UNIQUE STEEPHEAD STREAM SEGEMENTS IN SOUTHWEST GEORGIA: INVERTEBRATE DIVERSITY AND BIOMONITORING

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Abstract. The steephead streams we studied are springfed, relatively high gradient, and have greater substrate diversity than is typical of most Coastal Plain streams. The study objectives were: 1) to describe the physical characteristics of the streams and quantify the seasonal biodiversity in several streams draining managed forestlands, and 2) test and adapt rapid bioassessment methods. Our results show these streams to have high invertebrate diversity throughout the year with the highest occurring in winter and early spring. The streams and their valleys had a regionally unique assemblage of plants and animals. Bioassessment values indicated water quality to be fair to good when sampling with the fixed area modified Hess sampler and good to excellent when sampling multiple habitats using a D-frame kicknet. The values were calculated using the rapid assessment methods adapted by Save-Our-Stream (SOS) and the Hilsenhoff Family Biotic Index (FBI). The results of the bioassessment values indicate that the streamside management zones (SMZ's) implemented in these areas of silvicultural activity are effective in maintaining adequate water quality standards and supporting diverse and abundant aquatic life.

INTRODUCTION

Steephead stream valleys occur along the Apalachicola-Chatahoochee-Flint River basin (Wharton 1978). Some streams draining steepheads have perennial headwaters but become intermittent downstream while others drain directly into large rivers. We sampled three streams as part of a larger study of biodiversity of managed forestlands. The streams originate on the International Paper Southlands Experiment Forest (SEF), which has been managed as an experimental and working forest since 1947. Uplands surrounding the stream valleys are managed using a variety of silvicultural treatments. The streams and adjacent valleys are incorporated into streamside management zones (SMZ's) because unstable soils and steep slopes are very erodable. Our objective was to determine the biodiversity of invertebrates and describe the physical attributes of the streams. The second objective was to compare two sampling methods for use in bioassessment: a modified Hess sampler and a D-frame kicknet. The bioassessment data will be used to determine whether these streams are appropriate reference sites for use in assessing future streams in similar habitats.

Study Area

Southlands Experiment Forest (SEF) is located in Southwest Georgia on the Pelham Escarpment, East Gulf Coastal Plain Ecoregion. The average annual temperature is 20° C with approximately 260 freeze-free days. The mean annual rainfall is 125 cm,and is evenly distributed. The watersheds in this area are underlain by limestone creating karst topography and characterized by steep convex and concave landforms oriented SE to NW with a mean elevation of 29 m.

Studies on vegetation, amphibians, birds, and invertebrates indicate that these are areas with particularly high biological diversity. Species composition of the vegetation extending from the stream bank to approximately 50 m to 75 m uphill is complex (Hedman, unpublished data). These riparian areas contain overstory species found in several community types described by Kirchner and Morrison (1988): southern hardwood forest, oak hickory, and Appalachian cove. Dominant overstory species include sweetgum (*Liquidambar styraciflua*) , oaks (*Quercus alba, Q.rubra,* and *Q. nigra*), tulip poplar (*Liriodendron* *tulipifera*), black gum (*Nyssa sylvatica*), hickories (*Carya glabra*, *C. tomentosa*, and *C. ovata*), and American basswood (*Tilia americana)*.

METHODS

Sampling for Biodiversity

Three streams (Cemetery, Lundy Lane, and Snake Creek) were sampled in the summer, winter, and early spring of 1996-1997. Cross-sectional transects, corresponding to pre-existing vegetation sampling transects, were established along the length of the stream channels. Stream widths, water surface to bank full depths, and across channel widths were measured. Substrate percent and type were measured across the width of each channel. Percent canopy cover was estimated using a spherical densiometer. Invertebrates and benthic organic matter were collected using a modified Hess sampler (500µm mesh net) and preserved in 70% ethanol. Organic matter was sorted into coarse particulate organic matter (CPOM $\geq$ 1.00mm) and fine particulate organic matter (FPOM 0.5-1.0mm). Invertebrates were separated from the fractions and keyed to genus and species when possible. Benthic organic matter (BOM) was dried at 65° C, weighed for dry mass, ashed at 500° C, and weighed again to determine ash-free dry mass. Habitat and invertebrate data were explored using multivariate analysis (PC-ORD for Windows, Version 3.04, McCune and Mefford 1997). Principle Component analysis (PCA) and Non-metric Multivariate Analysis (NMS) ordinations were used to explore the invertebrate seasonal trends in the data. Infrequent taxa were deleted (<10% of the samples) to prevent skewing of the analyses. The data were log transformed to moderate the effects of unusually high densities of some taxa in the NMS.

Sampling for Bioassessment

A 12-inch D-frame kicknet was used to sample the same transects as were sampled for biodiversity. Approximately 10 sweeps were taken across habitats to obtain a sufficient sample (100-200 organisms) for each station. Habitats sampled include coarse woody debris, grassy undercut banks, clay substrate, and sand. Samples were taken to the laboratory, preserved, and identified. Data were analyzed with two biotic indices: Hilsenhoff FBI, and Save-Our-Streams rapid bioassessment. Samples from the study on biodiversity were compared with the kicknet samples. Bioassessment sampling was performed in the spring only.

RESULTS

Biodiversity

All streams had high invertebrate diversity and many invertebrates considered sensitive to water quality were present throughout the year (Figure 1 and Table 1). The sensitive taxa Ephemeroptera, Plecoptera, and Trichoptera (EPT) showed the most diversity in the spring. The presence of stress tolerant odonates in late spring and early summer indicates the change of invertebrate assemblage over time (Table 2). Many of the sensitive invertebrates identified are common in the southern Appalachians (Merritt and Cummins 1996, Wiggins 1996).

Table 1: Total Density (individual/m^2) of Sensitive Taxa Sampled Using a Modified Hess Sampler.

	Summer	Winter	Early spring		Summer	Winter	Early Spring
Trichoptera				**Coleoptera**			
Calamoceratidae	510	858	162	Dryopidae	112	37	0
Hydropsychidae	37	302	535	Dytiscidae	0	646	25
Leptoceridae	12	62	0	Elmidae	3605	3706	4600
Limnophilidae	0	25	12	**Total Density**	**3717**	**4389**	**4625**
Odontoceridae	385	957	535				
Philopotamidae	659	236	50	**Odonata**			
Psychomiidae	12	37	0	Calopterygidae	176	62	0
Uenoidae	37	12	0	Cordulegastridae	137	174	286
Unknown Trichoptera	12	99	25	Gomphidae	386	86	75
Total Density	**1676**	**2625**	**1319**	**Total Density**	**699**	**322**	**361**
				Plecoptera			
				Capniidae	0	12	0
				Perlidae	0	50	87
Diptera				Unknown Plecoptera	0	12	0
Ceratopogonidae	1579	7908	10196	**Total Density**	**0**	**74**	**87**
Chironomidae	4824	71209	15020				
Dixidae	50	274	583	**Ephemeroptera**			
Empipidae	0	25	75	Baetidae	174	3295	2114
Tabanidae	410	522	0	Caenidae	808	1144	2885
Tipulidae	4078	15442	6788	Ephemeridae	634	211	0
Unknown Diptera	87	323	1181	Heptageniidae	0	12	0
Total Density	**11028**	**95703**	**33843**	**Total Density**	**1616**	**4662**	**4999**

Principal Component Analysis explained 50% of the variance in the data, indicating that the physical characteristics measured were important in discerning seasonal habitat differences. Winter samples had the lowest percent canopy cover with leaves being the predominate substrate in the streams. Sand was the

Seasonal Abundance of Major Invertebrate Taxa

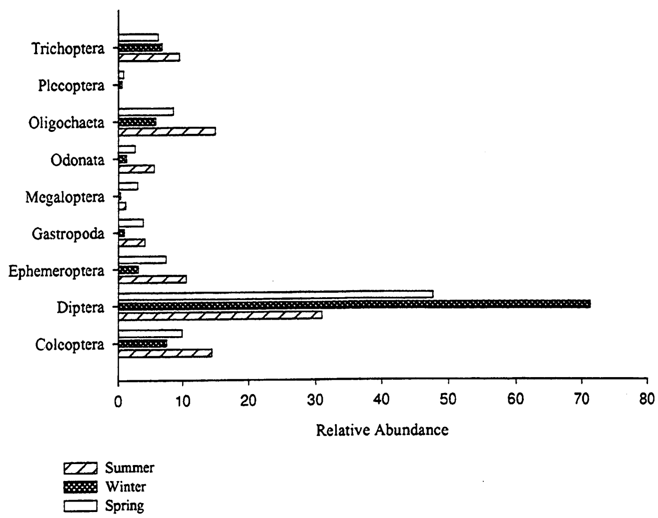

Figure 1: Seasonal abundance of major taxa sampled using a Hess sampler.

dominant substrate in the summer and early spring, then covered by leaves in the winter. NMS analysis explained 74% of the variation in the data and showed a strong correlation between the invertebrate assemblage and the seasonality of the streams. Substrate changes substrate dominated by leaves in winter, thus altering the food source for the invertebrates. The standing stocks of leaf litter were highest in winter, increasing the habitat for dipterans such as *Tipula* and *Pseudolimnophila* (Merritt and Cummins 1996) as well as other shredders and detritivores. In spring, leaf litter and sand were the dominant substrate with high densities of gastropods, plecyopods, and ephemeropterans. Elmidae (Coleoptera) and *Anicentropus* (Trichoptera) dominated the sandy-bottomed streams in the summer. Numerically dominant species throughout the year were *Elimia* (Gastropoda), *Anisocentropus frontalis* (Trichoptera), Ceratapogonidae (Diptera), Chironomidae (Diptera), Oligochaeta, *Pisideum* sp. (Plecypoda), *Psilotreta antica* (Trichoptera), *Pseudolimnophila* sp. (Diptera), and *Stenelmis* sp. (Coleoptera).

Bioasessment

SOS and FBI values indicated water quality ratings to be good to excellent in most of the sites sampled. When the same biotic indices were applied to the data from the modified Hess sampler, ratings were consistently lower (Table 2). D-frame net sampling of multihabitats captured a broader array of invertebrates than the fixed area sampling of the modified Hess sampler. Relative abundance values and total density indicate that the winter and early spring is the optimal time to make bioassessments in this type of stream (Figure 1 and Table 1). During cooler periods the Plecopterans, Ephemeropterans, and Trichopterans (EPT taxa) were found to be the most abundant and mature enough for identification.

DISCUSSION

Biodiversity

We identified ten genera of Trichoptera, notably *Diplectrona*, *Psilotreta*, and *Anisocentropus,* which were among the most abundant taxa collected. *Psilotreta* are commonly found in well shaded spring-fed streams, whereas, *Anisocentropus* are associated with trapped debris and wood snags in sandy bottomed streams (Pescador et al. 1995). *Diplectrona* are common in steephead streams of South Georgia and North Florida (Pescador et al. 1995). The Plecopterans identified are indicative of small, cool, spring seeps, whereas, most of the odonates identified are typical of warm, sandy-bottomed streams of the Coastal Plain (Stewart 1988).

The steephead regions of Florida and Southwest Georgia are the southern-most distribution of many Southern Appalachian plants and animals including many of the trichopterans we collected (Platt and Schwartz 1990). These unique regions contain isolated populations of disjunct communities that used these cool ravines as refugia after the ice age and gradually developed heat tolerance (Wharton 1978). Erosion is a serious threat to steepheads and these habitats are threatened by intensive agricultural and logging practices in the region (Wharton 1978).

Bioassessment

Hess sampling yielded higher invertebrate densities, whereas multihabitat kicknet samples had higher invertebrate diversity. Sampling method depends primarily on the objective of the study. If the objective is to quickly evaluate the general state of a stream then multihabitat sampling using D-frame kicknet and rapid bioassessment methods are appropriate. In these streams fixed method sampling with a Hess sampler is useful for calculating densities and collecting BOM within the stream channel. Although multihabitat quantitative sampling would be optimal, small stream size can limit the use of traditional fixed area sampler.

Table 2: Water Quality Ratings Comparing the Values of Two Sampling Methods. Sites are Snake Transect 1 (ST1, etc.), Modified From

	D-frame kicknet		Hess	
	SOS	Hilsenhoff	SOS	Hilsenhoff
ST1	Excellent	Very good	Fair	Fairly Poor
ST2	Good	Excellent	Fair	Fairly Poor
ST3	Good	Very Good	Fair	Good
ST4	Excellent	Good	Fair	Fairly Poor
CT1	Excellent	Excellent	Good	Fair
CT2	Good	Excellent	Fair	Fair
CT3	Good	Very Good	Good	Good
CT4	Excellent	Excellent	Good	Fair
CT5	Excellent	Excellent	Good	Fair
LT1/2	Poor*	Very Good*	Fair	Fair
LT3/4	Good	Very Good	Good	Good
LT5/6	Excellent	Excellent	Good	Fair

Winter and early spring is the optimal time to sample these streams for water quality ratings due to the high density and diversity of invertebrates (Table 1). EPT taxa are often used as indicators of good water quality due to their means of respiration (gills), therefore, sampling when they are most abundant will give the most accurate water quality ratings. Conditions in Coastal Plain streams become stressful in late spring and summer due to an increase in temperature and low dissolved oxygen concentration. These conditions leave only the most stress tolerant species.

The biomonitoring methods we employed are a rapid and effective way to detect major disturbances in the landscape (Hilsenhoff, 1988 and Ruhlman and Winn, 1997). The results indicate that the SEF streams have high water quality, indicating the SMZ's employed provide adequate buffers against erosion and nutrient enrichment that might result from the surrounding intensive land use.

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