

Stream Fishes of the Red River of the North Basin, United States: A Comprehensive Review

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Koel, Todd M., and John J. Peterka. 1998. Stream fishes of the Red River of the North basin, United States: A comprehensive review. *Canadian Field-Naturalist* 112(4): 631-646.

During 1993 and 1994 we obtained all known records of fish surveys conducted in the Red River of the North (Red River) basin in the United States. From these surveys, which occurred from 1892-1994 at 1026 stream sites by several state and federal agencies, colleges, and universities and from additional sampling conducted 1995-1997, it was determined that the ichthyofauna of the basin includes 84 species representing 19 families. Twenty-nine species were cyprinids, and 10, 9, 9, and 6 species were percids, centrarchids, catostomids, and ictalurids, respectively. The White Sucker (*Catostomus commersoni*), Fathead Minnow (*Pimephales promelas*), and Common Shiner (*Luxilus cornutus*) were the most common species, occurring at 60%, 53%, and 47% of sites sampled, respectively. Species which were most rare included the Largescale Stoneroller (*Camptostoma oligolepis*), Pugnose Shiner (*Notropis anogenus*), and Mottled Sculpin (*Cottus bairdi*), all found at <1% of sites. For 15 species, distributions were restricted either mostly or entirely to the eastern half of the Red River basin; eight of these species were found almost exclusively in the Otter Tail River drainage. The Longnose Gar (*Lepistosteus osseus*) was reported from the lower Otter Tail River in 1892, but likely no longer exists in the basin and is not considered a part of the current ichthyofauna. The Lake Sturgeon (*Acipenser fulvescens*) has not been collected from waters of the basin since the mid-1950s, but the species was reintroduced in the Otter Tail and Pelican rivers in 1997. Moderate reductions in range were also noted for several other species over the past century, including the Brassy Minnow (*Hybognathus hankinsoni*), Pearl Dace (*Margariscus margarita*), Hornyhead Chub (*Nocomis biguttatus*), Blacknose Shiner (*N. heterolepis*), Brown Bullhead (*Ameiurus nebulosus*), Banded Killifish (*Fundulus diaphanus*), Iowa Darter (*Etheostoma exile*), and River Darter (*Percina shumardi*).

Key Words: midwestern stream fishes, species richness, distribution patterns, temporal variability, extirpation, Red River, North Dakota, Minnesota.

The fishes of the Red River of the North (Red River) basin have been studied for more than a century, with the first published records of species distribution provided by Woolman (1896). The Red River basin in the United States includes portions of Minnesota, North Dakota, and a small portion of South Dakota. Historically, most surveys of fishes have focused on only North Dakota streams or only Minnesota streams, and there has never been a comprehensive site-specific study of Red River basin fishes. A study is required because two published lists of fish species present in the Red River basin are not in agreement; Crossman and McAllister (1986) listed 75 fish species for the Red River basin in the United States, while Underhill (1989) listed 80 species. Further, since the drainage basin crosses state boundaries, relatively little has been published about the distribution of stream fishes on a basin-wide scale.

Because of an apparent lack of any comprehensive distributional studies, the specific objectives of this study were to determine (1) the total number of fish species existing both historically and currently in streams of the Red River basin; (2) those fish species which currently have highly restricted distributional patterns; and (3) any significant temporal changes in

the distribution of each stream fish species. We reviewed all known published and non-published records of fish distribution in the Red River basin to produce a computerized database, and then plotted species distributions using a geographic information system (GIS). We also attempted to reconcile discrepancies among published lists of fish species in the Red River basin.

Study Area

The Red River is a northward-flowing river formed by the confluence of the Otter Tail and Bois de Sioux rivers at the neighboring cities of Wahpeton, North Dakota, and Breckenridge, Minnesota. The Red River forms the boundary between North Dakota and Minnesota as it meanders for 640 km to the international border at Manitoba, Canada (Figure 1). The straight-line distance from the origin of the Red River to Manitoba is 300 km. In Manitoba, the Red River joins with the Assiniboine River at Winnipeg and then drains into the south end of Lake Winnipeg. Waters from Lake Winnipeg flow via the Nelson River into Hudson Bay; thus, the Red River is a portion of the Hudson Bay drainage system.

Tributaries: The Red River is joined by several major tributaries as it flows toward Canada. Streams flowing from the west include the Wild Rice, Sheyenne, Elm, Goose, Turtle, Forest, Park, and Pembina rivers in North Dakota (Figure 1). Streams flowing from the east include the Buffalo, Wild Rice, Sandhill, Red Lake, Snake, Tamarac, Two, and Roseau rivers in Minnesota. The Pembina River arises in Canada and its mouth is at the Red River in the United States. The Roseau River arises in the United States and its mouth at the Red River is in Canada. Two major tributaries are named Wild Rice, a potential source of confusion.

Drainage basin: The Red River drainage basin in the United States encompasses a total of 101 526 km², which includes 53 924 km² in North Dakota, 46 118 km² in Minnesota, and 1484 km² in South Dakota (U.S. Army Corps of Engineers 1980) (Figure 1). Glacial Lake Agassiz deposited between 46 and 91 m of materials over the basin, shaping a broad, flat lake plain at its center surrounded by rolling uplands, wetlands, and lakes along the western and eastern margins. The fertile, productive soils and flat landscape have resulted in 66% of the total basin land area being used as cropland, and 8% as pasture and rangeland (Stoner et al. 1993). Forests, open water, and wetlands comprise the remaining 26% of the land area. Beach ridges and deltas of glacial Lake Agassiz (Teller and Bluemle 1983) lie at the transition zone between the flat lake plain and the upland areas that were not water covered. The most extreme transition occurs in the northwestern basin, where the Pembina Escarpment rises 183 m from the lake plain and forms an area of rolling hills (U.S. Army Corps of Engineers 1980). Stream slopes range from 0.4-1.0 m/km in upland areas to about 0.2-0.3 m/km in the lake plain (Stoner et al. 1993).

The Red River basin is bordered by the James River basin (Missouri River drainage) and the Devils Lake closed basin to the west, the Minnesota River basin (Mississippi River drainage) to the south, and the Mississippi and Rainy river (Hudson Bay drainage) basins to the east. Several of the headwaters of the Otter Tail, Wild Rice, and Red Lake rivers in the eastern portions of the Red River basin are in close geographic proximity to those of the Mississippi River, whereas streams in the western portions of the Red River basin are more distant from streams of neighboring drainage basins.

Methods

Collection of Fish Survey Data

Published and unpublished fish survey records for all streams in the Red River basin were collected and analyzed during 1993 and 1994. Also, we contacted fisheries biologists in the region during 1997 to determine if any recent changes had been noticed in fish distribution and to update our species list.

Search techniques during 1993 and 1994 included (1) a review of periodicals, theses, and government documents at the North Dakota State University library and other regional institutions through interlibrary loan; (2) personal visits and searches of files at the Minnesota Department of Natural Resources, Section of Fisheries, Region 6 Headquarters in Bemidji, Minnesota, under the guidance of Lee Sundmark and Robert Strand; (3) personal visits to the Bell Museum of Natural History, University of Minnesota and discussions with James Underhill and Jay Hatch; (4) written communications with Pat Bailey, Minnesota Pollution Control Agency; Kevin Cummings, Illinois Natural History Survey; Susan Jewett, Smithsonian Institution; Douglas Nelson, University of Michigan, Museum of Zoology; Eric Pearson, North Dakota State Department of Health; and Randy Kreil, North Dakota Game and Fish Department; and (5) communications by telephone with Luther Aadland, Minnesota Department of Natural Resources, Ecological Services Section; Gene Van Eeckhout, North Dakota Game and Fish Department; and Paul Glander, Minnesota Department of Natural Resources, Section of Fisheries. Unpublished surveys by members of the Department of Zoology, North Dakota State University were compiled and also incorporated. Methods of fish collection have included gears of various types, such as seines, trap nets, gill nets, and electroshocking devices (portable-generator type in small streams and large boat-type in downstream reaches and the Red River main stem).

Data storage: For sites sampled in 26 major tributaries and the Red River main stem, the stream, primary investigator, ecoregion classification, coordinates in latitude and longitude, date, and fish species occurrences in binary (presence or absence) format were tabulated in Quattro Pro (Borland, version 5.0). Records from the Pembina and Roseau rivers are only from the portion of each drainage that lies within the United States, downstream from the border for the Pembina River and upstream from the border for the Roseau River. Location information (usually township, range, and section) was used to plot all sampling sites on USGS 1:250 000 scale quadrangle maps. Latitude and longitude coordinates (decimal degrees) for each site were obtained using a Summagraphics Microgrid II digitizing pad with a Gateway 486DX personal computer running TOSCA (1993) software.

Production of species list: Based on stream survey records and lake surveys (conducted by Minnesota Department of Natural Resources), a comprehensive species list for the Red River basin was produced. Most fishes listed were found at multiple sites by several investigators in recent years. Not included on the list were incidental records of nonnative fishes (such as Goldfish, *Carassius auratus*, and Golden

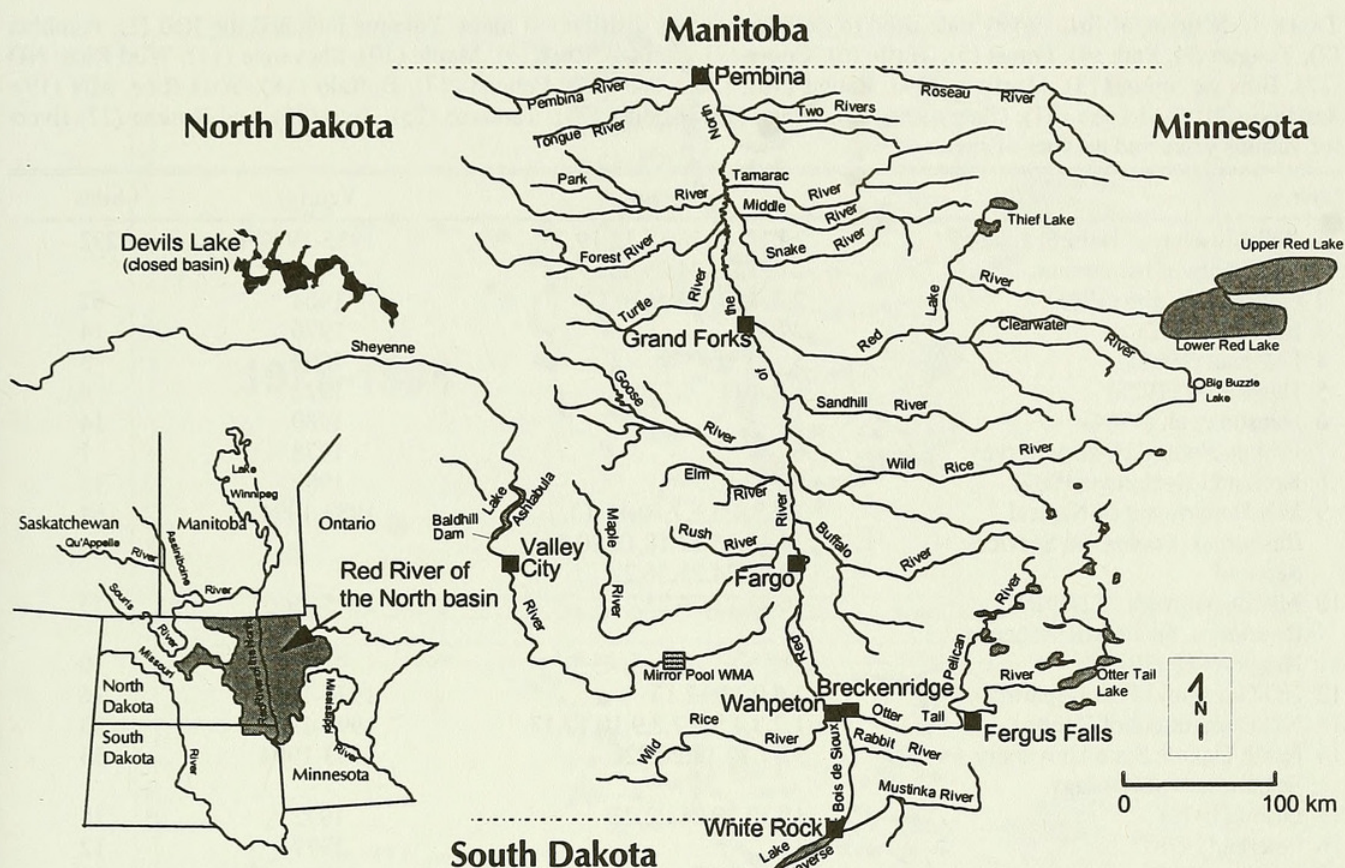


FIGURE 1. Streams in the Red River of the North basin in the United States for which fish survey records were obtained.

Orfe, *Leuciscus idus*) introduced from local aquaria and likely not part of naturally reproducing populations, and hybrid fishes, most of which were centrarchids. Also not included were species which were determined to be recorded in error in the literature. In cases where species were reported that had not been found historically in the Red River basin and appeared erroneous, the primary investigators of the reports were contacted to determine if voucher specimens of the species had been collected. Most errors were due to misidentification of fishes in the field. Common and scientific names of fish species followed those of the American Fisheries Society (Robins et al. 1991).

Mapping of Fish Distribution

Stream digitizing: All nonintermittent streams and lakes in the Red River basin were digitized from USGS 1:250 000 scale quadrangle maps using a Summagraphics Microgrid II digitizer and TOSCA (1993) software. Streams were entered as lines and lakes as polygons with separate files created for each quadrangle map. The VCONCATE module of TOSCA was then used to combine all stream files and all lake files into two complete coverages (layers). These layers then served as the base map upon which species distribution points were plotted.

Species distribution: For each fish species, a file containing the year and coordinates in latitude and

longitude of all sites where the species occurred was created from the Quattro Pro database. The coordinates were then sorted by year into three time periods (early, middle, and late), saved as separate files, and downloaded into an IDRISI (1993) geographic information system (GIS). In IDRISI the files were saved as vectors in binary data format using the CONVERTV module. Hard copies of distribution maps were created by overlaying vector files and printing from TOSCA (1993).

Results

History of Stream Fish Survey Effort in the Red River Basin

From records of stream fish surveys, data were acquired from 1026 sampling sites located throughout the Red River basin during the time period from 1892-1994 (Table 1). Although records of the University of Michigan, Museum of Zoology, and the Smithsonian Institution indicated that samples of fishes were collected during 1857 from the Red and Maple rivers by R. Kennicott and during 1860 from the Middle and Sandhill rivers by S. H. Scudder (Koel 1997), published survey records did not appear until the 1890s. The records from the mid-1800s do not contain accurate site location descriptions; none of these records were plotted on species distribution maps.

TABLE 1. Sources of fish survey data used to produce species distribution maps. Streams included the Red (1), Pembina (2), Tongue (3), Park (4), Forest (5), Turtle (6), Goose (7), Elm (8), Rush (9), Maple (10), Sheyenne (11), Wild Rice, ND (12), Bois de Sioux (13), Mustinka (14), Rabbit (15), Otter Tail (16), Pelican (17), Buffalo (18), Wild Rice, MN (19), Sandhill (20), Red Lake (21), Clearwater (22), Snake (23), Middle (24), Tamarac (25), Two (26), and Roseau (27) rivers for various years and number of sites.

Source	Stream	Year(s)	Sites
1 Bell Museum of Natural History, University of Minnesota	13,14,15,16,17,18,19,20, 21,22,23,24,25,26,27,28	1955-1979	292
2 Copes and Tubb (1965)	2,3,4,5,6,7,8,9,10,12	1964	62
3 Enblom (1982)	27	1976	14
4 Feldman (1963)	5	1962	8
5 Hankinson (1928)	1,2,4,11	1922	8
6 Hanson et al. (1984)	16	1980	14
7 Illinois Natural History Survey	6	1978	1
8 Kreil and Ryckman (1987)	2	1987	15
9 MN Department of Natural Resources, Ecological Services Section ¹	1,2,3,4,5,6,7,10,11,13, 14,15,16,17,18,19,20,21, 22,23,24,25,26,27	1983-1994	164
10 MN Department of Natural Resources, Section of Fisheries	16,21,22,24,25,27	1975-1992	53
11 Naplin et al. (1977)	19	1976	10
12 ND Game and Fish Department	1,8,9,11,12,13	1976-1989	76
13 ND Department of Health ¹	1,2,3,4,5,6,7,8,9,10,12,13	1993-1994	33
14 North Dakota State University, Department of Zoology	9,11,12,18,20,22	1993-1994	33
15 Olson (1932)	18,19,20,21,22,23	1932	18
16 Peterka (1978)	11	1977	12
17 Peterka (1992)	2,3,4,5,6,7	1991	48
18 Renard et al. (1983)	21	1976-1977	26
19 Renard et al. (1985)	1	1984	41
20 Russel (1975)	11,12	1974	38
21 Tubb et al. (1965)	11	1964	25
22 Wilson (1950)	11	1950	9
23 Woolman (1896)	1,2,3,4,5,6,7,10,11,14,16, 18,21	1892	18
24 University of Michigan, Museum of Zoology ²	6,10,11,16,21	1892-1951	9

¹Several sites were sampled during a cooperative effort by the Minnesota Department of Natural Resources, Minnesota Pollution Control Agency, North Dakota Department of Health, U.S. Environmental Protection Agency, and U.S. Geological Survey.

²Data also included collections by Hankinson (1922) and Woolman (1892).

The first published document regarding a survey of fishes in the Red River basin was provided by Woolman (1896), who sampled 18 sites on 13 streams. Other published records from surveys during 1892-1961 (early period) included Brannon (1912), Hankinson (1928), Olson (1932), Wilson (1950), Bailey and Allum (1962), Phillips and Underhill (1971), and Eddy et al. (1972). Unpublished records for this period existed at the University of Michigan, Museum of Zoology and the Bell Museum of Natural History, University of Minnesota. One-hundred twelve sites were sampled between 1892 and 1961 (Figure 2), and most streams were sampled for fishes at least at one site; however, only 51 sites were sampled in the basin prior to 1950. The Elm, Rush and Rabbit rivers, and the Wild Rice River in North Dakota were not sampled.

The 1960s marked the beginning of 30 years of

relatively intensive sampling of stream fishes in the Red River basin. Surveys were conducted by several state agencies and universities on all major streams and several minor tributaries. Published records from surveys during 1962-1977 (middle period) were provided by Feldman (1963), Copes (1965), Tubb et al. (1965), Copes and Tubb (1966), Reedstrom (1967), Reedstrom and Carlson (1969), Eddy and Underhill (1974), Russel (1975), Duerre (1975), Naplin et al. (1977), Peterka (1978), Owen et al. (1981), Enblom (1982), and Renard et al. (1983). Unpublished records for this period existed at the Bell Museum of Natural History, University of Minnesota. During 1962-1977, 439 sites were sampled for fishes (Figure 2). Most streams were sampled at multiple sites including both headwater and downstream reaches during this relatively short (16 year) time span. The streams for which records were lacking during the

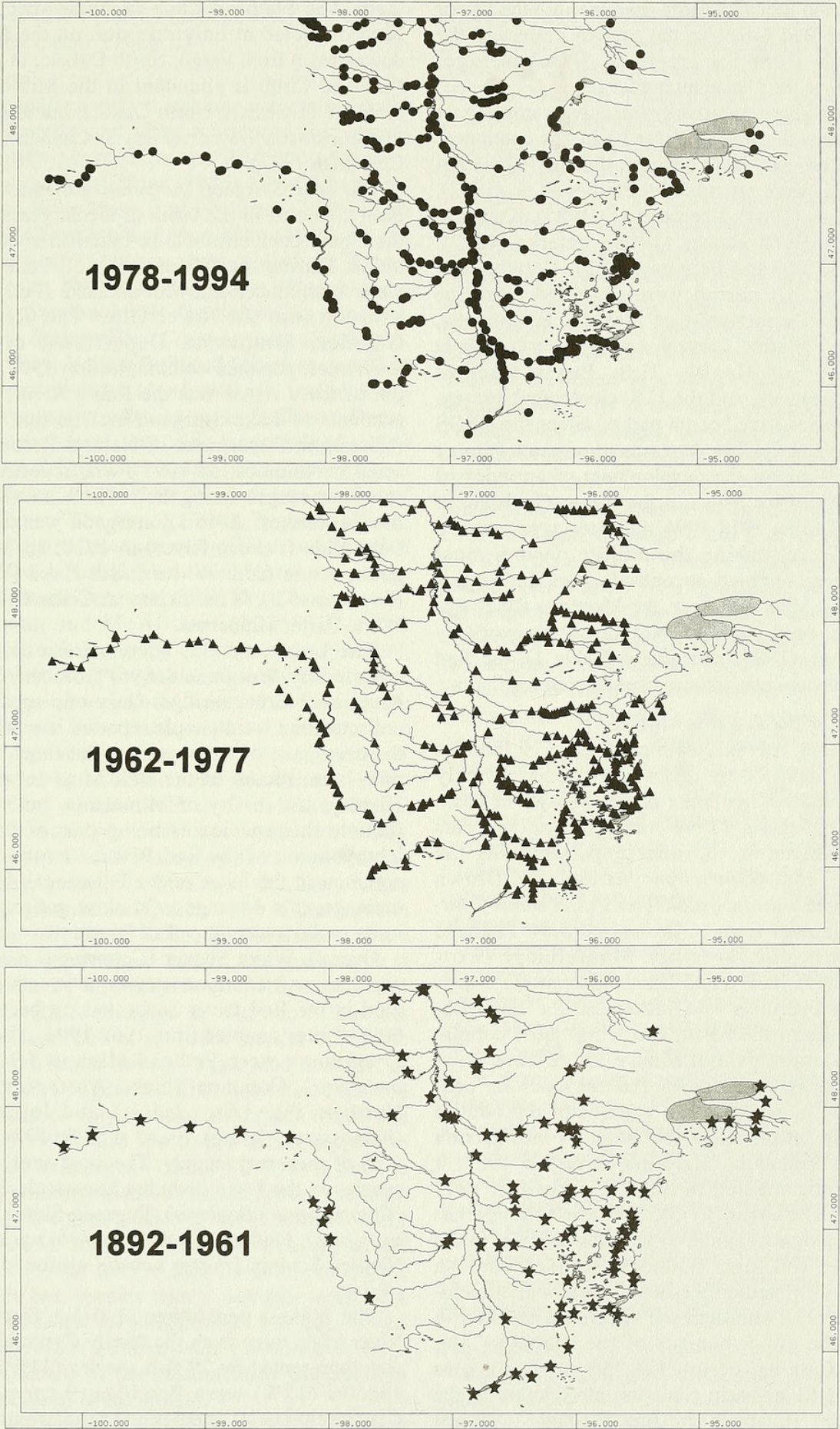


FIGURE 2. Stream sites sampled for fishes in the Red River of the North basin during 1892–1961 (early period, $n = 112$), 1962–1977 (middle period, $n = 439$), and 1978–1994 (late period, $n = 475$).

middle period included those draining into the Upper and Lower Red Lakes in the eastern basin and the Red River from its origin at Breckenridge, Minnesota, to the Canadian border.

In recent years, relatively intensive sampling of many streams in the Red River basin has continued. Published records from surveys during 1978-1994 (late period) were provided by Phillips et al. (1982), Hanson et al. (1984), Renard et al. (1985), Kreil and Ryckman (1987), Duerre (1988), Peterka (1992), Schmitt (1993), and Feigum (1995). Unpublished records for this period were obtained from the Minnesota Department of Natural Resources, Minnesota Pollution Control Agency, North Dakota Department of Health, U.S. Environmental Protection Agency, and the U.S. Geological Survey. These agencies have been a part of either the USGS National Water Quality Assessment program (Stoner et al. 1993) and/or the development of an index of biotic integrity for fishes in the basin (Goldstein et al. 1994). During 1978-1994, 475 sites were sampled (Figure 2). As during the middle period, most streams were sampled at multiple sites during this 17-year time span, however, the Mustinka River was sampled at only one site. Notably, from work by Renard et al. (1985) and others (Table 1), the Red River main stem was intensively sampled for fishes.

The Fishes of the Red River Basin

Eighty-four fish species representing 19 families have been reported by investigators and currently constitute the ichthyofauna of the Red River basin (Table 2). Of these, 77 are considered native to the basin and seven are introductions, including the Rainbow Trout (*Oncorhynchus mykiss*), Brown Trout (*Salmo trutta*), Brook Trout (*Salvelinus fontinalis*), Common Carp (*Cyprinus carpio*), Flathead Chub (*Platygobio gracilis*), Muskellunge (*Esox masquinongy*), and White Bass (*Morone chrysops*). All but the cyprinids were introduced for sport-fishery purposes in the basin, and while most populations of salmonids and Muskellunge have been maintained by state and/or federal stocking programs, the White Bass has apparently reproduced successfully in the basin following its introduction into Lake Ashtabula (Sheyenne River) in 1953; it was first documented in Lake Winnipeg in 1963 (Scott and Crossman 1973). The Muskellunge has recently become common in samples taken from the lower Otter Tail River (Luther Aadland, Minnesota Department of Natural Resources, personal communication 1997), although the species is stocked in lakes of the upper reaches of the drainage. The Common Carp has occurred at 25% of stream sites in the Red River basin since its introduction in the early 1900s. However, the Baldhill Dam upstream from Valley City has apparently been an effective barrier to the movement of this species into the upper Sheyenne River, as it has not been collected

there. The Flathead Chub (a single specimen) has been collected at only one site, on the Red River downstream from Fargo, North Dakota, in 1984. The Flathead Chub is abundant in the Missouri River drainage in western North Dakota, but also is native to the Hudson Bay drainage in Canada (Scott and Crossman 1973).

The Lake Sturgeon (*Acipenser fulvescens*) has not been collected in the basin in recent years, although there have been efforts to re-establish a viable population. During the fall of 1997, 50 Lake Sturgeon were reintroduced into Detroit Lake (Pelican River) and 200 into the lower Otter Tail River (Paul Glander, Minnesota Department of Natural Resources, personal communication 1997). The origin of these fishes was the Rainy River. Historical accounts of Lake Sturgeon include that by Strand (Minnesota Department of Natural Resources, personal communication 1994), who reported a single specimen caught during the 1950s in a walleye net in the Red Lakes. A 46 kg sturgeon was taken from Lake Lida (Pelican River) in 1920; an 80 kg sturgeon, taken from White Earth Lake (Wild Rice River) in 1926, is on display at Cedar Crest Resort, White Earth, Minnesota.

The Longnose Gar (*Lepistosteus osseus*) was reported by Woolman (1896) from the Otter Tail River near Breckenridge. Only one specimen was collected, but local people reported it as abundant in the deep parts of the stream at that time. The specimen is on record at the Bell Museum of Natural History, University of Minnesota, but we do not include this species as being part of the current ichthyofauna of the Red River. Longnose Gar are common in the lakes of the Pomme de Terre River drainage; this drainage is in close geographic proximity to the lower Otter Tail River.

Overall, White Sucker (*Catostomus commersoni*) was the most common species at stream sites sampled in the Red River basin, having been found at 60% of sites sampled from 1962-1994. Also relatively common were Fathead Minnow (*Pimephales promelas*), Common Shiner (*Notropis cornutus*), Northern Pike (*Esox lucius*), and Johnny Darter (*Etheostoma nigrum*), found at 53%, 47%, 39%, and 39% of sites, respectively. The most rarely occurring species in the basin included Largescale Stoneroller (*Campostoma oligolepis*), Pugnose Shiner (*Notropis anogenus*), Flathead Chub (*Platygobio gracilis*), and Mottled Sculpin (*Cottus bairdi*), all found at <1.0% of sites.

The highest percentage of fishes from the Red River basin were from the family Cyprinidae, which was represented by 29 fish species (34%), while 10 species (12%) were Percidae, 9 species (11%) Centrarchidae, 9 species (11%) Catostomidae, 6 species (7%) Ictaluridae, and 5 species (6%) Salmonidae. The families Petromyzontidae, Hiodontidae, and Esocidae were each represented by

two species (2%), and 10 families were represented by only one species (Table 2).

Discussion

From records of stream and lake surveys we documented 77 native and seven introduced fish species as currently present in the Red River basin. Crossman and McAllister (1986) listed 75 species for the Red River basin, and Underhill (1989) listed 80 species. Crossman and McAllister (1986) did not include Bowfin (*Amia calva*), Rainbow Trout, Brown Trout, Northern Hogsucker (*Hypentelium nigricans*), Smallmouth Buffalo (*Ictiobus bubalus*), Largescale Stoneroller (*Camptostoma oligolepis*), Common Carp, Yellow Bullhead (*Ameiurus natalis*), Central Mudminnow (*Umbra limi*), Largemouth Bass (*Micropterus salmoides*), or Rainbow Darter (*Etheostoma caeruleum*). The Logperch (*Percina caprodes*) and Bigmouth Buffalo (*Ictiobus cyprinellus*) were listed, but only for the Canadian reaches of the Red River. The Brook Trout, Pugnose Shiner, Green Sunfish (*Lepomis cyanellus*), and Mottled Sculpin (*Cottus bairdi*) were listed for other drainage basins in Canada, but not the Red River basin.

Crossman and McAllister (1986) listed the Northern Brook Lamprey (*Ichthyomyzon fossor*), Bullhead Minnow (*Pimephales vigilax*), and Longear Sunfish (*Lepomis megalotis*) for the Red River in the United States. No records of these species were found during the present study, and verification of records listed by Crossman and McAllister (1986) could not be obtained (E. J. Crossman, Royal Ontario Museum, personal communication 1994). The Northern Brook Lamprey is present in the Hudson Bay drainage in Manitoba, the Great Lakes drainage of Ontario and Quebec, and in drainages in Wisconsin, Michigan, Ohio, and Missouri in the United States (Lanteigne 1992). The northernmost distribution of the Bullhead Minnow is the Mississippi River drainage in southern Minnesota and Wisconsin (Lee et al. 1980; Becker 1983). Its range extends south through Texas and the Gulf of Mexico. The Longear Sunfish has been reported from the Hudson Bay drainage in Canada (Scott and Crossman 1973) and the upper Mississippi and Rainy river drainages (Underhill 1989), but the species is primarily distributed through the east-central and south-central United States (Lee et al. 1980; Becker 1983). Also included by Crossman and McAllister (1986) for the Red River in the United States were two species with a question mark. The Silvery Minnow (*Hybognathus nuchalis*) and Longnose Sucker (*Catostomus catostomus*) were listed, but results of the present study indicate that they do not occur in the system.

Underhill (1989) listed 80 fish species for the Red River, including 75 native and five introduced. Records of all these species were found during the present study. However, Underhill (1989) did not

include Smallmouth Buffalo, Yellow Bullhead, Muskellunge, Orangespotted Sunfish (*Lepomis humilis*), or Mottled Sculpin. The Smallmouth Buffalo has only recently been collected from the Red River basin; several individuals were collected from the lower Otter Tail River in 1996 and vouchers have been deposited at the Bell Museum of Natural History (Luther Aadland, Minnesota Department of Natural Resources, personal communication 1997). It is possible that this species is a recent immigrant from the upper Minnesota River basin to the south, as a natural connection exists between the Red and Minnesota river basins during years of high water (Clambey et al. 1983). The Yellow Bullhead is a native species which has occurred primarily in the lakes of the Otter Tail and Pelican river drainages. Its distribution is restricted entirely to the eastern reaches of the Red River basin (Figure 3). The Muskellunge is an introduced species found primarily in lakes of the Otter Tail and Pelican river drainages, although it has also been stocked in the Sheyenne River (Gene Van Eeckhout, North Dakota Game and Fish Department, personal communication 1994). The Orangespotted Sunfish has occurred primarily in the Sheyenne River, although it has been taken near the mouth of the Otter Tail River and at Lake Traverse (Figure 3). The Mottled Sculpin was reported by Minnesota Department of Natural Resources in unpublished records from sites on the Otter Tail River and the Clearwater River. We resampled sites on the Clearwater River during the summer of 1994 and confirmed its presence at the outlet of Big Buzzle Lake, a tributary to the Clearwater River (Figure 3). Specimens from this collection have been deposited at the Bell Museum of Natural History.

Compared with other large streams in the region, diversity of fishes in the Red River basin is high. The upper Mississippi River (above St. Anthony Falls, Minneapolis) has 69 species (Underhill 1989) of which 62 (74% of species present in the Red River drainage) are shared with the Red River. The Minnesota River has 88 species of which 73 (87%) are shared, and the Missouri River in North Dakota has 65 species (Ryckman 1981) of which 46 (55%) are shared. The ichthyofauna is most closely related to that of the Minnesota River to the south and the upper Mississippi River to the east, quite possibly due to post-glacial dispersal patterns of fishes (Stewart and Lindsey 1983; Underhill 1989; Mandrak and Crossman 1992; Radke 1992).

The Distribution of Stream Fish Species

From examination of distribution patterns of fish species in the Red River basin, the White Sucker, Common Shiner, Fathead Minnow, Creek Chub (*Semotilus atromaculatus*), Black Bullhead (*Ameiurus melas*), Northern Pike, Johnny Darter, Blackside Darter (*Percina maculata*), and Brook

TABLE 2. Continued.

Taxon	River Drainage																										
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
<i>Nocomis biguttatus</i>	X				X																X	X					
<i>Notemigonus chrysoleucas</i>											X										X	X					
<i>Notropis anogenus</i>	X	X				X				X	X		X		X	X		X									
<i>Notropis atherinoides</i>	X	X				X				X	X	X		X		X		X			X	X					
<i>Notropis bleinnius</i>	X	X		X	X	X				X	X					X		X			X	X		X			
<i>Notropis dorsalis</i>	X	X		X	X	X				X	X	X	X			X		X			X	X			X		
<i>Notropis heterodon</i>							X				X	X				X		X			X	X					
<i>Notropis heterolepis</i>											X	X				X		X			X	X					
<i>Notropis hudsonius</i>	X										X	X				X		X			X	X					
<i>Notropis rubellus</i>		X									X	X			X	X		X			X	X					
<i>Notropis stramineus</i>	X	X		X	X		X			X	X		X		X	X		X			X	X					
<i>Notropis texanus</i>																X		X			X	X					
<i>Notropis volucellus</i>											X					X		X			X	X					
<i>Phoxinus eos</i>																X		X			X	X					
<i>Phoxinus neogaeus</i>											X					X		X			X	X					
<i>Pimephales notatus</i>										X	X					X		X			X	X					
<i>Pimephales promelas</i>	X	X		X	X					X	X		X		X	X		X			X	X					
<i>Platygobio gracilis</i> ²	X	X		X	X					X	X					X		X			X	X					
<i>Rhinichthys atratulus</i>	X	X		X	X					X	X					X		X			X	X					
<i>Rhinichthys cataractae</i>	X	X		X	X					X	X					X		X			X	X					
<i>Semotilus atromaculatus</i>	X	X		X	X					X	X					X		X			X	X					
Ictaluridae																											
<i>Ameiurus melas</i>	X	X		X	X					X	X					X		X			X	X					
<i>Ameiurus natalis</i>	X	X														X		X			X	X					
<i>Ameiurus nebulosus</i>											X					X		X			X	X					
<i>Ictalurus punctatus</i>	X	X		X	X					X	X		X			X		X			X	X					
<i>Noturus flavus</i>	X	X									X		X			X		X			X	X					
<i>Noturus gyrinus</i>		X			X					X	X		X			X		X			X	X					
Umbridae																											
<i>Umbra limi</i>		X														X		X			X	X					
Esocidae																											
<i>Esox lucius</i>	X	X		X	X					X	X		X		X	X		X			X	X					
<i>Esox masquinongy</i> ²											X																
Cyprinodontidae																											
<i>Fundulus diaphanus</i>				X												X		X									

(Continued)

TABLE 2. Concluded.

		River Drainage																										
Taxon		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Gadidae																												
<i>Lota lota</i>	X																					X						
Percopsidae																												
<i>Percopsis omiscomaycus</i>	X	X	X	X	X	X	X	X	X	X	X	X	X									X						
Percichthyidae																												
<i>Morone chrysops</i> ²	X											X		X														
Centrarchidae																												
<i>Ambloplites rupestris</i>	X	X			X							X	X									X						
<i>Lepomis cyanellus</i>	X										X	X	X									X	X					
<i>Lepomis gibbosus</i>												X	X	X								X	X					
<i>Lepomis humilis</i>												X	X	X								X	X					
<i>Lepomis macrochirus</i>	X							X				X	X	X								X	X					
<i>Micropterus dolomieu</i>												X	X	X								X	X					
<i>Micropterus salmoides</i>												X	X	X								X	X					
<i>Pomoxis annularis</i>											X	X	X									X	X					
<i>Pomoxis nigromaculatus</i>	X	X			X			X			X	X	X									X	X					
Percidae																												
<i>Etheostoma caeruleum</i>										X		X	X									X						
<i>Etheostoma exile</i>									X		X	X	X									X						
<i>Etheostoma microperca</i>											X	X	X									X	X					
<i>Etheostoma nigrum</i>	X	X	X	X	X			X		X	X	X	X									X	X					
<i>Perca flavescens</i>	X	X	X	X	X			X		X	X	X	X									X	X					
<i>Percina caprodes</i>	X	X	X	X	X			X		X	X	X	X									X	X					
<i>Percina maculata</i>	X	X	X	X	X			X		X	X	X	X									X	X					
<i>Percina shumardi</i>																												
<i>Stizostedion canadense</i>	X	X		X	X			X		X	X	X	X									X	X					
<i>Stizostedion vitreum</i>	X	X	X	X	X			X		X	X	X	X									X	X					
Sciaenidae																												
<i>Aplodinotus grunniens</i>	X				X			X		X	X	X	X									X	X					
Cottidae																												
<i>Cottus bairdi</i>																	X					X						
Gasterosteidae																												
<i>Culaea inconstans</i>		X	X	X	X	X	X	X	X	X	X	X	X									X	X					
River Drainage	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	
Species Richness	44	32	20	31	31	27	33	14	22	30	56	23	32	17	21	73	49	54	56	29	65	55	19	21	22	31	46	

¹Species found in headwater lakes

²Introduced species

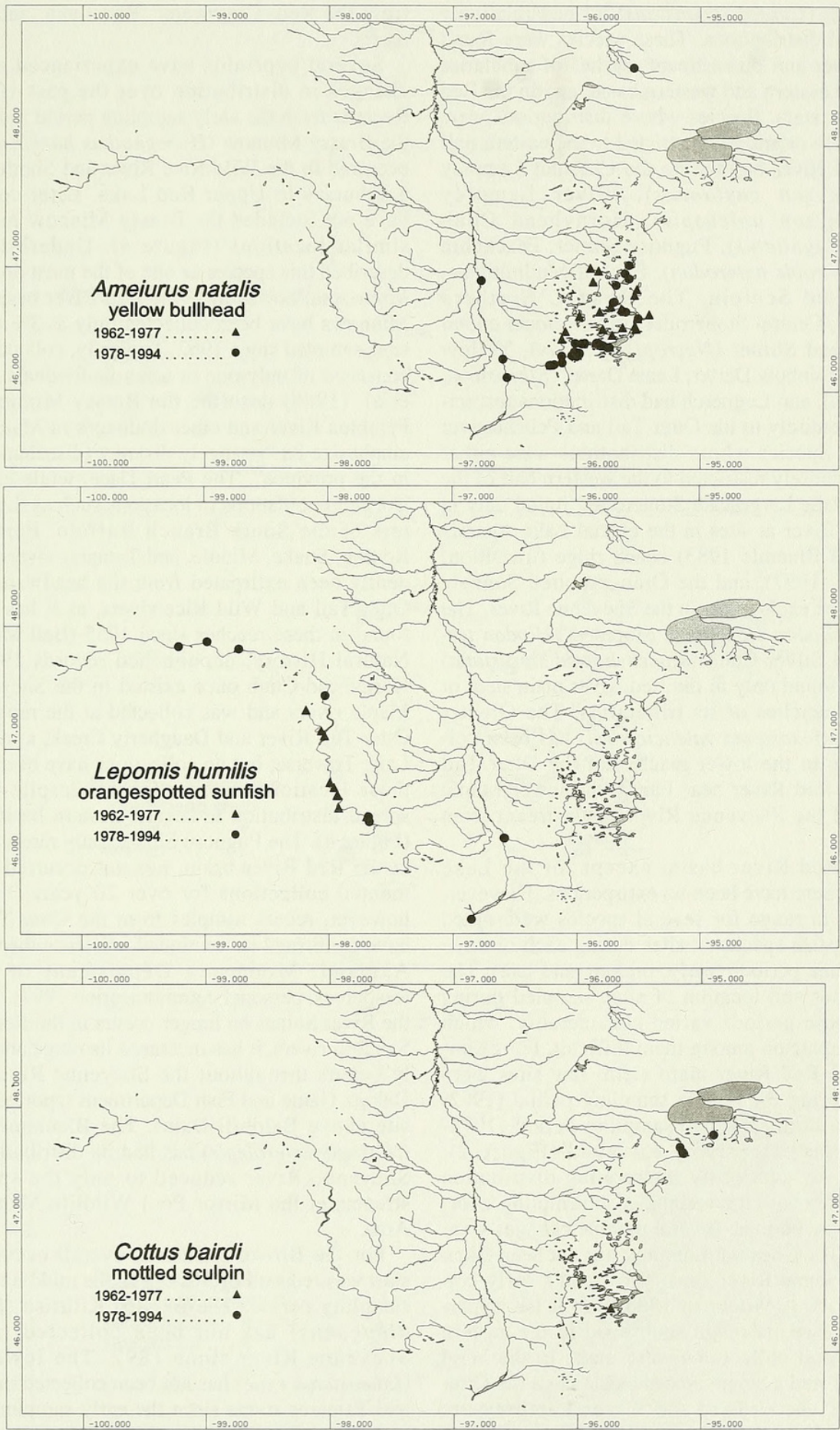


FIGURE 3. Distribution of the Yellow Bullhead, Orangespotted Sunfish, and Mottled Sculpin in the Red River of the North basin in the United States. None of these fishes were collected during the early sampling period (1892–1961).

Stickleback (*Culaea inconstans*) all had relatively widespread distributions. These species were found in headwater and downstream reaches of tributaries in both the eastern and western basin, and in the Red River main stem. Species whose distributions were either mostly or entirely restricted to the eastern half of the Red River basin were the Chestnut Lamprey (*Ichthyomyzon castaneus*), Silver Lamprey (*Ichthyomyzon unicuspis*), Hornyhead Chub (*Nocomis biguttatus*), Pugnose Shiner, Blackchin Shiner (*Notropis heterodon*), Central Mudminnow, and Mottled Sculpin. The Bowfin, Northern Hogsucker, Central Stoneroller (*Camptostoma anomalum*), Weed Shiner (*Notropis texanus*), Yellow Bullhead, Rainbow Darter, Least Darter (*Etheostoma microperca*), and Logperch had distributions restricted almost entirely to the Otter Tail and Pelican river drainages. Species whose distributions were either mostly or entirely restricted to the western half of the basin were the Largescale Stoneroller, found only in the Forest River at sites in the glacial Lake Agassiz (Teller and Bluemle 1983) beach ridge (transition) zone (Koel 1997), and the Orangespotted Sunfish, found almost exclusively in the Sheyenne River. The Goldeye (*Hiodon alosoides*), Mooneye (*Hiodon tergisus*), and Silver Chub (*Macrhybopsis storeriana*) have been found only in the Red River main stem or the lower reaches of its tributaries. The Greater Redhorse (*Moxostoma valenciennesi*) has been collected only in the lower reaches of the Otter Tail River, the Red River near Fargo, the lower Maple River, and the Sheyenne River downstream from Valley City.

In the Red River basin, except for the Lake Sturgeon, there have been no extirpations. However, reductions in range for several species were noted by plotting fish species at sites during each of three different time periods (early, middle, and late). The total number and location of sites sampled during each of these periods varied considerably, which makes comparison among them difficult. For example, on the Red River main stem, few sites were sampled during the middle sampling period (1962-1977), but during the late sampling period (1978-1994) it was extensively surveyed (Figure 2). Therefore, by cautiously interpreting distribution patterns, even with the variability in sampling effort between time periods, several notable changes were observed. The Chestnut Lamprey has not been taken in the Sheyenne River since Woolman's early collection in 1892 (Woolman 1896), but it has apparently increased its range southward in the eastern basin. Several collections were made in the Wild Rice River, and a single record exists from the Otter Tail River. Records of the Silver Lamprey are exclusively from the late sampling period, suggesting that the species has recently expanded its range in the basin. The Silver Lamprey has been collected

from the Red, Clearwater, Red Lake, and Buffalo rivers.

Several cyprinids have experienced moderate changes in distribution over the past 105 years. Records from the early sampling period indicate that the Brassy Minnow (*Hybognathus hankinsoni*) once occurred in the Wild Rice River and Shotley Brook, a tributary to Upper Red Lake. Later collections have not included the Brassy Minnow in these or similar locations (Figure 4). Underhill (1958) described this species as one of the most dominant in Minnesota; however, in the Red River basin, Brassy Minnows have been collected only at 3% of stream sites sampled since 1962. Typically, collections have consisted of only one or a few individuals. Harbicht et al. (1988) describe the Brassy Minnow in the Pembina River and other drainages in Manitoba and emphasize its "strangely disjunct (distribution) within the province". The Pearl Dace, while existing in isolated populations in locations such as the headwaters of the South Branch Buffalo, Park, Thief, Roseau, Snake, Middle, and Tamarac rivers, has evidently been extirpated from the headwaters of the Otter Tail and Wild Rice rivers, as it has not been found in these reaches since 1955 (Bell Museum of Natural History, unpublished records 1994). The Hornyhead Chub once existed in the Sheyenne and Maple rivers and was collected at the mouth of the Otter Tail River and Daugherty Creek, a tributary to Lake Traverse; but no collections have been made in those locations in recent years, despite its widespread distribution in several eastern basin streams (Figure 4). The Pugnose Shiner, only rarely collected in the Red River basin, has not occurred in documented collections for over 20 years (Figure 4), however, recent samples from the Otter Tail River have confirmed its continued existence there (Luther Aadland, Minnesota Department of Natural Resources, personal communication 1997). Although the River Shiner no longer occurs in the Red Lake or Sandhill rivers, it has increased its range and currently occurs throughout the Sheyenne River (North Dakota Game and Fish Department reported it at one site above Baldhill Dam). The Blacknose Shiner (*Notropis heterolepis*) has had its distribution in the Sheyenne River reduced to only the spring-fed streams at the Mirror Pool Wildlife Management Area.

For the Brown Bullhead, overall occurrence at sites was reduced by 10% from the middle to the late sampling period. The Banded Killifish (*Fundulus diaphanus*) has not been collected from the Sheyenne River since 1892. The Iowa Darter (*Etheostoma exile*) has not been collected in the Park and Tamarac rivers since the early sampling period, and the current distribution of the River Darter (*Percina shumardi*) appears to be restricted to the Thief, Middle, and Roseau rivers.

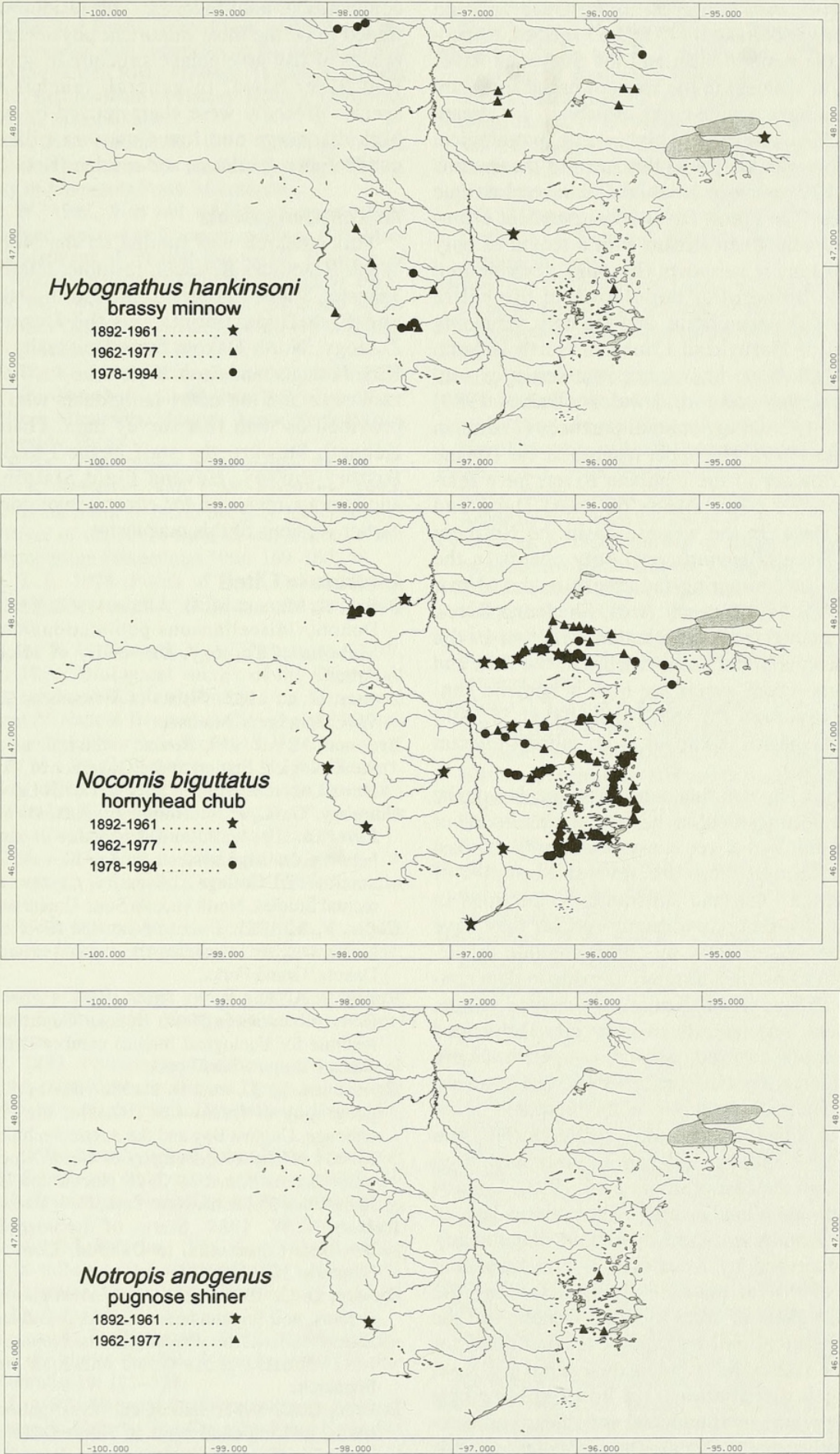


FIGURE 4. Distribution of the Brassy Minnow, Hornyhead Chub, and Pugnose Shiner in the Red River of the North basin in the United States.

Species diversity was highest in the Otter Tail and Red Lake river drainages (73 and 65 species, respectively) in the eastern basin and the Sheyenne River drainage (56 species) in the western basin; these are streams that have a wide range of habitats for stream fishes and have a relatively high, stable hydrological regime. However, we found that most of the streams in the Red River basin have one or several unique fish species. The Forest River is an excellent example. A relatively small stream with a length of only about 120 km, it supports the only documented Largescale Stoneroller population in the entire Hudson Bay drainage basin, and the only remaining population of Hornyhead Chubs in North Dakota. Hornyhead Chub are known to be intolerant of mud or silt substrates and turbid waters (Dalton 1989) often resulting from agricultural practices (Trautman 1957; Smith 1979). The upper reaches of the Tongue River, a tributary to the Pembina River, have relatively isolated populations of Pearl Dace and Finescale Dace. In the western basin the Northern Redbelly Dace (*Phoxinus eos*) only occurs in the Rush River and in spring-fed creeks in the Mirror Pool Wildlife Management Area, Sheyenne River. The only occurrences of Banded Killifish in the western basin is in the lower reaches of the Park and Turtle rivers where waters are high in specific conductance (average for the Turtle River is 3800 $\mu\text{S}/\text{cm}$); the species is known to be salinity tolerant (Houston 1990).

Overall, it appears that most fish species in the basin have been resilient in the face of a multitude of changes to the Red River ecosystem during the past century, although there are several examples of species which have had substantial reductions in range. The distributions of many species may have been influenced directly by anthropogenic disturbances such as barriers to migration due to dam construction, stream channelization, or sedimentation, while others may have been indirectly influenced through increased predation or competition with species which are not effected by these disturbances. The Lake Sturgeon was completely extirpated, probably due to a lack of migration corridors (Houston 1987); at least 300 dams of various sizes have been constructed in the basin (Stoner et al. 1993). Limited distribution and abundance of fishes due to lack of reproductive success caused by high levels of salinity was described by Koel (1993) and Koel and Peterka (1995) for another regional system, the Devils Lake chain of lakes in North Dakota, and the optimal chemical and hydrological conditions for Red River fishes have been described by Koel (1997). Fish distributions are best explained by several important environmental variables simultaneously (multivariate analysis). The coefficient of variation of mean monthly discharge, average low discharge in May, average annual discharge, specific

conductance, total hardness, and residue were determined to be the most important physiochemical correlates of fish assemblage structure in streams of the Red River basin. In general, reaches with high species diversity were characterized by waters with high discharge and low flow variability, specific conductivity, hardness, and residue (Koel 1997).

Acknowledgments

This research was funded by the North Dakota Water Resources Research Institute, Interbasin Biota Transfer Studies Program; the North Dakota Game and Fish Department; and the Department of Zoology, North Dakota State University. We thank Kirk Krueger and Josh Kadramas for field and lab assistance and the many individuals who graciously provided us with fish survey data. Thanks also to Kenneth Stewart, the staff at the Illinois Natural History Survey, Havana Field Station, and one anonymous reviewer for constructive comments on earlier versions of this manuscript.

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Author's Note

A detailed annotated list and site-specific distribution maps for all Red River fishes has been provided by Peterka and Koel (1996) and Koel (1997). The results of this research are also available on the world wide web at <http://www.npwrc.usgs.gov/resource/1998/norbasin/norbasin.htm> [Koel, Todd Marvin. 1997. Distribution of fishes in the Red River of the North basin on multivariate environmental gradients. Ph.D. thesis, North Dakota State University, Fargo, North Dakota. Northern Prairie Wildlife Research Center Home Page (Version 03June98)].

Received 12 January 1998

Accepted 8 July 1998



Koel, Todd Marvin. and Peterka, John J. 1998. "Stream fishes of the Red River of the North basin, United States: A comprehensive review." *The Canadian field-naturalist* 112(4), 631–646. <https://doi.org/10.5962/p.358491>.

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