

UNIONIDS AND MARGARITIFERIDS (MOLLUSCA: BIVALVIA) IN THE
SAINT CROIX RIVER BORDERING MINNESOTA AT
AFTON AND WILD RIVER STATE PARKS, 8 - 17 JUNE 1992

BY

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UNIONIDS AND MARGARITIFERIDS (MOLLUSCA: BIVALVIA) IN THE SAINT CROIX RIVER BORDERING MINNESOTA AT AFTON AND WILD RIVER STATE PARKS, JUNE 1992. Marian E. Havlik, Malacological Consultants, La Crosse, WI 54601

1 SUMMARY

Over 40 unionid and margaritiferid species (Mollusca: Bivalvia:) have been reported from the St. Croix River in recent times, but large areas have never been sampled. From 8 to 17 June 1992 we did random, semi-quantitative, and quantitative sampling by wading and SCUBA diving near the Minnesota shoreline of Wild River and Afton State Parks to determine the presence and habitat of rare bivalve mollusks.

A total of 1560 living unionid and margaritiferids were found (20 species). Four additional species were among 391 empty shells. One dead federally endangered Lampsilis higginsi (Lea, 1857), Higgins' Eye, was found near Afton State Park's north boundary. Elliptio dilatata (Rafinesque, 1820), Spike (32.0%) and Actinonaias ligamentina carinata (Barnes, 1823), Mucket (30.8%) dominated the fauna. No Dreissena polymorpha (Pallas, 1771), Zebra Mussel, were found.

Areas sampled at Wild River State Park were up to two meters deep, and had a diverse, abundant mussel fauna, particularly in sand, gravel, and cobble areas that also served as habitat for submergent aquatic vegetation. Thirteen sites (32 sub-sites) along the 18.7 mile border of Wild River Park yielded 1480 living unionid and margaritiferid mollusks with densities to 74/m² representing 19 living species. Two additional species were represented by empty shells only.

Proposed as federally endangered, 40 large, old Cumberlandia monodonta (Say, 1829), Spectacle Case, were found at Wild River Park. The largest, 235 mm long, was about 70 years old (independently aged three times). Their unique habitat of large boulders was limited. Since the smallest C. monodonta was 165 mm long, the absence of young adults strongly suggests a host fish problem. C. monodonta is reproducing below the Northern States Power dam, St. Croix Falls, WI.

Other living rare unionids found at Wild River were Cyclonaias tuberculata (Rafinesque, 1820), Purple Warty-Back (23 specimens up to 50 years of age), Alasmodonta marginata Say, 1818, Elk Toe, (29 specimens) and Pleurobema sintoxia (Rafinesque, 1820), Round Pig-Toe (17 specimens). At least six species showed evidence of recruitment.

Afton Park's unionid habitat was limited, and the fauna sparse, both in numbers and species diversity. Depths were up to six meters, or more, near the shoreline. Twelve sites (14 sub-sites) along the two mile border of Afton Park yielded 80 living unionids representing eight species. Recruitment was minimal, and some specimens were very slow growing (stunted length and height for age). Three additional species were represented by empty shells only.

This project was supported by the MNDNR, Division of Parks and Recreation's Working Capitol Account, and by the Minnesota Nongame Wildlife Tax Checkoff, through the MNDNR Nongame Wildlife Program.

2. INTRODUCTION AND BACKGROUND

In recent times, over 40 species of unionid and margaritiferid mollusks (Mollusca: Bivalvia) have been reported from the 250 miles of the Saint Croix National Scenic Riverway in Minnesota and Wisconsin (Baker 1928; Dawley 1944, 1947; Ecological Analysts 1981; Fuller 1978, 1980a, 1980b; Williams 1978; Mathiak 1979; Stern 1983; Malacological Consultants 1985; Havlik 1987, 1990; Havlik and Frink 1989; Doolittle 1988; and Heath 1989). Due to sampling methodologies of previous projects, large reaches of the Saint Croix River have never been sampled.

When my 1985 chance viewing of unionid shells at the Minnesota Interstate Park, Taylor's Falls, MN, revealed the possibility of two very rare unionid species, I was among the first to recognize the extreme importance of the unionid and margaritiferid bivalve mollusk fauna of the Saint Croix River, N of the upstream limits of the U.S. Army Corps of Engineers 9-foot navigation channel at Stillwater, MN, continuing upstream to the Northern States Power Dam (NSP) Dam at Saint Croix Falls, WI.

My subsequent 1987 study of the Saint Croix River for the Wisconsin Department of Natural Resources (WDNR) (Havlik and Frink 1989, Havlik 1990) from the NSP Dam, Saint Croix Falls, WI, downstream to nearly Stillwater, MN, yielded a number of unionid and margaritiferid species previously unreported from the Saint Croix, or unreported in recent times.

Our 1987 study was primarily a shoreline search to look for unionid and margaritiferid concentrations. Few live bivalve mollusks were sought or collected. Often rocky habitat seemed ideal for Cumberlandia monodonta (Say, 1829), Spectacle Case and Simpsonaias ambigua (Say, 1825), Salamander Mussel, both proposed as federally endangered, but scheduling prevented the time-consuming type of search needed to find these species (in-between and underneath large and flat rocks).

Despite the limitations of the 1987 shoreline study, Mississippi and Saint Croix River river records were established for 12 species, including the first living specimen found anywhere in many years of Quadrula fragosa (Conrad, 1835), Winged Maple Leaf (Havlik and Frink 1989, Havlik 1990). Q. fragosa was subsequently placed on the Federal Endangered Species list, July 1991. In addition to species reported from the 1987 study (32 living, 2 fresh-dead, one sub-fossil species), several additional living species have been reported by other researchers since 1987.

The 1987 lower Saint Croix study (Havlik and Frink 1989, Havlik 1990) was not meant to be a formal report. Abstracts of that study are available only from meeting programs of the 1989 Mississippi River Research Consortium and the 1990 Saint Croix Research Rendezvous. Therefore, the abstract of the 1989 Mississippi River Research Consortium is reprinted below.

"SHORELINE COLLECTIONS OF NAIAD MOLLUSKS (UNIONIDAE), LOWER ST. CROIX RIVER: NORTHERN STATES POWER DAM, ST. CROIX FALLS, WI, TO NEAR STILLWATER, MN. Marian E. Havlik, and James A. Frink, Wisconsin Department of Natural Resources, Box 7921, Madison, WI 53707.

A 1985 chance discovery of shells at the Interstate Park, Taylors Falls, MN, indicated a diverse mussel fauna in the St. Croix River. This was confirmed by a brief survey by Malacological Consultants, August 1986. In June 1987 a shoreline/shallow water collection was conducted by the WDNR from the Northern States Power Company (NSP) dam, St. Croix Falls, WI, down to 4 mi upstream (N) of Stillwater, MN. Objectives were to determine the unionids in that portion of the St. Croix, and to identify areas for future quantitative studies. NSP cooperation enabled collecting between the NSP dam and the Hwy 8 bridge. Sixty-one additional sites were randomly selected, mostly by the presence of shells on the shoreline, as a crew of 4 proceeded downriver. 35 species were found: 32 living, 2 represented by fresh-dead shells, and 1 represented by sub-fossil shells. Living species documenting recent UMR, states, and river records included Lampsilis higginsii (33 mile range extension), Lasmigona costata, Quadrula quadrula, Q. fragosa, Q. metanevra, Cyclonaias tuberculata, Elliptio crassidens, Ellipsaria lineolata, and Epioblasma triquetra. Recent records for several species, including Cumberlandia monodonta and Simpsonaias ambigua, were represented by fresh shells, but only sub-fossil Fusconaia ebena was found. We found no trace of Plethobasus cyphus (Dawley 1947). Truncilla truncata is dominant at the Parks; the large river form of Fusconaia flava is dominant downstream to Stillwater where Amblema plicata becomes dominant. This suggests different habitats, and different fish patterns. Many areas are vulnerable to human impacts (canoeists, fishermen, and persons looking for a food source). Since the river is protected, pollution does not seem to be a great problem, however not all species are doing well. Corbicula was not found above Stillwater" (Havlik and Frink 1989).

Sound management practices are difficult to impossible, if the organisms to be managed have not been identified and quantified, particularly when there are federal and state endangered and rare species involved such as Lampsilis higginsii (Lea, 1857), Higgins' Eye, Quadrula fragosa, Cumberlandia monodonta, Simpsonaias ambigua, Potamilus capax (Green, 1832), Fat Pocketbook, Fusconaia ebena (Lea, 1831), Ebony Shell, Elliptio c. crassidens (Lamarck, 1819), Elephant Ear, and Cyclonaias tuberculata (Rafinesque, 1820), Purple Warty-Back.

Doolittle (1988) gives the number of living unionid and margaritiferid mollusks he found in the entire Saint Croix River. Included in his sampling sites were the Wisconsin portions of the

Saint Croix River opposite several Minnesota State Parks.

Doolittle's sampling efforts and results near the Minnesota parks varied considerably, and were somewhat related to the actual length of shoreline sampled equivalent to the shoreline length of each Minnesota State Park (Table 2).

For instance, Doolittle (1988) found 12 unionid species near O'Brien Park, 22 species near Wild River Park (18.7 mile shoreline), and 16 species near Saint Croix Park, but only found four unionid species near Afton Park (2 mile shoreline).

Doolittle (1988) found the rare margaritiferid, Cumberlandia monodonta in the Saint Croix River, several miles upstream of Wild River Park near Raspberry Landing, SW of Grantsburg, WI. This find was quite a surprise to malacologists because prior to the mid-1980's most river researchers thought C. monodonta had never been reported upstream of Prairie du Chien, WI, on the Mississippi River system (Baker 1928, Fuller 1978).

The first recent C. monodonta in the Saint Croix River was reported in the mid-1980's by Richard Oehlenschlaeger, Science Museum of Minnesota (personal communication). Subsequently, Havlik and Frink (1989) and Havlik (1990) found C. monodonta upstream nearly to the NSP Dam, Saint Croix Falls, WI. The height of the dam was expected to have caused host fish access difficulties, so C. monodonta had not been expected upstream of the NSP dam.

Because of the various rare species found in 1987, Doolittle (1988) recommended additional field work on the Saint Croix River to refine inventory data and quantify rare species populations.

Our 1992 study plan was developed to fill part of the data gaps in the Minnesota state park faunal inventories, and to add to the present day knowledge of the Saint Croix unionid and margaritiferid fauna and habitats.

Despite difficulties associated with costly sampling of large and small rivers for rare freshwater mollusk populations (Isom and Gooch 1986; Kovalak et al. 1986), we planned to determine unionid diversity, density, relative abundance, and visually characterize the general and micro-habitats at sites along the Minnesota border of Saint Croix River Wild River and Afton State Parks.

We also planned to document and describe bivalve mollusk concentrations, rare species sites, shoreline middens, species represented only by empty shells, and exotic mollusks species.

The presence or absence of exotic mollusks was particularly important because of the imminent threat of Saint Croix National Scenic Riverway infestation by the exotic, Dreissena polymorpha (Pallas, 1771), Zebra Mussel.

3 METHODS

The general park locales are shown in Figure 1. Wild River State Park extends from approximately St. Croix River Mile 65.1 to 83.8. Afton State Park extends from St. Croix River Mile 7 to 9.

We planned to sample about two sites per river mile, starting at the upstream boundary of each park, avoiding Doolittle's (1988) sites which were mostly on the Wisconsin side of the River. Six days of sampling were planned at Wild River Park, and two days were planned at Afton Park.

To select study sites, we traveled by boat down the Saint Croix River, along the Wild River and Afton State Park shorelines, generally from upstream to downstream. We looked for freshwater mussels living in the water, shells washed in along the shoreline, and animal middens.

At each study site where practical, a 30 m transect was semi-quantitatively sampled by SCUBA diving, except when otherwise described. Generally the diver sampled about one meter on either side of the transect line. In one area of dense mussel concentrations the sampling was restricted to 15 cm on either side of the transect line.

Qualitative (random) sampling was done to the point of diminishing returns, for about one to two person hours. Shoreline searches were done by personnel experienced at quickly assessing the presence or absence of rare species.

In areas of significant mussel densities, limited quantitative sampling was done using 0.25 m² quadrats which were excavated 10 to 15 cm. Visual observations were recorded for each site, describing the substrata and general habitat.

Several study sites at Afton Park were selected at the request of Park and Minnesota Department of Natural Resources (MNDNR) personnel, because the area was being considered for shoreline development and a public boat dock. Since depths along the southern half of Afton Park were often quickly excessive for normal SCUBA diving (over 10 m deep within 10 to 15 meters offshore), sites in that area were chosen at the outfalls of drainage pipes and small streams because those depositional areas were generally less than 10 m deep.

In spite of repeated attempts to obtain additional funding, only half of the originally proposed funding was available for this project; no student help was available. Our scope of work had to be changed somewhat, for these reasons. A field decision was made that our project priority was to look at as many sites as possible, but in less depth, in order to determine the extent of the potential unionid and margaritiferid fauna at each park.

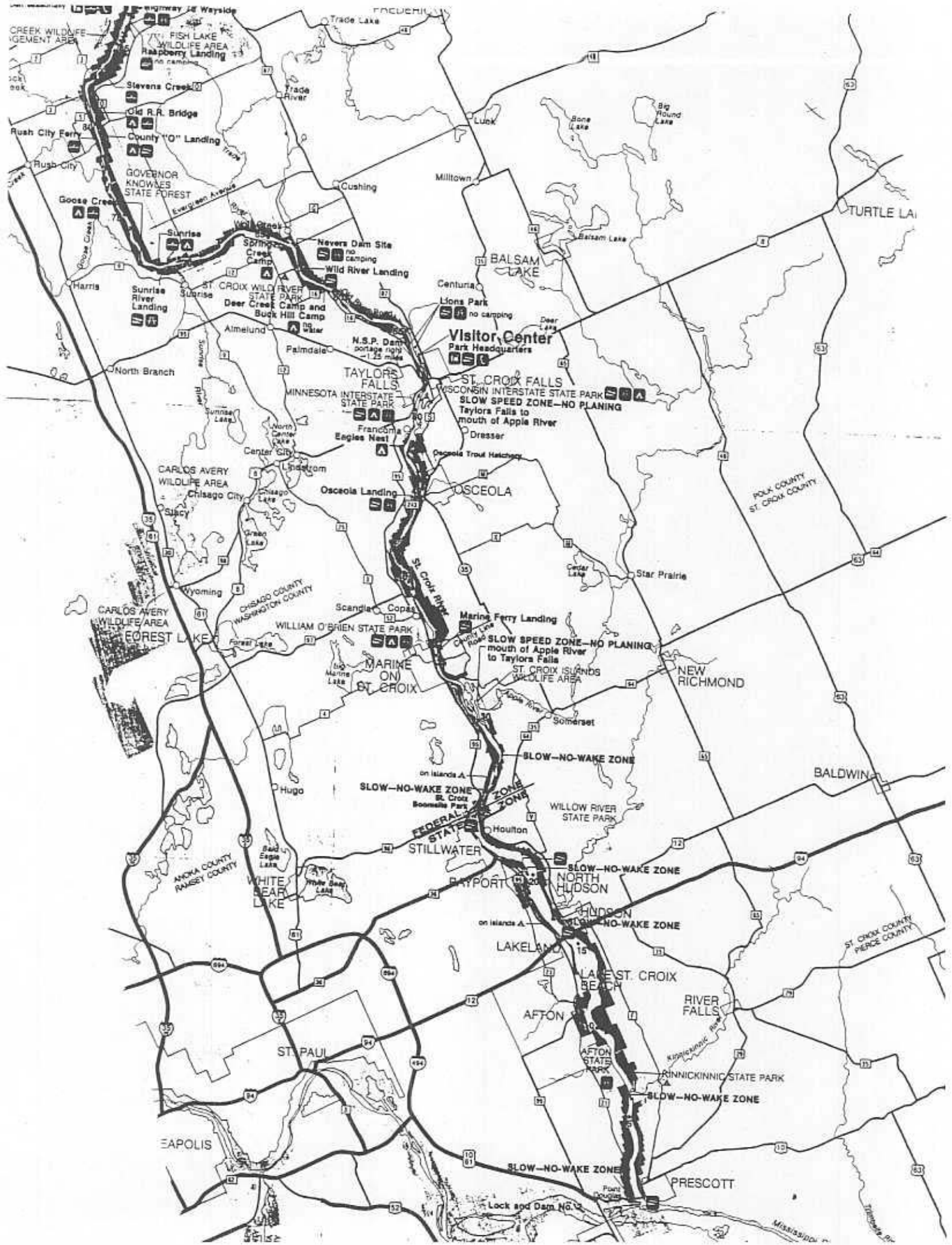
After samples were field sorted for adult and juvenile

mollusks, all living unionids and margaritiferids were identified, enumerated, and recorded as to collection method. Some living endangered and rare mollusks were measured, and aged. Empty shells were identified and enumerated as practical.

Museum voucher specimens were selected to represent small, medium and large size classes of each species, as practical. When more than one specimen of a species was found at each park, voucher specimens were also given to the respective State Parks. All specimens recovered were grossly examined for the presence of the exotic mollusks.

This project was conducted under the terms of scientific collecting permits from the Minnesota Department of Natural Resources, Special Permit #5894, the National Park Service #6590/2/0007, and a U.S. Fish and Wildlife Service federal endangered species collecting permit #PRT-69730.

3.1 FIGURE 1. STUDY LOCATION, AFTON AND WILD RIVER PARKS, MN



4 RESULTS

A total of 1560 living unionid and margaritiferid bivalve mollusks, representing 20 living species, were collected, identified, and enumerated from 8 to 17 June, 1992, at Wild River and Afton State Parks, Minnesota (Tables 1, 2, 3, 4). An additional four species were represented among the 391 empty shells identified and enumerated.

Numbers, species abundance, frequency of occurrence are given in the Appendix (Tables 2, 5). Sampling site locations at each park are shown in Figures 2 and 3.

No Dreissena polymorpha were found at either park.

In shallow areas, about three person-hours were spent collecting at each site, to the point of diminishing returns. More time was expended if the site was productive, and if there were volunteer personnel.

Most sites were sampled semi-quantitatively along a fixed transect. Limited quantitative sampling was done in areas of dense mussel concentrations. The time for processing specimens depended on the numbers and species found.

Thirteen shallow sites (32 sub-sites) along the 18.7 miles of Wild River State Park yielded 1480 living unionids and margaritiferids representing 19 bivalve species. An additional two species were represented among 368 empty shells collected. Living densities ranged from 4/m² to 74/m².

Twelve sites (14 sub-sites) along the two mile border of Afton State Park yielded 80 living unionids (eight living species plus three species represented among 23 empty shells). No quantitative sampling was done at Afton Park because no areas were found that had significant mussel populations.

No living sexually dimorphic, female endangered or rare species were found, so none were checked for their gravidity status, except as described below. Rare species that were measured and aged are described in the site specific results.

Living unionids and margaritiferids were aged by counting the rest rings. Rare living specimens were measured for length to the nearest mm at the greatest distance parallel to the hinge line. Previously, we had found shell length to be the most important measurement [based on our 1990 Mississippi River work at Prairie du Chien, WI (Havlik and Stein 1992)].

Unionid and margaritiferid mollusk species distribution, diversity, density, relative abundance, and visual habitat characterization at the two Saint Croix River state parks are given in individual site descriptions. Micro-habitats are documented,

particularly for endangered and rare unionid species. Empty shells were enumerated, identified, and noted as to fresh-dead or sub-fossil condition, as practical. These data did not indicate excessive recent bivalve mortality.

As required by my Minnesota scientific collecting permit, a clean cut of voucher specimens, of both living and dead species from each park, was deposited at the J. F. Bell Museum, Minneapolis, MN. When possible, we always retain museum voucher specimens illustrating small, medium and large size classes, and sexual dimorphism. Voucher specimens were also given to each park, when more than one specimen of a species was found. Empty shells of rare species were also retained, if the shells were in good condition.

The remainder of the living unionids were returned to the river as soon as practical. After processing, rare species were replaced in the substrata by hand, anterior end facing upstream.

Habitat and other descriptions such as the number of living and dead species, densities, and length and age measurements are discussed for each site. Site summaries are given in the Appendix (Tables 3, 4, 5).

Representative, labeled colored slides, taken during field work at both Wild River and Afton State Parks, are attached, including slides of the principal investigator working on this project.

4.1 WILD RIVER STATE PARK

Wild River State Park, one of the newest state parks in Minnesota, is over 7000 acres in size, and borders 18.7 miles of the upper Saint Croix River. Doolittle (1988) apparently sampled 8 sites opposite the Park, mostly along the Wisconsin shoreline, but also on a few islands.

4.1.1 WILD RIVER STATE PARK, SITE 1

Site 1 was 0.75 mile downstream of the northern (upstream) boundary of Wild River State Park. A total of 34 living unionids were found, representing nine living species (Table 3). Two species were represented by empty shells only.

Twenty-four specimens (9 species) were found along a 30 m transect (Table 4A). Only 10 living specimens (5 species), were randomly collected in sand, gravel, and cobble substrata. An additional species was represented among the considerable number of old dead shells found. Some sphaeriidae (fingernail clams) were also present.

4.1.2 WILD RIVER STATE PARK, SITE 2

Site 2 was about 2.5 mi upstream of the Sunrise River boat landing, at a Park sign, and 350 m downstream of an island. Although 239 living unionids were collected, representing 16 species (Table 4A), the large number was partly due to extra collecting efforts by two volunteers, in addition to our regular field crew of three.

Forty-one living mussels (10 species) were collected on a 30 m transect, and 175 specimens (15 species) were obtained during random collections. Three 0.25 m² quantitative samples had densities ranging from 20 to 44 unionids/m², for a mean of 30.6 unionids/m².

Submerged aquatic vegetation (Vallisneria americana), here and elsewhere, proved to be a reliable indicator of good unionid habitat at Wild River Park.

4.1.3 WILD RIVER STATE PARK, SITE 3

Site 3, 150 m upstream of the Sunrise River boat landing, was a very unique habitat for the margaritiferid mussel, Cumberlandia monodonta (Table 4A).

A total of 44 living unionids, representing four species, were collected from this site. The habitat consisted of a loose sand substrata, with some gravel, between large boulders, about 10 m from the shoreline. The boulders were up to 0.5 m in diameter, with some roughly set in a circular pattern, almost like a corral. These boulders apparently formed a protective area for C. monodonta.

This particular underwater rock and boulder arrangement was not noted at any other location along the Wild River Park shoreline.

Since there was very good visibility at this site, we (diving/snorkeling) were clearly able to see C. monodonta extended nearly vertically, out of the river bottom for about 1/2 of their length. We collected 40 living C. monodonta. An unknown number of additional C. monodonta were seen, but not removed from the substrata.

C. monodonta ranged from 165 mm to 235 mm in length. The largest C. monodonta was independently field aged by the three project researchers at 62, 70, and 72 years of age; the height was 65 mm and width 45 mm. Likely this specimen is at least 70 years of age, based on the annular rest-rings, and on the large size. The length of some other randomly collected C. monodonta were 177, 178, 189, 190, 190, 195, 196, 200, and 207 mm.

Field determination of the sex of non-gravid bivalve mollusk species is difficult, particularly when the species in question does not display sexual dimorphism. Two of the C. monodonta may have been female, based on somewhat distended gills. One C. monodonta may have been a male, based on non-distended gills. No gravid C. monodonta were observed.

Two Cyclonaias tuberculata were also aged and measured:

	LENGTH (mm)	HEIGHT (mm)	WIDTH (mm)	AGE1	AGE2	AGE3	MEAN AGE
1	111	89	50	49	50	42	47.0
2	84	76	42	36	38	36	36.6

This area, just upstream of the Sunrise River boat landing, appears to be a popular spot for shoreline sport fishing which could be problematic for this unique unionid population.

Mussels can be easily caught on fish hooks. Even if mussels are thrown back into the river, they may have less than a 40% chance of survival because they probably have been "injured" by the fish hook. In addition, because of their large size, and apparently advanced age, they may not be able to re-orient themselves in the substrata as easily as smaller and younger mussels, or mussels species with different shell morphology.

This area of the Saint Croix needs to be investigated more thoroughly, particularly on the Wisconsin side of the River.

Site 3 was suggested to us by Mark Hove, a graduate student collecting Cyclonaias tuberculata for another project, near this site.

4.1.4 WILD RIVER STATE PARK, SITE 4

A total of 300 living unionids, representing 13 species, were found at Site 4, immediately upstream of the Sunrise River Boat Landing. An additional 3 species were represented among the empty shells. Overall, 60% were Elliptio dilatata (Rafinesque, 1820), Spike.

The 30 m transect yielded 76 living mussels (12 species), and 117 empty shells (Table 4B). The random collection yielded 200 living specimens (12 species), including three Cyclonaias tuberculata and three Pleurobema sintoxia (Rafinesque, 1820), Round Pig-toe.

One 0.25 m² quadrat sample, excavated to 30 cm, yielded 20 living unionids (4 species) and 13 empty shells. A second quadrat yielded 1 living mussel and 14 empty shells. Densities at Site 4 ranged from 16 to 80 living unionids/m², with a mean of 48/m².

Submerged aquatic vegetation was present, and the rocks were covered with a considerable amount of filamentous algae.

4.1.5 WILD RIVER STATE PARK, SITE 5

Site 5, 0.5 mi downstream of the Sunrise River Boat Landing, was not nearly as productive as the previous sites a short distance upstream, even though the habitat appeared suitable and similar. Perhaps the reduced unionid fauna of 54 living unionids (9 species) at this site reflects some adverse effect from mouth of the nearby Sunrise River. One species was represented by empty shell only.

One Cyclonaias tuberculata, 18 years of age, was among 44 living unionids found along the 30 m transect (Tables 4B, 4C). Cumberlandia monodonta was represented only by two large empty shells, although there were boulders and rocks along the shoreline. Actinonaias ligamentina carinata (Barnes, 1823), Mucket, was the dominant species (42.6%).

Two 0.25 m² quadrat samples yielded 2, and 1, living specimens respectively. Densities were four to eight living unionids/m², with a mean of 6.0/m². Only seven living unionids (three species) were found during random sampling.

4.1.6 WILD RIVER STATE PARK, SITE 6

This site, about 2.5 mi downstream of the mouth of the Sunrise River in the midst of a moderately dense submerged aquatic vegetation bed of Vallisneria americana, was the most productive unionid area found at Wild River Park (Tables 3, 4C). Elliptio dilatata and Actinonaias l. carinata were dominant among the 413 unionids (15 species) collected.

Any potentially deleterious effects from the mouth of the Sunrise River, or other upstream source, seem to have disappeared by this site.

Over 1.5 hours of dive time were spent collecting on the 30 m transect. From the shoreline, and out for 15 m, 120 mussels (13 species) were collected from an area only 30 cm wide, however the number of unionids dwindled considerably in the area 15 to 30 m from the shoreline. Few empty shells were seen, except within 3 m of the shoreline.

Two 0.25 m² quadrats yielded 19 and 18 living unionids respectively (8 species). Densities ranged from 72 to 76 living unionids/m², for a mean of 74 unionids/m². The random collection yielded 234 unionids (14 species). At least five species showed recruitment. Rare species included Alasmodonta marginata Say, 1818, Elk Toe (11) and Pleurobema sintoxia (2).

This area of the Saint Croix needs to be investigated more thoroughly, particularly on the Wisconsin side of the River. We could have spent an entire day at Site 6.

4.1.7 WILD RIVER STATE PARK, SITE 7

Site 7 was the edge of a newly exposed gravel bar, about 5 miles downstream from the Sunrise River. There were many mussel trails, up to 20 m in length, in the shallow water areas (5 to 7 cm deep). Ninety-three living unionids, mostly young (small) specimens, were among the 10 species collected (Tables 3, 4). Pleurobema sintoxia (1) was the only rare species found.

Many young unionids had their anterior ends facing upstream, with their siphons (posterior ends) facing downstream. Most appeared to be seeking deeper water.

4.1.8 WILD RIVER STATE PARK, SITE 8

Site 8 was 0.5 mi upstream of the ice-breaker islands, above the old Nevers Dam Site. The site was around 1 m deep.

A total of 16 living unionids were found, representing 6 species. Another 10 species were represented by empty shells only (Table 3, 4D). This site was one, of four, throughout the study areas at both parks, where more dead than living unionid species were found.

There were also more dead species found at this site than at any other site. We found no apparent reason for this condition, unless perhaps the number of dead shells are related to the effects of ice breakup and the resulting ice jams around these islands.

The transect was done at the location of the second Park sign upstream of the Nevers Dam site. Nine specimens (5 species) were found alive on the 30 m transect, while 47 empty shells represented seven additional species.

One 0.25 m² quadrat, 15 m from shore, yielded 3 live unionids (mean density of 12/m²), and 13 empty shells. During a random search 4 specimens (4 species) were found alive, and 72 empty shells (13 species) were collected.

4.1.9 WILD RIVER STATE PARK, SITE 9

Site 9 was 125 m downstream of the ice breaker islands, and just above the old Nevers Dam site. This area was characterized by a good current, with some submerged aquatic vegetation (Vallisneria americana), and a sand, gravel, and cobble substrata. In terms of productivity, this site was quite different from Site 8, 0.5 mi upstream, even though there were still a large number of empty shells on the substrata.

Seventeen species were represented among the 208 living specimens found (Tables 3, 4D). This was the only site where Lasmigona complanata (Barnes, 1823), White Heel Splitter, was represented, but by an empty shell. Sixty unionids were found

alive on the 30 m transect, including four Cyclonaias tuberculata. There were numerous sphaeriids, and several fresh-water limpets (Ferissia sp.) found on shells along the transect.

Nine living unionids (three species) and 14 empty shells (four species) were found in one 0.25 m² quadrat sample, for a mean density of 36/m². Sixteen living species (139 unionids) were found during the random collection, including one C. tuberculata. Depths were 0.3 to 0.6 m.

Actinonaias l. carinata was dominant (89 specimens, 42.7%), and showed recruitment. Some small A. l. carinata, 10 to 19 mm long and one to two years old, had byssal threads.

Overall, most living unionid species were quite equally represented with multiple specimens. There were very few shells along the shoreline to indicate the diversity of the fauna in the river at this site.

4.1.10 WILD RIVER STATE PARK, SITE 10

Two hundred meters downstream of the Nevers Dam boat landing, the unionid fauna changed drastically. During a random search, only two living unionids (two species) were found, while 66 dead specimens were found, representing 5 species not found alive (Table 3, 4E).

The substrata was cobble. Since collecting in a rock substrata is more difficult than in a sand substrata, the number of living unionids may have been underestimated.

4.1.11 WILD RIVER STATE PARK, SITE 11

Site 11, immediately downstream of the Wild River boat landing, begins to show the effects of the impoundment created by the NSP dam, about 8 miles downstream. The current has decreased so the substrata becomes more mud than sand. The shoreline drops off sharply so searches are restricted to a very narrow band along the shoreline.

Lampsilis radiata luteola (Lamarck, 1819), Fat Mucket, became the dominant species in these conditions, representing 48 of the 73 living unionids found (7 species) (Table 3, 4E).

4.1.12 WILD RIVER STATE PARK, SITE 12

The collection at Site 12, downstream of the lower Wild River Park campground, was done at a midden pile along a very steep shoreline. The mud substrata dropped off sharply close to shore. Only 2 living L. r. luteola were found; five other species were represented by empty shells. More dead Fusconaia flava (Rafinesque, 1820), Pig-Toe, were found here than anywhere else at Wild River Park (Tables 3, 4E).

4.1.13 WILD RIVER STATE PARK, SITE 13

Site 13 was near the downstream boundary of the Park. Only two living L. r. luteola were found near the shore, in a cobble substrata (Table 3, 4E).

Collecting was halted on our last day at Wild River Park because of an electrical storm.

4.2 AFTON STATE PARK

The Lake Saint Croix portion of the Saint Croix River extends for nearly 25 miles, from Prescott, WI, to just upstream of Stillwater, MN. Lake Saint Croix is a true riverine lake formed by the influence of the Mississippi River, a short distance downstream at Prescott, WI.

Afton State Park is located about one-third of the way from the confluence (and influence) of the Mississippi River, on Lake Saint Croix, at about Saint Croix River Mile 7 to 9.

The shoreline area of Afton Park is largely protected by the nearby bluffs. The prevailing winds are mainly from a predominantly westerly direction.

Apparently none of Doolittle's (1988) Wisconsin sampling sites were opposite Afton State Park. As far as can be ascertained there does not appear to be any previous information on the unionid fauna of Afton State Park (Fuller 1878).

Sampling at Afton State Park was very different from sampling at Wild River Park. The results were also very different. Due to the paucity of the mussel fauna at Afton Park, we were able to sample more sites than planned.

4.2.1 AFTON STATE PARK, SITE 1

Site 1 was just downstream of the Afton Park northern boundary. The substrata was mud and sand. Fifty-three living unionids (seven species) were found. This was the most productive site at Afton Park.

There was a good deal of filamentous algae on the unionids. A few living pleurocerid gastropods were also found.

Lampsilis higginsii, a state and federal endangered species, was represented by the empty shell of an adult female, found during random sampling in 1.0 m of water. The specimen appeared to have been dead about five years. Twenty-three other living unionids (4 species) were found during random sampling.

On the 30 m transect, 30 specimens (5 species) were found, including one juvenile among 13 Amblema p. plicata (Say, 1817),

Three-Ridge (Tables 3, 5A).

Fusconaia flava was well represented by 12 living specimens. However, F. flava had a very slow growth rate which probably reflected the limited current along the west and protected shoreline of a riverine lake, and probably the limited availability of food. We have seen the phenomena previously, in other areas of Lake Saint Croix (Havlik 1987).

One (of six) dead Fusconaia flava appeared to have damage from a boat prop. The damaged F. flava shell was found in just under 1.0 m of water.

4.2.2 AFTON STATE PARK, SITE 2

Site 2 was located on the second "point of land" that juts out, downstream from the northern park boundary. Only three living Amblema p. plicata were found on the 30 m transect, and two other species were represented by empty shell (Tables 3, 5A). The substrata was silty, with rocks.

4.2.3 AFTON STATE PARK, SITE 3

Site 3 was primarily a shoreline search from the stairs near the park beach, continuing upstream for 500 m. The substrata was coarse sand, gravel, and cobble. Absolutely nothing was found, not even a shell flake (Tables 3, 5A)

4.2.4 AFTON STATE PARK, SITE 4

This site, at the foot of the stairs to the park beach, was chosen for sampling to help determine the most suitable site for future shoreline development at Afton State Park.

Sites 4, 5 and 6 area are in the downstream end of a bay. The substrata at Site 4 was primarily silty and rocky, and only one living and one dead mussel (two species) were found on a 30 m transect (Tables 3, 5A). Park personnel were conducting soundings in this area during the time of our sampling.

4.2.5 AFTON STATE PARK, SITE 5

Site 5, 15 m south of the stairs to the park beach, was chosen for a sampling transect to help determine the most appropriate site for future shoreline development at Afton Park. This site seems to be the most appropriate for shoreline development, including a boat dock, since the site was primarily silty and rocky, and no mussels were found on the transect, either living or dead (Tables 3, 5A). Park personnel were conducting soundings in this area during the time of our transect.

4.2.6 AFTON STATE PARK, SITE 6

This site, 30 m south of the stairs to the park beach, was

chosen for a sampling transect to help determine the most appropriate site for future shoreline developments at Afton Park. The site seems to be appropriate for shoreline development, since the site was primarily silty and rocky. One living mussel was found during random sampling, and no mussels were found on a 30 m transect (Tables 3, 5A). Park personnel were conducting soundings in this area during the time of our sampling.

4.2.7 AFTON STATE PARK, SITE 7

Site 7 was a shoreline and shallow water search from the beach stairs, south (downstream) and around the bay to the east-west power line across Lake Saint Croix. About 175 m N of the power line the sand substrata changes to rocks.

One living Amblema p. plicata was found lying on the predominantly sand substrata. Four living Toxolasma parvus (Barnes, 1823), Liliput Shell, were found including one very fresh-dead with the animal still attached (counted as alive for purposes of this report). Two other species were represented by empty shells only (Tables 3, 5B). There was also some submergent aquatic vegetation.

4.2.8 AFTON STATE PARK, SITE 8

Site 8 was a random search on the sandbar where Trout Brook empties into Lake Saint Croix. No mussels or shells were found (Tables 3, 5B). There were numerous toads and toad eggs.

4.2.9 AFTON STATE PARK, SITE 9

The transect at Site 9 was 100 m N of the power line crossing, at a sandy point along the shoreline. Only two living Amblema p. plicata were found (Tables 3, 5B). The substrata was sand; water depths were 2.5 to 3 m. The diver specifically checked rocks for Dreissena polymorpha, but none were seen.

4.2.10 AFTON STATE PARK, SITE 10

The 20 m transect at Site 10 was 250 to 300 m S (downstream) of the power line crossing, near the location of two large drain pipes. The larger drain pipe was on top of a small drain pipe. A park sign was also near the site. The substrata was sand, gravel, cobble for 3 m, then mostly sand and some large rocks. The maximum depth was 6 m.

Only three living unionids were found (two species) (Tables 3, 5B).

4.2.11 AFTON STATE PARK, SITE 11

Site 11 was about half way between the S Afton Park boundary and the power line crossing, downstream of Site 10, and near another drain pipe. The 20 m transect substrata was sand, gravel,

cobble, and some large rocks. The maximum depth was 6 m.

Nine living unionids (four species) were found (Tables 3, 5B). The smaller of two Fusconaia flava appeared stunted; this specimen was 41 mm long, and about 22 to 23 years of age.

4.2.12 AFTON STATE PARK, SITE 12

At Site 12, the 20 m transect was near the S boundary of Afton Park, at two large, side by side drainage pipes. A park sign was also located at this site. The maximum depth was 5 m.

Two of the three living mussels found were juveniles (Tables 3, 5B). The substrata was mostly large gravel for 6 m, similar to the shoreline. The substrata on the remainder of the transect was sand and some large rocks.

5 DISCUSSION

This study revealed a number of important bivalve mollusk populations, particularly at Wild River State Park. The bivalve mollusk fauna at Afton State Park is much more depauperate.

Rare bivalve mollusk species, and concentrations of unionids and margaritiferids, have been documented, and summarized in species lists, tables, and maps. Several areas had a large number of old dead shells which made it nearly impossible to document all of the bivalve mollusks that may live/or had lived in one particular area.

Of five Minnesota state and two federal endangered species that could have been found, only an empty shell of the federal and state endangered Lampsilis higginsii was found, at Afton State Park.

The Afton Park site was an interesting location for L. higginsii because only four living unionid species were found at that site. Ordinarily L. higginsii is only found in mussel beds of good diversity and density; neither was present at this site, or at Afton Park in general. There are however, good mussel populations in the other nearby areas of the lower Saint Croix River (Lake Saint Croix) (Fuller 1978, 1980a, 1980b; Malacological Consultants 1985; Havlik 1987).

The most important find at Wild River Park was locating a population of apparently only old specimens of Cumberlandia monodonta. No small or young C. monodonta were found dead or alive. This suggests a host fish problem.

Potential host fish for the Saint Croix River bivalve mollusks are given in Table 7 (Fuller 1978). Note that the host fish for a number of margaritiferid and unionid mollusk species are unknown.

General park literature indicates that Catfish, Northerns, Walleyes, Sauger, Small Mouth Bass, and Muskie are present.

However, conversations with park personnel and researchers indicate that about 90 fish species are present in the lower Saint Croix River. About ? fish species are present in the Saint Croix River upstream of the NSP dam at Saint Croix Falls. Over 50 fish species (Table 7) have been reported to be hosts for freshwater mussels (Fuller 1978).

Our previous work on both sides of the Saint Croix River, particularly at Stillwater, MN, showed rather a sparse mussel fauna on the Minnesota side of some sections of the lower Lake Saint Croix, but a dense fauna on the Wisconsin side of the river (Havlik 1987). This is probably due to water currents created by the prevailing westerly winds in a riverine lake.

Sampling on the Wisconsin side of the Saint Croix, opposite Afton State Park, should confirm if the same similar circumstances occur in that area of the lower Saint Croix River. Perhaps a more abundant fauna is present, but depths near the shoreline at Afton Park created safety problems which prevented extensive sampling.

Due to the nature of his study sampling regime, Doolittle (1988) only sampled about eight sites opposite Wild River Park, and he did not sample any sites in the vicinity of Afton State Park.

Doolittle (1989) did not describe the habitat at any of his sites. Thus, we were unable to compare our habitats to any of his nearby sites.

The 1987 Doolittle study sites in the Wild River Park area were aided by low water levels during a drought. Our 1992 study was done during moderate water levels.

Researchers working on large rivers are accustomed to describing sites as a specific River Mile. However, we were uncertain as to River Mile designations for each site. The River Mile number depended on the map to which you had referred; the numbers did not agree. We were unable to ascertain which maps Doolittle (1988) had used, and why he had two sets of river miles in his reports.

River miles should become standardized on any river that is the subject of numerous research projects, such as the Saint Croix River. These river miles should be consistent on all Saint Croix River maps. The Corps of Engineers maps seem to be the logical starting place to standardize river mileage, combined with USGS topographic maps.

Although agreeable to media coverage, Twin Cities' reporters that we worked with previously did not respond to our invitation to observe this project in progress. A biologist from the US Fish and Wildlife Service, Saint Paul, MN, Field Office had accepted our invitation to join us in the field at Wild River Park, but he had to cancel his plans at the last minute.

We were willing talk on radio shows, and to give public presentations at the two parks, but there were no opportunities to do so.

A presentation on this project was given at the Saint Croix River Research Rendezvous, 19 October 1993, Wilder Forest, Marine on Saint Croix, Minnesota. Another presentation is planned for the Mississippi River Research Consortium, April 1994, La Crosse, Wisconsin. Presentations include a statement that this project was funded by the Minnesota Nongame Wildlife Program from contributions to the Minnesota Nongame Wildlife Tax Checkoff.

6 RECOMMENDATIONS FOR BIVALVE MOLLUSK CONSERVATION AND MANAGEMENT

Unionid conservation must be undertaken so that the biological diversity may be maintained and enhanced in the Saint Croix National Scenic Riverway. The functional value of mussels in this river ecosystem must be maintained. Recommendations for unionid conservation, and the most urgent priorities for future research projects, are given below.

The Saint Croix National Scenic Riverway is one of the most unique river systems in North America. In 1987 I recommended to the National Park Service (NPS) and the Minnesota Department of Natural Resources, the closure of the entire Saint Croix River to the taking of any unionids, for any purpose, except scientific studies, in order to maintain and enhance the biological diversity of this unique nongame wildlife resource.

We understand that closure of the Saint Croix River, to any taking of mussels, was implemented by the MNDNR and the NPS in late 1988, and that closure still continues. There has been no commercial clamming in the Saint Croix River since at least 1987, mainly due to Wisconsin clamming regulations. The Wisconsin regulations should remain, and in fact would not be likely to be changed, given our present knowledge of the bivalve mollusk fauna of the Riverway, and the potential for exotic bivalve impacts.

Based on our 1992 study of the Saint Croix River, we continue to recommend that the Minnesota portion of the Saint Croix also remain closed to the taking of any living unionid and margaritiferid bivalve mollusk species for any purpose, whether it be for a food source, casual collecting, fish bait, or commercial clamming purposes, except for scientific research projects.

Sampling, similar to that done in this study, needs to be done on the Wisconsin side of the Saint Croix, particularly opposite Wild River State Park, in the vicinity of the Sunrise River mouth and boat landing, to determine the extent of the range of Cumberlandia monodonta. In addition, more intensive sampling in the unique habitat where C. monodonta survives would probably aid in determining if young C. monodonta are present. Simpsonaias ambigua may also live in those areas since that species occupies a habitat similar to C. monodonta.

Additional sampling by diving, and possibly by brailing, should be done in the pooled waters below the old Nevers Dam Site, downstream to the southern Wild River Park boundary. Depths were such that these areas were unable to be sampled by wading. In addition, inclement weather prevented diving in the lower areas of Wild River Park. The upstream extent of the adverse influence of the NSP dam at Saint Croix Falls, WI, may well extend nearly to the old Nevers dam site.

Based on our work, and the work of other recent researchers, we recommend that the area between the north boundary of Wild River Park and the old Nevers dam site be named a unionid refuge.

Alternately, and at a minimum, a unionid refuge for Cumberlandia monodonta should start at least 1.5 miles above the mouth of the Sunrise River, and continue downstream for at least 1.5 miles below the mouth of the Sunrise River. Some of this area may also need to be closed to shoreline fishing, particularly for 0.5 miles just upstream of the Sunrise River landing, although this probably would not be popular with the public.

We discourage any shoreline development at Wild River Park upstream of the old Nevers Dam Site, and particularly in the area of the mouth of the Sunrise River, and the Sunrise River boat landing, or in any other shallow areas.

We recommend against any enlargement of the parking area at the Sunrise River boat landing.

If any shoreline area is to be developed at Wild River Park, then we recommend that development be done downstream of the Wild River main boat landing.

The area that the Minnesota Division of Parks and Recreation is considering for a boat dock at Afton State Park, just downstream from the steps to the beach at the Park, seems, fortuitously, to be at the best site that could be chosen for developing the waterfront at Afton Park. The area is near the downstream end of a bay, and as a result is quite silty, with very few mussels near the shoreline. The large rocks in the water make the area unusable as a swimming beach because it would be difficult to walk there.

We see no particular biological problems with development of a boat parking dock in that area of Afton Park. We pointed out an exact suitable site to Afton Park personnel, who also happened to be working there at the time of our mussel sampling.

The Saint Croix River State Parks receive heavy use due to their proximity to a metropolitan area. Consequently additional mussel education urgently needs to be developed, to enhance citizen awareness and understanding for those who use the Riverway, particularly in regard to potential Zebra Mussel impacts on a unique mussel fauna. This could be accomplished through displays,

posters, and lectures at the parks.

The next time the Park brochures are updated, consideration should be given to some mention of mussels as part of the Park resources, and the regulations concerning them. But any specific information on rare species should be omitted.

Wider distribution of pamphlets, such as the mussel identification booklet published by the Wisconsin Department of Natural Resources, would be very helpful in educating the younger generation so that they will be more environmentally responsible in appreciating the Saint Croix River and its marvelous invertebrate fauna.

Another helpful publication, describing the problems created by agriculture, in addition to giving background information on freshwater mussels, is the pamphlet recently issued by the Minnesota Department of Agriculture (Mueller 1993).

Representative shell collections, deposited at both parks, should be used to create permanent educational displays.

Based on recent-past experiences with museum specimens, it is highly desirable to deposit excess voucher specimens, particularly of rare species from specific projects, in several institutions besides the Bell Museum, Minneapolis. Other suitable institutions include The Ohio State University Museum of Biological Diversity, Columbus, Ohio, the United States National Museum (Smithsonian Institution), Washington, D.C., and the Science Museum of Minnesota, Saint Paul. Important specimens have been lost, misplaced, or destroyed a number of times over the past few years, including a specimen of Lampsilis higginsii from the lower Minnesota River, Savage, MN.

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9 APPENDIX

10 TABLE 1. BIVALVE MOLLUSKS, SAINT CROIX RIVER, 1992

SAINT CROIX RIVER STATE PARKS

	WILD RIVER	AFTON PARK	TOTAL	JUVENILES
* 1 Cumberlandia monodonta (Say, 1819), Spectacle Case	40		40	
2 Anodonta imbecillis Say, 1829, Paper Pond Shell	D		D	
3 Anodonta grandis f. corpulenta Cooper, 1834, Stout Floater		D	D	
4 Strophitus u. undulatus (Say, 1817), Squaw Foot	29		29	
* 5 Alasmidonta marginata Say, 1818, Elk Toe	29		29	
6 Lasnigona complanata (Barnes, 1823), White Heel Splitter	D		D	
7 Lasnigona costata (Rafinesque, 1820), Fluted Shell	38		38	
8 Quadrula p. pustulosa (Lea, 1831), Pimple Back	34	1	35	J
9 Amblema p. plicata (Say, 1817), Three-Ridge	17	37	54	
10 Fusconaia flava (Rafinesque, 1820), Pig-Toe	41	27	68	J
*11 Cyclonaias tuberculata (Rafinesque, 1820), Purple Warty-Back	23		23	
*12 Pleurobema sintoxia (Rafinesque, 1820), Round Pig-toe	17		17	
13 Elliptio dilatata (Rafinesque, 1820), Spike	500		500	J
14 Obliquaria reflexa Rafinesque, 1820, Three-Horned Warty-Back	2	3	5	
15 Actinonaias ligamentina carinata (Barnes, 1823), Mucket	481		481	J
16 Obovaria olivaria (Rafinesque, 1820), Hickory Nut	49		49	
17 Truncilla truncata Rafinesque, 1820, Deer Toe	10	1	11	
18 Leptodea fragilis (Rafinesque, 1820), Fragile Paper Shell	9		9	
19 Potamilus alatus (Say, 1817), Pink Heel Splitter	10	1	11	
20 Toxolasma parvus (Barnes, 1823), Lilliput Shell		5	5	
21 Ligumia recta (Lamarck, 1819), Black Sand Shell	10		10	
22 Lampsilis radiata luteola (Lamarck, 1819), Fat Mucket	90	5	95	J
*23 Lampsilis higginsii (Lea, 1857), Higgins' Eye		D	D	
24 Lampsilis ventricosa (Barnes, 1823), Pocketbook	51	D	51	J
TOTAL:	1480	80	1560	
LIVING SPECIES:	19	8		
SPECIES WITH EMPTY SHELLS ONLY:	2	3		
SPECIES SHOWING RECRUITMENT:				6

D = SPECIES REPRESENTED BY EMPTY SHELLS ONLY

* = Wisconsin/Minnesota endangered or threatened bivalve mollusk species.

11 TABLE 2. BIVALVE MOLLUSKS, SAINT CROIX RIVER, MN, 1988 TO 1992

SAINT CROIX RIVER STATE PARKS

	1 AFTON	1A 1992	1B %	2 WILD RIVER	2A 1992	2B %	TOTAL 1992	% OF LIVING	SOURCE OF LIVE SPECIES
			AFTON 1992			WILD R. 1992			
* 1 Cumberlandia monodonta, Spectacle Case					40	2.70%	40	2.6%	H
2 Anodonta imbecillis, Paper Pond Shell				X	D		D		X
3 Anodonta grandis f. grandis, Floater				X					X
4 Anodonta g. corpulenta, Stout Floater	X	D					D		X
5 Strophitus u. undulatus, Squaw Foot				X	29	1.96%	29	1.9%	H
* 6 Alasmidonta marginata, Elk Toe				X	29	1.96%	29	1.9%	H
* 7 Simpsonaias ambigua, Salamander Mussel									X
8 Lasnigona complanata, White Heel Splitter				X	D		D		X
9 Lasnigona costata, Fluted Shell				X	38	2.57%	38	2.4%	H
10 Lasnigona compressa, Creek Heel Splitter				X					X
* 11 Tritogonia verrucosa, Buckhorn									X
* 12 Quadrula metanevra, Monkey-Face									X
13 Quadrula p. pustulosa, Pimple Back		1	1.3%	X	34	2.30%	35	2.2%	H
14 Amblema p. plicata, Three-Ridge	X	37	46.3%	X	17	1.15%	54	3.5%	H
15 Fusconaia flava, Pig-Toe	X	27	33.8%	X	41	2.77%	68	4.4%	H
* 16 Cyclonaias tuberculata, Purple Warty-Back				X	23	1.55%	23	1.5%	H
* 17 Pleurobema sintoxia, Round Pig-toe				X	17	1.15%	17	1.1%	H
18 Elliptio dilatata, Spike				X	500	33.9%	500	32.1%	H
19 Obliquaria reflexa, Three-Horned Warty-Back		3	3.8%	X	2	0.14%	5	0.3%	H
20 Actinonaias ligamentina carinata, Mucket				X	481	32.5%	481	30.8%	H
21 Obovaria olivaria, Hickory Nut				X	49	3.31%	49	3.1%	H
22 Truncilla truncata, Deer Toe		1	1.3%	X	10	0.68%	11	0.7%	H
23 Leptodea fragilis, Fragile Paper Shell				X	9	0.61%	9	0.6%	H
24 Potamilus alatus, Pink Heel Splitter		1	1.3%	X	10	0.68%	11	0.7%	H
25 Toxolasma parvus, Lilliput Shell	X	5	6.3%				5	0.3%	H
26 Ligumia recta, Black Sand Shell				X	10	0.68%	10	0.6%	H
27 Lampsilis radiata luteola, Fat Mucket		5	6.3%	X	90	6.08%	95	6.1%	H
* 28 Lampsilis higginsii, Higgins' Eye		D					D		H-D
29 Lampsilis ventricosa, Pocketbook		D		X	51	3.45%	51	3.3%	H
TOTAL SPECIMENS:		80	100%		1480	100%	1560	100%	
TOTAL LIVE SPECIES:	4	6		22	19		20		29
DEAD SPECIMENS:		23			368		391		
DEAD SPECIES ONLY:		3			2		4		
TOTAL SITES:		12			13				
		(14 sub-sites)			(32 sub-sites)				
TOTAL RIVER MILES:		2			18.7				

H = living species found, Havlik June 1992.

X = living species found in vicinity of Parks (Doolittle 1988).

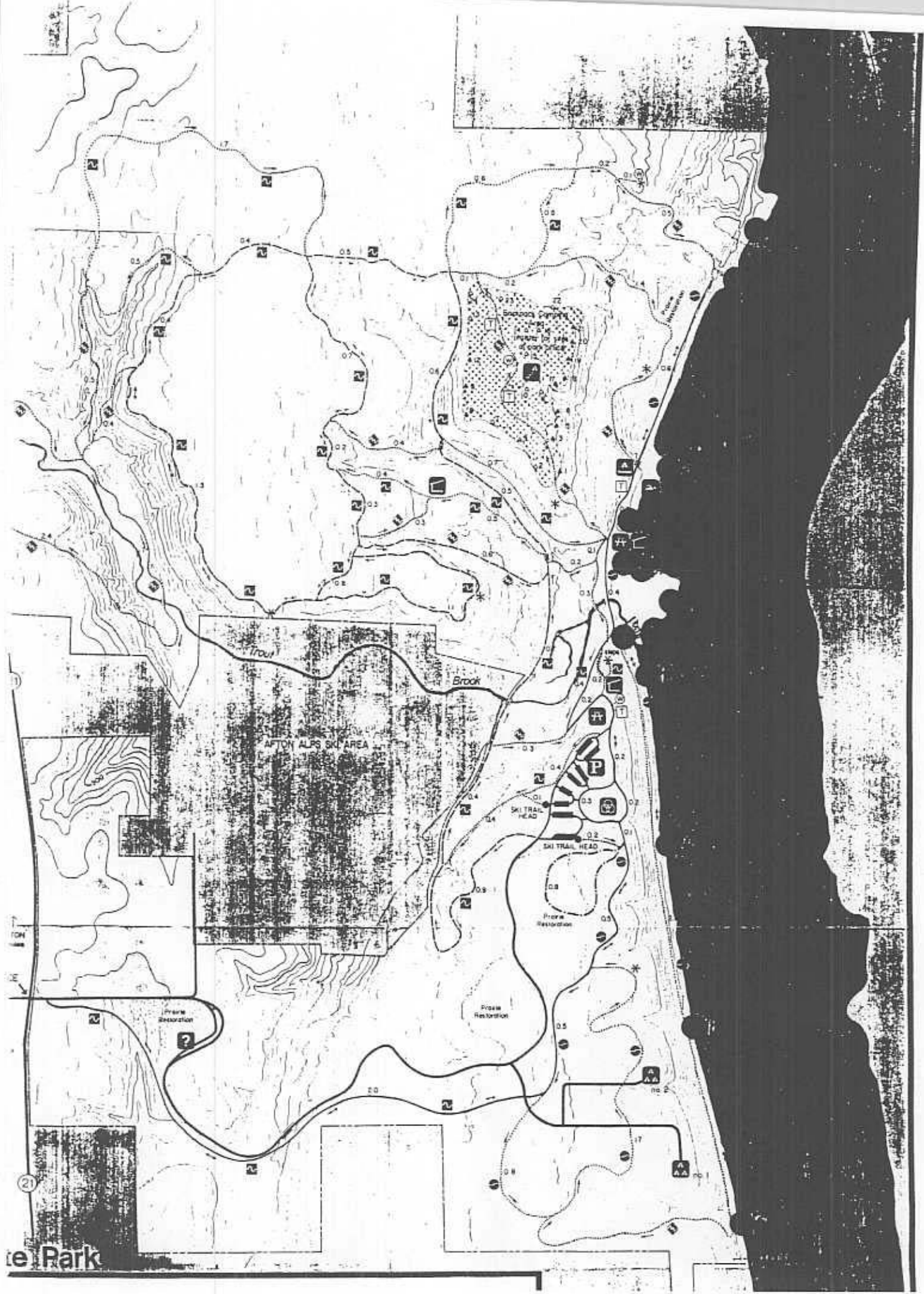
* = Wisconsin/Minnesota endangered or threatened mussel species.

D = SPECIES REPRESENTED BY EMPTY SHELLS ONLY

12 TABLE 3. BIVALVE MOLLUSKS AT WILD RIVER AND AFTON PARKS, BY SITE

WILD RIVER STATE PARK				AFTON STATE PARK			
UPSTREAM TO DOWNSTREAM				UPSTREAM TO DOWNSTREAM			
SITE #	# SPECIMENS	# SPECIES ALIVE DEAD		SITE #	# SPECIMENS	# SPECIES ALIVE DEAD	
1	34	9	2	1	53	7	1
2	239	16	-	2	3	1	2
3	44	4	-	3	-	-	-
4	300	13	3	4	1	1	1
5	54	9	1	5	-	-	-
6	413	15	-	6	1	1	-
7	93	10	2	7	5	2	2
8	16	6	10	8	-	-	-
9	208	17	1	9	2	1	-
10	2	2	5	10	3	2	-
11	73	7	-	11	9	4	-
12	2	1	5	12	3	3	-
13	2	1	-				
TOTAL:	1480			TOTAL:	80		

13 FIGURE 2. SAINT CROIX RIVER, WILD RIVER PARK, MINNESOTA



15 TABLE 4B. BIVALVE MOLLUSKS, SAINT CROIX RIVER, WILD RIVER PARK

SITE (UP>DOWNSTREAM): ST. CROIX RIVER MILE:	3A	3B	4A	4B	4C	4D	5A	5B	TOTAL 1992
SAMPLING TYPE:	R	R	T	Q	Q	R	T	R	
1 Cumberlandia monodonta	10	30					D		40
2 Anodonta imbecillis			D						D
3 Strophitus u. undulatus			D						D
4 Alasmidonta marginata				1		5			6
5 Lasmigona complanata									
6 Lasmigona costata			1			3	6		10
7 Quadrula p. pustulosa			6	D		1	3		10
8 Amblema p. plicata			3		D	1			4
9 Fusconaia flava			1	3	D	6			10
10 Cyclonaias tuberculata		2	8	D		3	1		14
11 Pleurobema sintoxia		1	2			3			6
12 Elliptio dilatata			23	12	3	125	6	5	174
13 Obliquaria reflexa									
14 Actinonaias l. carinata			27	4	1	38	22	1	93
15 Obovaria olivaria			2				1		3
16 Truncilla truncata									
17 Leptodea fragilis		1	1		D		1		3
18 Potamilus alatus									
19 Ligumia recta			D		D	2			2
20 Lampsilis radiata luteola			1			9	2	1	13
21 Lampsilis ventricosa			1			4	2		7
TOTAL SPECIMENS:	10	34	76	20	4	200	44	7	395
TOTAL LIVE SPECIES:	1	4	12	4	2	12	9	3	15
DEAD SPECIMENS:	-	1	117	13	14	1	3	-	149
DEAD SPECIES ONLY:			3	2	4		1		2
SUBSTRATA:									
SI = SILT									
M = MUD									
S = SAND	S	S	S	S	S	S	S	S	S
G = GRAVEL	G	G	G	G	G	G	G	G	G
C = COBBLE	C	C	C	C	C	C	C	C	C
B = BOULDER	B	B							

T = TRANSECT (USUALLY 30 M AND SEMI-QUANTITATIVE)

Q = 0.25 m² QUADRAT -

R = RANDOM COLLECTION

D = SPECIES REPRESENTED BY EMPTY SHELLS ONLY

16 TABLE 4C. BIVALVE MOLLUSKS, SAINT CROIX RIVER, WILD RIVER PARK

SITE (UP>DOWNSTREAM):	5C	5D	6A	6B	6C	6D	TOTAL
ST. CROIX RIVER MILE:							1992
SAMPLING TYPE:	Q	Q	T	Q	Q	R	
1 Cumberlandia monodonta							
2 Anodonta imbecillis							
3 Strophitus u. undulatus			2		1	13	16
4 Alasmidonta marginata			3	2	1	5	11
5 Lasmigona complanata							
6 Lasmigona costata			1	2	1	7	11
7 Quadrula p. pustulosa			1			2	3
8 Amblema p. plicata			2			1	3
9 Fusconaia flava			8			1	9
10 Cyclonaias tuberculata							
11 Pleurobema sintoxia						2	2
12 Elliptio dilatata	2	1	71	7	6	54	141
13 Obliquaria reflexa							
14 Actinonaias l. carinata			44	7	7	128	186
15 Obovaria olivaria			3	1		4	8
16 Truncilla truncata			1			1	2
17 Leptodea fragilis			1				1
18 Potamilus alatus							
19 Ligumia recta			1			4	5
20 Lampsilis radiata luteola			2		1	3	6
21 Lampsilis ventricosa			2		1	9	12
TOTAL SPECIMENS:	2	1	142	19	18	234	416
TOTAL LIVE SPECIES:	1	1	14	5	7	14	15
DEAD SPECIMENS:	-	-	-	-	-	-	0
DEAD SPECIES ONLY:							0
SUBSTRATA:							
SI = SILT							
M = MUD							
S = SAND	S	S	S	S	S	S	
G = GRAVEL	G	G	G	G	G	G	
C = COBBLE	C	C	C	C	C	C	
B = BOULDER							

T = TRANSECT (USUALLY 30 M AND SEMI-QUANTITATIVE)

Q = 0.25 m2 QUADRAT

R = RANDOM COLLECTION

D = SPECIES REPRESENTED BY EMPTY SHELLS ONLY

17 TABLE 4D. BIVALVE MOLLUSKS, SAINT CROIX RIVER, WILD RIVER PARK

SITE (UP>DOWNSTREAM):	7	8A	8B	8C	9A	9B	9C	TOTAL
ST. CROIX RIVER MILE:								
SAMPLING TYPE:	R	ABOVE OLD NEVERS DAM			T	R	O	
		T	R	Q				
1 Cumberlandia monodonta								
2 Anodonta imbecillis								
3 Strophitus u. undulatus			D		2	8		10
4 Alasmidonta marginata			D			7		7
5 Lasmigona complanata					D			D
6 Lasmigona costata		D	D		2	3		5
7 Quadrula p. pustulosa	3	D		D	5	4		12
8 Amblema p. plicata		3	1	D	2	2	D	8
9 Fusconaia flava	4	D	D	D	1	2	1	8
10 Cyclonaias tuberculata					4	1		5
11 Pleurobema sintoxia	1				2			3
12 Elliptio dilatata	7	3	D	1	11	35	4	61
13 Obliquaria reflexa		D			1	1		2
14 Actinonaias l. carinata	27	1	1	D	22	63	4	118
15 Obovaria olivaria	29	D	D		1	2		32
16 Truncilla truncata	1		D		3	3	D	7
17 Leptodea fragilis	D	D	D	D		1		1
18 Potamilus alatus	D	1	1		1	1		4
19 Ligumia recta	1	D	D					1
20 Lampsilis radiata luteola	1	1	1	1	1	4		9
21 Lampsilis ventricosa	19			1	2	2		24
TOTAL SPECIMENS:	93	9	4	3	60	139	9	317
TOTAL LIVE SPECIES:	10	5	4	3	15	16	3	18
DEAD SPECIMENS:	14	47	72	13	1	MANY	14	147
DEAD SPECIES ONLY:	2	7	9	5	1		2	1
SUBSTRATA:								
SI = SILT								
M = MUD								
S = SAND	S	S	S	S	S	S	S	
G = GRAVEL	G	G	G	G	G	G	G	
C = COBBLE								

T = TRANSECT (USUALLY 30 M. AND SEMI-QUANTITATIVE)
 Q = 0.25 m2 QUADRAT
 R = RANDOM COLLECTION
 D = SPECIES REPRESENTED BY EMPTY SHELLS ONLY

18 TABLE 4E. BIVALVE MOLLUSKS, SAINT CROIX RIVER, WILD RIVER PARK

SITE (UPSTREAM>DOWNSTREAM): ST. CROIX RIVER MILE:	10	11	12	13	TOTAL
SAMPLING TYPE:	DOWNSTREAM WILD R. LANDING				
	R	R	R	R	
1 Cumberlandia monodonta					
2 Anodonta imbecillis					
3 Strophitus u. undulatus					
4 Alasmidonta marginata					
5 Lasmigona costata					
6 Lasmigona complanata					
7 Quadrula p. pustulosa	D				D
8 Amblema p. plicata		1			1
9 Fusconaia flava	D	5	D		5
10 Cyclonaias tuberculata					
11 Pleurobema sintoxia					
12 Elliptio dilatata	D	12	D		12
13 Obliquaria reflexa					
14 Actinonaias l. carinata	1				1
15 Obovaria olivaria	1				1
16 Truncilla truncata	D		D		D
17 Leptodea fragilis		2	D		2
18 Potamilus alatus	D	4	D		4
19 Ligumia recta					
20 Lampsilis radiata luteola		48	2	2	52
21 Lampsilis ventricosa		1			1
TOTAL SPECIMENS:	2	73	2	2	79
TOTAL LIVE SPECIES:	2	7	1	1	11
DEAD SPECIMENS:	66	-	MANY	-	66
DEAD SPECIES ONLY:	5		5		2
SUBSTRATA:					
SI = SILT					
M = MUD	M	M	M	M	
S = SAND	S	S	S	S	
G = GRAVEL	G	G	G	G	
C = COBBLE					
B = BOULDER					

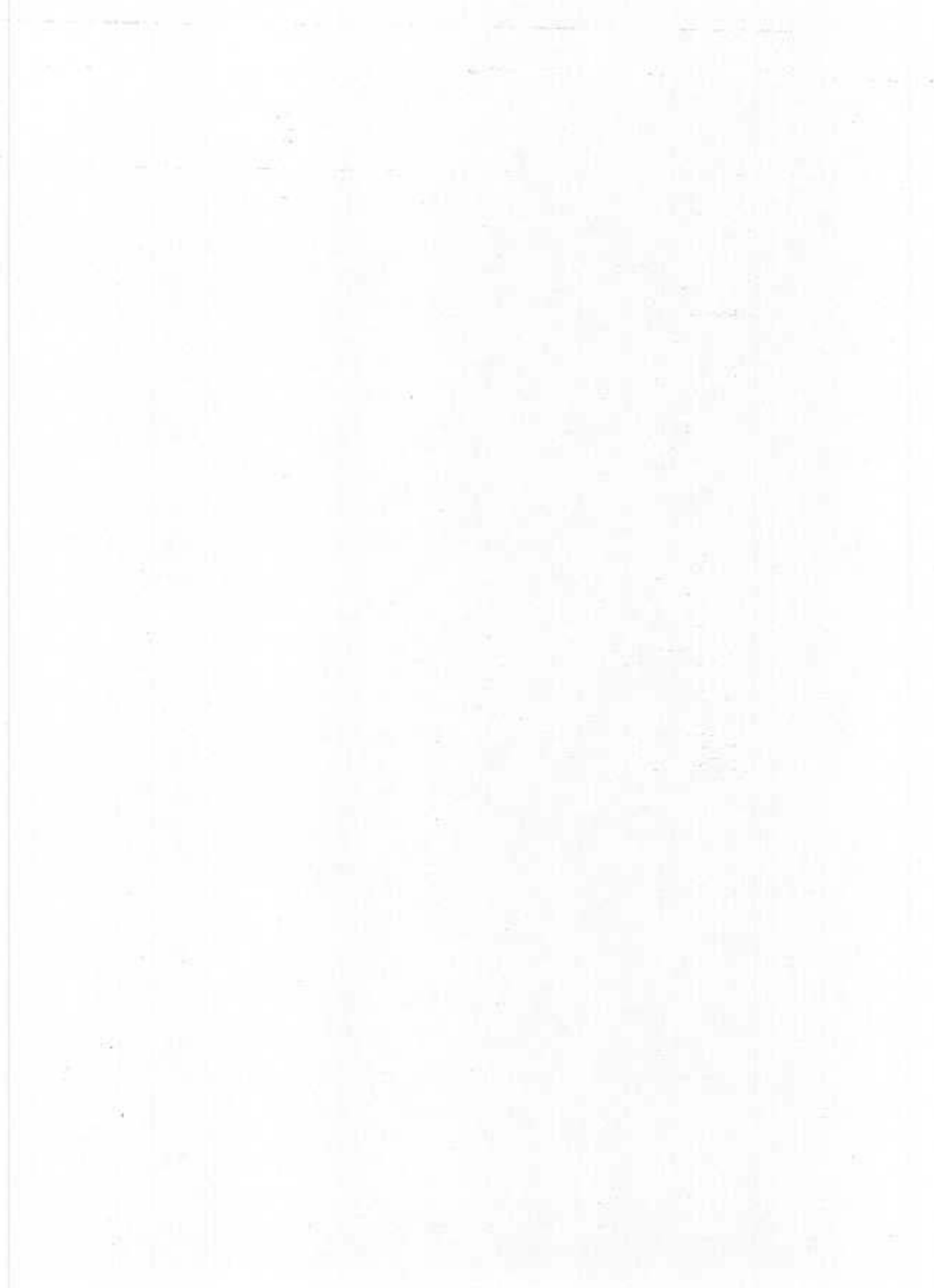
T = TRANSECT (USUALLY 30 M AND SEMI-QUANTITATIVE)

Q = 0.25 m2 QUADRAT

R = RANDOM COLLECTION

D = SPECIES REPRESENTED BY EMPTY SHELLS ONLY

19 FIGURE 3. SAINT CROIX RIVER, AFTON STATE PARK, MINNESOTA



general information
 NP-Baldwin
 3000-5000

TRAILS

Hiking
 Horseback/Hiking
 minimal/limited maintenance

PRIVATE PROPERTY
 Public Use Prohibited
 (except on designated trails)

SCALE

MILES 0 5 10 15
 KILOMETERS 0 2 4 6

INSET SCALE

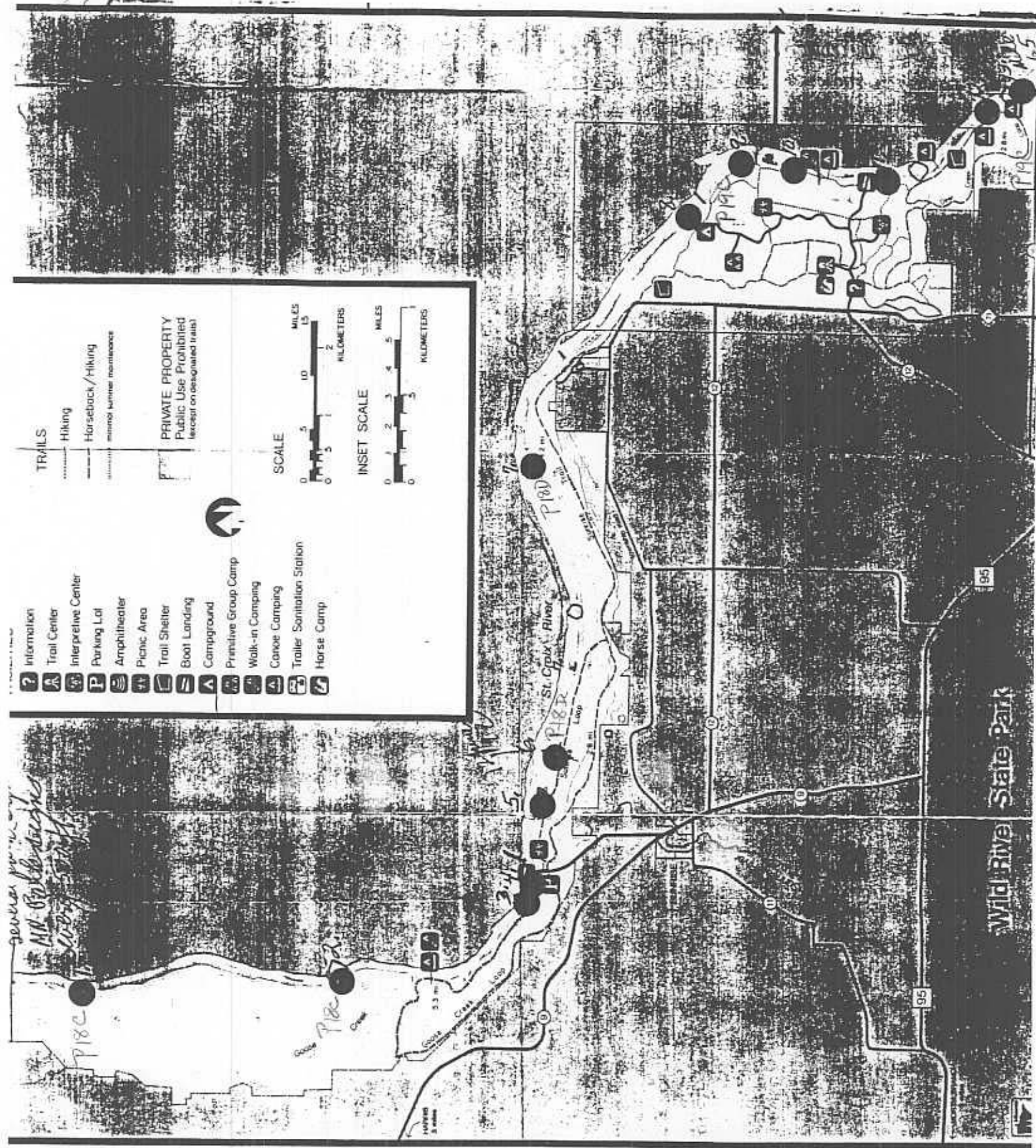
MILES 0 1 2 3 4 5
 KILOMETERS 0 1 2 3 4 5

Information

Trail Center
 Interpretive Center
 Parking Lot
 Amphitheater
 Picnic Area
 Trail Shelter
 Boat Landing
 Campground
 Primitive Group Camp
 Walk-in Camping
 Canoe Camping
 Trailer Sanitation Station
 Horse Camp

Map Symbols

Information
 Trail Center
 Interpretive Center
 Parking Lot
 Amphitheater
 Picnic Area
 Trail Shelter
 Boat Landing
 Campground
 Primitive Group Camp
 Walk-in Camping
 Canoe Camping
 Trailer Sanitation Station
 Horse Camp



21 TABLE 5B. BIVALVE MOLLUSKS, SAINT CROIX RIVER, AFTON STATE PARK

SITE (UPSTREAM>DOWNSTREAM): ST. CROIX RIVER MILE:		7	8	9	10	11	12	TOTAL 1992
SAMPLING TYPE:		BEACH TO SOUTH PARK BORDER						
		R	R	T	T	T	T	
1	Anodonta g. corpulenta	D						D
2	Quadrula p. pustulosa							
3	Amblema p. plicata	1		2	2	4	1	10
4	Fusconaia flava				1	2		3
5	Obliquaria reflexa					2	1	3
6	Truncilla truncata							
7	Potamilus alatus							
8	Toxolasma parvus	4						4
9	Lampsilis radiata luteola					1	1	2
10	Lampsilis higginsii							
11	Lampsilis ventricosa	D						D
TOTAL SPECIMENS:		5	0	2	3	9	3	22
TOTAL LIVE SPECIES:		2	0	1	2	4	3	5
DEAD SPECIMENS:		4	-	-	-	-	1	5
DEAD SPECIES ONLY:		2						2
SUBSTRATA:								
SI = SILT								
M = MUD								
S = SAND		S	S	S	S	S	S	
G = GRAVEL					G	G	G	
C = COBBLE		C			C	C	C	
B = BOULDER								

T = TRANSECT (USUALLY 30 M AND SEMI-QUANTITATIVE)
 R = RANDOM COLLECTION
 D = SPECIES REPRESENTED BY EMPTY SHELLS ONLY

22 TABLE 6. FREQUENCY OF MOLLUSCAN OCCURRENCE: SAINT CROIX PARKS

	WILD RIVER PARK (13 SITES)		AFTON PARK (12 SITES)	
	# SITES ALIVE	DEAD	# SITES ALIVE	DEAD
1 <i>Cumberlandia monodonta</i>	1	2	-	-
2 <i>Anodonta imbecillis</i>	-	1	-	-
3 <i>Anodonta grandis corpulenta</i>	-	-	-	1
4 <i>Strophitus u. undulatus</i>	4	2+	-	-
5 <i>Alasmidonta marginata</i>	4	2+	-	-
6 <i>Lasmigona costata</i>	6	2+	-	-
7 <i>Lasmigona complanata</i>	-	1	-	-
8 <i>Quadrula p. pustulosa</i>	7	2+	1	-
9 <i>Amblema p. plicata</i>	6	3	9	-
10 <i>Fusconaia flava</i>	7	4+	3	1
11 <i>Cyclonaias tuberculata</i>	5	2	-	-
12 <i>Pleurobema sintoxia</i>	6	1	-	-
13 <i>Elliptio dilatata</i>	9	2+	-	-
14 <i>Obliquaria reflexa</i>	1	1	2	-
15 <i>Actinonaias l. carinata</i>	9	1+	-	-
16 <i>Obovaria olivaria</i>	7	1	-	-
17 <i>Truncilla truncata</i>	4	3	1	-
18 <i>Leptodea fragilis</i>	7	3	-	-
19 <i>Potamilus alatus</i>	4	3	1	-
20 <i>Toxolasma parvus</i>	-	-	2	-
21 <i>Ligumia recta</i>	4	2	-	-
22 <i>Lampsilis radiata luteola</i>	11	-	3	2
23 <i>Lampsilis higginsii</i>	-	-	-	1
24 <i>Lampsilis ventricosa</i>	9	-	-	1

+ = SPECIES REPRESENTED BY EMPTY SHELLS. THESE SPECIES WERE PROBABLY AT MORE SITES, BUT WERE NOT SOUGHT AS EMPTY SHELLS.

23 TABLE 7. POTENTIAL HOST FISH FOR UPPER ST. CROIX BIVALVE MOLLUSKS

- *1. Cumberlandia monodonta, Spectacle Case: host unknown
2. Anodonta imbecillis, Paper Pond Shell: Green Sunfish, Creek Chub
3. Anodonta grandis f. grandis, Floater: 22 host fish sp. including Golden & Common Shiners, Creek Chub, White Sucker, Yellow Bullhead, Brook Stickleback, Rock Bass, Iowa & Johnny Darter
4. Strophitus u. undulatus, Squaw Foot: Green Sunfish, Creek Chub, Killifish, Largemouth Bass
- *5. Alasmodonta marginata, Elk Toe: White Sucker, Northern Hog Sucker, Shorthead Redhorse, Rock Bass, Warmouth
6. Lasmigona complanata, White Heel Splitter: Carp, Green Sunfish, Largemouth Bass, White Crappie
7. Lasmigona costata, Fluted Shell: Carp
8. Quadrula p. pustulosa, Pimple Back: White Crappie, Shovelnose Sturgeon, Black and Brown Bullhead, Channel/Flathead Catfish
9. Amblema p. plicata, Three-Ridge: 15 common fish sp. including Shortnose Gar, Northern Pike, Rock Bass, Green Sunfish
10. Fusconaia flava, Pig-Toe: Bluegill, White and Black Crappie
- *11. Cyclonaias tuberculata, Purple Warty-Back:
(may be unknown, but some recent research on this species)
- *12. Pleurobema sintoxia, Round Pig-Toe: ?Bluegill, ?Rosefin Shinner
13. Elliptio dilatata, Spike: Gizzard shad, Flathead Catfish, White Crappie, Black Crappie, Yellow Perch
14. Obliquaria reflexa, Three-Horned Warty-Back: Host unknown
15. Actinonaias ligamentina carinata, Mucket: 12 common fish species including American Eel, Tadpole Madtom, Green Sunfish, Bluegill, Small and Largemouth Bass, White and Black Crappie, Yellow Perch, Sauger
16. Obovaria olivaria, Hickory Nut: Shovelnose Sturgeon
17. Truncilla truncata, Deer Toe: Sauger, Drum
18. Leptodea fragilis, Fragile Paper Shell: Drum
19. Potamilus alatus, Pink Heel Splitter: Drum
20. Toxolasma parvus, Lilliput Shell: Green Sunfish, Warmouth Bluegill, White Crappie
21. Ligumia recta, Black Sand Shell: American Eel, Bluegill, Largemouth Bass, White Crappie, Sauger
22. Lampsilis radiata luteola, Fat Mucket: 13 common fish species including Common Shinner, White Sucker, Tadpole Madtom, White and Black Crappie
- *23. Lampsilis higginsii, Higgins' Eye: Sauger, Drum
24. Lampsilis ventricosa, Pocketbook: Bluegill, Small and Largemouth Bass, White Crappie, Yellow Perch

* = Wisconsin & Minnesota endangered or threatened mussel species

24 TABLE 8. 1993 SAINT CROIX RESEARCH RENDEZVOUS ABSTRACT

UNIONID MOLLUSKS IN THE ST. CROIX RIVER BORDERING MINNESOTA AT AFTON AND WILD RIVER STATE PARKS, JUNE 1992. Marian E. Havlik, Malacological Consultants, 1603 Mississippi, La Crosse, WI 54601

Over 35 unionid species have been reported from the St. Croix River in recent times, but large areas have never been sampled. In June 1992 we did semi-quantitative, random, and quantitative sampling by wading and SCUBA diving, near the Minnesota shorelines at Wild River and Afton State Parks to determine the presence and habitat of rare unionids. Park aquatic habitats differed greatly. Thirteen sites (32 sub-sites) along the 19 miles of Wild River Park yielded 1480 living unionids (densities to 74/m², 19 species plus 2 dead species). Twelve sites (14 sub-sites) along the two mile border of Afton State Park yielded 80 living unionids in depths to 6 m (8 species + 3 dead species), for a total of 1560 living specimens (20 species, + 4 species represented by empty shell only).

Proposed as federally endangered, 40 large, old Cumberlandia monodonta (Say, 1829), Spectacle Case, were found at Wild River. The largest, 235 mm long, was over 70 years old (independently aged three times). Their unique habitat of large boulders was limited. Since the smallest C. monodonta was 165 mm, the absence of young adults and juveniles strongly suggests a host fish problem. C. monodonta is reproducing below the NSP dam, St. Croix Falls, WI. Other living rare unionids found at Wild River were Cyclonaias tuberculata (Rafinesque, 1820), Purple Warty-Back (up to 50 years of age), Alasmidonta marginata Say, 1818, Elk Toe, and Pleurobema sintoxia (Rafinesque, 1820), Round Pig-Toe. One empty Lampsilis higginsii (Lea, 1857), Higgins' Eye, was found near Afton Park's north boundary. Elliptio dilatata (Rafinesque, 1820), Spike (32%) and Actinonaias ligamentina carinata (Barnes, 1823), Mucket (30.8%) dominated the fauna. Project was funded by the MNDNR Nongame Wildlife Program (supported by MN Nongame Wildlife Tax Checkoff).

AFTON WILD R.				AFTON WILD R			
<u>Cumberlandia monodonta</u>	40			<u>Elliptio dilatata</u>	500		
<u>Anodonta imbecillis</u>	D			<u>Obliquaria reflexa</u>	3	2	
<u>A. g. corpulenta</u>	D			<u>Actinonaias carinata</u>		481	
<u>Strophitus u. undulatus</u>	29			<u>Obovaria olivaria</u>		49	
<u>Alasmidonta marginata</u>	29			<u>Truncilla truncata</u>	1	10	
<u>Lasmigona complanata</u>	D			<u>Leptodea fragilis</u>		9	
<u>Lasmigona costata</u>	38			<u>Potamilus alatus</u>	1	10	
<u>Quadrula pustulosa</u>	1	34		<u>Toxolasma parvus</u>	5		
<u>Amblema p. plicata</u>	37	17		<u>Ligumia recta</u>		10	
<u>Fusconaia flava</u>	27	42		<u>Lampsilis r. luteola</u>	5	90	
<u>Cyclonaias tuberculata</u>	23			<u>Lampsilis higginsii</u>	D		
<u>Pleurobema sintoxia</u>	17			<u>Lampsilis ventricosa</u>	D	51	
				TOTALS:	80	1481	

Dawley, C. 1947. Distribution of aquatic mollusks in Minnesota. American Midland Naturalist 38:671-697.

Doolittle, T. C. J. 1988. Distribution and relative abundance of freshwater mussels in the Saint Croix National Riverway. Report, plus appendices, to WDNR. Not paginated.