RIPARIAN FOREST AND ADJACENT GRASS SEED PRODUCTION FIELD IN WESTERN OREGON: NITROGEN DYNAMICS AND WATER QUALITY

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Summary

The effectiveness of riparian zones in mitigating nutrients in ground and surface water depends on the climate, management and hydrogeomorphology of a site. The purpose of this study was to determine the efficacy of a well-drained, mixed-deciduous riparian forest to buffer a river from N originating from a poorly drained grass seed cropping system. The study was conducted on a study site located along the lower Calapooia River in Linn County, Oregon, U.S.A. from fall 1995 through the early summer 1999. The Calapooia River is a free flowing tributary of the Willamette River with a drainage area of 765 km^2 at our study site. The upper portion of the river basin drains forested land in the Cascade Mountains and the lower portion of the river drains low topography, poorly drained agricultural lands. The study site consisted of an intensively-managed perennial ryegrass seed cropping system and a mixed-deciduous riparian forest located on the inside meander bend of the river. An intermittent stream was located within a swale that cut from the cropping system through the riparian forest to the river. Plant communities at the site were described by McAllister et al. (2000). We found that water moved from the cropping system to the river through the slow movement of groundwater and also through the rapid drainage of surface water through the intermittent stream. Low groundwater NO_3^- concentrations (0.2-0.4 mg NO_3^- -N L^{-1}) in the surface wells of the cropping system (Table 1) were associated with low rates of mineralization and nitrification (Table 2) and high amounts of grass seed crop uptake of N (three year mean of 155 kg N ha^{-1} y^{-1}). The grass seed cropping system surface soil and sandy, well-drained riparian forest soil profile were predominantly aerobic, reducing the potential for removal of NO_3^- through denitrification. The riparian forest had higher rates of mineralization (0.32 kg N ha^{-1} d^{-1}) (Table 2) that produced quantities of soil N that were within range of plant uptake estimates leading to relatively low concentrations of groundwater nitrate (0.6-1.8 mg NO_3^- -N L^{-1}). During winter hydrological events, the riparian forest receives river water, giving this system the potential to not only influence nutrient concentrations in groundwater from conterminous agricultural landscapes but also from river water that contains nutrients from agricultural lands higher in the basin. Given the dynamic nature of the hydrology of our Calapooia River site, we believe the riparian forest plays a role not only in reducing export of nitrate from the cropping system to the river but also in processing nutrients from water exported from other in-river water.

Conclusions

- The hydrology of the site controls, to a large extent, the processing of N in ground and surface water.
- The dynamic nature of the water table in the riparian forest allows for both the reduction of nutrients originating from adjacent fields, as well as those transported down the Calapooia River network from lands higher in the basin.
- The very slow movement of water in the cropping system resulted in less water table fluctuations and overland flow through the swale during hydrologic events.
- Although the rapid movement of water from the cropping system through the swale allowed for little or no interaction of stream water NO_3^- with the riparian forest soil, the biogeochemical processing of N within the swale could be important in controlling export of N in this surface water.
- Although denitrification does not appear to contribute significantly to N removal from the site, the potential for biological uptake is high. Crop and forest vegetation had the potential to take up as much N as was contributed through mineralization (riparian forest) and fertilizer applications (cropping system).
- These results are relevant to riparian forests on the inside meander bends of rivers where alluvial deposits form in point bars and floodplain deposits and hyporheic flow of water from rivers and back are common.
- Given the dynamic nature of the hydrology of the site, we believe the riparian forest plays a role in reducing export of nitrate from the cropping system to the river.

Literature

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Table 1. Mean and standard error of groundwater nitrate concentrations in the riparian forest (Rows 1-4) and cropping system (Rows 5 & 6) at the various depths. Note that the shallowest wells are at different depths in the cropping system and riparian forest. Letters denote differences among rows for each depth with all dates combined ($p \leq 0.05$).

	Nitrate Concentrations ($mg\ NO_3^-$-$N\ L^{-1}$)				
Row	Depth 1 (0.15 - 0.47 m)	Depth 1 (0.9 - 1.4 m)	Depth 2 (1.5 - 2.0 m)	Depth 3 (2.1 – 2.6 m)	Depth 4 (2.7 – 3.2 m)
1	-	14 (5.0) a	13 (3.0) a	1.9 (0.53) a	1.1 (0.49) a
2	-	0.64 (0.15) b	0.65 (0.15) b	1.3 (0.20) a	1.6 (0.28) a
3	-	1.6 (0.56) b	1.6 (0.39) b	1.8 (0.26) a	3.1 (0.21) b
4	-	1.8 (0.41) b	1.2 (0.21) b	1.4 (0.21) a	1.2 (0.14) a
5	0.24 (0.07) a	-	6.7 (1.1) c	4.8 (0.42) b	-
6	0.44 (0.28) a	-	6.7 (0.62) c	6.5 (0.63) c	-

Table 2. Mean and standard error of mineralization and nitrification rates for the cropping system and riparian areas. Lake Creek (a contrasting poorly-drained riparian area adjacent to a poorly-drained grass seed crop) data were calculated from Davis et al. (2008) for comparison.

	Riparian		Cropping System	
	Mineralization ($kg\ ha^{-1}\ d^{-1}$)	Nitrification ($kg\ ha^{-1}\ d^{-1}$)	Mineralization ($kg\ ha^{-1}\ d^{-1}$)	Nitrification ($kg\ ha^{-1}\ d^{-1}$)
Calapooia				
1996-97	0.32 (0.08)	0.31 (0.08)	0.06 (0.03)	0.06 (0.02)
1997-98	0.30 (0.06)	0.30 (0.06)	0.16 (0.03)	0.17 (0.02)
1998-99	0.35 (0.06)	0.35 (0.06)	0.03 (0.01)	0.03 (0.01)
Lake Creek				
1996-97	0.21 (0.09)	0.04 (0.02)	0.18 (0.07)	0.11 (0.04)
1997-98	0.17 (0.05)	0.03 (0.01)	0.19 (0.05)	0.22 (0.04)
1998-99	0.28 (0.14)	0.00 (0.00)	0.23 (0.17)	0.08 (0.07)