GLOBAL POSITIONING SYSTEM (GPS) AND GEOGRAPHIC INFORMATION SYSTEM (GIS) ANALYSIS OF MOBILE HARVESTING EQUIPMENT AND SEDIMENT DELIVERY TO STREAMS DURING FOREST HARVEST OPERATIONS ON STEEP TERRAIN: EXPERIMENTAL DESIGN

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Abstract.—Sediment mobilized by forest harvest machine traffic contributes substantially to the degradation of headwater stream systems. This study monitored forest harvest machine traffic to analyze how it affects sediment delivery to stream channels. Harvest machines were outfitted with global positioning system (GPS) dataloggers, recording machine movements and working status. Sediment delivery to streams was monitored by scouting for overland sediment delivery paths after the completion of harvest operations. GPS positional data from the mobile harvesting equipment, along with the sediment delivery information, were analyzed in a geographic information system (GIS) to draw conclusions about the influences of buffer width; intended and actual canopy retention level; harvest equipment traffic intensity; slope; aspect; and trail type, length, and distance from stream on the delivery of sediment to headwater streams. Results from this study will have important implications for designing harvest roads and trails and effective streamside management zones (SMZs).

INTRODUCTION

The possible negative effects of timber harvesting on streams and riparian habitat are well documented. Forest operations in and around riparian areas can cause increased stream sediment levels, as well as increases in water temperature and nutrient delivery to streams (LeDoux and Wilkerson 2006). In 1972, the Federal Water Pollution Control Act and its related amendments directed the states to develop best management practices (BMPs) to address these nonpoint source pollution impacts of forest operations, of which sediment is commonly seen as the most important type in forested areas (Miller and Everett 1975). Most states' BMPs include SMZ recommendations or regulations in which a buffer strip is left undisturbed or minimally disturbed. This buffer strip is intended to filter sediment and nutrients as they travel through the SMZ, as well as mitigate the effect of canopy removal on stream temperature (Blinn and Kilgore 2001). Most sediment delivered to streams during forest operations involves road, trail, and landing construction and use (Croke and Hairsine 2006). There is thus a need for research into the mechanisms delivering sediment to small streams (Aust and Blinn 2004), and specifically how forest harvesting machinery and its associated transportation network deliver this sediment (Kreutzweiser and Capell 2001).

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METHODS

During a timber harvest on the University of Kentucky's Robinson Forest, MultiDAT GPS receivers (Castonguay Electronique, Longueuil, Quebec, Canada) were installed on all mobile harvesting equipment. At the completion of the harvest, GPS data were entered into ArcGIS software (ESRI, Redlands, CA). Three harvest boundaries will be focused on for this study, with three SMZ configurations. Boundary 1 had a 55-foot harvesting equipment buffer on the perennial stream section with canopy retention of 50-percent, a 25-foot buffer on the intermittent stream section with no canopy retention, and no buffer on the ephemeral channels with no canopy retention. Boundary 2 had 110-foot buffers on the perennial stream sections with 100-percent canopy retention, 50-foot buffers on the intermittent stream sections with 25-percent canopy retention, and 25-foot buffers on the ephemeral channels with retention of channel bank trees. Boundary 3 had a 55-foot buffer on the perennial stream section with 100-percent canopy retention, a 25-foot buffer on the intermittent stream section with 25-percent canopy retention, and no buffers on the ephemeral channels but with retention of the channel bank trees. After completion of the harvest, all perennial, intermittent, and ephemeral stream sections were scouted for overland sediment paths. Each of these paths was characterized by width, slope distance to source, slope degree, source type, skid trail morphology at source, and the influence of water-control structures.

Data will be analyzed by multiple linear regression. Each experimental unit encompasses a section of stream, the ground slope above that stream section, and the segments of the skid trail network directly upslope from the stream section. The response variable for the regression analysis will be the total width of sediment paths included in the experimental unit. Independent variables derived from the experimental unit to be analyzed in the regression will be: traffic intensity index (the number of GPS positions recorded divided by the area); SMZ buffer width; total linear feet of skid trail; linear feet of primary, secondary, and tertiary skid trail; unit slope; unit aspect; minimum distance from stream to skid trail; average distance from stream to skid trail; intended canopy retention percent; and average basal area actually retained post-harvest.

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