The effect of beaver dams on salmonid Abundance in the West Branch of the Maple River

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EEB 392 - Natural History and Evolution
August 15, 2018
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Abstract

The effects of the North American beaver, *Castor canadensis,* on stream ecosystems has been a contentious subject for many wildlife managers. Some studies suggest negative impacts on fish salmonid communities, whereas other studies have found the opposite. The goal of this study was to determine if beaver dams in a small Michigan stream increased or decreased salmonid abundance. Using a non-invasive observational approach, two different sections of the West Branch of the Maple River were sampled, one stretch containing five beaver dams and the other stretch containing none. It was found that salmonid abundance did not differ significantly between dammed and dam-free stretches of the river. Beaver dams in this specific stream appear to be a benign factor when considering salmonid abundance, which suggests that beaver dams do not need to be removed in order to maintain a healthy salmonid community. With regards to practical applications of said research a wildlife manager armed with this information can make more informed decisions when deciding how to properly manage streams similar to the West Branch of the Maple River.

Introduction:

Beaver dams are known to change the hydrological processes of streams (Collen & Gibson, 2001), however, a more indirect and far more contentious topic is their effects on stream fisheries. Some managers support the removal of beaver dams which are thought to have negative impacts for many of the sought-after game fish species such as salmonids. Others align with the notion that beaver dams and trout have coexisted for a long time, meaning that beaver dams do not negatively affect salmonid populations. Both sides have evidence to support their claims, but the inherent unique nature of every stream and dam is different, which is where the third party would state individual research must be conducted to conclude the effects of a particular dam in a specific river. Regardless of which argument one aligns with the answers at stake are vital to the proper management of the associated rivers fisheries and beavers.

Long before man built dams in the streams of North America, North American beavers, *Castor canadensis*, a semi-aquatic plant eating mammals built lodges and dams throughout the continent's network of streams and lakes (Hill 1982; Novak, 1987; Nolet, 1996). Historically, they were very abundant, being one of the main drivers of the North American fur trade. Beavers are commonly considered ecosystem engineers: species that create, modify or maintain habitats (Jones et al. 1994). This title comes from their ability to fell large trees and dam up streams (Wright et al. 2002, Müller- Schwarze 2011). Their ability to dam up streams allows them to alter the hydrological processes of a stream, potentially altering the depth and even course of the stream in proximity to the structure. These alterations affect not only the stream but also the surrounding riparian zone (Collen & Gibson, 2001).

Beavers won't build dams in streams within order above 4, and many prefer 1st or 2nd order streams(Collen & Gibson, 2001), this means beavers prefer to build in headwaters over downstream habitats. Many of these 1st and 2nd order headwater streams are also home to popular coldwater sportfish such as brook trout, *Salvelinus fontinalis*, and brown trout, *Salmo Trutta*. Beaver dams are a potential concern for anglers because of their hydrological, chemical and thermal effects on the stream, all of which can potentially affect the fish community. One such concern is that as the beavers dam up the rivers, and the habitat shifts from more dynamic to static conditions, species more adapted for lentic conditions such as centrarchids will be better able to displace trout (Collen & Gibson, 2001). Although this seems feasible, it has been shown that brown trout and brook trout may actually benefit from the impoundments created by beaver dams, and this can create fishing opportunities (Gibson, 1993). Another benefit of beaver dams is that trout have been known to overwinter in their impoundments, or the reservoir found on the upriver portion of their dam (Cunjak, 1996). An important caveat to these attributes is that beaver dams seem to have positive effects on fish communities in higher altitude, high relief streams, meaning streams which encounter significant elevation change from headwaters to the mouth, and negative effects on low altitude, low relief streams (Collen & Gibson, 2001). Some areas where beaver dams have been noted as advantageous for salmonids include: California (Gard, 1961), Colorado (Neff, 1957), New Mexico (Huey and Wolfrum, 1956), Utah (Rasmussen, 1941), Wisconsin (Patterson, 1951) and Wyoming (Grasse and Putnam, 1955). In contrast, beaver dams have been considered harmful in Maine (Hodgdon and Hunt, 1953), Michigan (Bradt, 1947) and New York (Bump, 1941). It has been shown that beaver dams could be considered harmful to sportfish in Michigan streams; however, there is conflicting literature on both sides of the contention. For example Shetter and Whalls (1955) found that the natural deterioration of a beaver dam in Michigan was so detrimental to fishing that the Department of

Natural Resources(DNR) manually reinstated the dam. It has been noted that beaver dams can create salmonid fishing opportunities in some streams but reduce them in others, so there must be careful research on the effects of beaver dams in any particular stream (Hale 1966). The relationship between beaver dams and fisheries complicates management for both the beavers and fishes (Cook 1940). Diligent research should be conducted on the effects of beaver dams to give wildlife managers the information they need to make decisions.

The main species of interest in this study is brook charr, *Salvelinus fontinalis,* commonly referred to as a "brook trout". The genus *Salvelinus* also contains the lake trout, *Salvelinus namaycush,* as well as potentially the most variable species of vertebrate in the world: the Arctic charr, *Salvelinus alpinus* (Klemetsen, 2013). The genus *Salvelinus* appears to have diverged from the main branch of Salmonidae during the Oligocene and the Miocene, 16–25 million years ago (Grewe et al., 1990; Osinov and Lebedev, 2004; Crête-Lafrenière et al., 2012; Shedko et al., 2013). It appears that the common ancestor of the brook charr and lake trout diverged from the rest of the genus *Salvelinus* approximately 5 million years ago, with speciation occurring approximately 2 million years ago (Esin & Markevich, 2018). The first appearance of the North American beaver appears to have taken place approximately 9-4.9 million years ago (Rybczynski, 2007; Flynn & Jacobs, 2007; Lindsay et al., 1984; Hugueney & Escuillie 1996; Xu, 1994; Lychev, 1983). According to these dates, beavers and brook trout have coexisted for at least 2 million years. This sets up the context for at least 2 million years of coevolution.

A paradox that should be noted is: If beaver dams do negatively effect trout abundance how would they have coevolved for more than 2 million years without displacement or extirpation? This idea was kept in mind when formulating predictions and hypothesis for the effects of beaver dams on trout communities.

In this study I used non-invasive observational techniques to gather information on trout abundance and spatial distribution in relation to the proximity of beaver dams in a Northern Michigan stream. My hypothesis was that there would be more trout found in the stretch of the river containing beaver dams, on top of this it was also hypothesized that more trout would be found in proximity to beaver dams. This hypothesis is based upon the anecdotal observation made in said stream, as well as literature which provides examples of the advantages of beaver dams, such as the deeper pools created which provide refuge for fish in low flow conditions, as well as act as an important overwintering location. The Dam's themselves could serve as shelter for trout and protect young Fry and parr from predation, as well as providing structure to stage around when feeding.

Methods:

I chose the West Branch of the Maple River as my study site, a tributary to the Maple River in Emmet County, MI in the Cheboygan River watershed. The headwater portions of the stream contain many active beaver dams. The lower portions of the stream are clear of beaver dams and were used as the control, free of beaver dams. The headwater stretch was closer to the source, located just west of the Pellston airport. Six beaver dams were located in the headwater stretch. Between the six beaver dams the river was split up into 5 sections, (Figure 1). Three of the sections were intradam regions between beaver dams that were in proximity (1A, 1C, 1E). Two of the sections were interdam regions (1B, 1D), longer stretches in between the intradam sections.

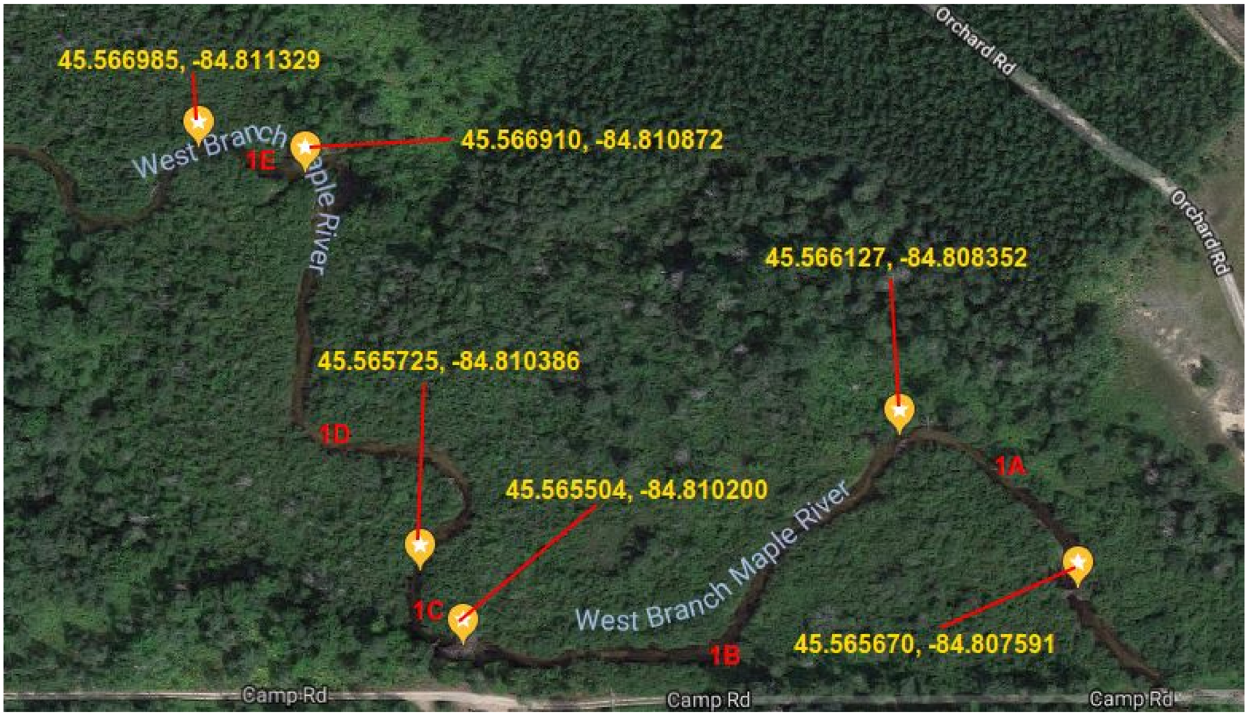

Figure 1he headwater stretch of the river, with the Sections 1A-1E in Red and the coordinates of all of the beaver dams.

The control stretch of the river was set up approximately 4.7 kilometers downstream of the headwater stretch. Measurements were done using satellite images and Google maps. The control stretch was partitioned into five sections, (Figure 2) with lengths corresponding to those of the headwater sections.

Figure 2

The five control sections (2A-2E) as well as the coordinates from which the survey started in yellow, with the coordinates of the end of the stretch in red.

The dependent species of interest in this study were the brook trout, and brown trout. Although, rainbow trout, *Oncorhynchus mykiss,* are known to inhabit the West Branch of the Maple River they are much less prevalent than brook and brown trout. However, all three salmonid species were included in the survey.

The survey itself was conducted using a GoPro Hero 5 black edition mounted on a 1 meter long rod. The camera started to record and was submerged at the beginning of each section. The camera was held underwater pointing towards locations likely to hold trout and each section was recorded at a uniform pace. Every survey, both headwater and control, was started from the most downstream location and continued upstream. The surveys themselves were conducted in pairs, both the headwater and control, on the same day at approximately the same time in order to control for changes in daily temperature and weather. After a survey the stretches of the river were allowed at least 24 hours with no contact.

Upon completing the video surveys, the footage was carefully inspected for trout. Other fish, such as cyprinids, were ignored. All trout were counted, from fry to adults. Every section of both stretches had a corresponding video survey which allowed me to count the number of trout observed in each section.

Results:

Table 1. Mean(± SE) number of salmonids compiled from three surveys of the control and the headwater study locations. Spit into Intradam(A,C,E) sections between beaver dams close in proximity, and Interdam(B,D) sections between more distant pairs of beaver dams.

Headwater				**Control**			
Intradam		**Interdam**		**Intradam**		**Interdam**	
Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
4.77	**3.49**	**8.5**	**2.42**	**5.77**	**3.66**	**9.66**	**3.14**

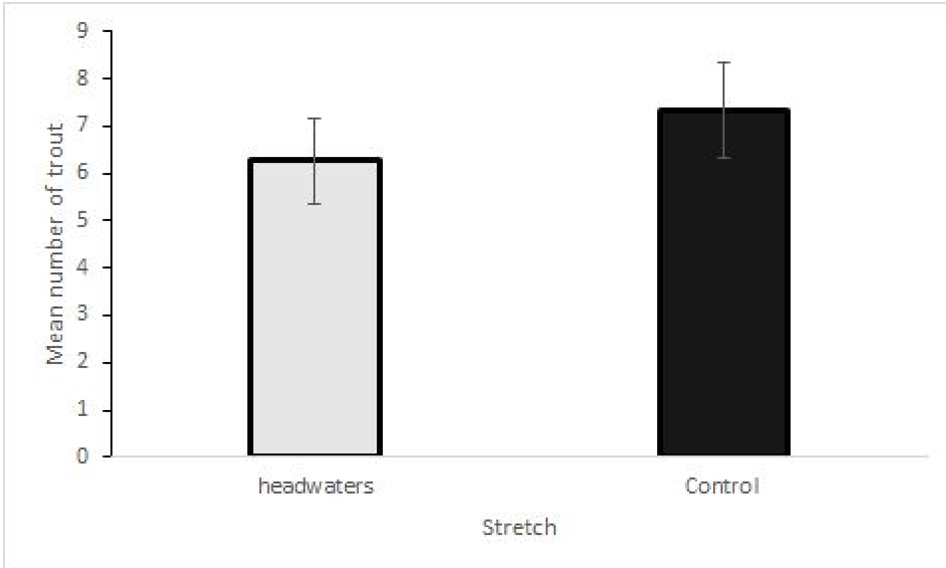

Figure 3. Depicts Mean(± SE) number of salmonids observed between headwater and control stretches(n=30).

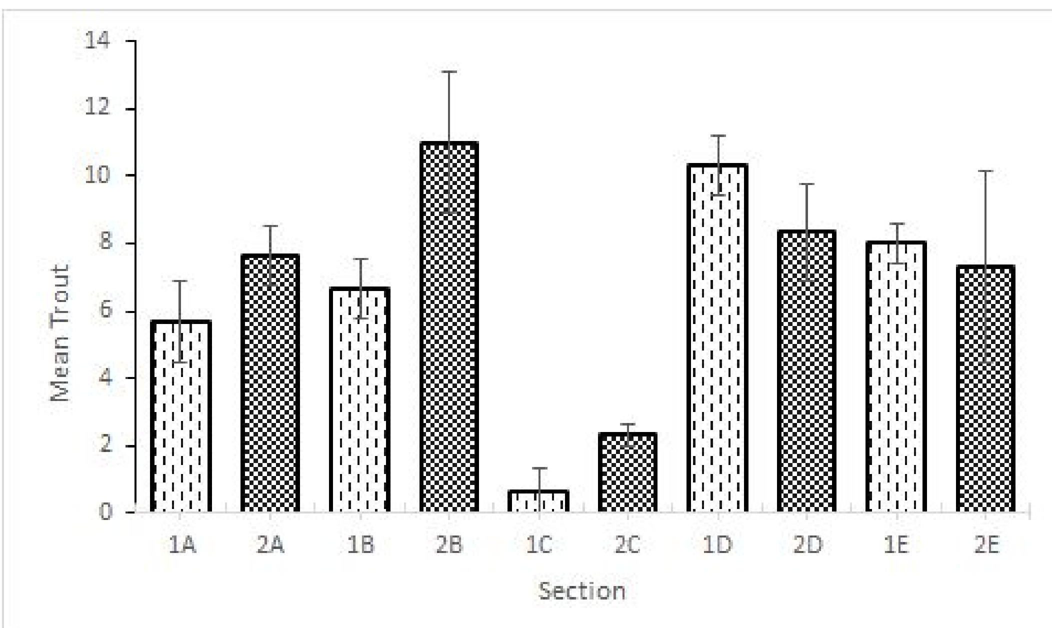

Figure 4. Mean(± SE) number of salmonids observed in each section of the river during three Trials(n=30). Dash lines=headwater Stretch, checkered=Control Stretch. (A,C,E)= intradam sections, (B,D)=Interdam Sections.

The mean numbers of trout was higher in the control stretch of the river overall (Figure 3). Based upon WILCOXON test for all 3 comparisons there was no statistical difference between the salmonid abundance in the control vs the headwater stretch, as well as intradam and interdam sections(P>.05). The C section of both stretches was visually much smaller than every other section(Figure 4). There was also no statistically significant difference between the mean number of salmonids found between intradam and interdam sections of the stream(Wilcoxon, P>.05).

Discussion:

Initially my prediction was that beaver dams increased salmonid abundance in their proximity, because it increased viable habitat for them to seek refuge and forage. Contrary to this to prediction, I found that there was actually no statistically significant difference between the abundance of salmonids found in stretches of the river with beaver dams compared to stretches that are dam free. There was also no statistically significant difference between the mean number of salmonids found between intradam and interdam sections of the stream.

Generally, it has been found that beaver dams negatively impact salmonids in low relief streams (Bradt, 1947; Collen & Gibson, 2001). The majority of Michigan's streams, including the West Branch of the Maple River fit into this low relief category. However, every stream is unique and individual dams can have various effects, positive or negative, on salmonid composition and distribution. This was highlighted in a Michigan stream, in which a study to found that the deterioration of a beaver dam was so detrimental to the fishery that they artificially restored the dam (Shetter and Whalls, 1955). These results coincide with the fact that beaver impoundments are known to be vital with regards to the salmonid survivability under extreme weather conditions (Cunjak, 1996; Gibson, 1993)

One study found that beaver dams have altered the macroinvertebrate community, both above and below them, within the West Branch of the Maple River (Rahn, 2012). Although this could potentially affect salmonids, it is known that salmonids have a very diverse diet and are opportunistic predators (DNR, 2012). Secondly the pools created on the upstream side of beaver dams are thought of as vital habitats for salmonids, important for overwintering and very important in times of low flow (Kemp et al 2012). One of the main concerns with beaver dams is their permeability to fish, with some dams acting as size-selective barriers and others that are almost entirely permeabile (Rahn, 2012). Considering the fact that brook trout are one of the smaller species of salmonids, it is plausible that brook trout may be able to penetrate and pass through dams more effectively than their larger counterpart, brown trout. These ideas were considered when formulating my initial prediction, although in light of all of the research it appears that beaver dams in this specific stream do not appear to, negatively or positively, affect salmonid abundance in the West Branch of the Maple River.

The results obtained in this study coincide with some research and contradict others, which highlights the contentious nature of the subject. One paradox that should be addressed is that if brook trout were in fact negatively affected by beaver dams, how would they have coevolved in proximity for more than 2 million years without displacement, and or local extinction? This was the main idea that the prediction that beaver dam's increase trout abundance resulted from.

It was also noted that during the survey, various cyprinids and Catostomids were observed, mainly creek chubs, *Semotilus atromaculatus,* and Northern hogsuckers, *Hypentelium nigricans,* which have both been noted as species that can competitively displace trout, specifically under warmer thermal regimes (Bailey and Stephens, 1951). This could potentially lead to the near uniform salmonid distribution observed, causing salmonids to spread out along the stream in order to avoid competition. It's also worth noting that the creek chubs noted were often in schools, and there wasn't any individual larger than approximately 10-12cm. Whereas the northern hogsuckers observed were much larger, as long as 30cm. This would lead me to predict that the creek chubs, probably pass through beaver dams in a similar fashion to small brook trout.

Another aspect of the study that deserves mention is the actual species of salmonids that were seen. The study itself really focused on the main salmonid found in the West Branch of the Maple River, the brook trout. However, it is known that brown trout and the less common rainbow trout also inhabit the stream. When counting the number of trout in each section it was nearly impossible to determine the species of salmonid, with each and every salmonid only captured on video for fractions of a second before they darted off to cover. We must realize that both rainbow trout and brown trout were introduced to these ecosystems about 150 year ago, so they could confound my results if I wanted to look at the effects of beaver dams on exclusively brook trout. The interactions of these species of trout with beavers and their dams is a relatively new phenomenon in North America and warrants more research.

The ecosystem that beavers and salmonids now occupy if far different from the untouched ecosystems in which both species coevolved. The ecosystem has seen significant changes in floral and faunal compositions as well as a new abiotic regime such as increased temperature and increased atmospheric carbon dioxide. It would be impossible to study the interactions between native salmonids and beavers now that the ecosystem has been altered. However, both salmonids and beaver persisist, nevertheless. Considering future repercussions of current human processes, the current study of ecology as well as the evolutionary background of beavers and salmonids is invaluable information with regards to preservation and management. Although our streams are forever altered, informed decision making and smart management will preserve these ecological interactions for future research and admiration.

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