ASSESSING THE EFFECTIVENESS OF SILVICULTURAL STREAMSIDE MANAGEMENT ZONES: A RESEARCH APPROACH

Brad W. Young, Stephen H. Schoenholtz, Eric D. Dibble, and Andrew W. Ezell
Forest and Wildlife Research Center
Mississippi State University, Starkville, Mississippi

INTRODUCTION

Forestry best management practices (BMP's) are aimed at preventing or minimizing water pollution from non-point sources on lands undergoing forest management activities. One of the most common tools of any BMP strategy is the use of a streamside management zone (SMZ) (MS Forestry Commission 1995). An SMZ can be defined as any vegetated area adjacent to a stream or other watercourse that serves as a buffer between the water resource and an area of disturbance. Streamside management zones adjacent to logging sites are believed to protect water quality by slowing the rate of overland flow, serving as catchments for sediment and nutrients, and minimizing changes in streamwater temperature (Coleman and Kupfer 1996; MS Forestry Commission 1995).

Although SMZ's are widely used in forestry practices in the Southeastern U.S., the majority of research on SMZ's has focused on their application in agricultural settings (Duda and Johnson 1985). With the exception of one study conducted in the Loess Hill Region of Mississippi (Keim and Schoenholtz 1999), there are no published reports of SMZ effectiveness adjacent to logging activities in the Gulf South (Comerford et al. 1992). Forest harvesting activities have increased dramatically throughout the Gulf South during the past two decades and the use of SMZ's is widely practiced as a part of these activities in order to protect streamwater quality. Thus, there is a critical need to assess the effectiveness of SMZ's in relation to forest harvesting activities in the Sand-Clay Hills Subsection of Mississippi, an area that is under intensive management for production forestry. This study is designed to evaluate the effectiveness of SMZ's in protecting water quality adjacent to forest harvesting activities. The purpose of this paper is to present our research approach for studying effectiveness of forestry SMZ's.

SITE DESCRIPTION

In order to limit variability, all streams for this study were chosen based on a set of predetermined criteria. Candidate streams were located within loblolly pine (*Pinus taeda*) stands that were designated for future harvest. Upstream areas of acceptable tracts were relatively free of disturbances such as roads, clearcuts, and agricultural fields. Stream reaches ≥ 200 m in length were designated for monitoring. After extensive searching, nine first- or second-order streams were accepted for the study. Four of the streams are located in Webster County, four of the streams are located in Choctaw County, and one stream is located in Calhoun County (Figure 1). Each county is within the Southeastern Mixed Forest Province, the Coastal Plain Middle Section, and the Sand-Clay Hill Subsection of Mississippi (Bailey 1995). Soils within the rolling-to-ruggedly-hilly topographic area are high in clay content. The A-horizon is either a sandy loam or silt loam (Hodgkins and others 1979).

TREATMENTS

Three treatments will be used in this experiment to test the effectiveness of SMZ's: (1) an unrestricted harvest; (2) a harvest with a predetermined SMZ; and (3) an uncut reference. Streams were selected based on the harvest schedule of adjacent loblolly pine stands. Each treatment will be replicated three times and will be performed on a watershed containing a first- or second-order perennial stream. The SMZ treatments will be delineated by local industry foresters according to company standards. Streamside management zones will be set according to the contour of the land and the vegetation present. This method of delineation is known to local foresters as "following the fern line." By these criteria, the SMZ will include all of the area below the first ridge adjacent to the stream. The SMZ will range from approximately 20 to 100 m in width on each side of the stream, depending on the site. Selective harvesting of individual stems will be allowed within SMZ's as practiced by local industry foresters. The unrestricted harvest will be conducted with no regard for the stream or residual habitat quality. Basal area removal within the riparian zone will approach 100% and the stand will be cut to the edge of the stream bank. Skidder traffic in the area will not be regulated and no trails will be designated before harvest. Skidders will likely run adjacent to streams. No harvesting or disturbance of any kind will be done in the reference treatment. Harvest of treatment watersheds began in late February, 2000 and should be concluded by the end of April, 2000.

MEASUREMENTS

Automatic water samplers (ISCO Model 2910 , ISCO Company, Lincoln, NE) have been placed both upstream and downstream from the designated treatment area in each stream. Upstream and downstream sampling points have been determined by the harvest boundary in relation to the stream (Figure 2). Sampling points for reference streams have been chosen to resemble length and physical characteristics of the treatment streams (Keim and Schoenholtz 1999). Samples are being collected from each water sampler at a regular interval of two weeks. Each sampler collects 250 ml of water every 12 hours. These samples are composited within the sampler and a representative subsample of 1 L is collected at each visit. The 1 L subsample is taken back to the laboratory and analyzed for total suspended sediment. In addition to samples taken by the automatic samplers, grab samples are also taken at each visit. These samples are analyzed (within 48 hours) by ion chromatography (Ion Chromatograph Model DX-500, Dionex Corporation, Sunnyvale, CA) to measure nitrate, orthophosphate, sulfate, and ammonium present in each stream. Stream water temperature, dissolved oxygen, electrical conductivity, and pH are recorded at the two sampling locations in each stream using a portable water analyzer (Autochek Model 51500, Perstorp Analytical, Wilsonville, OR). Turbidity is also evaluated using a portable turbidimeter (Turbidimeter Model 2020, LaMotte Company, Chestertown, MD) (Clesceri, Greenburg, and Trussell, 1989). All of the previously-mentioned parameters are measured during the biweekly visit at the upstream and downstream sampling point in each stream. Sampling began in September 1999, approximately five months before treatment. Grab samples were used initially for determination of total suspended sediment. Automatic samplers are being established just prior to or during the time of treatment. Sampling at this intensity will continue ≥ 12 mo after treatment.

Erosion and deposition within each watershed will be measured by transects of erosion stakes after treatments are imposed (Brooks *et al.* 1997). Stakes will be 2.5 cm diameter PVC pipe cut into 1 m lengths. Transects will be spaced 40 m apart and will run perpendicular to the stream channel on both sides. Stakes will be placed at even intervals along the transect for a length determined by the treatment. For the SMZ treatments, erosion stakes will run from the edge of the stream bank to the outer edge of the SMZ. Stakes within the riparian zone of the unrestricted-harvest and reference treatments will be measured at positions to resemble the widths of the SMZ treatments. Stakes will be measured 9 mo after harvest to determine the degree of erosion or deposition. As a correlation to erosion stake transect data, mineral soil exposure will also be measured following treatment at the time of erosion stake placement. This will be done by surveying a 1 m area adjacent to each stake within the treatment area. This procedure will be performed again 9 mo after treatment. These data will be used to correlate soil surface conditions with sediment movement within the watershed.

PRELIMINARY RESULTS

Temperature change from upstream to downstream locations during five months of pre-treatment sampling ranged from a decrease of 0.5° C in the streams designated to receive no SMZ to an increase of 1° C in the designated reference streams (Figure 3A). No patterns correlating to anticipated treatments were evident prior to treatment. Changes in electrical conductivity showed the most variation in the streams designated for the SMZ treatment, while streams designated to be uncut references showed a constant increase from upstream to downstream sampling points (Figure 3B). Streams draining areas that will be harvested without SMZ's showed minimal change from upstream to downstream points. There was very little change in the amount of dissolved oxygen from upstream to downstream over the course of the sampling period among all streams (Figure 3C). Turbidity was the only variable that showed statistical differences among designated treatments at the = .1 significance level (Figure 4A). This is possibly due to organic acids being leached into the SMZ treatment streams from November to mid-December. The large decrease in turbidity from upstream to downstream position in streams that will have no SMZ's observed on January 18, can be related to a decrease in suspended sediments (Figure 4B). However, changes in total suspended sediment between upstream and downstream positions were generally minimal throughout pre-treatment sampling. Changes in nitrate concentration were minimal between upstream and downstream sampling points and no patterns correlating to anticipated treatments were evident (Figure 5A). Sulfate content changes were almost non-existent for streams that will receive the no-SMZ treatment (Figure 5B). There was a constant, but insignificant, increase in sulfate content from upstream to downstream in streams designated for reference treatment. Streams that will receive SMZ's showed the most variation in sulfate changes between upstream and downstream positions, ranging from an increase of 8 mg/L to a decrease of 20 mg/L. Orthophosphate was undetectable in approximately 95% of samples taken.

PROJECT STATUS

Water quality sampling continues on a biweekly basis. Treatments are currently in place in four of the six watersheds designated for harvesting. Once all treatments are completed, erosion stake transects will be will be put into place and mineral soil exposure will be surveyed.

REFERENCES

Bailey, R.G. 1995. Description of the Ecoregions of the U.S. Forest Service Publication 1391.108 pp.

Brooks, K.N., P.F. Ffolliott, H.M. Gregersen, and L.F. DeBano. 1997. Hydrology and the Management of Watersheds. 2nd Edition. Iowa State University Press. Ames, Iowa. 502 pp.

Clesceri, L.S., A.E. Greenberg, and R.R. Trussell. 1989. Standard Methods for the Examination of Water and Wastewater. Washington, D.C. APHA, AWWA, WPCF.

Coleman, D.S. and J.A. Kupfer. 1996. Riparian water quality buffers: Estimates of effectiveness and minimum width in an agricultural landscape, western Tennessee. Southeastern Geographer. 36:113-127.

Comerford, N.B., D.G. Neary, and R.S. Mansell, ed. 1992. The effectiveness of buffer strips for ameliorating offsite transport of sediment, nutrients, and pesticides from silvicultural operations. NCASI Tech. Bulletin No. 631. NY, NY.

Duda, A.M. and R.J. Johnson. 1985. Cost effective targeting of agricultural non-point source pollution controls. Journal of Soil and Water Conservation. 40:108-110.

Hodgkins, E.J., M.S. Golden, and W.F. Miller. 1979. A Guide to Forest Site Classification in Alabama-Mississippi. Southern Coop. Series 210. Alabama Agricultural Experiment Station, Auburn University, Auburn, Alabama. 63 pp.

Keim, R.F. and S.H. Schoenholtz. 1999. Functions and effectiveness of silvicultural streamside management zones loessial bluff forests. Forest Ecology and Management.118:197-209.

Mississippi Forestry Commission. 1995. Mississippi's Best Management Practices Handbook. 37 pp.

Figure 1. Location of research streams in three-county area of Mississippi.

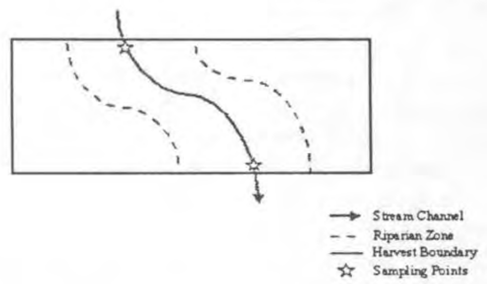

Figure 2. Stream sampling locations in relation to riparian zone and harvest boundary.

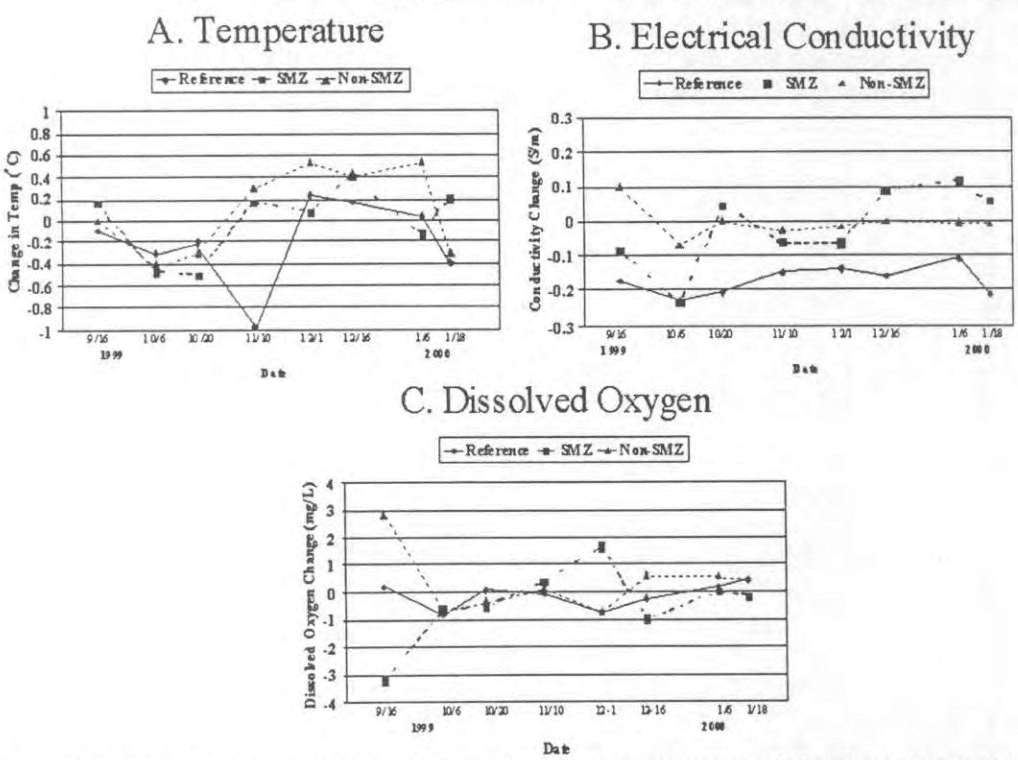

Figure 3. Changes in streamwater temperature, electrical conductivity, and dissolved oxygen between upstream and downstream sampling locations in the Sand-Clay Hills subsection of Mississippi.