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A SURVEY AND ANALYSIS OF THE UNIONID MOLLUSKS OF THE PLATTE RIVERS OF NEBRASKA AND THEIR MINOR TRIBUTARIES

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ABSTRACT

A survey conducted in the Platte basins in Nebraska between 1972 and 1995 documented a bivalve fauna consisting of sixteen native unionids and one introduced exotic species. Five new taxa were confirmed for the Platte basins in Nebraska, increasing the total reported for the region to eighteen unionids and one exotic taxon. The greatest species diversity was found to have existed in tributaries of the Platte rivers, while bivalves were uncommon in the main channel of the Platte River. Man-made environments provide significant habitat for some bivalves in the region.

† † †

This paper is a portion of a study initiated in 1972 to document the distributions of unionid mollusks throughout Nebraska. At that time, the sole publications on the bivalves of Nebraska were those of Aughey (1877) and Walker (1906). More recently, a number of papers have appeared on the bivalve fauna of the Platte basins (Baxa, 1981; Freeman and Perkins 1992; Lingle, 1992; Roedel, 1990). These reports are discussed in more detail in a later section of this paper.

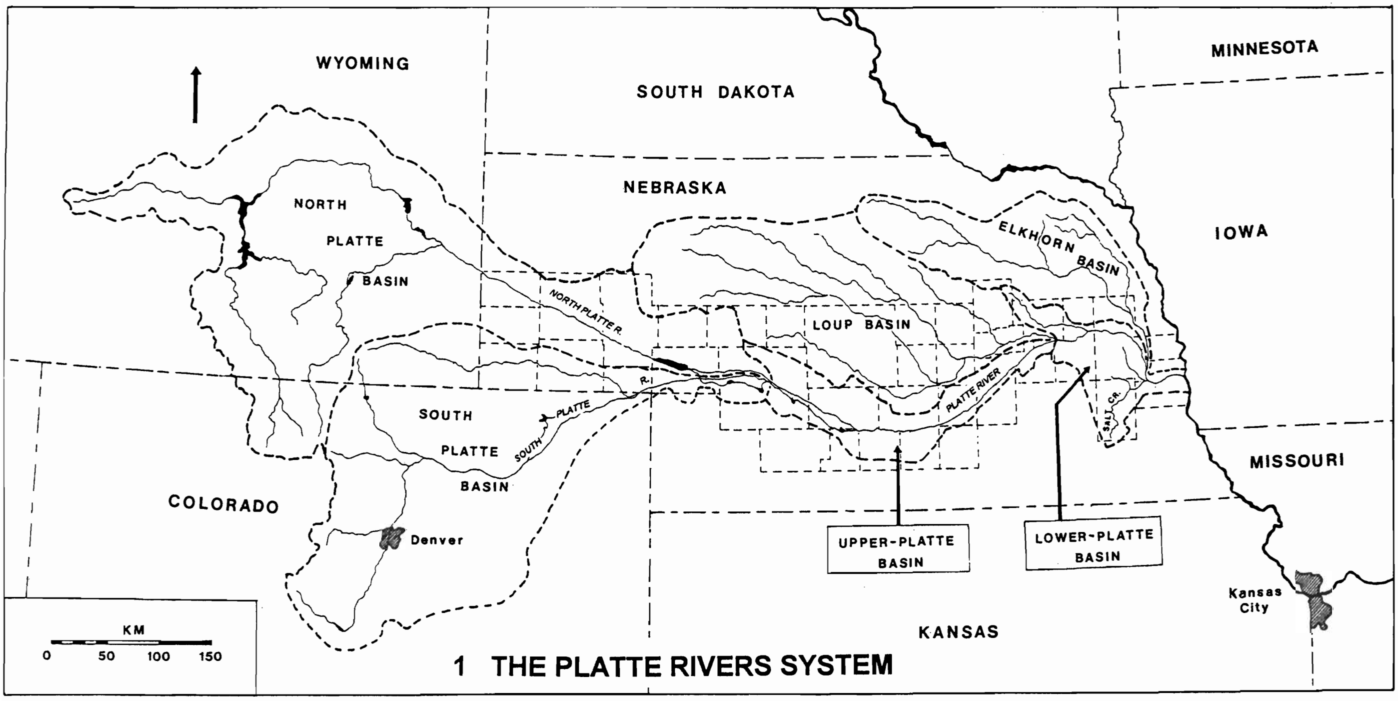
THE STUDY AREA

The Platte River system drains large portions of Colorado, Nebraska, and Wyoming (Map 1). In Nebraska, the Platte River and its major tributaries, the Loup and Elkhorn, constitute the primary drainage system, with a combined watershed of 106,110 km^2, approximately 53% of the entire state. The focus of this paper is more limited, including the Platte River proper, the North and South Platte rivers, and their minor tributaries but excluding the Loup and Elkhorn basins. The study area, hereinafter referred to as the Platte basins, encompasses a drainage basin of 48,612 km^2, about 24% of the area of Nebraska.

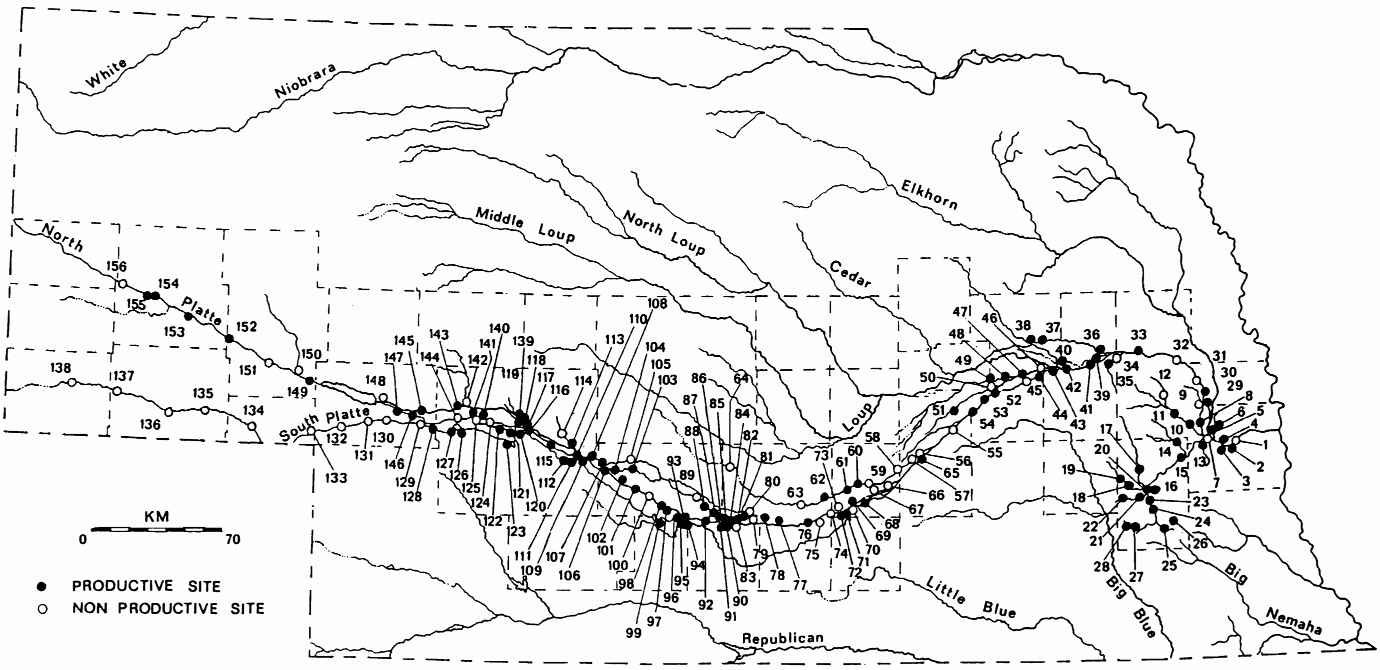
To facilitate the presentation and discussion of survey results, the study area has been broken into four basins: South Platte, North Platte, upper-Platte, and lower-Platte. The geographic description of the two former basins is self explanatory, but the two latter basins require further description. The lower-Platte is defined as encompassing the Platte River proper and its minor tributaries from its confluence with the Missouri River to the mouth of the Loup River. The upper-Platte extends upstream from the latter point to the confluence of the North and South Platte rivers.

Historically, the Platte rivers have been characterized by relatively swift current and a shifting sand substrate, a habitat known to be detrimental to unionid mollusks. The rivers were often quite wide, with several early explorers mentioning a width varying from one-half to three miles at various points in the upper-Platte basin (Williams, 1978), and they were shallow, generally not over six feet in depth, and on average much less. Mattes (1969) notes that early pioneers described the Platte as "a mile wide and an inch deep."

The North Platte, South Platte, and Platte rivers have been severely impacted by agricultural development primarily in the form of water withdrawal. Significant volumes of water are diverted from both the North and South Platte rivers before they enter Nebraska (Bentall, 1982). Additional withdrawals and diversions take place along the Platte rivers in Nebraska. A large volume of water is retained in Lake McConaughy on the North Platte River. In addition, two significant withdrawals occur in western Nebraska. The first is located below Lake McConaughy on the North Platte River, where water is diverted to the Sutherland Canal and to Sutherland and Maloney reservoirs. The second is below the confluence of the North and South Platte rivers, where water is diverted into the Tri-County Supply Canal and its three associ-



1 THE PLATTE RIVERS SYSTEM



2 COLLECTING SITES

ated reservoirs.

GOALS AND METHODS

The primary goal of this study was to document and understand the distributions of unionid mollusks in the Platte basins of Nebraska. Encompassed within this general goal was the desire to develop a model for the unionid distributions of the region which could account for current distributions as well as any changes in the fauna indicated in the survey. Ideally the model would accommodate changes in the fauna since the region was first settled.

Specific environments sampled in this study of the Platte basins included creeks, canals, ditches, sandpits, reservoirs, the Platte River main channel and side-channels (i.e. the North and South channels of the Platte River), and backwater areas of the Platte River. Collections were made near most bridges across the Platte rivers throughout the state and on many of the region's minor tributaries, usually at intervals of 8 to 16 km. Reservoirs and canals were sampled when water levels permitted. In 1976, a questionnaire was distributed to all conservation officers in the state requesting information on locations of known populations of bivalves, and all responses were investigated.

Unless otherwise noted, all collections were made by the author. Specimens were collected by hand or with a garden rake, usually under low-water conditions. Notes for each collection site were kept in field journals, recording collecting conditions and any environmental factors which appeared to impact unionid mollusks. Collection sheets were completed for each productive collection site, noting species taken and condition of specimens. Vouchers were identified by the author; identifications of all specimens collected prior to 1983 were corroborated by Dr. David H. Stansbery of the Ohio State University Museum of Biological Diversity in Columbus, Ohio.

In an effort to develop some historic depth to the study, a number of strategies were employed. Museums and universities in Nebraska were contacted in an attempt to locate unpublished records, and institutions responding affirmatively were visited. In addition, a concerted effort was made to examine and collect eroded valves encountered during the survey, with the goal of obtaining evidence of taxa no longer living in the region.

Most of the collection effort occurred in 1976, 1980, 1981, 1991, and 1994, but collections were obtained throughout the period 1972–1995. In addition, a number of collections dating to 1969 were donated to the author. Museum records provided data for two collection localities as well as confirmation of one of Aughey's (1877) records. Living specimens were generally retained as vouchers only when fresh empty shells were unavailable and thus relatively few live specimens were retained. All vouchers collected during this survey were deposited at the Ohio State University Museum of Biological Diversity. The nomenclature employed in this paper is that utilized by that institution.

RESULTS

A total of 156 sites were sampled in this survey (Map 2). Bivalves were represented by live specimens or empty shells at 108 sites, or 69 percent of all sites visited. Unionids were uncommon in the main channel of the Platte rivers, but were sometimes numerous in side-channels and backwaters of the Platte River. The most productive natural habitats encountered in this survey were the side-channels and backwaters of the Platte rivers and the small and large creek tributaries of the region. These areas produced specimens of all unionid taxa recovered in the study. Bivalves were also present in many man-made habitats including canals, ditches, sandpits, and reservoirs. Unionids were more numerous in restricted portions of some irrigation canals than in any other habitat.

Sixteen native unionids and the introduced bivalve *Corbicula fluminea* were documented for the Platte basins of Nebraska in this survey (Table 1). Five taxa were first definitively confirmed for the Platte basins. Three taxa—*Quadrula pustulosa pustulosa*, *Lampsilis teres teres*, and *L. ventricosa*—are first reported for the Platte basins in this study. In addition, *Ligumia subrostrata* and *Toxolasma parvus*, possibly collected previously in the Salt Creek basin (Walker, 1906), were collected in this survey, thus definitely confirming their presence in the region. Records for *Fusconaia flava* constitute the first report of this taxon in the study area since that of Aughey (1877). The records for *Strophitus undulatus undulatus* and *Lampsilis radiata luteola* appear to represent the first vouchered records of these taxa in the study area.

Only nine of the sixteen native taxa recovered in this survey were represented by live records. Two, *Quadrula pustulosa pustulosa* and *Toxolasma parvus,* were among the five new unionid taxa confirmed for the region in this survey. Seven taxa or 44 percent of the total were collected as empty shells. In most cases these shells were quite weathered, suggesting they are not of recent origin. Five of these taxa were restricted to the eastern portion of the study area. *Lampsilis ventricosa*, however, was also found in the central portion of the state, and *Leptodea fragilis* was collected in this survey only in the upper-Platte basin.

Table 1. Unionid mollusks collected from the Platte River basins in Nebraska by collection site. L = live; F = fresh shell; D = dry recent shell; WD = weathered dry shell; S = subfossil or chalky shell.

	LOWER-PLATTE BASIN					Salt Creek basin	
	Louisville Lakes	Fountain Creek	Gretna Hatchery	Unnamed ditch	Unnamed ditch	Clear Creek	Memphis Lake
Taxa[1] **Collection Sites:**	**2**	**3**	**4**	**5**	**6**	**8**	**10**
1. *Anodonta imbecillis* Say, 1829	WD	–	–	L	WD	–	WD
2. *Anodonta grandis grandis* Say, 1829	D	L	D	L	WD	L	WD
3. *Anodontoides ferussacianus* (Lea, 1834)	–	–	–	–	–	L	–
4. *Strophitus undulatus undulatus* (Say, 1817)	–	–	–	–	–	–	–
5. *Lasmigona complanata* (Barnes, 1823)	–	–	–	L	–	L	–
6. *Quadrula quadrula* (Rafinesque, 1820)	–	–	–	–	–	L	D
7. *Quadrula pustulosa pustulosa* (Lea,1831)	–	–	–	–	–	–	–
8. *Fusconaia flava* (Rafinesque, 1820)	–	–	–	–	–	–	–
9. *Uniomerus tetralasmus* (Say, 1830)	–	–	WD	D	–	–	D
10. *Leptodea fragilis* (Rafinesque, 1820)	–	–	–	–	–	–	–
11. *Potamilus ohiensis* (Rafinesque, 1820)	–	–	–	–	–	–	–
12. *Toxolasma parvus* (Barnes, 1823)	–	–	–	L	WD	–	WD
13. *Ligumia subrostrata* (Say, 1831)	–	–	–	–	–	–	–
14. *Lampsilis teres* f. *teres* (Rafinesque, 1820)	–	S	–	–	–	–	–
15. *Lampsilis radiata luteola* (Lamarck, 1819)	–	–	–	–	–	–	–
16. *Lampsilis ventricosa* (Barnes, 1823)	–	–	–	–	–	–	–
17. Unidentifiable unionid shell fragments	–	–	–	–	–	–	–
18. *Corbicula fluminea* (Muller, 1774)	–	–	–	–	–	–	–
Total Species Collected	2	2	2	5	3	4	5
Year(s) Collected	1975	1981	1974	1974	1981	1981	1981

[1]Arrangement of taxa follows Stansbery and Borror (1983).

Species diversity at most sites was low, averaging only 2.5 species per productive site (Table 2). Eighty percent of all productive sites contained less than four taxa, and only 4 of the 108 productive sites produced more than 5. Further, the taxa present at collection sites were quite uniform. Table 3 details species frequency documented in this survey by species occurrence. In that table, the presence of a given taxon at any given collection site constituted one occurrence. There were a total of 260 species occurrences documented at the 108 productive sites collected in this survey. Four species—*Anodonta grandis grandis*, *Anodontoides ferussacianus*, *Lasmigona complanata*, and *Quadrula quadrula*—accounted for 70% of this total.

Diversity was greatest in the eastern portion of the study area in the Salt Creek region of the lower-Platte basin, declining in the extreme western reaches of the study area to three species in the South Platte basin and six taxa in the North Platte basin. This general distributional pattern appears to reflect the natural decrease in habitat variability in the western portions of the study area and is consistent with the distributional patterns observed in the Elkhorn basin by Hoke (1994). In the South Platte basin, the natural decline in variability has been exacerbated by the elimination of bivalve habitat through unrestrained water withdrawals. In the summer of 1994, the South Platte River ceased flowing at sites 130, 131 and 132, and fish kills were observed at the two latter collection sites.

DISTRIBUTIONS

Distributions of taxa collected are discussed in detail below and have been cross-referenced to accompanying distribution maps. Circles, squares, and diamonds on these maps represent sites collected in this survey. A number of additional collection sites are shown as closed triangles and indicate sites collected by other researchers. These collection sites were included only when they materially enhanced the distributions documented in this survey.

Anodonta (Utterbackia) imbecillis (Map 3) was collected primarily from reservoirs, ponds, ditches, and sandpits in the upper- and lower-Platte basins. As such it was often associated with modified habitats; however, it was also collected in backwater ponds along the Platte rivers, and at site 102 from the upper-Platte

Table 1. Continued.

	LOWER-PLATTE BASIN, continued												
	Salt Creek basin, continued												
	Wahoo Creek	Callahan Creek	Rock Creek	Salt Creek	Holmes Lake	Oak Creek	Middle Creek		Salt Creek	Haines Branch	Conestoga Lake	Salt Creek	
Coll. site:	**11**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
1.	–	–	–	–	–	–	–	–	–	–	–	–	–
2.	–	–	S	–	–	S	L	S	–	S	–	D	L
3.	–	–	S	–	–	S	S	–	–	S	–	–	–
4.	–	–	–	–	–	S	–	S	–	–	–	–	–
5.	–	WD	D	–	–	S	D	–	–	–	–	D	–
6.	L	–	D	–	–	S	L	WD	–	–	–	L	L
7.	–	–	WD	–	–	S	WD	–	–	–	–	–	–
8.	–	–	S	–	–	S	S	S	–	–	–	–	–
9.	–	WD	D	WD	D	WD	WD	D	–	–	WD	–	D
10.	–	–	–	–	–	–	–	–	–	–	–	–	–
11.	–	–	–	–	–	–	–	–	–	–	–	D	–
12.	–	–	–	–	–	–	–	–	–	S	–	–	–
13.	–	–	–	–	–	S	S	–	–	–	–	–	–
14.	–	–	S	–	–	–	–	–	–	–	–	–	–
15.	–	–	–	–	–	–	–	–	S	–	–	–	–
16.	–	–	–	–	–	–	–	–	–	–	–	–	–
17.	–	–	–	–	–	–	–	–	–	–	–	–	–
18.	–	–	–	–	–	–	–	–	–	–	–	–	–
Tot. spp.	1	2	8	1	1	9	8	5	1	3	1	4	3
Year(s)	1981	1981	1981	1981	1977	1981	1981	1981	1981[2]	1969	1981	1982	1970[2] 1981

[2]Collected by Mr. Bob Thomas and given to the author.

River. Specimens were generally found in quiet water with little observable current and often in a soft mud or mud and sand substrate. The western distributional records for this taxon are at Lake McConaughy (Baxa, 1981; Freeman and Perkins, 1992). This bivalve has been reported for the Big Bend or west central reach of the upper-Platte River (Roedel, 1990; Lingle, 1992) and along the upper- and lower-Platte Valley (Freeman and Perkins, 1992).

Table 2. Diversity of productive collection sites.

	Productive collection sites			
Taxa per site	**Lower Platte**	**Upper Platte**	**North & South Platte**	**Total**
1	10	16	15	41
2	10	11	3	24
3	6	14	1	21
4	5	8	–	13
5	3	2	–	–
6	–	1	–	1
7	–	–	–	–
8	2	–	–	2
9	1	–	–	1
Total	37	52	19	108
Average	2.9	2.5	1.3	2.4

The bivalve most frequently encountered during the survey was *Anodonta (Pyganodon) g. grandis* (Map 4). It was one of only three unionids present in all four of the basins in the study area. Specimens were obtained at 65 collection sites or 35 percent of all sites sampled. This bivalve was the most abundant unionid in survey collections from reservoirs in the Salt Creek basin, backwaters of the Platte rivers, and in ponds and sandpits. Specimens were also present in both small and large canals, creeks and the side channels of the Platte rivers. Though occasionally found in good current, it was most frequently found in quiet water with little current, in soft mud or mud and sand substrates at depths of 0.1 to 1.0 km or more. *Anodonta g. grandis* has been reported for Lake McConaughy (Baxa, 1981), the Big Bend reach of the Platte River (Lingle, 1992; Roedel, 1990), for the Platte and North Platte rivers (Freeman and Perkins, 1992), and for the Salt Creek basin by Aughey (1877) and, possibly, Walker (1906). Its distribution in the South Platte basin extends into Colorado (Brandauer and Wu, 1978; Cockerell, 1889).

Table 1. Continued.

	LOWER-PLATTE BASIN, continued												
	– Salt Creek basin, continued												
	Unnamed creek	Wagon Train Lake	Bluestem Lake		Platte River		Backwater area	Skull Creek	Shell Creek			Lost Creek	
Coll. Site:	**25**	**26**	**27**	**28**	**29**	**30**	**33**	**35**	**36**	**37**	**38**	**39**	**40**
1.	–	F	–	–	–	–	D	–	–	–	–	–	–
2.	D	F	L	L	–	D	L	S	–	–	–	–	–
3.	–	–	–	–	–	–	–	–	–	–	–	L	–
4.	–	–	–	–	–	–	–	–	–	–	–	–	–
5.	–	–	–	–	–	–	–	S	–	WD	–	L	–
6.	–	–	–	–	–	–	–	–	L	WD	–	L	L
7.	–	–	–	–	–	–	–	–	S	WD	L	–	–
8.	–	–	–	–	–	–	–	–	–	–	–	–	–
9.	D	F	WD	L	–	–	–	–	–	–	–	–	–
10.	–	–	–	–	–	–	–	–	–	–	–	–	–
11.	–	–	–	–	WD	–	–	–	–	–	–	L	L
12.	–	–	L	–	–	–	–	–	–	–	–	–	–
13.	–	–	–	–	–	–	–	–	–	–	–	–	–
14.	–	–	–	–	–	–	–	–	–	–	–	–	–
15.	–	–	–	–	–	–	–	–	–	–	–	–	–
16.	–	–	–	–	–	–	–	–	–	S	–	–	–
17.	–	–	–	–	–	–	–	–	–	–	–	–	–
18.	–	–	D	–	–	–	–	–	–	–	–	–	–
Tot. spp.	2	3	4	2	1	1	2	2	2	4	1	4	2
Year(s)	1972	1975[3]	1981 1995	1981	1975	1972	1994	1981	1976	1981	1976	1976	1976

[3]Collected by personnel of the Nebraska State Historical Society.

Anodontoides ferussacianus (Map 5) was one of the most widely distributed bivalves, occurring in each of the four major basins in the study area and in most of the habitats sampled. The westernmost collection in Nebraska occurred in a small creek near Bridgeport at site 154 and represents a range extension of 270 km from previously published records. It was frequently present in small creeks throughout the Platte basins, where it was often the most abundant or only bivalve collected. Specimens were frequently collected from canals in central Nebraska, where it was also occasionally numerous. *Anodontoides ferussacianus* was often found in shallow water in a sand or sand and mud substrate in slow to moderate current. Parmalee (1967) reports it to be most common in clear lakes and small streams. Live specimens were infrequent in the eastern portion of the study area. The generally high turbidity of streams in the lower-Platte basin probably dictates its rarity in this portion of the study area. It has been reported in the Big Bend reach of the Platte River (Freeman and Perkins, 1992; Lingle, 1992; and Roedel, 1990), for Johnson Lake (Freeman and Perkins, 1992), and for the Salt Creek Basin (Aughey, 1877). Its distribution in the Platte basins extends beyond the western boundaries of Nebraska. Specimens were collected by the author in 1977 in Lodgepole Creek, a tributary of the South Platte River, near Hildreth, Wyoming. Beetle (1989) reports *A. ferussacianus* from the North Platte basin in Wyoming. In addition, it has been reported for the South Platte basin in Colorado (Brandauer and Wu, 1978; Cockerell, 1889; Henderson, 1920).

Strophitus u. undulatus (Map 6) was represented in this survey solely by weathered empty shells from the Salt Creek basin. It has been reported for the Big Bend reach of the upper-Platte basin by Roedel (1990), but Freeman and Perkins (1992) were unable to locate vouchers supporting this record. *Strophitus u. undulatus* was then listed for the Platte River by Freeman and Perkins (1992), based upon a tentative identification which could not be confirmed by Dr. David H. Stansbery. The specimens from this survey may thus constitute the first definitive vouchered records for this taxon in the Platte basins.

Lasmigona complanata (Map 7) was the second-most-frequently-collected bivalve in the survey. It was collected at sites throughout the upper- and lower-Platte basins as well as in the eastern sections of the

Table 1. Continued.

	LOWER-PLATTE BASIN, cont.				UPPER-PLATTE BASIN									
	Platte River		Clear Creek		Platte River	Prairie Creek		Silver Creek	Platte backwater		South Channel	Wood River		
Coll. Site:	**41**	**42**	**43**	**44**	**47**	**48**	**49**	**51**	**52**	**53**	**54**	**60**	**61**	**62**
1.	–	–	–	–	–	–	–	–	–	F	–	–	–	–
2.	L	–	–	–	–	–	–	WD	–	L	L	–	–	–
3.	D	–	L	F	F	–	L	WD	–	–	–	–	–	–
4.	–	–	–	–	–	–	–	–	–	–	–	–	–	–
5.	–	L	–	L	–	–	–	–	F	–	L	S	S	–
6.	–	–	–	L	–	L	L	–	–	–	–	–	–	S
7.	–	–	–	–	–	–	–	–	–	–	–	–	–	–
8.	–	–	–	–	–	–	–	–	–	–	–	–	–	–
9.	–	–	–	–	–	–	–	–	–	–	–	–	–	–
10.	–	–	–	–	–	–	–	–	–	–	–	–	–	–
11.	D	–	–	–	–	–	–	–	–	–	–	–	–	–
12.	–	–	–	–	–	–	–	–	–	–	–	–	–	–
13.	–	–	–	–	–	–	–	–	–	–	–	–	–	–
14.	–	–	–	–	–	–	–	–	–	–	–	–	–	–
15.	–	–	–	–	–	–	–	–	–	–	–	–	–	–
16.	–	–	–	–	–	–	–	–	–	–	–	–	–	S
17.	–	–	–	–	–	–	–	–	–	–	–	–	–	–
18.	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Tot. spp.	**3**	**1**	**1**	**3**	**1**	**1**	**2**	**2**	**1**	**2**	**2**	**1**	**1**	**2**
Year(s)	1994	1972	1976	1994	1994	1994	1976 1980	1980	1994	1994	1975	1994	1994	1994

North and South Platte basins. Though usually present only in small numbers, it was the most abundant bivalve at most collection sites in the Sutherland and Phelps County canals. It was also collected from backwaters and side channels of the Platte River, but was most abundant in habitats with good current. In quieter waters or streams with slow current, it was often found with *Anodonta g. grandis*. In backwater areas it was usually collected nearer to the current than *A. g. grandis*. Records at site 128 represent a Nebraska range extension of 110 km. It has been reported for the Big Bend reach of the Platte River (Roedel, 1990; Lingle, 1992) and for the upper- and lower-Platte basins by Freeman and Perkins (1992).

Quadrula quadrula (Map 8) was one of the most common bivalves collected in the upper- and lower-Platte basins. Though previously reported as the most abundant bivalve in the Platte River (Freeman and Perkins, 1992; Roedel, 1990), in this study it was the fourth-most-common taxon. It was especially common in the small creeks of eastern and central Nebraska, where it was often the most numerous bivalve collected or the only species encountered. It is usually found in mud, mud and sand or stable sand substrates in shallow water in slow to moderate current. It has been reported for the upper Platte (Lingle, 1992; Roedel ,1990) and for the upper- and lower-Platte (Freeman and Perkins, 1992).

Quadrula p. pustulosa (Map 9) was recovered live at a depth of one meter from one collection site on Shell Creek in the lower-Platte basin. Empty weathered shells were obtained from other collection sites on this stream as well as in the Salt Creek basin. The records from this survey represent the first reports of this taxon in the Platte basins. Hoke (1994) has noted that it appears to be declining in Nebraska, and the results from this survey support that conclusion.

Weathered specimens of *Fusconaia flava* (Map 10) were recovered at several sites in the Salt Creek basin in eastern Nebraska. The records from this survey constitute the first report of this taxon in the Platte basins since Aughey's study in 1877. The condition of the empty shells recovered is not supportive of extant populations in the basin, and the species has probably been extirpated from the study area.

Uniomerus tetralasmus (Map 11) was frequently collected in the eastern portion of the Platte basin, but it was also present in irrigation canals and in western

Table 1. Continued.

UPPER-PLATTE BASIN, continued

	Platte River	Platte backwater		South Channel		North Channel		Turkey Creek	Kearney Canal		South Channel
Coll. Site:	**65**	**68**	**69**	**71**	**72**	**76**	**77**	**78**	**81**	**82**	**90**
1.	–	D	–	–	–	D	–	–	–	–	–
2.	L	L	WD	L	L	L	D	L	D	L	L
3.	L	–	–	F	–	–	–	L	L	L	D
4.	–	–	–	–	–	–	–	–	–	–	–
5.	–	–	–	–	L	L	D	L	L	L	L
6.	–	–	–	D	–	–	D	L	D	L	–
7.	–	–	–	–	–	–	–	–	–	–	–
8.	–	–	–	–	–	–	–	–	–	–	–
9.	–	–	–	–	–	–	–	–	–	–	–
10.	–	–	–	D	–	–	–	–	–	–	–
11.	–	–	–	–	D	WD	D	–	D	L	–
12.	–	–	–	–	–	–	–	–	–	–	–
13.	–	–	–	–	–	–	–	–	–	–	–
14.	–	–	–	–	–	–	–	–	–	–	–
15.	–	–	–	–	–	–	–	–	–	–	–
16.	–	–	–	–	–	–	–	–	–	–	–
17.	–	–	–	–	–	–	–	–	–	–	–
18.	–	–	–	–	–	–	–	–	–	–	–
Tot. spp.	2	2	1	4	3	4	4	4	5	5	3
Year(s)	1994	1994	1994	1994	1994	1981	1967[4]	1981	1991	1991	1981

[4]Specimens examined from collections at Kearney State Teachers College (now the University of Nebraska at Kearney).

portion of the upper-Platte River. It was collected from small creeks, small canals and ditches with slow to moderate current as well as from quiet pools in lakes and reservoirs. The record at site 104 documents a western range extension of 110 km beyond those of earlier studies. It has been reported from the South Channel (i.e. side-channel) of the Platte River in central Nebraska (Freeman and Perkins, 1992; Lingle, 1992; Roedel, 1990) and, possibly, for the Salt Creek basin (Walker, 1906).

A single valve of *Leptodea fragilis* (Map 9) collected at site 71 in the South Channel of the Platte River in central Nebraska represents the only record of this species in the survey. It has been previously reported from the same area (Freeman and Perkins, 1992; Lingle, 1992; Roedel, 1990) and from the lower-Platte basin (Freeman and Perkins, 1992). *Leptodea fragilis* appears to be quite rare in the Platte River basin. Its apparent limited distribution in the Platte basins was unexpected in light of the fact that it is one of the most common bivalves in the Missouri River bordering Nebraska (Hoke, 1983). The earliest report in the Platte basins for this taxon was a tentative identification, as *Unio gracilis*, by Cockerell (1889).

Potamilus ohiensis (Map 12) was found throughout the upper- and lower-Platte basins. Specimens were collected from small creeks, side-channels of the Platte River, reservoirs, and large and small canals. In addition, several specimens were collected as empty shells from the main channel of the lower-Platte River. Live specimens were found in stable mud, sand, and mud and sand substrates, often in current, at depths of 0.1 to 1.0 km. *Potamilus ohiensis* has been reported for the side-channels of the upper-Platte River (Freeman and Perkins, 1992; Lingle, 1992; Roedel, 1990) and for Johnson Lake in the upper-Platte basin by Freeman and Perkins (1992).

Toxolasma parvus (Map 10) was collected from creeks, reservoirs and ditches in the eastern portion of the lower-Platte basin. *Toxolasma parvus* was probably collected previously from the Salt Creek basin (Walker, 1906); however, the collection locale cited is not specific. The records obtained in this study thus definitely confirm the presence of this taxon in the Platte basins. Specimens were collected in shallow water from substrates of mud or sand and mud in quiet water. Due to its small size, it is difficult to collect except under extreme low water conditions, and it is

Table 1. Continued.

	UPPER-PLATTE BASIN, continued															
	Buffalo Creek					Sand-pit	Sand-pit	Plum Creek	Phelps Co. Canal			S. Channel		Johnson Lake	Platte River	
Coll. Site:	**84**	**85**	**86**	**87**	**88**	**91**	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**101**	**102**
1.	–	–	–	–	–	D	D	–	–	–	–	–	–	–	–	WD
2.	D	D	D	D	L	L	–	–	F	L	–	–	D	WD	–	–
3.	WD	–	–	–	–	–	–	L	F	–	–	–	L	–	S	–
4.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
5.	–	D	D	D	L	L	–	L	F	L	L	S	D	–	–	–
6.	–	D	D	D	L	–	–	–	–	–	–	–	–	–	–	S
7.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
8.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
9.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	WD
10.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
11.	–	D	–	–	–	L	–	–	F	–	–	–	–	–	–	S
12.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
13.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
14.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
15.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
16.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
17.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
18.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Tot. spp.	2	4	3	3	3	4	1	2	4	2	1	1	3	1	1	4
Year(s)	1991	1991	1991	1991	1991	1994	1976	1980	1991	1980	1980	1994	1994	1972	1994	1981

probable that it is more widespread than is indicated in this survey.

Ligumia subrostrata (Map 13) was confirmed for the Platte basins in this survey. Weathered valves were collected at only one site in the Salt Creek basin. No evidence was found to indicate the presence of live populations at this time. A record reported by Walker (1906) which was probably collected in the Salt Creek basin, is the only other report of this taxon in the Platte basins. *Ligumia subrostrata* is extremely rare in Nebraska, and the only recent live record from the state is a single specimen reported for the Elkhorn River (Clausen and Havlik, 1994).

Lampsilis teres forma *teres* (Map 13) was collected from the Platte basins for the first time in this survey. Two weathered records were obtained from the eastern portion of the lower-Platte basin. Survey results provide no indication of extant populations in the basin at this time, however, it has recently been collected live from the tributary Elkhorn River basin (Hoke, 1994).

A single weathered valve of *Lampsilis radiata luteola* (Map 14) was collected from Salt Creek. This taxon was first reported for the Platte River basin by Aughey (1877); however, examination of surviving specimens dating from Aughey's tenure at the University of Nebraska State Museum did not reveal a voucher for this taxon from the study area. More recently, Freeman and Perkins (1992) note the collection and subsequent destruction of a valve of *L. r. luteola* from the North Platte River near Henry, Nebraska. They do not, however, include this taxon in their species list, perhaps due to the loss of the voucher record. The specimen collected in this study thus appears to be the only vouchered record of this taxon in the study area. Hoke (1994) noted the range of *L. r. luteola* in Nebraska has been much reduced in recent years, and the results of this survey are consistent with that view. Beetle (1989) has confirmed its presence in the North Platte basin in Wyoming.

Lampsilis ventricosa (Map 14) was first documented for the Platte basins in Nebraska in this survey. Subfossil valves were collected from tributaries of the Platte River in both the upper- and lower-Platte basins in east central Nebraska. *Lampsilis ventricosa* has been reported to be greatly reduced in distribution throughout Nebraska (Hoke, 1994) and the records from this survey support this conclusion. *Lampsilis ventricosa* was first reported for the Platte basins by Cockerell (1889) at Lodgepole Creek in Colorado. This record has been questioned by Brandauer and Wu (1978), and vouchers

Table 1. Continued.

	UPPER-PLATTE BASIN, continued										
	Cozad Canal		Platte River	Gothenburg Canal		Platte River	Return Canal	Jeffrey Reservoir		Pawnee Creek	Platte River
Coll. Site:	**103**	**104**	**106**	**107**	**108**	**109**	**110**	**111**	**112**	**113**	**115**
1.	–	–	–	–	–	–	–	–	–	–	–
2.	D	D	–	L	–	–	WD	L	WD	S	–
3.	–	D	–	L	L	F	–	–	–	–	WD
4.	–	–	–	–	–	–	–	–	–	–	–
5.	–	D	–	–	–	–	–	–	D	L	WD
6.	D	L	–	–	–	–	WD	–	–	L	WD
7.	–	–	–	–	–	–	–	–	–	–	–
8.	–	–	–	–	–	–	–	–	–	–	–
9.	D	D	–	–	–	–	–	–	–	–	–
10.	–	–	–	–	–	–	–	–	–	–	–
11.	–	–	–	L	–	–	WD	–	D	–	–
12.	–	–	–	–	–	–	–	–	–	–	–
13.	–	–	–	–	–	–	–	–	–	–	–
14.	–	–	–	–	–	–	–	–	–	–	–
15.	–	–	–	–	–	–	–	–	–	–	–
16.	–	–	–	–	–	–	–	–	–	–	–
17.	–	–	–	–	–	–	–	–	–	–	–
18.	–	D	D	–	–	–	–	–	–	–	–
Tot. spp.	3	6	1	3	1	1	3	1	3	3	3
Year(s)	1991	1991	1994	1991	1991	1994	1994	1991	1969[2] 1973[2]	1980	1981

[2]Collected by Mr. Bob Thomas and given to the author.

supporting the record are apparently not available. *Lampsilis ventricosa* has also been reported for the North Platte basin in Wyoming (Henderson, 1924).

Specimens of the introduced Asiatic bivalve *Corbicula fluminea* (Map 13) were obtained from four sites in the study area. Two of these records were isolated individuals from canals in the western portion of the upper-Platte basin. The record from site 147 represents a range extension of 135 km from previously published records. Two apparently reproducing populations were also located, one at Bluestem Lake in the Salt Creek basin and a second on the upper-Platte River at site 106. *Corbicula fluminea* was not collected from Bluestem Lake in 1981 when the lake was first sampled, but it was present in 1995, suggesting that the introduction of this taxon to this vicinity occurred after 1981. Freeman and Perkins (1992) have reported *C. fluminea* for the Cozad Canal and for Stagecoach and Wagontrain lakes in Lancaster County.

LITERATURE REVIEW AND COMPARISON

Most of the early records from the Platte basins in Nebraska were collected from the Salt Creek region of the lower-Platte basin. Aughey (1877) reported three unionids from tributaries of Salt Creek: *Anodonta g. grandis* as *A. decora* and *Lampsilis radiata luteola* as *Unio luteola* from Oak Creek; and *Anodontoides ferussacianus* as *Anodonta ferussaciana* from Middle Creek. In addition, Aughey listed one taxon, *Fusconaia flava* as *Unio hebetatus*, as occurring in "all Nebraska rivers." Examination of specimens at the University of Nebraska State Museum, where Aughey was Director of Cabinets in 1874, revealed a specimen of *F. flava* from Middle Creek dating from that period and confirmed its early presence in the lower-Platte basin. There is no evidence to indicate that Aughey successfully collected bivalves in the Platte basins, other than the Salt Creek basin records.

Walker (1906) reported records of four unionids from Nebraska that may have been collected in the Salt Creek basin. Unfortunately the collection locale cited, "Lincoln," is not specific. Since all of Walker's specimens were collected by Dr. R. H. Wolcott of the University of Nebraska–Lincoln, the collection locale probably refers to the city of Lincoln, which is in the Salt Creek basin. It is not possible, however, to confirm the collection locations for taxa reported by Walker. The sole

Table 1. Continued.

	UPPER-PLATTE BASIN, cont.				SOUTH PLATTE BASIN						
	Whitehorse Cr.			Platte pool blw. div. dam	N. Platte Hatchery	Fremont Slough		Lake Maloney	Sutherland Reservoir	Sutherland Canal	
Coll. Site:	**116**	**117**	**118**	**119**	**120**	**121**	**122**	**123**	**126**	**127**	**128**
1.	–	–	–	–	–	–	–	–	–	–	–
2.	–	S	L	D	WD	–	–	D	D	–	–
3.	L	L	L	–	–	L	F	–	–	L	–
4.	–	–	–	–	–	–	–	–	–	–	–
5.	L	L	L	–	–	–	–	D	–	L	L
6.	–	–	–	–	–	–	–	–	–	–	–
7.	–	–	–	–	–	–	–	–	–	–	–
8.	–	–	–	–	–	–	–	–	–	–	–
9.	–	–	–	–	–	–	–	–	–	–	–
10.	–	–	–	–	–	–	–	–	–	–	–
11.	–	–	–	–	–	–	–	–	–	–	–
12.	–	–	–	–	–	–	–	–	–	–	–
13.	–	–	–	–	–	–	–	–	–	–	–
14.	–	–	–	–	–	–	–	–	–	–	–
15.	–	–	–	–	–	–	–	–	–	–	–
16.	–	–	–	–	–	–	–	–	–	–	–
17.	–	–	–	–	–	–	–	–	–	–	–
18.	–	–	–	–	–	–	–	–	–	–	–
Tot. spp.	2	3	3	1	1	1	1	2	1	2	1
Year(s)	1981	1991	1991	1969[2]	1980	1993	1991	1973[2]	1972	1991	1991

[2]Collected by Mr. Bob Thomas and given to the author.

previous recent records from the Salt Creek basin were those of Freeman and Perkins (1992), who reported the collection of one taxon, *Corbicula fluminea*, at several lakes in this basin.

Early published references on the bivalves of the Platte basins in Nebraska other than the Salt Creek basin records are limited to a single reference by Cockerell (1889), tentatively identifying juvenile specimens of *Leptodea fragilis* as *Unio gracilis* from the Platte district in southwest Nebraska.

In the past fifteen years, a number of papers have appeared on the bivalves of the Platte basins in Nebraska. Three have focused upon relatively limited portions of these basins. Baxa (1981) collected three taxa at Lake McConaughy on the North Platte River. Roedel (1990) and Lingle (1992) reported upon bivalves recovered from several collection sites in the Big Bend reach of the upper-Platte River in central Nebraska. The most extensive previous work on the subject is that of Freeman and Perkins (1992), which reported eleven native unionids and one introduced taxon for the region based upon collections at 49 sites, 22 of them productive.

A summary of the bivalves collected or presumed collected from the Platte basins in Nebraska by all authors is presented in Table 4 and contrasted with results from this survey. As many as 15 unionids and the bivalve *Corbicula fluminea* may have been collected from the Platte basins prior to this survey. Thirteen of these unionids and *Corbicula fluminea* were collected in this study. Included in this total are records for two previously reported but apparently unvouchered taxa, *Strophitus u. undulatus* and *Lampsilis radiata luteola*. Two other taxa, *Ligumia subrostrata* and *Toxolasma parvus*, possibly reported for the region by Walker (1906), were positively confirmed for the Platte basins through the collection of specimens in this survey. In addition, a voucher supporting Aughey's (1877) report of *Fusconaia flava* in the study area was located, and additional records of this species were collected. Three taxa—*Quadrula p. pustulosa*, *Lampsilis t. f. teres*, and *Lampsilis ventricosa*—were first collected from the Platte basins of Nebraska.

The study also produced a number of new basin records. Table 5 summarizes the taxa reported by all authors for each of the four basins included in the study area. All but five of the basin records reported by other authors were confirmed in this survey and 13 new

Table 1. Continued.

	NORTH PLATTE BASIN											
	N. Platte backwater	N. Platte Canal		N. Platte River	N. Platte backwater	Sutherland Canal		N. Platte backwater	Sand-pit	Sand-pit	Unnamed creek	Sand-pit
Coll. Site:	**139**	**140**	**141**	**143**	**145**	**146**	**147**	**149**	**152**	**153**	**154**	**155**
1.	–	–	–	–	–	–	–	–	–	–	–	–
2.	L	–	–	–	–	L	L	L	L	–	–	L
3.	–	–	L	L	L	–	D	–	–	WD	L	–
4.	–	–	–	–	–	–	–	–	–	–	–	–
5.	L	–	–	–	–	–	–	–	–	–	–	–
6.	–	–	–	–	–	–	–	–	–	–	–	–
7.	–	–	–	–	–	–	–	–	–	–	–	–
8.	–	–	–	–	–	–	–	–	–	–	–	–
9.	–	–	–	–	–	–	–	–	–	–	–	–
10.	–	–	–	–	–	–	–	–	–	–	–	–
11.	–	–	–	–	–	–	–	–	–	–	–	–
12.	–	–	–	–	–	–	–	–	–	–	–	–
13.	–	–	–	–	–	–	–	–	–	–	–	–
14.	–	–	–	–	–	–	–	–	–	–	–	–
15.	–	–	–	–	–	–	–	–	–	–	–	–
16.	–	–	–	–	–	–	–	–	–	–	–	–
17.	–	S	–	–	–	–	–	–	–	–	–	–
18.	–	–	–	–	–	–	D	–	–	–	–	–
Tot. spp.	2	1	1	1	1	1	3	1	1	1	1	1
Year(s)	1993	1991	1991	1981	1994	1991	1991	1981	1981	1981	1980	1981[5]

[5]Collected by Mr. Joe Ulrich and given to the author.

basin records were documented. Four of these relate to taxa first recovered in this study while the remaining nine document expanded distributional ranges for taxa previously reported for the region. *Anodonta imbecillis*, *Stophitus u. undulatus*, *Quadrula p. pustulosa*, *Potamilus ohiensis*, *Lampsilis t.* f. *teres*, and *Lampsilis ventricosa* are first reported from the lower-Platte basin in this study. The latter is also here first reported for the upper-Platte basin. In addition, westernmost distributional records for *Quadrula quadrula*, *Uniomerus tetralasmus*, and *Potamilus ohiensis* were collected in this basin. The bivalve taxa reported from the North Platte basin in Nebraska doubled with the collection of *Anodontoides ferussacianus*, *Lasmigona complanata*, and *Corbicula fluminea*, which are first documented in this study. Finally, the three unionids reported for the Nebraska portion of the South Platte basin,—*Anodonta g. grandis*, *Anodontoides ferussacianus*, and *Lasmigona complanata*—represent the only bivalves ever reported for that region.

Only two previously-reported taxa were not collected in this study. *Anodonta grandis dakota* Frierson 1910 (Map 4) has been collected to date only from Lake McConaughy (Baxa, 1981). This area was not collected due to the high-water conditions existing when this reservoir was visited and the difficulty of collecting under these conditions without scuba equipment. *Potamilus alatus* (Say, 1817) was collected by Freeman and Perkins (1992) solely from the artificial habitat of the Schramm Aquarium ponds (Map 12), which were not sampled in this study. Four of the five basin records not confirmed in this survey were reported from the two aforementioned collection areas.

The increase in taxa recovered in this survey over other recent surveys is attributable to a research design which emphasized the collection of all habitats in the study area. Table 6 illustrates for all recent authors the taxa recovered from the Platte basins by habitat. Tributaries in the Platte basins were determined in this study to have been the most biologically diverse in the region. All the new taxa recovered in the survey were collected from tributaries of the Platte rivers as were records supporting taxa first reported for the region by Aughey (1877) and Walker (1906). As is evident from the table, these habitats were rarely sampled in other recent studies.

The Salt Creek basin contained more species of unionids than any other area in the Platte basins. Table 7 summarizes all the records published to date from the Salt Creek basin and contrasts them with the results of this survey. All the taxa reported in prior studies for this basin were collected in this survey, including the four reported by Walker (1906), which were probably collected in this basin. Seven additional taxa were first documented for the area in this survey. This region also appears to have experienced the greatest decline in diversity in the study area. Five taxa were represented solely by subfossil empty shells, and a sixth by weathered empty shells only.

ANALYSIS OF BIVALVE DISTRIBUTIONS

An understanding of current distributions is predicated upon a knowledge of current habitat and the relevant environmental parameters, both natural and man-made, impacting unionids in the region. Unionid mollusks were collected in six primary habitats in this study: tributary creeks, backwaters of the Platte, irrigation canals and ditches, reservoirs and sandpits, the main channel of the Platte, and the side-channels of the Platte rivers. For purposes of the discussion which follows, these habitats have been categorized by the manner and extent to which they appear to have been influenced by agricultural development into one of three groups: natural or largely unmodified habitat, modified habitat, and man-made habitat.

Natural habitats are so classified in that they exist independent of and usually despite the agricultural development of the Platte basins. The tributary creeks and the backwater areas of the Platte River fit this description. These are environments which have been negatively impacted by the agricultural development of the region, and they are environments which can either be assumed or proved to have existed as viable bivalve habitat in the region prior to the settlement of the area. The few early studies of bivalves in the Platte River system reported on records obtained from tributaries (Aughey, 1877; Cockerell, 1889).

The main and side-channels of the Platte rivers are classified as modified, based primarily upon the impacts upon these habitats brought about by the development of the Platte basins. It is possible that these habitats are formerly non-viable shifting-sand habitats which have become viable for bivalves as a result of the decline in flows and sandy sediment that has resulted from the creation of upstream reservoirs and water withdrawals. Irrigation canals, ditches, reservoirs and sandpits are denoted as man-made habitats.

Natural factors impacting unionids

The most significant natural factor affecting unionids in the Platte basins is the presence of shifting sand substrates. Bivalves were always either rare or totally absent in habitats where substrates consisted of shifting sand. This substrate is a primary characteristic of the main channels of the Platte rivers.

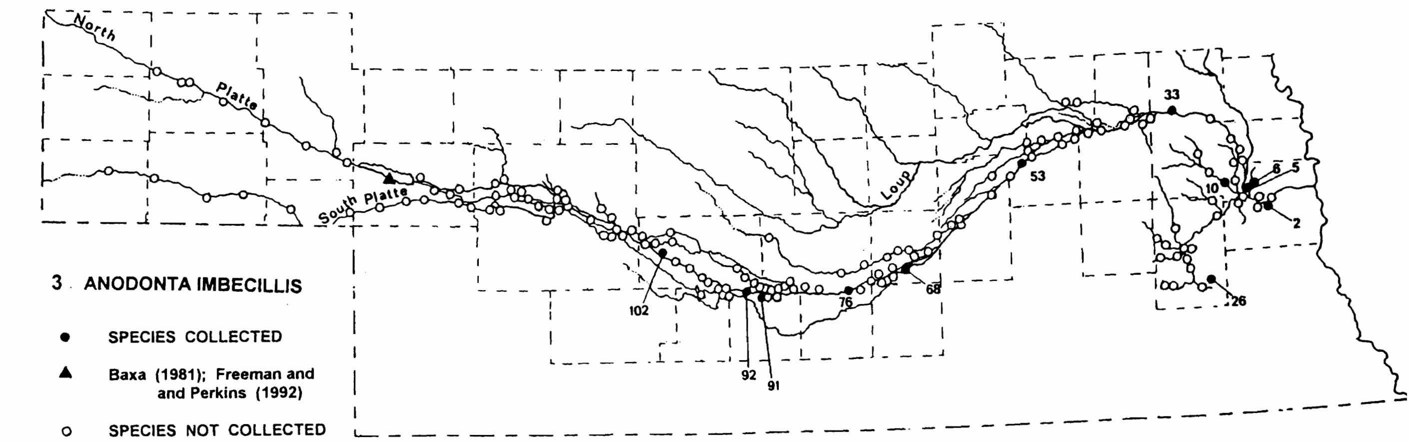
Table 3. Frequency of species occurrences.

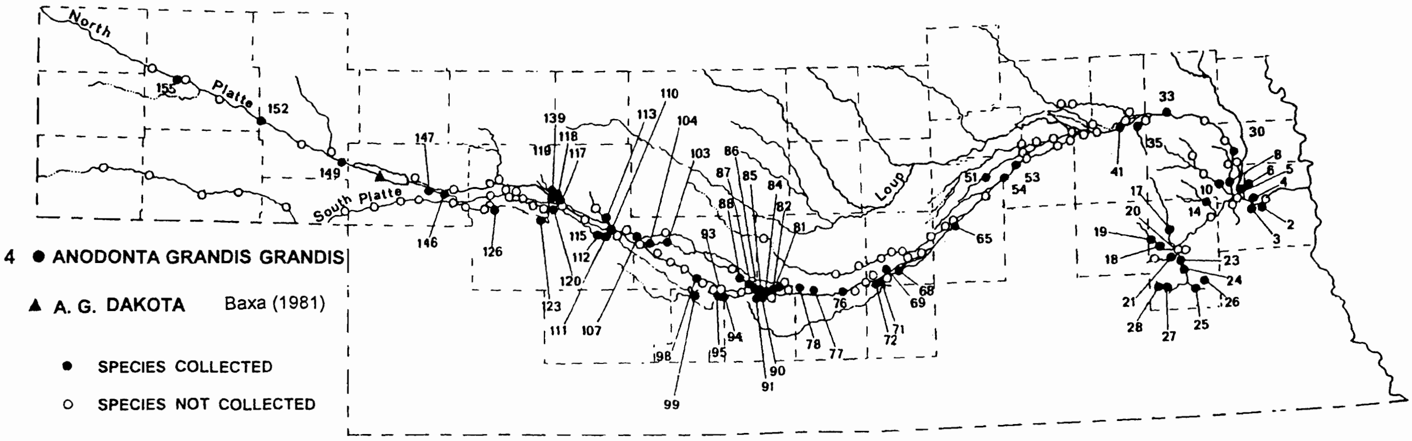
Taxa[1]	Species occurrences (Hoke, 1995)	Species frequency as % of total occurrences
Anodonta imbecillis	12	4.62
Anodonta g. grandis	65	25.00
Anodontoides ferussacianus	40	15.38
Strophitus u. undulatus	2	0.77
Lasmigona complanata	45	17.31
Quadrula quadrula	32	12.31
Quadrula p. pustulosa	6	2.31
Fusconaia flava	4	1.54
Uniomerus tetralasmus	19	7.31
Leptodea fragilis	1	0.38
Potamilus ohiensis	17	6.54
Toxolasma parvus	5	1.92
Ligumia subrostrata	2	0.77
Lampsilis teres f. *teres*	2	0.77
Lampsilis radiata luteola	1	0.38
Lampsilis ventricosa	2	0.77
Unidentifiable unionid shell fragments	1	0.38
Corbicula fluminea	4	1.54
Total	260	100.00

[1]Order of taxa follows Stansbery and Borror (1983).

Productive bivalve habitats were characterized by the absence of shifting sand substrates. Natural and modified habitats containing living bivalves or numerous empty shells were either small stream or backwater habitats. The small stream habitats include tributary creeks, the main channel of the Platte River immediately below the Tri-County diversion, and the North and South channels or side-channels of the Platte rivers. All these environments are characterized by slower currents than those of the Platte River main channels, and by resultant relatively stable substrates which are often free from shifting sand. Small-stream habitats are also generally distinguished by their meandering nature with many bends and occasional relatively deep pools. In addition, they are frequently shaded and thus cooler than the broad shallow expanses of the Platte River main channels.

Bivalve diversity in the Platte basins largely parallels the diversity of small-stream habitats. In the more western portions of the region, where unionid diversity


North Platte
South Platte
Loup
3 ANODONTA IMBECILLIS
● SPECIES COLLECTED
▲ Baxa (1981); Freeman and and Perkins (1992)
○ SPECIES NOT COLLECTED


North Platte
South Platte
Loup
4 ● ANODONTA GRANDIS GRANDIS
▲ A. G. DAKOTA Baxa (1981)
● SPECIES COLLECTED
○ SPECIES NOT COLLECTED

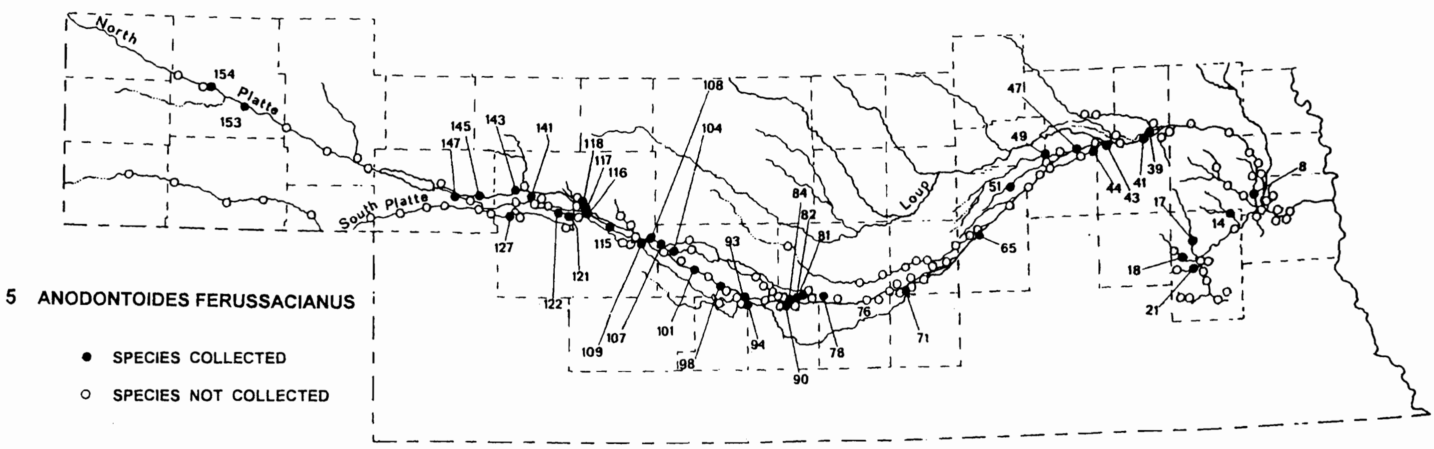

North Platte
South Platte
Loup
5 ANODONTOIDES FERUSSACIANUS
● SPECIES COLLECTED
○ SPECIES NOT COLLECTED

Table 4. Taxa reported for the Platte River basins of Nebraska. L = live; F = fresh shell; D = dry recent shell; WD = weathered dry shell; S = subfossil or chalky shell; X = condition not reported.

Taxa[1]	Hoke (1995)	Freeman & Perkins (1992)	Lingle (1992)	Roedel (1990)	Baxa (1981)	Walker[2] (1906)	Cockerell (1889)	Aughey (1877)
Anodonta imbecillis	L	X	D	L	L	–	–	–
Anodonta g. grandis	L	X	L	L	L	?	–	X
Anodonta grandis dakota	–	–	–	–	L	–	–	–
Anodontoides ferussacianus	L	X	L	X	–	–	–	X
Strophitus u. undulatus	S	X?	–	L?	–	–	–	–
Lasmigona complanata	L	X	L	L	–	–	–	–
Quadrula quadrula	L	X	L	L	–	–	–	–
Quadrula p. pustulosa	L	–	–	–	–	–	–	–
Fusconaia flava	S	–	–	–	–	–	–	X
Uniomerus tetralasmus	L	X	L	–	–	?	–	–
Leptodea fragilis	D	X	D	X	–	–	X?	–
Potamilus alatus	–	X	–	–	–	–	–	–
Potamilus ohiensis	L	X	L	L	–	–	–	–
Toxolasma parvus	L	–	–	–	–	?	–	–
Ligumia subrostrata	S	–	–	–	–	?	–	–
Lampsilis teres f. *teres*	S	–	–	–	–	–	–	–
Lampsilis radiata luteola	S	–	–	–	–	–	–	X
Lampsilis ventricosa	S	–	–	–	–	–	–	–
Corbicula fluminea	D	X	–	–	–	–	–	–
Total confirmed species	17	11	8	8	3	4	1	4

[1]Order of taxa follows Stansbery and Borror (1983).
[2]Collection locales indeterminate though probably from the Salt Creek basin.

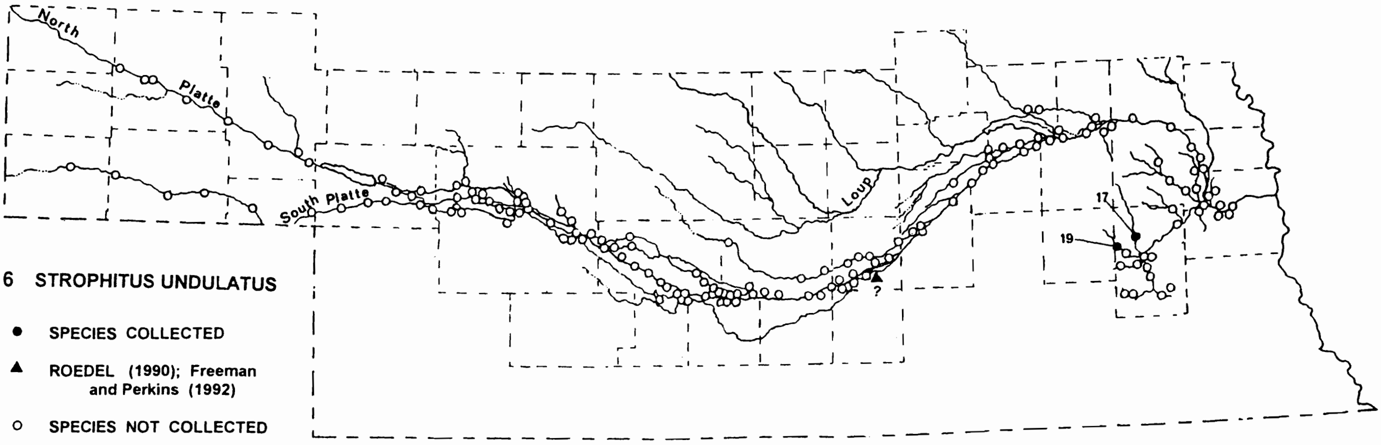
is low, this habitat is characterized by substrates consisting primarily of sand and by extremely shallow water. Deeper pools in some creeks in the western sections of the study area are often less than 0.4 meter in depth in the summer. The greatest unionid diversity in the study area was found in the tributaries of the lower-Platte basin. Small-stream habitat in this region provides much greater variety including diverse substrates such as mud, mud and sand, and even occasional rock-riffle areas as well as greater depths. The deeper pools support a greater variety of host fish upon which unionids are ultimately dependent for propagation, and in conjunction with the wider diversity of substrate habitat these tributaries provided unionid mollusks with environmental niches unavailable farther west.

Man-made factors impacting unionids

Overlaying the constraints imposed upon unionids by natural environmental parameters are the impacts of the development of the Platte basins. Development has produced both negative and positive consequences for bivalve mollusk habitat. Adverse affects have resulted in the degradation of naturally viable bivalve tributary and backwater habitat. Favorable impacts include the possible modification of previously non-viable habitat and the creation of new bivalve habitat.

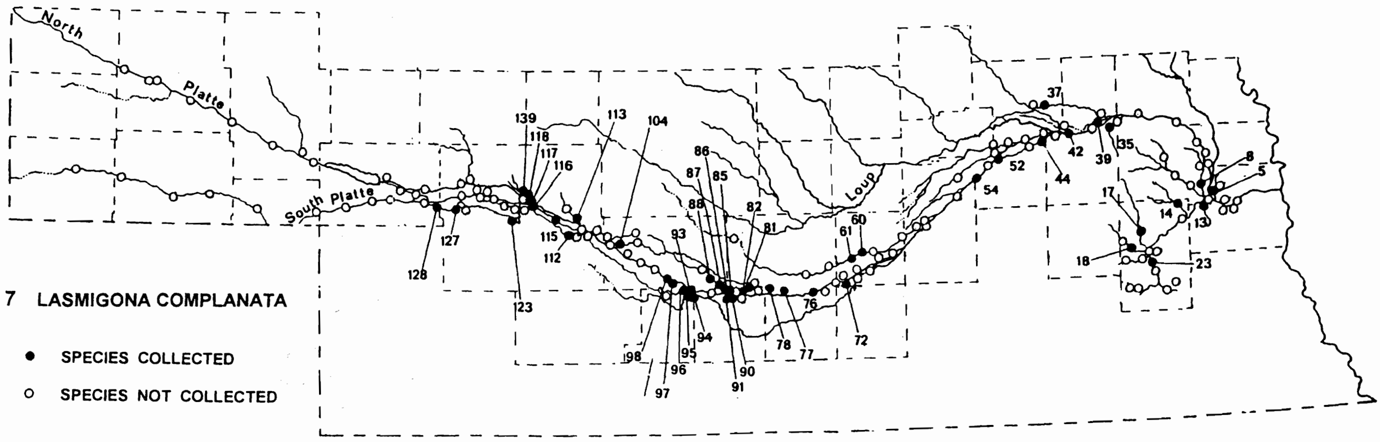
Specific factors adversely affecting unionids include dewatering due to irrigation withdrawals, channelization, pollution, turbidity, and grazing. Bliss and Schainost (1973a,b,c,d) documented the impact of the four former factors in the Platte basins. They indicate the relative importance of most of these factors varies, from east to west in the study area. Dewatering impacts an increasing percentage of stream-kilometers from east to west in the basins and correlates with the use of surface water for irrigation. Turbidity is highest in the eastern sectors, reflecting the erodible nature of the soils in both the upper- and lower-Platte basins (Bliss and Schainost, 1973a,b). Channelization and pollution are greater problems in the eastern portion of the study area where populations are greatest. Grazing along streams is a factor throughout the region.

Natural unionid habitats have been drastically impacted by the agricultural development of the region, and dewatering is one of the greatest agents of habitat destruction. The demise of tributaries in the Platte system was first noted by Henderson (1920) who reported upon the decline in flows and subsequent destruction of unionids on Lodgepole Creek in the Colo-



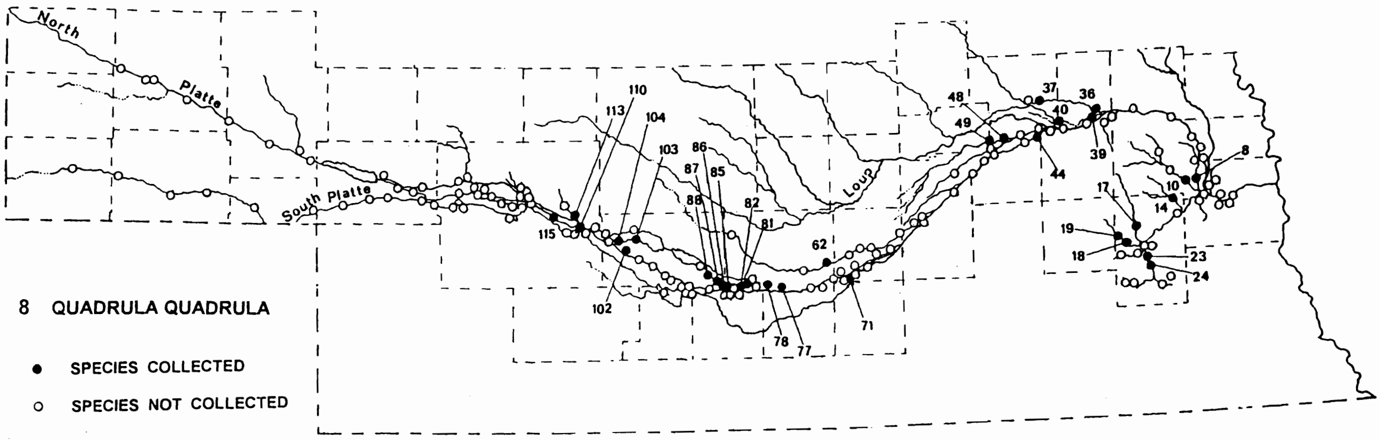
6 STROPHITUS UNDULATUS

- ● SPECIES COLLECTED
- ▲ ROEDEL (1990); Freeman and Perkins (1992)
- ○ SPECIES NOT COLLECTED



7 LASMIGONA COMPLANATA

- ● SPECIES COLLECTED
- ○ SPECIES NOT COLLECTED



8 QUADRULA QUADRULA

- ● SPECIES COLLECTED
- ○ SPECIES NOT COLLECTED

Table 5. Taxa reported for the study area by basin. L = live; F = fresh shell; D = dry recent shell; WD = weathered dry shell; S = subfossil or chalky shell; X = condition not reported; a = Hoke, 1995; b = Freeman and Perkins, 1992; c = Lingle, 1992; d = Roedel, 1990; e = Baxa, 1981; f? = Walker, 1906; g = Aughey, 1877.

	Basin							
	Lower Platte		**Upper Platte**		**South Platte**		**NorthPlatte**	
Taxa[1]	Condition[3]	Study[4]	Condition[3]	Study[4]	Condition[3]	Study[4]	Condition[3]	Study[4]
Anodonta imbecillis	L	a	F	a,b,c,d	–		L(e)	b,e
Anodonta grandis grandis	L	a,b,f?,g	L	a,b,c,d	D	a	L	a,b,e
Anodonta grandis dakota	–		–		–		L(e)	e
Anodontoides ferussacianus	L	a,g	L	a,b,c,d	L	a	L	a
Strophitus u. undulatus	S[2]	a	X?	b,d	–		–	
Lasmigona complanata	L	a,b	L	a,b,c,d	L	a	L	a
Quadrula quadrula	L	a,b	L	a,b,c,d	–		–	
Quadrula p. pustulosa	L	a	–		–		–	
Fusconaia flava	S[2]	a,g	–		–		–	
Uniomerus tetralasmus	L	a,b,f?	L(c)	a,b,c	–		–	
Leptodea fragilis	X	b	L(c,d)	a,b,c,d	–		–	
Potamilus alatus	X	b	–		–		–	
Potamilus ohiensis	L	a	L	a,b,c,d	–		–	
Toxolasma parvus	L	a,f?	–		–		–	
Ligumia subrostrata	S[2]	a,f?	–		–		–	
Lampsilis teres f. *teres*	S	a	–		–		–	
Lampsilis radiata luteola	S[2]	a,g	–		–		–	
Lampsilis ventricosa	S	a	S	a	–		–	
Corbicula fluminea	D	a,b	D	a,b	–		D	a
Total confirmed species	18		11?		3		6	

[1]Order of taxa follows Stansbery and Borror (1983).
[2]Taxa collected solely in the Salt Creek basin.
[3]The best specimen condition recovered in this study unless otherwise referenced.
[4]Lists all studies in which taxon was reported or believed reported (?) for a given basin.

rado portion of the South Platte basin. This pattern has continued. Bliss and Schainost (1973a,b) note that water rights for withdrawal of surface water in many tributaries in the upper- and lower-Platte basins exceed total flow during normal or low flow years. In addition, it can be assumed that much of the original backwater habitat along the North Platte and upper-Platte rivers has been destroyed due to dewatering. Williams (1978) noted that current channels of the North Platte and western portions of the upper-Platte rivers were only 10–20% of their 1865 width, and the channel of the central portion of the upper-Platte was only 60–70% as wide as in 1865. Channel shrinkage has no doubt resulted in significant loss of backwater areas.

Large volumes of water are retained in all of the Platte reservoirs in Nebraska, Colorado, and Wyoming, and additional withdrawals take place throughout the region. Bliss and Schainost (1973b,c) classified the South Platte and upper-Platte rivers as environmentally degraded throughout their length due to water diversion. In 1994, the South Platte River was not flowing at three collection sites in the study area. A portion of the upper-Platte is largely dewatered due to diversion of flow into the Tri-County Canal. Bentall (1982) reports the annual average amount of flow diverted at this point in the period from 1945 through 1980 to be 82.0% of total flow, with a range from 44.7% to 97.7%. Sections of the North Platte River have also been classified as environmentally degraded due to dewatering (Bliss and Schainost, 1973d).

The reservoirs have another less obvious impact upon the Platte rivers in the form of sediment retention. They block the natural flow of sandy sediment from upstream locations. Though no historic measurements are available, there is little doubt that the retention of sediment in upstream reservoirs coupled with the decrease in flows through much of the upper-Platte basin has resulted in more stable river substrates in some sections of the study area.

The impact of the dewatering of the main channels of the Platte rivers, while environmentally catastrophic, has probably produced some positive consequences for

Table 6. Taxa collected recently (1981–1995) in the Platte River basins of Nebraska by habitat. L = live; F = fresh shell; D = dry recent shell; WD = weathered dry shell; S = subfossil or chalky shell; X = condition not reported; a = Hoke, 1995; b = Freeman and Perkins, 1992; c = Lingle, 1992; d = Roedel, 1990; e = Baxa, 1981; f = Aughey, 1877.

	Platte River basin habitats					
	Tributary streams		Platte River backwaters		Platte River side-channels	
Taxa[1]	**Condition**[2]	**Study**[3]	**Condition**[2]	**Study**[3]	**Condition**[2]	**Study**[3]
1. *Anodonta imbecillis*	–		F	a	D	a,b,c,d
2. *Anodonta g. grandis*	L	a,b,f	L	a,b	L	a,b,c,d
3. *Anodonta grandis dakota*	–		–		–	
4. *Anodontoides ferussacianus*	L	a,b,f	L	a	L	a,b,c
5. *Strophitus u. undulatus*	S	a	–		X?	b?,d?
6. *Lasmigona complanata*	L	a,b	L	a,b	L	a,b,c,d
7. *Quadrula quadrula*	L	a	–		D	a,b,c,d
8. *Quadrula p. pustulosa*	L	a	–		–	
9. *Fusconaia flava*	S	a,f	–		–	
10. *Uniomerus tetralasmus*	D	a	–		L(c)	b,c
11. *Leptodea fragilis*	–		–		D	a,b,c
12. *Potamilus alatus*	–		–		–	
13. *Potamilus ohiensis*	L	a	–		D	a,b,c,d
14. *Toxolasma parvus*	S	a	–		–	
15. *Ligumia subrostrata*	S	a	–		–	
16. *Lampsilis teres* f. *teres*	S	a	–		–	
17. *Lampsilis radiata luteola*	S	a,f	–		–	
18. *Lampsilis ventricosa*	S	a	–		–	
19. *Corbicula fluminea*	–		–		–	
Total taxa	14		4		9?	

[1]Order of taxa follows Stansbery and Borror (1983).
[2]The best specimen condition recovered in this survey (unless otherwise noted) for this habitat
[3]Lists all studies (for which taxa and habitats may be associated) in which taxon was confirmed for a given habitat.

bivalves. These effects are primarily in the form of localized stabilization of the shifting sand substrates in the Platte River main channels. The natural state of these channels is characterized by shifting sand and, prior to development of the region, was almost certainly not viable habitat for unionids. Mattes (1969) quotes McBride (1850) on the pre-developed Platte River: "the bed of the stream is a mass of rolling quicksand." Presently, however, the sector immediately downstream from the Tri-County Canal diversion now supports some unionid populations. In this region, the natural flow of water and sandy sediment has been so reduced due to diversion of water that sand substrates are occasionally stable. The main channel of the river in this area more closely resembles a small creek than it does the North Platte River a few miles upstream. In 1994, the upper-Platte River at site 108 was only four meters in width.

It is probable that flow decreases are responsible for the apparent deterioration of the North and South channels of the Platte River in the eastern portion of the upper-Platte basin. It is equally possible that decreases in both flow and sediment may have converted formerly inhospitable shifting sand environments into viable unionid habitat in the side channels of the central or Big Bend reach of the upper-Platte River. One of the key characteristics of the side-channels at the present time is that they contain significant habitat that is, in part, free from shifting sand. They are less similar to the main channel of the Platte River than they are to tributary creeks. Whether such viable habitat could exist in this area without both the decrease in flows and sediment due to upstream agricultural development is questionable.

Stream channelization, while present throughout the Platte basins, appears to be most destructive to unionid habitat in the eastern portion of the upper-Platte basin and in the lower-Platte basin. Portions of Salt Creek and many other tributaries in the lower-Platte basin have been channelized. This process is continuing. Channelization of a number of sections of tributary creeks in the lower-Platte basin was observed during the course of this study. The loss of stream miles in the Salt Creek basin is especially unfortunate in that this area once contained the greatest bivalve diversity in the Platte basins.

Table 6. Continued.

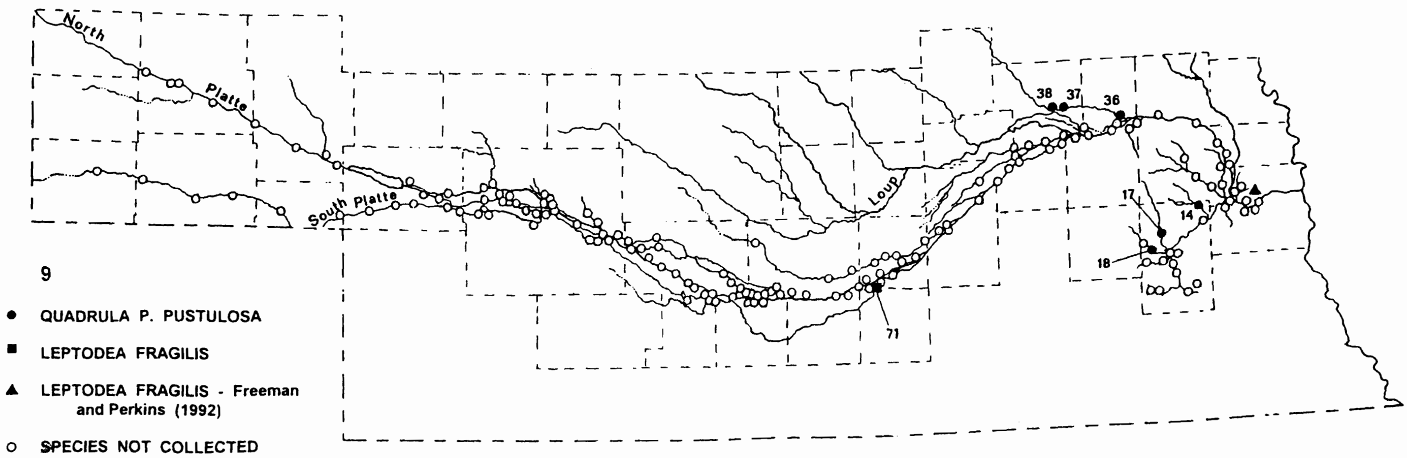
	Platte River basin habitats					
	Platte River main channel		Canals and ditches		Reservoirs, lakes, and sandpits	
Taxa[1]	**Condition[2]**	**Study[3]**	**Condition[2]**	**Study[3]**	**Condition[2]**	**Study[3]**
1.	X	b	L	a,b	L(e)	a,b,e
2.	L	a,b	L	a,b	L	a,b,e
3.	–		–		L(e)	e
4.	L	a,b,d	L	a,b	WD	a,b
5.	–		–		–	
6.	L	a	L	a,b	L	a
7.	D	a,b	L	a,b	D	a
8.	–		–		–	
9.	–		–		–	
10.	WD	a	D	a	L	a
11.	X	d	–		X	b
12.	–		–		X	b
13.	WD	a	L	a,b	D	a,b
14.	–		L	a	L	a
15.	–		–		–	
16.	–		–		–	
17.	–		–		–	
18.	–		–		–	
19.	D	a	D	a,b	D	a,b
Total taxa	9		9		12	

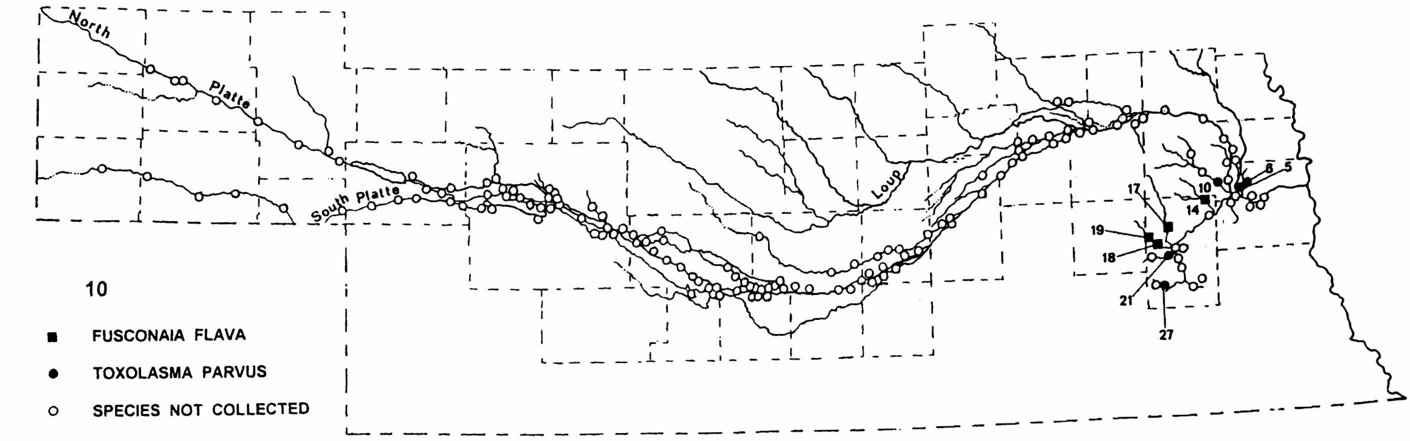
Pollution is also an important problem in the lower-Platte basin. A mussel kill was recorded at site 25 in 1972, apparently resulting from an algal bloom, and site 24 was probably the location of another mussel kill sometime prior to 1981. Bliss and Schainost (1973a) listed portions of several tributaries in the lower-Platte basin, including Salt Creek, as environmentally degraded due to pollution.

Creeks are exposed to grazing cattle throughout the region, and this practice destroys unionid habitat as well as bivalve populations. The impacts of grazing upon stream substrates varies depending upon the type of substrate. Sand substrates may become less stable and mud substrates become compacted by grazing cattle. Collections made at site 39 on Lost Creek before and after the introduction of cattle to the area revealed changes in both habitat and species abundance. After the introduction of cattle, the stream bottom was more level and the mud substrate was greatly compacted, and living bivalves were rare. Live unionids were usually absent in collections from portions of tributaries long exposed to grazing, but they were often present and occasionally abundant in ungrazed sections of the same streams. Hoke (1994) has noted a similar pattern in the Elkhorn basin of northeastern Nebraska.

Dewatering of natural habitat has been accompanied by the creation of new habitat in the form of ditches, irrigation canals, sandpits and reservoirs. Portions of canals in the upper-Platte River basin provide significant habitat for a number of bivalves, and partially offset the loss of natural habitat in the region. Large sections of many of these canals, however, are dewatered annually so the critical bivalve canal habitat is limited to relatively small canal sectors which contain water throughout the year.

The impact of canal habitat upon unionid mollusk distributions may have resulted in minor range extensions for three native species, *Lasmigona complanata*, *Uniomerus tetralasmus*, and *Potamilus ohiensis*. The most western record for each of these taxa was located in an irrigation canal. In addition, the most western record for *Corbicula fluminea*, an introduced taxon, was collected in canal habitat. The canals were also found in this study to provide habitat for at least three additional species within their natural ranges, *Anodonta g. grandis*, *Anodontoides ferussacianus*, and *Quadrula quadrula*. There was no evidence in this study to indicate that canals provide habitat for taxa not present in local natural habitats, however, these habitats do provide deeper water than is available in natural


North Platte
South Platte
Loup
38
37
36
17
14
18
71
9
QUADRULA P. PUSTULOSA
LEPTODEA FRAGILIS
LEPTODEA FRAGILIS - Freeman and Perkins (1992)
SPECIES NOT COLLECTED


North Platte
South Platte
Loup
17
19
18
21
27
10
14
8
5
10
FUSCONAIA FLAVA
TOXOLASMA PARVUS
SPECIES NOT COLLECTED

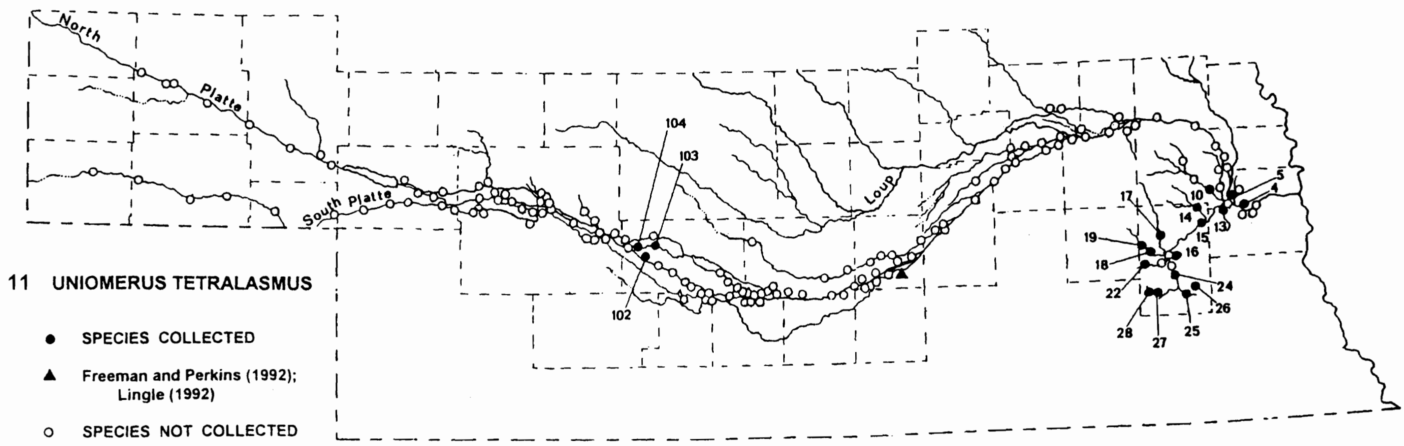

North Platte
South Platte
Loup
104
103
102
17
19
18
22
28
27
25
26
24
16
15
14
13
10
5
4
11 UNIOMERUS TETRALASMUS
SPECIES COLLECTED
Freeman and Perkins (1992); Lingle (1992)
SPECIES NOT COLLECTED

Table 7. Taxa reported for the Salt Creek basin. L = live; F = fresh shell; D = dry recent shell; WD = weathered dry shell; S = subfossil or chalky shell; X = condition not reported.

Taxa[1]	**Hoke (1995)**	**Freeman & Perkins (1992)**	**Walker**[2] **(1906)**	**Aughey (1877)**
Anodonta imbecillis	F	–	–	–
Anodonta g. grandis	L	–	?	X
Anodontoides ferussacianus	L	–	–	X
Strophitus u. undulatus	S	–	–	–
Lasmigona complanata	L	–	–	–
Quadrula quadrula	L	–	–	–
Quadrula p. pustulosa	WD	–	–	–
Fusconaia flava	S	–	–	X
Uniomerus tetralasmus	L	–	?	–
Leptodea fragilis	–	–	–	–
Potamilus ohiensis	F	–	–	–
Toxolasma parvus	L	–	?	–
Ligumia subrostrata	S	–	?	–
Lampsilis teres f. *teres*	S	–	–	–
Lampsilis radiata luteola	S	–	–	X
Lampsilis ventricosa	–	–	–	–
Corbicula fluminea	D	X	–	–
Total confirmed species	15	1	4	4

[1]Order of taxa follows Stansbery and Borror (1983).
[2]Collection locales indeterminate, though possibly from Salt Creek basin.

streams in the upper-Platte basin, and might be expected to contain as yet unlocated taxa.

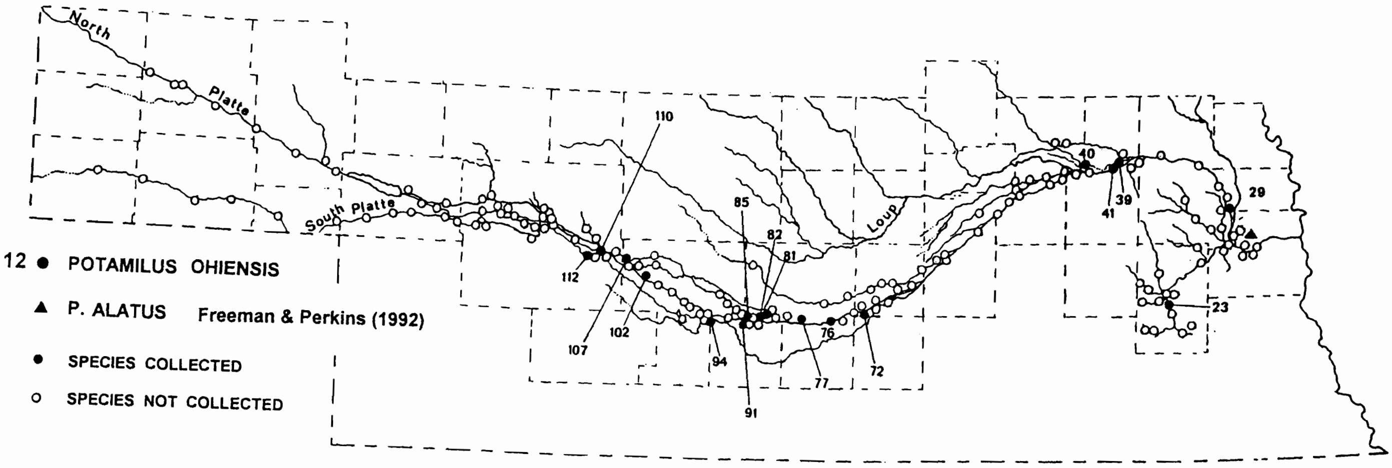
Creation of reservoirs and lakes has provided extensive habitat for some unionid taxa and is reflected in the abundance of *Anodonta g. grandis* in survey results. Seven additional unionids and the introduced bivalve *Corbicula fluminea* were documented in this study for this environment. Freeman and Perkins (1992) have collected two additional taxa, *Leptodea fragilis* and *Potamilus alatus*, from this type of habitat at the Schramm Aquarium ponds. One taxon, *Anodonta grandis dakota*, has only been collected from the study area in the reservoir habitat of Lake McConaughy (Baxa, 1981). The fact that it has not been collected elsewhere in the Platte River basins to date supports Baxa's comment that it may have been introduced to the study area.

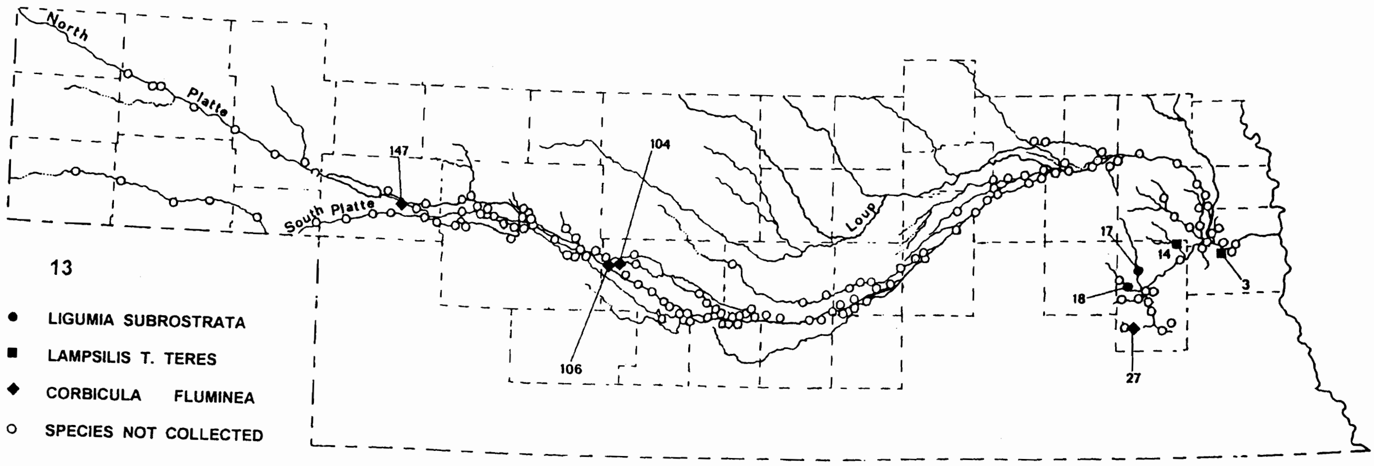
DISTRIBUTIONAL MODEL

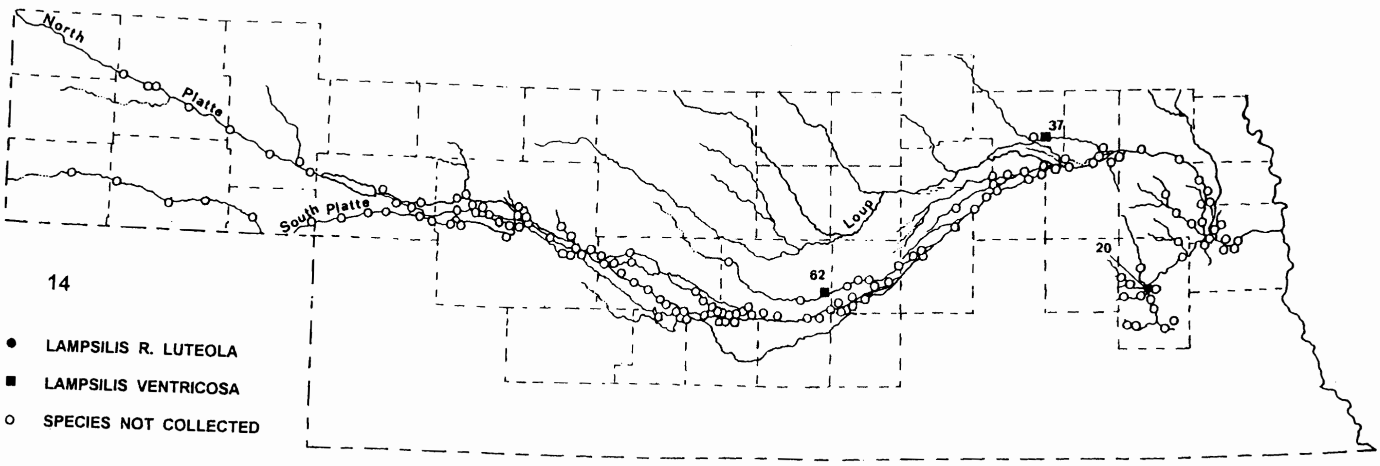
The unionid mollusk distributions in the Platte basins reflect a complex mosaic of severe natural and man-made environmental constraints. Pre-development distributions were probably limited geographically to tributary creeks, quiet backwaters of the Platte rivers, and perhaps to the side-channels. The main channels of the Platte rivers were almost certainly even less viable as bivalve habitat prior to the development of the region than is the case today. The greater flows and quantities of suspended sand in the pre-developed rivers probably produced even less stable shifting sand substrates than is the case today. It is possible though not certain that bivalves were unable to live in the side-channels of these rivers before agricultural development of the region.

Pre-development unionid diversity was probably greater than is the case today, and ranges of less tolerant species no doubt extended further westward. Some evidence supportive of this pattern is available in early reports of taxa no longer present in western sections of the Platte basins. Examples include unvouchered reports of *Lampsilis ventricosa* in Lodgepole Creek in Colorado, and *Leptodea fragilis* in the southwestern part of the Platte district in Nebraska (Cockerell, 1889).

Development of the region has put severe pressure upon all natural habitats and significantly reduced their extent and quality. Backwater areas have been largely eliminated through dewatering, and viable unionid creek habitat has been reduced through dewatering, channelization, grazing, and pollution. The degradation or loss of tributary habitat has resulted in range reductions and in the extirpation of less hardy species at the edges of their distributions.


North Platte
South Platte
Loup
110
85
82
81
40
39
41
29
112
107
102
94
91
76
77
72
23
12 ● POTAMILUS OHIENSIS
▲ P. ALATUS Freeman & Perkins (1992)
● SPECIES COLLECTED
○ SPECIES NOT COLLECTED


North Platte
South Platte
Loup
147
104
106
17
14
3
18
27
13
● LIGUMIA SUBROSTRATA
■ LAMPSILIS T. TERES
◆ CORBICULA FLUMINEA
○ SPECIES NOT COLLECTED


North Platte
South Platte
Loup
37
20
62
14
● LAMPSILIS R. LUTEOLA
■ LAMPSILIS VENTRICOSA
○ SPECIES NOT COLLECTED

Concurrent with the destruction of natural creek and backwater habitats, a number of new habitats have been created, and portions of others may have become viable for unionids. The latter include the western portion of the main channel of the upper-Platte River and possibly the side-channels of the upper-Platte River as well. Both habitats may have become viable due to the reduction in both flows and suspended sediment resulting from construction of upstream dams and surface-water withdrawal and the resultant decrease in shifting sand substrates. In addition, man-made habitat has been created from the development process including canals, ditches, sandpits and reservoirs. Portions of these new habitats which are not dewatered annually provide significant refugia for those species able to adapt to these environments.

CONCLUSION

The documented bivalve fauna of the Platte basins of Nebraska includes eighteen unionid taxa and the introduced bivalve *Corbicula fluminea*. Five of these, *Quadrula p. pustulosa*, *Toxolasma parvus*, *Ligumia subrostrata*, *Lampsilis t. teres*, and *Lampsilis ventricosa* were first reported or confirmed for the study area in this survey. Two other taxa, *Strophitus u. undulatus* and *Lampsilis radiata luteola*, though previously reported, were first documented with vouchered records through this study. In addition, a voucher supporting Aughey's (1877) report of *Fusconaia flava* for the area was located, and additional specimens collected.

The most important natural parameter impacting unionid populations throughout the region is the presence of shifting sand substrates. Since these substrates characterize the main channels of the major rivers in the region, unionids were probably restricted to backwater and small stream habitats prior to the development of the region. The distributions of bivalve fauna collected from the area substantiate the critical importance of tributary streams for unionid mollusks. Fifteen unionids were documented for this environment, and seven of these were restricted solely to this habitat. The importance of this type of habitat is underscored by the fact that most productive non-man-made habitats collected were characterized by their similarity to the habitat of small streams. The backwater areas of the Platte rivers are the only exception, but they are similar to small-stream habitat in their absence of shifting sand substrates.

Bivalve diversity was once highly concentrated in the tributaries of the extreme lower-Platte basin, but the development of the region has significantly impacted this habitat. Dewatering, channelization, pollution, and grazing have decreased the quality and quantity of all natural habitats. This is probably reflected in the absence of fresh shells for six of the seven taxa recovered solely from tributary streams.

Development of the region has been accompanied by the creation of new environments and the possible modification of some formerly unviable habitats into usable bivalve habitat. Irrigation canals, ditches, reservoirs, lakes, and sandpits now provide important habitats in the region for those bivalves that are able to adapt to these environments. In fact, at present, unionids may be numerically more abundant in these new environments than in the natural habitats of the region. The ultimate result of the development of the region, however, has been a decrease in the unionid diversity of the area.

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