

**Substrate preference of freshwater mussels
in the Cannon River, Northfield, Minnesota**

Kimberly J. Elson
Senior Integrative Exercise
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Table of Contents

Abstract	
Introduction	1
Background and Setting	2
Methods	5
<i>Site Description</i>	5
<i>Data Collection</i>	6
Results	8
Discussion	13
Conclusion	15
Recommendations for Future Studies	16
Acknowledgements	16
References Cited	17

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Advisors
Clint Cowan, Carleton College
Mary Savina, Carleton College

ABSTRACT

Freshwater mussels in the Cannon River in Northfield, MN are an integral part of the river ecosystem. As mussels can be considered the “canary in a coal mine” of river ecosystems, understanding their habitat and survival needs is essential in maintaining the health of streams. Water depth, average velocity, and bottom velocity were measured and riverbed substrate categorized at eight transects over a 450-meter reach of the Cannon River. Thirteen live mussels were found in three of the eight classified substrates, indicating their preference for sandy and coarse substrates for the species *Potamilus alatus* or pink heelsplitter. Further studies of mussel biology, as well as the physical changes over time of mussel habitat, need to be conducted for these findings to benefit conservation.

KEY WORDS: freshwater mussels, Cannon River, Minnesota, substrate preference, habitat stability, Unionidae

INTRODUCTION

Freshwater mussels of the family Unionidae play an important ecological role in the waters in which they live, and have had a significant economic role in Minnesota's history. Historically, mussels were hunted for meat and their shells harvested for the production of buttons. Today, 213 of the 297 native freshwater mussels in the United States and Canada are threatened or endangered (Minnesota Department of Natural Resources, 2009). The presence and abundance of mussels in a body of water are indicators of water quality since mussels feed by filtering large volumes of water and have been shown to store higher concentrations of pesticides and other contaminants than the water around them (Bedford et al. 1968). Mussels live by half-burying themselves in the riverbed, thereby stabilizing the substrate around them (Minnesota Department of Natural Resources, 2009). They are also a key food source for animals such as raccoons, muskrats, birds, and some species of fish (Minnesota Department of Natural Resources, 2009). In some cases, they are able to significantly increase available nutrients for the benthic community as they remove large amounts of suspended particulate matter thereby increasing the benthic biomass (Howard and Cuffey, 2006). The conservation of mussel populations is therefore beneficial to their habitats.

The Cannon River in Northfield, Minnesota, is home to several species of freshwater mussels (Swift and Wagenbach, 1999). In 1987, Davis published a study that identified 15 species of freshwater mussels in the Cannon River. Swift and Wagenbach (1999) conducted a follow-up study and found 12 species of mussel in the Cannon River. In 1997, Richmond and Jones conducted a survey of mussels specifically in the area directly downstream of the Northfield Dam. Their findings showed 5 species of

freshwater mussels living in this reach, which overlaps the reach in this study. While 26 of the state's 49 species of freshwater mussels are listed as endangered, threatened, or of special concern (Minnesota Department of Natural Resources, 2009), no work has been done in the Cannon River watershed since Swift and Wagenbach in 1999.

Freshwater mussels depend on three factors to survive: 1) distribution and availability of host fish for their larvae to parasitize and disseminate, 2) the physical characteristics of the stream at basin-level, and 3) the microhabitat characteristics, of which substrate is included (Box and Dorazio, 2002). This study focuses primarily on the last of these, specifically the substrate characteristics, and includes a description of the morphology of a small reach of the Cannon River. It also utilizes past surveys of freshwater mussels in the area in order to place the findings into the context of conservation of both mussel populations and stream health.

BACKGROUND AND SETTING

The Cannon River is a tributary of the Mississippi River and is located in southeastern Minnesota. The landscape around the Cannon was predominantly shaped by glaciation; the river runs through the eastern edge of the area of the latest glaciation, the Wisconsin (Sanderson, 1933). Since glaciation halted around 10,000 years ago, natural alterations to the landscape have been due to fluvial processes.

Prior to the 1850s, the Cannon River Watershed features included extensive wetlands, hardwood forests (the Big Woods), and the river had an overall low gradient (Swift and Wagenbach, 1999). The Cannon River had an unobstructed connection to the Mississippi River allowing organisms, especially fish, to move freely through the streams

and lakes of this watershed and into others connected to it (Swift and Wagenbach 1999). In 1852, with a treaty transferring all land rights from the Sioux Indians to Europeans, settlers began to extensively alter the natural landscape (Davis, 1987). Within just a matter of decades, settlers destroyed the Big Woods and wetlands that had dominated and stabilized the natural landscape since the last glaciation. The wetlands and Big Woods vegetation, which helped control flooding, were converted to wheat fields (Davis, 1987). The present-day Cannon River Watershed reflects these changes to the natural landscape, with an estimated 90% agricultural land use (Carlson et al., 2004). This transformation has affected water quantity and quality in rivers like the Cannon through changes in water and sediment runoff into the river. Examples of this include irrigation, addition of pesticides leading to water contamination, and destruction of the naturally erosion-resistant topsoil by tillage, which results in more runoff with an increased sediment load.

Settlers also dammed rivers for irrigation as well as for aesthetic reasons. The first dam was built in 1855 to power the Ames Flour Mill, one of 17 mills constructed on the Cannon River between Northfield and Faribault through the end of the 19th Century (Davis, 1987). Mussels depend on certain species of fish to distribute their larvae, and the introduction of dams created barriers to fish migration up and down stream (Sietman, 2003). According to residents, in the 1920s the Cannon was “paved with clams” (Davis, 1987). However, a commercial shell industry significantly reduced the mussel populations that were once evident (Sietman, 2003). The harvesting of mussels for their shells continued until the 1940s with the advent of plastic buttons, making clam shell buttons obsolete (Sietman, 2003). Today, it is illegal to collect mussels, dead or alive, without a permit in the state of Minnesota (Sietman, 2003).

The Northfield Dam, located approximately 900 meters upstream of this report's study area, is currently owned by the Malt-O-Meal Corporation and has no current function (Richmond and Jones, 1997). There is public desire to revert the Cannon to a wild and scenic river by removing the dam. However, there are concerns about the sediment trapped behind it. Richmond and Jones (1997) estimated that there is approximately 122,980 cubic meters of sediment trapped behind the dam, the release of which could alter the Cannon downstream in adverse ways.

A number of past studies have examined whether there is a correlation between substrate type and mussel habitat, the results of which have been varied. Many studies showed little direct correlation with substrate type but rather with substrate stability (Di Mayo and Corkum, 1995, Howard and Cuffey, 2003, Morales et al., 2006, Zigler et al., 2007). Stability generally refers to low shear stress, locations where the possibility of dislodgement during high discharge (i.e. a flood) is low, or where there are substrates larger than the mussels that create a flow refuge for the organism (Howard and Cuffey, 2003). Conversely, the presence of mussel beds could be the cause of higher substrate stability as mussels can help lessen the effects of floods and wave action (Johnson and Brown, 2000, Minnesota Department of Natural Resources, 2009). For studies that found a correlation with substrate type, coarser substrates and/or higher velocities (which usually correlate) were deemed the most suitable habitats for mussels (Brainwood et al., 2001, Haag et al., 2007, Hastie et al., 2003, Hornbach, 1994, Huehner, 1987, Johnson and Brown, 2000). There is also research to show that mussels prefer a low energy environment, like pools or near-bank areas (Box and Dorazio, 2002, Brown et al., 2001). Fine sediments are necessary in a mussel habitat since higher concentrations of fines are

usually associated with a higher concentration of organic matter, which represents a potential food source (Box and Dorazio, 2002).

METHODS

Site Description

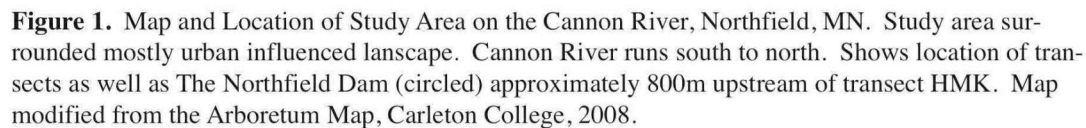
The site of this study is an approximately 450-meter reach of the Cannon River, from directly behind Laird Stadium of Carleton College approximately 830 meters downstream of the Northfield Dam and downstream to above the first braid downstream, about 150 meters upstream of the Cannon's confluence with Spring Creek (Figure 1). It is characterized by a variety of bed types, from silty, debris filled pools to the exposed bedrock of Prairie du Chien Dolomite. In multiple locations, large trees have fallen into the river, affecting the flow locally. This reach has an overall low gradient, between 0.22 meters per kilometer (m/km) in the upstream portion and 1.64 m/km further downstream. Average water velocity was relatively slow, an average of 0.23 meters per second (m/s) at the low flow conditions of late autumn 2009. The bottom velocity was approximately half of the average at 0.11m/s. The river thalweg meanders within the channel and is nonexistent near the rapids, and bifurcates where the river braids at the downstream end of the reach. The deepest section of this reach, again at low flow conditions, was 1.30 meters, which is relatively straight with very little meander and no braiding. The limited meander and braiding is probably due to adjacent land uses that restrict the river to its current channel. Upstream of this reach, the Cannon is flanked by impermeable surfaces (e.g. roads). Most of the reach is flanked by upland forest, though mowed grass, a

railroad, and other urban landscaping occur within tens of meters of the channel (Figure 1).

Data Collection

Eight transects perpendicular to the flow direction of the river were observed along the study reach. At six of the transects (1 through 6), depth was measured every two meters and water velocity was measured every four meters. A Flo-Mate™ Model 2000 Portable Flow Meter was used to measure average velocity. Velocity was also measured at the stream bottom, which would most directly affect mussels at the sediment-water interface. To obtain the average velocity, the six-tenths depth method was employed as outlined in the Bureau of Reclamation's Water Measurement Manual (2001). This method requires measuring the velocity at six-tenths the depth from the surface at each point in the river. Substrate was noted at each depth measurement and an estimate of relative percentages of silt/clay, sand (sediment <0.2cm), gravel (0.2-6cm), cobbles of two sizes (6-12cm and 12-25cm), boulders (>25cm), and bedrock was made. In addition, the presence of live clams or mussel shells was recorded. At the two other transects (SAA and HMK), observed by members of the Fall 2009 Carleton College Geomorphology class, depth was measured every meter and average velocity every two meters.

A reconnaissance of the entire reach was made by wading to select the best locations for the transects and note the overall change in substrate. Live mussels were noted along transects and counted if they were within a few meters of a transect. Mussel identification was aided through research of species that were found in this area historically. Information was gathered predominantly from two studies: Swift and



RESULTS

In the study reach, the Cannon River displays a variety of substrates, which can be divided into eight categories: 1) Silt 1, 2) Silt 2, 3) Sand 1, 4) Sand 2, 5) Gravel, 6) Mixed, 7) Cobble, and 8) Bedrock. These substrates are described in Table 1. The distribution of the substrates observed in this study is shown in Figure 2.

	Substrate Type	Description
1	silt 1	almost 100% silt
2	silt 2	80-90% silt with noticeable coarser substrates (usually cobbles)
3	sand 1	almost 100% sand
4	sand 2	over 50% sand with a mix of coarser substrates from gravel to boulders
5	gravel	over 50% gravel with a mix of coarser substrates as well as sand
6	mixed	no dominant sediment size but a mix of sand to cobble-sized substrate
7	cobble	over 50% cobbles with sand and gravel in between
8	bedrock	predominantly bedrock outcropping

Table 1. Substrate type and description for the eight substrates found in this reach.

Mussel shells and shell fragments were found at multiple locations. Since mussels tend to burrow and generally remain in a single location once they reach

maturity, and are able to move back to their preferred habitat if they get dislodged by a flood, only live mussels are truly useful for correlation with substrate. Empty shells are not as useful since there is no way of knowing if and how far the shells moved due to stream flow or predation.

Thirteen live mussels were observed at four of the eight transects: 1, 3, 5, and HMK. At transects 1, 3, and 5, substrate was Sand 2 or Mixed. The mussel found near transect HMK was in substrate Silt 2. The mussels at transects 1, 3, and 5 were identified as *Potamilus alatus*, commonly known as the pink heelsplitter (Figure 3). The one near transect HMK was identified as *Lampsilis siliquoidea*, commonly known as the fatmucket (Figure 4). See Table 2 for a summary of the microhabitat characteristics where each mussel was found.



Figure 3. *Potamilus alatus*, aka pink heelsplitter. Can grow up to 18cm in length. 12 live specimens were found in the Cannon River in sand to cobble substrates. Historically the most abundant species in the Cannon River Watershed. Image from Sietman, 2003.

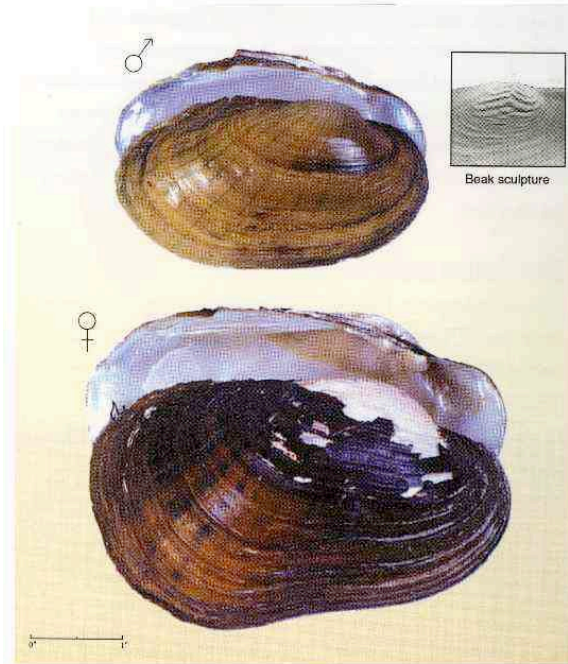


Figure 4. *Lampsilis siliquoidea*, aka fatmucket. Inflated shell structure allows these mussels to live in softer substrates. Can grow up to 15cm in length. One member of this species was found in a predominantly silty substrate in the Cannon River. Image from Sietman, 2003.

Since this survey focused predominantly on the physical properties of the reach, a mussel survey done of the same reach was reviewed for more details on the mussels. Richmond and Jones (1997) found 42 live mussels representing five species: *Lasmigona complanata*, *Lampsilis cardium*, *Lampsilis siliquoidea*, *Ligumia recta*, and *Potamilus alatus*. Fifteen of these mussels were found in the same reach as this study: thirteen *Potamilus alatus* and one of each *Lampsilis cardium* and *Ligumia recta*. *Ligumia recta* are classified in the state of Minnesota as “special concern,” meaning that, while not threatened or endangered, are en route to becoming so, or live in a threatened habitat. The extent of substrate classification performed by Richmond and Jones was that in most sites, live mussels were found in “cobbles.”

Transect	Number of Mussels	Substrate Type	Depth (cm)	Bottom Velocity (m/sec)	Average Velocity (m/sec)	% Silt/Clay	% Sand (<0.2cm)	% Gravel (0.2-6cm)	% Cobble (6-12cm)	% Cobble (12-25cm)	% Boulder (>25cm)	% Bedrock
1	1	4	29	0.16	0.58	0	60	10	30	0	0	0
1	2	4	15	0.12	0.1	0	50	20	30	0	0	0
1	2	4	9	0.05	0.2	0	40	30	30	0	0	0
1	2	6	16	0.1	0.28	0	0	50	50	0	0	0
3	1	4	49	0.19	0.7	0	50	25	20	5	0	0
3	1	4	45	0.26	0.67	0	50	25	20	5	0	0
3	1	4	35	0.34	0.65	0	50	25	20	5	0	0
3	1	4	36	0.48	0.85	0	50	25	20	5	0	0
2m upstream of 3m downstream of HMK	1	4	9	0.44	0.62	0	60	40	0	0	0	0
	1	2	65	0.05	0.05	80	5	10	5	0	0	0
Total (Number of Mussels)/ Mode (Substrate Type)/ Average (Depth, Velocities, % Sediments)	13	4	30.8	0.219	0.47	8	41.5	26	22.5	2	0	0

Table 2. Characteristics of microhabitat where each live mussel was observed. See Figure 2 for location in the reach. See Table 1. for description of Substrate Types.

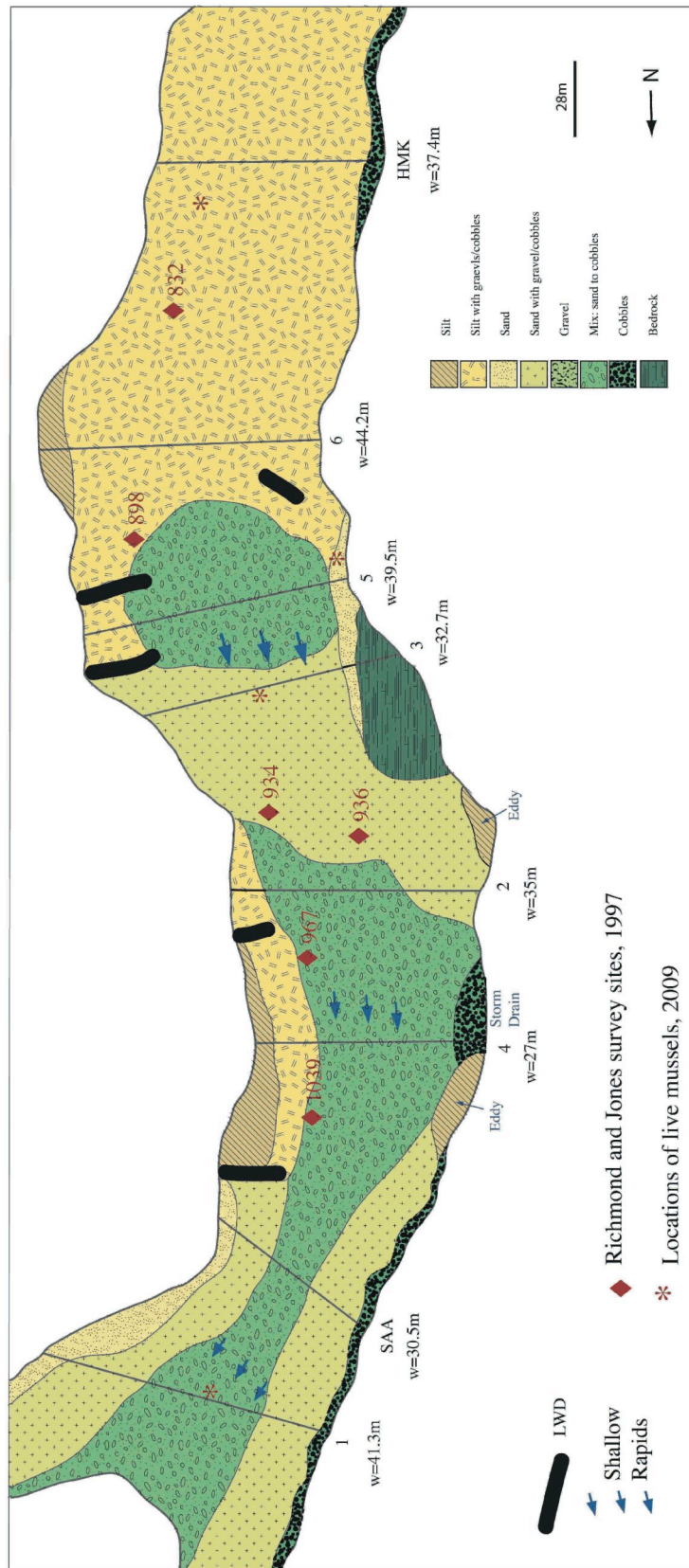


Figure 2. Map of substrate distribution in study area of the Cannon River in Northfield, MN. Colors represent different substrates, lines crossing the river are transect locations. Mussels were found mostly in coarser substrates, except for the one near transect HMK. Richmond and Jones (1997) report all of the substrates at their study sites were “cobbles.” Mussels were identified as such: at 898 there were 8 *Potamilius alatus*, at 934, 5 *Potamilius alatus*, at 1039, 1 *Legumia recta* and 1 *Lampsilis car-dium*. No mussels were found at the other sites. From this study, 7 *Potamilius alatus* were found near transect 1, 4 *Potamilius alatus* near transect 3, 1 *Potamilius alatus* upstream of transect 5, and 1 *Lampsilis siliquoides* about 3m downstream of transect HMK. River vertically exaggerated 2x. LWD= Large woody debris. W is width in meters of the river at each transect.

DISCUSSION

The mussels found in this survey tended to show substrate preference to sandy substrates, with cobbles and other coarse substrates present. This is consistent with other findings that mussels, or at least the *Potamilus alatus*, depend on stable substrates that can create flow refuges, with a water velocity that allows for a steady supply of potential food (Di Maio and Corkum, 1995, Haag et al., 2007, Hastie et al., 2003, Howard and Cuffey, 2003 and others). For a river such as the Cannon, substrate is sufficiently diverse that despite being primarily benthic, a mussel that detaches from its host fish can still find habitable or preferable substrate within a short distance. In a larger, more homogenous river, a mussel is more dependant on its host fish for the substrate in which it ends up inhabiting.

In this study, one outlier was encountered: the mussel at transect HMK that was observed in a predominantly silt substrate. Individual mussel physiology could provide an explanation for this. Tevesz and McCall (1979) found that mussels with inflated shell structure could live in muddier and finer grained substrates. *Lampsilis siliquoidea* falls into this category (Sietman, 2003) and is known to live in the area historically (Richmond and Jones, 1997). The results of this study can only support the substrate preferences of the *Potamilus alatus* as one specimen of *Lampsilis siliquoidea* does not allow for generalizing the occurrence of the entire species. The sample size was also insufficient for any sort of statistical analysis.

Newton et al. (2008) identified connectivity of suitable habitats for mussels as a factor in conserving a species and their habitats. Connectivity refers to the ability of an organism to move between different patches of suitable habitat; in other words, the ability

of a species to maintain its existence in a dynamic, heterogeneous habitat such as a river. In the case of mussels in the Cannon River, connectivity depends on the amount of suitable substrate on the riverbed, the abundance, availability, and mobility of the host fish, and the nature of the landscape around the Cannon. Human interaction with the environment, in the form of damming, irrigation, introducing toxins to the land and water, and channelization can all lead to fragmenting the river system and reducing connectivity. Freshwater mussels are especially vulnerable when it comes to river fragmentation as they depend on a host fish to complete their life cycle, have relatively long life spans, a limited ability to move, and a poor juvenile survival rate (Newton et al., 2008). Urbanization and agricultural practices not only reduce connectivity, but also tend to increase river incision leading to higher bankfull capacities and higher shear stress during flooding, creating undesirable mussel habitat (Gangloff and Feminella, 2007). The concept of connectivity may be especially important in rivers such as the Cannon where mussel beds are relatively small (this study encountered at most seven mussels in a single area) and should one of these areas be locally eradicated, other mussel beds would be needed to repopulate these areas.

Stream morphology and fluvial habitats are characteristically dynamic environments due to the directional flow of water and the interaction of the water with the riverbed (Leopold et al., 1964, Newton et al., 2008). Streambeds can change in a short time period compared to other geologic phenomena, either seasonally or in a single flood event. The mussels that inhabit and depend on stream environments are consequently vulnerable to these changes. Roscoe and Reddings, 1964 (as cited in

Huehner, 1987), suggest that whole populations of mussels can be displaced by high discharge over a matter of hours.

One of the most important factors in mussel distribution is the availability of host fish (Box and Dorazio, 2002, Carlson et al., 2004, Newton et al., 2008). Mussel larvae grow and mature as a parasite on certain species of fish and fall off when they mature into functional adults (Sietman, 2003). The Northfield Dam has likely had a significant impact on the mussel distribution in the Cannon River, as the dam acts as a fish barrier. Aside from problems with sediment trapped behind it, removal of the dam could improve the ability of the Cannon's mussels to repopulate the area, as host fish would gain a wider range of mobility.

CONCLUSION

Multiple specimens of *Potamilus alatus* were found in sandy and coarse substrate suggesting the need for high velocity, refuge from the flow, and stability over time in freshwater mussel habitat. However, the literature indicates many more factors that influence where mussels are able to live, namely availability of their host fish, connectivity of their habitat, land use around the stream, and characteristics of the stream at bankfull. This study represents a snapshot of the Cannon River, taken at relatively low flow; a year from now, duplicating this study may yield very different results. These factors all need to be taken into account if conservation of these species is to be successful. An abundance of suitable substrate will not help the survival of an endangered freshwater mussel should their host fish not be around to disperse the larvae.

RECOMMENDATIONS FOR FUTURE STUDIES

Noting the transitory nature of freshwater mussel habitat, an updated mussel survey of the area would aid an understanding of substrate preferences, as it has been a decade since the last comprehensive survey was conducted. Shear stress at bankfull has been shown to limit mussel abundance (Gangloff and Feminella, 2007). Therefore continual surveying of the Cannon, especially during flood conditions, and the stability of the substrate would also allow a better understanding of these substrate preferences. It would also increase the understanding of the Cannon River itself and the influence of humans around it. An approach combining biologic and geologic principles might provide a particularly useful assessment of factors for conservation of mussel habitat and general stream health. Such an approach would seek to incorporate the landscape and physical habitat characteristics (such as processes affecting substrate), but also take inventory of biological effects and needs of mussels and fish and other organisms.

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