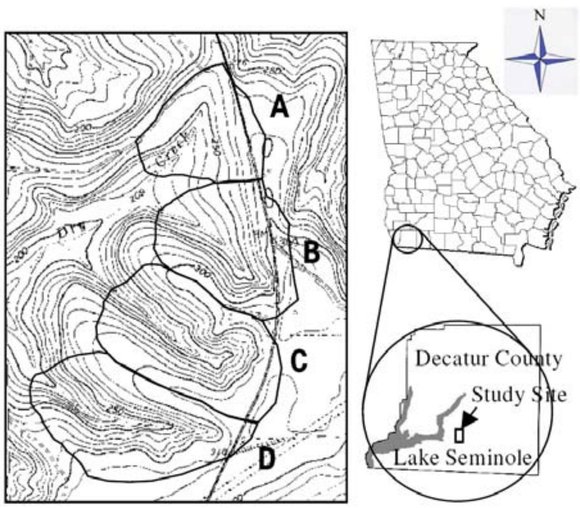

Figure 1. Experimental watersheds and their location.

The study area is located on the Pelham escarpment between the Dougherty Plain and Tifton Upland. The underlying geologic units are the Hawthorne (Miocene), Miccosukee (Pliocene) and the Chattahoochee (Oligocene) Limestone formations that form the Tifton Upland. The Dougherty Plain is underlain by the Suwannee (Oligocene) and Ocala (Eocene) Limestone, which compose the geologic units of the Upper Floridan Aquifer. The overlying soils of the four watersheds are Ultisols with the major soil series of the uplands being the Lakeland, Orangeburg, Lucy, Norfolk and Wagram units, which are well drained, loamy sands over sandy loams, with the exception being the Lakeland series which is a excessively well drained sand. The slopes are generally the Eustis and Esto series which are well drained, fine sandy loams over clay loams and moderately excessively well drained, fine sands respectively. The riparian soils are primarily of the Chiefland series which are moderately well drained to well drained, fine sands. The Climate is temperate with hot humid summers and cool winters. During the winter precipitation is dominated by long duration, low intensity frontal systems and the summer is dominated by high intensity short duration thunderstorms, with a mean annual rainfall of 1250 millimeters. Mean annual potential evapotranspiration averages 990 to 1150 millimeters (International Paper Co., 1980).

Experimental Treatments

Two watersheds (A & D) have remained as a reference and two have undergone treatments (B & C). Treatments include clearcut harvesting and partial thinning of SMZs (fall 2003), mechanical and chemical site preparation as well as a site preparation controlled burn (fall 2004) and planting (winter 2005). The SMZs in the treatment watersheds were bisected, the downstream half of the SMZs were thinned up to 50% remaining canopy cover or 11.5 square meters of basal area and the upstream sections riparian area was left intact.

Data Collection

Data is collected at six sites, one site per watershed outlet and one site per harvested watershed between the thinned and unthinned SMZs, with Parshall 9 inch H-flume. Stream stage and discharge are recorded on 15 minute intervals using Teledyne Isco bubbler flow meters (Model 4230). Twelve 100 mL bottles collect 100 mL of baseflow every 6000 cubic feet of stream flow and twelve 100 mL bottles collect 1000mL of stormflow every fifteen minutes once the program is initiated. The stormflow program is dependent on a specific precipitation rate and change in stage for each of the six sites using Teledyne Isco automated samplers (Model 6720). Both baseflow samples and stormflow samples are analyzed for total suspended solid concentration (TSS) and inorganic suspended solid concentration (SSC). TSS and SSC are analyzed by filtering an aliquot of sample through a, pre-weighed, 0.47 micron glass fiber filter. The filters are then dried for 24 hours at 60 degrees Celsius and weighed to determine TSS. They are then ashed for 1 hour at 550 degrees Celsius to determine SSC.

RESULTS AND DISCUSSION

Annual precipitation has varied from a low of 587 mm to a high of 1784 mm. The water budgets indicate that yield decreased in all watersheds even as the precipitation increased from the preharvest period (years 1 and 2) to the post harvest period (years 3, 4, and 5) (Table 1). This is the opposite effect of harvesting on water yield from what the literature reports (Beasley, 1976, Hewlett et al. 1984). The increase in water yield is directly due to decreased evapotranspiration from the harvesting of trees (Yoho, 1980).

There was no significant increase in peak storm flow after harvest, but there was a slight increase in base flow of the treatment streams to alpha = 0.05 (Summer, 2006).

The double mass curves of accumulative precipitation in centimeters vs. accumulative runoff in centimeters, Figure 2, reveal that the treatment watersheds (B & C) discharge increases with respect to both reference

Table 1. Pre-harvest and post harvest yields for watersheds A, B, C, and D. Pre-harvest data are years 1 and 2. Post harvest data are years 3, 4, and 5.

Year	A1 (%)	B1 (%)	C1 (%)	D1 (%)	Rainfall (mm)
1	9.0	19.4	20.0	4.7	865
2	26.6	42.5	39.5	24.4	1220
3	5.6	24.9	25.0	7.4	1325
4	36.2	48.2	55.3	30.8	1784
5	13.2	37.6	55.1	24.1	587

watersheds during the post harvest period. The discharge for watershed D increases with respect to watershed A. Watershed D is showing a treatment effect, therefore watershed A is considered to be a more reliable reference. Before the harvest the slopes of the two reference watersheds were not statistically different (α = 0.05). After the harvest it appears that watershed D began to receive more groundwater flow as a result of reduced evepotranspration.

Figures 3 and 4, show diurnal fluctuations of stream flow as a result of evapotranspiration for all streams. Leon Bren (1997) reports that the fluctuations are in direst responses to riparian vegetation only, vegetation on the mid and upper slopes contribute nothing to the slope or amplitude of the fluctuations. These fluctuations are also characteristic of a gaining stream, with a gradual rising limb and a sharp, longer falling limb (Lundquist and Cyan, 2002). Further analyses of diurnal fluctuations are in progress.

Total suspended sediment yield decreased for all watersheds after harvest. It appears that both sediment yield and water yield are more dependent on climactic variations than on treatment effects.

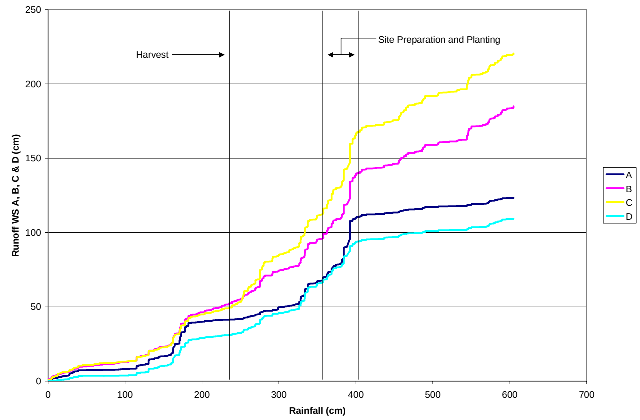

Figure 2. Double mass curve of all watersheds (cm) vs. precipitation (cm). Watersheds A & D are reference and B & C are treatment.

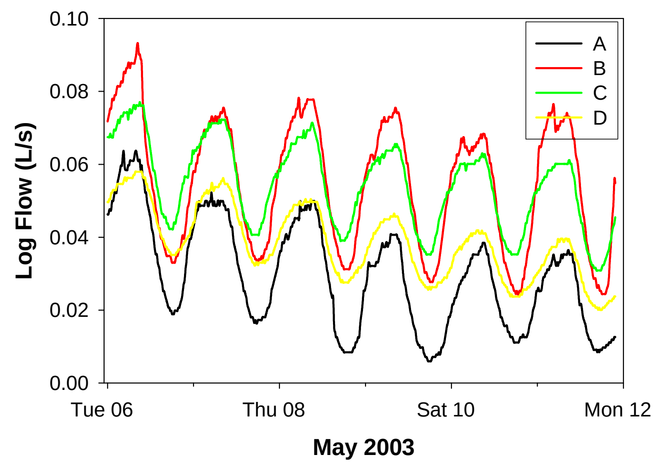

Figure 3. Diurnal fluctuation of all watersheds before harvest.

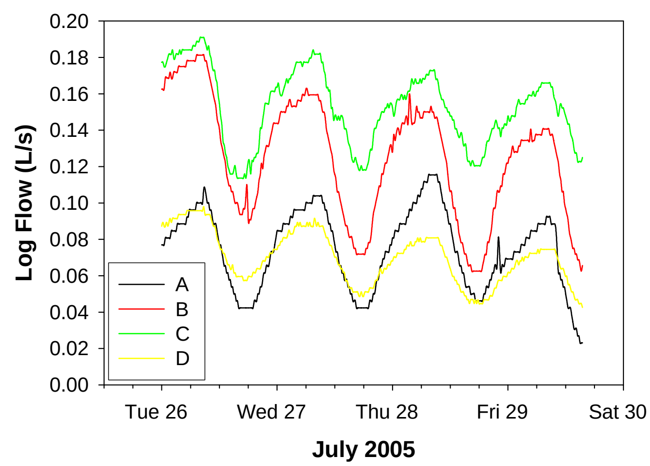

Figure 4. Diurnal fluctuations after harvest.

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