STREAM MACROINVERTEBRATES AND AMPHIBIANS AS INDICATORS OF ECOSYSTEM STRESS: A CASE STUDY FROM THE COASTAL PLAIN, GA

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Abstract. Conservation buffers are one strategy adopted by various federal and state agencies to aid in the reduction of agricultural impacts on surface and ground water systems. A diversified row crop and beef cattle operation located on a tributary of the Lower Chattahoochee River in Early County, southwest Georgia was the selected site for this study. A suite of indicators were chosen to evaluate the impact of agriculture on three unfenced and two fenced stream sites. Preliminary results provide no discernible differences in herpetofaunal captures between sites, except for larval salamanders captured within bimonthly invertebrate samples, which were more abundant at fenced sites. Percentages of EPT, Coleoptera and Crustacea were also higher at fenced sites, which also showed lower levels of nitrate-N, suspended solids, and fecal coliforms. Exclusion sites, which had been fenced out three years prior to this study, suggest some recovery from cattle impacts.

INTRODUCTION

Intensive agricultural land use continues to be a major contributor of non-point source (NPS) pollution to Georgia's streams and rivers, associated with over 60% of reported waterway problems (EPA 1994). Hydraulic alterations of waterways, alteration of flow rates, and the disruption of wildlife habitat through changes in chemical concentrations and increases in sedimentation, are additional consequences of intensive, high production agriculture (Schultz et al. 1995). Degradation of waterways will continue unless appropriate management techniques are employed. Conservation buffers are one management strategy to help reduce agricultural impacts on surface and ground water systems. In order for agricultural watersheds to meet designated uses as defined under the Clean Water Act (CWA), various federal and state agencies have promoted the use of conservation buffers through programs such as the Georgia Stream Buffer Initiative. A major component of this project is to monitor the physical, chemical and biological changes that occur following buffer installment at selected demonstration sites.

The primary objective of this study was to evaluate the short-term effectiveness of stream restoration efforts using buffers in a typical grazing practice within the Coastal Plain, Georgia. This was done by assessing differences in stream macroinvertebrate and amphibian communities, physical habitat structure, and correlating this to overall water quality.

BACKGROUND

Conservation Buffers

Conservation buffers are small areas or strips of land permanently maintained in vegetation designed to intercept pollutants and manage other environmental concerns such as habitat degradation. Several studies have shown the effectiveness of buffers at removing sediment and nutrients such as NO_3-N (Lowrance 1992; Verchot et al. 1997), as well as controlling pesticide transport from surface and subsurface flow (Lowrance et al. 1997).

Although an extensive amount of data are available, essential questions concerning buffer effectiveness still remain. Limited data exist in the Southeastern U.S. and even fewer studies are available in regards to buffer effectiveness in the Gulf Coastal Plain. Data available from these studies predominately consist of plot-size treatments, not larger whole farm studies. Finally, conservation has been centered on the protection and restoration of public lands even though more than 70% of the entire landmass of the conterminous U.S. and Hawaii, and over 90% of Georgia resides in private lands (NRCS 1996).

Biotic Indicators of Ecosystem Stress

Indicators of ecosystem stress ideally would have the combined attributes of being holistic, early warning, and diagnostic (Rapport 1992). Additionally these indicators need to be abundant and tractable, readily sampled and occur in stable numbers. "Sensitive species" such as stream macroinvertebrates and amphibians are obvious candidates as indicators of stream health. Invertebrates have been shown to be excellent indicators of changes in stream quality due to agricultural impacts (Lenat 1984). In addition, amphibian species are thought to be highly sensitive to disturbances, in both terrestrial and aquatic environments due to their life histories, specific microhabitat requirements, and specialized physiological adaptations (Stebbins and Cohen 1995). Both invertebrate and amphibian species were used in this study to take more of a holistic approach in evaluating the overall health of the study streams impacted by agricultural practices.

SITE DESCRIPTION AND METHODS

The participating Best Management Practice (BMP) demonstration site is located on Factory Creek, a tributary of the lower Chattahoochee Watershed, in Early County, southwest Georgia. The farm is a 900-acre diversified row crop and beef cattle operation, underlain by easily eroded cretaceous sands and clays in a region characterized by frequently meandering streams and steep gullies (Brantly 1916).

Three unfenced stream reaches (B-1, B-2, and B-3) and two fenced (R-1 and R-2; fenced from cattle access) reaches were sites for this study and are located within the same drainage basin of Factory Creek. All are first- order perennial streams.

At all sites, composite invertebrate samples were collected bimonthly (February-October 2002) using a 500µm-mesh Hess sampler, then preserved in ethanol for sorting and identification in the laboratory.

Herpetofaunal searches included: searches of natural cover objects along transects (Jaeger 1994); artificial cover boards (Fellers and Drost 1994); dip netting (Heyer et al. 1994), and tree pipes (Boughton et. al 2000). All searches were conducted bimonthly (March –November 2002), except for tree pipes which were surveyed on a monthly basis (May- December).

Grab samples were collected biweekly for chemical and biological water quality analysis which was measured by quantifying: NO_3-N, NH_4-N, PO_4-P, Cl^-, TKN, Total-P, suspended solids, fecal coliforms (fc), and fecal streptococci (fs).

Stream habitat evaluations were conducted once at each site, with physical characterizations consisting of general land use, description of stream origin and type, summary of riparian vegetation structure, and measurements of instream parameters such as width, depth, flow, temperature, dissolved oxygen (DO), and substrate.

RESULTS

Water Quality

Mean concentration levels for nitrate, suspended solids, and turbidity were lowest at the fenced sites compared to the three cattle access sites (Table 1). FC levels were also lowest at fenced streams, and FC to FS ratios for all sites indicated that bacterial sources were from livestock contamination (FC/FS<0.7) (Geldreich 1967).

Macroinvertebrates

Percentages of EPT, Coleoptera, and Crustacea individuals were higher at the fenced sites (Figs.1a, b). Overall, communities for each site were mostly comprised of Dipterans (70-93 %), with Chironomidae as the dominant family (69-77%).

Amphibians

We observed 18 herpetofaunal species overall, of which 4 were salamander species [Apalachicola Dusky Salamander (*Desmognathus Apalachicolae),* Southern Two-lined Salamander (*Eurycea cirrigera),* Southeastern Slimy Salamander (*Plethodon grobmani)* and the Red Salamander (*Pseudotrition ruber)*]. No significant differences in abundance were found in dipnetting, searches under natural cover objects or coverboards.

Table 1. Mean water quality concentrations for study sites

Site	NO_3-N (mg/l)	PO_4-P (mg/l)	Suspended Solids (mg/l)	f.coliform (col/100ml)
B-1	0.05	0.03	5.83	317
B-2	0.06	0.02	2.84	505
B-3	0.03	0.02	3.40	584
R-1	0.02	0.01	0.62	152
R-2	0.02	0.01	0.73	102

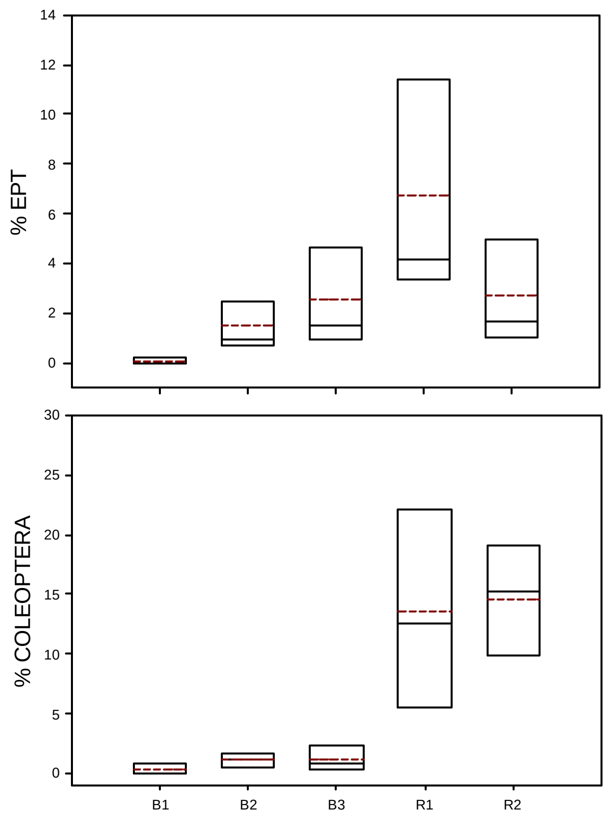

Figure 1. The range of percentages for EPT (a) and Coleoptera (b) for all sites, Feb-Oct 2002.

Larval salamanders (*E.cirrigera)* were found within invertebrate samples and the number of individuals was significantly higher at fenced sites.

Three hylid species utilized tree pipe refugia [Gray treefrog (*Hyla chrysoscelis),* Green treefrog (*H. cinerea)*, and the Squirrel treefrog (*H. squirella)*]. *H.squirella* were captured most frequently (n=186 captures) followed by *H.cinerea* (n=15 captures) and *H.chrysoscelis* (n=3 captures). No significant differences between sites were found in species presence or total number of individuals inhabiting tree pipes.

Physical Habitat Measures

All stream reaches maintained a 15-30 meter forested buffer, and showed no differences in percent canopy cover. Number of shrub and ground cover species were higher at fenced sites, and percent bare ground was higher at unfenced sites. Width to depth ratios (W: D), average riparian width and number of coarse woody debris (CWD) were highest at site B-1, and basal area was the lowest (Table 2). No significant differences

Table 2. Physical habitat measures for fenced and unfenced sites

Site	No. Shrub Species	No.CWD	W: D (cm)	Bare (%)	Basal Area (m^2)
B-1	11	103	61	33	20
B-2	0	34	7	31	86
B-3	0	95	10	30	42
R-1	18	70	12	10	54
R-2	18	52	11	10	67

were found between sites for flow, temperature, and levels of DO.

DISCUSSION

Anthropogenic disturbances such as those resulting from agricultural practices destabilize stream ecosystem function (Stevens and Cummins 1999). In particular, grazing in riparian areas can have impacts on water quality such as the removal of streamside vegetation, alteration of channels and banks through destabilization, compaction of soils, and deposition of wastes directly into streams. The most apparent effects are increased nutrient loads, increased sediment transport, degradation of riparian and aquatic habitat, and increased erosion and runoff (Armour et al. 1991).

Preliminary results of this study show significant differences in measurements (chemical, physical, biotic) at each of the study sites. This may be due to past land practices and the resultant land transformations. For example, fenced sites (R-1 and R-2) chosen for this study were excluded from cattle access three years ago, which may be cause for some similarities to unfenced sites. Site B-1 an unfenced site, also has a history of disturbance, and was extremely altered by an upland eroding gulley. During storms, loads of sediment washed into the stream and may be cause for higher levels of suspended solids and wider yet shallower stream channels. Sediment transport frequently buried coverboards in addition to leaf litter and woody objects, covering important instream habitat for invertebrates and amphibian larva. Except for B-1, most sites were similar in measurements of stream width and depth, riparian width, flow, DO, temperature and overstory coverage. Interesting differences were found in the numbers of instream versus riparian herpetofauna. No significant differences in herpetofaunal searches within the riparian zone were found between fenced and unfenced sites, yet instream abundance of salamander larvae was higher at fenced sites. This result, coupled with higher understory vegetative scores and higher invertebrate metric scores of sensitive taxa, suggest better chemical and physical stream conditions at the fenced sites.

A study by Homyack and Giuliano also found no differences in numbers of herpetofaunal species between fenced and unfenced streams. Perhaps riparian vegetation structure, an important habitat component for amphibians has not recovered sufficiently, and that water quality and instream habitat has improved.

It is difficult to assess exactly how much fenced sites have recovered, however we can speculate from preliminary metric scores, physical habitat measures, and chemical water data that these sites are recovering, indicating that conservation buffers are effective in reducing grazing impacts.

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