Patterns of Sediment and Phosphorus Accumulation in a Riparian Buffer

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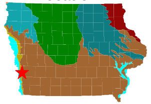
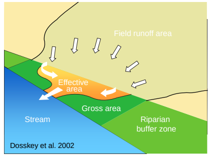
Setting and background

Location



A multi-species riparian buffer was planted in Autumn 2000 along the stream draining Watershed 1 of the Deep Loess Research Station (DLRS) near Treynor Iowa. This buffer became fully established during 2002. This watershed had been managed under long-term conventional tillage until 1995, and was converted to no-tillage in 1996. The DLRS represents a region of erosion-prone, deep-loess soils found east of the Missouri River.

Underlying hypothesis:
Seasonality and pathways of runoff have implications for performance and design of riparian buffers.



Objectives

1: To determine amount and distribution of sediment accumulation in the buffer during three years following full establishment of vegetation.

2: To quantify trapped soil phosphorus in accumulated sediment.

3: To identify patterns of phosphorus in soil water and ground water.

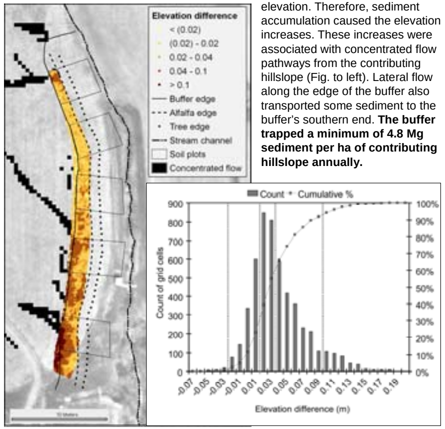
Experimental layout

Methods:

- **Sediment accumulation was estimated by comparing topographic surveys of the buffer, conducted in August 2002 and September 2005** using a survey-grade GPS system. The surveys were focused in the switchgrass zone of the buffer, adjacent to the crop.
- Soil samples were collected from five plots by vegetation zone and total soil P was measured.
- Dissolved P was monitored quarterly in shallow ground water wells, and monthly in soil water using ceramic-cup samplers installed in each vegetation type, including the crop.
- To place estimates of sediment trapping in context, the sediment discharge record from the watershed outlet, downstream from the buffer, was also summarized.

Sediment accumulation in buffer

Much of the switchgrass zone of the buffer increased in elevation from 2002 to 2005; about one third of the survey area showed elevation increases > 4 cm, and 6% showed increases >10 cm. When re-surveyed in 2005, buffer benchmarks had to be excavated, but were within 0.9 mm of their original elevation. Therefore, sediment accumulation caused the elevation increases. These increases were associated with concentrated flow pathways from the contributing hillslope (Fig. to left). Lateral flow along the edge of the buffer also transported some sediment to the buffer's southern end. **The buffer trapped a minimum of 4.8 Mg sediment per ha of contributing hillslope annually.**



Two conservation practices were implemented in sequence: no-tillage in 1996, then a riparian buffer *established* in 2002. However, the additive effectiveness of these practices in reducing watershed sediment loss was difficult to determine due to climate variability (large storms in the late 1990s and drought in the early 2000s). Contributions from a gully headcut below the buffer was considered in evaluating the watershed's sediment record.

Table 1. Sediment losses from the watershed and the gully headcut during three time periods. Annual gully sediment is the average per year based on Thomas et al., 2005.

Period	Conservation practices	Sediment load Total A	Sediment load Gully B	Runoff C	Sediment load per unit runoff =A/C
		$Mg\ ha^{-1}\ yr^{-1}$		$mm\ yr^{-1}$	$Mg\ ha^{-1}\ mm^{-1}$
1975-1995	None (Conventional tillage)	20.7	8.7	41.1	0.50
1995-2001	No tillage	28.2	5.3	85.7	0.33
2002-2005†	No tillage, established buffer	4.4	††	15.8	0.28

† - Only includes runoff observed from August 2002 through September 2005, to match interval between surveys. Total sediment for 2005 was estimated

†† – not measured

Phosphorus in accumulated sediment

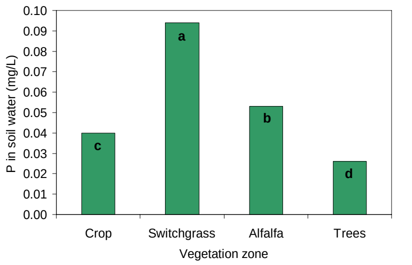
The switchgrass zone of the buffer trapped at least 26.7 kg of P from 2002 through 2005, or 9.6 kg per ha of contributing area. This was based on sediment accretion and total soil P concentrations, Variation in soil P trapped among five soil plots was nearly an order of magnitude (Table 2).

Table 2. Estimates of phosphorus trapped by sediment accumulation in the switchgrass zone of the buffer, based on mean sediment accumulation (elevation increase) and total soil P found at 0-5 cm in 2005.

Soil Plot	Volume sediment accumulation	Mass sediment accumulation	Total P, 0-5 cm depth	Mass P accumulation
	$m^3\ m^{-2}$	$Mg\ m^{-2}$	$g\ Mg^{-1}$	$g\ m^{-2}$
1	0.059	0.073	757	55
2	0.040	0.049	790	39
3	0.016	0.020	693	14
4	0.008	0.010	702	7
5	0.029	0.036	660	24

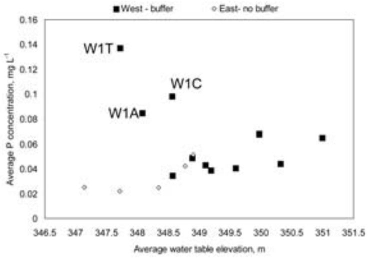
Phosphorus in soil water

Phosphorus concentrations in soil water were greatest beneath the switchgrass (see Fig. below), and beneath areas where sediment accumulation was greatest. This probably resulted from a seasonal mismatch between runoff delivery and growth of switchgrass. While half of the watershed runoff was delivered during spring, switchgrass is a warm season grass that exhibits most growth after mid-summer.



Phosphorus in ground water

Phosphorus concentrations in ground water were greatest where sediment accumulations occurred, suggested enhanced infiltration associated with sediment trapping could result in offsite movement of P to groundwater, and to streams.



Average dissolved P concentrations in ground water, plotted by water table elevation for each monitoring well. Labeled points refer to well IDs given in lower left panel.

Conclusions

Sequential topographic surveys, combined with soil sample analyses, provided a viable method to quantify sediment and P trapped in a riparian buffer during several years.

Recommendations to improve buffer design are apparent from the results. Selection and arrangement of species could help buffers reduce P losses, specifically:

Buffer performance could be optimized by positioning higher-water-use species where runoff will predictably be routed, and by selecting species to synchronize the seasonality of plant water uptake with that of runoff.

The buffer trapped significant sediment and P despite no-tillage management of the contributing hillslope. Combining edge-of-field and in-field practices in sensitive environments like Iowa's Loess Hills is important to the success of conservation efforts.

Variation in climate prevented us from using the watershed's sediment record to fully assess the combined effects of no-tillage and buffer practices on sediment yield. This cautions against reliance on before-after studies to conduct conservation-practice assessments.

Publication of this study:
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