SOIL EROSION FROM HARVESTED SITES VERSUS STREAMSIDE MANAGEMENT ZONE SEDIMENT DEPOSITION IN THE PIEDMONT OF VIRGINIA

William A. Lakel III, W. Michael Aust, C. Andrew Dolloff, and Amy W. Easterbrook[1]

Abstract—Forestry best management practices were primarily developed to address two major issues related to soil erosion: water quality and site productivity. Sixteen watersheds managed as loblolly pine plantations in the piedmont region were monitored for soil erosion and water quality prior to treatment. Subsequently, all watersheds were harvested with clear-cutting, ground-based skidding, prescribed burning, and installation of fire lines. Four blocks were established on the basis of geology, soils, topography, vegetation, and management. Within each block, 5 SMZ treatments (25-feet-wide, 50-feet-wide with and without partial harvest, and 100-feet-wide with and without partial harvest) were installed. On-site erosion was estimated for the watershed and within each major disturbance category (harvest, skid trails, fire lines) and contrasted with the quantity of sediment trapped by the various SMZ treatments.

INTRODUCTION

Streamside management zones (SMZs) are widely recommended for the protection of water quality during and after forest harvesting (Blinn and Kilgore 2001, VDOF 2002). Research has indicated that SMZs can be important for collecting and filtering runoff from harvested sites as well as reducing thermal pollution from direct sunlight (Kochenderfer and Edwards 1990, VDOF 2002). It is also widely accepted that these riparian buffers have significant value as wildlife habitat. Numerous studies have shown the positive impacts of SMZs (Castelle and others 1994), but few have investigated the efficacy of various widths and harvest levels.

It was hypothesized that the SMZs might collect measurable sediment moving downslope from cutover areas and firelines. It was also expected that different SMZ widths and harvest levels might impact the amount of sediment eroded or deposited.

EXPERIMENTAL DESIGN AND SITE CHARACTERISTICS

This study includes 16 watersheds in the Piedmont Plateau in Buckingham County, VA. The study is an incomplete block design with four blocks and four treatments. The SMZ treatments are (1) 25 feet wide, (2) 50 feet wide with no thin, (3) 50 feet wide thinned, and (4) 100 feet wide with no thin. Pre-harvest data was collected and analyzed in 2002 (Easterbrook 2005). The watersheds were clear-cut in summer and fall 2003, and erosion measurements were re-taken in February 2005. SAS® software (SAS Institute, Cary NC) was used to determine significant differences between treatment means by the Tukey-Kramer procedure for all comparisons.

The Piedmont plateau of Virginia is typical of the Piedmont in the Southeast in general. Elevations range from 200 feet above sea level to the east and 1,200 feet above sea level to the west. Local slopes occasionally exceed 30 percent. Extensive agriculture since the 1700s has led to severe soil erosion and loss of significant site productivity (USDA 2002). The watersheds are dominated by old field sites that were abandoned after the Civil War and reclaimed by native shortleaf pine (*Pinus echinata* Mill.) and Virginia pine (*Pinus virginiana* Mill.) as well as a mix of hardwood species such as white oak (*Quercus alba* L.), scarlet oak (*Quercus coccinea* Muenchh.) hickory (*Carya spp*.), red maple (*Acer rubrum* L.), and black gum (*Nyssa sylvatica* Marsh.). Non-native loblolly pine (*Pinus taeda* L.) plantations were initially planted in the 1970s (Gembroys 1974, Schultz 1997, USDA 2002, Van Lear and others 2004).

RESULTS AND DISCUSSION

Pre-harvest Erosion

Pre-harvest erosion in the SMZs using steel rebar erosion rod transects—The re-bar was pounded into the ground in three transects per SMZ and measured periodically to determine sediment aggradation or degradation across each SMZ. Pre-harvest erosion was estimated in the upland sections of each watershed using the USLE method described by Dissmeyer and Foster (1984). Figure 1 demonstrates the results of the

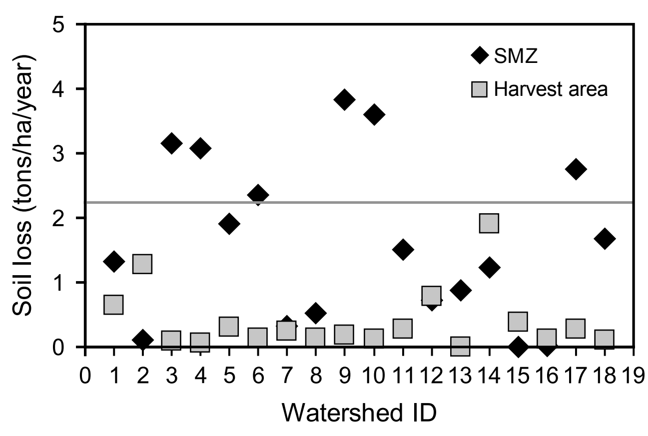

Figure 1—Pre-harvest soil loss for the SMZs in tons/ha/year.

[1] Instructor and Professor, respectively, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061; Project Leader, Coldwater Fisheries Unit, USDA Forest Service, Southern Research Station, Blacksburg, VA 24061; and Graduate Research Assistant, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.

Citation for proceedings: Connor, Kristina F., ed. 2006. Proceedings of the 13th biennial southern silvicultural research conference. Gen. Tech. Rep. SRS–92. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 640 p.

erosion rod method in each SMZ. The erosion for the upland section of the watersheds was very minor as expected for mature forest stands. The SMZ erosion was somewhat higher, probably because of steeper slopes and residual soil instability from past agricultural erosion (Easterbrook 2005).

Post-harvest Erosion

Post-harvest erosion was measured exactly as above with the same three re-bar transects in each SMZ. USLE was again used as described by Dissmeyer and Foster (1984) for the cutover upland areas. Weighted average USLE erosion estimates for roads, skid trails, fire lines, and cutover area were used to determine overall erosion from the clear-cut. Table 1 shows that there are no significant differences between treatments for the USLE estimates in clear-cut areas at the α=0.10 level. It is evident that sediment movement within the SMZs was significantly different for the narrow 25 foot SMZ than for all other SMZ types. These narrow, highly disturbed SMZs showed a significant sediment deposition of 56 tons per acre per year 1.5 years after harvest. All other SMZ types showed substantial sediment losses (table 1).

Pre-harvest data indicates a significant level of soil instability within the SMZs even in the absence of harvesting operations (fig. 1). It is likely that the extensive agricultural history and the rolling topography of this area contribute greatly to the ongoing soil instability. Preliminary post-harvest data indicates that forest harvesting did not greatly increase soil erosion estimates in upland clear-cuts but likely exacerbated the soil instability problem in the SMZs. It is common for harvesting activities to increase surface water runoff for up to 5 years until plant and tree regeneration advances adequately to reduce overland and base flow by raising evapotranspiration (Aust and Blinn 2004, Kochenderfer and Edwards 1990, Kochenderfer and Wendel 1983). This runoff could be responsible for the highly elevated soil erosion experienced in most of the SMZs.

Table 1—Post-harvest soil erosion (-) or deposition (+) by SMZ type within the SMZ (sediment rods) and in the upland clear-cut area (USLE) in tons per acre per year. Statistical significance (α = 0.10) is noted with lower case letters

SMZ type	In clear-cut	In SMZ
	- - - *tons/acre/year* - - -	
25 feet	-1.3 a	+56 a
50 feet	-2.8 a	-57 b
50 feet thin	-3.7 a	-35 b
100 feet	-5.1 a	-53 b

The narrowest SMZs were 25 feet in width and had significant understory growth not common in the wider SMZs, perhaps because of increased sunlight in the narrower buffers. This increase in vegetation may have had a beneficial soil protective and evapotranspiration function which could have helped prevent the soil erosion evident in the wider buffers (table 1). No current vegetation data is available to allow an in depth discussion of that possibility. The data also does not currently indicate that this "narrow buffer effect" is due to the lower landscape position with less local slope in which the narrow buffers naturally occur.

LITERATURE CITED

Aust, W.M.; Blinn, C.R. 2004. Forestry best management practices for timber harvesting and site preparation in the Eastern United States: an overview of water quality and productivity research during the past 20 years. Water, Air, and Soil Pollution: Focus. 4: 5-36.

Blinn, C.R.; Kilgore, M.A. 2001. Riparian management practices, a summary of state guidelines. Journal of Forestry. 99(8): 11-17.

Castelle, A.J.; Johnson, A.W.; Conolly, C. 1994. Wetland and stream buffer size requirements - a review. Journal of Environmental Quality. 23: 878-882.

Dissmeyer, G.E.; Foster, G.R. 1984. A guide for predicting sheet and rill erosion on forest land. Gen. Tech. Publ. R8-TP 6. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southern Region. 40 p.

Easterbrook, A.W. 2005. Unpublished masters thesis data. Blacksburg, VA: Virginia Polytechnic Institute and State University, Department of Forestry.

Gembroys, S.R. 1974. The structure of hardwood forest ecosystems of Prince Edward County, Virginia. Ecology. 55: 614-621.

Kochenderfer, J.N.; Edwards, P.J. 1990. Effectiveness of three streamside management practices in the central Appalachians. In: Coleman, S.S.; Neary, D.G., comp. eds. Proceedings of the sixth biennial southern silvicultural research conference. Gen. Tech. Rep. SE-70. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station: 688-700.

Kochenderfer, J.N.; Wendel, G.W. 1983. Plant succession and hydrologic recovery on a deforested and herbicided watershed. Forest Science. 29(3): 545-558.

Schultz, R.P. 1997. The ecology and culture of loblolly pine (*Pinus taeda* L.). Agric. Handb. 713. Washington, DC: United States Department of Agriculture, Forest Service. 1-1 to 12-28 p.

United States Department of Agriculture (USDA). 2002. Soil survey of Appomattox County, Virginia. Natural Resources Conservation Service. [Not paged].

VanLear, D.H.; Harper, R.A.; Kapeluck, P.R.; Carroll, W.D. 2004. History of piedmont forests: implications for current pine management. In: Connor, K.F., ed. Proceedings of the 12th biennial southern silvicultural research conference. Gen. Tech. Rep. SRS-71. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 127-131.

Virginia Department of Forestry (VDOF). 2002. Virginia's forestry best management practices for water quality. Fourth edition. Charlottesville, VA: Virginia Department of Forestry. 216 p.