Freshwater Mussels (Bivalvia: Unionoidea) in Streams of Northwestern Kansas

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ABSTRACT -- We summarized archeological records, historical reports, and information from recent surveys of the distributions of freshwater mussels (Bivalvia: Unionoidea) within the Republican and Smoky Hill river basins in northwestern Kansas. Archeological and historical collections included 24 species of mussels from the study area. We collected living individuals or empty shells of 19 of these species in streams during 1995 through 1998. Eleven of the 24 species known from the study area apparently have been extirpated, and at least four species have undergone substantial range reductions. Some extirpations might have occurred before the arrival of EuroAmerican settlers, but most extirpations and range reductions probably resulted, at least in part, from agricultural development and other human impacts that began in the late 19th Century. Nine species seemed to have relatively stable distributions, and some of these might be abundant in impoundments, which were not included in our surveys.

Key words: freshwater mussels, Kansas mussels, Kansas River Basin, Unionidae.

Forty-six species of freshwater mussels (Bivalvia: Unionoidea) were native to Kansas (Murray and Leonard 1962, Eberle 1994, Bleam and Distler 1996, Couch 1997, Bleam et al. 1998, Brian Obermeyer, unpubl. data), but several species probably have been extirpated (Obermeyer et al. 1997). The greatest species richness of freshwater mussels in the state occurs in streams of the southeast (Murray and Leonard 1962). In northwestern Kansas, unstable river substrates, low annual precipitation, and stream intermittency produce an unsuitable habitat for most species of freshwater mussels.

Historical records of unionid mussels from this region began in 1885. Early reports by Call (1885a, 1885b, 1885c, 1887) and Scammon (1906) provide important baseline information on mussel distributions in the study area at the time of settlement by EuroAmericans and prior to construction of the large impoundments on the river main stems. This information is supplemented by archeological studies conducted by

Kivett (1953), Wedel (1959), and Robert Warren (Illinois State Museum, pers. comm.). Murray and Leonard (1962) published a summary of mussels in Kansas that included information on species in northwestern Kansas. Miller and Hibbard (1972) reported 13 extant species of mussels from the Smoky Hill River Basin near Kanopolis Reservoir. Between 1972 and 1980, employees of the Kansas Biological Survey reported eight species from northwestern Kansas (Liechti and Huggins 1977, Schuster and DuBois 1979). Eberle et al. (1986) collected three species of mussels from Big Creek, a tributary of the Smoky Hill River. Sanders et al. (1993) provided a brief summary of the status of mussels and other organisms in the Kansas River Basin based on museum and literature records. Hoke (1997) sampled streams throughout the region from 1983 to 1988 in the Smoky Hill River Basin and from 1988 through 1997 in the Republican River Basin. He collected living mussels and empty shells of 19 species.

The purpose of our study was to assess the historical and current status of mussels in the streams of northwestern Kansas and to compare our results with those of Hoke (1997). The extensive survey by Hoke (1997) in the Smoky Hill River Basin was conducted primarily in 1983 during an extended drought, when the low water levels made mussels susceptible to desiccation and predation. Our study was conducted during a period when streamflows had been restored in much of the study area by a period of average to above average precipitation that began in 1993.

METHODS and MATERIALS

Our study area included the Republican and Smoky Hill river basins from their confluence near Junction City, Kansas, west to the Colorado border and north to the Nebraska line, an area of approximately 69,000 km^2 (Fig. 1). The Smoky Hill River has two major tributaries, the Solomon and Saline rivers. These four rivers and their tributaries originate on the High Plains of eastern Colorado and western Kansas. They generally flow from west to east across northwestern Kansas, although the Republican River Basin drains an extensive area of southwestern Nebraska and northeastern Colorado. We did not sample any impoundments or marshes.

Lotic habitats in the area consisted mainly of sand and silt-covered sand substrates, with occasional gravel riffles and depositional habitats, such as backwater pools. Average annual precipitation in the study area ranges from 38 cm in the west to 85 cm in the east, most of which falls as rain during the summer (Goodin et al. 1995). Although stream levels fluctuate with precipitation inputs and withdrawals for irrigation and other uses, the lower reaches of the Republican, Smoky Hill, Solomon, and Saline rivers usually maintain surface water throughout the year. Many tributaries are intermittent, but some smaller streams maintain year-round flow derived from groundwater seepage, especially those in the eastern portion of the study area. Seven federal reservoirs impound the main stems of the four rivers, and impoundments have been constructed on many tributary streams (Fig. 1). Six additional reservoirs have been constructed in the Republican River Basin of Colorado and Nebraska. Human

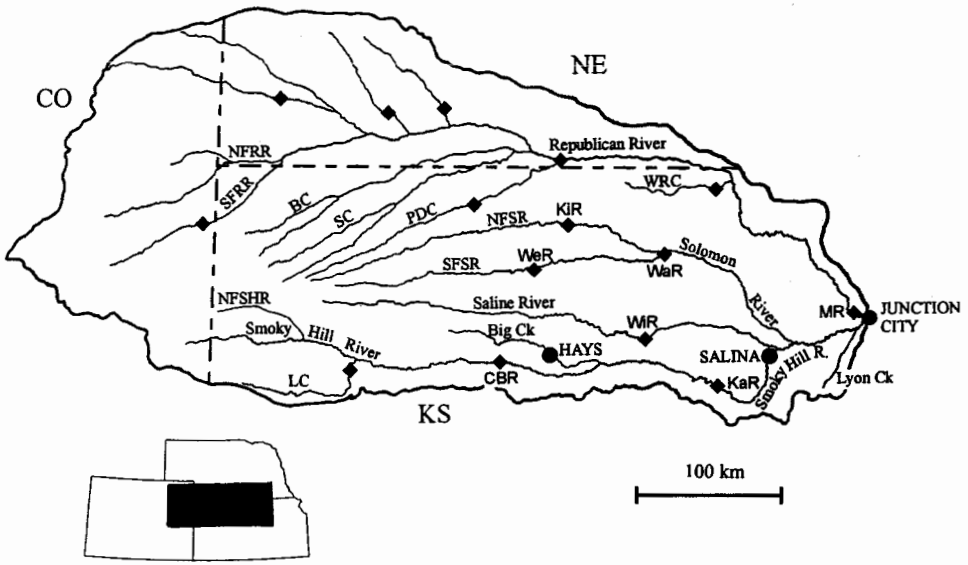

Figure 1. Diagram of principal streams and reservoirs in the Republican and Smoky Hill river basins. The study area includes those stream segments within Kansas. The following stream and reservoir names have been abbreviated on the figure. Streams: BC = Beaver Creek, LC = Ladder Creek, NFRR = North Fork Republican River, NFSHR = North Fork Smoky Hill River, NFSR = North Fork Solomon River, PDC = Prairie Dog Creek, SC = Sappa Creek, SFRR = South Fork Republican River, SFSR = South Fork Solomon River, and WRC = White Rock Creek. Reservoirs: CBR = Cedar Bluff Reservoir, KaR = Kanopolis Reservoir, KiR = Kirwin Reservoir, MR = Milford Reservoir, WaR = Waconda Reservoir, WeR = Webster Reservoir, and WiR = Wilson Reservoir.

impacts in the study area are largely agricultural. Land use consists mainly of grassland and cropland, some of which is irrigated by surface water diversions or groundwater withdrawals. Urban impacts are relatively limited, but could be locally important. Only two cities in our study area have populations that exceed 10,000 people; Salina (44,000 people) and Hays (18,000 people) are both located in the Smoky Hill River Basin.

Samples from 81 sites were collected by fieldcrews from Fort Hays State University (FHSU) from June 1995 through May 1997. Fieldcrews from the Kansas Department of Wildlife and Parks (KDWP) collected mussels from 27 sites from May through August during 1996, 1997, and 1998. The reaches sampled ranged from 100 to 1000 m in length. People waded in the channel to search for live mussels and walked along sandbars to collect empty valves and shell fragments for 30 to 60 minutes at each site. Voucher specimens were deposited in the Sternberg Museum of Natural History at Fort Hays State University, Hays, Kansas.

Initially, we classified specimens collected by FHSU fieldcrews into five categories: live, fresh, recently-dead, weathered, and subfossil. Fresh specimens had some soft tissue still attached to the shell. Recently-dead valves had intact nacre and periostracum (except for typical erosion of the umbo) but no soft tissue. Weathered shells had erosion of the periostracum. Subfossil shells were eroded to a white, chalky appearance with no periostracum. We assumed that the presence of fresh and recently-dead specimens indicated that a species was extant at a site during our study period, and we combined these two categories in our tabular summary. The presence of only weathered or subfossil shells at a site was taken as an indication that a species no longer occurred at that site. Specimens from the KDWP samples originally were classified into three categories: live, recent, and weathered. Specimens in the weathered category were reexamined for separation into the weathered and subfossil categories used in our summary. For comparative purposes, the six categories defined by Hoke (1997) were reduced to conform with our four categories.

Based on the definitions below, we also categorized each species as common, uncommon, rare, or extirpated within the study area. These categories were based on the number of sites at which live, fresh, and recently-dead shells were collected, not on the numbers of individuals obtained. Species considered to be common occurred in more than 15% of the collection sites. Species recorded at 5 to 15% of the sites were referred to as uncommon, and those found at 1 to 4% of the localities were classified as rare. Species represented only by weathered or subfossil shells in our surveys or the study by Hoke (1997) were considered to be extirpated from the study area, as were species not reported since 1910 or those known only from archeological records.

RESULTS and DISCUSSION

A summary of archeological, historical, and recent collections of mussels from northwestern Kansas is provided in Table 1. Archeological records and early (pre-

Table 1. Species of mussels (Unionidae) collected in the Republican and Smoky Hill river basins of northwestern Kansas. The 13 species marked with an asterisk (*) were considered to be extant within streams in the study area. References from which the archeological and historical records were derived are discussed in the text, as are the definitions of the following categories: L = live, R = fresh or recently-dead shell, W = weathered shell, and S = subfossil shell. When individuals from more than one category were collected, the first available category in the sequence L – R – W – S is given in the table.

Species	Archeological Collections "pre-1800"	Historical Reports 1880-1906	Historical Reports 1970-1984	Hoke (1997) 1983-1997	FHSU/KDWP Surveys 1995-1998
Amblema plicata	X	X		W	W
**Anodontoides ferussacianus*	X	X	X	L	L
Elliptio dilatata	X				
**Fusconaia flava*	X		X	R[1]	W
Lampsilis cardium	X			S	
Lampsilis siliquoidea	X		X	W	W
Lampsilis teres	X		X	W	W
**Lasmigona complanata*	X	X		L	L
**Leptodea fragilis*	X	X	X	L	L
Ligumia recta	X	X			
**Ligumia subrostrata*	X	X	X	R[1]	W
Obovaria olivaria	X			W	S
Pleurobema sintoxia	X				
Potamilus alatus	X	X	X		S

Table 1 Cont.

Species	Archeological Collections "pre-1800"	Historical Reports 1880-1906	Historical Reports 1970-1984	Hoke (1997) 1983-1997	FHSU/KDWP Surveys 1995-1998
**Potamilus ohiensis*		X	X	L	L
Potamilus purpuratus	X	X	X		
**Pyganodon grandis*	X	X	X	L	L
**Quadrula pustulosa*	X		X	L	L
**Quadrula quadrula*	X	X	X	L	L
**Strophitus undulatus*	X	X		R[1]	R[1]
**Toxolasma parvus*	X	X		R[2]	W
Tritogonia verrucosa	X	X	X	W	W
**Uniomerus tetralasmus*	X	X	X	L	L
**Utterbackia imbecillis*		X		L	R
Total Species (24)	22	16	14	19	19

[1] fresh or recently-dead specimens taken only from Lyon Creek (Fig. 1) in 1983 and one species (*S. undulatus*) taken again in 1996.

[2] fresh or recently-dead specimens reported only from the Saline River NW of Hays and two reservoir sites (Webster Reservoir and Wilson Reservoir); all samples obtained during 1983.

1910) surveys included 24 species as they are currently recognized (Turgeon et al. 1998). Nineteen of these species were represented in our samples. Of the historical fauna, we suggest that 11 species have been extirpated from the study area and 13 species are extant.

Extirpated species

Of the 11 extirpated species, four might have been extirpated from our study area prior to settlement of northwestern Kansas by EuroAmericans. The spike (*Elliptio dilatata*) and round pigtoe (*Pleurobema sintoxia*) have been reported only in archeological samples, each from only one location (Wedel 1959; Robert Warren, Illinois State Museum, pers. comm.). The hickorynut (*Obovaria olivaria*) was represented by subfossil shells in our samples and in archeological samples (Kivett 1953). Hoke (1997) collected only subfossil shells of the hickorynut except for a weathered shell near the mouth of the Smoky Hill River. Hoke (1997) also collected subfossil shells of the plain pocketbook (*Lampsilis cardium*). The plain pocketbook was absent from our samples, but was reported from archeological sites (Kivett 1953, Robert Warren, Illinois State Museum, pers. comm.). We suggest that the spike, plain pocketbook, and round pigtoe likely were extirpated from northwestern Kansas prior to settlement by EuroAmericans; however, all three species are still extant in Kansas. The hickorynut might have persisted a short time in the study area near the mouth of the Smoky Hill River, but it is considered to have been extirpated from the entire state sometime after 1905 (Murray and Leonard 1962). The hickorynut characteristically inhabits large rivers and once was locally abundant in the study area. We found 153 subfossil valves of the hickorynut at one site on the Republican River. The other seven extirpated species (Table 1) were represented by weathered valves or in historical reports, which indicates that they probably were present in the study area at the time of settlement by EuroAmericans. However, two of these species, black sandshell (*Ligumia recta*) and bleufer (*Potamilus purpuratus*), as well as the spike and round pigtoe, were not present in our samples or those collected by Hoke (1997). The absence of weathered or subfossil shells of these four species suggests that they might not have been abundant within our study area.

Extant species

Of the 13 extant species, the distributions in 1983 of the wabash pigtoe (*Fusconaia flava*), pondmussel (*Ligumia subrostrata*), and creeper (*Strophitus undulatus*) apparently were limited to Lyon Creek, the lowermost major tributary of the Smoky Hill River east of Salina (Hoke 1997). The creeper was collected as recently-dead shells from Lyon Creek during 1995 to 1998, but the wabash pigtoe and pondmussel were represented only by weathered valves in our samples. A fourth species, the lilliput (*Toxolasma parvus*), was reported in low numbers by Hoke (1997) from the Saline and Solomon river basins during his 1983 survey. Only weathered valves of the lilliput were collected from the Solomon and Smoky Hill rivers during our studies. The small size of the lilliput could cause it to be overlooked. Information on

the other nine extant species collected during the 1995 to 1998 surveys is summarized in the following paragraphs.

Cylindrical Papershell (*Anodontoides ferussacianus*) – rare. Living, fresh, or recently-dead specimens of the cylindrical papershell were collected in the Smoky Hill and Saline rivers near Hays. In addition to these stream reaches, Hoke (1997) found evidence of extant populations in the Smoky Hill River southeast of Hays during his 1983 survey. He stated that the cylindrical papershell was the most common bivalve collected at several of his sites on the Smoky Hill River (Hoke 1997). Robert Warren (Illinois State Museum, pers. comm.) reported 134 valves from archeological sites in the Solomon River Basin, and Scammon (1906) reported the cylindrical papershell from the upper Republican River Basin in Kansas. We have no evidence of extant populations in the Solomon or Republican river basins within northwestern Kansas from our surveys; however, Hoke (1997) suggested that populations still occurred in the upper Republican River Basin in Nebraska. The cylindrical papershell is listed as a species in need of conservation in Kansas (Kansas Administrative Regulation 115-15-2). It is the only protected species still extant in the study area, and its range in northwestern Kansas has been reduced to segments of the Smoky Hill and Saline rivers. However, it is one of only three species of mussels reported from eastern Colorado, within the South Platte River Basin (Wu 1989).

White Heelsplitter (*Lasmigona complanata*) – rare. Our collections included only weathered shells of the white heelsplitter from the Solomon River Basin, where Hoke (1997) reported live specimens in his 1983 collections. The absence of the white heelsplitter in our extensive collections during the 1995 to 1998 surveys in the Solomon River Basin suggests that its status is uncertain in this drainage. Hoke (1997) indicated that it was not abundant at any of his collection localities. Hoke (1997) also reported live specimens from the Saline River, but we collected no white heelsplitters in this basin. Our samples included live and recently-dead specimens from the lower Republican River Basin and recently-dead specimens from the Smoky Hill River Basin (North Fork Smoky Hill River and Lyon Creek). Hoke (1997) reported the presence of live specimens in the two lowermost Smoky Hill River tributaries (Chapman Creek and Lyon Creek). Thus, the range of the white heelsplitter in northwestern Kansas seems largely to have been reduced to the lower Republican and Smoky Hill river basins.

Fragile Papershell (*Leptodea fragilis*) – common. Living, fresh, or recently-dead fragile papershells were collected at 19 sites in the Solomon and Republican river basins during the 1995 to 1998 surveys. Its absence from the Smoky Hill and Saline rivers was unexpected. Hoke (1997) collected the fragile papershell in all four major river basins, but it was limited to the lower reaches of the Smoky Hill and Saline rivers (downstream from Kanopolis and Wilson reservoirs, respectively). Based on the presence of weathered shells, this species historically occupied a larger portion of the Smoky Hill River that extended as far west as Hays. The fragile papershell is tolerant of impounded habitats and unstable substrates (Wisconsin Department of Natural

Resources 1985, Distler and Bleam 1995). We found the species to be locally abundant. Below the spillway of the small dam on the Solomon River at Minneapolis, we counted 53 broken, fresh valves.

Pink Papershell (*Potamilus ohiensis*) – common. During the 1995 to 1998 surveys, the pink papershell was the species collected most frequently. Living, fresh, or recently-dead specimens were collected at 30 sites in the Smoky Hill, Saline, Solomon, and Republican river basins. The pink papershell was the third most frequently encountered taxon in the surveys by Hoke (1997), but it was absent from the archeological record, which might be because its thin-shelled valves do not preserve well. However, similarly thin-shelled valves of cylindrical papershell and fragile papershell were present in archeological samples (Wedel 1959, Robert Warren, Illinois State Museum, pers. comm.). Thus, the absence of the pink papershell from the archeological record and its present abundance suggest that this species has extended its range in northwestern Kansas. This expansion probably is due, in part, to the fact that the pink papershell, like the fragile papershell, is tolerant of impounded habitats and unstable substrates (Wisconsin Department of Natural Resources 1985, Distler and Bleam 1995).

Giant Floater (*Pyganodon grandis*) – uncommon. The giant floater was collected throughout the study area during the 1995 to 1998 surveys, but living, fresh, or recently-dead individuals were uncommon. The giant floater prefers quiet pools with muddy bottoms (Murray and Leonard 1962). We suspect that the giant floater was poorly represented in our samples, because none of our collections were made in reservoirs or ponds. The giant floater was the most frequently encountered taxon in the collections made by Hoke (1997), who sampled several impoundments. It is one of three species of mussels reported from eastern Colorado (Wu 1989).

Pimpleback (*Quadrula pustulosa*) – uncommon. Live, fresh, or recently-dead pimplebacks were collected primarily in the Solomon River Basin during the 1995 to 1998 surveys and by Hoke (1997) during 1983. Both surveys also collected living specimens in the Smoky Hill River south of Salina. The recent distribution of the pimpleback was similar to its historical distribution in the Solomon River Basin and the lower Smoky Hill River Basin. The pimpleback was reported from an archeological site near the mouth of the Republican River (Robert Warren, Illinois State Museum, pers. comm.), but no valves have been collected from streams in the lower Republican River Basin. Possibly, the shells at the archeological site were transported from streams in adjacent basins. Although it was not widespread, the distribution of the pimpleback seemed to be stable.

Mapleleaf (*Quadrula quadrula*) – common. During the 1995 to 1998 surveys, living, fresh, or recently-dead mapleleafs were collected at 20 sites in the Smoky Hill, Saline, Solomon, and Republican river basins. It was the second most frequently encountered taxon in the surveys by Hoke (1997). The mapleleaf was most abundant in the Smoky Hill River; one site southeast of Hays included a riffle with 33 live individuals, the most collected at a single site. The density of the mapleleaf in this mussel bed was 0.75 mussels per m^2. Although the mapleleaf appears to have occupied

a wider distribution historically in the Republican and Solomon river basins, it remains one of the most widespread species in northwestern Kansas. The mapleleaf is tolerant of impounded habitats (Wisconsin Department of Natural Resources 1985).

Pondhorn (*Uniomerus tetralasmus*) – rare. The pondhorn was collected throughout the study area during the 1995 to 1998 surveys, but living, fresh, or recently-dead individuals were rare. As with the giant floater, we suspect that the pondhorn was poorly represented in our samples, because no reservoirs or ponds were sampled. Living or recently-dead pondhorns were collected in the westernmost collection localities near the Colorado border in our samples and in the survey by Hoke (1997). It is one of only three species of mussels reported from eastern Colorado (Wu 1989). The pondhorn is well-suited to the intermittent streams of the High Plains. They can aestivate for long periods when surface water is absent (Wu 1989). Fuller (1974) suggested that the pondhorn could survive more demanding environmental conditions than any other Nearctic mussel.

Paper Pondshell (*Utterbackia imbecillis*) – rare. Living, fresh, or recently-dead specimens of paper pondshells were collected only in the Smoky Hill River Basin near Hays during the 1995 to 1998 surveys and the study by Hoke (1997). Both surveys collected the paper pondshell in Big Creek near the site where Scammon (1906) reported it. We found one weathered valve in the Republican River, which is the first indication that this species occurred in this basin within Kansas. We suspect that the paper pondshell was poorly represented in our samples because no reservoirs or ponds were sampled. This species prefers stream backwaters or other pond-like habitat (Murray and Leonard 1962). However, the paper pondshell does not appear to be as abundant and widespread as other "pond species", such as the giant floater and pondhorn, which often are found in creeks (Hoke 1997).

Assessment of the mussel fauna

The study by Hoke (1997) was largely conducted during 1983 within the Smoky Hill, Solomon, and Saline river basins, which comprise the major portion of our study area. This was a period of extended drought (Hoke 1997). The FHSU and KDWP surveys were conducted after the flood year of 1993, which initiated the restoration of surface flows to many streams that became dry during the 1980's. For example, the pool elevation in Cedar Bluff Reservoir on the Smoky Hill River near the longitudinal center of our study area steadily rose a total of 13 m between 1993 and 1998, and the surface area increased from 627 ha to 2671 ha (Troy Schroeder, KDWP, pers. comm.). The results of our surveys were virtually identical to those reported by Hoke (1997), which suggests that the species richness of the mussel fauna has been relatively stable during the last two decades. However, losses and potential losses were noted.

The probable extirpation of 11 species from the mussel fauna inhabiting streams in northwestern Kansas (Table 1) represents a 46% decline in species richness. The wabash pigtoe and creeper probably are restricted to Lyon Creek in the lower Smoky Hill River Basin, and the cylindrical papershell and white heelsplitter have greatly reduced ranges. These four species represent 17% of the historical mussel fauna, and

we consider them to be the species most threatened with extirpation within the study area. Thus, we suggest that 63% of the native mussel fauna in northwestern Kansas has been extirpated or is in danger of being extirpated. These losses mirror those reported elsewhere in western Kansas (Distler and Bleam 1995).

The pondmussel, pondhorn, paper pondshell, giant floater, and lilliput were not common in our samples, but they are tolerant of ponded water and might be relatively widespread in the largely unsampled impoundments throughout northwestern Kansas. The status of these five species needs to be more thoroughly assessed. The pimpleback was uncommon in our samples, but its distribution seemed to be relatively stable. The fragile papershell was common during our surveys, but it might have been extirpated from the Smoky Hill and Saline river basins. The mapleleaf and pink papershell were the two most common species in our samples; they occurred in all four basins. The mapleleaf apparently suffered minor reductions in its range, but the pink papershell might have expanded its distribution within the study area.

Several possible reasons have been given for the decline in species richness of mussels on the Great Plains (Distler and Bleam 1995, Hoke 1997). Climate change is one factor suggested as partly responsible for unionid range regressions. In the 1850's, a period of relatively more arid conditions began in western Kansas and Nebraska (Bryson 1980). Such a change in climate could have reduced streamflows and increased the likelihood of mortality among mussels from desiccation and predation. This might have been a factor in the extirpation of the spike, plain pocketbook, hickorynut, and round pigtoe prior to settlement of the region by EuroAmericans. Climate change also might have reduced the distributions of other species of mussels, but the extirpation of seven species apparently took place after changes initiated by EuroAmericans began to impact streams in the study area.

Among these changes were the cultivation of large areas of land. Intensive cultivation caused siltation of the smaller, typically clear tributary streams (Cross and Moss 1987, Sanders et al. 1993). The increased load of suspended particles clogs the filtering and respiratory structures of the mussels and reduces their available food supply of plankton (Murray and Leonard 1962, McMahon 1991). High turbidity is especially detrimental to young mussels and has been implicated in the elimination or reduction of unionid populations (Ellis 1931, Cvancara 1983, Obermeyer et al. 1997). Agricultural development also included practices that retained runoff and contributed to a reduction in streamflows throughout northwestern Kansas (Jordon 1982). Further reductions in streamflows resulted from the use of surface and groundwater withdrawals for irrigation (Jordon 1982). Changes in mean annual precipitation were only a minor factor in the decreased runoff that occurred in northwestern Kansas from 1940 through 1990 (Ratzlaff 1997).

Another factor implicated in the decline of species richness of freshwater mussels is the construction of impoundments, which began with the first EuroAmerican settlers in northwestern Kansas. Small mill dams and other water retention structures were first built during the late 1800's. They were followed in the latter half of the 1900's by large federal reservoirs on the river main stems and some of their principal tributaries.

Dams act as barriers to the movements of fishes that serve as glochidial hosts and help to disperse mussels. Watters (1996) found that the upstream distribution of the fragile papershell and pink heelsplitter (*Potamilus alatus*) ended at small dams (heights of 1 to 17.7 m). The effectiveness of a dam as a barrier to mussel dispersal depends on the height of the dam and how frequently it is inundated. If the water in the stream is deeper than the dam, it would be possible for fish that carry glochidia to move upstream. In addition to the federal reservoirs, there are several municipal dams and irrigation diversion dams within northwestern Kansas that we suspect are rarely or infrequently inundated, thereby restricting the natural dispersal of mussels through their host fishes.

Dams also regulate streamflows and usually lower peak discharges. In addition, impoundments reduce the loads of suspended sediment, which causes the water to be more erosive immediately downstream. This erosive capability causes the channel to become narrower and more deeply incised in western Kansas rivers (Sanders et al. 1993, Distler and Bleam 1995). Tributary streams also can become more deeply incised to match the lower elevation of river main stem, and this has been cited as one possible reason for the decline in the mussel fauna in the Ninnescah River Basin in south-central Kansas (Distler and Bleam 1995). The construction of dams probably is beneficial to some species, such as the giant floater, pondhorn, and paper pondshell. Dams create large areas of impounded water, increase plankton levels, stabilize stream substrates, and facilitate the establishment of populations of sunfishes (Centrarchidae) and catfishes (Ictaluridae) (Cross and Moss 1987, Sanders et al. 1993) that commonly serve as glochidial hosts (Parmalee and Bogan 1998). However, the overall impact of dams has been detrimental to native species of both mussels and fishes (Cross and Moss 1987, Howells et al. 1996, Obermeyer et al. 1997).

Changes in the species of fishes present in northwestern Kansas also might impact the mussel fauna. Species of native fishes that serve as hosts for mussel glochidia could be extirpated, which might prevent successful recruitment of new generations of mussels. However, host species of fishes (Parmalee and Bogan 1998) for all of the extirpated and extant species of mussels reported from northwestern Kansas still occur in the study area (Cross and Collins 1995). Thus, changes in habitat apparently were the principal factors in the extirpations and range reductions noted for the study area. Possibly, the introduction of non-native species of fishes could introduce non-native species of mussels into an area. Perhaps this was the case with the pink papershell and paper pondshell, two extant species that were absent from archeological reports (Table 1).

The dramatic reduction of the species richness of mussels in northwestern Kansas is a cause of concern. Although only two species (black sandshell and hickorynut) of the 24 species reported from northwestern Kansas have been extirpated from the entire state, the potential loss of over 60% of any taxonomic group in such a large area could result in the loss of valuable genetic diversity. Efforts to learn more about the genetic make-up, life history, and distributional status of freshwater mussels in Great Plains streams are essential to their conservation.