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THE FRESHWATER MUSSELS (MOLLUSCA: BIVALVIA: UNIONIDAE) OF THE LITTLE BLUE RIVER DRAINAGE OF NORTHEASTERN KANSAS AND SOUTHEASTERN NEBRASKA

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ABSTRACT

A survey in the Little Blue Basin documented the presence of 22 extant or extirpated unionid mollusk species. Bivalve habitat is severely impaired by surface and subsurface water withdrawals, erosion, siltation, and grazing. Chemical contaminants and other pollutants washed into area streams from agricultural fields probably exert a further deleterious impact upon the fauna of the region. Half of the species recovered were represented only by chalky or badly weathered shells, suggesting their possible elimination from the basin. The generally poor condition of shells of many of the remaining species suggests they are also in severe decline in the region.

† † †

This study is an expansion of an initial survey to document the freshwater mollusks of Nebraska. Since many of the rivers in southern Nebraska flow into northern Kansas, an area that was also largely undocumented, a decision was made to survey each of the four major rivers in southern Nebraska in their entirety irrespective of the artificial political boundaries of the region. The goals of this expanded survey were to document the unionid mollusks in each river basin, and to develop a model to explain the distributions revealed by the survey. The results of studies on the Big Nemaha and Republican rivers have been previously published (Hoke 1996, 1997a). The Big Blue River, and its major tributary the Little Blue River are the remaining rivers encompassed by this project.

METHODS

The Little Blue originates in Adams County, Nebraska, and flows 396 km in a generally east southeasterly direction to its confluence with the Big Blue River above Blue Rapids, Kansas (Fig. 1). The stream drains a basin of 9,158 km^2 and straddles two of the major physiogeographic regions of North America, the Great Plains to the west and the Central Lowlands to the east (Fenneman 1931). In the Little Blue Basin, the demarcation line between the two regions is located around the Kansas-Nebraska border. The Kansas portion of the stream flows primarily through terrain that was subjected to glaciation during the Pleistocene, and though generally characterized by sandy substrates, occasionally flows across gravel riffles. The western or Nebraska portion of the stream has a sand bottom throughout. Minckley (1959) describes the channel of the Little Blue River in Kansas as generally "deep and fairly uniform in width" and contrasts it with the broad, shallow, and braided sandy rivers such as the Kansas. Native vegetation in the Little Blue Basin once consisted primarily of mixed grass prairie, and forested areas were confined to corridors along the river, creeks, and ravines. Currently, the native prairie is largely supplanted by modern agriculture. In 1976, only 1.5 percent of the Nebraska portion of the basin was forested (NNRC 1976).

The survey utilized anecdotal information from biologists and local citizens in locating populations and in learning about past conditions in the Little Blue Basin. In 1976 a questionnaire was mailed to conservation officers of the Nebraska Game and Parks Commission on a statewide basis requesting information on the locations of known freshwater mussel populations. The responses received provided a number of potential collection localities in the Nebraska portion of the Little Blue Basin, and in some instances anecdotal information was also received regarding the locations of former populations as well. During the coarse of the survey, comments were also actively sought from local residents of the basin regarding the location of both past and present mollusk populations, as well as other observations relevant to obtaining an understanding of local unionids.

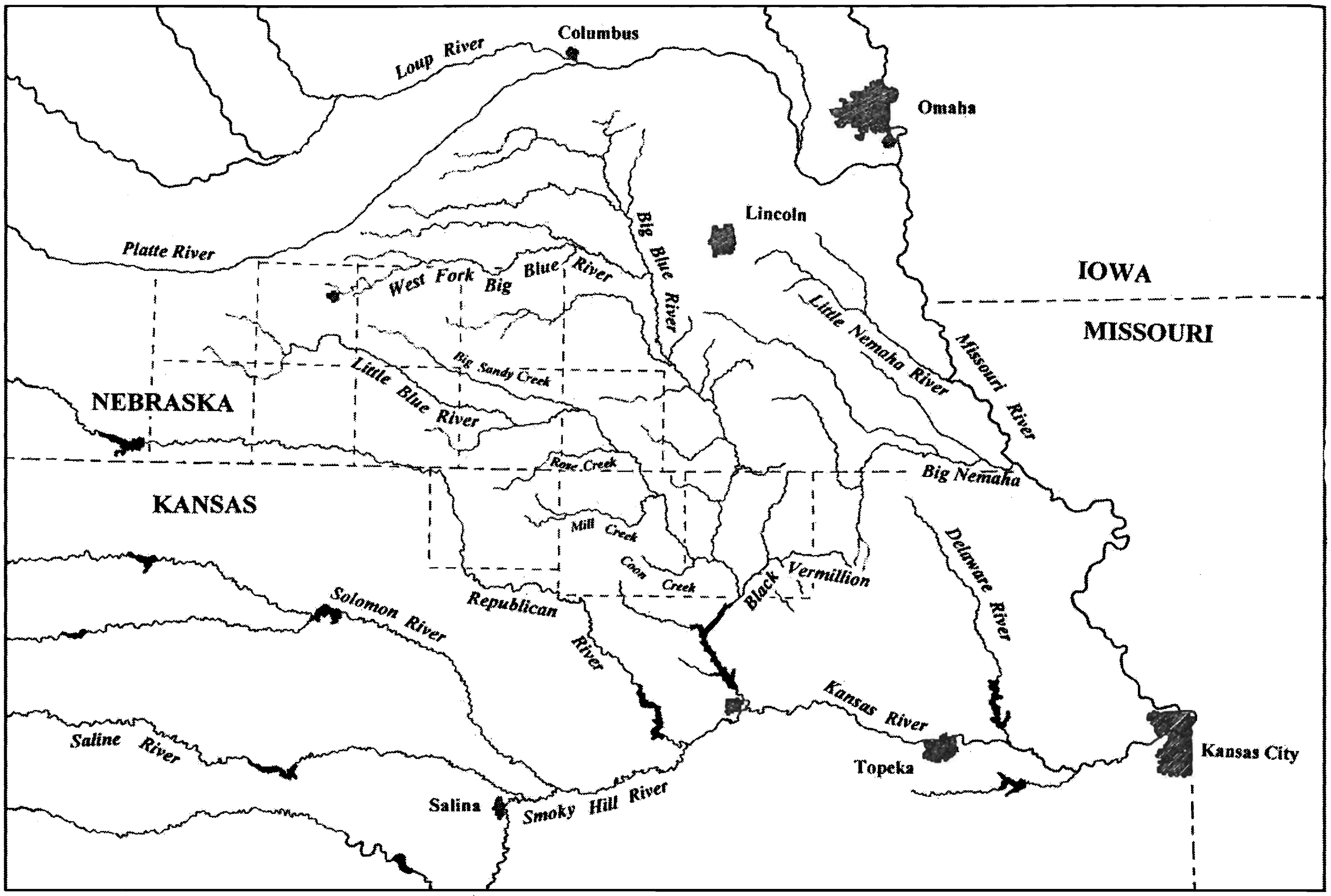


Figure 1. The location of the Little Blue Basin.

Site selection was primarily determined by the presence of bridge access points and the absence of "No Trespassing" signs on adjacent land. In addition, an attempt was made to locate collection points at intervals no greater than 13 to 16 km apart along the rivers and major tributaries of the Little Blue River. Other than farm ponds, few lentic habitats exist in the basin, so the collection effort focused on lotic habitats, and only one lentic site was sampled. Specimens were collected by hand or with the use of a garden rake when water levels were low. Sites were collected until diversity plateaued or the legally accessible reaches had been covered at a given locale. Collection sites were marked on USGS maps, and field notes were maintained for each site collected noting time of collection, weather conditions, and relevant observations of environmental conditions. In addition, a photographic record was usually made at each collection locale. In an effort to preserve the biological resources of the study area, recent shells were collected in preference to live specimens whenever possible and few live unionids were retained.

Collection activities were conducted in 1972, 1975, 1976, 1985, 1988, 1990, and 1995. In an effort to locate species from the Little Blue Basin that were not present in survey results, collections at a number of museums around the country were examined. These facilities are listed in a later section of this paper. In addition, the Kansas Department of Wildlife and Parks was contacted to learn of the existence of any recent unionid surveys in the Kansas portion of the basin.

Specimens were identified primarily by the author, however, a number of shells were sent to other experts for identification or for corroboration of the author's identifications. All specimens recovered have been donated to the Museum of Biological Diversity, The Ohio State University, Columbus, Ohio. The nomenclature utilized in this paper follows Turgeon et al. (1998).

RESULTS

Forty-nine collection sites are represented in this survey of the Little Blue Basin (Fig. 2). Forty-eight were sampled by the author. One site is a previously unpublished and relatively recent (1967) collection discovered in the Biology Department of the University of Nebraska at Kearney. Unionid mollusks were recovered from 34 of the 49 sites or a little over 69 percent of

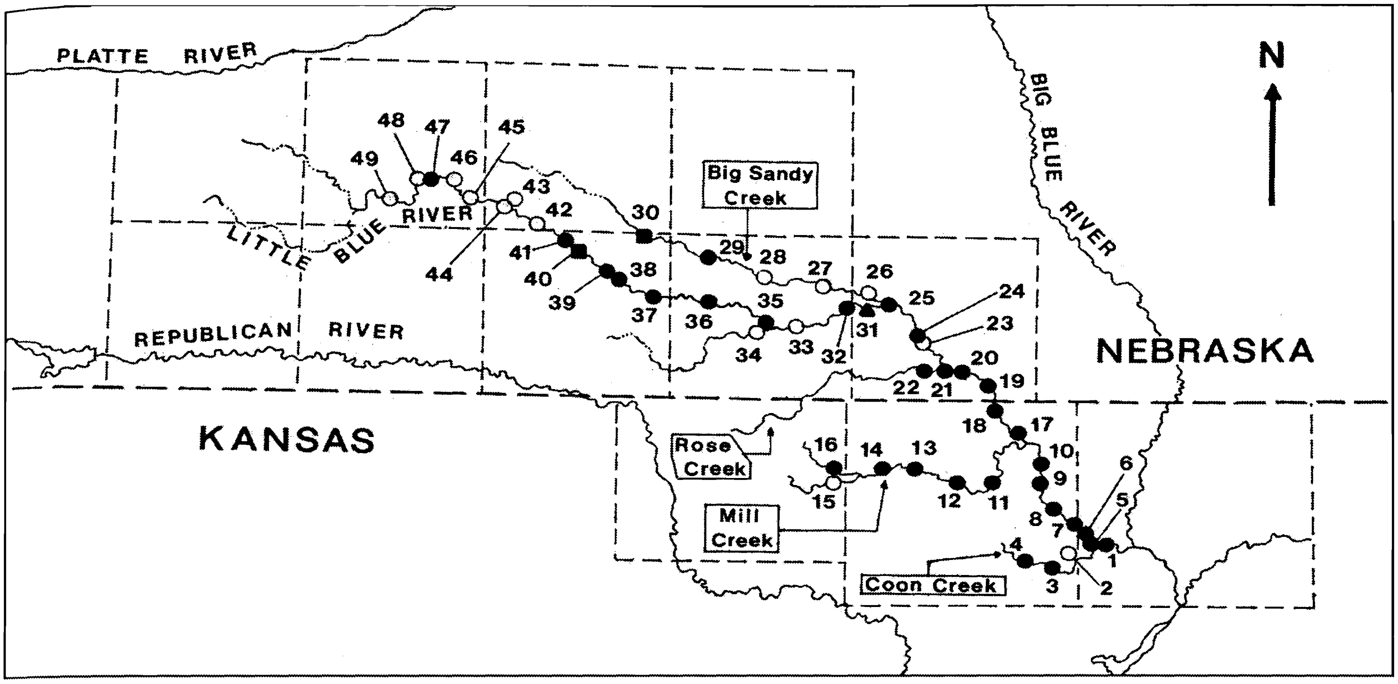


Figure 2. Collection sites in the Little Blue Basin. Filled circles represent productive collection sites; open circles are unproductve ones; filled squares are sites at which I found only unidentifiable shell fragments; and the filled triangle is the site of a collection at the University of Nebraska at Kearney.

the collection locales sampled. Most of the sites in the lower (Kansas) reaches of the river were productive; in contrast, the upper (Nebraska) reaches of the basin were often barren, and when productive yielded fewer species as well. Productivity was greatest in the Little Blue River where 73 percent of all sites yielded bivalves, while 61 percent of the creek locales sampled produced unionid mollusks. The single lentic site sampled was also productive.

Species diversity for all sites averaged 4.6 species per productive site. Diversity of river sites was 4.9 species per productive site, while that of creeks was 4.2 species per site. The most biologically diverse river sites encountered in the survey (sites 1, 8, and 9) produced 11 species each, while the richest creek locale (site 3) yielded 10 species. The most diverse collection sites were all located in the lower (Kansas) portion of the Little Blue Basin.

The twenty-two species recovered from the Little Blue Basin are presented by collection locale and best condition in Table 1. The most salient fact that emerges from an examination of the collection results is the poor condition of the specimens recovered. Only four species, (*Leptodea fragilis*, *Potamilus alatus*, *P. ohiensis*, and *Quadrula quadrula*), were recovered alive, and only seven others (*Lampsilis cardium*, *Lampsilis siliquoidea*, *Lasmigona c. complanata*, *Pyganodon grandis*, *Quadrula p. pustulosa*, *Strophitus undulatus*, and *Uniomerus tetralasmus*) were collected as recent or moderately weathered shells. The remaining eleven species were represented solely by badly weathered or chalky valves suggesting they may no longer survive in the region. Significantly, four of these species (*Anodontoides ferussacianus*, *Fusconaia flava*, *Lampsilis teres*, and *Truncilla truncata*) are currently listed as SINC species (Species In Need of Conservation) by the Kansas Department of Wildlife and Parks on a statewide basis.

Most of the species represented solely by weathered shells were restricted to the lower or Kansas portion of the basin. These include the two SINC species, *Fusconaia flava* and *Truncilla truncata*, as well as *Amblema plicata*, *Ligumia subrostrata*, *Obovaria olivaria*, *Quadrula fragosa*, *Toxolasma parvus*, and *Tritogonia verrucosa*. Most of these unionids appear to be at or near the edge of their historic ranges, and they may have been always rather rare in the basin. Particularly surprising was the collection of *Quadrula fragosa*, a federally endangered bivalve, recovered from two sites in the extreme eastern portion of the study area (Hoke 1997b). In contrast, *Ligumia recta* was once rather widely distributed, with a range extending far into the upper reaches of the Little Blue basin. *Anodontoides ferussacianus* and *Lampsilis teres* were also collected from both the upper and lower portions of the basin, where they were equally infrequent.

The most common species represented in survey results were *Lampsilis cardium*, *Lampsilis siliquoidea*, *Quadrula p. pustulosa*, and *Quadrula quadrula*. The condition of the specimens collected for these species

Table 1. Unionid mollusks collected from the Little Blue River Basin by collection site and best condition: L = live; F = fresh dead; R = Recent; D = slightly to moderately weathered; WD = well weathered; S = subfossil or chalky condition.

	Little Blue Basin								
	Little Blue River								
Year(s) Collected	1985	1985	1985	1988	1985	1985	1988	1985	1988
Species / **Map Reference**	1	5	6	7	8	9	10	17	18
1. *Amblema plicata* (Say, 1817)	-	-	-	-	S	-	-	-	-
2. *Anodontoides ferussacianus* (Lea, 1834)	-	-	-	-	-	-	-	-	-
3. *Fusconaia flava* (Rafinesque, 1820)	-	-	-	-	-	-	-	-	-
4. *Lampsilis cardium* Rafinesque, 1820	S	-	-	S	S	S	S	S	-
5. *Lampsilis siliquoidea* (Barnes, 1823)	S	-	-	S	D	D	S	S	-
6. *Lampsilis teres* (Rafinesque, 1820)	-	-	-	-	-	-	-	-	-
7. *Lasmigona c. complanata* (Barnes, 1823)	S	-	-	-	-	D	S	-	-
8. *Leptodea fragilis* (Rafinesque, 1820)	D	-	-	R	L	L	WD	D	R
9. *Ligumia recta* (Lamarck, 1819)	S	WD	S	S	S	S	-	-	-
10. *Ligumia subrostrata* (Say, 1831)	-	-	-	-	WD	-	-	-	-
11. *Obovaria olivaria* (Rafinesque, 1820)	-	-	-	-	S	-	-	-	-
12. *Potamilus alatus* (Say, 1817)	WD	-	-	S	WD	L	-	-	-
13. *Potamilus ohiensis* (Rafinesque, 1820)	WD	-	D	-	L	L	R	D	L
14. *Pyganodon grandis* (Say, 1829)	-	-	-	-	-	-	WD	-	WD
15. *Quadrula fragosa* (Conrad, 1835)	S	-	S	-	-	-	-	-	-
16. *Quadrula p. pustulosa* (Lea, 1831)	S	-	-	S	WD	D	-	S	-
17. *Quadrula quadrula* (Rafinesque, 1820)	WD	-	D	S	S	L	L	-	-
18. *Strophitus undulatus* (Say, 1817)	-	-	-	-	-	S	-	-	-
19. *Toxolasma parvus* (Barnes, 1823)	-	-	-	-	-	-	-	-	-
20. *Tritogonia verrucosa* (Rafinesque, 1820)	S	-	-	-	-	S	-	-	-
21. *Truncilla truncata* Rafinesque, 1820	-	-	S	-	-	-	-	-	-
22. *Uniomerus tetralasmus* (Say, 1831)	-	-	-	-	-	-	-	-	-
23. Unidentifiable Unionid	-	-	-	-	-	-	-	-	S
Total Species Represented:	11	1	5	7	11	11	7	5	4

testifies to the deterioriation of the region's unionid fauna. *Quadrula quadrula*, the most widespread species in the basin, appears to be in the best health of the four. It was recovered live or as recent or moderately weathered valves at twelve of the twenty locales at which it was present. *Quadrula p. pustulosa* was collected in recent to moderately weathered condition at only three of seventeen locales. *Lampsilis cardium,* though represented at sixteen locales, was recovered only as chalky valves at fourteen of these sites, and *L. siliquoidea* was collected at eleven of fourteen sites only as specimens in badly weathered or chalky condition.

Leptodea fragilis and *Potamilus ohiensis* seem to be adjusting to or possibly even thriving in the basin. Both were represented largely by live specimens or recent shells in the ranges in which they were documented in this study, and they were often numerous as well. This suggests either that they are currently stable in the basin or perhaps even expanding their ranges. Both species are at least holding their own in the Republican and Smoky Hill basins to the west (Hoke 1997a).

Examination of museum collections did not add to the number of species documented for the study area, though several of the facilities visited housed at least some specimens from the region. Vouchers for two species, *Obovaria olivaria* (USNMNH 25908) and *Potamilus alatus* (USNMNH 83929), collected in the nineteenth century from the "Little Blue River, Kansas" were discovered at the U. S. National Museum of Natural History. Additional specimens with more detailed locale information were located at the Kansas Biological Survey. Subsequent to the conclusion of this survey, seven sites in the Little Blue Basin were sampled by the Kansas Department of Wildlife and Parks. These collections are discussed below.

Table 1. Continued.

	Little Blue Basin, continued														
														Tributary Str.	
	Little Blue River, continued													Coon Creek	
Yrs. Coll.	**1988**	**1976**	**1990**	**1990**	**1967**	**1990**	**1990**	**1990**	**1990**	**1972 75/90**	**1972 75/90**	**1975**	**1975**	**1995**	**1995**
Map R.	**19**	**20**	**24**	**25**	**31***	**32**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**3**	**4**
1.	-	-	-	-	-	-	-	-	-	-	-	-	-	S	S
2.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	WD
3.	-	-	-	-	-	-	-	-	-	-	-	-	-	S	-
4.	S	S	S	S	R	S	S	-	-	S	S	-	-	-	-
5.	-	S	-	S	R	S	-	-	S	-	-	-	-	S	-
6.	-	S	-	-	-	-	-	-	-	-	-	-	-	-	-
7.	-	-	-	-	R	-	-	S	-	-	-	-	-	WD	-
8.	L	R	-	-	-	-	-	-	-	-	-	-	-	-	-
9.	-	-	-	S	-	S	-	-	-	-	-	-	-	-	-
10.	-	S	-	-	-	-	-	-	-	-	-	-	-	S	S
11.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13.	WD	D	-	-	-	-	-	-	-	-	-	-	-	-	-
14.	-	-	-	-	-	-	S	-	-	-	-	-	-	S	S
15.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16.	S	S	S	S	R	S	S	S	S	S	-	-	-	S	-
17.	-	S	-	S	R	-	S	-	-	R	S	-	S	D	-
18.	-	-	-	S	-	-	-	-	-	-	-	-	-	S	D
19.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22.	-	-	-	-	-	-	-	-	-	-	-	-	-	S	-
23.	S	-	-	-	-	-	-	-	-	-	S	S	-	-	-
Tot.	5	8	2	6	5	4	4	2	2	3	3	1	1	10	5

* Collection of the Department of Biology at the University of Nebraska at Kearney.

DISCUSSION

Published references on the unionid fauna of the Little Blue Basin are extremely limited. Aughey (1877) reported 41 unionoid species, representing 35 currently recognized taxa, for the "Blue" river in Nebraska; however, since all of his known sites are along the Big Blue River (Hoke 2000), it is possible Aughey may not have collected in the Little Blue Basin. In any event, there is some question as to the identity of the species he actually recovered (Bolick 1993, Hoke 2000). Early papers on the unionid mussels of Kansas do not mention the Little Blue River (Call 1885a, 1885b, 1885c, 1886, 1887, Scammon 1906), and Murray and Leonard (1962) did not illustrate any historic or recent collection sites within the basin in their study of Kansas mussels.

Analysis of collection records from the Kansas Biological Survey identified four sites in the Little Blue Basin and six species collected between 1975 and 1977 (Table 2). These records were reported in two papers (Liechti and Huggins 1977, Schuster and Dubois 1979); however, most of the records in these sources are given only by county or by county within the Big Blue Basin. The only published specimen clearly indicated to be from the Little Blue Basin is *Potamilus alatus* (Liechti and Huggins 1977).

Additional collection efforts were conducted by the Kansas Department of Wildlife and Parks in the lower portion of the Basin between 1996 and 2000 and are summarized in Table 3. Nine collections at seven locales produced evidence of nineteen species. The survey also documented the most diverse site in the Little Blue Basin. A locale on the lower reach of Coon Creek produced fifteen species; however, eleven were collected

Table 1. Continued.

	Little Blue Basin, continued											
	Tributary Streams, continued									Lakes		
	Mill Creek					Rose Creek		Big Sandy Creek		Unnamed Lake	Basin Totals Species Occurrences	
Yrs. Coll.	1985	1988	1985	1985	1985	1976	1976	1990	1990	1990		
Map R.	**11**	**12**	**13**	**14**	**16**	**21**	**22**	**29**	**30**	**47**	**Number**	**Percent**
1.	-	-	-	-	-	-	-	-	-	-	3	1.94
2.	-	-	-	-	S	-	-	-	-	-	2	1.29
3.	-	-	-	-	-	-	-	-	-	-	1	0.65
4.	S	-	-	-	-	-	-	-	-	-	16	10.32
5.	-	WD	-	-	-	S	-	-	-	-	14	9.03
6.	-	WD	-	-	-	-	-	-	-	-	2	1.29
7.	-	WD	-	-	-	WD	R	-	-	-	9	5.81
8.	WD	-	-	-	-	-	-	-	-	-	10	6.45
9.	-	-	-	-	-	-	-	-	-	-	8	5.16
10.	-	-	-	-	S	-	-	-	-	-	5	3.23
11.	-	-	-	-	-	-	-	-	-	-	1	0.65
12.	-	-	-	-	-	-	-	-	-	-	4	2.58
13.	-	-	-	-	-	-	-	-	-	-	9	5.81
14.	S	WD	D	-	S	-	R	-	-	R	11	7.10
15.	-	-	-	-	-	-	-	-	-	-	2	1.29
16.	-	-	-	-	-	-	D	-	-	-	17	10.97
17.	L	R	-	D	D	D	R	-	-	-	20	12.90
18.	-	-	-	-	S	S	-	-	-	-	6	3.87
19.	-	-	-	-	S	-	-	-	-	-	1	0.65
20.	-	-	-	-	-	-	-	-	-	-	2	1.29
21.	-	-	-	-	-	-	-	-	-	-	1	0.65
22.	-	WD	-	WD	D	-	D	S	-	-	6	3.87
23.	-	-	-	-	-	-	-	-	S	-	5	3.23
Tot.	4	6	1	2	7	4	5	1	1	1	155	100.00

only as weathered shells. In total, the survey recovered recent shells for only six unionids. Thus the condition of specimens recovered by the Kansas Department of Wildlife and Parks largely mirrors that of specimens collected in the current study and supports the hypothesis that the unionid fauna of the Little Blue Basin is in severe decline.

Table 4 summarizes the collection results from all studies of the Little Blue Basin by study, environment, best condition of shells, and general geographical area. Particularly interesting are the differences in species richness between the upper and lower portions of the basin and the species composition of the various environments. The decline in species richness in the upper basin probably reflects both the impact of declining water tables discussed below and an absence of rocky riffle areas. *Obovaria olivaria*, *Quadrula fragosa* and *Truncilla truncata* have been recovered only from the extreme eastern reaches of the Little Blue River and usually in association with rocky riffle areas, while *Anodontoides ferussacianus*, *Fusconaia flava* and *Uniomerus tetralasmus*, present in basin creeks, were not represented in collections from the Little Blue River. The other species documented for the basin were recovered from both the Little Blue River and basin creeks, though some exhibit a propensity for one habitat or the other. *Pyganodon grandis* and *Strophitus undulatus* were most often, but not exclusively, associated with creek habitats, while *Potamilus alatus* was generally recovered from the Little Blue River. *Pyganodon grandis* and *Uniomerus tetralasmus* were the only species collected from lentic environments in the Little Blue Basin, though it is likely that a thorough examination of basin lentic environments would reveal some populations of *Utterbackia imbecillis* and perhaps *Ligumia subrostrata*.

Table 2. Unionid mollusks collected from the Little Blue Basin by the Kansas Biological Survey: X = species collected ; - shell condition not recorded.

	Little Blue Basin				
	Little Blue River		Mill Creek	State Lake	
Species Year Collected / Map Reference	1976 A	1976 D	1977 E	1975 G	Basin Total
Lasmigona c. complanata	-	-	X	-	1
Leptodea fragilis	X	-	X	-	2
Potamilus alatus	X	-	-	-	1
Potamilus ohiensis	-	X	-	-	1
Quadrula p. pustulosa	-	-	X	-	1
Quadrula quadrula	X	-	X	-	2
Uniomerus tetralasmus	-	-	-	X	1
Total Species Represented:	3	1	4	1	9

Table 3. Unionid mollusks collected from the Little Blue Basin by the Kansas Department of Wildlife and Parks between 1996 and 2000 by best condition by locale: L = live; R = recent; WD = weathered.

	Little Blue Basin							
	River		Tributary Creeks					
	Little Blue		Coon Creek	Mill Creek		* Rose Creek	Basin Summary	
Year Collected	1999 2000	1998	1997 1998	1996	2000	1997 1998	Species Occurrences	
Species Map Reference	C**	J	B	F	H	K	Number	%
Amblema plicata	WD	-	WD	-	-	-	2	3.70
Anodontoides ferussacianus	-	-	WD	-	-	WD	2	3.70
Fusconaia flava	-	-	WD	WD	-	-	2	3.70
Lampsilis cardium	WD	WD	WD	WD	WD	-	5	9.26
Lampsilis siliquoidea	WD	-	WD	-	-	-	2	3.70
Lampsilis teres	-	-	WD	WD	-	-	2	3.70
Lasmigonia c. complanata	-	-	R	R	-	WD	3	5.56
Leptodea fragilis	R	R	R	R	R	R	6	11.11
Ligumia recta	WD	-	-	WD	-	-	2	3.70
Ligumia subrostrata	WD	-	WD	-	WD	WD	4	7.41
Potamilus alatus	-	-	R	-	-	-	1	1.85
Potamilus ohiensis	L	R	-	L	-	-	3	5.56
Pyganodon grandis	-	-	WD	-	WD	WD	3	5.56
Quadrula p. pustulosa	WD	WD	WD	WD	-	-	4	7.41
Quadrula quadrula	WD	WD	R	R	L	-	5	9.26
Strophitus undulatus	WD	-	WD	-	WD	-	3	5.56
Toxolasma parvus	WD	-	-	-	-	-	1	1.85
Tritogonia verrucosa	-	WD	WD	WD	-	-	3	5.56
Uniomerus tetralasmus	-	-	-	-	-	L	1	1.85
Total Species Represented:	11	6	15	10	6	6	54	100.00

* Includes results from two separate sites on adjoining sections of land.
**Sites "C" and "8" (collected in this study) are the same locale. Records from site "C" that duplicate those in the current study are not shown on the accompanying distribution maps.

Table 4. Summary of all unionid mollusks collected from the Little Blue River Basin by study, best condition and environment: L = live; F = fresh dead; R = recent; D = slightly to moderately weathered; WD = well weathered; S = chalky or subfossil condition; and X = species present, shell condition unrecorded.

	Little Blue R.		Creeks		Lakes	Basin Summary			
Species	Lower Basin	Upper Basin	Lower Basin	Upper Basin	Total Basin	All Rivers	All Creeks	All Lakes	Total Basin
Amblema plicata	WD[a,c]	-	WD[a,c]	-	-	WD	WD	-	WD
Anodontoides ferussacianus	-	-	WD[a,c]	WD[c]	-	-	WD	-	WD
Fusconaia flava	-	-	WD[a,c]	-	-	-	WD	-	WD
Lampsilis cardium	WD[a,c]	*R[a,d]	WD[a,c]	-	-	*R	WD	-	*R
Lampsilis siliquoidea	D[a,c]	*R[a,d]	WD[a,c]	S[a]	-	*R	WD	-	*R
Lampsilis teres	-	S[a]	WD[a,c]	-	-	S	WD	-	WD
Lasmigona c. complanata	D[a]	*R[a,d]	R[a,b,c]	R[a,c]	-	*R	R	-	R
Leptodea fragilis	L[a,b,c]	L[a]	R[a,b,c]	R[c]	-	L	R	-	L
Ligumia recta	WD[a,c]	S[a]	WD[c]	-	-	WD	WD	-	WD
Ligumia subrostrata	WD[a,c]	S[a]	WD[a,c]	WD[c]	-	WD	WD	-	WD
Obovaria olivaria	S[a]	-	-	-	-	S	-	-	S
Potamilus alatus	L[a,b]	-	R[c]	-	-	L	R	-	L
Potamilus ohiensis	L[a,b,c]	D[a]	L[c]	-	-	L	L	-	L
Pyganodon grandis	WD[a]	S[a]	D[a,c]	R[a,c]	R[a]	WD	R	R	R
Quadrula fragosa	S[a]	-	-	-	-	S	-	-	S
Quadrula p. pustulosa	D[a,c]	*R[a,d]	WD[a,b,c]	D[a]	-	*R	D	-	*R
Quadrula quadrula	L[a,b,c]	R[a,d]	L[a,b,c]	R[a]	-	L	L	-	L
Strophitus undulatus	WD[a,c]	S[a]	D[a,c]	S[a]	-	WD	D	-	D
Toxolasma parvus	WD[c]	-	S[a]	-	-	WD	S	-	WD
Tritogonia verrucosa	WD[a,c]	-	WD[c]	-	-	WD	WD	-	WD
Truncilla truncata	S[a]	-	-	-	-	S	-	-	S
Uniomerus tetralasmus	-	-	D[a]	L[a,c]	X[b]	-	L	X	L
Total Species Represented:	18	12	19	10	2	19	19	2	22

[a] = Hoke; [b] = Kansas Biological Survey; [c] = Kansas Department of Wildlife and Parks; [d] = Biology Department, Univiersity of Nebraska at Kearney; * Recent designation due solely to museum specimens at the University of Nebraska at Kearney, collected in 1967 from one site.

The distributions of all bivalves collected during this and other recent surveys are illustrated in Figs. 3 through 24. Circles indicate sites collected by the author, while triangles and diamonds indicate collections by others. The triangle in the upper (Nebraska) basin references the single collection from the Biology Department at the University of Nebraska at Kearney. Triangles in the lower (Kansas) basin denote collections of the Kansas Biological Survey and diamonds indicate collections of the Kansas Department of Wildlife and Parks.

ANALYSIS

The bivalve ranges illustrated in Figs. 3–24 are the product of the original native populations of the region and the environmental alterations brought about by the settlement and agricultural development of the area. The Little Blue Basin was untouched by western man until the 1840's when the Oregon Trail cut through its prairies. The region was settled between 1850 and 1870. By the early twentieth century, a number of small dams had been constructed in the basin to harness the flow of the river and some of its tributaries for mills and the generation of electrical power. In portions of the basin in Nebraska, Bouc (1983) notes the construction of "at least 14" dams at one time or another. Other dams may have been present in the Kansas portion of the basin; however, the author was unable to locate any related references. Though most of these structures have since been removed, there are still a small number of extant power dams along the Little Blue in Nebraska. Anecdotal accounts suggest reaches of the river immediately below these structures often provided good habitat for some bivalve species. These accounts are supported by the collection of relic shells at site 35, just below the ruins of one of these dismantled dams.

Today the Little Blue Basin is much changed from its original state. The activity that most significantly impacts bivalve mollusks in the basin is extensive withdrawal of surface and subsurface water for irrigation of cropland and the resultant declines in groundwater levels. The close association of declining groundwater levels with well drilling was first documented for the period 1949–1973 (NNRC 1973). Declines have no doubt accelerated since that study as center pivot irrigation technology has become more common in the region. By 1994, in some parts of the Little Blue Basin in Nebraska, groundwater levels had declined by more than nine meters from presettlement levels (Mack et al. 1996a). The association of these declines with well drilling in 1994–95 is illustrated by Mack et al. (1996a, 1996b). Lowered water tables result in the dewatering of reaches of creeks and the Little Blue River that once supported unionids. This is most noticeable in the upper Little Blue Basin but may also be in evidence in the upper reaches of lower basin creeks. Anecdotal reports from a number of sources indicate the former presence of populations of mussels along now largely dry reaches of Big Sandy Creek and the Little Blue River in the upper Little Blue Basin. The anecdotal accounts are supported by the recovery of unionid shell fragments in some of these areas. The Little Blue River was dry in 1990 above site 48, and small tributaries such as Pawnee Creek (site 43) were also dry at that time.

Erosion and siltation doubtlessly exert a negative effect upon the native unionids of the region, though it is not possible to quantify the impact. Crops are sometimes planted to the very edge of stream banks, resulting in heavy losses of topsoil during rainstorms. At site 7 along the Little Blue River, the author noted a large expanse of eroded soil in the stream bottom adjacent to a plowed field. The eroded topsoil was as much as two meters in depth and covered a large portion of the stream bottom immediately below the field. Eroded silt often fills up the deeper holes in stream bottoms, and thus eliminates habitat for potential host fish (Bliss and Schainost 1973) as well as for the mussels themselves. Silt is known to be detrimental to unionids and has been reported to be the agent responsible for severe decreases in many freshwater mussel populations (Ellis 1936).

Unrestricted access of domesticate livestock to stream bottoms also negatively impacts unionids. The cattle compact mud substrates and can destabilize sandy substrates, and thus substantially change the value of stream bottoms as bivalve habitat. The hooves can damage the shells of adult unionids, and crush those of younger specimens.

The lowering of water tables coupled with the introduction of livestock to stream bottoms work together to destroy both the extant unionid fauna and the shells that evidence the fauna as well. In 1972, the author obtained anecdotal accounts of live populations along the Little Blue River at Angus, Nebraska, from two individuals who resided in the area in the 1950s, prior to the advent of extensive water withdrawls from the basin. Visiting that site (38) later in the year, he observed numerous large subfossil shells of *Lampsilis cardium* but only a single recent valve (*Quadrula quadrula*) was collected at that time. A trip to the same site in 1975 resulted in the collection of only a few battered subfossil valves. The site was again revisited in 1990, and only a few unidentifiable flakes of shell

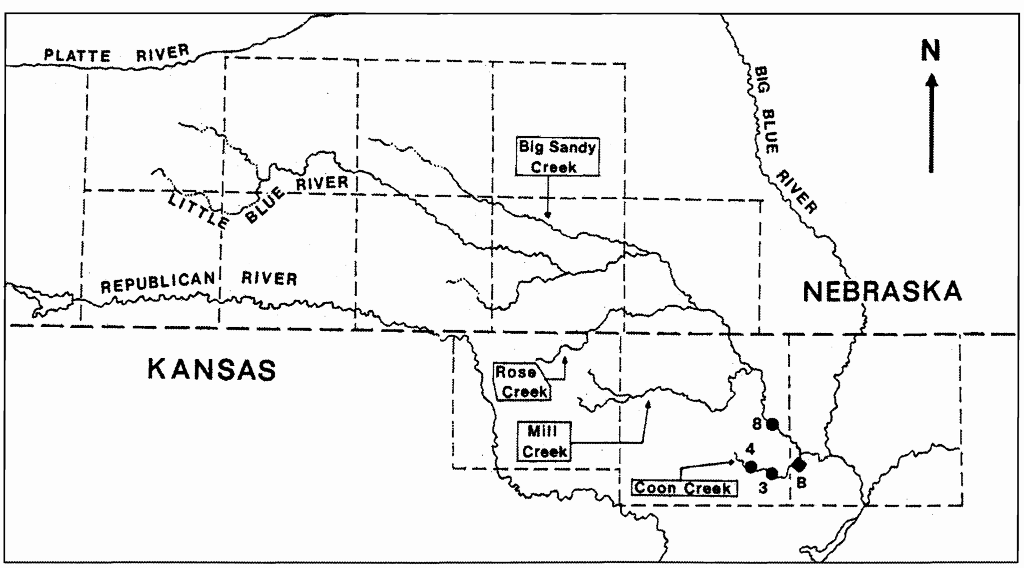
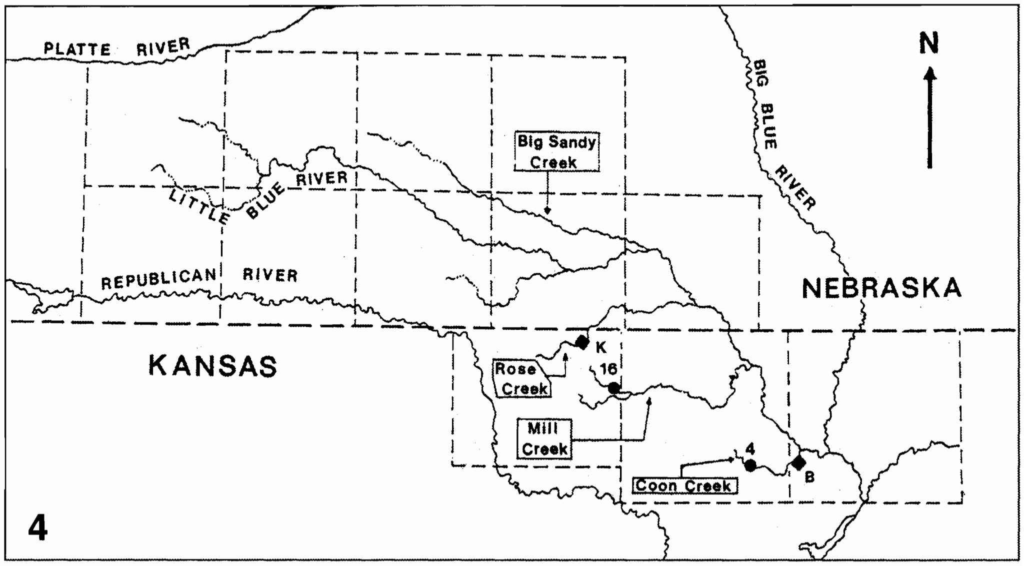
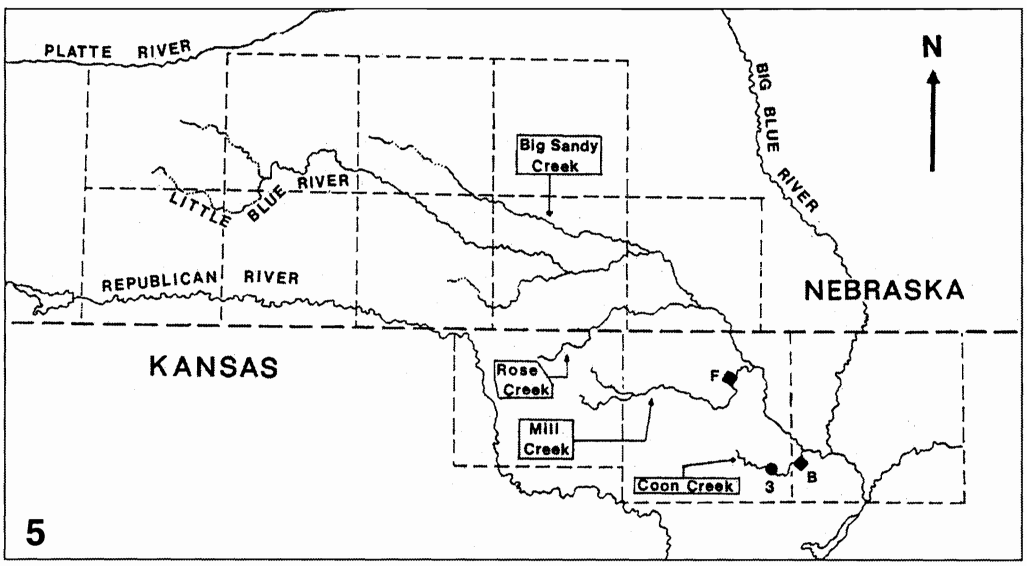
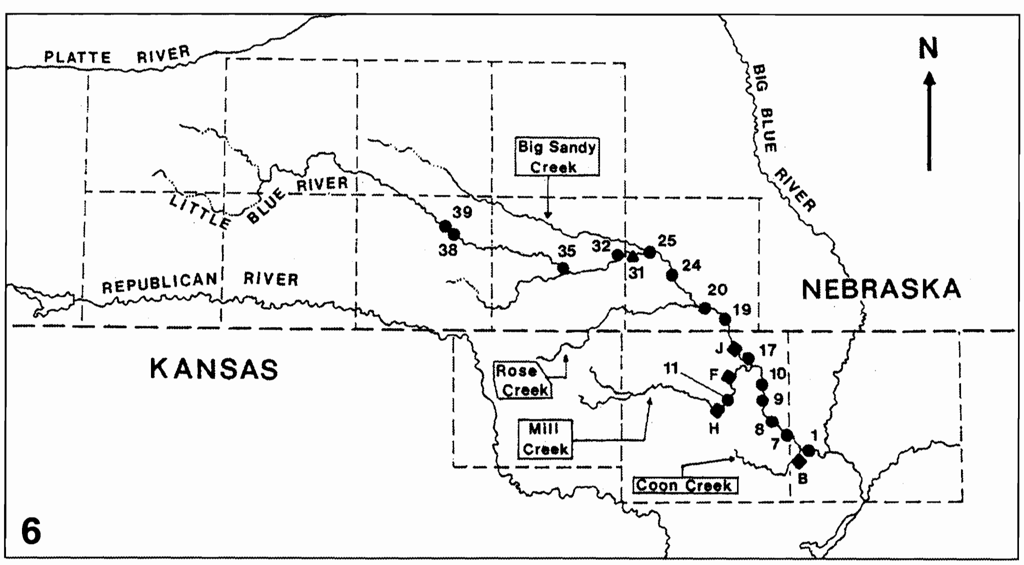


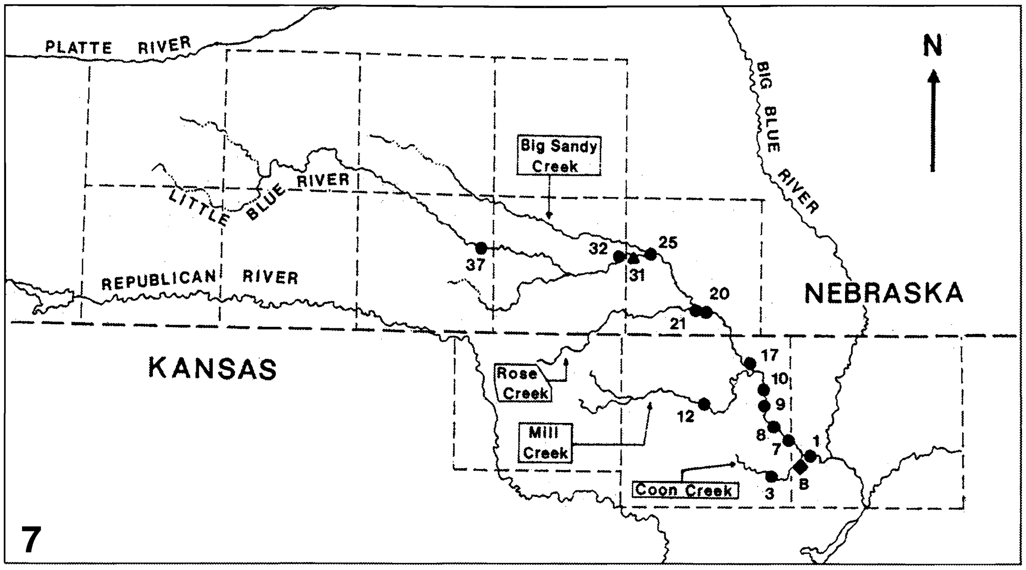
Figure 3. Distribution of *Amblema plicata*. In this and the maps that follow, filled circles represent sites at which I collected a given species; filled diamonds are sites collected by the Kansas Department of Wildlife and Parks; filled triangles in Nebraska represent collections of specimens from the Biology Department at the University of Nebraska at Kearney; and filled triangles in Kansas represent collections by the Kansas Biological Survey.

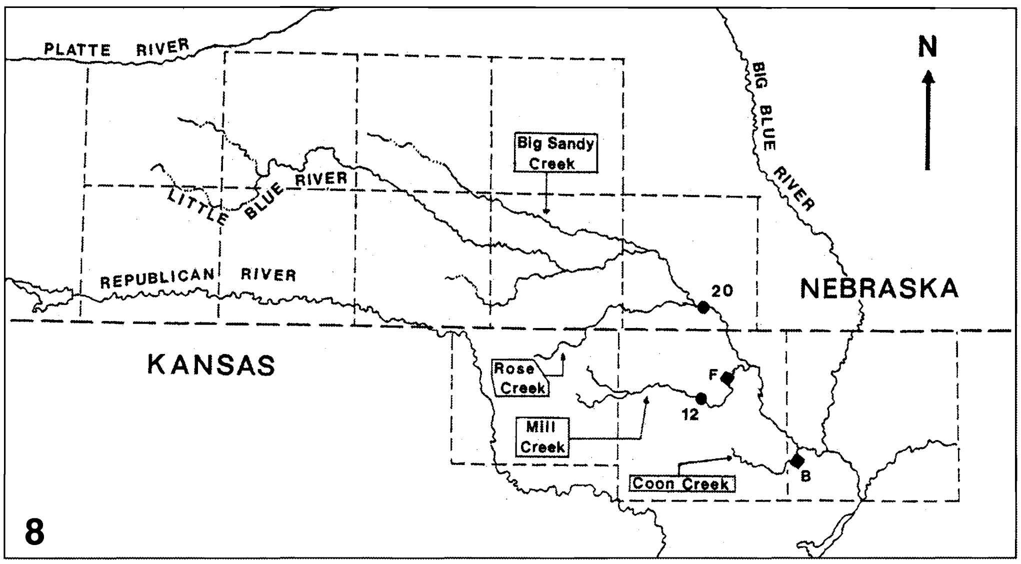


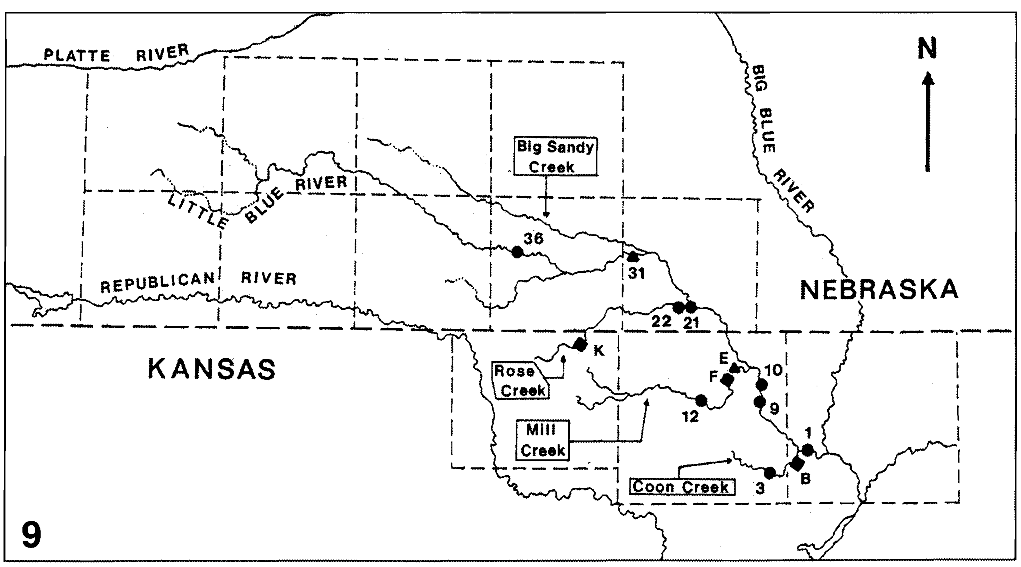




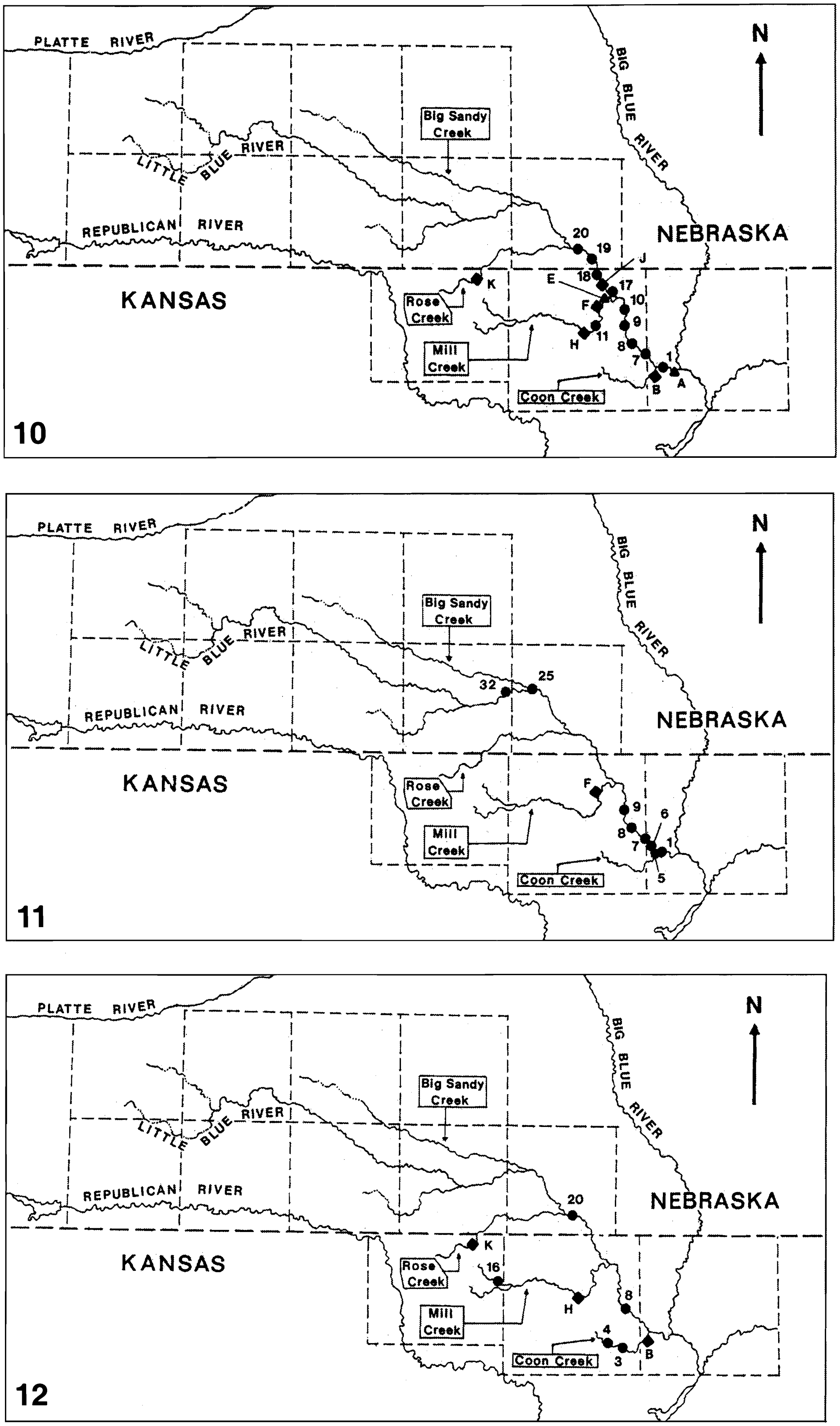
Figures 4–6. Distributions of **4**. *Anodontoides ferussacianus*, **5**. *Fusconaia flava*, **6**. *Lampsilis cardium*.







Figures 7–9. Distributions of **7**. *Lampsilis siliquoidea*, **8**. *Lampsilis teres*, **9**. *Lasmigona complanata complanata*.



Figures 10–12. Distributions of **10**. *Leptodea fragilis*, **11** *Ligumia recta*, **12**. *Ligumia subrostrata*.

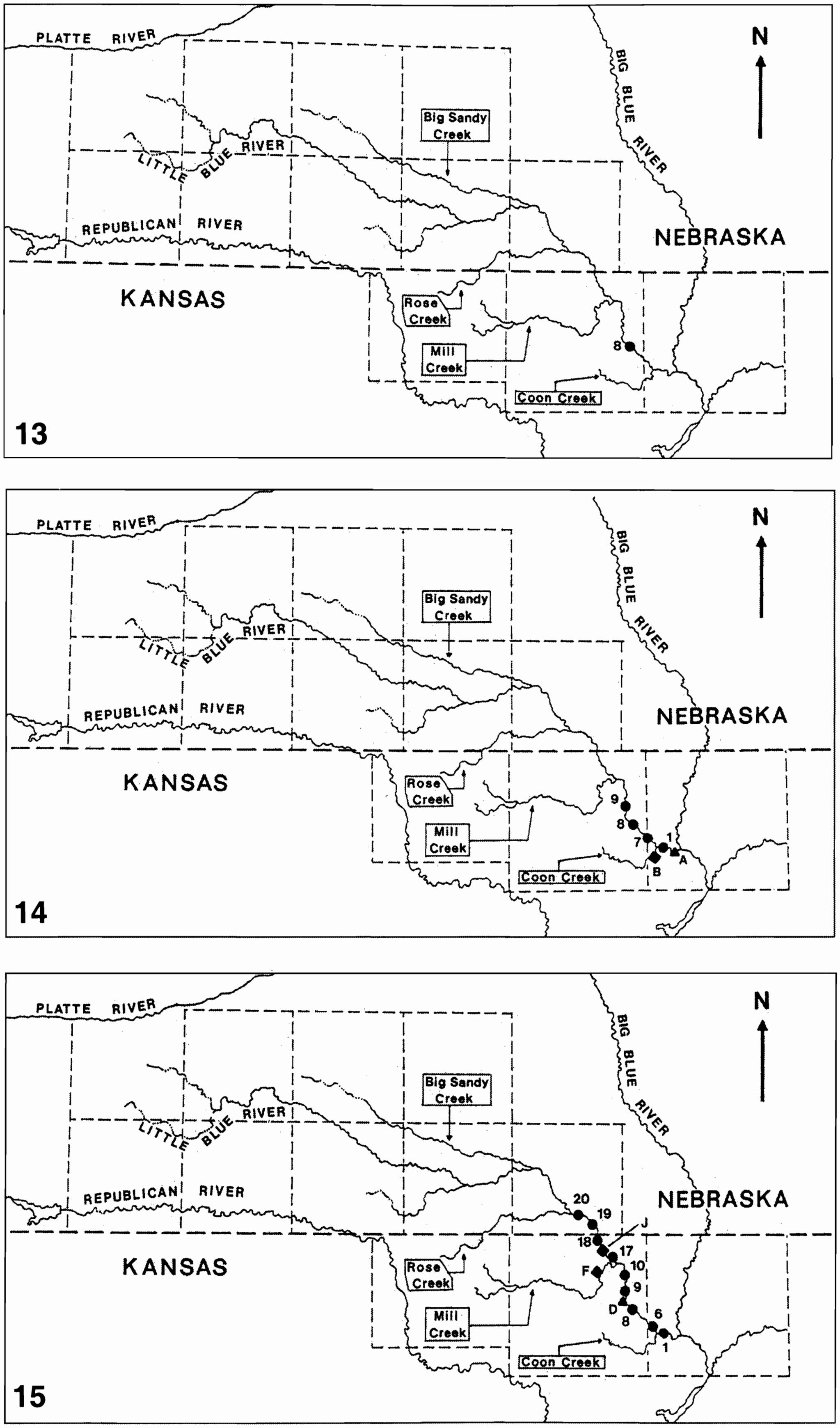


Figure 13–15. Distributions of **13**. *Obovaria olivaria*, **14**. *Potamilus alatus*, **15**. *Potamilus ohiensis*.

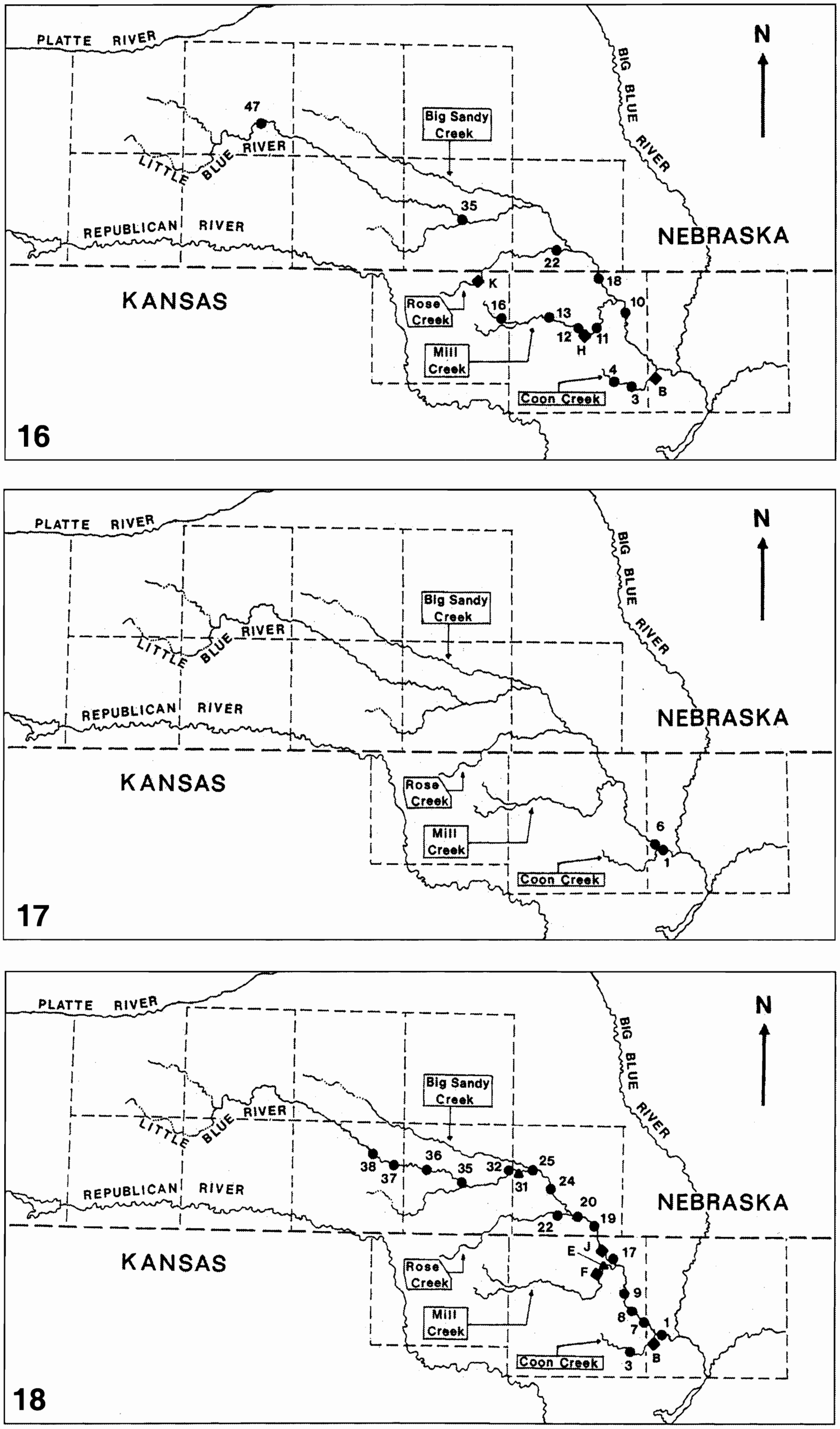
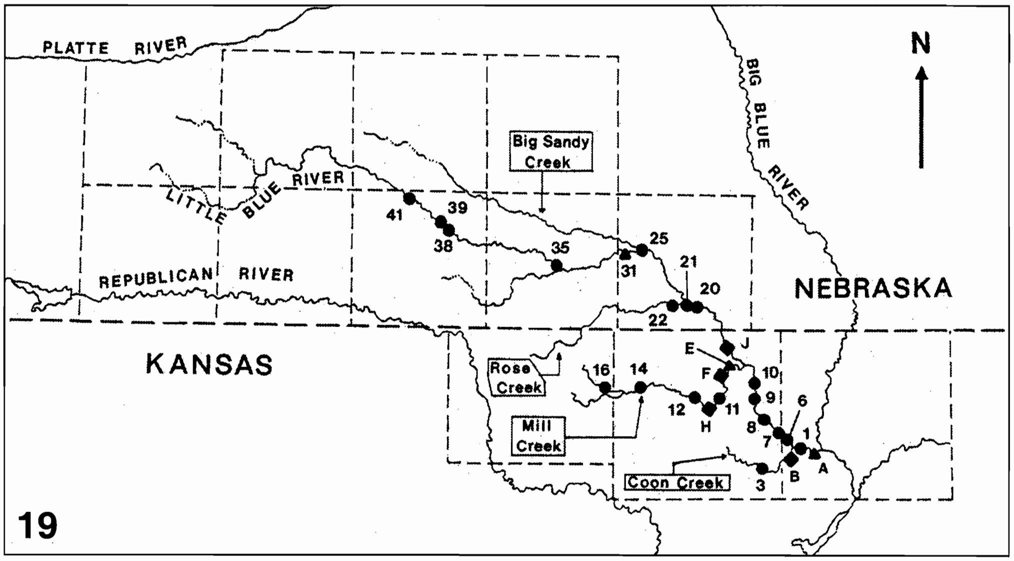
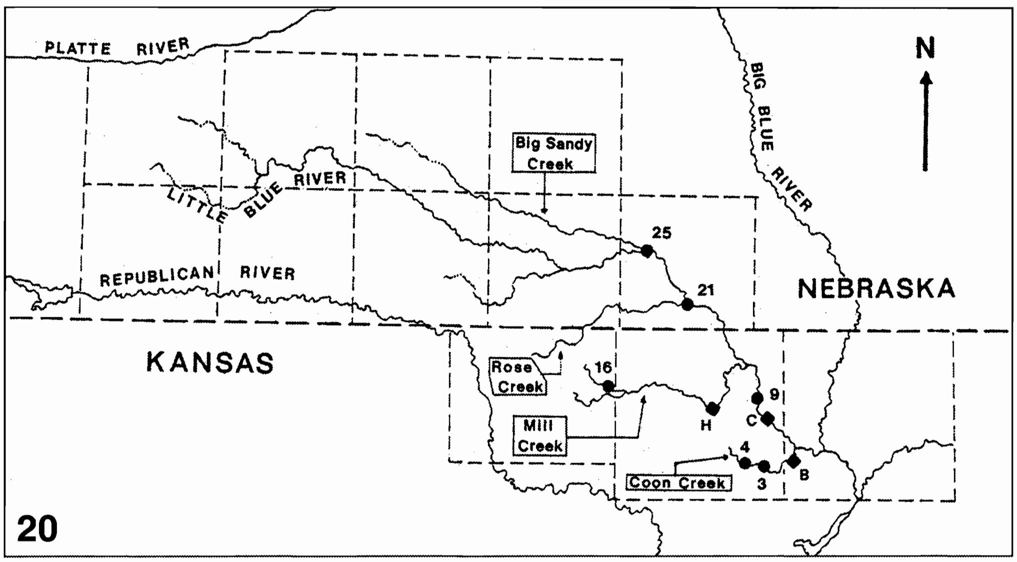
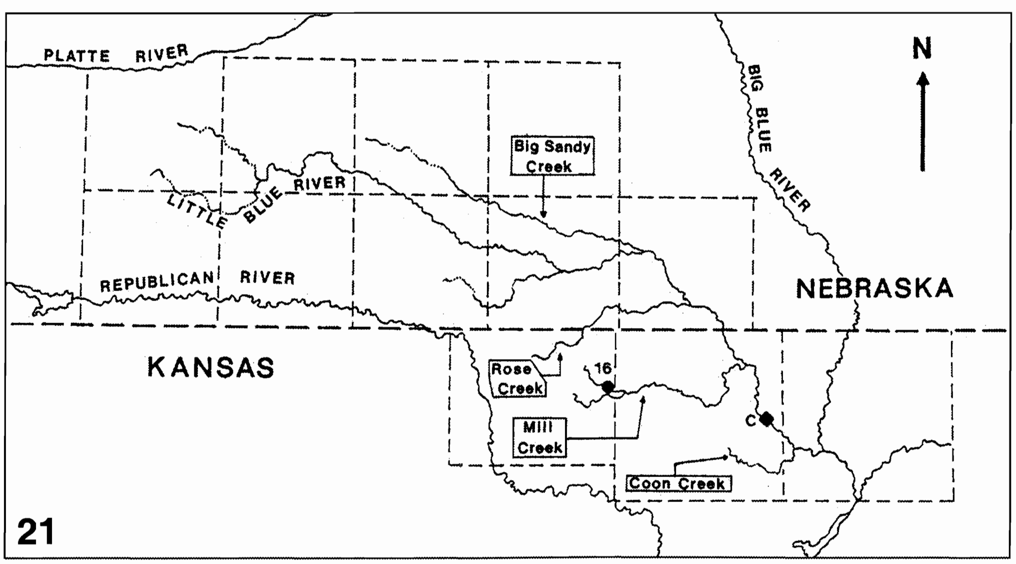


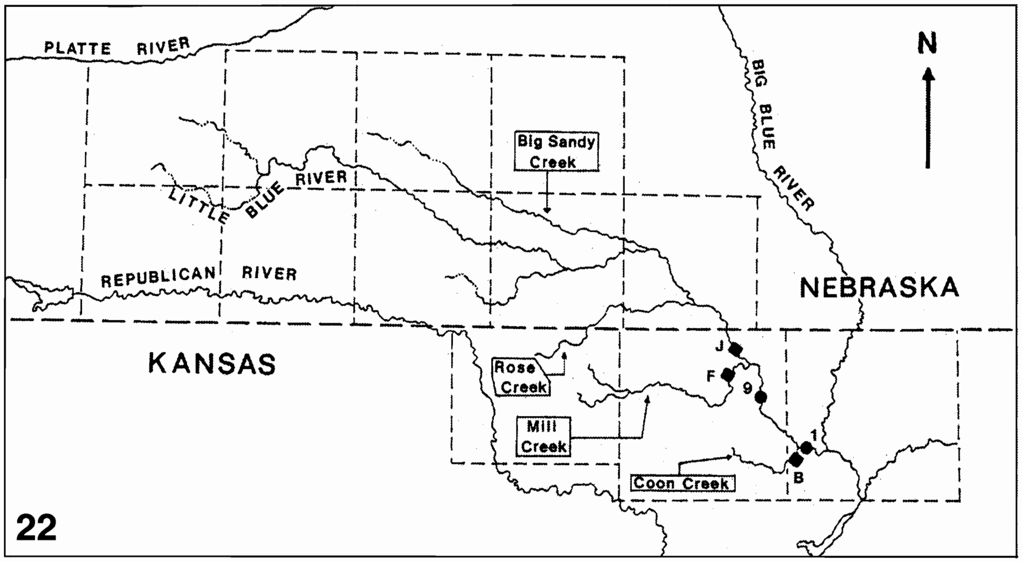
Figure 16–18. Distributions of **16**. *Pyganodon grandis*, **17**. *Quadrula fragosa*, **18**. *Quadrula pustulosa pustulosa*.

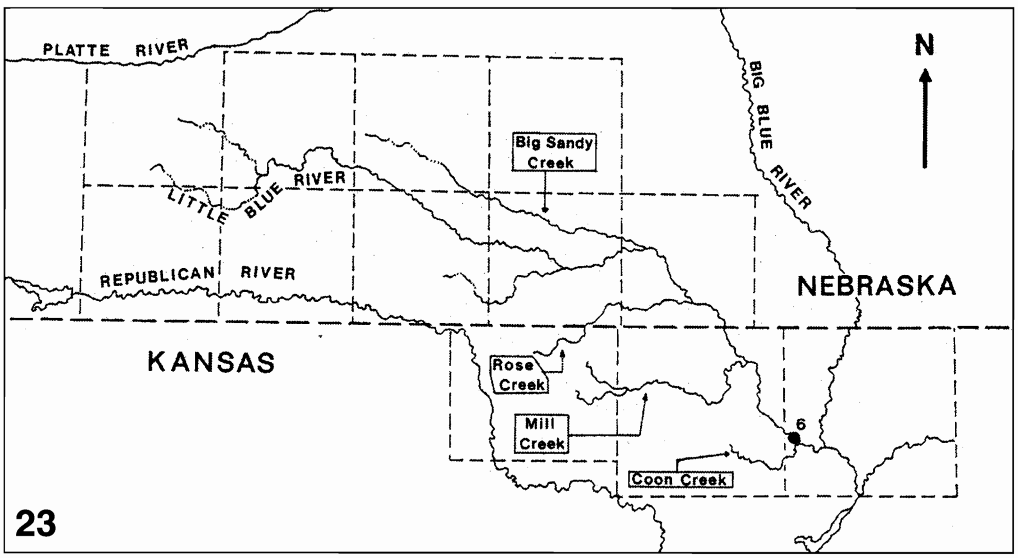






Figures 19–21. Distributions of **19**. *Quadrula quadrula*, **20**. *Strophitus undulatus*, **21**. *Toxolasma parvus*.





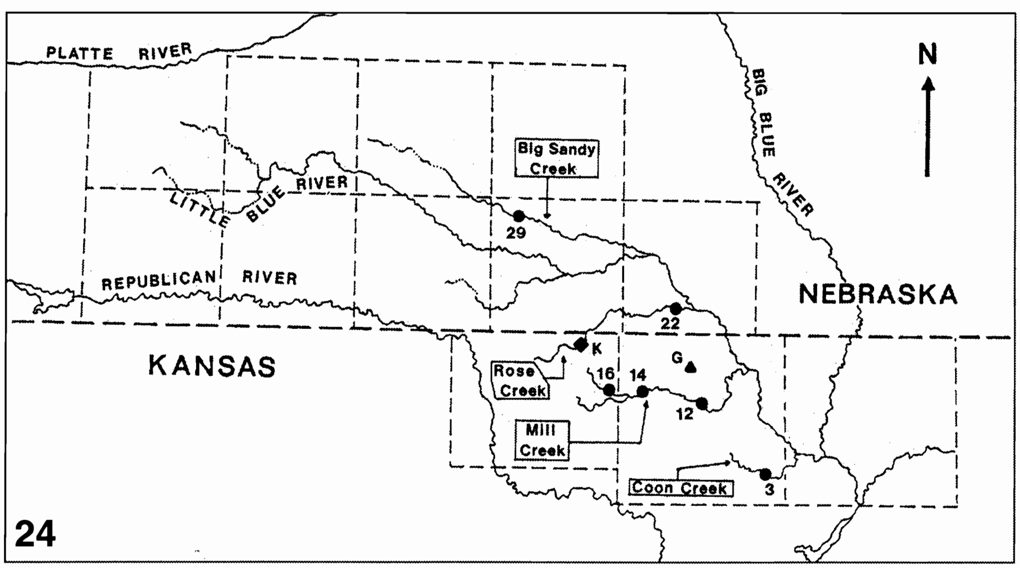


Figure 22–24. Distribution of **22**. *Tritogonia verrucosa*, **23**. *Truncilla truncata*, **24**. *Uniomerus tetralasmus*.

were present. Apparently, the lowered water levels in the river resulted in the introduction of cattle to the river bottom subsequent to 1972, and over a period of years these animals crushed and effectively destroyed almost all evidence of the unionid fauna that had formerly existed at this locale.

It is likely unionids are also adversely impacted by pollution in the form of chemicals washed in from surrounding agricultural fields, and from animal waste directly deposited in streams where streambeds have been opened to direct access by grazing animals. Pollution from chemicals is inferred from the agricultural usage of the basin's land. Animal waste was observed by the author in streambeds in the upper reaches of the Little Blue River. The detrimental effect of concentrated animal waste in streams has been documented (Prophet 1967, Prophet and Edwards 1973).

The combined impact of all these environmental stressors would be very damaging to the unionid fauna of any stream. It is likely the effect would be magnified on populations located at the very edge of their natural distributions as are those of the Little Blue Basin.

CONCLUSION

In this survey, the historic bivalve fauna of the Little Blue Basin was determined to have consisted of at least 22 species. The near absence of early collection activities in the region coupled with the destruction of relict specimens due to grazing activities probably precludes a complete inventory of all the species once present as well as a thorough documentation of their presettlement ranges. It is likely the distributions of some species once extended further to the west than is documented in this study. Since the settlement and agricultural development of the area, unionids have been negatively impacted by erosion, siltation, grazing of livestock, pollution, and the lowering of water tables and river levels resulting from withdrawal of subsurface and surface water for irrigation of croplands. It is possible that half of the documented unionid fauna of the Little Blue Basin has been lost and the ranges of most of the remaining species are in severe decline.

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