Comparison of Fish and Macroinvertebrate Biodiversity in a Floodplain and a Non-floodplain Lake

Christian Slone,[1] Spencer Trimpe,[2] Molly Williams[3] and Chris Lorentz, Ph.D.

The Center for Ohio River Research & Education, Thomas More University Biology Field Station, 8309 Mary Ingles Highway, California, Kentucky 41007

[1]Murray State University, [2]Thomas More University, [3]Hillsdale College

Abstract

The effects of river-flood events on river ecosystems have been studied intensively, but the effects on the surrounding floodplain aquatic ecosystems are largely unknown. Rivers periodically flood and reach floodplain lakes. Consequently, the flood water alters water chemistry and adds biota to the lakes. In order to study the potential effects of Ohio River floods on floodplain lake biodiversity, we compared the fish and macroinvertebrate biodiversity of a floodplain lake to those of a non-floodplain lake. The floodplain lake at River Pines RV Resort in New Richmond, Ohio was sampled for fish and macroinvertebrates at varying habitats and the same was done at the non-floodplain lake, Campbell County Game & Fish in Alexandria, Kentucky. Although there are uncontrolled factors in both lakes such as different morphological characteristics, stocking, and use of chemical algaecides, results show that the lakes have similar macroinvertebrate biodiversity and that the floodplain lake's fish are notably more biodiverse than in the non-floodplain lake. The results gathered suggest that floodplain lakes can contain higher biological diversity than non-floodplain lakes in both macroinvertebrate and fish assemblages.

Introduction

The flat area of land adjacent to any river or stream is known as a floodplain; any lake located within the floodplain is subject to occasional connectivity with and flooding from the main river. Floodplain lakes are a point of interest in local ecological systems because their food webs are greatly influenced by the influx of new organisms from floods (Feyrer et al. 2004). Although the full effects of river floods on floodplain lakes are not known, several studies have demonstrated that flood events can positively affect the lake ecosystem. For example, some juvenile fish that hatch in these lakes have better growth conditions than other nearby lakes. Additionally, they can act as a nursery for young fish, allowing riverine species to develop in the lake before reentering the river ecosystem through another flood event (Jeffres et al. 2008). Floodplain lakes can sustain populations of macroinvertebrates unique to non-floodplain lakes (Hill et al. 2017). In order to further examine the effects of flooding on floodplain lake biodiversity, a study was conducted on an Ohio River floodplain lake and a nearby non-floodplain lake to compare differences in macroinvertebrate populations and fish assemblages. We predicted that the biodiversity would be higher in a floodplain lake than a non-floodplain lake for fish and macroinvertebrate communities.

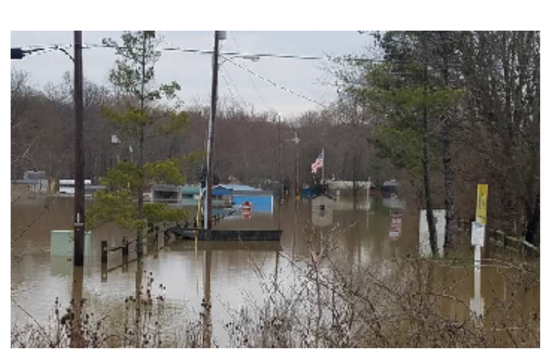

Figure 1. Ohio River flood that reached the floodplain lake (March 2018).

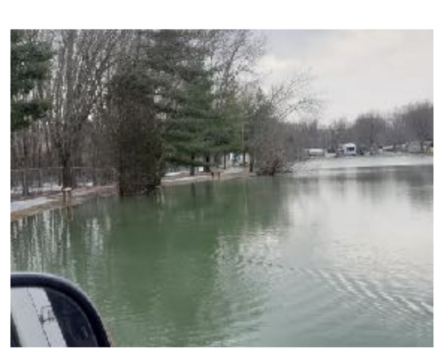

Figure 2. Ohio River flood that caused backwater flooding from nearby tributaries that reached the floodplain lake (December 2020).

We located a floodplain and a non-floodplain lake located seven and a half miles from each other and that are both under two acres in size. Before comparison, it is essential to acknowledge that they are each managed with different chemical algaecides and stocking practices, in addition to having very different depth profiles.

Methods

Study Sites: The River Pines RV Resort Lake in New Richmond, Ohio (38.9684956, -84.2890443) is a 1.7 acre lake that was sampled on June 15, 2021 as the floodplain lake. The Campbell County Game & Fish Lake in Alexandria, Kentucky (38.8948791, -84.3919518) is a 1.1 acre lake that was sampled on June 24, 2021 as the non-floodplain lake. A comprehensive survey was conducted at both lakes in order to compare them based on physical, chemical, and biological data.

Figure 3. Aerial view of the floodplain lake (right), located 347 m from the Ohio River (left).

Figure 4. Aerial view of the non-floodplain lake.

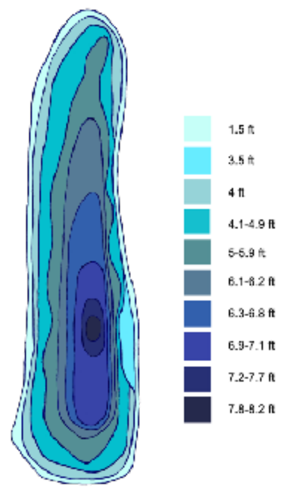

Figure 5. Bathymetric map of the floodplain lake.

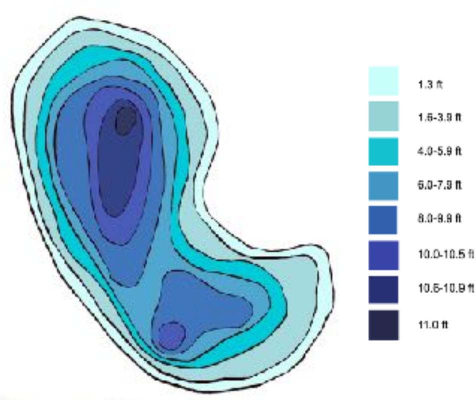

Figure 6. Bathymetric map of the non-floodplain lake.

Water chemistry: Parameters including water temperature (ºC), pH, dissolved oxygen (mg/L), and conductivity (µS/cm) were measured with a YSI probe. The turbidity was found with a secchi disk.

Physical parameters: Physical specifications including perimeter and average width were calculated using Google Earth satellite imagery. Depth was measured at over 40 evenly spaced points in each lake with a sonar depth finder, and this information was used to develop a bathymetric map. Volume was estimated using the average width, average length, and average depth for each lake.

Macroinvertebrates: Macroinvertebrates were collected with aquatic sampling dip nets using five jabs at each observed potential microhabitat. After being placed in 95% ethanol, samples were taken to the laboratory, sorted to order, and identified with a dissecting scope.

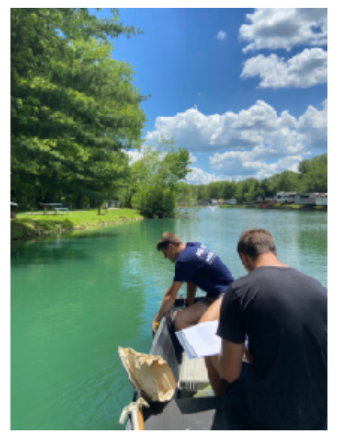

Figure 7. Christian and Spencer measuring water chemistry at the floodplain lake.

Figure 8. Spencer collecting macroinvertebrates from the non-floodplain lake.

Figure 9. Molly collecting macroinvertebrates from the non-floodplain lake.

Fish: Both lakes were electrofished for approximately 45 minutes around the entire shoreline and five passes across the width of the lake. After collection with a dip net, fish were placed into 65-liter livewells with freshly oxygenated water. Next, the fish were measured for total and standard lengths, and mass was found with hanging spring scales. After processing, the fish were released.

Figure 10. Collecting, identifying, and measuring fish by electrofishing the floodplain lake.

Results

The chemical data from both lakes were relatively similar, making the study sites ideal for comparison. The physical data showed that although the floodplain lake has more shoreline and a bigger volume, the non-floodplain lake has greater average and maximum depths. The depth profiles revealed that the non-floodplain pond has a greater littoral zone and more topographical variation.

Table 1. Average chemical data from both the floodplain lake and non-floodplain lake

Chemical Data		
	Floodplain Lake	Non-floodplain Lake
Average Water Temp (°C)	26.66 (±0.30)	24.62 (±0.04)
Average pH	8.33 (±0.10)	8.25 (±0.14)
Average Dissolved Oxygen (mg/L)	6.29 (±0.29)	6.31 (±0.09)
Average Conductivity (µS/cm)	255.4 (±0.16)	114.74 (±0.09)
Average Secchi Depth (cm)	63.1 (±3.21)	64 (±6.57)

Table 2. Physical data from both the floodplain lake and non-floodplain lake.

Physical Data		
	Floodplain Lake	Non-floodplain Lake
Average Depth (ft)	5.1 (±1.22)	6.1 (±3.02)
Maximum Depth (ft)	7.7	11
Volume (m^3)	35,380.22	27,643.44
Average Width (m)	39.15 ± 5.76	41.68 ±7.59
Perimeter (m)	426.81	291.28

The diversity of macroinvertebrate assemblages in the floodplain lake was slightly higher than that of the non-floodplain lake, despite the higher abundance in the non-floodplain lake. The Shannon-Wiener diversity index scores for these assemblages were much closer together than those of the fish assemblages. Due to the closeness of these values, the higher score of the floodplain lake's macroinvertebrate biodiversity is not notable.

Overall, the diversity of fish assemblages in the floodplain lake was higher than that of the non-floodplain lake based on Shannon-Wiener diversity index scores. The floodplain lake also contained several riverine species such as Freshwater Drum, Sauger, Gizzard Shad, Striped Bass, and Common Carp not found in the non-floodplain lake.

Table 3. Relative biodiversity scores of fish and macroinvertebrate assemblages in both the floodplain and non-floodplain lake.

	Macroinvertebrate Data		Fish Data	
	Floodplain Lake	Non-floodplain Lake	Floodplain Lake	Non-floodplain Lake
Abundance	54	261	123	207
Species Richness	6	8	15	7
Species Evenness	0.869	0.682	0.667	0.419
Shannon Diversity Index	1.557	1.419	1.805	0.815

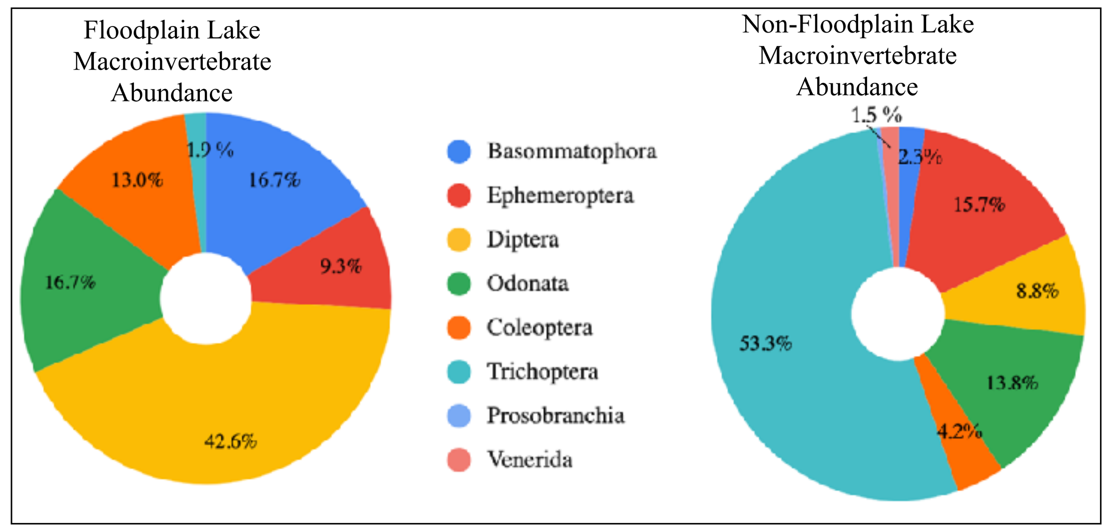

Figure 11. Macroinvertebrate abundance by order in both the floodplain lake and non-floodplain lake

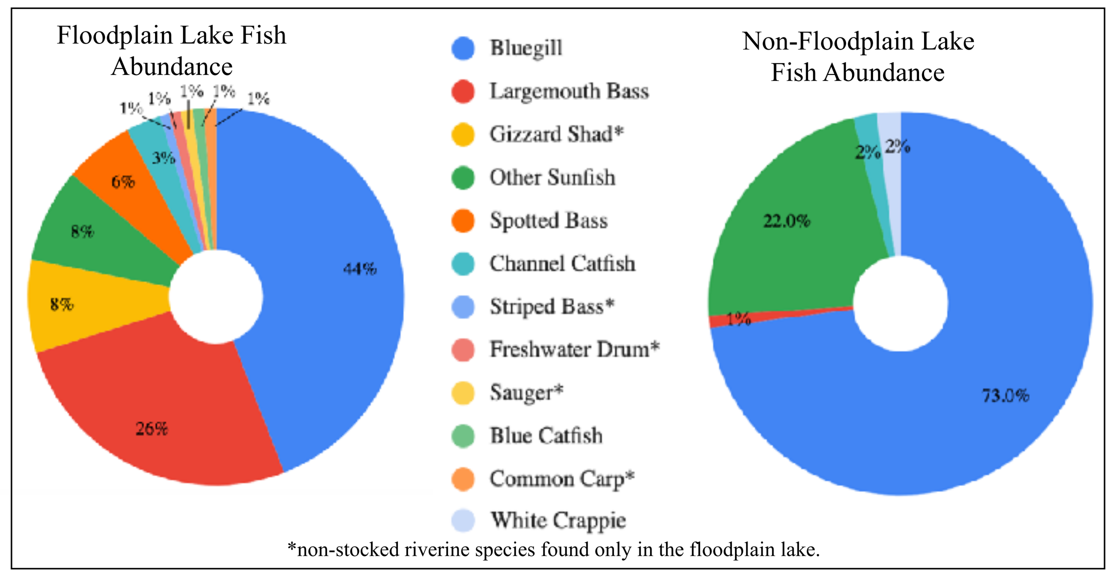

Figure 12. Fish abundance by species in both the floodplain lake and non-floodplain lake

Conclusions

Despite the non-floodplain lake having qualities that are more conducive to biodiversity such as greater morphological heterogeneity and more types of fish and macroinvertebrate habitats, the floodplain lake still has a higher diversity overall. Although the lakes have distinct depth profiles and are managed differently, the presence of non-stocked riverine species in the floodplain lake is evidence that the occasional influx of river water provides fish species with the opportunity to move into the lake, increasing its biodiversity. This finding confirms previous research findings that floodplain lakes can act as nurseries for river endemic fish, but the population dynamics between lake endemic and riverine species are still unknown (Hill et al. 2017). However, there was only a marginal difference in macroinvertebrate diversity that could be determined between the two lakes. As a result, no conclusions could be drawn suggesting that river-flood events affect macroinvertebrate biodiversity in floodplain lakes. Despite this, the results indicate that floodplain lakes can contain greater biological biodiversity than nearby non-floodplain lakes.

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For Further Information

Christian Slone (cslone2@murraystate.edu), Spencer Trimpe (sntrim83@thomasmore.edu), and Molly Williams (mwilliams1@hillsdale.edu)