NORTH DAKOTA GAME AND FISH DEPARTMENT

Final Report

A Two Phase Population Survey of Mussels in North Dakota Rivers

Project T-24-R

May 1, 2008 – April 30, 2011

Terry Steinwand

Director

Submitted by Michael G. McKenna

Chief, Conservation and Communications Division

Bismarck, ND

May 2011

A Two Phase Population Survey of Mussels in North Dakota Rivers

Final Report

Prepared for the North Dakota Game and Fish Department

By

Dr. Andre DeLorme
Department of Biology, Valley City State University,
Valley City ND

Table of Contents:

I. EXECUTIVE SUMMARY

Freshwater mussel populations are in serious decline in many areas of North America due to pollution, placement of dams, and other factors. The purpose of this project was to document the species found in the state of North Dakota, determine their ranges, and gather information on their population dynamics. In year one of this project (summer of 2008) we conducted a qualitative rapid assessment protocol. Timed searches were performed at 153 sites on 28 rivers; 7,780 mussels were identified and measured with the vast majority being returned to their site of collection. In year two of this project (summer of 2009) we took a subset of 30 sites from the 2008 data and returned for a more rigorous quantitative sampling protocol. Also, qualitative sampling on 7 more sites was done. In year three we performed a combination of qualitative and quantitative sampling to complete our coverage of the state. We sampled an additional 80 qualitative sites and 6 quantitative sites. The majority of these sites, 49, were located in the western part of the state and are part of the Missouri River Drainage. An additional 29 sites were done on rivers in the Red River Basin and 2 sites were done on Long Creek which is a part of the Souris River Drainage.

Several points can be made from our three years of data. The western part of the state is relatively devoid of mussels. For example, our qualitative searches of the Little Missouri found no live mussels. The eastern half of the state, on the other hand, exhibited healthy populations of mussels. Specifically the Sheyenne, Maple, and Goose Rivers had good numbers of mussels with diverse populations. We had difficulty trying to sample mussels in the two large rivers, the Red River and the Missouri River. This could be a combination of the inefficiency of our dredge and the difficulty in finding mussels beds in large rivers. We documented two new species records for the state; the deer toe, *Truncilla truncata*, and the fragile papershell, *Leptodea fragilis.* This brings the total number of mussel species in the state to 15.

II. INTRODUCTION

Mussels are one of the most threatened groups of animals in North America. Williams et al. (1993) estimated that 71.1% of the North American mussel fauna was endangered, threatened, or of special concern. A recurring theme of many recent mussel surveys is the decline in both abundance and diversity in the native mussel species. Jones et al. (2001) report that mussels species have been reduced from 27 to 18 species in the upper Clinch River in Tazewell County, Virginia. In a study of the Republican and Smoky Hill river basins in northwestern Kansas, Bergman et al. (2000) found that 11 species have been extirpated when compared to the historical fauna. Poole and Downing (2004) examined mussel demographics in Iowa watersheds comparing data from 1984 and 1985 to a resampling effort done in 1998. They found that maximum species richness for a site was reduced from 22 to 15 species and that all mussel species were extirpated from 47% of the reaches sampled. This particular study is troublesome in that it involves rivers and streams in a primarily agricultural area, and states that a large component of the loss in mussels is due to the agricultural practices in the area. Since North Dakota is largely an agricultural state, it is important to document the current status of our mussel populations.

Alan Cvancara, a geology professor at the University of North Dakota, did the majority of work in the state on mussels back in the 1960's and 1970's (Cvancara, 1970; Cvancara and Freeman, 1978; Cvancara, 1983). However, very little is known about the current status of North Dakota mussels. The last thorough mussel survey in North Dakota was done over 18 years ago by the ND Game and Fish (Jensen et al., 2001). This study focused exclusively on the Sheyenne and Red Rivers. The Valley City State University (VCSU) Macroinvertebrate lab has done several small scale studies on the Sheyenne and in many places has found healthy mussel populations (Tompkins and DeLorme, 2007; DeLorme, unpublished data). Other rivers in the state have not been surveyed since the 1970's and most work done was 30 to 40 years ago (Cvancara, 1970; Cvancara, 1983). Taking into consideration the reported changes in mussel populations in other areas, it is important that we document the mussel fauna of North Dakota rivers and streams.

Mussels are long-lived organisms that act as good indicators of water quality. It is very important that their distribution and population demographics be documented.

III. METHODS

III. A. Qualitative sampling

Wadeable Rivers

Our qualitative sampling consisted of a timed search of designated sites. It was patterned after Villella and Smith (2005). In wadeable areas it consisted of a timed search throughout the site for 2 person hours (p-h). In most cases it was a crew of 4 biologists searching for 30 minutes. The four searchers would spread themselves across the river and slowly walk upstream. Several other crew members assisted with buckets to collect mussels found. There were several variations on this. In several small narrow streams, we would send 2 searchers in one direction and the other two in the other direction. We also had several sites with large numbers of mussels. Because of the time constraints in measuring mussels, we instituted a policy of stopping after 15 minutes (a total of one person hour) if we found over one hundred mussels by that time.

The method of searching depended on the river conditions. In shallow, relatively clear water we used visual and tactile observations for finding mussels. Tactile searching can consist of either feeling with the hands or, in deeper waters, detecting mussels with the feet. For many of the sites we did our searches with snorkeling gear. In deeper and more turbid waters foot tactile searching was employed. The majority of sites had these deeper turbid waters and so we used special sampling nets made for us by WildCo. The nets consist of a rectangular net with ¼ mesh with a handle attached. These nets allowed us to dig into the substrate to collect the mussels. During the search all mussels encountered were collected into buckets. At the end of the prescribed time all mussels were identified, measured, and then returned to their habitat. If we encountered specimens that we were unsure of the identity, we saved up to two specimens of that type for later identification in the lab. We also collected empty shells of freshly dead mussels. In this case, a freshly dead mussel means a shell that has a minimum of erosion and still has intact periostracum and nacre. These empty shells serve two purposes; to document species collected at the site and provide specimens for thin sectioning of shells. All shells were placed in bags and labeled.

Non Wadeable Rivers

In the Missouri River, where depths are often greater than 1.5 meters, we used a dredge employed from a pontoon with a winch and boom. We would do a minimum of three “pulls” per site. This would consist of aligning the pontoon so that it is backing upstream with the dredge being pulled on the front of the pontoon (which is pointing downstream). A pull would be anywhere from 50 – 800 meters. Once the pull was completed, the dredge would be lifted on to the pontoon deck and mussels and shells would be sorted from the debris in the net. After the dredge was checked, it would be lowered back into the water and the pontoon would start the next pull approximately where the previous pull had ended. Anywhere from 3- 5 pulls were done at a sight.

III. B Quantitative Survey

Our quantitative surveys were based on the work of Strayer and Smith (2003) and Villella and Smith (2005). Data from the rapid assessment described above was used to stratify our sites into either high or low density sites. Villella and Smith (2005) used an arbitrary number of 30 mussels in one p-h from rapid assessment to determine whether a site was considered low or high density. Based on our experience in year one sampling we used the value of 50 mussels in one p-h as a cutoff between low and high density sites. Another feature of this approach is that the two types of sites, low density and high density, are sampled with two different methods, each adapted for the particular type of site (Strayer and Smith, 2003; Villella and Smith, 2005). Low density sites are sampled using an adaptive clustering method and high density sites are sampled using a systematic sampling method as described in Strayer and Smith (2003). Both methods employ a quadrat sampling regime. We use a 0.25 m^2 quadrat since Pooler and Smith (2005) showed that this size quadrat gave more accurate and precise abundance estimates and generally better spatial predictions than a 1 m^2 quadrat. This size quadrat worked well in our studies.

Sampling High Density Sites

The systematic sampling advocated by Strayer and Smith (2003) involves choosing quadrats at regular distances from a random starting point and incorporating three random starts in the sampling. To do this a site is measured and divided into quadrats. The number of quadrats to be sampled is then determined. We usually sampled around 100 quadrats per site. After determining the number of quadrats for a site, we determine the interval between quadrats using the following formula:

$$k = \text{square root of } \frac{L \times W}{q/r}$$

where k is the interval between quadrats, L is the length of the stream reach, W is the width of the stream reach, q is the number of quadrats to be sampled, and r is the number of random starts (Strayer and Smith, 2003). After these numbers are determined the start points for the three random starts are generated and quadrats are placed at the intervals determined both along stream and across stream. See Figure 1 for an example.

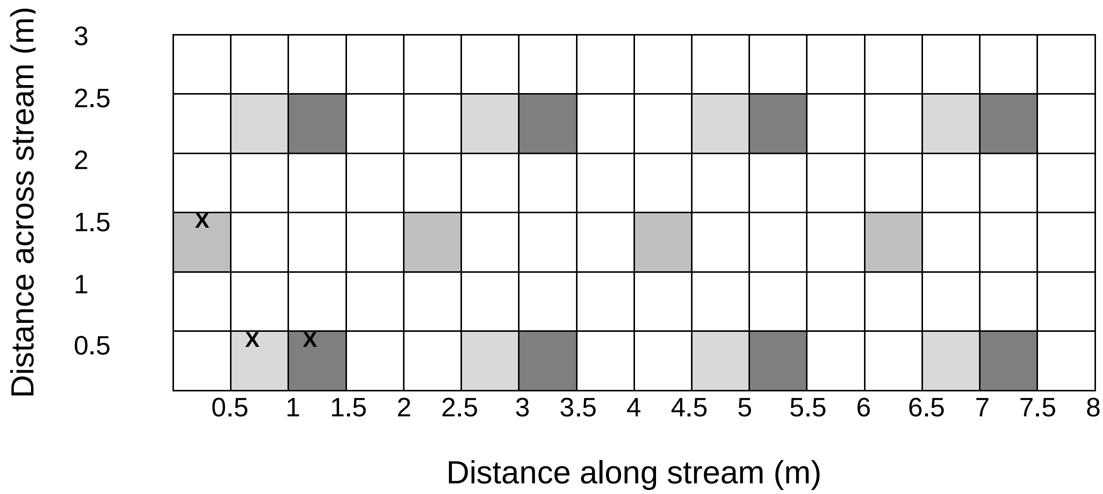


Figure 1. Systematic sampling with random starts. In this example the site to be sampled is 8 meters by 3 meters. We want to sample 20 to 25 quadrats. Using the formula described above we determine that the quadrats need to be 2 meters apart. We choose three random start points which are represented by Xs in the quadrat. From the three random starts we choose all other quadrats at 2 meter intervals both along and across stream. Notice that the middle random start only goes along stream where as the other two random starts go both across and along stream. In this example we would sample 20 quadrats.

The advantages of systematic sampling with multiple random starts are that it gives good spatial coverage of the site, it describes the spatial distribution of mussels within a site, and it allows sample variance to be calculated properly.

Sampling low density sites

An adaptive-cluster method of sampling was used for sampling mussels at low density sites. In this method the site is once again divided into quadrats as described for systematic sampling. A set of random quadrats are generated and checked. If the number of mussels in a quadrat is greater than a certain threshold, then the four quadrats surrounding it are sampled. Every time a quadrat exceeds the threshold, the surrounding four quadrats are sampled. See Figure 2 for an example.

Since mussel beds, especially at low densities, are often very patchy in the distribution of individuals, this method is well adapted to measuring that distribution.

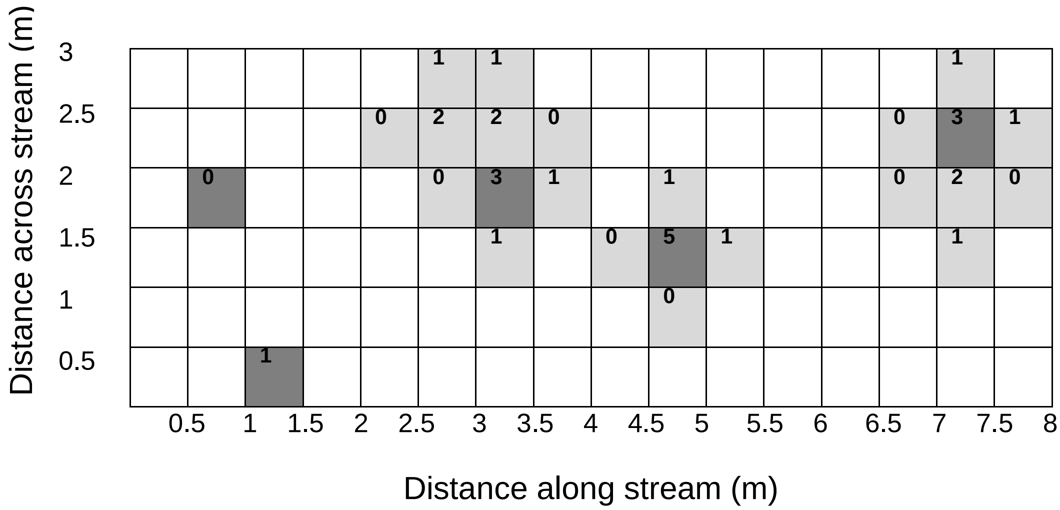


Figure 2. Adaptive cluster sampling. In this example sampling starts with five random quadrats and two mussels is considered the threshold for sampling adjacent quadrats. Dark gray squares are the original five quadrats, light gray squares are the adjacent quadrats, and the numbers represent the number of mussels collected in each quadrat. In this example 24 quadrats were sampled.

Excavation of quadrats

Mussels are well known to burrow in the bottom sediments. This is believed to have a direct impact on their detection, especially small and young mussels (Smith et al., 2001; Schwalb and Pusch, 2007). In order to fully sample the mussel fauna of North Dakota rivers we will need to do some excavation of quadrats in both types of quantitative sampling. Following guidelines of Smith et al. (2000), we excavated 25% of the quadrats we sampled to a depth of 10 cm.

III. C. Thin sectioning shells.

Using the techniques described by Neves and Moyer (1988) to age mussel shells, we thin sectioned 30 – 35 shells using a Buehler Isomet low-speed saw with a diamond-impregnated blade (Buehler, Evanston, Illinois). Shells were cut from the center of the umbo to the ventral margin. Cut valves are glued to petrographic microslides (27 X 46 mm), placed into a chuck, attached to the cutting arm of the saw, and sectioned. Thin sections of shells were examined under a dissecting microscope and the internal growth lines counted. Internal growth lines are considered true annuli if they are continuous from the umbo region to the outer surface of the shell. It is assumed, based on the work of Neves and Moyer (1988) in the rivers of southwest Virginia, that one annulus is formed each year. This technique has been used in a variety of studies where age determination is needed to examine population dynamics (Rogers et al., 2001; Jones and Neves, 2004; and Jones et al., 2004).

IV. RESULTS

Qualitative sampling

Many eastern rivers showed healthy populations of mussels. For example, in year 3 we sampled 29 sites in the Red River basin and found mussels in 23 of them for a find rate of 82.9%. In our first year our find rate for wadeable sites was 85%, with the majority of the sites being in the Red River drainage with some from the Souris and some from the central part of the Missouri drainage. Far western rivers however, showed low numbers of mussels. In year 3 we found mussels at only 4 of 33 far western sites for a find rate of 12.1%. These four sites had very few mussels, with the greatest number being 19 live mussels at a site on the Little Muddy north of Williston (see Table 1.). In addition there was not much diversity found in these rivers. Three of the four sites had only one species, *Pyganodon grandis*. The site on the Little Muddy had three species including *Pyganodon grandis*, *Lasmigona complanata*, and *Lampsilis siliquiodea*. These are the three most widely distributed species in the state.

River	Site ID	# of mussels	# of species
Beaver Creek	Bvr01	1	1
Charbonneau Creek	Ch01	0	0
Clear Creek	Cl01	0	0
Cherry Creek	Cr01	0	0
Cherry Creek	Cr02	0	0
Cattail Creek	Ct01	0	0
Deep Creek	DeC01	0	0
Grand River	Gr01	0	0
Little Beaver Cr.	LBe01	2	1
Long Creek	LC01	0	0
Long Creek	LC02	0	0
Little Missouri	LM01	0	0
Little Missouri	LM02	0	0
Little Missouri	LM03	0	0
Little Missouri	LM04	0	0
Little Missouri	LM05	0	0
Little Missouri	LM06	0	0

River	Site ID	# of mussels	# of species
Little Missouri River	LM07	0	0
Little Muddy River	LMu00	19	3
Little Muddy River	LMu01	0	0
Little Muddy River	LMu02	0	0
Lonesome Creek	Ln01	0	0
Douglas Creek Mid. Branch	MDo01	3	1
Sand Creek	Sa01	0	0
Sand Creek	Sa02	0	0
Spring Creek	Sg01	0	0
Shell Creek	ShC01	0	0
Tobacco Garden Creek	TG01	0	0
Tobacco Garden Creek	TG02	0	0
Tobacco Garden Creek	TG03	0	0
Timber Creek	Ti01	0	0
Douglas Cr. W. Branch	WDO01	0	0
White Earth River	WE01	0	0

Table 1. Western Rivers. This table lists the number of live mussels and mussels species found in the sites sampled in the western part of the state. For more details on the locations of a specific site, see Appendix A.

As a river, the Sheyenne showed the highest diversity with 11 of the 15 North Dakota species found in the river. In our year one qualitative sampling we had 17 of 25 sites (68%) that had 5 species present with two of them having 9 species at a site (see Appendix B.) Other eastern rivers such as the Maple and Goose Rivers also showed good diversity and numbers. The Maple River had 9 different species across the 11 sites sampled and the Goose River had eight species found in its various branches. In these two rivers the highest numbers of mussels found was in the Maple at a site near Durbin where 169 mussels in a one p-h search (15 minutes with four searchers, half of the normal time) were found.

Large River Sampling

Our attempts to sample the Red River and Missouri River with a bottom dredge were not very successful. We did 25 sites in the Red by dredge. While we had some success in the upstream reaches, between Wahpeton and Fargo, in the deeper parts of the river we seldom brought up live mussels in the dredge, although we would bring up many dead shells. Sampling of the Missouri River using a dredge was even less successful. The focus was primarily on the Bismarck area and south to the North Dakota/South Dakota border. In this area the river is considered to be part of Lake Oahe. Eleven sites were sampled using a pontoon to deploy a dredge. No live mussels were found and no empty shells were found. We think to get any kind of useful survey of the Red River or Missouri River it is going to have to be done by scuba.

IV. B. Species accounts:

This section provides an overview to the distribution and generalized abundances for all 15 species of North Dakota mussels. In certain cases we compare to the historical records of Cvancara (1983) for the state distributions and also mention the work of Jensen et al. (2001) in relation to the Sheyenne and Red rivers. It should be noted that such comparisons are rather subjective and not necessarily easily quantified (see Discussion section for further explanation). See Appendix D for range maps.

Subfamily Ambleminae: There were three species of Ambleminae found in our surveys and they were all restricted to the Red River Basin. All three species were fairly common, with numbers and ranges that seemed to exceed those given by Cvancara (1983) on work done in 1965 and Jensen et al. (2001) on work done in 1991-1992. This is encouraging because all three species are listed as a level II species in North Dakota's Comprehensive Wildlife Conservation Strategy (CWCS) Wildlife Action Plan. A level II designation means that they are in need of conservation, but have had support from other wildlife programs.

Threeridge, *Amblema plicata:*
A. plicata was common to locally abundant in some areas of the Red River basin. We collected and measured 824 individuals making it the 4th most common mussel in our study, even though it was only found in the Red River drainage. It was well represented in the Sheyenne River and also found in the Red River and the Pembina. It is most likely common in the Red River, but live mussels were not often collected in our dredge. It was usually found with *F. flava*, *L. recta*, and *Q. quadrula*.

Wabash Pigtoe, *Fusconaia flava:*
F. flava was also fairly common with 306 individuals collected and measured. Cvancara found it only in the Red and Sheyenne Rivers. We found it in these two rivers along with the Turtle River.

Mapleleaf, *Quadrula quadrula:*
While we did not find large numbers of *Q. quadrula* (43 live animals were collected and recorded), it was found in a variety of rivers. We found it in the Sheyenne River, the Pembina River, the Elm, the Bois de Sioux, and the Wild Rice River. We also found it in the Red River; once again it was a species that is probably more abundant in the Red but our dredge did not pick it up. Cvancara (1983) only found live *Q. quadrula* in the Red River, Jensen et al. (2001) found it in both rivers but with only 3 live animals in the Sheyenne. We also only collected 3 live *Q. quadrula* from the Sheyenne.

Subfamily Anodontinae

Cylindrical papershell, *Anodontoides ferussacianus:*
A. ferussacianus is a species whose range has seemed to diminish compared to Cvancara, yet it was found in relatively high numbers in some places. The largest numbers were found in Baldhill Creek and the Turtle River.

White Heelsplitter, *Lasmigona complanata:*
Another common mussel in the state, *L. complanata* was found in all three drainages in the state in good numbers. It can grow to a fairly large size and older individuals tended to have thick shells. It is listed as a level II species in North Dakota's CWCS Wildlife Action Plan. A level II designation means that they are in need of conservation, but have had support from other wildlife programs. This species is well established in many areas of North Dakota.

Creek Heelsplitter, *Lasmigona compressa:*
Unfortunately, *L. compressa* has seemed to become quite rare in the state. It's range included the Forest River, Baldhill Creek, and the Maple River. Cvancara (1983) reported it from the upper Sheyenne River, the Wintering River, and the Pembina but we did not find it in these rivers. Jensen et al. (2001) reported 3 specimens from the

Sheyenne. It is listed as a level II species in North Dakota's CWCS Wildlife Action Plan. The status of this species should be of concern.

Giant Floater, *Pyganodon grandis:*
P. grandis is a common mussel found throughout the state. It is known to occupy a variety of habitats and often was the only mussel collected in some sites. In fact the highest density of mussels was in the McClusky canal were 5 minutes of collecting by the four person crew resulted in 384 mussels, all giant floaters.

Creeper, *Strophitus undulatus:*
S. undulatus was a species with a more scattered range and fairly low numbers (only 24 were collected during the surveys). It was found in the Forest River, South Branch of the Park River, and the Sheyenne River. The majority of our specimens were taken from the Sheyenne River. This is interesting because Jensen et al. (2001) did not find any live specimens of *S. undulatus* in the Sheyenne River.

Subfamily Lampsilinae

Plain Pocketbook, *Lampsilis cardium:*
L. cardium was found in both the Red River Drainage and the Missouri River Drainage. In the Missouri River Drainage it was found primarily in the Heart and Knife rivers. Cvancara had found live mussels at only one site in the Missouri River Drainage and so the population seems to have expanded somewhat in the western part of the state. In the eastern part of the state it has a good distribution with healthy populations in the Red and Sheyenne rivers.

Fat Mucket, *Lampsilis silquiodea:*
L. silquiodea was the most common mussel collected in our efforts with a total of 2741 being collected and measured. It was found throughout the state and often in large numbers. The largest number collected at one site was 218 in the Wintering River, part of the Souris River drainage. Other large populations were found in several rivers.

Fragile papershell, *Leptodea fragilis:*
L. fragilis is a new record for the state. Live animals were found at only one site, the site on the James River where our other new state record, *T. truncata*, was found (see below). We found seven live *L. fragilis* mussels at that site in 2008. We returned to the site in the fall of 2010 and found 5 live mussels. In addition we found several dead shells on the Apple River near Bismarck. It is possible that this species has a wider range within the Missouri River basin and could be found in the Missouri itself. This was a confusing one to compare to Cvancara's work. He listed the fragile papershell as *Proptera laevissima*, which is no longer considered a valid name. It appears that he was referring to *Potamilus ohiensis*, the pink papershell (see below). Bill Jensen with

the North Dakota Game and Fish showed me a letter from Dr. Cvancara that says that *Leptodea fragilis* has never been documented in North Dakota. We are certain our specimens are *L. fragilis*, pictures of these mussels were sent to Dr. G. Thomas Watters, curator of the Ohio State University mollusk collection. He verified both of our identifications of *L. fragilis* and *T. truncata*.

Black Sandshell, *Ligumia recta:*
The range of *L. recta* in the Sheyenne reached above Baldhill Dam almost to the upper region of the Sheyenne River. It was also found in the Pembina River, Red River, and the Wild Rice River. It was never present in large numbers, the highest number we recorded from one site was 20 at a site on the Sheyenne River (Site ID: Sh16). However, it seems to be more common in the Sheyenne than what was found in either Jensen et al. (2001) or Cvancara's (1983) work.

Pink Heelsplitter, *Potamilus alatus:*
P. alatus was widespread in the eastern part of the state. We found it throughout the Red River, in fact it was one of the few species we consistently collected live with our dredge. In addition it was found in the Sheyenne, the Wild Rice, the Bois de Sioux, and the Pembina. Comparing to Cvancara (1983), this mussel has expanded its range in the eastern portion of North Dakota. Jensen et al. (2001) reported it in the Sheyenne only at the site nearest the confluence with the Red River. We found this species further up the Sheyenne all t he way to just downstream from the town of Lisbon. At this site we found one particularly large living specimen in the Sheyenne River, it measured 19.4 cm (over 7 ½ inches) in length and was one of the largest mussels collected.

Pink papershell, *Potamilus ohiensis:*
We only found one living mussel for *P. ohiensis*, and this was on the Knife River. However we did find empty shells at a site on the Apple River near Bismarck. This is a reduction in range compared to what Cvancara reported for this species (referred to as *Proptera laevissima* in his work). This is a level III species in North Dakota's CWCS Wildlife Action Plan meaning it is a "species in moderate need of conservation, but is believed to be on the edge of it's range in North Dakota".

Deertoe, *Truncilla truncata:*
T. truncata is a new record for the state. One live animal was found in 2008 and 3 more were found in the fall of 2010 at the same site; no empty shells were found. We collected it from the James River, which has populations of this mussel in South Dakota (Perkins and Backlund, 2003). This is a small species in size, the smallest adult mussel in North Dakota. This may be part of the reason for it not being found earlier or in larger

numbers. It will be interesting to see if our quantitative sampling will pick up more individuals this summer.

IV. C. Thin sectioning of shells

In our first attempt at thin sectioning we had some problems trying to determine how to section large shells. We thin sectioned 30 – 35 shells that consisted of *P. grandis*, *L. silquiodea*, and *F. flava*. Four different people then aged the resulting slides and their results compared. Unfortunately there was a wide disagreement in the results. Much of the problem was due to inconsistencies in determining what a true growth ring was. In addition, the examination was difficult because you could only focus on one area of the slide at a time. We then devised a method of taking a variety of pictures through our stereomicroscope and then putting together a composite picture so growth rings could be followed along the entire length of the shell and counted properly. We then compared the growth rings of a single species, *P. grandis*, from three different sites (see figure 3). One site was on the Sheyenne River, one on the James River, and the third was from the McClusky Canal. We took 30 mussels form each site.

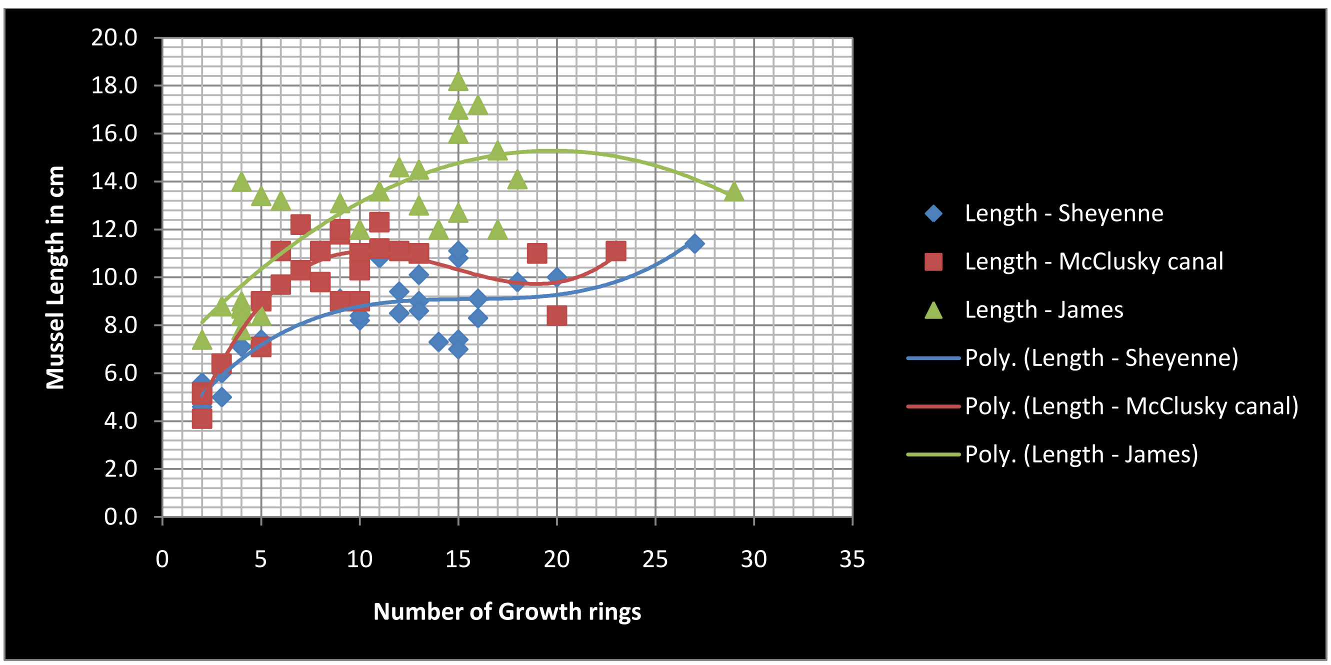


Figure 3. Comparison of mussel length to number of growth rings of the mussel *P. grandis* from three different sites. (Taken from Bommersbach et. al, 2010)

After cleaning and thin sectioning we had composite pictures of 81 mussels for comparison. Our data showed that the size of a mussel not only was determined by the number of growth rings, but that there must be other site specific growth factors. For example, the mussels from the James River were much larger than the other two sites, yet had a comparable range of growth rings. This would suggest that other factors, such as nutrient levels, play a role in mussel growth.

Quantitative sampling

Overall in years two and three (2009-2010) 36 sites were sampled quantitatively. Eleven of these sites were done as high density sites (Figure 4) and nineteen were done with the low density site protocol (Figure 5). The site with the highest density was on the Sheyenne River, the second highest densities were found in a tributary to the Sheyenne, Baldhill Creek. Densities were highly variable, even between the two 100 meter stretches at a particular site. For example, at site Sh16 the first 100 meters had an average density of 37.3 mussels per square meter and the second 100 meters had an average density of 56.8 mussels per square meter (see Appendix C). The overall average was 46.8 mussels per meter squared.

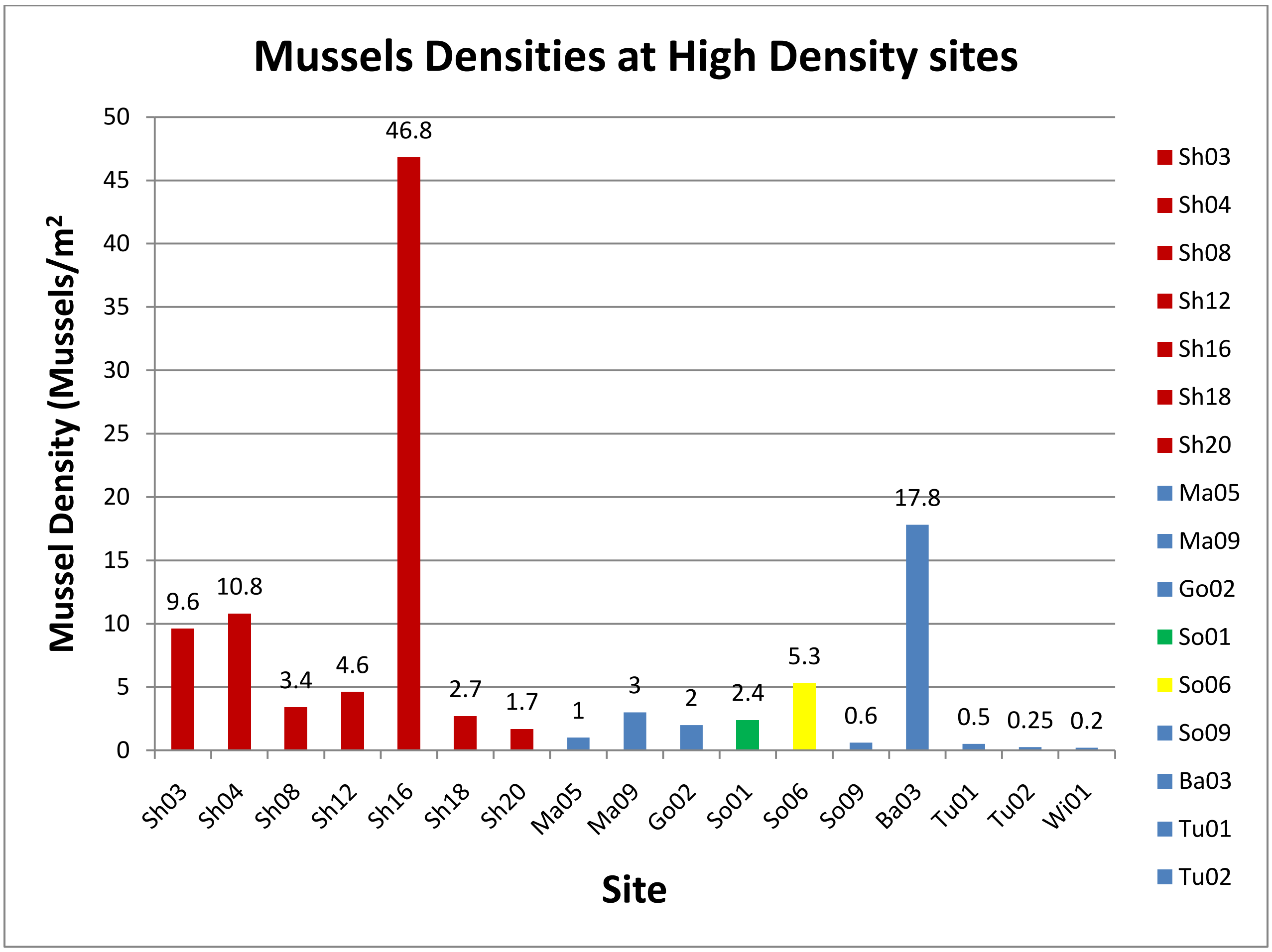


Figure 4. Average mussel densities at each site measured with the high density site protocol. These numbers are an average of the two 100 meter stretches at each site. Locations of each of the sites can be found in Appendix A.

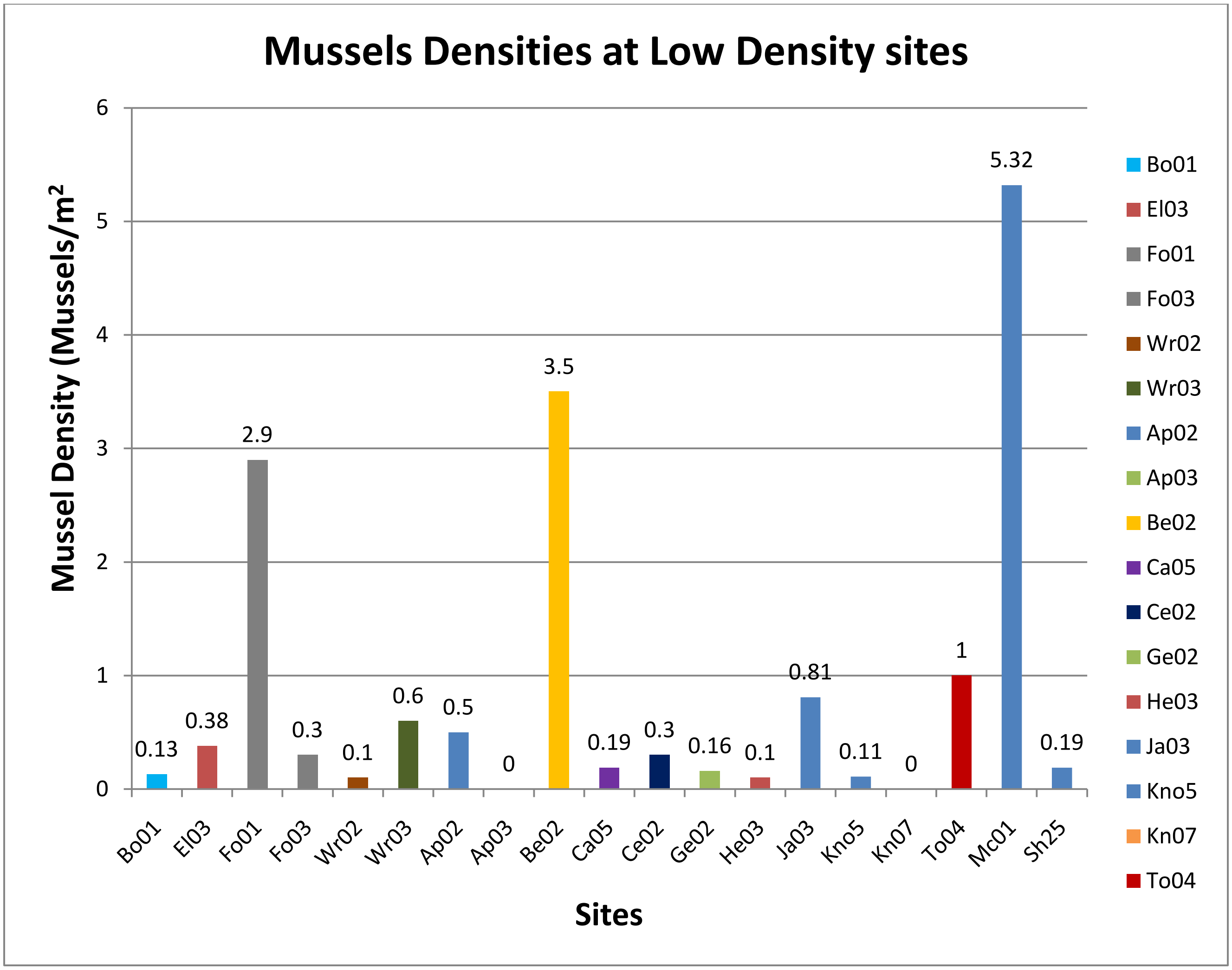


Figure 5. Average mussel densities at each site measured with the low density site protocol. These numbers are an average of the two 100 meter stretches at each site. Locations of each of the sites can be found in Appendix A.

V. DISCUSSION

Overall our method for qualitative sampling of wadeable rivers worked well. Part of the purpose of this project was to provide protocols for future sampling. Our use of 4 searchers doing a primarily tactile search was quick and efficient allowing us to sample up to 6 sites a day. An important part of our method was obtaining the sampling nets from Wildco with a heavier, wider mesh. Our method for large rivers, use of a dredge, was suspect in its ability to pick up live specimens. This raises the question as to what are the mussel populations in our two largest rivers? As far as we can tell, Cvancara did not sample the Missouri River, nor can we find any records of anyone else doing a mussel survey on this river. Our attempts at sampling the Missouri were not very successful. Part of this could be attributed to the recent rise in water levels for this river.

This makes examining the shoreline for empty shells, a good way to assess the presence of mussels, a rather useless endeavor. To do a thorough study of the Missouri River, and the Red River for that matter, it is probably best to bring in a professional dive team to do a thorough search. This is beyond the scope of our expertise. Sampling the Missouri is an important goal for the future.

Comparison to past work is tricky at best. Qualitative protocols are meant to give a quick method of determining what is in the river. By no means do these methods pick up every mussel at a given site, in fact they probably only detect a percentage of the mussel population, especially in the deeper, turbid sites where foot tactile searching was done. These types of surveys are not good for calculating relative densities or population age statistics because they have an inherent bias in what you are sampling. With these methods you tend to sample the larger specimens that are on the sediment surface. It is encouraging that we found as many specimens as we did. However it is very possible that we not only missed some percentage of individuals at each site, we possibly missed some species. Since Cvancara (1983) and Jensen et al. (2001) used similar methods, the same is probably true for them. As an example, Jensen et al. (2001) only found Pink Heelspltters (*P. alatus*) at the most downstream site on the Sheyenne River. We found *P. alatus* extending up to near Lisbon. In fact we found 4 specimens that ranged in length from 15.8 – 19.4 cm in size at this site. These are very large mussels that are most likely much older than 20 years old, so they were probably there when Jensen et al. (2001) sampled in 1992. This example is not meant to criticize Jensen et al. (2001), in fact their protocols utilized scuba and snorkeling and in many places on the Sheyenne they sampled two years. It is to point out that even a good qualitative sampling may not pick up all species at a site. In addition, all three studies, Cvancara (1983) Jensen et al. (2001), and our current study are merely snapshots in time. Cvancara's work ranged from 1965 to 1978, yet most of the sites he visited in that time were only sampled once with several of them being resampled once. Although they are considered to be new state records, to say that *L. fragilis* and *T. truncata* were not present in North Dakota until quite recently is based on a very small sample size for each river. Unfortunately, North Dakota rivers do not have a long list of historical records for mussel species. To get a true picture of the mussel populations there is a need for a quantifiable survey done on a regular basis throughout the state.

One obvious outcome of our project was the fact that the eastern rivers have healthy populations of mussels. The Sheyenne River had the largest and most diverse mussel populations in the state. The Goose River and the Maple River also stood out as having high diversity and numbers of mussels. It is interesting to note that Cvancara (1983) did not find these high numbers or diversity in his work. On the Goose he found a total of 7 live mussels, all *P. grandis*, over 4 sites. That compares to our 100 mussels representing 8 species over 3 sites. In the Maple he only found 32 live mussels representing 3 species over 4 sites. We found 516 live mussels representing 9 species over 11 sites. Once again it is difficult to say with certainty that mussels have greatly increased in these rivers, but the numbers are compelling for this argument.

In their report on Sheyenne and Red River mussel populations, Jensen et al. (2001) raised several concerns. First, in comparing populations sampled in 1992 to those sampled in the early 1970's, they point out that both the Sheyenne River and Red River seem to have shown a decline in populations for most species of Anodontinae and Lampsilinae subfamilies. Secondly, they express concern for members of the subfamily Ambleminae for several reasons including their need to have fairly dense population structures for reproductive success. Our work seems to show that the Ambleminae are at least maintaining, if not increasing their range and numbers. While this is true for some species of the other two subfamilies, there are some members of both Anodontinae and Lampsilinae that do seem to be showing a decline statewide. The Creek Heelsplitter, *L. compressa*, is the species that seems to be in the greatest decline. Other species of concern would be the Pink Papershell, *P. oheinsis*, and the Creeper, *S. undulata*. It should be pointed out however, that these species, along with our two new state records, could all be classified as being on the edge of their range. Mussel distributions are at their greatest in the southeast area of the United States, the number of species tends to decrease as you go west and north. So it is possible that these species were never found in large numbers in North Dakota. Once again without sufficient historical records it is difficult to tell. All of the species found in North Dakota are common in other areas of the United States. Looking at what has been described so far, North Dakota does not have any endemic species of mussels.

The fact that we found two new species could be due to several factors. One possibility is that they may have been there, but no one ever documented them. As stated earlier, Cvancara only visited many of his sites one time. This is especially true of the sites in the Missouri River drainage, where both of our specimens were found. The alternative possibility is that they truly are new to the state in the last couple of decades. One interesting correlation that should be considered is the flow differences between rivers 30 to 40 years ago and the current flows today. A quick look at gaging station data from the USGS gauging station at LaMoure shows that the average July flow for the James River was 135 cfs from 1965 to 1975. Looking at the same station from 1995 to 2005 the average July flow was 563 cfs (USGS National Water Information Service; Web Interface , 2009). The eastern part of North Dakota is experiencing an extended wet cycle that began in the early 1990's. This certainly could be a factor in mussel distributions. At the same time, the western part of the state had been experiencing low flow and drought conditions. Once again this could be a factor in mussel distributions in that part of the state.

Our quantitative protocols worked well. It was interesting that we had to raise our limit for determining low or high density protocols from 30 mussels/person hour, used by Villela and Smith(2005), to 50 mussels/person hour because of the relatively high numbers we found in our qualitative searches. We had two sites with very high densities, one on the Sheyenne with an average density of 46.8 mussels per square meter over the two 100 meter stretches and one on Baldhill Creek with a density of 17.8 mussels per square meter over the two 100 meter stretches. A calculation of the number of mussels in a 100 meter stretch at the Sheyenne River site comes to over 100,000 mussels. Even sites with seemingly small densities such as Apple 02, which had a density of 0.5 mussels per square meter, represent a relatively healthy population. If the river was ten meters wide and you have this density over 100 meters, that is a population of approximately 500 mussels in this 100 meter stretch of river.

As pointed out in Table 1, very few mussels were found in western these rivers. This was not overly surprising because historical records indicate that mussels are not as numerous in the western edge of the state and are pretty much limited to the three primary species in the state *P. grandis*, *L. silquiodea*, and *L. complanata*. In comparing to Cvancara (1983), he found substantially higher numbers in the White Earth River and the Little Muddy than we did. Our sampling did not find any mussels in the White Earth and only one site on the Little Muddy with mussels. Whether this is indicative of a decrease in mussel populations since the time of Cvancara's work or it is due to the chance nature of our sampling techniques is hard to determine.

In summary, we found the overall mussel populations to be in relatively good condition in most of the state. Their future may be threatened, however, by several factors. The healthiest populations in the state, in the Sheyenne River, may soon be exposed to the highly saline waters of Devils Lake when the Devils Lake outlets begin to run at full capacity. In addition, eastern North Dakota is about to undergo a huge increase in drain tiling. This practice of putting drainage tiles underneath farm fields to drain away excess water will have negative effects on water quality. Many of the soils in this part of the state are highly saline and the drainage of this water into our rivers and streams could be detrimental to our mussel populations. It will be important to monitor our mussel populations in the future.

IV. LITERATURE CITED

Bergman, S.M., Eberle, M.E. and Obermeyer, B.K. 2000. Freshwater mussels (Bivalvia: Unionoidea) in Streams of Northwestern Kansas. *The Prairie Naturalist* 32(1):1-15.

Cvancara, A. M. 1970. Mussels (Unionidae) of the Red River Valley in North Dakota and Minnesota, U.S.A. *Malacologia* 10(1):57-92.

Cvancara, A.M., and Freeman, P. G. 1978. Diversity and distribution of mussels (Bivalvia: Unionacea) in a eutrophic reservoir, Lake Ashtabula, North Dakota. *The Nautilus* 92(1):1-9.

Cvancara, A. M. 1983. Aquatic Mollusks of North Dakota. Report of Investigation No. 78: North Dakota Geological Survey. 1-141.

Jensen, W.F., Kriel, R.L., Dyke, S.R., Schumaker, J.D. and M.G. Mckenna. 2001. Distribution, relative abundance, and species diversity of freshwater mussels in the Sheyenne and Red Rivers of eastern North Dakota. North Dakota Fisheries Investigations Report #42. North Dakota Game and Fish.

Jones, J.W., R.J. Neves, M.A. Patterson, C.R. Good, and A. DiVittorio**.** 2001. A status survey of freshwater populations in the upper Clinch River, Tazewell County, Virginia. *Banisteria* 17: 20-30.

Poole, K. E. and Downing, J. A. 2004. Relationship of declining mussel biodiversity to stream-reach and watershed characteristics in an agricultural landscape. *Journal of the North American Benthological Society* 23(1):114-125.

Pooler, P.S., and Smith, D.R. 2005. Optimal sampling design for estimating spatial distribution and abundance of a freshwater mussel population. *Journal of the North American Benthological Society* 24(3):525-537.

Schwalb, A. N., and Pusch, M.T. 2007. Horizontal and vertical movements of unionid mussels in a lowland river. *Journal of the North American Benthological Society* 26(2):261-272.

Strayer, D. L., and Smith, D.R. 2003. A Guide to Sampling Freshwater Mussel Populations. American Fisheries Society Monograph 8.

Smith, D. R., R. F. Villella, D. P. Lemarié, and S. von Oettingen. 2001. How much excavation is needed to monitor freshwater mussels. Pages 203-218. In Tankersley, R. A., D.I. Warmolts, G.T. Watters, B.J. Armitage, P.D. Johnson, and R.S. Butler (editors).

Freshwater Mollusk Symposium Proceedings. Ohio Biological Survey, Columbus, Ohio. xxi + 274 pp.

Tompkins, T.J. and DeLorme A.W. 2007. Population Analysis of Unionid Bivalves in the Sheyenne River. *Proceedings of the North Dakota Academy of Science* 61:21.

Villella, R.F. and Smith, D.R. 2005. Two-phase sampling to estimate river-wide populations of freshwater mussels. *Journal of the North American Benthological Society* 24(2):357-368.

Williams, J.D., Warren, M.L, Cummings, K.S., Harris, J.L. and R.J. Neves. 1993. Conservation status of freshwater mussels of the United States and Canada. *Fisheries*: 18:6-22.

Acknowledgements

Thanks to Louis Wieland, lab manager for the VCSU Macroinvertebrate lab. He coordinated much of the sampling activities and produced most of the data included in this report. Thanks to Dr. Jerry van Amburg from Concordia College for his collaboration and wealth of field experience. Also thanks to our student researchers Jacob Mertes, Andrew Hager, Adam Bomersbach, Kaleb Cox, and Caitlin Miller from Valley City State University; and Pat Williamson, Jarryd Campbell, Matt Schlenvogt, Joe Bruenjes and Tyler Chase from Concordia College. Their long hours in the water were much appreciated.

Appendix A – List of Sites sampled in during the three period of the study with location and date sampled

River	SiteID	Location	Date	Lat	Long
Deep Creek	DeC01	11 mi W and 7 mi N of Amidon	8/13/2010	46.57638	-103.55780
Antelope Creek	An01	11 mi S of Dickinson	6/24/2008	46.72121	-102.78989
Antelope Creek	Ant01	0.5 mi N of Dwight	7/15/2010	46.31147	-96.73420
Antelope Creek	Ant02	2.25 mi E of Galchutt	7/15/2010	46.38405	-96.76348
Apple Creek	Ap01	0.5 mi W and 2.25 mi N of Menoken	6/18/2008	46.85594	-100.54052
Apple Creek	Ap02	0.25 mi N and 1.75 mi E of Pierce	6/18/2008	46.79437	-100.65744
Apple Creek	Ap03	N of University of Mary	6/18/2008	46.74128	-100.75336
Bald Hill Creek	Ba01	2.25 mi N of Revere	6/16/2008	47.38923	-98.32895
Bald Hill Creek	Ba02	2 mi E of Walum	6/16/2008	47.26991	-98.15617
Bald Hill Creek	Ba03	3.5 mi E and 0.75 mi N of Dazey	6/16/2008	47.20096	-98.12058
Bald Hill Creek	Ba04	6 mi E of Dazey on Hwy 26	6/16/2008	47.18298	-98.07030
Beaver Creek	Be01	0.25 mi S of Burnstad	6/19/2008	46.38493	-99.63425
Beaver Creek	Be02	16.5 mi W of Wishek	6/19/2008	46.26045	-99.90350
Beaver Creek	Be03	S of Linton	6/19/2008	46.25595	-100.23281
Beaver Creek	Be04	8 mi W of Linton	6/19/2008	46.26176	-100.39899
Beaver Creek	Be05	11.5 mi W and 1 mi S of Linton	6/21/2010	46.24677	-100.47427
Badger Creek	Bg01	1 mi E of Livona	6/21/2010	46.50054	-100.52613
Bonehill Creek	Bn01	1 mi W and 2 mi S of Dickey	7/28/2010	46.50254	-98.49415
Bonehill Creek	Bn02	2.5 mi S and 1 mi E of Dickey	7/28/2010	46.50195	-98.44547
Bois De Sioux River	Bo01	1.75 mi E of Fairmount	8/14/2008	46.05097	-96.56609
Bois De Sioux River	Bo02	1 mi S of Tyler	8/10/2010	46.15244	-96.57953
Bear Creek	Br01	5 mile North and 1 mile East of Oakes	8/12/2009	46.21131	-98.06834
Buffalo Creek	Bu01	0.5 mi W and 1 mi N of Durbin	7/12/2010	46.82314	-97.15853
Beaver Creek	Bv01	1.75 miles West of Montpelier (James Drainage)	8/13/2009	46.70236	-98.62225
Beaver Creek	Bvr01	5.5 mi E and 8.5 mi S of Ray	6/9/2010	48.21876	-103.03910
Cannonball River	Ca01	1 mi W of New England	6/24/2008	46.54282	-102.88868
Cannonball River	Ca02	NE of Regent	6/25/2008	46.42674	-102.55035
Cannonball River	Ca03	1 mi W and 1 mi S of Burt	6/25/2008	46.35407	-102.17290
Cannonball River	Ca04	1.5 mi E and 2.5 mi S of New Leipzig	6/26/2008	46.34045	-101.91252
Cannonball River	Ca05	1 mi E and 13.5 mi S of Carson	6/26/2008	46.22276	-101.53970
Cannonball River	Ca06	1 mi W of Porcupine	7/16/2008	46.21896	-101.11462
Cannonball River	Ca07	0.5 mi S and 0.25 mi E of Breien	7/16/2008	46.37652	-100.93470
Cedar Creek	Ce01	3.5 mi E and 11 mi N of Reeder	6/24/2008	46.26489	-102.86731
Cedar Creek	Ce02	7.75 mi E and 10.5 mi N of Hettinger	6/25/2008	46.15526	-102.47569
Cedar Creek	Ce03	1 mi W and 22.5 mi S of New Leipzig	6/25/2008	46.05080	-101.95879
Cedar Creek	Ce04	0.5 mi W and 6 mi N of Watauga	6/26/2008	46.01300	-101.56174

River	SiteID	Location	Date	Lat	Long
Cedar Creek	Ce05	13.25 mi S of St. Gertrude	7/16/2008	46.09172	-101.33382
Charbonneau Creek	Ch01	1 mi W and 0.25 mi S of Cartwright	7/20/2010	47.85332	-103.94273
Clear Creek	Cl01	3.5 mi N and 7 mi W of Keene	7/21/2010	47.97781	-103.09464
Cole Creek	Co01	7.5 mi S of Grand Forks	7/14/2008	47.81739	-97.02212
Cole Creek	Co02	5.5 mi S of Grand Forks	7/14/2008	47.84580	-97.00774
Cherry Creek	Cr01	4 mi S and 2.25 mi W of Watford City	7/21/2010	47.7476	-103.33177
Cherry Creek	Cr02	5 mi E of Watford City	7/21/2010	47.80526	-103.17601
Cattail Creek	Ct01	0.75 mi N and 11 mi W of Grassna	6/22/2010	46.09854	-100.52459
Des Lacs River	De01	NE of Donnybrook	7/28/2008	48.51260	-101.88204
Des Lacs River	De02	4.5 mi NW of Carpio	7/28/2008	48.47918	-101.79953
Des Lacs River	De03	1 mi NW of Foxholm	7/28/2008	48.37897	-101.58229
Elm River	El01	2 mi E of Galesburg	7/7/2008	47.26785	-97.36528
Elm River	El02	2 mi N and 4.5 mi W of Grandin	7/7/2008	47.26714	-97.09868
Elm River	El03	2.5 mi W of Hendrum, MN	7/7/2008	47.26561	-96.86230
Elm River	Em01	7 miles W and 1.5 miles S of Ellendale (James Draingage)	8/12/2009	45.98186	-98.67055
Forest River	Fo01	1 mi S of Fordville	6/5/2008	48.20693	-97.79536
Forest River	Fo02	2 mi N of Inkster	6/5/2008	48.17934	-97.64391
Forest River	Fo03	1.5 mi S and 2.25 mi W of Forest River	6/5/2008	48.19474	-97.51762
Forest River	Fo04	2 mi E and 2.5 mi N of Forest River	6/4/2008	48.25195	-97.42690
Forest River	Fo05	0.5 mi W and 1 mi S of Minto	6/4/2008	48.27905	-97.38338
Forest River	Fo06	1.5 mi S and 1.5 mi E of Minto	6/4/2008	48.26709	-97.33343
Forest River	Fo07	2 mi E and 2 mi N of Ardoch	6/3/2008	48.23723	-97.29749
Green River	Ge01	1 mi S of New Hradec	7/17/2008	46.98715	-102.88446
Green River	Ge02	8 mi E of Dickinson	6/24/2008	46.89190	-102.61747
Goose River	Go01	4.5 mi E and 1 mi N of Murray	7/13/2010	47.44003	-97.17806
Goose River	Go02	at the City Park in Hillsboro	7/13/2010	47.4073	-97.05988
Goose River	Go03	1.5 mi W and 1 mi S of Caledonia	7/13/2010	47.44506	-96.92125
Goose River Middle Branch	GoM01	4 mi W and 2.5 mi N of Portland	6/30/2010	47.53782	-97.45325
Goose River North Branch	GoN01	13 mi W of Buxton	6/30/2010	47.59953	-97.37474
Goose River South Branch	GoS01	2 mi W of Portland	6/30/2010	47.50096	-97.40555
Grand River	Gr01	S of Haley	8/2/2010	45.95799	-103.12038
Hawk Creek	Ha01	Dana	6/18/2008	46.57504	-100.23003
Heart River	He01	9 mi S of Richardton	6/24/2008	46.74582	-102.30796
Heart River	He02	1 mi SE of Lake Tschida	7/16/2008	46.58297	-101.79997
Heart River	He03	11 mi N of Lark	6/27/2008	46.60920	-101.38180
Heart River	He04	8.5 mi S and 3 mi E of Judson	6/27/2008	46.70340	-101.21306
Heart River	He05	4 mi W of Mandan	6/27/2008	46.83362	-100.97417
Horsehead Creek	Hh01	12.75 mi W of Temvik	6/21/2010	46.37095	-100.52026
James River	Ja01	5.5 mi E and 2 mi N of Fesseden	6/11/2008	47.67082	-99.51192
James River	Ja02	1.5 mi S and 4 mi E of New Rockford	6/11/2008	47.66011	-99.05486

River	SiteID	Location	Date	Lat	Long
James River	Ja03	1 mi N and 8 mi E of Bordulac	6/11/2008	47.39917	-98.79758
James River	Ja04	Jamestown	8/7/2008	46.89141	-98.68988
James River	Ja05	Montpelier	8/7/2008	46.70038	-98.59404
James River	Ja06	Dickey	8/7/2008	46.53681	-98.46529
James River	Ja07	0.5 mi W of Lamoure	8/7/2008	46.35531	-98.30597
James River	Ja08	4 mi N and 2 mi W of Oakes	8/7/2008	46.19704	-98.13013
Knife River	Kn01	0.5 mi N of Manning	7/17/2008	47.23660	-102.77056
Knife River	Kn02	W of Marshall on Hwy 8	7/17/2008	47.13759	-102.33514
Knife River	Kn03	5 mi E and 1 mi S of Marshall	7/17/2008	47.12666	-102.22852
Knife River	Kn04	5.5 mi S of Zap	7/17/2008	47.20903	-101.91268
Knife River	Kn05	1 mi S of Hazen	7/17/2008	47.28522	-101.61848
Knife River	Kn06	1.5 mi E of Hazen on Hwy 200	7/18/2008	47.29932	-101.58855
Knife River	Kn07	5.5 mi W and 0.5 mi N of Stanton	7/18/2008	47.32787	-101.50228
Little Beaver Creek	LB01	14 mi W nd 4.5 mi S of Linton	6/22/2010	46.20421	-100.52031
Little Beaver Creek	LBe01	SW of Marmarth	8/3/2010	46.29006	-103.94057
Long Creek	LC01	4.25 mi N of Crosby	7/19/2010	48.97441	-103.29018
Long Creek	LC02	4 mi N and 3 mi E of Bounty	7/19/2010	48.97912	-103.11430
Little Missouri River	LM01	17.25 mi S of Marmarth	8/3/2010	46.04753	-103.95422
Little Missouri River	LM02	NE of Marmarth on Hwy 12	8/3/2010	46.29779	-103.91668
Little Missouri River	LM03	at Three V Crossing	8/3/2010	46.56161	-103.78856
Little Missouri River	LM04	11.5 mi S of Medora	8/5/2010	46.75366	-103.59904
Little Missouri River	LM05	2.75 mi N of Medora in TR Park	8/4/2010	46.954	-103.53065
Little Missouri River	LM06	10 mi N of Medora	8/4/2010	47.05839	-103.53328
Little Missouri River	LM07	14 mi S and 4.25 mi W of Watford City in TR Park	8/5/2010	47.59159	-103.34130
Little Muddy River	LMu00	11 mi E and 4.25 mi S of Bonetraill	7/20/2010	48.35654	-103.59909
Little Muddy River	LMu01	2.25 mi N and 5.25 mi W of Spring Brook	6/9/2010	48.28456	-103.57349
Little Muddy River	LMu02	7 mi N and 2 mi E of Williston	7/20/2010	48.24121	-103.58398
Lonesome Creek	Ln01	0.25 mi NE of Charbonneau	7/20/2010	47.85556	-103.75687
Long Lake Creek	Lo01	2 mi E and 1.5 mi N of Dana	6/18/2008	46.59784	-100.18498
Little Pembina River	LPe01	4 mi S of Vang	7/7/2010	48.8489	-98.11758
Little Pembina River	LPe02	4 mi S and 4 mi W of Walhalla	7/7/2010	48.86507	-98.00667
Little Yellowstone Creek	LY01	3.25 mi S and 1 mi E of Kathryn	7/29/2010	46.63081	-97.94479
Maple River	Ma01	5 mi E of Pillsbury	6/23/2010	47.21058	-97.68573
Maple River	Ma02	6.75 mi W of Ayr	6/23/2010	47.03626	-97.63303
Maple River	Ma03	3 mi E of Tower City	6/23/2010	46.91971	-97.60921
Maple River	Ma04	5 mi S and 3 mi W of Buffalo	6/17/2010	46.84715	-97.60818
Maple River	Ma05	3 mi W and 1 mi S of Alice	6/17/2010	46.74569	-97.61810
Maple River	Ma06	Enderlin below Dam	7/1/2010	46.62739	-97.60035
Maple River	Ma06.5	2 mi E and 0.5 mi S of Enderlin	7/12/2010	46.62365	-97.55103
Maple River	Ma07	2.5 mi E of Enderlin on Hwy 46	6/29/2010	46.62957	-97.54301

River	SiteID	Location	Date	Lat	Long
Maple River	Ma07.5	4 mi S of Chaffee	7/12/2010	46.71891	-97.34622
Maple River	Ma08	2.75 mi S of Lynchburg	7/1/2010	46.73491	-97.26307
Maple River	Ma09	Near Durbin below Dam	6/29/2010	46.80496	-97.14577
Maple River	Ma10	S of Interstate 5.5 mi E of Casselton	7/8/2010	46.8762	-97.08229
Maple River	Ma11	1 mi N of Mapleton	7/10/2010	46.90531	-97.05273
Maple River	MaJ01	4.5 miles E and 3.5 miles S of Ellendale (James Drainage)	8/12/2009	45.93676	-98.45338
McClusky Canal	Mc01	3 mi W and 1 mi S of McClusky	7/18/2008	47.47170	-100.50170
Douglas Creek Mid. Branch	MDo01	4.75 mi E and 2 mi N of Emmet	6/8/2010	47.67404	-101.54960
Missouri River	Mi01	0.25 mi N of Rock Haven	6/16/2010	46.87728	-100.88837
Missouri River	Mi02	0.5 mi E of Mandan	6/16/2010	46.82976	-100.85178
Missouri River	Mi03	0.5 mi N of I94	6/16/2010	46.82671	-100.83585
Missouri River	Mi04	1 mi W of Livona	6/21/2010	46.50228	-100.58250
Missouri River	Mi05	1.5 mi NE of Cannon Ball	6/21/2010	46.40857	-100.58313
Missouri River	Mi06	4.25 mi SW of Cannon Ball	6/21/2010	46.33593	-100.55429
Missouri River	Mi07	16 mi W and 1 mi N of Linton	6/21/2010	46.28047	-100.57036
Missouri River	Mi08	16 mi W and 2.5 mi S of Linton	6/22/2010	46.23375	-100.56799
Missouri River	Mi09	3 mi N of Fort Yates	6/22/2010	46.13684	-100.64326
Missouri River	Mi10	2 mi SE of Fort Yates	6/22/2010	46.07987	-100.59420
Missouri River	Mi11	7 mi SE of Fort Yates	6/22/2010	46.01119	-100.54160
Pembina River	Pe01	6.25 mi W of Walhalla	8/13/2008	48.91689	-98.05599
Pembina River	Pe02	4.75 mi W and 1.5 mi S of Walhalla	8/13/2008	48.90035	-98.01819
Pembina River	Pe03	S of Walhalla on Hwy 32	8/12/2008	48.91360	-97.91713
Pembina River	Pe04	3 mi W and 0.5 mi N of Leroy	8/12/2008	48.92953	-97.81825
Pembina River	Pe05	0.5 mi S and 2 mi W of Neche	8/12/2008	48.97811	-97.60316
Pembina River	Pe06	6 mi N and 2 mi E of Bathgate	8/12/2008	48.96296	-97.43709
Pembina River	Pe07	2 mi W and 2 mi S of Pembina	8/12/2008	48.94339	-97.29377
Pipestem Creek	Pi01	6.5 miles South and 2 miles West of Carrington	8/13/2009	47.35588	-99.16286
Pipestem Creek	Pi02	2.75 miles West of Pingree	8/13/2009	47.1679	-98.9688
Park River	PM01	1 mi E and 2 mi S of Nash (Middle Branch)	7/23/2008	48.44257	-97.49163
Park River	PN01	0.5 mi E of Hoople (N Branch)	7/23/2008	48.53547	-97.62270
Park River	PR01	3 mi E and 4 mi S of Herrick	7/23/2008	48.45352	-97.17001
Park River	PS01	4 mi W and 1 mi N of Grafton (S Branch)	7/23/2008	48.42731	-97.49129
Painted Woods Creek	PWC01	0.5 mi E and 1 mi N of Merida	6/8/2010	47.25922	-100.91980
Red River	Re01	Wahpeton	7/1/2008	46.28856	-96.59592
Red River	Re02	0.5 mi W of Brushvale, MN	7/1/2008	46.36789	-96.65583
Red River	Re03	2 mi E of Frontier	7/2/2008	46.80277	-96.79623
Red River	Re04	Fargo	7/2/2008	46.87318	-96.77900
Red River	Re05	N of Fargo	7/2/2008	46.91417	-96.75723
Red River	Re06	N of Fargo	7/7/2008	46.92609	-96.76173
Red River	Re07	1.5 mi N and 1 mi W of Georgetown, MN	7/7/2008	47.09807	-96.81789

River	SiteID	Location	Date	Lat	Long
Red River	Re08	1 mi W of Halstad, MN N of Hwy 200	7/9/2008	47.35663	-96.84753
Red River	Re09	1.5 mi N and 1 mi E of Caledonia	7/10/2008	47.47823	-96.86858
Red River	Re10	2 mi W of Climax, MN	7/10/2008	47.60635	-96.85500
Red River	Re11	8 mi E and 1 mi S of Thompson	7/14/2008	47.75969	-96.93715
Red River	Re12	S of Grand Forks	7/14/2008	47.89929	-97.02366
Red River	Re13	Grand Forks	7/14/2008	47.91928	-97.01630
Red River	Re14	N of Grand Forks	7/22/2008	47.94792	-97.05554
Red River	Re15	3.25 mi E and 1 mi N of Manvel	7/22/2008	48.09065	-97.10897
Red River	Re16	4 mi E of Poland	7/22/2008	48.19991	-97.13729
Red River	Re17	5 mi E and 5 mi N of Warsaw	7/23/2008	48.37093	-97.14934
Red River	Re18	7 mi E and 1 mi N of Oakwood	7/23/2008	48.44302	-97.14944
Red River	Re19	7.5 mi E of Cashel	7/23/2008	48.48507	-97.14021
Red River	Re20	2.5 mi S and 1.5 mi E of Drayton	7/23/2008	48.53320	-97.14862
Red River	Re21	2 mi N of Robin, MN	7/24/2008	48.59790	-97.14464
Red River	Re22	3.5 mi N and 1 mi E of Robin, MN	7/24/2008	48.62283	-97.12997
Red River	Re23	2.5 mi N and 2 mi E of Bowesmont	7/24/2008	48.72311	-97.13107
Red River	Re24	2 mi E of Joliette	7/24/2008	48.81890	-97.18092
Red River	Re25	Pembina	7/24/2008	48.96703	-97.23883
Sand Creek	Sa01	8 mi W and 7 mi N of Amidon	8/4/2010	46.58182	-103.50122
Sand Creek	Sa02	11.5 mi NW of Amidon	8/5/2010	46.5913	-103.50097
Spring Creek	Sg01	3.75 mi S of Bowman on Hwy 85	8/2/2010	46.12493	-103.41100
Sheyenne River	Sh01	4.5 mi S and 0.5 mi W of Harvey	6/10/2008	47.70248	-99.94891
Sheyenne River	Sh02	2.25 mi S of Wellsburg	6/10/2008	47.79846	-99.79360
Sheyenne River	Sh03	3 mi S of Flora	6/10/2008	47.90792	-99.41576
Sheyenne River	Sh04	4 mi W of Sheyenne	6/10/2008	47.83252	-99.20791
Sheyenne River	Sh05	8.5 mi E of Sheyenne	8/6/2008	47.83361	-98.93490
Sheyenne River	Sh06	1 mi W and 12 mi S of Tokio	8/6/2008	47.75036	-98.84009
Sheyenne River	Sh07	3.5 mi S and 0.5 mi W of Hamar	8/6/2008	47.79473	-98.58794
Sheyenne River	Sh08	2.5 mi W and 0.5 mi S of Pekin	8/6/2008	47.78101	-98.38003
Sheyenne River	Sh09	4 mi W of Kloten	8/6/2008	47.71264	-98.16126
Sheyenne River	Sh10	10.5 mi N of Cooperstown	8/8/2008	47.59768	-98.12059
Sheyenne River	Sh11	1 mi S and 7.5 mi W of Finley	8/8/2008	47.49952	-97.99392
Sheyenne River	Sh12	4 mi E and 1 mi N of Shepard	8/8/2008	47.39741	-98.04311
Sheyenne River	Sh13	1.5 mi below Baldhill Dam	7/8/2008	47.01595	-98.10062
Sheyenne River	Sh13.5	Upstream of Co Hwy 21, Below Dam in Valley City	7/29/2010	46.91576	-98.01048
Sheyenne River	Sh14	4 mi S of Valley City	7/8/2008	46.86473	-97.99726
Sheyenne River	Sh15	1.5 mi N of Kathryn	8/1/2008	46.70184	-97.97626
Sheyenne River	Sh16	1 mi E of Kathryn below dam	8/4/2008	46.67372	-97.94555
Sheyenne River	Sh17	Little Yellowstone Park S of Hwy 46	8/4/2008	46.62917	-97.94008
Sheyenne River	Sh18	4 mi E of Fort Ransom	8/4/2008	46.51420	-97.84402

River	SiteID	Location	Date	Lat	Long
Sheyenne River	Sh19	4 mi N and 5 mi W of Lisbon	8/4/2008	46.50011	-97.77248
Sheyenne River	Sh20	2 mi E and 4 mi S of Lisbon	8/4/2008	46.38384	-97.63319
Sheyenne River	Sh21	8.5 mi E and 4 mi S of Lisbon	8/5/2008	46.38427	-97.50066
Sheyenne River	Sh22	1 mi S of Anselm	8/5/2008	46.51490	-97.48970
Sheyenne River	Sh23	1 mi W and 2 mi S of Power	8/5/2008	46.53073	-97.26124
Sheyenne River	Sh24	3.25 mi S of Kindred	8/5/2008	46.60319	-97.03228
Sheyenne River	Sh25	1 mi S and 1 mi W of Horace	8/5/2008	46.74637	-96.92700
Shell Creek	ShC01	2.5 mi W and 5 mi N of Parshall	6/9/2010	48.02617	-102.18133
Souris River	So01	14.5 mi W of Sherwood	7/29/2008	48.96630	-101.94733
Souris River	So02	2.5 mi S and 13.5 mi W of Sherwood	7/29/2008	48.92265	-101.92673
Souris River	So03	5.5 mi N of Tolley	7/29/2008	48.80841	-101.82539
Souris River	So04	3 mi E of Foxholm	7/28/2008	48.37186	-101.50613
Souris River	So05	2.5 mi E and 2 mi S of Burlington	7/29/2008	48.24592	-101.37198
Souris River	So06	Minot	7/29/2008	48.22699	-101.25285
Souris River	So07	1 mi W and 0.5 mi N of Sawyer	7/29/2008	48.09805	-101.07880
Souris River	So08	0.5 mi W of Verendrye	7/31/2008	48.12485	-100.74929
Souris River	So09	8.5 mi S and 6 mi W of Towner	7/30/2008	48.22514	-100.53722
Souris River	So10	8 mi E of Bantry	7/30/2008	48.50608	-100.43449
Souris River	So11	1.5 mi N and 3.75 mi E of Upham	7/30/2008	48.60261	-100.64677
Souris River	So12	S of Canada	7/30/2008	48.99633	-100.95767
Spring Creek	Sp01	0.5 mi S and 0.5 mi E of Kathryn	7/28/2010	46.67167	-97.95717
Swan Creek	Sw01	1 mi S and 4 mi E of Casselton	7/8/2010	46.87611	-97.13206
Turtle Creek	TC01	3 mi E of Washburn	7/18/2008	47.28675	-100.96392
Tobacco Garden Creek	TG01	3 mi E and 8 mi N of Watford City	7/21/2010	47.91844	-103.22659
Tobacco Garden Creek	TG02	3 mi S and 1.25 mi E of Banks	7/21/2010	47.9924	-103.16650
Tobacco Garden Creek	TG03	2.75 W and 3 mi N of Banks	7/21/2010	48.08192	-103.12777
Timber Creek	Ti01	11 mi N of Rawson	7/10/2010	47.97863	-103.55148
Tongue River	To01	4.75 mi W and 1 mi S of Akra	7/24/2008	48.76097	-97.83147
Tongue River	To02	1 mi E of Akra	7/24/2008	48.77810	-97.70726
Tongue River	To03	3 mi E and 4 mi N of Cavalier	7/24/2008	48.85194	-97.55637
Tongue River	To04	3.5 mi W and 2 mi S of Pembina	7/24/2008	48.91988	-97.31953
Turtle River	Tu01	4 mi W and 1 mi N of Arvilla	7/22/2008	47.93728	-97.58092
Turtle River	Tu02	4 mi E and 5 mi N of Arvilla (N of GF AFB)	6/2/2008	47.99086	-97.40674
Turtle River	Tu03	3.75 mi E of Mekinock	6/2/2008	48.01489	-97.28236
Turtle River	Tu04	4 mi N and 0.5 mi E of Manvel	6/2/2008	48.13528	-97.16744
Turtle River	Tu05	3.5 mi E and 1.75 mi S of Poland	6/3/2008	48.17429	-97.14769
Douglas Creek West Branch	WDo01	1 mi W and 3 mi S of Emmet	6/8/2010	47.60607	-101.67069
White Earth River	WE01	11.75 mi S of White Earth @ 1804 Intersection	6/9/2010	48.21185	-102.77976
Wintering River	Wi01	Hamlin	7/15/2008	48.17130	-100.53971
Wild Rice River	WR01	1.5 mi W of Mantador	7/15/2008	46.16652	-97.28312

River	SiteID	Location	Date	Lat	Long
Wild Rice River	WR02	0.5 mi E and 5.5 mi S of Farmington	7/15/2008	46.16739	-97.01078
Wild Rice River	WR03	2 mi S of St. Benedict	7/15/2008	46.19057	-96.74168
Wild Rice River	WR04	4 mi E and 5.5 mi N of Karlsruhe	7/31/2008	46.70095	-96.84112

Appendix B – Sheyenne River Qualitative Data

Site #	Search time	Mussels/ hour	# of species	Species found	# of individuals measured
SH01	2 hr	0	0	none	0
SH02	2hr	0	0	none	0
SH03	1 hr	108	4	*Pyganodon grandis*	95
				Lampsilis siliquoidea	10
				Strophitus undulatus	1
				Anodontoides ferusacianus	2
SH04	2 hr	51	3	*Pyganodon grandis*	73
				Lampsilis siliquoidea	28
				Lasmigona complanata	1
SH05	1 hr	144	3	*Lampsilis siliquoidea*	99
				Pyganodon grandis	42
				Lasmigona complanata	3
SH06	1 hr	149	3	*Lampsilis siliquoidea*	71
				Pyganodon grandis	75
				Lasmigona complanata	3
SH07	40 min.	506	2	*Lampsilis siliquoidea*	156
				Pyganodon grandis	187
SH08	1 hr	238	6	*Lampsilis siliquoidea*	191
				Pyganodon grandis	29
				Strophitus undulatus	7
				Lasmigona complanata	4
				Fusconaia flava	4
				Anodontoides ferusacianus	3
SH09	1 hr	172	6	*Lampsilis siliquoidea*	90
				Pyganodon grandis	58
				Lasmigona complanata	13
				Amblema plicata	7
				Fusconaia flava	3
				Anodontoides ferusacianus	1
SH10	2 hr	69.5	5	*Lampsilis siliquoidea*	86
				Pyganodon grandis	40
				Amblema plicata	9
				Lasmigona complanata	2
				Strophitus undulatus	2

Site #	Search time	Mussels/ hour	# of species		# of individuals measured
SH11	1 hr	182	5		162
				Pyganodon grandis	7
				Amblema plicata	6
				Lasmigona complanata	4
				Fusconaia flava	3
SH12	1 hr	106	6	*Lampsilis siliquoidea*	80
				Pyganodon grandis	10
				Amblema plicata	8
				Strophitus undulatus	4
				Lasmigona complanata	3
				Fusconaia flava	1
SH13	2 hr	32	2	*Lampsilis siliquoidea*	61
				Amblema plicata	3
SH14	2 hr	66.5	7	*Lasmigona complanata*	58
				Amblema plicata	18
				Fusconaia flava	17
				Lampsilis siliquoidea	17
				Pyganodon grandis	10
				Lampsilis cardium	7
				Ligumia recta	6
SH15	2 hr	36.5	7	***Amblema plicata***	34
				Lampsilis siliquoidea	10
				Pyganodon grandis	10
				Fusconaia flava	8
				Lasmigona complanata	8
				Lampsilis cardium	2
				Ligumia recta	1
SH16	1 hr	328	8	***Amblema plicata***	90
				Fusconaia flava	63
				Lampsilis siliquoidea	44
				Lasmigona complanata	37
				Pyganodon grandis	37
				Lampsilis cardium	34
				Ligumia recta	20
				Strophitus undulatus	3

Site #	Search time	Mussels/ hour	# of species	Species found	# of individuals measured
SH17	1 hr	218	8	***Fusconaia flava***	65
				Lampsilis cardium	63
				Amblema plicata	62
				Ligumia recta	12
				Lampsilis siliquoidea	7
				Pyganodon grandis	5
				Anodontoides ferusacianus	3
				Strophitus undulatus	1
SH18	1 hr	199	6	***Amblema plicata***	116
				Fusconaia flava	53
				Ligumia recta	16
				Lampsilis cardium	11
				Lampsilis siliquoidea	2
				Lasmigona complanata	1
SH19	2 hr	52	6	***Fusconaia flava***	44
				Lampsilis cardium	25
				Ligumia recta	15
				Amblema plicata	13
				Lampsilis siliquoidea	6
				Strophitus undulatus	1
SH20	2 hr	99	9	***Amblema plicata***	122
				Fusconaia flava	16
				Lampsilis siliquoidea	14
				Pyganodon grandis	13
				Lasmigona complanata	11
				Lampsilis cardium	7
				Ligumia recta	7
				Potamilus alatus	6
				Quadrula quadrula	2
SH21	2 hr	112.5	6	***Amblema plicata***	187
				Ligumia recta	21
				Fusconaia flava	8
				Lampsilis cardium	5
				Lampsilis siliquoidea	2
				Lasmigona complanata	2

Site #	Search time	Mussels/ hour	# of species	Species found	# of individuals measured
SH22	2 hr	28	6	***Amblema plicata***	38
				Fusconaia flava	9
				Lampsilis siliquoidea	3
				Ligumia recta	3
				Lampsilis cardium	2
				Lasmigona complanata	1
SH23	2 hr	14.5	8	*Lampsilis cardium*	7
				Lampsilis siliquoidea	7
				Lasmigona complanata	4
				Amblema plicata	3
				Fusconaia flava	3
				Ligumia recta	3
				Pyganodon grandis	1
				Potamilus alatus	1
SH24	2 hr	5.5	5	*Lampsilis siliquoidea*	5
				Lampsilis cardium	3
				Fusconaia flava	1
				Potamilus alatus	1
				Pyganodon grandis	1
SH 25	2 hr	28	9	***Amblema plicata***	21
				Ligumia recta	15
				Lampsilis cardium	5
				Pyganodon grandis	5
				Lampsilis siliquoidea	4
				Fusconaia flava	3
				Quadrula quadrula	1
				Lasmigona complanata	1
				Potamilus alatus	1

Species in bold are listed as a level II species in North Dakota's CWCS Wildlife Action Plan.

Appendix C – Sheyenne River Quantitative Data

Sh03 - 3 mi S of Flora - Lat: 47.90792 Long: -99.41576

First 100 M 6/30/2009

Mussel	Total	Density	% Total
Fatmucket	16	0.91	17.8%
Giant Floater	74	4.23	82.2%
Total	90		
Mussels/M^2	**5.14**		
M^2 Sampled	17.5		
Quadrats Sampled	70		
Upstream	14		
Downstream	9		
~ Area (M^2)	1150		
Mussels in 100 M's	5914		

Second 100 M 6/30/2009

Mussel	Total	Density	% Total
Fatmucket	27	1.83	12.3%
Giant Floater	193	13.08	87.7%
Total	220		
Mussels/M^2	**14.92**		
M^2 Sampled	14.75		
Quadrats Sampled	59		
Upstream	12		
Downstream	12		
~ Area (M^2)	1200		
Mussels in 100 M's	17898		

Total

Mussel	Total	Density	% Total
Fatmucket	43	1.33	13.9%
Giant Floater	267	8.28	86.1%
Total	310		
Mussels/M^2	**9.61**		
M^2 Sampled	32.25		
Quadrats Sampled	129		
Upstream	13		
Downstream	10.5		
~ Area (M^2)	2350		
Mussels in 200 M's	22589		

Sh04 - 4 mi W of Sheyenne - Lat: 47.83252 Long: -99.20791

First 100 M 7/21/2009

Mussel	Total	Density	% Total
Fatmucket	159	4.93	47.7%
Giant Floater	174	5.40	52.3%
Total	333		
Mussels/M^2	**10.33**		
M^2 Sampled	32.25		
Quadrats Sampled	129		
Upstream	14.5		
Downstream	19.5		
~ Area (M^2)	1700		
Mussels in 100 M's	17553		

Second 100 M 7/21/2009

Mussel	Total	Density	% Total
Fatmucket	38	1.21	10.7%
Giant Floater	318	10.10	89.3%
Total	356		
Mussels/M^2	**11.30**		
M^2 Sampled	31.5		
Quadrats Sampled	126		
Upstream	20		
Downstream	19		
~ Area (M^2)	1950		
Mussels in 100 M's	22038		

Total

Mussel	Total	Density	% Total
Fatmucket	197	3.09	28.6%
Giant Floater	492	7.72	71.4%
Total	689		
Mussels/M^2	**10.81**		
M^2 Sampled	63.75		
Quadrats Sampled	255		
Upstream	17.25		
Downstream	19.25		
~ Area (M^2)	3650		
Mussels in 200 M's	39449		

Sh08 - 2.5 mi W and 0.5 mi S of Pekin - Lat: 47.78101 Long: -98.38003

First 100 M 7/20/2009

Mussel	Total	Density	% Total
Threeridge	3	0.09	4%
White Heelsplitter	2	0.06	2%
Wabash Pigtoe	17	0.52	21%
Fatmucket	49	1.50	60%
Creeper	7	0.21	9%
Cylindrical Papershell	3	0.02	4%
Total	81		
Mussels/M^2	**2.40**		
M^2 Sampled	32.75		
Quadrats Sampled	131		
Upstream	15		
Downstream	12		
~ Area (M^2)	1350		
Mussels in 100 M's	3246		

Second 100 M 7/20/2009

Mussel	Total	Density	% Total
Threeridge	2	0.08	2%
White Heelsplitter	3	0.12	3%
Wabash Pigtoe	7	0.28	7%
Fatmucket	81	3.24	79%
Giant Floater	2	0.08	2%
Creeper	4	0.16	4%
Total	103		
Mussels/M^2	**4.12**		
M^2 Sampled	25		
Quadrats Sampled	100		
Upstream	14.5		
Downstream	18		
~ Area (M^2)	1625		
Mussels in 100 M's	6695		

Total

Mussel	Total	Density	% Total
Threeridge	5	0.09	2.7%
White Heelsplitter	5	0.09	2.7%
Wabash Pigtoe	24	0.42	13.0%
Fatmucket	130	2.25	70.7%
Giant Floater	2	0.03	1.1%
Creeper	11	0.19	6.0%
Total	184		
Mussels/M^2	**3.19**		
M^2 Sampled	57.75		
Quadrats Sampled	231		
Upstream	14.75		
Downstream	15		
~ Area (M^2)	2975		
Mussels in 200 M's	9479		

Sh12 - 4 mi E and 1 mi N of Shepard - Lat: 47.39741 Long: -98.04311

First 100 M 7/16/2009

Mussel	Total	Density	% Total
Threeridge	26	1.09	19.8%
White Heelsplitter	3	0.13	2.3%
Wabash Pigtoe	1	0.04	0.8%
Fatmucket	81	3.41	61.8%
Giant Floater	8	0.34	6.1%
Creeper	12	0.51	9.2%
Total	131		
Mussels/M^2	**5.52**		
M^2 Sampled	23.75		
Quadrats Sampled	95		
Upstream	18		
Downstream	21		
Area (M^2)	1950		
Mussels in 100 M's	10756		

Second 100 M 7/23/2009

Mussel	Total	Density	% Total
Threeridge	12	0.42	11%
White Heelsplitter	10	0.35	9%
Wabash Pigtoe	4	0.14	4%
Fatmucket	55	1.91	50%
Giant Floater	18	0.63	16%
Creeper	11	0.38	10%
Total	110		
Mussels/M^2	**3.83**		
M^2 Sampled	28.75		
Quadrats Sampled	115		
Upstream	20		
Downstream	20		
Area (M^2)	2000		
Mussels in 100 M's	7652		

Total

Mussel	Total	Density	% Total
Threeridge	38	0.72	16%
White Heelsplitter	13	0.25	5%
Wabash Pigtoe	5	0.10	2%
Fatmucket	136	2.59	56%
Giant Floater	26	0.50	11%
Creeper	23	0.44	10%
Total	241		
Mussels/M^2	**4.59**		
M^2 Sampled	52.5		
Quadrats Sampled	210		
Upstream	19		
Downstream	20.5		
Area (M^2)	3950		
Mussels in 200 M's	18132		

Sh16 - 1 mi E of Kathryn below dam - Lat: 46.67372 Long: -97.94555

First 100 M 8/3/2009			
Mussel	Total	Density	% Total
Threeridge	172	6.49	17.4%
Plain Pocketbook	234	8.83	23.7%
White Heelsplitter	67	2.53	6.8%
Wabash Pigtoe	153	5.77	15.5%
Fatmucket	189	7.13	19.1%
Black Sandshell	128	4.83	13.0%
Giant Floater	29	0.78	2.9%
Creeper	15	0.40	1.5%
Total	987		
Mussels/M^2	**37.25**		
M^2 Sampled	26.5		
Quadrats Sampled	106		
Upstream	16		
Downstream	16.5		
Area (M^2)	1625		
Mussels in 100 M's	60524		

Second 100 M 8/4/2009			
Mussel	Total	Density	% Total
Threeridge	199	7.96	14.0%
Plain Pocketbook	218	8.72	15.3%
White Heelsplitter	55	2.20	3.9%
Wabash Pigtoe	550	22.00	38.7%
Fatmucket	153	6.12	10.8%
Black Sandshell	155	6.20	10.9%
Giant Floater	38	1.52	2.7%
Creeper	53	2.12	3.7%
Total	1421		
Mussels/M^2	**56.84**		
M^2 Sampled	25		
Quadrats Sampled	100		
Upstream	24		
Downstream	17		
Area (M^2)	2050		
Mussels in 100 M's	116522		

Total			
Mussel	Total	Density	% Total
Threeridge	371	7.20	15%
Plain Pocketbook	452	8.78	19%
White Heelsplitter	122	2.37	5%
Wabash Pigtoe	703	13.65	29%
Fatmucket	342	6.64	14%
Black Sandshell	283	5.50	12%
Giant Floater	67	1.30	3%
Creeper	68	1.32	3%
Total	2408		
Mussels/M^2	**46.76**		
M^2 Sampled	51.5		
Quadrats Sampled	206		
Upstream	20		
Downstream	16.75		
Area (M^2)	3675		
Mussels in 200 M's	171833		

Sh18 - 4 mi E of Fort Ransom - Lat: 46.5142 Lat: -97.84402

First 100 M 8/5/2009

Mussel	Total	Density	% Total
Threeridge	22	1.14	47.8%
Plain Pocketbook	6	0.31	13.0%
White Heelsplitter	1	0.05	2.2%
Wabash Pigtoe	13	0.67	28.3%
Fatmucket	2	0.10	4.3%
Black Sandshell	2	0.10	4.3%
Total	46		
Mussels/M^2	**2.38**		
M^2 Sampled	19.25		
Quadrats Sampled	77		
Upstream	23		
Downstream	20		
Area (M^2)	2150		
Mussels in 100 M's	5124		

Second 100 M 8/5/2009

Mussel	Total	Density	% Total
Threeridge	23	0.93	31.5%
Plain Pocketbook	7	0.28	9.6%
Wabash Pigtoe	35	1.41	47.9%
Fatmucket	1	0.04	1.4%
Black Sandshell	7	0.28	9.6%
Total	73		
Mussels/M^2	**2.94**		
M^2 Sampled	24.75		
Quadrats Sampled	99		
Upstream	22		
Downstream	20		
Area (M^2)	2100		
Mussels in 100 M's	6181		

Total

Mussel	Total	Density	% Total
Threeridge	45	1.02	37.8%
Plain Pocketbook	13	0.30	10.9%
White Heelsplitter	1	0.02	0.8%
Wabash Pigtoe	48	1.09	40.3%
Fatmucket	3	0.07	2.5%
Black Sandshell	9	0.20	7.6%
Total	119		
Mussels/M^2	**2.70**		
M^2 Sampled	44		
Quadrats Sampled	176		
Upstream	22.5		
Downstream	20		
Area (M^2)	4250		
Mussels in 200 M's	11494		

Sh20 - 2 mi E and 4 mi S of Lisbon - Lat: 46.38384 Long: -97.63319

First 100 M 8/6/2009			
Mussel	Total	Density	% Total
Threeridge	27	1.06	60.0%
Plain Pocketbook	9	0.35	20.0%
Mapleleaf	2	0.08	4.4%
White Heelsplitter	1	0.04	2.2%
Wabash Pigtoe	2	0.08	4.4%
Fatmucket	3	0.12	6.7%
Black Sandshell	1	0.04	2.2%
Total	45		
Mussels/M^2	**1.76**		
M^2 Sampled	25.5		
Quadrats Sampled	102		
Upstream	27		
Downstream	11.5		
Area (M^2)	1925		
Mussels in 100 M's	3397		

Second 100 M 8/6/2009			
Mussel	Total	Density	% Total
Threeridge	38	1.37	84.4%
Plain Pocketbook	1	0.04	2.2%
Mapleleaf	1	0.04	2.2%
White Heelsplitter	2	0.07	4.4%
Wabash Pigtoe	1	0.04	2.2%
Black Sandshell	1	0.04	2.2%
Pink Heelsplitter	1	0.04	2.2%
Total	45		
Mussels/M^2	**1.62**		
M^2 Sampled	27.75		
Quadrats Sampled	111		
Upstream	21		
Downstream	25		
Area (M^2)	2300		
Mussels in 100 M's	3723		

Total			
Mussel	Total	Density	% Total
Threeridge	65	1.22	72.2%
Plain Pocketbook	10	0.19	11.1%
Mapleleaf	3	0.06	3.3%
White Heelsplitter	3	0.06	3.3%
Wabash Pigtoe	3	0.06	3.3%
Fatmucket	3	0.06	3.3%
Black Sandshell	2	0.04	2.2%
Mussels/M^2	**1.69**		
M^2 Sampled	53.25		
Quadrats Sampled	213		
Upstream	24		
Downstream	18.25		
Area (M^2)	4225		
Mussels in 200 M's	7141		

Sh25 - 1 mi S and 1 mi W of Horace - Lat: 46.74637 Long: -96.92700

First 50 M 8/7/2009			
Mussel	Total	Density	% Total
White Heelsplitter	0	0	0
Fatmucket	0	0	0
Threeridge	0	0	0
Plain Pocketbook	0	0	0
Total	0		
Mussels/M^2	**0.00**		
M^2 Sampled	17		
Quadrats Sampled	68		
Upstream	16.5		
Downstream	17.5		
Area (M^2)	850		
Mussels in 50 M's	0		

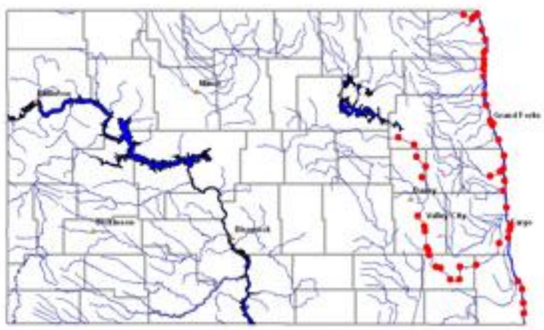
Second 100 M 8/7/2009			
Mussel	Total	Density	% Total
White Heelsplitter	2	0.06	20.0%
Fatmucket	5	0.14	50.0%
Threeridge	2	0.06	20.0%
Plain Pocketbook	1	0.03	10.0%
Total	10		
Mussels/M^2	**0.28**		
M^2 Sampled	36		
Quadrats Sampled	144		
Upstream	20		
Downstream	16		
Area (M^2)	1800		
Mussels in 100 M's	500		

Total			
Mussel	Total	Density	% Total
White Heelsplitter	2	0.04	20.0%
Fatmucket	5	0.09	50.0%
Threeridge	2	0.04	20.0%
Plain Pocketbook	1	0.02	10.0%
Total	10		
Mussels/M^2	**0.19**		
M^2 Sampled	53		
Quadrats Sampled	212		
Upstream	18.25		
Downstream	16.75		
Area (M^2)	2625		
Mussels in 150 M's	495		

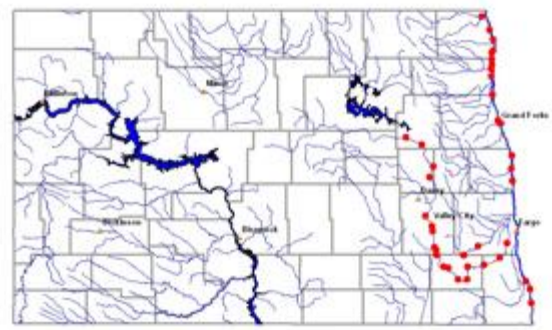
Appendix D – Range Maps of North Dakota Mussel Species

Subfamily Ambleminae

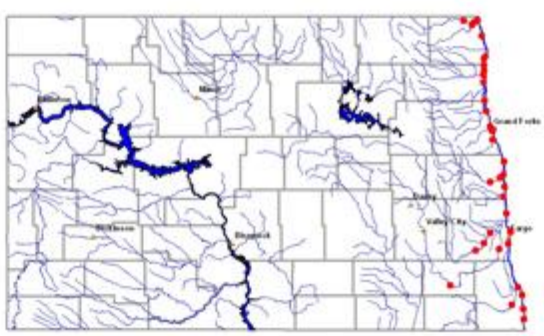
Amblema plicata;
Three Ridge



Fusconaia flava;
Wabash Pigtoe

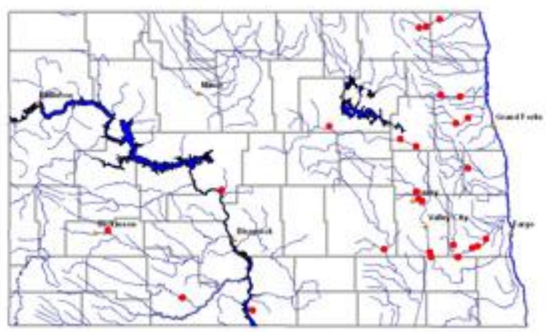


Quadrula quadrula;
Mapleleaf

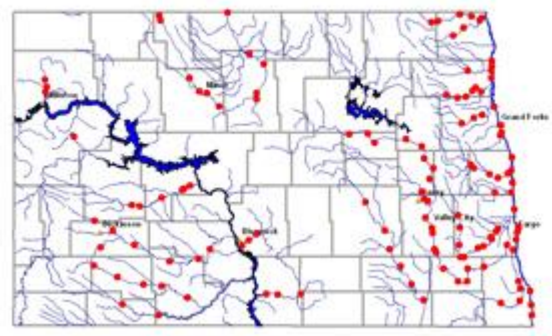


Subfamily Anodontinae

Anodontoides ferussacianus
Cylindrical papershell

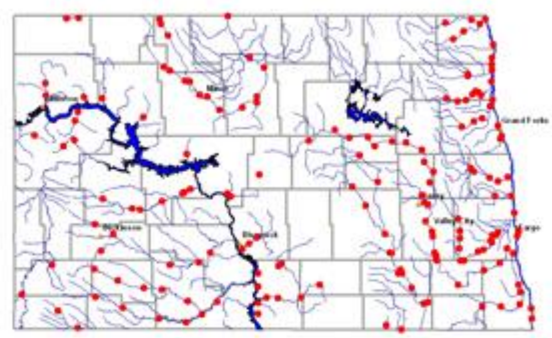


Lasmigona complanata
White Heelsplitter,

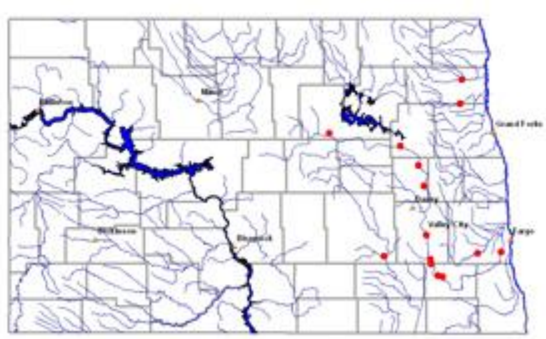


Lasmigona compressa
Creek Heelsplitter

Pyganodon grandis
Giant Floater

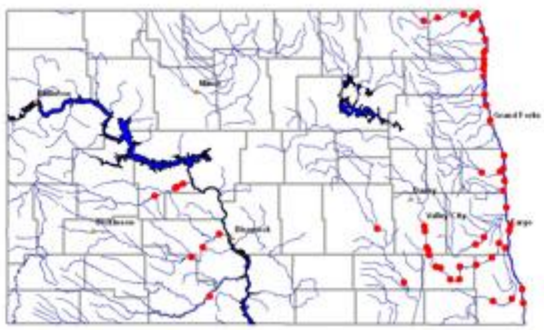


Strophitus undulatus
Creeper

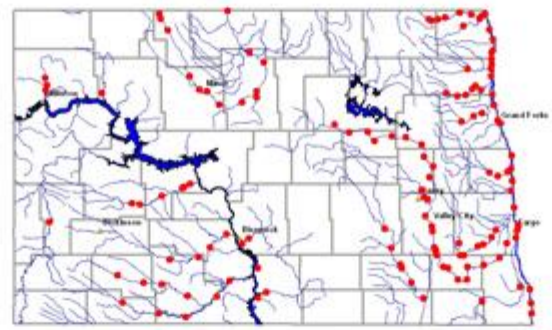


Subfamily Lampsilinae

Lampsilis cardium
Plain Pocketbook

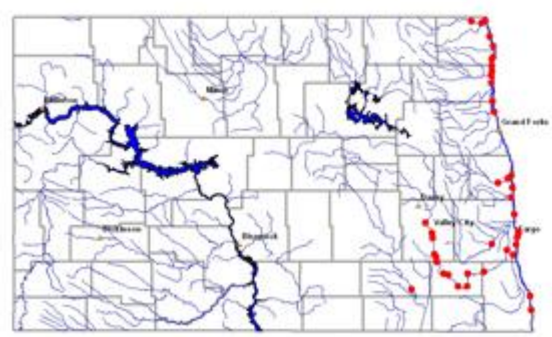


Lampsilis silquiodea
Fatmucket

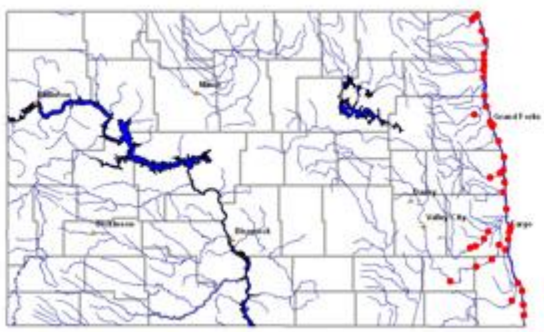


Leptodea fragilis
Fragile Papershell (includes sites with dead shells)

Ligumia recta
Black Sandshell



Potamilus alatus
Pink Heelsplitter



Potamilus ohiensis
Pink Papershell

Truncilla truncata
Deertoe