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Distributions, Assemblage Structure, and Habitat Associations of Fishes in Two Streams of the Red Bird River Watershed, Kentucky

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DEDICATION

This thesis is dedicated to my wife Jaspreet Smith and my entire family: Alahana Smith, Gary Smith, Katherine Smith, Jessica Thomas, Jagjit Chahal, Jasbir Chahal, and Jasleen Chahal for all of their support and guidance throughout this process. They all have provided motivation and inspiration that has allowed me to finish this project.

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ABSTRACT

The spatial and temporal variation in fish distribution, assemblage structure, and habitat associations were investigated in relation to the available macrohabitats (riffle, run, or pool) in Gilbert's Big Creek and Elisha Creek, 2^{nd} and 3^{rd} order streams, respectively, located within the Red Bird River watershed in southeastern Kentucky. A total of 7,662 individuals were captured; 3,038 from Gilbert's Big Creek (21 species) and 4,624 from Elisha Creek (19 species). The most prevalent species overall in both streams was the creek chub (*Semotilus atromaculatus*). Most fish species were distributed in the middle sampling sites in the spring, the lower sites in the summer, and the middle sites in the fall for both streams. Species richness increased from the upper to the lower sections of both streams during all seasons. Darter species (*Etheostoma* and *Percina*) selected riffles and runs while avoiding pools; whereas cyprinids selected pools while avoiding riffles and runs. Elisha Creek produced more total individuals; but overall the distributions, assemblage structures, and habitat associations exhibited by the fish communities in both Gilbert's Big Creek and Elisha Creek were very similar to what has been reported for the same species within their geographical range.

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CHAPTER 1

INTRODUCTION

The evaluation of fish assemblage structure and seasonal distribution can be valuable in understanding the processes that regulate the composition of fish species in a stream at any given time. There have been a number of studies that have examined the structure of stream fish communities over a gradient of both time and space (e.g., Freeman et al., 1988; Johnston and Maceina, 2009; Meyer et al., 2007; Moyle and Vondracek, 1985; Ross et al., 1985). However, the composition and distribution of fish species present in headwater streams can vary throughout the year as stream conditions fluctuate with the seasons (Freeman et al., 1988).

Species richness and diversity will normally increase as the stream size increases along a gradient (Vannote et al., 1980). The size of a stream accounts for increasing habitat heterogeneity, the development of riffle/ pool systems, and habitat volume in general (Schlosser, 1987). These conditions are variable and are highly dependent upon the amount of disturbance in the system. Disturbances can include any event that disrupts an ecosystem or community structure and causes changes in the physical environment or natural resources (Pickett, 1985). Gorman and Karr (1978) found that fish assemblage structure was much more consistent in streams with low levels of disturbance compared to streams with some form of habitat modification.

Fish species composition in a stream is known to change seasonally and it is thought to be a product of interactive segregation (Gorman and Karr, 1978). This segregation controls the assemblage structure of a fish community and is dependent upon substrate, depth, and current (Gorman and Karr, 1978; Guenther and Spacie, 2006). These habitat characteristics are influenced by the seasonal fluctuations in the stream's flow regime. The volume of flow in headwater streams varies over time and is dependent upon hydrologic inputs from tributaries and groundwater (Allan, 1995). The seasonal changes in hydroperiod can modify the stream's flow, depth, and width; thus influencing fish assemblage structure (Hodges and Magoulick, 2011; Matthews et al., 2013; Mueller and Pyron, 2010).

The possible number of fish species present in Kentucky's headwater streams varies depending upon the unique conditions at each location (Kuehne, 1962). The impact of seasonally fluctuating flow rates on fish assemblages in lotic systems in eastern Kentucky is poorly understood. Gilbert's Big Creek is a 2^{nd} order stream and Elisha Creek is a 3^{rd} order stream that occupy the same watershed in southeastern Kentucky (i.e., Red Bird River) (Figure 1)[1]. I investigated how variation in the availability of macrohabitats (riffles, runs, and pools), relative to the seasonal hydro periods, impacted the distribution, assemblage structure, and habitat associations of fishes in each stream.

[1] Tables are present in Appendix A. Figures are located in Appendix B.

CHAPTER 2

STUDY AREA

The Red Bird River consists of 562 linear kilometers (349 miles) of streams that drain a watershed of 50,690 hectares (125,257 acres) (Red Bird River Watershed Collaborative, 2012) (Figure 1). The watershed encompasses parts of eastern Clay County, western Leslie County, and northeastern Bell County in southeastern Kentucky. The area is located in the mountainous terrain of the Eastern Kentucky Coal Field physiographic region which is underlain by coal, sandstone, and shale (Kentucky River Basin Assessment Report, 2013). The Red Bird River is joined by Goose Creek and Bullskin Creek to form the South Fork of the Kentucky River. Gilbert's Big Creek and Elisha Creek are tributaries to the South Fork of the Kentucky River (Figure1). The headwater reaches of the left and right forks of Elisha Creek have been designated by the Kentucky Division of Water as exceptional waters (Red Bird River Watershed Collaborative, 2012).The complete headwaters of Gilbert's Big Creek and part of the headwaters of Elisha Creek are located in the Redbird Wildlife Management Area (WMA). This area is located within the Red Bird District of the Daniel Boone National Forest. The Redbird WMA is cooperatively managed by the United States Forest Service (USFS) and the Kentucky Department of Fish and Wildlife Resources (KDFWR). Gilbert's Big Creek's watershed drains 14.97 km^2 while Elisha Creek drains 21.13 km^2 (Kentucky Watershed Viewer, 2014); both streams lie within the Mixed Mesophytic Forest Region (Jones, 2005). The upper and middle sections of both Gilbert's Big Creek and Elisha Creek generally flow through forested areas with complete riparian cover. The headwaters of both streams are part of the Redbird Crest Trail system that is subjected to off-highway vehicles, hikers, horseback riders, and mountain bikers

(USDA Forest Service, 2014). The lower sections of both Gilbert’s Big Creek and Elisha Creek flow through private property with little riparian cover and minimal agricultural practices.

CHAPTER 3

METHODS

The method employed to select sampling sites in this study was based on the probability-based random sampling design of the United States Environmental Protection Agency (EPA, 2002). The length of both Elisha Creek and Gilbert's Big Creek from the confluence with the Red Bird River to the highest area of perennial flow was determined using ArcGIS (ESRI, 2009). The highest area of perennial flow was established as being where the solid blue line for the stream ends and the dotted line begins. Each stream was divided into 100-meter sampling sites (Compton and Taylor, 2013) which were numbered (Figure 2). Sites were randomly selected until the total distance to be surveyed equaled 10% of the stream's total length; this resulted in 10 sample sites on Gilbert's Big Creek and 13 on Elisha Creek. Starting from the confluence with the Red Bird River, each study stream was divided into three sections (lower, middle, and upper) and the section in which each sampling site occurred was noted. Gilbert's Big Creek had two sites in the lower section and four sites in both the middle and upper sections. Elisha Creek had two sites in the lower section, five sites in the middle section, and six sites in the upper section. Ten 2 x 5 meter plots with a 5- meter buffer between each plot were assessed at each sample site (Compton and Taylor, 2013). Prior to the beginning of sampling activities plots within each sample site were randomly assigned to left bank, stream center, or right bank from the perspective of facing upstream. Plots were sampled beginning at the downstream end of each sampling site and working upstream. All sites were sampled in spring (May), summer (August), and fall (October) of 2013.

Fishes were collected at each plot using a Smith-Root backpack electro-shocker (Vancouver, WA) and dip nets. In an attempt to reduce fish mortality, plots were shocked for an average of one minute with the voltage maintained between 150 and 250 volts. Captured fishes were placed in an aerated 18.9 liter bucket, identified, recorded, and released unharmed back into the same plot in which they were collected. Each plot was identified as a riffle, pool or run (Jowett, 1993). Depth (cm) was measured at the center and four corners of each plot using a meter stick (Figure 3). Additionally, maximum plot depth (cm) was determined (Compton and Taylor, 2013). Wetted stream width (m) was determined at each plot using a measuring tape.

The following parameters were calculated by stream section (upper, middle, lower) and season (spring, summer, fall) for both streams. Catch-per-unit-of-effort (CPUE) for fishes was determined by dividing the total numbers of fishes collected within each stream section by total time sampled and expressed as number of fishes captured/hour. The Shannon-Wiener Index (H'; Krebs, 1999) was used to assess the diversity of fish species within both streams. Shannon-Wiener index values take into consideration both the number of species in the community and proportion of each species in relation to the total number of individuals in the community. Subsequently, the results of these indices can reach large values (Krebs, 1999); but typically do not seem to exceed 5.0 (Washington, 1984). The Percentage Similarity measure (P; Krebs, 1999) was used to determine similarity between the fish communities in Gilbert's Big Creek and Elisha Creek. Scores for the index can range between 0 (no species in common between the two streams) to 100 (communities are identical in species composition). Krebs (1999) noted that in spite of its simplicity, the percentage similarity measure is one of the best quantitative similarity coefficients available.

Relative abundance of fish species was determined for each section (upper, middle, and lower) of both streams during each season (spring, summer, and fall). In addition, Strauss's Linear Selectivity Index (L; Strauss, 1979) was employed to assess the use of riffle, run, and pool habitats across sections. Strauss's Linear Selectivity Index was used to determine if fish communities in Gilbert's Big Creek and Elisha Creek were selecting or avoiding (or were inaccessible) certain stream macrohabitats (riffles, runs, pools). Scores for the index can range between -1 (macrohabitat avoidance or inaccessibility) to 1 (macrohabitat preference). Percentages of riffles, runs, and pools were determined by taking the overall number of habitats observed for a particular section during a season and then dividing this number into the value observed for a particular macrohabitat. Indices were calculated separately for total individuals of all darter species and for total individuals of all cyprinid species. Linear selectivity values range from 1.0 (habitat selection) to -1.0 (habitat avoidance).

CHAPTER 4

RESULTS

A total of 7,662 fish were collected during this study; 3,038 individuals from Gilbert's Big Creek, 4,624 from Elisha Creek (Table 1). There was a total of 28 species collected from both streams with ten representing darter species (35.7 %), nine being cyprinid species (32.1 %), three centrarchid species (10.7 %), three catostomid species (10.7 %), two lamprey species (7.1 %), and one species of sculpin (3.6 %). The lamprey species were only present in the lower sampling sections near the confluence with the Red Bird River, while the variegate darters and sculpins were only found in the middle sampling sections. There were 21 species collected from Gilbert's Big Creek and 19 species from Elisha Creek (Table 1). Overall more fishes were collected from Elisha Creek regardless of the season. Species richness showed similar trends for the two streams for most seasons (Table 2). Distribution patterns and species richness for both streams were similar in the spring. The middle section of both streams exhibited the highest species richness while the upper section had the lowest richness. Catch-per-unit-effort (CPUE) in Gilbert's Big Creek had similar trends in both the spring and summer seasons, i.e., lowest numbers in the upper section, highest in the lower section (Table 2). There was an overall increase in CPUE as the seasons progressed that was most evident in the upper section of this stream. The CPUE for Elisha Creek during the spring and summer sampling seasons also had similar trends with the highest numbers occurring in the lower section and the lowest from the middle section (Table 2 and Figure 4) with the CPUE steadily increasing as the seasons progressed.

The upper, middle, and lower sections of Gilbert's Big Creek and Elisha Creek were similar in fish composition in the spring (P = 68%, 74%, 60%, respectively); while the upper sections exhibited the greatest community similarity in the summer (P = 83%, 65%, 72%, respectively) and fall (P = 93%, 73%, 82%, respectively). Fish species diversity generally increased from the upper to the lower sections of both Gilbert's Big Creek and Elisha Creek during all seasons (Table 2). The highest diversity occurred in the lower section of Gilbert's Big Creek ($H' = 0.92$) during the summer; while the lowest diversity occurred in the upper section of Elisha Creek during the summer ($H' = 0 .27$). The most prevalent species overall in both streams was the creek chub (*Semotilus atromaculatus*). The central stoneroller (*Campostoma anomalum*) was the dominant species across all seasons in the lower section of Elisha Creek.

Riffles, runs, and pools were distributed relatively evenly throughout the lower, middle, and upper sampling sections of both Gilbert's Big and Elisha Creeks during the spring (Figures 5 and 6). Riffles and runs diminished during the summer and pools became the more prevalent macrohabitat for both streams. With progression through the fall, connectivity throughout both streams declined where runs were no longer present and the majority of macrohabitats sampled were pools (>80%) connected by shallow riffles. Stream width and depth decreased across seasons. In Gilbert's Big Creek width decreased by 2.8 meters and depth decreased 71.3 cm in the upper sections, a decrease of 1.6 m in width and 56 cm in depth for the middle sections, and a decrease of one m in width and 24.5 cm in depth for the lower sections. In Elisha Creek width decreased by 0.3 m and depth decreased by 52 cm in the upper sections, a decrease of 1.2 m in width and 41.9 cm in depth in the middle sections, and a decrease of 1.5 m in width and 63 cm in depth in the lower sections. Overall both stream widths and depths were highest during the spring and lowest during the summer and fall.

Creek chubs accounted for 51.2% of the total number of individuals collected in Gilbert's Big Creek and 69.1% of the individuals collected from Elisha Creek. During the spring and summer sampling periods the creek chubs were the species with the highest relative abundance in all sampling sections except for the lower section of Elisha Creek, where the central stoneroller was the most prevalent species (Figures 7 and 8). During the fall sampling period the creek chubs were again the species with the highest relative abundance in all sampling sections with the exception of the lower section of Elisha Creek; where it was equal in relative abundance to the central stoneroller (Figure 9). Darter species in the upper sections of both streams selected runs during the spring (Table 3). The darters in Gilbert's Big Creek selected runs and avoided pools during the summer. However, the darters in Elisha Creek selected runs in the lower and middle sections but selected pools in the upper section during the summer (Table 3). In the fall, darters in both streams selected pools and avoided riffles. During all seasons, cyprinids selected pools and avoided riffles in both streams (Table 4). The one exception was in the lower section of Elisa Creek during the summer when individuals selected runs (Table 4).

CHAPTER 5

DISCUSSION

Several studies have documented seasonal fish assemblage structures and distributions in high gradient streams (e.g., Freeman et al., 1988; Johnston and Maceina, 2009; Meyer et al., 2007; Moyle and Vondracek, 1985; Ross et al., 1985). These studies have given insight into the mechanisms that determine a stream's species composition at any given time. It is known that the composition and distribution of fish species varies throughout the year as stream conditions vary with seasonal fluctuations (Freeman et al., 1988). The results of this study builds upon the previous studies by focusing on Gilbert's Big Creek and Elisha Creek in the Red Bird River watershed, Kentucky.

Seasonal distributions of fish species varied in this study with most individuals in middle sections in the spring, lower in the summer, and middle again in fall for both streams. Such seasonal movement of species along the stream gradient has been noted by other researchers (Freeman et al., 1988; Gillette et al., 2012; Gorman and Karr, 1978). The dominant species of fishes present in both Gilbert's and Elisha Creeks were the creek chub (*Semotilus* atromaculatus) and rainbow darter (*Etheostoma* caeruleum) during all seasons. The creek chub being the dominant species comes as no surprise due to its tolerance and adaptability and its proclivity to colonize new areas (Etnier and Starnes, 1993). Freeman et al. (1988), who conducted their study in streams similar to those assessed in this project, found mottled sculpins (*Cottus bairdi*) and longnose dace (*Rhinichthys cataractae*) to be the dominant species. They interestingly found darters to be rare during their sampling periods.

The fish assemblage structure of the two streams examined in this study were very similar. Overall the highest species diversity was in the middle sections of the streams, with the upper sections being the least diverse. This would make sense considering the lower sections of both streams are privately owned and both water quality and riparian vegetation diminished in these sections. This could possibly explain why the less tolerant species, e.g., *Etheostoma spilotum E. variatum*, would be absent from these sections. From the lower to the upper sections of both streams assessed in this study, the creek chub was the only consistent species in large numbers (Figures 7 - 9).

Fish species diversity in this study decreased as elevation and stream gradient increased. This scenario mirrors the pattern for headwaters noted by Vannote et al. (1980). There was some variation in the number of fishes collected and diversity in the spring sampling period where Elisha Creek initially had a higher diversity; but locals explained there was an exceptionally large spate event on Gilbert's Big Creek about a week before I arrived to begin sampling. The water volume of both study streams diminished from spring through summer and into fall. This decrease in water volume also decreased stream width and subsequently the distribution of fishes in the streams. The decrease of water volume appears to have concentrated fish in the most available habitat, i.e., pools.

The fish habitat association patterns observed in both streams examined in this study indicated that darter species overall selected riffles and runs while they avoided pools; while cyprinids selected pools while avoiding riffles and runs. The seasonal hydroperiod caused variation in the volumes of water in both streams. With larger volumes of water in the spring, darter species mostly selected riffles and runs. As the volume diminished in the summer and further into the fall, darters moved more into the pools that were left as the streams began to dry up and the riffles disappeared. Cyprinids continually associated with the pools throughout all seasons, hence there was little variation in the habitat associations for these species. The habitat associations noted in this study were expected since darters are benthic dwelling species that prefer the shallower, faster moving waters, e.g., riffles and runs, while the cyprinids prefer deeper, slower pools (Etnier and Starnes, 1993). Freeman et al. (1988), Meyer et al. (2007), Mueller and Pyron (2010), Poff and Allan (1995), and Ross et al. (1985) found similar associations for the same species captured in this study. Overall the distributions, assemblage structures, and habitat associations exhibited by the fish communities in both Gilbert's Big Creek and Elisha Creek were very similar to what has been reported for the same species within their geographical range.

CHAPTER 6

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APPENDIX A:

TABLES

Table 1. Total number of each fish species collected by season (Spring, Summer, Fall 2013) in the three sections (lower, middle, and upper) of Gilbert's Big Creek and Elisha Creek, Red Bird River watershed, Kentucky.

Species:	*Lampetra aepyptera*	*Campostoma anomalum*	*Chrosomus erythrogaster*	*Cyprinella whipplei*	*Luxilus chrysocephalus*	*Notropis ariommus*
Spring						
Gilbert's						
Upper	0	1	18	0	0	0
Middle	0	9	35	0	1	0
Lower	0	9	4	0	3	0
Elisha						
Upper	0	2	15	0	0	0
Middle	0	2	0	0	2	0
Lower	0	19	0	0	8	0
Summer						
Gilbert's						
Upper	0	2	31	0	0	0
Middle	0	18	51	0	1	0
Lower	0	45	11	1	14	1
Elisha						
Upper	0	14	73	0	0	0
Middle	0	13	0	0	4	0
Lower	0	72	0	0	9	0
Fall						
Gilbert's						
Upper	0	11	78	0	0	0
Middle	0	87	140	0	2	0
Lower	3	59	20	0	7	0
Elisha						
Upper	0	41	141	0	0	0
Middle	0	66	4	0	5	0
Lower	0	100	0	0	15	0

Table 1. (cont'd)

Species:	*Notropis buccatus*	*Notropis rubellus*	*Pimephales notatus*	*Semotilus atromaculatus*	*Catostomus commersonii*	*Hypentelium nigricans*
Spring						
Gilbert's						
Upper	0	0	0	45	0	0
Middle	0	0	1	74	5	1
Lower	0	0	1	36	0	1
Elisha						
Upper	0	0	0	203	0	0
Middle	0	0	0	34	0	1
Lower	0	0	1	13	0	0
Summer						
Gilbert's						
Upper	0	0	0	201	1	0
Middle	0	0	0	98	1	2
Lower	0	1	6	80	0	2
Elisha						
Upper	0	0	1	912	2	0
Middle	0	0	1	275	3	0
Lower	0	4	0	53	3	4
Fall						
Gilbert's						
Upper	0	0	1	583	1	3
Middle	5	0	0	362	5	9
Lower	0	0	2	81	0	14
Elisha						
Upper	0	0	0	1148	0	0
Middle	0	1	1	459	1	8
Lower	0	0	2	100	0	9

Table 1. (cont'd)

Species:	*Moxostoma duquesnei*	*Cottus bairdi*	*Ichthyomyzon fossor*	*Lepomis cyanellus*	*Lepomis macrochirus*	*Micropterus dolomieu*
Spring						
Gilbert's						
Upper	0	0	0	0	0	0
Middle	0	0	0	0	0	0
Lower	0	0	0	0	0	0
Elisha						
Upper	0	0	0	0	0	0
Middle	0	0	0	0	0	0
Lower	0	0	0	0	0	0
Summer						
Gilbert's						
Upper	0	3	0	0	0	0
Middle	0	0	0	0	0	0
Lower	1	0	2	2	4	0
Elisha						
Upper	0	0	0	3	1	0
Middle	1	0	0	0	0	0
Lower	0	0	0	0	0	0
Fall						
Gilbert's						
Upper	0	5	0	0	0	0
Middle	0	0	0	0	0	0
Lower	0	0	0	0	2	0
Elisha						
Upper	0	0	0	0	0	0
Middle	0	0	0	0	0	2
Lower	0	0	0	0	0	1

Table 1. (cont'd)

Species:	*Etheostoma baileyi*	*Etheostoma blennioides*	*Etheostoma caeruleum*	*Etheostoma flabellare*	*Etheostoma nigrum*	*Etheostoma spilotum*
			Spring			
Gilbert's						
Upper	0	3	8	9	0	1
Middle	0	4	29	19	5	1
Lower	0	1	11	15	8	0
Elisha						
Upper	0	0	6	13	0	3
Middle	0	4	11	7	1	1
Lower	0	6	14	12	0	0
			Summer			
Gilbert's						
Upper	0	2	18	18	0	2
Middle	0	9	78	64	1	6
Lower	1	8	33	36	2	0
Elisha						
Upper	0	2	19	25	0	5
Middle	2	13	126	23	1	1
Lower	2	6	59	27	0	1
			Fall			
Gilbert's						
Upper	0	5	36	18	0	4
Middle	1	4	84	29	19	12
Lower	5	7	38	9	8	3
Elisha						
Upper	0	0	20	29	0	14
Middle	5	22	118	16	5	2
Lower	15	8	49	8	4	0

Table 1. (cont'd)

Species:	*Etheostoma variatum*	*Percina copelandi*	*Percina maculata*	*Percina stictogaster*	*TNI*
Spring					
Gilbert's					
Upper	0	0	0	2	87
Middle	0	2	1	3	190
Lower	0	1	0	1	91
Elisha					
Upper	0	0	0	1	243
Middle	0	0	6	1	70
Lower	2	0	2	0	77
Summer					
Gilbert's					
Upper	0	0	0	7	285
Middle	0	0	2	7	338
Lower	0	0	2	4	256
Elisha					
Upper	0	0	0	2	1059
Middle	0	3	0	11	477
Lower	0	3	3	3	249
Fall					
Gilbert's					
Upper	0	0	0	13	758
Middle	1	0	2	15	777
Lower	0	0	0	0	258
Elisha					
Upper	0	0	0	2	1395
Middle	2	0	0	7	724
Lower	10	0	2	7	330

Table 2: Species richness, Diversity, and catch-per-unit-effort (CPUE), by season (spring, summer, fall 2013) in the three sections (lower, middle, upper) of Gilbert's Big Creek and Elisha Creek. Red Bird River watershed, Kentucky.

	Gilbert's Big Creek				Elisha Creek		
	Upper	Middle	Lower		Upper	Middle	Lower
				Spring			
Species Richness	8	15	12		7	11	9
Diversity	0.67	0.78	0.78		0.29	0.72	0.83
CPUE/hour	127	264	296		285	120	207
				Summer			
Species Richness	10	13	20		12	14	14
Diversity	0.48	0.80	0.83		0.25	0.59	0.80
CPUE/hour	346	400	553		1052	520	623
				Fall			
Species Richness	12	16	14		7	17	14
Diversity	0.39	0.72	0.81		0.31	0.56	0.79
CPUE/hour	1098	971	815		1674	1089	1073

Table 3. Strauss linear selection (L) values for riffle, run, and pool habitat usage by darter species for Gilbert's Big Creek and Elisha Creek, 2013. L values range from 1 (preference) to -1 (avoidance).

		Spring			Summer			Fall		
		Upper	Middle	Lower	Upper	Middle	Lower	Upper	Middle	Lower
Gilbert's	Riffle	-0.06	0.07	-0.03	0.08	0.02	0.02	-0.13	-0.09	-0.04
Creek	Run	0.21	0.01	0.03	0.10	0.14	-0.03	0.00	0.00	0.00
	Pool	-0.12	-0.08	0.09	-0.18	-0.16	0.02	0.13	0.09	0.04
Elisha	Riffle	-0.09	0.05	0.04	-0.15	-0.03	-0.05	-0.18	-0.14	-0.03
Creek	Run	0.12	0.09	-0.08	-0.07	0.02	0.12	0.00	0.00	0.00
	Pool	-0.03	-0.14	0.04	0.23	0.01	-0.07	0.18	0.14	0.03

Table 4. Strauss linear selection (L) values for riffle, run, and pool habitat usage by cyprinid species for Gilbert's Big Creek and Elisha Creek, 2013. The L values range from 1 (preference) to -1 (avoidance).

		Spring			Summer			Fall		
		Upper	Middle	Lower	Upper	Middle	Lower	Upper	Middle	Lower
Gilbert's	Riffle	-0.20	-0.13	-0.26	-0.11	-0.09	-0.15	-0.11	-0.09	-0.07
Creek	Run	-0.01	0.16	0.03	0.06	0.04	-0.08	0.00	0.00	0.00
	Pool	0.23	-0.03	0.23	0.05	0.05	0.23	0.11	0.09	0.07
Elisha	Riffle	-0.16	-0.39	-0.08	-0.07	-0.13	0.01	-0.16	-0.17	0.00
Creek	Run	-0.16	-0.01	0.01	-0.01	-0.06	0.13	0.00	0.00	0.00
	Pool	0.32	0.40	0.07	0.09	0.19	-0.14	0.16	0.17	0.00

APPENDIX B:

FIGURES

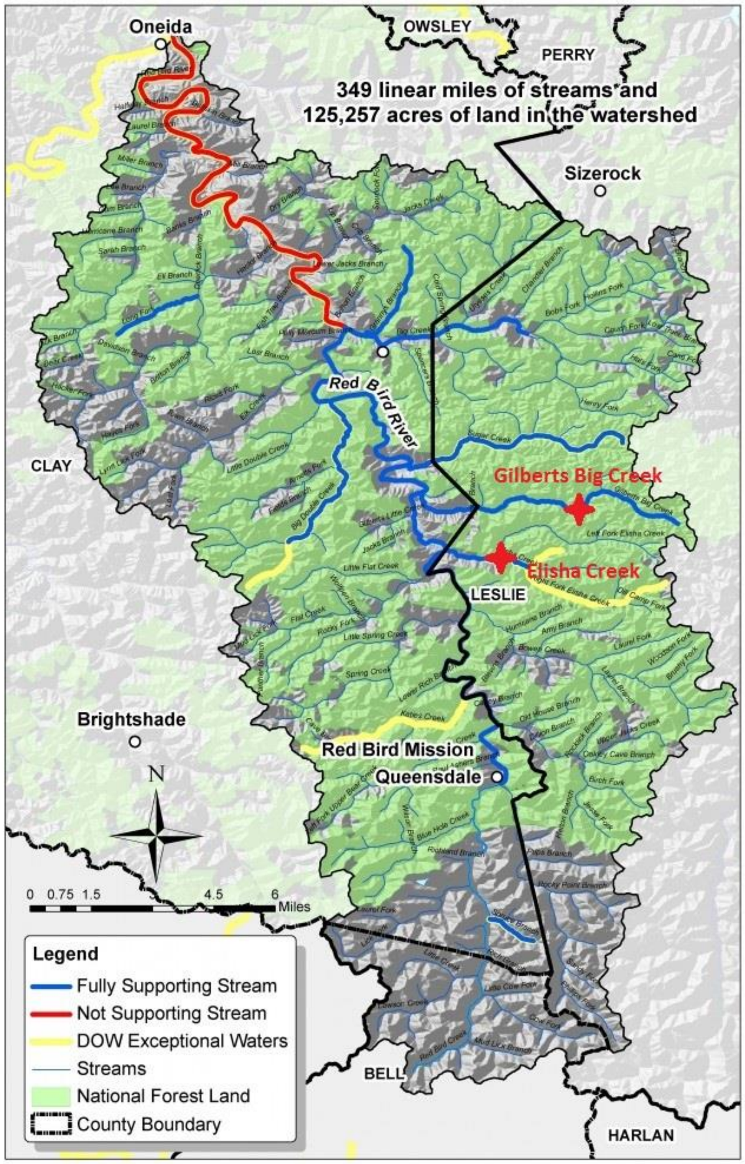

Figure 1. Map of the Red Bird Watershed in southeastern Kentucky indicating the location of Gilbert's Big Creek and Elisha Creek (http://www.redbirdriverwatershed.com/what-is-the-red-bird-watershed/red-bird-river-watershed-1/).

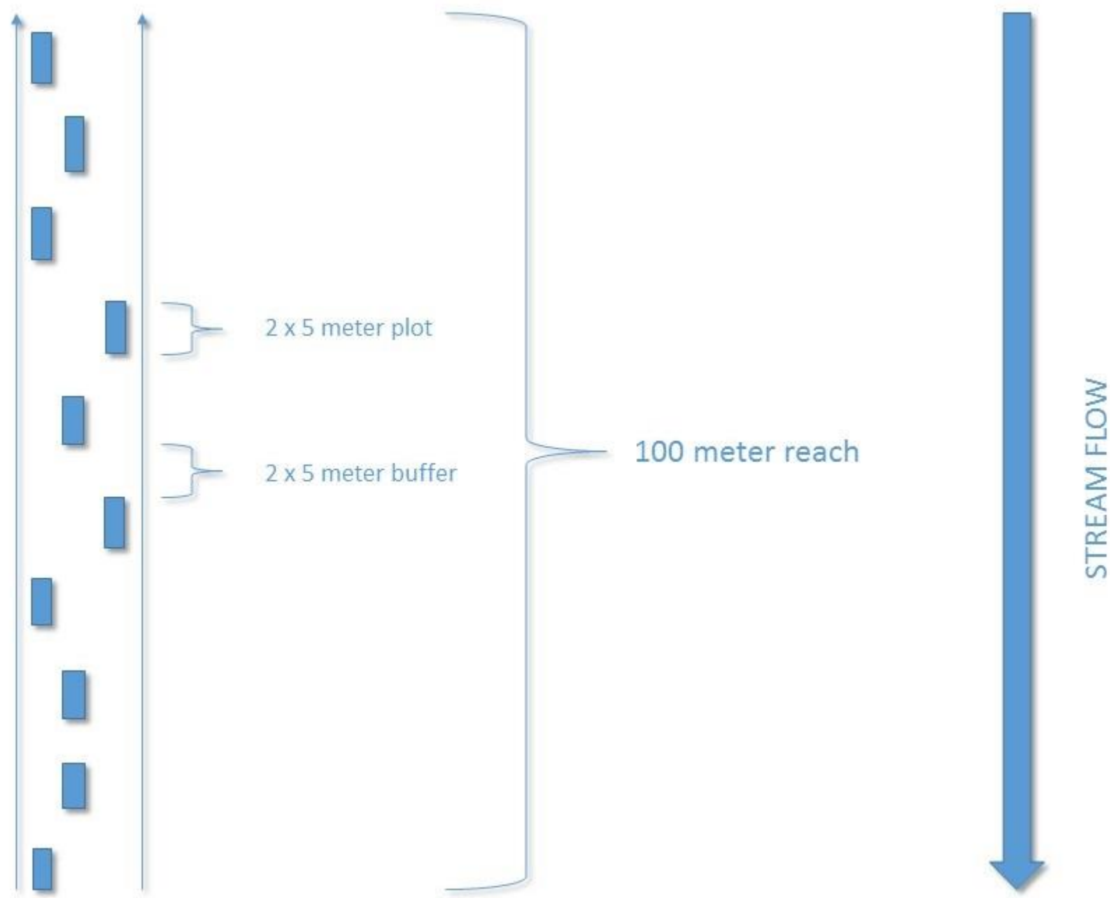

Figure 2. Sampling design within each 100 meter sampling site assessed in Gilbert's Big Creek and Elisha Creek, Red Bird River Watershed, Kentucky.

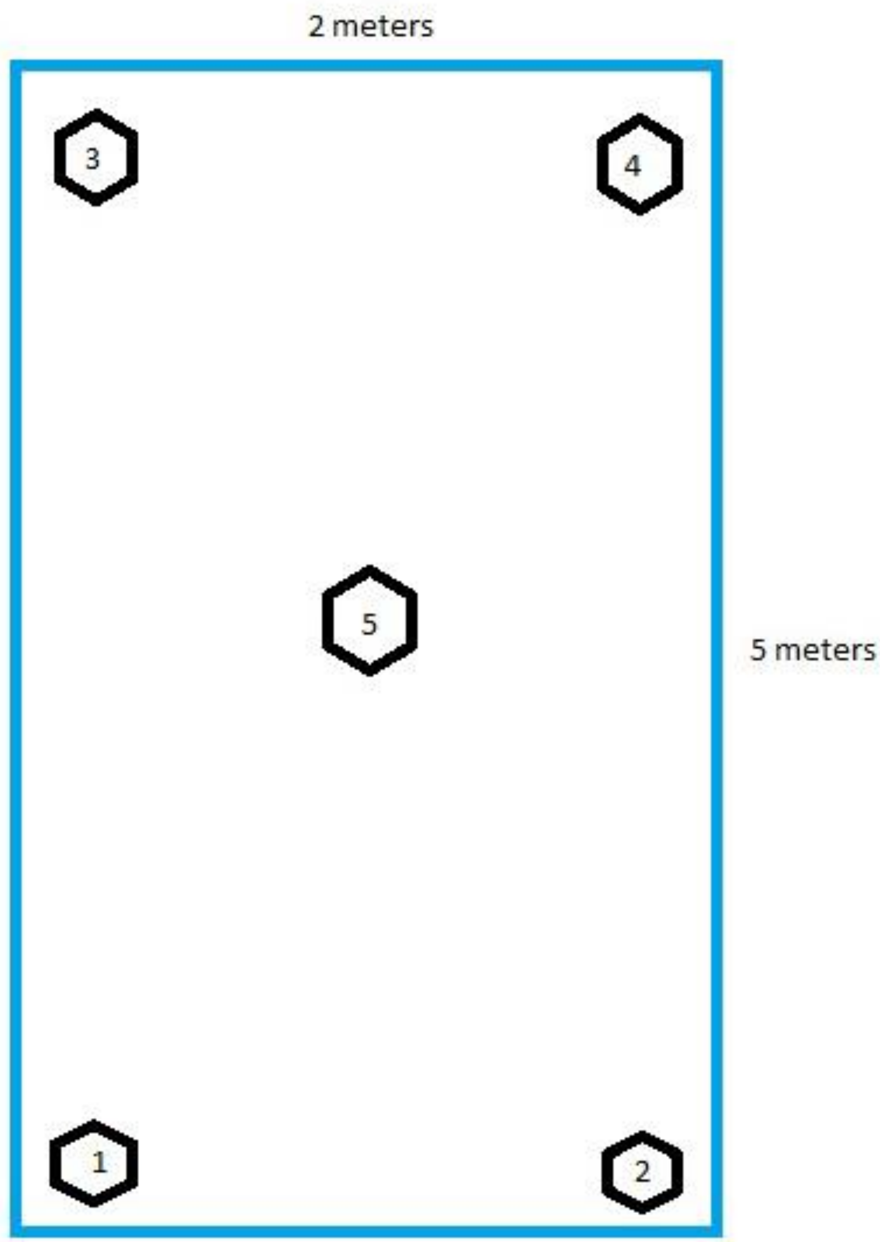

Figure 3. Diagram illustrating locations of 5 points within a 2 X 5 m plot where microhabitat data were collected as part of this study.

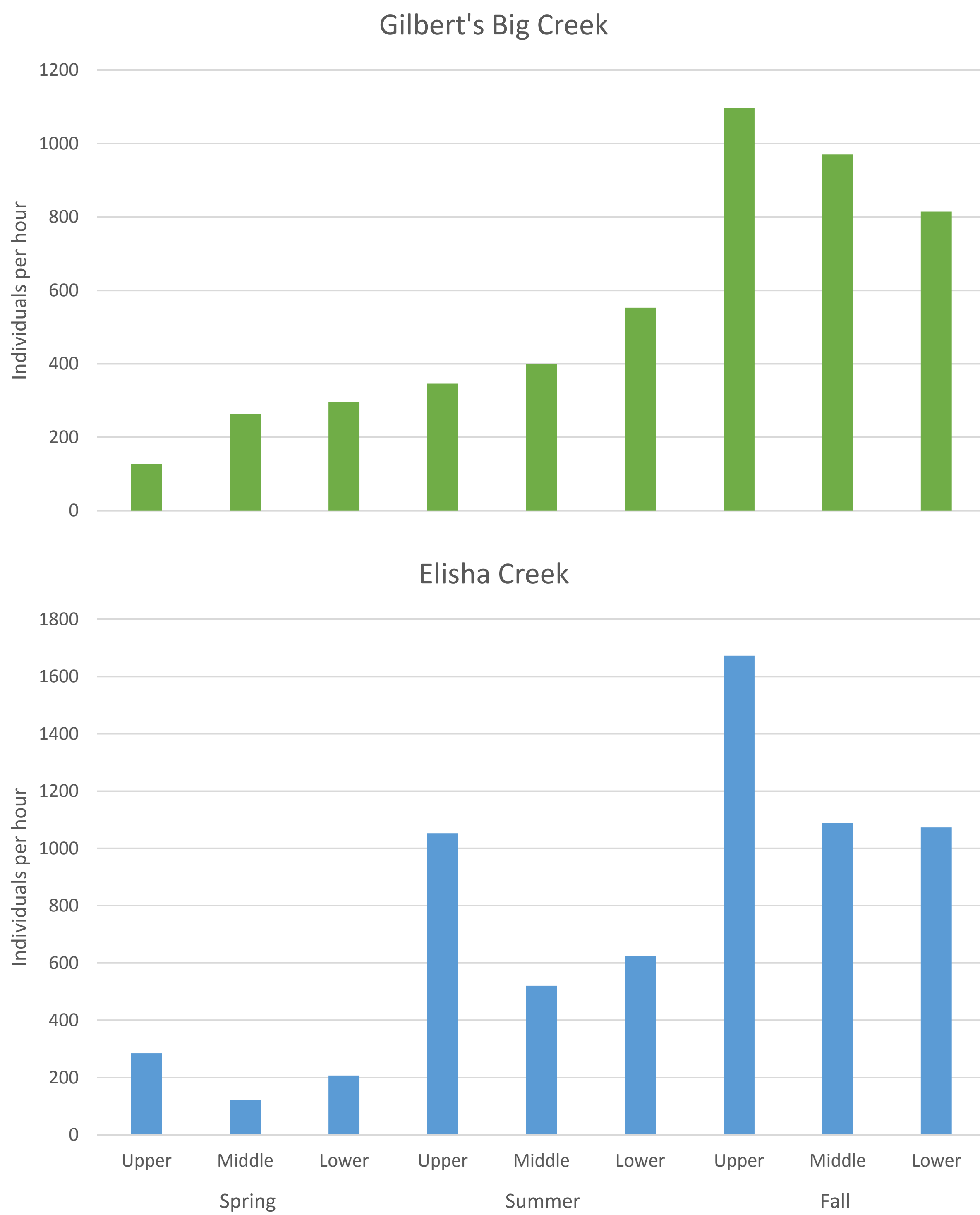

Figure 4. Catch-per-unit-effort (CPUE) by stream section (upper, middle, lower) and season (Spring, Summer, Fall) for Gilbert's Big Creek and Elisha Creek.

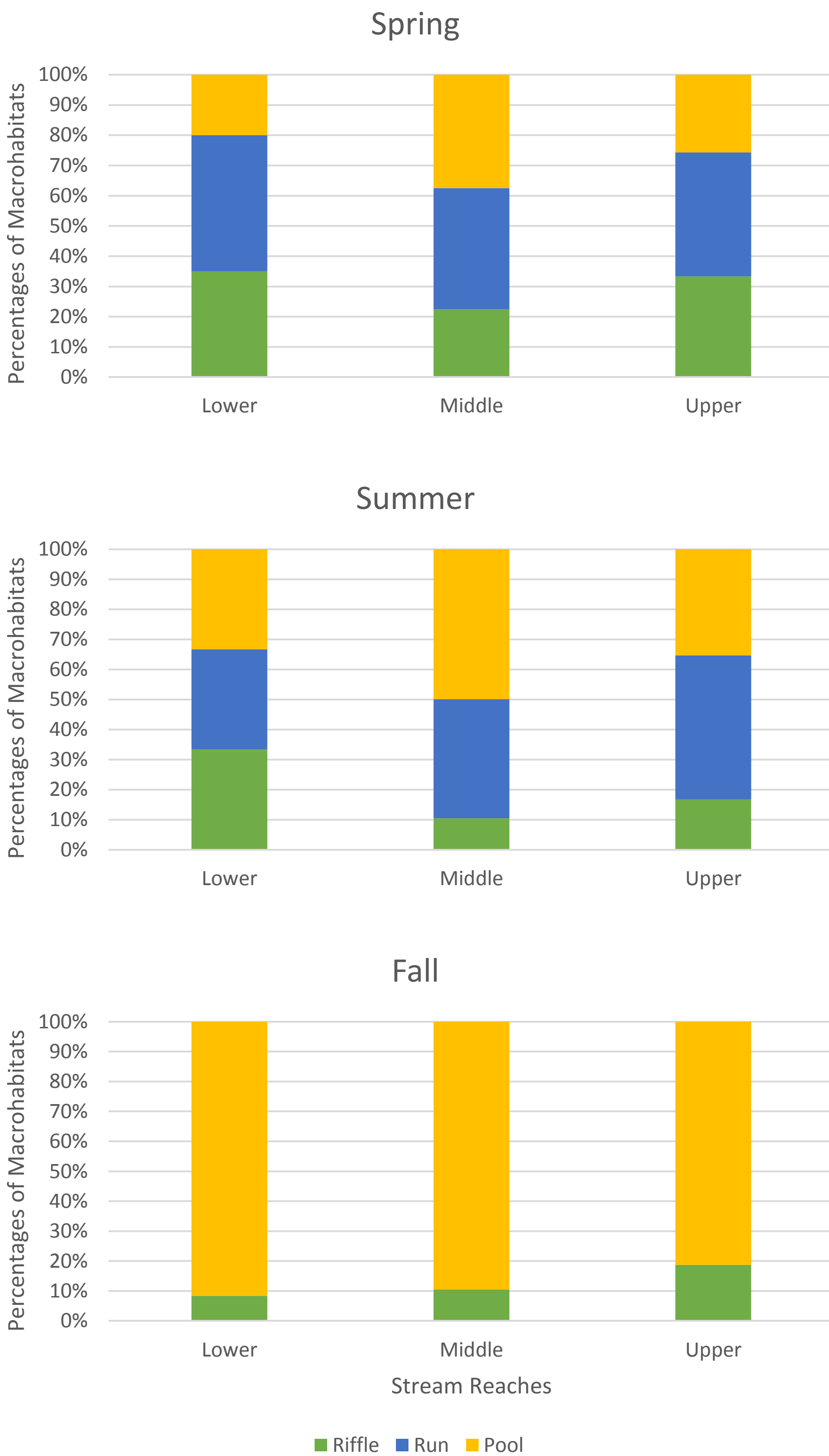

Figure 5. Seasonal percentages of riffles, runs, and pools in lower, middle, and upper sections of Gilbert's Big Creek during the Spring, Summer, and Fall of 2013.

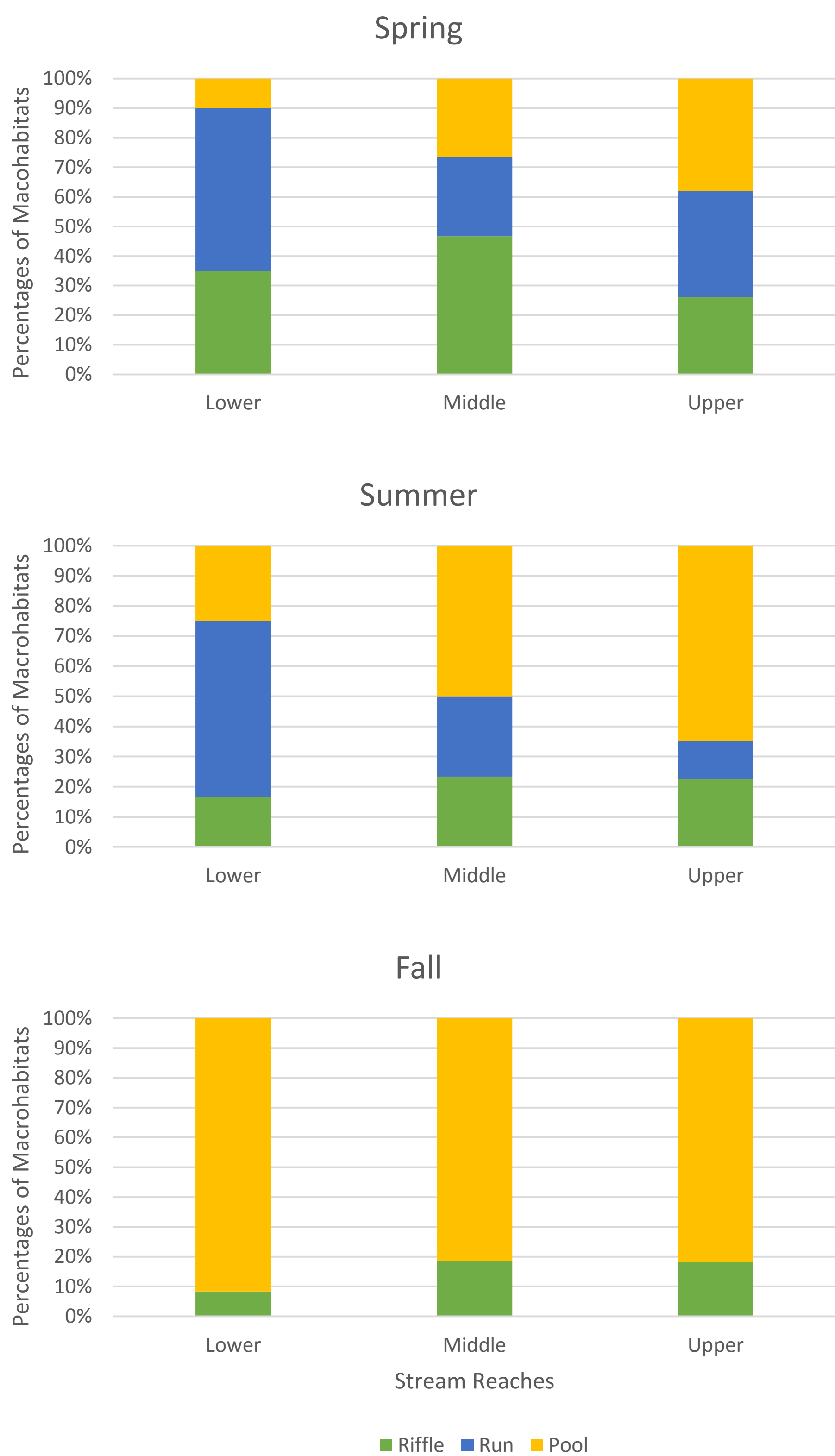

Figure 6. Seasonal percentages of riffles, runs, and pools in lower, middle, and upper sections of Elisha Creek during the Spring, Summer, and Fall of 2013.

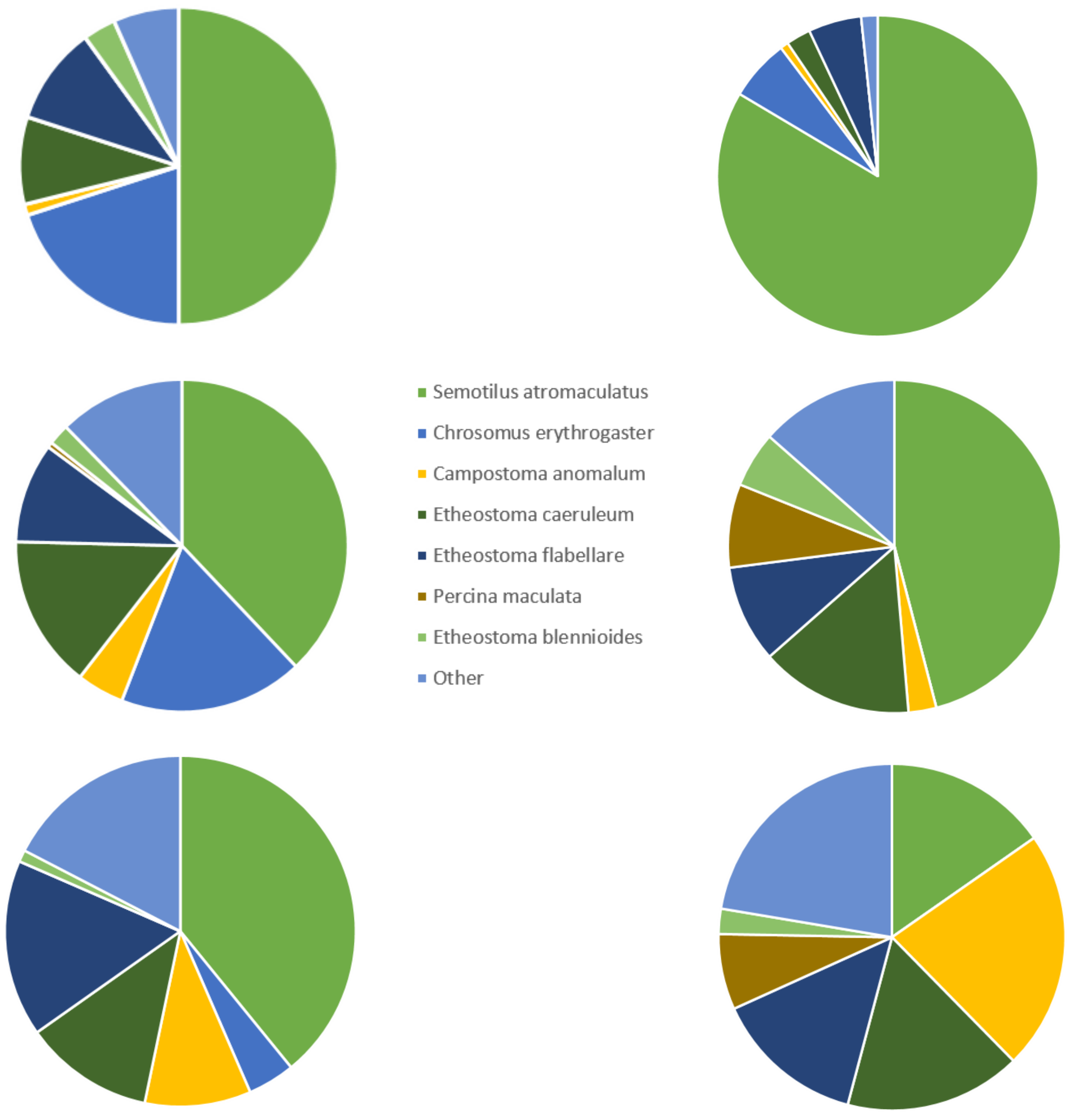

Figure 7. Relative abundance of fish species in upper, middle and lower Gilbert's Big Creek (left column) and Elisha Creek (right column), Spring 2013. Pie-charts in descending order (upper, middle, lower) from top of page.

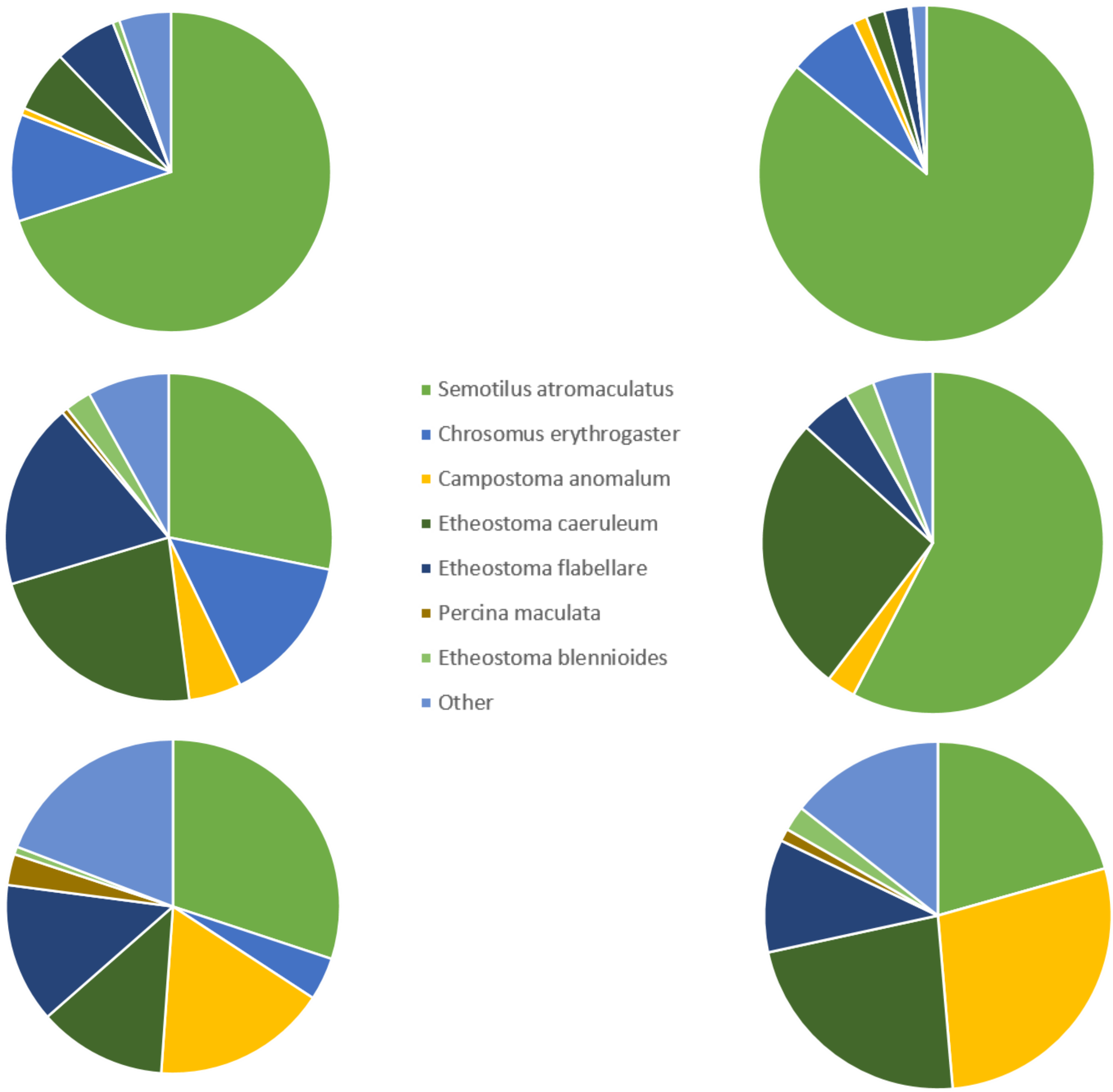

Figure 8. Relative abundance of fish species in upper, middle and lower Gilbert's Big Creek (left column) and Elisha Creek (right column), Summer 2013. Pie-charts in descending order (upper, middle, lower) from top of page.

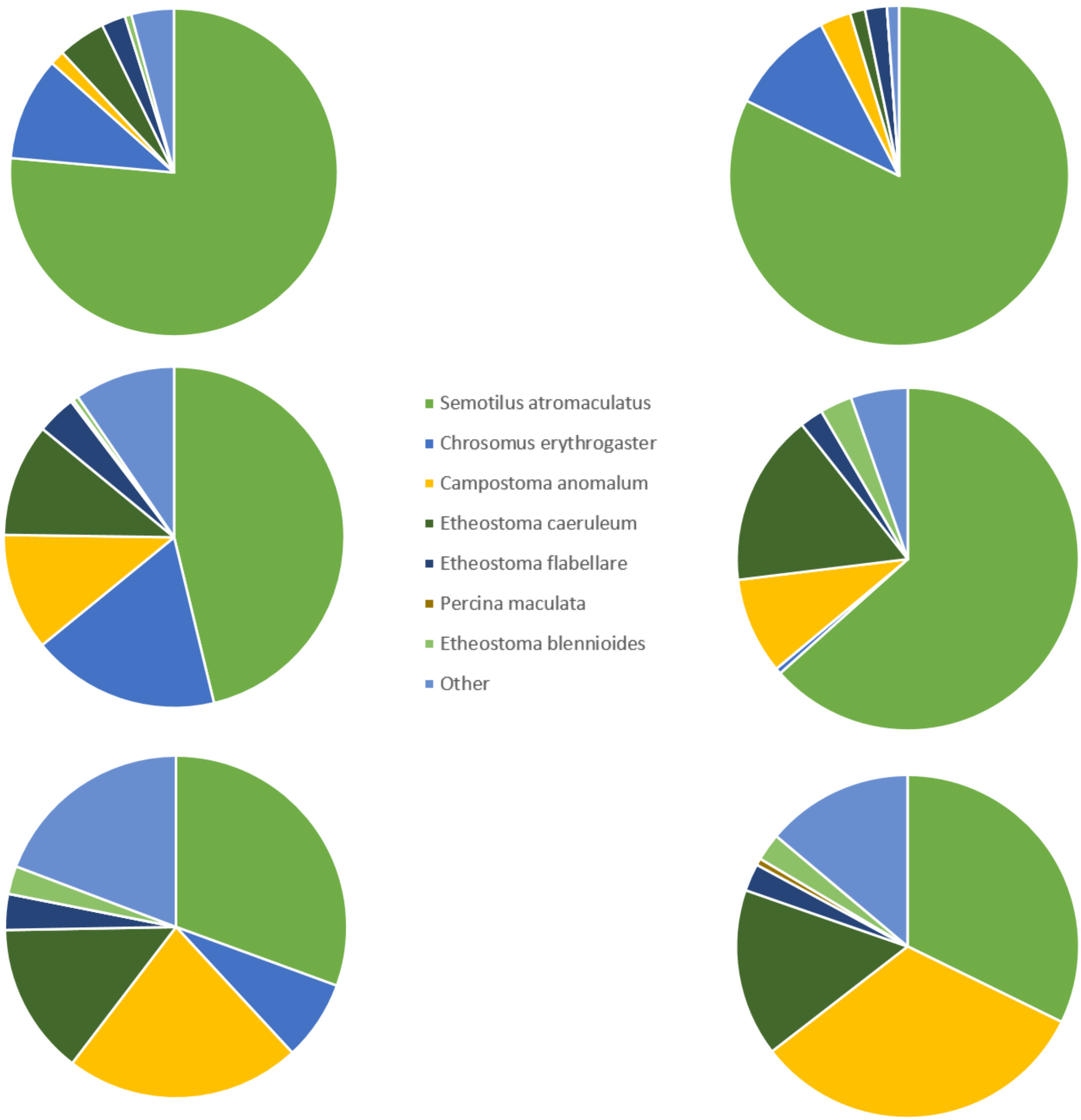

Figure 9. Relative abundance of fish species in upper, middle and lower Gilbert's Big Creek (left column) and Elisha Creek (right column), Fall 2013. Pie-charts in descending order (upper, middle, lower) from top of page.