# RETENTION OF PHOSPHORUS FROM SIMULATED RUN-OFF WITHIN FORESTED STREAMSIDE MANAGEMENT ZONES (SMZs) OF THE PIEDMONT

W. J. White, A. Pinho, L.A. Morris, C.R. Jackson

*AUTHORS:* Warnell School of Forest Resources, University of Georgia, Athens, GA 30602.
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**Abstract.** This project investigated the retention of phosphorus and clay in 5m (wide) x 10m (deep) plots located in streamside management zones in commercial timber to which simulated runoff was applied from a tank and dispenser system. The purpose of the project was to quantify the filtering/adsorption benefits of SMZs with respect to phosphorus and clay. Plots were located on five slopes ranging from 2%-20% and either had an undisturbed forest floor or had the forest floor removed. Surface water samples were collected at 0, 2, 4, 6, and 10 meters within the SMZ during a 1-hour runoff simulation and analyzed for total phosphorus concentrations.

## INTRODUCTION

It is well established that riparian forests are effective in trapping sediments and nutrients produced in agricultural practices (Lowrance 1998, Hayes et al, 1984, Hayes et al 1979). Riparian Forest Buffer Systems (RFBS) are accepted as a pollution control practice by the USDA-Natural Resources Conservation Service when most of the pollutant movement is in shallow groundwater and diffuse overland flow (Lowrance 1998).

Most studies about RFBSs have been in agricultural environments (Lowrance 1998, Hayes et al. 1984, Hayes et al. 1979), where upland management differs greatly from silvicultural practices. Limited research has been conducted to validate the need for, and the effectiveness of RFBSs in managed forest systems.

Georgia BMPs call for the maintenance of SMZs along streams. The minimum SMZ width for a perennial stream with moderate adjacent slopes is 40 feet. SMZs provide a number of functions. This project evaluates the ability of RFBSs on silvicultural land to retain phosphorus and seeks a better understanding of the processes that occur within the RFBS that lead to P retention.

The overall chemical quality of water draining from forests is generally high. Some forest practices, however, may alter concentrations of certain chemicals, thus affecting water quality. Forest harvesting and site preparation, especially fertilization, can affect concentrations of important plant and aquatic ecosystem nutrients (Binkley and Brown 1993).

In the southeastern United States, about 350,000 ha of pine plantations were fertilized in 1996 mainly with nitrogen (N) and phosphorus (P) (NCSFNC 1997). With the current intensification of fertilizer use in southeastern forests and increasing concern over non-point source pollutants, the impacts of fertilizer use needs to be re-evaluated.

## MATERIALS AND METHODS

### Sites selection and plot establishment

Five sites, along a gradient of slope classes from <2% up to 20%, were established in recently established or designated SMZs in the Piedmont of northeastern Georgia. On each site, a 5-m wide plot was established beginning at the edge of the undisturbed SMZ and extending 10 m toward the stream. Additionally, in order to evaluate the influence of ground (litter) disturbance in SMZ, a second plot was established on sites with intermediary slopes, determined as 5-7%, 10-12%and 15-17% slope classes. On this plot, the litter layer was removed from the forest floor. Slope was determined using a clinometer.

### Runoff simulation

Simulated runoff was formulated on the basis of expected concentrations and content of runoff associated with a rainfall event with a return frequency of one year occurring immediately after fertilization application. This amounted to approximately 3600 gallons of water applied to a 5 meter wide by 10 meter deep plot over a period of about one hour. This simulated runoff was distributed along the upper edge

of the SMZ using a 5-m wide dispersing system similar to one described by McCutcheon et al. 2000 shown in Figure 1.

On the basis of collections completed during the spring 2001, clay concentrations in runoff from operationally prepared and planted forest sites of the Piedmont have been found to be from 4 to 7 mg $L^{-1}$ (W. J. White, unpublished data). To approximate this concentration of colloidal clay, 5.7 kg of commercially

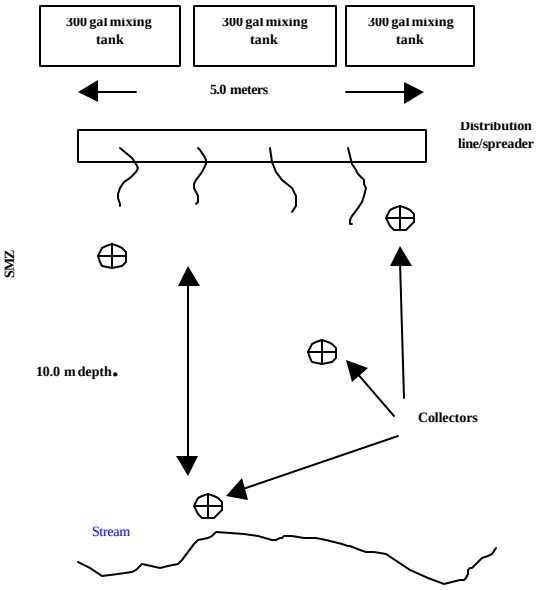


**Figure 1. Schematic representation of experimental plot for study of SMZ filtering of colloidal clay, phosphorus.**

mined kaolin uncleaned of iron-oxide coatings was added to water in 300-gal tanks along with 4.835 g of diammonium phosphate. The tank was mixed, allowed to equilibrate for a brief period and then dispersed into the SMZ. Multiple mixing tanks were used as a means of maintaining flow while mixing an individual tank.

## Instrumentation and sampling

Four surface runoff and sediment samplers as described by Franklin et al (in press) were installed on each plot at 2.0, 4.0, 6.0, and 10.0 m from the upslope edge of the SMZ. During each simulated runoff event, samples were collected from PVC collectors as the collectors filled. Samples were also taken as water came out of the flow spreader in order to evaluate initial concentrations entering the SMZ.

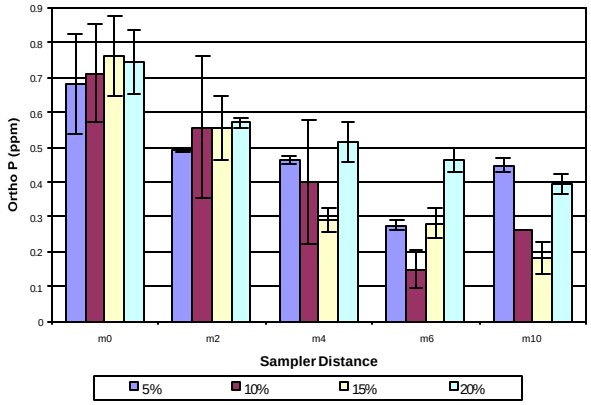


**Figure 2. Phosphorus concentrations (ppm) in surface water across all slope classes with forest floor intact.**

## Sample Analyses

During each sampling event water from collectors and the flow spreader was sub-sampled to a volume of 500. Total P was measured on both filtered and non-filtered samples following Standard Methods of Water and Wastewater Treatment (Clesceri et al. 1998). After sample filtration total dissolved P was measured by standard methods.

## PRELIMINARY RESULTS AND DISCUSSION

Since it is assumed that the retention of P sorbed to soil within the RFBS will be associated with the retention of the soil itself; the following results deal with the soluble fraction of P in surface water flow.

Preliminary results show retention of phosphorus in the natural forest floor in all slope classes. Figure 2. compares concentrations of P in mg/L across slope classes with the natural forest floor intact. Initial concentrations were approximately 0.7 ppm and final concentrations ranged from approximately 0.45 to 0.2 ppm of P.

The 15% slope had the greatest decrease in concentration and the 5 % slope had the least decrease in concentration. These results may seen counterintuitive, but it is believed that the conditions of the forest floor may have a greater effect on soluble phosphorus adsorption than the slope class.

Figure 3. shows the difference between the retention capability of a 5 percent slope plot when the litter layer is intact or disturbed. Disturbance and removal of the natural forest floor resulted in a decrease in the

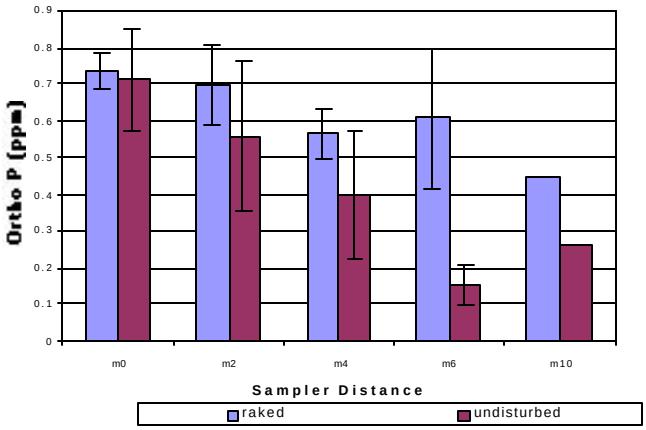


**Figure 3. Comparison between the effects of undisturbed and disturbed forest floor on phosphorus retention on 10% slope.**

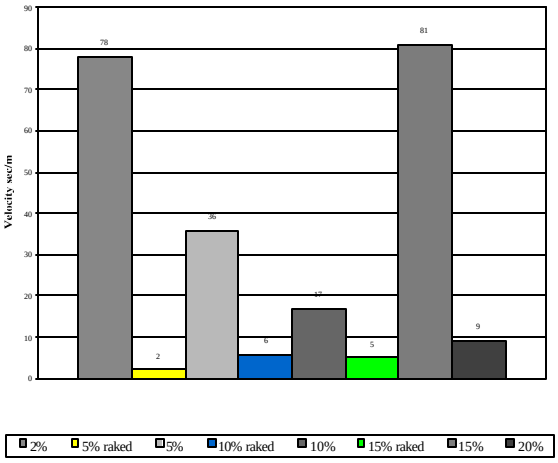


**Figure 4. Velocity of surface water flow in seconds per meter on undisturbed forest floors compared to disturbed conditions.**

retention of phosphorus. This difference is mostly due to the fact that the forest floor litter layer acts as a natural water dispersing system that distributes the water and decreases the velocity.

Figure 4. allows us to see the relationship between the type of cover present on the forest floor and the velocity of the surface water flow. It appears that when the natural forest floor is left intact the velocity of the water entering the plot is in fact much slower than in the disturbed plot. This decrease discourages the formation of rills and gullies as well as increasing the contact time of the water with the interface between the mineral soil and decomposing organic litter layer where most of the phosphorus sorption is believed to be taking place.

It would be expected that with steeper slope there would be increased velocity and Figure 4. shows this to be true for the plots that have had the forest floor removed. Therefore it is very important that special care be taken not to disturb steep slope RFBS.

## CONCLUSIONS

Phosphorus concentration decrease as water flows through 10 meter buffer strips, but it is important to note that undisturbed plots are better at retaining P than disturbed plots. Forest floor disturbance can be as important as slope in influencing P retention. Steep slope RFBSs should be treated with more care and no forest floor disturbance of any kind may be recommended in these slopes.

## LITERATURE CITED

Binkley, D, and TC Brown. 1993. Forest practices as non-point sources of pollution in North America. Water Resources Bulletin 29:729-740.

Clesceri, L. S., et al. (eds.) 1998. Standard methods for the examination of water and wastewater 20th edition. United Book Press, Baltimore

Franklin, D. H., M. L. Cabrera, J. L. Steiner, D. M. Endale, W. P. Miller. Evaluation of percent Flow captured by a small in-field runoff collector. Transactions of ASAE. In Press

Hayes, J. C., B. J. Barfield, et al. 1979. Filtration of sediment by simulated vegetation, II. Unsteady flow with non-homogeneous sediment. Transactions of the ASAE 22(5): 1063-1067.

Hayes, J. C., B. J. Barfield, et al. 1984. Performance of grass filters under laboratory and field conditions. Transactions of the ASAE 27(5): 1321-1331.

Lowrance, R. 1998. Riparian forest ecosystems as filters for nonpoint-source pollution. P. 113-141. In. M.L. Pace and P.M. Groffman (ed.) Limitations and Frontiers in Ecosystem Science.

McCutcheon, S. C., J. C. Hayes, C. A. Williams, C. P. Weisskopf and S. J. Klaine. 2000. Evaluation of vegetative filter strips to control urban runoff into Charleston Harbor and other coastal waters. Project Report for the Charleston River Project, Charleston SC.

NCSFNC (North Carolina State Forest Nutrition Cooperative) 1997. Twenty-sixth annual report. Raleigh, NC.