USING ADOPT-A-STREAM IN THE COASTAL PLAIN: A LOOK AT THE MACROINVERTEBRATE INDEX

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Abstract. As major threats to Georgia's waterways continue, volunteer-based monitoring groups such as Georgia Adopt-A-Stream (GA AAS) have become a vital source of information on aquatic ecological condition. Biological monitoring is an important component of the program, with macroinvertebrates serving as the primary tool for assessing water quality. We evaluated the validity and applicability of the GA AAS macroinvertebrate index on three impacted and two reference streams within an agricultural landscape in the Coastal Plain region of southwest Georgia. We compared these findings to a concurrent study that examined the condition of streams impacted by grazing livestock, through water quality, physical and vegetative parameters as well as macroinvertebrate metrics. The GA AAS index for macroinvertebrates proved to be effective in separating sites with different impacts, showing similar results as most invertebrate indices, and appears to be a valid tool to assess the ecological condition of Coastal Plain streams.

INTRODUCTION

The Georgia Adopt-A-Stream (AAS) program was created in 1993 as an initiative to increase public awareness of the State's nonpoint source pollution and water quality issues while developing an appreciation for aquatic resources within communities (GA DNR, 2000). Similar to other stream volunteer initiatives, these goals are accomplished by creating individual and community steward groups that are involved in the monitoring and enhancement of streams and rivers across the state of Georgia.

In order to determine the health of aquatic systems, volunteers collect a suite of information regarding a stream's physical, chemical, and biological condition. These data are intended to aid government agencies in the protection of aquatic resources through the identification of streams in need of restorative efforts, tracking long-term trends in stream health, and locating sources of pollution. It is important that volunteer monitoring protocols be compared and analyzed statistically to confirm that they reach the same conclusions as the professional protocols (Engel and Voshell, 2002).

Benthic macroinvertebrate assemblages serve as the primary tool used to assess water quality in the AAS program, and are especially valuable in assessing stream disturbances (Rosenberg and Resh, 1993). The macroinvertebrate index used by GA AAS was adapted from the Izaak Walton League's Save Our Streams (SOS) methodology, primarily developed for high gradient streams of the north Georgia Piedmont and mountain's region. Important to the utility and validity of such indices, a regional applicability of the macroinvertebrate index should be examined because differences in communities occur due to regional land characteristics (i.e. geology, disturbances) and stream properties (i.e. flow, temperature, discharge) (Strand and Merritt, 1999).

This study sought to (1) evaluate the applicability of the GA AAS index for macroinvertebrates in Coastal Plain streams of southwest Georgia and (2) evaluate the validity of this index compared to professionally recognized invertebrate metrics to assess the ecological condition of streams. We compared our findings to a concurrent study (Muenz, 2004) that examined the condition of streams impacted by grazing livestock practices through chemical and physical parameters as well as macroinvertebrate metrics.

SITE DESCRIPTION AND METHODS

This study is located on Factory Creek, a tributary of the lower Chattahoochee Watershed, in Early County, Georgia. The farm, through which Factory Creek flows, is a 900-acre diversified row crop and beef cattle operation. Underlain by easily eroded cretaceous sands and clays, this region (Fall Line Hills of the Coastal Plain) is characterized by frequently meandering streams and steep gullies.

Three unfenced stream reaches (UF-1, UF-2, and UF-3) and two fenced (F-1 and F-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 to second order perennial streams.

At all sites, composite invertebrate samples were collected bimonthly (February 2002-February 2003) using a 500µm-mesh Hess sampler, then preserved in ethanol for sorting and identification in the laboratory. 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.

Multiple parameters and were tested in the analysis. Invertebrate metrics were chosen based on those found valuable for bioassessment, those able to be included due to taxonomic resolution (Rosenberg and Resh, 1993; Barbour et al., 1996; Davis, 2000), in addition to metrics found valuable from the main study (i.e. % Elmidae; see Muenz, 2004).

The Georgia Adopt-A-Stream index score and ranking (e.g. excellent, good, fair, or poor water quality) for stream macroinvertebrates was calculated for each stream during all sampling dates. Principal Components Analysis (PCA) (PCORD Version 2.0, MjM Software Design, Gleneden Beach Oregon, USA) was used to visualize and compare AAS ratings and parameters measured within the main study (i.e. macroinvertebrate metrics and chemical/biological variables) among sites for each date. Each PCA had r^2 cut-off's of 0.25. Three axes were selected for interpretation and each stream was designated with a separate symbol.

Relationships between the axes and variables are important when interpreting the PCA ordinations. First, variables or vectors furthest from the origin explain the most variation. Variables close together are positively correlated, with those on opposite sides of the axis negatively correlated, and those at right angles are not correlated. Finally, sites close together are more similar than those farther apart.

RESULTS

Macroinvertebrate Metric Scores and AAS Ratings

Higher percentages of more sensitive metrics such as Ephemeroptera-Plecoptera-Trichoptera (EPT), Elmidae (Coleoptera), Crustacea (Decapoda and Amphipoda), and clingers were found at fenced sites, whereas percentages of Dipterans and dominant family were highest at the unfenced sites. Site UF-1 was characterized by the lowest percentages of many metrics including %EPT, Chironomidae, Elmidae, and EPT/Chironomidae.

The Georgia Adopt-A-Stream index for stream macroinvertebrates showed sites ranking anywhere from 'poor' to 'good' water quality, with most sites scoring lowest in late summer/early fall (Aug-Oct). Both fenced sites overall scored a 'good' rating, with highly variable ranges for sites F-1(6-25) and F-2 (9-33), but consistently higher than unfenced sites (Figure 1). Site UF-1 (1-13) ranked the lowest overall, 'poor,' and the other two unfenced sites UF-2 (4-18) and UF-3 (4-18) had similar ranges and both scored an overall 'fair' water quality rating (Figure 1). None of these sites scored 'excellent' except in December 2002 at fenced site F-2.

The PCA for the AAS macroinvertebrate index determined that the first two axes explained 65 % of the variation, and cumulatively 74 % with the inclusion of the third axis (Figure 2; Axis 3 not shown). Fenced sites were positively correlated with axis 1 and showed a grouping of more sensitive taxa groups on the right (i.e. EPT and Elmidae) and more tolerant groups on the left (dipterans). The four metrics (vectors) % Elmidae, % clingers, number of genera, EPT, and % Diptera and suspended solids had respective r^2 values of 0.75, 0.72, 0.87, 0.62, 0.81, and 0.53 with Axis 1. The AAS index score had an r^2 of 0.79 and was positively correlated with the more sensitive metrics on Axis 1, and negatively correlated with the metric % Diptera and the variable suspended solids.

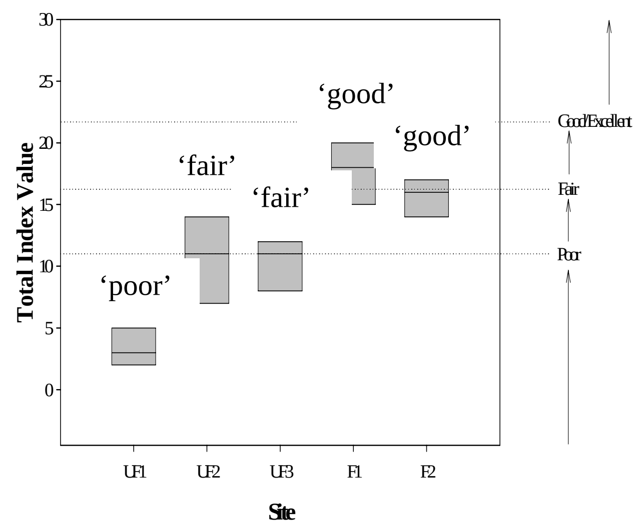

Figure 1. Box Plots for Georgia Adopt-A-Stream Macroinvertebrate Index Values and Ratings for Water Quality at Each Site from February 2002 to February 2003 (median, 25th and 75th percentiles, maximum value, minimum value and outliers).

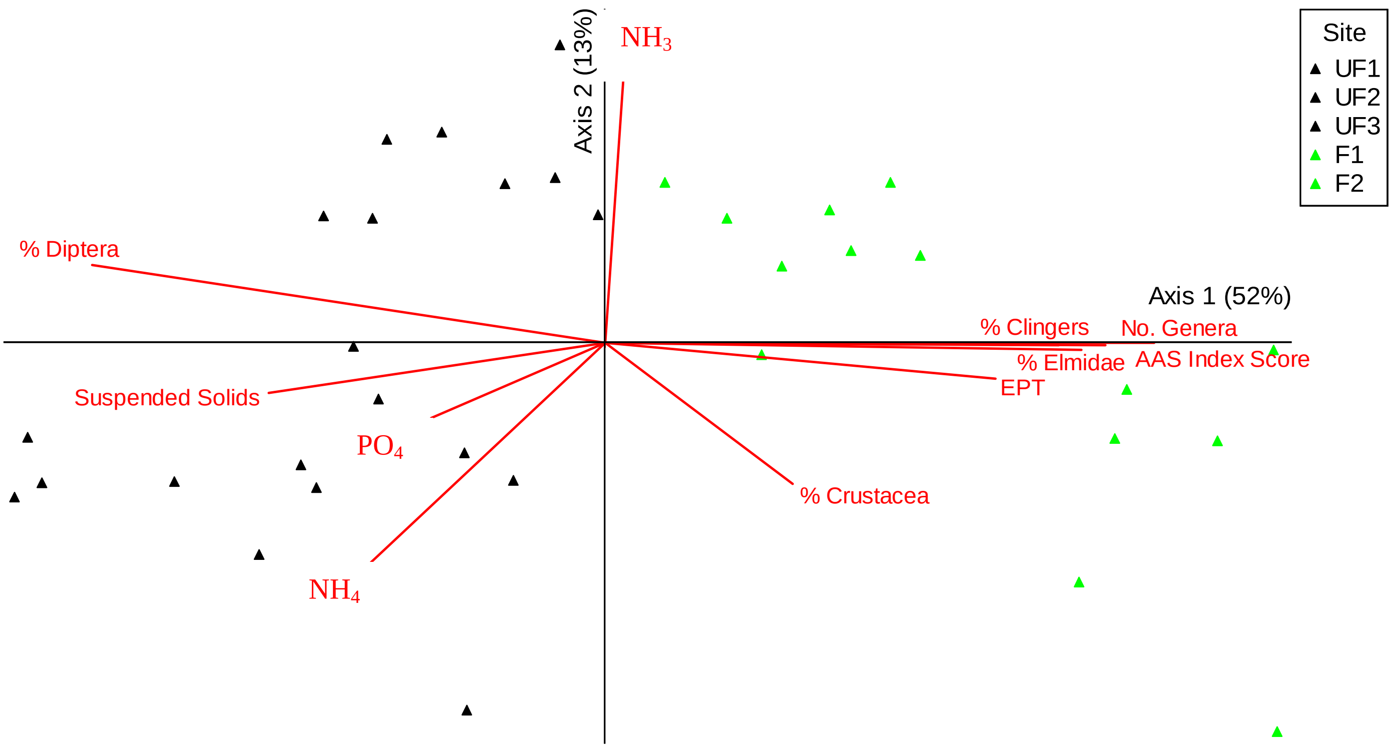

Figure 2. First and second axes of the principal components analysis (PCA) for macroinvertebrate metrics and AAS rankings at all sites. Points represent individual site/dates and vectors indicate each variable. Percent variation is explained in parentheses.

Chemical and Physical Measures

Variability among sites for chemical and physical habitat measures existed, with those sites in the same treatment as most similar (i.e. F-1 and F-2). In addition to macroinvertebrate metrics, variables that were found to separate stream sites were nitrate-N, suspended solids, and fecal coliforms, of which fenced sites showed lower and more stable levels (Table 1; Muenz, 2004). No significant differences were found between sites for velocity, temperature, dissolved oxygen, and percent canopy cover over the stream. Vertical vegetative coverage, % leaf litter and number of shrub and ground cover species were highest at fenced sites, whereas percent bare ground within the riparian area was highest at unfenced sites. Most sites maintained a considerable buffer ranging from 10m (site UF-1) to over 30m (Site UF-2).

Table 1. Mean Water Quality Concentrations and Physical Habitat Measures for Study Sites.

Site	NO_3-N (mg/l)	Leaf Litter Cover (%)	Suspended Solids (mg/l)	f.coliform (col/100ml)
UF-1	0.57	13	5.83	189
UF-2	0.24	25	2.84	608
UF-3	0.80	42	3.40	378
F-1	0.57	83	0.62	111
F-2	0.56	75	0.73	96

DISCUSSION

Site Differences

Overall, sites identified as ‘good’ or ‘poor’ by the AAS index corresponded to fenced and unfenced sites respectively, and did show different degrees of impact as identified by chemical and biological assessments. Sites ranking ‘poor’ or ‘fair’ generally had less leaf litter cover in the riparian area, elevated levels of nutrients and sediment, and lower percentages of more sensitive invertebrate taxa. These results are similar to other studies that examined the effects of agriculture and buffers on streams in the Coastal Plain (Gregory, 1996; Davis, 2000). Overall these differences in measurements suggest that sites fenced from cattle many years ago demonstrate better water quality and habitat structure and that buffers are benefiting these streams.

Implications for the AAS Macroinvertebrate Index

Macroinvertebrate indices and metrics are often applicable only to a particular geographic area, and it is suggested that they be adjusted and tested according to regional conditions (Lenat, 1993). This provides a more effective and accurate tool for assessing stream condition. For example, streams in the Coastal Plain are typically sandy-bottomed and low to medium gradient, harboring fewer sensitive taxa than higher gradient streams due to factors such as high temperatures, slow flow, and low dissolved oxygen (Davis, 2000). Our results indicated that the AAS macroinvertebrate index was applicable to Coastal Plain perennial streams, and can serve as a useful indicator of overall stream health in this region.

It is also suggested that volunteer monitoring protocols be compared and analyzed statistically to confirm that they reach the same conclusions as the professional protocols (Engel and Voshell, 2002). Although this study was based on a relatively small sample size, strong relationships were apparent between the AAS index score and many of the measured variables, demonstrating similarities between the macroinvertebrate index as compared to professional data. These findings suggest that the Georgia Adopt-A-Stream index is useful and can aid in the identification of streams in need of restorative efforts or in tracking long-term changes in stream health.

Monitoring information is crucial to the act of environmental regulation, however aquatic biologists often are limited to sampling sites once every few years, limiting their ability to detect short-term changes in stream health (Engel and Voshell, 2002). Volunteer efforts are often used to aid in these information needs because groups can sample multiple locations at one time, and data is often readily available. Because of the need for indices to be regionally applicable, additional examinations of the AAS index are underway in the Coastal Plain and will be compared to the results from this study.

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