Flood Mediated Change of the Fish Community in Congaree National Park Streams

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Introduction

Floods are a major environmental event that can shape the behavior, abundance, and community composition of fishes (Welcomme and Halls 2001). The magnitude, timing, and duration of flood events can differentially affect the abundance and reproductive success of the various fish species. In the floodplains of the Amazon River, the flood cycle is the dominant factor that shapes fish community composition (Saint-Paul et al. 2000). Theiling et al. (1999) demonstrated that fish communities responded to flooding of an artificial wetland with increased species diversity immediately after flooding. In a study of hydrologic data in Congaree National Park (CNP) from 1973-1982, Patterson et al. (1985) showed that river water inundated as much as 90% of the Park approximately once per year. However in 2001-2002, major flooding of CNP did not occur and by the end of 2002 South Carolina was in an extended drought period.

During this extended drought in 2001-2002, Rose and Bulak (2005) surveyed the fish community of CNP using standard electrofishing techniques. Fifty electrofishing surveys were conducted from 33 unique stream sites within CNP during this effort. In summary, this effort collected 56 species of fish and defined three distinctive fish community types within CNP that were associated with specific habitat conditions. The habitat types were characterized as higher gradient-permanent, lower gradient permanent, and low gradient-temporary.

From February through June 2003, major flood events inundated most of CNP including the stream sites sampled in 2001-2002 (Rose and Bulak 2005). This provided an opportunity to assess whether changes in the fish community were apparent shortly after inundation. Thus, our objective for this study was to compare the fish community

observed during pre-flood drought conditions with the community observed immediately after major flooding.

Methods

Congaree National Park is located approximately thirty miles southeast of Columbia, South Carolina. The park is recognized as an International Biosphere Reserve, National Natural Landmark, Wilderness Area, and "Globally Important Bird Area." It features some of the tallest trees in the east and one of the highest forest canopies in the world. In 2003 the park encompassed over 22,200 acres with about 10,000 acres of old-growth forest making it the largest intact tract of old-growth bottomland hardwood forest in the United States.

The northern boundary of the park receives water from five tributary basins. Four of the basins extend from the Sand Hills, through the Atlantic Southern Loam Plains, before transitioning into the Southeastern Floodplains and Low Terraces ecoregion. These basins collect water to form Myers Creek, Dry Branch, Cedar Creek, and Tom's Creek/McKenzie Creek. The fifth unnamed basin is a small basin that originates in the Atlantic Southern Loam Plains and contributes little water to the park. The Congaree River, which collects water from the entire Congaree River basin including the Saluda River, Enoree River, Tyger River, Pacolet River and the Broad River, forms the southern boundary of the park.

The park is characterized by features typical of its ecoregion including a large, sluggish river, sandy or silty low gradient streams, and oxbow lakes, ponds and swamps (Griffith et al. 2002). Bottomland hardwood forests and cypress-gum swamps are the principal habitats found in CNP. CNP has an interconnected network of streams, guts,

sloughs and oxbow lakes that connect with the Congaree River during high water and flood events. When floodwaters recede, many of the streams and guts loose their connection to other sites in the network and cease to flow or flow very slowly. Other CNP streams continue to flow well even through drought conditions. Consequently, the habitat available to fish in CNP varies greatly.

Five stream sites that were sampled prior to the 2003 flood were re-sampled in 2003. The stream sites and site number were upper Dry Branch, site 101, Tom's Creek, site 104, Cedar Creek, site 112, Weston Lake Slough, site 116, and lower Dry Branch, site 132 (Figure 1). Sites were re-sampled in June – October 2003 in periods when floodwaters had receded from CNP (Figure 2). In general, at the time of sampling, the stream conditions (width and depth) were similar for both the pre and post flood samples.

Streams were sampled using the same multi-pass depletion method for both pre and post flooding samples. A 100-meter stream segment that contained representative habitats was delineated. Block nets with a mesh size of no larger than 0.635 centimeters were placed at both the upstream and downstream boundaries of the stream segment. Depending on the size of the stream, one, two or three, Smith Root battery-powered, 24 volt, backpack, electrofishing units were used to make three consecutive upstream passes through the sampling reach. Generally, where new species were found on the third pass, a fourth pass was made. One electrofishing unit was used where the stream was less than 3 meters wide while two units were used where the stream width was between 3 and 6 meters. Three units were used for streams wider than 6 meters or where an adequate sample would not be obtained with only two units. To minimize size and species selectivity bias associated with electrofishing, we established standard frequency and

pulse-width settings at 60Hz and 6ms, respectively. The low conductivity conditions associated with CNP streams usually required settings of between 600 and 900 volts to provide adequate current to effectively sample the fish. An attempt was made to collect and numerate all stunned fish. Where possible, collected fish were field identified to species, measured and returned to the water alive. Where field identifications were uncertain, the fish were preserved in 10% buffered formalin and identified in a laboratory using appropriate keys (Rohde 1999). Selected specimens were sent to regional experts in fish taxonomy to confirm identifications. Representative specimens of each species were collected and are housed according to NPS requirements at the South Carolina Department of Natural Resources Eastover Fisheries Research Laboratory. Standard abbreviations were assigned to all the fish species that were collected (Table 1).

Standard physical, chemical and biological information were collected at each sampling location. Physical measurements included stream width, depth, and flow. The average stream width was determined by measuring the wetted width at the downstream limit of the sample reach and then every 25 m to the upstream extent of the sample reach. All five measurements were averaged to determine the overall average stream width. The average depth was determined by taking three evenly spaced depth measurements along each transect where wetted width was measured. All fifteen observations were averaged to determine the average stream depth. Chemical measurements included temperature, dissolved oxygen (DO), pH, and conductivity, which were measured with Yellow Springs models 60 (pH) and 85 (temperature, DO, conductivity) water quality assessment instruments. Biological information included fish identified to species, individual counts and length (mm) on every fish.

To group sites into hierarchical classification groups based on the similarity of their fauna, a cluster analysis was performed (McCune 2002). A fourth root power transformation ($b = x_{ij}^{0.25}$; where b is the species matrix and x is the abundance of species j in sample unit i) was performed on the species matrix to reduce the effect that large differences in fish abundance between samples may have had on the analysis (Clarke 1993). The Sørensen distance equation was utilized to calculate the similarity. The method used for group linking was the flexible beta method (beta = -0.15). Groups were classified as distinct if an adjacent cluster in the dendogram retained less than 25% of its information. To facilitate interpretation, the cluster analysis dendogram was coded to illustrate the separate groupings.

Results

Eight post-flood samples were obtained in 2003 – two samples at sites 101, 104, and 116 and single samples at sites 112 and 132. These samples were compared to 11, pre-flood samples collected at these sites during 2001-2002 (Table 2). An inspection of the average of measured habitat variables indicates that habitat conditions were similar before and after the flood (Table 3).

Similar species richness was observed at the sample sites during pre and post flood conditions. A total of 38 and 37 species were collected during pre and post flooding sampling, respectively (Table 4). Seven species (blackbanded sunfish, channel catfish, flat bullhead, green sunfish, piedmont darter, snail bullhead, and spotted sucker) were only sampled during pre-flood sampling while seven species (bowfin, black crappie, carp, longnose gar, mud sunfish, pumpkinseed, and redear sunfish) were only collected during post-flood sampling. While overall species richness was similar, species richness tended

to increase after the flood, increasing at four of the five sites and remaining unchanged at the other site (Figure 3).

The absolute abundance of individual species both increased and decreased after the flood event (Figure 4). Pirate perch and redfin pickerel showed the greatest increase after flooding. Bluegill, flier, golden shiner, warmouth, and yellow bullhead were other common species that increased in abundance after flooding. Conversely, redbreast sunfish, sailfin shiner, eastern mudminnow, creek chubsucker, and margined madtom were common species that decreased in abundance after the flood event.

The relative contribution of individual species to the collections also showed that some increased while others decreased (Figure 5). As with absolute abundance, pirate perch and redfin pickerel showed the greatest increase in relative abundance after the flood event. Redbreast sunfish, creek chubsucker, and sailfin shiner showed the greatest decrease after the flood.

Cluster analysis showed a significant difference in the pre- and post-flood fish community at sites 104 and 112 (Figure 6). There was also a divergence in fish community composition at sites 101, 116, and 132, though these divergences were smaller than the pre-selected criterion for significance.

Discussion

This study supports the premise that others have stated that floods are a major environmental event that can shape the behavior, abundance, and community composition of fishes (Welcomme and Halls 2001). It is evident from the results that certain species exploited the flood event to increase population abundance while others

decreased in abundance, as they apparently preferred the more stable conditions that existed prior to the flood.

The change in community structure resulting from flooding indicates that monitoring efforts of the fish community must consider recent hydrologic events when making assessments of community condition. The results and conclusions obtained by Bulak and Rose (2005), performed during a prolonged drought, are only applicable to sampling during a similar environmental period. We would anticipate that the fish community immediately after the flood would, if not affected by a major environmental event, likely return towards the conditions found during the prolonged drought of 2000-2002. Additional sampling at various times after a flood event is needed to better understand the rate of change in the fish community.

From a management perspective, this study has provided insights to the reactions of certain economically important species to flood events. Redfin pickerel, a popular sportfish, was obviously enhanced by the flooding event. Conversely, redbreast sunfish, a very popular sport fish, was not enhanced by the flooding event.

Recommendations

- Conduct additional sampling at key sites to better understand the rate of change of the fish community after a major flood event, which reshapes the community. The ultimate goal of future sampling should be to be able to predict fish community status as a function of recent environmental/hydrological events.
- Combine this data with pre-flood data and develop a major publication detailing the dynamics of streams that flow through bottomland hardwood forests, such as found at CNP; this effort would require a full literature review.

- Display this data to the public so they will better understand the relation between flooding events and the condition of the biotic community.

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Tables

Table 1: A list of fish species collected by South Carolina Department of Natural Resources (SCDNR) in the lakes and streams of Congaree National Park from 1999 through 2003.

Family Name	Scientific Name	Common Name	SCDNR Code
Lepisosteidae	*Lepisosteus osseus*	Longnose gar	LNG
Amiidae	*Amia calva*	Bowfin	BFN
Anguillidae	*Anguilla rostrata*	American eel	AEL
Clupeidae	*Dorosoma cepedianum*	Gizzard shad	GZS
	Dorosoma petenense	Threadfin shad	TFS
Umbridae	*Umbra pygmaea*	Eastern mudminnow	EMM
Esocidae	*Esox americanus*	Redfin pickerel	RFP
	Esox niger	Chain pickerel	CHP
Cyprinidae	*Cyprinella chloristius*	Greenfin shiner	GFS
	Cyprinella nivea	Whitefin shiner	WFS
	Cyprinus carpio	Common Carp	CRP
	Hybognathus regius	Eastern silvery minnow	ESM
	Nocomis leptocephalus	Bluehead chub	BHC
	Notemigonus crysoleucas	Golden shiner	GLS
	Notropis cummingsae	Dusky shiner	DKS
	Notropis hudsonius	Spottail shiner	STS
	Notropis maculatus	Taillight shiner	TLS
	Notropis petersoni	Coastal shiner	CSH
	Pteronotropis hypselopterus	Sailfin shiner	SFS
Catostomidae	*Erimyzon oblongus*	Creek chubsucker	CCS
	Minytrema melanops	Spotted sucker	SPS
	Moxostoma macrolepidotum	Shorthead redhorse	SHR
Ictaluridae	*Ameiurus brunneus*	Snail bullhead	SBH
	Ameiurus natalis	Yellow bullhead	YBH
	Ameiurus nebulosus	Brown bullhead	BBH
	Ameiurus platycephalus	Flat bullhead	FBH
	Ictalurus punctatus	Channel catfish	CCF
	Noturus gyrinus	Tadpole madtom	TPM
	Noturus insignis	Margined madtom	MGM
	Pylodictis olivaris	Flathead catfish	FCF
Amblyopsidae	*Chologaster cornuta*	Swampfish	SWF
Aphredoderidae	*Aphredoderus sayanus*	Pirate perch	PIP
Cyprinodontidae	*Fundulus lineolatus*	Lined topminnow	LTM
Poeciliidae	*Gambusia holbrooki*	Mosquitofish	MSQ
Atherinidae	*Labidesthes sicculus*	Brook silverside	BSS
Percichthyidae	*Morone americana*	White perch	WTP
Centrarchidae	*Acantharchus pomotis*	Mud sunfish	MDS
	Centrarchus macropterus	Flier	FLR
	Elassoma zonatum	Banded pygmy sunfish	BPS
	Enneacanthus chaetodon	Blackbanded sunfish	BBS
	Enneacanthus gloriosus	Bluespotted sunfish	BLS
	Lepomis auritus	Redbreast sunfish	RBS
	Lepomis cyanellus	Green sunfish	GSF
	Lepomis gibbosus	Pumpkinseed	PPS
	Lepomis gulosus	Warmouth	WAR
	Lepomis macrochirus	Bluegill	BLG
	Lepomis marginatus	Dollar sunfish	DSF
	Lepomis microlophus	Redear sunfish	RES
	Lepomis punctatus	Spotted sunfish	SOS
	Micropterus salmoides	Largemouth bass	LMB
	Pomoxis nigromaculatus	Black crappie	BLC
Percidae	*Etheostoma fusiforme*	Swamp darter	SWD
	Etheostoma olmstedi	Tessellated darter	TSD
	Etheostoma serriferum	Sawcheek darter	SCD
	Perca flavescens	Yellow perch	YLP
	Percina crassa	Piedmont darter	PDD

Table 2: A list of the sites sampled for fish before and after a 2003 flood event in the Congaree National Park. Post-flood samples are denoted with an asterisk.

Site Name	Coordinates	Site ID	Sample #	Date
Dry Branch (upper)	Lat: 33.830037	Site 101	11	6/19/2001
	Long: -80.812916		35	9/5/2001
			42	6/13/2002
			61*	6/17/2003
			66*	9/26/2003
Tom's Creek	Lat: 33.809660	Site 104	15	6/28/2001
	Long: -80.723859		34	8/31/2001
			43	6/21/2002
			63*	6/26/2003
			67*	10/10/2003
Cedar Creek	Lat: 33.837457	Site 112	19	7/17/2001
	Long: -80.858626		38	9/14/2001
			56	7/23/2002
			65*	9/2/2003
Weston Lake Slough	Lat: 33.811202	Site 116	28	8/15/2001
	Long: -80.814185		64*	8/29/2003
			68*	10/24/2003
Dry Branch (lower)	Lat: 33.821944	Site 132	31	8/22/2001
	Long: -80.816749		62*	6/25/2003

Table 3: The average measured habitat variables that could affect sampling efficiency at each of five sites sampled repeatedly before and after a flood event in Congaree National Park.

		Temp (C)	DO (mg/l)	pH	Conductivity (mS)	Width (m)	Depth (m)
Site 101	**Pre-flood**	20.10	4.36	6.11	38.87	2.66	0.12
	Post-flood	20.55	4.81	5.82	36.45	3.18	0.23
Site 104	**Pre-flood**	22.80	5.06	6.09	30.40	4.42	0.28
	Post-flood	21.45	6.34	6.11	29.45	5.59	0.45
Site 112	**Pre-flood**	26.73	5.22	6.50	24.30	6.69	0.63
	Post-flood	27.30	6.14	6.38	24.70	7.30	0.65
Site 116	**Pre-flood**	23.40	4.37	6.26	38.10	6.66	0.22
	Post-flood	19.95	2.16	6.57	55.75	5.25	0.23
Site 132	**Pre-flood**	21.30	4.40	6.09	33.50	3.73	0.22
	Post-flood	22.10	3.62	5.69	34.80	5.52	0.25

Table 4: The number of each species of fish collected during repeated samples at each of five sites before and after a flood event within the Congaree National Park. Post-flood samples are denoted with an asterisk.

		Site 101					Site 104					Site 112				Site 116			Site 132	
	Sample #	11	35	42	61*	66*	15	34	43	63*	67*	19	38	56	65*	28	64*	68*	31	62*
SPECIES	bbh								5								3			
	bbs								1											
	bfn				5	2				2	3						1			1
	blc														1					
	blg	32	17	8	14	37		1	2	15	17	4	3	36	22	54	11	5	56	249
	bls	2				3									5	1	19	8	5	22
	bps	2	2													9	8	41	4	3
	bss				3	4			1		1	12	2	1	2		104	2		
	ccf											2	1	4						
	ccs	24	18	11	14	20	1	6	35	3	4					61	1	10	36	2
	chp	1		1	7	8			3	3	16			4	5	1	8	7	1	6
	crp																14			
	csh														8	1				
	dks					3	27	45	87	23	11		1	13	89	26	73			
	dsf	8	8	1	16	24	13	31	24	11	30	10	3	10	45	35	7	5	54	81
	emm	21	44	23	6					4						8		4	18	8
	esm																44			
	fbh											1	1	5						
	flr	4	5	5	14	34				5	25				6	16	163	22	8	5
	gls	12	7	1	4	10					25				14	3	86	54	15	1
	gsf												1							
	lmb						2	2	3	1		3	1	2	2	6	1	4	2	4
	lng														1		14	2		
	ltm					3							1			1		1	2	
	mds					5				5	8				2			1		
	mgm		1		1	3	2	5	3	1	2	20	33	42	10					
	msq	32	42	20							1		4	1	5	15	13	62	20	
	pdd											2	1							
	pip	23	31	45	58	115	11	35	71	74	151	6	24	6	109	150	241	406	76	118
	pps				1	3												7		1
	rbs	10	11		2	21	20	61	34	5	15	32	37	38	19	118	53	3	17	
	res					3											49	27		2
	rfp	17	15	21	79	98	13	16	32	118	118	2	4	1	24	31	123	106	35	128
	sbh											4								
	scd				1	6	1	4	4	2		1			1	2	3	7	15	5
	sfs						39	70	45	6	16					3				
	sos	2	1				6	10	17	4	10	1	2	4	6	20			6	2
	sps								1					1						
	swf		1		1			1		1	1								1	1
	tls														3	4				
	tpm	1			3			1	4		2	2	1	1	3	18	1	1	5	4
	tsd											4	13	5		14				
	war	8	12	4	8	31	1	2	3	2	10	2	1	9	5	5	39	35	18	38
	ybh	2	10	2	4	20		2	5	1	89				6	8	4	23	4	
	ylp					2								41	1		2	21		2

Figures

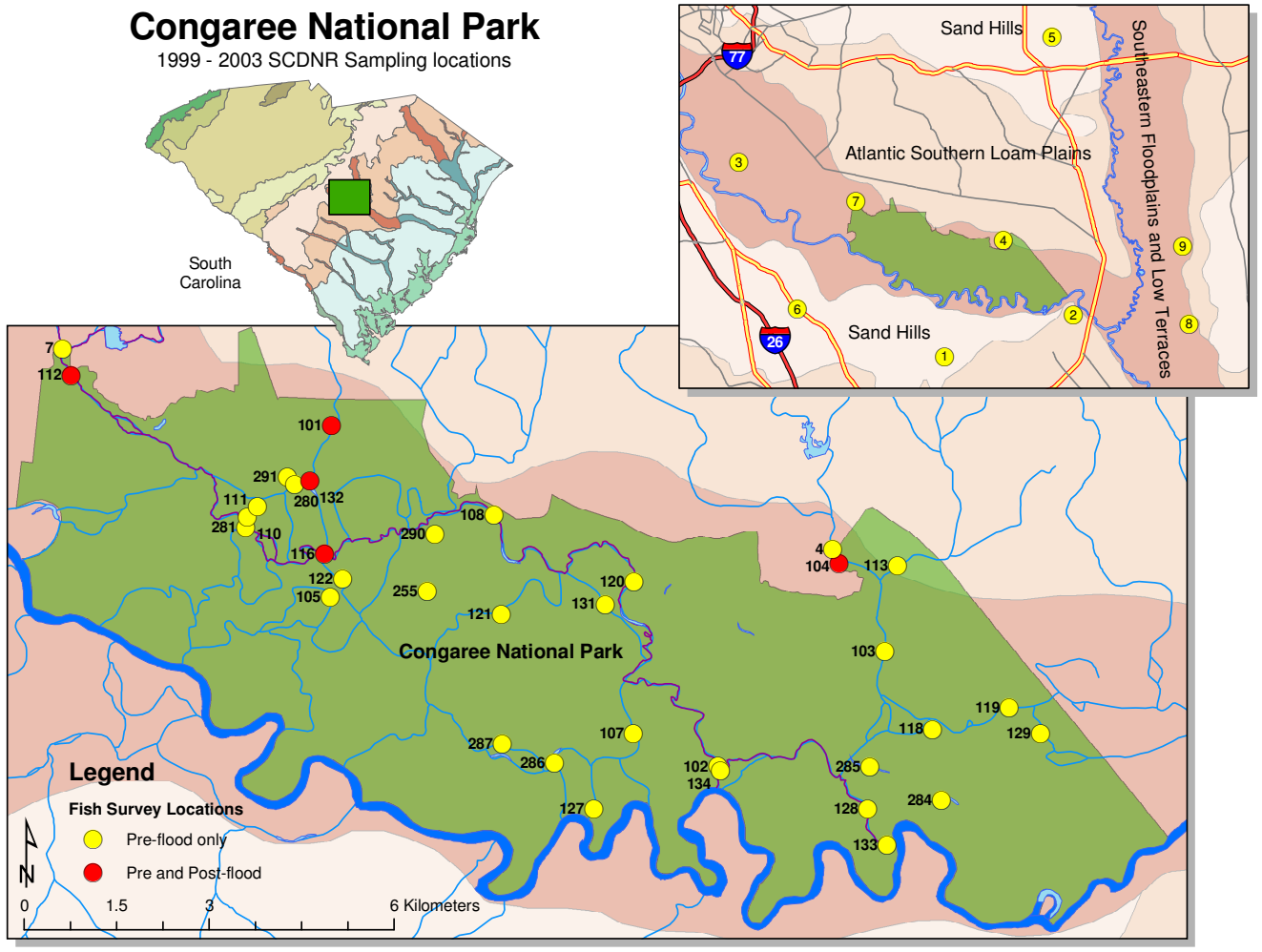

Figure 1: Sites sampled during a four-year study of the fish community in the Congaree National Park

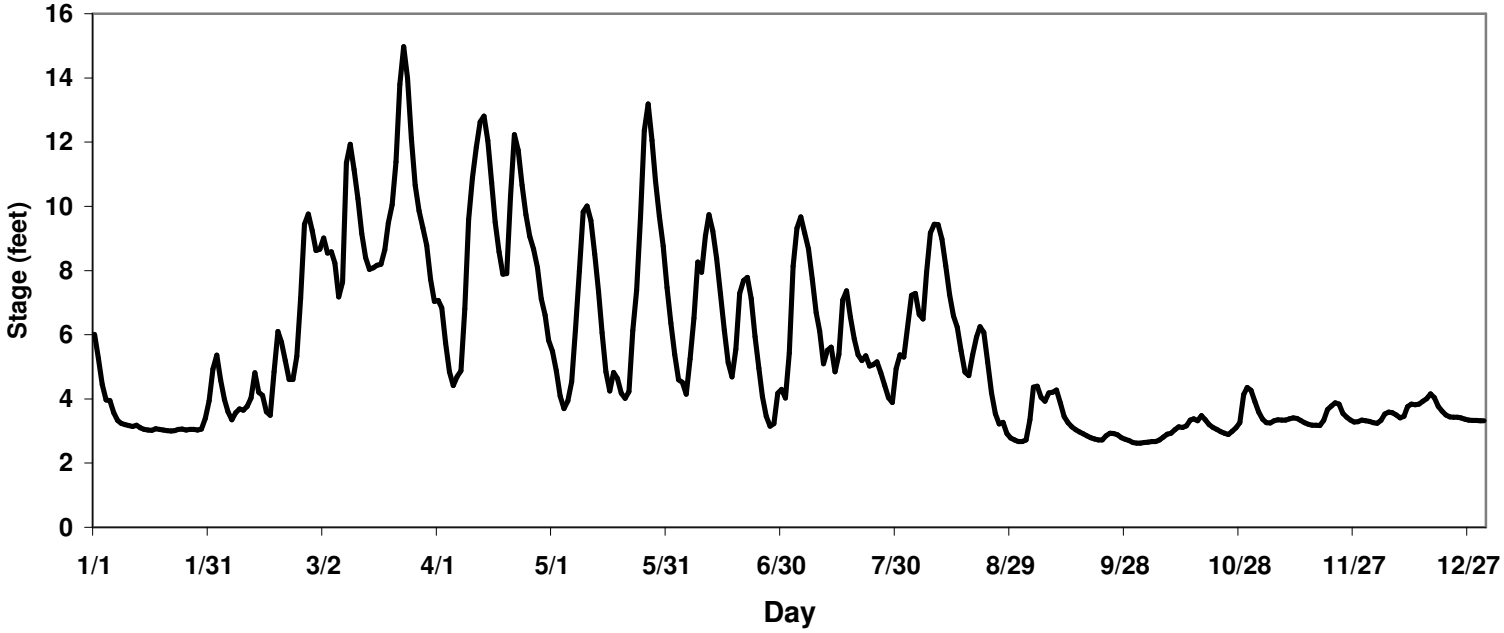

Figure 2: Water stage at the Cedar Creek USGS gauging station during the 2003 flooding events.

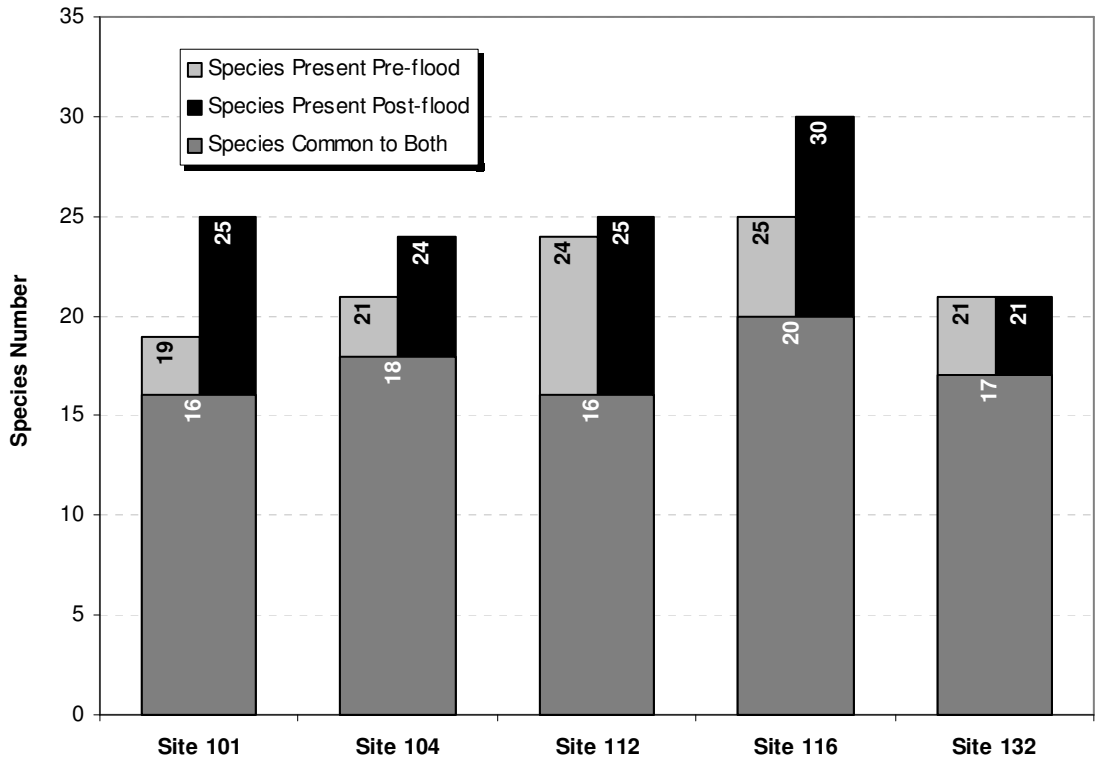

Figure 3: The total number of fish species collected from five sites both before and after a flood event in Congaree National Park.

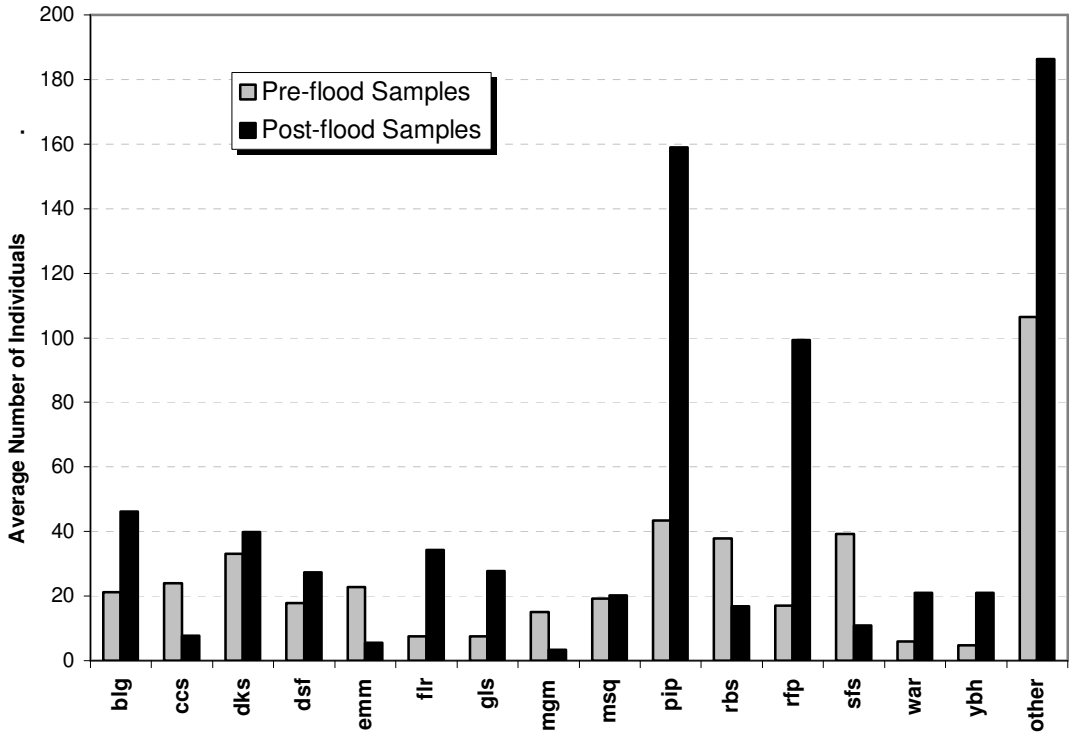

Figure 4: The average total abundance of selected fish species from five locations before and after a flood event in the Congaree National Park.

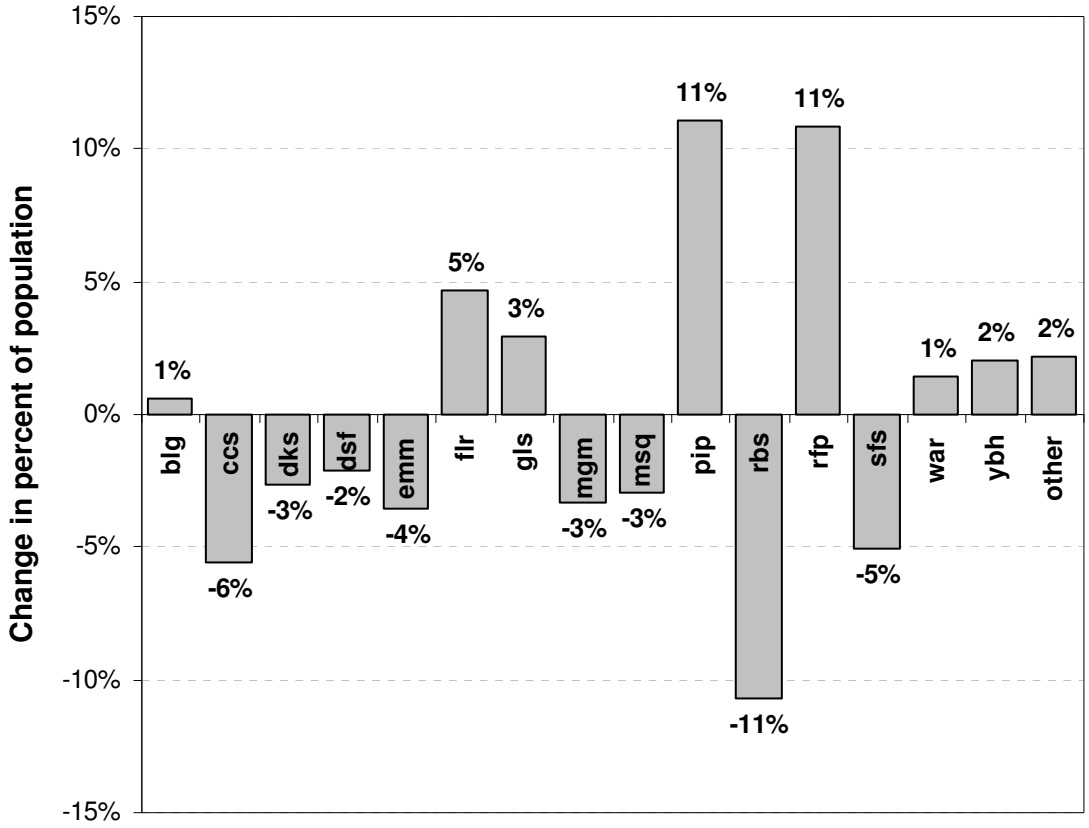

Figure 5: The change in the relative percent of population of selected fish species after a flood averaged from fives sites in Congaree National Park. Fish species abbreviations are found in Table 1.

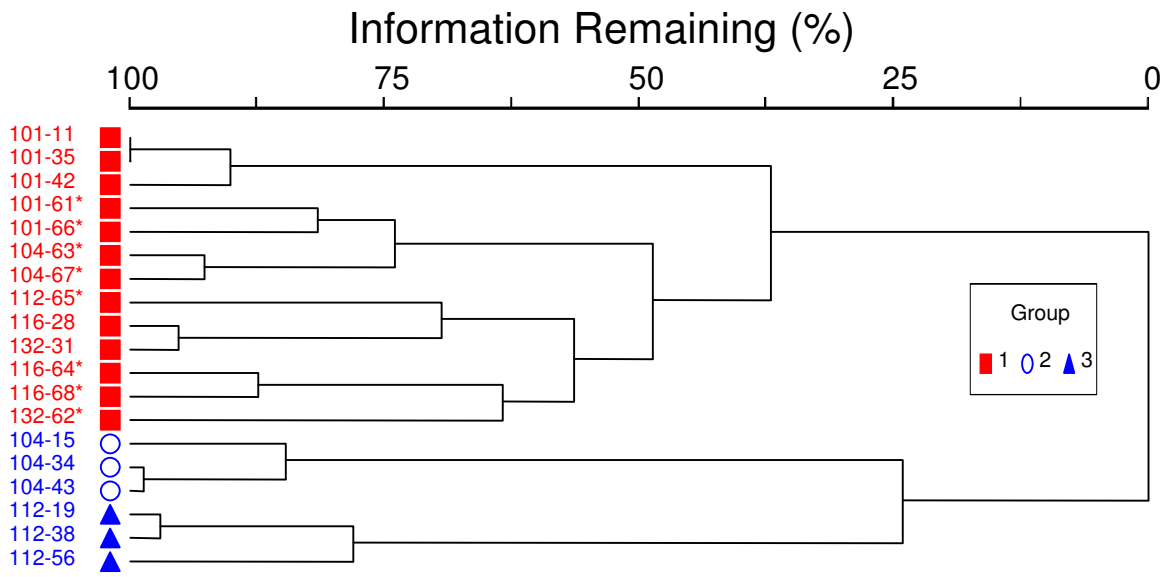

Figure 6. Similarity of fish communities in five Congaree National Park sites before and after a flood as indicated by cluster analysis (Sorensen (Bray-Curtis, Flexible Beta = -0.15)). The site identifier, first three digits, and sample number, last two digits, are provided in the left hand column and further defined in Table 2. Post-flood samples are denoted with an asterisk. Groups were classified as distinct if an adjacent cluster retained less than 25% of its information.