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Keeping Up With Research 137

Assessing the Effectiveness of Various Riparian Buffer Vegetation Types

Charles J. Barden, Kyle R. Mankin, Daniel Ngandu, Wayne A. Geyer, Daniel L. Devlin, and Kent McVay

Agricultural riparian buffer research has focused on examining water flow through native forest stands or grass filter strips (Sheridan et al. 1999), and has been conducted primarily in the Mid-Atlantic and southeastern United States (Jordan et al. 1993; Lowrance et al. 1984). Recently established riparian buffer strips, usually adjacent to crop fields, have become increasingly common in the Midwest. The climate, soils, and hydrology differ considerably between the Midwest and the eastern seaboard, thus the effectiveness of newly planted riparian buffers for filtering agricultural field runoff needs to be documented.

The hydrology of Kansas surface water resources has been dramatically altered since settlement in the 1800s. Cropland tillage practices, urban and transportation development, channel straightening, and livestock grazing practices all have led to accelerated water movement through watersheds, which increases nonpoint source pollution and streambank erosion. In much of the state, native riparian area vegetative cover has been greatly reduced. Re-establishing riparian buffers along streams may reduce flood damage and streambank erosion, improve wildlife habitat, and filter pollutants, such as nutrients, pesticides, bacteria, and sediments.

Kansas State University
Agricultural Experiment Station and Cooperative Extension Service

ABOUT THE AUTHORS

Charles Barden, Extension Forester and Associate Professor, Horticulture, Forestry and Recreation Resources

Wayne Geyer, Professor, Horticulture, Forestry and Recreation Resources

Kyle Mankin, Assistant Professor, Biological and Agricultural Engineering

Daniel Ngandu, graduate student, Biological and Agricultural Engineering

Daniel Devlin, Professor, Agronomy

Kent McVay, Assistant Professor, Agronomy

All authors are affiliated with Kansas State University, Manhattan, Kansas.

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Effectiveness of a riparian buffer in removing pollutants from runoff water is dependent on maintaining sheet flow across the buffer and increasing infiltration and subsurface flow. In many Kansas fields, riparian buffers may not be functioning effectively because of the concentration of runoff into channelized flow prior to movement across the buffer. The concentration of flow may result from terrace channelization or development of micro-relief near or in the riparian buffer, which is caused by soil movement from tillage, sedimentation, or flood deposits that form a levy on the streambank. Dosskey et al. (1997) provide a qualitative ranking of the effectiveness of various vegetation types for providing the benefits associated with an effective riparian buffer system.

Natural Resource Conservation Service (NRCS) standards for riparian buffer establishment call for a minimum width of 75 feet and a maximum average width of 150 feet. A native grass planting is called a grass filter strip, while a planting including trees and shrubs is defined as a riparian forest buffer. Many farmers are reluctant to enroll a wide strip of land for riparian buffer establishment, especially with trees. Therefore, research is needed to examine the effectiveness of narrow buffers, which are more likely to be adopted by farmers. The objective of this study was to assess the filtering ability of a very narrow riparian buffer strip design.

METHODS

Site Description

The site is located in northeastern Kansas, Geary County, along a tributary of Mill Creek in the Flint Hills physiographic province. The 5-acre crop field used in the study overlays a silty clay loam soil. It is used for annual forage crop production and occasional grazing.

A narrow buffer (40 feet wide) was established in 1995 with a variety of grasses, shrubs, and fallow (allowing natural succession) treatments. The three buffer types chosen for runoff monitoring were: (1) three rows (spaced 3 by 6 feet) of American plum (*Prunus americana*), planted with a native grass strip (Figure 1); (2) three rows of American plum with a fallow strip; (3) the entire plot left fallow for 7 years following a single cultivation to allow natural succession. Three runoff collection plots were established within each of three buffer types. Each of the plots selected received similar amounts of runoff, due to the topography of the field.

Sampling

Surface runoff was sampled as it left the field and entered the buffer, and again as the water exited the buffer at the stream bank edge (Figure 1). The surface runoff sampling apparatus consisted of a buried 3 gallon sump, a marine bilge pump powered by a 12-volt battery, and a splitter assembly trough that would remove 1/16 and 1/64 of the runoff to be sampled; the rest of the water was returned to flow through the buffer. The splitter assembly trough had six baffles that removed half of the runoff at each baffle. The runoff samples were held in 5 gallon carboy jugs. Sampling from two different splitters was needed to provide an estimate of total runoff volume for various sized storms. For example, after a very large storm, the 1/16 sample carboy would overflow, so the water sample was taken from the 1/64 splitter. In contrast, following a small runoff event, the 1/64 sample carboy would not yield enough volume for chemical analysis, thus the 1/16 sample would be used. For more details regarding the sampling apparatus, see Mankin et al. (2001).

Most of the runoff volume (> 92%) was returned to the buffer to continue flowing towards the stream. Sheet metal panels were inserted into the ground to prevent meandering flow paths that may have resulted in bypassing of the rear sampler.

Immediately following significant rainfall events, the water samples were retrieved and brought to the Kansas State University Agronomy Soil and Water Testing Lab. Runoff samples were analyzed for concentrations of total suspended solids (sediment), total phosphorus (and fractions), and total nitrogen (and fractions).

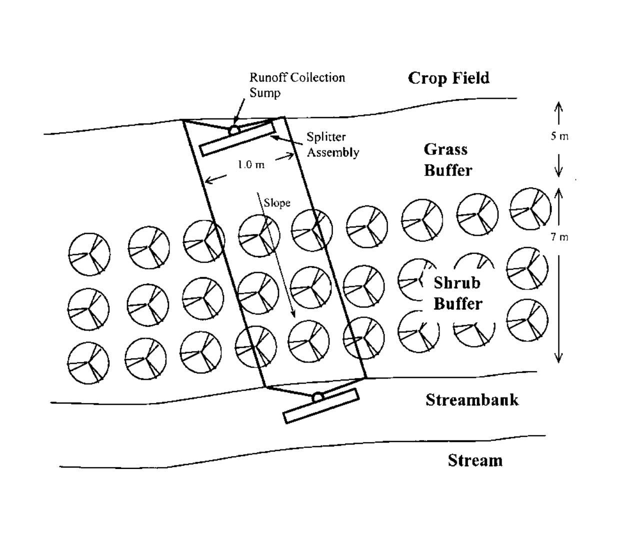

Figure 1. Overhead view of the runoff sampling apparatus in the Plum/Native Grass buffer.

Surface runoff samples were collected after four storm events that occurred between June and August, 2001. Due to drought conditions in 2002, no natural runoff occurred, thus the plots were irrigated with simulated runoff three times during August and September. The simulated surface runoff was created by mixing tap water with 4 kg of field soil, 45 g of ammonium nitrate, and 6.9 g of sodium phosphate in a pickup-mounted 210 gallon tank. This mixture closely approximated the components found in the natural runoff collected the previous year. The vegetation was characterized with a step-point sampler for each type of buffer in September 2002.

RESULTS

All buffer vegetation types reduced runoff contaminants. The reduction in total suspended solids (TSS) concentration was highly variable for the natural runoff in 2001. The mean ranged from under 40% reduction for the Plum/Fallow plots, to over 75% reduction for the Plum/Grass plots (Figure 2). Due to the variability of the data, though, there were no statistically significant differences between the vegetation types in TSS reduction.

Reduction in TSS concentration was uniformly very high for the simulated runoff data collected in 2002, with all buffer types resulting in over 90% reduction. As expected, data were less variable for the controlled, simulated runoff, resulting in much narrower standard errors (Figure 2).

For simplicity, only the total phosphorus concentration and total nitrogen concentration will be presented. The various fractions of each nutrient were highly variable making them difficult to summarize. Trends for total phosphorus were different than observed for TSS. In 2001, all three vegetation types resulted in more than 50% reduction in concentration, again with the Plum/Fallow plot data being the most variable (Figure 3). The 2002 data showed slight differences, with means ranging from 40% for the Plum/Grass plot to almost 60% for the Fallow plot. Differences were not statistically significant.

Total reduction in nitrogen concentration was much less variable. Nitrogen reduction showed a different trend than TSS, and also had lower mean reductions, as would be expected for a highly soluble nutrient that is not bound to sediment (Figure 4). Plum/Fallow plots had the greatest reduction, almost 55%. Fallow plots showed less than 45% reduction in nitrogen runoff and Plum/Grass were intermediate in nitrogen reduction (Figure 4).

In 2002, nitrogen runoff reduction was significantly less than seen in 2001 for the Plum/Fallow (35%), while reductions for the other vegetation types were similar to 2001 results.

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The strong filtering ability of the plots with natural weedy vegetation resulting from 7 years in fallow was surprising. To better understand these results vegetation characteristics were considered. Both the fallow and the seeded zones had over 98% vegetative ground cover, although there were differences in the type of vegetation. The fallow plots were dominated by cool season grasses (50%), primarily downy brome (*Bromus japonicus*), which, when combined with other annuals, accounted for over 60% of the vegetation points sampled. Conversely, the native grass area was dominated by the warm season perennial grasses (>80%) that were planted, such as Indian grass (*Sorghastrum nutans*) and switch grass (*Panicum virgatum*). The planted American plums had achieved crown closure, averaging almost 6 feet in both height and crown width, with numerous sucker sprouts appearing between the rows.

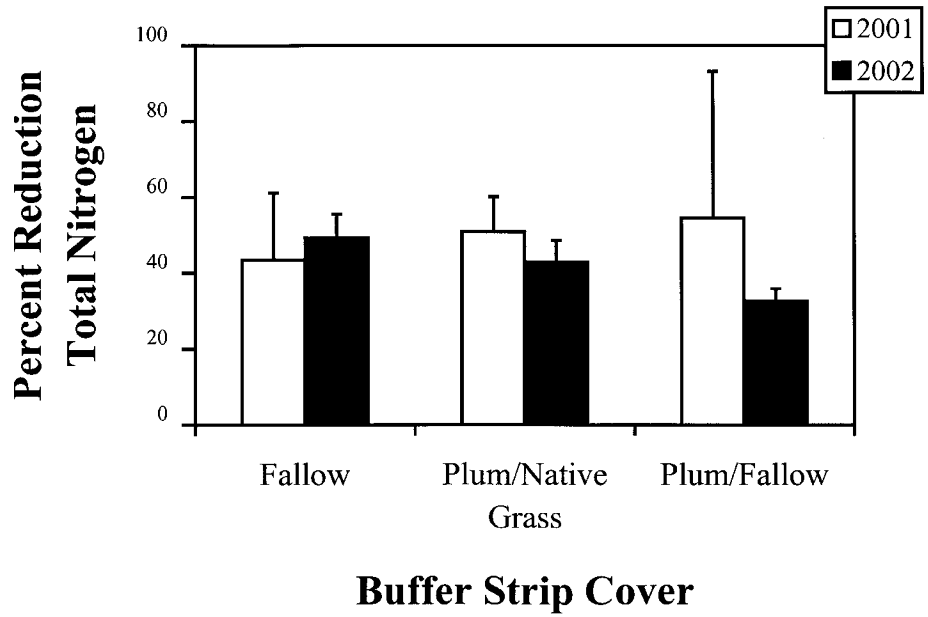

Figure 4. Average total nitrogen concentration reduction from surface runoff achieved by three types of riparian buffer strip vegetation. Results from 2001 represent natural precipitation events and 2002 results represent simulated runoff. Standard error bars are shown.

DISCUSSION

Runoff Components

The reduction in TSS concentration was highly variable with the 2001 natural runoff, but uniformly high under the 2002 simulated runoff. This may have been due to the inherent natural variability in the 2001 runoff events, and, conversely, the uniformity of contaminants and flow rate applied in the simulated runoff collected in 2002.

Total phosphorus would have a component bound to sediment. In fact, the reduction in concentration of runoff phosphorus was similar to reductions observed in TSS, when comparing buffer types and years, ranging from 40% to 60%.

Total nitrogen concentration reduction was the least of the three components measured and also had the least variability by buffer type and year, with reductions ranging from 35% to 55%. Narrow riparian buffers were less effective in filtering a soluble nutrient like nitrogen because of the relatively short residence time and the direct flow paths through the narrow buffer.

Vegetation

The 7-year-old buffer plots all had well-established vegetation. The fallow and planted plots had complete ground cover, with annuals dominating the fallow plots, and warm season perennials and shrubs dominating the planted areas. The fallow plots had equal proportions of mostly annual cool and warm season grasses, which appeared to filter surface runoff quite effectively.

Future Research

The observed reductions in runoff pollutants are consistent with those reported in other studies. However, the efficiency of the fallow plots was greater than expected. These will be examined in the future to compare standing biomass and soil infiltration rates. Runoff volume data will be further analyzed to allow mass balance calculations, which will determine the reduction in total pollutant loading. There are other sites in Kansas currently being monitored. These include a planted prairie grass filter strip and a native, mature riparian woodland.

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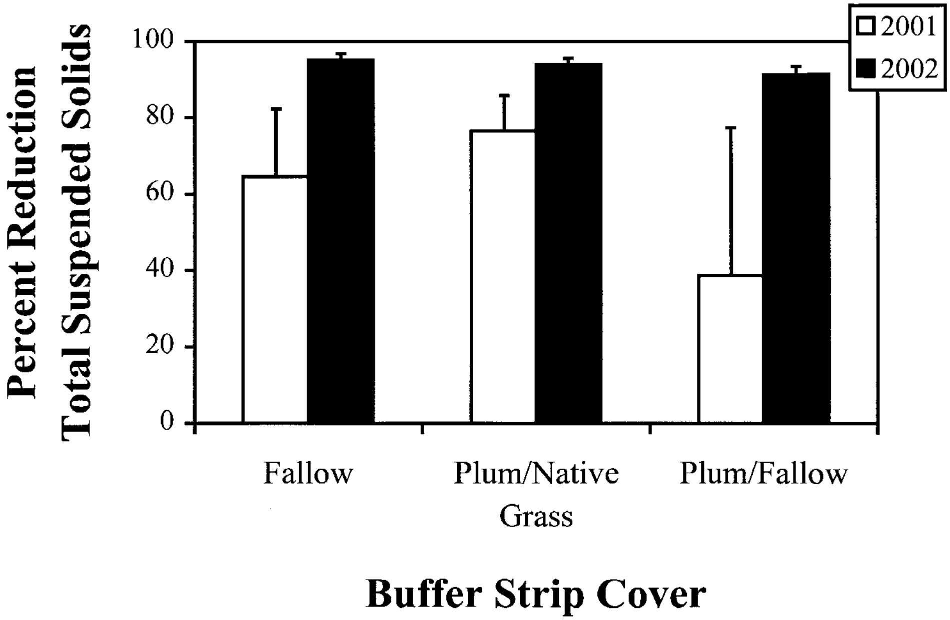

Figure 2. Average total suspended solids (TSS) concentration reduction from surface runoff achieved by three types of riparian buffer strip vegetation. Results from 2001 represent natural precipitation events and 2002 results represent simulated runoff. Standard error bars are shown.

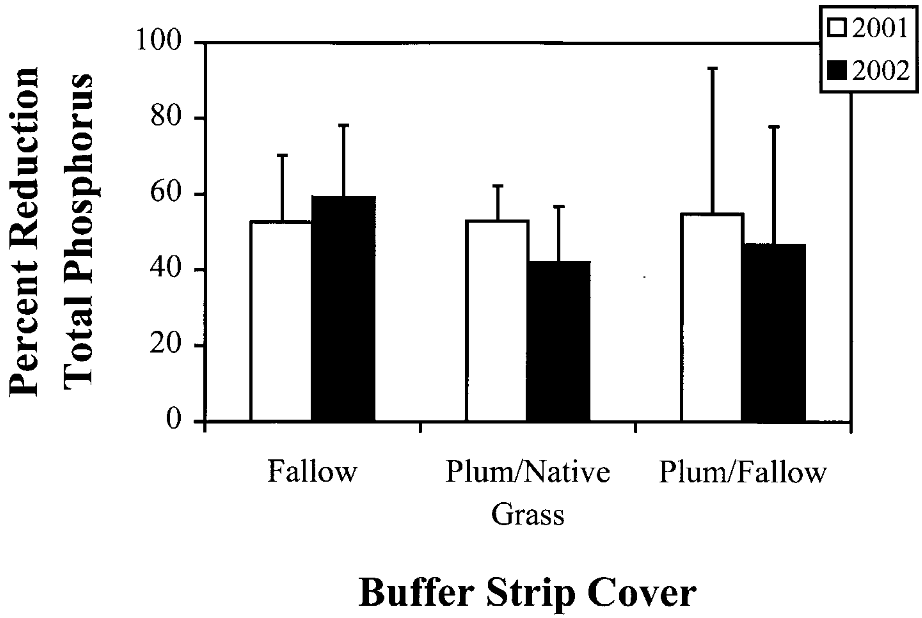

Figure 3. Average total phosphorus concentration reduction from surface runoff achieved by three types of riparian buffer strip vegetation. Results from 2001 represent natural precipitation events and 2002 results represent simulated runoff. Standard error bars are shown.