

Investigating the comparison between bird diversity and apex aquatic predators
in sub-alpine beaver ponds

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NSF REU Full-Independent Research 2021

Abstract

Predation of native salamanders by non-native trout in Colorado is a wildlife concern. Understanding the dynamics of how the different species interact is important. Cascade effects in the environment are caused by declines of species in a community. Birds, fish, and amphibians are deeply connected, therefore observing birds may help understand the ecosystem. Bird diversity is a crucial indicator to understand environmental changes and health. The research focused on the effects of different apex aquatic predators and the number of different bird species near beaver ponds. Point counts were conducted to observe birds visually and aurally for 15 minutes. The comparison between pond type and number of different species was significant, suggesting that different aquatic predators may affect bird communities. In future research, analyzing the tree canopy and pond depth would provide a useful distinction of each pond.

Introduction

Colorado is a prime location for fishing. There are more than 9,000 miles of rivers, 2,000 natural lakes and hundreds of streams. However, the majority of Colorado's fishing is due to stocking the natural waters for sport fishing. Studies have shown that non-native, predatory fish have negative influences on native amphibians (Pilliod *et al.*, 2012). Interactions between non-native and native organisms have led to native species displacement, habitat avoidance, and local extinction (Pilliod *et al.*, 2012). Understanding of how native populations adapt and coexist is crucial for making wildlife management decisions (Pilliod *et al.*, 2012). When non-native species are abruptly introduced to an environment, some native prey are unable to quickly develop defenses, ultimately leading to declining populations (Pilliod *et al.*, 2012). The threatened populations can include vital food resources for birds. For example, trout reduced salamander hatching and larvae survival to nearly zero in predation trials performed by Pearson and Goater (Pearson and Goater, 2009). Using outdoor mesocosms, the survival rate of salamanders was reduced by 39%. Furthermore, minnows caused 41% reductions in salamander survival and exposure caused larvae to spend more focus time avoiding (Pearson and Goater, 2009). Consequently, the food resource is either declining or more difficult for birds to retrieve.

Negative impacts of non-native salmonids include past the boundaries of individual ponds and extends the impacts on a landscape scale (Pilliod *et al.*, 2012). Specifically, in the Rocky Mountains, there is limited suitable habitat for relocation or potential possibilities, which puts these communities at higher risks (Pilliod *et al.*, 2012). Fish decrease the quality of breeding locations, areas with high prey abundance, and overwintering grounds for amphibians (Pilliod *et al.*, 2012). Occurring through excessive predation or causing amphibians to avoid vital habitat areas all together. On a larger scale, this leads to a landscape-scale influence. Fish can facilitate other non-native species to invade environments (Pilliod *et al.*, 2012). Fish that move into streams or moving water bodies influence various animals' ability to travel to crucial habitats, isolate populations, and prevent recolonization (Bradford *et al.*, 1993; Knapp *et al.*, 2003). Mountain environments are highly threatened due to the lack of suitable habitat for the

inhabitants, leading to further range contractions (Pilliod *et al.*, 2012). The infiltration of additional invasive species can cause a collapse of other species, unintentionally.

Populations of frogs and salamanders have gone extinct from areas where fish have been introduced (Pilliod *et al.*, 2012). The pattern is apparent where fish were absent prior to human intervention. In various experiments, non-native, introduced fish have been removed, resulting in amphibian populations rapidly returning to sizes similar to those absent of fish. In study, they found that *A. macrodactylum* was less likely to breed in a water body if fish were present (Bahls, 1990; Tyler *et al.*, 1998; Pilliod and Peterson, 2001; Bull and Marx, 2002; Welsh *et al.*, 2006; Pearson and Goater, 2008). Fish and salamander larvae are both dependent on deep bodies of water to survive the winter. Therefore, the overlap has led to extinction of *A. macrodactylum* in deep water bodies where fish also inhabit (Tyler *et al.*, 1998; Pearson and Goater, 2009).

Amphibians and fish are greatly impacted by beaver ponds (Snodgrass and Meffe, 1998; Schlosser and Kallemeyn, 2000; Collen and Gibson, 2000; Skelly and Freidenburg, 2008; Metts *et al.*, 2009). Beaver dams create deep pools that allow for extended hydroperiods that allow for water-breeding amphibians to breed in slow moving water. (Romansic *et al.*, 2020). Birds receive access to open water for habitats, with up to five times a greater density (Nummi and Holopainen, 2014). Furthermore, a greater diversity of bird species can be found near active beaver ponds, compared to abandoned beaver ponds (Nummi and Holopainen, 2014). To understand how native salamanders and non-native fish interact, birds can be used as indicators.

Bird diversity and abundance are two important factors to understand how birds are reacting to environmental changes and health (MacArthur and MacArthur, 1961). Bird diversity measures the variety of different species in a sample area (MacArthur and MacArthur, 1961). On the other hand, bird abundance measures the density of birds in a sample area (MacArthur and MacArthur, 1961). Birds play an important role as a predator by being able to regulate populations of their diet organisms which influence predator-prey dynamics (MacArthur and MacArthur, 1961). Studying how birds react to environmental changes is important to understanding how the ecosystem is being impacted.

Methodology

Data Collection

Between July 13 and July 25, 2021, thirty beaver ponds were selected for observation (Figure 2). Ten ponds were selected for each predator type, including salamander, fish, and no predator. Site determination was based on searching for subalpine ponds with satellite maps. Ponds were accessed by trails and GPS software. Beaver ponds were selected for observation for their ability to host fish and salamander predators. Upon reaching each pond, a survey of the predator type was conducted. Once the predator and observation location were found, a 10 minute waiting period began. The period was established for birds to acclimate to the observer's presence. Then point counts began; at each spot, birds were observed for 15 minutes. During this time, all birds seen and heard were counted. The specific count of each species heard was not included. Each session was recorded with Voice Memos app on a mobile device, to use as a

future reference. If there were difficulties with identification, recordings were run through the Merlin ID app or compared to regional bird sounds. Unknown observations in the field were recorded and compared to the National Geographic Bird Field Guide. The process was repeated at each pond.

To ensure biosecurity safety, sterilization of all field equipment including shoes and waders were cleaned with a 10% bleach solution to ensure no transfer of chytrid fungus (*Batrachochytrium dendrobatidis*).

Statistical Analysis

All data was compiled into Microsoft Excel. Each bird species was identified and listed. The number of different species was compared to the type of predator in each pond using an ANOVA test in RStudio. Next, a Tukey's honestly significant difference test was conducted. The purpose of Tukey's was to test differences among sample means for significance.

Results

There was a significant difference in bird species diversity among ponds that varied in predator type ($F = 3.63$, $p = 0.039$; Figure 1). However, the Tukey test was unable to distinguish which of the treatments varied from each other, although several comparisons were marginally significant (Nothing-Fish: 0.06, Salamander-Fish: 0.07, Salamander-Nothing: 0.99), suggesting that ponds with fish had higher bird diversity than those with salamanders or no predator.

Discussion

Stocking fish does not show detrimental impacts to the environment. Surveyed fish ponds showed a higher range of the number of different bird species. This may suggest that stocking beaver ponds provide birds an ecological advantage or reliable food source. However, the majority of the birds observed were Passeriformes, where their diets consist of insects, seeds, and plants.

Salamander and no predator ponds had a similar mean, which could indicate that the decline of salamander ponds do not provide a significant ecological advantage for birds.

It was surprising to see that the non-native fish predator pond had the greatest number of different bird species. It poses questions about how the native bird species are reacting to the non-native species in the habitat. Are there new bird species coming into their non-native range, will that lead to competition between different species?

Three main other factors to investigate in a future study are (1) radius from observation point, (2) understanding tree canopy, and (3) depth of water. The radius of the observation point is important to understand where the birds are and influence on the studied ponds. However, figuring out how this would work with audio sounds is difficult. For example, at certain ponds, the American Three-toed Woodpecker was heard in the background. Understanding if the bird was located in the radius of the observation point would be difficult to understand. Another factor to incorporate into a future study would be understanding tree cover using a densiometer.

The tree canopy around each pond greatly varied, therefore this could influence the diversity of perching birds in the area. Lastly, understanding the shoreline and depth of the water is a significant factor because different birds will inhabit those areas. For example, the Spotted Sandpiper was found in ponds that were observed to be shallow. In an environment, where the canopy and vegetation was similar, but the pond depth was deeper, there were no Spotted Sandpipers.

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Tables and Figures

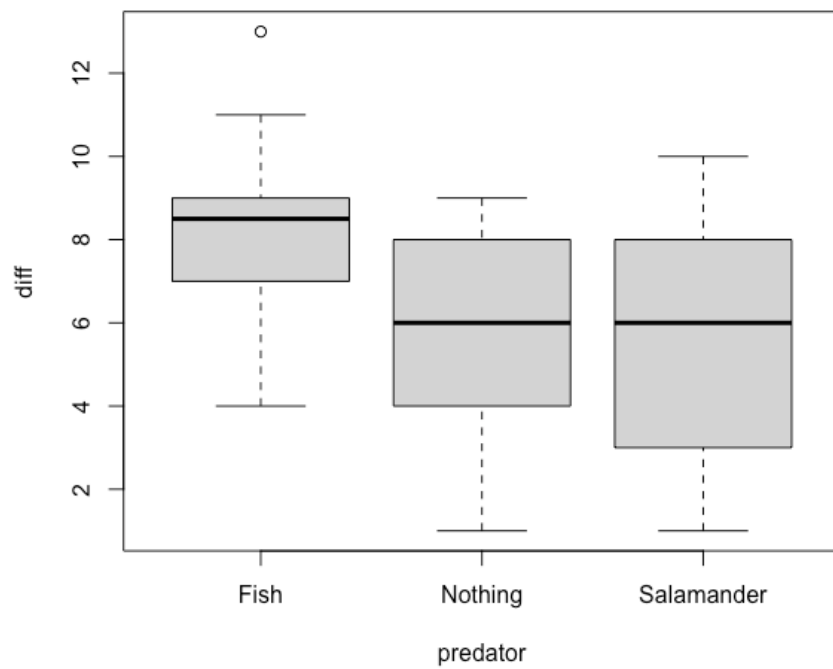


Figure 1: Boxplot comparing the different number of bird species observed versus the type of predator. Each thick black line represents the mean value.

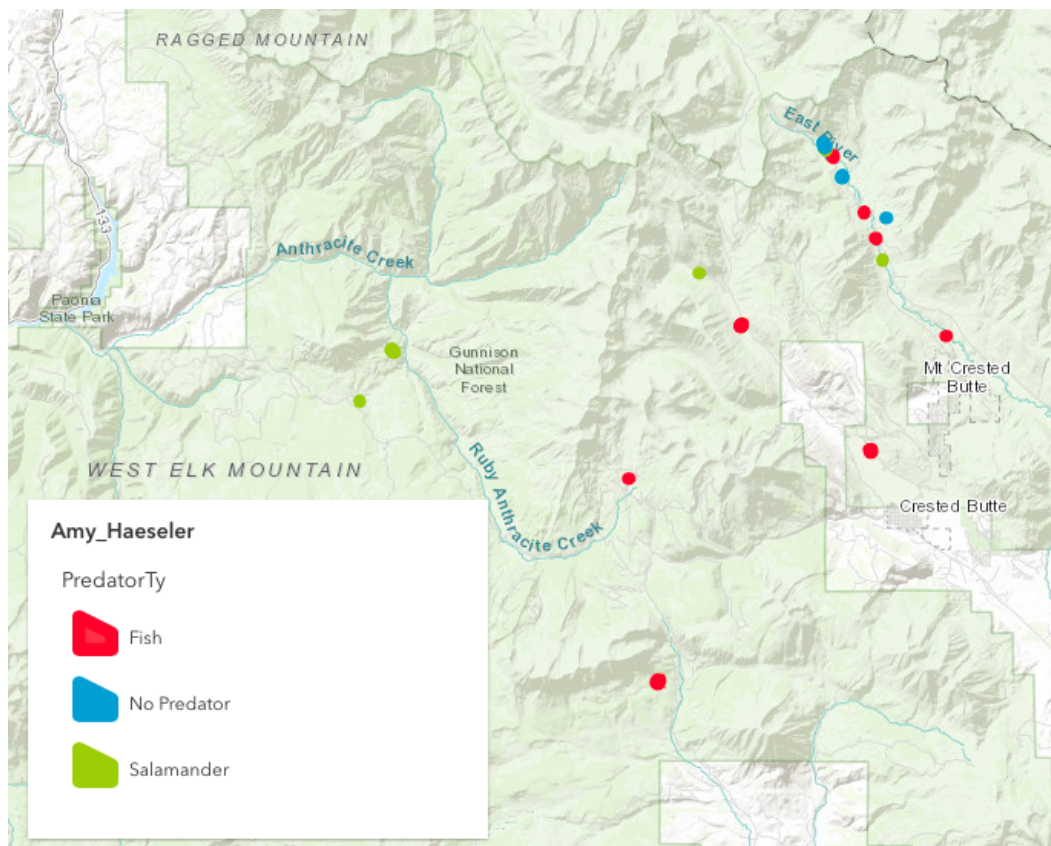


Figure 2: Map of all 30 observation sites around the Gunnison Basin. Each different color represents the type of predator found in each pond.

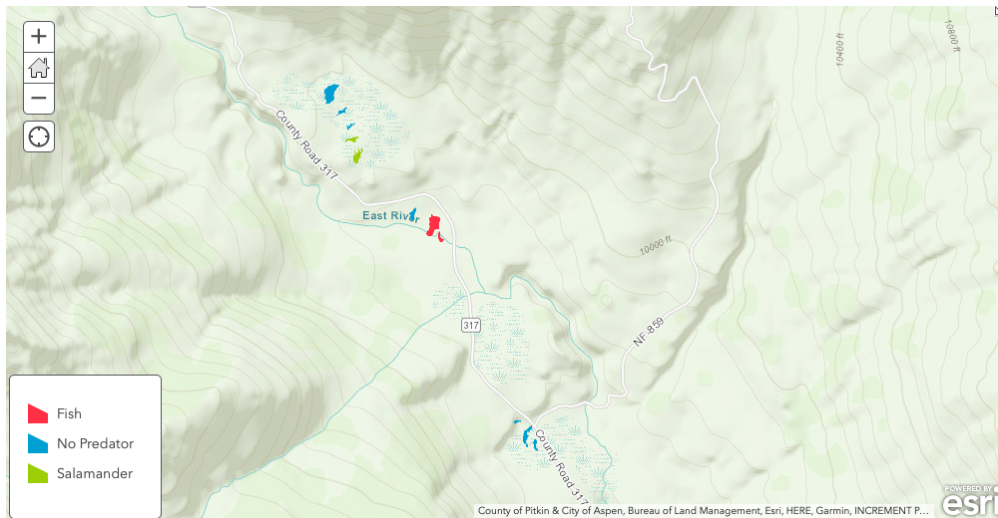


Figure 3: A closer look at the Upper East River Valley pond locations. Includes Bellview #2, Bellview #3, Bellview #4, Belleview #5, Bellview #1, Thistle #1, Thistle #3, Thistle #2, Trailriders #2, Trailriders #1, and Trailriders #3 (from top to bottom).

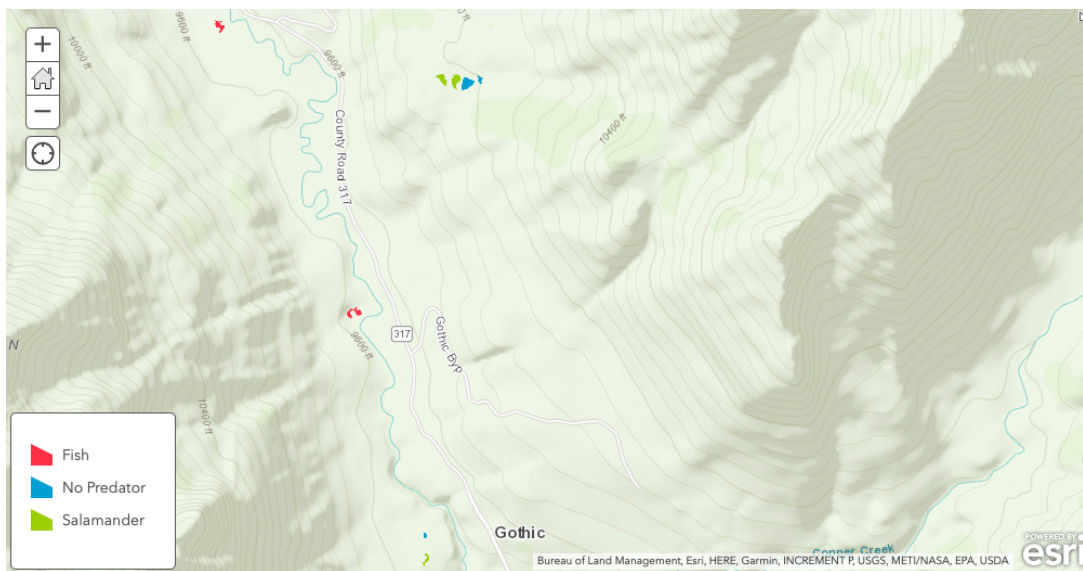


Figure 4: A closer look at the Upper East River Valley pond locations. Includes East River Valley #2, 401 #4, 401 #3, 401 #2, 401 #1, East River Valley #2, Mammal Lab #1, and Mammal Lab #2 (from top to bottom, left to right).