1971

Holocene Mollusks of the Knife and Heart Rivers, Southwestern North Dakota

Joanne R. Groenewold

HOLOCENE MOLLUSKS OF THE KNIFE AND HEART RIVERS, SOUTHWESTERN NORTH DAKOTA

by

Joanne R. Groenewold

A Senior Thesis submitted to the faculty of the Geology Department at the University of North Dakota in partial fulfillment of the requirements for the Degree of Bachelor of Science of Geology.

Grand Forks, N. Dak.

May, 1971

This Thesis submitted by Joanne R. Groenewold in partial fulfillment of the requirements for the Degree of B. S. in Geology from the University of North Dakota is hereby approved by the Faculty Advisor under whom the work has been done.

Frank Kaiser
Advisor

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

ABSTRACT

From 12 collecting sites in the Knife River, southwestern North Dakota, at least 15 species of aquatic mollusks were found. From 4 fossil sites on the same river, at least 17 species of aquatic mollusks were found in addition to 11 species of fossil terrestrial gastropods. From 18 collecting sites in the Heart River, southwestern North Dakota, at least 18 species of aquatic mollusks are presently living. From 6 fossil sites on this river, at least 10 species of aquatic mollusks were found in addition to 4 species of fossil terrestrial gastropods. The unionid family was represented in the Knife and Heart River by each having 6 species living presently and 4 species as fossil. The pisidiid family was represented in both rivers by two genera. The Knife River contained 7 species of aquatic gastropods living presently and the Heart River contained 10 species living presently. As aquatic gastropod fossils, however, there were 11 species from the Knife River and 4 species from the Heart River.

Of the unionids, Leptodea laevissima (Lea) occurs alive in the lower reaches of both rivers but does not occur as a fossil. One specimen of Lampsilis ventricosa (Barnes) establishes the existence of this species in the Missouri River drainage presently; this species does occur as fossil. Anodontoides ferussacianus (Lea) was not found in the fossil assemblage of the Heart River.

The living aquatic gastropod faunas of the two rivers are approximately equivalent to the aquatic gastropod fossil fauna. The fossil assemblage of the Heart River did contain Probythinella lacustris (Baker),

a species that was not found in the Knife River. The fossil presence of Armiger crista (Linnaeus, Stagnicola caperata (Say), and Lymnaea stagnalis (Linne) indicate that most of the fossil sediments studied were deposited in a pond or slow-water environment.

The fossil terrestrial gastropods do not indicate any different environments than those found presently on the two rivers. The requirements of Oxyloma retusa (Lea), preferring moist conditions, and Discus cronkhitei (Newcomb), preferring woodland conditions, are adequately met.

Therefore, a significant change in the regiman of the rivers is not evident as the total species are essentially the same, living or fossil.

The molluscan faunal fossil finds are post- 5,440 years B. P. $\pm$ 200 years or late Holocene.

INTRODUCTION

The Knife and Heart Rivers of southwestern North Dakota (Plate 1) are a part of the Missouri River drainage. The Knife River flows eastward and drains an area of 5,780 km^2; it has a yearly mean discharge of 4.2 m^3/sec, based on observations over a 36 year period (U. S. Geological Survey, 1969). It joins the Missouri River near Stanton, N. Dak., about 16 km south of Lake Sakakawea. South of the Knife River, and nearly paralleling it, is the Heart River which drains an area of 8,075 km^2 and has a yearly mean discharge of 5.0 m^3/sec (U. S. Geological Survey, 1969). The Heart River empties into the Missouri River about 8.1 km below Bismarck, or 16 km north of the Oahe Reservoir. Both of these rivers have recorded periods of no flow for up to several days since 1933, when such periods were first recorded (U. S. Geological Survey, 1969).

In 1964, while the U. S. Geological Survey was mapping this particular area of North Dakota, W. C. Rasmussen and G. D. Mowat collected several shells of unionids from Quaternary terrace gravels and Recent alluvium which were donated to the Department of Geology, University of North Dakota. Brophy (1966) measured a stratigraphic section near Zap, N. Dak., while he was studying a possible Bison (Superbison) crassicornis find. He noted wood, shells, and bones, including the skull of B. crassicornis in a lower, interbedded sand, silt, and clay unit. He returned to the same site in the fall of 1970 and collected additional unionid shells and bones. Brophy loaned the author the entire collection of unionid shells for her study. During the summers of 1967-1969, Alan M. Cvancara of the University of North Dakota Department of Geology, as part of a

study of the living aquatic mollusks of N. Dak., collected from the Knife and Heart Rivers and their tributaries. Accompanying him in 1967 and 1968 was W. J. Stewart, who collected fossil mollusks in the vicinity of Cvancara's living mollusk stations.

The primary purpose of this study is to compare the fossil mollusks with those living presently in the rivers. Natural and/or man-made changes in the regimen of the rivers are then evaluated on the basis of these mollusks.

METHODS

Field methods

W. J. Stewart measured each fossiliferous section with a hand level. Two types of samples were taken. One was a channel sample of the entire section; each lithologic unit was sampled separately. The size of the samples ranged from 1100 cm^3 to 4200 cm^3, averaging about 2600 cm^3. The other sample was a grab sample taken primarily for unionids but also to insure that as many species as possible would be obtained from the exposure.

The living fauna was collected by A. M. Cvancara and D. Kemp. Unionids were taken by hand picking. Where water was relatively clear, unionids were located with the aid of a Turtox Fishscape, an aluminum alloy cylinder (0.6 m X 0.15 m) fitted with a glass plate at one end; in turbid water, these mollusks were found by feel with hands and feet. A kitchen food strainer was passed through vegetation and bottom sediment to collect gastropods and pisidiids.

Laboratory work

All the unit samples from the measured sections were weighed and their volume was determined. The unit samples were wet-sieved through

Tyler sieves 5, 9, 16, 32, 60, 115, and 250. Each Tyler-sized portion was weighed and recorded; the difference between the sum of those weights and the total weight was the weight of the silt and clay that had escaped. The grab samples were also wet-sieved and picked for fossils.

Fossils were picked under a 24 power American Optical Spencer microscope with sensitive forceps or a fine brush. Only Tyler 5, 9, 16, and 32 sieves were picked. The specimens per unit were separated into small vials for each species indentified. Thus a count was able to be made for each unit. The grab sample was picked in the same way but the number of individuals per species were not counted as such numbers would be invalid.

A. M. Cvancara was able to make a count of unionid individuals per species from each station in his study of living mollusks. Those numbers must be expressed according to time rather than volume because of the different methods of collection. Relative abundance of pisidiids and gastropods were estimated in the field.

RESULTS

Fossil sites

The four fossiliferous sites on the Knife River are as follows (Text-figures 1 and 2):

Hazen site A (F1). Right bank, Kineman Creek, 199 m upstream from bridge on N. Dak. 200, NE¼ NE¼ sec. 13, T. 144 N., R. 86 W., 8.4 km east of Hazen, south Mercer Co., N. Dak.

Zap site A (F2). North slope of irrigation ditch, 424 m due south and 161 m east of bridge (bridge in sec. 8, T. 144 N., R. 89 W.), NW¼ sec. 17, T. 144 N., R. 89 W., 5.2 km west-northwest of Zap, south Mercer Co., N. Dak.

Hazen site B (F3). Right bank, Knife River, 217 m below bridge (bridge on N. Dak. 200, crossing T. line common to T. 144 N. and T. 145 N.), SW¼ sec. 34, T. 145 N., R. 85 W., 10.8 km east-northeast of Hazen, north Mercer Co., N. Dak.

Zap site B (F4). NW¼ sec. 17, T. 144 N., R. 89 W., 5.5 km west-

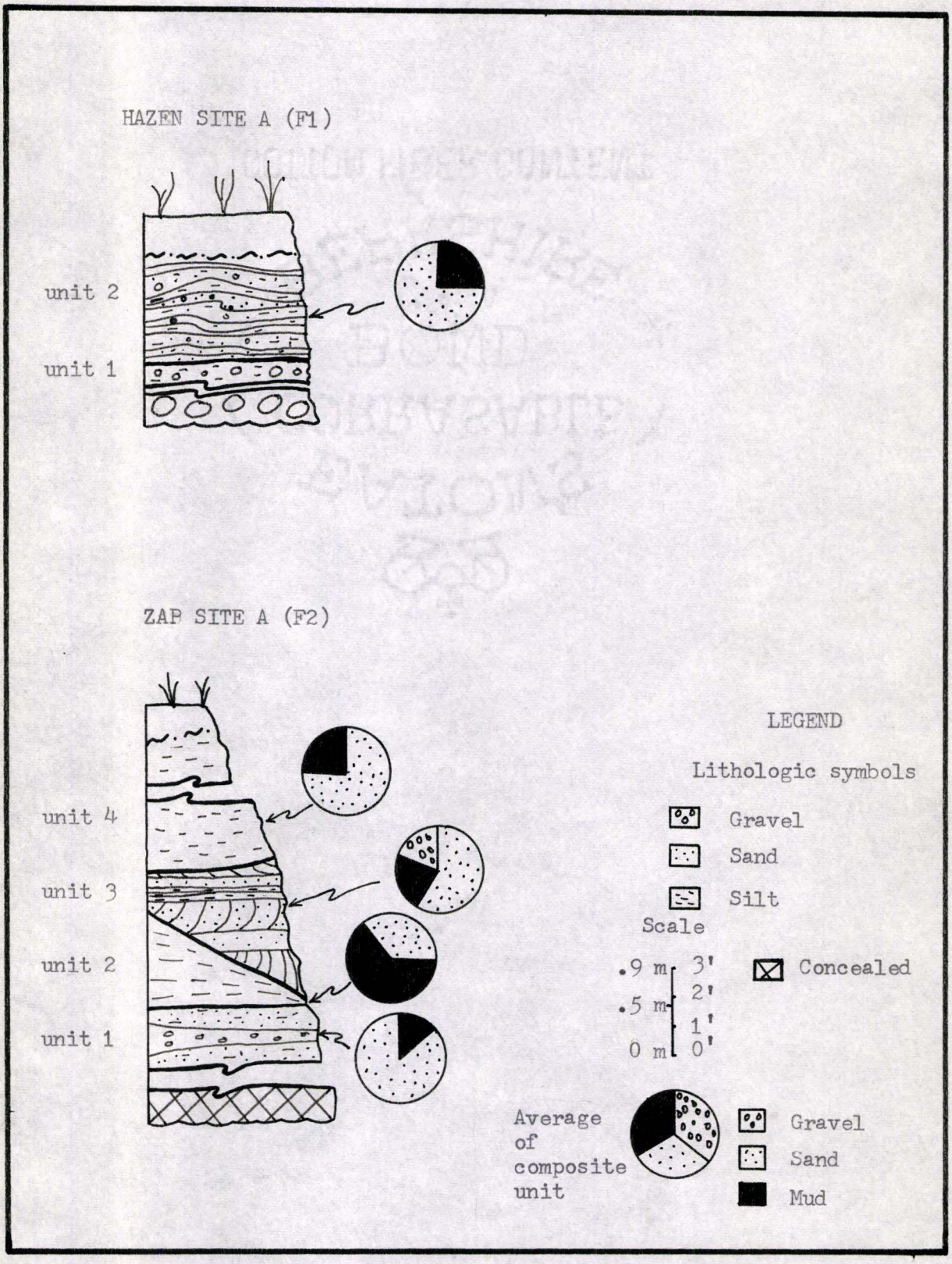

Figure 1.--Measured sections F1 and F2 on the Knife River. See Plate 1 for location. Table 1 shows the molluscan fossil assemblage per unit.

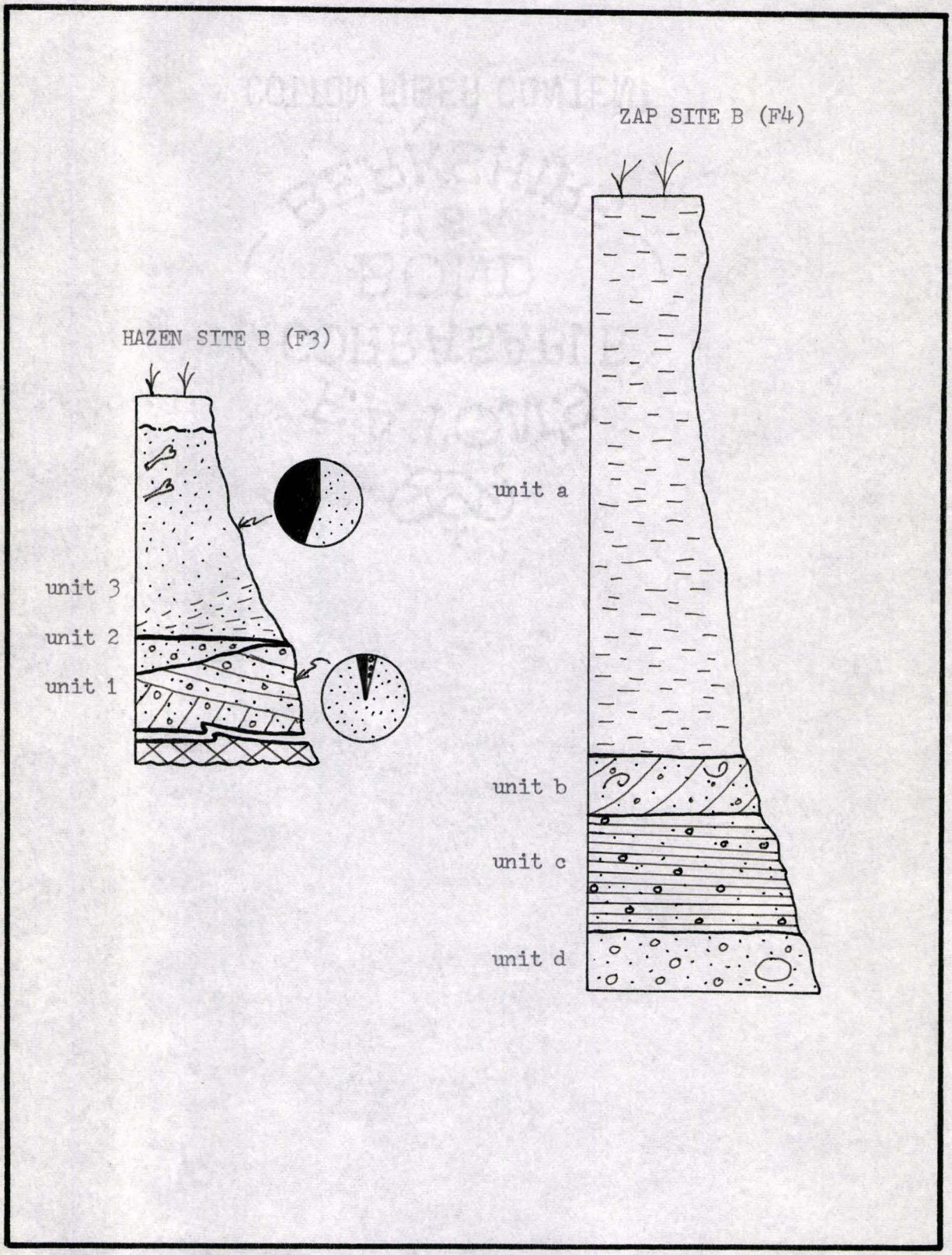

Figure 2.--Measured sections F3 and F4 on the Knife River. See Plate 1 for location. Table 1 shows the molluscan fossil assemblage per unit. See Figure 1 for the legend.

northwest of Zap, Mercer Co., N. Dak. (Approximately the same site as F2; Brophy, 1966).

The six fossiliferous sites on the Heart River are as follows (Text-figures 3 and 4):

Flasher site (F1). Left bank, Heart River, 527 m below bridge (bridge on sec. line common to secs. 29 and 30), N½ SW¼ sec. 29, T. 136 N., R. 84 W., 12.1 km north-northwest of Flasher, southeast Morton Co., N. Dak.

Almont site (F2). Left bank, Big Muddy Creek, 32.8 m below bridge (bridge on sec. line common to secs. 7 and 12), NW¼ SE¼ sec. 7, T. 137 N., R. 85 W., west Morton Co., N. Dak.

Judson site (F3). Right bank, Sweet Briar Creek, 22.8 m below bridge (bridge in sec. 14), center of SW¼ sec. 14, T. 139 N., R. 84 W., 3.2 km north-northeast of Judson, northeast Morton Co., N. Dak.

Lake Tschida site (F4). USGS M2569 (202a). Grant Co., N. Dak., Clark Butte NE quad. (1960), 1:24,000. NW¼ NW¼ NW¼ sec. 33, T. 137 N., R. 90 W. 5th P. M., 108 m S86°E from northwest cor. sec. 33. Elev. about 659 m. Fossils from Quaternary terrace gravel. Collectors: Rasmussen and Mowat.

Glen Ullin site A (F5). USGS M2570 (202). Grant Co., N. Dak., Clark Butte NE quad. (1960), 1:24,000. SW¼ SW¼ SW¼ sec. 28, T. 137 N., R. 90 W. 5th P. M., 138 m N60°E from southwest cor. sec. 28. Recent alluvium of Heart River. Collectors: Rasmussen and Mowat.

Glen Ullin site B (F6). USGS M2573 (280). Grant Co., N. Dak., Clark Butte NE quad. (1960), 1:24,000. NE¼ NE¼ SW¼ sec. 28, T. 137 N., R. 90 W. 5th P. M., 1.03 km N48°E from southwest cor. sec. 28, in left bank of small tributary 45 m from junction with Heart River. Elev. 624 m Fossils from fine sandy alluvium 0.8 m below terrace level and 4.2 m above Heart River. Collectors: Rasmussen and Mowat.

Complete lithologic descriptions of all sites except F4, F5, and F6 on the Heart River are in Appendix A.

Fossil mollusks

General.--The four fossiliferous sites on the Knife River yielded a molluscan assemblage of 28 species of unionids, pisidiids, aquatic and terrestrial gastropods (Table 1). The six fossiliferous sites of the Heart River yielded an assemblage of 14 species within the same families (Table 2).

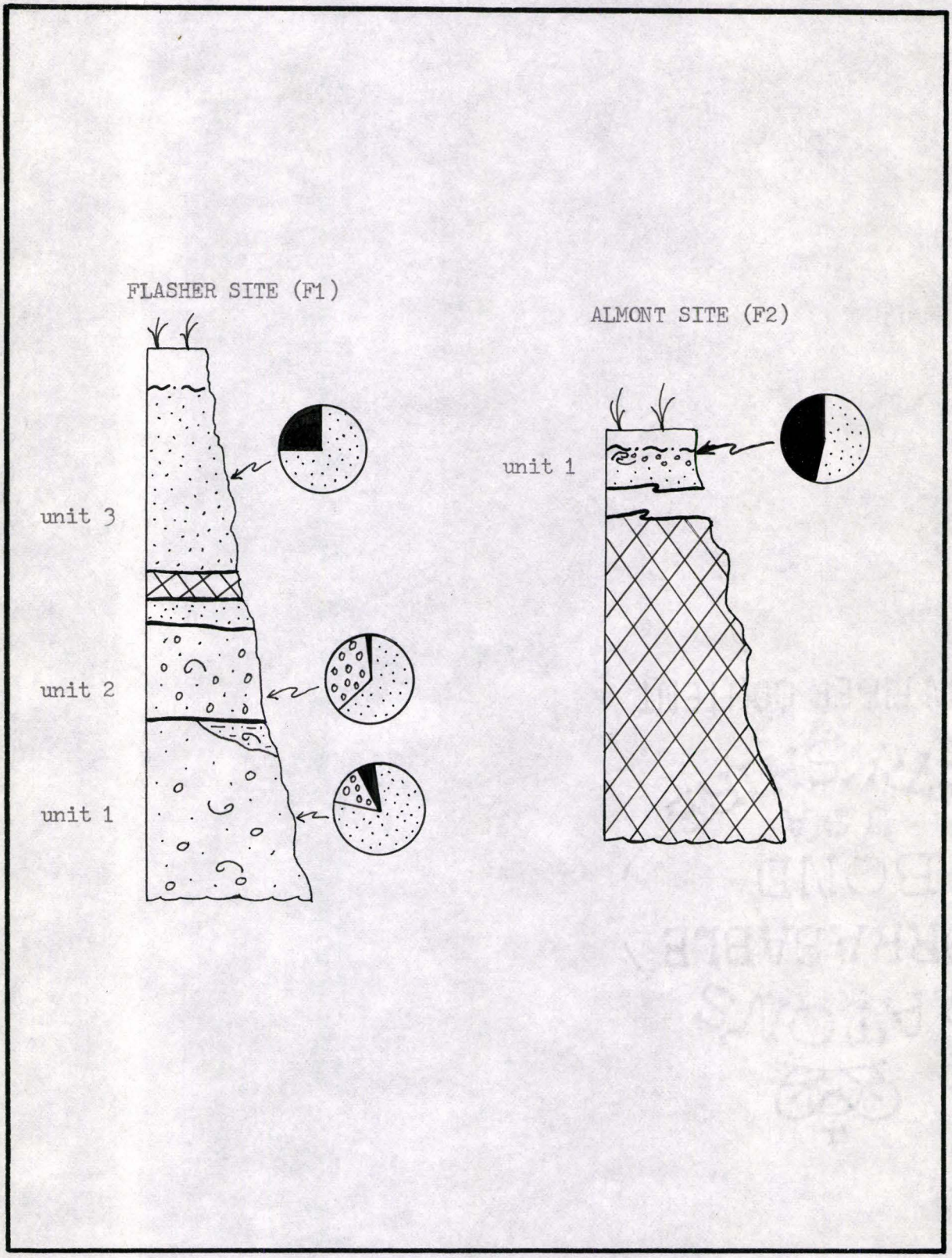

Figure 3.--Measured sections F1 and F2 on the Heart River. See Plate 1 for location. Table 2 shows the molluscan fossil assemblage per unit. See Figure 1 for legend.

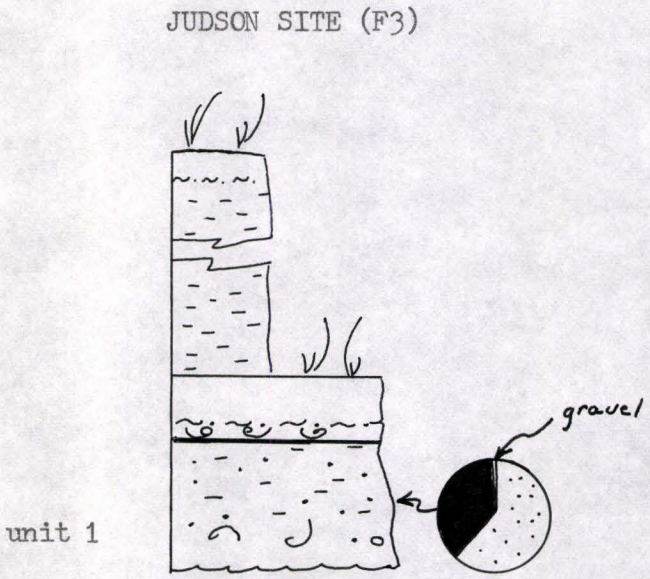

Figure 4.--Measured section F3 on the Heart River. See Plate 1 for location. Table 2 shows the molluscan fossil assemblage per unit. See Figure 1 for legend.

Table 1.--Occurrence of fossil mollusks and predominant sediment types per unit of four sites on the Knife River, North Dakota. Numerical values indicate number of individuals per desiganted volume of sediment of the unit samples. In the grab samples, only the species presence is indicated (X). See Plate 1 for location of sites.

SPECIES	FOSSIL LOCALITY AND SAMPLE SIZE										
	F1				F2					F3	
	unit 2a	unit 2b			unit 1	unit 2	unit 3	unit 4		unit 1	unit 3a
	*(A431)	(A432)	(A433)	(A434)	(A435)	(A436)	(A437)	(A438)	(A439)	(A440)	(A441)
	2010cc	3860cc			1530cc	2150cc	3680cc	4240cc		1820cc	3450cc
Unionid bivalves											
1.Lasmigona complanata (Barnes)	-	-	-	-	-	-	-	-	-	-	-
2.Anodonta grandis Say	-	-	X	X	-	-	-	-	X	-	-
3.Anodontoides ferussacianus (Lea)	-	-	X	X	-	-	-	-	X	-	-
4.Lampsilis siliquoidea (Barnes)	-	-	-	-	-	-	-	-	-	-	-
Pisidiid bivalves											
5.Sphaerium	10/2	41/2	X	X	-	1/2	3/2	-	-	2/2	-
6.Pisidium	32/2	274/2	X	X	1/2	-	14/2	1/2	X	2/2	-
Aquatic gastropods											
7.Valvata tricarinata (Say)	-	-	-	-	-	-	-	-	-	-	-
8.Lymnaea stagnalis (Linne)	-	-	-	-	-	-	-	-	X	-	-
9.Stagnicola caperata (Say)	-	2	X	-	-	-	2	-	-	-	-
10.Fossaria obrussa (Say)	5	125	X	X	-	-	7	-	X	2	-
11.Ferrissia parallella (Haldeman)	-	1	-	-	-	-	-	-	-	-	-
12.Ferrissia rivularis (Say)	-	-	X	-	-	-	-	1	-	-	-
13.Helisoma anceps (Menke)	9	179	X	X	-	-	10	-	X	1	-
14.Gyraulus parvus (Say)	52	511	X	X	-	2	55	4	X	7	-
15.Armiger crista (Linnaeus)	2	9	X	-	-	-	-	-	-	-	-
16.Physa integra Haldeman	3	5	-	-	-	-	1	-	X	-	-
17.Physa gyrina (Say)	-	23	X	X	-	-	6	-	-	-	-
Terrestrial gastropods											
18.Carychium exiguum (Say)	2	3	X	X	-	-	-	-	-	-	-
19.Vertigo ovata Say	1	5	X	X	-	-	-	-	-	-	-
20.Gastrocopta armifera (Say)	-	1	-	-	-	-	-	-	-	-	-
21.Gastrocopta pentodon (Say)	3	2?	X	X	-	-	-	-	-	-	-
22.Vallonia gracilicosta Reinhardt	-	3	X	X	-	-	4	-	X	3	-
23.Catinella avara Say	4	73	X	X	-	-	17	-	X	1	-
24.Oxyloma retusa (Lea)	-	6	X	X	-	-	-	-	X	-	-
25.Discus cronkhitei (Newcomb)	-	-	-	-	-	-	-	-	-	-	-
26.Hawaiia minuscula (Binney)	6	92	-	X	-	-	3	-	X	-	-
27.Retinella electrina Gould	-	-	X	-	-	-	1	-	-	-	-
28.Zonitoides arboreus (Say)	-	2	-	X	-	-	-	-	-	-	-
PREDOMINANT SEDIMENT TYPE	S	S			S	SM	S	S		S	S

F1=Hazen site A, F2=Zap site A, F3=Hazen site B, and F4=Zap site B. Units arranged from oldest to youngest.
*Accession number of the Department of Geology, University of North Dakota.
SM=sandy mud, MS=muddy sand, and S=sand.

Table 1 cont.

	F3 cont.			F4
	unit 3b (A442) 3300cc	(A443)	(A444)	NDSU Zap
Unionid bivalves				
1.	-	-	-	20/2
2.	-	-	-	2/2
3.	-	-	-	-
4.	-	X	-	6/2
Pisidiid bivalves				
5.	-	X	X	-
6.	-	X	-	-
Aquatic gastropods				
7.	-	X	-	-
8.	-	-	-	-
9.	-	X	-	-
10.	-	-	-	-
11.	-	-	-	-
12.	-	-	-	-
13.	-	X	-	-
14.	-	X	-	-
15.	-	-	-	-
16.	-	-	-	-
17.	-	X	-	-
Terrestrial gastropods				
18.	-	-	-	-
19.	-	-	-	-
20.	-	-	-	-
21.	-	-	-	-
22.	1	X	-	-
23.	-	X	-	-
24.	-	-	-	-
25.	-	X	-	-
26.	1	-	-	-
27.	-	-	-	-
28.	-	-	-	-
PREDOMINANT SEDIMENT TYPE	SM			S

Underlined numbers are those individulas with periostracum present.

Table 2.--Occurrence of fossil mollusks and predominant sediment type of six sites on the Heart River, North Dakota. Numerical values indicate the number of inidviduals per designated volume of sediment of unit samples. In the grab samples, only the species presence is indicated (X). See Plate 1 for location of sites.

SPECIES	FOSSIL LOCALITY AND SAMPLE SIZE										
	F1					F2		F3			F4
	unit 1	unit 2	unit 3a	unit 3b		unit 1		unit 1	unit 2		USGS
Unionid bivalves	*(A424)	(A423)	(A422)	(A421)	(A425)	(A426)	(A427)	(A428)	(A429)	(A430)	M2569
	1090cc	1660cc	2155cc	2780cc		2620cc		2520cc	2780cc		(202a)
1. Lasmigona complanata (Barnes)	-	-	-	-	X	-	X	-	-	-	1/2
2. Anodonta grandis Say	-	-	-	-	-	-	X	-	-	-	-
3. Lampsilis siliquoidea (Barnes)	5/2	-	-	-	X	-	X	-	-	-	3/2
4. Lampsilis ventricosa (Barnes)	4/2	-	-	-	-	-	-	-	-	-	-
Pisidiid bivalves											
5. Sphaerium	-	-	-	-	X	-	-	-	-	X	-
6. Pisidium	11/2	3/2	-	-	-	-	-	-	-	X	-
Aquatic gastropods											
7. Valvata tricarinata (Say)	2	-	-	-	-	-	-	-	-	-	-
8. Probythinella lacustris (Baker)	24	8	3	-	-	-	-	-	-	-	-
9. Fossaria obrussa (Say)	-	-	-	-	-	-	-	-	-	X	-
10. Gyraulus parvus (Say)	1	1	-	2	-	-	-	-	-	X	-
Terrestrial gastropods											
11. Vertigo ovata Say	-	-	-	-	-	-	-	-	-	-	-
12. Gastrocopta armifera (Say)	-	-	1	-	-	-	-	-	-	-	-
13. Vallonia gracilicosta Reinhardt	2	-	8	2	-	-	-	-	-	X	-
14. Catinella avara Say	-	-	-	-	X	-	-	-	-	-	-
PREDOMINANT SEDIMENT TYPE	MS	S	S	S		MS		MS	S		G

F1=Flasher site, F2=Almont site, F3=Judson site, F4=Lake Tschida site, F5=Glen Ullin site A, and F6=Glen Ullin site B. Units arranged from oldest to youngest.
*Accession number of the Department of Geology, University of North Dakota.
MS=muddy sand, S=sand, and G=gravel.

Table 2 cont.

	F5 USGS M2570 (202)	F6 USGS M2573 (280)
Unionid bivalves		
1.	2/2	-
2.	2/2	-
3.	-	28/2
4.	-	-
Pisidiid bivalves		
5.	-	-
6.	-	-
Aquatic gastropods		
7.	-	-
8.	-	-
9.	-	-
10.	-	-
Terrestrial gastropods		
11.	-	-
12.	-	-
13.	-	-
14.	-	-
PREDOMINANT SEDIMENT TYPE	S	S

Underlined numbers are those individuals with periostracum present.

Sediment types per unit in the rivers ranged from gravel to sandy mud; however, 70 percent of all units were sand. No correlation of sediment type with molluscan species was observed.

Unionids.--The Knife River contained four species of fossil unionids. Anodonta grandis Say was most common. Anodontoides ferussacianus (Lea) occurred in the same units as Anodonta grandis, with the exception of its not being collected with Anodonta grandis at Zap site B. Lasmigona complanata (Barnes) and Lampsilis siliquoidea (Barnes) only occurred rarely.

The Heart River also contained four species of unionids. Lampsilis siliquoidea was most common; Lasmigona complanata also occurred commonly but not as often or in as large number as Lampsilis siliquoidea. Anodonta grandis was found only rarely. The presence of Lampsilis ventricosa (Barnes) in unit 1 of the Flasher site was an important rare occurrence.

Pisidiids.--Pisidiids are very difficult to identify at the specific level. The author, therefore, only separated the family at the generic level. It is the opinion of the author, however, that perhaps as many as six different species within these two genera occur at the fossil sites.

Sphaerium and Pisidium occurred abundantly at the Knife River sites; however, they both occurred only commonly at the Heart River sites. Pisidium generally seemed to occur in greater numbers than Sphaerium in the fossil assemblages of both rivers.

Aquatic gastropods.--Eleven species of fossil aquatic gastropods were found in the Knife River. Gyraulus parvus (Say), Helisoma anceps (Menke), and Fossaria obrussa (Say) occurred abundantly at all sites. Physa gyrina (Say), Physa integra Haldeman, and Stagnicola caperata (Say) occurred commonly also. Ferrissia rivularis (Say), Ferrissia parallella (Haldeman), Valvata tricarinata (Say), and Lymnaea stagnalis (Linne)

occurred only rarely. Armiger crista (Linnaeus), an important species find, was present only at Hazen site A.

Only four species of fossil aquatic gastropods occurred in the Heart River. Probythinella lacustris (Baker) and Gyraulus parvus occurred most often. Valvata tricarinata and Fossaria obrussa occurred each in one unit at one site.

Terrestrial gastropods.--Eleven species of terrestrial gastropods were found in the sediment of the Knife River. Catinella avara Say and Hawaiia minuscula (Binney) occurred abundantly. Vallonia gracilicosta Reinhardt occurred commonly throughout the fossiliferous sediment of the Knife River; Retinella electrina Gould and Discus cronkhitei (Newcomb) occurred only rarely. Vertigo ovata Say, Carychium exiguum (Say), Gastrocopta pentodon (Say), Gastrocopta armifera (Say), Oxyloma retusa (Lea), and Zonitoides arboreus (Say) were found only at Hazen site A.

The Heart River contained four species of terrestrial gastropods. Vallonia gracilicosta appeared commonly in the fossiliferous sediment and Vertigo ovata, Gastrocopta armifera, and Catinella avara appeared only rarely.

Living mollusks

A. M. Cvancara and D. Kemp collected a total of at least 15 living molluscan species from 12 stations on the Knife River and tributaries (Table 3). These included six unionids, two genera of pisidiids, and seven aquatic gastropods.

Anodonta grandis and Lasmigona complanata are the predominant unionids; Anodontoides ferussacianus seems to occur only rarely. One living specimen of Lampsilis ventricosa was collected at Zap, North Dakota; otherwise it is evidenced only by empty shells at two other stations. Leptodea laevissima (Lea) was collected at one station in the lower reaches of the

Table 3.--Distribution and relative abundance of live mollusk species and predominant bottom sediment at each station sampled in the Knife River, North Dakota. Stations are arranged in a general downstream direction; numerical values for the unionids are the calculated specimens collected per hour by two persons. Letter sumbols for relative abundance are: A=abundant, C=common, U=uncommon, R=rare, and X indicates the species was present but abundance data was not recorded. A double asterisk (**) indicates that a species presence was evidenced only by empty shells.

SPECIES	STATIONS											
	1	2	3	4	5	6	7	8	9	10	11	12
Unionid bivalves		*A373	A220	A219	A218	A223	A222	A221	A217	A224	A242	A216
1.Lasmigona complanata (Barnes)	-	-	4	19.5	3	2	28	1.5	-	6	-	**
2.Anodonta grandis Say	-	-	24	58.4	3	8	6.7	-	**	**	-	-
3.Anodontoides ferussacianus (Lea)	-	-	2	-	**	-	-	-	-	-	-	-
4.Leptodea laevissima (Lea)	-	-	-	-	-	-	-	-	-	1.2	-	-
5.Lampsilis siliquoidea (Barnes)	-	-	-	1.5	1.5	-	10.7	**	**	2.4	-	**
6.Lampsilis ventricosa (Barnes)	-	-	-	-	1.5	-	-	-	-	**	-	**
Pisidiid bivalves												
7.Sphaerium	-	-	U	-	-	R	R?	-	-	-	-	-
8.Pisidium	-	-	-	-	-	R	-	-	-	-	R	-
Aquatic gastropods												
9.Valvata tricarinata (Say)	-	**	-	-	-	-	-	-	-	-	-	-
10.Stagnicola palustris (Müller)	-	-	-	-	-	-	-	-	-	-	X	-
11.Stagnicola caperata (Say)	-	C-A	-	-	-	-	-	-	-	-	X	-
12.Ferrissia rivularis (Say)	-	-	-	A	-	C	-	-	-	-	-	-
13.Gyraulus parvus (Say)	-	C	-	-	-	-	-	-	-	-	-	-
14.Physa integra Haldeman	-	-	-	-	U	C	-	-	-	-	-	-
15.Physa gyrina (Say)	-	C-A	U?	-	-	-	-	-	-	-	A	-
PREDOMINANT BOTTOM SEDIMENT	***M	M	GS	SG	S	SG	G	GS	S	GS	S	S

*Accession number of the Department of Geology, University of North Dakota.
Stations 1, 2, and 11 were pond collections.
***M=mud, S=sand, GS=gravelly sand, SG=sandy gravel, and G=gravel.

Knife River, a very important species find. Pisidiids occur only rarely in the Knife River. Aquatic gastropods do not appear commonly except in isolated areas. However, when aquatic gastropods are present, Physa gyrina and Ferrissia rivularis occur in the greatest numbers. Stagnicola palustris occurred only rarely; Valvata tricarinata was only evidenced by an empty shell.

The bottom sediment ranged from mud to gravel, with 33 percent of the stations having a predominantly sand bottom.

The Heart River yielded at least 18 species of mollusks (Table 4); included are six species of unionids, two genera of pisidiids, and ten species of aquatic gastropods.

Anodonta grandis and Lasmigona complanata are the predominant unionids. Lampsilis siliquoidea occurs only rarely. Lampsilis ventricosa was only evidenced by empty shells at one station in the lower reaches of the river. The pisidiids appear to be more common in the Heart River than in the Knife River. Physa gyrina, Physa integra, Gyraulus parvus, and Ferrissia rivularis are the aquatic gastropods that predominate presently. Helisoma anceps and Lymnaea stagnalis occur only rarely. One shell of Probythinella lacustris was collected from one station in the Heart River, an anomalous find as no other member of the Hydrobiidae is found living in the Knife or Heart Rivers presently.

The bottom sediment ranged from mud to gravel with 50 percent of the stations having a sand bottom.

DISCUSSION

Comparison of living and fossil mollusks

The living molluscan fauna of the Knife and Heart Rivers does not differ significantly from the fossil fauna.

Table 4.--Distribution and relative abundance of live mollusk species and predominant bottom sediment at each station sampled in the Heart River, North Dakota. Stations are arranged in a general downstream direction; numerical values for the unionids are the calculated specimens collected per hour by two persons. Letter symbols for relative abundance are: A=abundant, C=common, U=uncommon, R=rare, and X indicates the species was present but abundance data was not recorded. A double asterisk (**) indicates the species presence was evidenced only by empty shells.

SPECIES	STATIONS														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Unionid bivalves	*A225	A318		A372	A319	A317		A384	A310	A348	A301	A298	A300	A299	A383
1.Lasmigona complanata (Barnes)	63	3.3	-	-	2.4	2	-	-	**	-	53.7	**	**	0.7	-
2.Anodonta grandis Say	91.4	4.3	-	-	6	-	-	-	-	-	0.9	5	**	-	-
3.Anodontoides ferussacianus (Lea)	-	6.5	-	-	1.2	1	-	-	-	**	10.2	-	**	-	-
4.Leptodea laevissima (Lea)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.Lampsilis siliquoidea (Barnes)	-	**	-	-	-	-	-	-	**	-	-	**	**	1.4	-
6.Lampsilis ventricosa (Barnes)	-	-	-	-	-	-	-	-	-	-	-	-	-	**	-
Pisidiid bivalves															
7.Sphaerium	C	C	-	-	-	-	-	-	-	-	C	U	**	R	-
8.Pisidium	U	C	-	-	U	U	-	-	-	U-R	U-C	U	-	R	-
Aquatic gastropods															
9.Probythinella lacustris (Baker)	-	-	-	-	-	-	-	-	-	-	-	**?	-	-	-
10.Lymnaea stagnalis (Linne)	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-
11.Stagnicola palustris (Müller)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C
12.Stagnicola caperata (Say)	-	R	-	A	-	-	-	-	-	-	-	-	-	-	-
13.Fossaria obrussa (Say)	-	-	-	C?	-	-	-	-	-	-	-	-	-	-	-
14.Ferrissia rivularis (Say)	U?	-	-	-	C	-	-	R	-	-	-	U?	R	-	-
15.Helisoma anceps (Menke)	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-
16.Gyraulus parvus (Say)	-	-	-	C-A	C	-	-	-	U	X	C	-	-	-	A
17.Physa integra Haldeman	-	A	-	-	C	C	-	-	U	-	A	-	-	-	-
18.Physa gyrina (Say)	A	-	-	A	C	-	-	U	-	A	-	C	-	-	C-A
PREDOMINANT BOTTOM SEDIMENT	***SG	SG	SM	SM	S	S	M	MS	G	G	S	S	S	S	S

*Accession number of the Department of Geology, University of North Dakota.
Stations 3, 4, 7, and 8 are pond collections.
***M=mud, SM=sandy mud, MS=muddy sand, GS=gravelly sand, S=sand, SG=sandy gravel, and G=gravel.

Table 4 cont.

	16 A257	17 A325	18
Unionid bivalves			
1.	2.3	**	-
2.	**	-	-
3.	-	-	-
4.	-	**	-
5.	**	**	-
6.	-	-	-
Pisidiid bivalves			
7.	-	-	-
8.	C	-	-
Aquatic gastropods			
9.	-	-	-
10.	-	-	-
11.	-	-	-
12.	-	-	-
13.	-	-	-
14.	-	-	-
15.	U	-	-
16.	-	-	-
17.	C-A	-	-
18.	C-A	-	-
PREDOMINANT BOTTOM SEDIMENT	SG	S	S

Anodonta grandis and Lasmigona complanata are consistently the most common unionids found living in both rivers; they also predominate at the fossil sites. They are very hardy species and do not indicate any particular ecological trend. Cvancara (1970) concluded these mollusks were found generally throughout the state. Living Anodontoides ferussacianus, when present, always accompanies Anodonta grandis: however, Anodonta grandis may occur alone. The fossil assemblage of the Knife River indicated this same occurrence; however, Anodontoides ferussacianus was not recovered from the fossiliferous sediment of the Heart River. The author believes that with a greater sampling density of the Heart River, this species might have been recovered. A. ferussacianus has a fragile shell of a relatively small size and is therefore easily broken. Leptodea laevissima presumably occurs rarely today in North Dakota only in the lower parts of the tributaries of the Missouri River (Cvancara, 1970). This species, therfore, may have been but recently introduced into the lower reaches of the Knife and Heart Rivers as it is not found as a fossil. Another interpretation of the distribution pattern of this species may involve ecological barriers in the other parts of the rivers toward this species, thus limiting a suitable environment for its existence. The presence of living Lampsilis ventricosa in the area is evidenced by a single specimen from the Knife River, although empty shells were collected at two stations on both rivers. L. ventricosa does occur as a fossil at the Flasher site on the Heart River. The author is unable to determine if this species is declining in numbers presently or if it is now being re-introduced into the southwestern North Dakota area after being unable to live here for a period of time.

The two pisidiid genera are present in varying amounts in each river, both as fossils and living specimens. No significant trends are

obvious for the family.

Certain aquatic gastropod species can be indicative of a particular fresh-water environment. However, the majority of the species found as fossil or living can tolerate a variety of conditions. The presence of Probythinella lacustris is indicated in the living molluscan fauna of the Heart River as a dead specimen, and the author believes that it is a washed-in fossil specimen. P. lacustris is known almost exclusively from rivers and lakes (Hibbard and Taylor, 1960, p. 81). No other member of the Hydrobiidae is found alive or as a fossil in this area. Lymnaea stagnalis was also found alive in the Heart River; however, L. stagnalis occurred only as a fossil in the Knife River. This species is found in more or less stagnant parts of ponds or lakes or rivers upon vegetation (Baker, 1928). The other living species found in both rivers which seem to indicate a pond or slow-water environment are Stagnicola caperata and Physa gyrina. Stagnicola palustris was also collected from quiet water situations. Fossaria obrussa, found in the Heart River alive and in the Knife and Heart Rivers as fossil, exists in small bodies of water (Baker, 1928, pt. I, p. 296). Gyraulus parvus occurred in the greatest abundance at the pond sites, although this species was collected in the Knife River itself. G. parvus occurred at nearly all the fossil sites on both rivers, reaching a great abundance at Hazen site A. One empty shell of Valvata tricarinata was found in the Knife River; however, it was indicated as a fossil in both rivers. This species only lives in permanent lakes and rivers (Hibbard and Taylor, 1960, p. 80). As both rivers have periods of no flow, this species is rarely found. Ferrissia rivularis and Helisoma anceps are primarily river and creek species (LaRocque, 1968). Physa integra, a species widely adaptable to different environments, is not found in ponds as is Physa gyrina; instead, it lives in the river or creek.

Two species of aquatic gastropods that were found as fossils in the Knife River but were not collected from either river presently are Armiger crista and Ferrissia parallella. A. crista, found at Hazen site A, is a pond species preferring shallow quiet water (LaRocque, 1968). Ferrissia parallella is also usually found in quiet water (LaRocque, 1968).

Essentially the gastropod fauna of the Knife and Heart Rivers has not changed radically, although the fossiliferous sites of the Heart River did not indicate as many species as the Knife River. There are not enough data from the Heart River to interpret a change in the regimen of the river if such a change did occur. There appear to be some species, especially Armiger crista, Stagnicola caperata, and Lymnaea stagnalis and to a lesser extent, Stagnicola palustris, which seem to indicate that most of the fossil sites represent a ponded environment. Hazen site A on the Knife River contains most of the pond species in their greatest numbers.

Terrestrial gastropods may not be direct evidence of the aquatic environment but certain species indicate the type of shading along the banks of the rivers. Again, most of the species collected from fossil sites on both rivers were not species that were restricted to a particular environment. Vertigo ovata, Gastrocopta armifera, Vallonia gracilicosta, and Catinella avara were found in the sediments of both rivers. These gastropods are all common species; being able to live in marshes or on grasslands and in some cases in woodland areas (Hibbard and Taylor, 1960) (Leonard, 1959). More species of terrestrial gastropods were found at Hazen site A than the other sites on the Knife River; Carychium exiguum, Gastrocopta pentodon, Oxyloma retusa, Discus cronkhitei, Hawaiia minuscula, Retinella electrina, and Zonitoides arboreus. Oxyloma retusa and Discus cronkhitei seem to be the only terrestrial gastropods that prefer any

the Heart River contained 4 species of terrestrial fossil gastropods.

Four fossil species of unionids occurred in the Knife River compared with sex species living presently. Leptodea laevissima occurs alive in the lower reaches of both rivers but does not occur as a fossil. This species is either a newcomer to this area and is just becoming established or else an ecological barrier exists elsewhere in the rivers. Lasmigona complanata and Anodonta grandis are the most common unionids, living or as fossils. Lampsilis siliquoidea also occurs as a common unionid but is not as common as the other two species generally. The author feels the absence of Anodontoides ferussacianus in the fossil fauna of the Heart River is not an important omission as this fossil's presence would probably occur if the sampling density of this river was increased. Otherwise, A. ferussacianus always occurred with Anodonta grandis in fossil and living situations, although A. grandis could occur alone. One specimen of Lampsilis ventricosa establishes the existence of that species in the Missouri River drainage presently. The author is not able to determine if this species is re-establishing itself after being unable to live here for a time or if it is having difficulty surviving now.

The numbers of aquatic gastropods are different in the fossil faunas of the two rivers; The Knife River has 11 species and the Heart River has 4 species. The Heart River, however, showed evidence of Probythinella lacustris, a species that the fossil assemblage of the Knife River did not contain. The fossil presence of Armiger crista, Stagnicola caperata, and to a lesser extent, Lymnaea stagnalis, seems to indicate that the fossil sediments were deposited in a pond or slow-water environment, such as a river's backwash, a cut-off oxbow lake, or a ponded area of an intermittent stream. The presently living gastropod fauna of both rivers is approximately equivalent to the

aquatic gastropod fossil fauna.

The fossil terrestrial gastropods do not seem to indicate any different environments than those found presently at the Knife and Heart Rivers. Oxyloma retusa, preferring moist conditions, and Discus cronkhitei, preferring woodland conditions, were the species that indicated the more restricted conditions than did the other species of fossil terrestrial gastropods. The requirements of these two species as well as the other terrestrial gastropod species are adequately met presently as both rivers contain low areas and shading along their banks presently.

Therefore, a signigicant change in the regimen of the rivers is not evident. The fossil molluscan fauna and the living molluscan fauna vary to a slight degree, but this is probably due to localized conditions.

The author believes all the molluscan faunal finds are post-5,440 years B. P. $\pm$ 200 years or late Holocene.

ACKNOWLEDGMENTS

This study was supported by the Undergraduate Research Participation Program during the summer of 1970 with funds provided by the National Science Foundation Grant GY-7619.

The writer wishes to thank Dr. A. M. Cvancara for his compilation of data of the living molluscan fauna and for advice on her study and her manuscript. His suggestions were greatly appreciated. She is also grateful to the following people: W. J. Stewart, for his measured sections and fossil collections of the six fossil sites; J. A. Brophy, for his donation of unionid specimens from Zap site B; and the United States Geological Survey, for their donation of unionid specimens from the Lake Tschida site, Glen Ullin site A, and Glen Ullin site B.

APPENDIX A

Lithologic descriptions of fossil sites

HAZEN SITE A (F1). Right bank, Kineman Creek, 199 m upstream from bridge on N. Dak. 200, NE¼ NE¼ sec. 13, T. 144 N., R. 86 W., 8.4 km east of Hazen, south Mercer Co., N. Dak. Section measured by W. J. Stewart 8/10/67 (Figure 1).

Unit	Lithologic description	Thickness in meters
	Top of section--soil.	
2	Pebbly, maximum 0.02 m, medium to coarse sand beds and fine to medium sand beds, 0.09-0.02 m thick very fine sandy mud. All beds lenticular and irregular. Beds contain much coal and "scoria". All sediment has orange streaks. Irregular lenticular sand and sandy mud beds both with a maximum thickness of 0.09 m. Sandy layers contain many snails and mussels. Color of sand beds is medium light gray (N6) with dark yellow orange streaks (10 YR 6/6), color of sandy mud layers is dusky yellow brown (10 YR 2/2) to grayish brown (5 YR 3/2).	1.08
1	Very coarse to medium sandy gravel, maximum 0.1 m. Color of sandy gravel is medium brown (5 YR 3/4).	0.24
	Concealed by boulders	0.39
	Total thickness	1.71

ZAP SITE A (F2). North slope of irrigation ditch, 424 m due south and 161 m east of bridge (bridge in sec. 8, T. 144 N., R. 89 W.), NW¼ sec. 17, T. 144 N., R. 89 W., 5.2 km west-northwest of Zap, south Mercer Co., N. Dak. Section measured by W. J. Stewart 7/19/67 (Figure 1).

Unit	Lithologic description	Thickness in meters
	Top of upper floodplain; 3.9 m below is lowest floodplain.	
4	Medium to very coarse sand, thinly bedded. Color of sand is very pale orange.	1.80-3.30
3	Pebbly, maximum 0.02 m, medium to coarse sand. Cross-cutting beds, set 0.42-0.18 m, layers of medium to fine sand 0.21-0.12 m thick. Color of medium to very coarse sand is yellow gray	0.48-1.38

(5 Y 7/2) with some limonitic color to dark yellow orange (10 YR 6/6), color of layers of medium to fine sand is yellow gray (5 Y 7/2).

2	Very fine sandy mud. Color of very fine sandy mud is plae yellow brown (10 YR 6/2) with limonitic streaks.	0.12-0.90
1	Medium to very coarse sand with many particles of coal and "scoria", maximum 0.30-0.03 m thick, fine to medium sandy and muddy sand layers, and pebbly, maximum 0.04 m, sand layers. Color of medium to very coarse sand is medium red orange (10 R 6/6) and much black, color of fine to medium sandy and muddy sand is (dry) pale red (10 YR 6/2) to (wet) gray red (10 R 4/2).	0.6
	Section base concealed by slump.	1.95
	Total thickness	7.23

HAZEN SITE B (F3). Right bank, Knife River, 217 m below bridge (bridge on N. Dak. 200, crossing T. line common to T. 144 N. and T. 145 N.), SW¼ sec. 34, T. 145 N., R. 85 W., 10.8 km east-northeast of Hazen, north Mercer Co., N. Dak. Section measured by W. J. Stewart 7/18/67 (Figure 2).

Unit	Lithologic description	Thickness in meters
	Top of floodplain.	
3	Fine to very fine sandy silt to basal muddy, fine to very fine sand 0.18 to 0.63 m thick. Large mannal bones contained in unit. Sediment gradually moistens downward. Color of fine to very fine sandy silt is (weathered) very pale orange (10 YR 8/2) to dark yellow brown (10 YR 4/2), color of muddy, fine to very fine sand is (weathered) very pale orange (10 YR 8/2) to grayish brown (5 YR 3/2) with Fe oxide stains.	2.4
2	Fine to very coarse sandy gravel, maximum 0.06 m. Color of fine to very coarse sandy gravel is pale yellow brown (10 YR 6/2) to medium red orange (10 R 6/6).	0.06-0.36
1	Pebbly, maximum 0.05 m, medium coarse sand, some local coal particles. Cross-beds of sand. Color of pebbly, medium coarse sand is yellow gray (5 Y 7/2) with black coal particles and Fe oxide precipitate.	0.6

	Base of section concealed by slump.	1.89
	Total thickness	5.31

ZAP SITE B (F4). NW¼ sec. 17, T. 144 N., T. 89 W., 5.5 km west-northwest of Zap, Mercer Co., N. Dak. Section measured by J. A. Brophy (1966) (Figure 2).

Unit	Lithologic description	Thickness in meters
a	Silty, sandy alluvium, tan, bedding indistinct, no fossils seen.	5.7
b	Sand and gravel, cross-bedded to east (downstream), contains clam shells.	0.6-1.2
c	Interbedded amounts of gravel, beds thin, oxidized in upper 0.3-0.6 m, unoxidized below, lower 0.6 m contains wood (C-14 dated as 5,440 years B. P. ± 200 years), shells and bones.	1.2-1.8
d	Sand and gravel, stones up to boulder size.	0.15 (exposed)
	Total thickness	8.25

FLASHER SITE (F1). Left bank, Heart River, 527 m below bridge (bridge on sec. line common to secs. 29 and 30), N½ SW¼ sec. 29, T. 136 N., R. 84 W., 12.1 km north-northwest of Flasher, southeast Mercer Co., N. Dak. Section measured by W. J. Stewart 8/26/68 (Figure 3).

Unit	Lithologic description	Thickness in meters
	Top of section; 1.2 m below is top of main floodplain.	3.3
3	Fine sand. Color of fine sand is (wet) olive gray (5 Y 4/1) to (dry) light olive gray (5 Y 6/1).).27 m of section is concealed by slump.	
2	Pebbly, maximum 0.09 m, mostly 0.05 m, very coarse to coarse sand. More pebbly than unit below. Mussel found in muddy sand. Color of pebbly, very coarse sand is pale yellow brown (10 YR 6/2).	0.99
1	Very fine to fine muddy sand, varying maximum 0.3 m to pinch out at top of unit. Bottom of unit is pebbly, maximum 0.03 m, mostly 0.02 m, very coarse to coarse sand grading downward to coarse to medium sand, cross-bedded in upper	1.80

	0.54 m, set is about 0.18 m dipping in a downstream direction. Color of very fine to fine muddy sand is olive gray (5 Y 3/2), color of very coarse to coarse sand is (dry) olive gray (5 Y 6/1) to (wet) olive gray (5 Y 4/1).	
	Total thickness	6.09

ALMONT SITE (F2). Left bank, Big Muddy Creek, 32.8 m below bridge (bridge on sec. line common to secs. 7 and 12), NW¼ SE¼ sec. 7, T. 137 N., R. 85 W., west Morton Co. N. Dak. Section measured by W. J. Stewart 7/9/68 (Figure 3).

Unit	Lithologic description	Thickness in meters
	Top of floodplain.	
1	Muddy, very fine sand with many roots, soil zone with much organic debris. Shell zone 0.15 m thick and about 0.2 m below floodplain. Color of muddy, very fine sand is olive gray (5 YR 4/1) in zone containing shells to light olive gray below.	0.60
	Rest of section concealed by slump	2.40
	Total thickness	3.00

JUDSON SITE (F3). Right bank, Sweet Briar Creek, 22.8 m below bridge (bridge in sec. 14), center of SW¼ sec. 14, T. 139 N., R. 84 W., 3.2 km north-northeast of Judson, northeast Morton Co., N. Dak. Section measured by W. J. Stewart 8/22/67 (Figure 4).

Unit	Lithologic description	Thickness in meters
	Top of bank. Top of floodplain is 2.43 m above bank.	
	Soil with shell zone about 0.06 m thick.	
1	Very fine to fine muddy sand, bottom 0.15 m has very fine to fine sandy mud. Color of very fine to fine muddy sand is (dry) yellow gray (5 Y 7/2) to (wet) olive gray (5 Y 4/1), color of bottom very fine to fine sandy mud is (only wet) dusky blue (5 PB 3/2) to dark gray (N3) with orange streaks parallel and perpendicular to bedding.	0.99
	Total thickness	3.87

LITERATURE CITED

Baker, F. C. 1928. The fresh water mollusks of Wisconsin. Wisc. Geol. and Nat. History Surv. Bull. 70, Pt. I:507 p.

Brophy, John A. 1966. A possible Bison (Superbison) crassicornis of Mid-hypsithermal age from Mercer County, N. D. N. Dak. Acad. Sci. Proc. XIX:214-223.

Clampitt, Philip T. 1970. Comparative ecology of the snails Physa gyrina and Physa integra (Basommatophora: Physidae). Malacologia 10 (1): 113-151.

Cvancara, Alan M. 1970. Illustrated key to the genera and species of North Dakota mussels. Contrib. Institute for Ecological Studies (3):16 p.

Hibbard, C. W., and Taylor, D. W. 1960. Two late Pleistocene faunas from southwestern Kansas. Contrib. Mus. Paleontol. Univ. Mich., 16 (1):1-223.

LaRocque, A. 1968. Pleistocene Mollusca of Ohio. Ohio Geol. Surv. Bull. 62, Pt. 3:197 p.

_____ 1970. Pleistocene Mollusca of Ohio. Ohio Geol. Surv. Bull. 62, Pt. 4:218 p.

Leonard, A. B. 1959. Handbook of gastropods in Kansas. Univ. Kansas Nat. History Misc. Pub. (20):224 p.

U. S. Geological Survey. 1969. Water resources data for North Dakota, 1969. U. S. Government Printing Office, Washington D. C. 165 p.

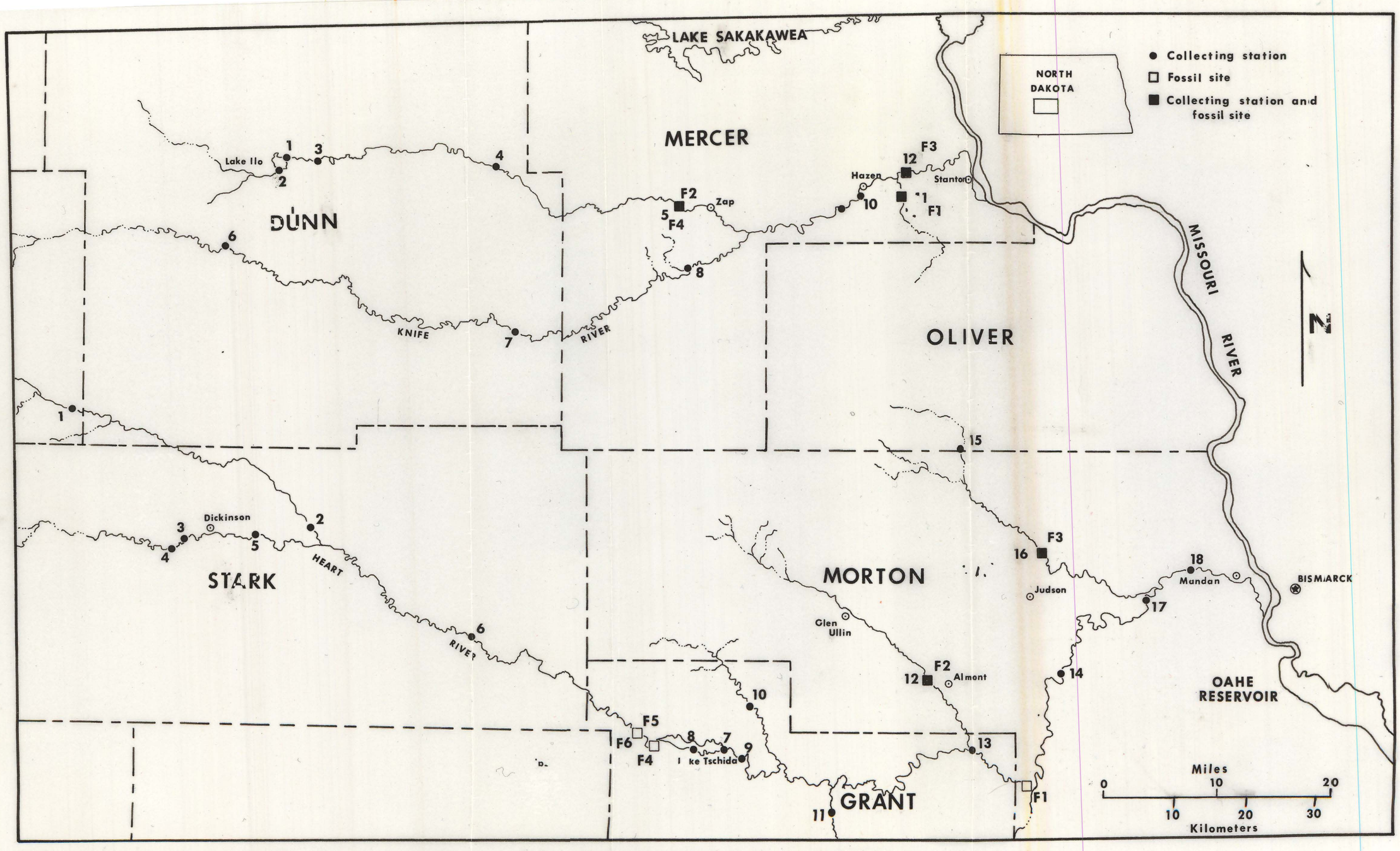

Plate 1. — Location map of collecting stations and fossil sites on the Knife and Heart Rivers.