AN ALTERED PRAIRIE STREAM: HISTORICAL FISH FAUNA CHANGES IN MINNESOTA'S BLUE EARTH RIVER

Collin A. Nienhaus

Mapleton, MN

INTRODUCTION

The Blue Earth River (Figure 1) is the largest tributary by volume of the Minnesota River, winding northwards 108 miles from the junction of its West and Middle branches to its mouth in Mankato in south-central Minnesota (MPCA n.d.). It meanders sharply through rich agricultural land, but a century and a half ago, it would have cut through expansive tallgrass prairie (Figure 2). Mostly free-flowing, one dam—the hydroelectric Rapidan Dam built in 1910—impounds the river 12 miles from its mouth. The river's name refers to unusual bluish-green clay discovered in its banks not far south of Mankato in 1683 by Pierre-Charles Le Sueur, the first European to explore this region (MN DNR 2016). Thinking it contained valuable copper, approximately 15 tons were mined and some was shipped back to France. It was eventually determined that the ore contained no copper. By 1701 the Europeans had left, thus sparing the river from possible early ecological harm. Later harm could not be prevented, however, and the Blue Earth River has undergone anthropogenic changes throughout its history to the detriment of its fish community.

Nowadays, the Blue Earth River receives limited attention from canoeists and kayakers, as well as from local anglers targeting Channel Catfish *Ictalurus punctatus,* nongame fish like the ubiquitous Common Carp *Cyprinus carpio,* or the popular Walleye *Sander vitreus*. Like other Minnesota River tributaries, the Blue Earth boasts a surprisingly impressive Walleye fishery. In most other ways, it is beleaguered with problems. The modern Blue Earth River suffers from an altered hydrologic regime, poor water quality, extensive erosion, and consequently a diminished fish fauna due to the near wholescale conversion from prairie to intensive row-crop agriculture. The fish fauna is further impacted by more than a century of lost connectivity due to the Rapidan Dam.

Figure 1. Map of the Blue Earth River watershed in south-central Minnesota and north-central Iowa. (Modified by Collin A. Nienhaus from Wikipedia.com)

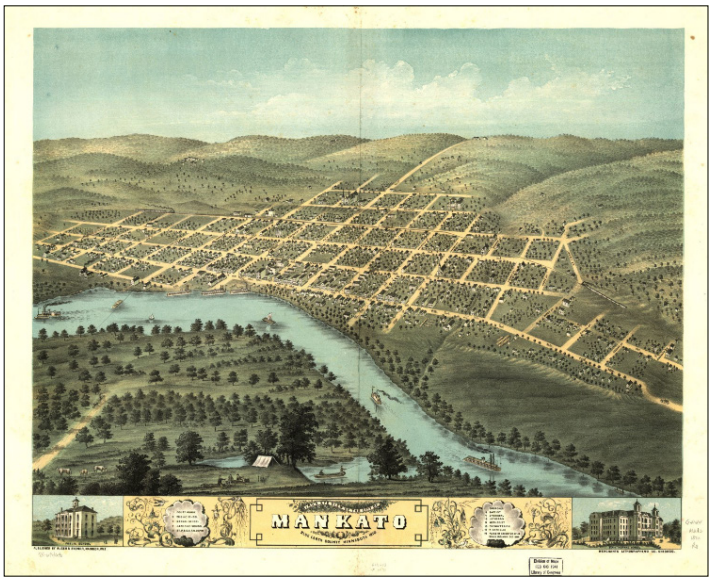

Figure 2. Print from 1870 showing the growing city of Mankato nestled amongst the native landscape of tallgrass prairie and forested river bottoms. The river shown is the Minnesota. (Image A. Ruger, Library of Congress)

Photos by the author unless otherwise indicated.

Collin Nienhaus is a science teacher at Maple River Public Schools in Mapleton, MN. He is a multispecies angler and native fish hobbyist with a backyard fish pond and several aquariums in his classroom. He is particularly interested in the conservation of nongame fishes and water quality within the greater Minnesota River basin.

Having lived within a dozen miles or so of the Blue Earth River for most of my life, I take particular interest in this undervalued resource. For those outside of south-central Minnesota, the story of the Blue Earth is not unlike the story of many other troubled Midwestern prairie streams. In this paper, I describe what the river was once like and speculate on what has changed.

MODERN PROBLEMS

The condition of the modern-day Blue Earth River was summarized in a 2020 Watershed Monitoring and Assessment Report completed by the Minnesota Pollution Control Agency (MPCA) (Nagle et al. 2020). Unsurprisingly, a poor diagnosis for it and its tributaries emerged from this two-year watershed study. All stream reaches assessed for *E. coli* bacteria (n=27) had levels too high to meet water quality standards for recreation uses. A total of 73% of stream reaches (n=73) were listed as impaired due to poor water chemistry metrics. Somewhat surprisingly, a slight majority of 65 assessed reaches (50.8%) met fish Index of Biotic Integrity (IBI) standards. However, all but five of these were ditched streams subjected to lower standards than natural ones. The average fish IBI score for 16 mainstem Blue Earth River sites was only 38.4 out of 100. The entire length of the Blue Earth River is currently listed as "Impaired" by the MPCA due to deficiencies in fish IBI score, turbidity, fecal coliform bacteria, and mercury in fish tissues.

These results are not surprising considering the land use of the watershed. Cropland—primarily corn and soybeans—constitutes 85.4% of the watershed (Nagle et al. 2020). Developed land makes up an additional 6.9% of the watershed, meaning 92.3% of the land has been significantly altered by humans. Extensive agricultural drainage has left only 2.6% of the watershed covered in wetlands; soil analyses put the historical percentage at 54%—a loss of 96%. Less water retention in the face of moderate region-wide precipitation increases means the river carries a much greater volume of water now. Research on the Minnesota River shows flow volumes have doubled there in the past 80 years, with the increase mainly attributable to the landscape's reduced ability to hold water (MPCA 2017).

In plain language, the Blue Earth River is a dirty river. It is a sandy stream, with a fair amount of coarse substrates in swift current areas. Siltation is high, and substantial bank erosion (Figure 3) has created a wide, unstable, and shallow channel with sizable sandbars exposed during low water. The river's upper reaches have, on average, a low gradient (Figure 4), but the gradient increases to a moderate level in the last dozen or so miles above its mouth. Fish habitat in the form of trees fallen from crumbling banks is fairly abundant, however. Minnesota Stream Habitat Assessment (MSHA) scores on the mainstem river averaged 46.0 out of 100 for 14 assessed sites (Nagle et al. 2020).

Water clarity during much of the open water season is poor. Even modest rainfalls cause spikes in discharge and turbidity. From spring melt to early summer, its high, turbulent waters are usually stained chocolate milk brown. The late summer low-water period is characterized by clearer but often algae-stained water from high nutrient levels. The river clears up in the fall with cool, low flows and generally remains this way throughout winter. Transparency measurements (n=197) at the river's mouth in Mankato's Sibley Park from 2000–2013 during the open water season averaged only 23.6 cm (9.3 in.) (MPCA 2022).

Figure 3. Blue Earth River near Mankato, Blue Earth County, MN, 28 June 2022. Continuously turbid water and a very wide channel are features of the modern river.

HISTORICAL DESCRIPTIONS

It is impossible to compare the wealth of limnological data on today's river to the past when such data were not collected, so a few brief snapshots of the pre-settlement river must do. French explorer Joseph Nicollet recorded observations of the Blue Earth River on two occasions during his 1838 expedition across south-central Minnesota. His first encounter showed that this river always has and always will move sediment. It is a sharply meandering stream that erodes through a relatively young (<14,000-year-old) postglacial landscape. Nicollet described the river a few miles southwest of modern-day Vernon Center on August 15, 1838, possibly after a late summer rainstorm: "The Blue Earth here is 80 feet wide; the waters are troubled and yellowish, as if yellow clay were in suspension; strong current" (Nicollet 1993:118).

On the return trip, Nicollet's team crossed the river a few miles south of the prior location, near present-day Amboy. A botanist on his crew, Samuel Geyer, made this note on September 25, 1838: "The river is about 28 yards [84 feet] wide at the crossing place, & 3 feet deep in an average [sic]. The water is very clear. The bed gravelly & very Swift Current" (Nicollet 1993:127). His observation of a clear river was typical of the many other Minnesota River Basin tributaries the two men encountered during their travels. Today, most of these streams are seldom clear.

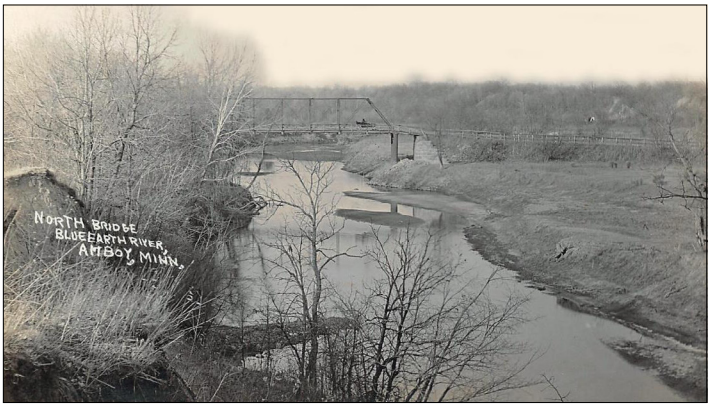

Figure 4. Postcard from 1912 showing the upper Blue Earth River near Amboy, Blue Earth County, MN. (Image from LakesnWoods.com)

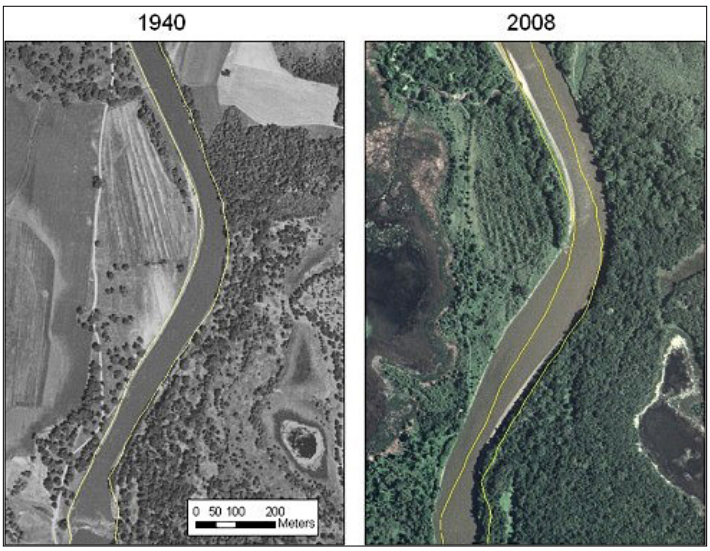

Figure 5. Aerial photographs showing channel widening in the lower Minnesota River due to increased flow volumes and associated erosion (image from Lauer et al. 2017). Though not as severe, widening in tributaries like the Blue Earth River is significant.

Simultaneously clear, deep, and swift-flowing water as Geyer noted rarely occurs in the modern Blue Earth River. When flows and depths are high, visibility is low, and vice versa. Regarding width, rough measurements using Google Maps in this area show that the river ranges from 100 to 200 feet wide, with an average of about 150 feet. Even without knowing the explorer's exact measurement methodology, it is safe to presume the river has widened significantly. Comparisons of aerial photographs in the Minnesota River Basin from 1938 to 2015 show that the Minnesota River has widened at a rate of about 62% in a period of 72 years and its tributaries at a rate of 31% over the same time period (Figure 5; Lauer et al. 2017).

Further downstream and years later, Ulysses Cox surveyed the fish species of the lower Blue Earth River for the United States Commissioner of Fish and Fisheries from 1891 to 1896. He described the river at its mouth (Figure 6):

> At Mankato it has a bed which is 200 feet in width, but the stream during the dry season narrows down to a mere brook not more than 10 feet in width on the ripples and having a depth of 6 inches or less. Notwithstanding, there are holes in which fish can live the entire year, and at the proper season bass and pike [i.e., Smallmouth Bass *Micropterus dolomieu* and Walleye, sometimes known, even today, as "wall-eyed pike"] fishing is excellent at various places. The bottom is generally sandy or gravelly, and in a few places it is covered with bowleders [sic]. The water is pure [i.e., clear] but warm (Cox 1896:606).

At present, widths are in excess of 400 feet in places, and a flowing channel of only 10 feet is probably an impossibility even in drought years. Sadly, Cox was already observing pollution at this time. The Minnesota River upstream of Mankato was "clear" and "pure" while downstream the river was "contaminated by sewage, where, during low water, very few of the higher forms of aquatic animals are found" (Cox 1896:606).

A more recent scientific description of the lower 10 miles of the Blue Earth was done by Minnesota Department of Conservation biologist Jerome H. Kuehn from July 22–24, 1948 while investigating the river's rapidly declining Smallmouth Bass (Figure 7) fishery. In 1937, a short-lived dam was built at the river's mouth in Mankato's Sibley Park to create a recreational impoundment. In the same reach Cox had observed four decades before, Kuehn noted the following:

> The 10-mile section of the river averages about 150 feet in width. It is usually 4 to 5 feet deep but several holes of 6 to 9 foot depth are present . . . The flow of the water is quite fast down to the [Sibley Park impoundment]. Springs are frequent along the banks of the stream.... The stream bottom is made up of gravel, rubble, and boulders for the greater extent of its length, with some sand and much silt over the original bottom in the lower mile above the Sibley Park dam . . . The frequent rapids over rubble and boulders probably prevent any oxygen depletion due to cannery wastes from upstream. Chemical analysis of the water showed it to be normal in this sector with slightly higher than average fertility (Kuehn 1948:1–2).

Kuehn also observed that siltation was "not apparent" except in the mile above the Sibley Park Dam. Like Nicollet, he

Figure 6. Confluence of the Blue Earth (left) and Minnesota (right) rivers at modern day Sibley Park, Mankato, MN, ca. 1908 (Photo by Frederick J. Krost, Library of Congress). Unusual about this image is a well-vegetated island, which is a nonexistent feature in the flashy, unstable modern river.

Figure 7. Smallmouth Bass from the Cedar River, Mower County, MN, 2 Aug 2021.

did note the river could be periodically cloudy, saying "almost all erosion of this basin is found farther upstream, and so far it has not affected the sector of stream surveyed except to make the water turbid at times" (Kuehn 1948:4). Now, the modern river is continuously turbid for long stretches during the open water season.

One particularly interesting snippet of Kuehn's report was his description of cannery wastes: "Population [sic] of this river by vegetable canneries has been common in the past above the Rapidan dam. Untreated or unlagooned wastes have depleted oxygen in stream areas below the canneries and fish kills often have been reported" (Kuehn 1948:4). The cannery problem was quickly dismissed as a culprit in the falling bass population because fish kills in the apparently well-oxygenated downstream reach weren't happening to his knowledge. Similarly, he ruled out the effects of the Sibley Park Dam and overfishing as having relatively minor impacts.

Ultimately, Kuehn pointed to high flow rates as the most probable environmental stressor on this species that requires slack water habitat for nest-building. Research after Kuehn's study has shown that high flow rates are an important cause of nest failures in riverine Smallmouth Bass populations (Lukas and Orth 1995; Smith et al. 2005). Kuehn's prescient primary management recommendation was to control floods and erosion in order to provide an "adequate amount of clean, evenly flowing water during each spawning season" (Kuehn 1948:6).

FISH FAUNA CHANGES

It is difficult to state with much certainty which fishes have been lost from the Blue Earth River, but 13 species are possible (Table 1). Doing so is difficult in part because scant historical fish survey records exist. Available data consists of Cox (1896), Kuehn (1948), 1990–1992 MPCA surveys (n=12), and post-2000 MPCA surveys (n=33), the bulk of which were conducted in 2017. Some late 20th century vouchered fish specimens from various sources stored at the University of Minnesota's James Ford Bell Museum (JFBM) complete the dataset. Extirpations would not necessarily be indefinite because fishes from the Minnesota or Le Sueur rivers (the latter being the lower Blue Earth's largest tributary) could recolonize the lower river below Rapidan Dam. In the upper river, extirpations would be permanent pending dam removal.

Figure 8. Suspected extirpated species from the Blue Earth River. Top: Western Sand Darter from the Zumbro River, Wabasha County, MN, 24 Sep 2002. (Photo by Konrad Schmidt) Bottom: Rainbow Darter from Rose Creek, Mower County, MN, 1 Jul 2021. (Photo by Clinton Dexter-Nienhaus)

Cox (1896) was the first biologist to survey the Blue Earth River, which he did near Mankato in the 1890s. European settlers arrived in this region in earnest in the 1850s, so he was not surveying a virgin river, but he did visit it before Minnesota's early 20th century boom in agricultural drainage began (Hanson 1987). Species he sampled that are now likely absent from the river are Western Sand Darter *Ammocrypta clara* (Figure 8; Cox reported as "common on sand bars"), Banded Killifish *Fundulus diaphanus* ("rather common"), Brown Bullhead *Ameiurus nebulosus* ("rare"), Shoal Chub *Macrhybopsis hyostoma* ("not common"), Blacknose Shiner *Notropis heterolepis* ("very common"), and Rainbow Darter *Etheostoma caeruleum* (Figure 8; "not common"). Brown Bullhead, Shoal Chub, and Rainbow Darter were more recently collected in the 1970s, with specimens of the latter two species vouchered at the JFBM (JFBM 2022). All of these aforementioned species are known in the literature to be sensitive to poor habitat and water quality (Becker 1983; Pflieger 1997; Kansas Fishes Committee 2014; Robison and Buchanan 2020).

The reported high abundance of Western Sand Darter, a rare species in Minnesota and elsewhere, is particularly remarkable. The last valid record of this species from the entire Minnesota River Basin was 1970 (Jay Hatch, personal communication), so its decline was apparently rapid and complete. It is intolerant of fluctuating flows, siltation, and turbidity and is in decline across its range (Becker 1983; Pflieger 1997; Robison and Buchanan 2020). A unique species, its preference for dwelling on biologically unproductive sand flats of large rivers where few other benthic fishes reside and its behavior of nestling beneath sand to escape swift flows (Becker 1983) are not replicated by other native species of the stream and make its loss an exceptionally heavy blow to the Blue Earth River's biodiversity.

Table 1. Possible extirpated fish species from the Blue Earth River (BER). Current status in the Minnesota River Basin is based on post-2000 MPCA Biological Monitoring surveys (MPCA 2022), JFBM records (JFBM 2022), and MN DNR Fishes of Minnesota Mapper database records (MN DNR 2022).

Species Name	Last Record from BER (Source)	Current Status in Minnesota River Basin
Rock Bass *Ambloplites rupestris*	ca. 1896 (Cox)	Uncommon to fairly common in western streams, including the Chippewa, Cottonwood, Lac Qui Parle, and Yellow Medicine river systems
Brown Bullhead *Ameiurus nebulosus*	1973 ,(JFBM - MN DNR)	Rare, mainly in the Pomme de Terre and upper Minnesota rivers
Bowfin *Amia calva*	ca. 1896* (Cox, lower Le Sueur R. near BER)	Fairly common in lakes of the northwestern and northeastern parts of the basin, present in the Pomme de Terre R. and a few other northwestern streams
Western Sand Darter *Ammocrypta clara*	ca. 1896 (Cox)	Extirpated, last recorded in the basin in 1970 (Jay Hatch, pers. comm.)
Rainbow Darter *Etheostoma caeruleum*	1973 (JFBM - Robert Bellig)	Fairly common in Yellow Medicine River, rare in a few other western streams
Banded Killifish *Fundulus diaphanus*	ca. 1896 (Cox)	Common in lakes of the upper Chippewa River, Hawk Creek, and Pomme de Terre River systems, uncommon in streams of this region
Chestnut Lamprey *Ichthyomyzon castaneus*	ca. 1896* (Cox, Minnesota River near BER mouth)	Extirpated, one other record from 1853 in the Watonwan River watershed
Silver Lamprey *I. unicuspis*	1990 (MPCA)	Rare in the Minnesota River
Shoal Chub *Macrhybopsis hyostoma*	1975 (JFBM - James Erickson)	Fairly common in the Minnesota River, only two post-2000 records from tributaries
Greater Redhorse *Moxostoma valenciennesi*	1990* (JFBM - MN DNR, lower reaches of Elm Cr. near BER)	Rare in western rivers: Lac Qui Parle, Pomme de Terre, Redwood, Yellow Bank, Yellow Medicine, and upper Minnesota
River Shiner *Notropis blennius*	1948 (Kuehn)	Rare in a few streams, primarily the Minnesota and Yellow Medicine rivers, newest record is 2005, most are much older
Blacknose Shiner *N. heterolepis*	ca. 1896 (Cox)	Fairly common in lakes and some streams of the upper Chippewa and Pomme de Terre river systems, known from only two lakes elsewhere
Carmine Shiner *N. percobromus*	1948 (Kuehn)	Fairly common in several western streams, rare elsewhere

Nearly as significant are Cox's descriptions of Banded Killifish as "rather common" and Blacknose Shiner as "very common" (Figure 9) in the Blue Earth River. Both are clear water, vegetation-associates that are much more common in lakes than rivers. Cox did not discuss vegetation in the river but did state that the nearby Minnesota River was "comparatively free from aquatic vegetation" (Cox 1896:606). This implies there was at least some vegetation in a river that is now devoid of aquatic plants. Further, two specimens of the vegetation associate Bowfin *Amia calva* were sampled in the nearby lower Le Sueur River; it can be assumed that it once inhabited but is now gone from the Blue Earth. One important disclaimer is that Cox's description of each species' abundance was applied to multiple waters in addition to the Blue Earth: the more westerly Pomme de Terre River and nearby Lake Washington for Banded Killifish and the Pomme de Terre, Minnesota River, and "ponds near Minnesota River at Mankato'' for Blacknose Shiner (Cox 1896:609). Their abundance in the Blue Earth may or may not have reached that of the other locations.

Unfortunately, Cox's dataset is problematic to interpret for several reasons. First, his employed gear was not defined (he probably relied on a variety), and his specimens are no longer available for examination. Sadly, they are thought to have been destroyed by fire in the Old Main building of the Mankato

Figure 9. Clear-water, vegetation-associated fishes presumed to be extirpated from the Blue Earth River. Top: Banded Killifish, Fish Lake, Le Sueur County, MN, 31 May 2017. Bottom: Blacknose Shiner, Pomme de Terre River, Otter Tail County, MN, 11 August 2003. (Photos by Konrad Schmidt)

Figure 10. Suspected extirpated species from the Blue Earth River. Top: Carmine Shiner from Rose Creek, Mower County, MN, 1 Jul 2021. (Photo by Clinton Dexter-Nienhaus) Bottom: Greater Redhorse from the Straight River, Steele County, MN, 8 Aug. 2021.

Normal School—today's Minnesota State University, Mankato (Underhill 2009). Second, the nomenclature he used is antiquated and sometimes difficult to reconcile with modern species names. For example, the darter species *Boleichthys fusiformis* ("rare") does not appear in Eschmeyer's Catalog of Fishes as such but it is there as *Boleosoma fusiforme* and is synonymous with the Swamp Darter *Etheostoma fudiforme* (Fricke et al. 2022; Chris Scharpf, personal communication). The name was misapplied to some specimens of Iowa Darter *E. exile* both in Minnesota and Iowa during the late 1800s and early 1900s (Jay Hatch, personal communication). Cox also identified other specimens of Iowa Darter as *E. iowae,* adding further confusion to his species list.

Another example is the minnow species *N. cayuga* that Cox listed as "very common." The name is a synonym for Bridle Shiner *N. bifrenatus,* an Atlantic coast species. Again, this was a misapplication of a name, this time to populations of Blacknose Shiner in Iowa and Minnesota (Jay Hatch, personal communication). *Hybopsis kentuckiensis* ("not common") likely refers to Hornyhead Chub *Nocomis biguttatus* and it does appear as an official synonym *Luxilus kentuckiensis* in Eschmeyer's catalog.

A third problem arises from inaccurate identification of some species. Slender Madtom *Noturus exilis* ("one specimen; not common") was likely the somewhat similar Stonecat *N. flavus*. Currently, Slender Madtom is known from one stream in southeastern Minnesota's Cedar River Basin (MN DNR n.d.). Further, "silvery minnow" *Hybognathus nuchale* [sic], was probably not Mississippi Silvery Minnow and was more likely the yet to be described Brassy Minnow *H. hankinsoni,* a common species in the region today.

Finally, Cox did not report several expected common species from the river (e.g., Freshwater Drum *Aplodinotus grunniens,* Quillback *Carpiodes cyprinus,* Channel Catfish, Golden Redhorse *Moxostoma erythrurum,* Silver Redhorse *M. anisurum,* Sand Shiner *Notropis stramineus,* and Slenderhead Darter *Percina phoxocephala*). Freshwater Drum and Channel Catfish were taken by Cox from the Minnesota River, however. Kuehn (1948) sampled all of these species a half-century later, so it is more likely these absences are related to sampling bias rather than actual fish community changes. Far from perfect, his data are the oldest view of the Blue Earth River, and the bulk of reported species are likely accurate.

Kuehn (1948) sampled with a 30-foot seine, which was admittedly biased against larger species and those living amongst rocks. His data suggest the loss of Carmine Shiner *N. percobromus* (Figure 10). His is the only record of the species from the Blue Earth River and there are no extant specimens in JFBM collection to confirm its historical presence in the stream. Three records from the nearby Le Sueur and Maple rivers from 2008 are in the collection, however. Curiously, he is also the only biologist to collect Silver Chub *Macrhybopsis storeriana* from this river. I do not suggest this species has changed in status, as it is apparently difficult to sample. It is not known to be pollution intolerant and has been sampled many times in recent years from the Minnesota and Le Sueur rivers (MPCA 2022).

Cox and Kuehn are both in agreement on the historical status of the Blue Earth River's black bass species. Cox described Smallmouth Bass as "common . . . many fine specimens are taken with hook and line" (Cox 1896:610). Kuehn wrote of the river's reputation as a quality bass stream: "Smallmouth bass fishing is reported to have been excellent prior to 1938–40" (Kuehn 1948:1). Rock Bass *Ambloplites rupestris* were "common" according to Cox, but Kuehn didn't find any. Smallmouth Bass were last sampled and vouchered in 1992 by the MPCA and are still caught on occasion by anglers in the lower Blue Earth. However, Rock Bass have not been recorded in the river since Cox and are presumed extirpated. The niches vacated by these clear water-associated, sight-feeding predators were probably filled by the abundant Channel Catfish and Walleye, both of which are well-adapted for murky water environments. Walleye were common in the historic Blue Earth River but the historical status of Channel Catfish is not clear. Cox mentioned Channel Catfish could be common in the Minnesota River near Mankato in spring but did not report them at all from the Blue Earth. A forward-thinking Kuehn predicted that "Channel Catfish can be expected to increase in numbers if siltation continues" (Kuehn 1948:5), a prognostication that has appeared to come true.

Three final suspected extirpated species are Greater Redhorse *Moxostoma valenciennesi* (Figure 10), Chestnut Lamprey *Ichthyomyzon castaneus* (Figure 11), and Silver Lamprey *I. unicuspis*. Cox found or collected one Chestnut Lamprey in the Minnesota River near the Blue Earth's mouth; Kuehn found none of the three. Chestnut Lamprey are likely extirpated from the entire Minnesota River drainage. One specimen stored at the Smithsonian National Museum of Natural History (USNM 979) was collected in 1853 from an unknown stream (probably Willow Creek) in Galena Township, Martin County in the Watonwan River watershed (the Watonwan is the upper Blue Earth River's largest tributary.). Silver Lamprey were most recently

Figure 11. The Blue Earth River has presumably lost both of Minnesota's native parasitic lamprey species, Chestnut and Silver. Pictured (top) is a Chestnut Lamprey recently detached from just in front of the dorsal fin of a White Sucker (bottom), Buffalo River, Clay County, MN, 1 May 2015.

collected four times in the Blue Earth River from 1984–1990 by the MPCA and Minnesota Department of Natural Resources (MN DNR) (Konrad Schmidt, personal communication). In the Minnesota River, one Silver Lamprey was collected in 1939 and then not reported again until 2012–2015 when the species was found at seven localities. One Greater Redhorse (JFBM 26021) was collected in 1992 by the MN DNR from Elm Creek near its confluence with the Blue Earth River (Figure 12). All three are pollution sensitive species that were certainly more widespread in the past.

Figure 12. Preserved Greater Redhorse specimen (JFBM 26021) captured from Elm Creek near its confluence with the Blue Earth River, Faribault County, MN, 22 Sept. 1992. This is the only extant record of this species from anywhere in the Blue Earth, Le Sueur, or Watonwan river watersheds.

One now-absent species sampled by both Cox and Kuehn has a murkier status, River Shiner *N. blennius*. Cox listed the species as "common" and Kuehn caught three individuals. No vouchered specimens exist in the JFBM, and the MPCA has not sampled any in recent years. Misidentification in the past or present is a possibility given its similarity to other local nondescript *Notropis* shiners like Bigmouth, *N. dorsalis,* Sand, and Mimic *N. volucellus*. Though not particularly well-studied, the species is not known in the literature to be highly sensitive to turbidity (Becker 1983; Robison and Buchanan 2020), although declines have been noted in Kansas (Eberle 2014).

Changes have also occurred to the fish fauna that have not involved outright species losses. Cox described four small-water species—Central Stoneroller *Campostoma anomalum,* White Sucker *Catostomus commersonii,* Common Shiner *Luxilus cornutus,* and Creek Chub *Semotilus atromaculatus* (Figure 13)—as "common" or "very common." Central Stoneroller, White Sucker, and Creek Chub are still common in suitable headwater streams of the watershed but are rare in the modern lower river (MPCA 2022). Common Shiner—a species associated with fairly clear

Figure 13. Creek Chub from the Steward River, Freeborn County, MN, 8 May 2022.

Figure 14. Rapidan Dam on the Blue Earth River south of Mankato, Blue Earth County, MN. (Photo by Mankato Free Press)

waters—are extremely rare in the watershed and absent from the mainstem. They are, however, apparently increasing in recent years in the adjacent Le Sueur River basin (MPCA 2022). Additionally, Northern Hog Sucker *Hypentelium nigricans* are present in low-moderate numbers now but are probably not "very common" as Cox reported them.

A few species have probably increased, including some that prefer larger, more turbid streams. These include River Carpsucker *Carpiodes carpio,* Gizzard Shad *Dorosoma cepedianum,* Bigmouth Buffalo *Ictiobus cyprinellus,* Smallmouth Buffalo *I. bubalus,* Flathead Catfish *Pylodictis olivaris,* and Sauger *Sander canadensis* that were not collected in the Blue Earth River by Cox or Kuehn but are now found regularly in the lower river (MPCA 2022). Gizzard Shad in particular are quite abundant. Interestingly, neither Cox nor Kuehn reported the now moderately common Fantail Darter *E. flabellare,* a species not specifically associated with large rivers or turbidity (Becker 1983; Robison and Buchanan 2020). It is possible that this rock-riffle species was simply missed by their gear. Kuehn in particular noted his method of seining was biased against rock-associated fishes but did sample four other darter species. The most obvious change to the river's fish fauna is the proliferation of invasive Common Carp. Cox found none in 1896; now they are the river's most common large fish species by a considerable margin. Common Carp made up just under 56% of the total fish biomass in 12 MPCA electrofishing surveys conducted on the river in 2017 (MPCA 2022). The remainder of the 66 total species sampled throughout the river's history appear to have stable populations or do not show a clear trend with existing data.

RAPIDAN DAM

The Rapidan Dam (Figure 14) is an 87-foot-high hydroelectric dam built in 1910 and renovated as recently as 1986 (MN DNR

Table 2. Fish species potentially excluded from the upper Blue Earth River by the Rapidan Dam. Data based primarily on post-2000 MPCA Biological Monitoring surveys (MPCA 2022).

Species Name	Status in the upper Blue Earth River	Status in the lower Blue Earth River	Status in the upper Le Sueur River Watershed
Lake Sturgeon *Acipenser fulvescens*	Absent	Absent (rare in MN River)	Absent
Blue Sucker *Cycleptus elongatus*	Absent	Absent (rare in MN River)	Absent
Gizzard Shad *Dorosoma cepedianum*	Absent	Abundant	Common
Banded Darter *Etheostoma zonale*	Absent	Rare	Uncommon
Mooneye *Hiodon tergisus*	Absent	Rare	Rare
Shortnose Gar *Lepisosteus platostomus*	Absent	Rare	Common
Smallmouth Bass *Micropterus dolomieu*	Absent	Rare	Rare
White Bass *Morone chrysops*	Absent	Rare	Absent
Hornyhead Chub *Nocomis biguttatus*	Absent	Rare	Uncommon but increasing
Emerald Shiner *Notropis atherinoides*	Absent	Abundant	Common
Bullhead Minnow *Pimephales vigilax*	Absent	Rare	Absent
Paddlefish *Polyodon spathula*	Absent	Absent (rare in MN River)	Absent
Flathead Catfish *Pylodictis olivaris*	Absent	Uncommon	Uncommon
Sauger *Sander canadensis*	Absent	Uncommon	Uncommon
Shovelnose Sturgeon *Scaphirhynchus platyrhynchus*	Absent	Rare	Rare

2016). There is no mechanism for fish passage, so fishes moving upstream from the Le Sueur, Minnesota, and lower Blue Earth rivers are blocked. There are 15 species that are potentially excluded from the upper river by the dam (Table 2). In addition to this list are any of the aforementioned extirpated species still found in the Minnesota River basin that might recolonize the upper Blue Earth River in the future.

Species in Table 2 were selected based on their documented presence below the dam in the Blue Earth, Le Sueur, or Minnesota rivers but not above it (MPCA 2022). A lack of historical survey data on the upper Blue Earth River (all records are post-1990) means that these suggestions are speculative, but it is reasonable to assume species present in the modern unimpounded upper Le Sueur River system were once present in the similar upper Blue Earth River. The upper Le Sueur River system includes the Big Cobb, Little Cobb, and Maple rivers.

Interestingly, the upper Blue Earth River's largest tributary—the Watonwan River—enters above Rapidan Dam and is also missing the listed species. Fishes extirpated from these two rivers from causes like drought, fish kills from cannery wastes, declining water quality, or other environmental stressors could not have been recolonized from downstream due to the dam.

Three of the listed species in Table 2 that are not currently present in the lower Blue Earth or Le Sueur rivers are Blue Sucker *Cycleptus elongatus*, Lake Sturgeon *Acipenser fulvescens*, and Paddlefish *Polyodon spathula*, large migratory species that are rare but possibly increasing in the Minnesota River (MPCA 2017). Perhaps future improvements in habitat and water quality in both rivers could lead to these species accessing the Blue Earth to spawn. Two migratory species left off the list but known from the lower Blue Earth River are American Eel *Anguilla rostrata* (1990) and Muskellunge *Esox masquinongy* (2005, angling); they are exceptionally rare in this region and not typically associated with this type of stream. Most of the species excluded by the dam would probably not be particularly abundant under current conditions, but all have significant value to the general public. Ten are targetable by hook-and-line; Emerald Shiner *N. atherinoides* and Gizzard Shad are important forage species for gamefish; and the remaining two—Banded Darter *E. zonale* and Paddlefish—boast striking appearances.

LOOKING FORWARD

It is probably unrealistic to believe the Blue Earth River will ever return to exactly what it once was. Modern society at home and abroad is dependent upon this region's agricultural production, and the endless prairie-wetland landscape cannot feasibly return in whole. Plus, 98% of the land is privately owned (Nagle et al. 2020), making management actions complicated. Ideally, more and more chunks of prairie and wetland can be brought back, and wise, targeted management practices aimed at reducing sediment loads and reducing flow rates can be implemented to allow the river to at least resemble its former self.

What would be the worth in doing so? I can only imagine the recreational and economic value provided by the Blue Earth River if it offered a Smallmouth Bass fishery approaching that of Minnesota's famous Otter Tail, Rum, or Root rivers. The MN DNR still advertises Smallmouth Bass as a gamefish species for the Blue Earth River in its State Water Trail literature (MN DNR 2016), although few fish exist (somewhat miraculously) in the poor habitat. Walleye fishing can be fairly good now in an unhealthy stream, but Cox reminds us that it was excellent in the past. Furthermore, appealing microfishes like Banded and Rainbow darters, Banded Killifish, and Carmine Shiner would be engaging to nature enthusiasts.

One comparatively "easy" fix is the removal of the aging Rapidan Dam. As of May 2022, the Blue Earth County Board of Commissioners has been collecting the public's input on whether to repair the dam again or remove it for good. If it were removed, an exciting "flood" of fishes would be able to colonize waters where some probably haven't existed for many decades. Failure to do so would not allow the full suite of fish species to take advantage of future water quality improvements in the upper watershed. What the future holds for this stream is unknown, but it is my greatest hope that the Blue Earth River's worst decades are behind it and a strong recovery can commence.

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