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A Survey and Analysis of the Unionid Mollusks of the Elkhorn River Basin, Nebraska

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A SURVEY AND ANALYSIS OF THE UNIONID MOLLUSKS OF THE ELKHORN RIVER BASIN, NEBRASKA

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ABSTRACT

Surveys in the Elkhorn River Basin between 1972 and 1994 documented a unionid fauna of 28 taxa. Two additional taxa were documented by museum records, bringing the total to 30 confirmed for the region. In recent collections only eleven species were found as live specimens or fresh shells, suggesting the possible loss of as much as 63% of the documented fauna of the Basin. Biological diversity was once greatest in the eastern portion of the Basin, reflecting the greater variety of habitats in this region. At present, the greatest diversity appears to be found in the western portion. This reversal of biologic diversity probably reflects the extent of habitat degradation in the eastern portion. *Arcidens confragosus*, *Lampsilis teres* f. *teres*, and *Obovaria olivaria* are newly reported for Nebraska.

† † †

The unionid fauna of the Elkhorn Basin in particular and of Nebraska in general has been relatively unstudied. At the inception of this study, the sole published reference on the bivalve mollusks of the Elkhorn Basin was a species list for the Elkhorn in Aughey's (1877) study of the mollusks of Nebraska, in which he reported twenty-one taxa for the Basin. Recently, Clausen and Havlik (1994) recovered nine species from the Elkhorn River Basin during collection activities in 1993. These reports are discussed in detail later in this paper.

THE ELKHORN RIVER BASIN

The Elkhorn River Basin is the easternmost river basin in the Platte River drainage, and its confluence with the Platte River mainstem occurs less than 40 km above the Platte's juncture with the Missouri River. Draining about 18,000 km^2 in northeastern Nebraska (Fig. 1), the Elkhorn River is geographically the smallest of the three basins comprising the Platte River drainage in Nebraska. The rivers, streams, and lakes of the Elkhorn River Basin have been extensively impacted by agricultural development.

The Elkhorn River mainstem currently flows 455 kilometers from its source in the sand hills of Rock County to its mouth in Sarpy County (Bentall et al., 1971). The substrate of the Elkhorn River mainstem throughout its course consists primarily of sand, often shifting sand, a substrate unfavorable to unionids. The substrates of tributary streams, however, are variable and include stable sand, mud, clay, gravel, and combinations of all of these. The Elkhorn River and its tributaries have been subjected to extensive channelization, and 18.8% or 468 of the Basin's original 2494 stream kilometers have been eliminated by channelization (Bliss and Schainost, 1973). Approximately 153 stream kilometers have been lost from the Elkhorn mainstem, with much of the remaining loss due to the channelization of Logan Creek. Bentall et al. (1971) reports the loss of 129 of an original 241 stream kilometers due to the channelization of the lower portion of that stream.

GOALS

The primary goal of this study was to document the distributions of unionid mollusks in the Elkhorn River Basin and, to the extent possible, to identify and document any changes noted in the native fauna. Due to the general absence of documented records for the region, effort was focused not only upon the location of extant populations in the area, but also upon attempting to reconstruct the original fauna of the Basin. Encompassed within these general goals was the corollary objective of developing a model for the unionid distributions observed which could account for current distributions and any changes noted in the fauna.

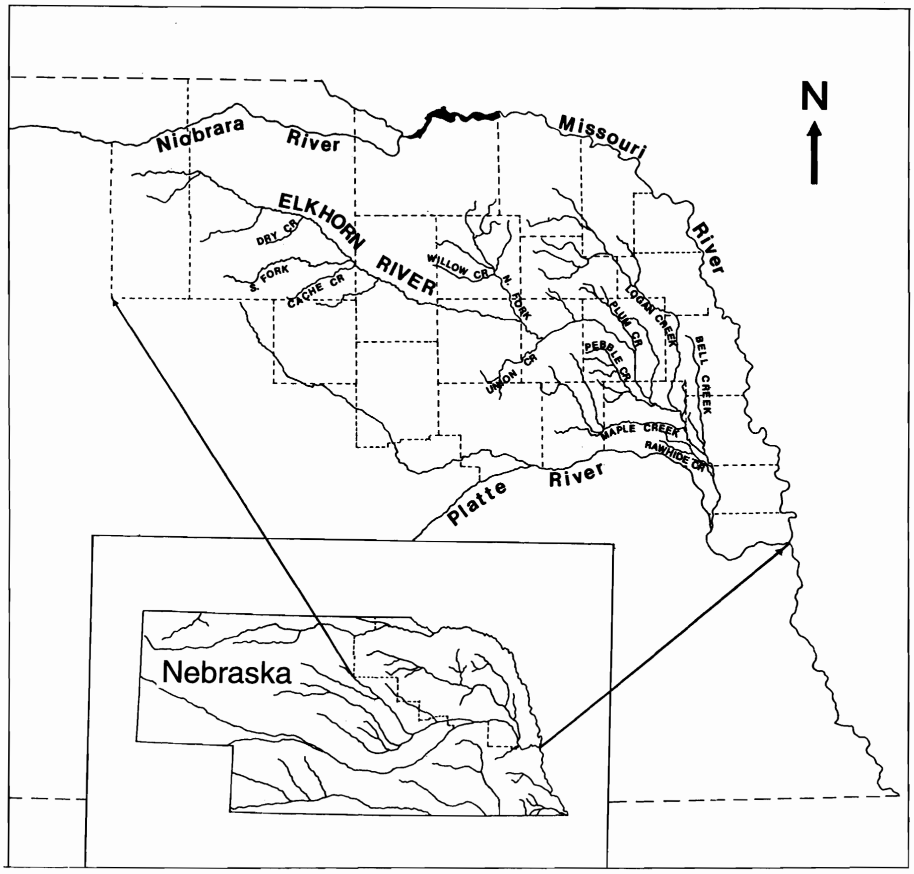


Figure 1. Counties of the Elkhorn River Basin in perspective.

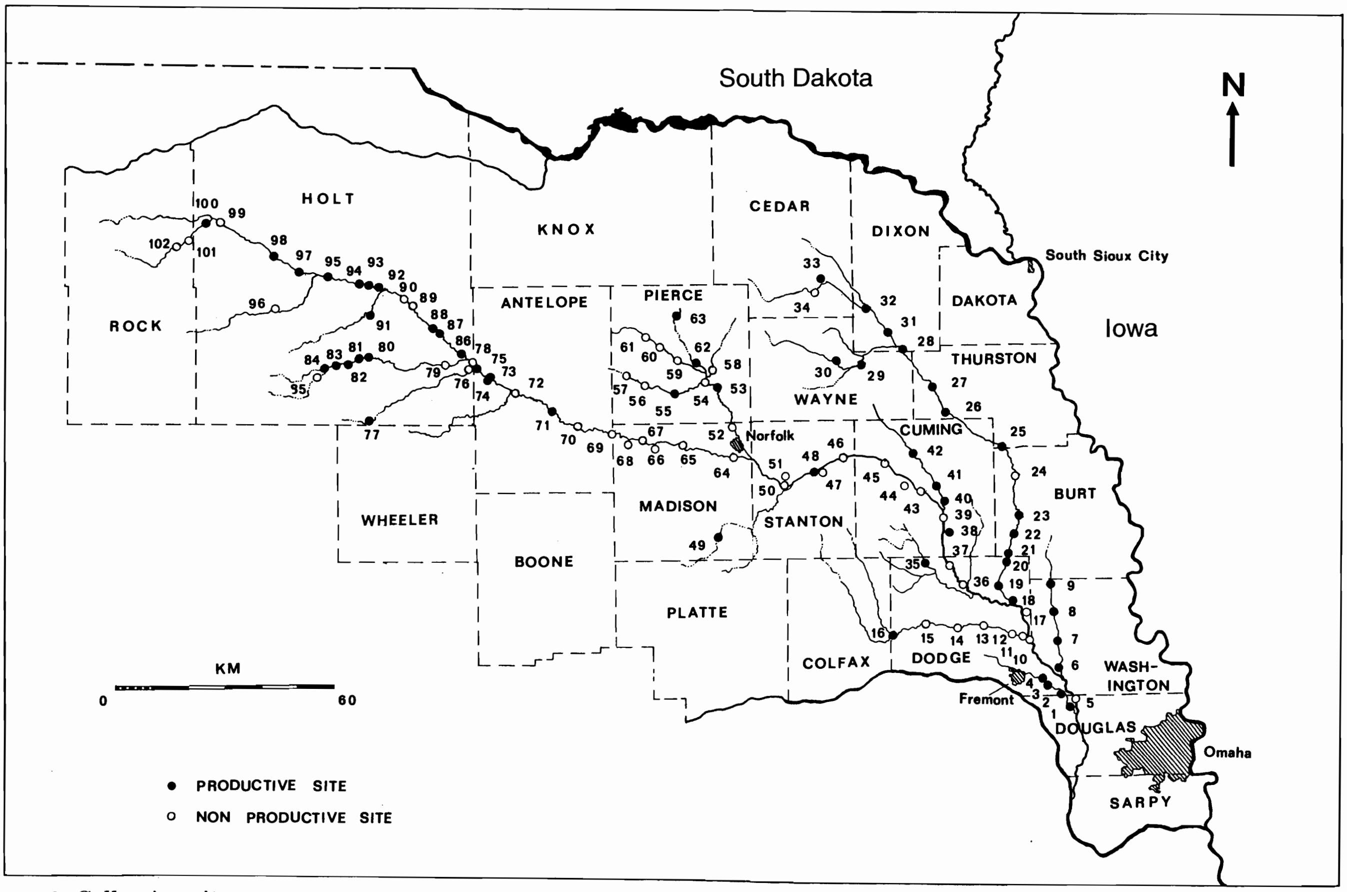


Figure 2. Collection sites.

METHODS

It was understood at the inception of the study that the general absence of published specific site records from the Basin would severely restrict the extent to which comparisons of the existing fauna could be made. To overcome this handicap, the following strategies were employed to reconstruct the original fauna of the region:

1. Local colleges and universities were contacted with the goal of locating early records from Nebraska.
2. Empty shells and even subfossilized or chalky shells were actively collected throughout the survey in an effort to identify taxa that might no longer be represented by living populations.
3. Local residents were questioned concerning the presence or former presence of unionid mollusks in area streams, and factors associated with any noted changes.
4. Dry sections of streams were examined in an effort to document the existence of former populations.
5. Tributaries were collected extensively with the goal of locating isolated populations which might have been extirpated from the Elkhorn mainstem.

Collecting took place from 1972 to 1994, but the majority of the activity occurred in 1976, 1981, and 1993-1994. In addition, a number of unionids collected from the region in 1969, encompassing seven collection sites, were donated to the writer. Collections were made by hand or with the aid of a garden rake, generally under low-water conditions. An attempt was made to collect every 8 to 10 miles along all rivers and major tributaries in the region. Collecting sites were determined primarily by access and by collecting conditions. All potential habitats in the study area were sampled during the survey. Collection activities were conducted at numerous sites in the Elkhorn River mainstem and its major tributaries. In addition, small creeks, ponds, oxbow lakes, ditches, and portions of dry creeks were sampled in an attempt to gain a full understanding of past and present bivalve distributions in the Elkhorn Basin.

Conditions at collection sites were recorded in field notebooks, with particular attention given to conditions which appeared to impact unionids. In addition, pertinent conversations with local residents were also documented. All collection sites were marked on USGS 1:250,000 scale maps. Collection sheets were prepared for each productive site and specimens were identified by species and condition and posted to the appropriate sheet. Living specimens were generally retained as vouchers only when fresh shells were unavailable at a given collection site. Therefore, relatively few live specimens were retained during the study. All specimens collected during this study were deposited in the Ohio State University Museum of Biological Diversity in Columbus, Ohio.

In 1976, a questionnaire was mailed to all conservation officers of the Nebraska Game and Parks Commission requesting locations of unionid populations noted by conservation officers in their areas. All responses were investigated. In addition, in 1981, area colleges and universities were contacted in an effort to locate unpublished records of bivalve mollusks in the state. Each institution responding affirmatively to this inquiry was visited, and any related specimens were examined and identified by the author.

Names reported by Aughey (1877) were converted into current nomenclature through use of Burch's (1975) synonymy, supplemented by the aid of David H. Stansbery of the Ohio State University Museum of Biological Diversity. All identifications of specimens collected prior to 1982 were corroborated by David H. Stansbery and agree with the records of that institution. Post-1982 records have been identified by the author. The nomenclature employed in this paper is that utilized by the Ohio State University Museum of Biological Diversity.

RESULTS

A total of 102 collection sites were sampled in this survey of the Elkhorn River Basin (Fig. 2). A number of localities on the upper portion of the Elkhorn River mainstem were sampled as many as three times over the course of the study. Unionid mollusks were recovered at 56 sites or 55 per cent of the locations sampled. Twenty-eight taxa were collected from these localities (Table 1), and two more were confirmed for the region through records located in museum collections. A specimen of *Alasmidonta marginata* Say, 1818 from the Elkhorn was located in the collections at the University of Nebraska State Museum and examined by the author. A specimen of *Lampsilis higginsi* (Lea, 1857) was previously located at the National Museum of Natural History and the identification verified by Havlik (1980).

Only eight of the twenty-eight species collected during survey activities were collected live. New live records for two species, *Anodontoides ferussacianus* and *Lampsilis teres* f. *teres*, were added to those reported by Clausen and Havlik (1994) for the Elkhorn River Basin. The latter is also a new record for Nebraska. Fresh empty shells of one additional unionid, *Toxolasma parvus*, were recovered from an oxbow of the Elkhorn

Table 1. Unionid molluscs collected from the Elkhorn River Basin by collection site. See Table 2 for complete names and citations. L = live; F = fresh shell; D = dry recent shell; WD = weathered dry shell; S = subfossil or chalky shell.

	Elkhorn River mainstem													
Taxa[1] Coll. Site:	**48**	**71**	**74**	**75**	**86**	**87**	**88**	**92**	**93**	**94**	**95**	**97**	**98**	**100**
1. *Anodonta imbecillis*	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2. *Anodonta g. grandis*	–	–	L	–	–	D	D	D	–	–	L	–	WD	D
3. *Anodontoides ferussacianus*	–	L	L	–	–	–	–	–	WD	–	–	L	D	L
4. *Strophitus u. undulatus*	–	–	–	–	–	–	–	–	–	–	–	–	–	–
5. *Arcidens confragosus*	–	–	–	–	–	–	–	–	–	–	–	–	–	–
6. *Lasmigona complanata*	–	–	–	–	–	–	–	D	–	–	–	–	WD	L
7. *Lasmigona compressa*	–	–	–	–	–	–	–	–	–	–	–	–	–	–
8. *Tritogonia verrucosa*	–	–	–	–	–	–	–	–	–	–	–	–	–	–
9. *Quadrula quadrula*	–	–	–	–	–	–	–	–	–	–	–	–	–	–
10. *Quadrula p. pustulosa*	–	–	–	–	–	–	–	–	WD	–	–	–	–	–
11. *Amblema p. plicata*	–	–	–	–	–	–	–	–	–	–	–	–	–	–
12. *Fusconaia flava*	–	–	–	–	–	–	–	–	–	–	–	–	–	–
13. *Uniomerus tetralasmus*	–	–	–	–	–	S	–	–	–	–	–	–	–	–
14. *Actinonaias ligamentina car.*	–	–	–	–	–	–	–	–	–	–	–	–	–	–
15. *Obovaria olivaria*	–	–	–	–	–	–	–	–	–	–	–	–	–	–
16. *Truncilla truncata*	–	–	–	–	–	–	–	–	–	–	–	–	–	–
17. *Truncilla donaciformis*	–	–	–	–	–	–	–	–	–	–	–	–	–	–
18. *Leptodea fragilis*	S	–	–	–	–	–	–	–	–	–	–	–	–	–
19. *Potamilus alatus*	–	–	–	–	–	–	–	–	–	–	–	–	–	–
20. *Potamilus purpuratus*	–	–	–	–	–	–	–	–	–	–	–	–	–	–
21. *Potamilus ohiensis*	–	–	–	–	–	–	–	–	–	–	–	–	–	–
22. *Toxolasma parvus*	–	–	–	–	–	–	–	–	–	–	–	–	–	–
23. *Ligumia recta*	–	–	–	–	–	–	–	–	–	–	–	–	–	–
24. *Ligumia subrostrata*	–	–	–	–	–	–	–	–	–	–	–	–	–	–
25. *Lampsilis teres* f. *teres*	–	–	–	–	–	–	–	–	–	–	–	–	–	–
26. *Lampsilis teres* f. *anodont.*	–	–	–	–	–	–	–	–	–	–	–	–	–	–
27. *Lampsilis radiata luteola*	–	–	–	–	–	–	–	–	–	–	–	–	–	–
28. *Lampsilis ventricosa*	–	–	WD	WD	D	D	L	D	L	D	L	L	D	L
Total species collected:	1	1	3	1	1	3	2	3	2	1	2	2	5	4
Year(s) collected:	1994	1980	1993 1980	1993	1980	1993	1993	1993	1993 1974 1969[2]	1969[2]	1974	1974	1993 1974 1969[2]	1993

[1]Arrangement of taxa follows Stansbery and Borror (1983).
[2]Collected by Mr. Bob Thomas and given to the author.

River. The remaining nineteen taxa were collected as empty shells in varying states of preservation. Five of these corroborate records first reported for the Elkhorn Basin by Aughey (1877). The remaining fourteen unionids have not been previously reported for the Elkhorn River Basin. Two of these records, *Arcidens confragosus* and *Obovaria olivaria*, are new records for the state of Nebraska.

Living unionids were most common in the upper Elkhorn Basin in Holt County and in sections of tributary creeks with good flow which had not been subjected to heavy siltation or intensive grazing. Live populations are present and even locally abundant in Elkhorn tributaries in the lower portion of the Basin. Bivalves were infrequent in the Elkhorn River mainstem below the Holt County line. Live unionids were, however, collected from the Elkhorn River mainstem and backwaters in Antelope County in 1981. The recent statement by Clausen and Havlik (1994) that unionids are not present below the Holt County line either represents a recent change in the molluscan populations or the difficulty of locating scattered individuals under the generally high water conditions which prevailed in the Elkhorn Basin in 1993, when their survey was conducted.

Species diversity at productive collection sites ranged from 1 to 19 species per site with an average of 3.2. The greatest diversity was found in the Logan Creek Basin in the northeastern Elkhorn River Basin, with an average of 5.3 species per site. Much of this diversity was concentrated at collection sites 19 and 28, with 19 and 14 species respectively included in the

Table 1. Continued.

	Elkhorn tributaries													
	Rawhide Creek				**Bell Creek**				**Maple Creek**	**Logan Creek**				
Coll.site:	**1**	**2**	**3**	**4**	**6**	**7**	**8**	**9**	**16**	**18**	**19**	**20**	**21**	**22**
1.	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2.	–	L	L	L	–	–	–	–	S	WD	–	–	–	–
3.	–	–	–	–	–	–	–	–	S	–	–	–	–	–
4.	–	–	–	–	WD	–	–	–	S	–	WD	–	–	S
5.	–	–	–	–	–	–	–	–	–	–	WD	WD	–	–
6.	L	L	D	–	–	L	L	WD	–	–	L	–	–	L
7.	–	–	–	–	–	–	–	–	–	–	WD	–	–	–
8.	–	–	–	–	–	–	–	–	–	–	WD	S	–	–
9.	L	L	L	–	L	L	L	L	WD	–	L	S	–	L
10.	–	–	–	–	–	–	–	–	–	–	WD	–	–	–
11.	–	–	–	–	–	–	–	–	–	–	WD	–	–	–
12.	–	–	–	–	WD	–	–	–	–	–	WD	S	S	–
13.	–	L	L	–	L	–	–	–	WD	–	–	–	–	–
14.	–	–	–	–	–	–	–	–	–	–	–	–	–	–
15.	–	–	–	–	–	–	–	–	–	–	–	WD	–	–
16.	–	–	–	–	–	–	–	–	–	–	WD	–	–	–
17.	–	–	–	–	–	–	–	–	–	–	WD	–	–	–
18.	–	–	–	–	–	–	–	–	–	–	WD	–	S	–
19.	–	–	–	–	–	–	–	–	–	–	WD	–	–	–
20.	–	–	–	–	–	–	–	–	–	–	–	–	–	–
21.	–	–	–	–	–	–	–	–	–	–	WD	–	–	–
22.	–	–	WD	–	–	–	–	–	WD	–	–	–	–	–
23.	–	–	–	–	–	–	–	–	–	–	WD	–	–	–
24.	–	–	–	–	–	–	–	–	–	–	WD	–	–	–
25.	–	–	–	–	WD	–	–	–	–	–	L	–	–	–
26.	–	WD	–	–	–	–	–	–	–	–	–	–	–	–
27.	–	–	–	–	WD	–	–	–	–	–	WD	–	S	–
28.	–	–	–	–	–	–	–	–	–	–	WD	S	–	–
Tot. spp.:	2	5	5	1	6	2	2	2	6	1	19	6	3	3
Year(s):	1981	1976	1994	1994	1981	1994	1981	1982	1981	1976	1981 1976	1981	1982	1981

collections from those sites. If these two collection sites are excluded from the computation of the average diversity of the Logan Creek drainage, the average for that system falls to 3.4 species per site.

The nineteen taxa collected only as empty shells were recovered primarily from the eastern portion of the Elkhorn Basin. Only three of these have been collected above the Logan Creek drainage. Two species, *Quadrula pustulosa pustulosa* and *Leptodea fragilis*, were recovered above this point in this survey. A third species, *Ligumia subrostrata*, was restricted to one site on Logan Creek in this study, but a single live specimen was collected by Clausen and Havlik (1994) in Holt County, confirming a wider distribution for that species.

The concentration of biological diversity in the eastern portion of the Elkhorn Basin was one of the most significant results of this survey. Within this region ranges were often extremely limited. Of the sixteen taxa confined to the eastern portion of the Elkhorn, only three were collected from more than one tributary drainage. *Strophitus undulatus undulatus* was the most widespread of these, with records on Bell, Maple, and Logan creeks. Two taxa, *Fusconaia flava* and *Lampsilis radiata luteola* were collected from both Bell and Logan creeks. The remaining taxa were restricted in their distributions to a single creek.

Species frequency was low for most species in the Elkhorn Basin (Table 2), and this was especially true for those species with ranges restricted to the lower Elkhorn Basin. *Lampsilis teres anodontoides* was collected only from Rawhide Creek and then only at site 2. Twelve species were confined to the Logan Creek drainage, and eight of these were located at only one collection site each, indicating their rarity in the

Table 1. Continued.

	Elkhorn tributaries														
	Logan Creek, continued										Pebble Cr.	Oxbow Lk.	Plum Creek		
Coll. site:	**23**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**35**	**38**	**40**	**41**	**42**
1.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2.	–	–	–	–	WD	S	WD	S	–	S	–	L	S	S	–
3.	–	–	–	–	WD	–	S	–	–	–	–	–	–	S	S
4.	WD	–	S	–	WD	–	–	S	–	–	–	–	–	–	–
5.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
6.	L	–	–	–	WD	S	WD	S	S	–	–	–	WD	D	–
7.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
8.	–	–	–	–	WD	–	–	–	–	–	–	–	–	–	–
9.	L	L	–	WD	WD	–	–	S	–	–	WD	–	–	–	WD
10.	–	–	–	–	WD	–	–	S	–	–	–	–	–	–	–
11.	–	–	S	WD	WD	–	–	–	–	–	–	–	–	–	–
12.	WD	WD	–	WD	WD	S	WD	S	–	–	–	–	–	–	–
13.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
14.	–	–	–	WD	–	–	–	–	–	–	–	–	–	–	–
15.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
16.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
17.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
18.	–	–	–	–	WD	–	–	S	–	–	–	–	–	–	–
19.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
20.	–	–	–	–	–	S	–	–	–	–	–	–	–	–	–
21.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
22.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
23.	–	–	–	–	WD	–	–	–	–	–	–	–	–	–	–
24.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
25.	WD	L	–	–	WD	–	–	–	–	–	–	–	–	–	–
26.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
27.	–	–	–	WD	WD	–	–	–	–	–	–	–	–	–	–
28.	–	–	–	WD	WD	–	–	–	–	–	–	–	–	–	–
Tot. spp.:	5	3	2	6	14	4	4	7	1	1	1	1	2	3	2
Year(s):	1981	1981	1981	1981	1981	1981	1981	1981	1981	1981	1994	1974	1972	1976	1976

Elkhorn Basin. *Lasmigona compressa*, *Truncilla truncata*, *T. donaciformis*, *Potamilus alatus*, and *P. ohiensis* were collected only at site 19, which may have been the site of a mussel kill. *Obovaria olivaria* was collected only at site 20, and then only as a single weathered valve. *Actinonaias carinata ligamentina* and *Potamilus purpuratus* were collected solely at sites 27 and 29 respectively, and then only as subfossil or chalky valves. *Arcidens confragosus*, *Tritogonia verrucosa*, *Amblema plicata plicata*, and *Ligumia recta* were collected from multiple sites in the Logan Creek system.

It is probable that most of the nineteen taxa recovered as empty shells in this survey have been extirpated from the Elkhorn Basin. *Quadrula pustulosa pustulosa* and *Ligumia subrostrata* have been collected live within the Elkhorn Basin by Clausen and Havlik (1994). A number of species, though not collected as live or fresh empty shells, were represented by empty shells in relatively good condition. It is possible that these species still survive within the Elkhorn River Basin. Included in this category were *Arcidens confragosus*, *Fusconaia flava*, *Truncilla truncata*, and *Potamilus alatus*. The best preserved shells of all of these taxa were collected from site 19 on the lower portion of Logan Creek.

Distributions

The distributions of the taxa recovered in this survey are discussed in more detail below and are cross-referenced to the accompanying distribution maps. The arrangement of taxa follows Stansbery and Borror (1983). Darkened circles indicate collection sites at which evidence of a given taxon was recovered in the form of either a live specimen or an empty shell. Open circles indicate collection sites that did not produce records for a given taxon. All sites denoted by circles were collected in this study. Records recovered by

Table 1. Continued.

	Elkhorn tributaries												
	Union Cr.	N. Fork Elkhorn			Willow Cr.	Oxbow Lk.	Cache Cr.	South Fork Elkhorn					Dry Cr.
Coll. site:	**49**	**53**	**62**	**63**	**55**	**73**	**77**	**80**	**81**	**82**	**83**	**84**	**91**
1.	–	–	–	–	–	L	–	–	–	–	–	–	–
2.	L	–	L	–	–	L	–	WD	D	–	–	WD	–
3.	–	–	L	WD	–	–	L	L	D	S	WD	–	F
4.	–	–	–	–	–	–	–	–	–	–	–	–	–
5.	–	–	–	–	–	–	–	–	–	–	–	–	–
6.	WD	–	L	–	–	–	–	–	–	–	L	–	–
7.	–	–	–	–	–	–	–	–	–	–	–	–	–
8.	–	–	–	–	–	–	–	–	–	–	–	–	–
9.	D	–	–	–	–	–	–	–	–	–	–	–	–
10.	–	–	–	–	–	–	–	–	–	–	–	–	–
11.	–	–	–	–	–	–	–	–	–	–	–	–	–
12.	–	–	–	–	–	–	–	–	–	–	–	–	–
13.	WD	–	–	–	–	–	–	WD	–	–	–	–	–
14.	–	–	–	–	–	–	–	–	–	–	–	–	–
15.	–	–	–	–	–	–	–	–	–	–	–	–	–
16.	–	–	–	–	–	–	–	–	–	–	–	–	–
17.	–	–	–	–	–	–	–	–	–	–	–	–	–
18.	–	–	–	–	–	–	–	–	–	–	–	–	–
19.	–	–	–	–	–	–	–	–	–	–	–	–	–
20.	–	–	–	–	–	–	–	–	–	–	–	–	–
21.	–	–	–	–	–	–	–	–	–	–	–	–	–
22.	–	–	–	–	–	F	–	–	–	–	–	–	–
23.	–	–	–	–	–	–	–	–	–	–	–	–	–
24.	–	–	–	–	–	–	–	–	–	–	–	–	–
25.	–	–	–	–	–	–	–	–	–	–	–	–	–
26.	–	–	–	–	–	–	–	–	–	–	–	–	–
27.	–	–	–	–	–	–	–	–	–	–	–	–	–
28.	–	L	L	–	L	–	–	L	L	–	–	–	–
Tot. spp.:	4	1	4	1	1	3	1	4	3	1	2	1	1
Year(s):	1994	1976	1976	1993	1993	1980	1974 1969[2]	1993 1969[2]	1993	1993	1993	1993	1969[2]

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

Clausen and Havlik (1994) have been included on the distribution maps only for locales in which a given taxon was not recovered during this survey. In those instances the relevant collection sites have been denoted as darkened triangles on the associated maps.

Anodonta (*Utterbackia*) *imbecillis* was collected at only one site in this survey, an oxbow lake in Antelope County (Fig. 3). Live specimens were collected from a soft-mud-and-sand substrate in quiet water. Oxbow lakes are common in the Elkhorn Basin, but they were sampled infrequently in this survey due to access problems. It is thus probable that this species is significantly more common than is indicated from the results of this survey. *Anodonta imbecillis* was also collected by Clausen and Havlik (1994) in their survey of the Elkhorn Basin, though not as a live record. It has been reported in Nebraska in the Loup drainage (Hoke, 1994) as *Utterbackia imbecillis*, and as *A. imbecillis*, for the Platte River (Baxa, 1981; Freeman and Perkins, 1992; Lingle, 1992; Roedel, 1990).

Anodonta (*Pyganodon*) *grandis grandis* was the unionid most frequently recovered during the study (Fig. 4). It has been reported previously for the Elkhorn Basin (Aughey, 1877; Clausen and Havlik, 1994). In this study, it was found to be present in area creeks, oxbow lakes, and in the mainstem of the Elkhorn River in the upper reaches of the Basin in Holt County. Live specimens were taken from mud, mud and sand, and sand substrates in quiet water, and in slow to moderate current. Despite its abundance in this study, *A. g. grandis* is probably under-represented in survey results since, like *A. imbecillis*, it is often found in oxbow

Table 2. Species frequency of unionid mollusks collected from the Elkhorn River Basin.

Taxa[1]	Species frequency: Number of sites present	Species frequency: As a percent of productive sites[2]
Anodonta (Utterbackia) imbecillis Say, 1829	1	1.79
Anodonta (Pyganodon) grandis grandis Say , 1829	26	46.43
Anodontoides ferussacianus (Lea, 1834)	19	33.93
Strophitus undulatus undulatus (Say, 1817)	8	14.29
Arcidens confragosus (Say, 1829)	2	3.57
Lasmigona complanata (Barnes, 1823)	22	39.29
Lasmigona compressa (Lea, 1829)	1	1.79
Tritogonia verrucosa (Rafinesque, 1820)	3	5.36
Quadrula quadrula (Rafinesque, 1820)	19	33.93
Quadrula pustulosa pustulosa (Lea, 1831)	4	7.14
Amblema plicata plicata (Say, 1817)	4	7.14
Fusconaia flava (Rafinesque, 1820)	11	19.64
Uniomerus tetralasmus (Say, 1831)	7	12.50
Actinonaias ligamentina carinata (Barnes, 1823)	1	1.79
Obovaria olivaria (Rafinesque, 1820)	1	1.79
Truncilla truncata Rafinesque, 1820	1	1.79
Truncilla donaciformis (Lea, 1827)	1	1.79
Leptodea fragilis (Rafinesque, 1820)	5	8.93
Potamilus alatus (Say, 1817)	1	1.79
Potamilus purpuratus (Lamarck, 1819)	1	1.79
Potamilus ohiensis (Rafinesque, 1820)	1	1.79
Toxolasma parvus (Barnes, 1823)	3	5.36
Ligumia recta (Lamarck, 1819)	2	3.57
Ligumia subrostrata (Say, 1831)	1	1.79
Lampsilis teres f. *teres* (Rafinesque, 1820)	5	8.93
Lampsilis teres f. *anodontoides* (Lea, 1831)	1	1.79
Lampsilis radiata luteola (Lamarck, 1819)	5	8.93
Lampsilis ventricosa (Barnes, 1823)	21	37.50

[1]Arrangement of taxa follows Stansbery and Borror (1983).
[2]This value was calculated by dividing the number of sites present by the total number of productive collection sites (56) in this survey.

lakes, which were not sampled extensively. *Anodonta g. grandis* has been reported, as *Pyganodon grandis grandis*, from the Loup system (Hoke, 1994) in Nebraska, the Missouri River bordering Nebraska (Hoke, 1983), and the Platte River (Baxa, 1981; Freeman and Perkins, 1992; Lingle, 1992; Roedel, 1990).

Anodontoides ferussacianus was one of the most frequently encountered species in this survey (Fig. 5), though it has not been previously collected in the Elkhorn Basin. Live specimens were recovered from the upper Elkhorn River Basin in Antelope and Holt counties and from one site in the North Fork of the Elkhorn River. It was also collected from the eastern portion of the Elkhorn Basin, but these records were all empty shells, often highly weathered. *Anodontoides ferussacianus* is typically found in clear water in small streams (Oesch, 1984; Parmalee, 1967). The records recovered in the eastern portion of the Elkhorn River Basin conform to this pattern. Most of these streams, however, are now very turbid, suggesting a possible rationale for the absence of living populations in this area at the present time. This unionid has been collected in the Loup system (Hoke, 1994) and in the Platte drainage (Freeman and Perkins, 1992; Lingle, 1992; Roedel, 1990).

Though relatively widespread in the lower Elkhorn River Basin in this survey (Fig. 6), *Strophitus undulatus undulatus* has not been collected previously in the study area. Live specimens were not recovered in this survey. This mussel was recently reported to be abundant at one location on the Platte River (Roedel, 1990), but Freeman and Perkins (1992) were not able to corroborate this report definitively, though they did report the species for the Platte based upon a tentative identification of one valve. *Strophitus undulatus undulatus* bears a superficial resemblance to *Anodontoides ferussacianus*, and it is possible that the latter has been confused with *S. u. undulatus*. There are no other recent reports of this species in Nebraska. It has probably been extirpated from the Elkhorn Basin.

The recovery of specimens of *Arcidens confragosus* in this survey represents the first time this species has ever been reported for Nebraska. Empty shells of this unionid were collected from two sites along the lower portion of Logan Creek (Fig. 7). The shells of one specimen were in relatively good condition, suggesting that live animals may still reside in the collection area.

Lasmigona complanata was found throughout the Elkhorn River Basin (Fig. 8). It was present at more collection sites than any other bivalve with the exception of *Anodonta grandis grandis*, but it was usually not abundant when found. Live individuals were located in sand, mud, sandy mud, and mud and clay substrates in water ranging from a few centimeters to 0.8 meter in depth. It was collected in tributaries throughout the study region and was often found in current. In addition, several specimens in collections at Wayne State College came from oxbow lakes in Stanton and Cuming counties. *Lasmigona complanata* has also been collected from the Elkhorn by Clausen and Havlik (1994). Recent reports of this bivalve in Nebraska include collections in the Loup system (Hoke, 1994), the Missouri River (Hoke, 1983), and the Platte River (Freeman and Perkins, 1992; Lingle, 1992; Roedel, 1990).

The record for *Lasmigona compressa* represents the first report of this species in Nebraska in over a century. Aughey (1877) reported this bivalve as *Unio pressus* for the Nemaha River. It appears to be extremely rare in the Missouri River Basin. Murray and Leonard (1962) did not report this unionid for Kansas, and Oesch (1984) does not report it as occurring in Missouri. It has not previously been reported for the Elkhorn Basin. Represented at only one site (Fig. 9) as weathered empty shells, the probability of extant populations of *L. compressa* in the Elkhorn Basin is extremely doubtful.

The distribution of *Tritogonia verrucosa* in this study was confined to Logan Creek (Fig. 10). Specimens recovered in this study are the first records of this taxon in the Elkhorn Basin. The existence of live populations of this bivalve in the Elkhorn Basin is doubtful. *Tritogonia verrucosa* was formerly infrequent but widespread throughout eastern Nebraska. There are, however, no recent live records for this species anywhere in the interior of the state. It has been reported for the Missouri River bordering Nebraska by Hoke (1983).

Quadrula quadrula was first reported for the Elkhorn by Aughey (1877). Though it was categorized as extremely rare by Clausen and Havlik (1994), it was, in this study, one of the most common bivalves collected in the Elkhorn Basin (Fig. 11). Live specimens in this survey were confined to the eastern portion of the Elkhorn Basin. When live populations were present, this bivalve was often either the most abundant species or the only species at a collection site. The upstream face of a small beaver dam on the lower portion of Bell Creek at site 6 contained more than twenty living individuals *in situ*. *Quadrula quadrula* was often found in slow to moderate current in a stable sand or firm mud bottom, but it also occurred in sand and gravel substrates. This bivalve is well distributed in Nebraska and has been reported for the Loup system (Hoke, 1994), the Missouri River (Hoke, 1983), and the Platte River (Freeman and Perkins, 1992; Lingle, 1992; Roedel, 1990).

Specimens of *Quadrula pustulosa pustulosa* were recovered in good condition from site 19 on Logan Creek, and from site 93 in the Elkhorn River in Holt county (Fig. 12). The specimens from site 19 were numerous, suggesting the presence of a recent population in the area. Though not recovered live in this survey a single live specimen was recovered from the upper Elkhorn by Clausen and Havlik (1994). *Quadrula p. pustulosa* was once widespread in eastern Nebraska, but its range has been drastically reduced. It appears less able to tolerate changed conditions than is *Q. quadrula*, and live specimens of the latter are frequently present when *Q. p. pustulosa* is represented solely by weathered valves.

Amblema plicata plicata was present only in the Logan Creek drainage in this survey (Fig. 13). The specimens obtained in this study constitute the first records for this species in the Elkhorn Basin. *Amblema p. plicata* was formerly present in eastern Nebraska. Though it is reported to be highly tolerant to pollution (Oesch, 1984), there are no recent reports of live populations in the state. It has probably been extirpated from the Elkhorn Basin.

Fusconaia flava was first reported for the Elkhorn River by Aughey (1877). The collection of specimens in this survey supports his report. Though well represented in survey collections (Fig. 14), *F. flava* was not found live at any collection site. Specimens collected at site 19 were both numerous and in relatively good condition, raising the possibility of the existence of an extant population in the vicinity. This bivalve was once common and widespread in eastern Nebraska, but no recent live specimens have been collected in the state. Parmalee (1967) has attributed siltation as the cause of its extermination from some rivers in Illinois.

Live specimens of *Uniomerus tetralasmus* (Fig. 15) were recovered from the lower Elkhorn River Basin. This species was collected live from mud, mud and sand, and mud and gravel substrates in shallow water with slow current. *Uniomerus tetralasmus* has recently been reported for the Elkhorn Basin (Clausen and Havlik, 1994), the Loup system (Hoke, 1994), and for the Platte (Freeman and Perkins, 1992; Lingle, 1992; Roedel, 1990).

Actinonaias ligamentina carinata was represented in survey collections by a single fragmentary subfossil valve collected from one site (Fig. 16). This unionid has not previously been reported for the Elkhorn Basin. The presence of extant populations of *A. l. carinata* in the Elkhorn Basin is extremely doubtful, and it has probably been extirpated from the region.

A single weathered valve of *Obovaria olivaria* was collected at one site on Logan Creek in this study (Fig. 17). This taxon has not been previously reported for the Elkhorn Basin or from Nebraska. *Obovaria olivaria* has probably been extirpated from the Elkhorn Basin.

Specimens of *Truncilla truncata* and *T. donaciformis* were recovered from only one site in the Elkhorn Basin (Fig. 9). Specimens of *T. truncata* were numerous and in relatively good condition, suggesting the possibility of the presence of a live population in the vicinity. Both of these taxa are new records for the Elkhorn River Basin. Live specimens have not been collected recently in the interior of the state, but both species have been recovered from the Missouri River along the Nebraska border with South Dakota (Hoke, 1983).

Empty shells of *Leptodea fragilis* were collected from five collection sites in the eastern portion of the Elkhorn Basin in this study (Fig. 18). It has previously been reported for the Elkhorn by Aughey (1877) and by Clausen and Havlik (1994). The absence of live records for this unionid is somewhat surprising since it is one of the most common bivalves found in the Missouri River along the Nebraska border (Hoke, 1983) but is consistent with recent records from the Platte River, where it is present but not common (Freeman and Perkins, 1992; Lingle, 1992; Roedel, 1990).

Potamilus alatus was collected in this study at only one site (Fig. 9). It was originally reported for the Elkhorn by Aughey (1877). One of the specimens recovered in this study may have been fairly recent in origin. This bivalve has been reported in the Platte Valley from the Schramm Aquarium ponds, an artificial habitat, by Freeman and Perkins (1992). It has recently been collected live in a natural habitat, the Missouri River, along the Nebraska-South Dakota border (Hoke, 1983).

Specimens of *Potamilus purpuratus* collected in this study document this species in the Elkhorn drainage for the first time (Fig. 19). Since this bivalve was represented solely by subfossilized or chalky valves, the presence in the Elkhorn Basin of an extant population is highly doubtful.

Potamilus ohiensis was limited to only one site in this study (Fig. 9). This bivalve has not been reported previously for the Elkhorn Basin by any source. *Potamilus ohiensis* is one of the few unionids that are silt tolerant, and its scarcity in this study is surprising. It has been reported in Nebraska for the Loup River drainage (Hoke, 1994), the Missouri River (Hoke 1983), and the Platte River (Freeman and Perkins, 1992; Lingle, 1992; Roedel, 1990).

The records for *Toxolasma parvus* collected in this study corroborated Aughey's (1877) report of this species in the Elkhorn Basin (Fig. 20). Fresh empty shells of *T. parvus* were collected from an oxbow of the Elkhorn River in Antelope county, indicating the presence of a live population. *Toxolasma parvus* appears typically in a mud or mud and sand substrate in quiet water or in slow current. It is probably more abundant than the results of this survey suggest. This bivalve is the smallest unionid found in Nebraska and is thus difficult to collect. In addition, oxbow lakes appear to be one of its common habitats, and this habitat was not sampled extensively in this survey.

Specimens of *Ligumia recta* collected in this survey constitute the first report of this species in the Elkhorn Basin. Records collected were weathered and were geographically confined to Logan Creek (Fig. 21). *Ligumia recta* was formerly widespread in eastern Nebraska, but no extant populations have been located within the state in recent years. It probably has been extirpated from the Basin.

Ligumia subrostrata was first reported by Aughey (1877) for the Elkhorn Basin. In this survey its distribution was limited to a single site on Logan Creek (Fig. 22). The only other report of this species is a single live specimen collected on the upper Elkhorn by Clausen and Havlik (1994). No additional recent live records of this species have been reported elsewhere in the state. It is extremely rare and should be considered endangered in Nebraska.

Lampsilis teres f. *teres* (Fig. 23) was collected live at two locations in Logan Creek, and empty shells were found at three additional locations on Logan and Bell creeks in the eastern portion of the Elkhorn Basin.

Live specimens were found in a stable sand substrate in current in 20 to 60 centimeters of water. These records constitute the first documentation of this form of the species in Nebraska. The record for *Lampsilis teres* f. *anodontoides* collected from Bell Creek in this survey (Fig. 24) confirmed the report by Aughey (1877).

Lampsilis radiata luteola was recovered in this study solely from collection sites within the lower Elkhorn Basin (Fig. 25). It was first documented for the Elkhorn Basin in this survey. The distribution of this bivalve in Nebraska has been drastically reduced in recent years, and live populations are extremely rare in Nebraska. There is no evidence at present to suggest that extant populations of *L. r. luteola* currently survive in the Elkhorn Basin.

The third-most-frequently encountered unionid in this survey was *Lampsilis ventricosa* (Fig. 26). Living populations were confined to portions of the upper Elkhorn River Basin in Holt County, and some scattered populations in the North Fork Elkhorn River Basin. Where living populations were located, they usually were the most abundant species present. Live individuals were found in sand, sand and mud, and mud substrates at depths ranging from a few centimeters to a meter, and were generally located in slow to moderate current. Several specimens at site 88 were collected from an oxbow of the Elkhorn River which was still partially connected to the river. Live populations appear to be absent from the lower portion of the Basin at the present time. The recovery of empty shells from Logan Creek, however, indicates this has not always been true. *Lampsilis ventricosa* has been previously reported for the Elkhorn Basin (Aughey, 1877; Clausen and Havlik, 1994). Scattered live specimens of this bivalve have been collected by the writer in eastern Nebraska, but its range in the state has been greatly reduced. The populations of *L. ventricosa* in the upper Elkhorn Basin may be the only reproducing populations remaining in the state. As such, they should be protected and closely monitored.

LITERATURE REVIEW AND DISCUSSION

Aughey (1877) reported 21 taxa from the Elkhorn River Basin, 20 from the Elkhorn and an additional taxon, *Quadrula cylindrica*, from Logan Creek (Table 3). Since *Unio cornutus* (Barnes) and *Unio phillipsi* (Conrad) are considered synonyms for *Obliquaria reflexa*, his species list for the Basin includes only twenty valid modern taxa. Ten of Aughey's records were confirmed for the Elkhorn River Basin in this study as noted on Table 3. Nine were confirmed through records collected during the survey. A final species, *Alasmidonta marginata*, was confirmed through examination of specimens at the University of Nebraska State Museum.

At least three of Aughey's remaining taxa are probably misidentified based upon known distributional ranges. Burch (1975) reports the distributional range of *Epioblasma flexuosa* as the Ohio River drainage, and that of *Actinonaias pectorosa* as the Tennessee and Cumberland drainages. The range for *Elliptio complanata* has been reported as the "Apalachicola River system; Altamaha River system of Georgia north to St. Lawrence River system of Canada and in the Interior Basin west to Lake Superior and parts of the Hudson Bay drainage" (Burch, 1975).

The appropriate disposition of the seven remaining taxa reported by Aughey is less clear. *Anodonta suborbiculata* has recently been collected from the Missouri River along the Nebraska border (Hoke, 1983). Oesch (1984) reports westernmost Missouri records for five of Aughey's taxa as follows: *Cumberlandia monodonta*, Osage River in central and west central Missouri; *Quadrula metanevra*, Grand River of northwestern Missouri; *Pleurobema sintoxia*, Lamine River, central Missouri; and *Obliquaria reflexa*, northwestern Missouri. Two of the taxa, *Quadrula cylindrica* and *Potamilus capax*, have not been reported within the Missouri River Basin by any other source.

A number of attempts were made to locate voucher specimens supporting Aughey's remaining seven taxa. Collections at the University of Nebraska State Museum, where Aughey was appointed Director of Cabinets in 1874, were examined, but only a few specimens were located dating from his tenure at that institution, and only one of them, that for *Alasmidonta marginata*, supported any of his published records for the Elkhorn River Basin. A specimen catalogued as *Unio capax* (Green), which may date from Aughey's tenure, was actually a female *Lampsilis ventricosa,* suggesting though not conclusively proving that Aughey's record for *Potamilus capax* was a misidentification. Until such time as they can be substantiated by documented voucher specimens, the seven remaining taxa reported by Aughey for the Elkhorn River Basin may best be considered as possible but unconfirmed taxa.

One last early record for the Elkhorn Basin was reported by Havlik (1980): a specimen of *Lampsilis higginsi* in the National Museum of Natural History collected by Bruner in 1891 near West Point, Nebraska. The validity of this record has been understandably questioned on distributional grounds by Havlik (1980). Havlik (1983) associates the presence of *L. higginsi* with populations of *Obovaria olivaria* and *Megalonaias nervosa* (Rafinesque, 1820). The documentation of *O. olivaria* for the Elkhorn Basin in this study strengthens the possibility that Bruner's record is correct. In the absence of any evidence to the contrary *Lampsilis*

Table 3. Taxa reported for the Elkhorn River Basin by Aughey (1877).

Aughey (1877)[1]	Currently recognized name
Unio anodontoides Lea	*Lampsilis teres* f. *anodontoides* (Lea, 1831)[2]
Unio alatus Say	*Potamilus alatus* (Say, 1817)[2]
Unio asperrimus Say	*Quadrula quadrula* (Rafinesque, 1820)[3]
Unio capax Green.	*Potamilus capax* (Green, 1832)
Unio complanatus Soland.	*Elliptio complanata* (Lightfoot, 1786)
Unio cornutus Bar.	*Obliquaria reflexa* Rafinesque, 1820
Unio cylindricus Say	*Quadrula cylindrica* (Say, 1817)
Unio foliatus Hild.	*Epioblasma flexuosa* (Rafinesque, 1820)
Unio gracilis Bar.	*Leptodea fragilis* (Rafinesque, 1820)[3]
Unio hebetatus Con.	*Fusconaia flava* (Rafinesque, 1820)[2]
Unio metanevra Raf.	*Quadrula metanevra* (Rafinesque, 1820)
Unio mississippiensis Con.	*Ligumia subrostrata* (Say, 1831)[3]
Unio monodontus Say	*Cumberlandia monodonta* (Say, 1829)
Unio ovatus Say	*Lampsilis ventricosa* (Barnes, 1823)[3]
Unio parvus Barnes	*Toxolasma parvus* (Barnes, 1823)[2]
Unio pectorosus Con.	*Actinonaias pectorosa* (Conrad, 1834)
Unio phillipsi Con.	*Obliquaria reflexa* Rafinesque, 1820
Unio solidus Lea	*Pleurobema sintoxia* (Rafinesque, 1820)
Margaritana marginata Say	*Alasmidonta marginata* Say, 1818[4]
Anodonta grandis Say	*Anodonta (Pyganodon) grandis grandis* Say, 1829[3]
Anodonta suborbiculata Say	*Anodonta suborbiculata* Say, 1831

[1]The names of taxa reported by Aughey (1877) are given unchanged from his original report and in his arrangement.
[2]Taxon confirmed through records collected in this study only.
[3]Taxon confirmed through records collected in both this study and that of Clausen and Havlik (1994).
[4]Taxon confirmed through examination of specimen at the University of Nebraska State Museum.

higginsi is considered, in this paper, to be confirmed for the Elkhorn Basin.

The sole previous recent study of the unionids of the Elkhorn Basin is that of Clausen and Havlik (1994). They reported the presence of nine bivalves based upon collections made in 1993 at 149 sites within the Elkhorn River Basin. All their records were confirmed in this study, and an additional nineteen taxa were recovered as well. Three of these represent living populations. Two species, *Anodontoides ferussacianus* and *Lampsilis teres* f. *teres*, were collected as live specimens, and a third, *Toxolasma parvus* was recovered as fresh empty shells. The remaining sixteen taxa were represented by empty shells in varying states of preservation. Table 4 summarizes the unionids that have been reported from all sources for the Elkhorn River Basin to date. The significant difference in findings between this study and that of Clausen and Havlik (1994) appears to be the product of a lack of collecting effort in Basin tributaries in the latter study, coupled with a focus in that study upon the lower reaches of tributaries sampled. The lower sections of tributaries in the eastern portion of the Basin are often subjected to heavy siltation and are generally devoid of unionid mollusks.

ANALYSIS OF DISTRIBUTIONAL DATA

No living unionids and only a single subfossil shell were recovered from the Elkhorn River below the Antelope County line in this survey. While these data generally support the conclusion of Clausen and Havlik (1994) that unionids are absent from the Elkhorn River below Holt County, this conclusion is at variance with statements by a number of local residents. Unionids are certainly not common in this region, but it may be too early to arrive at a definitive conclusion that they are entirely absent, especially with regard to the lower Elkhorn River. Field work conducted by Clausen and Havlik (1994) in this section of the river was conducted under high-water conditions in 1993, and this area was not extensively collected in the current study due to high-water conditions during fieldwork in 1993 and 1994. Due to the shifting-sand substrate now characteristic of the Elkhorn mainstem, it is probable that any live unionids are present only in backwaters of the river or in isolated microhabitats.

The general absence of bivalves from a river with a shifting-sand substrate is, in itself, not surprising. This

Table 4. Summary of unionid taxa reported for the Elkhorn River Basin in Nebraska. X = reported ; L = live ; F = fresh shell; WD = weathered dry shell; S = subfossil or chalky shell; M = museum specimen.

Status Taxa Reported[1]	Study Hoke (1994)	 Clausen & Havlik (1994)	 Aughey (1877)	Museum records	Total reported
Confirmed taxa					
Anodonta (Utterbackia) imbecillis Say, 1829	L	F	–	–	L
Anodonta (Pyganodon) grandis grandis Say, 1829	L	L	X	–	L
*Anodontoides ferussacianus (*Lea, 1834)	L	–	–	–	L
Strophitus undulatus undulatus (Say, 1817)	WD	–	–	–	WD
Alasmidonta marginata Say, 1818	–	–	X	M[2]	M
Arcidens confragosus (Say, 1829)	WD	–	–	–	WD
Lasmigona complanata (Barnes, 1823)	L	L	–	–	L
Lasmigona compressa (Lea, 1829)	WD	–	–	–	WD
Tritogonia verrucosa (Rafinesque, 1820)	WD	–	–	–	WD
Quadrula quadrula (Rafinesque, 1820)	L	L	X	–	L
Quadrula pustulosa pustulosa (Lea,1831)	WD	L	–	–	WD
Amblema plicata plicata (Say, 1817)	WD	–	–	–	WD
Fusconaia flava (Rafinesque, 1820)	WD	–	X	–	WD
Uniomerus tetralasmus (Say, 1831)	L	L	–	–	L
Actinonaias ligamentina carinata (Barnes, 1823)	S	–	–	–	S
Obovaria olivaria (Rafinesque, 1820)	WD	–	–	–	WD
Truncilla truncata Rafinesque, 1820	WD	–	–	–	WD
Truncilla donaciformis (Lea, 1827)	WD	–	–	–	WD
Leptodea fragilis (Rafinesque, 1820)	WD	WD	X	–	WD
Potamilus alatus (Say, 1817)	WD	–	X	–	WD
Potamilus purpuratus (Lamarck, 1819)	S	–	–	–	S
Potamilus ohiensis (Rafinesque, 1820)	WD	–	–	–	WD
Toxolasma parvus (Barnes, 1823)	F	–	X	–	F
Ligumia recta (Lamarck, 1819)	WD	–	–	–	WD
Ligumia subrostrata (Say, 1831)	WD	L	X	–	L
Lampsilis teres f. *teres* (Rafinesque, 1820)	L	–	–	–	L
Lampsilis teres f. *anodontoides* (Lea, 1831)	WD	–	X	–	WD
Lampsilis radiata luteola (Lamarck, 1819)	WD	–	–	–	WD
Lampsilis higginsi (Lea, 1857)	–	–	–	M[3]	M
Lampsilis ventricosa (Barnes, 1823)	L	L	X	–	L
Total confirmed taxa	**28**	**9**	**10**	**2**	**30**
Unconfirmed taxa					
Cumberlandia monodonta (Say, 1829)	–	–	X	–	X
Anodonta suborbiculata Say, 1831	–	–	X	–	X
Quadrula cylindrica (Say, 1817)	–	–	X	–	X
Quadrula metanevra (Rafinesque, 1820)	–	–	X	–	X
Pleurobema sintoxia (Rafinesque, 1820)	–	–	X	–	X
Obliquaria reflexa Rafinesque, 1820	–	–	X	–	X
Potamilus capax (Green, 1832)	–	–	X	–	X
Total unconfirmed taxa	**-**	**-**	**7**	**-**	**7**
Probable misidentified taxa					
Elliptio complanata (Lightfoot, 1786)	–	–	X	–	X
Actinonaias pectorosa (Conrad, 1834)	–	–	X	–	X
Epioblasma flexuosa (Rafinesque, 1820)	–	–	X	–	X
Total probable misidentified taxa	**-**	**-**	**3**	**-**	**3**
Total taxa reported	**28**	**9**	**20**	**2**	**40**

[1]Arrangement of taxa follows Stansbery and Borror (1983).
[2]University of Nebraska State Museum, Lincoln, Nebraska.
[3]National Museum of Natural History, cited by Havlik (1980).

Table 5. Summary of recent unionid records from the Elkhorn River Basin by basin sector.

Taxa[1]	Unionids by basin sector[2]		
	Lower	Middle	Upper
Anodonta (Utterbackia) imbecillis Say, 1829	–	X[3]	X
Anodonta (Pyganodon) grandis grandis Say, 1829	X	X[4]	X[4]
Anodontoides ferussacianus (Lea, 1834)	X	X	X
Strophitus undulatus undulatus (Say, 1817)	X	–	–
Arcidens confragosus (Say, 1829)	X	–	–
Lasmigona complanata (Barnes, 1823)	X	X[4]	X[4]
Lasmigona compressa (Lea, 1829)	X	–	–
Tritogonia verrucosa (Rafinesque, 1820)	X	–	–
Quadrula quadrula (Rafinesque, 1820)	X	X[4]	X[3]
Quadrula pustulosa pustulosa (Lea, 1831)	X[4]	–	X[4]
Amblema plicata plicata (Say, 1817)	X	–	–
Fusconaia flava (Rafinesque, 1820)	X	–	–
Uniomerus tetralasmus (Say, 1831)	X	X	X[4]
Actinonaias ligamentina carinata (Barnes, 1823)	X	–	–
Obovaria olivaria (Rafinesque, 1820)	X	–	–
Truncilla truncata Rafinesque, 1820	X	–	–
Truncilla donaciformis (Lea, 1827)	X	–	–
Leptodea fragilis (Rafinesque, 1820)	X[4]	X[4]	–
Potamilus alatus (Say, 1817)	X	–	–
Potamilus purpuratus (Lamarck, 1819)	X	–	–
Potamilus ohiensis (Rafinesque, 1820)	X	–	–
Toxolasma parvus (Barnes, 1823)	X	–	X
Ligumia recta (Lamarck, 1819)	X	–	–
Ligumia subrostrata (Say, 1831)	X	–	X[3]
Lampsilis teres f. *teres* (Rafinesque, 1820)	X	–	–
Lampsilis teres f. *anodontoides* (Lea, 1831)	X	–	–
Lampsilis radiata luteola (Lamarck, 1819)	X	–	–
Lampsilis ventricosa (Barnes, 1823)	X	X[4]	X[4]
Recent confirmed totals:	**27**	**8**	**10**

[1]Arrangement of taxa follows Stansbery and Borror (1983).
[2]Unless otherwise noted, all records were collected in this study only.
[3]Recovered by Clausen and Havlik (1994).
[4]Recovered in both this survey and that of Clausen and Havlik (1994).

type of habitat has long been known to be very detrimental to bivalves. There is some evidence to suggest, however, that the shifting-sand substrates currently characteristic of the Elkhorn River mainstem may be a product of channelization and not the natural state of this river.

Aughey (1877) provided few specific locations for taxa reported in his study. He did, however, distinguish between the "Logan" and "Elkhorn" rivers. This suggests that species with the latter as a distributional reference were recovered from the Elkhorn mainstem. This assumption is reinforced by the record of *Lampsilis higginsi* in the National Museum of Natural History which is reported to have been collected in the Elkhorn River at West Point, Nebraska (Havlik, 1980). Since all of these early records were collected by Lawrence Bruner, it would appear that Aughey's designation of "Elkhorn" in his distributional lists indicates Elkhorn River mainstem collection points. This is significant in that neither Clausen and Havlik (1994) nor this study were successful in locating live unionids in the middle and lower reaches of the Elkhorn River mainstem. Since these reaches have been channelized in the years subsequent to Bruner's collections, it suggests that channelization of the river has been responsible for the current absence of unionids. It also suggests that the channelization of the river may have produced the shifting-sand substrate which currently characterizes the Elkhorn mainstem, except for its headwaters. Comments from a long-time resident of Dodge County support this conclusion. She reported the Elkhorn River in

Table 6. Live unionid mollusks from the Elkhorn River Basin by basin sector. L = live; F = fresh shell.

Taxa[1]	**Unionids by basin sector**[2]		
	Lower	**Middle**	**Upper**
Anodonta (Utterbackia) imbecillis Say, 1829	–	F[3]	L
Anodonta (Pyganodon) grandis grandis Say, 1829	L	L[4]	L[4]
Anodontoides ferussacianus (Lea, 1834)	–	L	L
Lasmigona complanata (Barnes, 1823)	L	L	L[4]
Quadrula quadrula (Rafinesque, 1820)	L	L[3]	L[3]
Quadrula pustulosa pustulosa (Lea, 1831)	–	–	L[3]
Uniomerus tetralasmus (Say, 1831)	L	–	L[3]
Toxolasma parvus (Barnes, 1823)	–	–	L
Ligumia subrostrata (Say, 1831)	–	–	L[3]
Lampsilis teres f. *teres* (Rafinesque, 1820)	L	–	–
Lampsilis ventricosa (Barnes, 1823)	–	L[4]	L[4]
Recent confirmed totals:	**5**	**6**	**10**

[1]Arrangement of taxa follows Stansbery and Borror (1983).
[2]Unless otherwise noted, all records were collected in this study only.
[3]Recovered by Clausen and Havlik (1994).
[4]Recovered in both this survey and that of Clausen and Havlik (1994).

Dodge County formerly contained many pools 10–15 feet in depth, and that these pools and the related fishery disappeared after upstream sections of the Elkhorn River were channelized.

The unionid distributions may best be discussed by dividing the study area into three geographic segments. They are the lower, middle, and upper Elkhorn basins. The lower Elkhorn Basin extends from the mouth of the Elkhorn River mainstem to the point upstream from the mouth of Logan Creek, and includes the Logan Creek drainage. The middle Elkhorn Basin extends from this point to the Antelope County line and includes the North Fork of the Elkhorn River. The upper Elkhorn Basin is defined as that portion in Antelope and Holt counties.

Analysis of distributional data collected during this study indicates that the greatest unionid species diversity in the Elkhorn River Basin occurred in the lower or eastern portion of the Basin (Table 5), and the greatest diversity was in Logan Creek. The distributions of sixteen species recovered in this survey were confined to the lower Elkhorn River Basin, and twelve of these were collected solely from the Logan Creek drainage. Only one species, *Lampsilis teres teres*, was collected alive. The current status of the remaining fifteen species is uncertain, but the creeks of the lower Basin are significantly degraded, and it seems unlikely that many unionids on the extreme western margin of their ranges would be able to survive the added stresses of a degraded environment.

Significantly, while species diversity appears at one time to have been greatest in the lower Elkhorn Basin, live populations from recent surveys have been found to be most diverse in the upper Elkhorn Basin (Table 6). Ten of the eleven unionids recently reported as live records or fresh empty shells from the Elkhorn Basin were present in the upper Elkhorn Basin. *Lampsilis t. teres* was the only unionid present solely in the lower Elkhorn Basin. In contrast, live or fresh empty shells of *Ligumia subrostrata*, *Toxolasma parvus*, and *Quadrula pustulosa pustulosa* were found only in the upper Elkhorn Basin. Live specimens of *Anodontoides ferussacianus*, and *Lampsilis ventricosa* were recovered from the upper Elkhorn Basin and the western portion of the middle Elkhorn Basin. All of these species were also found in the lower Elkhorn Basin, but then only as empty shells. It is apparent that conditions in the lower Elkhorn Basin, though once favorable for unionids, are now often unfavorable.

Before the extensive modification and destruction of the riparian habitat of the Basin, the lower Elkhorn Basin was the most favorable locality for unionids. This region contained streams with diverse substrate habitats, such as the gravel habitats of Logan Creek. In addition, the region receives greater precipitation than the upper portion of the Basin, and streams and rivers were probably deeper, supporting a greater variety of fish, which are necessary as hosts for unionids during the early weeks of their life cycle. Unionid species diversity decreased in the middle and upper portions of the Basin due to the natural decline of habitat variability and host fish characteristic of the upper portions of most rivers.

The environmental factors currently impacting the distributions of unionids in the Elkhorn River Basin are often not natural and vary from east to west within the Basin. They reflect primarily the economic basis of local communities. In the upper Basin, the local economies are based primarily upon ranching, and intensive grazing of cattle is the primary environmental problem for unionids. The middle Elkhorn Basin economy varies, changing eastward from ranching to farming. In this area, grazing continues to be a problem for unionids, but in addition, channelization, pollution from cattle and hog feeding operations, and siltation of streams become increasingly important. The economy of the lower Basin is also based upon farming and cattle and hog raising. Environmental impacts of farming are most severe in the eastern portion of the Elkhorn River Basin.

Grazing appears to be the primary detriment to unionids in the upper Elkhorn Basin. The rivers and creeks in this portion of the drainage are shallow, and adjacent land is frequently utilized for the grazing of cattle. The cattle crush living unionids and preclude the possibility of their reintroduction by destroying riparian habitat. Stream substrates composed of mud and clay are compacted by the weight of the heavy animals, while sand substrates are destabilized. In both situations, the stream bottom is often leveled, and stable deeper pools which provide habitat for fish are largely destroyed. Intensive grazing also destroys streamside woodlands and results in increased water temperatures and the elimination of plants which stabilize stream banks increases siltation. Finally, cattle pollute the streams with animal waste. It is noteworthy that all highly productive collection sites in the upper Elkhorn River Basin were ungrazed. In several instances, productive collection sites were demarcated by the barbed-wire fences marking road right-of-ways. Unionids were present within the road right-of-ways, but absent from the adjacent grazed portions of the river.

Along the upper Elkhorn River within the course of this study, a number of changes in fauna have been observed. *Anodontoides ferussacianus* appeared to be less common in 1993 at some sites than it was earlier in this study. The species was not recorded for the Elkhorn River Basin by Clausen and Havlik (1994), and though it was recovered live from two locations by the author in 1993, it seemed to be much rarer than in the past. It is notable that this species is generally associated with clear streams in the headwaters of drainage basins. A decrease in the abundance of *A. ferussacianus* suggests a decrease in water quality, and indicates a need for further study. In addition, a number of the sites successfully collected in 1980 and 1981 were non-productive in 1993, indicating further pressure on unionids in this reach of the Basin.

Unionids appear to be infrequent in the middle reaches of the Elkhorn River mainstem. Only one subfossil valve fragment was collected in the river from this area. A local conservation officer reported in 1993 that unionids were present but extremely infrequent in this section of the river. It is possible that no viable populations exist in this reach. Unionids present may represent glochidia dropped into favorable micro-habitats and not a reproducing population. Unionids are present in tributaries along this reach of the Elkhorn River when local conditions are favorable. Grazing, though still a major detriment to unionids, becomes less important in this reach as farming becomes more important in local economies and topographical relief increases. On the North Fork of the Elkhorn River, grazing restricts the growth of unionid populations along Willow Creek, where ranching activities predominate. On the North Fork of the Elkhorn River above Pierce, however, siltation appears to be the major factor limiting unionid populations. Stream bottoms sampled in this farming area were often overlaid by silt, sometimes to a depth of a foot or more.

Unionids in the eastern portion of the Elkhorn River Basin have been impacted by extensive channelization of the Elkhorn River mainstem, and Logan Creek, as well as by the less extensive channelization of other major tributaries in the region including portions of Maple, Bell, and Plum Creeks. The impact of channelization appears to have been greatest in those streams with a predominantly sand substrate. In those instances, unionids or evidence of them was virtually absent from the affected area. Unionids do not survive in shifting-sand substrates, and channelization increases a stream's gradient enabling it to more readily transport sand than would be true with a reduced gradient. Affected areas such as the Elkhorn River mainstem from Stanton through Cuming counties, the lower Elkhorn mainstem, and the lower portion of Maple Creek, were devoid of live unionids. In fact, the only evidence of unionids from all sites in these stream sectors in this survey was a single fragmentary subfossil valve from site 48 on the Elkhorn River mainstem.

In contrast, unionids were present in channelized sections of creeks with clayey substrates, such as Bell Creek. Logan Creek, a totally dredged channel (Bentall, 1971), contained the greatest unionid diversity of any stream in the Elkhorn River Basin. The substrate in this stream varied from sand, to clay, to gravel and rock. Many unionids documented in this study came from a single site on Logan Creek which may have been a depository for victims of a mussel kill along the creek sometime around 1981. Since Logan Creek was dredged around 1900, virtually all species represented in survey collections must date after that time. The diversity of unionids on Logan Creek suggests that bivalves can at least partially recover from the effects of channelization if other factors are favorable. The fact that most of the unionid diversity in this creek was recovered at only two sites suggests that the occurrence of such favorable conditions is extremely rare in a channelized stream. The absence of fresh shells for most of the Logan Creek bivalve fauna suggests that many species have been extirpated from the region since 1900 due to factors other than channelization.

Unfortunately, unionids in the eastern portion of the Elkhorn River Basin are subject to many additional environmental pressures. Siltation resulting from erosion of agricultural land is a major problem. The eastern portion of the Elkhorn River Basin is both the most heavily farmed and is also the area with the greatest average surface slope (Bentall, 1971). These factors, combined with the frequent local practice of plowing to the very edge of creek banks, result in heavy erosion of topsoil. The Nebraska Natural Resource Commission (1975, p. 4-1 & 4-2) reported the loss of part or all of the topsoil of cultivated slopes of this region, and further stated that subsoil now forms a principal part of the plow layer of local fields. The erosion process loads area streams with silt, and silt is highly detrimental to most unionid species. It is significant that in 1981 a local resident reported live unionids to have been common along the lower portion of Logan Creek until a cloudburst several years earlier, which forced a huge load of silt into the creek at that time. In 1981, the grassy banks of Logan Creek at site 19 were covered to a depth of up to 8 cm with loose silt.

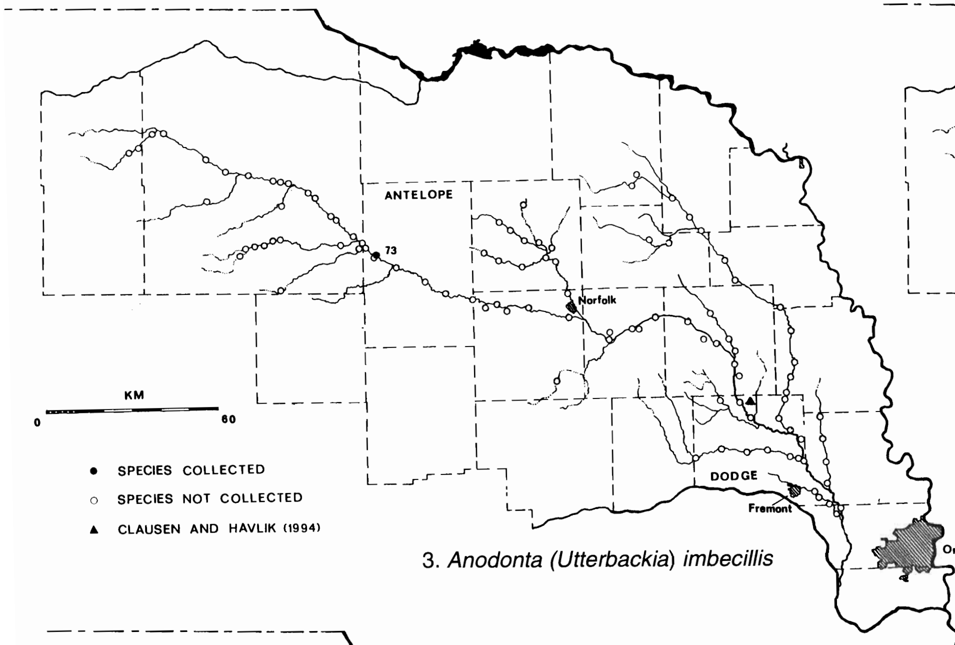
Another threat to unionids in the eastern Elkhorn River Basin is the apparent lowering of water levels in some of the creeks in the region. The decline in water levels occurs in two forms. In some instances, the water table appears to have dropped from former levels. In the writer's collecting at site 6 on Bell Creek in 1981, a local resident was shocked to see him in knee-deep water. Thirty years before, as a youth he had swum in the creek and recalled it as having been 6-7 feet in depth at that point. It is significant that he also recalled the creek at that time to have been bordered by woods, and not farmlands. The second factor impacting water levels in the Basin is surface withdrawal of stream waters for irrigation. Bliss and Schainost (1973) reported irrigation-water allocations for some Basin streams exceeded total flow in normal or dry years. In 1976, Logan Creek was reported to be only a trickle above Oakland (Omaha World Herald, 1976), partially the result of a drought, but also the result of surface water withdrawals for irrigation of local fields. Site 16 on the upper portion of Maple Creek was littered with subfossil unionids when collected in 1981, but no evidence of recent unionids was obtained, and the creek was dry at that time. The fact that the creek bed was generally free of vegetation may indicate surface water withdrawal as the cause for the absence of flow at this site.

Pollution is a problem throughout the basin, and has eliminated or degraded significant unionid habitat. Eutrophication was observed in oxbow lakes open to grazing cattle in the upper Basin. Site 73, highly productive in 1981, was clogged with algae in 1993 when only a single specimen was retrieved. Animal waste from cattle-feeder and hog-raising operations impacts the streams and rivers throughout the Elkhorn Basin, but it is most concentrated on its lower reaches. In a 1975 report, the Nebraska Natural Resource Commission reported fecal coliform counts in the Elkhorn River near Waterloo, Nebraska at 329,000 per 100 ml—over 1,600 times the average monthly Nebraska standard measurement for polluted waters.

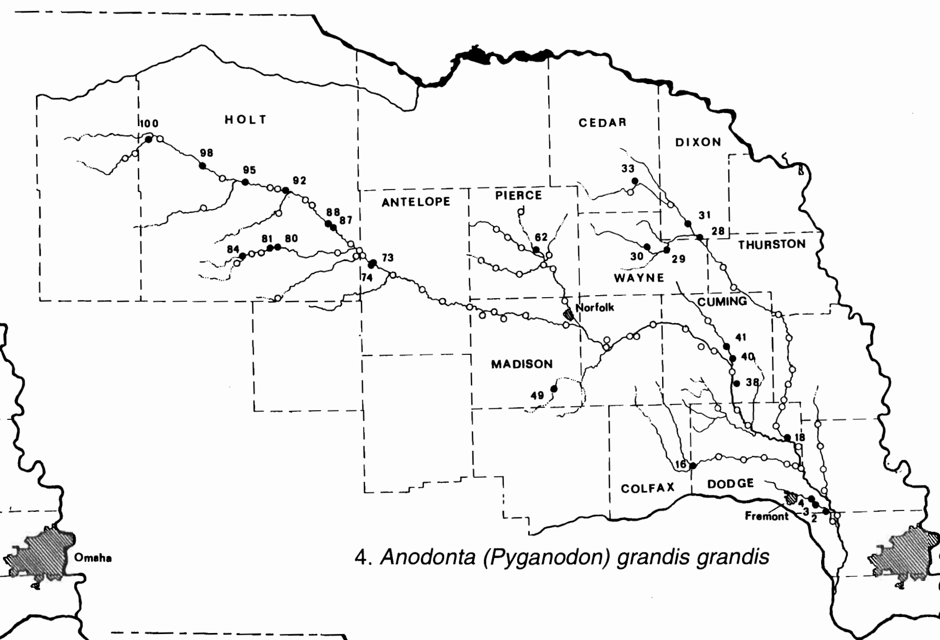
CONCLUSION

The Elkhorn River Basin formerly supported a comparatively rich unionid fauna consisting of at least 30 taxa. At present only eleven species are known to survive in the Basin. The ranges of most extant species appear to have been greatly restricted due to environmental damage associated with the development of the Basin for agriculture. Two species have not been collected from the region in over one hundred years. Of the seventeen additional taxa from the study area, sixteen were definitely present in the Basin after 1900 in dredged portions of Logan Creek, but their current status is uncertain. In view of the extent of habitat degradation that has occurred in the area, it is probable that most of these species have been extirpated from the Elkhorn Basin.

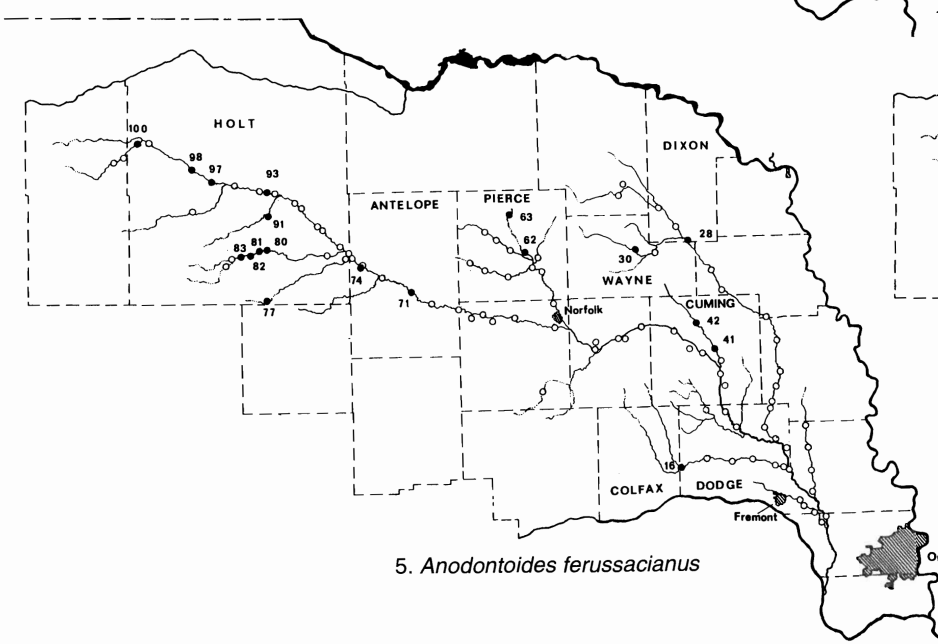
Unionid mollusk species diversity was formerly greatest in the lower portion of the Basin. In contrast, diversity of extant populations is now greatest in the upper portion of the Basin. There is no evidence to indicate that unionid habitat has increased or improved in the upper portion of the Basin, and much evidence to the contrary. The fact that unionid species diversity is greatest in the upper Basin at present appears to reflect the fact that this region has been less environmentally degraded than the more easterly portions of the Basin which have experienced a drastic decline in unionid habitat and species diversity.



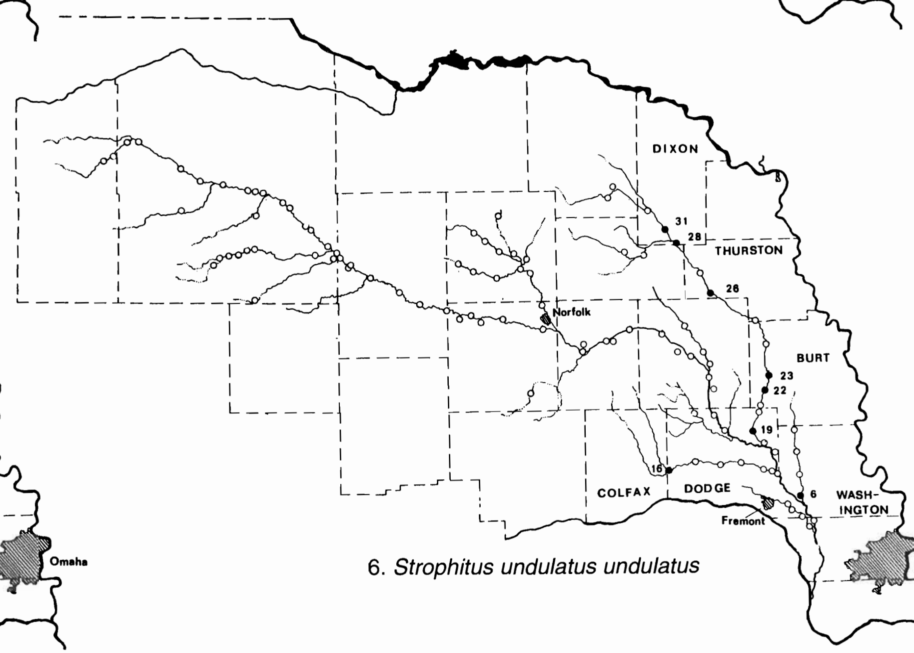
3. *Anodonta (Utterbackia) imbecillis*



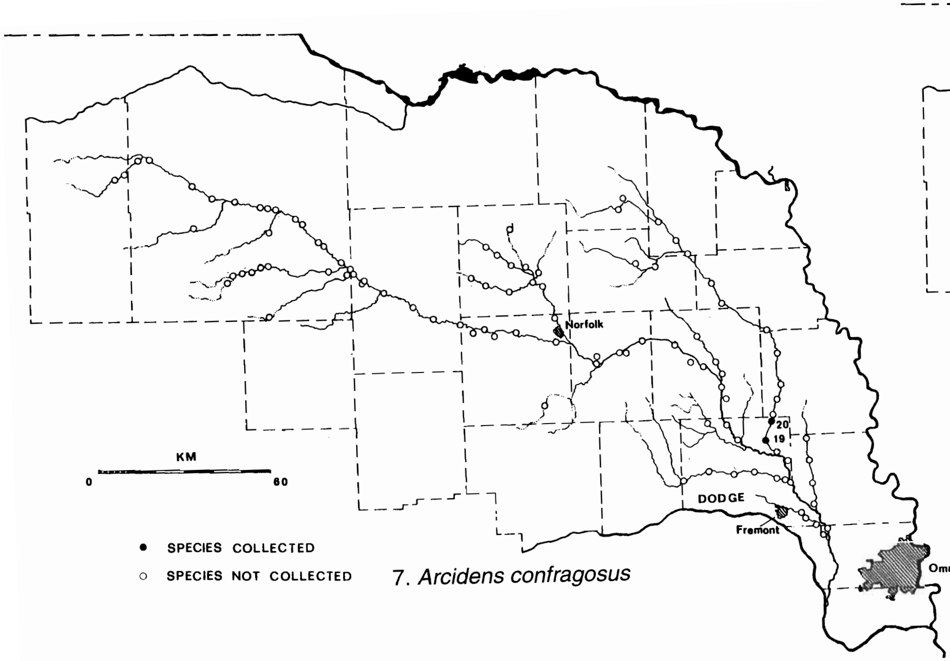
4. *Anodonta (Pyganodon) grandis grandis*



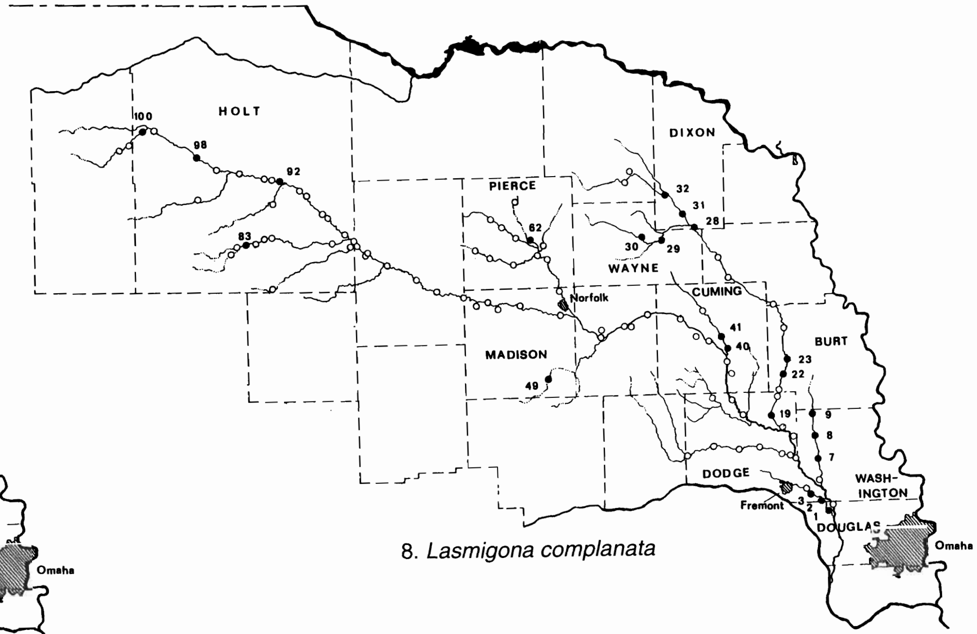
5. *Anodontoides ferussacianus*



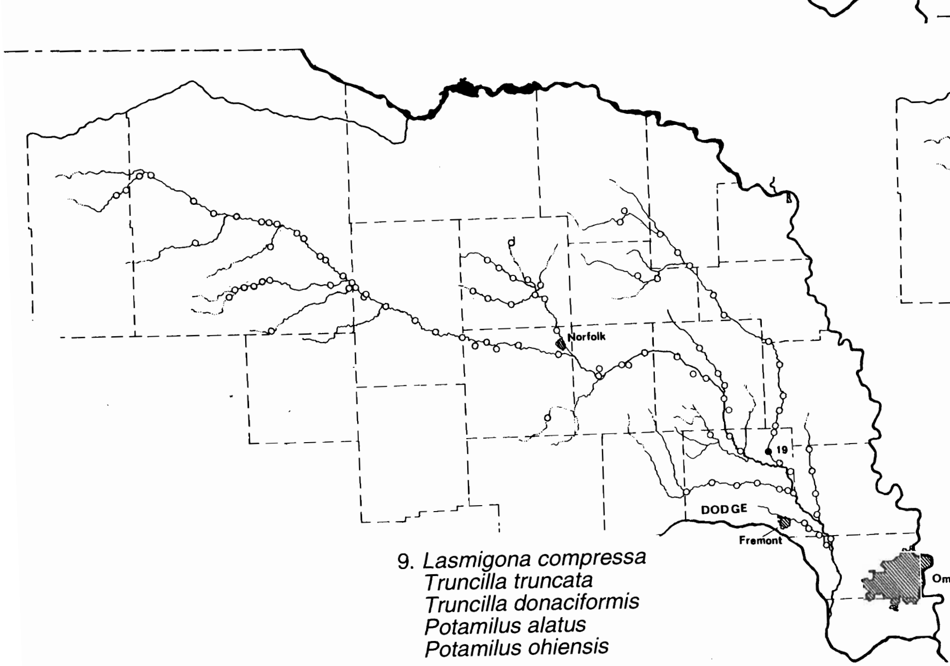
6. *Strophitus undulatus undulatus*



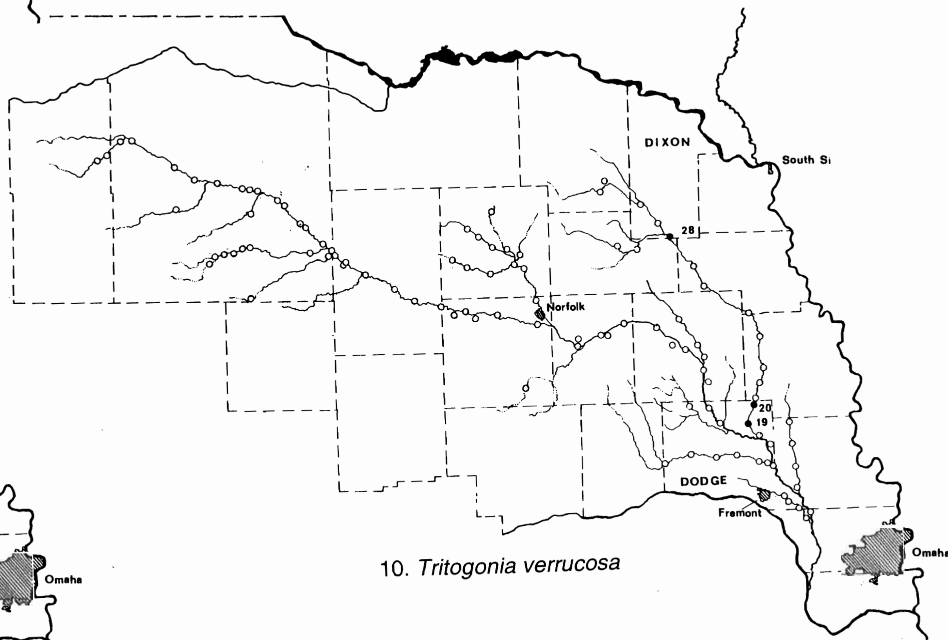
7. *Arcidens confragosus*



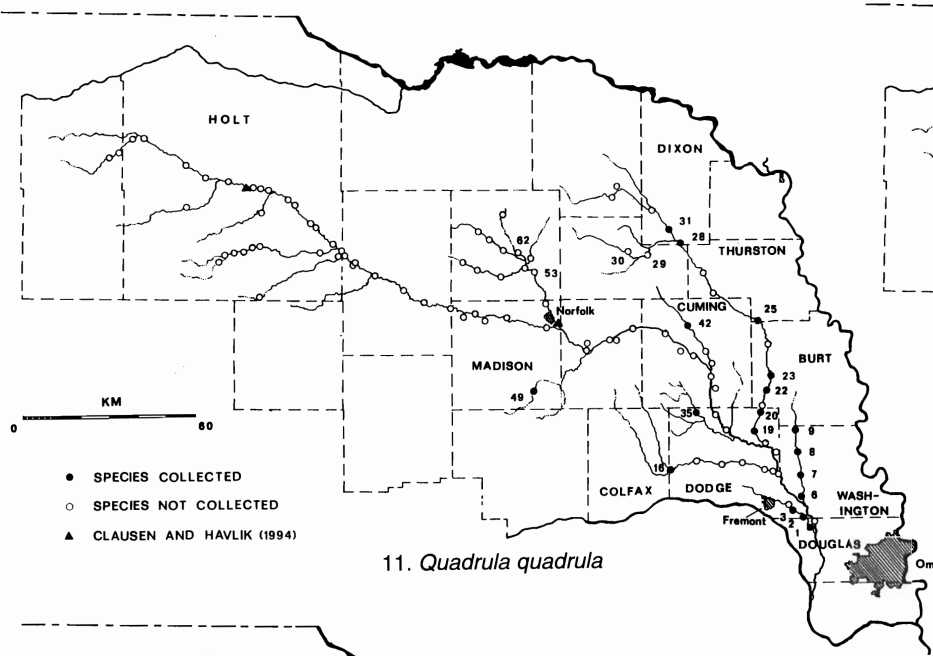
8. *Lasmigona complanata*



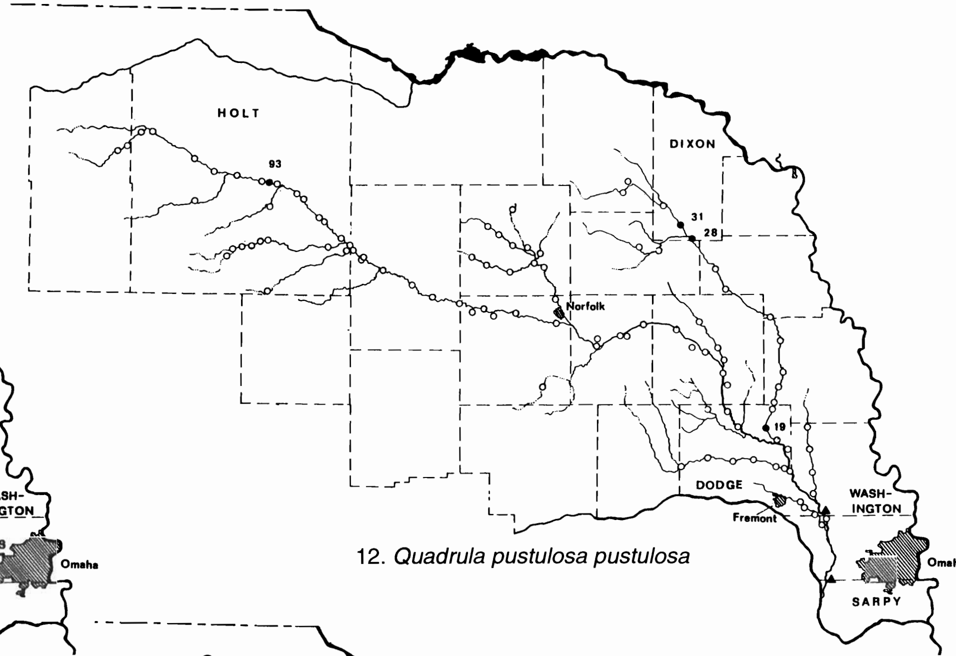
9. *Lasmigona compressa*
Truncilla truncata
Truncilla donaciformis
Potamilus alatus
Potamilus ohiensis



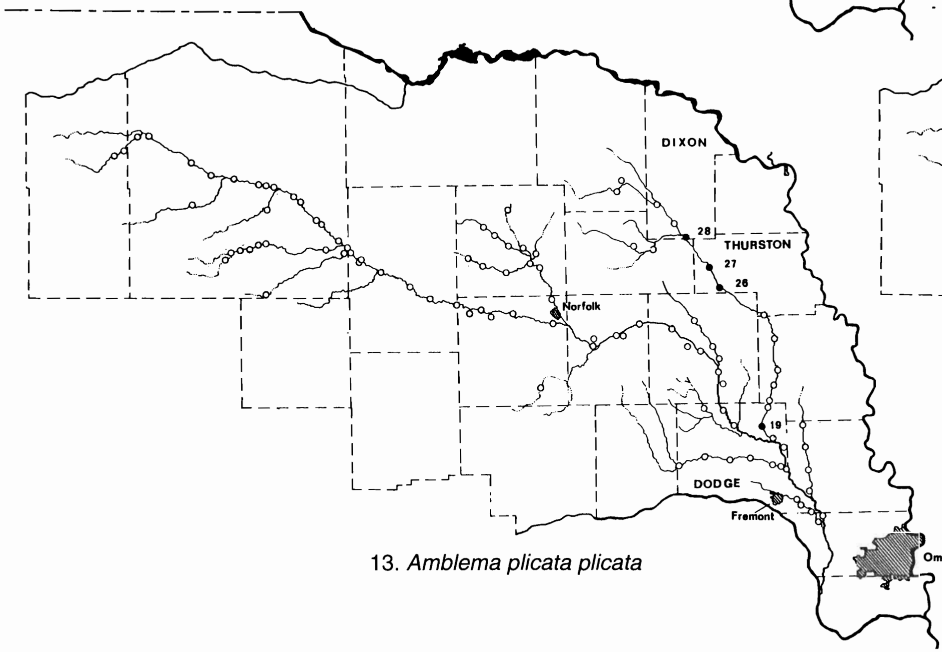
10. *Tritogonia verrucosa*



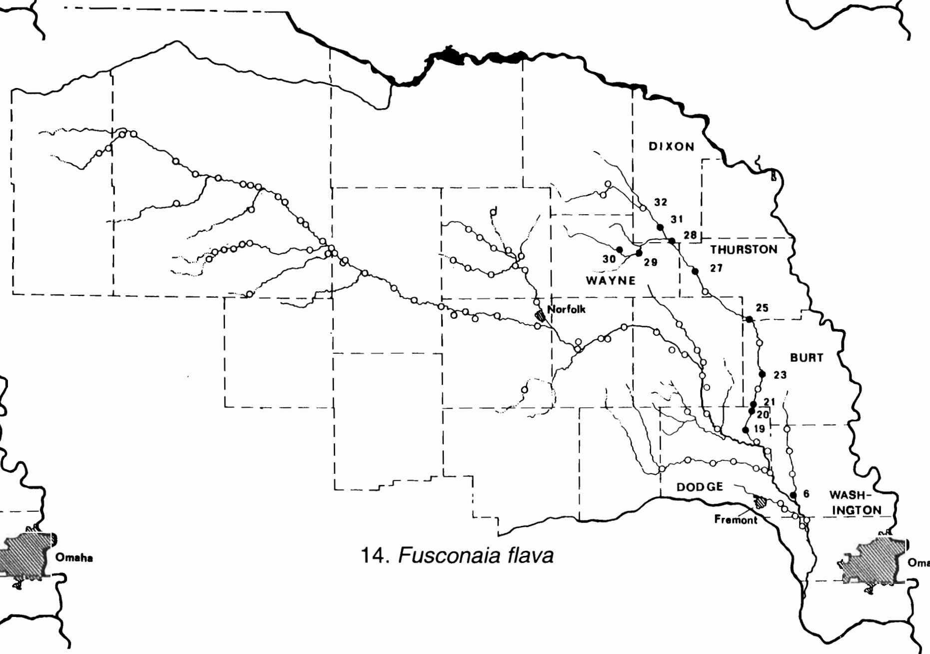
11. *Quadrula quadrula*



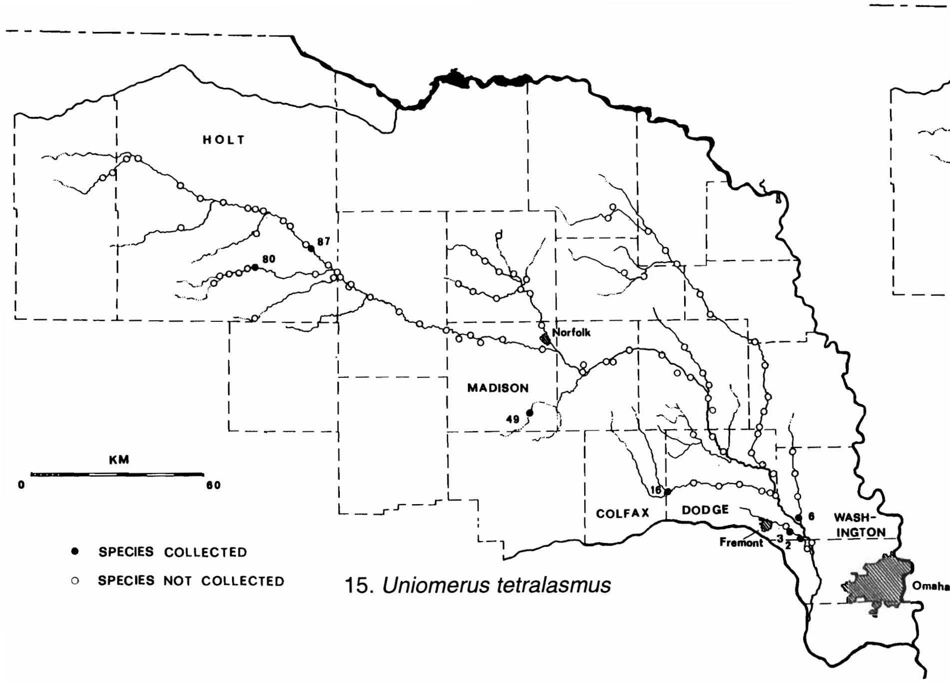
12. *Quadrula pustulosa pustulosa*



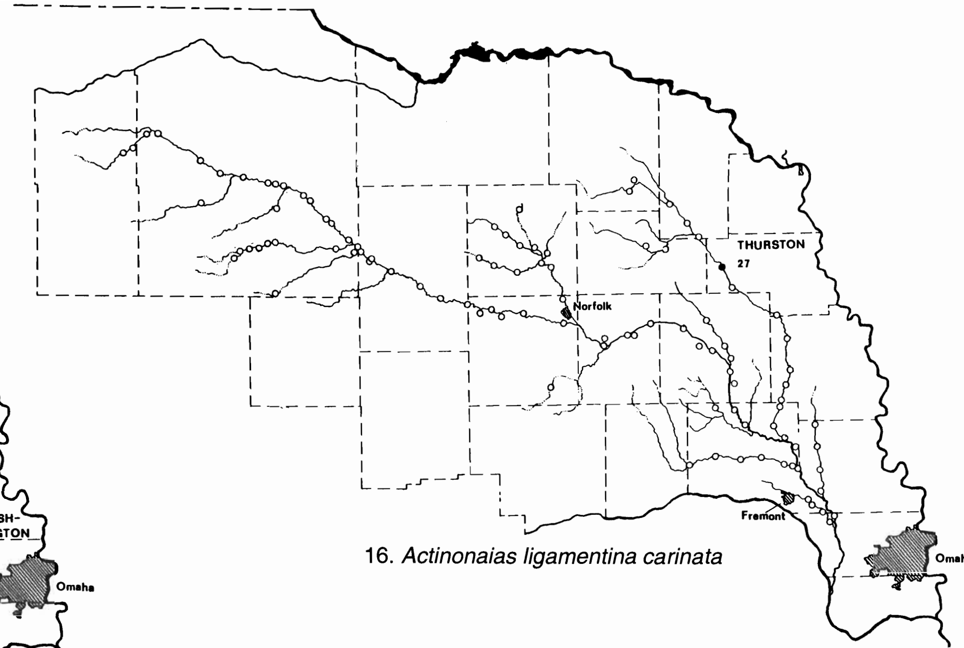
13. *Amblema plicata plicata*



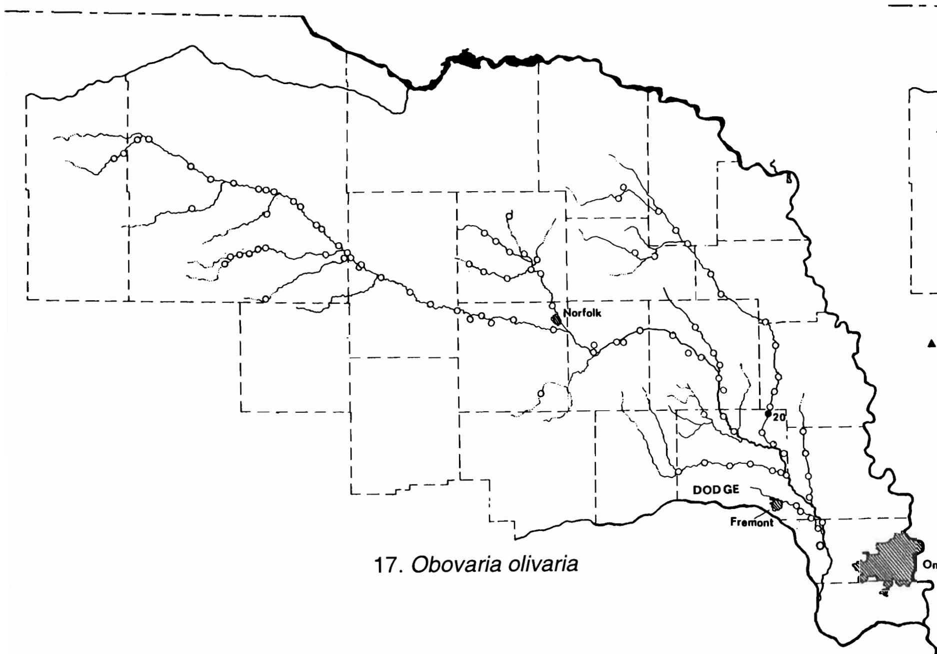
14. *Fusconaia flava*



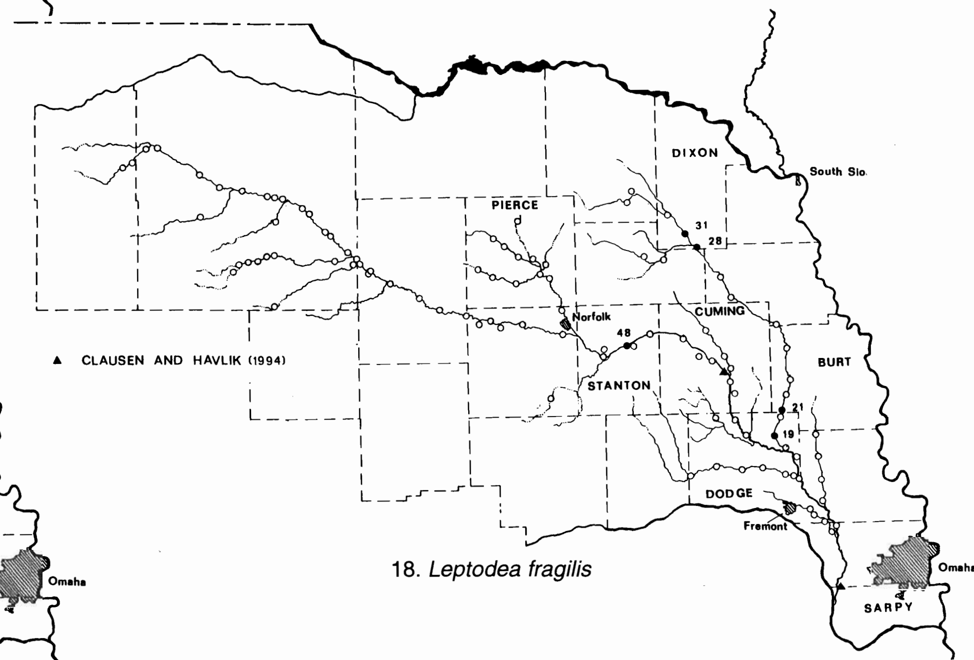
15. *Uniomerus tetralasmus*



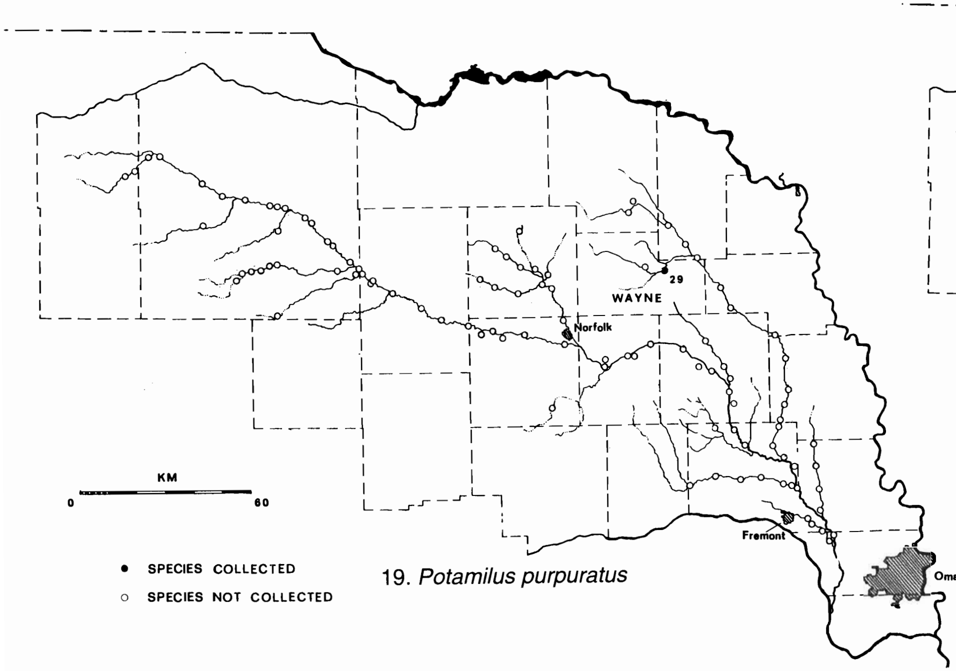
16. *Actinonaias ligamentina carinata*



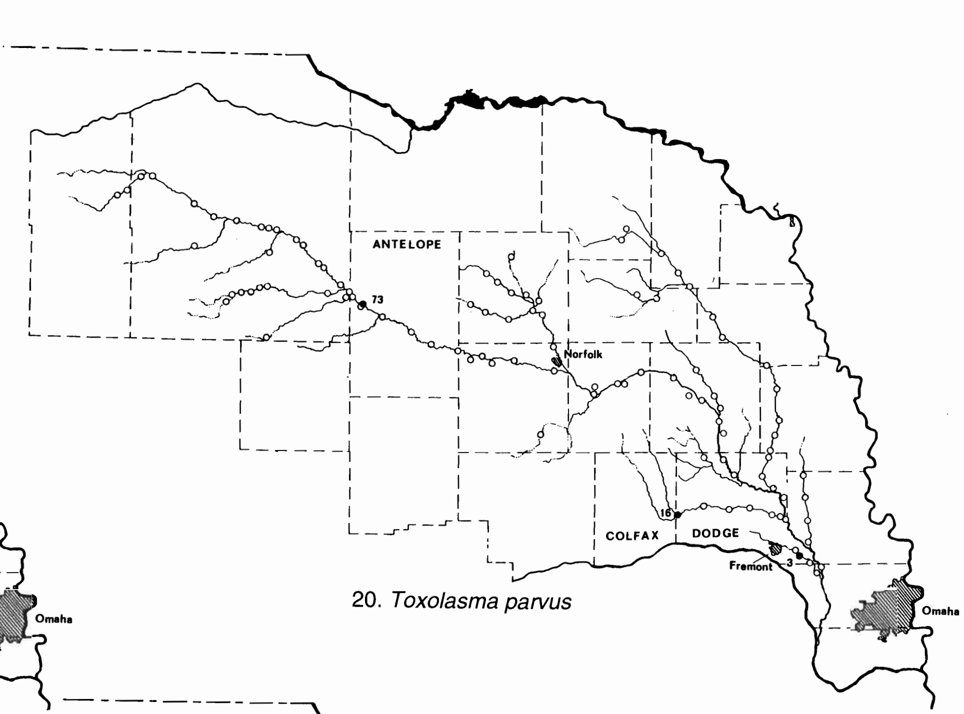
17. *Obovaria olivaria*



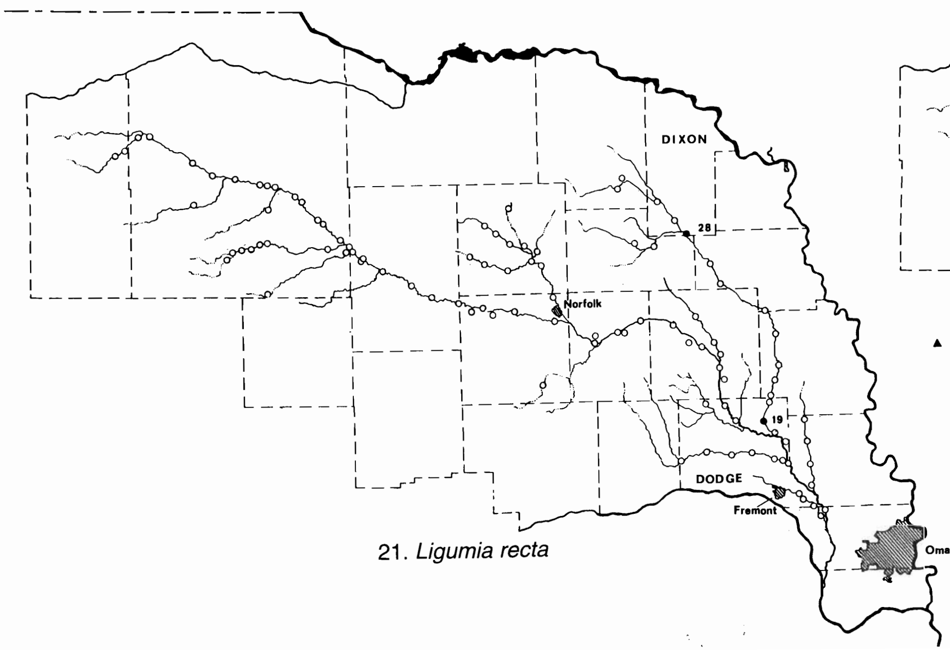
18. *Leptodea fragilis*



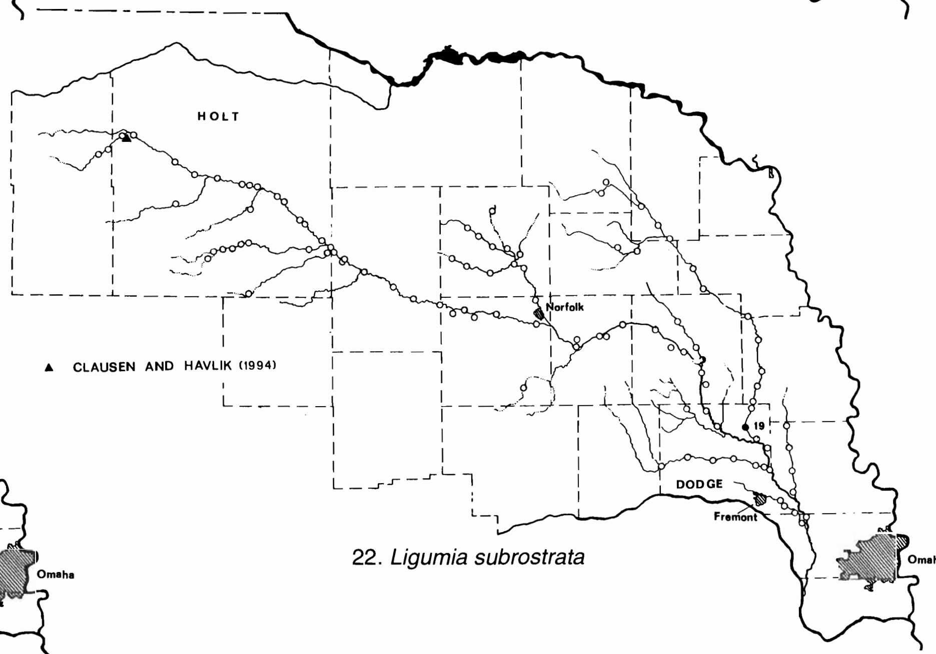
19. *Potamilus purpuratus*



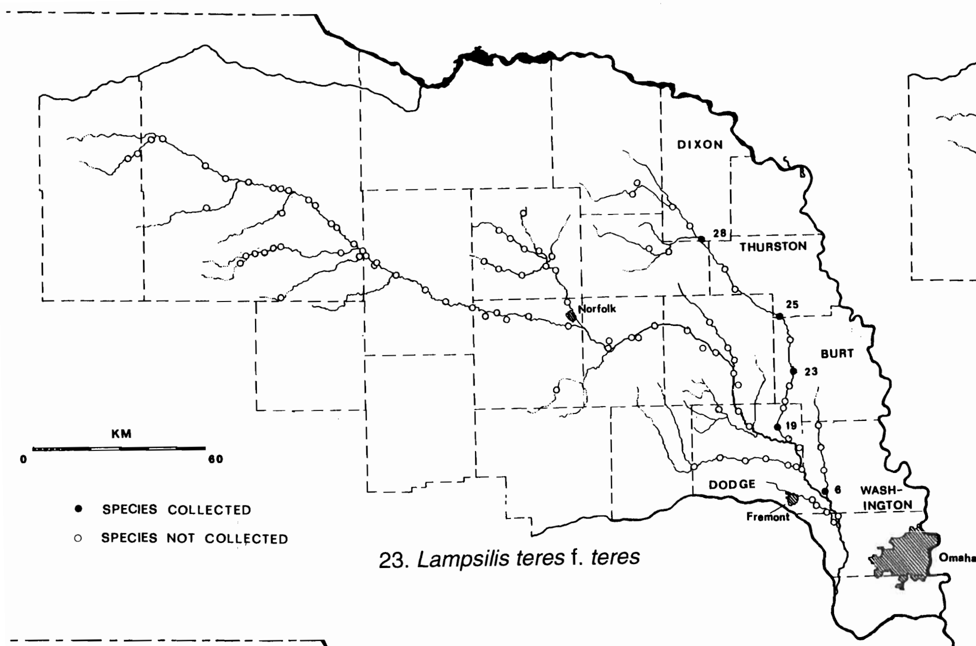
20. *Toxolasma parvus*



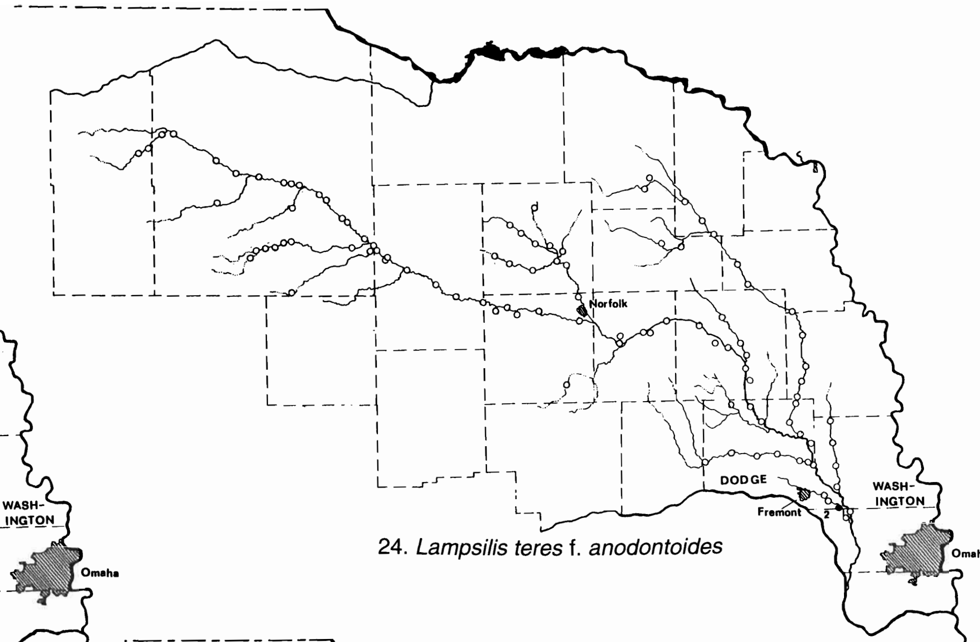
21. *Ligumia recta*



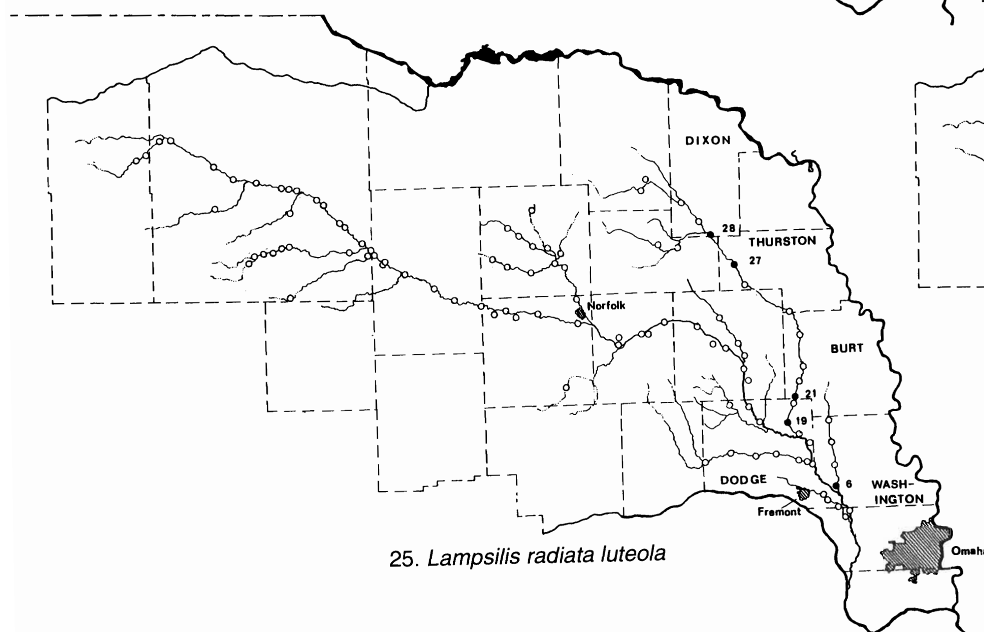
22. *Ligumia subrostrata*



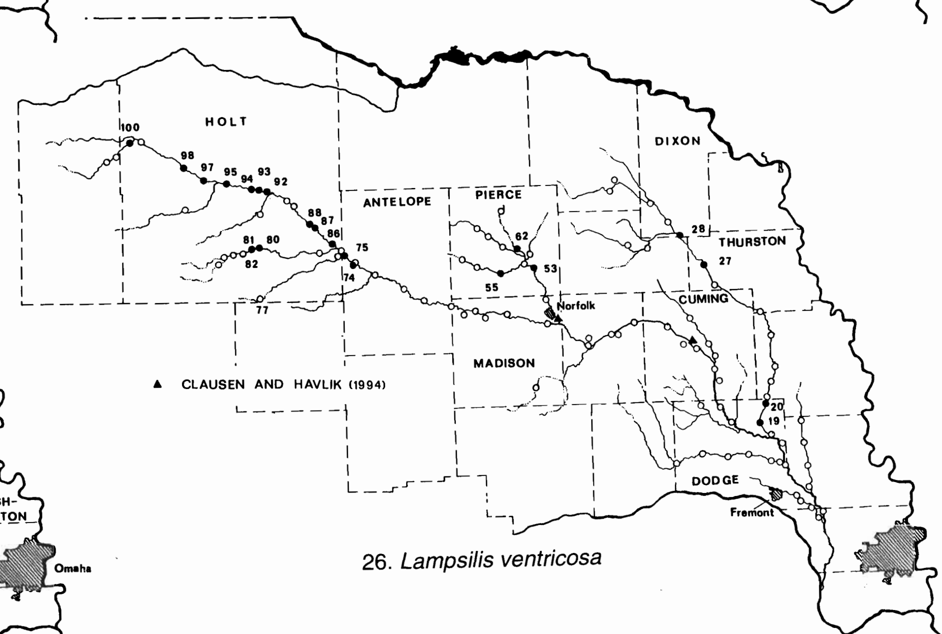
23. *Lampsilis teres* f. *teres*



24. *Lampsilis teres* f. *anodontoides*



25. *Lampsilis radiata luteola*



26. *Lampsilis ventricosa*

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Dr. David H. Stansbery, Ohio State University Museum of Biological Diversity, spent time in translating the names of Aughey's taxa into modern equivalents. In addition, I am indebted to him for corroborating and occasionally correcting some of my early identifications, for advice and counsel throughout this project, and for the considerable effort involved in reviewing the initial manuscript.

LITERATURE CITED

Aughey, Samuel. 1877. Catalogue of the land and freshwater shells of Nebraska. *Bulletin of the U.S. Geological and Geographical Survey of the Territories* 3(3): 697–704.

Baxa, Mark D. 1981. Anodonta species of Lake McConaughy, western Nebraska. *The Nautilus* 95: 180–183.

Bentall, Ray and others. 1971. *Water supplies and the land – the Elkhorn River Basin of Nebraska*. Lincoln, University of Nebraska Conservation and Survey Division: 51 pp.

Bliss, Q. P., and S. Schainost. 1973. *Elkhorn Basin stream inventory report*. Lincoln, Nebraska Game and Parks Commission: 14 pp.

Burch, J. B. 1975. *Freshwater Unionacean clams (Mollusca: Pelecypoda) of North America*. Malacological Publications: 204 pp.

Clausen, Mary K., and Marian E. Havlik. 1994. *A survey of the unionid mollusks (Mollusca: Bivalvia) of the Elkhorn River Basin, Nebraska*: 38 pp.

Freeman, Patricia W., and Keith Perkins. 1992. *Survey of mollusks of the Platte River, Final Report*.

Havlik, M. E. 1980. The historic and present distribution of the endangered naiad mollusk *Lampsilis higginsi* (Lea, 1857). *Bulletin of the American Malacological Union, Inc.*: pp. 9–12.

———. 1983. Naiad mollusk populations (Bivalvia: Unionidae) in pools 7 and 8 of the Mississippi River near La Crosse, Wisconsin. *American Malacological Union Bulletin* 1: 51–59.

Hoke, Ellet. 1983. Unionid mollusks of the Missouri River on the Nebraska border. *American Malacological Union Bulletin* 1: 71–74.

———. 1994. *An initial survey of the unionid mollusks of the Loup River system in Nebraska. Triannal Unionid Report No. 4*. Asheville, North Carolina, U. S. Fish and Wildlife Service.

Lingle, K. L. 1992. *Habitat and microhabitat preferences of adult freshwater mussels (Mollusca: Bivalvia: Unionidae) of the Platte River, Nebraska*. M. S. Thesis, University of Nebraska at Kearney: 143 pp.

Murray, Harold D., and A. Bryon Leonard. 1962. *Handbook of unionid mussels in Kansas*. Lawrence, University of Kansas Museum of Natural History, Miscellaneous Publication No. 28: 184 pp.

Nebraska Natural Resources Commission. 1975. *Elkhorn River Basin water quality management plan*.

Oesch, R. D. 1984. *Missouri naiades: A guide to the mussels of Missouri*. Jefferson City, Missouri Department of Conservation: 270 pp.

Omaha World Herald. 1976. *Weather, irrigation blamed as rivers, streams drop*. Evening Edition, July 2, 1976.

Parmalee, P. W. 1967. *The fresh-water mussels of Illinois*. Vol. 8. Springfield, Illinois State Museum: 108 pp.

Roedel, M. D. 1990. Unionid molluscs in the Big Bend Reach of the Platte River, Nebraska. *Prairie Naturalist* 22: 27–32.

Stansbery, David H., and Kathy Borror. 1983. *A list of the recent freshwater bivalve mollusks of the Holarctic region catalogued into the Ohio State University Museum of Zoology Collection*: 3 pp.