

Chironomidae and other aquatic macroinvertebrates of a first order stream: community response after habitat fragmentation.

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ABSTRACT: Chironomidae and other aquatic macroinvertebrates of a 1st order stream: community response after habitat fragmentation. The macroinvertebrate community is one component of the lotic system that best reflects the level of environmental integrity. Environmental impacts may result in the lowering of biological diversity and in the modification of functional structure of this community. Based on this premiss, in the present study was analysed the influence of habitat fragmentation resulting of damming and deforestation of a stream of first order on the benthic macrofauna. The analysis was done on three segments of the Fazzari stream (São Carlos, SP, Brazil): 1 – preserved segment, near to the headstream and protected with riparian vegetation; 2 – segment without riparian vegetation, localized downstream of two reservoirs; 3 – segment downstream of segment 2, situated in a area partially covered by riparian vegetation. The collections were done during the dry season (August to October/ 2003) with aid of a Surber collector in 10 points on each segment (5 in pools and 5 in riffles). The specimens were identified until family level, except for Chironomidae, which were separated by morfotypes. The results pointed out higher richness and diversity in segment 1; segments 2 and 3 had lower richness and diversity levels and an elevated participation of Chironomus larvae (genera with many tolerant species). Other metric of evaluations also pointed the lost of biological integrity in the stream sections above the reservoirs. The analysis of feeding groups indicated differences in the distribution of functional groups, with greater participation of shredders in the vegetated segment 1 and dominance of collectors in segments 2 and 3. Although the analysis of grouping considered all together segments 2 and 3, other metrics of evaluation seem to indicate that segment 3 presents a discrete recovery, possibly due to the presence of the riparian vegetation.

Key-words: Aquatic Macroinvertebrates, lotic systems, Chironomidae, habitat fragmentation, first order stream.

RESUMO: Chironomidae e outros macroinvertebrados aquáticos em um córrego de 1^o ordem: resposta da comunidade frente à fragmentação do habitat. A comunidade de macroinvertebrados, em geral, é um dos componentes dos sistemas lóticos que melhor reflete o grau de integridade ambiental. Impactos ambientais podem resultar na diminuição da diversidade biológica e na modificação da estrutura funcional desta comunidade. Com base nesta premissa o presente estudo teve por objetivo analisar a influência da fragmentação do habitat resultante do represamento e desmatamento num córrego de primeira ordem. Foram analisados três segmentos do córrego: P 1 - trecho preservado, próximo à nascente e protegido por mata ripária; P 2 - trecho descampado, localizado a jusante de dois pequenos reservatórios; P 3 - trecho a jusante do trecho dois, localizado em área parcialmente recoberta por mata ripária. As coletas, realizadas no período de estiagem/2003, foram feitas, aleatoriamente, com o auxílio do coletor tipo Surber em 10 pontos de cada trecho, sendo 5 em remansos e 5 em corredeiras. Os exemplares foram identificados até o nível de família, exceto Chironomidae que foram separados em morfotipos. Os resultados apontaram maior riqueza e diversidade no trecho 1; os trechos 2 e 3 apresentaram valores mais baixos de riqueza e diversidade e elevada participação de larvas de Chironomus

(gênero com espécies tolerantes à poluição). A análise das guildas alimentares indicou diferenças significativas na distribuição dos grupos funcionais, com maior participação de fragmentadores no trecho florestado e predomínio de coletores nos trechos 2 e 3. Embora a análise de agrupamento tenha reunido os trechos 2 e 3, outras métricas de avaliação parecem indicar que o trecho 3 apresenta discreto sinal de recuperação, possivelmente devido à presença da mata ciliar.

Palavras-chaves: Macroinvertebrados aquáticos, sistemas lóticos, Chironomidae, fragmentação do habitat.

Introduction

In the past years, there has been evidenced many alterations in aquatic systems, as a consequence of activities of deforestation, agricultural activities, mining, damming, pollution, canalization of water courses, and others, that in general cause habitat fragmentation and loss of biological integrity.

The construction of dams has great influence in the transportation of fine particles that fill interstitial spaces, in the light penetration in water, in the productiveness of the system and in the formation of unstable substrate (Cortes et al., 1998). Other alterations, such as destruction of riparian vegetation, result in increase of soil erosion and accumulation of sediments, in the homogenization of habitats, and in modification of trophic balance between allochthonous and autochthonous organic matter (Maridet et al., 1995; Joly et al., 2000). All these impacts reflect in modification of structural characteristics of the rivers and streams and also in areas around the hydrographical basin. These environmental alterations determine the re-arrangements in the biological communities, that results in new assemblages which characteristics may supply information about environmental impacts.

The biological diversity, habitat diversity, functional groups diversity and community index are, among others, some of the metrics of diagnostic environmental alterations used in evaluation programs of water quality and environmental monitoring (Thorne & Williams, 1997). The aquatic macroinvertebrates, especially the benthic, are considered appropriate organisms for this analysis (Rosenbeg & Resh, 1993; Resh & Jackson, 1993). Some of the advantages that these groups offer are its great number in almost all aquatic systems, its poor capacity for locomotion, its tolerance to many levels and types of pollution, its relatively high life cycle, making possible the elucidation of temporary changes resulting by environmental impacts.

Considering the problematic above exposed, the present study had as main goal, to verify possible changes in the structure of aquatic macroinvertebrates community in a first order stream, impacted by fragmentation generated by the destruction of riparian vegetation and damming.

Study area

The Fazzari stream, situated in the campus of Universidade Federal de São Carlos, in São Carlos - SP is an affluent of the Monjolinho river, which is an affluent of the Jacaré-Guaçu river that later connects with the Tietê river, in Ibatinga - SP (Roque & Trivinho-Strixino, 2001). It is a first order stream, with low flow, that has an extension of approximately 1,500 m. Along its course there are a preserved area with an exuberant riparian vegetation in its headstream, and after this, three small dams and a deforested stretch.

The faunistic study was done in three segments of the stream: P 1, next to the streamhead in a area with preserved riparian vegetation; P 2, situated downstream of point 1, after two dams. In this segment, the water is partially canalized from the dam ducts discharge and flow in a deforestate segment; P 3, situated in a segment after many riffle and pools, that go through a area partially covered with riparian vegetation.

Material and methods

The macrofauna was collected during the dry season (August to October/2003) using a Surber sampler, with area of 0.1m² and 0.25 mm mesh. In each point it were taken 10 randomly samples (5 in pools and 5 in riffles). The collected material was conditioned in plastic buckets with water from the stream and transported to the laboratory where was processed and sorted on plastic trays under transiluminated light. The organisms sorted were preserved in alcohol 70% after previous fixation in formalin 4% and deposited in the collection of Aquatic Entomology Laboratory.

The specimens were identified until family level using identification manuals (McCafferty, 1981; Thorp & Covich, 1991; Merritt & Cummins, 1996). The Chironomidae larvae were identified until genera level and these separated in morfotypes (Trivinho-Strixino & Strixino, 1995; Wiederholm, 1983). The functional feeding group classification followed Merritt & Cummins, (1996) for all macroinvertebrates; the chironomid larvae guilds classification followed Henrique-Oliveira et al. (2003). It was considered the following feeding groups: collectors gatherers and filterers, shredders, scrapers and predators.

Data analysis

The community structure was analysed by enumeration of specimens, relative distribution of families and by estimates of numeric density averages in each segment. Besides this, to evaluate the biotic integrity of the stream, it was determined the community characteristics by the following metrics: diversity index of Shannon, richness index of Margalef, BMWP and Belgian biotic index, EPT (Ephemeroptera, Plecoptera and Trichoptera) percentage, the ratio (%) of the number of EPT families by the total number of macroinvertebrates families ($EPT / Total\ Families \times 100$), the ratio between the individual numbers of EPT and Chironomidae ($EPT / Chironomidae$), the the ratio between the Chironomidae number and the total of individuals collected ($Chironomidae / Total\ Individuals$), and the ratio between the number of Chironomus larvae and total Chironomidae number ($Chironomus / Chironomidae$).

The comparison between the faunistic macrobenthonic group from the three points and segments of pool and riffles were done by the application of similarity percentage (Whittaker & Fairbanks, 1958) by grouping analysis, utilizing the UPGMA "unweighted pair-group average" method. The dendrogram of similarity resulted from this analysis was constructed using MVSP program.

Results and discussion

It was identified a total of 3,829 macroinvertebrate specimens of 40 families that showed different distribution in the 3 analyzed points (Tab. I and II). P 1 was the richest, with 32 families, of which Chironomidae (51.2%), Ceratopogonidae (5.4%), Simuliidae (5.8%) and Hydropsychidae (5.0%) were the most representative. In P 2, with 20 families, Chironomidae (66.6%), Ceratopogonidae (7.0%), Naididae (7.6%) and Tubificidae (5.9%) were the most abundant. In P 3, with 26 families collected, there was a predominance of Chironomidae (57.3%), Simuliidae (20.9%) and Hydropsychidae (5.3%).

The use of EPT richness and its proportion in relation to other macroinvertebrates families as a metric of environmental evaluation has been used by other authors (Resh & Jackson, 1993; Lenat, 1988; Roque & Trivinho-Strixino, 2000; Brabec et al., 2004). The representatives of these orders of Insecta that include the more sensitive species to environmental impacts (Rosenberg & Resh, 1996) showed very different participation in the 3 segments of the Fazzari Stream. At P 1, the most preserved characteristics reflected in a greater EPT richness, with 10 families and 15% of the total individuals. On the

contrary, in P 2, downstream of the reservoirs, the group practically disappeared. In P 3, with only 3 families, Hydropsychidae was the most numerous (Tabs. I and III). In the way of this particular study, this metric showed itself efficient, because allowed the diagnosis of loss of environmental integrity of points 2 and 3.

Table I: Total number (n) and relative participation (%) of the macroinvertebrate families in the 3 sections of Fazzari Stream (in boldface the families with > 5%)

	P 1		P 2		P 3	
	n	%	n	%	n	%
Hydracarina			8	1.44	5	0.20
Dytiscidae	9	1.34	4	0.72	10	0.39
Elminthidae	27	4.00			109	4.20
Noteridae	2	0.30	1	0.18		
Hydrophilidae	2	0.30	3	0.54	10	0.39
Curculionidae	1	0.15				
Chrysomelidae	1	0.15	2	0.36	7	0.27
Syrtidae			1	0.18	1	0.04
Haliplidae			5	0.90		
Gyrinidae			1	0.18		
Tipulidae	28	4.15	11	2.00	14	0.54
Chironomidae	345	51.20*	378	66.55	1457	57.30
Ceratopogonidae	36	5.40	39	7.00	86	3.37
Simuliidae	39	5.80	12	2.16	541	20.90
Empididae	2	0.30				
Culicidae	1	0.15			9	0.35
Psychodidae					1	0.04
Baetidae	5	0.75				
Leptophlebiidae	25	3.80				
Naucoridae	3	0.45			1	0.04
Veliidae	3	0.45	1	0.18		
Belostomatidae						0.08
Sialidae	11	1.63				
Corydalidae					1	0.04
Libellulidae	2	0.30	17	3.06	15	0.57
Coenagrionidae	11	1.63	4	0.72	7	0.27
Calopterygidae	1	0.15			7	0.27
Aeshnidae	3	0.45			3	0.12
Perlidae	14	2.07			25	0.97
Gripopterygidae	2	0.30				
Hydropsychidae	33	5.00	1	0.18	138	5.30
Odontoceridae	2	0.30			37	1.43
Leptoceridae	3	0.45				
Polycentropodidae	15	2.23				
Philopotamidae	2	0.30				
Psychomyiidae	3	0.44				
Bivalvia					21	0.80
Glossiphoniidae	28	4.15	1	0.189	43	1.66
Tubificidae	12	1.78	33	5.85	11	0.43
Naididae	3	0.45	42	7.56	6	0.23
Total	674		564		2558	

Table II: Total number (n) and relative participation (%) of the Chironomidae taxa in the 3 sections of Fazzari Stream (in boldface the taxa with > 5%)

Chironomidae	P 1		P 2		P 3	
	n	(%)	n	(%)	n	(%)
Ablabesmyia (Karelia) sp1	27	7.83	26	6.88	39	2.67
Ablabesmyia gr.annulata sp1	50	14.50	2	0.53	32	2.20
Clinotanypus sp.1	7	2.03	27	7.14	3	0.20
Coelotanypus sp.1	7	2.03	4	1.06		
Denopelopia sp.1			5	1.32	3	0.20
Djalmabatista sp.2	24	6.95				
Fittkauimyia sp.1	1	0.30			21	1.44
Guassutanypus sp.1	11	3.20			14	0.96
Labrundinia sp.1	1	0.30			35	2.40
Larsia sp.1	1	0.30	5	1.32	2	0.14
Pentaneura sp.1	6	1.74	1	0.26		
Procladius sp.1			5	1.32	2	0.14
Corynoneura sp.1	2	0.58			2	0.14
Metriocnemus sp.1			1	0.26	23	1.58
Nanocladius sp.1					1	0.07
Parametriocnemus sp.1	1	0.30	19	5.02	111	7.62
Thienemanniella sp.3	2	0.58	1	0.26	19	1.30
Caladomyia sp.1	16	4.64				
Caladomyia sp.2	12	3.48	1	0.26	1	0.07
Caladomyia sp.3	1	0.30				
Rheotanytarsus sp.1			1	0.26	26	1.78
Tanytarsus sp.1			13	3.44	22	1.51
Tanytarsus sp.2			2	0.53	1	0.07
Tanytarsus sp.3	1	0.30	1	0.26		
Tanytarsus sp.4	3	0.87				
Tanytarsus sp.5	7	2.03	1	0.26	8	0.55
Tanytarsus sp.6	19	5.50				
Tanytarsus sp.7	4	1.16	1	0.26		
Tanytarsus sp.8	9	2.60				
Beardius sp.1	3	0.87				
c.f. Pelomus sp.1	13	3.77				
Chironomus sancticaroli			7	1.85		
Chironomus sp.2			57	15.08	5	0.34
Chironomus sp.3	1	0.30	46	12.17	7	0.48
Chironomus sp.4	21	6.08	94	24.87	881	60.46
Demicryptochironomus sp.1			1	0.26		
Endotribelos sp.1	21	6.08			3	0.20
Endotribelos sp.2	6	1.74			3	0.20
Endotribelos sp.3	10	2.90	6	1.60	19	1.30
Endotribelos sp.4	2	0.58				
Endotribelos sp.5	22	6.38			2	0.14
Endotribelos sp.6	1	0.30			20	1.37
Fissimentum sp 1	5	1.45				
Goeldichironomus maculatus			1	0.26		
Microchironomus sp.1	1	0.30				
Nilothauma sp.1	1	0.30				
Parachironomus sp.1					1	0.07
Paratendipes sp.1	4	1.16			2	0.14
Paratendipes sp.2			6	1.60		
Polypedilum (Asheum) sp.1			1	0.26		
Polypedilum (Polypedilum) sp.1	3	0.87			4	0.27
Polypedilum (Polypedilum) sp.2	4	1.16	8	2.11	134	9.20
Polypedilum (Tripodura) sp.3			30	7.93	2	0.14
Polypedilum gr fallax sp.4	3	0.87	3	0.79	3	0.20
Pseudochironomus sp.1	1	0.30	1	0.26		
Stenochironomus sp.1	11	3.20	1	0.26	6	0.41
TOTAL	345		378		1457	

Table III: Summary of the main community characteristics and evaluation metrics of the 3 sections of Fazzari stream.

	P 1	P 2	P 3
Family numbers	32	20	26
Numerical density (n ^o ./0.1m ²)	67.3	53.8	261.6
± LC 95%	20.7	23.1	118.1
(Chironomidae/Total).100	50.0%	66.0%	57.6%
(n ^o indiv. EPT/Total indiv.) .100	15.50%	0.17%	7.50%
(Chironomus/Chironomidae).100	5.0%	56.0%	60.0%
EPT/Chironomidae	0.30	0.01	0.13
Shannon diversity index (H')	3.04	2.04	2.16
Margalef index (I _{Mg})	4.75	3.01	3.18
(n ^o fam. EPT/ total fam.). 100	31.20	10.00	11.54
BMWP	160	68	93
IB	10	5	8

The numeric dominance of Chironomidae, in general, is observed in various freshwater systems (Bass, 1986; Cohen, 1986), although high numerical density of its larvae may be indicative of environmental disturbance (Coimbra et al., 1996; Marques et al., 1999). In any way, the diagnosis of possible disturbance must be assessed together with the knowledge of taxa that compose this family and of its tolerance to the environmental modifications. By these means, the morfotype distribution of Chironomidae genera can give additional information for evaluation the system. In the Fazzari stream, Chironomidae were represented by 56 morfotypes and 33 genera (Tab. II). The larvae of Chironomini contributed with the highest number of taxa and individuals in all stream segments; P 3 also showed a higher numerical and taxa participation of Orthoclaadiinae (Fig. 1). This fact is related to the greater water flow in this segment due to the presence of many riffles, habitat more favourable for Orthoclaadiinae larvae (Trivinho-Strixino & Strixino, 1995). This aspect becomes more evident with the analysis distribution of these taxonomic unities in the pools and riffles of the stream (Fig. 2).

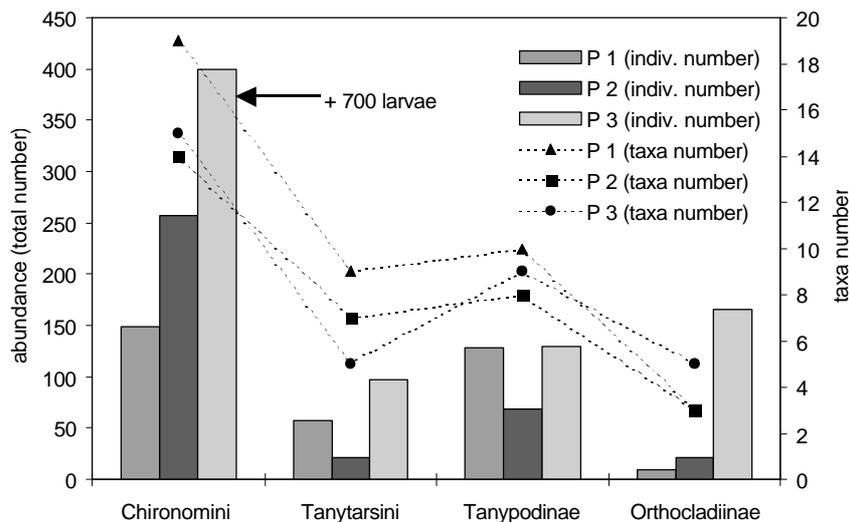


Figure 1: Taxa number and total individuals of Chironomidae subfamilies and tribes in the 3 sections of Fazzari stream.

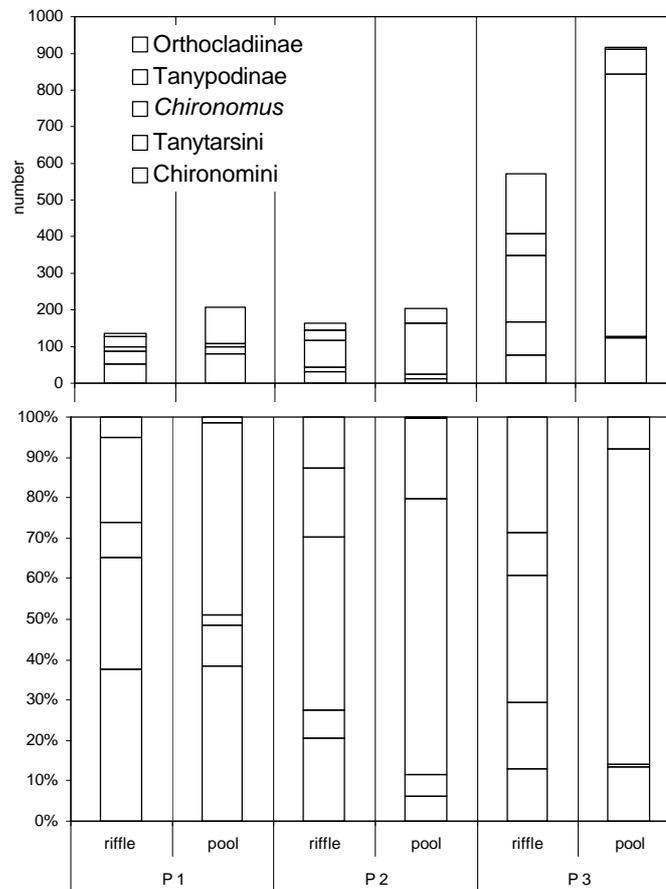


Figure 2: Number of individuals and relative participation (%) of Chironomidae group on riffles and pools sections of Fazzari stream.

The expressive numerical dominance of *Chironomus* larvae in P 2 and P 3 may be indicative of the loss habitat impact and eutrophication. In these segments the larvae of the genera were represented respectively by 4 and 3 taxa (Tab. II).

The community index, together with other metrics, gave consistent information in respect to the faunistic characteristics of the stream and of the integrity in the different segments analyzed (Tab. III). P 1 had a higher diversity than P 2 and P 3. Besides this, the proportions between sensitive and tolerant taxa (EPT/Chironomidae; *Chironomus*/Chironomidae) clearly pointed out the differences, which without any doubt reflect the deforestation impacts, the damming and possibly the presence of organic effluents, particularly in segment 2. The expressive participation of Oligochaeta in this segment seems to confirm the existence of organic pollution.

The faunistic arrangements in the three points of the stream resulted in a distribution difference of feeding groups (Fig. 3). Although the proportion of collectors is elevated in all stream, the presence of riparian vegetation in P 1 facilitates the occurrence of a higher number of shredders. In this segment, the taxa that more contributed to this functional category were *Stenochironomus* and *Endotribelos* larvae (Tab. II), genera that feed on vegetable fragments (wood, leaves and fruits in decomposition) (Borkent, 1984; Henrique-Oliveira et al., 2003). In the other two segments, the higher participation of collectors is mainly due to the great number of *Chironomus* larvae.

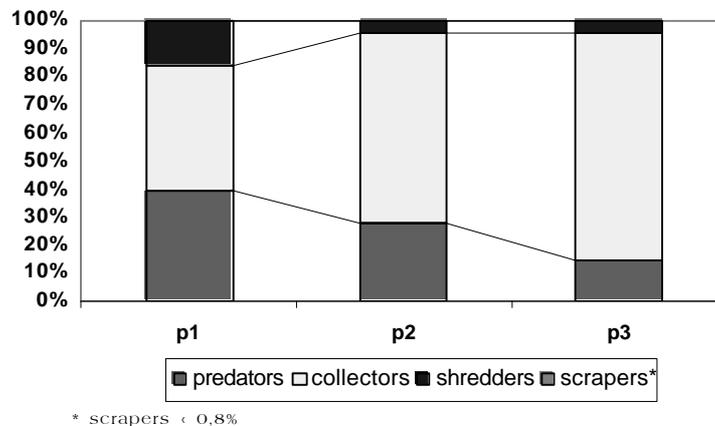


Figure 3: Relative participation of macroinvertebrate feeding guilds in the 3 sections of Fazzari stream.

The reported differences above are evidenced in the similarity dendrogram (Fig. 4). Two groups can be differentiated: one containing both types of habitats (pools and riffles) of P 1 and riffles of P 3 and the other associating the pools in P 3 and P 2. It is interesting to mention that P 3 showed an intermediate situation in the community analysis and in the dendrogram it was dissociated to the two groups. This result can be related to the higher amount of oxygen in the water, due to the declivity (bigger riffles) and the partial vegetation covering of the segment that resulted in a grouping of its riffles with P 1. The abundance of larvae and pupae of Simuliidae (Diptera), and of Elminthidae larvae (Coleoptera), typical insects of faster waters (Ward, 1992), confirm this observation.

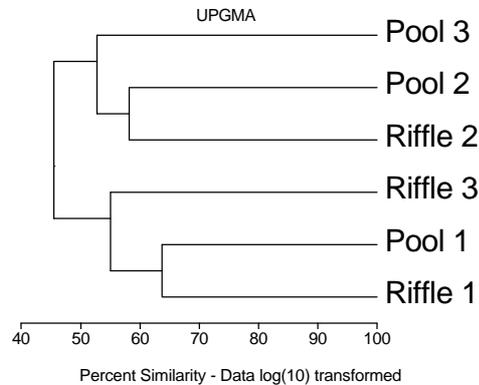


Figure 4: Similarity dendrogram (PSc) between the riffle and pool sections of the Fazzari stream.

We can conclude that the discrepancy between the results of the community metrics, biological diversity and functional diversity indices in the three analyzed segments can be related to the presence of the two damming and of the destruction of riparian vegetation. This relation was verified in other studies as Ormerod et al. (1993) and Steward & Samways (1998), of which stressed the importance of conservation of streams in forested areas for the maintenance of the environmental integrity and aquatic macroinvertebrate diversity.

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