Protecting Water Resources with Streamside Management Zones

by Chris Barton, Emma Witt, and Jeff Stringer

In the steep sloping hills of Eastern Kentucky, water resource issues abound. As Mark Twain is credited with stating so poignantly: "Whiskey is for drinking; water is for fighting over." And fight they do. Whether the culprit is coal mining, timber harvesting, straight piping of sewage or any number of construction or agricultural activities, discussions on the impact of land use on water quality and quantity in the region are often emotionally—and sometimes politically—fueled. Take for instance a study performed at Robinson Forest that created quite a stir from groups such as Kentucky Heartwood, the Kentucky Resources Council, the Sierra Club and the Kentucky Waterways Alliance. The study's aim was to provide critical information needed to determine the effectiveness of forestry best management practices (BMPs) for Eastern Kentucky, but some voiced concern that the potential degradation to water resources from the study outweighed benefits that may be gained by conducting the experiment.

Photo courtesy: UK Department of Forestry

View of Streamside Management Zone (SMZ) research harvest showing the uncut SMZ along the stream in the middle of the photo surrounded by harvested side slopes.

Forestry Best Management Practices

The Commonwealth of Kentucky has established forestry BMPs that are designed to reduce nonpoint source pollution (NPSP). When asked whether Kentucky's BMPs are sufficient for protecting water resources, our answer has been, "We think so." The reason for the wishy-washy response is two-fold. First, few studies have been performed to examine specific BMP guidelines and test their effectiveness. Second, recommendations for many BMPs that are employed in Eastern Kentucky were developed from information gathered outside the region. For example, Kentucky forestry BMPs addressing riparian streamside management zones (SMZs) were developed in part from demonstrations in New Hampshire in the 1950s. Given that the forest industry in Kentucky has experienced considerable growth over the past few decades, the need for establishing BMPs specific for Eastern Kentucky forests is essential for ensuring the protection and preservation of water resources in the region.

Forested watersheds play an important role in maintaining water quality. Nationally, forests comprise one-third of the land area but provide two-thirds of our water supply. Undisturbed forests have several characteristics that promote high surface-water quality, but forest harvesting operations can result in negative impacts to water quality. Increases in erosion, litter disturbance, flow duration, nutrient export, temperature, and connectivity between road networks and stream channels have been associated with timber harvesting. Streamside management zones are utilized to provide a buffer between upland forest harvesting operations and the stream. The importance of SMZs for filtering erosion, utilizing nutrients, maintaining in-stream and near-stream temperatures, and providing habitat and corridors for aquatic and terrestrial fauna has been identified but not well quantified.

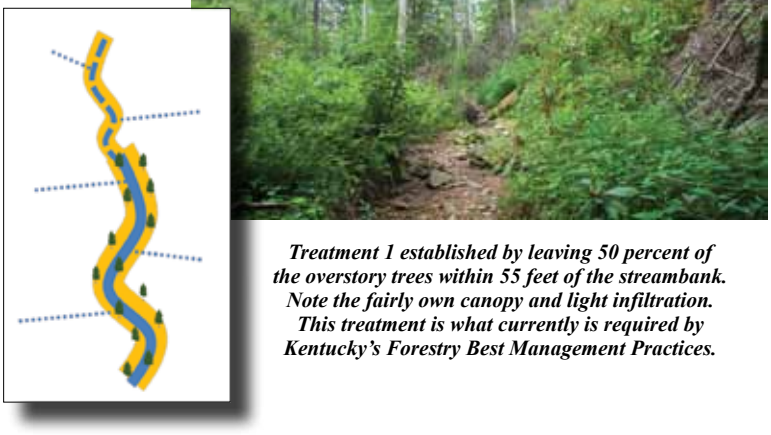
Most states in the Appalachian Region have two specifications associated with SMZs—one related to the distance of the nearest severe disturbance (e.g. roads or log landings) and a second relating to the allowable harvest within the SMZ. For perennial streams, the distance to severe disturbance increases as the upland slope increases due to the higher potential of surface runoff impacts with higher upland grades. Within the SMZ, most states allow some amount of overstory removal. For example, Kentucky allows 50 percent overstory removal. Intermittent streams are not considered to have the same potential NPSP impact as perennial streams,

so the distance to disturbance is shorter relative to perennial streams and 100 percent harvest is allowed within the SMZ. Finally, no SMZ (width or canopy retention) is required for ephemeral streams in Kentucky. Other SMZ requirements vary considerably among states. For example, North Carolina requires 75 percent of the trees remaining in the perennial and intermittent riparian zone, while West Virginia and Pennsylvania allow 100 percent harvest within the riparian zone on both perennial and intermittent streams. The differences in SMZs among states do not necessarily reflect best available knowledge but are the culmination of battles among forestry groups, environmental groups, and policy makers within each state. The region needs better information on the effectiveness of SMZs. Given these conditions, despite the protest, we moved forward with our study to provide the needed information.

SMZ Study Design

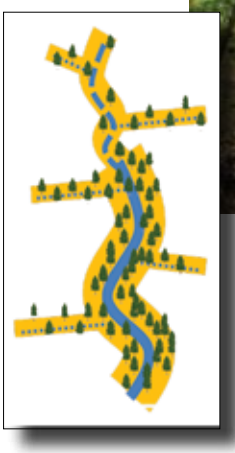
Eight headwater watersheds were included in the study. Each was located in the 3,800 acre Clemons Fork watershed at Robinson Forest (in parts of Breathitt, Knott and Perry counties) and all were outfitted with a weir or flume to monitor flow continuously. Watersheds ranged in area from 70 to 275 acres. Water quality and quantity monitoring began in 2004. Six watersheds were harvested from June 2008 to October 2009. The remaining two watersheds were not harvested to serve as controls. Both control watersheds (Falling Rock Branch and Little Millseat Branch) are listed as exceptional waters by the Commonwealth of Kentucky. Treatment watersheds were harvested using a shelterwood with reserves, or two-aged deferment, harvest method with a target post-harvest basal area of approximately 15 square feet per acre. Harvesting equipment included wheeled cable and grapple skidders, tracked dozers, and tracked feller-bunchers. Skid trails were constructed along hillslope contours, where feasible, at various intervals from the top to the bottom of slopes. The skid trail system comprised 6 percent to 12 percent of the watershed area.

The six harvested watersheds were treated with one of three SMZ combinations. Treatment 1 was based on the Kentucky SMZ guidelines and included a 55-foot perennial SMZ with 50 percent overstory retention and a 25-foot intermittent SMZ with no overstory retention requirement. Treatment 2 maintains the 55-foot perennial SMZ but requires 100 percent canopy retention and 25 percent canopy retention in the 25-foot intermittent SMZ. In addition, improved crossings were used in ephemeral stream crossings and the nearest channel bank tree was retained. Treatment 3 increased the perennial SMZ width to 110 feet with 100 percent canopy retention and the intermittent SMZ width to 55 feet with 25 percent canopy retention and included a 25-foot SMZ around ephemeral streams. The nearest channel bank tree also was retained, and improved stream crossings were used in the ephemeral streams. For Treatment 1, ephemeral streams were crossed at right angles using unimproved crossings (fords). Improved crossings in Treatments 2 and 3 included portable wooden skidder bridges, steel pipes/culverts, and PVC pipe bundles.



Treatment 1 established by leaving 50 percent of the overstory trees within 55 feet of the streambank. Note the fairly own canopy and light infiltration. This treatment is what currently is required by Kentucky's Forestry Best Management Practices.

Treatment 2 leaves all of the overstory trees within 55 feet of the streambank providing more shade on the stream than Treatment 1.



Treatment 3 retains all of the trees within 110 feet of the stream bank providing more shade and keeps sources of sediment (skid trails) farther away from the stream than treatments 1 or 2.

Photos courtesy: Matt Barton

Stream Crossings and Ephemeral SMZs

Stream crossings are generally considered as the primary avenue for sediment delivery to streams. Our results showed that the use of any improved crossing type significantly decreased sediment production and transport over a ford in ephemeral streams (Figure 1). Results also indicated that limiting equipment disturbance on or directly adjacent to the stream channel can result in suspended sediment concentrations similar to those measured in unharvested ephemeral streams. Operationally this can be accomplished by increasing the amount of residual overstory trees left next to ephemeral channels and/or by restricting the operation of equipment next to channels. However, while limiting equipment operations and ground disturbance around channels can help in reducing TSS, the importance of appropriate crossing selection, construction, maintenance, and removal cannot be overemphasized. While the appropriate use of crossings is paramount to limiting sediment production, providing canopy retention around ephemeral channels can also offer thermal protection, maintain coarse woody debris inputs, influence carbon and nitrogen dynamics, and retain some habitat characteristics. These findings suggest that the extension of forestry BMPs to ephemeral streams is effective in reducing sediment from harvesting operations. In states that already have recommendations for ephemeral stream protection, mandating improved crossing use for all ephemeral crossings is prudent. When further improvements in sediment reduction are warranted, as would be the case with streams containing flora or fauna particularly sensitive to sedimentation, additional canopy retention and equipment limiting zone recommendations could prove valuable.

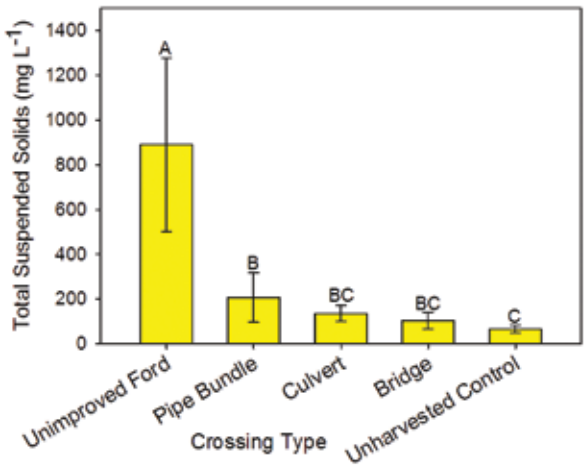


Figure 1. Average suspended sediment in storm flow from ephemeral streams with differing crossing treatments. Bars with similar letters are not statistically different. Unimproved fords produced significantly greater amounts of sediment than other crossing types that provide an elevated surface for equipment to travel.

Perennial SMZ Effectiveness

Findings from the study showed that the Kentucky guidelines for SMZ width and canopy retention (Treatment 1) are just as effective at maintaining non-storm sample suspended solid concentrations as treatments 2 or 3, which required increased canopy retention or SMZ width. However, Treatment 1 was found to be significantly less effective at mitigating increases in either suspended solids or turbidity from storm events (Figure 2). Little statistical difference was found between the effectiveness of Treatment 2 or Treatment 3. Treatment 3 was also shown to maintain sediment levels similar to control watersheds (not harvested) in both base flow and storm flow conditions. Similar was true between Treatment 3 and the control for most parameters examined. While Treatment 1 was found to be statistically higher than the other treatments it is important to note that the increase found by this study does not warrant concern for the majority of streams in Kentucky that are warm water aquatic habitats.

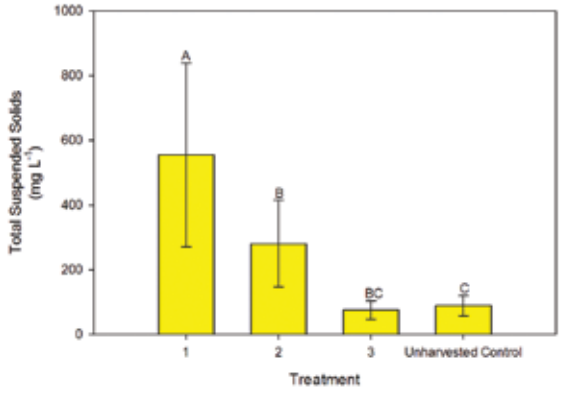


Figure 2: Average suspended sediment in storm flow from perennial streams with differing SMZ treatments. Bars with similar letters are not statistically different. Treatment 1 yielded significantly higher sediment amounts than the other treatments, while treatment 3 exhibited similar suspended sediment concentrations as observed in the unharvested control watershed.

The differences observed between Treatment 1 and Treatments 2 and 3 are due to use of improved crossings at ephemeral streams and increased canopy retention in perennial, intermittent, and ephemeral segments. While the exact contribution of improved crossings versus increased canopy retention to sediment reduction at the perennial outlet may not be determined from these data, the combination of minimizing the hydrologic and sediment connectivity of the skid trail system and stream network and maximizing the amount of undisturbed forest floor near streams has a definite impact of sediment transport.

Path Forward

The large watershed-scale study proved valuable for meeting our objective to examine BMP effectiveness in Eastern Kentucky. Not only were we able to examine water quality and quantity responses to harvesting, but the study design allowed us to examine many other important aspects of the forest. On-going studies include: an examination of the influence of these treatments on biota (aquatic insects, salamanders, snakes, birds); an assessment of invasive species occupancy and pathways for colonization; sediment source tracking; and an economic and environmental examination of harvest trafficking patterns. Long-term monitoring will continue and much more information from the study will be shared with the forestry community in Kentucky and elsewhere.

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This research project was overseen and directed by Dr. Chris Barton (barton@uky.edu), Professor, and Dr. Jeff Stringer (stringer@uky.edu), Extension Professor, of the University of Kentucky Department of Forestry. The research also served as the Ph.D. project by Emma Whitt (witt0287@umn.edu), who is currently a Post/Doctoral Associate at the University of Minnesota.