

Unionacean Mussels, Past and Present, from Six Streams in Kansas and Oklahoma

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ABSTRACT

Species of freshwater mussels (Bivalvia, Unionacea) were surveyed in six streams of south-central Kansas and north-central Oklahoma. Present fauna, fossil and archeological materials, and previous records were considered in an attempt to place the fauna in a historical perspective. Streams vary from those with a fairly intact fauna at present to those with a depauperate fauna.

INTRODUCTION

In this study the present and some fossil and archeological occurrences of freshwater mussels (Bivalvia, Lamellibranchia, Unionacea) were surveyed in six streams in south-central Kansas and north-central Oklahoma. The six streams (Fig. 1) were Grouse Creek and Big and Middle Caney rivers, heading in Cowley, Elk and Chautauqua counties, Kansas, and Salt Bird and Hominy creeks, heading in Osage County, Oklahoma. Only the segment of Big Caney River above its confluence with Middle Caney River and the segment of Bird Creek above its confluence with Hominy Creek were investigated.

All these streams originate in hilly areas. In the western part of the region considered are the Flint Hills, formed on rocks of Permian age, among which are strata of resistant cherty limestone. These strata contribute to extensive stream gravels and form stream bottoms in some places. Salt and Grouse creeks flow entirely within the Flint Hills. Big Caney River heads in the Flint Hills and receives its more important upper tributaries from these hills, which lie to the west of its valley in Kansas. The uppermost tributaries of Bird and Hominy creeks also head in the Flint Hills. However the major parts of these streams (as well as that segment of Big Caney River in Oklahoma, considered here) flow through the Osage Hills in which sandstone strata of Pennsylvanian age are the chief contributors to stream gravels and where sandy bottoms commonly occur. Northward, in Kansas, the

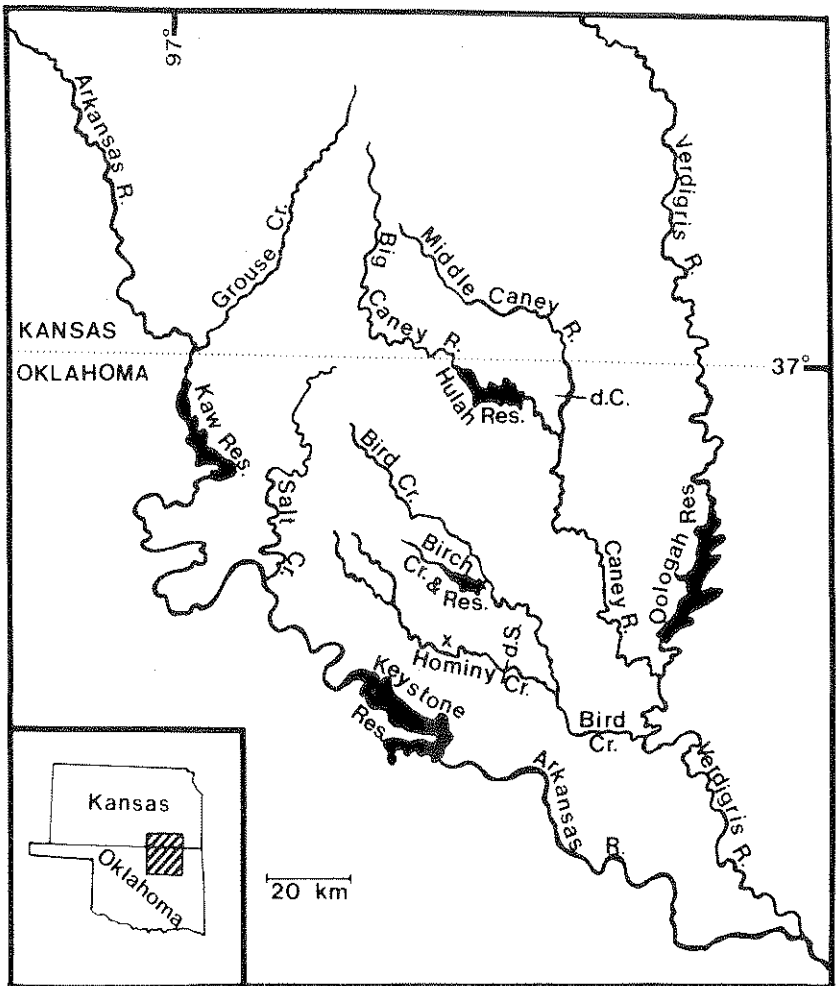


Fig. 1. Map of a part of southeastern Kansas and northeastern Oklahoma, showing streams mentioned in text. Abbreviations and symbols: Cr. = Creek; d.C. = dam that will impound Copan Reservoir; d.S. = dam that will impound Skiatook Lake; R. = River; Res. = Reservoir; x = Locality OS-114 (Big Hawk Shelter).

Chautauqua Hills (a continuation of the Osage Hills of Oklahoma) are drained in their southern part by Middle Caney River.

The watersheds of the streams in Kansas were settled by people of European origin in the late 1860's and in the 1870's. Stream valleys and some upland areas were cultivated in the late 1800's and early 1900's. Most of the previously cultivated upland has been returned to pasture in the past 50

years and in the past 20 years many valley fields have been sown to grasses so that there is less cultivated land in the watersheds than formerly in this century. It seems likely that siltation of these streams has been concomitantly reduced.

The watersheds in Osage County, Oklahoma, remained property of the Osage Indian Tribe until 1906, when individual allotments were made to tribal members (Mathews, 1961:772). Before that time little cultivation was practiced. Subsequently, lands were sold to non-Indians and cultivated tracts were developed, principally along valleys of the larger creeks and in level terrain in the upper part of the Salt Creek watershed. However, most of the upland of Osage County has remained range land to the present time.

There has never been any large-scale industrial development in the watersheds of the stream segments surveyed and the towns are all small; Pawhuska, the largest, presently has some 6000 inhabitants. Beginning about 1915, there were significant discoveries of petroleum in the region. Oil wells were drilled in watersheds of all six streams with those of Salt and Homin creeks being most affected and that of Big Caney River the least affected.

In the 1960's a watershed program was initiated in the drainages of Big and Middle Caney rivers, which involved the construction of numerous small reservoirs on smaller streams in the systems. My observations indicate that this has resulted in more equable flow in streams with less flooding than formerly and more flow during droughts. This seemed to be the case in comparing flow for two summers during droughts, when I spent much time along Big Caney River: 1956, with prolonged intermittency, and 1978, with reduced flow only.

METHODS

Numbering of stations where collections were made is explained in the list of localities, hereafter. Stations sampled ranged from 0.1 to 1.0 km in stream length. Some collections were made on tributaries of the stream considered but these are not listed, as the uppermost segments of the streams, proper, seemed adequately to characterize habitats and faunas of smaller creeks of the systems. Stations were visited only during summer months, between 1969 and 1979, with years indicated in the list of localities. Specimens were collected by hand. Species taken are indicated in Table 1-4.

At many stations bank sediments contained fossilized shells of mussels which contributed to knowledge of former inhabitants of the streams. No radiometric dates were obtained from these fossils, although these would have been desirable. The sediments seem surely to be of relatively late Holocene age, probably between a century (pre-entrenchment) and a few thousands of years old. None of the deposits mentioned contained artifact

Table 1. Species of unionacean mussels taken at ten localities in Big Caney River and its floodplain deposits. Locality designations are explained in the section "Localities of Collections." Abbreviations concerning specimens are: L = living or with flesh adhering; F = fresh with nacre and periostracum in well preserved condition; W = weathered, probably fossil in many cases; * = fossil (in place) from streambank deposits. L and F are judged to be species presently living at locality. Only one of the designations L, F or W is used per given locality and employed, as applicable, in that order. All fossil occurrences are indicated.

Species	Localities									
	C-1	C-2	C-3	C-4	C-5	C-6	C-7	C-8	C-9	C-10
<i>Amblema plicata</i>		*	F	L*	L	L*	L*	L*	F	W
<i>Anodonta grandis</i>		L	L*	L*	F	L	L	F	F	F
<i>Anodonta imbecillis</i>	L	F	F	F	F	F	L	F		
<i>Carunculina parva</i>		F		F*	F	L				
<i>Fusconaia flava</i>		*	*	*	L	L*	L*	W*		F
<i>Lampsilis ovata</i>		F	L	L*	L	L*	L*	L*	F	F
<i>Lampsilis radiata</i>	*	*	*	*	L	L*	*	*		
<i>Lampsilis rafinesqueana</i>							*	W	W	
<i>Lampsilis teres</i>			*	*	W	L*	L*	L*	F	F
<i>Lasmigona complanata</i>					L	L	L	L	L	F
<i>Lasmigona costata</i>						*				
<i>Leptodea fragilis</i>						L	L	L	L	F
<i>Ligumia subrostrata</i>	L*	L*	F*	L*	L	L*	L*	L*		F
<i>Obliquaria reflexa</i>						L	L			F
<i>Proptera laevis</i>						L		F	L	F
<i>Proptera purpurata</i>				*		L	L	L*	F	F
<i>Ptychobranthus occidentalis</i>				*		*	W*	W*		
<i>Quadrula pustulosa</i>				F	F	L*	L	L*	F	L
<i>Quadrula quadrula</i>				F	L	L	L	L	L	F
<i>Strophitus undulatus</i>		L	L*	L	L	L*	L*	L*		
<i>Tritogonia verrucosa</i>				*	L	L*	L*	L*	L	F
<i>Truncilla donaciformis</i>									F	F
<i>Truncilla truncata</i>						L	L	L	L	F
<i>Unio merus tetralasmus</i>	L					L				
Total, present fauna (L + F):	3	6	6	9	13	20	16	15	13	15

attributable to presence of European man in the area. Fossils are indicated by asterisk in Tables 1-4. Through the courtesy of Donald Henry, University of Tulsa, mussels obtained in three archeological excavations in the drainages of Hominy and Bird creeks were examined (localities designated "OS" in list of localities). Radiocarbon determinations were available for Loc. OS-114 (referred to, hereafter, as Big Hawk Shelter) and ranged from approximately 200 A.D. to 1500 A.D. (Table 5).

Specimens from each locality are deposited in collections of the Department of Biological Sciences, University of Texas at El Paso. Representatives of species taken in each stream were deposited with the National

Table 2. Species of mussels taken in Grouse Creek and its floodplain deposits. Abbreviations and symbols are explained in Table 1.

Species	Localities								
	G-1	G-2	G-3	G-4	G-5	G-6	G-7	G-8	G-9
<i>Amblema plicata</i>		L*	L*	L	L	L	L*	L*	W
<i>Anodonta grandis</i>		L*	L	L	L	L	L	F	F
<i>Anodonta imbecilis</i>		F				F	L		
<i>Carunculina parva</i>		F		F	F			F	
<i>Fusconaia flava</i>		*	W	W	L	L	W*	W*	
<i>Lampsilis ovata</i>		*	L	L	L	L	F	F	L
<i>Lampsilis radiata</i>		*	L*	L	L	L	W*	F	
<i>Lampsilis teres</i>		W	L	F	L	L	W	L	
<i>Lasmigona complanata</i>			L	F	L	L	F	F*	L
<i>Leptodea fragilis</i>							L	L	L
<i>Ligumia subrostrata</i>	F	L*	L*	L	L	L	L*	L	W
<i>Obliquaria reflexa</i>									*
<i>Proptera laevissima</i>									F
<i>Proptera purpurata</i>		W	W	W	F	W	W	W	L
<i>Quadrula pustulosa</i>		*	F*	L	L	L	F	L*	W
<i>Quadrula quadrula</i>			L*	L	L	L	F	L	L
<i>Strophitus undulatus</i>			L	L	L	L	L	L	
<i>Tritogonia verrucosa</i>			F	L	L	L	L	L*	L
<i>Unio merus tetralasmus</i>	F								
Total (L + F):	2	5	11	12	14	13	11	13	8

Museum of Natural History and with the Museum of Ohio State University Representatives from the streams in Kansas were deposited with the State Biological Survey of Kansas, Lawrence.

Nomenclature employed follows that of Burch (1975) except for my use of *Ligumia subrostrata* (not *nasuta*) and of *Proptera* (not *Leptodea*) *laevissima*.

PREVIOUS STUDIES

There have been few previous records of unionaceans from the stream surveyed. Murray and Leonard (1962:Figs. 3, 35, 38) mapped *Amblema plicata*, *Ligumia subrostrata* and *Lampsilis radiata siliquoidea* in the Big and/or Middle Caney systems and recorded (p. 122) *Leptodea fragilis* from Silver Creek, a tributary of Grouse Creek.

Liechti and Huggins (1977) reported *Anodonta imbecilis*, *Lampsilis ovata*, *Ligumia recta* and *Truncilla truncata* from Big Caney River, 2.4 km west of Elgin, Chautauqua County, Kansas. From the same stream near Cedar Vale (my Loc. C-6) they reported *Tritogonia verrucosa*, *Strophitus undulatus* and *Proptera alata*. Guenter Schuster of the State Biological

Table 3. Species of mussels taken in Middle Caney River and Bird Creek. Abbreviations and symbols are explained in Table 1. Conditions for collecting were poor at Loc. M-4.

Species	Localities												
	M-1	M-2	M-3	M-4	M-5	M-6	B-1	B-2	B-3	B-4	B-5	B-6	B-7
<i>Amblema plicata</i>		W*	L*	W	W			W*	L	F	W	W	
<i>Anodonta grandis</i>	W	F	F*	L	F	F		L	F	L	F		
<i>Anodonta imbecilis</i>	F	F	L				F	F		L			
<i>Carunculina parva</i>		F	F				F	F	F	F	F		
<i>Fusconaia flava</i>		W	W*				*	W	W				
<i>Lampsilis ovata</i>			W*	W		W	*						
<i>Lampsilis radiata</i>	*	W	W*				*	W	W	W			
<i>Lampsilis teres</i>	*	L	L*		L	L		L	L	F	L	L	F
<i>Lasmigona complanata</i>		L	L	F	L	L	*				L	F	F
<i>Leptodea fragilis</i>		L	L		L	L					L	L	L
<i>Ligumia subrostrata</i>	L	L	L*	L	L	F	L*	F	L	L	L	F	L
<i>Proptera laevisissima</i>						F					L	F	F
<i>Proptera purpurata</i>		L		W	L	L					W	F	
<i>Quadrula pustulosa</i>						F					F		
<i>Quadrula quadrula</i>			F	F	L	L							F
<i>Strophitus undulatus</i>			*										
<i>Tritogonia verrucosa</i>		W			F	L						W	L
<i>Truncilla donaciformis</i>											L		
<i>Truncilla truncata</i>			W			W							
<i>Unio merus tetralasmus</i>								L	F	L			
Total (L + F):	2	8	9	4	8	10	3	6	6	7	9	6	7

Survey of Kansas has reidentified (pers. comm., 10 August 1978) the specimens of "*Ligumia recta*" as *Lampsilis teres* and the specimens of "*Proptera alata*" as *Proptera purpurata*. A record of "*Elliptio complanatus*" from Big Caney River, west of Elgin, by Mackie and Huggins (1976: Table 2) seems to be in error as *E. complanata* is a species of drainages far to the east and northeast of Kansas (Burch, 1975:11).

The only previous records, known to me, for the streams surveyed in Oklahoma are those reported by Isely (1924), based on his survey of the unionaceans of eastern Oklahoma in 1910-1912. He sampled the lowermost part of Salt Creek and Bird Creek at Catoosa and Nelagoney.

In the following sections, species are categorized in relation to their past and present distributions, proceeding from extirpated species, progressively, to better represented species.

EXTIRPATED SPECIES

Four species formerly existed in some streams of the area but seem to have been extirpated.

Table 4. Species of unionacean mussels taken in Salt Creek and Hominy Creek. Abbreviations and symbols are explained in Table 1.

Species	Localities												
	S-1	S-2	S-3	S-4	S-5	S-6	S-7	H-1	H-2	H-3	H-4	H-5	H-6
<i>Amblema plicata</i>		W	L	L*	F	W	W		W	*	W	*	
<i>Anodonta grandis</i>		F	F	L*	F		F						
<i>Anodonta imbecilis</i>			L	L		L	F	F					
<i>Carunculina parva</i>	F	L	F			F		F	F			F	
<i>Fusconaia flava</i>				*	W		*						
<i>Lampsilis ovata</i>				*									
<i>Lampsilis radiata</i>				*	W	*				*			
<i>Lampsilis teres</i>		F	L	L*	L	L	L		W	*	L	L	
<i>Lasmigona complanata</i>		L	F	L	F	F	L				L	L	
<i>Lasmigona costata</i>				*									
<i>Leptodea fragilis</i>		L	L	L	L	L	L		L	F	L	L	L
<i>Ligumia subrostrata</i>	F	L	L	L*	F	F	W	L	F	L	L	L	
<i>Obliquaria reflexa</i>				*			W						
<i>Proptera laevisissima</i>					F	F	F			F	F		L
<i>Proptera purpurata</i>		F	F	L*	F	L	L			*			
<i>Quadrula pustulosa</i>						L	L						
<i>Quadrula quadrula</i>			F	L*	F	F	L						
<i>Tritogonia verrucosa</i>				*			W			*			
<i>Truncilla donaciformis</i>													L
<i>Unio merus tetralasmus</i>								L	F	F			
Total (L + F):	2	7	10	9	9	10	9	4	4	4	5	6	2

Lasmigona costata (Rafinesque). The Fluted Mussel was represented only by fossils found in streambank deposits along (1) Big Caney River at Loc. C-6 and (2) Salt Creek at Loc. S-4 and at a nearby, unnumbered locality. These represent isolated, western records as compared to the present known distribution of this species. Neither Isely (1924:Table 2), in Oklahoma, nor Murray and Leonard (1962:86), in Kansas, recorded it west of the Neosho (Grand) River drainage. Schuster (1979) did not take it in a survey of the upper Verdigris River system in Kansas.

Ptychobranhus occidentalis (Conrad). A single fresh shell (132 × 70 mm) of this species from Big Caney River is in collections of the National Museum of Natural History. This specimen (USNM 424940) was collected by C. E. Burt in October, 1932, at "Camp Ta-la-hi, 5 mi. SE of Cedarvale." As no fresh shells or living specimens have been found in Big Caney River in this survey it is deemed likely that the species has become extinct since 1932, perhaps during the drought of the 1930's when the stream suffered from depleted discharge and prolonged intermittency. Burt may have regarded the specimen noted above as a rarity already in 1932, as he saw fit

Table 5. Unionacean shells (numbers of single valves indicated) from archeological locality OS-114 (Big Hawk Shelter). Radiocarbon determinations (on charcoal) are indicated under "Date, A.D." and are by laboratories of Southern Methodist University. Dates are based upon Libby half-life of 5568 ± 30 years and are not recalibrated to calendar years.

Level (in cm)	Date, A.D.	<i>Ambleria plicata</i>	<i>Fusconia flava</i>	<i>Lampsilis ovata</i>	<i>Lampsilis radiata</i>	<i>Lampsilis teres</i>	<i>Lampsilis</i> sp.	<i>Lasinigona complanata</i>	<i>Ligumia subrostrata</i>	<i>Proptera purpurata</i>	<i>Quadrula pustulosa</i>	<i>Quadrula quadrula</i>	<i>Strophitus undulatus</i>	<i>Tritogonia verrucosa</i>	Unidentified	Total	
0-10		5	3						4							1	13
10-20	1530 \pm 70	13	2			6			1		1		1			1	25
20-30	1230 \pm 20	29	3	4		3			3				1	7	2	53	
30-40	1053 \pm 51	35	4	3	2	18		2	4		3	1		8	3	82	
40-50	1179 \pm 44	55	6	7	5	20	4	1	8		2	1		6	12	127	
50-60	819 \pm 56	50	11		2	12			8		4			1	5	93	
60-70	660 \pm 50	37	7	2	3	3			10		4			7	2	75	
70-80	628 \pm 48	78	8	2	3	9		1	5		2		1	9	7	125	
80-90	412 \pm 83	28	9	5	2	8	1		7					2	5	67	
90-100	332 \pm 60	7	3	3	1	3	2		3						2	24	
100-110	200 \pm 70	2	2													4	
120-130						1										1	
Totals:		339	58	26	18	83	7	4	53	1	16	1	3	40	40	689	

to single it out for deposition in the National Museum. The species must formerly have been well represented in the middle segment of Big Caney (Table 1). Elsewhere in Kansas, living specimens have been reported from a single locality on Spring River, Cherokee County (Branson, 1967:288; Liechti and Huggins, 1977:25) and collected there by me (1 August 1972). Shells (some fresh) were found by Schuster (1979:20) in the upper Verdigris River.

Lampsilis rafinesqueana Frierson. Specimens of this species were identified by David Stansbery, Ohio State University. This species has sometimes been ascribed to *Actinonaias carinata* (Barnes) or to *A. ligamentina* (Lamarck). Only weathered valves and fossils of this species were found and only on Big Caney River at Locs. C-7, C-8 and C-9 (and elsewhere near these stations). The species now seems extinct in Big Caney River. Schuster did not find it in his survey of the upper Verdigris system (1979:23) and deemed it to be extirpated there.

Ligumia recta (Lamarck). Two greatly weathered valves, seemingly of this species, were found by Charles Cope in gravels of Big Caney River between stations C-7 and C-8, 1.5 km S Hewins, Chautauqua County, in June, 1979. This seems to be a sensitive species, especially vulnerable to

extirpation. Schuster (1979:17) failed to take it in his survey of the upper Verdigris system. He concluded that it had become a rare species in Kansas.

SPECIES FOUND LIVING ONLY IN BIG CANEY RIVER

Obliquaria reflexa Rafinesque and *Truncilla truncata* Rafinesque were found living only in Big Caney River. Numbers of specimens of both of these species seem to have increased at Loc. C-7 since 1970. These species were not found at Loc. C-6 in early years of this survey but appeared there in the mid-1970's with small specimens first observed. Possibly both species are increasing in numbers in the stream and extending their range upstream. This may be in response to changed stream conditions (such as more stable discharge) brought about by the watershed program, mentioned above, involving construction of small reservoirs on headwaters.

Fossils of *O. reflexa* were found at the lowermost locality (G-9) on Grouse Creek and a weathered valve of *T. truncata* was found in stream gravel 1.75 km north of G-9. Weathered shells and fossils of both *O. reflexa* and *T. truncata* were found in Walnut River in western Cowley County, Kansas. Weathered shells of *T. truncata* also occur in Middle Caney River (Table 2). Isely (1924:Table 2) noted presence of both species in lowermost Salt Creek and I found weathered shells and fossils of *O. reflexa* on Salt Creek in this survey (Table 4). Thus, these seem to be species that formerly occurred in the lower parts of most or all of the stream segments surveyed and which have suffered marked restriction of range except in Big Caney River.

SPECIES FOUND LIVING ONLY IN BIG CANEY RIVER AND GROUSE CREEK

Four species were found living only in Big Caney River and Grouse Creek, although all occurred, in the past, in one or more of the other streams surveyed.

Fusconaia flava (Rafinesque). The Pig-Toe Mussel was found, as a fossil, often abundantly in all six streams surveyed and from the three archeological sites noted above (see Table 5). It was reported from two stations (Catoosa and Nelagoney) on Bird Creek by Isely (1924:Table 2). In the present survey, *F. flava* was found living only in the middle segments of Big Caney River and Grouse Creek. Even in these areas, living specimens or fresh shells were rare, except at Loc. C-5, where they were noted as common on 2 August 1978. Living specimens seemed to be more frequently found in the later than they were in the earlier 1970's on Big Caney River.

Fusconaia flava, once an abundant species in the six streams, seems to have been especially intolerant of changing stream environments, culminating in its probable extinction in all but two of the streams. It will be of interest to observe whether it will increase in numbers in Big Caney River in the future.

Lampsilis ovata (Say). The Pocketbook Mussel was common in the middle segments of Big Caney River and Grouse Creek. Weathered shells were found at several stations on Middle Caney River (as they were also in gravels of the Walnut River in western Cowley County, where the species no longer seems to occur). Isely (1924:Table 2) recorded it from lowermost Bird Creek at Catoosa and I found fossils in streambank deposits at Loc. B-1 on upper Bird Creek and at Loc. S-4 on Salt Creek. In archeological deposits of Big Hawk Shelter, *L. ovata* was found at several levels (Table 5). Thus, it seems formerly to have occurred much more widely in the region than it does at present, perhaps when conditions in other streams more closely approximated those in which it persists in Grouse Creek and Big Caney River.

Lampsilis radiata siliquoidea (Barnes). The Fat Mucket Mussel was taken at several stations on Grouse Creek, being most common at Locs. G-5 and G-6. It was less common in Big Caney River and was found only at Locs. C-5 and C-6. It formerly must have been a common species in the upper and middle parts of all six streams as it is an abundant fossil in their bank sediments. It occurs at all three archeological sites but most abundantly at OS-135 on Birch Creek, a small tributary of Bird Creek. It seems clearly to have suffered severe restriction of range, marked especially by its disappearance from upstream waters (see Tables 1-4). Its extirpation from four of the six streams suggests that it is a sensitive species, whose future existence here may be in jeopardy. Schuster (1979:16) did not find *L. r. siliquoidea* in a survey of Elk, Fall and upper Verdigris rivers in Kansas. However, I have taken it between his collecting sites 14 and 15 on Elk River at Elk Falls. It now seems to be restricted to a short middle segment of Elk River as it is in Big Caney River and Grouse Creek. In contrast to recent findings, Scammon (1906:288) found it to be abundant in eastern Kansas in the early years of this century. Such former abundance accords with the fossil evidence noted above.

Strophitus undulatus (Say). The Squaw-Foot Mussel was a common species in the upper and middle parts of Grouse Creek and Big Caney River but rare or absent at lower stations on both streams. It was not found living in the other streams surveyed but occurred at three levels in the archeological deposits of Big Hawk Shelter and at one level at OS-138 along Hominy Creek (Table 5). Fossils were found at Loc. M-3 on Middle Caney River. These records indicate wider distribution in the past, but now greatly reduced to stream segments with especially favorable habitats.

The four species discussed in this section are nearing, in the streams surveyed, the westernmost limits of their range in the Arkansas River System. Thus, natural restraints may make their existence here precarious so that the addition of further (possibly relatively slight) deleterious factors might tip the balance towards extirpation. Only 150 km to the east, the

situation may remain more as it was in the survey area a century ago. There in the drainage of Spring River, Branson (1967:287) noted that *Lampsilis radiata siliquioidea* (=his *L. luteolus*) "Both in numbers and distribution . . . is the most common species encountered . . ." Fossils suggest that this description might have applied to the upper parts of some of the stream considered in this study in past times. Branson (1967:284) also noted that *Strophitus undulatus* (=his *S. rugosus*) was "one of the most widespread species in the Spring River System." and he reported *Lampsilis ovata* and *Fusconaia flava* from numerous stations.

All the (non-extirpated) species discussed to this point may have an uncertain future in the streams where they survive, given their history of decimation in other, nearby streams. Their status could well deserve monitoring in the future.

SPECIES PRIMARILY OF BIG CANEY RIVER AND GROUSE CREEK BUT FOUND IN FAVORABLE AREAS ELSEWHERE

Four species occurred widely in Big Caney River and Grouse Creek and less commonly in some other streams. It seems likely that these are species somewhat more tolerant of deteriorating environments than the preceding groups but which have, nevertheless, undergone some restriction of range especially in streams of the Osage and Chautauqua Hills.

Amblema plicata Say. The Blue-Point Mussel seems an especially significant species in a paleoecological sense. Fossils in sediments of stream banks and weathered shells found in stream gravels indicate that it formerly occurred commonly in all streams surveyed except in their uppermost part (Tables 1-4). The species still occurs at all but the uppermost stations on Big Caney River. In Grouse Creek it is absent from the uppermost station (G-1) and only weathered shells were found at the lowermost station (G-9). On Bird Creek and Middle Caney River, *A. plicata* seems presently to be restricted to the middle part of the streams, although formerly more widespread both upstream and downstream, judging by fossils and weathered shells. In Hominy Creek it has disappeared from the living fauna, although it is the most common species represented in materials from the two archeological sites (see Table 5). Fossils in streambanks and weathered shells are common at some localities on Hominy Creek. Thus, there seems to have been a change from abundance to extirpation in Hominy Creek.

Quadrula pustulosa (Lea). The Pimple-Back Mussel occurs commonly in Grouse Creek and Big Caney River but is rare in Middle Caney River and Bird and Salt creeks. It was absent in collections from Hominy Creek but occurred at several levels, archeologically, in Big Hawk Shelter (Table 5). Thus, it seems to be another species unable to tolerate present conditions of Hominy Creek.

Tritogonia verrucosa (Rafinesque). The past and present distributions

patterns of the Pistol-Grip Mussel are much like those of *Quadrula pustulosa*. It occurs commonly in the middle and lower parts of the three streams heading in Kansas. Isely (1924:Table 2), in his survey of 1910–1912, found it at two stations on Bird Creek and at one station on Salt Creek. On Salt Creek, in my survey, only weathered valves (Loc. S-7) and fossils (Loc. S-4) were found. A living specimen was found at the lowest station (B-7) on Bird Creek. On Hominy Creek only fossils were taken (Loc. H-3); however, it occurred at several levels in deposits of Big Hawk Shelter (Table 5).

Proptera purpurata (Lamarck). The Purple Shell Mussel was found commonly from Loc. C-6, downstream, in Big Caney River. It also occurred as a fossil, upstream, at Loc. C-4, indicating a former greater range headward. A similar situation may apply on Grouse Creek, where only weathered shells were found at upper stations. On Bird Creek fresh shells of *P. purpurata* were found only at a lower station (B-6); however, Isely (1924:Table 2) recorded it upstream at Nelagoney (my Loc. B-3). Here, again, the species seems formerly to have occurred farther upstream. It seems to have disappeared from Hominy Creek; however, fossil shells were found at Loc. H-3 and one valve was found in archeological deposits from Big Hawk Shelter. In contrast to the other streams heading in Oklahoma, *P. purpurata* was common in Salt Creek (Table 4).

Generally, in the Oklahoma streams considered, the species discussed in this section seem to have suffered much decimation. In Hominy Creek the situation is similar for all four species—former occurrence, with some species abundant, but all species now extirpated.

WIDESPREAD SPECIES

Eleven species seem better to have withstood environmental changes of streams in the region than have those discussed above. Most of these species occur in all streams surveyed. Exceptions are *Anodonta grandis grandis* Say, lacking in Hominy Creek, and *Truncilla donaciformis* (Lea), which seems to have a more southeastern distribution and likely never occurred in Salt or Grouse creeks. Some of these species may actually have increased in numbers and/or extended their ranges, as discussed below.

Several of these species are generally associated with (but not restricted to) upstream habitats, where they may have suffered least from any environmental changes of streams. Such species include *Uniomerus tetralasmus* (Say), *Anodonta imbecilis* Say, *Carunculina parva* (Barnes) and *Ligumia subrostrata* (Say). In contrast to the above group are *Proptera laevis* (Lea) and *Truncilla donaciformis* (Lea), which were associated with downstream habitats. The remaining species are somewhat intermediate between the two groups noted above in regard to distribution in the streams.

In the streams heading in Kansas, *Anodonta g. grandis* occurred at all

but the uppermost stations. In Salt and Bird creeks it occurred at most stations. *Leptodea fragilis* (Rafinesque) and *Lampsilis teres* (Rafinesque) had similar distributions and habitats. In the sandier streams of the Osage and Chautauqua Hills these species extended far headward as they did also in Salt Creek, a more gravelly stream. In Big Caney River and Grouse Creek they were absent from upper stations.

Lasmigona complanata (Barnes) was found in the middle and lower segments of all streams surveyed. Living specimens were absent at uppermost stations but it occurred, as a fossil, at Loc. B-1 on Bird Creek.

Quadrula quadrula (Rafinesque) was taken in middle and lower segment of all streams surveyed except Hominy Creek. A single shell was found in archeological materials from Big Hawk Shelter. It was well preserved; possibly it had been transported from another stream by Indians, as a curiosity

SPECIES THAT MAY HAVE EXTENDED THEIR RANGE OR INCREASED IN NUMBERS

Fossil assemblages from bank deposits of Big Caney River and Grouse Creek contained a number of species that are commonly associated with *Quadrula quadrula* at the present time. However, fossils of *Q. quadrula* were found only at one locality on Grouse Creek (Loc. G-3). This suggests that *Q. quadrula* may be a hardy species, numbers of which have increased relatively recently, while some less tolerant species, such as *Fusconai flava* and *Lampsilis radiata siliquoidea*, have been declining in numbers.

In most streams *Ligumia subrostrata*, the Pond Mussel, was common upstream but declined in numbers downstream. However in Hominy Creek it was the dominant species at all stations except the lowermost one (H-6), suggesting that it may have achieved increased population levels in the middle part of the stream while a number of other species were becoming extinct.

It has been suggested above that some species of Big Caney River, in particular *Obliquaria reflexa* and *Truncilla truncata*, may be, at this time increasing their range and their numbers in response to a watershed improvement program.

DISCUSSION OF STREAMS AND THEIR FAUNAS

From the above particular cases noted, some generalities seem derivable concerning past, present, and possibly the future of the unionaceans and their distributional patterns in the streams concerned.

1. *Big Caney River and Grouse Creek.* The watersheds of these two streams adjoin and the streams are similar habitat-wise and faunally. Big Caney River yielded 21 and Grouse Creek 18 living species (some represented by fresh shells). Grouse Creek seemingly lacks living *Obliquari*

reflexa, *Truncilla truncata* and *T. donaciformis*. However, *O. reflexa* and *T. truncata* occurred there formerly.

Silver Creek, a lower, and the largest tributary of Grouse Creek, receives drainage at this time from an extensive hog farm located just above the confluence of Silver and Grouse creeks. Here large tracts of land have been denuded of vegetation by swine. What effect this source of silt and animal waste may have on the streams and their unionacean faunas is not known.

2. *Middle Caney River.* Only 13 species were found living in this stream; however, fossils and weathered shells indicate that at least four additional species occurred there in the past: *Fusconaia flava*, *Lampsilis radiata siliquoidea*, *Lampsilis ovata* and *Truncilla truncata*. The fauna is similar to but less diverse than that of Big Caney River. Middle Caney has a lower gradient and less discharge than Big Caney. At present it is characterized by narrow, shallow pools that extend for long distances between short riffles and that have bottoms of mud or sand. The stream is also much entrenched in most of its middle and lower course. On the favorable side, however, several small reservoirs have been constructed in the watershed in Kansas and these seem to have produced permanent flow in much of the stream. The lower part of Middle Caney River is being impounded near Copan, Washington County, Oklahoma, with construction largely completed in the summer of 1978. The relatively (for the stream) diverse assemblage at Loc. M-6 will be inundated by this impoundment.

3. *Salt Creek.* In Salt Creek only 12 living species were found. However, six additional species are known to have lived there formerly from the earlier survey of Isely (1924) and from fossil evidence. All six of these occur in streambank deposits at Loc. S-4. Thus, the fauna shows considerable change, temporally. This change may be attributable to practices of the petroleum industry. The middle and lower parts of Salt Creek flow through an area that contained large oilfields in the period 1915–1930. Pollution from oil and salt water spillage must have been common during this period. It seems likely that much or all of the unionacean fauna, except in headwaters, where oil wells were not located, was extirpated. Although there are still some oil wells in the Salt Creek watershed, these seem to be controlled to minimize escape of pollutants. Perhaps there is now underway the reestablishment of a unionacean fauna in Salt Creek, but one that differs from the original fauna. The “reestablished” fauna probably draws propagules from upstream populations that escaped extirpation. However, the original fauna may have been derived chiefly from a Pleistocene Arkansas River, a river probably more hospitable to mussels than the present sandy stream. Existence of such a former Arkansas River fauna seems likely as it is otherwise difficult to understand how mussels were disseminated to various tributaries such as Salt and Grouse creeks and the Chikaskia River. The fauna of the

middle part of Salt Creek now faces a new threat as an impoundment of the creek, near Shidler, is planned.

4. *Bird Creek.* This stream heads on the eastern flank of the Flint Hills but shortly flows into the Osage Hills. In its upper segment it once seemingly possessed a relatively rich fauna similar to that of upper Big Caney River and Grouse Creek at present. This is shown by the fossil assemblage found at Loc. B-1: *Fusconaia flava*, *Lasmigona complanata*, *Lampsilis ovata*, *Lampsilis radiata siliquoidea* and *Ligumia subrostrata*. Of these, only *L. subrostrata* persists at this locality at present and the first three species noted seem to have been extirpated from the entire stream. The fossil assemblage suggests that the stream was formerly larger and/or more permanent at Loc. B-1.

At Loc. B-2, at Pawhuska, weathered shells of *Amblema plicata*, *Fusconaia flava* and *Lampsilis r. siliquoidea* occur and at Loc. B-3, at Nelagoney, a population of *A. plicata* still survives. In his survey of 1910–1912 Isely (1924:72; Table 2) listed the following species at Nelagoney (those not found there in my survey are indicated by asterisk): *F. flava**, *A. plicata*, *Anodonta g. grandis*, *Tritogonia verrucosa**, *Proptera purpurata**, *Carunculina parva*, *Ligumia subrostrata* and *L. r. siliquoidea**. As in some other streams, it appears that *P. purpurata* and *T. verrucosa* formerly extended farther upstream than at present.

Further evidence of the marked change in the fauna of the Bird Creek System is produced by archeological materials from Loc. OS-135 along upper Birch Creek, a tributary. This site was excavated to a depth of 120 cm in a pre-impoundment survey related to Birch Lake (with dam on Birch Creek near Barnsdall). The present fauna of Birch Creek near OS-135 comprises *Anodonta imbecilis*, *Unio merus tetralasmus* and *Ligumia subrostrata*. *Ligumia subrostrata* also occurs at most levels in the archeological deposits. In great contrast to the present fauna, however, was the presence of *Amblema plicata* (all levels), *Fusconaia flava* (30–70 cm), *Lampsilis r. siliquoidea* (30–110 cm) and *Lampsilis teres* (20–40 cm).

5. *Hominy Creek.* This stream is also destined to be impounded, by a dam located west of Skiatook, to produce "Skiatook Lake." Construction is in progress (1977–1979). Locs. H-5, H-4 and possibly H-3 will be inundated. A pre-impoundment archeological survey produced mussels from two sites (Locs. OS-114 and OS-138). In OS-114, Big Hawk Shelter, material had been deposited for about 1300 years from approximately 200 to 1500 A.D. They (together with fossils and weathered shells) indicate a much different fauna formerly existed in Hominy Creek. The present fauna comprises only nine species; the archeological fauna comprises three of these plus nine additional species. Seemingly, more faunal diminution has taken place in Hominy Creek in the past century than in the preceding 2000 years

Thus, Hominy Creek exhibits an extreme in regard to decimation of unionacean faunas in this region. What contributed to this decimation? Whatever the causes, they likely also contributed to faunal impoverishment, of a less marked nature, in other streams surveyed herein. Factors that might have been involved are:

a. *Nature of the Osage-Chautauqua Hills as related to stream bottoms and siltation.* Hominy Creek is situated almost entirely in the Osage Hills. Sandstones of these hills produce sandy floodplains, which, in turn, have been easily and deeply incised by streams in the past century and in which stream bottoms of sand and silt predominate. Such a change in nature of bottom sediments may have contributed to the demise of the former fauna of Hominy Creek, which may have contained species that were ecologically attuned to more gravelly stream bottoms and to clearer waters. In this regard, I note that streams of the Flint Hills have preserved a richer fauna than streams of the Osage/Chautauqua Hills, for example: Big versus Middle Caney River and Salt Creek versus Hominy Creek (despite pollution in Salt Creek).

b. *Intermittency.* Intermittency has been severe in streams of this region at times in this century, especially during the famed drought of the 1930's and in the 1950's (personal observations). Intermittent conditions were also noted on Hominy and Salt creeks in August, 1978. I suggest that intermittency could well have been detrimental to aquatic species requiring well oxygenated waters, related to continuous stream flow, or which, for this or other reasons, preferred a riffle habitat. This could have involved either post-larval mussels themselves or the fish hosts of their glochidia.

c. *Pollution.* It seems likely that there has been, at times in the past 60 years, pollution in Hominy Creek related to the petroleum industry. Oil wells and associated facilities are still numerous in the watershed and some are even located on the banks of the creek. Insecticides seem a possible, although undocumented, factor in causing decreases in populations and extirpation of species of mussels. However, cultivated fields are not extensive in the watershed, which is predominantly utilized for grazing.

LOCALITIES OF COLLECTIONS

Each stream is designated by a letter and stations, for each stream, are numbered, beginning with 1, upstream. Distances are from approximate centers of towns mentioned. Years in which collections were made are indicated in parentheses at the end of each description.

Bird Creek

Localities B-1 to B-5 are in Osage County, B-6 and B-7 in Tulsa County, Oklahoma.

B-1. 11.25 km NW Pawhuska on North Bird Creek. SW $\frac{1}{4}$, Sec. 1, T. 26 N, R. 8 E. (1976, 1978).

B-2. W side of Pawhuska. SW $\frac{1}{4}$, Sec. 4 and NW $\frac{1}{4}$, Sec. 9, T. 25 N, R. 9 E. (1976-1978).

B-3. N side of Nelagoney at bridge. SE $\frac{1}{4}$, NE $\frac{1}{4}$, Sec. 20, T. 25 N, R. 10 E. (1976, 1977).

B-4. 0.95 km N Barnsdall below dam and above area of waterfalls. Central part, N $\frac{1}{2}$, SE $\frac{1}{4}$, Sec. 7, T. 24 N, R. 11 E. (1977).

B-5. S side of Avant. S $\frac{1}{2}$, NW $\frac{1}{4}$, Sec. 7, T. 23 N, R. 12 E. (1977, 1978)

B-6. 2.9 km N and 0.8 km E Skiatook, where crossed by Oklahoma Highway 11. SW $\frac{1}{4}$, SW $\frac{1}{4}$, Sec. 12, T. 22 N, R. 12 E. (1977, 1978).

B-7. 3.2 km ENE Sperry. NE $\frac{1}{4}$, NE $\frac{1}{4}$, Sec. 18, T. 21 N, R. 13 E. (1978)

Big Caney River

C-1 and C-2 are in Elk County and C-3 to C-8 in Chautauqua County Kansas. C-9 is in Osage County and C-10 in Washington County, Oklahoma

C-1. 2.4 km NW Grenola in area near mouth of Shrader Branch. SE $\frac{1}{4}$ SE $\frac{1}{4}$, Sec. 7, T. 31 S, R. 9 E. (1976).

C-2. 3.4 km S and 0.4 km W Grenola. SE $\frac{1}{4}$, SE $\frac{1}{4}$, Sec. 30, T. 31 S, R. 9 E. (1976-1978).

C-3. 6.75 km S and 0.8 km W Grenola. N $\frac{1}{2}$, NE $\frac{1}{4}$, Sec. 7, T. 32 S, R. 9 E. (1976-1978).

C-4. 1.9 km SE Cloverdale. SE $\frac{1}{4}$, SE $\frac{1}{4}$, Sec. 36, T. 32 S, R. 8 E. (1975-1978).

C-5. 3.45 km N and 0.4 km E Cedar Vale. S $\frac{1}{2}$, NE $\frac{1}{4}$, Sec. 35, T. 33 S, R. 8 E. (1978).

C-6. E side of Cedar Vale from U.S. Highway 166 for 0.8 km upstream. W $\frac{1}{2}$, NW $\frac{1}{4}$, Sec. 12, T. 34 S, R. 8 E. (1969-1978).

C-7. 3.55 km NW Hewins, immediately below Osro Falls. SW $\frac{1}{4}$, SE $\frac{1}{4}$ Sec. 29, T. 34 S, R. 9 E. (1974-1978).

C-8. 5.8 km WNW Elgin at Fletchers Ford, near Wilson Cemetery. NW $\frac{1}{4}$ SW $\frac{1}{4}$, Sec. 8, T. 35 S, R. 10 E. (1969, 1974-1978).

C-9. 0.8-1.0 km downstream from Hulah Reservoir dam. NW $\frac{1}{4}$ NW $\frac{1}{4}$ Sec. 12, T. 28 N, R. 11 E. (1975-1978).

C-10. 7.55 km SW Copan. NE $\frac{1}{4}$, NE $\frac{1}{4}$, Sec. 2, T. 27 N, R. 12 E. (1978)

Grouse Creek

All localities are in Cowley County, Kansas.

G-1. 1.4 km S Butler-Cowley County boundary. SE $\frac{1}{4}$, SE $\frac{1}{4}$, Sec. 10 (oversize), T. 30 S, R. 8 E. (1976).

G-2. 8.2 km NNE Cambridge. SW $\frac{1}{4}$, SE $\frac{1}{4}$, Sec. 34, T. 30 S, R. 7 E. (1976-1978).

- G-3. 1.8 km NNW Cambridge. S $\frac{1}{2}$, SW $\frac{1}{4}$, Sec. 21, T. 31 S, R. 7 E. (1976–1978).
- G-4. 7.4 km SSW Cambridge. NE $\frac{1}{4}$, NE $\frac{1}{4}$, Sec. 19, T. 32 S, R. 7 E. (1977, 1978).
- G-5. 4.8 km N Dexter. SW $\frac{1}{4}$, NW $\frac{1}{4}$, Sec. 31, T. 32 S, R. 7 E. (1976–1978).
- G-6. 1.6 km NNW Dexter. SW $\frac{1}{4}$, NE $\frac{1}{4}$, Sec. 12, T. 33 S, R. 6 E. (1969–1978).
- G-7. 0.8 km W of mouth of Crab Creek. NW $\frac{1}{4}$, SE $\frac{1}{4}$, Sec. 32, T. 33 S, R. 6 E. (1976).
- G-8. 2.0 km SW Vinton. NW $\frac{1}{4}$, SW $\frac{1}{4}$, Sec. 13, T. 34 S, R. 5 E. (1977, 1978).
- G-9. 2.65 km S Silverdale, adjacent to Scout Camp Ko-Ha-Me. NW $\frac{1}{4}$, SE $\frac{1}{4}$, Sec. 8, T. 35 S, R. 5 E. (1974, 1975).

Hominy Creek

All localities are in Osage County, except H-6 in Tulsa County, Oklahoma.

- H-1. 11.25 km WNW Wynona on Little Hominy Creek. NE $\frac{1}{4}$, Sec. 9, T. 24 N, R. 8 E. (1976, 1977).
- H-2. 6.9 km N and 1.3 km E Hominy; 0.8 km ESE of junction of Big and Little Hominy creeks. SE $\frac{1}{4}$, SW $\frac{1}{4}$, Sec. 7, T. 23 N, R. 9 E. (1978).
- H-3. 4.0 km NE Hominy. NE $\frac{1}{4}$, NE $\frac{1}{4}$, Sec. 32, T. 23 N, R. 9 E. (1976).
- H-4. 2.6 km NW Morgans Corner. E $\frac{1}{2}$, NE $\frac{1}{4}$, Sec. 16, T. 22 N, R. 10 E. (1976–1978).
- H-5. Ca. 12 km W Skiatook. NE $\frac{1}{4}$, NW $\frac{1}{4}$, Sec. 28, T. 22 N, R. 11 E. (1976, 1978).
- H-6. 2.0 km NE Sperry. NE corner, Sec. 13, T. 21 N, R. 12 E. (1978).

Middle Caney River

Localities M-1 to M-4 are in Chautauqua County, Kansas; M-5 in Washington County, Oklahoma.

- M-1. 1.3 km SW Belknap Cemetery. NE $\frac{1}{4}$, NW $\frac{1}{4}$, Sec. 30, T. 32 S, R. 10 E. (1978).
- M-2. Immediately below mouth of Pool Creek, in area of Butchers Falls (on Pool Creek). NE $\frac{1}{4}$, SW $\frac{1}{4}$, Sec. 25, T. 33 S, R. 10 E. (1978, 1979).
- M-3. S and SW of Sedan. S $\frac{1}{2}$, Sec. 3, T. 34 S, R. 11 E. (1977–1979).
- M-4. 1.4 km NNW Peru. NW $\frac{1}{4}$, NE $\frac{1}{4}$, Sec. 16, T. 34 S, R. 12 E. (1977).
- M-5. 2.8 km NE Niotaze. NE $\frac{1}{4}$, NE $\frac{1}{4}$, Sec. 21, T. 34 S, R. 13 E. (1978).
- M-6. 3.2 km NW Copan. SE $\frac{1}{4}$, SE $\frac{1}{4}$, Sec. 7, T. 28 N, R. 13 E. (1976, 1978).

Salt Creek

All localities are in Osage County, Oklahoma.

- S-1. 1.2 km ENE Grainola. NE $\frac{1}{4}$, NE $\frac{1}{4}$, Sec. 3, T. 28 N, R. 6 E. (1976)
- S-2. 8.0 km S Grainola and 8.0 km W Foraker. NE $\frac{1}{4}$, Sec. 33, T. 28 N, R. 6 E. (1977-1979).
- S-3. 2.1 km SE Shidler. SW $\frac{1}{4}$, SE $\frac{1}{4}$, Sec. 34, T. 27 N, R. 6 E. (1977-1979).
- S-4. 4.8 km SW Shidler. NE $\frac{1}{4}$, SE $\frac{1}{4}$, Sec. 7, T. 26 N, R. 6 E. (1976-1979).
- S-5. E part of Burbank. SW $\frac{1}{4}$, SW $\frac{1}{4}$, Sec. 25, T. 26 N, R. 5 E. (1976-1977).
- S-6. 1.75 km SE Remington. NW $\frac{1}{4}$, NW $\frac{1}{4}$, Sec. 19, T. 25 N, R. 6 E (1976-1978).
- S-7. 3.4 km NW Fairfax. SW $\frac{1}{4}$, SW $\frac{1}{4}$, Sec. 36, T. 25 N, R. 5 E. (1976-1978).

Archeological Sites

OS-114 (Big Hawk Shelter) and OS-138. 11.7 km ESE of Hominy. NW $\frac{1}{4}$ SE $\frac{1}{4}$, Sec. 7, T. 22 N, R. 10 E. These shelters are located in a south-facing escarpment, rising above the floodplain of Hominy Creek. OS-138 is 25 m E of OS-114.

OS-135. 7.2 km ENE of Wynona on N side of Birch Creek and E side of Barnsdall-Wynona road. NE $\frac{1}{4}$, SE $\frac{1}{4}$, Sec. 17, T. 24 N, R. 10 E.

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