Fish assemblage dynamics in an adventitious stream: a landscape perspective.

*Schaefer, J.F. and Kerfoot, J. R.

Southern Illinois University Edwardsville
Department of Biology
Edwardsville, IL 62026

*corresponding author
jacscha@siuc.edu

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Abstract -

Recent studies of stream fish assemblages have begun to incorporate landscape properties in explaining the dynamics seen at individual sites in riverine systems. In this approach, stream and river landscapes (riverscapes) are viewed over greater spatial and temporal scales to understand the dynamics seen at individuals sites. Adventitious streams are feeder tributaries of mainstreams at least 3 orders greater in magnitude. Interface sites between adventitious streams and their mainstreams are often more diverse and variable than either the feeder stream or mainstream alone. We used fish assemblage data from 21 sites over three periods (1967, 1995 and 2001) from an adventitious stream drainage (Piasa Creek: Jersey, Madison and Macoupin CO., IL) to test the hypothesis that assemblage variability and diversity would be greatest at downstream interface sites and decrease further upstream. There was a correlation between distance from the mouth the stream and assemblage variability as well as mean diversity. We hypothesize that the distribution of some species within the drainage are best explained by larger scale landscape properties and their influence on fish movement patterns.

Introduction

Recent studies of stream fish assemblages have begun to incorporate landscape properties in explaining the dynamics seen at individual sites (Fausch *et al.*, 2002; Robinson *et al.*, 2002; Tockner *et al.*, 2002; Schlosser and Kallemeyn, 2000; Schlosser, 1995a; Schlosser, 1991). In this approach, the entire stream or river landscape (riverscape) must be viewed over greater spatial and temporal scales to understand the dynamics seen at individual sites (Fausch *et al.*, 2002). For example, beaver ponds have been shown to affect fish assemblages at the reach and basin scale through a number of processes including migration and source-sink dynamics (Snodgrass and Meffe, 1999; Snodgrass and Meffe, 1998; Schlosser, 1995b). Numerous studies have shown a relationship between local species richness and larger scale phenomena such as overall drainage richness and position in the drainage (Matthews and Robinson, 1998; Obendorff *et al.*, 1998; Osborne and Wiley, 1992). Faunal assemblage composition in floodplain pools may also change depending on landscape attributes such as connectivity with the main channel (Robinson *et al.*, 2002; Castella *et al.*, 1984). One landscape property of aquatic ecosystems that has not been well studied are the interfaces between small tributaries and the larger rivers or lakes into which they flow. Willis and Magnuson (2000) found that tributary interfaces with lakes had higher diversity values than the lakes or streams alone and thus constituted an ecotone. This study was fairly limited in spatial scope and did not address how far upstream the influence of the lake could be seen. Taylor *et al.* (1996) showed the interface site with Lake Texoma had the most variable assemblage of five mainstream sites in the upper Red River Basin. In our study, we assess the influence of a large river on a smaller tributary (adventitious stream) by quantifying temporal

variability of the fish assemblage as a function of the distance to the river-tributary interface.

Adventitious streams are feeder tributaries (usually 1st -3rd order) that empty into a mainstream at least 3 orders greater in magnitude (Gorman, 1986; see also Minshall *et al.*, 1985; and Vannote *et al.*, 1980). This large change in stream order can result in abrupt community differences at the interface point and an overall break in the river continuum (Vannote *et al.*, 1980). Gorman (1986) speculated that communities at the interface would be more diverse and more variable due to the influence of the riverine fauna. In Roxybury Creek (a 3rd order tributary of the 7th order Wisconsin River), much of the variation in abundance of dominant species can be attributed to migrations into and out of the Wisconsin River (Mendelson, 1975). Harel and Dorris (1968) found that benthic macroinvertebrate communities at adventitious stream interfaces were more similar to those at higher order stream communities than those of the same order, while Whiteside and McNatt (1972) found a similar trend in fish communities. There has been no study investigating the extent of these effects, asking if the observed increases in assemblage variability and diversity are localized or spread throughout the riverscape (Gorman, 1986; Minshall *et al.*, 1985).

There are many possible explanations for these trends seen in adventitious stream interface sites. Tributaries are often used as spawning and nursery areas for riverine species (Matthews, 1998) and therefore one might expect adventitious stream sites to have greater diversity. In addition to upstream movement by riverine species for reproduction, downstream reaches of tributaries tend to be more uniform in structure leading to more vagile fish populations and higher fish movement and dispersal compared to the more heterogeneous upper reaches (Gorman, 1986). As a result, assemblages at the interface between adventitious streams and their

mainstreams are expected to be higher in diversity and more variable over time.

In this paper we investigate the variability in fish communities over time at 21 sites throughout the drainage of an adventitious stream. The Piasa Creek Watershed covers more than 78,000 hectares in portions of Jersey, Madison and Macoupin counties in Illinois and consists of the main channel of Piasa Creek as well as a number of smaller tributaries (Smith *et al.*, 1969; Fig. 1). Piasa Creek is an adventitious stream located near the confluence of the Mississippi, Illinois and Missouri Rivers. Due to its location, it is one of the more dramatic cases of an adventitious stream and might be especially prone to the effects seen in this type of riverscape. It is clear that the adventitious stream interface sites are impacted by proximal riverine assemblages but no study to date has quantified how far upstream these effects (assemblage variability and increased diversity) might be seen. We hypothesize that the influence of the large river assemblage will be strongest in Piasa Creek at the interface with the Mississippi River and that these effects will decrease with distance upstream. Specifically, our hypotheses are: 1) the three tributaries in the Piasa Creek drainage are physically different in the habitat variables measured 2) the fish assemblages in these three tributaries are different, 3) sites closer to the interface with the Mississippi River will have higher diversity and show greater community change over time than sites in the upper reaches of the drainage. We use species diversity and community change over time at 21 sites in the Piasa Creek drainage as response variables to address these hypotheses.

Methods

Fish Assemblage and Analysis

Historical fish community data were compiled from Smith *et al..* (1969) and Shaw (1995). Smith *et al..* (1969) sampled a total of 31 sites by seine in summer and fall of 1967. We used only data from sites that were subsequently sampled by Shaw (1995) and the authors in the fall of 2001 (21 total). For sites that were sampled more than once in a year we, used the mean abundance (rounded down) among summer and fall samples and eliminated rare species (see below). Shaw (1995) sampled each site in summer and winter but because of very low abundances in winter samples we used only the summer data. Data for 2001 samples were from collections made by the authors in August-October of that year. Fish from all three periods were collected by seine and placed in 10% formalin for later identification in the lab. Fish above 100mm were identified in the field and released. Collections from 2001 were made under Southern Illinois University Edwardsville Animal Care Protocol I.D.# 01-28-02-JFS-1. Ten sites were eliminated from Smith *et al..* (1969) because they were not sampled in 1995 or could not be sampled in 2001. For example, the downstream most site in the drainage (A1 on Fig. 1) is now a marina and could not be accurately sampled by seine. The final data set consisted of 21 sites in three major tributaries sampled in each time period. Sites are named as in Smith et. al. (1969) with each of the three tributaries (Mill Creek, Little Piasa East and Piasa Creek) assigned a letter (C, E and B respectively) and numbered consecutively from the mouth to the headwaters (Fig. 1). For analyses that compared the three tributaries we considered site G1 as part of the B tributary. We eliminated any species that was only collected once in the 63 samples. These species included: *Lepisosteus osseus*, *Hiodon alosoides*, *Ctenopharyngodon idella*, *Notropis blennius*, *Pimephales vigilax*, *Ictiobus niger*, *Labidesthes sicculus*, *Pomoxis nigromaculatus*, *Lepomis megalotis* and *Morone chrysops*. The final data matrix consisted of 21 sites sampled 3 times

yielding a total of 20,504 fish and 35 species (Appendix 1).

For analysis of fish community data a detrended correspondence analysis (DCA, PCORD ver. 3.2) was performed on percent abundance (by collection) across all 63 collections. Mean Euclidian distance in DCA space between the three sample times at each site was used as one assay of community change (Taylor *et al.*, 1996). For qualitative measures of community change and diversity we calculated the mean Jaccards index of similarity (NTSYS ver. 2.1) and mean species diversity among all dates at each site.

Environmental Data and Analysis

We collected environmental variables at 16 of the 21 sites (Fig 1). At each of these sites we laid 10 transects in the area where fish were seined. For each transect we measured stream width, depth and estimated the percent composition of seven substrate categories (silt, mud, sand, gravel, cobble, boulder and bedrock) at three points along each transect. For each site we calculated a mean width and depth as well as coefficient of variation (CV) in width and depth as an assay of habitat heterogeneity. To test the hypothesis that the three tributaries were physically different in the variables measured a PCA was performed on the 11 environmental variables (seven substrate types, mean depth, CV depth, mean width, CV width) collected and a one-way ANOVA was used to test for differences in principal component (PC) I scores between the tributaries.

Position in the Drainage

To quantify the position of each site in the drainage we used relative distance from the

mouth and the "downstream link" (D-link) as described in Osborne and Wiley (1992). Relative distance from the mouth was quantified by measuring (on topographic maps) the distance between the site and the Mississippi River and dividing that by the total length of that tributary from its headwaters to the Mississippi River. Relative position was therefore on a scale of 0 (at the furthest downstream interface) to 1.0 (headwaters). Our second measure of position in the drainage, D-link, is defined as the stream link number at the next downstream confluence (Matthews, 1998; Osborne and Wiley, 1992). Stream link numbers are determined by the total number of headwater tributaries upstream of any given point. These measures have an advantage over stream order in that they account for position in the drainage. For example, a first order stream lower in the drainage will have a higher link number than a first order stream higher in the drainage (see Osborne and Wiley, 1992 for discussion).

Results

Environmental Data

The first two axes of the PCA explained 46.7% of the variance in the 11 environmental variables measured (Fig. 2). There was a significant difference ($F_{2,13}$=24.5, p<0.001) in PC I scores (26.8% of variance) between the three tributaries. The B tributary contained more of the smaller substrates (gravel, mud and silt) while the C and E tributaries tended to have more boulder and bedrock. Sites in the B tributary also had a greater mean width, mean depth and CV in width than the C and E sites (Fig. 2).

Community Data

The most abundant species across all sites and times were *Campostoma anomalum* (present in 87% of collections, 17.1% of all individuals), *Semotilis atromaculatus* (87% of collections, 15.8% of all individuals), *Notropis dorsails* (78% of collections, 22.1% of all individuals) and *Etheostoma spectabile* (81% of collections, 8.1% of all individuals, Appendix 1). There was a significant difference in community structure between the three tributaries (ANOVA on DCA axis I scores, $F_{2,18}=6.49$, $p<0.003$; ANOVA on DCA axis II scores $F_{2,18}=2.27$, $p<0.113$, Fig 3).

There were significant correlations between relative position from the mouth and Euclidian distance in DCA space ($r=-0.495$, $p<0.023$, Fig 4a), species diversity ($r=-0.554$, $p<0.01$, Fig 4b) and Jaccards Index of similarity ($r=0.695$, $p<0.01$, Fig. 4c). The same trends were seen using D-link as the measure of position in the drainage (Euclidian distance in DCA space, $r=0.707$, $p<0.001$; species diversity, $r=0.622$, $p<0.003$; Jaccards Index, $r=-0.679$, $p<0.001$). Signs of the correlations are reversed because D-link increases from the headwaters to the confluence while relative distance to the mouth decreases from the headwaters to the confluence. The mean amount of change at each site differed among the three tributaries. There were significant differences in mean amount of change over time between the three tributaries in Euclidian distance in DCA space ($F_{2,18}=4.92$, $p<0.02$), change in species diversity ($F_{2,18}=5.42$, $p<0.014$), but not in change in Jaccards index ($F_{2,18}=0.75$, $p<0.49$).

Discussion

Recent reviews (Fausch *et al.*, 2002; Robinson *et al.*, 2002) of landscape processes as applied to riverine systems emphasized the importance of looking at these systems at larger

spatial and temporal scales. The results of this study show that local community properties such as diversity and variability in assemblage structure are effected by events that occur at these larger spatial and temporal scales. Our first two hypotheses were supported: each of the three main tributaries in this drainage have distinct physical qualities and fish assemblages. Our data also show that not only is the interface site (B1) more diverse and variable but that diversity and variability over time decrease further upstream in the drainage. In the Piasa Creek drainage there were significant correlations between distance from the interface site and decreasing species diversity and decreased assemblage variability over time. These trends were seen in the drainage as a whole, even though the physical properties and assemblage structure of three tributaries were different. Further studies documenting this trend in other drainages and with other fauna would improve our understanding of the role of landscape properties in the dynamics of stream assemblages (Fausch *et al.*, 2002).

Because larger order streams are physically larger, one could hypothesize that a simple species area relationship would predict the correlation between diversity and position in the drainage (Matthews and Robinson, 1998). However, we found no significant correlations between mean width, mean depth or volume (mean width x mean depth) and species diversity in this study.

One obvious explanation for the trends observed are that some large river fish may have moved into the lower reaches of Piasa Creek to use it as spawning or nursery areas. For example, adult *Dorosoma cepdianum* and *Notropis athernoides* were only found in the downstream most sites (B1, B2, B3, B4 and C1) in the drainage and are typically only found in smaller tributaries during spawning periods (Mendelson, 1975). Another species, *Stizostedion vitreum*, was only

collected as juveniles at the B1site in late summer, indicating they were using Piasa Creek as a nursery area. Conversely, the most abundant species in the drainage (*Campostoma anomalum)* was found at all of the sites except the site with by far the greatest diversity (B1). It's possible that very wide and muddy (Fig. 2) downstream areas of the B tributary are unfavorable enough to isolate populations of *C. anomalum* in the C tributary from those in the B and E tributaries. Similarly, two species typically found in headwater regions with larger substrate (*Cottus carolinae* and *Phoxinus erythrogaster*) were found only in the headwaters of the C tributary (C4 and C5) over the entire study period. The most likely explanation is that they are also isolated by unfavorable habitat found downstream at sites C1, C2 and B1. On the PCA of habitat variables (Fig 2), site C1 fell within the polygon of B sites that had more mud and silt, typical of downstream reaches where these species are not found.

Clearly movement into and out of the tributaries in the Piasa Creek Drainage is one of the most important factors to consider in monitoring the fish assemblages over time. Much of this movement is going to be linked to reproductive behavior and therefore seasonal in nature. Therefore it follows that within-year variation at downstream sites is large compared to headwater sites and that the time of year samples are taken needs to be considered. Monitoring and management of this and other similar stream ecosystems needs to account for these larger spatial and temporal scale properties.

Overall, it is well known that individual stream sites are influenced by many factors both upstream and downstream. The literature is full of examples of upstream events impacting assemblages downstream but our study presents an example of a downstream phenomenon impacting upstream sites. Many of the patterns of individual species distributions in the drainage

can potentially be explained by various aspects of the riverscape. Movement rates of fish, source-sink dynamics and boundary properties in this drainage seem to be the determining factor in many of theses cases.

Acknowledgments

List of Figures

Figure 1. Map of the Piasa Creek Drainage modified from Smith *et al.* (1967). Labeled sites represent sites with fish data from 1967, 1995 and 2001. Closed symbols represent sites where environmental data were collected in fall of 2001, open symbols represent sites without environmental data. Unlabeled sites do not have complete data from all three periods and were not used for any analysis.

Figure 2. Plot of PCA of environmental variables. Polygons are drawn around all sites within the three main tributaries. Variables listed along the x axis had loadings of at least 0.40 with PC I.

Figure 3. Plot of DCA of assemblage data. Each tributary is on a pane with symbols matching the labels in figure 1. For each site there are three points representing the three samples in time. Scale of the axes is the same for all three panes.

Figure 4. Correlations between the relative distance to the mouth and: euclidian distance in DCA space (top pane), Jaccards index (middle pane) and mean diversity over time (lower pane) for all sites combined. ● =B tributary,◆=E tributary, ▲=C tributary.

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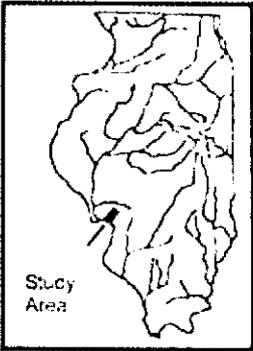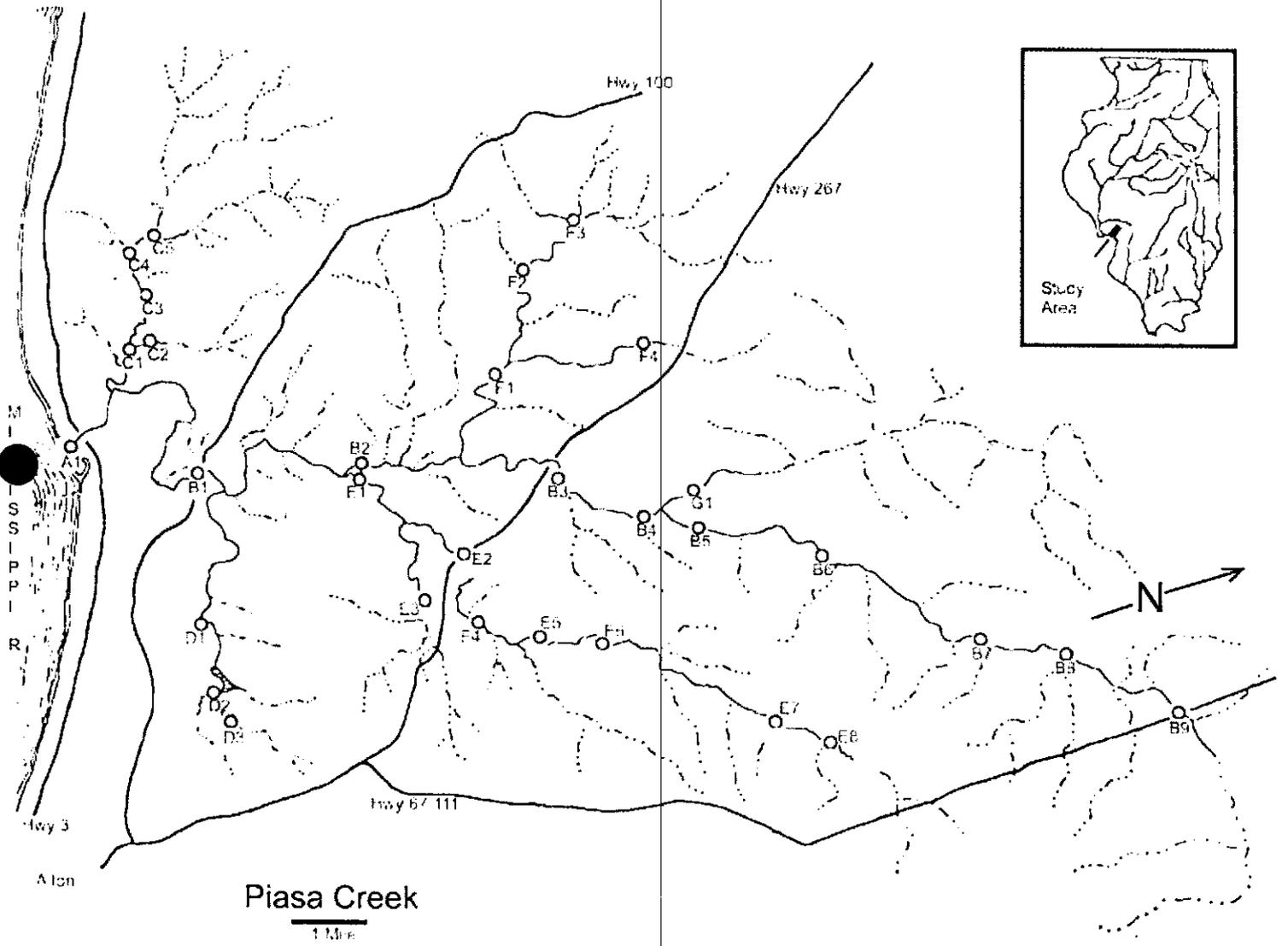
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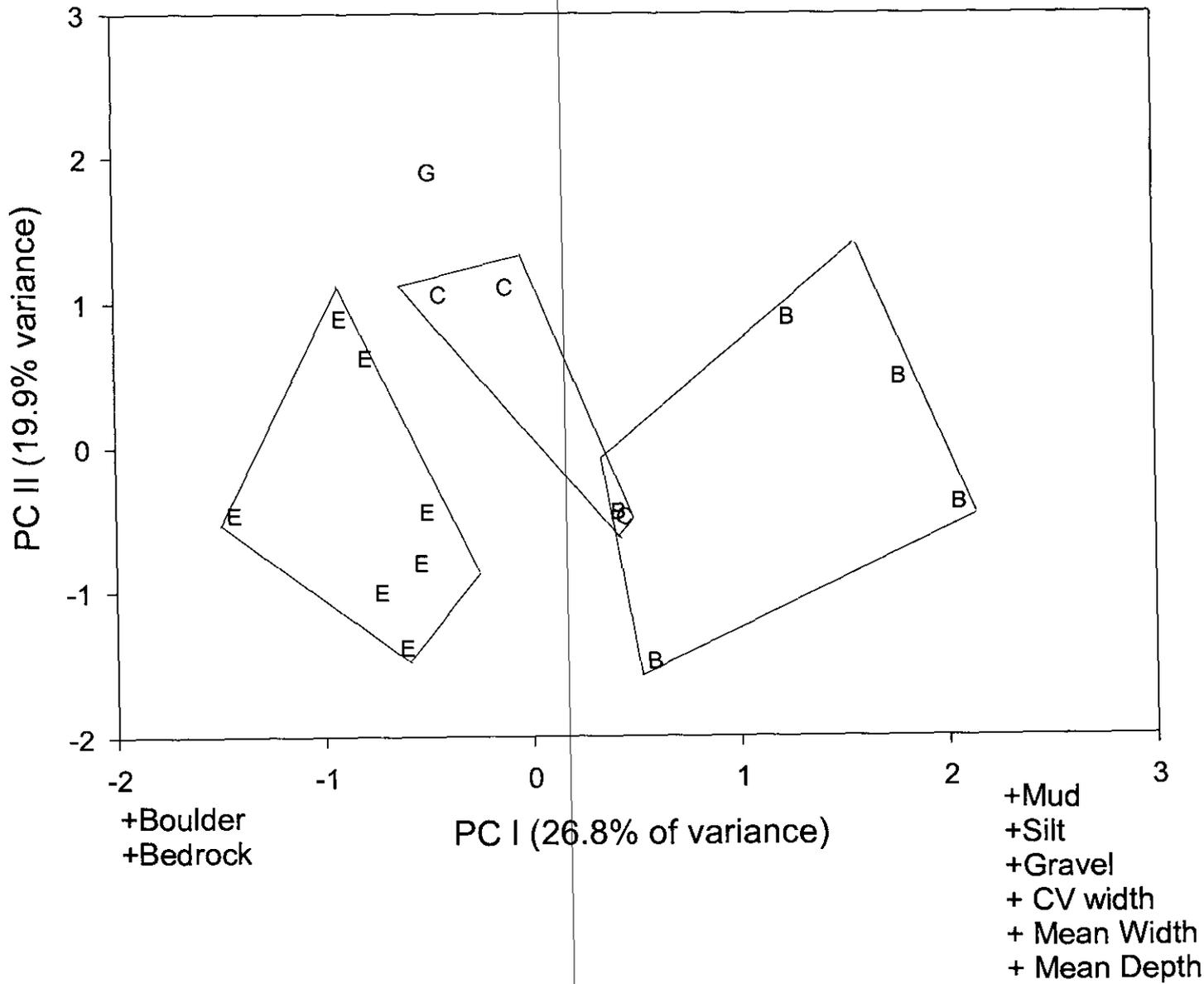introduction. *Freshwater Biol.* **47**:497-500.

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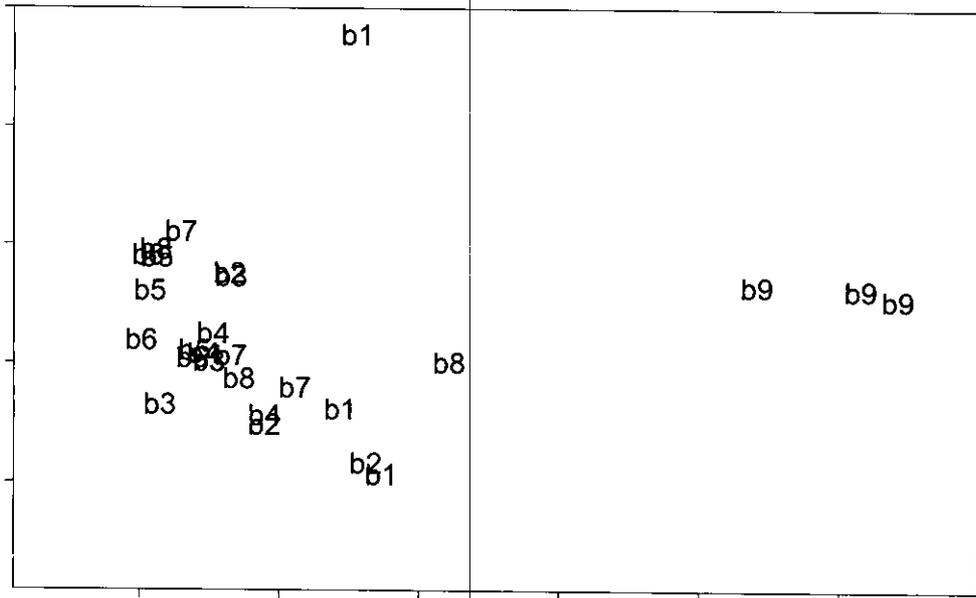
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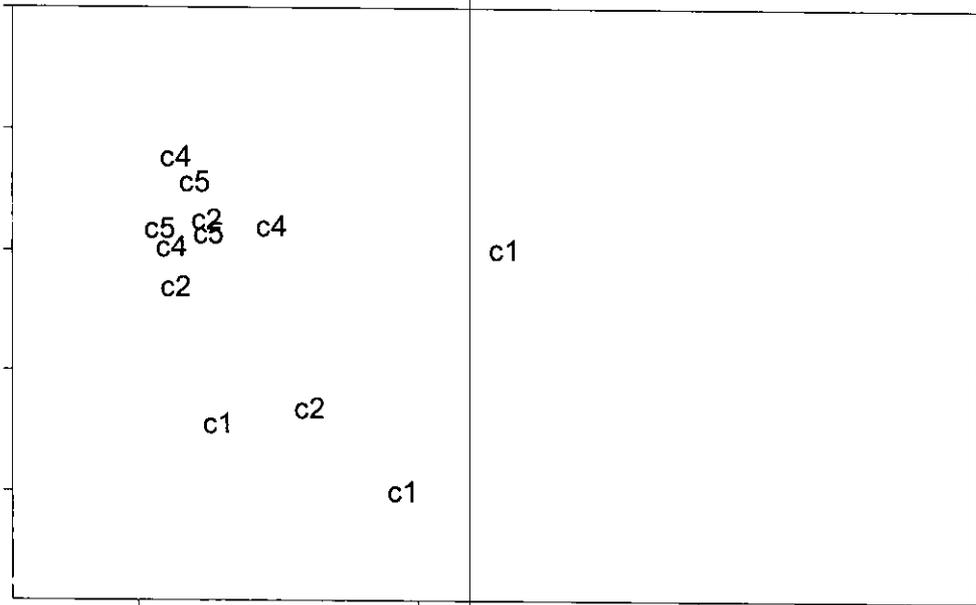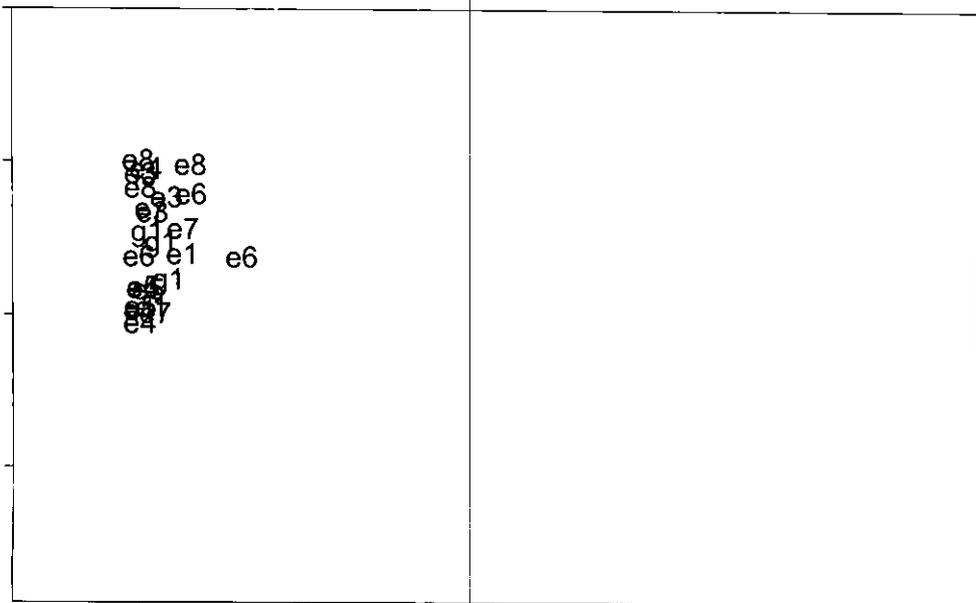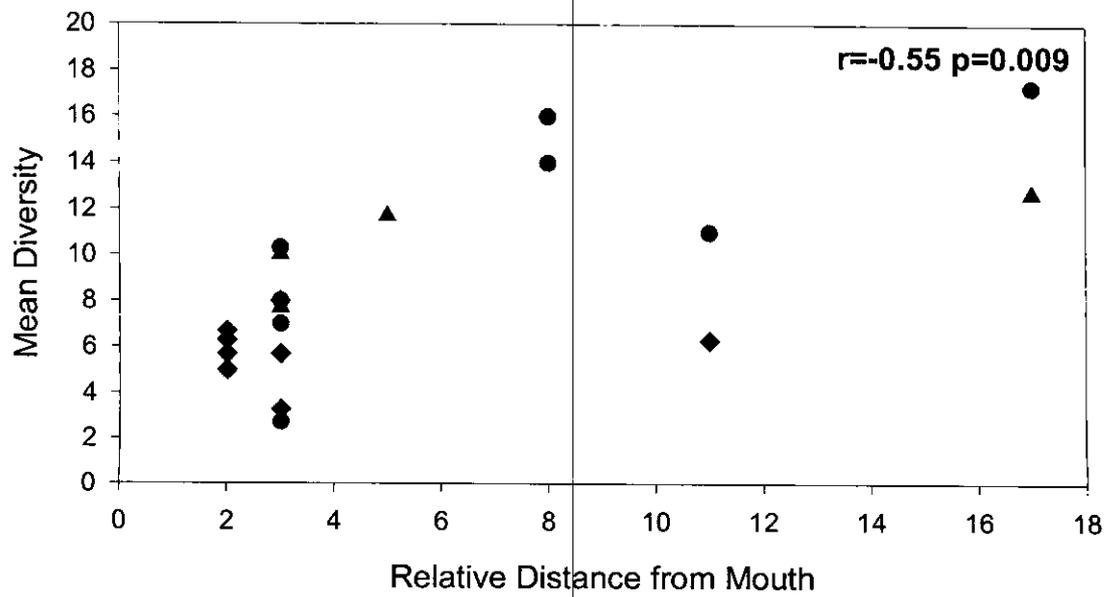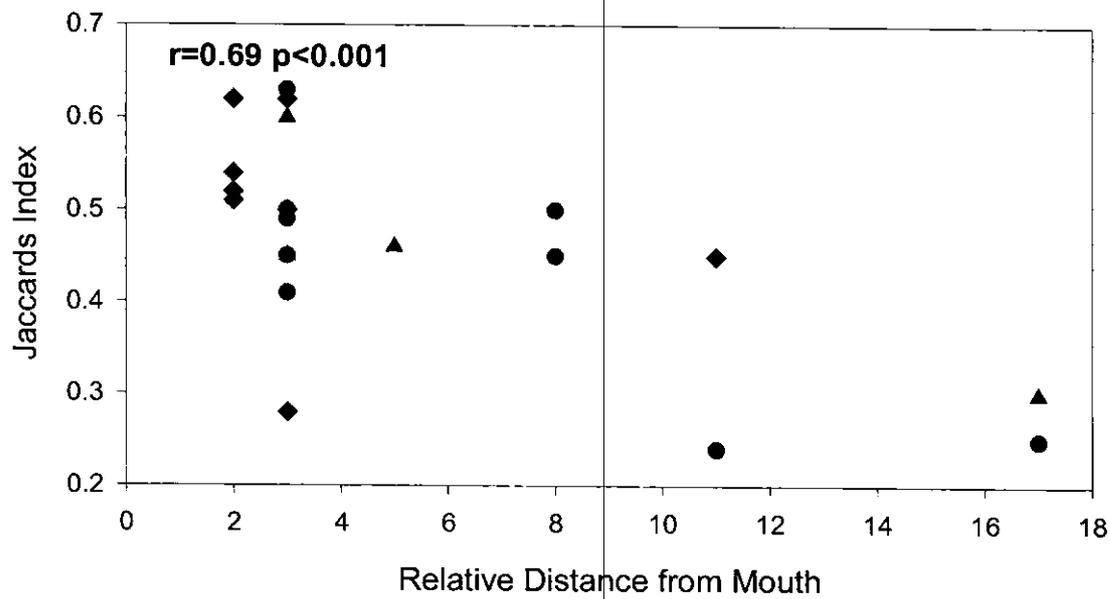
Hwy 100

Hwy 267

Hwy 3

Alton

Hwy 67/111

M I S S I S S I P P I R

Piasa Creek

1 Mile

N

Study Area

A1

B1
B2
F1
B3
B4
B5
B6
B7
B8
B9

C1 C2
C3
C4

D1
D2
D3

E2
E3
E4
E5
E6
E7
E8

F1
F2
F3
F4

G1

PC II (19.9% variance)

PC I (26.8% of variance)

+Boulder
+Bedrock

+Mud
+Silt
+Gravel
+ CV width
+ Mean Width
+ Mean Depth

Axis II

Axis II

Axis II

Axis I

Top panel:
- y-axis: Euclidian Distance in DCA Space (0, 50, 100, 150, 200, 250, 300)
- x-axis: Relative Distance from Mouth (0, 2, 4, 6, 8, 10, 12, 14, 16, 18)
- r=-0.50 p=0.023

Middle panel:
- y-axis: Jaccards Index (0.2, 0.3, 0.4, 0.5, 0.6, 0.7)
- x-axis: Relative Distance from Mouth (0, 2, 4, 6, 8, 10, 12, 14, 16, 18)
- r=0.69 p<0.001

Bottom panel:
- y-axis: Mean Diversity (0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20)
- x-axis: Relative Distance from Mouth (0, 2, 4, 6, 8, 10, 12, 14, 16, 18)
- r=-0.55 p=0.009

The Influence Of Land Use On The Fish Community In A Midwestern Drainage

SIUE Funderburg, C., Zacha, S. and Schaefer, Jacob F.
Department of Biology

Abstract

Land use practices have been shown to affect fish community structure through increased sedimentation. Some of the mechanisms thought to be at work here are 1) changing food availability, 2) habitat loss through substrate changes, 3) decreasing light penetration (increased turbidity) and primary productivity and 4) decreased survival of larvae and eggs. The rate of siltation in many drainages has increased steadily in the last 150 years as agricultural land use has increased. The Piasa Creek Watershed covers over 78,000 acres in portions of Jersey, Madison and Macoupin counties. Much of this land is agricultural. To investigate the effects of land use on stream ecosystems we examined fish community structure, habitat complexity and the diet of a common cyprinid species (Creek Chub) at 21 sites in the drainage. We hypothesize that sites impacted by agricultural land use (higher in sediment load) will have different community structure, habitat availability and food availability.

Introduction

Land use practices in a drainage can have major effects on the aquatic communities of that drainage. Altering the landscape of a watershed can drastically change water quality parameters, flow and temperature regimes and primary productivity (Ringler and Hall 1975, Walser and Bart 1999) and therefore the composition and stability of the biological community in that system. The diversity, composition and stability of fish communities are often good indicators of the overall effects of these types of changes in a watershed (Wood and Armitage, 1997). One way in which land usage has been shown to change fish communities is through increased sedimentation (Berkman and Rabeni 1987, Cooper 1987, Rabeni and Smale 1995). These changes in the fish community can be caused by 1) changing food availability, 2) habitat loss through substrate changes, 3) decreasing light penetration (increased turbidity) and primary productivity (Wood and Armitage, 1997) and 4) decreased survival of larvae and eggs (Wood and Armitage 1997). The rate of siltation in many drainages has increased steadily in the last 150 years as agricultural land use has increased (Rabeni and Smale, 1995). Determining what role siltation has played in changing fish communities is an important question when considering the impact of agriculture on ecosystems and how to manage land to minimize anthropogenic damage while maintaining agricultural productivity.

The Piasa Creek Watershed covers over 78,000 acres in portions of Jersey, Madison and Macoupin counties (II). The drainage consists of the main channel of Piasa creek as well as four subdrainages (Fig. 1). Agricultural practices and increased urbanization over the last 50 years has led to increased sedimentation and other pollutants in the water (Smith et al 1969, Shaw 1995). These types of changes have been shown to impact freshwater fish communities (Walser and Bart 1999). We examined fish community data and stream habitat data in an attempt to determine what effects land use practices might have on fish communities.
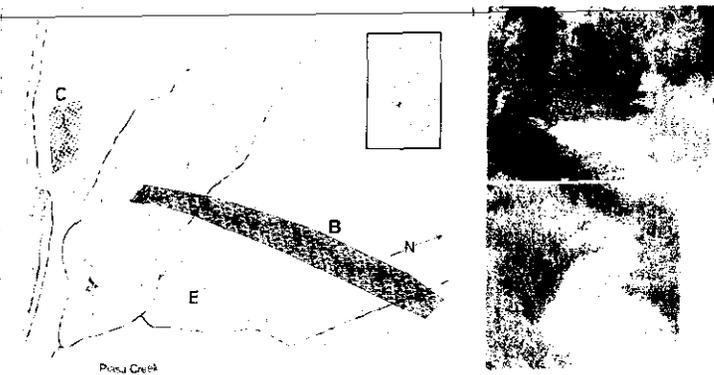
Methods

Fish samples were taken from 32 sites within the drainage(Fig. 1). Collections were made in 1967 (Smith et al 1969), 1995 (Shaw 1995) and in the fall of 2001. For all surveys, all fish were collected by seine and preserved in 10% formalin for later identification in the lab. Fish were identified to species and community data used represented a percent abundance for each species at each site. Community data were analyzed with a detrended correspondence analysis (DCA). For some analyses, all sunfish were pooled and are referred to as Lepomis sp. For DCA, community data across all periods (1967, 1995 and 2001) was pooled.

All environmental data were collected in the fall of 2001. At each site, substrate composition, presence of cover, and depth were measured at three points along 10 transects. Stream width (at each transect), canopy cover, turbidity, pH, temperature, salinity and conductivity were measured at each site. We used coefficient of variation (CV) in width, depth and substrate type to assay habitat heterogeneity at each site. To investigate similarities in environmental variables across all sites, a principal components analyses (PCA) was run using all environmental data.
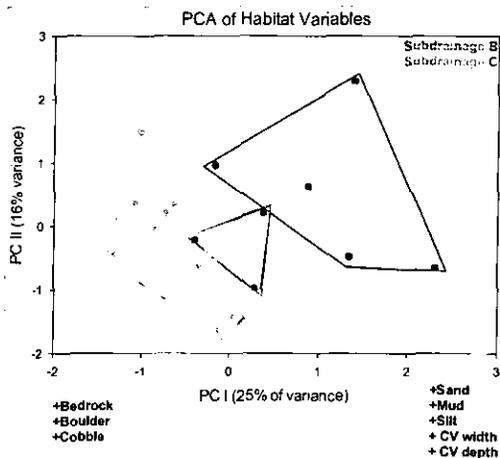

Figure 1 – Map of Piasa Creek drainage. The three subdrainges we focused on are highlighted. Individual sites within subdrainages are labeled.

Two sites in the drainage. Top photo shows a site with more mud and silt substrate, bottom photo shows a site with gravel bars and larger substrate.

PCA of Habitat Variables

+Bedrock
+Boulder
+Cobble

+Sand
+Mud
+Silt
+ CV width
+ CV depth

Figure 3. PCA analysis of habitat variables. Each dot represents one site where variables where measured. Symbols are color coded by subdrainage and polygons are drawn around all points for each subdrainage.

Results

Principal components analysis of the habitat variables showed the three subdrainages were physically distinct (Figs. 1,3). Sites in subdrainage B tended to have smaller substrate (more sand, silt and mud) and were more variable in width and depth. The smaller substrate is also consistent with what you would expect in areas with high agricultural land use (Walser and Bart, 1999). Sites in subdrainage E tended to have larger substrate (more cobble, boulder and bedrock) and were less variable in width and depth. Sites in subdrainage C were intermediate to B and E on these variables (Figs. 1,3).

Detrended Correspondence Analysis of fish community data showed little difference among subdrainages (Fig. 4). Fish communities were dominated (91% of individuals collected) by Notropis dorsalis, Lepomis sp., Campostoma anomalum, Etheostoma spectabile and Semotilus atromaculatis (Fig. 2). Sites with the smaller substrate tended to have fewer C. anomalum and E.spectabile. Notropis dorsalis and Lepomis sp. tended to be more common in the sites with the smaller substrate (Figs. 3, 5).

DCA of Fish Community Data

Figure 4. DCA analysis on stream fish community data. Each dot represents one sample at one site. Data from three collection periods is pooled. Symbols are color coded by subdrainage, polygons represent clusters for each subdrainage.

Discussion

The three subdrainages we focused on were significantly different in habitat parameters. Subdrainage B has smaller substrate, possibly a consequence of extensive agricultural land usage and subsequent increased rates of siltation. Subdrainage C and E have larger substrate and are less variable in width and depth. While the physical differences among the subdrainages are easily quantifiable the differences in the fish community are not. The visible trends in the community data (more Lepomis sp and N.dorsalis in high silt areas) are what one would expect in areas impacted by agriculture (Walser and Bart 1999) but more long term data are needed. Campostoma anomalum and E. spectabile are the only two common species in the drainage that are dependant on solid substrate and might be expected to be sensitive to increased siltation. Indeed, these two species are less common in the higher silt B subdrainage. If there is a causal relationship then one would expect continued community change in response to siltation rates. Conversely, one might expect that mitigation attempts to reduce sediment input from agricultural lands to reverse these trends. There is a project underway to reduce the sediment load of Piasa Creek by 50% over the next ten years. Future work on this system will involve monitoring the community (both fish and invertebrate) dynamics, quantifying the source of sediment inputs and quantifying land usage in each of the subdrainages using GIS and aerial photos.

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16.8% Etheostoma spectabile

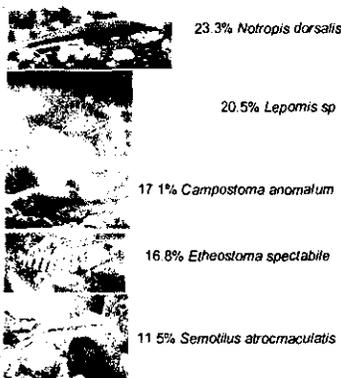11.5% Semotilus atrocmaculatis

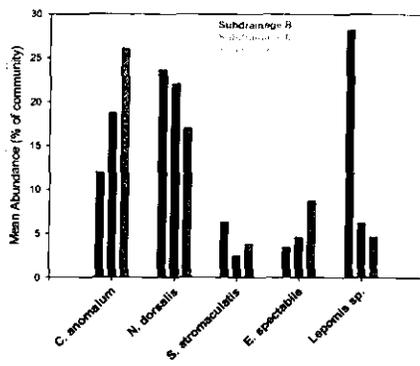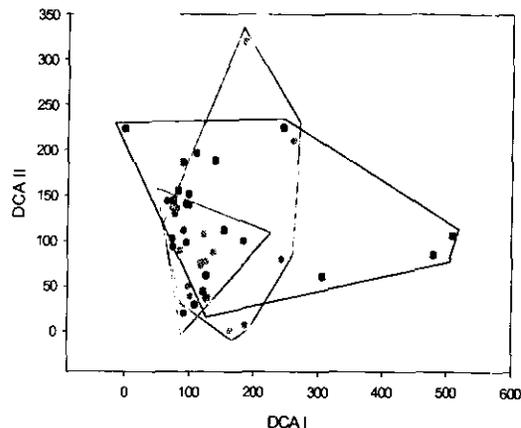Figure 2. Dominant fish groups of Piasa Creek ranked by percent abundance for all samples in fall of 2001.

Figure 5. Mean abundance of the 5 dominant groups of fish for each of the three subdrainages. Subdrainage colors match those in other figures.

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Introduction

Movement between habitats is essential for the life history of stream fish (Schaeffer, 2001). Most fish species occur in pools and semipermeable barriers, such as riffles, restrict their movement. The effects of these barriers can create a patchy distribution in the streams. Both abiotic and biotic factors are responsible for the movement of stream fishes (Schaeffer, 2001). Some examples of these factors are as follows: The ability to sustain populations prone to local extinction due to drought, floods, and pollution, the ability to move to areas of higher food quantity or quality, to gain access to prey or to avoid predators, and to gain access to spawning habitat. The most successful species are those that can move quickly to get to the preferred habitat.

A quantitative understanding of movement rates of stream fishes can be important in ecological applications such as the management of species invasions, biocontrol practices, pest outbreaks, and fragmented populations. Research that describes and explains patterns of organism movement may be useful in basic and applied interests. Rates of dispersal can influence metapopulation dynamics, predator-prey interactions, the coexistence of competitors, and community structure among the stream fishes (Skalski & Gilliam, 2000).

Freeman (1995) found that small fishes may occupy relatively limited areas of streams. Also, small fishes are considered to be specialists that leads to a view of stream fish assemblages existing as relatively distinct units that are spatially determined by variations in habitat (Freeman 1995). The "restricted movement paradigm" (RMP) is a concept that states that stream fishes are sedentary, never leaving a particular pool or stretch of stream. However, populations of fishes are not likely to be completely

sedentary. While movement is restricted, there is a proportion of fishes that do move and sometimes they move long distances (Smithson & Johnston, 1999).

This study concentrated on the movement and dispersal of nongame stream fish at four sites in Piasa Creek. It was a mark/recapture study that included stream fish from five families: Cyprinidae, Percidae, Cottidae, Catostomidae, and Fundulidae. The null hypothesis states that according to the RMP, we expect to find limited movement away from the release point by the marked fish. The study took place over a period of about two months from mid-February through mid-April. Therefore, the effects of the spring rains and the cooler temperatures associated with the time of year were variables out of our control.

Methods

This study is part of ongoing research in Piasa Creek that has been taking place since the 1960's. There were four sites that were used in the study. The sites that were chosen were B3, B5, C4, and B2. We chose these sites on the basis of previous captures of a high number of a variety species of fish. Two visits were made to each site, one visit for the clipping day and one for the recapture day.

On the first visit at each site, we performed seine hauls until we caught approximately 100 fish. After we caught the fish, we clipped a fin with small scissors to mark the fish. We clipped the dorsal fin on all of the species of fish except for the darter *(Etheostoma spectabile)* and the sculpin *(Cottus carolinae)*. We clipped the pectoral fin on these two species because they were much easier to clip and it would be easier to identify them as recaptures with this fin. We also recorded the species of each of the clipped fish. Since we did this in the field, we may not have assigned the correct species

to all of the fish because we did not want to disturb the fish any more than was absolutely needed. After we were done handling the fish, we allowed them to time to calm down before we released them back into the stream. When we released the fish, we released all of them into a single pool and recorded that location.

On the second visit to each site, we surveyed approximately 100m of stream. The 100m of stream were divided into 10m sections. Section 1 was the farthest upstream while section 10 was the farthest downstream. Section 5 was located at the release point from the first visit. We surveyed each 10m section with four to six seine hauls. We placed all of the fish from each section into a Ziploc bag that contained 10% formalin and water. The fish were then brought back to the lab where I looked for clipped fins. No statistical tests were used to evaluate the study. There were, however, many graphs that were made to show the distribution of the total fish that were caught and the number of recaptures that we found.

Results

We clipped a total of 352 fish from all of the sites combined. We caught a total of 652 fish on the second visit at each site. Of those 652 fish, 20 of the fish had clipped fins (recaptures). As the graphs show, we caught the majority of the fish from those sections that contained higher habitat diversity. We also caught more fish in those sections that contained deeper pools in the stream.

At site B3, the majority of the fish that were caught were the bigmouth shiner *(Notropis dorsalis)*. The site contained a lot of sediment, which is the preferred habitat of the shiner. There were five recaptures at this site and they were all shiners. As Figure 1 shows, the recaptured fish were caught downstream in sections 7 and 10. Site B5 also

contained a large number of shiners but there were also a large number of darters

(Etheostoma spectabile). Figure 2 shows a more even distribution of fish caught but the

recaptured fish were still located downstream. There were two recaptures at this site and

they were once again bigmouth shiners.
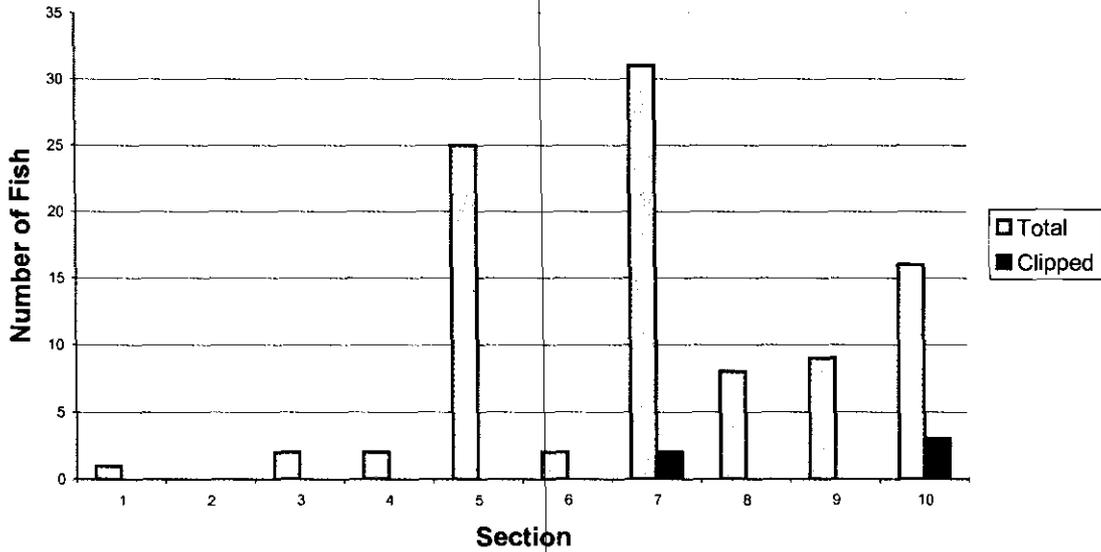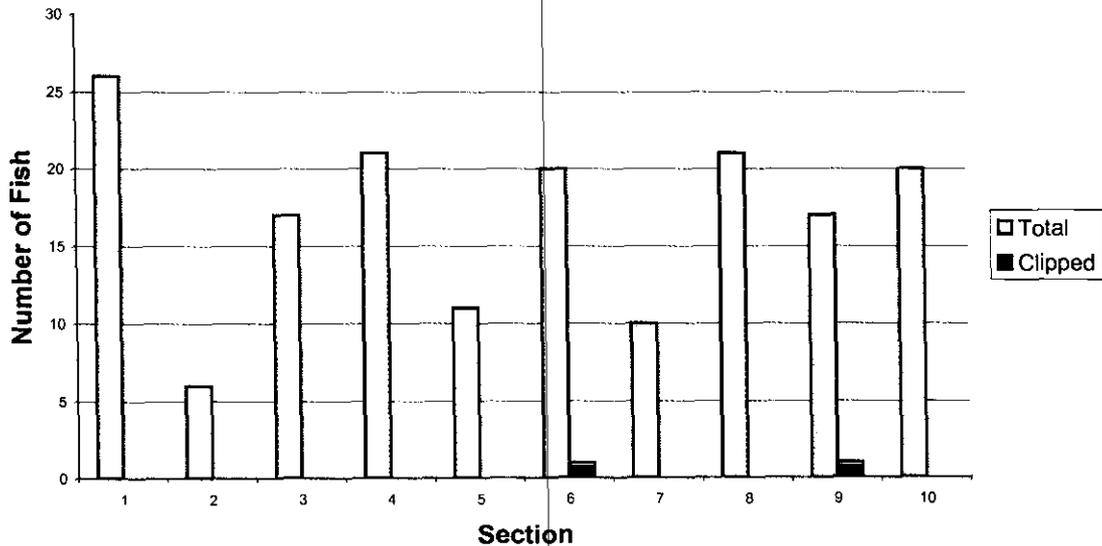
Fig.1 Fish Caught at B3 on Recapture Day

Fig.2 Fish Caught at B5 on Recapture Day

Site C4 contained little to no sediment but instead had a faster current with larger

rocks for substrate. Because of this, there were hardly any shiners at this site. However,

the vast majority of the fish that we caught were sculpin *(Cottus carolinae)*. This site

was the only site out of the four that we surveyed that contained any sculpin. Figure 3

shows that we found only one recapture (downstream) and that was a recapture of a

sculpin. The recapture at this site was the only recapture that we found that was not a

bigmouth shiner. We caught the most fish at site B2. The vast majority of the fish that

we caught here were the shiners. We recaptured 12 shiners at this site. According to

Figure 4, we had one recapture that went upstream to section 4, four recaptures at the

release point (section 5), and seven recaptures that were downstream of the release point.

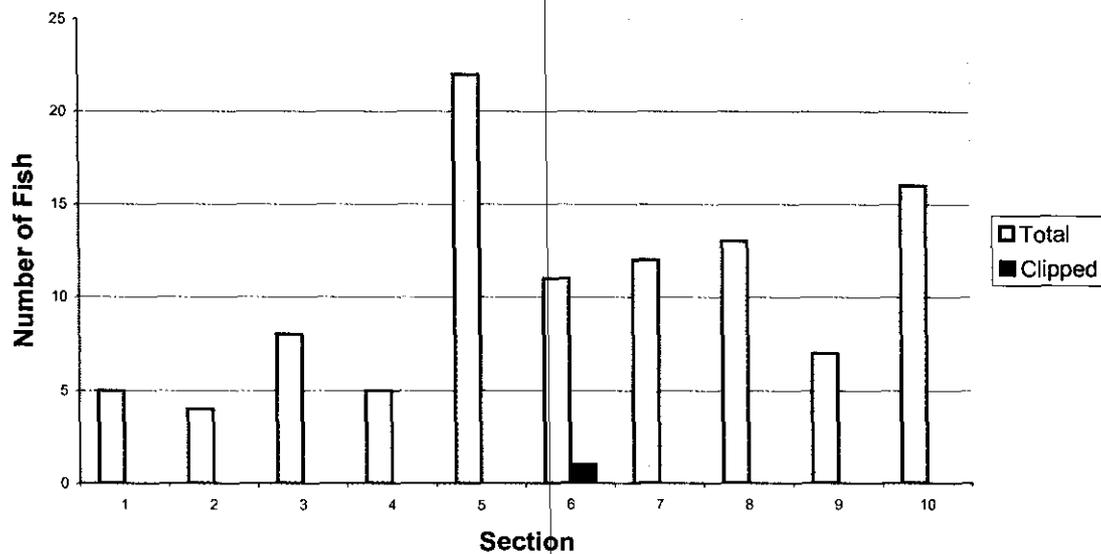**Fig.3 Fish Caught at C4 on Recapture Day**
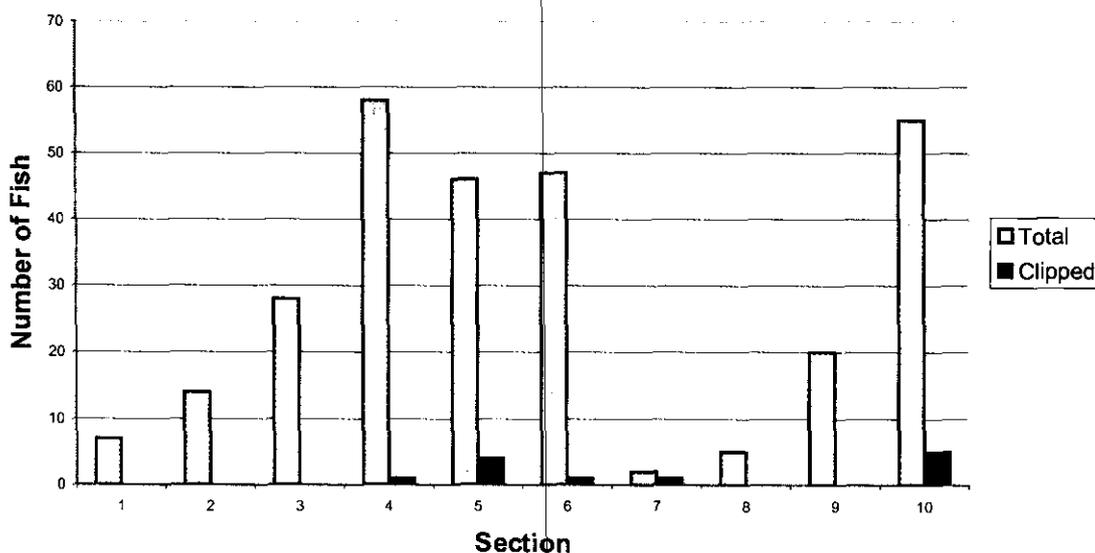
Fig.4 Fish Caught at B2 on Recapture Day

Figure 5 shows the total recaptured fish from all of the sites. The graph shows

that only four out of the 20 recaptured fish stayed in the release section while the other 16

(80%) moved out of the release section. Of those fish that did move, virtually all of them

moved downstream. Also, 12 of the 20 recaptured fish moved more than one section

away from the release section. The one fish that did move upstream was found at the last

site that was surveyed (site B2). A possible explanation for this is that an increase in

temperature may have triggered the fish to begin looking for spawning habitat. The

graph shows an increase in recaptures at section 10. This finding shows that the majority

of the fish did move downstream and that the majority of the clipped fish that we did not

catch could have went even further downstream.

Fig.5 Total Recaptured Fish From All Sites
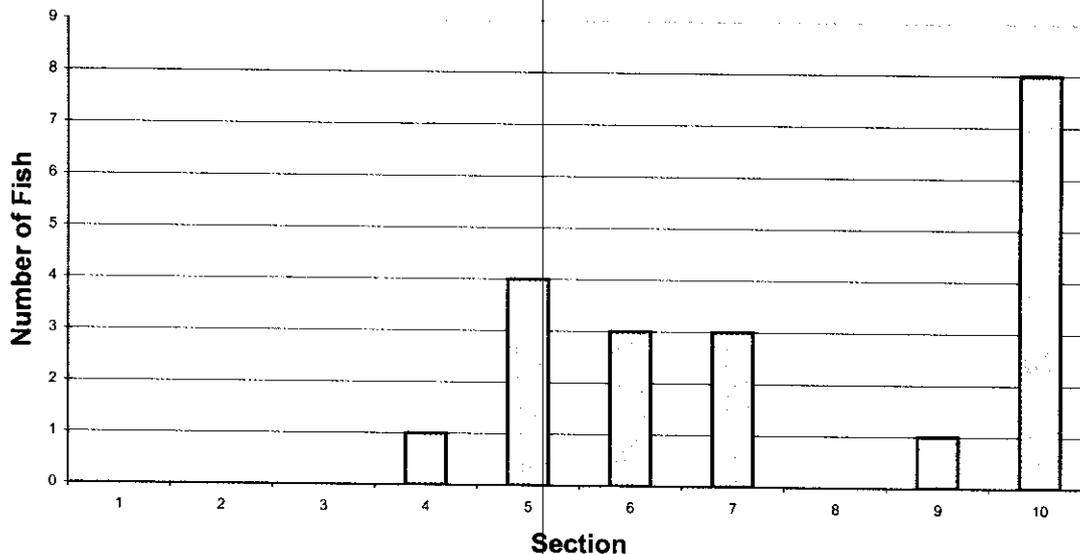
Discussion

The results that we obtained from this study did not support the RMP or our hypothesis. Our results showed that 80% of the recaptures did move from the release section. These results contradict other studies' results that suggest that stream fish tend to be sedentary with only a few mobile individuals in the population (Goforth & Foltz, 1998). There may, however, be some explanations for why our study did not model the RMP.

This study was done at a time of year that included cold weather months and there was always a possibility for heavy rains. A study conducted by Goforth and Foltz (1998) showed that downstream movements of stream fish were more numerous in the cold weather months than was expected. Also, there were dramatic changes in stream depth and flow between the two visits that were made to each site. The effects of these changes

could have washed the clipped fish downstream where we found the majority of the recaptures. These effects could have also pushed the unrecaptured clipped fish even further downstream than our study included. Plus, fish are known to repopulate streams partially or totally defaunated by floods (Sheldon & Meffe, 1994). The late winter temperatures and early spring rains could have had a lot to do with our results. Our seining efficiency could have been lower than was expected also. We may have missed some of the clipped fish when we were seining for them on our second visits.

According to Figure 5, the majority of the recaptures were downstream and the increase of recaptures at section 10 was very interesting. It would have been interesting to see what additional sections further downstream would have contained. The single recapture that was found upstream could have been due to a search for spawning habitat but it also could have been attributed to a number of different reasons. For instance, the fish could have been avoiding a predator or it could have been migrating to an area of stream that was less densely populated since it seems that the majority went downstream. Another possible reason could be similar to Sheldon and Meffe's (1994) study of repopulation where they found that upstream pools were colonized more slowly than downstream pools. If more time was given between the two visits at each site, it could have been possible that we may have found more upstream movements.

Performing further research on this study may be able to explain some of the questions that this study has proposed. First of all, the study would benefit from performing repeated samplings of a larger area. If a larger area (more sections) was studied at each site, it would give you the ability to see what additional sections upstream and especially downstream contain. Also, if repeated samplings were conducted at each

site you could catch fish that you initially missed and you would be able to see fish movements over a longer period of time. Performing the study at a different time of year may show the RMP to hold true. If the study were completed again in summer and early fall, the fish species may be more inclined to stay in the release section because of the absence of flooding and the moderately warm temperatures.

Acknowledgments

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The Influence Of Land Use On The Fish Community In A Midwestern Drainage

Funderburg, C., Zacha, S. and Schaefer, Jacob F.
Department of Biology

Abstract

Land use practices have been shown to affect fish community structure through increased sedimentation. Some of the mechanisms thought to be at work here are 1) changing food availability, 2) habitat loss through substrate changes, 3) decreasing light penetration (increased turbidity) and primary productivity and 4) decreased survival of larvae and eggs. The rate of siltation in many drainages has increased steadily in the last 150 years as agricultural land use has increased. The Piasa Creek Watershed covers over 78,000 acres in portions of Jersey, Madison and Macoupin counties. Much of this land is agricultural. To investigate the effects of land use on stream ecosystems we examined fish community structure, habitat complexity and the diet of a common cyprinid species (Creek Chub) at 21 sites in the drainage. We hypothesize that sites impacted by agricultural land use (higher in sediment load) will have different community structure, habitat availability and food availability.

Introduction

Land use practices in a drainage can have major effects on the aquatic communities of that drainage. Altering the landscape of a watershed can drastically change water quality parameters, flow and temperature regimes and primary productivity (Ringler and Hall 1975, Walser and Bart 1999) and therefore the composition and stability of the biological community in that system. The diversity, composition and stability of fish communities are often good indicators of the overall effects of these types of changes in a watershed (Wood and Armitage, 1997). One way in which land usage has been shown to change fish communities is through increased sedimentation (Berkman and Rabeni 1987, Cooper 1987, Rabeni and Smale 1995). These changes in the fish community can be caused by 1) changing food availability, 2) habitat loss through substrate changes, 3) decreasing light penetration (increased turbidity) and primary productivity (Wood and Armitage 1997) and 4) decreased survival of larvae and eggs (Wood and Armitage 1997). The rate of siltation in many drainages has increased steadily in the last 150 years as agricultural land use has increased (Rabeni and Smale, 1995). Determining what role siltation has played in changing fish communities is an important question when considering the impact of agriculture on ecosystems and how to manage land to minimize anthropogenic damage while maintaining agricultural productivity.

The Piasa Creek Watershed covers over 78,000 acres in portions of Jersey, Madison and Macoupin counties (Il). The drainage consists of the main channel of Piasa creek as well as four subdrainages (Fig. 1). Agricultural practices and increased urbanization over the last 50 years has led to increased sedimentation and other pollutants in the water (Smith et al. 1969, Shaw 1995). These types of changes have been shown to impact freshwater fish communities (Walser and Bart 1999). We examined fish community data and stream habitat data in an attempt to determine what effects land use practices might have on fish communities.
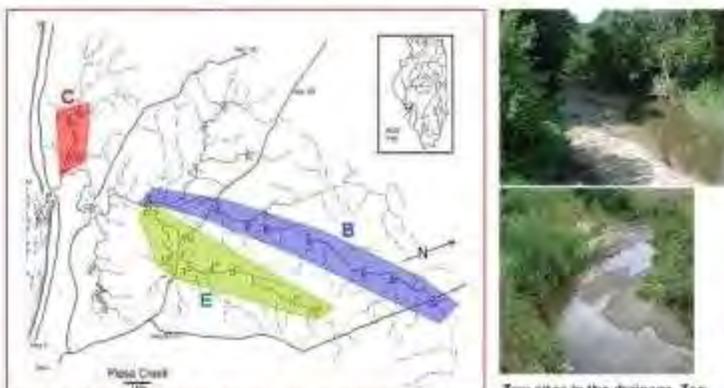

Figure 1 - Map of Piasa Creek drainage. The three subdrainges we focused on are highlighted. Individual sites within subdrainages are labeled.

Two sites in the drainage. Top photo shows a site with more mud and silt substrate, bottom photo shows a site with gravel bars and larger substrate.

Methods

Fish samples were taken from 32 sites within the drainage(Fig. 1). Collections were made in 1967 (Smith et al 1969), 1995 (Shaw 1995) and in the fall of 2001. For all surveys, all fish were collected by seine and preserved in 10% formalin for later identification in the lab. Fish were identified to species and community data used represented a percent abundance for each species at each site. Community data were analyzed with a detrended correspondence analysis (DCA). For some analyses, all sunfish were pooled and are referred to as Lepomis sp. For DCA, community data across all periods (1967, 1995 and 2001) was pooled.

All environmental data were collected in the fall of 2001. At each site, substrate composition, presence of cover, and depth were measured at three points along 10 transects. Stream width (at each transect), canopy cover, turbidity, pH, temperature, salinity and conductivity were measured at each site. We used coefficient of variation (CV) in width, depth and substrate type to assay habitat heterogeneity at each site. To investigate similarities in environmental variables across all sites, a principal components analyses (PCA) was run using all environmental data.
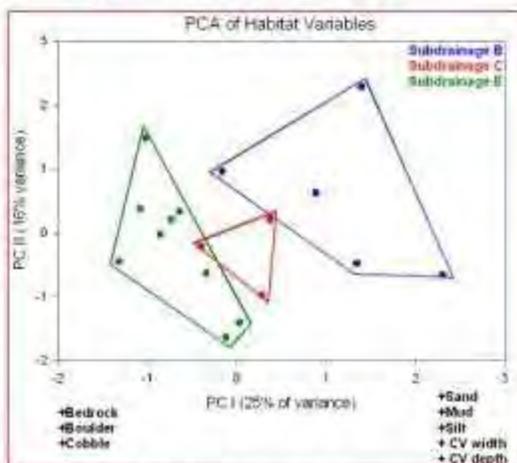

Figure 3. PCA analysis of habitat variables. Each dot represents one site where variables where measured. Symbols are color coded by subdrainage and polygons are drawn around all points for each subdrainage.
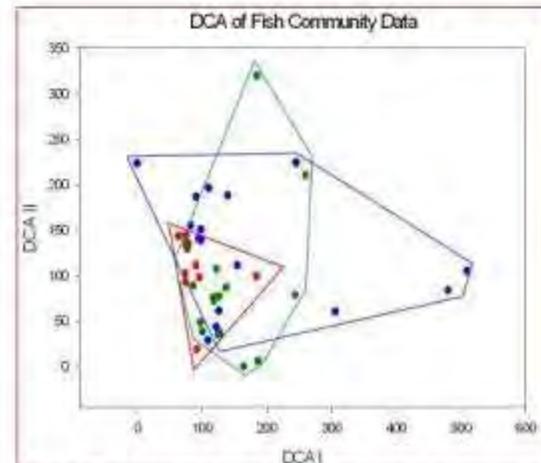

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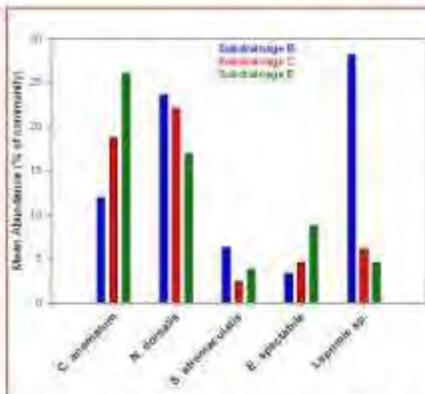

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