INITIAL ASSESSMENT OF FORESTRY STREAMSIDE MANAGEMENT ZONES IN LOESS BLUFFS

Richard F. Keim and Stephen H. Schoenholtz
Department of Forestry
Mississippi State University

INTRODUCTION

The non-point source pollution potential of forest harvesting and management activities (EPA 1980) has prompted many states to adopt voluntary or mandatory Best Management Practices (BMPs) programs to reduce such effects and protect stream water quality. One important component of BMPs is the Streamside Management Zone (SMZ) - a reduced-impact area adjacent to a stream designed to provide a buffer from watershed disturbance activities. As a component of BMPs, SMZs are expected to ameliorate increases of sediment and nutrient inflows to streams, as well as to modify stream temperature changes (Lowrance et al. 1985). The filtering ability of SMZs is due to the roughness of the intact forest floor that slows water flowing overland (Cooper et al. 1987). This loss of velocity decreases the water's sediment-moving capacity (Warrington et al. 1980; MacDonald et al. 1991). Negatively affecting SMZ effectiveness is slope steepness (Mississippi Forestry Commission 1989). However, there has been limited research done on SMZ effectiveness applicable to the coastal-plain South, particularly the loess bluff region of Mississippi. One objective of this ongoing research is to study the effectiveness of SMZs on small, first-order intermittent streams in watersheds that have highly erodible loess soils and slopes as steep as 100%.

MATERIALS AND METHODS

Loess Bluffs. The region of aeolian deposits (loess) parallel to the eastern edge of the Mississippi River floodplain from Louisiana to the upper Midwest is known as the Loess Bluffs. Loess can be up to 30 m thick (Wascher et al. 1947); depth of deposition decreases with distance from the Mississippi River (Frazee et al. 1970). This study was located approximately 4 km from the western edge of the bluffs, where deposition is very deep. Loess, at 96% silt and of aeolian origin, has little internal structure, is very unstable, and is subject to high rates of erosion. The terrain of the Loess Bluffs is therefore deeply dissected and very steep, and large active gullies are common.

The favorable nutrient status and water-relations properties of loess make it ideal for quality hardwood production forestry. Historically, natural regeneration has been achieved through selectively harvesting approximately 50% of the standing timber on a cycle of 10 to 15 years. Tree felling has been by chainsaw and log removal by skidders equipped with 30-m cables to allow access into the steep terrain. Many voluntary BMPs have been practiced, though SMZs have not been applied to first-order streams.

Study Design. First-order watersheds were selected in three blocks delimited by slope steepness and watershed size; one treatment was randomly assigned to each watershed within each block. Watershed size ranged from five to 15 ha. Watersheds were selected within each block to be similar in slope characteristics and forest cover. Each watershed had a similar history of selection-system harvests and none had been cut within the past 12 years.

Four treatments were investigated: (1) Unrestricted Harvest, (2) 30-m SMZ delineated, cable removal of timber from within the SMZ ("Cable-Only SMZ"), (3) 30-m SMZ delineated, no removal of timber from within the SMZ ("No-Harvest SMZ"), and (4) Un-cut Reference (Table 1).

The Unrestricted Harvest treatment follows the standard operating procedures for the area, where no SMZ was delineated. Streams were crossed indiscriminately by skidders and harvesting in the streamside zone was of equal intensity as on the ridges. The Cable-Only SMZ treatment disallowed skidder entry into the streamside zone and prohibited stream crossing by skidders. Harvesting within the SMZ was limited to 20%, and log removal was by cable only. The No-Harvest SMZ treatment prohibited any harvesting activity in the streamside zone. In both SMZ treatments, harvesting outside of the SMZ was achieved in the same way as in the Unrestricted Harvest. The Reference treatment received no harvesting activity on the entire watershed.

The SMZ width of 30 m was applied to both sides of the stream and was chosen based on recommendations from other research as well as from the Mississippi BMP handbook (Mississippi Forestry Commission 1989) and practical limits.Most SMZ research for forestry has focused on mountainous regions, where SMZ recommendations range up to 100 m (NCASI 1992). Nearly all SMZ research for the coastal-plain South has been conducted in predominantly agricultural watersheds (Lowrance et al. 1988). The 30-m width approximates Mississippi BMP guidelines for severely erodible soils on very steep slopes, while allowing access by existing machinery.

Measurements

Suspended Sediment. Automatic water samplers were placed at the base of each stream to take a 25-ml sample once every hour. The samplers were visited every two weeks and a composite sample was drawn from each one. These samples were analyzed in the laboratory for total suspended sediment (TSS) by standard procedure (APHA 1987).

Mineral Soil Exposure. Within 30 m of each stream, mineral soil exposure was measured within two weeks after treatment by ocular estimation of a one-m^2 area delineated by a square frame. Exposed mineral soil was defined as the percent mineral soil observed (no organic litter or herbaceous ground cover) when viewed from directly above the frame. Observations were made in exposure classes of 10% increments, plus classes of 3% and 97% exposure. The measurements were taken in transects perpendicular to the stream, comprising estimates at distances of 5 m, 10 m, 15 m, 20 m, 25 m, and 30 m from the stream. Transects were spaced 40 m apart. The number of transects varied by watershed size and ranged from 11 to 44.

RESULTS AND DISCUSSION

Suspended Sediment

Biweekly measurements of TSS were not significantly different among the treatments during the first 11 months after treatment (Figure 1). However, two trends are notable. Total suspended sediments in the Unrestricted Harvest watersheds show several peaks and higher fluctuations than other treatments, whereas Reference treatment TSS levels showed the lowest fluctuations among sampling periods. Total suspended sediments over the first 11 months of the study show significant increases in the Unrestricted Harvest treatment, whereas the SMZ treatments had TSS levels comparable to the Reference treatment (Table 2). This suggests that both SMZ treatments were effective in reducing streamwater TSS during the first year after harvesting.

Mineral Soil Exposure

Treatment and slope position interacted to significantly affect mineral soil exposure in the SMZ. At distances of five- and ten m from streams, the Unrestricted Harvest had significantly higher mineral soil exposure than the other treatments (Figure 2). Furthermore, within the Unrestricted Harvest treatment, the 5-m location had higher mineral soil exposure than was observed at distances $\geq$ 15 m (Figure 3). Relatively high exposure in lower-slope positions in the Unrestricted Harvest treatment can be explained by the concentration of skid trails which were commonly located parallel to streams.

At upslope SMZ boundaries, 30 m from the stream, mineral soil exposure was higher in the Cable-only SMZ treatment (Figure 2). This location also had higher mineral soil exposure than locations closer to the stream in the Cable-only SMZ areas (Figure 3). A high level of disturbance at the edge of the Cable-only SMZ by concentrated skidder traffic and log skidding may have caused this higher mineral soil exposure. In contrast, relatively low mineral soil exposure in lower-slope positions of the Cable-only SMZ treatment (Figure 3) may be the result of tree slash accumulations from tree bucking within the SMZ. Slash accumulations at the SMZ edge in the No-Harvest SMZ may also explain mineral soil exposures lower than at lower slope positions (Figure 3).

Mineral Soil Exposure vs. Suspended Sediment

Average mineral soil exposure across the six measurement locations in each watershed explained 69% of the variation in streamwater TSS. However, mineral soil exposure five m from streams was the most important individual predictor of streamwater TSS, accounting for 38% of the observed variation (Figure 4). These preliminary results suggest that streamwater TSS is sensitive to the amount of mineral soil exposed and that forestry SMZs that minimize forest floor disturbance, particularly near the stream channel, can decrease sediment delivery.

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Table 1. Streamside Management Zone treatments applied to first-order watersheds in the loess bluffs.

Watershed Treatment	Non-SMZ Harvest Level	Non-SMZ Timber Removal Method	SMZ Harvest Level	SMZ Timber Removal Method
Unrestricted Harvest	50%	Skidder and Cable	50%	Skidder and Cable
Cable-Only SMZ	50%	Skidder and Cable	20%	Cable Only
No-Harvest SMZ	50%	Skidder and Cable	0%	N/A
Reference	0%	N/A	0%	N/A

Table 2. Effect of Streamside Management Zone treatments on overall total suspended sediment in the loess bluffs.[1]

Treatment	TSS (mg/l)
Unrestricted Harvest	1750.6a[2]
Cable-Only SMZ	587.1b
No-Harvest SMZ	341.5b
Reference	153.5b

[1]Values are eleven-month means of biweekly composite samples.
[2]Letters indicate LSD significance groupings at α=0.05.

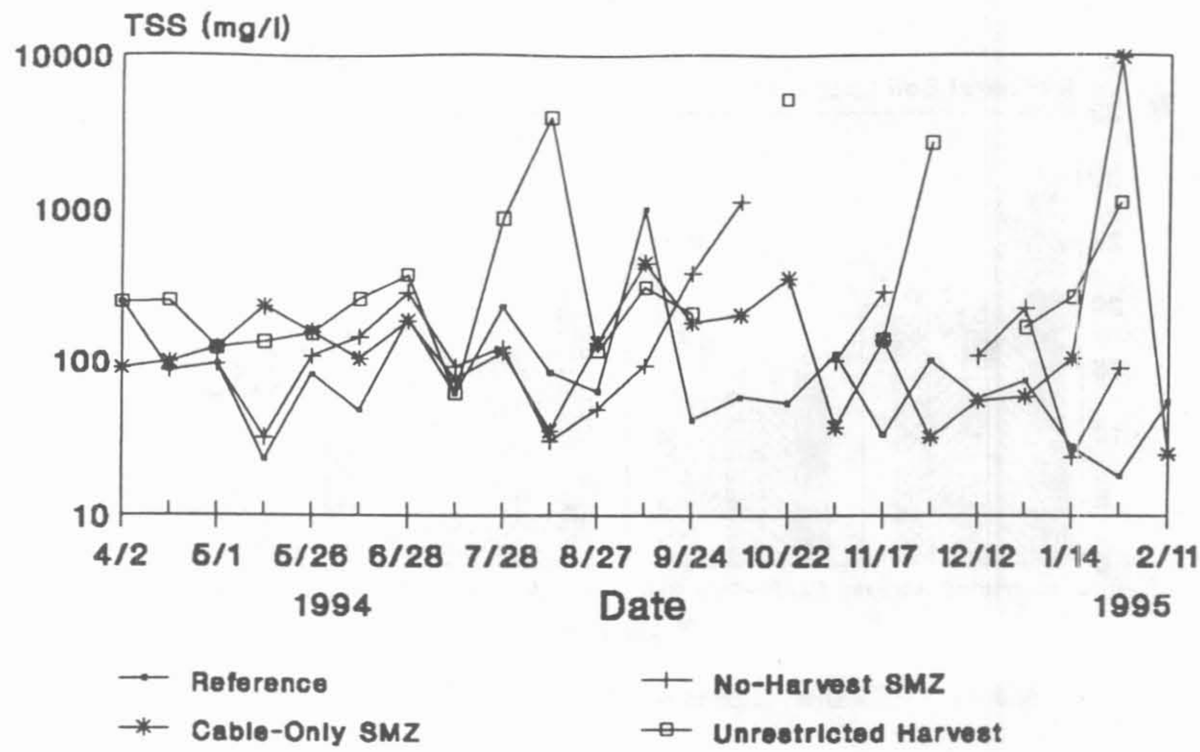

Figure 1. Monthly total suspended sediment values from four Streamside Management Zone treatments in the loess bluffs.

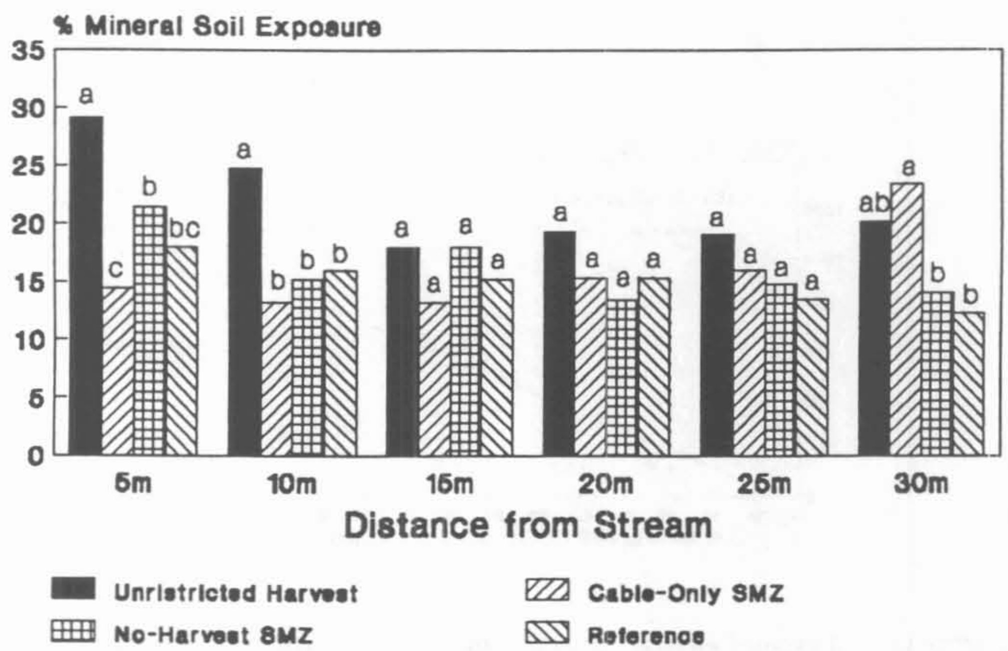

Figure 2. Effect of percent mineral soil exposure at different slope positions for four Streamside Management Zone treatments in first-order watersheds in the loess bluffs. Letters indicate LSD significance groupings (α=0.05) among treatments within each position.

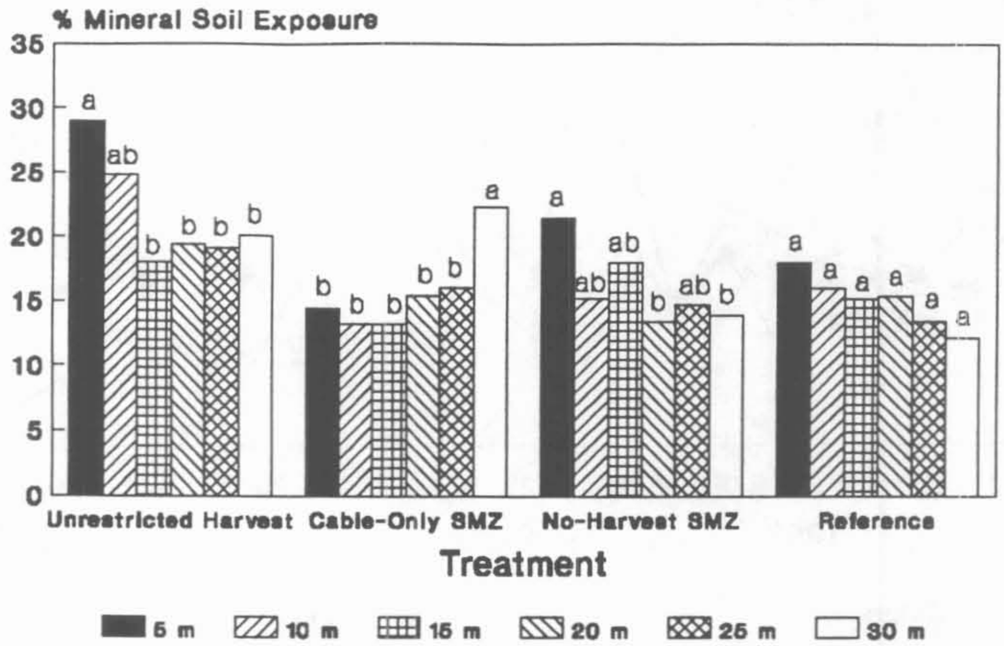

Figure 3. Effect of slope position on percent mineral soil exposure in first-order watersheds for four Streamside Management Zone treatments in the loess bluffs. Letters indicate LSD significance groupings (α=0.05) among positions within each treatment.

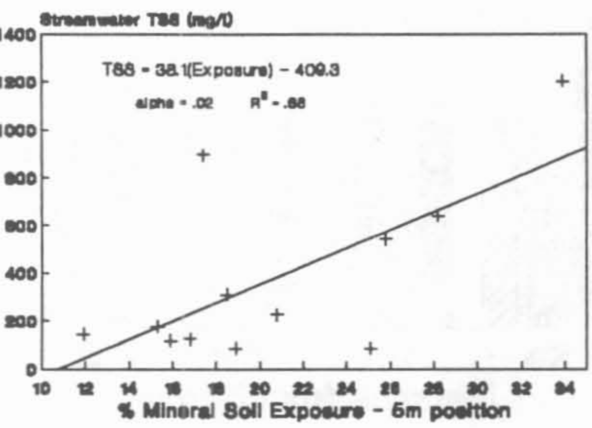

Figure 4. Average percent exposed mineral soil at 5 m distance from first-order streams in the loess bluffs as a predictor of streamwater total suspended sediment.