The Effects of Beaver Dams on Trout Habitat in the West Branch of the Maple River

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Abstract: Managing river systems for both trout and beaver is a complex task. We surveyed beaver dams along the West Branch of the Maple River, Emmet Co., MI to determine if dams had a negative effect on trout habitat in this river. We sampled dissolved oxygen, temperature, and macroinvertebrate communities above and below dams. No significant difference was found in dissolved oxygen levels or in water temperature above or below dams. There was no significant difference in the diversity of macroinvertebrates above or below dams or in the EPT values above or below dams. However, there were significantly more collectors below dams than above. There was also a significantly higher abundance and taxa richness of macroinvertebrates below dams. Our study suggests that beaver dams do not have a negative impact on trout habitat in the West Branch of the Maple River.

Introduction:

River management is a complex issue that must take into consideration the changing wants and needs of multiple interest groups (Tonello et al 2012). Pressure for management comes from a variety of public sources, from environmentalists to anglers. Complicating river ecosystem management is the combination of beaver and trout in riverine habitats and the unresolved assumption that beaver affect trout habitat either positively or negatively. The link between beaver and trout can complicate management plans for both species (Cook 1940) because beaver are ecosystem engineers that can have strong effects on streams.

Beaver build dams in order to create deep pools where food can be stored (Kurta 1995). Sediment builds up behind the dam (Colleen and Gibson 2001) and ponds flood into nearby woodlands, creating a large lentic habitat (Hagglund and Sjoberg 1999). Water can be warmer in these pools as dams may decrease river shading (Collen and Gibson 2001). Beaver dams have been shown to negatively affect water chemistry above the dam (Tonello et al), but also may stabilize hydrological effects and water temperatures downstream (Collen and Gibson 2001).

These changes in stream dynamics alter macroinvertebrate communities (Pliuraite and Kesminas 2012). Because of the differences in lotic and lentic habitats, dominant taxa usually vary above and below dams (Margolis et al 2001) and taxa above dams come to resemble those of natural lentic areas in larger streams (Naiman et al 1988). For example, the abundance of the orders *Ephemeroptera, Plectoptera*, and *Trichoptera* (EPT), the proportional abundance of which are often used to measure water quality, are usually lower above dams due to lotic conditions and habitat homogeneity caused by sediment deposition.(Collen and Gibson 2001). In contrast, the abundance of *Diptera*, especially *Chironomidae* , increases above dams because of this habitat change (Collen and Gibson 2001). Changes in habitat and the resulting distribution of taxa will likely change the diversity above and below dams. Dams may also reduce total macroinvertebrate density (Tonello et al 2012).

This change in habitat also affects the distribution of macroinvertebrate functional feeding groups. Beaver ponds and dams often contain a high number of collectors because of an increase in fine particulate organic matter; shredders are not usually found in beaver ponds because of lentic conditions (Collen and Gibson 2001).

Beaver mediated changes in physical habitat can impact fish populations. For example, beaver often coexist with trout species and their effects on trout habitat are complex. Sedimentation upstream of beaver dams has the potential to negatively affect species such as brook trout(*Salvelinus fontinalis)*, that require shallow gravelly areas with a continuous flow of oxygen for spawning (MDNR 2012). Both the loss of spawning habitat and increased water temperature upstream of dams may negatively affect brook trout spawning (Cook 1940). The presence of beaver dams may also block fish migration to upstream spawning sites(Tonello et al 2012). In contrast, beaver dams may positively affect trout populations as the dam itself may provide cover for fish, and pools provide habitat for larger fish and more angling opportunities for humans (Colleen and Gibson 2001)

Beaver and trout share a complex history in terms of management. Beaver were once common throughout North America, but excessive fur trapping beginning in the seventeenth century caused the near extinction of the species by 1900 (Naiman et al 1988). In 1920, a hunting ban on beaver was established in the state of Michigan. As populations stabilized, balancing management of beaver populations with trout populations rose to the forefront, with limited trapping of beaver legalized in 1934 (Bradt 1935). Literature shows that the controversy of managing riparian for either trout or beaver dates back at early as 1935 (Brady 1935,Cook 1940). For example, in 1935, over 4,000 beaver dams were removed throughout Michigan to improve fish habitat (Bradt 1935). In 1935, it was suggested that, rather than choosing between beaver or trout, the question which needed addressing was how to control beaver populations in trout streams. Bradt (1935) suggested that management should focus on supporting the largest possible beaver populations without interfering with trout fishing.

This management philosophy is still in place today. The MDNR's Beaver Management Policy, activated in 2001, is based on managing beaver and trout habitat for human use. They focus on protecting rarer habitats and resources, in this case high quality coldwater steams needed for trout, while maintaining the rarer natural resource, an abundant beaver population. This modern policy is focused on protecting trout populations largely because of public pressure from anglers (Tonello et al 2012).

Our study focused on beaver effects on cold water trout streams as we surveyed beaver dams on a section of high quality trout stream in northern Michigan. The West Branch of the Maple River is a 16 mile tributary to the Maple River in Emmet County, MI in the Cheboygan River watershed. This river has

Type 1 trout stream regulations, including an eight and ten inch minimum size limit for brook and brown and for rainbow trout, respectively and a daily possession limit of five fish. This river has been managed for trout since 1938. The West Branch Maple River has a large population of brook trout with high fish growth rates (Godby 2010). Currently, the steam is not stocked with trout but the river is managed for naturally reproducing trout populations (Godby 2010). There is concern that there may be an overabundance of beaver in the West Branch Maple River and our survey aims to both determine how many beaver dams are present and how they affect the stream. We hypothesized that beaver dams will affect both water quality and macroinvertebrate abundance and community. Specifically, we hypothesize that:

i. dissolved oxygen (DO) levels will be higher below dams than above dams.
ii. average water temperature will be higher above dams than below dams.
iii. water quality, as measured by the EPT index will be higher below dams than above dams.
iv. macroinvertebrate diversity will be greater below dams than above dams.
v. the macroinvertebrate collectors will be more abundant above dams than below.

Methods:

Study Site

We surveyed beaver dams on the West Branch of the Maple River in Emmett County, MI near the town of Pellston from Camp Road to E31 (Figure 1). We walked the river downstream until we came to a dam, where we collected data. All data was collected between 7/19 and 7/31, 2012.

Physical and Chemical Characteristics

We recorded the location of each dam using a GPS and determined if the dam was active or inactive. Dams that showed signs of recent upkeep, including fresh cuts of green wood in the dam, were considered active. The width of each dam was measured from bank to bank. The water depth below stream of the dam was measured as well as the height of the dam from the surface of the water. These two measurements were combined for total dam height. Additionally, we collected dissolved oxygen levels and water temperature above and below each dam using an YSI dissolved oxygen meter.

Macroinvertebrate Sampling

We sampled for macroinvertebrates at each active dam. Using kick nets, we thoroughly sampled macroinvertebrates for 10 minutes each above and below dams, distributing our efforts equally among habitats. Macroinvertebrates were then placed in Whirlpacks with water and returned to the lab. At the lab, macroinvertebrates were sorted and stored in 95% ethanol. Insects were identified to family groups, except in the case of Oligiochaeta, which were identified to order. We also identified functional feeding groups (FFG) of all macroinvertebrates. Unidentifiable emerging dipteral larvae were excluded from data analysis.

Statistical Analysis

A one-tailed t-test was used to compare dissolved oxygen (mg/L) values above and below dams. Water temperature (in C) above and below dams were also compared using a one-tailed t-test. The average total abundance of functional feeding groups was determined for above and below dams for each of five FFG: filtering collector, gathering collector, predator, scraper, and shredder. The means of each of these FFGs for above and below dams were compared using a two-tailed t-tests. Gathering collectors and filtering collectors were also combined into a larger collector group; the means for above and below dams were compared using a one-tailed t-test. The proportion of *Ephemeroptera*, *Plecoptera*, and *Trichoptera* (EPT) present at a dam was used as a measure of water quality, with a higher EPT number representing higher water quality. The average EPT value for above and below dams were calculated and these means were compared using a one-tailed t-test.

Average taxa richness (S) was calculated above and below each active dam sampled, where S = the total number of taxa present in an area, and were compared using a two-tailed t-test. In this study, taxa is defined as either family or order in the case of Oligochaeta. Average total macroinvertebrate abundance was determined above and below dams; these means were compared using a two-sided t-test. Shannon's diversity (H') indices were also calculated for above and below each dam sampled. The average H' of macroinvertebrates was calculated for above and below dams. A one-tailed t-test was used to compare these means.

Results:

Physical and Chemical Characteristics of Dams

Seven dams were located between Camp Road and East 31 (Figure 1). Six dams were active and one dam was inactive (Table 1). These dams ranged in width from 7.10 m to 14.38 m and in total height from 64 cm to 133 cm.

The average dissolved oxygen above dams was 8.56 mg/L and the average below was 8.62 mg/L (Table 2). Oxygen levels did not differ significantly above and below dams ($t=1.78$, $df=12$, $p=0.28$). The average water temperature above dams was 19.56 C and the average below was 19.24 C (Table 2).

There was no significant difference in water temperature above and below dams (t=1.78, df=12, p=0.41).

Macroinvertebrate Survey

Thirty-nine taxonomic groups were found in this survey. Six distinct taxa were found above dams including the family Caenidae (Table 3) Fourteen distinct taxonomic groups were found below dams in including the family Hydropsychidae (Table 4) .Twenty taxonomic groups were found both above and below dams (Table 5).

Gathering collectors were the most abundant of the five identified functional feeding groups both above and below dams (Figure 2, 3). There was no significant difference in average number of filtering collectors (t=2.77, df=4, p=0.17), gathering collectors (t=2.23, df=10, p=0.09), predators (t=2.36, df=7, p = 0.52), scrapers (t=2.57,df=5,p=0.18)) or shredders (t=2.23, df=10, p=1.00) above and below dams. However, when gathering collectors and filtering collectors were combined into one functional feeding group, the average number of collectors was significantly higher below (42.17 individuals) dams than above dams (15. 67 individuals) (t=1.81, df=10, p =0.01) (Table 4).

Though EPT tended to be higher below dams (51.8 %) than above (31.5%), the difference was not significant (t=1.81, df=10, p=0.07) (Figure 5). This indicates that there is a not a significant difference in water quality above and below dams.

Trends suggest diversity (H') is greater below streams (H' = 2.10) than above (H' = 1.81); however, there was no significant difference in average diversity above or below dams (t=1.81, p=0.07,df=10) (Table 6, Figure 6). Taxa richness was significantly greater below dams (13.00 taxa) than above dams (9.17 taxa) (t=2.23, df=10, p=0.02) (Table 6, Figure 7). Macroinvertebrate abundance was also significantly greater below beaver dams (67.33 individuals) than above dams (26.50 individuals) ($t=2.23$, $df=10$, $p=0.03$) (Figure 8).

Discussion:

Overall, we found that beaver dams affected stream dynamics but not as we had originally hypothesized. Counter to our hypotheses, dissolved oxygen was not significantly lower above dams and water temperature was not significantly greater above dams. Rather, dissolved oxygen levels and water temperature were stable above and below dams. Dams affected the macroinvertebrate communities, though not in ways we expected. There was not a significant difference in the distribution of any of the five functional feeding groups or in EPT values above and below dams. There was also not a significant difference in macroinvertebrate diversity values above and below dams, though trends suggest a greater diversity below stream. However, there was a significant difference in the number of collectors, taxa richness, and abundance above and below dams, all of which were greater below dams.

Collen and Gibson (2001) found that the effects of beaver dams on water temperature are highly variable by site because they are influenced by shading, groundwater input, and steam flow (Collen and Gibson 2001). The pools created by the dams we surveyed were surrounded by vegetative cover which likely provided shade and kept the pools cool. Had water temperatures proved warmer in ponds, intensive management practices such as dam removal may have proven ineffective as removing dams generally does not substantially reduce water temperature in streams (McRae and Edwards 1994). Bledzki et al (2011) found that dissolved oxygen levels were higher above dams than below due, in part, to an increase in CPOM. It may be that our pools have less CPOM, as also suggested by the lower number of collectors found above our dams, that results in a stabilized DO level above and below ponds.

There was not a significant difference in the distribution of any of the five functional feeding groups above and below dams. However, when filtering collectors and gathering collectors were combined, there were significantly more collectors below the dam, counter to our hypothesis. We suspected that ponds above the dam would have a greater abundance of collectors because coarse, particulate, and dissolved organic matter build up in beaver ponds and provide a food source for collectors (Collen and Gibson 2001). However, the ponds we sampled had fine, mucky substrate that was relatively homogenous while areas sampled below dams had multiple substrate types including gravel, cobble, and sand. It may be that the habitat heterogeneity below the dams provided a greater number of habitats for collectors.

We found no significant difference in EPT values above or below dams. This decrease in water quality is also likely caused by beaver-induced habitat changes above and below the dams. Studies indicated that the total number of emerging Ephemeroptera and Plecoptera was reduced above dams as many members of these orders require lentic conditions (Collen and Gibson 2001). Piluraite and Kesminas (2012) also noted a lower number of Ephemeroptera and Trichoptera individuals and a decrease in water quality above dams. Additionally, studies indicate that the total number of Ephemeroptera, Plecoptera, and Trichoptera is higher below dams (Collen and Gibson, 2001), as is water quality.

We found no significant difference in species diversity above or below dams. These findings are supported by Margolis et al (2001), who found no difference in taxa diversity. Unlike Margolis et al (2001), who found no difference is taxa richness, our study showed significantly higher taxa richness below dams. This finding is supported by Piluraite and Kesminas (2012) who also found a decrease in species richness above dams. It is likely that our increase in taxa richness below dams is caused by the observed increase in habitat heterogeneity, as studies suggest that taxa richness increases with habitat heterogeneity (Piluraite and Kesminas 2012). Our observed increase in abundance below ponds is likely caused by this same increase in habitat heterogeneity.

These finding indicate a change in the composition of the macroinvertebrate community above and below dams. These changes in the macroinvertebrate communities above and below dams reflect changes in the ability of different macroinvertebrates to handle the more lentic habitats of beaver ponds (Maryolis et al 2001). This is demonstrated by the different taxa found above and below dams. For example, Hydropsychidae is a family of net-spinning caddisflies in the order Trichoptera. They are collectors who are limited to areas of cobble with a fast flow of water (Bouchard 2004). We found Hydrospsychidae below the dams in the river but not above because they cannot tolerate the slow currents and mucky substrate of the beaver pools. Conversely, Caenidae are a family of the order Ephemeroptera that we found in the beaver ponds but not below the dams. These collectors are adapted to thrive in areas of low current, and are unable to live in the fast currents below dams (Bouchard 2004).

All of these findings have impacts on trout. Stable water temperatures and dissolved oxygen levels mean that trout are not negatively affected by a low oxygen level or warmer water temperatures in pools. The shift in macroinvertebrate communities above and below dams results in a shift in available food sources for trout. However, trout feed on large numbers of aquatic macroinvertebrates, including Ephemeroptera, Plecoptera, and Diptera; worms, zooplankton, terrestrial insects, and other fish (DNR 2012). Their diet is versatile, and they will generally consume any available food sources (DNR 2012), so this shift in community may not necessarily limit feeding.

Several other considerations for trout habitat exist which were not sampled in this study. These include the loss of spawning grounds due to sedimentation build up behind dams, an increase in the number of pools in a pond, and the obstruction of fish movement by dams (Collen and Gibson 2001). While sediment build up directly behind dams may cause the loss of some spawning grounds, it may conserve others. Sediment trapped behind dams is unable to transfer downstream so that gravel spawning grounds further downstream are protected (Kemp et al 2012). Secondly, pools can provide a refuge for fish in winter months or in droughts due to weak currents, deep water, and stable temperatures (Kemp et al 2012). Finally, the effects that dams have on fish movement are not easily predicted. Fish can become stuck at dams which seem passable or they may pass through dams which would appear to block movement. Dams are generally considered to be semi-permeable, meaning some proportion of fishes is able to pass through them in both directions (Kemp et al 2012).

Much of our understanding of stream ecology comes from research which began long after stream ecosystems were altered by the removal of beaver. What we know may not accurately represent the 'natural' state of stream ecosystems which include beaver (Naiman et al 1988). Dams are not always necessarily harmful to trout (Collen and Gibson 2001), and in some instances, artificial dams mimicking those created by beaver are even installed in streams to improve trout habitat. These dams provide shelter, deep pools, and an increase in macroinvertebrate food sources for trout (Gard 1961). Additionally, beaver ponds allow access for fishing where otherwise few might exist (Collen and Gibson 2001). We conclude that, at least for the West Branch of the Maple River, dams may not negatively impact trout. However, it should also be noted that this study surveys only a small portion of the West Branch Maple River, the results of which are extrapolated to the river as a whole. We recommend that no drastic change in management is needed at this time as current management practices appear to effectively balance the needs of both trout and beaver.

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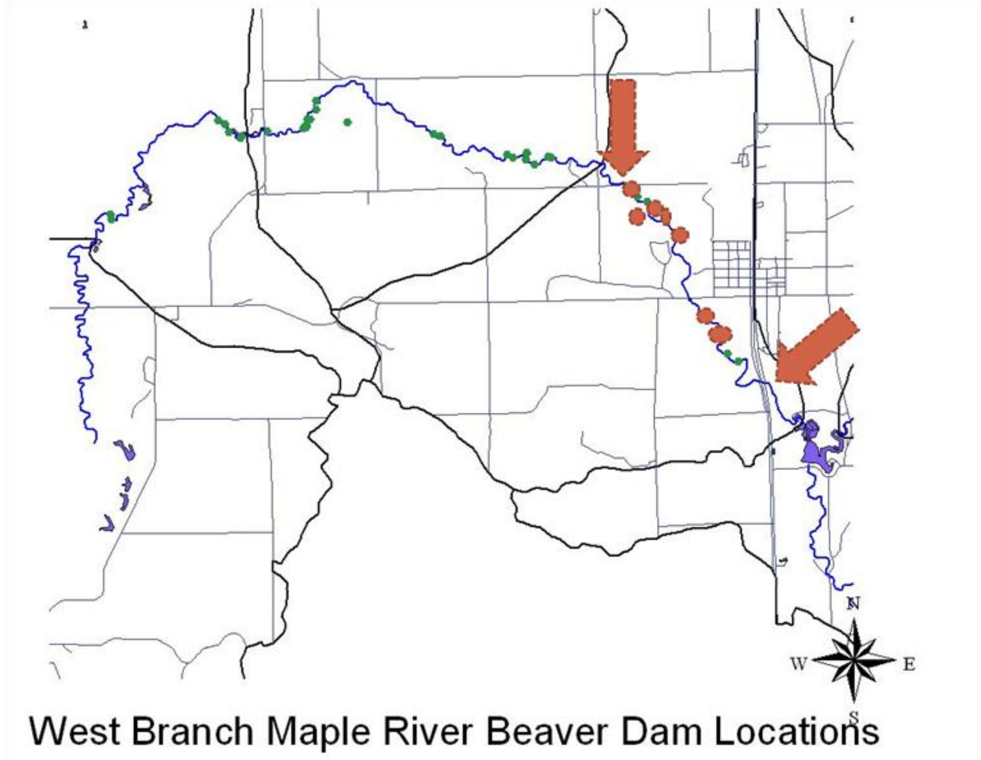

Figure 1. Approximate locations of beaver dams on the West Branch of the Maple River. Arrows indicate the starting and stopping points of this survey.

Table 1. Location, activity status, water depth, dam height from water surface, total dam height, and maximum dam width for 7 dams surveyed on the West Branch of the Maple River in July, 2012.

Dam	Location	Active (Y/N)	Water Depth (cm)	Dam Height from Water Surface (cm)	Total Dam Height (cm)	Maximum Dam Width (m)
1	45.54807N, 84.79326W	Y	54	56	110	14.38
2	45.54787N, 84.79290W	N	27	98	125	13.20
3	45.56033N,84.67720W	Y	18	68	86	9.60
4	45.56343N, 84.80125W	Y	45	19	64	7.10
5	45.56058N, 84.80013W	Y	20	63	83	10.40
6	45.56053N, 84.80022W	Y	48	85	133	8.90
7	45.55891 N, 84.79823W	Y	24	86	110	11.42
Average			33.71± 24.81	67.86 ± 24.76	101.56± 24.76	10.71± 2.51

Table 2. Average dissolved oxygen and water temperature above and below sampled dams on the West Branch of the Maple River. No significant differences exist in the dissolved oxygen levels ($t=1.78$, $df=12$, $p=0.28$) or in the water temperature ($t=1.78$, $df=12$, $p=0.41$) above and below dams.

Variable	Above	Below
Dissolved Oxygen (mg/L)	8.56 ± 0.22	8.62 ± 0.17
Water Temperature (°C)	19.56 ± 2.43	19.24 ± 2.56

Table 3. Taxa found in sampled ponds above beaver dams in the West Branch of the Maple River.

Order	Family
Decapoda	Decapoda
Ephemeroptera	Caenidae
Ephemeroptera	Baetiscidae
Gastropoda	Lymnaeidae
Gastropoda	Planorbidae
Megaloptera	Sialidae
Odonata	Gomphidae

Table 4. Taxa found below beaver dams in the West Branch of the Maple River.

Order	Family
Amphipoda	Amphipoda
Coleoptera	Elmidae
Diptera	Althoricidae
Diptera	Athericidae
Diptera	Tipulidae
Ephemeroptera	Baetiscidae
Ephemeroptera	Siphluridae
Gastropoda	Gastropoda
Hemiptera	Corixidae
Megaloptera	Corydalidae
Plectopera	Perlidae
Trichoptera	Helicopsynchidae
Trichoptera	Hydropsychidae
Trichoptera	Phryganeidae

Table 5. Taxa found both above and below ponds sampled in the West Branch of the Maple River in July, 2012.

Order	Family
Bivalvia	Sphaeriidae
Coleoptera	Elmidae
Diptera	Ceratopogonidae
Diptera	Chironomidae
Ephemeroptera	Baetiscidae
Ephemeroptera	Ephemeridae
Ephemeroptera	Leptohyphidae
Gastropoda	Aplexa
Gastropoda	Physidae
Hirudinea	Hirudinea
Isopoda	Asellidae
Odonata	Calopterydigae
Odonata	Gomphidae
Odonata	Cordulegastridae
Oligochaeta	Oligochaeta
Trichoptera	Brachycentridae
Trichoptera	Glossosomatidae
Trichoptera	Leptoceridae
Trichoptera	Limnophilidae
Trichoptera	Philopotamidae

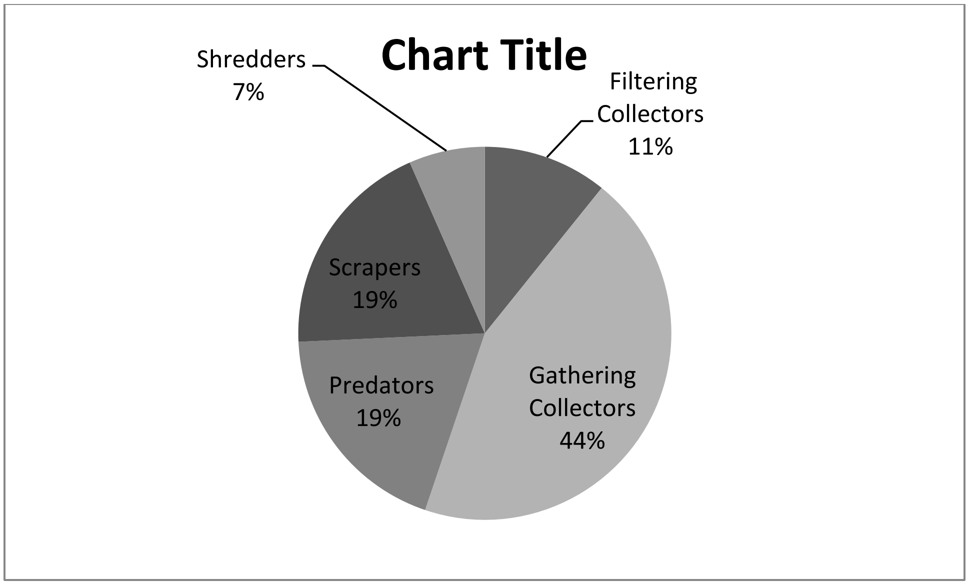

Figure 2. The average of functional feeding groups above six active beaver dams in the West Branch of the Maple River as sampled July, 2012.

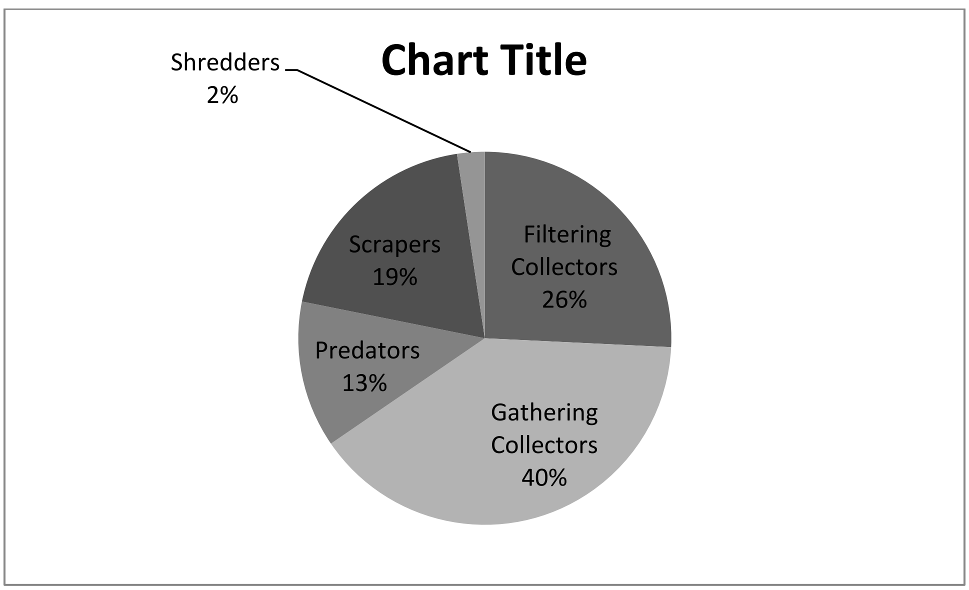

Figure 3. The average of functional feeding groups below six active beaver dams in the West Branch of the Maple River as sampled July, 2012.

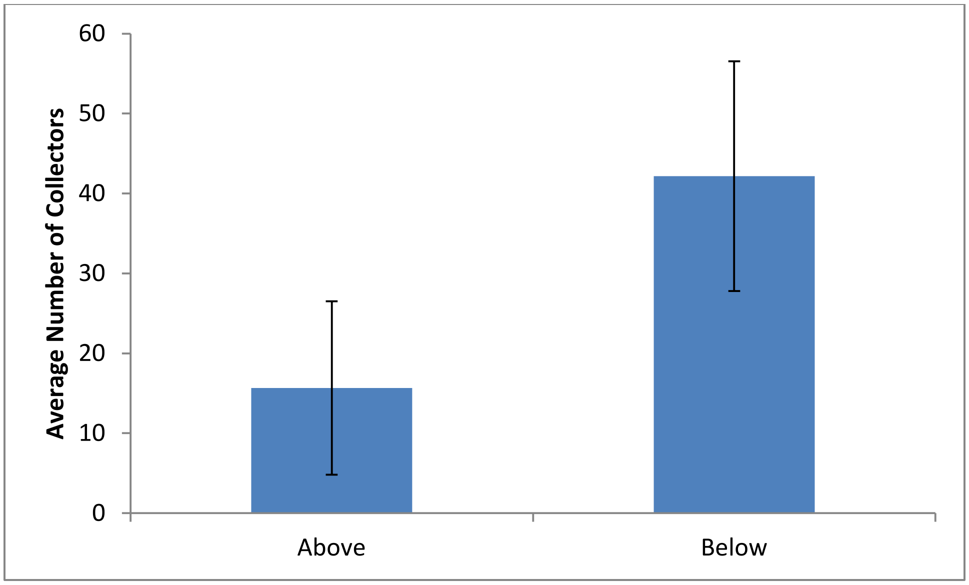

Figure 4. The average number of collectors (filtering collectors and gathering collectors) for above and below dams sampled in the West Branch of the Maple River in July, 2012. There was a significantly higher abundance of collectors below dams than above ($t=1.81$, $df=10$, $p=0.01$). Error bars indicate 2 standard errors from the mean.

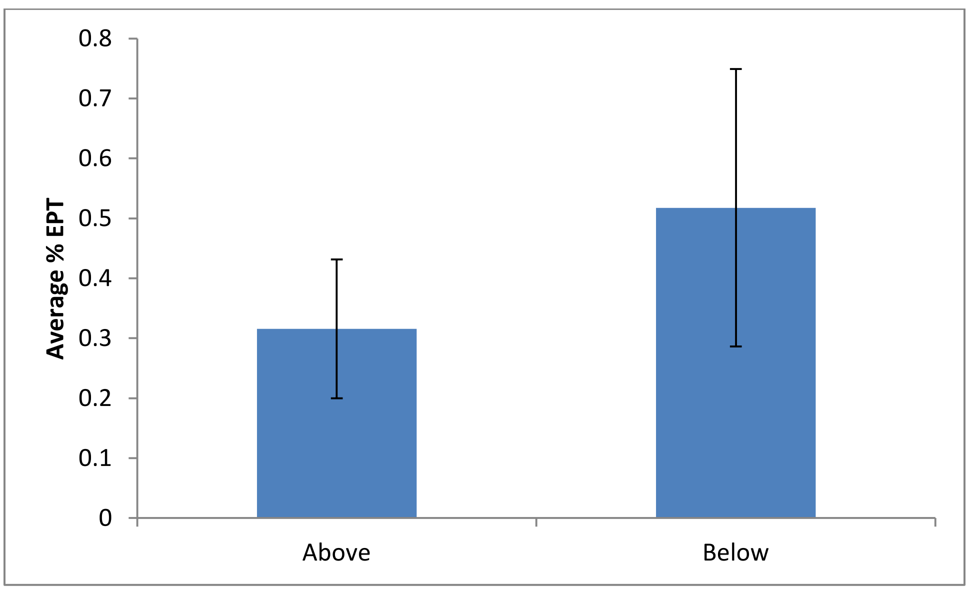

Figure 5. The average EPT of six active beaver dams in the West Branch of the Maple River as sampled in July, 2012. Pools above beaver dams had an average EPT of 0.315 and water below beaver dams had an average EPT of 0.518. There is no significant difference in the EPT, and therefore water quality, above and below dams ($t=1.81$, $df=10$, $p=0.07$). Error bars indicate 2 standard errors from the mean.

Table 6. Shannon's Diversity Index (H') and Taxa Richness (S) for six active dams sampled for macroinvertebrates in the West Branch of the Maple River in July 2012.

Dam #	A/B	H'	S
1	Above	1.48	10
3	Above	1.73	6
4	Above	2.14	12
5	Above	1.70	6
6	Above	1.78	8
7	Above	2.05	13
1	Below	2.22	13
3	Below	2.21	15
4	Below	2.11	14
5	Below	1.41	10
6	Below	2.47	13
7	Below	2.22	13

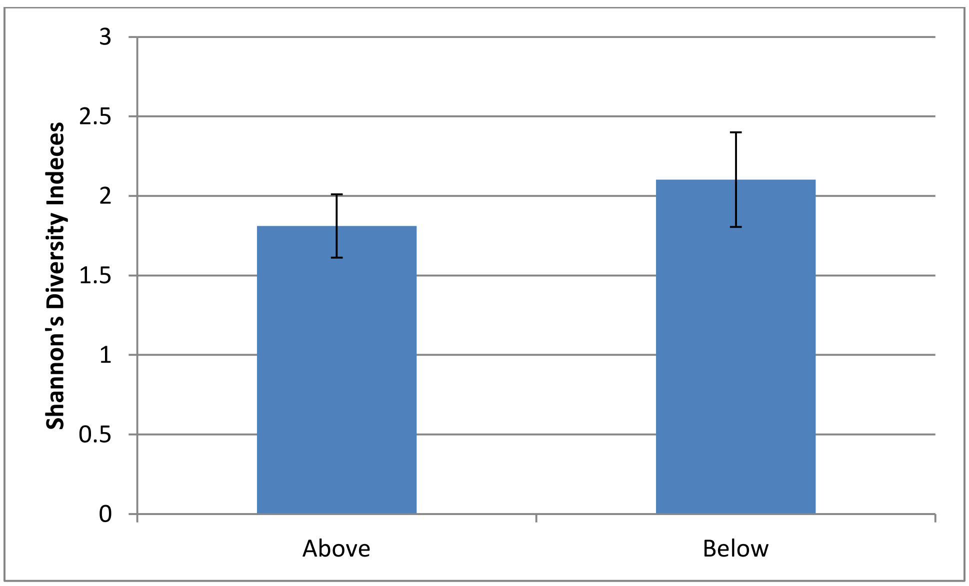

Figure 6. Average Shannon's diversity indices (H') for macroinvertebrates sampled above and below beaver dams in the West Branch of the Maple River in July, 2012. Above dam pools had an average H' of 1.81 and below dams had an average H' of 2.10. No significant difference in H' exists above and below beaver dams ($t=1.81$, $p=0.07$, $df=10$). Error bars indicate 2 standard errors from the mean.

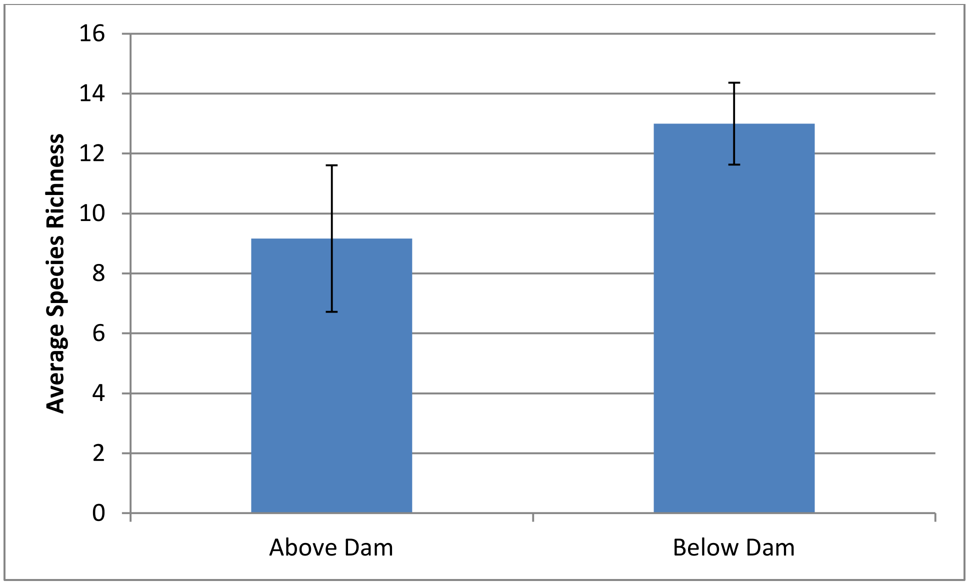

Figure 7. Taxa richness was significantly greater below dams than above (t=2.23, p=0.02, df =10). Error bars indicate 2 standard errors from the mean.

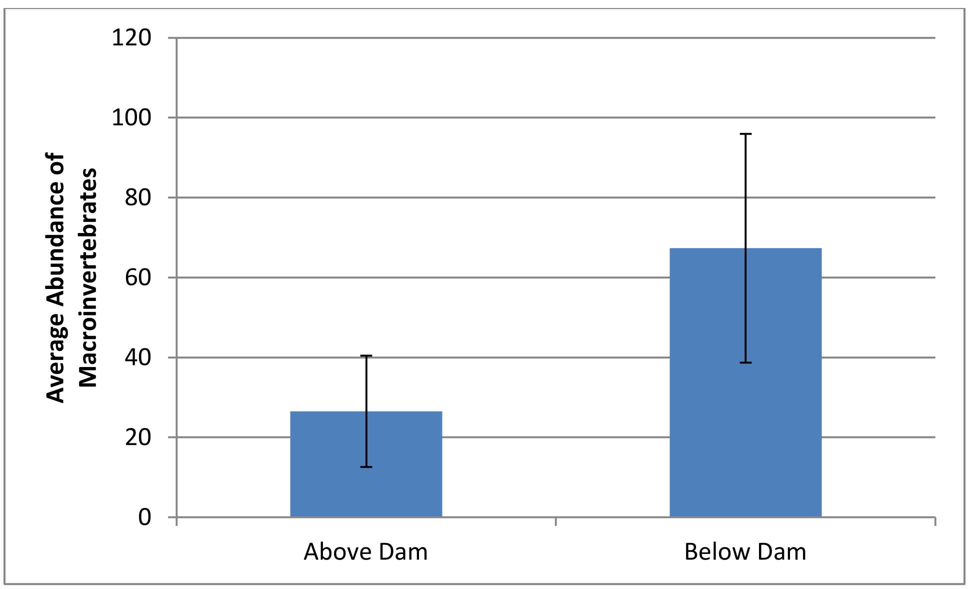

Figure 8. The average macroinvertebrate abundance was signinficantly greater below beaver dams than above beaver dams (t=2.23,df=10, p=0.03). Error bars indicate 2 standard errors from the mean.