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Fishes of Champaign County, Illinois: as affected by 120 years of stream changes

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Research Article

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Abstract

With data spanning over 120 years, the Fishes of Champaign County is a comprehensive, long-term investigation into the changing fish communities of east-central Illinois. Surveys first occurred in Champaign County in the late 1880s (40 sites), with subsequent surveys in 1928–1929 (125 sites), 1959–1960 (143 sites), and 1987–1988 (141 sites). Between 2012 and 2015, we resampled 122 sites across Champaign County. The combined data from these five surveys have produced a unique perspective into not only the fish communities of the region, but also insight into in-stream habitat changes during the past 120 years. After a period of degradation, fish communities appear to be improving throughout the county, demonstrated by the return of two state-threatened species that had not been recorded since 1928. Our analysis of in-stream habitat indicates a general trend away from small streams of various substrate types toward wider, deeper streams with a more uniform substrate. Fish community data support the results, indicating a shift from typical headwater species to those species that frequent deeper streams with more stable flows. Long-term surveys such as this are rare, and the data and analyses of these surveys can provide managers with valuable information to further restoration efforts using a historical perspective.

INTRODUCTION

The ecosystem in which we live affects many aspects of our day-to-day lives. Changes to these ecosystems for the benefit of humans often degrade the natural environment (Pickett et al. 1989). At the basic level, these alterations modify ecosystem functions by disturbing natural nutrient flows through the environment (Meyer et al. 2005; Vaughn 2010). On a broader scale, these landscape changes have been shown to alter regional climates and weather patterns (Pielke et al. 1999; Raddatz 2007). Recent evidence even suggests that ecosystem alterations impact human health (Myers et al. 2013). While the effects of environmental alterations are often complex in nature, tracking the effects of said changes can be accomplished by monitoring the natural biota of an ecosystem (Karr 1981; Kerans and Karr 1994; Stohlgren et al. 1998).

Many characteristics of aquatic ecosystems make them vulnerable to degradation due to human changes (Moyle and Leidy 1992). In-stream and landscape changes have led to decreases in water quality, alterations of the natural flow regime, and changes to physical habitat, all of which can alter the fish communities of a waterbody. Understanding and documenting changing communities in response to environmental changes is an essential step in the conservation of aquatic organisms. Unfortunately, community data spanning the breadth of landscape changes are often not available or lacking.

The stream fish communities of Champaign County, Illinois, are among the most intensively studied fishes in the New World (Larimore and Smith 1963) but have not been immune to ecosystem alterations. Currently an agricultural and urban landscape, the marsh prairie streams of Champaign County have been altered to meet the needs of its human residents. Agriculture flourishes because the once shallow, meandering streams are now designed to efficiently remove water from the moist soil. Developed urban centers contribute to degraded stream reaches due to chronically poor water quality. Pressures on aquatic communities due to these alterations are not temporally static, thus continued, long-term investigations are needed to fully understand the effects alterations have on ecosystems.

The first surveys of fish communities in Champaign County occurred at the turn of 20th century. Stephen A. Forbes and Robert E. Richardson included 48 localities from Champaign County in their statewide fish surveys (Forbes and Richardson 1908), with the goal of understanding the localized distribution of stream fishes. Thompson and Hunt (1930) surveyed 132 county sites in 1928–1929, and their 132 sites were revisited again in 1959–1960 (Larimore and Smith 1963) and 1987–1988 (Larimore and Bayley (1996). The goals of the Fishes of Champaign County project were best stated by Larimore and Smith (1963):

> "Throughout this study, emphasis has been placed on changes – changes in the county resulting from agricultural development and population increase, changes in the streams resulting from natural and human modifications, changes in aquatic habitats resulting from new developments in land use practices, and changes in the fishes as these adaptable animals adjusted to new conditions in their naturally unstable aquatic environment."

Therefore, we continued the long-term monitoring of the fishes of Champaign County and revisited these sites in 2012–2015.

Description of the County

Previous authors (e.g., Larimore and Smith 1963; Larimore and Bayley 1996) provided detailed descriptions of the history and landscape characteristics of Champaign County. Their descriptions of the geologic history, historical ecosystem, soils, and the development of agriculture are still relevant to this day and require no further explanation here, other than Champaign County lies within the Grand Prairie and has been glaciated at least twice and the subsequent rich and fertile soils have been anthropogenically altered (e.g., dredged, channelized, polluted via point and non-point sources). Subsequently, these alterations in the physicochemical aspects to aquatic ecosystems in Champaign County have resulted in significant changes to aquatic assemblages. General stream habitats described by Larimore and Smith (1963) and Larimore and Bayley (1996) remain adequate descriptions of stream habitats in Champaign County during our surveys and will also not be further expanded upon. Although many characteristics of the county have remained the same, others have changed over the span of this project. Most notably, weather, agricultural practices, and human populations have changed during the 100+ years of this project. These changes are described below.

Weather

Daily weather observations have been recorded in Urbana, IL (the county seat of Champaign County) starting in 1901. Thompson and Hunt (1930) reported the annual average temperature at Urbana to be 10.7°C (51.2°F) and average annual precipitation of 87.0 cm (34.26 inches). Temperature and precipitation averages reported in the two subsequent surveys showed little change from these measurements, averaging 11.1°C (52°F) and 91 cm (36 inches) (Larimore and Smith 1963; Larimore and Bayley 1996). Climate data obtained from the Illinois State Climatologists Office (Illinois State Water Survey [ISWS] 2017) showed that the average annual temperature during our project (2012–2015) was 11.3°C (52.05°F), while average annual precipitation was 103.5 cm (41.22 inches).

Reports of annual climatic averages fail to capture the degree of annual variation in the weather of east central Illinois. Annual average temperature in Champaign County since 1901 has ranged from the lowest in 1917 of 9.2°C (48.5°F) to the highest of 13.1°C (55.5°F) in 2012 while annual precipitation has varied from a low of 62.7 cm (24.68 inches) in 1914 to a high of 148.7 cm (58.54 inches) in 1993. Remarkably, with the exception of the surveys in 1928 (Thompson and Hunt 1930), weather conditions during the last three surveys were very similar. Mean temperature during the summer of 1928 (June to August) was 21.9°C (71.5°F) with 27.9 cm (11.01 inches) of rain. Total precipitation during the summers of 1959, 1988, and 2012 was 12.9 cm (5.07 inches), 13.3 cm (5.24 inches), and 21.5 cm (8.45 inches), respectively. Rainfall during the summer of 2012 was similar to the summers of 1959 and 1988 until the end of August, when the remnants of Hurricane Isaac caused a rainfall event of 3–5 inches across Champaign County. Similarly, mean summer temperatures during these years were 24.4°C, 24.6°C, and 24.6°C (76.0°F, 76.2°F, and 76.2°F), respectively (ISWS 2017).

While each of the last three surveys have occurred during relatively dry summers, there is evidence that annual precipitation has increased since 1901. Mean annual precipitation from 1901 to 2012 is 96.5 cm (38 inches). Average annual precipitation for the 30 years prior to each survey (i.e., 1901–1930 for the Thompson and Hunt survey) increased from 89.9 cm (35.4 inches) in 1930 to 93.5 cm (36.8 inches) in 1959, 99.3 cm (39.1 inches) in 1988, and 103.4 cm (40.7 inches) in 2012 (ISWS 2017).

Analyses of morphological characteristics of streams must account for climactic conditions that could reveal significant changes in stream depth and width due to drought or wetter than average conditions. We analyzed the National Centers for Environmental Information's Historic Palmer Drought Indices tool (www.ncdc.noaa.gov/temp-and-precip/drought/historical-palmers/) for the years in which the majority of the samples were collected by Thompson and Hunt (1930), Larimore and Smith (1963), Larimore and Bayley (1996), and our survey. Samples from Thompson and Hunt (1930) occurred in slightly wetter conditions than other surveys, while abnormally hot and dry conditions were present for Larimore and Smith (1963), Larimore and Bayley (1996), and our survey. Such conditions should be noted when examining the following results.

Temperature trends since 1901 are less clear than those observed in precipitation. Annual mean temperature from 1901 to 2012 was 11.1°C (52.0°F). Annual temperatures for the 30 years prior to the Larimore and Smith (1963) survey and our survey were slightly warmer than average at 11.6°C (52.9°F) and 11.3°C (52.3°F), respectively. Conversely, the 30-year period preceding the Thompson and Hunt (1930) and Larimore and Bayley survey were slightly cooler than average at 51.3°F and 51.7°F (ISWS 2017).

Agricultural Practices

Arguably one of the most substantial changes in agricultural practices that has benefitted the streams of Champaign County is the creation and use of the Conservation Reserve Program (CRP). Officially established in the 1985 Farm Bill (https://www.congress.gov/bill/99th-congress/house-bill/2100/text) to reduce soil erosion and create wildlife habitat, this program subsidizes landowners that remove vulnerable lands from agricultural production and establishing native land cover. Due to its novelty during the Larimore and Bayley (1996) surveys, the effects of new CRP lands likely had not been apparent at that time. Total Champaign County CRP land in 1988 was only 758 acres (US Department of Agriculture [USDA] 2016a). By 2012, the CRP acreage had increased to 9,964, while acreage peaked in 2007 at 10,600 acres (roughly 1.67% of Champaign County lands).

Another soil conservation practice gaining prevalence in Illinois is the use of conservation tillage practices (no-till, mulch till, and reduced till). These practices delay soil work until prior to planting in the spring, leaving crop residues on the soil and limiting the surface area exposed to erosional forces (Phillips et al. 1980). The USDA estimated that only 15% of the cropland in the North Central Region of the United States (including Illinois) utilized conservation tillage practices in 1975 (USDA 1975). In Illinois, 52.9% of cropland was using conservation tillage by 1994, and that value increased to 68.2% by 2011 (Illinois Department of Agriculture [IDA] 2013). Over the same time, the percentage of acreage with less than the soil loss tolerance value (T) increased from 74.1% to 82.9% across the state. The most recent data for Champaign County measured 57.1% of total cropland acreage using conservation tillage and 93% of acreage less than T (IDA 2015).

Along with better soil conservation practices, the streams of Champaign County may see benefit from increased use of genetically modified crops. Proponents of genetically modified crops argue that these crops produce higher yields, even during droughts, and require fewer pesticide applications. There are little data supporting the latter of these claims, as pesticide use has increased in Champaign County since the early 1990s (USDA 2012). However, data do suggest that the use of genetically modified crops results in higher production. In Champaign County, the amount of land planted as corn and soybeans has remained constant, between 519,000 and 560,000 acres, since 1988. Champaign County corn production for 1988 and 1990 averaged 39.3 million bushels and average soybean production 11.2 million bushels (USDA 1990). In 2015 and 2016 those values increased to 56.5 million bushels of corn and 16.3 million bushels of soybeans (USDA 2016b). Corn and soybean production during the droughts of 1988 and 2012 was 19.6 million bushels of corn and 7.2 million bushels of soybeans in 1988 and 31.4 million bushels of corn and 11.4 million bushels of soybeans in 2012. The ability to produce substantial amounts of crops on less land could lead to more land being set aside for conservation purposes.

While we have focused on the benefits of these changes in agricultural practices, each has potential drawbacks. Changes in economic and political climates could reduce CRP lands due to reduction in federal funding for such programs and increases in commodity prices leading to the desire to produce crops on once CRP lands when contracts end. Conservation tillage practices have increased in popularity with the advent of effective herbicides that control the weeds that prosper on fields during the off season. The use of off-season herbicides and the creation of herbicide-resistant genetically modified crops are clear factors explaining the increase in herbicide usage in the county and across the country. Many weed species too have developed resistant strains due to increased herbicide applications, causing more product to be used and newer herbicides to be created. While studies suggest the concentrations of pesticides that end up in streams and rivers is not high enough to be lethal to large, adult fishes, primary producers, Daphnia spp., and potentially young-of-the-year fishes can be negatively affected (Battaglin and Fairchild 2002; Belden et al. 2006; Brasfield et al. 2015). Loss of habitat and disruption of the food chain due to pesticides in streams and rivers has the distinct possibility to degrade fish communities.

Population

Champaign County has seen a greater than fourfold increase in population since the surveys of Forbes and Richardson (1908) in 1900. At that time, Champaign County was home to 47,622 people (US Census Bureau 1900). The 30 years between the Thompson and Hunt (1930) survey and the Larimore and Smith (1963) survey saw the population increase from 64,273 (US Census Bureau 1930) to 132,436 (US Census Bureau 1960), the largest increase between surveys. County population during the last census was 201,081 (US Census Bureau 2010) with the 2016 enrollment of the University of Illinois at Urbana-Champaign (46,951 students) being roughly the same as the 1900 population of the entire county.

Populations continue to trend toward urbanization in Champaign County. At the beginning of the 20th Century nearly 69% of the county's population was rural (US Census Bureau 1900). By the time of the Thompson and Hunt (1930) survey, rural populations made up less than half of the total population (48%; US Census Bureau 1930). In 2000, the county's rural population only comprised 16% of the total population (US Census Bureau 2000). While the proportion of the total population living in rural areas has decreased since 1900, the total population numbers have remained relatively constant. Total rural population in Champaign County was 32,796 in 1900, 30,865 in 1930, 32,170 in 1990, and showed a slight decrease in 2000 at 28,397. These data suggest that the overwhelming majority of population increases in Champaign County are due to population growth in urban centers.

FISHES COLLECTED

Methods

The earliest data collected for this study came from Forbes and Richardson's (1908) assessment of Illinois fishes. From their statewide survey, we were able to identify 41 sites within the county that were surveyed between 1885 and 1901. Most of these sites are located within the Vermilion River (n = 28) and the Sangamon River (n = 8) basins. Only 5 sites from this time period were from the three basins that incorporate the southern portions of Champaign County with 3 sites from the Embarras River basin, 2 from the Kaskaskia, and none from the Little Vermilion.

Thompson and Hunt (1930) performed the initial, detailed analysis of the fish communities of Champaign County in 1928–1929. Their goal was to provide a more quantitative analysis of the local distributions of stream fishes and included 125 sampling locations within the county. Fifteen of their sites correspond to sites initially visited by Forbes and Richardson (1908). Thompson and Hunt (1930) sampled 19 sites within the Embarras River basin, 14 in the Kaskaskia, 31 in the Sangamon, 56 in the Vermilion, and 4 in the Little Vermilion, and the sites surveyed by them are the sites that have been revisited in subsequent surveys.

Very little deviation in sampling locations has occurred in the three subsequent Champaign County fish surveys since Thompson and Hunt (1930). Larimore and Smith (1963) resampled 117 of the 125 Thompson and Hunt sites in 1959–1960; they also sampled 26 additional sites for additional presence/absence data. In 1987–1988, Larimore and Bayley (1996) revisited 119 of the initial sites, as well as 22 of Larimore and Smith's additional sites. Our survey was conducted between 2012 and 2015. We were only able to revisit 108 sites sampled by Thompson and Hunt (1930), and 14 of the additional sites sampled by Larimore and Smith (1963). Many sites on the main branch of the Sangamon River were not resampled during this survey due to conditions (e.g., depths and access restrictions) that made the replication of previous sampling methods impossible.

As technologies have changed over the past 130 years, so too have the methods for performing fish community surveys. Initial surveys of Champaign County's fish communities were conducted using a basic minnow seine without the use of block nets. As portable electrofishing devices became more prevalent and were shown to be more efficient at capturing fish, Larimore and Smith (1963) developed the sampling methods used during the last three surveys—Larimore and Smith (1963), Larimore and Bayley (1996), and our survey. This method used a 30-foot electric seine to stun fishes along a 150-foot reach of the stream. Block nets were placed on both the upstream and downstream ends of the 150-foot reach to prevent fishes from swimming away from the electric current.

Changes in sampling methodologies make direct comparisons of those surveys performed with the minnow seine and the electric seine problematic. The electric seine with block nets has been shown to be more efficient at both estimating relative abundance and species richness at a site (Bayley et al. 1989; Bayley and Dowling 1990, 1993). Direct abundance comparisons between the two sampling methods would be skewed in favor of the surveys that utilized the electric seine. Therefore, the best comparisons of abundance that can be used to compare surveys performed with a minnow seine and the electric seine would be to use the proportional abundance of each species during each survey, whereas each fish species would be represented as a proportion of the total catch for both sampling methods.

Differences in species richness from both sampling methods are not as problematic as differences in relative abundance. The constraining of sites where the electric seine was used to 150 feet does not generally allow for multiple habitats to be sampled. Samples performed with the minnow seine were not constrained to a specified length of stream, leaving the samplers free to seine all the habitats present at a given location and providing a reasonable representation of the number of species present. It is probable that neither sampling method can detect all the species present in a given area. To account for those unseen species in a given sampling period, we estimated the species richness of each sampled basin via a bootstrap method using the equation:

$$Richness = SP_O + \sum_i (1 - p_i)^N$$

where SP_O is the number of observed species, p_i is the frequency of species *i*, and *N* is the number of sites per basin (Palmer 1990; Colwell and Coddington 1994). We performed the species richness estimations using the vegan package (Oksanen et al. 2016) in R v.3.2.2 (R Core Team 2016). Because these estimations use the relative abundance of each species at each site, the surveys performed by Forbes and Richardson (1908), which only recorded presence/absence of species, were not incorporated in these analyses.

In addition to fish collection methods, the knowledge of fish taxonomy has also changed since the inception of this project. Fish nomenclature (see Appendix 1 – annotated list of fishes) for this edition follows An Atlas of Illinois Fishes (Metzke et al. 2022). Certain species pairs were not considered separately in the earliest surveys of Champaign County due to changes in taxonomy, even though both unique species likely could have inhabited the streams of the county. Examples of such species include Orangethroat Darter (*Etheostoma spectabile*) and Rainbow Darter (*Etheostoma caeruleum*), Largemouth Bass (*Micropterus salmoides*) and Spotted Bass (*Micropterus punctulatus*), Redfin Shiner (*Lythrurus umbratilis*) and Ribbon Shiner (*Lythrurus fumeus*), and Spotfin Shiner (*Cyprinella spiloptera*) and Steelcolor Shiner (*Cyprinella whipplei*) (Larimore and Bayley 1996). For analysis purposes, these species were grouped for the Forbes and Richardson (1908) and Thompson and Hunt (1930) surveys and analyzed as individual species for the remaining surveys. Three changes in taxonomy have occurred since the last survey (i.e., Larimore and Bayley 1996). The first was the division of Rosyface Shiner (*Notropis rubellus*) into two species—the Rosyface Shiner and the Carmine Shiner (*Notropis percobromus*). These two species are morphologically indistinguishable but genetically distinct, with the Rosyface inhabiting Champaign County (Wood et al. 2002; Berendzen et al. 2008; Scott et al. 2018). A second change occurred when the Western Creek Chubsucker (*Erimyzon claviformis*) was removed from the synonymy of the Creek Chubsucker (*Erimyzon oblongus*) based upon genetic analysis (Hunt et al. 2021). The third major change since the last survey was the reclassification of minnows and carps. Formerly all were listed under the Family Cyprinidae; however, true minnows are now in the Family Leuciscidae, whereas carps remained in Family Cyprinidae (Tan and Armbruster 2018).

The different basins encompassed by Champaign County each have historically distinct fish communities. Changes to the landscape have affected each basin at different times throughout the entirety of the project, likely causing changes in fish communities unique to a specific basin. Discussing changes to the fish communities at the county level, and not distinguishing between the fish communities of the different drainages present, would not allow for these unique changes to be analyzed, potentially obscuring long-term changes in distribution or relative abundance. Our analyses, therefore, are focused on fish communities in each basin in Champaign County, rather than the county as a whole. By doing so we hope to be better able to detect unique changes to fish communities, rather than summarizing the fish community of the entire county. In addition to the tables and figures herein, our publication has three appendices – Appendix 1 (species presence/absence and annotated list of fishes), Appendix 2 (patterns of occurrence and abundance), and Appendix 3 (species distribution maps). Lastly, because of the changes in taxonomy since Forbes and Richardson (1908) and Thompson and Hunt (1930), the inclusion of one species found in the first two surveys could indicate the presence of two species in subsequent surveys; therefore, species richness listed below for the first two surveys could include a range (where applicable).

Results: Species Richness

Embarras River Basin

The Embarras River basin has shown the greatest increase in species richness over the span of the project (Table 1, Figure 1). Combined, Forbes and Richardson (1908) and Thompson and Hunt (1930) observed 28–31 species from the Embarras basin. Larimore and Smith (1963) were the first to use the electric seine and their survey also yielded a total of 28 species, two of which were not recorded during the initial two surveys. The Larimore and Bayley survey (1996) and ours observed 39 and 41 species from the Embarras basin, respectively. Estimations of species richness showed no noticeable differences between the Thompson and Hunt (1930) and Larimore and Smith (1963) surveys or the Larimore and Bayley (1996) survey and ours, yet the two most recent surveys showed a richness greater than 2 standard errors over the Thompson and Hunt (1930) and Larimore and Smith (1963) surveys (Figure 2). The estimated species richness of our survey was 45 (±2) and 41 (±2) for the Larimore and Bayley (1996) survey, where the estimated species richness was 28 (±2) for the Thompson and Hunt (1930) surveys and 30 (±2) for Larimore and Smith (1963) surveys. Larimore and Bayley (1996) and our survey collected four species that were not reported in previous surveys.

Three species collected during our survey are considered introduced species. The Common Carp (*Cyprinus carpio*) is the longest standing of introduced species in the Embarras basin and was collected during all surveys except Forbes and Richardson (1908). The other two introduced species had not been collected during any of the previous surveys. We collected Redear Sunfish (*Lepomis microlophus*) and Western Mosquitofish (*Gambusia affinis*) during our survey. Redear Sunfish

TABLE 1 Summary of the number of fish species collected in the Embarras River, Kaskaskia River, Sangamon River, Vermilion River, and Little Vermilion River basins during each of the five surveys of Champaign County. Introduced species are those known to be stocked into the ponds, lakes, and streams of the county or are likely due to aquaria release.

	Forbes and Richardson (1908)	Thompson and Hunt (1930)	Larimore and Smith (1963)	Larimore and Bayley (1996)	Sherwood and others (our study)
Embarras River basin					
Native species	12 - 14	25 -28	27	38	38
Introduced species	0	1	1	1	3
Previously unrecorded species	12 - 14	16 - 17	2	10	6
Previously recorded species not taken	0	2	4 - 5	4	8
Total number of species recorded	12 - 14	26 - 29	28	39	41
Cumulative number of species	12 - 14	28 - 31	32 - 33	43	49
Kaskaskia River basin					
Native species	20 - 21	30 - 31	33	36	37
Introduced species	0	0	3	1	2
Previously unrecorded species	20 - 21	16	10	5 - 6	5
Previously recorded species not taken	0	6	10 - 11	13	16
Total number of species recorded	20 - 21	30 - 31	36	37	39
Cumulative number of species	20 - 21	36 - 37	46 - 47	53	58
Sangamon River basin					
Native species	35 - 38	47 - 50	50	54	52
Introduced species	1	1	1	3	3
Previously unrecorded species	36 - 39	18	9	6	2
Previously recorded species not taken	0	6	14 - 15	14 - 15	17 - 18
Total number of species recorded	36 - 39	49 - 52	51	57	55
Cumulative number of species	36 - 39	54 - 57	65 - 66	71 - 72	73 - 74
Vermilion River basin					
Native species	38 - 45	45 - 49	50	49	56
Introduced species	1	1	3	4	3
Previously unrecorded species	39 - 46	11	9	6	2
Previously recorded species not taken	0	7	12 - 13	18	13
Total number of species recorded	39 - 46	46 - 50	53	53	59
Cumulative number of species	39 - 46	50 - 57	65 - 66	72	74
Little Vermilion River basin					
Native species	-	16 - 18	17	7	14
Introduced species	-	0	1	0	0
Previously unrecorded species	-	16 - 18	5	0	0
Previously recorded species not taken	-	0	3 - 5	13 - 15	6 - 8
Total number of species recorded	-	16 - 18	18	7	14
Cumulative number of species	-	16 - 18	21 - 23	21 - 23	21 - 23

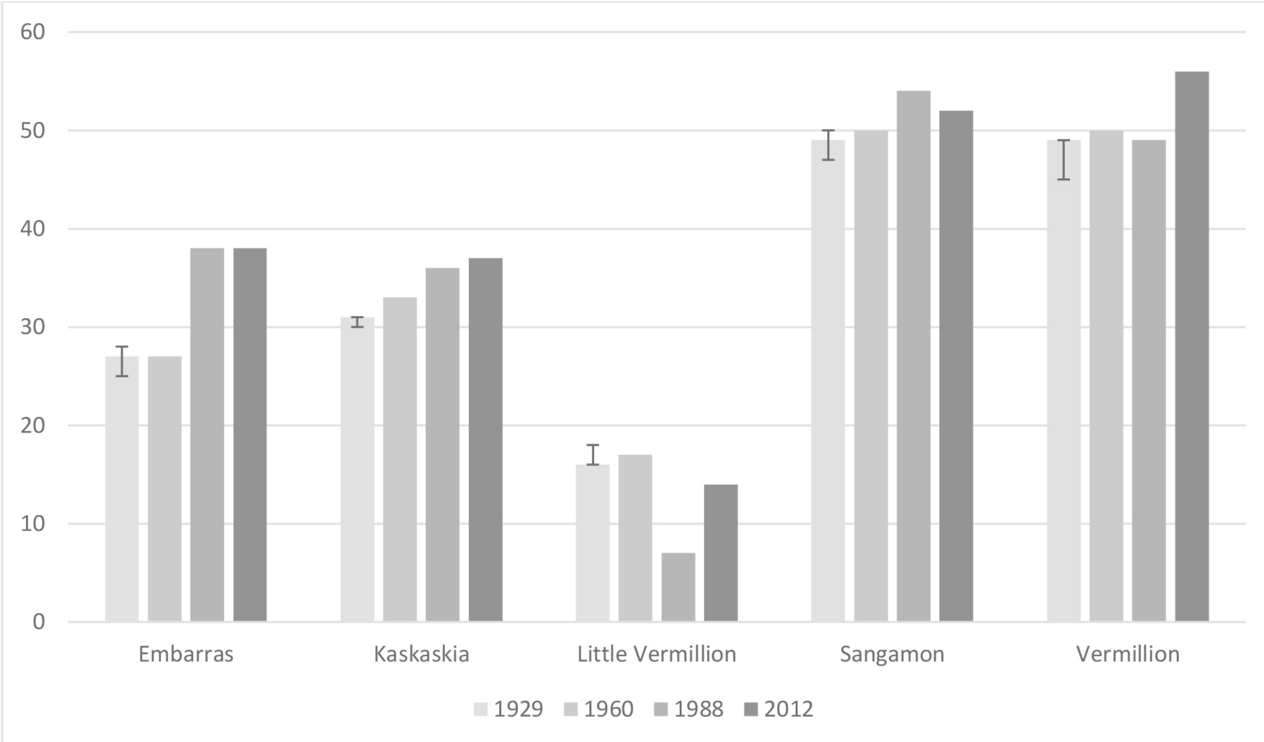

FIGURE 1 The number of species observed, by basin, during the last four surveys of Champaign County fishes. Error bars on 1929 sample's bars are due to some species not being distinguished by samplers and indicate the range of possible numbers of species observed.

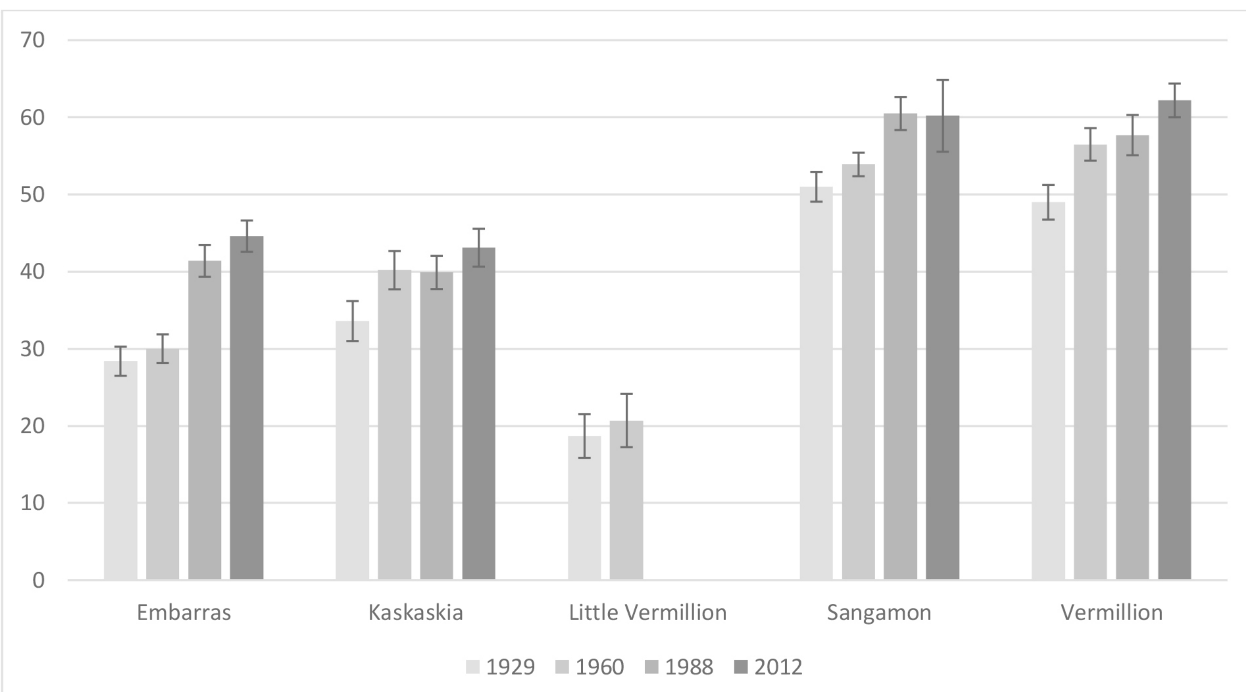

FIGURE 2 Estimated species richness, by basin, during the last four surveys of Champaign County fishes. Estimates were calculated using a bootstrap method discussed in Palmer (1990) and Colwell and Coddington (1994). Error bars represent ±1 standard error from the estimate.

has been routinely stocked into ponds in Champaign County since the 1950s and shortly after began appearing in streams (Larimore and Bayley 1996). Larimore and Bayley (1996) suggested that the appearance of Western Mosquitofish was likely due to aquaria releases and was likely only temporary residents of the Salt Fork of the Vermilion. Our survey collected this species at numerous sites in all but the Sangamon and Little Vermilion basins, suggesting this species has developed a stable residence in the streams of Champaign County.

Only one species that was collected from the Embarras basin during the initial two surveys has not been collected in subsequent surveys. The Bigeye Chub (*Hybopsis amblops*) was collected at 2 sites in the Embarras basin by Thompson and Hunt (1930). Bigeye Chub is listed as state-threatened in Illinois (Illinois Endangered Species Protection Board [IESPB] 2020) and was thought to be extirpated from the state in the 1970s and 1980s (Smith 1979; Warren and Burr 1988). Recent collections of the Bigeye Chub in the Vermilion, Little Vermilion, and tributaries of the Wabash River suggest that populations of this species are rebounding in the region (Sherwood and Wylie 2015). The last record of this species in the Embarras basin was in 1950 from Hurricane Creek in Cumberland County (INHS #16913) and it is likely this species is presently absent from the entire basin.

Eight species were collected in the Embarras basin during at least two of the past three surveys that were not reported during the initial two surveys (Appendix 1 – Table 1). Half of those species are native to the streams of Champaign County but likely increasing in prevalence due to emigration from constructed ponds and reservoirs. Gizzard Shad (*Dorosoma cepedianum*) and Fathead Minnow (*Pimephales promelas*) are common forage/bait fishes that have established due to bait bucket releases or stocking into ponds and/or reservoirs (Larimore and Bayley 1996). Channel catfish (*Ictalurus punctatus*) and Bluegill (*Lepomis macrochirus*) are commonly stocked as sport fishes and were collected in streams of the Embarras basin during the last two surveys. Native species that have appeared in the Embarras basin are the Spotted Sucker (*Minytrema melanops*), Brindled Madtom (*Noturus miurus*), Dusky Darter (*Percina sciera*), and Spotted Bass (*Micropterus punctulatus*), which is a Species in Greatest Need of Conservation in Illinois (Illinois Department of Natural Resources [IDNR] 2005).

Kaskaskia River Basin

The number of species collected in the Kaskaskia River basin has remained stable over the duration of all surveys (Table 1, Figure 1). Initial surveys of Forbes and Richardson (1908) and Thompson and Hunt (1930) observed 36–37 species from sites in the Kaskaskia basin. Surveys with the electric seine observed a similar number of species with Larimore and Smith (1963) observing 36 species, Larimore and Bayley (1996) 37 species, and 39 species from our survey. Species richness estimations showed Larimore and Smith (1963), Larimore and Bayley (1996), and our survey were richer than the Thompson and Hunt (1930) survey by greater than 1 standard error and were not different from one another (Figure 2). While it is possible that this increase was due to more efficient sampling gear, species that were captured since Larimore and Smith (1963) and not during the earliest two surveys had been collected by minnow seine in other basins during the initial two surveys.

Four introduced species were collected in the Kaskaskia basin through all surveys. Once again, the most encountered introduced species was the Common Carp, collected during Larimore and Smith (1963), Larimore and Bayley (1996), and our survey. Larimore and Smith (1963) collected a Goldfish (*Carassius auratus*) and a Redear Sunfish during their surveys and neither of these species have been collected in the Kaskaskia basin since. Our survey yielded two Western Mosquitofish at one location in the Kaskaskia basin.

Larimore and Smith (1963), Larimore and Bayley (1996), and our survey failed to detect six species in the Kaskaskia that were initially collected by Forbes and Richardson (1908) and/or Thompson and Hunt (1930). Two large reservoirs on the Kaskaskia River, Lake Shelbyville and Carlyle Lake, appear to be restricting the ranges of species that were once present in Champaign County. The collection of two Pugnose Minnows (*Opsopoeodus emiliae*) at one site during the Thompson and Hunt (1930) survey represents one of two collection localities of this species in the entirety of the Kaskaskia basin, the other being a record from 1929 at Keyesport, IL (TU #53413), which is presently Carlyle Lake. Goldeye (*Hiodon alosoides*), Warmouth (*Lepomis gulosus*), Bluntnose Darter (*Etheostoma chlorosoma*), and Spotted Sucker were all collected during the initial surveys of the county and have not been collected since. Recent collection records of the Goldeye in the Kaskaskia River were located near Carlyle, IL (IDNR 2015) and downstream, there have been recent collections of Spotted Sucker and Bluntnose Darter in tributaries of the Kaskaskia between the reservoirs (INHS #104784, INHS #48582), and Warmouth have been collected in Carlyle Lake as recently as 2008 (INHS #101914). Shorthead Redhorse (*Moxostoma macrolepidotum*) are often collected in the Kaskaskia River just downstream of Champaign County (Illinois Natural History Survey [INHS] 2016) but have not been collected in this project since Thompson and Hunt (1930). Although the Mississippi Silvery Minnow (*Hybognathus nuchalis*) was collected during the Larimore and Smith (1963) survey, it was not observed during Larimore and Bayley (1996) or our survey, nor were there any records of this species occurring above Lake Shelbyville since shortly after its construction in 1970 (INHS 2016).

As seen in the Embarras basin, Bluegill was collected in the Kaskaskia basin during Larimore and Smith (1963), Larimore and Bayley (1996), and our survey, but was not collected during the initial two surveys. Largemouth Bass (*Micropterus salmoides*), another commonly stocked sport fish, has been observed in the Kaskaskia basin in only the last two surveys. Other species that were not initially collected during the initial two surveys but were collected multiple times since Larimore and Smith (1963) were Red Shiner (*Cyprinella lutrensis*), Golden Redhorse (*Moxostoma erythrurum*), White Crappie (*Pomoxis annularis*), Orangethroat Darter (*Etheostoma spectabile*), Slenderhead Darter (*Percina phoxocephala*), and Freshwater Drum (*Aplodinotus grunniens*) (Appendix 1 – Table 2). Additionally, the collection of a young Quillback (*Carpiodes cyprinus*) during our survey was the first time it has been collected in the Kaskaskia basin during this project since Forbes and Richardson (1908).

Sangamon River Basin

Observed species richness in the Sangamon River basin has remained relatively constant from the initial surveys to during our surveys (Table 1, Figure 1). Forbes and Richardson (1908) observed 35–38 species during their survey and Thompson and Hunt (1930) 47–50. Together, these two surveys collected 54–57 species. The Larimore and Smith (1963) and Larimore and Bayley (1996) surveys collected 50 and 54 species, respectively, while our survey yielded 52 species. Although the observed species richness has remained constant, estimates of species richness increased by 1 greater than 1 standard error for the last two surveys when compared to the Thompson and Hunt (1930) and Larimore and Smith (1963) surveys (Figure 2). Estimated species richness was 61 (±2) and 60 (±5) for Larimore and Bayley (1996) and our survey, while being 51 (±2) and 54 (±2) during the Thompson and Hunt (1930) and Larimore and Smith (1963) surveys. The larger margin of error for our survey was likely due to the fewer number of sites sampled in the Sangamon basin compared to the other surveys.

Our survey yielded three species that are considered introduced to the Sangamon basin and there were four introduced species collected in all surveys. Common Carp was collected during every survey since Forbes and Richardson (1908). White Bass (*Morone chrysops*) was collected at three sites by Larimore and Bayley (1996), yet it was not collected prior to them nor collected during our survey. Larimore and Bayley (1996) proposed that this species has migrated upstream from Lake Decatur where it has been stocked. Stocking of Walleye (*Sander vitreus*) occurs in reservoirs in the Sangamon basin, as well as in the river itself, and was recorded during Larimore and Bayley (1996) and our survey. The most recent introduced species is the Redear Sunfish, which was collected at three sites during our survey.

Six species were collected in the Sangamon basin by either Forbes and Richardson (1908) or Thompson and Hunt (1930) that have not been collected since. Two of these species, Pallid Shiner (*Hybopsis amnis*) and Blacknose Shiner (*Notropis heterolepis*), are listed as state-endangered in Illinois (IESPB 2020). Currently, Pallid Shiners are only known to occur in sections of the Kankakee River in Illinois and the Blacknose Shiner is limited primarily to lakes and streams in McHenry and Lake counties (INHS 2016). Black Buffalo (*Ictiobus niger*), Spotted Sucker, and Slender Madtom (*Noturus exilis*) have only been scarcely collected throughout the entirety of the Sangamon basin (INHS 2016). The Mississippi Silvery Minnow was collected by Forbes and Richardson (1908), but no other surveys collected this species, nor has it been collected elsewhere in the Sangamon basin since the mid-1960s (INHS 2016).

Nine native species were collected in the Sangamon basin since Thompson and Hunt (1930) that were not collected during the initial two surveys (Appendix 1 – Table 3). Two additional species—Dusky Darter and Bullhead Minnow (*Pimephales vigilax*)—were found during the initial surveys but were not collected again until our survey. Both species occur in medium to large streams in moderate currents and are most abundant in clear water (Smith 1979). Silty water may be a reason they were absent from the Larimore collections.

Vermilion River Basin

Fifty-six native species were observed in the Vermilion River basin during our survey. Species observed in the previous surveys remained constant at 49–50 species (Table 1, Figure 1). The surveys performed in the 1890s and 1920s combined to observe 50–57 species. Estimates of species richness suggests a more gradual increase in species richness in the Vermilion basin over the span of this project. The estimated number of species of our survey (62 ± 2) was higher by more than 1 standard error than both the Thompson and Hunt (1930) (49 ± 2) and Larimore and Smith (1963) surveys (57 ± 2) but not more than the Larimore and Bayley (1996) survey (58 ± 3) (Figure 2).

Five introduced species were collected from the Vermilion basin. Like the other basins, the most long-standing introduced species is the Common Carp. Goldfish was collected at one site in both the Larimore and Smith (1963) and Larimore and Bayley (1996) surveys but was not collected during our survey. Western Mosquitofish was collected at 10 sites during our survey yet had only been previously collected at two sites by Larimore and Smith (1963). The last two surveys collected Redear Sunfish at multiple sites within the Vermilion basin. Larimore and Bayley (1996) collected one Northern Pike (*Esox lucius*) in the Salt Fork near Homer Lake and suggested that it was an escapee from the lake (Larimore and Bayley 1996).

Initial collections by Forbes and Richardson (1908) and Thompson and Hunt (1930) collected five species in the Vermilion basin that have not been collected in subsequent surveys. Neither Larimore and Smith (1963), Larimore and Bayley (1996), or our survey collected Silver Chub (*Macrhybopsis storeriana*), Emerald Shiner (*Notropis atherinoides*), or Mississippi Silvery Minnow in the Vermilion basin in Champaign County. Contemporary statewide surveys collected each of these species in the Vermilion basin on the mainstem from Danville to the Illinois/Indiana border. Thompson and Hunt (1930) recorded one Slender Madtom from the Middle Fork of the Vermilion, although this species is largely known to occur primarily in the tributaries of the upper Mississippi River basin and not in the Wabash or Ohio River basins (Page and Burr 2011). One Illinois state-threatened species is among those that have not been recently collected in the county. The Bigeye Shiner (*Notropis boops*) was collected during the Thompson and Hunt (1930) survey at two sites on the Middle Fork in Champaign County, but recent statewide surveys have this species limited to areas of the North Fork of the Vermilion River in Vermilion County (INHS 2016).

Four species were collected during our survey that were not observed during the initial surveys in the Vermilion basin (Appendix 1 – Table 4), the most notable of which was the collection of four Bluebreast Darters (*Etheostoma camurum*) at one location on the Salt Fork during our survey. Within Illinois, the Bluebreast Darter only inhabits the Vermilion basin and is listed as state-endangered in Illinois (Tiemann 2008; IESPB 2020). River Carpsucker (*Carpiodes carpio*), Dusky Darter, and Gizzard Shad were each only collected in the Vermilion basin during the last two surveys. As was observed in the Sangamon basin, the Bullhead Minnow was collected during our survey, but had not been observed since Thompson and Hunt (1930). The state-threatened Bigeye Chub was collected at three locations on the Salt Fork, where it had not been observed since the Thompson and Hunt (1930) survey.

Little Vermilion River Basin

The Little Vermilion River basin has been the least sampled of any of the stream systems of Champaign County. There were no records of Forbes and Richardson (1908) sampling the Little Vermilion basin, so the initial observed species count only includes the Thompson and Hunt (1930) survey in which they collected 16–18 species (Table 1). Larimore and Smith (1963) were able to resample all locations on the Little Vermilion visited by Thompson and Hunt (1930) and observed 17 species. However, neither Larimore and Bayley (1996) nor we sampled all the Little Vermilion locations from Thompson and Hunt (1930). The Larimore and Bayley (1996) survey collected seven species from one site and our survey collected 14 species from two sites. The estimated species richness for the initial two surveys showed no apparent differences, where the Thompson and Hunt (1930) survey was estimated at 19 (±3) species and Larimore and Smith (1963) at 21 species (±3) (Figure 2). The number of locations performed by the last surveys were not sufficient to generate a useful estimate of species richness in the Little Vermilion basin. The presence/absence table for the Little Vermilion basin is available in Appendix 1 – Table 5, but the scant number of samples performed during Larimore and Bayley (1996) and our survey does not allow for any other meaningful analyses to be performed on the Little Vermilion basin.

Results: Distribution and Relative Abundance

Embarras River Basin

Surveys of the Embarras River basin yielded 14 species increasing in both distribution (proportion of sites where collected) and relative abundance (proportion of total catch) over the last century (Appendix 2 – Tables 1 and 2; Appendix 3 – Figures 1 to 62). Redear Sunfish represents the only introduced species that has been increasing in both occurrence and relative abundance in the Embarras basin and was collected at 12% of sites while representing less than 0.01% of the total catch during our survey. Three other common sport fish species were among the 14 species mentioned. Largemouth Bass, Channel Catfish, and Bluegill account for about 6% of the total catch of Embarras River sites (0.5%, 0.02%, and 5%, respectively), but none of these species were collected at these sites until Larimore and Bayley (1996) (Table 2). Four species showed either an increase in relative abundance or distribution without an increase in the other. Pirate Perch (*Aphredoderus sayanus*) and Blackstripe Topminnow (*Fundulus notatus*) increased in distribution but did not increase in relative abundance, whereas Sand Shiner (*Notropis stramineus*) increased in relative abundance without an increase in the number of sites where it was observed.

Two species in the Embarras basin experienced an increase in both relative abundance and distribution following a decrease of both. Silverjaw Minnow (*Ericymba buccata*) was observed at 53% of sites and represented ~9% of the total catch during the 1929 survey, which fell to 25% of sites and 2% of the total catch during Larimore and Smith (1963), but then increased to 47% of sites and totaled 5% of the catch during our survey. Similarly, Orangethroat/Rainbow Darters were collected at 37% of sites during Thompson and Hunt (1930), falling to 25% during Larimore and Smith (1963) and 26% during Larimore and Bayley (1996), but were found at 53% of sites during our survey. These species represented 2% of the total catch by Thompson and Hunt (1930), down to ~0.2% during the Larimore and Smith (1963) and Larimore and Bayley (1996) surveys but increased to 1% during our survey. Neither species was more prevalent in either relative abundance or distribution during our survey. Longear Sunfish (*Lepomis megalotis*) has fluctuated in distribution over the time of the project (from 47% of sites during Thompson and Hunt [1930], 13% during Larimore and Smith [1963], 84% during Larimore and Bayley [1996], and 77% during our survey). The relative abundance of Longears followed a similar pattern with 3% of total catch during Thompson and Hunt (1930), 0.4% during Larimore and Smith (1963), and 12% during Larimore and Bayley (1996), yet it was only 7% of the total catch of our survey, possibly indicating the population of this species in the Embarras is currently in decline. Conversely, Bluntnose Minnow (*Pimephales notatus*) and Grass Pickerel (*Esox americanus*) increased in relative abundance during our survey after a decline in abundance. Bluntnose Minnow accounted for 53% of the total catch reported in Thompson and Hunt (1930), which fell to 28% and 17% in the following surveys and up to 37% after our survey. The less abundant Grass Pickerel was 0.3% of the 1929 catch and fell to ~0.08% during the Larimore and Smith (1963) and Larimore and Bayley (1996) surveys but rebounded back to 0.3% of our survey.

Only one species experienced an overall decline in distribution and relative abundance in the Embarras basin over the span of this project. The state-threatened Bigeye Chub was collected at 10% of sites and only represented 0.1% of the total catch during the Thompson and Hunt (1930) survey. The Bigeye Chub experienced a drastic decline throughout Illinois during the 20th century (Sherwood and Wylie 2015). Although it has been observed recovering in the Vermilion and Little Vermilion basins, it remains uncollected from the Embarras basin since the time of Thompson and Hunt (1930).

While only one species has experienced an overall decline in the Embarras basin, nine species have experienced a decline in both distribution and relative abundance after a period of increase (Appendix 2 – Tables 1 and 2; Appendix 3 – Figures 1

TABLE 2 Proportional occurrence and abundance of selected species observed in the Embarras River basin during the last four Champaign County fish surveys, grouped by overall pattern observed.

		Thompson and Hunt (1930)	Larimore and Smith (1963)	Larimore and Bayley (1996)	Sherwood and others (our study)
Increasing Species					
Aphredoderus sayanus	*Occurrence*	15.80%	12.50%	26.30%	29.40%
Pirate Perch	*Abundance*	0.29%	0.18%	0.40%	0.18%
Fundulus notatus	*Occurrence*	31.60%	43.80%	78.90%	76.50%
Blackstripe Topminnow	*Abundance*	0.61%	6.17%	8.30%	5.22%
Ictalurus punctatus	*Occurrence*	0.00%	0.00%	5.30%	5.90%
Channel Catfish	*Abundance*	0.00%	0.00%	0.02%	0.02%
Lepomis macrochirus	*Occurrence*	0.0%	0.0%	21.1%	82.4%
Bluegill	*Abundance*	0.00%	0.00%	0.10%	5.10%
Micropterus salmoides	*Occurrence*	0.0%	0.0%	10.5%	41.2%
Largemouth Bass	*Abundance*	0.00%	0.00%	0.13%	0.49%
Notropis stramineus	*Occurrence*	21.10%	37.50%	68.40%	41.20%
Sand Shiner	*Abundance*	1.97%	0.60%	5.71%	15.07%
Increase after Decrease					
Etheostoma spectabile/caeruleum	*Occurrence*	36.8%	25.0%	26.3%	52.9%
Orangethroat/Rainbow Darter	*Abundance*	2.43%	0.28%	0.18%	1.21%
Ericymba buccata	*Occurrence*	52.6%	25.0%	47.7%	47.1%
Silverjaw Minnow	*Abundance*	8.77%	2.30%	4.47%	5.39%
Pimephales notatus	*Occurrence*	78.9%	87.5%	94.7%	70.6%
Bluntnose Minnow	*Abundance*	53.54%	27.66%	17.21%	37.46%
Decreasing Species					
Hybopsis amblops	*Occurrence*	10.5%	0.0%	0.0%	0.0%
Bigeye Chub	*Abundance*	0.11%	0.00%	0.00%	0.00%
Decrease after Increase					
Catostomus commersonii	*Occurrence*	21.1%	37.5%	21.1%	5.9%
White Sucker	*Abundance*	0.68%	1.38%	0.13%	0.02%
Esox americanus	*Occurrence*	15.80%	31.30%	42.10%	29.40%
Grass Pickerel	*Abundance*	0.32%	0.08%	0.88%	0.31%
Etheostoma nigrum	*Occurrence*	42.1%	62.5%	57.9%	41.2%
Johnny Darter	*Abundance*	1.29%	3.34%	1.35%	0.39%
Lepomis megalotis	*Occurrence*	47.4%	12.5%	84.2%	76.5%
Longear Sunfish	*Abundance*	2.61%	0.42%	12.04%	6.94%
Luxilus chrysocephalus	*Occurrence*	5.3%	12.5%	52.6%	23.5%
Striped Shiner	*Abundance*	0.04%	0.32%	3.14%	0.49%
Semotilus atromaculatus	*Occurrence*	73.7%	87.5%	78.9%	52.9%
Creek Chub	*Abundance*	9.52%	26.53%	8.09%	1.13%

to 62). Eight of these species are classified as Tolerant of poor water quality in at least a portion of their overall range (Barbour et al. 1999) with the exception of Johnny Darter (*Etheostoma nigrum*), which is classified as moderately tolerant to poor water quality. These species likely increased across the Embarras basin during periods of poor water quality due to the removal of competition from less tolerant species. As water quality improved over the later parts of the 20th century, intolerant species have become more prevalent, thus potentially competing with these species and causing a recent decline in their relative abundance and distribution.

Kaskaskia River Basin

Compared to the Embarras basin, fewer species in the Kaskaskia River basin showed an overall increase in distribution and relative abundance. Seven species collected could be considered as increasing in both characteristics (Appendix 2 – Tables 1 and 2; Appendix 3 – Figures 1 to 62), with three of these species only appearing in our survey, three others collected only during the last two surveys, and the seventh, Black Crappie (*Pomoxis nigromaculatus*), initially collected by Forbes and Richardson (1908) and not again until our survey. Additionally, three sunfish species (Genus *Lepomis*) have expanded the number of sites in which they are found in the Kaskaskia basin. Bluegill was not collected in either the Forbes and Richardson (1908) or Thompson and Hunt (1930) surveys but was found at 31% of sites during Larimore and Smith (1963) and have since increased to over 60% of sites in both of the last two surveys (Table 3). Green Sunfish (*Lepomis cyanellus*) and Longear Sunfish were collected from 29% and 50%, respectively, of sites during the Thompson and Hunt (1930) survey and have both increased to over 60% of sites in the last two surveys. Only the Bluntnose Minnow and Blackstripe Topminnow occur in more sites in the Kaskaskia than these three Sunfishes. Six species showed an increase in relative abundance over the last century. Most notably, the Blackstripe Topminnow represented only 1% of the total catch during Thompson and Hunt (1930), which has increased to 26% of total catch during our survey.

Golden Shiner (Notemigonus crysoleucas), Redfin Shiner (*Lythrurus umbratilis*), and Spotfin/Steelcolor Shiner (*Cyprinella spiloptera/whipplei*) showed recent increases in distribution and relative abundance in the Kaskaskia basin after a period of decline. Golden Shiner was observed in 64% of sites and was ~5% of the collected fish during the Thompson and Hunt (1930) survey. Distribution and relative abundance dropped to 15% and 0.07% during Larimore and Smith (1963) but rose to over 30% of sites and ~0.6% in the past two surveys. Redfin Shiner occurred at 57% of sites in surveys by Thompson and Hunt (1930) and 46% in surveys by Larimore and Smith (1963), comprising 7% and 1% of relative abundance, respectively. The Larimore and Bayley (1996) surveys detected Redfin Shiners at 15% of sites constituting 0.3% of total catch while our survey detected this species at 46% of sites, totaling 3% of the total catch. Larimore and Smith (1963) and Larimore and Bayley (1996) collected Spotfin/Steelcolor Shiners at 8% of sites with a relative abundance of less than 0.1%, down from 21% of sites and 0.8% of total catch during Thompson and Hunt (1930). These species represented 0.4% of our survey and were found at 15% of sites in the Kaskaskia basin. Thompson and Hunt (1930) recorded Silverjaw Minnow at 43% of sites, which fell to 39% during Larimore and Smith (1963) and to 8% during Larimore and Bayley (1996). Our survey observed this species at 15% of sites. Silverjaw Minnows often occur in large schools, and it seems unlikely to catch only a few individuals of this species during a survey, which could be the cause of the apparent fluctuations in relative abundance recorded throughout the last century. Conversely, occurrence of Pirate Perch has fluctuated over the period of the project, yet relative abundance dropped from 5% during Thompson and Hunt (1930) to 0.2% during Larimore and Smith (1963) and 0.7% during Larimore and Bayley (1996) but rose slightly to 1% of the total catch of our survey.

Species showing an overall decline in both distribution and relative abundance in the Kaskaskia basin over the span of the project include Mississippi Silvery Minnow, Hornyhead Chub (*Nocomis biguttatus*), Spotted Sucker, and Johnny Darter. Hornyhead Chub was observed in 93% of sites and represented 23% of the total catch during the Thompson and Hunt (1930) survey, which has fallen to 15% of sites and 0.1% of the total catch of our survey. Similarly, although not quite as drastic, Johnny Darter occurrence was 93% during the Thompson and Hunt (1930) survey and 53% of sites during our surveys with a proportional catch falling from 4% to 0.7%. Thompson and Hunt (1930) collected Mississippi Silvery Minnow at 64% of sites and Larimore and Smith (1963) found it at 23% of sites; however, it was not collected by either Larimore and Bayley (1996) or us. Forbes and Richardson (1908) and Thompson and Hunt (1930) both collected Spotted Sucker during their surveys in the Kaskaskia and its tributaries, but it too has not been collected in any subsequent survey. Three other species showed decreasing relative abundances over the project period but not decreases in distribution (Appendix 2–Table 2; Appendix 3–Figures 1 to 62).

Roughly 36% of the species collected from the Kaskaskia basin during our survey decreased in occurrence after initially increasing (Appendix 2 – Table 1). This pattern was seen in the relative abundance of seven of these species. Common Carp was not collected during the Thompson and Hunt (1930) survey but was located at 39% of sites during Larimore and Smith (1963) and 46% during Larimore and Bayley (1996) with a peak relative abundance of 3% of total catch during Larimore and Smith (1963). Occurrence and relative abundance have fallen to 6% and 0.4% during our survey. The species with the most drastic of changes was Striped Shiner (*Luxilus chrysocephalus*). Thompson and Hunt (1930) found this species at 86% of sites, which increased to 92% during Larimore and Bayley (1996) with relative abundance near 25% of total catch. These numbers dropped during our survey to 46% of sites and 3% of the total catch. During our survey, Orangethroat Darter was collected at 23% of sites and represents 0.5% of total catch. Although Orangethroat Darter was not collected by Thompson and Hunt (1930), it was found at 54% of sites during Larimore and Smith (1963) with a relative abundance of 4%.

TABLE 3 Proportional occurrence and abundance of selected species observed in the Kaskaskia River basin during the last four Champaign County fish surveys, grouped by overall pattern observed. Introduced species denoted by *.

		Thompson and Hunt (1930)	Larimore and Smith (1963)	Larimore and Bayley (1996)	Sherwood and others (our study)
Increasing Species					
Fundulus notatus	*Occurrence*	42.9%	69.2%	100.0%	84.6%
Blackstripe Topminnow	*Abundance*	1.17%	1.82%	10.50%	26.47%
Lepomis cyanellus	*Occurrence*	28.6%	38.5%	69.2%	61.5%
Green Sunfish	*Abundance*	0.36%	0.20%	0.91%	0.75%
Lepomis macrochirus	*Occurrence*	0.0%	30.8%	69.2%	61.5%
Bluegill	*Abundance*	0.00%	0.09%	2.44%	1.40%
Lepomis megalotis	*Occurrence*	50.0%	46.2%	69.2%	69.2%
Longear Sunfish	*Abundance*	1.58%	0.20%	6.06%	4.39%
Increase after Decrease					
Aphredoderus sayanus	*Occurrence*	42.9%	23.1%	46.2%	38.5%
Pirate Perch	*Abundance*	5.39%	0.22%	0.74%	1.13%
Cyprinella spiloptera/whipplei	*Occurrence*	21.4%	7.7%	7.7%	15.4%
Spotfin/Steelcolor Shiner	*Abundance*	0.81%	0.02%	0.06%	0.38%
Lythrurus umbratilis	*Occurrence*	57.1%	46.2%	15.4%	46.2%
Redfin Shiner	*Abundance*	6.86%	0.07%	0.59%	0.62%
Notemigonus crysoleucas	*Occurrence*	64.3%	15.4%	30.8%	38.5%
Golden Shiner	*Abundance*	4.68%	0.07%	0.59%	0.62%
Ericymba buccata	*Occurrence*	42.9%	38.5%	7.7%	15.4%
Silverjaw Minnow	*Abundance*	0.92%	4.48%	0.32%	3.12%
Decreasing Species					
Etheostoma nigrum	*Occurrence*	92.9%	69.2%	46.2%	53.8%
Johnny Darter	*Abundance*	4.07%	2.50%	0.47%	0.70%
Hybognathus nuchalis	*Occurrence*	64.3%	23.1%	0.0%	0.0%
Mississippi Silvery Minnow	*Abundance*	3.46%	4.89%	0.00%	0.00%
Minytrema melanops	*Occurrence*	7.1%	0.0%	0.0%	0.0%
Spotted Sucker	*Abundance*	0.05%	0.00%	0.00%	0.00%
Nocomis biguttatus	*Occurrence*	92.9%	92.3%	84.6%	15.4%
Hornyhead Chub	*Abundance*	22.67%	4.26%	8.17%	0.11%
Decrease after Increase					
*Cyprinus carpio**	*Occurrence*	0.0%	38.5%	46.2%	5.6%
Common Carp	*Abundance*	0.00%	3.15%	0.53%	0.40%
Luxilus chrysocephalus	*Occurrence*	85.7%	76.9%	92.3%	46.2%
Striped Shiner	*Abundance*	25.67%	33.74%	23.05%	2.61%
Etheostoma spectabile	*Occurrence*	0.0%	53.8%	38.5%	23.1%
Orangethroat Darter	*Abundance*	0.00%	3.58%	2.26%	0.54%

Sangamon River Basin

Five of the ten species observed to be increasing in both occurrence and relative abundance in the Sangamon River basin since the beginning of this project were sport fish. As previously mentioned, Redear Sunfish and Walleye are not native to the basin, and though they are increasing in both occurrence and relative abundance, neither was found in more than 12% of sites, and each was less than 0.1% of total catch (Table 4). The first noted occurrence of Largemouth Bass in the Sangamon basin was by Larimore and Smith (1963), when it was found at 10% of sites and was less than 0.1% of total catch. Largemouth Bass occurred in 44% of sites and was 0.5% of total catch during our survey. Flathead Catfish (*Pylodictis olivaris*) was first collected by Larimore and Bayley (1996) at 7% of sites in the Sangamon basin and increased to 11% of sites during our survey. Relative abundance of Flathead Catfish has remained ~0.1% in both surveys. A more substantial increase was observed in the Rock Bass (Ambloplites rupestris) population in the Sangamon basin. First observed by Larimore and Smith (1963) from 16% of sites, it was observed at 50% of sites during our survey. When it was first observed during this project, Rock Bass comprised less than 0.1% of the total catch during early collections by Thompson and Hunt (1930) and increased to ~2% of total catch in our survey. Additional species that showed both an increase in relative abundance and distribution over the span of the project are Longnose Gar (*Lepisosteus osseus*), Silver Redhorse (*Moxostoma anisurum*), Yellow Bullhead (*Ameiurus natalis*), Tadpole Madtom (*Noturus gyrinus*), and Logperch (*Percina caprodes*).

Only two species showed an increase in relative abundance and distribution after a period of decrease in the Sangamon basin, neither of which have ever been abundant during this project. Bullhead Minnow was not collected in either of the Larimore surveys after Thompson and Hunt (1930) observed it at 7% of sites with a relative abundance of 0.06%. Our survey collected this species at 6% of sites and it was 0.24% of total catch. A similar pattern was also observed with the Mud Darter (*Etheostoma asprigene*). Three primarily headwater species showed a similar pattern for relative abundance, but not in occurrence. Relative abundances of Grass Pickerel, Pirate Perch, and Orangethroat Darter all decreased after the Thompson and Hunt (1930) surveys. Current Sangamon populations of Grass Pickerel and Pirate Perch have returned to a similar proportion as seen during Thompson and Hunt (1930) with Orangethroat Darter up to 1% of total catch (relative abundance was 4% during Thompson and Hunt [1930] and 0.8% during Larimore and Bayley [1996]).

While sport fish species appear to be increasing in the Sangamon basin, seven of the eight species observed decreasing in both relative abundance and occurrence were smaller-bodied species of the families Leuciscidae and Percidae. Our survey failed to observe four species that were once relatively common (occurring at more the 25% of sites) in the Sangamon basin. Most notably, Silverjaw Minnow was observed at 84% of sites during the Thompson and Hunt (1930) survey, in which it was 11% of the total catch. Silverjaw Minnow showed consistent declines during the Larimore surveys—55% occurrence and 2% of total catch during Larimore and Smith (1963) and 26% occurrence and 0.8% of total catch during Larimore and Bayley (1996)—and it was not collected during our survey. Other species not collected during our survey were Mississippi Silvery Minnow (25% of sites of Forbes and Richardson [1908] survey), Orangespotted Sunfish (*Lepomis humilis*, 75% of sites of Forbes and Richardson [1908] survey), and Banded Darter (Etheostoma zonale, 26% of sites during Thompson and Hunt [1930] survey). Other declining species include Hornyhead Chub, Golden Shiner, Suckermouth Minnow (*Phenacobius mirabilis*), and Slenderhead Darter. Hornyhead Chub was collected at nearly 90% of sites during both the Forbes and Richardson (1908) and Thompson and Hunt (1930) surveys and was 7% of the total Thompson and Hunt (1930) catch. During our survey, it was collected at 39% of sites and 2% of total catch.

Four species showed recent decreases in occurrence following early increases, while relative abundance steadily declined over the project period (Table 3). Fathead Minnow, Creek Chub (*Semotilus atromaculatus*), White Sucker (*Catostomus commersonii*), and Johnny Darter were all collected at over 60% of sites by Thompson and Hunt (1930) in the Sangamon basin, ranging from 1% to 7% of total catch. Johnny Darter and Creek Chub were observed in over 90% of sites during the Larimore and Smith (1963) survey. None of these species were observed at more than 45% of sites during our survey with the Fathead Minnow not being collected in either of the last two surveys. Each of these species consisted of less than 1% of the total catch. The Bigmouth Shiner (*Notropis dorsalis*) has decreased in both relative abundance and occurrence after showing an increase in both. Occurrence of this species in the Sangamon increased from 16% of sites during Thompson and Hunt (1930) to 74% of sites during Larimore and Smith (1963) with a relative abundance of 0.5% and 12%, respectively. Our survey observed this species at only 6% of sites and it only represented 0.1% of the total catch.

Vermilion River Basin

Much of the Vermilion River basin in Champaign County has been affected by pollution since before the Thompson and Hunt (1930) survey. However, Larimore and Bayley (1996) noted vast improvements in water quality of the streams in the Vermilion basin. The fact that nine species were increasing in both occurrence and relative abundance reflects the continued improvement of the quality of these streams. Seventeen species showed increases in the number of sites where they were observed and 19 increased in relative abundance (Appendix 2 – Tables 1 and 2; Appendix 3 – Figures 1 to 62). Two of these species, Western Mosquitofish and Redear Sunfish, are introduced to the Vermilion basin, yet Western Mosquitofish occurred at 14% of sites and account for 1% of the total catch (Table 5). Originally observed by Thompson and Hunt (1930) at 2% of sites and 0.01% of total catch, Bluegill were prevalent in the Vermilion basin, appearing at nearly 60% of sites and 1% of total catch. In contrast to the Sangamon basin, Hornyhead Chub have been increasing in the Vermilion system. Proportions of Hornyhead Chub during the Thompson and Hunt (1930) survey were 7% of sites and 0.2% of catch, which during our survey was 50% of sites and 2% of catch.

TABLE 4 Proportional occurrence and abundance of selected species observed in the Sangamon River basin during the last four Champaign County fish surveys, grouped by overall pattern observed. Introduced species denoted by *.

		Thompson and Hunt (1930)	Larimore and Smith (1963)	Larimore and Bayley (1996)	Sherwood and others (our study)
Increasing Species					
Ambloplites rupestris	*Occurrence*	0.0%	16.1%	22.2%	50.0%
Rock Bass	*Abundance*	0.00%	0.06%	0.76%	1.58%
*Lepomis microlophus**	*Occurrence*	0.0%	0.0%	0.0%	11.1%
Redear Sunfish	*Abundance*	0.00%	0.00%	0.00%	0.07%
Micropterus salmoides	*Occurrence*	0.0%	9.7%	44.4%	44.4%
Largemouth Bass	*Abundance*	0.00%	0.06%	0.48%	0.56%
Pylodictis olivaris	*Occurrence*	0.0%	0.0%	7.4%	11.1%
Flathead Catfish	*Abundance*	0.00%	0.00%	0.10%	0.05%
Sander vitreus	*Occurrence*	0.0%	0.0%	3.7%	5.6%
Walleye	*Abundance*	0.00%	0.00%	0.01%	0.05%
Increase after Decrease					
Aphredoderus sayanus	*Occurrence*	9.7%	9.7%	7.4%	44.4%
Pirate Perch	*Abundance*	0.53%	0.01%	0.20%	1.07%
Esox americanus	*Occurrence*	12.9%	0.0%	44.4%	55.6%
Grass Pickerel	*Abundance*	0.17%	0.00%	0.51%	0.73%
Etheostoma asprigene	*Occurrence*	0.0%	3.2%	0.0%	11.1%
Mud Darter	*Abundance*	0.00%	< 0.01%	0.00%	0.05%
Pimephales vigilax	*Occurrence*	6.5%	0.0%	0.0%	5.6%
Bullhead Minnow	*Abundance*	0.06%	0.00%	0.00%	0.24%
Decreasing Species					
Lepomis humilis	*Occurrence*	12.9%	0.0%	7.4%	0.0%
Orangespotted Sunfish	*Abundance*	0.06%	0.00%	0.20%	0.00%
Ericymba buccata	*Occurrence*	83.9%	54.8%	25.9%	0.0%
Silverjaw Minnow	*Abundance*	11.14%	1.96%	0.84%	0.00%
Decrease after Increase					
Catostomus commersonii	*Occurrence*	71.0%	58.1%	44.4%	27.8%
White Sucker	*Abundance*	1.63%	0.94%	0.53%	0.20%
Etheostoma nigrum	*Occurrence*	74.2%	90.3%	40.7%	44.4%
Johnny Darter	*Abundance*	3.12%	4.80%	0.80%	0.63%
Notropis dorsalis	*Occurrence*	16.1%	74.2%	37.0%	5.6%
Bigmouth Shiner	*Abundance*	0.53%	12.10%	1.02%	0.12%
Pimephales promelas	*Occurrence*	61.3%	51.6%	0.0%	0.0%
Fathead Minnow	*Abundance*	1.03%	0.56%	0.00%	0.00%
Semotilus atromaculatus	*Occurrence*	83.9%	90.3%	55.6%	33.3%
Creek Chub	*Abundance*	6.72%	5.39%	1.97%	0.41%

Ten species were increasing in relative abundance and occurrence after early decreases in the Vermilion basin (Table 4), three of which are Illinois Species in Greatest Need of Conservation (IDNR 2005). As previously mentioned, Bigeye Chub (state-threatened) has recently shown an increase in relative abundance and occurrence in Illinois (Sherwood and Wylie 2015). This species was found by Forbes and Richardson (1908) at 14% of sites and by Thompson and Hunt (1930) at 10% of sites. After being absent from the basin during the Larimore and Smith (1963) and Larimore and Bayley (1996) surveys, our survey collected Bigeye Chub at 6% of sites and the 0.3% relative abundance was equal to its abundance during the Thompson and Hunt (1930) survey. A single Eastern Sand Darter (Ammocrypta pellucida) (state-threatened) was found at one location on the Middle Fork (2% of sites), which was the first collection of this species during this project since Larimore and Smith (1963). This species has since been found in the Salt Fork (Tiemann et al. 2020). The exact relative abundance and occurrence of Black Redhorse (*Moxostoma duquesnei*) during the initial surveys is unknown because the initial surveyors did not distinguish this species from the Golden Redhorse, although it is probable that both species were collected during the Forbes and Richardson (1908) and Thompson and Hunt (1930) surveys. Larimore and Smith (1963) failed to collect a Black Redhorse but the last two surveys observed it at 11% and 14% of sites, respectively. Relative abundance of this species has increased from 0.09% during Larimore and Bayley (1996) to 0.4% during our survey.

In contrast to the numerous species that have rebounded after decreasing in the Vermilion basin, five species showed a continuing decrease over the duration of the project. Mississippi Silvery Minnow and Mud Darter were both collected by Forbes and Richardson (1908) and have not been observed in any of the following surveys. Fantail Darter (*Etheostoma flabellare*) was collected at ~10% of sites up until the Larimore and Smith (1963) survey but was absent from the last two surveys. Forbes and Richardson (1908) collected Orangespotted Sunfish at 21% of sites and Blackside Darter (*Percina maculata*) at 43%. Larimore and Bayley (1996) collected them at 11% and 8% of sites, respectively, yet neither of these species was observed during our survey.

Similarly, only two species in the Vermilion basin have experienced a decrease in relative abundance and distribution after first increasing in both (Appendix 2 – Tables 1 and 2; Appendix 3 – Figures 1 to 62). The initial surveys by Forbes and Richardson (1908) collected Creek Chub at only 4% of sites. The following three surveys had collected this species at over 80% of sites with a relative abundance reaching 19% of total catch during Larimore and Smith (1963). The proportion of sites where Creek Chub was collected during this survey decreased to 54% and the proportion of the total catch declined to 1%. Although not likely native to the Vermilion basin (Page and Smith 1970), Red Shiner was first collected by Larimore and Bayley (1996) at 13% of sites (relative abundance of 0.5%). Our survey observed Red Shiners at 2% of sites with a relative abundance of 0.02%. Similar patterns in Common Carp occurrence were observed, where the Thompson and Hunt (1930) survey observed it at 4% of sites, which raised to a maximum of 34% of sites during Larimore and Smith (1963) and has fallen to 8% during our survey. This species represented 0.02% of total catch during 1929, 2% during Larimore and Smith (1963), and 0.1% during Larimore and Bayley (1996). Relative abundance of our survey was back to 1.5% yet may be skewed due to the collection of over 200 young-of-the-year Common Carp that were stranded by low water at 1 site on the Saline Branch above Urbana.

STREAM HABITAT

Transformation of the streams of Champaign County began prior to the initial surveys reported in 1908 by Forbes and Richardson (Hay and Stall 1974). As machinery capable of tilling prairie soils for agriculture became available, a greater desire to drain the marsh prairies that once occurred in Champaign County emerged. This required transforming shallow, meandering prairie streams into straight, high-banked ditches, more efficient at draining the landscape. By the time of the Forbes and Richardson (1908) survey, 36% of the land in Champaign County had been incorporated into drainage districts. This proportion grew to 82% by the time of the survey by Larimore and Smith (1963). These transformations mostly affect headwater streams in the county, leaving the higher-order streams unchannelized.

Channelization has not only changed the general appearance of streams but has altered flow and physical habitats as well. Thompson and Hunt (1930) describe the process where differentiation of habitat occurred in the weeks following the dredging process, in which gravelly riffles, pools, and runs redeveloped in a dredged stream. Stream bank vegetation repopulated in the years following, providing further in-stream cover and leading to the growth of bankside trees, which added further stream cover. As vegetation began to impede the path of water, and the stream filled with silt from fields, the dredge machine would return to start the process again (Thompson and Hunt 1930). Decades of drainage maintenance led to further physical changes. Larimore and Smith (1963) reported a decrease in depth and an increase in stream width when compared to Thompson and Hunt (1930), as well as a decrease in gravelly substrate and an increase in sand and silt substrates. Speculations as to the causes of changes in fish communities in Champaign County over the last century are informed by these observations of cotemporaneous habitat changes.

Methods

Since Thompson and Hunt (1930), investigators have made some note of the physical habitat at each of the sites where fish communities were collected. Although some measurements of habitat were more quantitative than others, each measured stream width and depth at a site, recorded the dominant substrate types, and noted any in-stream cover (e.g., aquatic macrophytes, overhanging vegetation, woody debris). These descriptions were used to create a habitat character presence/absence matrix for each site sampled in a basin, for each sampling period. Average stream width at a site was separated into

TABLE 5 Proportional occurrence and abundance of selected species observed in the Vermilion River basin during the last four Champaign County fish surveys, grouped by overall pattern observed. Introduced species denoted by *. Percentages with ? are for combination of Black and Golden Redhorse.

		Thompson and Hunt (1930)	Larimore and Smith (1963)	Larimore and Bayley (1996)	Sherwood and others (our study)
Increasing Species					
*Gambusia affinis**	*Occurrence*	0.0%	1.9%	0.0%	14.0%
Western Mosquitofish	*Abundance*	0.00%	< 0.01%	0.00%	1.14%
Lepomis macrochirus	*Occurrence*	1.8%	3.8%	31.6%	58.0%
Bluegill	*Abundance*	0.01%	0.02%	0.22%	1.42%
*Lepomis microlophus**	*Occurrence*	0.0%	0.0%	2.6%	10.0%
Redear Sunfish	*Abundance*	0.00%	0.00%	0.01%	0.06%
Micropterus dolomieu	*Occurrence*	7.1%	17.0%	13.2%	36.0%
Smallmouth Bass	*Abundance*	0.07%	0.31%	0.04%	0.15%
Nocomis biguttatus	*Occurrence*	8.9%	17.0%	42.1%	50.0%
Hornyhead Chub	*Abundance*	0.23%	0.12%	2.38%	2.31%
Increase after Decrease					
Ammocrypta pellucida	*Occurrence*	5.7%	1.6%	0.0%	2.0%
Eastern Sand Darter	*Abundance*	0.14%	< 0.01%	0.00%	< 0.01%
Etheostoma blennioides	*Occurrence*	10.7%	13.2%	2.6%	30.0%
Greenside Darter	*Abundance*	0.74%	0.16%	0.01%	0.92%
Hybopsis amblops	*Occurrence*	10.7%	0.0%	0.0%	6.0%
Bigeye Chub	*Abundance*	0.28%	0.00%	0.00%	0.26%
Moxostoma duquesnei	*Occurrence*	10.7%?	0.0%	10.5%	14.0%
Black Redhorse	*Abundance*	0.48%?	0.00%	0.09%	0.37%
Decreasing Species					
Etheostoma flabellare	*Occurrence*	10.7%	9.4%	0.0%	0.0%
Fantail Darter	*Abundance*	0.13%	0.06%	0.00%	0.00%
Lepomis humilis	*Occurrence*	17.9%	7.5%	10.5%	0.0%
Orangespotted Sunfish	*Abundance*	0.23%	0.07%	0.14%	0.00%
Percina maculata	*Occurrence*	19.6%	18.9%	7.9%	1.8%
Blackside Darter	*Abundance*	0.16%	0.20%	0.04%	0.01%
Decrease after Increase					
Cyprinella lutrensis	*Occurrence*	0.0%	0.0%	13.2%	2.0%
Red Shiner	*Abundance*	0.00%	0.00%	0.45%	0.02%
*Cyprinus carpio**	*Occurrence*	3.6%	34.0%	28.9%	8.0%
Common Carp	*Abundance*	0.02%	1.59%	0.14%	1.48%
Ericymba buccata	*Occurrence*	62.5%	52.8%	73.7%	34.0%
Silverjaw Minnow	*Abundance*	17.91%	16.17%	7.86%	2.11%
Semotilus atromaculatus	*Occurrence*	89.3%	84.9%	81.6%	54.0%
Creek Chub	*Abundance*	11.60%	18.95%	12.70%	1.36%

five groups (<2 m wide, 2–4 m, 4–6 m, 6–8 m, and >8 m) and maximum depth into four groups (<0.25 m deep, 0.25–0.50 m, 0.50–0.75 m, and >0.75 m). The matrix included seven substrate classifications (cobble, gravel, sand, hardpan, detritus, muck, and silt) as well as five in-stream cover variables (overhanging vegetation, tree roots, aquatic macrophytes, woody debris, and algae). The resultant was a matrix of 21 variables describing site habitat across all samples within a basin. In the Vermilion River basin, the Salt Fork downstream of Sidney and sites on the Middle Fork were analyzed separately, using the same number of characters but higher average widths and maximum depth groups due to generally larger size of these reaches.

Nonmetric multidimensional scaling (NMDS) was used to ordinate the habitat characteristics measured for each site in a basin, while grouping by sampling period. A 95% confidence ellipse was projected onto the NMDS plot around the weighted average score for each sampling period. If little variation in habitat characteristics was observed between sampling periods, ellipses for each sampling period would overlap, while nonoverlapping ellipses would suggest significant changes in stream habitat between sampling periods. Additionally, because each ellipse represents confidence around a mean score, periods with more diverse habitat measurements would have more variation around a mean score, thus a larger confidence interval. Thus, larger ellipses signify more habitat diversity.

Differences in habitat characteristics were tested using one-way analysis of similarities (ANOSIM). Habitat characteristics for each sampling period were individually tested against all other sampling periods to determine the significance of the differences observed between all sampling periods. Significant differences detected between sampling periods by ANOSIM analyses were then examined using a similarities percentage test (SIMPER). SIMPER analyses assisted in identifying the habitat characteristics that contributed to the differences observed between sampling periods. NMDS, ANOSIM, and SIMPER analyses were performed using the vegan package (Oksanen et al. 2016) in R v.3.2.2 (R Core Team 2016). ANOSIM analyses utilized Bray-Curtis dissimilarity index run for 1,000 permutations and the SIMPER analyses were also run for 1,000 permutations.

Analyses of stream habitat were performed at the basin level. The Vermilion River basin was separated into two categories–tributaries and main branch. Sites on the Middle Fork and Salt Fork downstream of Sidney represent considerably different habitat types than those of the smaller, channelized headwater streams that comprise the majority of sampling locations in the basin. Sites from the Middle Fork and Salt Fork were thus categorized as main branch and analyzed separately. Habitat characteristics of the main branch of the Sangamon River were excluded from analyses due to lack of data from Larimore and Bayley (1996) and our survey. Major changes in stream habitat for each basin are described below.

Results

Embarras River Basin

The NMDS ordination analysis of habitat characteristics at sites in the Embarras River basin suggests that features observed in the recent study are different than those observed by previous investigators (Figure 3). The confidence ellipse representing habitats observed by Thompson and Hunt (1930) are wholly separated from those of our survey, while ellipses for the Thompson and Hunt (1930) and Larimore and Smith (1963) surveys are roughly of similar size and appear to be larger than those of Larimore and Bayley (1996) as well as our survey (Figure 3). These patterns suggest a decrease in habitat diversity over the span of all surveys. Differences in habitat through time were confirmed by ANOSIM tests. Current habitat of the Embarras basin was shown to be significantly different from all other surveys (Thompson and Hunt [1930]: $R = 0.301$, $p = 0.001$; Larimore and Smith [1963]: $R = 0.156$, $p = 0.022$; Larimore and Bayley [1996]: $R = 0.264$, $p = 0.001$) (Table 6). The only other surveys that were significantly different were the Thompson and Hunt (1930) and Larimore and Bayley (1996) surveys ($R = 0.183$, $p = 0.001$).

Three substrate types (silt, sand, and gravel) were the most common across all sampling periods. While the proportion of sites with silt and gravel showed no significant differences among any of the sampling periods, the proportion of sites with sand has increased (Table 7). Similarities percentage (SIMPER) tests revealed that the proportion of sites with sand substrates significantly increased ($p = 0.004$) between Thompson and Hunt (1930) and Larimore and Smith (1996): 0.42 and 0.82, respectively. The influx of sandy substrates has remained constant through the remaining surveys and no significant differences were observed between the last three surveys.

Morphological characteristics of sites in the Embarras showed significant changes through time. The proportion of streams less than 2 m wide has significantly dropped from 0.58 during Thompson and Hunt (1930) to 0.06 during our survey ($p = 0.007$; Table 8). Sites less than 2 m wide initially dropped from 0.58 to 0.27 ($p = 0.019$) between the Thompson and Hunt (1930) and Larimore and Smith (1963) surveys. Though no significant differences were detected between the last three surveys, all three surveys had a significantly smaller proportion of sites less than 2 m wide than the Thompson and Hunt (1930) survey. Maximum site depth has also changed over the duration of the project. Maximum depth was varied at the time of the Thompson and Hunt (1930) survey with 0.42 of sites being greater than 0.75 m deep and the remaining were less than 0.50 m deep (Table 9). Sites greater than 0.75 m deep dropped to zero during the Larimore and Smith (1963) survey ($p = 0.03$; Table 9), resulting in the highest proportion of sites measured between 0.25 and 0.50 m deep occurring in 1959. No sites were measured to be less than 0.25 m deep during our survey (Table 9) and the proportion of sites 0.50–0.75 m deep was significantly greater than all other surveys (TH: $p = 0.001$, LS: $p = 0.013$, LB: $p = 0.002$).

Along with observed changes in the substrate and morphology of Embarras basin streams, a change in in-stream cover has also been detected (Table 10). The proportion of sites with aquatic

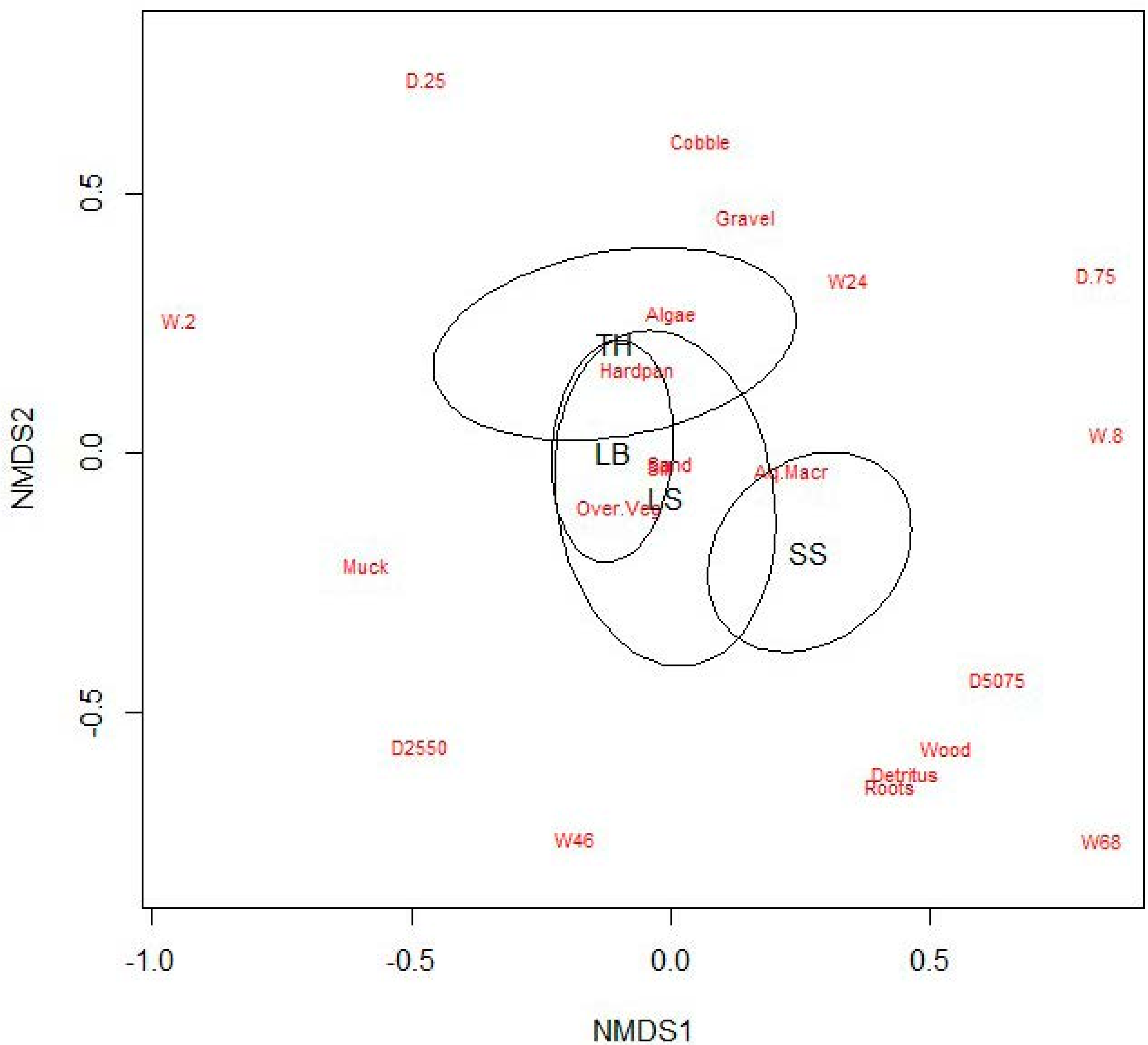

FIGURE 3 Nonmetric multidimensional scaling ordination plot of habitat characteristics observed in the Embarras River basin during each survey of Champaign County fishes. Ovals represent a 95% confidence interval around the weighted average score for each sampling period. TH = Thompson and Hunt (1930), LS = Larimore and Smith (1963), LB = Larimore and Bayley (1996), and SS = Sherwood and others (our study).

macrophytes, woody debris, and exposed tree roots have all significantly increased between Thompson and Hunt (1930) and our survey (Table 10). Sites with aquatic macrophytes remained relatively constant through the first three surveys, but have observed a recent, significant (*p* = 0.003) increase during our survey, as compared to the Thompson and Hunt (1930) survey. No sites were measured as having exposed roots during the first two surveys, while Larimore and Bayley (1996) observed them at 0.11 of sites. This proportion has increased to 0.31 during our survey (*p* = 0.002; Table 10).

Kaskaskia River Basin

Cumulative analyses of habitat characteristics suggest the habitat in the streams of the Kaskaskia River basin have changed over the course of this study. NMDS ordination ellipses (Figure 4) showed no overlap between the characteristics measured during our survey and any other survey. Additionally, there was very little overlap between the Thompson and Hunt (1930) survey and the Larimore and Smith (1963) and Larimore and Bayley (1996) surveys, while there was strong overlap between the Larimore and Smith (1963) and Larimore and Bayley (1996) surveys (Figure 4). ANOSIM results indicate that all surveys, except for the Larimore and Smith (1963) and Larimore and Bayley (1996) surveys, are significantly different from one another (Table 6).

With the presence of cobble and muck, the Kaskaskia basin had more substrate types than documented in the Embarras

TABLE 6 Results of the one-way analysis of similarities among habitat characteristics observed during the last four surveys of Champaign County fishes in the Embarras River, Kaskaskia River, Sangamon River, Vermilion River tributaries, and Vermilion River main branch (Salt Fork and Middle Fork). Numbers are the ANOSIM statistic R with the p-value in parentheses; italicized text indicates a significant difference (α = 0.05).

	Thompson and Hunt (1930)	Larimore and Smith (1963)	Larimore and Bayley (1996)
Embarras River basin			
Larimore and Smith	0.095 (0.083)		
Larimore and Bayley	0.183 (*0.001*)	0.093 (0.091)	
Sherwood and others	0.301 (*0.001*)	0.156 (*0.022*)	0.264 (*0.001*)
Kaskaskia River basin			
Larimore and Smith	0.217 (*0.003*)		
Larimore and Bayley	0.298 (*0.001*)	-0.050 (0.857)	
Sherwood and others	0.438 (*0.001*)	0.290 (*0.002*)	0.338 (*0.001*)
Sangamon River basin			
Larimore and Smith	0.156 (*0.001*)		
Larimore and Bayley	ND	ND	
Sherwood and others	0.263 (*0.001*)	0.463 (*0.001*)	ND
Vermilion River tributaries			
Larimore and Smith	0.098 (*0.004*)		
Larimore and Bayley	0.183 (*0.001*)	0.054 (*0.039*)	
Sherwood and others	0.297 (*0.001*)	0.372 (*0.001*)	0.327 (*0.001*)
Vermilion River main branch			
(Salt Fork and Middle Fork)			
Larimore and Smith	0.369 (*0.005*)		
Larimore and Bayley	0.290 (*0.001*)	0.212 (*0.008*)	
Sherwood and others	0.200 (*0.023*)	0.107 (0.07)	0.301 (*0.001*)

basin. As observed in the Embarras basin, the proportion of sites with sand substrate has drastically increased, from zero during Thompson and Hunt (1930) to 0.92 during our survey (p = 0.001; Table 7). The proportion of sites containing silty substrates remained significantly unchanged through the first three surveys but significantly dropped during our survey (p = 0.001).

Similar to the Embarras basin, the streams of the Kaskaskia basin have generally become wider over the course of this study (Table 8). The proportion of sites less than 2 m has consistently decreased from 0.33 during Thompson and Hunt (1930) to zero during our survey. Only 0.14 of all sites were greater than 4 m during Thompson and Hunt (1930), which rose to 0.69 during our survey (Table 8). Site maximum depth appears to have increased over the study as well (Table 9). The most significant increase in proportion was observed in those sites measuring 0.50–0.75 m, which was 0.13, 0.08, 0.08 during the first three surveys, respectively, and 0.62 during our survey (p = 0.001, 0.001, and 0.003, respectively). Overall, the proportion of sites greater than 0.50 m deep increased from 0.20 during Thompson and Hunt (1930) to 0.93 during our survey (Table 9).

There have been no notable changes in the in-stream cover in the Kaskaskia basin over the span of the project. The most dominant cover type has continued to be overhanging vegetation. While the proportion of sites with aquatic macrophytes was highest during our survey, we did not detect any significant differences among surveys.

TABLE 7 Proportion of sites (N) in which the major substrate types were observed during each of the last four surveys in the Embarras River, Kaskaskia River, Sangamon River, Vermilion River tributaries, and Vermilion River main branch (Salt Fork and Middle Fork). Superscripts indicate a significant difference ($\alpha = 0.05$) between surveys where 1 = Thompson and Hunt (1930), 2 = Larimore and Smith (1963), 3 = Larimore and Bayley (1996), and 4 = Sherwood and others (our study).

	Thompson and Hunt (1930)	Larimore and Smith (1963)	Larimore and Bayley (1996)	Sherwood and others (our study)
Embarras River basin	*N* = 19	*N* = 11	*N* = 19	*N* = 16
Gravel	0.47^{3}	0.27	0.47^{1}	0.44
Sand	0.42^{234}	0.82^{1}	0.95^{1}	0.88^{1}
Silt	0.79	1.00	0.89	0.75
Kaskaskia River basin	*N* =15	*N* = 13	*N* = 13	*N* = 13
Cobble	0.07	0.15	0.08	0.08
Gravel	0.67	0.62	0.38	0.54
Sand	0.00^{234}	0.85^{1}	0.85^{1}	0.92^{1}
Silt	0.60	0.77	0.92	0.23
Muck	0.27^{4}	0.00^{4}	0.00^{4}	0.15^{123}
Sangamon River basin	*N* = 18	*N* = 18	*N* = 0	*N* = 13
Cobble	0.39^{24}	0.06^{1}	-	0.08^{1}
Gravel	0.50	0.56	-	0.77
Sand	0.67	0.89	-	0.85
Silt	0.67^{4}	0.89	-	0.54^{1}
Muck	0.11	0.06	-	0.23
Vermilion River tributaries	*N* = 31	*N* = 25	*N* = 32	*N* = 37
Cobble	0.03	0.08	0.25^{4}	0.11^{3}
Gravel	0.52^{3}	0.52	0.50^{1}	0.81
Sand	0.45^{234}	0.88^{1}	0.91^{1}	0.92^{1}
Silt	0.42^{23}	0.92^{14}	0.75^{14}	0.27^{23}
Muck	0.29^{24}	0.08^{1}	0.00	0.19^{1}
Vermilion River main branch				
(Salt Fork and Middle Fork)	*N* = 8	*N* = 10	*N* = 9	*N* = 10
Cobble	0.63^{2}	0.10^{1}	0.44	0.30
Gravel	1.00^{4}	0.90^{4}	0.78^{4}	0.30^{123}
Sand	0.63^{3}	1.00	0.78^{1}	0.90
Silt	0.25^{23}	0.90^{1}	1.00^{14}	0.40^{3}
Muck	0.00	0.00	0.00	0.10

TABLE 8 Proportion of sites (N) for each average width category measured during each of the last four surveys in the Embarras River, Kaskaskia River, Sangamon River, Vermilion River tributaries, and Vermilion River main branch (Salt Fork and Middle Fork). Superscripts indicate a significant difference (α = 0.05) between surveys where 1 = Thompson and Hunt (1930), 2 = Larimore and Smith (1963), 3 = Larimore and Bayley (1996), and 4 = Sherwood and others (our study).

	Thompson and Hunt (1930)	Larimore and Smith (1963)	Larimore and Bayley (1996)	Sherwood and others (our study)
Embarras River basin	*N* = 19	*N* = 11	*N* = 19	*N* = 16
< 2 m	0.58^{234}	0.27^{1}	0.21^{1}	0.06^{1}
2 – 4 m	0.21	0.45	0.42	0.50
4 – 6 m	0.05^{3}	0.18	0.32^{1}	0.06
6 – 8 m	0.11	0.00	0.05	0.19
> 8 m	0.05	0.09	0.00	0.19
Kaskaskia River basin	*N* =15	*N* = 13	*N* = 13	*N* = 13
< 2 m	0.33^{2}	0.23^{1}	0.08	0.00
2 – 4 m	0.53^{23}	0.23^{1}	0.15^{1}	0.31
4 – 6 m	0.07^{3}	0.31	0.46^{1}	0.23
6 – 8 m	0.00	0.08	0.15	0.23
> 8 m	0.07	0.15	0.15	0.23
Sangamon River basin	*N* = 18	*N* = 18	*N* = 0	*N* = 13
< 2 m	0.28	0.06	-	0.08
2 – 4 m	0.72^{4}	0.56	-	0.15^{1}
4 – 6 m	0.00^{4}	0.11^{4}	-	0.38^{12}
6 – 8 m	0.00^{2}	0.28^{1}	-	0.08
> 8 m	0.00^{4}	0.00^{4}	-	0.31^{12}
Vermilion River tributaries	*N* = 31	*N* = 25	*N* = 32	*N* = 37
< 2 m	0.42^{234}	0.12^{1}	0.03^{1}	0.00^{1}
2 – 4 m	0.29	0.32	0.47	0.46
4 – 6 m	0.10^{4}	0.12	0.06	0.30^{1}
6 – 8 m	0.13	0.16	0.09	0.03
> 8 m	0.06	0.28	0.34	0.22
Vermilion River main branch				
(Salt Fork and Middle Fork)	*N* = 8	*N* = 10	*N* = 9	*N* = 10
< 10 m	0.38^{234}	0.00^{1}	0.00^{1}	0.00^{1}
10 – 15 m	0.25	0.40	0.22	0.40
15 – 20 m	0.13	0.50	0.33	0.30
20 – 25 m	0.25	0.00	0.22	0.30
> 25 m	0.00	0.10	0.22	0.00

TABLE 9 Proportion of sites (N) for each maximum depth category measured during each of the last four surveys in the Embarras River, Kaskaskia River, Sangamon River, Vermilion River tributaries, and Vermilion River main branch (Salt Fork and Middle Fork). Superscripts indicate a significant difference (α = 0.05) between surveys where 1 = Thompson and Hunt (1930), 2 = Larimore and Smith (1963), 3 = Larimore and Bayley (1996), and 4 = Sherwood and others (our study).

	Thompson and Hunt (1930)	Larimore and Smith (1963)	Larimore and Bayley (1996)	Sherwood and others (our study)
Embarras River basin	*N* = 19	*N* = 11	*N* = 19	*N* = 16
< 0.25 m	0.37[3]	0.36	0.47[1]	0.00
0.25 – 0.50 m	0.21	0.45	0.42	0.25
0.50 – 0.75 m	0.00[4]	0.18[4]	0.11[4]	0.50[1,2,3]
> 0.75 m	0.42[2,3,4]	0.00[1]	0.00[1]	0.25[1]
Kaskaskia River basin	*N* =15	*N* = 13	*N* = 13	*N* = 13
< 0.25 m	0.20[3]	0.23	0.38[1]	0.00
0.25 – 0.50 m	0.60[4]	0.69[4]	0.46	0.08[1,2]
0.50 – 0.75 m	0.13[4]	0.08[4]	0.08[4]	0.62[1,2,3]
> 0.75 m	0.07[4]	0.00	0.08	0.31[1]
Sangamon River basin	*N* = 18	*N* = 18	*N* = 0	*N* = 13
< 0.25 m	0.17[2]	0.56[1,4]	-	0.00[2]
0.25 – 0.50 m	0.33	0.33	-	0.15
0.50 – 0.75 m	0.22[4]	0.11[4]	-	0.54[1,2]
> 0.75 m	0.28[4]	0.00	-	0.31[1]
Vermilion River tributaries	*N* = 31	*N* = 25	*N* = 32	*N* = 37
< 0.25 m	0.19[3]	0.32[3]	0.50[1,2,4]	0.00[3]
0.25 – 0.50 m	0.26	0.48	0.34	0.27
0.50 – 0.75 m	0.29[4]	0.16	0.16	0.38[1]
> 0.75 m	0.26[4]	0.04	0.00	0.35[1]
Vermilion River main branch				
(Salt Fork and Middle Fork)	*N* = 8	*N* = 10	*N* = 9	*N* = 10
< 0.50 m	0.00	0.20[3]	0.33[2]	0.00
0.50 – 1.00 m	0.25	0.50	0.44	0.50
1.00 – 1.50 m	0.50	0.30	0.22	0.30
> 1.50 m	0.25[4]	0.00	0.00	0.20[1]

TABLE 10 Proportion of sites (N) where in-stream habitat variables were observed during each of the last four surveys in the Embarras River, Sangamon River, and Vermilion River tributaries. Superscripts indicate a significant difference (α = 0.05) between surveys where 1 = Thompson and Hunt (1930), 2 = Larimore and Smith (1963), 3 = Larimore and Bayley (1996), and 4 = Sherwood and others (our study). Variables were not recorded in either the Kaskaskia River basin or Vermilion River main branch (Salt Fork and Middle Fork).

	Thompson and Hunt (1930)	Larimore and Smith (1963)	Larimore and Bayley (1996)	Sherwood and others (our study)
Embarras River basin	*N* = 19	*N* = 11	*N* = 19	*N* = 16
Overhanging vegetation	0.47^{23}	0.64^{1}	0.84^{1}	0.81
Aquatic macrophytes	0.32^{4}	0.36	0.37	0.81^{1}
Tree roots	0.00^{4}	0.00	0.11^{4}	0.31^{13}
Woody debris	0.00^{4}	0.18^{4}	0.00^{4}	0.44^{123}
Algae	0.11^{2}	0.36^{1}	0.11	0.19
Sangamon River basin	*N* = 18	*N* = 18	*N* = 0	*N* = 13
Overhanging vegetation	0.33^{2}	0.83^{14}	-	0.08^{2}
Aquatic macrophytes	0.17^{4}	0.44	-	0.85^{1}
Woody debris	0.06	0.06	-	0.50
Algae	0.11	0.17	-	0.00
Vermilion River tributaries	*N* = 31	*N* = 25	*N* = 32	*N* = 37
Overhanging vegetation	0.61^{4}	0.48	0.63	0.32^{1}
Aquatic macrophytes	0.16^{4}	0.16^{4}	0.19^{4}	0.84^{123}
Tree roots	0.00	0.00	0.03^{4}	0.11^{3}
Woody debris	0.13	0.16	0.03	0.11
Algae	0.19^{2}	0.44^{134}	0.03^{2}	0.03^{2}

Sangamon River Basin

Habitat data for the Sangamon River basin from the Larimore and Bayley (1996) survey could not be located, so it was omitted from these analyses. Additionally, the inability of our survey to sample many of the main stem sites on the Sangamon River sites led us to constrain analyses to the sampled tributaries in the Sangamon basin. With these data limitations in place, significant differences in habitat characteristics were detected among Thompson and Hunt (1930), Larimore and Smith (1963), and our survey (Figure 5). All three surveys were shown to be significantly different from one another based on the ANOSIM test (Table 6). Although substantial overlap can be observed on the NMDS ordination between the Thompson and Hunt (1930) and Larimore and Smith (1963) surveys, the significant difference documented was likely a product of reduced diversity among sites during the Larimore and Smith (1963) survey.

Increases in the proportion of sites with sandy substrate were not as drastic in the Sangamon basin as was observed in the Embarras and Kaskaskia basins (Table 7). Thompson and Hunt (1930) found the proportion of sandy substrate at sites across the basin to be relatively common (proportion = 0.67). Although the proportion of sites increased to 0.89 during the Larimore and Smith (1963) survey and 0.85 during the 2012 survey, these changes were not significant. Changes in sites with cobble substrate have significantly decreased since the Thompson and Hunt (1930) surveys. The initial survey observed cobble at 0.39 of sites, compared to 0.06 and 0.08 during the Larimore and Smith (1963) and our survey, respectively (p = 0.016 and 0.031).

Average width and maximum depth of tributaries in the Sangamon basin increased over the course of the study. Streams were exclusively less than 4 m wide at the time of Thompson and Hunt (1930) with the majority (0.72) 2–4 m wide. Sites 2–4

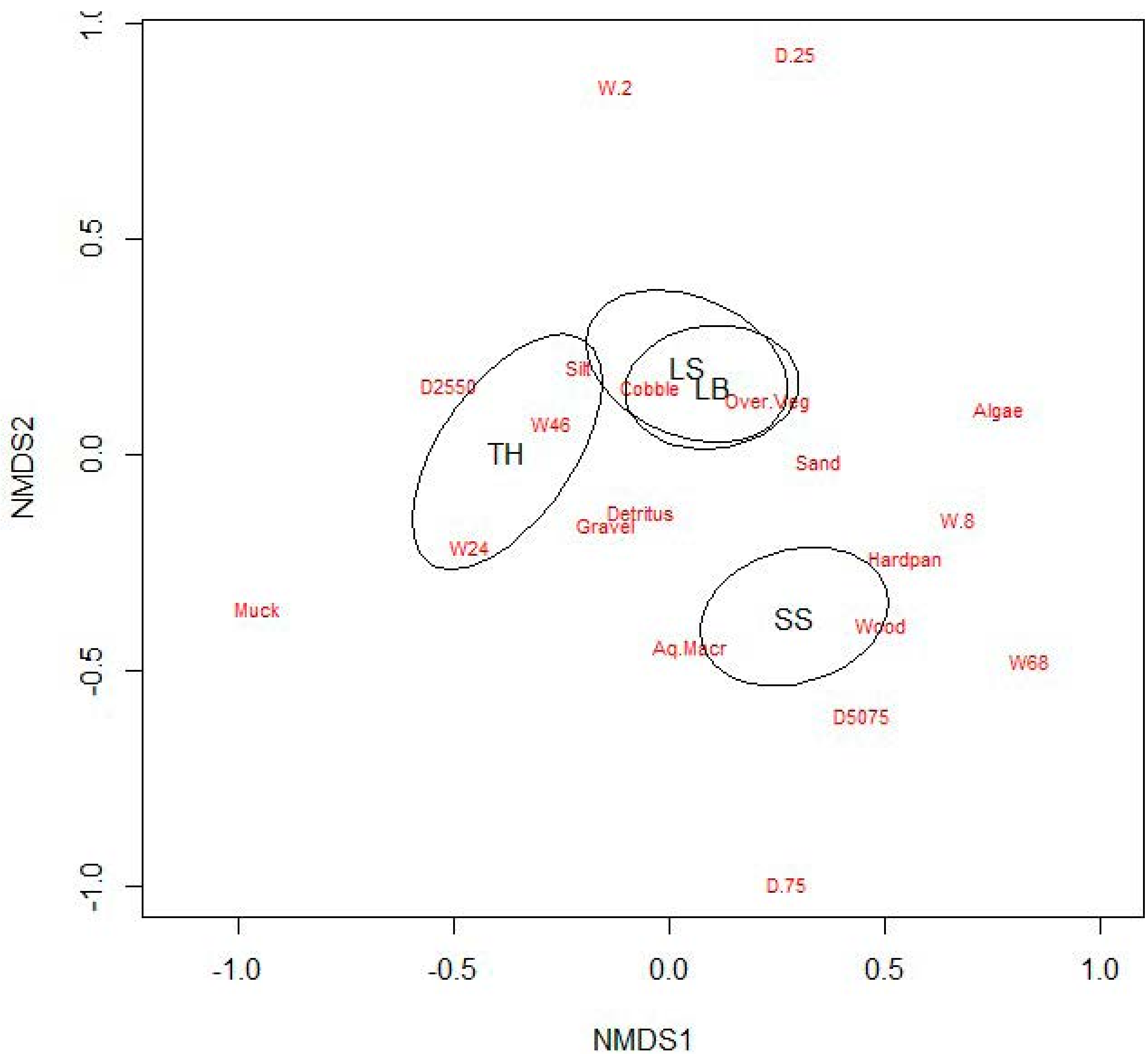

FIGURE 4 Nonmetric multidimensional scaling ordination plot of habitat characteristics observed in the Kaskaskia River basin during each survey of Champaign County fishes. Ovals represent a 95% confidence interval around the weighted average score for each sampling period. TH = Thompson and Hunt (1930), LS = Larimore and Smith (1963), LB = Larimore and Bayley (1996), and SS = Sherwood and others (our study).

m wide decreased in subsequent surveys, ultimately representing only 0.15 of sites during our survey (p = 0.002; Table 8). No sites were greater than 8 m wide in either the Thompson and Hunt (1930) or Larimore and Smith (1963) surveys, while 0.31 of sites fell within this category in our survey (p = 0.001 and 0.005, respectively). Maximum depth was somewhat evenly dispersed across groups during the Thompson and Hunt (1930) survey (Table 8) and an overall decrease was observed during the Larimore and Smith (1963) survey due to a lack of sites that were greater than 0.75 m deep and an increase in the proportion of sites less than 0.25 m (p = 0.002). No sites less than 0.25 m were observed during the 2012 survey and the proportion of sites 0.50–0.75 m was significantly greater than both the previous surveys (p = 0.004 and 0.013).

Two changing trends in in-stream cover in the Sangamon basin were detected over the span of the project. First, the proportion of sites with overhanging vegetation significantly increased between the Thompson and Hunt (1930) and Larimore and Smith (1963) surveys (p = 0.003; Table 10), then significantly decreased between Larimore and Smith (1963) and our survey (p = 0.001). Second, the proportion of sites with aquatic macrophytes increased from 0.17 during Thompson and Hunt (1930) to 0.44 during Larimore and Smith (1963), then increased again to 0.85 of sites during our survey. The increase observed between Thompson and Hunt (1930) and our survey was significant (p = 0.001), while the change between Larimore and Smith (1963) and our survey was not (p = 0.203).

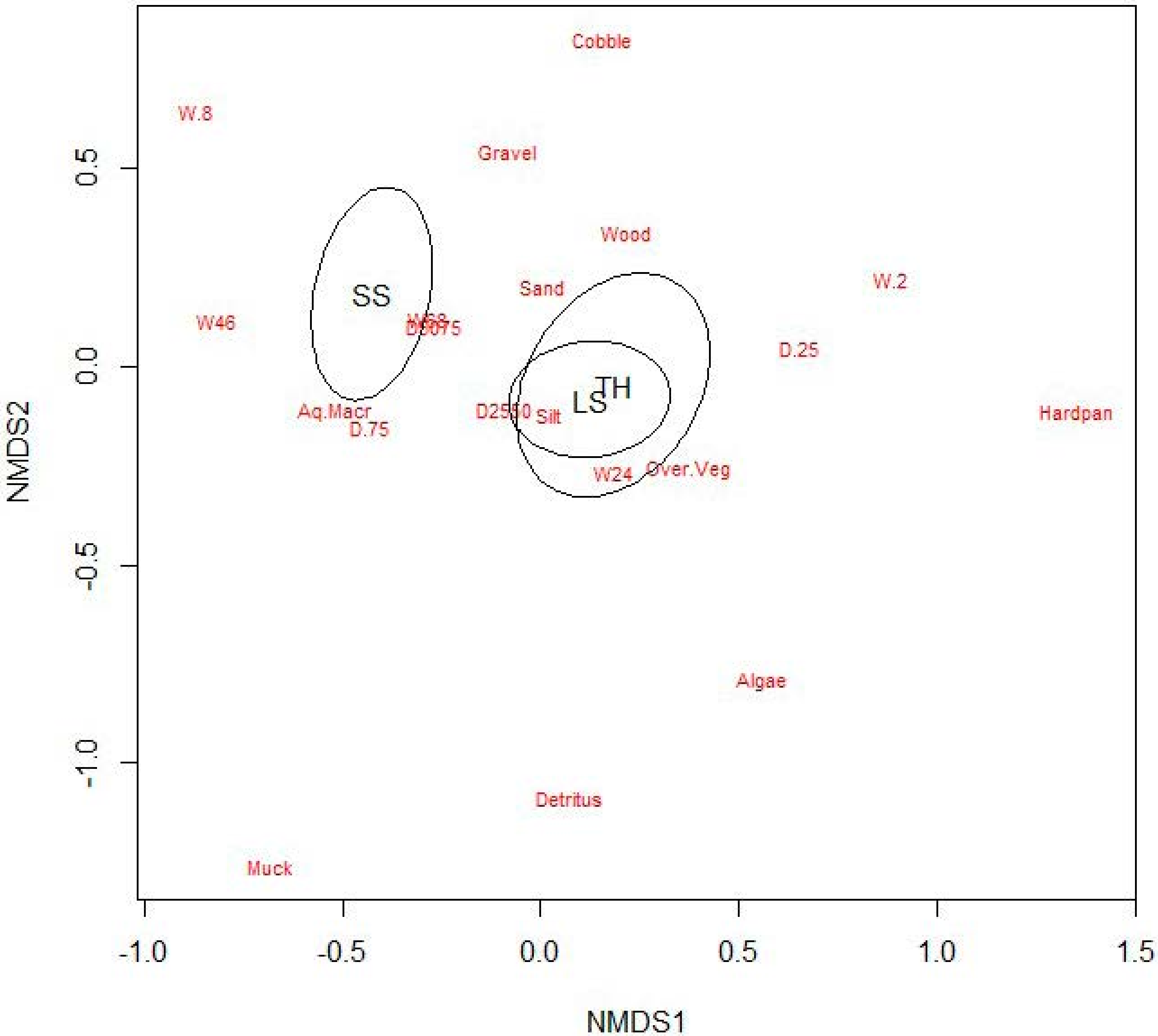

FIGURE 5 Nonmetric multidimensional scaling ordination plot of habitat characteristics observed in the Sangamon River basin tributaries during each survey of Champaign County fishes. Ovals represent a 95% confidence interval around the weighted average score for each sampling period. TH = Thompson and Hunt (1930), LS = Larimore and Smith (1963), and SS = Sherwood and others (our study). No habitat data were available for the Larimore and Bayley (1996) surveys.

Vermilion River Basin

Tributaries

Similar trends in changing habitat characteristics were observed in the tributaries of the Vermilion River basin as were documented in other Champaign County streams. Habitat characteristics from each time period were shown to be significantly different from one another (Table 6). NMDS ordination for the Vermilion River tributaries shows no intersection between the Thompson and Hunt (1930) survey, our survey, and the Larimore and Smith (1963) and Larimore and Bayley (1996) surveys as a group (Figure 6). Although significant differences were detected between the Larimore and Smith (1963) and Larimore and Bayley (1996) surveys by the ANOSIM test, there was substantial overlap in the ordination plot. The *R* statistic from the ANOSIM test was relatively low, suggesting low differentiation between the characteristics measured. The measured significant difference was likely a product of the large number of surveys that were taken in Vermilion River tributaries in both surveys.

As observed in the Embarras and Kaskaskia basin, the proportion of sites with sandy substrates has significantly increased (Table 7). Sites with sandy substrate increased from 0.45 during Thompson and Hunt (1930) to 0.88 during the Larimore and Smith (1963) survey (p = 0.001) and did not significantly change

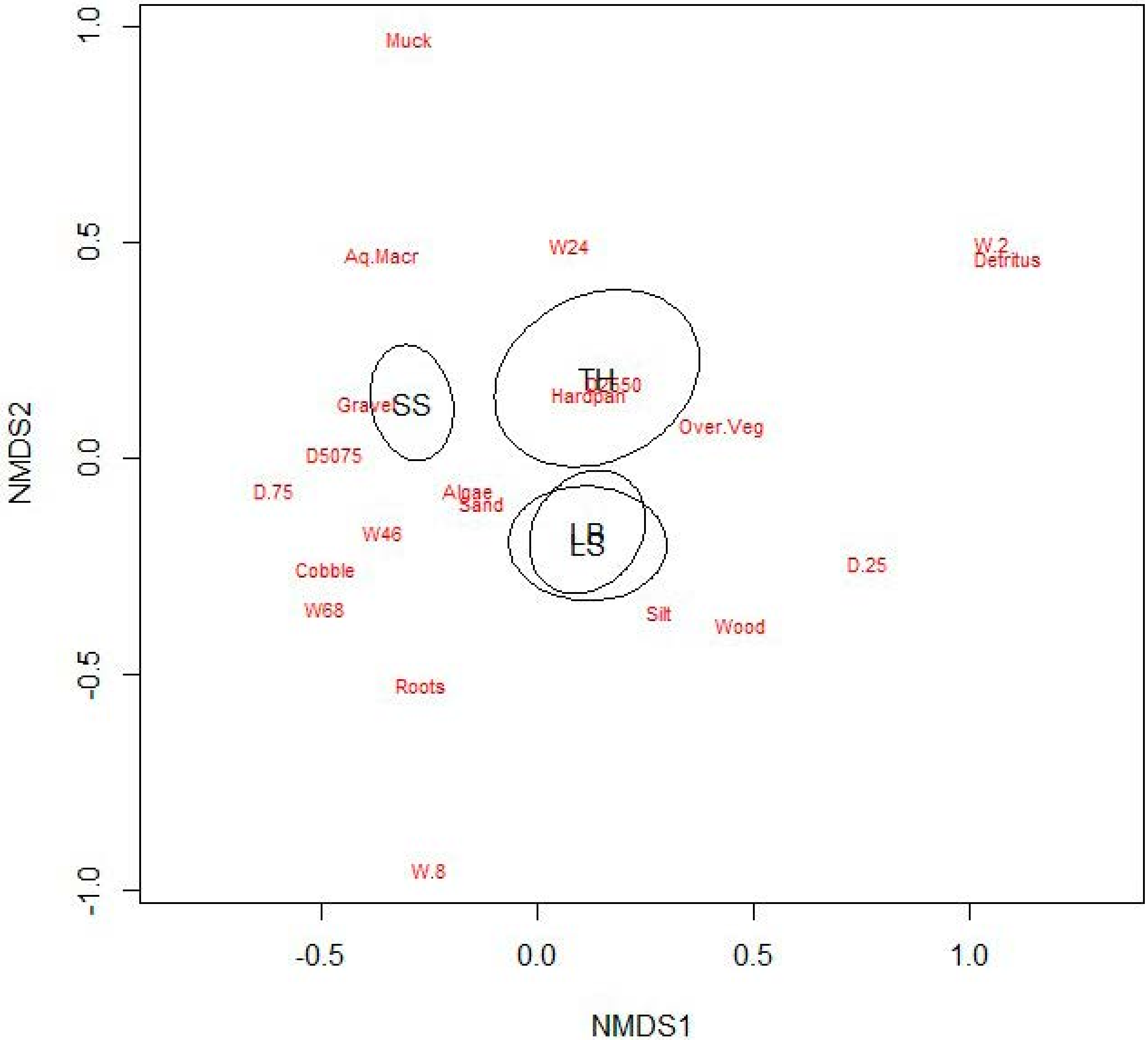

FIGURE 6 Nonmetric multidimensional scaling ordination plot of habitat characteristics observed in the Vermilion River basin tributaries during each survey of Champaign County fishes. Ovals represent a 95% confidence interval around the weighted average score for each sampling period. TH = Thompson and Hunt (1930), LS = Larimore and Smith (1963), LB = Larimore and Bayley (1996), and SS = Sherwood and others (our study).

in the subsequent surveys. Silt substrates also increased in proportion between the Thompson and Hunt (1930) survey (0.42) and the Larimore and Smith (1963) survey (0.92) ($p = 0.005$). No significant change in proportion of silt substrates was observed between the Larimore and Smith (1963) and Larimore and Bayley (1996) surveys, but this proportion significantly decreased to 0.27 during our survey (Table 7).

Only two average stream width groups have experienced a significant change over the duration of this project (Table 8). The proportion of sites less than 2 m wide was significantly less in the last three surveys when compared to the Thompson and Hunt (1930) sample, while a significant increase in the proportion of sites 4–6 m wide was detected between the Thompson and Hunt (1930) and current surveys. Once again, maximum depth was relatively evenly dispersed among groups during the Thompson and Hunt (1930) survey (Table 9). Overall, maximum depth trended shallower during the second and third surveys while becoming deeper during our survey.

The most notable change in in-stream cover has been the significant increase in the proportion of sites with aquatic macrophytes observed during the most recent survey (Table 10). Aquatic macrophytes were observed in roughly 0.16 of sites during the first three surveys, which increased to 0.84 during our survey. Overhanging vegetation did not significantly change among the first three surveys but was significantly less during our survey when compared to the Thompson and Hunt (1930) survey (p = 0.009).

Main Branch (Salt Fork and Middle Fork)

Unsurprisingly, the habitat characteristics observed in the main branch sites of the Vermilion basin have shown the least change over the span of the project. The NMDS ordination ellipses of all but the Larimore and Bayley (1996) survey showed some overlap (Figure 7). Significant differences were detected from the ANOSIM tests in all but one of the six sample comparisons (Table 6). The nonsignificant changes were between Larimore and Smith (1963) and our survey. The R value of the comparison between our survey and the Thompson and Hunt (1930) survey was the smallest of any basin-wide comparison of the two surveys (R = 0.20) and was statistically not significant.

The proportion of sites with silt substrate followed a trend similar to what was documented in the Vermilion River tributaries (Table 7). Significant increases were observed between the Thompson and Hunt (1930) survey and the Larimore and Smith (1963) and Larimore and Bayley (1996) surveys, followed by a significant decrease during our survey. Sites with gravel substrate appear to have decreased over the span of the project. While the proportions of sites with gravel substrate was not significantly different among the first three surveys, the proportion observed during our survey was significantly less than all other surveys (p = 0.001, 0.008, and 0.007, respectively). Sand substrate was common during the first survey and, although it appears to have increased in later surveys, no significant changes were detected.

During the Thompson and Hunt (1930) survey, the largest proportion of sites (0.38) were less than 10 m wide (Table 8). No other subsequent survey measured a main branch site less than 10 m wide. The remaining width groups showed no significant changes between sampling periods. Maximum depth measurements appear to have initially decreased during the Larimore and Smith (1963) and Larimore and Bayley (1996) surveys, while increasing during our survey, a similar trend as was seen in the tributaries (Table 9). Although these trends may have appeared to have occurred, no notable significant changes were detected in maximum depth.

Few comparisons of in-stream cover between groups emerged as significant over the span of the project. While some significant differences were detected among surveys, no apparent trends in in-stream cover were notable.

LAND USE

"The environment of a stream is sensitive to almost any activity within the watershed."

– Larimore and Smith (1963)

Changes in land use patterns of Champaign County were first quantitatively examined by Larimore and Bayley (1996). Although previous surveys linked some stream characteristics to certain land use practices, they lacked an effective way to quantify basin land use practices. Today, Geographic Information Systems (GIS) coupled with satellite imagery and analyses have vastly increased our abilities to quantify changes to the landscape. With nearly $2 billion (USDA 2016a) being spent annually to influence landowners to adopt land use practices for erosion control and wildlife habitat, analyses such as these are needed to enhance our understanding of the effects of land use on stream fish biota.

Methods

Initial analyses performed by Larimore and Bayley (1996) were accomplished using ARC/INFO software and land use data derived from U.S. Geological Survey (USGS) topographic maps from the 1950s (15-minute) and 1980s (7.5-minute). Topographic maps from the time of the Thompson and Hunt (1930) survey that represent the entirety of the county were not available, so no analyses were performed on land use prior to the Larimore and Smith (1963) survey. Land use data derived from topographic maps were limited compared to resources available during our surveys. This method reduces the number of land use categories to urban, forest, water (lakes), barren, and agriculture. Areas of forest, urban, water, and barren land uses were delimited using GIS software and all remaining land in the county was assumed to be agriculture. The land labeled as agriculture in these analyses includes cultivated crops and pastureland, as well as grasslands and roads outside of urban areas. To make direct comparisons across time periods, we repeated these methods using modern topographic maps (7.5-minute), as well as those from the 1950s and 1980s and ArcMap 10.3 (ESRI, Redlands, California, USA).

Current satellite derived land use data provide a more complete representation of the landscape of Champaign County. These data encompass more land use categories, as well as a finer scope from which analyses can be made. We utilized the 2011 version of the National Land Cover Database (NLCD 2011; Homer et al. 2015) accessed through the Multi-Resolution Land Characteristics Consortium (www.mrlc.gov/nlcd2011.php). This data set represents 17 land cover classifications at a resolution of 30 m. Data sets such as NLCD 2011 are not available for the time periods other than the present-day survey, making direct comparisons impossible. NLCD 2011 data from the present-day were utilized to determine the accuracy of land use data derived from topographic map analyses, as well as an analysis of the land use within a 30 m, 60 m, and 120 m stream buffer, similar to the analysis performed by Larimore and Bayley (1996). We felt this data set was more suitable for the buffer analysis due to the finer resolution and the lack of grassland data (a common land use near streams) from topographic maps. Although NLCD 2011 has better resolution, grassy buffers less than 30 m are often not detected and are recorded as the major land use category in the area, usually cultivated crops in Champaign County. Due to this choice, it is likely our analysis underestimated the amount of grassland in the 30 m buffer while overestimating cultivated crops.

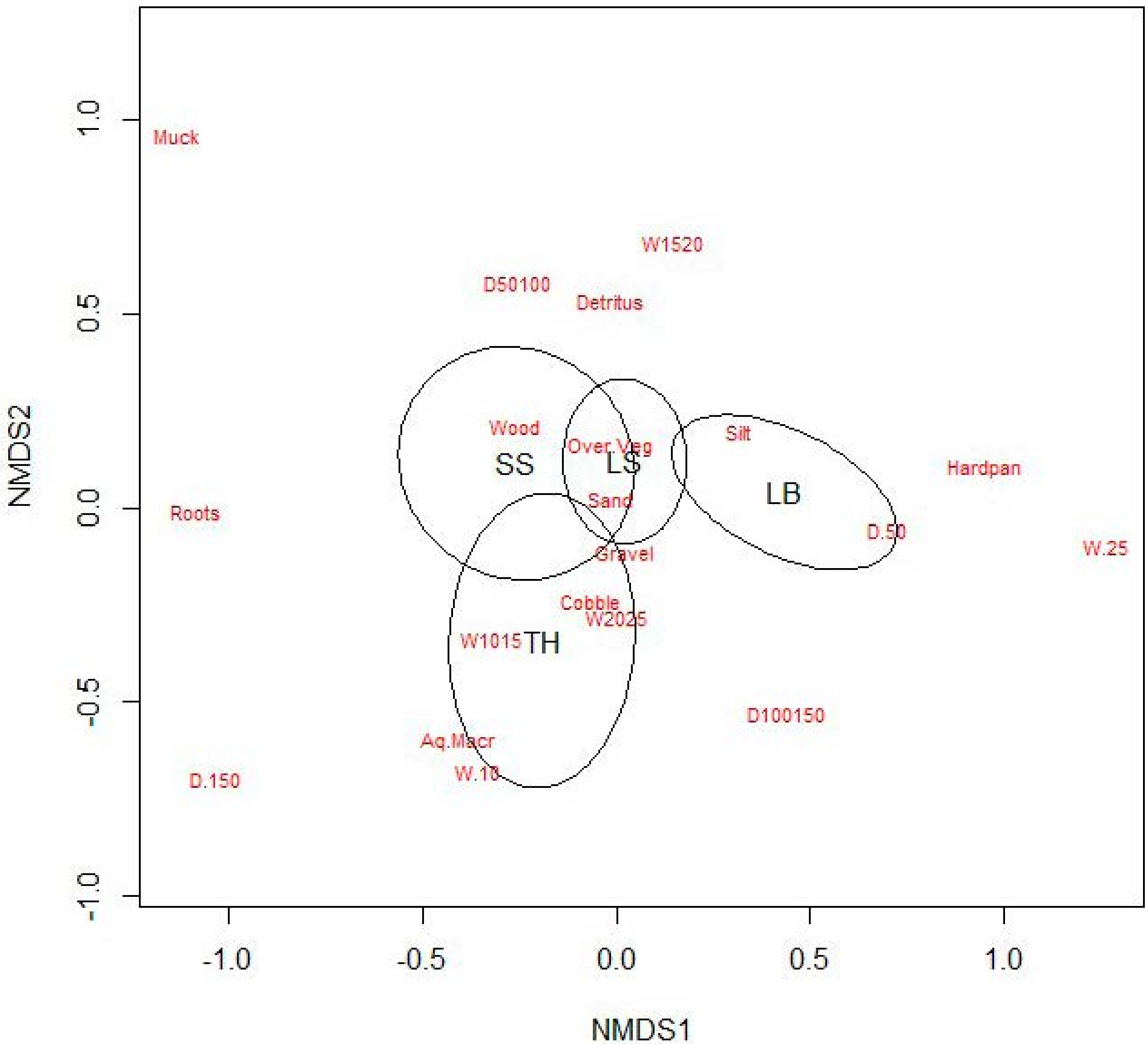

FIGURE 7 Nonmetric multidimensional scaling ordination plot of habitat characteristics observed in the main channels of the Middle Fork and Salt Fork of the Vermilion River basin during each survey of Champaign County fishes. Ovals represent a 95% confidence interval around the weighted average score for each sampling period. TH = Thompson and Hunt (1930), LS = Larimore and Smith (1963), LB = Larimore and Bayley (1996), and SS = Sherwood and others (our study).

Additionally, data representing the land cover of Illinois in the early 1800s (IDNR 2003) were available (Figure 8). These data were composed of 12 land cover types and were derived from notebooks from the Public Land Survey System. Analysis of pre-settlement land cover data helped determine the overall changes in each land cover type, as well as provide a guide for future land use decisions by determining where certain land covers are lacking. Pre-settlement data were analyzed in ArcMap 10.3 (ESRI) at a 30-m resolution.

Land use/cover analyses were performed by each basin in Champaign County. Basins were delimited using the USGS Watershed Boundary Dataset (Watershed Boundary Data set for HUC8, Illinois; http://datagateway.nrcs.usda.gov [Accessed 26 Sept 2016]). Land use of the Little Vermilion basin in Champaign County was very unremarkable and therefore omitted from discussion. Pre-settlement land use of the Little Vermilion was estimated to be almost exclusively prairie (99.7%), which has been nearly exclusively transformed into cultivated crops (94.1% of current land cover). No other patterns of land use change in this basin were observed.

Results: Topographic and Satellite Comparison

Land use classifications derived from current topographic

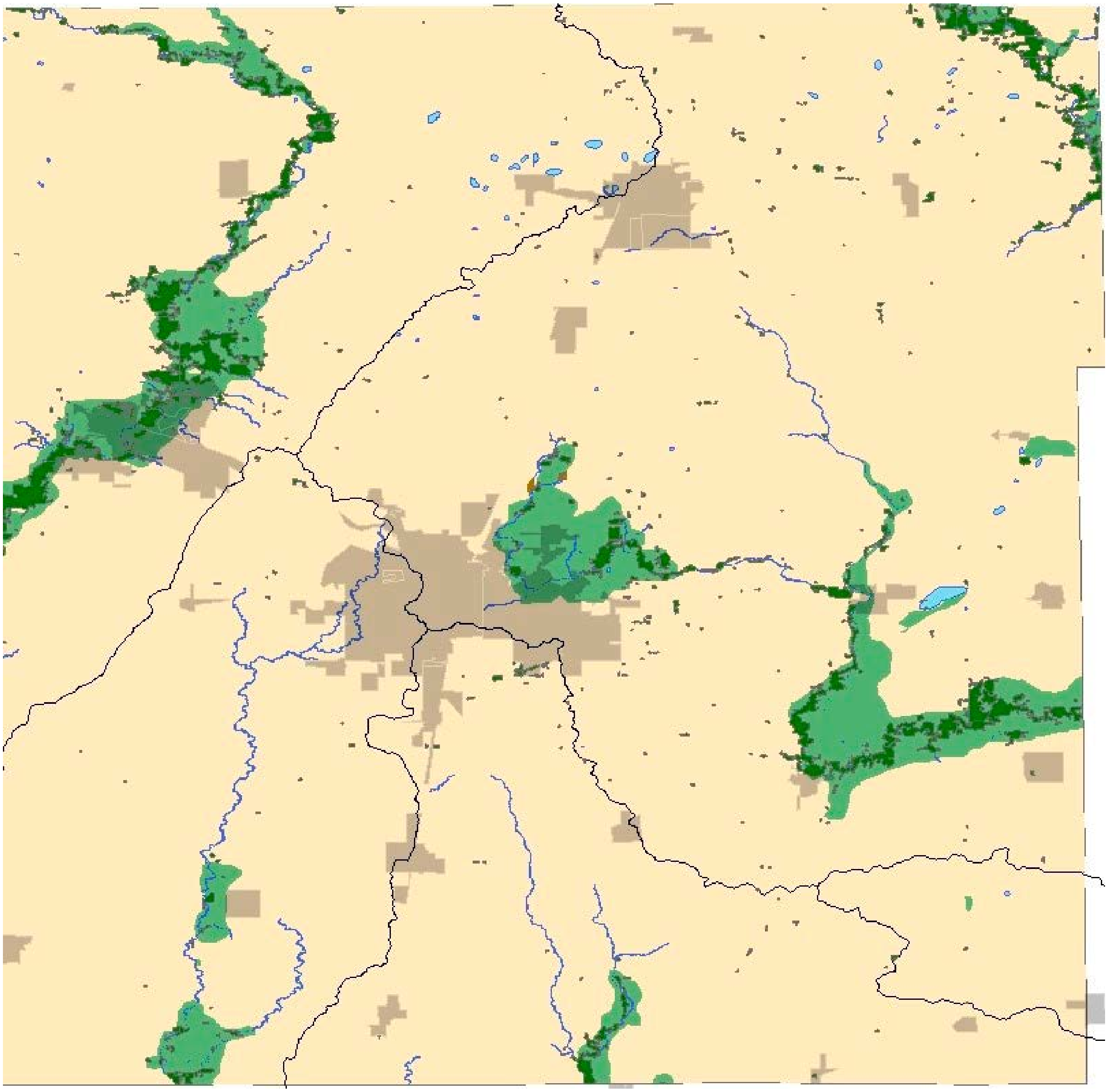

FIGURE 8 Historical land cover of Champaign County with current municipalities and forest lands. Tan areas represent prairielands, green areas are historical forests, blue are rivers and lakes, and brown are historical wetlands. Light gray areas are current municipalities and dark green represent current forest cover. Black lines delimited the basin in Champaign County.

maps compared reasonably well to those from satellite imagery (NLCD; Table 11). Estimates of agricultural land based on topographic maps ranged from 90.7% to 93.4% of a basin's total land area. The percentage of cultivated cropland use from NLCD data ranged from 85.0% to 88.1%, indicating that data from topographic maps overestimated a basin's agricultural land use by 4.8–6.8%. The Hay/Pasture category of NLCD data was not included in estimates of agricultural land use for these analyses. Several areas of this land use category were explored via satellite imagery and were more often found to be grasslands that are neither hayfields nor livestock pastures. Omitting this category from agriculture estimates does not solely account for the differences noted between the two analyses, as it only totals 1.1–2.1% of land cover in a basin. The most likely reason for the discrepancies noted between methods is roads. Rural roads are primarily indicated by the Developed-Open Spaces category of the NLCD data and represent 3.7–5.1% of a basin's land use. Both land use categories were included in the agriculture layer

TABLE 11 Differences in the percentage of agricultural, urban, and forest lands in each basin derived from topographical map (Topo) analysis and satellite imagery analysis.

	Agriculture			Urban			Forest		
	Topo	*Satellite*	*Difference*	*Topo*	*Satellite*	*Difference*	*Topo*	*Satellite*	*Difference*
Embarras	93.4 %	88.1 %	5.3 %	6.0 %	7.2 %	−1.2 %	0.6 %	0.5 %	0.1 %
Kaskaskia	90.7 %	85.9 %	4.8 %	8.9 %	10.0 %	−1.1 %	0.4 %	0.3 %	0.1 %
Sangamon	93.4 %	86.6 %	6.8 %	2.5 %	4.3 %	−1.8 %	4.1 %	3.5 %	0.6 %
Vermilion	91.1 %	85.0 %	6.1 %	6.4 %	7.5 %	−1.1 %	2.5 %	2.1 %	0.4 %

using topographic maps.

Forest land estimations were also overestimated by topographic map analyses (Table 11). Topographic maps estimate that 0.4–4.1% of a basin's land use was forest, whereas NLCD data ranged from 0.3% to 3.5%. Differences between basin estimations ranged from 0.1% to 0.6%. Many of the remaining forest lands in Champaign County are in areas near rivers and gullies and are irregular in shape. The differences noted between methods are likely due to over delimiting (rounding edges) during the delineation of forest layers from topographic maps.

It is probable that the overestimation of agricultural and forest lands using topographic maps led to the underestimation of urban lands. Differences between urban land estimations ranged from −1.1% to 1.8%. Total urban land use estimates were 2.5–8.9% using topographic maps and 4.3–10.0% from NLCD data. Four urban land uses are differentiated in the NLCD data, open spaces, low, medium, and high intensity. For our analyses, low, medium, and high intensities were combined. Major roads and rural homesteads are often classified as low or medium intensity urban in NLCD data. These areas were classified as agricultural using topographic maps, which is a possible reason that urban land use was higher in the topographic analysis.

Embarras River Basin

Historically, the Embarras River basin was the least forested basin in Champaign County (Figure 9) with the exception of the Little Vermilion basin. Forest land only consisted of 1.8% of the early 1800s basin land cover with the bulk of the forest being near the Champaign–Douglas County line and extending north along the East Branch to a point along Illinois Highway 130 about 8 km (5 miles) south of Philo (Figure 8). Prairie land made up the remaining 98.2% of the basin, most of which was converted to agriculture by the 1950s survey (Figure 10).

Analysis of topographic maps suggest that urban land cover has shown the largest increase in the Embarras basin over the span of this study (Figure 11). Only 0.4% of the basin was urbanized in the 1950s, which increased to 5.4% and 6.0% in the 1980s and 2010s, respectively. This was largely due to the expansion of the Village of Savoy and southern Urbana. Increases in urban land cover have corresponded to decreases in agriculture lands from the 1950s to the present day. Forest lands dropped from 0.5% to 0.3% from the 1950s to the 1980s but was measured to be 0.6% during our survey, roughly a third of the area of early 1800s forest land.

Current near-stream land use was not reflective of the overall land use of the Embarras basin. Forest and grass lands occur at higher percentage near streams when compared to the entire basin. NLCD data indicate that 5.5% of the land within 30 m of a stream was forested, although forest makes up only 0.5% of the entire basin (Figure 12). The percentage of grasslands ranges from 12.9% of the area within 30 m to 9.6% within 120 m, where the total area of grasslands in the basin was only 1.7% (Figure 13). As mentioned, the Hay/Pasture layer was included under grasslands for our analyses due to many of the areas of Hay/Pasture in the NLCD data being mislabeled grasslands. One exception to this was a parcel of 150 acres of pasture south of Champaign used for beef cattle research at the University of Illinois, through which a short stretch of the Embarras River flows.

Kaskaskia River Basin

Prairie lands made up 96.6% of the early 1800s landscape of the Kaskaskia River basin. Similar to the Embarras basin, the majority of the forest lands were concentrated near the southern border near the Kaskaskia River (Figure 8). This patch, along with a smaller forest to the west of Sadorus, equaled 3.4% of the total basin land cover. According to topographic maps, 97.7% of land was converted to agriculture by the 1950s, reducing the percentage of forest to 0.4%.

Urban land use within the Kaskaskia basin has showed the most change since the 1950s. The expansion of the city of Champaign westward has increased the amount of urban land use from 0.4% in the 1950s, to 8.9% in the recent study (Figure 11). Increases in urban land have primarily decreased the amount of agriculture lands in the basin, which dropped from 97.7% in the 1950s to 90.7% during our surveys (Figure 10) with forest lands remaining constant over the past 60 years (Figure 9). Larimore and Bayley (1996) reported a greater than 60% decrease in the amount of forest between the 1950s and 1980s, which was likely due to their overlooking forest patches along Twomile Slough near its confluence with the Kaskaskia River (Larimore and Bayley 1996; Figure 9).

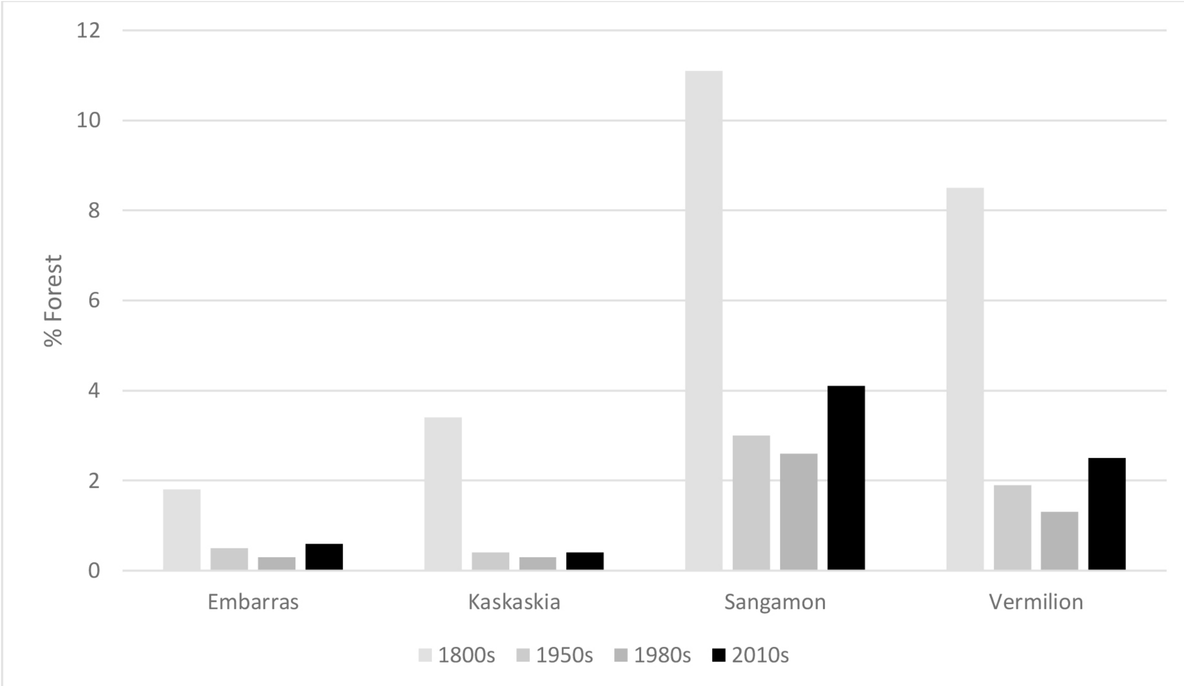

FIGURE 9 Percentage of forested land in the major drainages of Champaign County from the early 1800s, 1950s (Larimore and Smith 1963), 1980s (Larimore and Bayley 1996), and 2010s (present survey).

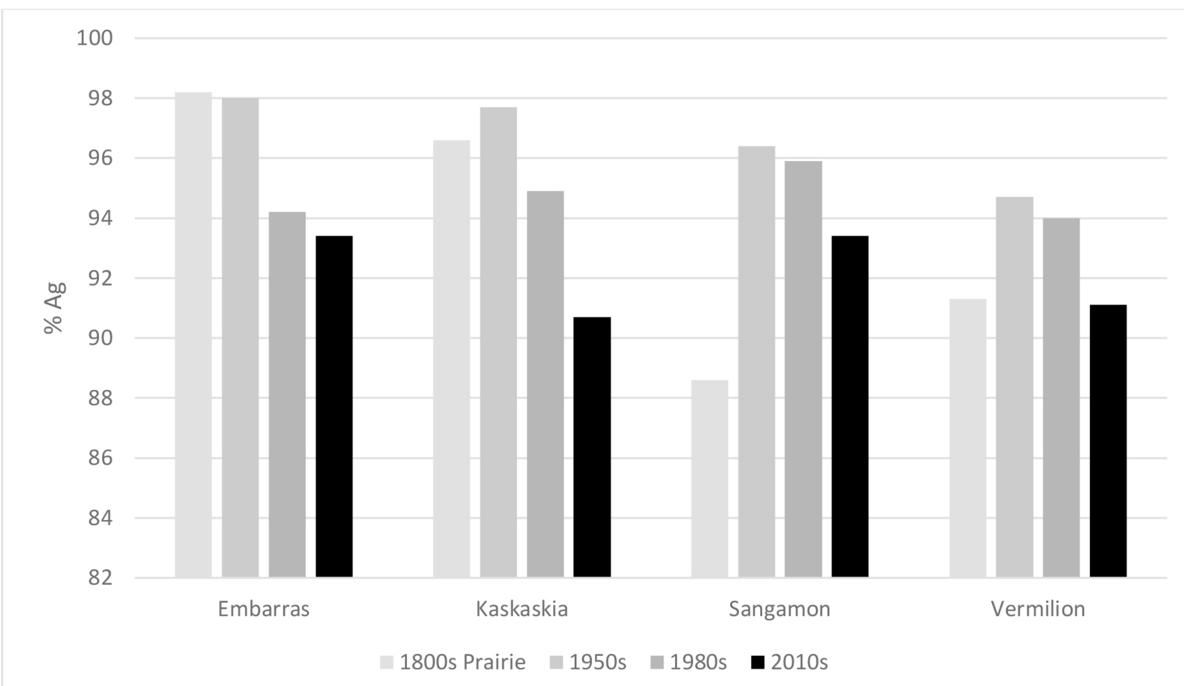

FIGURE 10 Percentage of agriculture land, and 1800s prairie land, in the major drainages of Champaign County from the early 1800s (prairie land), 1950s (Larimore and Smith 1963), 1980s (Larimore and Bayley 1996), and 2010s (present survey).

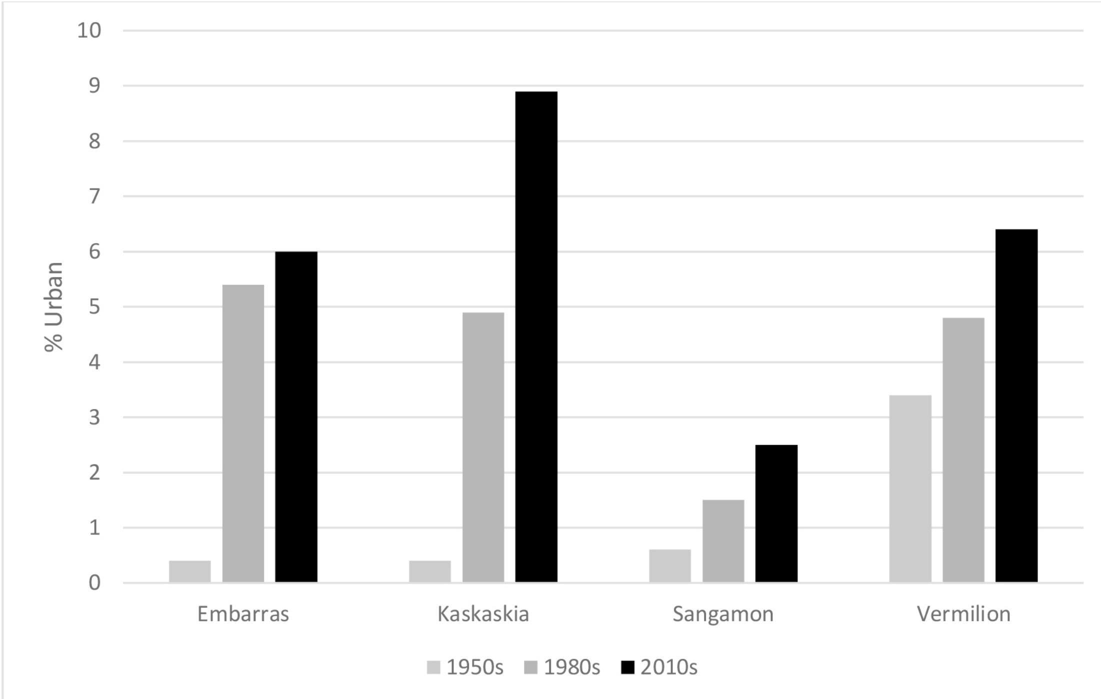

FIGURE 11 Percentage of urban land cover in the major drainages of Champaign County from the 1950s (Larimore and Smith 1963), 1980s (Larimore and Bayley 1996), and 2010s (present survey).

Stream-side areas of the Kaskaskia have a similar percentage of urban land use as seen throughout the basin. NLCD data indicate that 10% of the Kaskaskia basin is currently classified as urban land use with 9.6% of area within 30 m of a stream also urbanized (Figure 14). The majority of urban land within the buffer zone occurs along Copper Slough and Phinney Branch in western Champaign. Both forest and grasslands occur in higher percentages in the buffered areas than occur within the entire basin. When compared to the other basins in Champaign County, the Kaskaskia has the highest percentage of urban (Figure 14) and agriculture (Figure 15) and the lowest percentage of grass (Figure 13) and forest (Figure 12) lands within the buffer zone.

Sangamon River Basin

Early 1800s land cover of the Sangamon River basin in Champaign County consisted of 11.1% forest land, the most of all Champaign County basins. As seen in other basins, forest lands of the Sangamon basin followed the path of the Sangamon River with the largest areas located near present-day Mahomet. By the 1950s, 96.4% of the basin land use was agriculture with only 3% of forest lands remaining and likely very little prairie remaining.

Since the 1950s the Sangamon basin has experienced a modest decline in the proportion of agriculture land, from 96.4% to 93.4% during our surveys (Figure 10). The influx of urban land that was observed in the Kaskaskia and Embarras basins has not occurred in the Sangamon, although it has increased (Figure 11). Urban land was measured at 0.6% of total basin land use in the 1950s and is currently 2.5%. Only a slight increase in the amount of forest land has been observed since the 1950s. Current forest land in the basin comprises 4.1% of the basin, up from 3.0% in the 1950s and 2.6% in the 1980s (Figure 9).

Current forest lands of the Sangamon basin are still primarily located along the path of the Sangamon River. NLCD data showed that 26.6% of the lands within the 30 m stream buffer are forested, as well as 20.3% of the land within 120 m (Figure 12). This is drastically higher than the total percentage of forested land in the basin. The Sangamon basin has the lowest percentage of agriculture land within stream buffers in the county, comprising only 62.7% of the land within 30 m of streams (Figure 15). With urban land uses only making up 2.5% of the 30 m buffers, it is the lowest percentage of urban land within 30 m of streams in the county (Figure 14). Grasslands are only slightly more common near a stream when compared to the basin as a whole with 3.1% within 30 m and 2.1% throughout the basin (Figure 13).

Vermilion River Basin

Three large, forested areas made up 8.5% of the Vermilion River basin in the early 1800s (Figure 8). One area, in the northeast corner of the county, followed the path of the Middle Fork as it passes through the county. The second was a contiguous stretch along the Salt Fork from St. Joseph south to Sidney, then east to the Champaign–Vermilion County line. The final is what

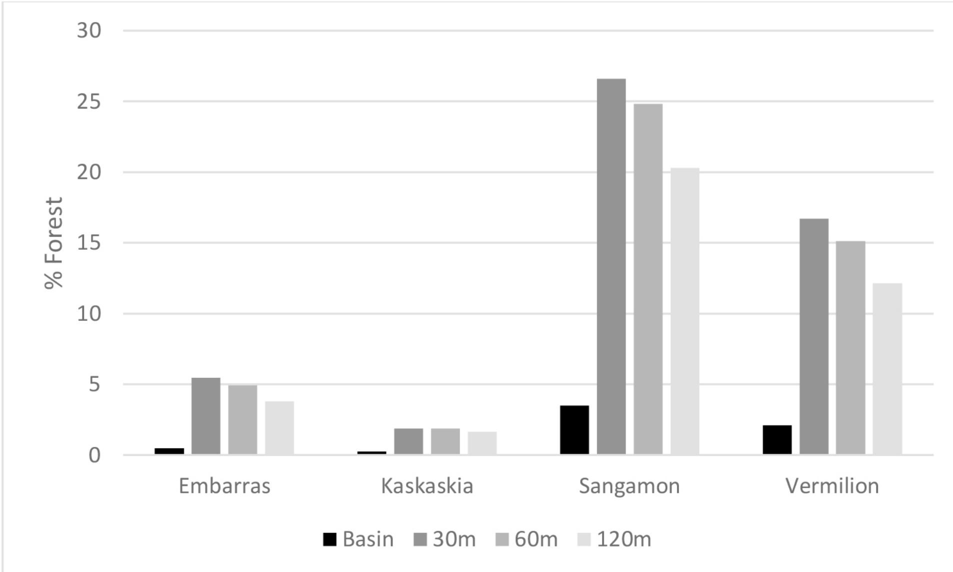

FIGURE 12 Percentage of forested land within the entire basin and within 30 m, 60 m, and 120 m buffers of the streams of Champaign County, separated by major basins.

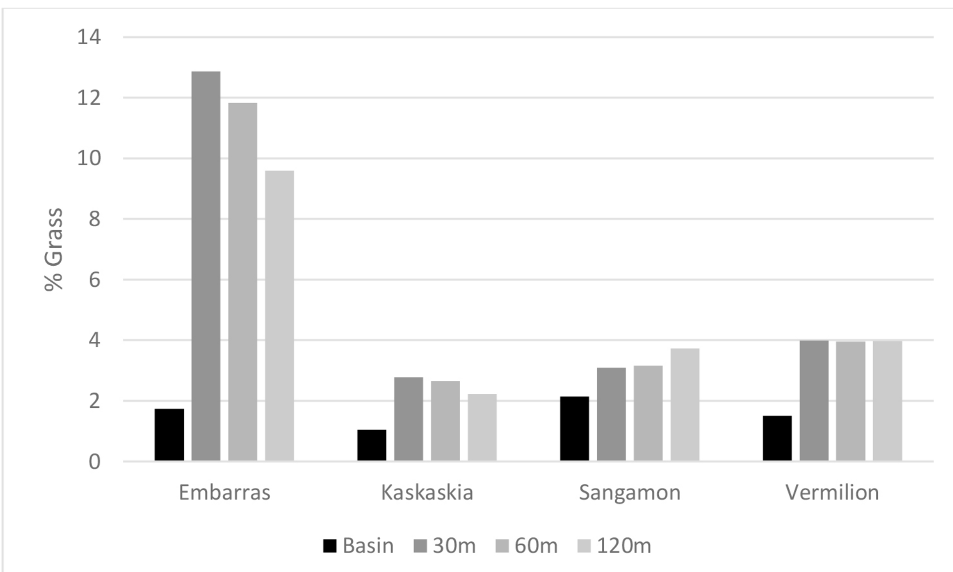

FIGURE 13 Percentage of grassland within the entire basin and within 30 m, 60 m, and 120 m buffers of the streams of Champaign County, separated by major basins.

has been known as the "Big Grove," which was located north of Urbana to the east of the Saline Branch. Like the other basins of the county, agriculture had become the dominant land use by the 1950s, at 94.7% of total land use. Forest lands fell to 1.9% of land use, which were primarily near the Middle Fork and Salt Fork with only a few patches of the Big Grove remaining.

Only minor changes in land use have occurred in the Vermilion basin since the 1950s. Most notably, urban land use has increased from 3.4% in the 1950s to 6.4% during our survey (Figure 11). These increases have primarily occurred in southeast Urbana. Agricultural lands have decreased slightly, from 94.7% to 91.1% (Figure 10). The percentage of forest land has remained relatively constant, equaling 1.9% in the 1950s, up to 2.5% in the current analysis (Figure 9).

Like the Sangamon basin, the Vermilion basin has more forest and grasslands, and less urban and agriculture lands within the

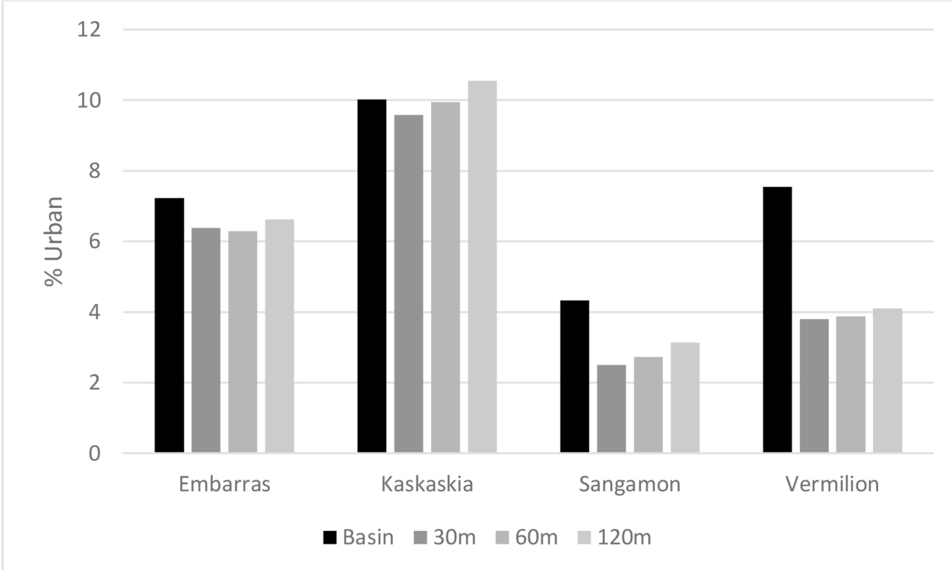

FIGURE 14 Percentage of urban land within the entire basin and within 30 m, 60 m, and 120 m buffers of the streams of Champaign County, separated by major basins.

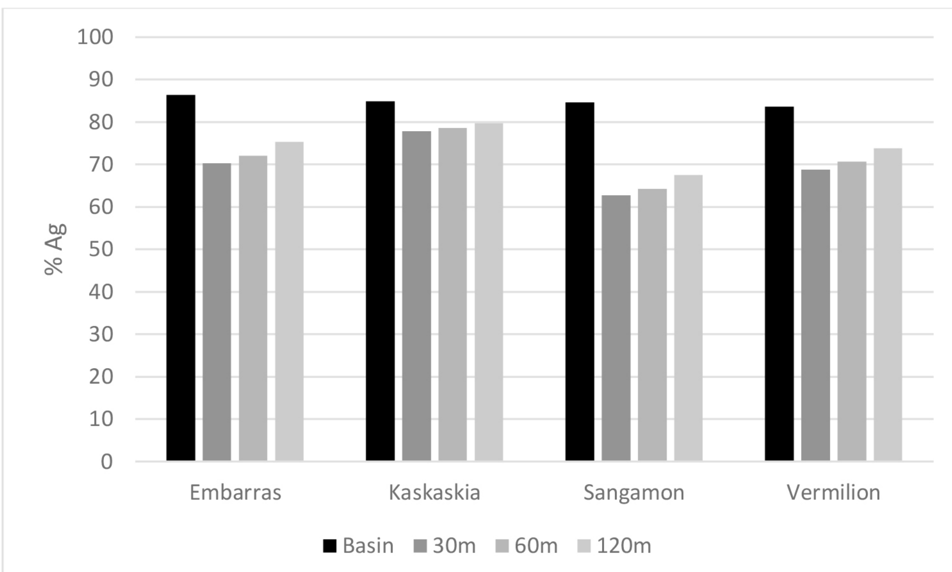

FIGURE 15 Percentage of agriculture land within the entire basin and within 30 m, 60 m, and 120 m buffers of the streams of Champaign County, separated by major basins.

buffer zone when compared to the entire basin. Currently, 16.9% of the 30 m buffer land is forested, dropping to 12.1% at 120 m with 2.1% of the total basin forested (Figure 12). Grasslands only comprise 1.5% of the total basin area yet make up ~4% of the land within all buffer distances (Figure 13). Urban and agriculture lands make up 7.5% and 83.6% of the total Vermilion watershed, respectively, while urban land is only found in 3.8% of the 30 m buffer zone (Figure 14) and agriculture at 68.8% of the same buffer (Figure 15).

POLLUTION

Pollution has been affecting the distribution of Champaign County fishes prior to the initial samples of Forbes and Richardson (1908) at the end of the 19th century. At that time, human wastes were becoming an issue in the streams flowing through the cities of Champaign and Urbana (Boneyard Creek and Saline Branch, then West Branch of the Salt Fork of the Vermilion). Initially, each city had independent sewage systems that emptied into Boneyard Creek (Urbana, near the Big Four Rail shops at 223 N. Broadway) and Saline Branch (Champaign, near present-day wastewater treatment facility) (Baker 1922). In 1894, septic tanks were installed in each system (Baker 1922) to service the wastes of the combined 9,500 people living in Champaign-Urbana at the time (US Census Bureau 1900).

In addition to human wastes, industrial growth and the resulting discharge of wastes such as tar and oil created another pollution source in Boneyard Creek and Saline Branch. Until the market was developed that made it profitable to recover waste tar, it was common to dump all wastes (wastewater, oil, and tar) into a ditch that ran parallel to the Big Four tracks (Hilscher 1915). Systems that captured waste tar for resale limited the amount of industrial pollutants that entered Boneyard Creek but were subject to inundation due to heavy rainfalls and plugged drainage tiles (Hilscher 1915). Such an instance in July 1915 resulted in complaints and the subsequent report by Hilscher (1915), in which he describes the entirety of Boneyard Creek being covered in oil. High water events throughout the remainder of the year resulted in nearby stream banks and lawns being coated in tar and oil.

The most disturbing accounts of pollution occur in the years just prior to the Thompson and Hunt (1930) survey. By 1928, the combined populations of Champaign and Urbana reached over 25,000 people (US Census Bureau 1930), greatly exceeding the capacity of the septic tanks installed in 1894. Overflow from these systems once again led to the discharge of untreated human wastes into Boneyard Creek and Saline Branch. Scientists from the State Water Survey estimated that the flow of Saline Branch downstream of Urbana was 3 million gallons per day and that the combined outflow from the Urbana and Champaign septic tanks was 1.5 million gallons per day (Baker 1922). Today, it is staggering to think that half of the flow of a medium-sized stream would be untreated human wastes. Thompson and Hunt (1930) note that two other stream systems were polluted with human wastes at the time of their samples. The City of Champaign had an additional sewage outlet on the western edge of the city that discharged sewage into Copper Slough of the Kaskaskia River basin and sewage from the Village of Rantoul into the East Branch (Salt Fork) Vermilion near the eastern edge of town. They also document a fish kill that occurred a few years prior to their samples on Drummer Creek (Sangamon River basin) that was likely due to pollution from a canning facility near Gibson City (Thompson and Hunt 1930).

Legislation in 1917 created the Urbana-Champaign Sanitary District and a new wastewater treatment facility on the Saline Branch was completed in the years just prior to the samples of 1928 (Larimore and Smith 1963). In the 31 years between the Thompson and Hunt (1930) and Larimore and Smith (1963) fish surveys, wastewater treatment facilities were installed on the west side of Champaign, Rantoul, and the growing Chanute Air Force Base. This time period also saw the loss of many of the industries that were the source of most of the industrial pollution to Boneyard Creek and Saline Branch (Larimore and Smith 1963). Although this period saw the cessation of pollutants like untreated human waste, tar, and oil, new pollutants had emerged including pesticides, modified water temperatures, and chemicals contained in the effluent of the new wastewater treatment facilities. The continual degradation of Champaign County streams due to pollution led Larimore and Smith (1963) to identify seven areas of chronic water pollution throughout the county (Figure 16; Larimore and Smith 1963). These areas had known pollution sources that created degraded fish communities when compared to similar, non-polluted streams of the area.

There is little doubt that legislation passed between the Larimore and Smith (1963) and Larimore and Bayley (1996) surveys, including the Water Pollution Control Act of 1966, Federal Water Pollution Control Act Amendment of 1972, Clean Water Act of 1972 & 1977, and the Water Quality Act of 1987, helped pave the way for more suitable aquatic habitats in the streams of Champaign County. Additionally, researchers in the mid-1980s suggested that chlorine and ammonia, common chemicals found in wastewater effluent at this time, were detrimental to aquatic biota (Blake-Coleman 1984; Karr et al. 1985; Paller et al. 1988). This discovery led to regulations that limited the amount of each chemical in the effluent of wastewater treatment facilities. With the current laws and regulations in place, many of the chronic sources of pollution that have plagued the streams of Champaign County are no longer the primary sources of aquatic deterioration.

Although many of the chronic sources of pollution have been resolved, acute exposures of many pollutants still affect the streams of Champaign County. Accidental releases of pollutants such as industrial chemicals and livestock feedlot wastes often result in fish kills along the stream where the release occurred. Fish kills caused by accidental releases have been documented in both Larimore and Smith (1963) and Larimore and Bayley (1996), thus are not a novel problem plaguing the streams of the county. Though high summer temperatures and low water levels often result in natural fish kills that are attributable to decreased dissolved oxygen levels, the fish kills presented in the following section will be those that have been the result of nonnatural occurrences.

This section discusses observations in the fish communities found across all Champaign County surveys in each of the areas of chronic pollution as described by Larimore and Smith (1963). A brief description of each pollution source will be presented, as well as any fish kills that have occurred since 2000. Observations will be separated by basin with the exception of the Embarras and Little Vermilion basins, from which there were no pollution-related observations made and thus were omitted.

Kaskaskia River Basin

Two areas in the Kaskaskia River basin were identified as areas of chronic pollution (Figure 16). Copper Slough and Phinney Branch were classified as areas of heavy pollution due to industrial and domestic wastes prior to 1959. Additionally, a wastewater treatment facility was constructed on Phinney Branch in 1956 near the Duncan Road bridge (based on 1970 Bondville Topographic Map) and was in use until a new facility was constructed in the 1970s at the corner of Windsor and Rising

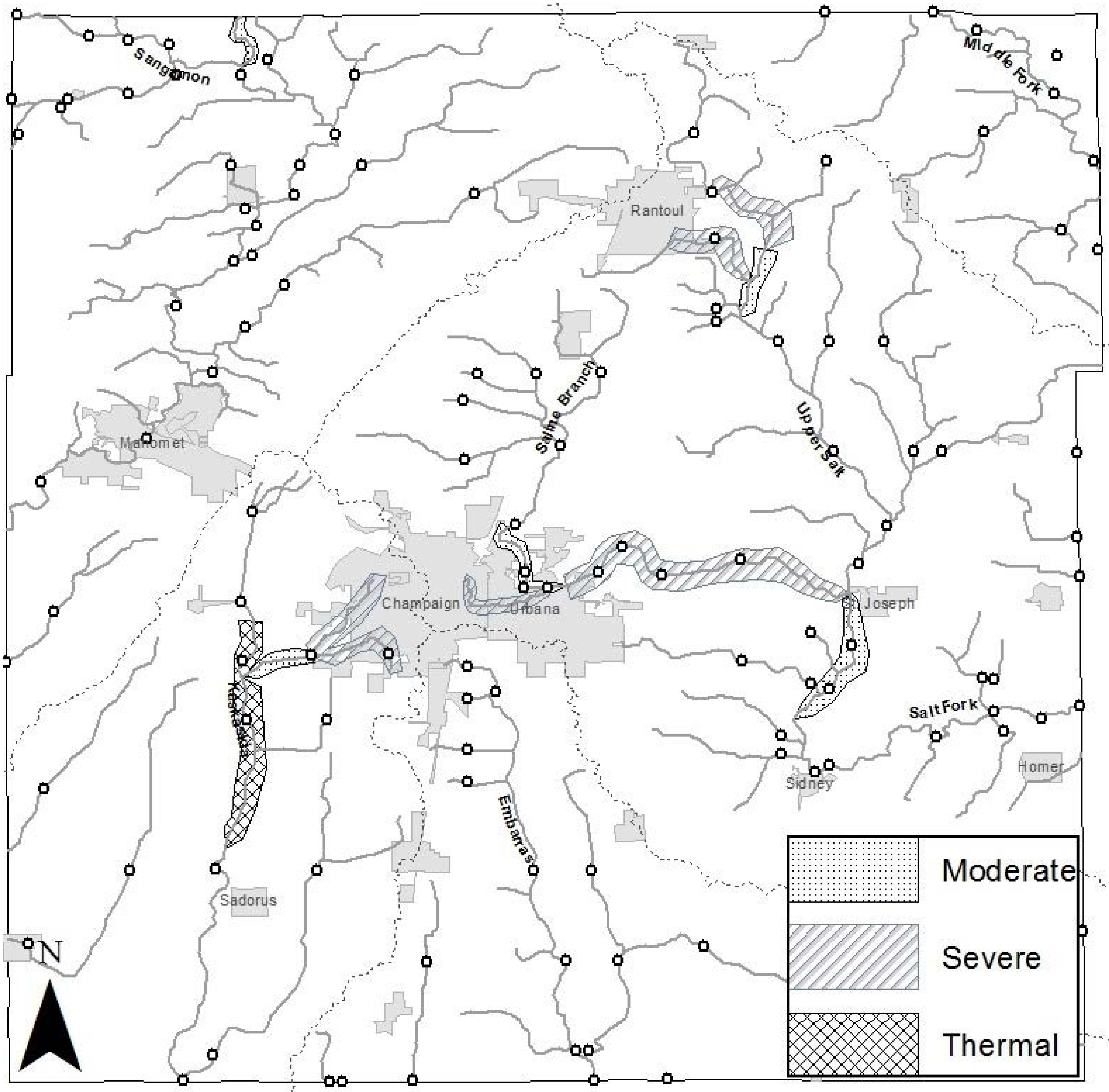

FIGURE 16 Distribution of polluted sections of Champaign County streams. Circles represent sites that were sampled by Thompson and Hunt (1930) and repeated through remainder of surveys. Recreated from Larimore and Smith (1963).

Roads in southwest Champaign. Since 2000, there have been six fish kills that have occurred on these streams, four of which are known to be from pollutants and two that were of unknown origin (IDNR 2016).

Thompson and Hunt (1930) surveyed the fishes at three sites in this system—two on Phinney Branch and one on Copper Slough. In all, these samples yielded 9 species. Larimore and Smith (1963) sampled two of the three sites (Copper Slough and Phinney Branch near the confluence of the two) and Larimore and Bayley (1996) only sampled near the confluence of the streams. Both surveys observed 20 species in the affected area with 12 species being observed in both samples. We sampled all three sampling locations in this area reported by Thompson and Hunt (1930) and observed 21 species. The recent observations of Johnny Darter mark the first time since the Thompson and Hunt (1930) survey that it was found in this area. Additionally, our survey recorded Orangethroat Darter and Brook Silverside (*Labidesthes sicculus*) from this region, which had not been recorded from this area in any of the previous surveys.

The second area of chronic pollution is located on the Kaskaskia River and starts roughly 1 km south of Illinois Highway 10 and stretches downstream about 10 km (Figure 16). Larimore and Smith (1963) noted this reach due to altered water temperatures from well water being discharged into the stream for use in a chemical plant near Ficklin. This drastically changed the thermal regime of this section of stream with July water temperatures measured at 32°C above the discharge point and 15.6°C near the discharge. Larimore and Bayley (1996) reported that this process was discontinued after only a few years and was not affecting this stretch of stream at the time of their survey. Discharge of well water has since resumed after the last survey, although the specifics are unknown (Trent Thomas, IDNR, pers. comm.). This section of the Kaskaskia River includes the mouth of Copper Slough and has been affected by two fish kills that originated as pollutants from Copper Slough (IDNR 2016).

Two survey sites fall within the area of the Kaskaskia River affected by thermal change. The site closest to the discharge point appears the most affected by these practices. Twelve species were collected at this site during Thompson and Hunt (1930). After discharge began, species richness fell to 7 during the Larimore and Smith (1963) survey and rebounded to 16 during the Larimore and Bayley (1996) survey when discharge was no longer occurring. Data from our survey suggests that resuming discharge of well water has again affected species richness at both sites in this area. Samples from our survey observed 8 species at the site directly downstream and 11 at the site farther downstream, from which 23 species were observed in 1987.

Sangamon River Basin

Larimore and Smith (1963) identified two areas of the Sangamon River basin in their areas of chronic pollution. They labeled a small section of the Sangamon River, between Mahomet and the Champaign–Piatt County line, as affected by excessive siltation, yet no other details were presented. The other is a section of moderate pollution on the lower section of Drummer Creek, between the Champaign–Ford County line and its mouth on the Sangamon River. Drummer Creek flows south from Gibson City, where it received domestic wastes and pollutants from a soybean mill and packing plant (Larimore and Smith 1963). Wastes from Gibson City have caused fish kills on Drummer Creek since the time of Thompson and Hunt (1930), and Larimore and Smith (1963) stated that they were practically an annual occurrence in 1959. Fish kills on Drummer Creek have become less frequent since the mid-1970s (Larimore and Bayley 1996) and the last recorded fish kill prior to our survey occurred in 2002 (IDNR 2016).

A novel area of concern has emerged in recent years in the Sangamon basin. Since 2000, four large fish kills have occurred on Lone Tree Creek. These occurrences have affected 9.9–18.5 km of Lone Tree Creek and the Sangamon River, killing thousands of fish along the affected area (IDNR 2016). Despite recent and repetitive harms, long-term trends on Lone Tree Creek have been positive. Surveys conducted by Thompson and Hunt (1930) and Larimore and Smith (1963) each collected 28 species from six sites on Lone Tree Creek. Species richness increased to 29 during Larimore and Bayley (1996) and 33 species were collected during our survey. It is apparent that fish communities in the adjacent sections of Lone Tree Creek and the Sangamon River provide a suitable recolonization source that has been able to handle these situations.

Vermilion River Basin

Much of the documented chronic pollution that has occurred in Champaign County has occurred in the Vermilion River basin. Four areas of severe pollution were identified by Larimore and Smith (1963). The Saline Branch from Urbana to St. Joseph, the Upper Salt Fork downstream of Rantoul, and the stream flowing through Chanute Air Force Base were all severely impacted by sewage, whereas Boneyard Creek was affected by historical industrial pollutants (Figure 16). Additionally, three areas were identified as areas of moderate pollution. These areas are adjacent to the areas of severe pollution and include the Salt Fork from St. Joseph to a few kilometers north of Sidney, the Salt Fork southeast of Chanute Air Force Base, and the Saline Branch upstream of Urbana to the wastewater treatment facility.

Both Thompson and Hunt (1930) and Larimore and Smith (1963) described Boneyard Creek as having no permanent fish populations at the time of their respective surveys. No samples were taken during the Larimore and Bayley (1996) survey, yet they mentioned that schools of fish had been observed throughout Urbana at many times during the year (Larimore and Bayley 1996). We sampled one site on Boneyard Creek at Race Street in Urbana. This survey resulted in 190 individuals and 16 species. Observations from this survey, along with records from the INHS Fish Collection (INHS 2016), resulted in 20 species from Boneyard Creek since 2006. Although these data suggest a great improvement to the aquatic biota of Boneyard Creek, nearly the entirety of its watershed is urbanized, making this stream quite vulnerable to pollutant spills and the resulting fish kills.

It is arguable that the Saline Branch has been the stream that has been the most affected by chronic pollution in Champaign County, and like Boneyard Creek, it has seen a drastic improvement in fish communities over the span of this project (Table 12). The four areas are Saline Branch (and tributaries) upstream of the wastewater treatment facility, Saline Branch downstream of the wastewater treatment facility to the confluence of the Upper Salt Fork, Salt Fork from the confluence of Saline Branch to Sidney, and from Sidney to the Champaign–Vermilion County line. The area of the Saline Branch from Urbana–St. Joseph has seen the greatest increase in species richness with less than 10 species being observed during both Thompson and Hunt (1930) and Larimore and Smith (1963) but increasing to 21 species during Larimore and Bayley (1996) and to 40 species during our survey.

There is also evidence that the pollution stemming from Champaign–Urbana had affected more of the Salt Fork than estimated by Larimore and Smith (1963). The areas from Urbana–St. Joseph and St. Joseph–Sidney, both recorded as polluted by Larimore and Smith (1963), each saw a near tenfold increase in

TABLE 12 Species richness observed in four sections of the Saline Branch, its tributaries, and Salt Fork of the Vermilion River during five sampling periods from 1899 to 2012.

	Above Urbana	Urbana – St. Joseph	St. Joseph – Sidney	Downstream of Sidney
Forbes and Richardson (1908)	22	26	24	25
Thompson and Hunt (1930)	17	6	19	22
Larimore and Smith (1963)	16	4	14	34
Larimore and Bayley (1996)	21	21	15	27
Sherwood and others (our study)	34	40	33	43

non-carp biomass (expressed as g/m²) since the Larimore and Bayley (1996) survey (Table 13). Additionally, the area of the Salt Fork downstream of Sidney saw a threefold increase in native biomass. These increases are due, in large part, to an increase in large-bodied Catostomids returning to these areas (Table 13). Generally, Catostomids prefer clean rivers and streams and an increase in Catostomid species richness and relative abundance is likely indicative of better water quality throughout the affected areas (Smith 1979; Becker 1983; Pflieger 1997).

Like Boneyard Creek, the Saline Branch is highly susceptible to pollution-induced fish kills due to wastewater effluent and drainage connections in Champaign and Urbana. In 2002 a large ammonia release affected approximately 16 km (10 miles) of the Saline Branch and Salt Fork (Batten 2004). This release was responsible for ~80,000 fish killed from Urbana to downstream of St. Joseph. Batten (2004) studied the aftermath of this release and found that neither species richness nor relative abundance had returned to pre-release levels two years post-spill. Recent observations of state-threatened Bigeye Chub in the Saline Branch and Salt Fork shows that this system is one of the few streams in Illinois where this species still occurs and any future spills, like the one occurring in 2002, could have negative effects on the recovery of this species in Illinois.

Larimore and Bayley (1996) noted improvements of the fish communities in the Upper Salt Fork near Rantoul and Chanute Air Force Base from three locations near the affected area (Table 14). Species richness was lowest at the two locations most affected (directly downstream of the Rantoul wastewater treatment facility and downstream of Chanute Air Force Base) during the Larimore and Smith (1963) survey (five and two species, respectively). Species richness rose to 15 at one site during the Larimore and Bayley (1996) survey and a similar number of species were observed during our survey (Table 14). Due to the decommissioning of Chanute Air Force Base in 1993 and improvements in the Rantoul Wastewater Treatment facility, it appears as though the chronic sources of pollution affecting these streams have been alleviated.

DISCUSSION

Embarras River Basin

Species richness in the Embarras River basin has increased since the time of the initial surveys. Of the 31 species collected during the Forbes and Richardson (1908) and Thompson and Hunt (1930) surveys, only the state-threatened Bigeye Chub was not collected in the past two surveys. Four species that have only recently been observed in the Embarras are often associated with slow-moving areas of medium-sized streams and sandy substrates, including Brook Silverside, Spotted Sucker, Hornyhead Chub, and Highfin Carpsucker (*Carpiodes velifer*) (Becker 1983). With habitat data suggesting that the streams of the Embarras have become wider and deeper, and an increase in sand substrates, the appearance of these species is not unexpected. The large increase in the amount of sand may also have contributed to increasing the relative abundance of Sand Shiners from about 2% during the Thompson and Hunt (1930) survey to 15% during our survey.

Increases in the prevalence of woody debris are a possible explanation of the appearance of two species, Dusky Darter and Brindled Madtom, in recent years. Dusky Darter is often

TABLE 13 Non-carp biomass (g/m²), Catostomid species richness, and Catostomid abundance observed in four sections of the Saline Branch and Salt Fork of the Vermilion River during the last three surveys of Champaign County fishes (weights were not recorded during the first two surveys).

	Above Urbana	Urbana – St. Joseph	St. Joseph – Sidney	Downstream of Sidney
Non-carp Biomass (g/m²)				
Larimore and Smith (1963)	4.1	0.1	0.5	3.6
Larimore and Bayley (1996)	6.7	1.9	1.3	6.0
Sherwood and others (our study)	5.6	10.7	14.2	14.9
Catostomid Species				
Larimore and Smith (1963)	2	0	4	6
Larimore and Bayley (1996)	2	3	1	7
Sherwood and others (our study)	3	6	9	9
Catostomid Abundance				
Larimore and Smith (1963)	65	0	8	90
Larimore and Bayley (1996)	16	9	1	38
Sherwood and others (our study)	27	53	38	134

associated with areas of debris and Brindled Madtom will use flat pieces of wood as nest site cover, and both species tend to favor pools with little to moderate flows (Etnier and Starnes 1993). Only small increases in forest land were observed between the present-day and the two previous studies, although the amount of tree-related in-stream cover (roots and debris) has increased. Because the current amount of forest land within 30 m of streams is higher than the basin as a whole, it is possible that the small increase in forest lands has occurred primarily in areas directly adjacent to streams, which could lead to an increase in tree root and woody debris.

Two of the most widespread of Illinois fishes showed evidence of decline in the Embarras. Creek Chub was present at nearly 90% of sites during the Larimore and Smith (1963) survey and comprised 27% of all fishes caught in that survey. Although still common during our survey (53% of sites), the relative abundance of this species has fallen to 1% of all fishes caught. Creek Chubs are notoriously tolerant of poor water quality and disturbance (Becker 1983), and the quality of the streams of the Embarras was greatly diminished during the mid-20th century (Smith 1968, 1971), causing little competition and allowing this species to thrive. Improvements in water quality, and the resulting competition from other species, could have led to decreases in Creek Chub. Additionally, Creek Chub do well in small, intermittent streams where few other species occur (Etnier and Starnes 1993). The widening and deepening of the streams of the Embarras has reduced the area of small intermittent streams to be exploited almost solely by the Creek Chub. Johnny Darter has also shown a decrease in relative abundance during our survey, although little evidence is apparent to explain this decrease. One possibility may be due to increased competition pressures from other benthic fishes.

Kaskaskia River Basin

Initial project surveys of the Kaskaskia River basin observed 36–37 species, similar to the number of species observed during the two most recent surveys. While overall richness has not changed over the span of these surveys, community compositions appear to have changed. Four of the seven species that were collected during the initial surveys, though not during the last two, tend to favor softer substrates (i.e., silt; Smith 1979; Becker 1983; Etnier and Starnes 1993). Retzer (2005), in his examination of species richness at 32 sites throughout the Kaskaskia basin, reported a significant decline in richness among 32 sites between 1982 and 1998. He hypothesized that anthropogenic disturbances (i.e., row-crop agriculture and construction of reservoirs) caused habitat alterations. These physicochemical changes resulted in fragmented populations, or even extirpation, of native fishes. The apparent disappearance of Mississippi Silvery Minnow, Pugnose Minnow, Warmouth, and Bluntnose Darter coincides with the loss of silty substrates measured over the course of this project. Thompson and Hunt

TABLE 14 Species richness observed in sites on the Upper Salt Fork that have been affected by pollution from the Rantoul Wastewater Treatment Facility and Chanute Air Force Base.

	Thompson and Hunt (1930)	Larimore and Smith (1963)	Larimore and Bayley (1996)	Sherwood and others (our study)
Upstream of Rantoul	7	10	14	16
Downstream of Rantoul	12	5	*No sample*	16
Downstream of Chanute AFB	13	2	15	13

(1930) made no reports of sandy substrates during their survey, while 0.60 of sites contained silt. The proportion of sites containing silt was 0.23 during our survey and sand was present at 0.92 of sites.

Silt substrates gradually increased during the Larimore and Smith (1963) and Larimore and Bayley (1996) surveys (0.77 and 0.92, respectively), thus it is unlikely that the present absence of silt is solely to blame for the loss of species. The Kaskaskia basin has shown the largest increase in urban land use and during our survey has the highest proportion of urban land cover of all basins in Champaign County. Impervious surfaces associated with urban land cover have been shown to negatively affect stream fish communities (Lenat and Crawford 1994; Wang et al. 1997, 2000, 2001). Additionally, the extended period of chronic pollution that occurred in the Kaskaskia basin has likely diminished populations of these largely intolerant fish species (Karr et al. 1985; Paller et al. 1988; Barbour et al. 1999). Although still present during our survey, Hornyhead Chub decreased over the span of the project. Thompson and Hunt (1930) collected it at 93% of sites, totaling 23% of the total catch. While observed at only 15% of locations during our survey, the relative abundance of this species has diminished to just 0.11% of total catch. No observed trends in habitat or landscape were apparent to describe such a decrease.

The species that have appeared to replace absent species are those associated with larger rivers and/or sandy substrates. Some species that have appeared since Larimore and Smith (1963) are Highfin Carpsucker, Golden Redhorse, Brook Silverside, Slenderhead Darter, and Freshwater Drum. As seen in the Embarras, stream measurements of the Kaskaskia basin have tended toward deeper and wider streams when compared to the Thompson and Hunt (1930) survey. Some of these differences could be due to additional water added to this stream from the groundwater pumping and the discharge of wastewater effluent near Champaign, allowing for these streams to act as larger lotic environments than they were initially.

Sangamon River Basin

As the largest drainage system that flows through Champaign County, the Sangamon River basin is also one of the most specious. Observed species richness has been near or above 50 species in all surveys since Thompson and Hunt (1930). As observed in the Kaskaskia River basin, there were changes in the composition of the fish community in the Sangamon basin while species richness has remained constant. Nine species that were originally observed in the Sangamon basin during the initial two surveys have not been observed during the last two surveys. Conversely, 10 species that were not initially observed were found since Larimore and Smith (1963). The appearance of four species—Bluegill, Largemouth Bass, Redear Sunfish, and Walleye—is largely linked to the stocking of these species for recreational fisheries in ponds, reservoirs, and the river. The appearance of other species, along with the apparent disappearance of species, can largely be attributed to changes in habitat.

Overall habitat changes in the Sangamon basin are similar to changes in the Embarras and Kaskaskia. Site depths in the Sangamon showed to be deeper during our surveys than they were during the Thompson and Hunt (1930) surveys with the proportion of sites less than 0.25 m deep decreasing from 0.17 during Thompson and Hunt (1930) to zero during our survey. Species like the Bigmouth Shiner and Silverjaw Minnow are typically associated with these shallow, headwater habitats (Pflieger 1997) and both decreased in the Champaign County section of the Sangamon basin. Silverjaw Minnow was not collected in the Sangamon basin during our survey, yet it comprised 11.1% of the total catch during the Thompson and Hunt (1930) survey. Similarly, the Bigmouth Shiner made up 12% of the total catch during Larimore and Smith (1963), which decreased to 0.12% during our survey. The tendency toward deeper waters is likely one reason that Silver Redhorse has appeared in the Sangamon in more recent surveys (Smith 1979).

Along with changing stream dimensions, substrates in the Sangamon have tended toward a gravel and sand dominated system from a more diverse array of substrates. Species that were not observed during our survey that are associated with larger substrates, such as Slender Madtom and Banded Darter, have been replaced with species that prefer relatively finer substrates like the Logperch and Freckled Madtom (*Noturus nocturnus*). Pallid Shiner and Slough Darter (*Etheostoma gracile*) have not been observed since the initial surveys, and each species prefers silt substrates (Etnier and Starnes 1993). Rock Bass, a species associated with silt-free environments (Smith 1979), was not collected during the Thompson and Hunt (1930) survey yet it was observed at half of the sites in the Sangamon during our survey. Many of the species that are no longer observed in the Sangamon are intolerant of poor water quality and turbidity (Barbour et al. 1999) and historical degrading of the Sangamon River is likely largely to blame for their disappearance.

Vermilion River Basin

Habitat changes in the tributaries of the Vermilion River basin are much like those observed in the other basins of Champaign County. These streams appear to have shifted from narrow and shallow to wider and deeper channels, while substrates that were once more diverse are now dominated by sand and gravel. Many of the streams in the Vermilion basin had been subjected to decades of pollution that likely caused the disappearance of most of the species lost (Baker 1922; Smith 1968). However, in his examination of species composition from 40 sites collected between 1876 and 1998, Retzer (2005) reported only four extirpations from the Vermilion basin, which was equivalent to only 8% of the native fish fauna of the basin. Many fish species have either recently expanded their ranges or have been discovered for the first time in the Vermilion basin (Tiemann 2008; Tiemann et al. 2015, 2021), and it is likely a product of habitat as the Vermilion basin is one of the least altered systems in Illinois (Retzer 2005). Conservation activities, like dam removal (i.e., Smith et al. 2017), are occurring throughout the basin. The discovery of Bluebreast Darter, as well as the Eastern Sand Darter (Tiemann et al. 2020) in the Salt Fork in Champaign County and the reappearance of species like Bigeye Chub suggest that refuge populations have occurred elsewhere in the Vermilion basin. However, changes in habitat could deter the natural recovery of other species in the Vermilion basin.

Changes in habitat are likely to blame for the decrease in Fantail Darter in the Vermilion basin. Fantail was observed in around 10% of sites in the Vermilion during both Thompson and Hunt (1930) and Larimore and Smith (1963), indicating that it likely was still present in areas that were not affected by pollutants. While still present in Vermilion County (Retzer 2005), neither the Larimore and Bayley (1996) survey nor ours was able to collect Fantails in the Vermilion basin in Champaign County. Smith (1979) states that this species is primarily found in shallow riffles of smaller tributaries. Over the span of the project, the tributaries of the Vermilion basin have become deeper. No sites during our survey were measured under 0.25 m in depth, although the proportion of sites during the Larimore and Bayley (1996) survey was 0.50. The lack of Fantail Darters during the Larimore and Bayley (1996) survey, despite there apparently being adequate habitat, is unexplainable.

Species gained by the Vermilion basin largely mirror those seen in the other basins of Champaign County. Red Shiner was observed in the Vermilion basin during the last two surveys. Page and Smith (1970) suggested that this species was ecologically incompatible with Spotfin Shiner (*Cyprinella spiloptera*). The appearance of the Red Shiner in the Vermilion basin has not appeared to affect populations of Spotfin Shiner in Champaign County. Red Shiner was more prevalent and abundant during the Larimore and Bayley (1996) sampling than was found during our survey. Spotfin Shiners increased in both relative abundance (from 5% to 8%) and occurrence (from 45% of sites to 79%) between the Larimore and Smith (1963) and Larimore and Bayley (1996) surveys, when Red Shiner was likely first introduced. Relative abundance and occurrence of Red Shiners then dropped between Larimore and Bayley (1996) and our survey, while both remained constant for the Spotfin Shiner over the same time period.

SUMMARY

To our knowledge, the Fishes of Champaign County is the longest long-term dataset on fishes in the United States. With data from the 1900s, 1930s, 1960s, 1990s, and now 2010s, we can continue to understand how fishes assemblages respond to a highly altered, ever-changing landscape. Because of anthropogenic activities, significant alterations to aquatic ecosystems, including shifts in fish species richness and distributions, have occurred in Champaign County over the last 125 years.

Dredging and channelization is the most significant alteration in Champaign County since pre-settlement. More than 80% of the land in Champaign County has been incorporated into drainage districts. Most of these transformations have affected the physicochemical aspects of headwater streams in the county. However, through head-cutting, these effects have cascaded downstream and have altered higher-order, unchannelized streams. Many Champaign County streams have shifted from narrow and shallow channels with diverse substrates, to wider and deeper channels dominated by sand and gravel substrates. These changes have caused shifts in the fish community. For example, in the Sangamon River basin, Slender Madtom and Banded Darter, two species associated with larger substrates, have been replaced by the Freckled Madtom and Logperch, which are two species that prefer relatively finer substrates. Also, some species, like Mississippi Silvery Minnow and Bluntnose Darter, appear to have disappeared entirely in the county because of habitat alterations.

Champaign County also has seen an increase in urbanization during the last century. For example, the Embarras River basin has seen an increase in urbanization from 0.4% in the 1950s to 6.0% in the 2010s. Also, some entire streams in Champaign County, like Boneyard Creek (Vermilion River basin) reside in an urban environment. These increases in urbanization make stream more vulnerable to pollutant spills, thus increasing the likelihood of fish kills. A recent example occurred in the Saline Branch (Vermilion River basin) in the early 2000s, when a large ammonia release from a wastewater effluent affected more than 10 km of stream and was responsible for approximately 80,000 fishes killed. These pollution events, and their subsequent remedies, have shown effects that last on the decade scale and perhaps more permanent time scales, as many species of fishes appear to have disappeared from Champaign County entirely.

The anthropogenetic disturbances witnessed in Champaign County have shifted fish assemblages over the 125 years. Natural resource agencies and concerned citizens have begun mitigating the above anthropogenic disturbances, and fish assemblages have responded. For example, several rare and imperiled species, like the Bigeye Chub and Eastern Sand Darter, have expanded their ranges within the Vermilion River basin since 2000. However, with continued urbanization and climate change affecting our world, continuation of this project will hopefully continue to provide valuable data on the response of fish communities to an ever-changing landscape.

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APPENDIX 1 – SPECIES PRESENCE/ABSENCE TABLES WITH ANNOTATED LIST OF FISHES

TABLE 1 Fishes recorded from the Embarras River basin in Champaign County during each of the five surveys. Species recorded = + ; species not distinguished by collector but may have occurred = ?; undistinguished by collector but preserved specimen contain species = ?+; no record = blank. Gray shading indicates introduced species.

Family *Species*	Forbes and Richardson 1899 – 1901	Thompson and Hunt 1928 – 1929	Larimore and Smith 1959 – 1960	Larimore and Bayley 1987 – 1988	Sherwood and others 2012 – 2015
Clupeidae					
Dorosoma cepedianum Gizzard Shad				+	+
Leuciscidae					
Campostoma anomalum Central Stoneroller		+	+	+	+
Cyprinella spiloptera Spotfin Shiner	?	?	+	+	+
Cyprinella whipplei Steelcolor Shiner	?	?	+	+	+
Ericymba buccata Silverjaw Minnow	+	+	+	+	+
Hybopsis amblops Bigeye Chub		+			
Luxilus chrysocephalus Striped Shiner		+	+	+	+
Lythrurus fumeus Ribbon Shiner				+	
Lythrurus umbratillis Redfin Shiner		+	+	+	+
Nocomis biguttatus Hornyhead Chub					+
Notemigonus crysoleucas Golden Shiner		+	+	+	+
Notropis stramineus Sand Shiner	+	+	+	+	+
Phenacobius mirabilis Suckermouth Minnow	+		+		+
Pimephales notatus Bluntnose Minnow	+	+	+	+	+

(Table 1 continued)

Family / *Species*	Forbes and Richardson 1899 – 1901	Thompson and Hunt 1928 – 1929	Larimore and Smith 1959 – 1960	Larimore and Bayley 1987 – 1988	Sherwood and others 2012 – 2015
Pimephales promelas Fathead Minnow				+	+
Semotilus atromaculatus Creek Chub	+	+	+	+	+
Cyprinidae					
Cyprinus carpio Common Carp		+	+	+	+
Catostomidae					
Carpiodes cyprinus Quillback		+		+	
Carpiodes velifer Highfin Carpsucker					+
Catostomus commersonii White Sucker		+	+	+	+
Erimyzon oblongus Western Creek Chubsucker	+	+	+	+	+
Hypentelium nigricans Northern Hog Sucker		+	+	+	+
Minytrema melanops Spotted Sucker				+	+
Moxostoma duquesnei Black Redhorse		?		+	
Moxostoma erythrurum Golden Redhorse		?		+	+
Ictaluridae					
Ameiurus melas Black Bullhead		+		+	
Ameiurus natalis Yellow Bullhead	+		+	+	+
Ictalurus punctatus Channel Catfish				+	+
Noturus miurus Brindled Madtom			+	+	+

(Table 1 continued)

Family *Species*	Forbes and Richardson 1899 – 1901	Thompson and Hunt 1928 – 1929	Larimore and Smith 1959 – 1960	Larimore and Bayley 1987 – 1988	Sherwood and others 2012 – 2015
Esocidae					
Esox americanus Grass Pickerel		+	+	+	+
Aphredoderidae					
Aphredoderus sayanus Pirate Perch		+	+	+	+
Fundulidae					
Fundulus notatus Blackstripe Topminnow	+	+	+	+	+
Poeciliidae					
Gambusia affinis Western Mosquitofish					+
Atherinidae					
Labidesthes sicculus Brook Silverside					+
Centrarchidae					
Lepomis cyanellus Green Sunfish	+	+	+	+	+
Lepomis macrochirus Bluegill				+	+
Lepomis megalotis Longear Sunfish		+	+	+	+
Lepomis microlophus Redear Sunfish					+
Micropterus punctulatus Spotted Bass				+	+
Micropterus salmoides Largemouth Bass					+
Percidae					
Etheostoma asprigene Mud Darter				+	
Etheostoma blennioides Greenside Darter		+	+	+	+

(Table 1 continued)

Family *Species*	Forbes and Richardson 1899 – 1901	Thompson and Hunt 1928 – 1929	Larimore and Smith 1959 – 1960	Larimore and Bayley 1987 – 1988	Sherwood and others 2012 – 2015
Ethostoma caeruleum Rainbow Darter	?	?	+	+	+
Etheostoma nigrum Johnny Darter	+	+	+	+	+
Etheostoma spectabile Orangethroat Darter	?	?	+		+
Percina caprodes Logperch			+		
Percina maculata Blackside Darter		+	+	+	+
Percina phoxocephala Slenderhead Darter				+	
Percina sciera Dusky Darter				+	+

TABLE 2 Fishes recorded from the Kaskaskia River basin in Champaign County during each of the five surveys. Species recorded = + ; species not distinguished by collector but may have occurred = ?; undistinguished by collector but preserved specimen contain species = ?+; no record = blank. Gray shading indicates introduced species.

Family / *Species*	Forbes and Richardson 1899 – 1901	Thompson and Hunt 1928 – 1929	Larimore and Smith 1959 – 1960	Larimore and Bayley 1987 – 1988	Sherwood and others 2012 – 2015
Hiodontidae					
Hiodon alosoides Goldeye		+			
Clupeidae					
Dorosoma cepedianum Gizzard Shad	+				
Leuciscidae					
Campostoma anomalum Central Stoneroller		+	+	+	+
Cyprinella lutrensis Red Shiner			+	+	+
Cyprinella spiloptera Spotfin Shiner	?	?	+		+
Cyprinella whipplei Steelcolor Shiner	?	?		+	+
Ericymba buccata Silverjaw Minnow	+	+	+	+	+
Hybognathus nuchalis Mississippi Silvery Minnow		+	+		
Luxilus chrysocephalus Striped Shiner		+	+	+	+
Lythrurus umbratilis Redfin Shiner	+	+	+	+	+
Nocomis biguttatus Hornyhead Chub		+	+	+	+
Notemigonus crysoleucas Golden Shiner	+	+	+	+	+
Notropis dorsalis Bigmouth Shiner			+	+	
Notropis stramineus Sand Shiner		+	+	+	+

(Table 2 continued)

Family *Species*	Forbes and Richardson 1899 – 1901	Thompson and Hunt 1928 – 1929	Larimore and Smith 1959 – 1960	Larimore and Bayley 1987 – 1988	Sherwood and others 2012 – 2015
Opsopoeodus emiliae Pugnose Minnow		+			
Phenacobius mirabilis Suckermouth Minnow	+	+	+	+	+
Pimephales notatus Bluntnose Minnow	+	+	+	+	+
Pimephales promelas Fathead Minnow			+		
Semotilus atromaculatus Creek Chub		+	+	+	+
Cyprinidae					
Carassius auratus Goldfish			+		
Cyprinus carpio Common Carp			+	+	+
Catostomidae					
Carpiodes cyprinus Quillback	+				+
Carpiodes velifer Highfin Carpsucker					+
Catostomus commersonii White Sucker		+	+	+	+
Erimyzon oblongus Western Creek Chubsucker	+	+	+	+	+
Hypentelium nigricans Northern Hog Sucker		+	+	+	+
Minytrema melanops Spotted Sucker	+	+			
Moxostoma erythrurum Golden Redhorse				+	+
Moxostoma macrolepidotum Shorthead Redhorse		+			

(Table 2 continued)

Family *Species*	Forbes and Richardson 1899 – 1901	Thompson and Hunt 1928 – 1929	Larimore and Smith 1959 – 1960	Larimore and Bayley 1987 – 1988	Sherwood and others 2012 – 2015
Ictaluridae					
Ameiurus melas Black Bullhead	+	+	+	+	
Ameiurus natalis Yellow Bullhead	+	+	+	+	+
Ictalurus punctatus Channel Catfish					+
Noturus gyrinus Tadpole Madtom	+		+	+	+
Esocidae					
Esox americanus Grass Pickerel	+	+	+	+	+
Aphredoderidae					
Aphredoderus sayanus Pirate Perch		+	+	+	+
Fundulidae					
Fundulus notatus Blackstripe Topminnow	+	+	+	+	+
Moronidae					
Morone mississippiensis Yellow Bass			+		
Poeciliidae					
Gambusia affinis Western Mosquitofish					+
Atherinidae					
Labidesthes sicculus Brook Silverside					+
Centrarchidae					
Lepomis cyanellus Green Sunfish	+	+	+	+	+
Lepomis gulosus Warmouth	+				

(Table 2 continued)

Family *Species*	Forbes and Richardson 1899 – 1901	Thompson and Hunt 1928 – 1929	Larimore and Smith 1959 – 1960	Larimore and Bayley 1987 – 1988	Sherwood and others 2012 – 2015
Lepomis humilis Orangespotted Sunfish	+			+	
Lepomis macrochirus Bluegill			+	+	+
Lepomis megalotis Longear Sunfish	+	+	+	+	+
Lepomis microlophus Redear Sunfish			+		
Micropterus salmoides Largemouth Bass				+	+
Pomoxis annularis White Crappie				+	+
Pomoxis nigromaculatus Black Crappie	+				+
Percidae					
Etheostoma caeruleum Rainbow Darter			+		
Etheostoma chlorosoma Bluntnose Darter		+			
Etheostoma nigrum Johnny Darter		+	+	+	+
Etheostoma spectabile Orangethroat Darter			+	+	+
Percina caprodes Logperch		+	+	+	+
Percina maculata Blackside Darter		+	+	+	
Percina phoxocephala Slenderhead Darter				+	+
Sciaenidae					
Aplodinotus grunniens Freshwater Drum				+	+

TABLE 3 Fishes recorded from the Sangamon River basin in Champaign County during each of the five surveys. Species recorded = + ; species not distinguished by collector but may have occurred = ?; undistinguished by collector but preserved specimen contain species = ?+; no record = blank. Gray shading indicates introduced species.

Family *Species*	Forbes and Richardson 1899 – 1901	Thompson and Hunt 1928 – 1929	Larimore and Smith 1959 – 1960	Larimore and Bayley 1987 – 1988	Sherwood and others 2012 – 2015
Lepisosteidae					
Lepisosteus osseus Longnose Gar				+	+
Lepisosteus platostomus Shortnose Gar				+	
Clupeidae					
Dorosoma cepedianum Gizzard Shad		+	+	+	+
Leuciscidae					
Campostoma anomalum Central Stoneroller	+	+	+	+	+
Cyprinella lutrensis Red Shiner			+	+	+
Cyprinella spiloptera Spotfin Shiner	?	?	+	+	+
Cyprinella whipplei Steelcolor Shiner	?	?	+	+	+
Ericymba buccata Silverjaw Minnow		+	+	+	
Hybognathus nuchalis Mississippi Silvery Minnow	+				
Hybopsis amnis Pallid Shiner		+			
Luxilus chrysocephalus Striped Shiner	+	+	+	+	+
Lythrurus umbratilis Redfin Shiner	+	+	+	+	+
Nocomis biguttatus Hornyhead Chub	+	+	+	+	+
Notemigonus crysoleucas Golden Shiner	+	+	+	+	+

(Table 3 continued)

Family *Species*	Forbes and Richardson 1899 – 1901	Thompson and Hunt 1928 – 1929	Larimore and Smith 1959 – 1960	Larimore and Bayley 1987 – 1988	Sherwood and others 2012 – 2015
Notropis dorsalis Bigmouth Shiner		+	+	+	+
Notropis heterolepis Blacknose Shiner	+				
Notropis stramineus Sand Shiner	+	+	+	+	+
Notropis volucellus Mimic Shiner			+		
Phenacobius mirabilis Suckermouth Minnow	+	+	+	+	+
Pimephales notatus Bluntnose Minnow	+	+	+	+	+
Pimephales promelas Fathead Minnow	+	+	+		
Pimephales vigilax Bullhead Minnow	+	+			+
Semotilus atromaculatus Creek Chub	+	+	+	+	+
Cyprinidae					
Cyprinus carpio Common Carp	+	+	+	+	+
Catostomidae					
Carpiodes carpio River Carpsucker				+	
Carpiodes cyprinus Quillback	+	+	+	+	+
Carpiodes velifer Highfin Carpsucker		+	+	+	+
Catostomus commersonii White Sucker	+	+	+	+	+
Erimyzon oblongus Western Creek Chubsucker	+	+	+	+	+

(Table 3 continued)

Family *Species*	Forbes and Richardson 1899 – 1901	Thompson and Hunt 1928 – 1929	Larimore and Smith 1959 – 1960	Larimore and Bayley 1987 – 1988	Sherwood and others 2012 – 2015
Hypentelium nigricans Northern Hog Sucker	+	+	+	+	+
Ictiobus bubalus Smallmouth Buffalo					+
Ictiobus cyprinellus Bigmouth Buffalo		+		+	
Ictiobus niger Black Buffalo		+			
Minytrema melanops Spotted Sucker	+				
Moxostoma anisurum Silver Redhorse			+	+	+
Moxostoma duquesnei Black Redhorse	?	?	+	+	
Moxostoma erythrurum Golden Redhorse	?	?	+	+	+
Semotilus atromaculatus Shorthead Redhorse		+	+	+	+
Ictaluridae					
Ameiurus melas Black Bullhead	+	+		+	+
Ameiurus natalis Yellow Bullhead		+	+	+	+
Ictalurus punctatus Channel Catfish	+	+	+	+	+
Noturus exilis Slender Madtom		+			
Noturus flavus Stonecat	+	+	+	+	+
Noturus gyrinus Tadpole Madtom	+		+	+	+
Noturus nocturnus Freckled Madtom				+	+

(Table 3 continued)

Family *Species*	Forbes and Richardson 1899 – 1901	Thompson and Hunt 1928 – 1929	Larimore and Smith 1959 – 1960	Larimore and Bayley 1987 – 1988	Sherwood and others 2012 – 2015
Pylodictis olivaris Flathead Catfish			+	+	+
Esocidae					
Esox americanus Grass Pickerel		+		+	+
Aphredoderidae					
Aphredoderus sayanus Pirate Perch		+	+	+	+
Fundulidae					
Fundulus notatus Blackstripe Topminnow	+	+	+	+	+
Moronidae					
Morone chrysops White Bass				+	
Morone mississippiensis Yellow Bass			+		
Centrarchidae					
Ambloplites rupestris Rock Bass			+	+	+
Lepomis cyanellus Green Sunfish	+	+	+	+	+
Lepomis humilis Orangespotted Sunfish	+	+		+	
Lepomis macrochirus Bluegill			+	+	+
Lepomis megalotis Longear Sunfish		+	+	+	+
Lepomis microlophus Redear Sunfish					+
Micropterus dolomieu Smallmouth Bass		+	+	+	+
Micropterus salmoides Largemouth Bass			+	+	+

(Table 3 continued)

Family *Species*	Forbes and Richardson 1899 – 1901	Thompson and Hunt 1928 – 1929	Larimore and Smith 1959 – 1960	Larimore and Bayley 1987 – 1988	Sherwood and others 2012 – 2015
Pomoxis annularis White Crappie	+	+	+	+	+
Pomoxis nigromaculatus Black Crappie	+	+		+	+
Percidae					
Etheostoma asprigene Mud Darter	+		+		+
Etheostoma caeruleum Rainbow Darter	?	?			
Etheostoma flabellare Fantail Darter		+	+	+	+
Etheostoma gracile Slough Darter		+			
Etheostoma nigrum Johnny Darter	+	+	+	+	+
Etheostoma spectabile Orangethroat Darter	?	?	+	+	+
Etheostoma zonale Banded Darter		+	+		
Percina caprodes Logperch			+	+	+
Percina maculata Blackside Darter	+	+	+	+	+
Percina phoxocephala Slenderhead Darter	+	+	+	+	+
Percina sciera Dusky Darter	+				+
Sander vitreus Walleye				+	+
Sciaenidae					
Aplodinotus grunniens Freshwater Drum		+	+	+	+

TABLE 4 Fishes recorded from the Vermilion River basin in Champaign County during each of the five surveys. Species recorded = + ; species not distinguished by collector but may have occurred = ?; undistinguished by collector but preserved specimen contain species = ?+; no record = blank. Gray shading indicates introduced species.

Family *Species*	Forbes and Richardson 1899 – 1901	Thompson and Hunt 1928 – 1929	Larimore and Smith 1959 – 1960	Larimore and Bayley 1987 – 1988	Sherwood and others 2012 – 2015
Lepisosteidae					
Lepisosteus osseus Longnose Gar			+		
Clupeidae					
Dorosoma cepedianum Gizzard Shad				+	+
Leuciscidae					
Campostoma anomalum Central Stoneroller	+	+	+	+	+
Cyprinella lutrensis Red Shiner				+	+
Cyprinella spiloptera Spotfin Shiner	?	+	+	+	+
Cyprinella whipplei Steelcolor Shiner	?	?	+	+	+
Ericymba buccata Silverjaw Minnow	+	+	+	+	+
Hybognathus nuchalis Mississippi Silvery Minnow	+				
Hybopsis amblops Bigeye Chub	+	+			+
Luxilus chrysocephalus Striped Shiner	+	+	+	+	+
Lythrurus umbratilis Redfin Shiner	+	+	+	+	+
Macrhybopsis storeriana Silver Chub	+				
Nocomis biguttatus Hornyhead Chub	+	+	+	+	+
Notemigonus crysoleucas Golden Shiner	+	+	+	+	+

(Table 4 continued)

Family *Species*	Forbes and Richardson 1899 – 1901	Thompson and Hunt 1928 – 1929	Larimore and Smith 1959 – 1960	Larimore and Bayley 1987 – 1988	Sherwood and others 2012 – 2015
Notropis atherinoides Emerald Shiner		+			
Notropis boops Bigeye Shiner		+			
Notropis dorsalis Bigmouth Shiner			+		
Notropis percobromus (rubellus) Carmine (Rosyface) Shiner			+		+
Notropis stramineus Sand Shiner	+	+	+	+	+
Notropis volucellus Mimic Shiner			+		
Phenacobius mirabilis Suckermouth Minnow	+	+	+	+	+
Pimephales notatus Bluntnose Minnow	+	+	+	+	+
Pimephales promelas Fathead Minnow		+		+	+
Pimephales vigilax Bullhead Minnow		+			+
Semotilus atromaculatus Creek Chub	+	+	+	+	+
Cyprinidae					
Carassius auratus Goldfish			+	+	
Cyprinus carpio Common Carp	+	+	+	+	+
Catostomidae					
Carpiodes carpio River Carpsucker				+	+
Carpiodes cyprinus Quillback	+		+	+	+

(Table 4 continued)

Family *Species*	Forbes and Richardson 1899 – 1901	Thompson and Hunt 1928 – 1929	Larimore and Smith 1959 – 1960	Larimore and Bayley 1987 – 1988	Sherwood and others 2012 – 2015
Carpiodes velifer Highfin Carpsucker		+	+	+	+
Catostomus commersonii White Sucker	+	+	+	+	+
Erimyzon oblongus Western Creek Chubsucker	+	+	+	+	+
Hypentelium nigricans Northern Hog Sucker	+	+	+	+	+
Minytrema melanops Spotted Sucker	+	+		+	+
Moxostoma anisurum Silver Redhorse			+	+	+
Moxostoma duquesnei Black Redhorse	?	?		+	+
Moxostoma erythrurum Golden Redhorse	?	?	+	+	+
Moxostoma macrolepidotum Shorthead Redhorse	+			+	+
Ictaluridae					
Ameiurus melas Black Bullhead	+	+		+	+
Ameiurus natalis Yellow Bullhead	+	+	+	+	+
Ictalurus punctatus Channel Catfish	+		+	+	+
Noturus exilis Slender Madtom		+			
Noturus flavus Stonecat		+	+	+	+
Noturus gyrinus Tadpole Madtom	+	+	+	+	+
Noturus miurus Brindled Madtom	+	+	+	+	+

(Table 4 continued)

Family *Species*	Forbes and Richardson 1899 – 1901	Thompson and Hunt 1928 – 1929	Larimore and Smith 1959 – 1960	Larimore and Bayley 1987 – 1988	Sherwood and others 2012 – 2015
Pylodictis olivaris Flathead Catfish			+		
Esocidae					
Esox americanus Grass Pickerel	+	+	+	+	+
Esox lucius Northern Pike				+	
Fundulidae					
Fundulus notatus Blackstripe Topminnow	+	+	+	+	+
Poeciliidae					
Gambusia affinis Western Mosquitofish			+		+
Atherinidae					
Labidesthes sicculus Brook Silverside	+	+	+		+
Centrarchidae					
Ambloplites rupestris Rock Bass			+	+	+
Lepomis cyanellus Green Sunfish	+	+	+	+	+
Lepomis gulosus Warmouth					+
Lepomis humilis Orangespotted Sunfish	+	+	+	+	
Lepomis macrochirus Bluegill		+	+	+	+
Lepomis megalotis Longear Sunfish	+	+	+	+	+
Lepomis microlophus Redear Sunfish				+	+
Micropterus dolomieu Smallmouth Bass		+	+	+	+

(Table 4 continued)

Family *Species*	Forbes and Richardson 1899 – 1901	Thompson and Hunt 1928 – 1929	Larimore and Smith 1959 – 1960	Larimore and Bayley 1987 – 1988	Sherwood and others 2012 – 2015
Micropterus punctulatus Spotted Bass	?	?	+	+	+
Micropterus salmoides Largemouth Bass	?+	?	+	+	+
Pomoxis annularis White Crappie	+		+		
Percidae					
Ammocrypta pellucida Eastern Sand Darter		+	+		+
Etheostoma asprigene Mud Darter	+				
Etheostoma blennioides Greenside Darter	+	+	+	+	+
Etheostoma caeruleum Rainbow Darter	?	?	+	+	+
Etheostoma camurum Bluebreast Darter					+
Etheostoma flabellare Fantail Darter	+	+	+		
Etheostoma nigrum Johnny Darter	+	+	+	+	+
Etheostoma spectabile Orangethroat Darter	?	?	+	+	+
Percina caprodes Logperch	+	+	+		+
Percina maculata Blackside Darter	+	+	+	+	+
Percina phoxocephala Slenderhead Darter		+	+	+	+
Percina sciera Dusky Darter				+	+

TABLE 5 Fishes recorded from the Little Vermilion River basin in Champaign County during four surveys. Species recorded = + ; species not distinguished by collector but may have occurred = ?; undistinguished by collector but preserved specimen contain species = ?+; no record = blank. Gray shading indicates introduced species.

Family *Species*	Thompson and Hunt 1928 – 1929	Larimore and Smith 1959 – 1960	Larimore and Bayley 1987 – 1988	Sherwood and others 2012 – 2015
Leuciscidae				
Cyprinella spiloptera Spotfin Shiner	?	+		+
Cyprinella whipplei Steelcolor Shiner	?			
Ericymba buccata Silverjaw Minnow	+			+
Lythrurus umbratilis Redfin Shiner	+	+		+
Notemigonus crysoleucas Golden Shiner	+	+	+	+
Notropis stramineus Sand Shiner		+		+
Pimephales notatus Bluntnose Minnow	+	+		+
Semotilus atromaculatus Creek Chub	+	+		+
Cyprinidae				
Cyprinus carpio Common Carp		+		
Catostomidae				
Catostomus commersonii White Sucker	+			+
Erimyzon oblongus Western Creek Chubsucker	+	+		+
Hypentelium nigricans Northern Hog Sucker		+		
Minytrema melanops Spotted Sucker		+		
Ictaluridae				
Ameiurus melas Black Bullhead	+	+	+	+

(Table 5 continued)

Family *Species*	Thompson and Hunt 1928 – 1929	Larimore and Smith 1959 – 1960	Larimore and Bayley 1987 – 1988	Sherwood and others 2012 – 2015
Ameiurus natalis Yellow Bullhead	+	+	+	
Esocidae				
Esox americanus Grass Pickerel	+	+	+	+
Fundulidae				
Fundulus notatus Blackstripe Topminnow	+	+	+	
Centrarchidae				
Lepomis cyanellus Green Sunfish	+		+	+
Lepomis megalotis Longear Sunfish	+	+	+	+
Percidae				
Etheostoma blennioides Greenside Darter		+		
Etheostoma caeruleum Rainbow Darter	?			
Etheostoma nigrum Johnny Darter	+	+		
Etheostoma spectabile Orangethroat Darter	?	+		+

ANNOTATED LIST OF FISHES

Ninety-six fish species that have been collected in the current or past surveys of the Fishes of Champaign County, or have been observed near the county, are annotated in the below list. Species' synonymies, when different from the current accepted name, are listed for each species. Reexamination of composite species from the Forbes and Richardson (1908) and Thompson and Hunt (1930) collections were performed by Larimore and Smith (1963).

Following each account is a collection summary for each of the five surveys. The two letters refer to the authors of the survey, where FR = Forbes and Richardson (1908), TH = Thompson and Hunt (1930), LS = Larimore and Smith (1963), LB = Larimore and Bayley (1996), and SS = Sherwood and others (our study). The number following the initials indicates the number of locations where the species was observed during that survey. A "?" following initials indicates the exact number of collection locations is unknown due to composite species. Finally, in parentheses are the drainages in which that species was observed.

AMIIDAE

Amia calva Linnaeus, **Bowfin.** Larimore and Smith note that several large Bowfin were captured in Kaufman's Clear Lake (now Kaufman Lake, Champaign Park District). They were initially stocked as a sport fish, but no records have been observed since. LS 1 (Kaskaskia)

ANGUILLIDAE

Anguilla rostrata (Lesueur), **American Eel**. Reported as *Anguilla chrysypa* by Thompson and Hunt (1930), they told of a report of one from the Embarras River near Villa Grove in 1928. The following two surveys did not report this species being taken near Champaign. A 2016 collection of an American Eel in a Vermillion County pond near the Middle Fork of the Vermillion River is the most recent report of this species near Champaign County.

LEPISOSTEIDAE

Lepisosteus osseus (Linnaeus), **Longnose Gar.** Gars were designated as a "trash fish" for much of the 19th and 20th centuries, labeled as voracious predators that hinder populations of more desirable fish species (Forbes and Richardson 1908). Due to this label, gars were the target of eradication by anglers and managers alike. Longnose Gars are the most common gar species in the creeks and small rivers of Illinois (Smith 1979). This species has been collected in the county in each of the last three surveys and thought of as rare in the county by both Larimore and Smith (1963) and Larimore and Bayley (1996). Gar are most efficiently sampled with large river sampling techniques (i.e., boat electrofishing, passive net sets) and though they likely have never been abundant in the streams of Champaign County, the sampling methodologies used during Champaign County surveys could possibly overlook this species. LS 1 (Middle Fork), LB 1 (Sangamon), SS 1 (Sangamon)

Lepisosteus platostomus Rafinesque, **Shortnose Gar**. Shortnose Gars are most common in the larger rivers of Illinois and rarely stray into creeks like the Longnose Gar (Smith 1979). A single individual was collected by Larimore and Bayley (1996), which is the only record from all five surveys. This species is encountered often in the middle and lower reaches of both the Sangamon and Kaskaskia rivers. LB 1 (Sangamon)

HIODONTIDAE

Hiodon alosoides (Rafinesque), **Goldeye**. Named *Hiodon tergisus* by Thompson and Hunt (1930), their collection of one individual from the Kaskaskia River at the Champaign–Douglas County line is the only specimen taken from Champaign County. Typically a riverine species, it has been recently collected in the middle Embarras and Sangamon rivers, downstream of Champaign County. TH 1 (Kaskaskia)

CLUPEIDAE

Dorosoma cepedianum (Lesueur), **Gizzard Shad**. This species has become more common in Champaign County in recent years. Gizzard Shad are commonly stocked as forage for sport fishes and Larimore and Bayley (1996) hypothesize that the increase is due to escapement from reservoirs. FR 1 (Kaskaskia), TH 2 (Sangamon), LS 12 (Embarras, Salt Fork, Sangamon), LB 23 (all drainages), SS 20 (all drainages)

LEUCISCIDAE

Campostoma anomalum (Rafinesque), **Central Stoneroller**. Central Stonerollers have recently shown a slight decrease in Champaign County when compared to previous surveys. The shallow, sandy nature of streams during previous surveys created an ideal environment for this species. As the depth of these streams increased in recent years, the preferred habitat of this species has decreased. This species is still widespread throughout the county. FR 17 (Middle Fork, Salt Fork, Sangamon), TH 64 (all drainages), LS 102 (all drainages except Little Vermilion), LB 75 (all drainages), SS 52 (all drainages except Little Vermilion)

Cyprinella lutrensis (Baird & Girard) **Red Shiner.** Named *Notropis lutrensis* by Larimore and Smith (1963), their 1959 collection was the first record of this species in Champaign County. Primarily an Illinois River basin species, it was noted as expanding eastward by Page and Smith (1970) to the detriment of *Cyprinella spiloptera* and *Cyprinella whipplei*. Larimore and Bayley (1996) recorded it at four sites on the Middle Fork and our survey only recorded it at one site on the Salt Fork near Rantoul, in the Vermilion basin. Although still located in the Vermilion basin, it does not appear to be hindering either *C. spiloptera* or *C. whipplei* in the Vermilion basin in Champaign County. LS 21 (Kaskaskia, Sangamon), LB 13 (Kaskaskia, Middle Fork, Sangamon), SS 12 (Kaskaskia, Salt Fork, Sangamon)

Cyprinella spiloptera (Cope) **Spotfin Shiner**. This species was not differentiated from *Cyprinella whipplei* at the time of the Forbes and Richardson (1908) or Thompson and Hunt (1930) surveys and was named as *Notropis whipplii* by both. Larimore and Smith (1963) examined 34 extant collections made by Thompson and Hunt (1930) and determined that 32 contained *C. spiloptera*. This species was labeled as *Notropis spilopterus spilopterus* × *hypsisomatus* by Larimore and Smith (1963), although there are no recognized subspecies of this species today. This species is relatively common in Champaign County and appears to be stable in all drainages. FR ?, TH 32? (Kaskaskia, Middle Fork, Salt Fork, Sangamon), LS 63 (all drainages), LB 75 (Embarras, Middle Fork, Salt Fork, Sangamon), SS 64 (all drainages)

Cyprinella whipplei Girard **Steelcolor Shiner**. Combined with *Cyprinella spiloptera* during the first two surveys (see *C. spiloptera* above). Larimore and Smith (1963) determined this species was present at 16 Thompson and Hunt (1930) sites. Not as common in the county as *C. spiloptera* but appears to be remaining stable. FR ?, TH 16 (all but Little Vermilion), LS 27 (Embarras, Middle Fork, Salt Fork, Sangamon), LB 20 (all drainages), SS 28 (all but Little Vermilion)

Ericymba buccata Cope, **Silverjaw Minnow.** Reported as *Ericymba buccatus* by previous authors, the Silverjaw Minnow is one of the most common species in the county. It has declined in the Sangamon basin over the century and was not taken by us in this basin during the recent survey, although there have still been recent collections in the basin. Larimore and Bayley (1996) noted that this species prefers clear, sandy headwater streams, thus the morphological changes in streams that have occurred over this time period could account for its decline. FR 22 (Embarras, Kaskaskia, Middle Fork, Salt Fork), TH 79 (all drainages), LS 78 (all drainages except Little Vermilion), LB 48 (all drainages), SS 31 (all drainages except Sangamon)

Hybognathus nuchalis Agassiz **Mississippi Silvery Minnow**. This species was recorded from all but the Little Vermilion and Embarras basins in Champaign County by Forbes and Richardson (1908) and Thompson and Hunt (1930). Once most prevalent from Sangamon and Kaskaskia rivers in Illinois, this species has all but vanished from recent collections in those basins. Etnier et al. (1979) noted a similar disappearance of this species from the Tennessee River basin after the construction of impoundments. The construction of impoundments on the Sangamon and Kaskaskia rivers may be the cause of this species declining in both basins. This species is still present in the Embarras River, below the Charleston dam. One extant specimen from the Larimore collection in 1987 on Hayes Branch (Embarras basin) was identified as *H. nuchalis* and represents the last known collection of this species in the county. FR 4 (Middle Fork, Salt Fork, Sangamon), TH 9 (Kaskaskia), LS 9 (Kaskaskia), LB 1 (Embarras)

Hybopsis amblops (Rafinesque), **Bigeye Chub**. Although the Bigeye Chub was once thought to be nearly extirpated from Illinois, it has been becoming more abundant in the Vermilion and Little Vermilion basins. The recent collections of this species in Champaign County are the first such records since 1928. It is currently listed as threatened in Illinois. FR 6 (Middle Fork, Salt Fork), TH 8 (Embarras, Middle Fork, Salt Fork), SS 3 (Salt Fork)

Hybopsis amnis (Hubbs & Greene), **Pallid Shiner**. Referred to *Notropis heterolepis, N. cayuga,* and *N. c. atrocaudalis* by Thompson and Hunt (1930) and *N. amnis amnis* by Larimore and Smith (1963). This species is rare throughout Illinois with the exception of the Kankakee River. The Thompson and Hunt (1930) collections are the only known records of this species in Champaign County. TH 3 (Sangamon)

Luxilus chrysocephalus Rafinesque, **Striped Shiner**. Reported as *Notropis cornutus* by Forbes and Richardson (1908) and Thompson and Hunt (1930) and *N. chrysocephalus* by Larimore and Smith (1963), this species is overly common in the streams of Champaign County. FR 9 (Salt Fork, Sangamon), TH 54 (Kaskaskia, Middle Fork, Salt Fork, Sangamon), LS 64 (all drainages), LB 103 (all drainages), SS 70 (all but Little Vermilion)

Lythrurus fumeus (Evermann), **Ribbon Shiner**. First collected in Champaign County by Larimore and Smith (1963), it has only been observed in the Embarras River basin. Although Larimore and Bayley (1996) collected this species at three sites, we did not observe any during the recent survey. LS 1 (Embarras), LB 3 (Embarras)

Lythrurus umbratilis (Girard), **Redfin Shiner**. Labeled as *Notropis umbratilis atripes* by Forbes and Richardson (1908) and Thompson and Hunt (1930) and *N. u. cyanocephalus* by Larimore and Smith (1963). This species is relatively common throughout the county. FR 8 (Salt Fork, Sangamon), TH 69 (all drainages), LS 97 (all drainages), LB 67 (all drainages), SS 47 (all drainages)

Macrhybopsis storeriana (Kirtland), **Silver Chub**. Typically a large riverine species, the only records of Silver Chub in Champaign County were taken by Forbes and Richardson (1908) (named *Hybopsis storeriana* by Larimore and Smith [1963]). FR 2 (Middle Fork, Salt Fork)

Nocomis biguttatus (Kirtland), **Hornyhead Chub**. Reported as *Hybopsis kentuckiensis* by Forbes and Richardson (1908) and Thompson and Hunt (1930) and *H. biguttata* by Larimore and Smith (1963). Larimore and Bayley (1996) stated that the map dot representing this species in the Embarras from Forbes and Richardson (1908) and Smith (1979) was an error, due to the absence of this species in the Embarras from all Champaign County surveys. Our survey included two sites in the Embarras basin in which eight Hornyhead Chub were collected. FR 10 (Middle Fork, Salt Fork, Sangamon), TH 46 (Kaskaskia, Middle Fork, Salt Fork, Sangamon), LS 70 (Kaskaskia, Middle Fork, Salt Fork, Sangamon), LB 57 (Kaskaskia, Salt Fork, Sangamon), SS 44 (all but Little Vermilion)

Notemigonus crysoleucas (Mitchill), **Golden Shiner.** Named *Abramis crysoleucas* by Forbes and Richardson (1908) and Thompson and Hunt (1930). Although tolerant of poor water conditions, this species thrives in clear, vegetated habitats of low-gradient streams and ditches (Pflieger 1997). Its distribution in the county appears to have decreased from Larimore and Smith (1963) and Larimore and Bayley (1996), to which the latter hypothesized that a reduction in aquatic vegetation in the drainages' ditches is to blame. The distribution looks to have expanded in the recent survey. FR 20 (Kaskaskia, Middle Fork, Salt Fork, Sangamon), TH 41 (all drainages), LS 46 (all drainages), LB 12 (all drainages except Middle Fork), SS 19 (all drainages)

Notropis atherinoides Rafinesque, **Emerald Shiner.** A species common in the larger creeks and rivers of Illinois, it has been rarely taken in Champaign County. Only seven collections of this species have occurred over all surveys, all prior to the Larimore and Bayley (1996) survey. FR 2 (Salt Fork, Sangamon), TH 3 (Middle Fork), LS 2 (Embarras, Salt Fork)

Notropis boops Gilbert, **Bigeye Shiner**. Referred to as *Notropis illecebrosus* by Forbes and Richardson (1908) and Thompson and Hunt (1930). Bigeye Shiner is considered Endangered in Illinois and still inhabits areas of the Vermilion and Little Vermilion drainages. No individuals have been collected in the county since 1928, although a collection from 2011 occurred in the Little Vermilion near Sidell, (10.5 km 6.5 miles) east of Champaign County. FR 1 (Salt Fork), TH 2 (Middle Fork)

Notropis dorsalis (Agassiz), **Bigmouth Shiner**. Referred to as *Notropis gilberti* by Forbes and Richardson (1908) and Thompson and Hunt (1930). The distribution of this species appears to be declining in the county. Its distribution in the county drastically increased between the Thompson and Hunt (1930) and Larimore and Smith (1963) surveys and has gradually declined since. FR 1 (Salt Fork), TH 5 (Sangamon), LS 28 (Kaskaskia, Middle Fork, Sangamon), LB 18 (Kaskaskia, Sangamon), SS 5 (Embarras, Salt Fork, Sangamon)

Notropis heterolepis Eigenmann & Eigenmann, **Blacknose Shiner**. Reported as *Notropis cayuga* and *N. c. atrocaudalis* by Forbes and Richardson (1908), their collections are the only records of this species in the county. Records of this species from Thompson and Hunt (1930) were misidentified *Hybopsis amnis*. FR 2 (Salt Fork, Sangamon)

Notropis rubellus (Agassiz), **Rosyface Shiner**. Recent phylogenetic studies of the *N. rubellus* complex have exposed uncertainties in the distribution of this species throughout its range. These analyses identify the potential of multiple species occurring and there is some uncertainty on whether the species present in Illinois is *N. rubellus* or *N. percobromus.* We follow the analyses of Berendzen et al. (2008), which places *N. rubellus* in Illinois. Most often found in large creeks, this species has increased in the Vermilion River basin since the Thompson and Hunt (1930) survey. TH 3 (Middle Fork), LS 6 (Middle Fork), LB 2 (Middle Fork, Salt Fork), SS 14 (Middle Fork, Salt Fork)

Notropis stramineus (Cope), **Sand Shiner.** Often misnamed as *Notropis blennius* by Forbes and Richardson (1908) and Thompson and Hunt (1930), this species was represented in many of the latter's *N. blennius* collections. Also named *Notropis deliciosus* and *N. ludibundus* by previous authors. This species is one of the most abundant species in Champaign County. FR ?, TH 32 (all drainages except Little Vermilion), LS 93 (all drainages), LB 75 (all drainages), SS 55 (all drainages)

Notropis volucellus (Cope), **Mimic Shiner**. Also included within the extant Thompson and Hunt (1930) *Notropis blennius* collections (2 locations). This species is most often located in the boarder rivers of Illinois, although can be taken in larger tributaries. It has not been identified in the county since Larimore and Smith (1963). FR ?, TH 2 (Middle Fork), LS 3 (Middle Fork, Sangamon)

Opsopoeodus emiliae Hay, **Pugnose Minnow**. Only two collections of this species have occurred over the span of these surveys, both being taken by Thompson and Hunt (1930). TH 2 (Kaskaskia)

Phenacobius mirabilis (Girard), **Suckermouth Minnow**. Once generally distributed throughout the county, the Suckermouth Minnow appears to have decreased in recent years. FR 18 (Embarras, Kaskaskia, Salt Fork, Sangamon), TH 25 (Kaskaskia, Middle Fork, Salt Fork, Sangamon), LS 34 (all drainages except Little Vermilion), LB 23 (Kaskaskia, Middle Fork, Salt Fork, Sangamon), SS 3 (Embarras, Salt Fork, Sangamon)

Pimephales notatus (Rafinesque), **Bluntnose Minnow**. Along with the Sand Shiner, the Bluntnose Minnow is one of the most common species in Champaign County. FR 37 (all drainages except Little Vermilion), TH 111 (all drainages), LS 134 (all drainages), LB 111 (all drainages), SS 89 (all drainages)

Pimephales promelas Rafinesque, **Fathead Minnow**. Primarily a species of the Mississippi River drainage in Illinois and until the last two surveys, was only collected in the Sangamon and Kaskaskia River basins. During the Larimore and Bayley (1996) and current surveys, this species was not collected in either basin, but rather in the Embarras and Vermilion basins. Its common use as a bait fish may explain its spread to these basins. Smith (1979) notes that this species does best in the absence of the Bluntnose Minnow, possibly why it is not prevalent in the county. FR 4 (Sangamon), TH 19 (Sangamon), LS 20 (Kaskaskia, Sangamon), LB 4 (Embarras, Salt Fork), SS 2 (Embarras, Salt Fork)

Pimephales vigilax (Baird & Girard), **Bullhead Minnow**. Referred to as *Cliola vigilax* by Forbes and Richardson (1908) and Thompson and Hunt (1930). Primarily thought to be a large riverine species, it was not taken in either of the Larimore surveys. Our survey collected this species at two locations in the county. FR 6 (Sangamon), TH 4 (Salt Fork, Sangamon), SS 2 (Middle Fork, Sangamon)

Semotilus atromaculatus (Mitchill), **Creek Chub**. A prototypical headwater stream species, the Creek Chub is well-adapted to life in historic prairie streams. Its declining distribution in Champaign County is likely due to the loss of headwater habitats. FR 9 (Middle Fork, Salt Fork, Sangamon), TH 101 (all drainages), LS 126 (all drainages), LB 90 (all drainages), SS 49 (all drainages)

CYPRINIDAE

Carassius auratus Linnaeus, **Goldfish**. Goldfish have become established in many rivers and streams in Illinois. There have only been three records of this species during these surveys and the absence of any collections in the most recent survey suggests they have not become established in the county. LS 2 (Kaskaskia, Salt Fork), LB 1 (Salt Fork)

Cyprinus carpio Linnaeus, **Common Carp**. Introduced to Illinois in 1879 (Smith 1979), Common Carp are the most widespread aquatic invasive species in the state. Often associated with poor water quality and degraded streams, it appears to be becoming less prevalent in Champaign County. However, large adults are often seen from the banks and large schools of young carp have been collected in all surveys. FR 4 (Middle Fork, Salt Fork, Sangamon), TH 11 (Embarras, Salt Fork, Sangamon), LS 56 (all drainages), LB 33 (all drainages), SS 16 (Embarras, Kaskaskia, Salt Fork, Sangamon)

CATOSTOMIDAE

Carpiodes carpio (Rafinesque), **River Carpsucker**. Sporadically found in the medium rivers of Illinois, River Carpsuckers are typically found in large rivers. This species is occasionally collected in the larger streams of Champaign County. LS 1 (Middle Fork), LB 5 (Middle Fork, Sangamon), SS 2 (Salt Fork)

Carpiodes cyprinus (Lesueur), **Quillback**. Referred to as *Carpiodes velifer* by Forbes and Richardson (1908) and Thompson and Hunt (1930). Once relatively widespread throughout the county, it appears the distribution of this species has diminished in recent years. FR 10 (Middle Fork, Salt Fork, Sangamon), TH 9 (Middle Fork, Sangamon), LS 27 (Middle Fork, Salt Fork, Sangamon), LB 33 (Embarras, Kaskaskia, Middle Fork, Salt Fork, Sangamon), SS 4 (Salt Fork, Sangamon)

Carpiodes velifer (Rafinesque), **Highfin Carpsucker**. Reported as *Carpiodes difformis* by Forbes and Richardson (1908) and Thompson and Hunt (1930). FR 8 (Kaskaskia, Middle Fork, Salt Fork, Sangamon), TH 4 (Middle Fork, Sangamon), LS 9 (Middle Fork, Salt Fork, Sangamon), LB 11 (Middle Fork, Salt Fork, Sangamon), SS 5 (Embarras, Kaskaskia, Salt Fork, Sangamon)

Catostomus commersoni (Lacepede), **White Sucker.** Tolerant of most aquatic habitats and a range of water quality, White Suckers are the most widespread Sucker in Champaign County. FR 14 (Middle Fork, Salt Fork, Sangamon), TH 63 (all drainages), LS 76 (all drainages except Little Vermilion), LB 41 (all drainages), SS 24 (all drainages)

Erimyzon claviformis (Girard), **Western Creek Chubsucker**. Reported in conjunction with *Erimyzon sucetta oblongus* by Forbes and Richardson (1908) and Thompson and Hunt (1930), as *Erimyzon oblongus claviformis* by Larimore and Smith (1963), and as *Erimyzon oblongus* by Larimore and Bayley (1996). Another typical headwater stream species, it too has shown decreasing distribution in the county. FR 22 (all drainages except Little Vermilion), TH 43 (all drainages), LS 79 (all drainages), LB 59 (all drainages), SS 38 (all drainages)

Hypentelium nigricans (Lesueur), **Northern Hog Sucker**. Referred to as *Catostomus nigricans* by Forbes and Richardson (1908) and Thompson and Hunt (1930). This species can be found almost anywhere there is swift water over coarse gravel in Champaign County. FR 7 (Middle Fork, Salt Fork, Sangamon), TH 27 (all drainages except Little Vermilion), LS 42 (all drainages except Little Vermilion), LB 29 (all drainages), SS 20 (all drainages except Little Vermilion)

Ictiobus bubalus (Rafinesque), **Smallmouth Buffalo**. Typical of larger rivers, this species was only ever taken in the county at one station on the Sangamon River by Forbes and Richardson (1908). Our survey collected this species at two locations on the Sangamon River and a young specimen in the Kaskaskia basin. FR 1 (Sangamon), SS 3 (Kaskaskia, Sangamon)

Ictiobus cyprinellus (Valenciennes), **Bigmouth Buffalo**. Another big river species, this species is rarely collected in Champaign County. Numerous large adults were observed in flooded roadside ditches of the Kaskaskia basin in the spring of 2013. Spring floods had likely triggered them to run upstream to spawn from lower in the Kaskaskia, where they are taken frequently. TH 1 (Sangamon), LB 1 (Sangamon)

Ictiobus niger (Rafinesque), **Black Buffalo**. Reported as *Ictiobus urus* by Thompson and Hunt (1930), their collection of this species on the Sangamon River is the only record of this species in the county. TH 1 (Sangamon)

Minytrema melanops (Rafinesque), **Spotted Sucker**. The distribution of the Spotted Sucker is continuing to expand since the Larimore and Smith (1963) survey. Although Forbes and Richardson (1908) collected it from four basins in the county, it appears to be rebounding in only the Embarras and Vermilion basins. FR 15 (Kaskaskia, Middle Fork, Salt Fork, Sangamon), TH 4 (Kaskaskia, Salt Fork), LS 1 (Little Vermilion), LB 9 (Embarras, Middle Fork, Salt Fork), SS 15 (Embarras, Middle Fork, Salt Fork)

Moxostoma anisurum (Rafinesque), **Silver Redhorse**. Primarily found in the larger streams of Champaign County, Silver Redhorse are not particularly common, although one site on the Salt Fork produced nine large adults during our survey. TH 1 (Sangamon), LS 7 (Salt Fork, Sangamon), LB 11 (Middle Fork, Salt Fork, Sangamon)

Moxostoma duquesnei (Lesueur), **Black Redhorse**. Not distinguished from *Moxostoma erythrurum* by Forbes and Richardson (1908) and Thompson and Hunt (1930), thus there are no records of this species from the first two surveys. It is likely that this species historically occurred in multiple basins throughout the county. It has only been taken in the county during the last two surveys. LB 7 (Embarras, Middle Fork, Salt Fork, Sangamon), SS 10 (Kaskaskia, Middle Fork, Salt Fork)

Moxostoma erythrurum (Rafinesque), **Golden Redhorse**. Referred to as *Moxostoma aureolum* by Forbes and Richardson (1908) and Thompson and Hunt (1930). The Golden Redhorse is the most widespread and abundant Redhorse in the county. FR 11 (Middle Fork, Salt Fork, Sangamon), TH 22 (all drainages except Little Vermilion)

Moxostoma macrolepidotum (Lesueur), **Shorthead Redhorse**. Reported as *Moxostoma breviceps* by Forbes and Richardson (1908) and Thompson and Hunt (1930). Shorthead Redhorse have remained stable in the county through all surveys. FR 4 (Middle Fork, Salt Fork), TH 6 (Kaskaskia, Sangamon), LS 8 (Sangamon), LB 10 (Sangamon), SS 7 (Middle Fork, Salt Fork, Sangamon)

ICTALURIDAE

Ameiurus melas (Rafinesque), **Black Bullhead**. Reported as *Ictalurus melas* by Larimore and Smith (1963). Never overly common in the county, Thompson and Hunt (1930) noted that the Black Bullhead is most prevalent in oxbow ponds near small streams, which have become increasingly rare in Champaign County. FR 12 (Kaskaskia, Middle Fork, Salt Fork, Sangamon), TH 12 (all drainages except Middle Fork), LS 7 (all drainages except Middle Fork), LB 17 (all drainages), SS 10 (Little Vermilion, Salt Fork, Sangamon)

Ameiurus natalis (Lesueur), **Yellow Bullhead**. Referred to as *Ictalurus natalis* by Larimore and Smith (1963). A bullhead of sluggish streams, this species has become much more common over the course of these surveys. FR 6 (Kaskaskia, Salt Fork), TH 15 (all drainages except Embarras), LS 38 (all drainages), LB 69 (all drainages), SS 51 (all drainages except Little Vermilion)

Ameiurus nebulosus (Lesueur), **Brown Bullhead**. The only records of this species in Champaign County are from Larimore and Smith (1963). They note that it was stocked into Franzen's Fishing Lake (location unknown to authors) as a sport fish. LS 1 (Salt Fork)

Ictalurus punctatus (Rafinesque), **Channel Catfish**. The distribution of this popular sport fish has remained constant over all surveys. FR 4 (Middle Fork, Salt Fork, Sangamon), TH 11 (Salt Fork, Sangamon), LS 17 (Middle Fork, Salt Fork, Sangamon), LB 12 (Embarras, Middle Fork, Salt Fork, Sangamon), SS 12 (all drainages except Little Vermilion)

Noturus exilis Nelson, **Slender Madtom**. Reported as *Schilbeodes exilis* by Thompson and Hunt (1930), their two collections are the only records of this species in the county. TH 2 (Middle Fork, Sangamon)

Noturus flavus Rafinesque, **Stonecat**. Stonecats have been frequently collected wherever swift water flows over coarse gravel in the Sangamon and Vermilion basins in Champaign County. FR 1 (Sangamon), TH 5 (Middle Fork, Salt Fork, Sangamon), LS 22 (Middle Fork, Salt Fork, Sangamon), LB 12 (Middle Fork, Salt Fork, Sangamon), SS 14 (Middle Fork, Salt Fork, Sangamon)

Noturus gyrinus (Mitchill), **Tadpole Madtom**. Referred to as *Schilbeodes gyrinus* by Forbes and Richardson (1908) and Thompson and Hunt (1930). This species appears to be increasing in occurrence in the last two surveys. FR 13 (Kaskaskia, Salt Fork, Sangamon), TH 8 (Salt Fork), LS 18 (Kaskaskia, Salt Fork, Sangamon), LB 30 (Kaskaskia, Salt Fork, Sangamon), SS 34 (Kaskaskia, Salt Fork, Sangamon)

Noturus miurus Jordan, **Brindled Madtom**. Reported as *Schilbeodes miurus* by Forbes and Richardson (1908) and Thompson and Hunt (1930). The distribution of this species has increased in the recent survey likely due to deeper and cleared water. FR 2 (Salt Fork), TH 2 (Salt Fork), LS 8 (Embarras, Middle Fork, Salt Fork), LB 5 (Embarras, Middle Fork), SS 26 (Embarras, Middle Fork, Salt Fork)

Noturus nocturnus Jordan & Gilbert, **Freckled Madtom**. A species of deep riffles, it has never been common in Champaign County. LS 2 (Sangamon), LB 5 (Sangamon), SS 1 (Sangamon)

Pylodictis olivaris (Rafinesque), **Flathead Catfish**. Reported as *Leptops olivaris* by Thompson and Hunt (1930). Sampling gear used in these surveys are not the most effective at collecting Flathead Catfish. It is likely they are more common in the county than recorded by our data. TH 1 (Sangamon), LS 4 (Middle Fork, Salt Fork, Sangamon), LB 4 (Sangamon, Salt Fork), SS 2 (Sangamon)

ESOCIDAE

Esox americanus Gmelin, **Grass Pickerel**. Referred to as *Esox vermiculatus* by Forbes and Richardson (1908) and Thompson and Hunt (1930). The last two surveys have found the Grass Pickerel at many more sites than the first three. This may be attributable to cleaner water and more aquatic and overhanging vegetation. FR 10 (Kaskaskia, Middle Fork, Salt Fork, Sangamon), TH 26 (all drainages except Middle Fork), LS 17 (all drainages), LB 57 (all drainages), SS 52 (all drainages)

Esox lucius Linnaeus, **Northern Pike**. Once stocked in Homer Lake, individuals collected in the Salt Fork were likely impoundment escapees. Recent efforts by the IDNR to reestablish populations of Northern Pike in the Embarras River have led to it being collected there near Camargo. LB 1 (Salt Fork)

APHREDODERIDAE

Aphredoderus sayanus (Gilliams), **Pirate Perch**. Pirate Perch are and have been a common species of the drainage ditches of all except the Vermilion and Little Vermilion basins. FR 1 (Sangamon), TH 12 Embarras, Kaskaskia, Sangamon), LS 13 (Embarras, Kaskaskia, Sangamon), LB 12 (Embarras, Kaskaskia, Sangamon), SS 23 (Embarras, Kaskaskia, Sangamon)

FUNDULIDAE

Fundulus notatus (Rafinesque), **Blackstripe Topminnow**. This species is also very prevalent in the drainage ditches of the county. FR 14 (Embarras, Kaskaskia, Salt Fork, Sangamon), TH 41 (all drainages), LS 54 (all drainages), LB 98 (all drainages), SS 85 (all drainages except Little Vermilion)

POECILIIDAE

Gambusia affinis (Baird & Girard), **Western Mosquitofish**. Perceived as a temporary resident by Larimore and Bayley (1996), the increased distribution of this species since the Larimore and Smith (1963) survey suggests it is now a permanent fixture of the streams of Champaign County. LS 2 (Salt Fork), SS 17 (Embarras, Kaskaskia, Salt Fork)

ATHERINOPSIDAE

Labidesthes sicculus (Cope), **Brook Silverside**. Our survey observed this species at more sites than any previous surveys. FR 6 (Salt Fork, Sangamon), TH 5 (Salt Fork), LS 3 (Salt Fork), LB 2 (Salt Fork), SS 14 (Embarras, Kaskaskia, Middle Fork, Salt Fork)

MORONIDAE

Morone chrysops (Rafinesque), **White Bass**. A popular sport fish stocked in the downstream reservoirs of the Kaskaskia and Sangamon rivers, this species has been observed in these rivers in Champaign County after spring floods. Although observed at seven sites on the Sangamon by Larimore and Bayley (1996), our survey failed to observe any in the county. LB 7 (Sangamon)

Morone mississippiensis Jordan & Eigenmann, **Yellow Bass**. Yellow Bass were once stocked in Kaufman Lake and Lake-of-the-Woods and collections by Larimore and Smith (1963) in the Sangamon River were presumed to be migrants from Lake Decatur. This species has not been collected in the county since Larimore and Smith (1963). LS 3 (Kaskaskia, Sangamon)

CENTRARCHIDAE

Ambloplites rupestris (Rafinesque), **Rock Bass**. The one site in which Thompson and Hunt (1930) collected Rock Bass was the first and only in the county until Larimore and Smith (1963). It appears this species has continued to expand its distribution in the county; our current survey observed it at 10 more sites than the Larimore and Bayley (1996) survey. TH 1 (Salt Fork), LS 16 (Middle Fork, Salt Fork, Sangamon), LB 15 (Middle Fork, Salt Fork, Sangamon), SS 25 (Middle Fork, Salt Fork, Sangamon)

Lepomis cyanellus (Rafinesque), **Green Sunfish**. One of the most, if not the most, common sunfish in Champaign County. It has always been and is currently found in many locations in all drainages. FR 23 (all drainages except Little Vermilion), TH 38 (all drainages), LS 75 (all drainages except Little Vermilion), LB 83 (all drainages), SS 73 (all drainages)

Lepomis gulosus (Cuvier), **Warmouth**. Referred to as *Chaenobryttus gulosus* by Forbes and Richardson (1908), Thompson and Hunt (1930), and Larimore and Smith (1963). Never common in the county, sparse collections of this species occur in all surveys except for Larimore and Bayley (1996). FR 3 (Kaskaskia), TH 1 (Salt Fork), LS 1 (Sangamon), SS 2 (Middle Fork, Salt Fork)

Lepomis humilis (Girard), **Orangespotted Sunfish**. Larimore and Bayley (1996) noted that this species appeared to be decreasing since the time of Forbes and Richardson (1908) and it was not collected at any locations during our survey. FR 16 (Kaskaskia, Middle Fork, Salt Fork, Sangamon), TH 13 (Middle Fork, Salt Fork, Sangamon), LS 9 (Middle Fork, Salt Fork, Sangamon), LB 8 (Kaskaskia, Middle Fork, Salt Fork, Sangamon)

Lepomis macrochirus Rafinesque, **Bluegill**. Reported as *Lepomis pallidus* by Forbes and Richardson (1908) and Thompson and Hunt (1930). The distribution of Bluegill is continuing to increase throughout the county. Rare during the first two surveys, its increase in the county is likely due to the continued stocking in the impoundments and ponds of Champaign County. FR 2 (Salt Fork, Sangamon), TH 1 (Salt Fork), LS 16 (Kaskaskia, Salt Fork, Sangamon), LB 44 (all drainages), SS 67 (all drainages except Little Vermilion)

Lepomis megalotis (Rafinesque), **Longear Sunfish**. Prior to the spread of the Bluegill, the Longear was the dominant sunfish of the permanent streams of Champaign County. This species has become more widespread in the county in the last two surveys (LB and SS), likely due to more permanent flows and deeper waters in streams that were once intermittent. FR 16 (Kaskaskia, Middle Fork, Salt Fork), TH 37 (all drainages), LS 44 (all drainages), LB 101 (all drainages), SS 85 (all drainages)

Lepomis microlophus (Gunther), **Redear Sunfish**. Historically found in southern Illinois, this species is another sport fish transplant that has found its way into the streams of Champaign County. Larimore and Bayley (1996) questioned whether it had established as a permanent resident of streams in Champaign County; however, the multiple collections across drainages during our survey suggest it has indeed established in streams. LS 1 (Kaskaskia), LB 2 (Salt Fork), SS 10 (Embarras, Salt Fork, Sangamon)

Micropterus dolomieu Lacepede, **Smallmouth Bass**. Populations of Smallmouth have remained stable in the Vermilion and Sangamon basins throughout all surveys. FR 1 (Salt Fork), TH 16 (Middle Fork, Salt Fork, Sangamon), LS 37 (Kaskaskia, Middle Fork, Salt Fork, Sangamon), LB 28 (Middle Fork, Salt Fork, Sangamon), SS 24 (Middle Fork, Salt Fork, Sangamon)

Micropterus punctulatus (Rafinesque), **Spotted Bass**. Likely not distinguished from *Micropterus salmoides* by Forbes and Richardson (1908) and Thompson and Hunt (1930), no extant collections of either are available from this time frame. A species most common to the Wabash River tributaries of eastern and southern Illinois, it is still observed in the Embarras and Vermilion basins in Champaign County, although its decreased distribution could be due to increased pressures from the Largemouth Bass. No extant specimen of this species from the Kaskaskia or Sangamon basins exists to be verified. FR ?, TH ?, LS 9 (Middle Fork, Salt Fork), LB 15 (Embarras, Middle Fork, Salt Fork), SS 5 (Embarras, Salt Fork)

Micropterus salmoides (Lacepede), **Largemouth Bass**. The prevalence of this species has continued to increase in the streams of the county. Although it is apparent that naturally reproducing populations occur in these streams, stream populations of this species are likely bolstered by escapees from impoundments and ponds. FR ?, TH ?, LS 14 (Middle Fork, Salt Fork, Sangamon), LB 24 (all drainages), SS 43 (all drainages except Little Vermilion)

Pomoxis annularis Rafinesque, **White Crappie.** A naturally occurring sport fish in the streams of the county, though never overly prevalent. Larimore and Bayley (1996) attribute the increase in distribution during the Larimore and Smith (1963) survey to increased stocking at that time. All other surveys appear to have a constant distribution. FR 4 (Embarras, Salt Fork, Sangamon), TH 2 (Sangamon), LS 16 (Kaskaskia, Middle Fork, Salt Fork, Sangamon), LB 8 (Kaskaskia, Sangamon), SS 4 (Kaskaskia, Sangamon)

Pomoxis nigromaculatus (Lesueur), **Black Crappie.** Referred to as *Pomoxis sparoides* by Forbes and Richardson (1908) and Thompson and Hunt (1930). Another naturally occurring sport fish in county streams, it has never been widespread in the county. FR 7 (Kaskaskia, Salt Fork, Sangamon), TH 3 (Sangamon), LS 2 (Salt Fork, Sangamon), LB 2 (Sangamon), SS 3 (Kaskaskia, Sangamon)

PERCIDAE

Ammocrypta pellucida (Putnam), **Eastern Sand Darter**. Listed as threatened in Illinois, the Eastern Sand Darter has only ever been collected in the Middle Fork in Champaign County. Our collection in the recent survey is the first since Larimore and Smith (1963). TH 2 (Middle Fork), LS 3 (Middle Fork), SS 1 (Middle Fork)

Etheostoma asprigene (Forbes), **Mud Darter**. Reported as *Etheostoma jessiae* by Forbes and Richardson (1908). The Mud Darter is a species that prefers the flows of large creeks and rivers and thus has never been overly common in Champaign County, in which it has been primarily observed in the Sangamon River. FR 2 (Salt Fork, Sangamon), LS 1 (Sangamon), LB 1 (Embarras), SS 2 (Sangamon)

Etheostoma blennioides Rafinesque, **Greenside Darter**. Referred to as *Diplesion blennioides* by Forbes and Richardson (1908) and Thompson and Hunt (1930). Restricted to Wabash River tributaries in Illinois, it has become more widespread in the Embarras and Vermilion basins in the recent survey. FR 7 (Salt Fork), TH 10 (Embarras, Middle Fork, Salt Fork), LS 13 (Embarras, Little Vermilion, Middle Fork, Salt Fork), LB 3 (Embarras, Middle Fork), SS 24 (Embarras, Middle Fork, Salt Fork)

Etheostoma caeruleum Storer, **Rainbow Darter**. Seven collections of *Etheostoma coeruleum* by Thompson and Hunt (1930) included *Etheostoma spectabile*, which likely indicates the two species were not separated by them or Forbes and Richardson (1908). Rainbow Darters remained stable in the county during the Larimore and Smith (1963) and Larimore and Bayley (1996) surveys but have seen an increased distribution during our survey. FR ?, TH 7 (Embarras, Middle Fork, Salt Fork), LS 7 (Embarras, Kaskaskia, Middle Fork, Salt Fork), LB 9 (Embarras, Middle Fork, Salt Fork), SS 17 (Embarras, Middle Fork, Salt Fork)

Etheostoma camurum (Cope), **Bluebreast Darter**. An endangered species in Illinois, it is only known from the Vermilion River basin. Our current collection of four individuals from the Salt Fork north of Homer represents the first time this species was collected during Champaign County surveys. Two previous records of this species at this site were collected in 1949 and 1952 by a Wildlife class from the University of Illinois (Field Museum of Natural History Fishes Collection #s 79491 & 79536). SS 1 (Salt Fork)

Etheostoma chlorosoma (Hay), **Bluntnose Darter**. Reported as *Boleosoma camurum* by Forbes and Richardson (1908) and Thompson and Hunt (1930). One collection by Forbes and Richardson (1908) and one by Thompson and Hunt (1930) represent the only records of this species from the county. FR 1 (Sangamon), TH 1 (Kaskaskia)

Etheostoma flabellare Rafinesque, **Fantail Darter**. The Fantail Darter is most commonly found in shallow water riffles and its apparent decline in the county could be caused by the increased depths in many of the streams of Champaign County. FR 2 (Salt Fork), TH 16 (Embarras, Middle Fork, Salt Fork, Sangamon), LS 18 (Middle Fork, Salt Fork, Sangamon), LB 1 (Sangamon), SS 4 (Sangamon)

Etheostoma gracile (Girard), **Slough Darter**. Referred to as *Boleichthys fusiformes* by Thompson and Hunt (1930). Thompson and Hunt's (1930) collection of one specimen remains the only record of this species in Champaign County. TH 1 (Sangamon)

Etheostoma nigrum Rafinesque, **Johnny Darter**. Reported as *Boleosoma nigrum* by Forbes and Richardson (1908) and Thompson and Hunt (1930). Johnny Darters have historically and are currently one of the most common darters in the streams of Champaign County. FR 19 (Embarras, Salt Fork, Sangamon), TH 82 (all drainages), LS 80 (all drainages), LB 42 (all drainages), SS 42 (all drainages except Little Vermilion)

Etheostoma spectabile (Agassiz), **Orangethroat Darter**. Four extant Thompson and Hunt (1930) collections of *Etheostoma coeruleum* included *Etheostoma spectabile*, indicating this species had not been differentiated from Rainbow Darters by them and likely Forbes and Richardson (1908). The historical distribution of this species in the county is uncertain, but it has remained relatively common since the Larimore and Smith (1963) survey. FR ?, TH 4 (Sangamon), LS 60 (all drainages), LB 34 (Kaskaskia, Salt Fork, Sangamon), SS 48 (all drainages)

Etheostoma zonale (Cope), **Banded Darter**. A species that is most common in northern and central Illinois, there are few records of this species occurring in the Sangamon basin in Champaign County. TH 8 (Sangamon), LS 6 (Sangamon)

Percina caprodes (Rafinesque), **Logperch.** Never particularly common in the county, this species has been observed in all surveys and has been recorded from each basin. FR 2 (Salt Fork, Sangamon), TH 2 (Kaskaskia, Middle Fork), LS 10 (all drainages except Salt Fork), LB 4 (Kaskaskia, Middle Fork, Sangamon), SS 6 (Kaskaskia, Salt Fork, Sangamon)

Percina maculata (Girard), **Blackside Darter**. Reported as *Hadropterus aspro* by Forbes and Richardson (1908) and Thompson and Hunt (1930). Thomas (1970) noted that this species was often found in quiet pools near woody debris, which is often where they were collected during our survey. The loss of such habitat may account for the decreased distribution of this species over the span of all surveys. FR 15 (Salt Fork, Sangamon), TH 24 (all drainages except Little Vermilion), LS 49 (all drainages except Little Vermilion), LB 13 (all drainages), SS 7 (Embarras, Middle Fork, Sangamon)

Percina phoxocephala (Nelson), **Slenderhead Darter**. Referred to as *Hadropterus phoxocephalus* by Forbes and Richardson (1908) and Thompson and Hunt (1930). This species has remained stable in the county during all surveys. FR 3 (Salt Fork, Sangamon), TH 8 (Middle Fork, Salt Fork, Sangamon), LS 18 (Middle Fork, Salt Fork, Sangamon), LB 3 (Embarras, Kaskaskia, Middle Fork), SS 11 (Kaskaskia, Middle Fork, Salt Fork, Sangamon)

Percina sciera (Swain), **Dusky Darter**. Larimore and Smith (1963) stated that their collection of this species in the Middle Fork was the first record of this species in Champaign County. Larimore and Bayley (1996) noted that Forbes and Richardson (1908) collected two at one site on the Sangamon and suggested this as an error based on the original note and that this species has not been collected outside the Wabash drainage in Illinois. One extant specimen of a Dusky Darter from the Larimore Collection is recorded in the INHS Fish Collection from the Sangamon River. Our survey recorded one individual from the Sangamon River near where the Larimore record was collected. LS 1 (Middle Fork), LB 3 (Embarras, Middle Fork), SS 12 (Embarras, Middle Fork, Salt Fork, Sangamon)

Sander vitreus (Mitchill), **Walleye**. Reported as *Stizostedion vitreum* by Larimore and Bayley (1996). A popular sport fish that has been historically stocked in the Salt Fork and Sangamon. LB 1 (Sangamon), SS 1 (Sangamon)

SCIAENIDAE

Aplodinotus grunniens Rafinesque, **Freshwater Drum**. Mostly associated with larger rivers, small drum (<300 mm, or 12 inches) are often found in the Kaskaskia and Sangamon basins in Champaign County. TH 3 (Sangamon), LS 4 (Sangamon), LB 13 (Kaskaskia, Sangamon), SS 11 (Kaskaskia, Sangamon)

APPENDIX 2 – PATTERNS OF OCCURRENCE AND ABUNDANCE TABLES

TABLE 1 Occurrence patterns for species recorded from all Champaign County fishes surveys, grouped by basin. Overall increase in occurrence = I; increase then decrease = ID; overall decrease = D, decrease than increase = DI, fluctuating occurrence = F, stable occurrence = S; sparse occurrence = Sp; no record = blank. Gray shading indicates introduced species.

Family / *Species*	Embarras	Kaskaskia	Sangamon	Vermilion
Lepisosteidae				
Lepisosteus osseus Longnose Gar			I	
Clupeidae				
Dorosoma cepedianum Gizzard Shad	I	I	I	I
Leuciscidae				
Campostoma anomalum Central Stoneroller	ID	ID	D	I
Cyprinella lutrensis Red Shiner		ID	I	ID
Cyprinella spiloptera Spotfin Shiner	ID	DI	S	DI
Ericymba buccata Silverjaw Minnow	DI	DI	D	ID
Hybognathus nuchalis Mississippi Silvery Minnow		D	D	D
Hybopsis amblops Bigeye Chub	D			DI
Luxilus chrysocephalus Striped Shiner	ID	ID	D	ID
Lythrurus umbratilis Redfin Shiner	ID	DI	S	ID
Nocomis biguttatus Hornyhead Chub	I	D	D	I
Notemigonus crysoleucas Golden Shiner	F	DI	D	DI
Notropis dorsalis Bigmouth Shiner		ID	ID	Sp

(Table 1 continued)

Family *Species*	Embarras	Kaskaskia	Sangamon	Vermilion
Notropis percobromus (rubellus) Carmine (Rosyface) Shiner				I
Notropis stramineus Sand Shiner	ID	ID	F	F
Phenacobius mirabilis Suckermouth Minnow	F	S	D	D
Pimephales notatus Bluntnose Minnow	ID	D	DI	S
Pimephales promelas Fathead Minnow	ID		ID	Sp
Pimephales vigilax Bullhead Minnow			DI	DI
Semotilus atromaculatus Creek Chub	ID	ID	ID	ID
Cyprinidae				
Cyprinus carpio Common Carp	F	ID	F	ID
Catostomidae				
Carpiodes carpio River Carpsucker				S
Carpiodes cyprinus Quillback	F		S	F
Carpiodes velifer Highfin Carpsucker	I		F	S
Catostomus commersonii White Sucker	ID	ID	ID	F
Erimyzon oblongus Western Creek Chubsucker	ID	ID	F	F
Hypentelium nigricans Northern Hog Sucker	I	F	ID	I
Ictiobus cyprinellus Bigmouth Buffalo			Sp	
Minytrema melanops Spotted Sucker	I	D		DI

(Table 1 continued)

Family *Species*	Embarras	Kaskaskia	Sangamon	Vermilion
Moxostoma anisurum Silver Redhorse			I	S
Moxostoma duquesnei Black Redhorse	F	ID	D	DI
Moxostoma erythrurum Golden Redhorse	I		ID	I
Moxostoma macrolepidotum Shorthead Redhorse			F	DI
Ictaluridae				
Ameiurus melas Black Bullhead	F	F	D	DI
Ameiurus natalis Yellow Bullhead	ID	ID	I	ID
Ictalurus punctatus Channel Catfish	I	I	F	S
Noturus flavus Stonecat			F	I
Noturus gyrinus Tadpole Madtom		ID	I	DI
Noturus miurus Brindled Madtom	I			DI
Noturus nocturnus Freckled Madtom			Sp	
Pylodictis olivaris Flathead Catfish			I	Sp
Esocidae				
Esox americanus Grass Pickerel	ID	ID	I	DI
Aphredoderidae				
Aphredoderus sayanus Pirate Perch	I	F	I	
Fundulidae				
Fundulus notatus Blackstripe Topminnow	I	ID	ID	DI

(Table 1 continued)

Family *Species*	Embarras	Kaskaskia	Sangamon	Vermilion
Poeciliidae				
Gambusia affinis Western Mosquitofish	I	I		I
Atherinidae				
Labidesthes sicculus Brook Silverside	I	I		DI
Centrarchidae				
Ambloplites rupestris Rock Bass			I	I
Lepomis cyanellus Green Sunfish	ID	I	F	DI
Lepomis gulosus Warmouth				I
Lepomis humilis Orangespotted Sunfish		Sp	D	D
Lepomis macrochirus Bluegill	I	I	I	I
Lepomis megalotis Longear Sunfish	DI	I	ID	DI
Lepomis microlophus Redear Sunfish	I		I	I
Micropterus dolomieu Smallmouth Bass			ID	I
Micropterus salmoides Largemouth Bass	I	ID	I	I
Pomoxis annularis White Crappie		ID	S	Sp
Pomoxis nigromaculatus Black Crappie		I	DI	
Percidae				
Ammocrypta pellucida Eastern Sand Darter				DI
Etheostoma asprigene Mud Darter			DI	D

(Table 1 continued)

Family *Species*	Embarras	Kaskaskia	Sangamon	Vermilion
Etheostoma blennioides Greenside Darter	I			DI
Etheostoma caeruleum Rainbow Darter	DI	ID	ID	I
Etheostoma camurum Bluebreast Darter				I
Etheostoma flabellare Fantail Darter			D	D
Etheostoma nigrum Johnny Darter	ID	D	ID	F
Etheostoma zonale Banded Darter			D	
Percina caprodes Logperch		S	I	DI
Percina maculata Blackside Darter	ID	ID	ID	D
Percina phoxocephala Slenderhead Darter		I	D	S
Percina sciera Dusky Darter	I		DI	I
Sander vitreus Walleye			I	
Sciaenidae				
Aplodinotus grunniens Freshwater Drum		I	ID	

TABLE 2 Abundance patterns for species recorded from all Champaign County fishes surveys, grouped by basin. Overall increase in abundance = I; increase then decrease = ID; overall decrease = D, decrease than increase = DI, fluctuating abundance = F, stable abundance = S; sparse abundance = Sp; no record = blank. Gray shading indicates introduced species.

Family *Species*	Embarras	Kaskaskia	Sangamon	Vermilion
Lepisosteidae				
Lepisosteus osseus Longnose Gar			I	
Clupeidae				
Dorosoma cepedianum Gizzard Shad	ID	I	ID	I
Leuciscidae				
Campostoma anomalum Central Stoneroller	ID	ID	ID	ID
Cyprinella lutrensis Red Shiner		I	ID	ID
Cyprinella spiloptera Spotfin Shiner	F	DI	I	I
Ericymba buccata Silverjaw Minnow	DI	F	D	D
Hybognathus nuchalis Mississippi Silvery Minnow		D	D	D
Hybopsis amblops Bigeye Chub	D			DI
Luxilus chrysocephalus Striped Shiner	ID	ID	ID	I
Lythrurus umbratilis Redfin Shiner	S	DI	S	F
Nocomis biguttatus Hornyhead Chub	I	D	D	I
Notemigonus crysoleucas Golden Shiner	DI	DI	D	ID
Notropis dorsalis Bigmouth Shiner		ID	ID	I
Notropis percobromus (rubellus) Carmine (Rosyface) Shiner				I

(Table 2 continued)

Family *Species*	Embarras	Kaskaskia	Sangamon	Vermilion
Notropis stramineus Sand Shiner	I	F	F	I
Phenacobius mirabilis Suckermouth Minnow	F	D	D	ID
Pimephales notatus Bluntnose Minnow	DI	F	F	D
Pimephales promelas Fathead Minnow	ID		D	Sp
Pimephales vigilax Bullhead Minnow			DI	DI
Semotilus atromaculatus Creek Chub	ID	D	D	ID
Cyprinidae				
Cyprinus carpio Common Carp	S	ID	I	F
Catostomidae				
Carpiodes carpio River Carpsucker				I
Carpiodes cyprinus Quillback	F		S	ID
Carpiodes velifer Highfin Carpsucker	I		F	D
Catostomus commersonii White Sucker	ID	D	D	D
Erimyzon oblongus Western Creek Chubsucker	ID	ID	I	ID
Hypentelium nigricans Northern Hog Sucker	I	S	F	S
Ictiobus cyprinellus Bigmouth Buffalo			Sp	
Minytrema melanops Spotted Sucker	I	D		DI
Moxostoma anisurum Silver Redhorse			I	I

(Table 2 continued)

Family *Species*	Embarras	Kaskaskia	Sangamon	Vermilion
Moxostoma duquesnei Black Redhorse	F	I	D	DI
Moxostoma erythrurum Golden Redhorse	I		I	S
Moxostoma macrolepidotum Shorthead Redhorse			DI	I
Ictaluridae				
Ameiurus melas Black Bullhead	F	F	F	D
Ameiurus natalis Yellow Bullhead	ID	ID	I	I
Ictalurus punctatus Channel Catfish	I	I	S	S
Noturus flavus Stonecat			ID	F
Noturus gyrinus Tadpole Madtom		I	I	F
Noturus miurus Brindled Madtom	I			DI
Noturus nocturnus Freckled Madtom			Sp	
Pylodictis olivaris Flathead Catfish			I	Sp
Esocidae				
Esox americanus Grass Pickerel	DI	F	DI	DI
Aphredoderidae				
Aphredoderus sayanus Pirate Perch	S	DI	DI	
Fundulidae				
Fundulus notatus Blackstripe Topminnow	ID	I	I	I

(Table 2 continued)

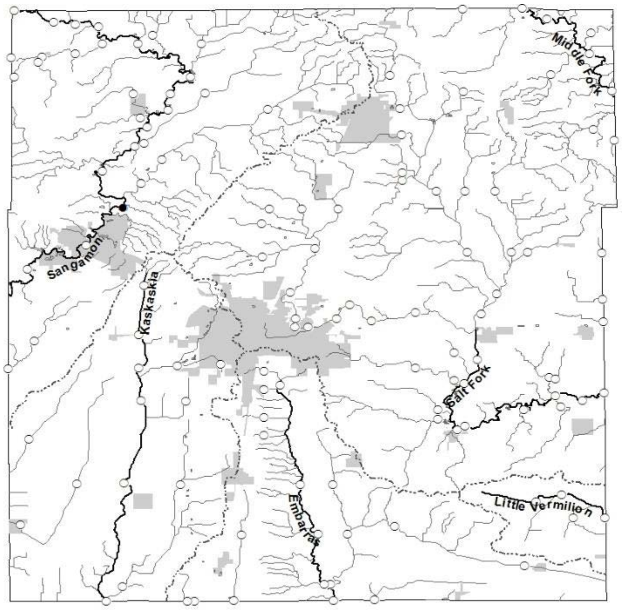
Family *Species*	Embarras	Kaskaskia	Sangamon	Vermilion
Poeciliidae				
Gambusia affinis Western Mosquitofish	I	I		I
Atherinidae				
Labidesthes sicculus Brook Silverside	I	I		DI
Centrarchidae				
Ambloplites rupestris Rock Bass			I	S
Lepomis cyanellus Green Sunfish	ID	S	I	I
Lepomis gulosus Warmouth				I
Lepomis humilis Orangespotted Sunfish		Sp	D	D
Lepomis macrochirus Bluegill	I	ID	ID	I
Lepomis megalotis Longear Sunfish	F	F	I	I
Lepomis microlophus Redear Sunfish	I		I	I
Micropterus dolomieu Smallmouth Bass			D	F
Micropterus salmoides Largemouth Bass	I	I	I	I
Pomoxis annularis White Crappie		I	S	Sp
Pomoxis nigromaculatus Black Crappie		I	I	
Percidae				
Ammocrypta pellucida Eastern Sand Darter				DI
Etheostoma asprigene Mud Darter			DI	D

(Table 2 continued)

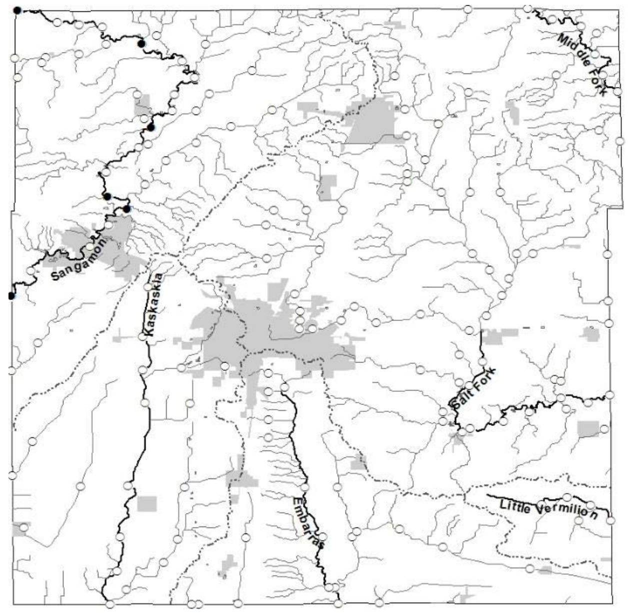
Family *Species*	Embarras	Kaskaskia	Sangamon	Vermilion
Etheostoma blennioides Greenside Darter	I			DI
Etheostoma caeruleum Rainbow Darter	DI	ID	DI	ID
Etheostoma camurum Bluebreast Darter				I
Etheostoma flabellare Fantail Darter			S	D
Etheostoma nigrum Johnny Darter	ID	D	D	D
Etheostoma zonale Banded Darter			D	
Percina caprodes Logperch		S	I	DI
Percina maculata Blackside Darter	S	D	S	D
Percina phoxocephala Slenderhead Darter		I	D	S
Percina sciera Dusky Darter	I		I	I
Sander vitreus Walleye			I	
Sciaenidae				
Aplodinotus grunniens Freshwater Drum		I	DI	

APPENDIX 3 – SPECIES DISTRIBUTION MAPS SINCE THOMPSON AND HUNT (1930)

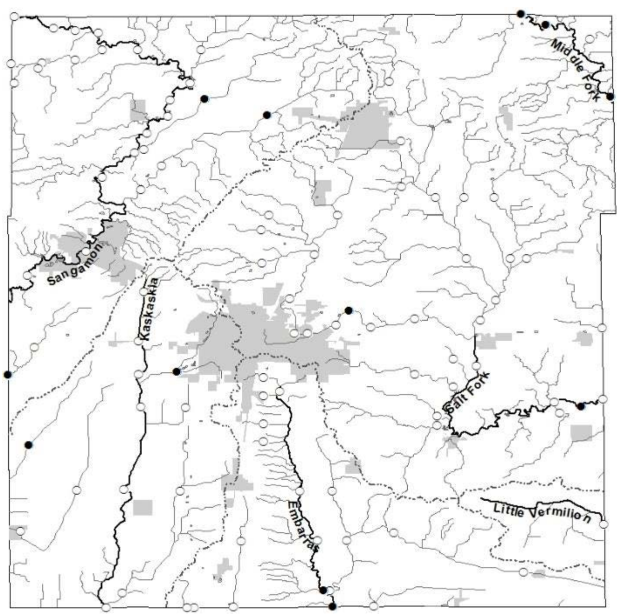
Figure 1



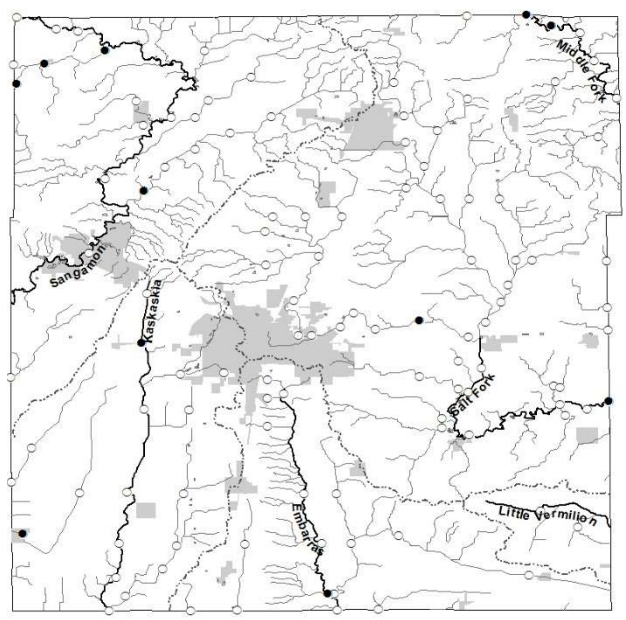
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



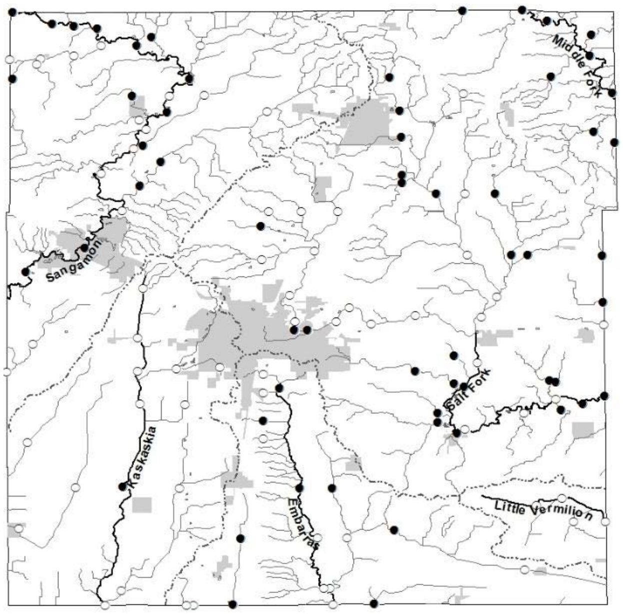
Sherwood & Stein (2012 – 2015)

Dorosoma cepedianum, Gizzard Shad

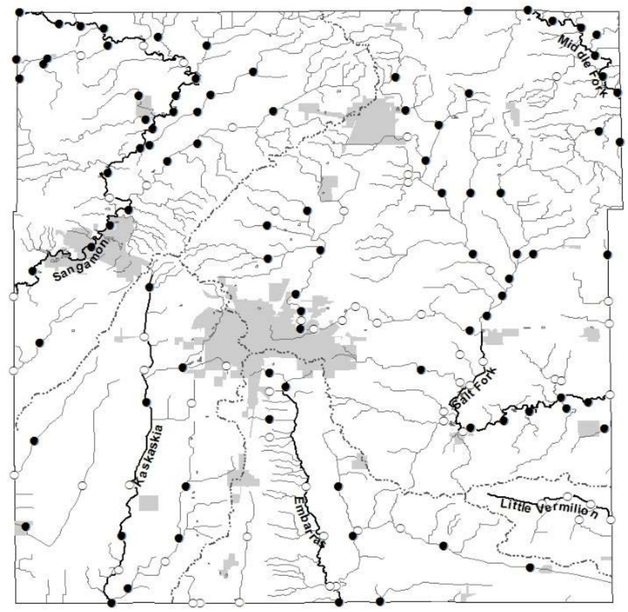
○ = species absent

● = species present

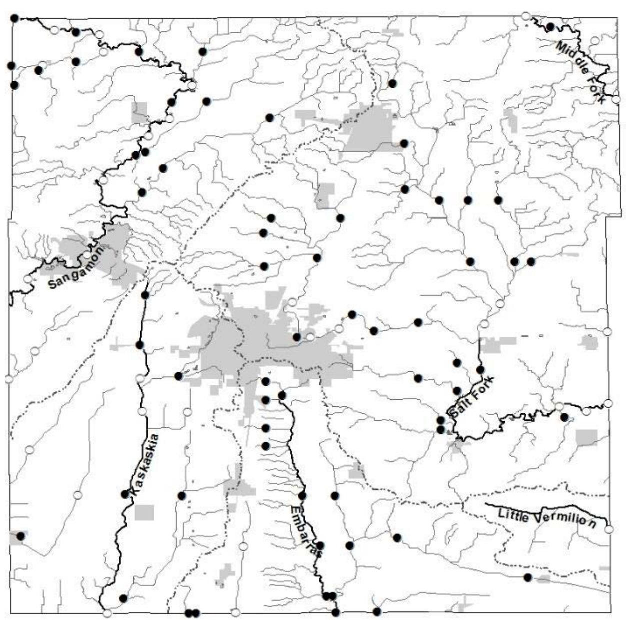
Figure 2



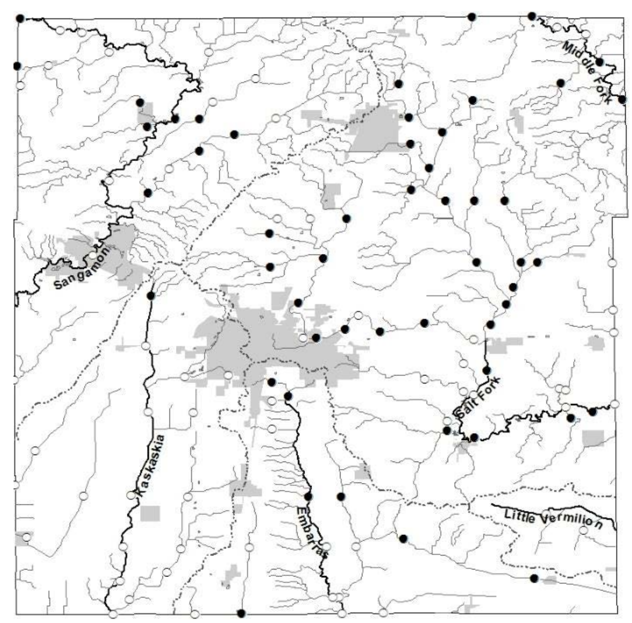
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



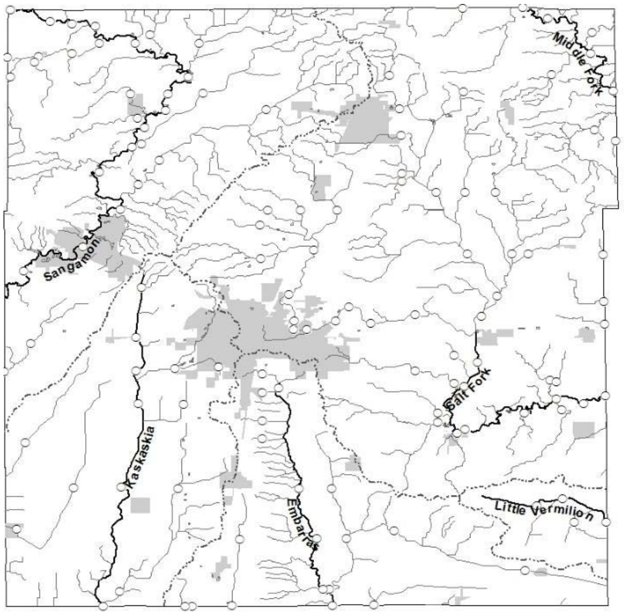
Sherwood & Stein (2012 – 2015)

Campostoma anomalum, Central Stoneroller

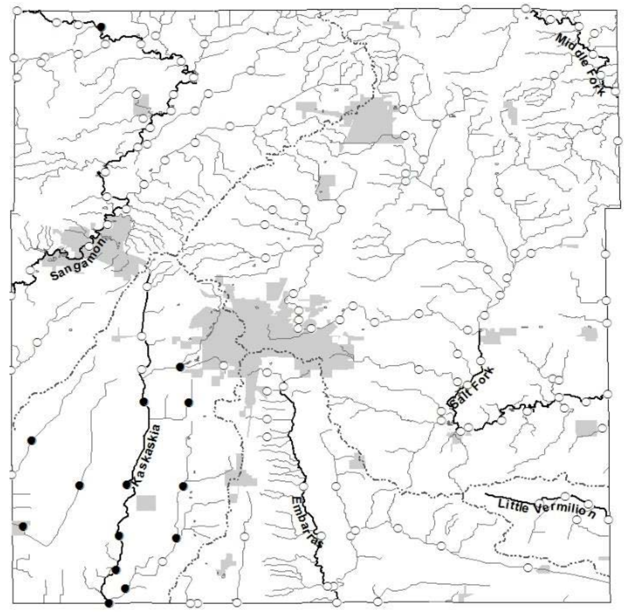
○ = species absent

● = species present

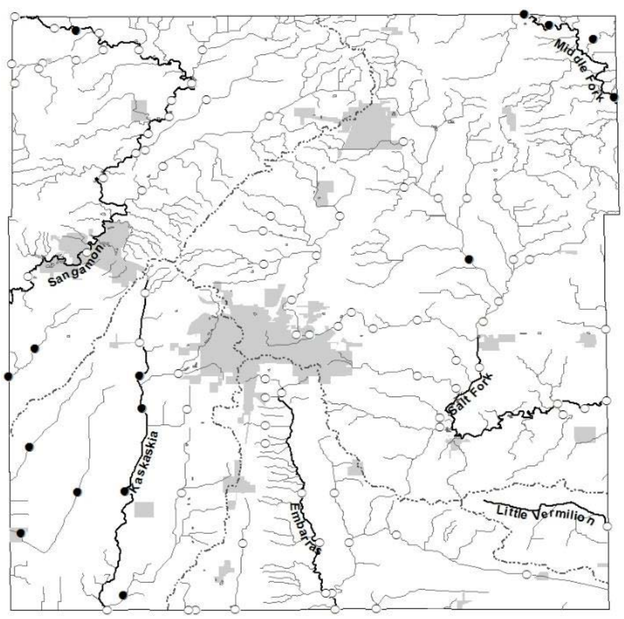
Figure 3



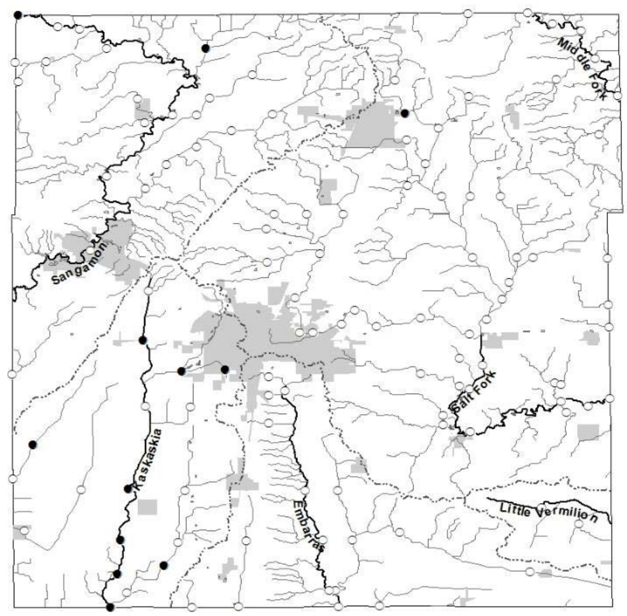
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



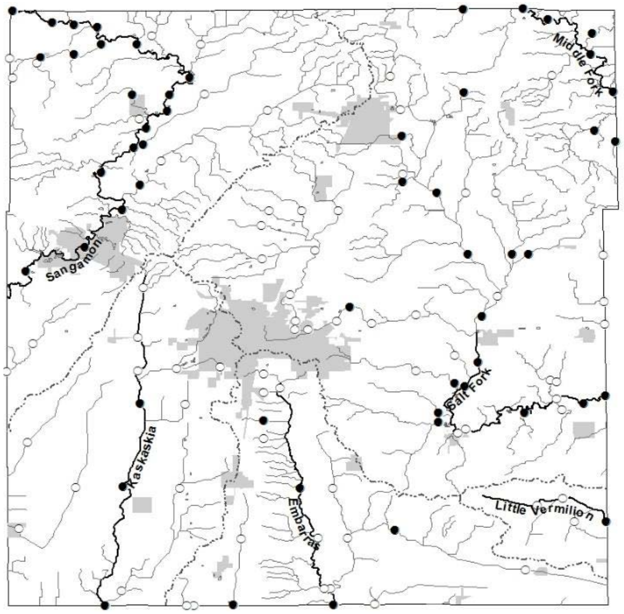
Sherwood & Stein (2012 – 2015)

Cyprinella lutrensis, Red Shiner

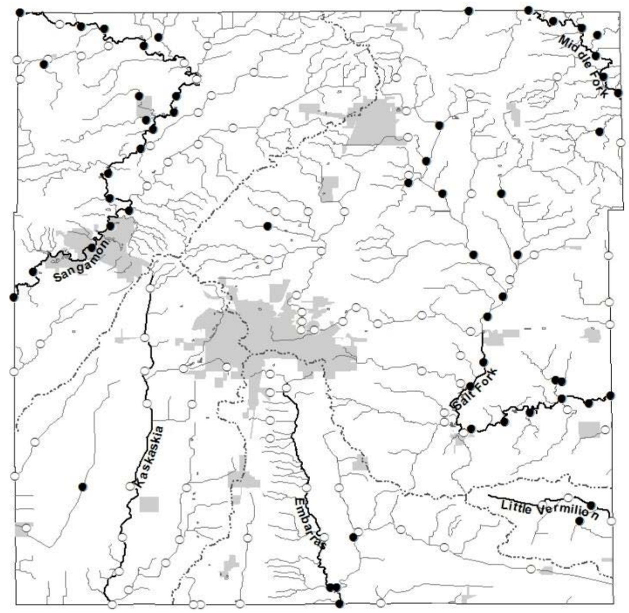
○ = species absent

● = species present

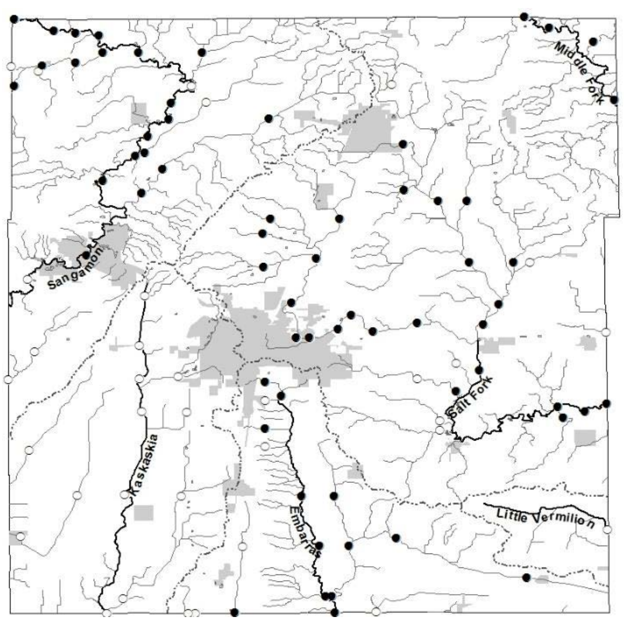
Figure 4



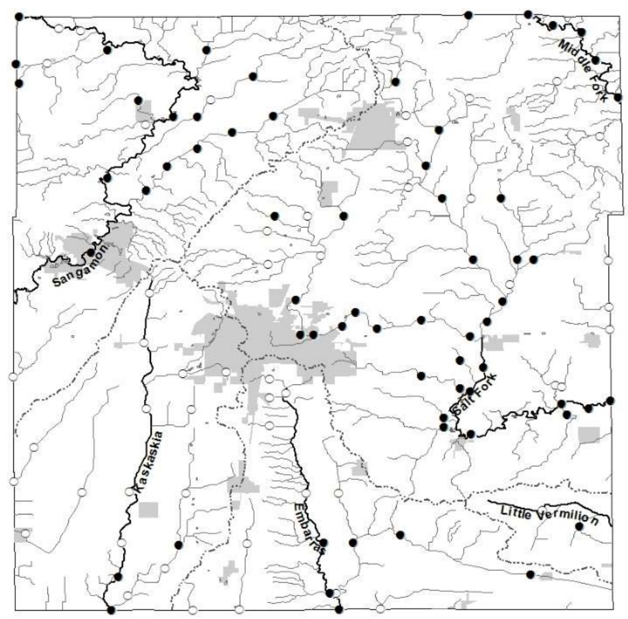
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



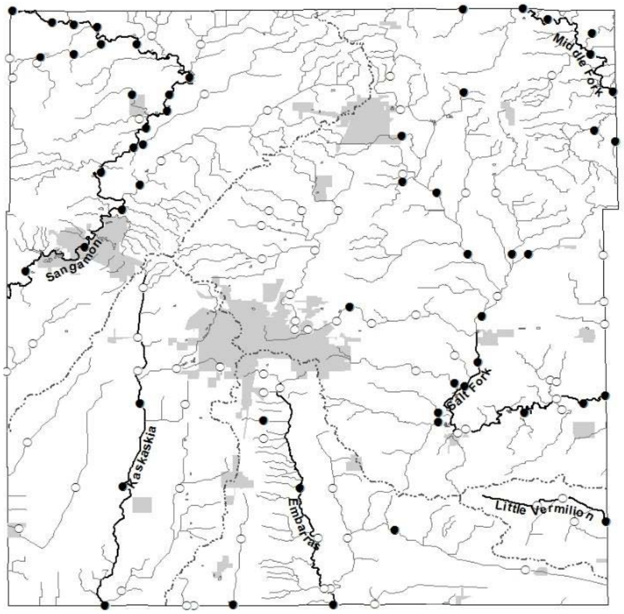
Sherwood & Stein (2012 – 2015)

Cyprinella spiloptera, Spotfin Shiner

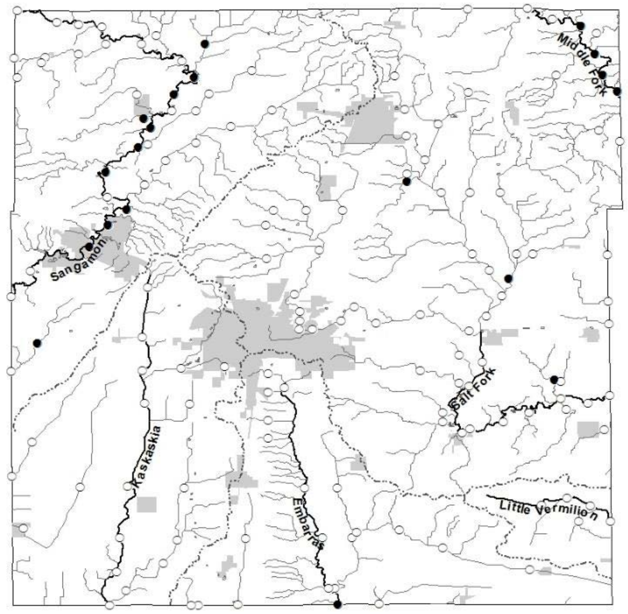
○ = species absent

● = species present

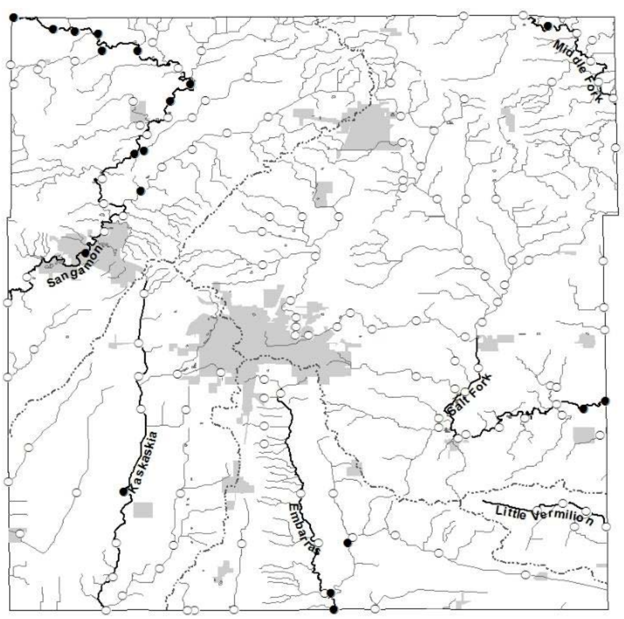
Figure 5



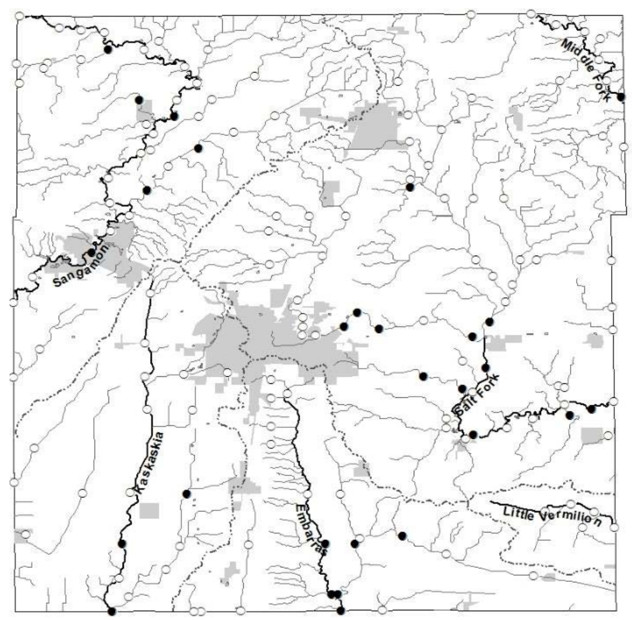
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



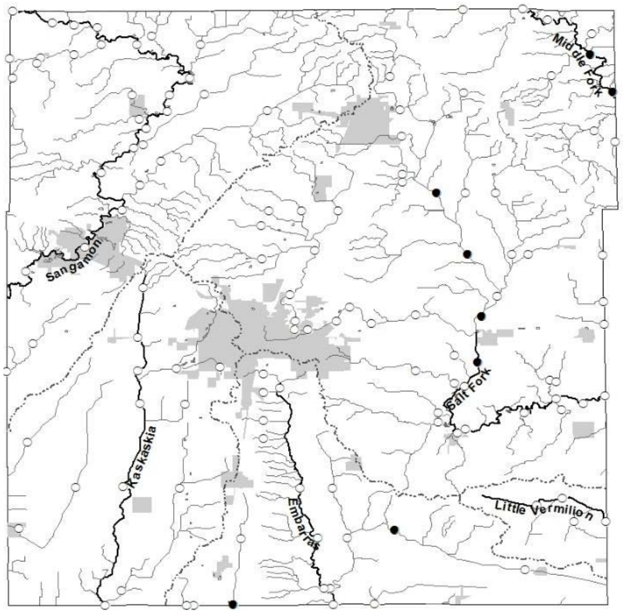
Sherwood & Stein (2012 – 2015)

Cyprinella whipplei, **Steelcolor Shiner**

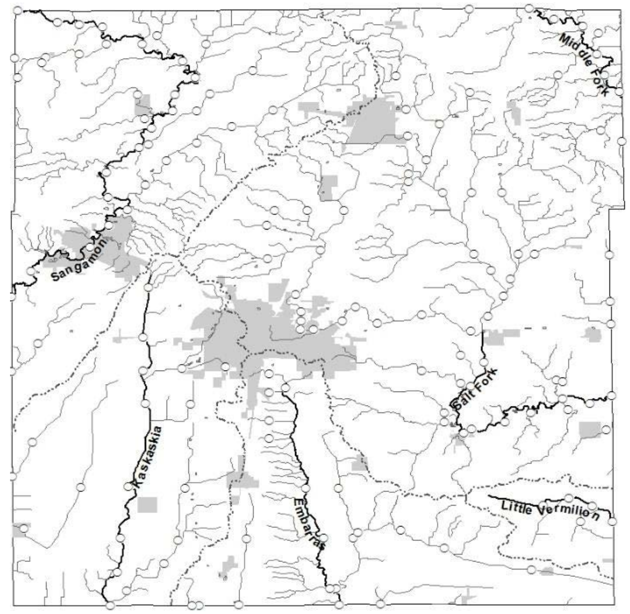
○ = species absent

● = species present

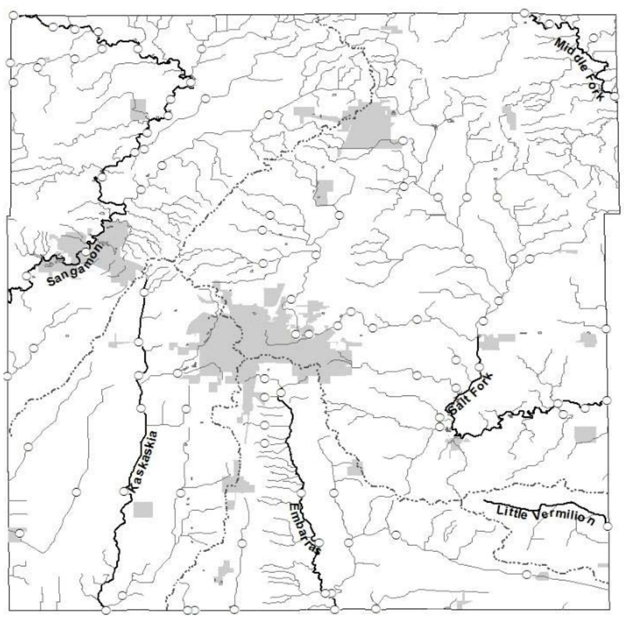
Figure 6



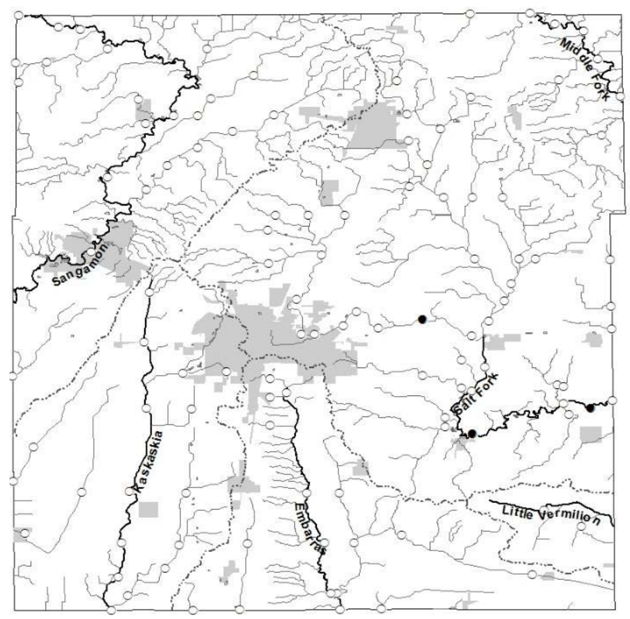
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



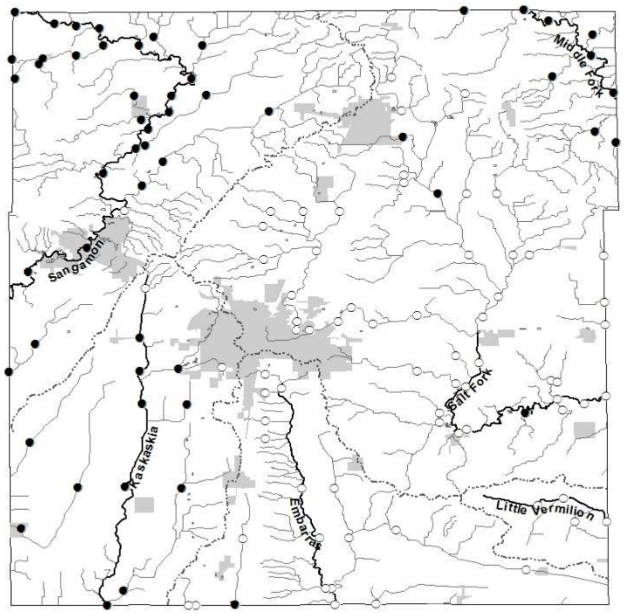
Sherwood & Stein (2012 – 2015)

***Hybopsis amblops,* Bigeye Chub**

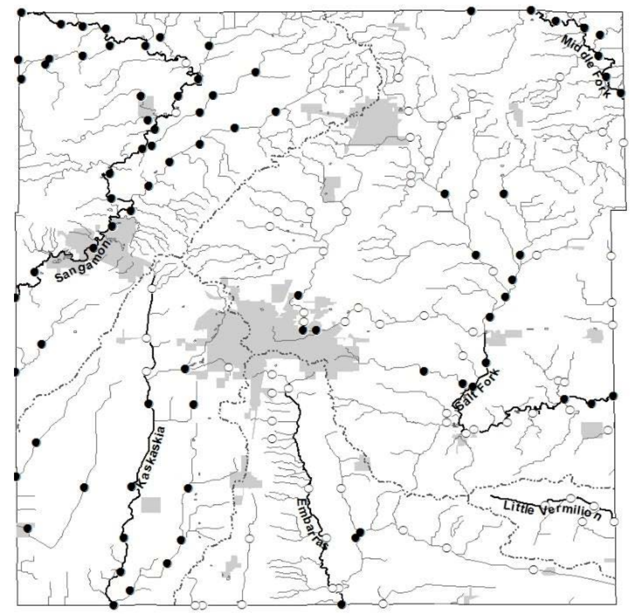
○ = species absent

● = species present

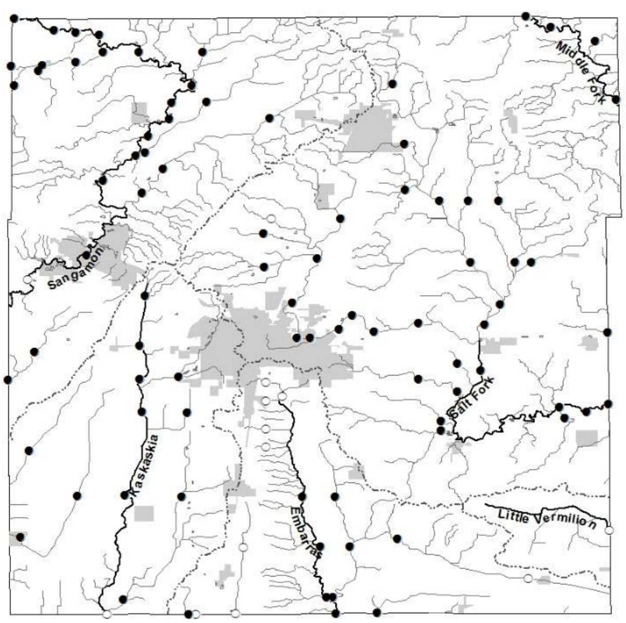
Figure 7



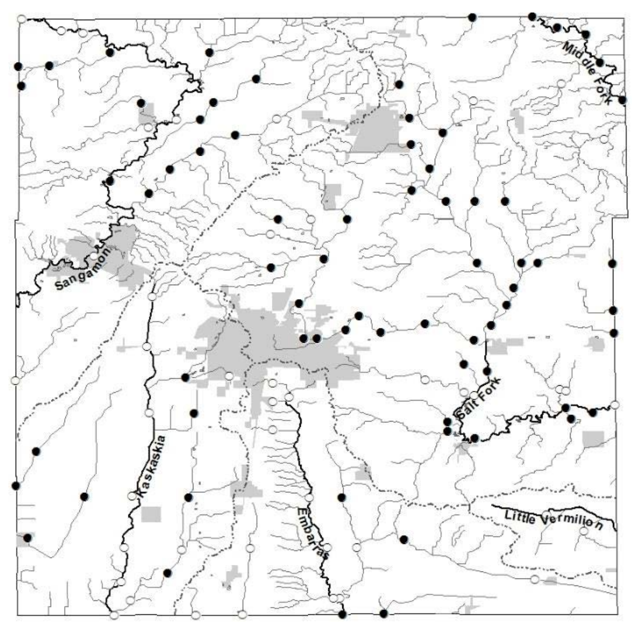
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



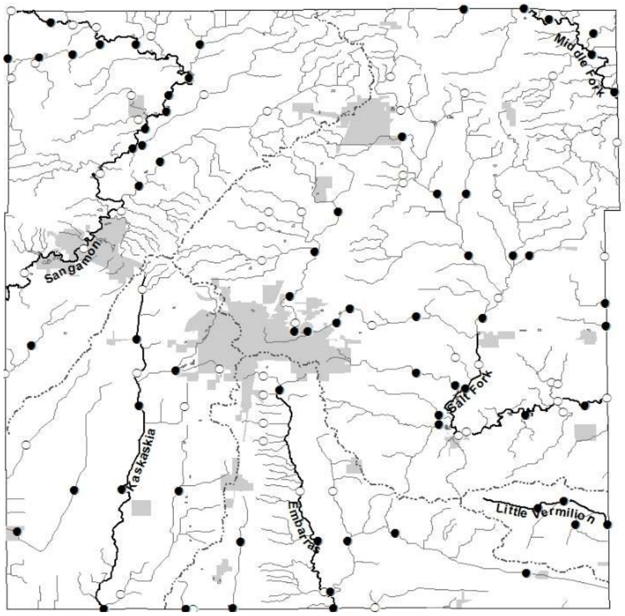
Sherwood & Stein (2012 – 2015)

***Luxilus chrysocephalus*, Striped Shiner**

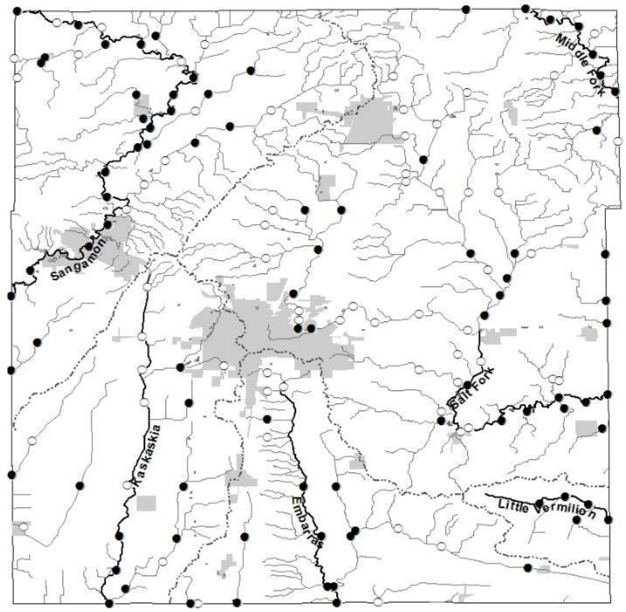
○ = species absent

● = species present

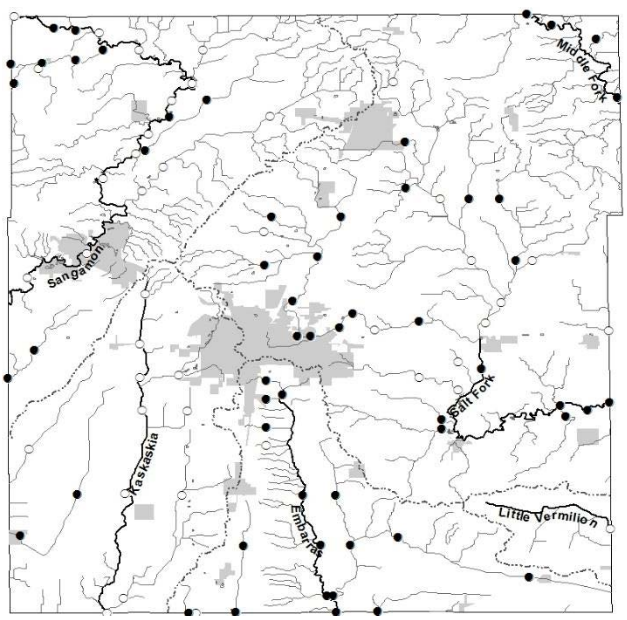
Figure 8



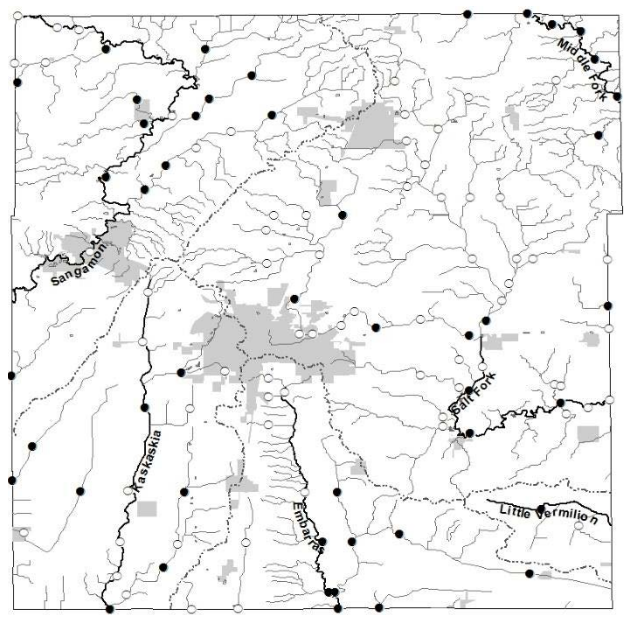
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



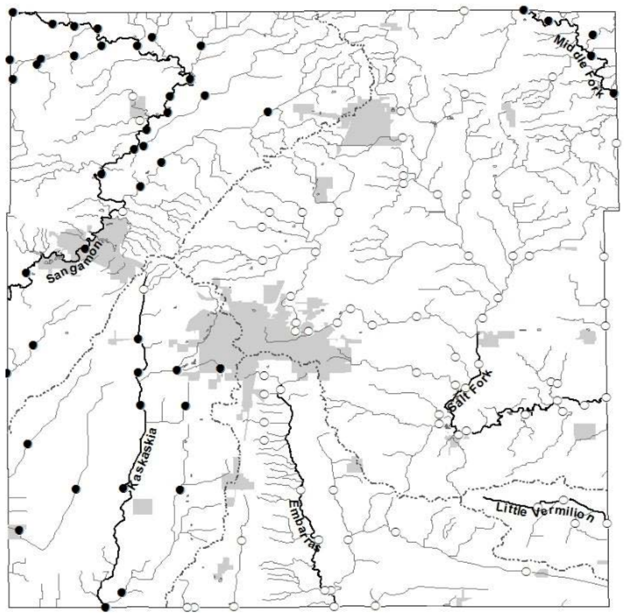
Sherwood & Stein (2012 – 2015)

Lythrurus umbratilis, Redfin Shiner

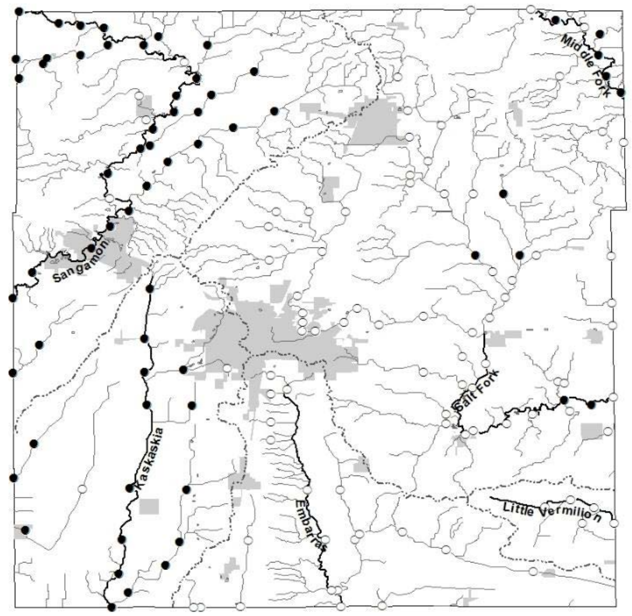
○ = species absent

● = species present

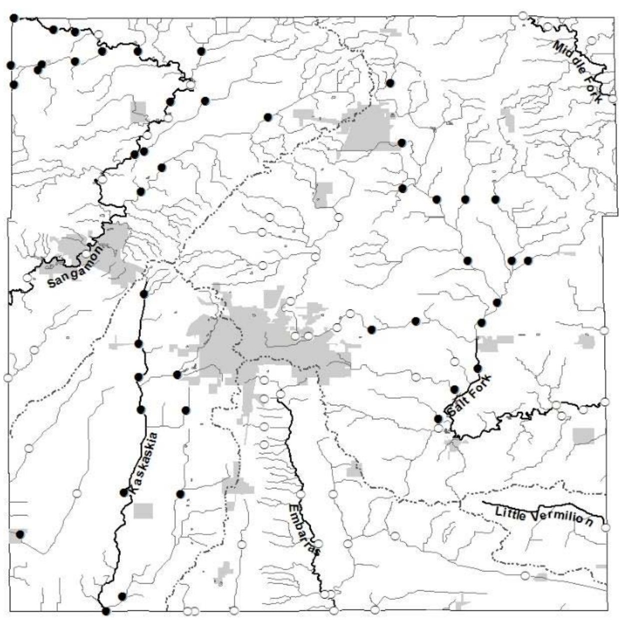
Figure 9



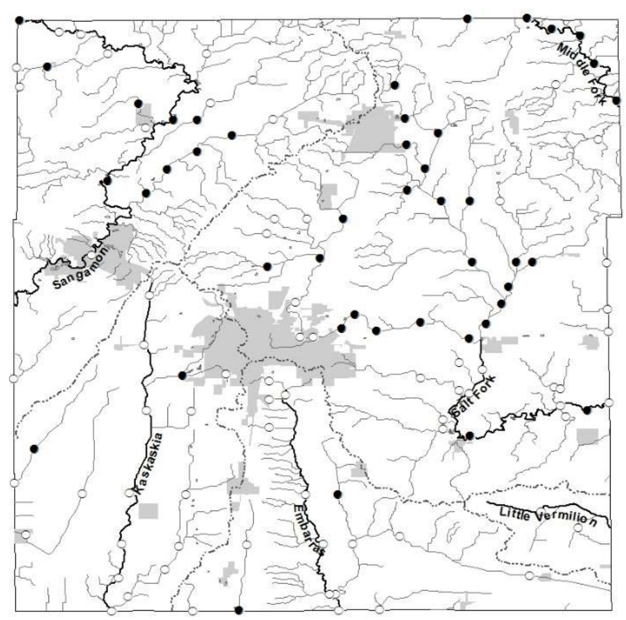
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



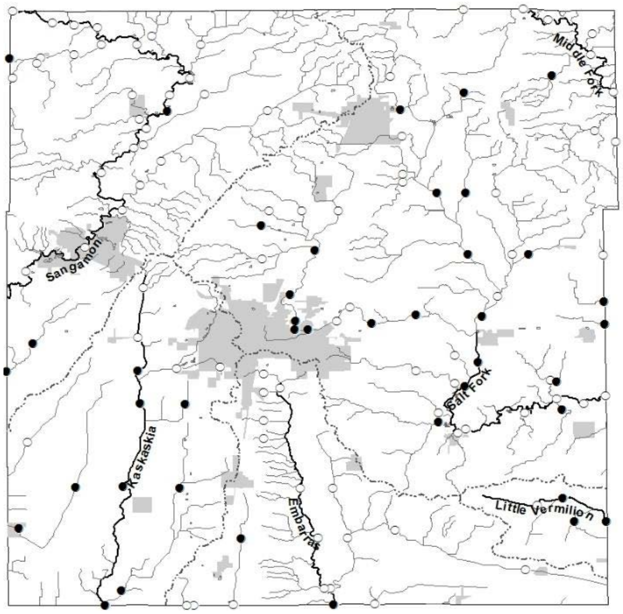
Sherwood & Stein (2012 – 2015)

***Nocomis biguttatus,* Hornyhead Chub**

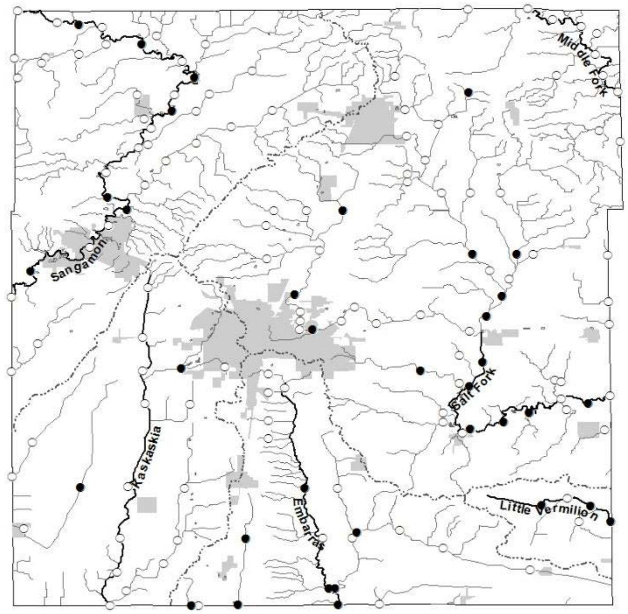
○ = species absent

● = species present

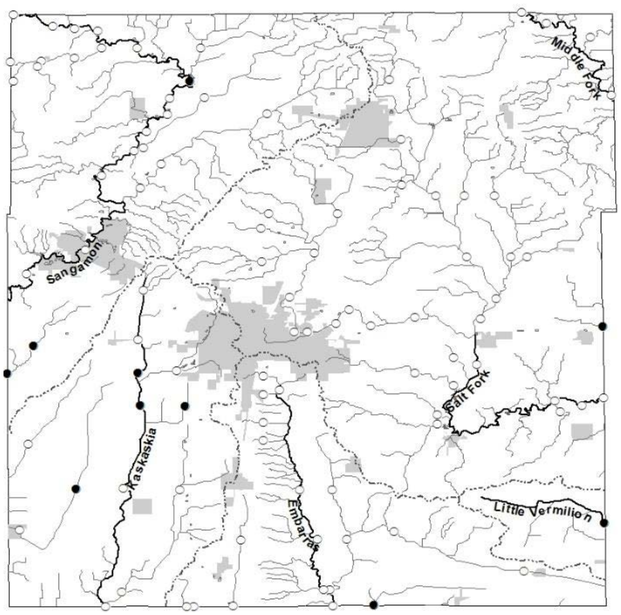
Figure 10



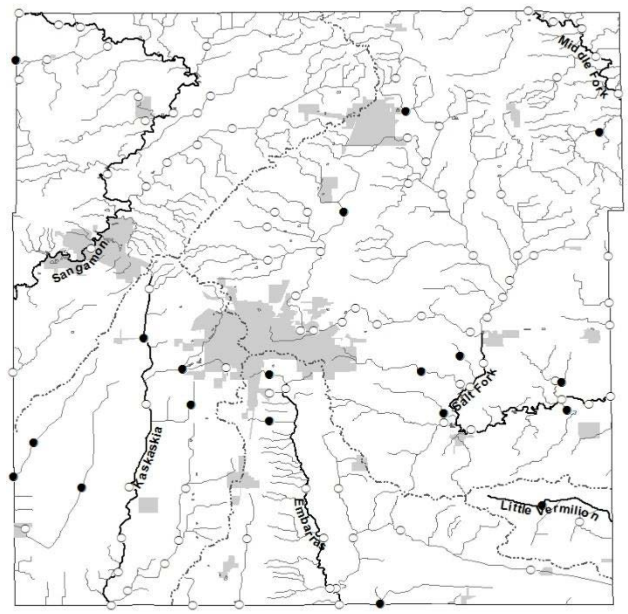
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



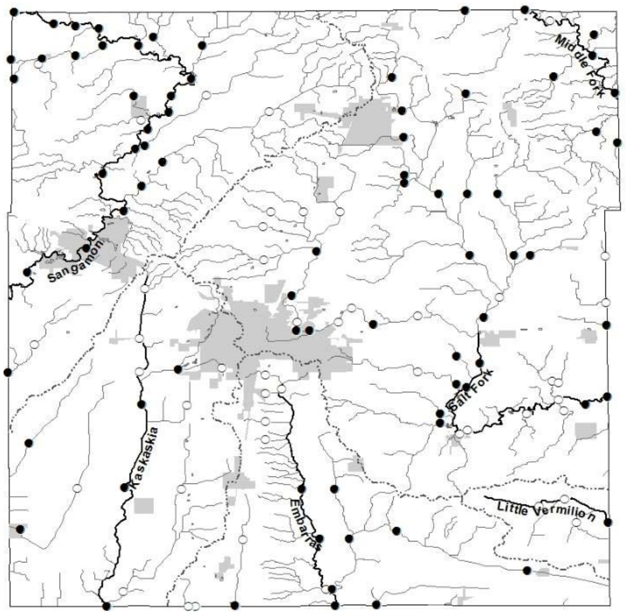
Sherwood & Stein (2012 – 2015)

Notemigonus crysoleucas, Golden Shiner

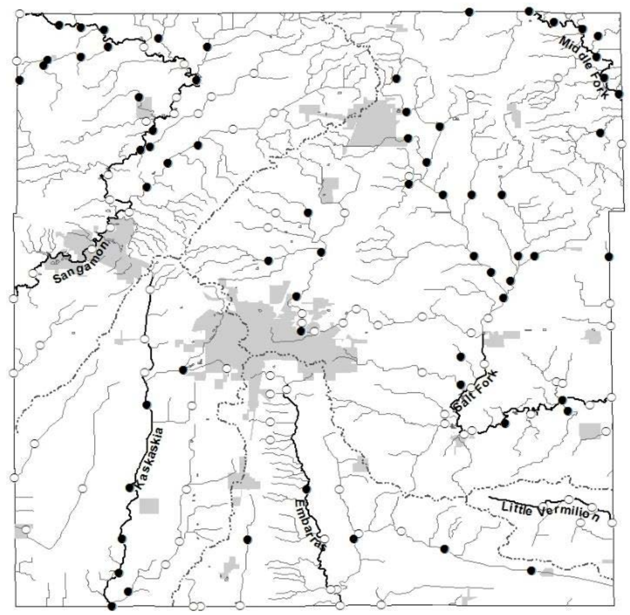
○ = species absent

● = species present

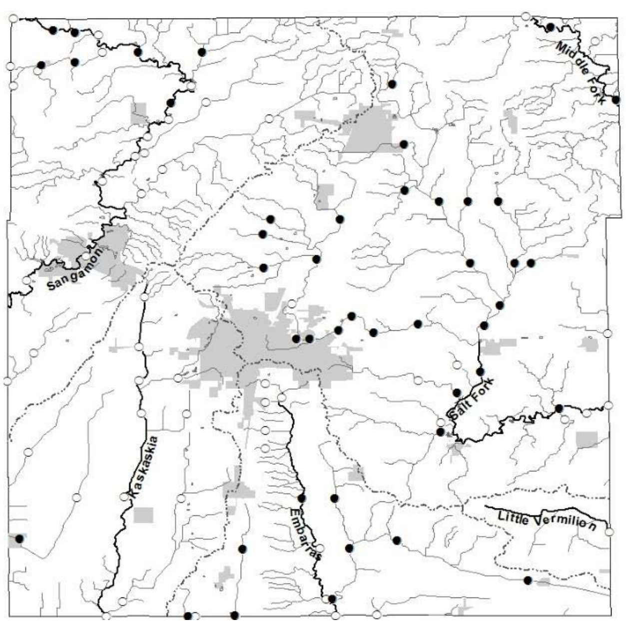
Figure 11



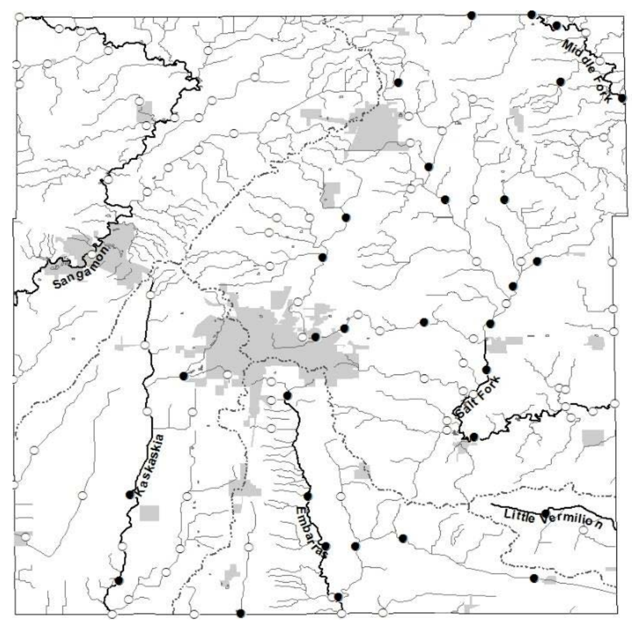
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



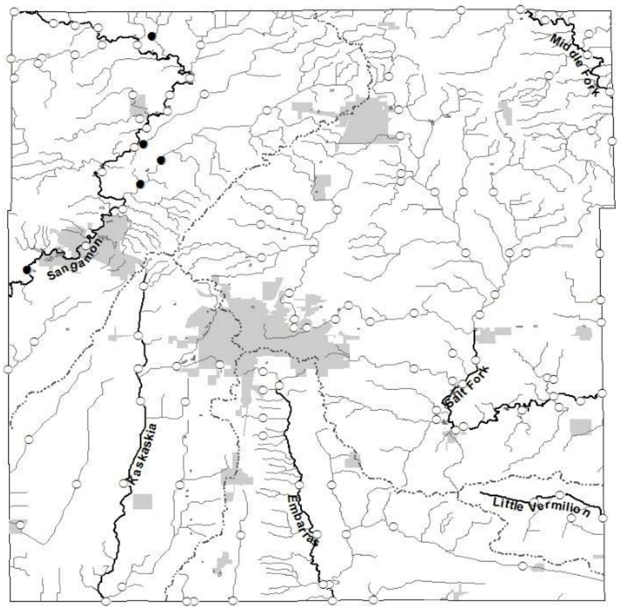
Sherwood & Stein (2012 – 2015)

Notropis buccata, **Silverjaw Minnow**

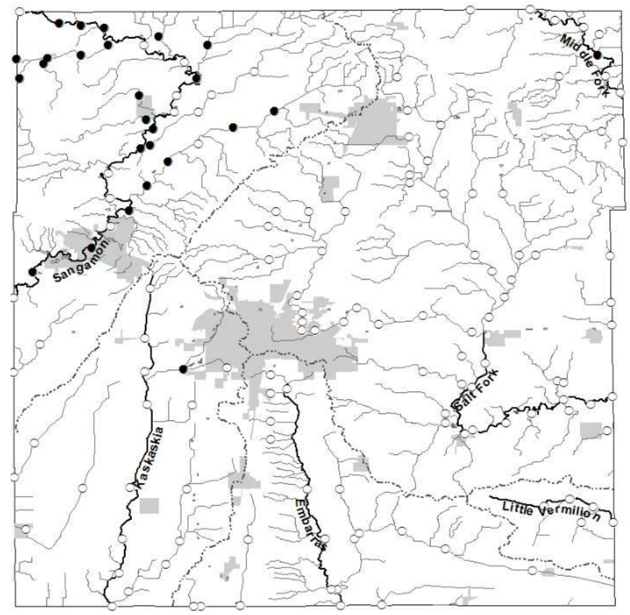
○ = species absent

● = species present

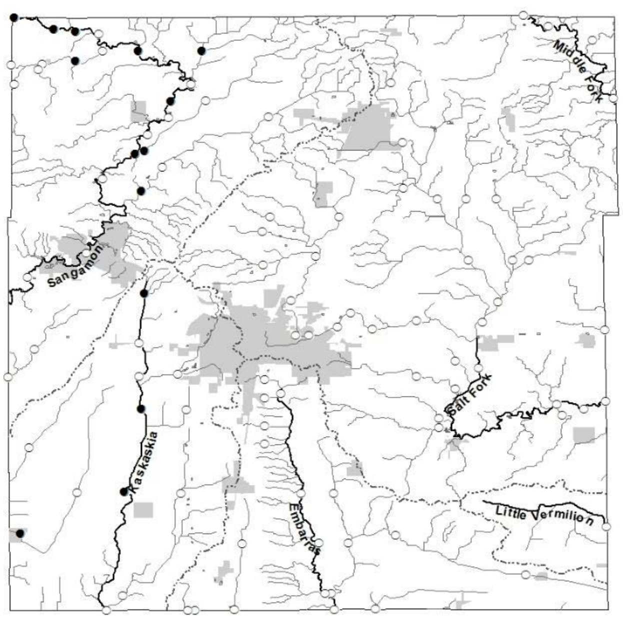
Figure 12



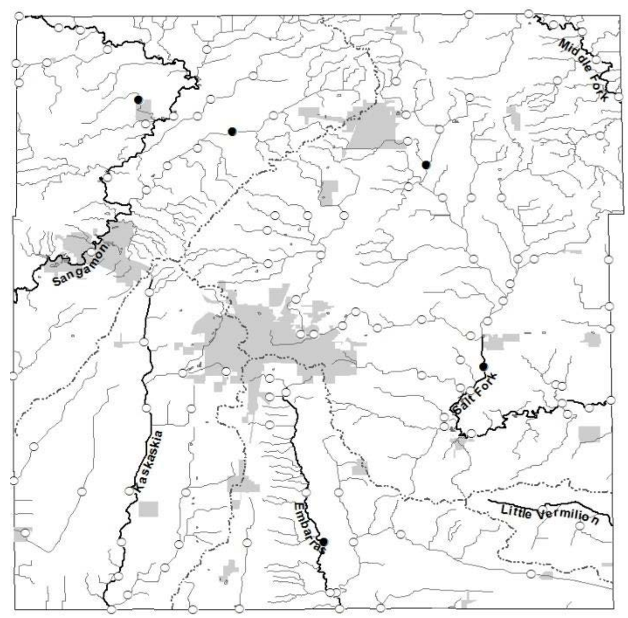
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



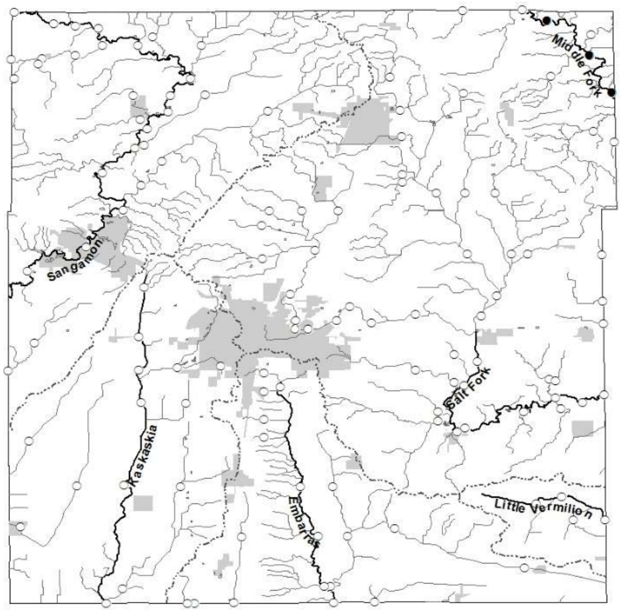
Sherwood & Stein (2012 – 2015)

***Notropis dorsalis,* Bigmouth Shiner**

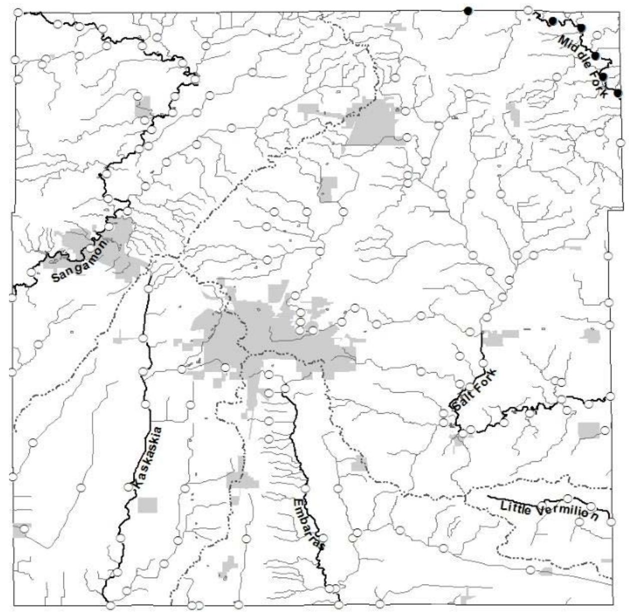
○ = species absent

● = species present

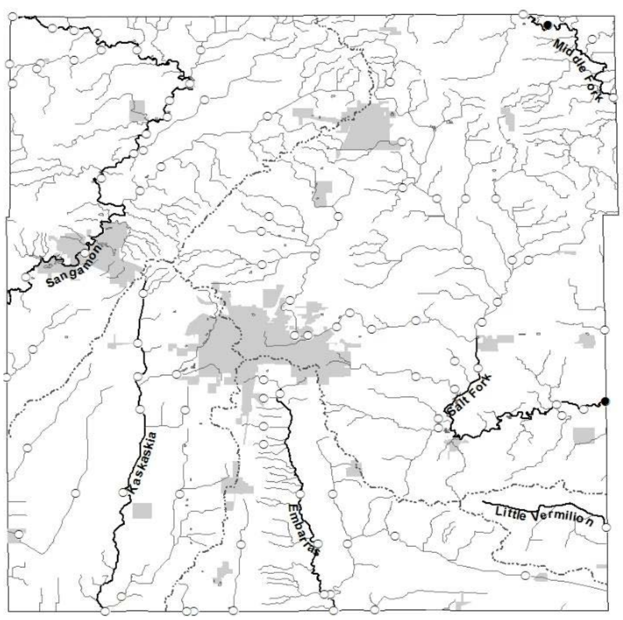
Figure 13



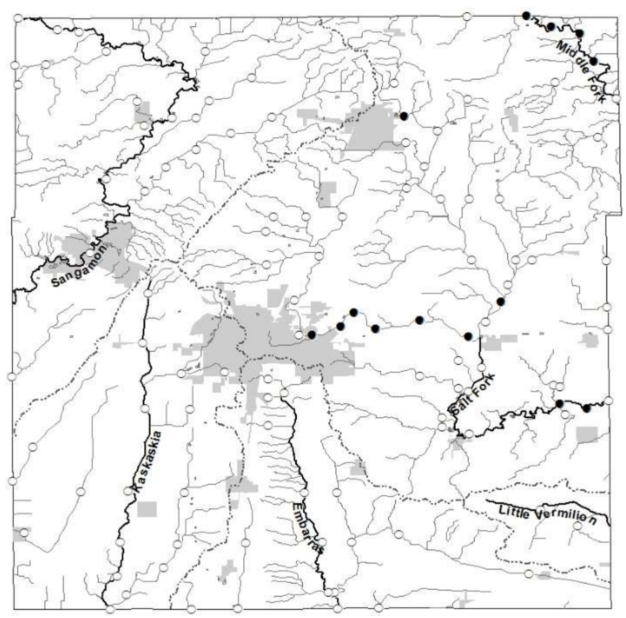
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



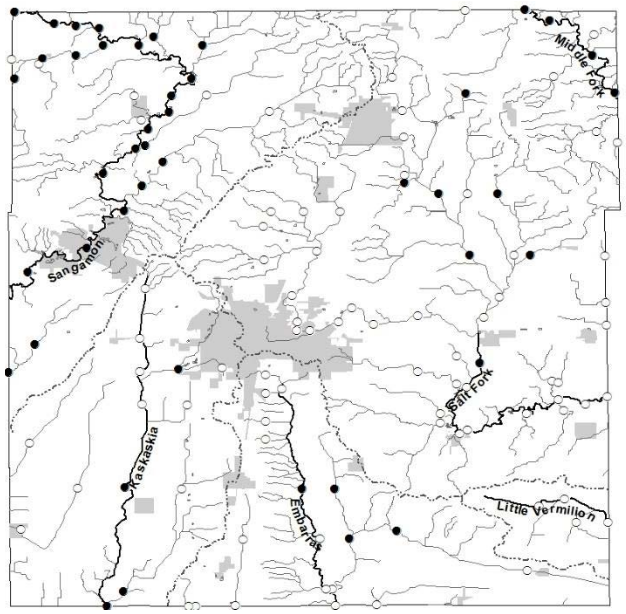
Sherwood & Stein (2012 – 2015)

***Notropis rubellus*, Rosyface Shiner**

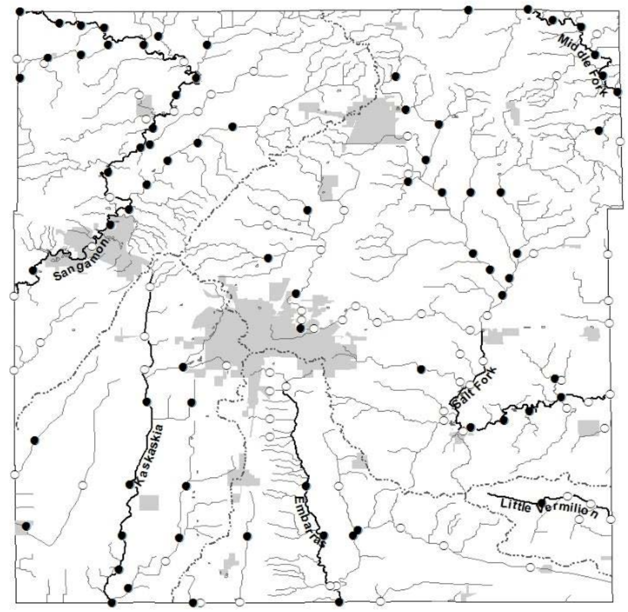
○ = species absent

● = species present

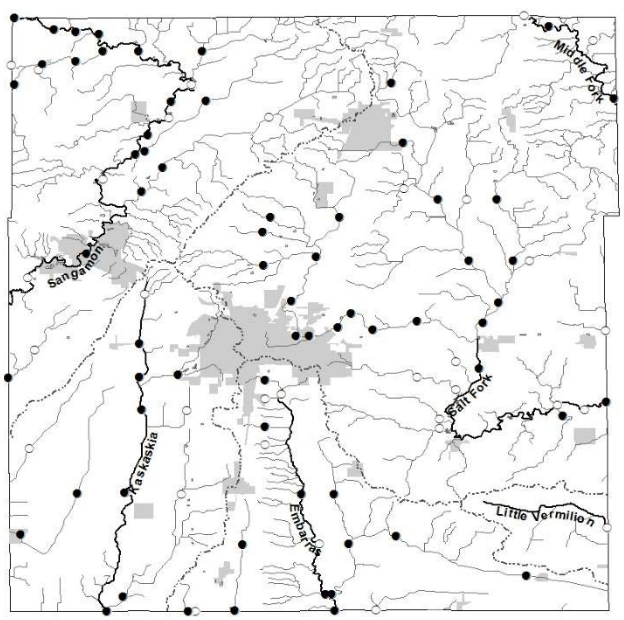
Figure 14



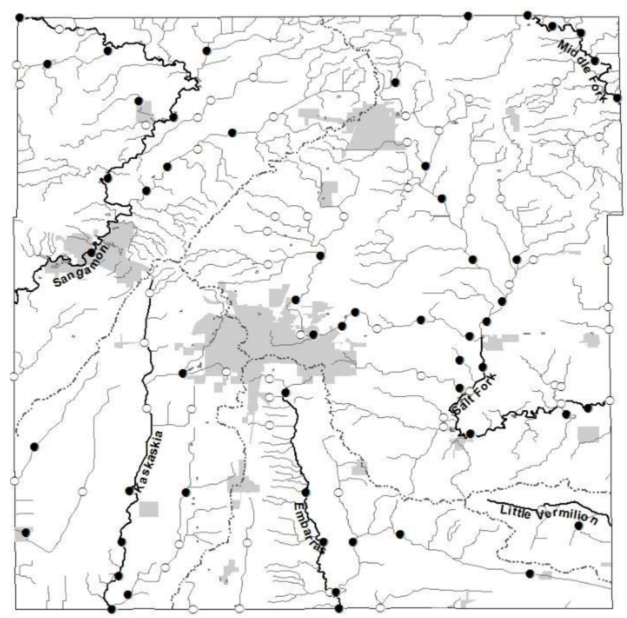
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



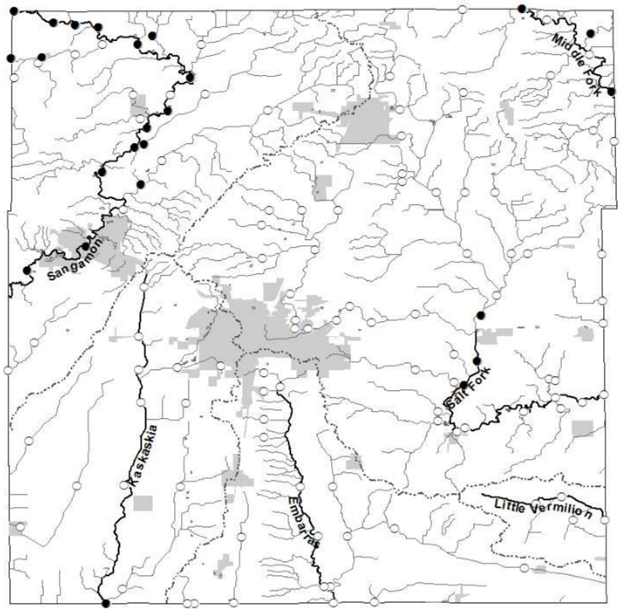
Sherwood & Stein (2012 – 2015)

Notropis stramineus, **Sand Shiner**

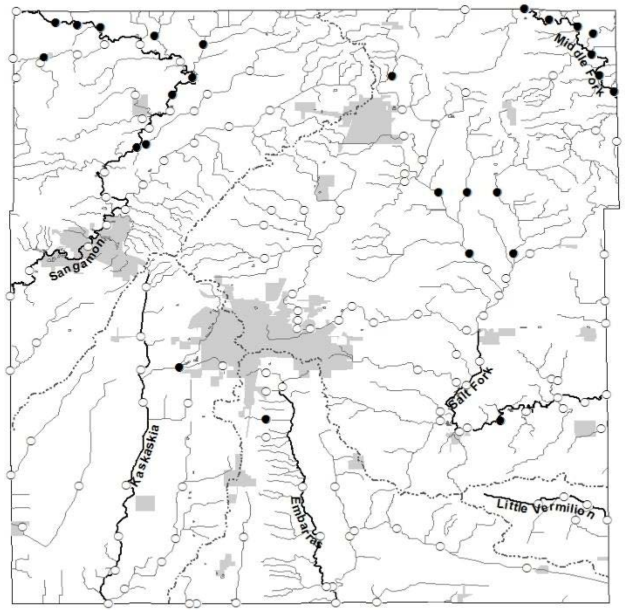
○ = species absent

● = species present

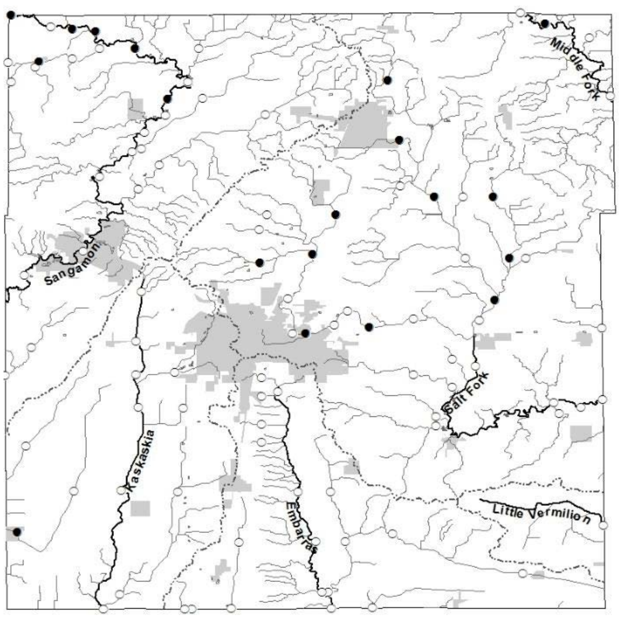
Figure 15



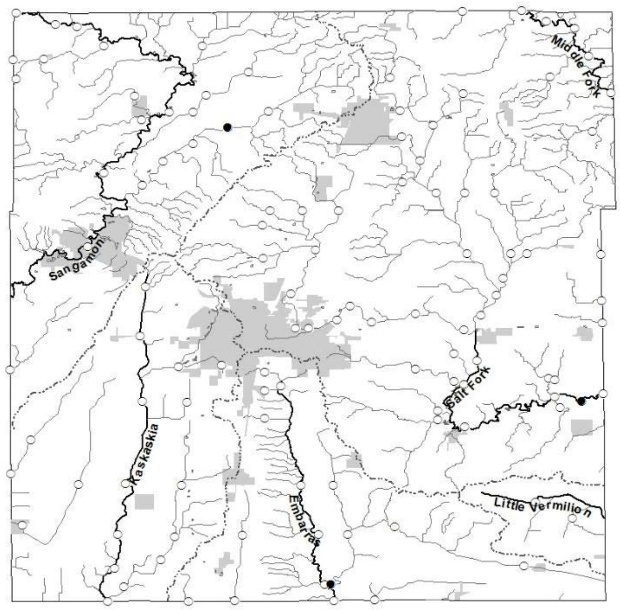
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



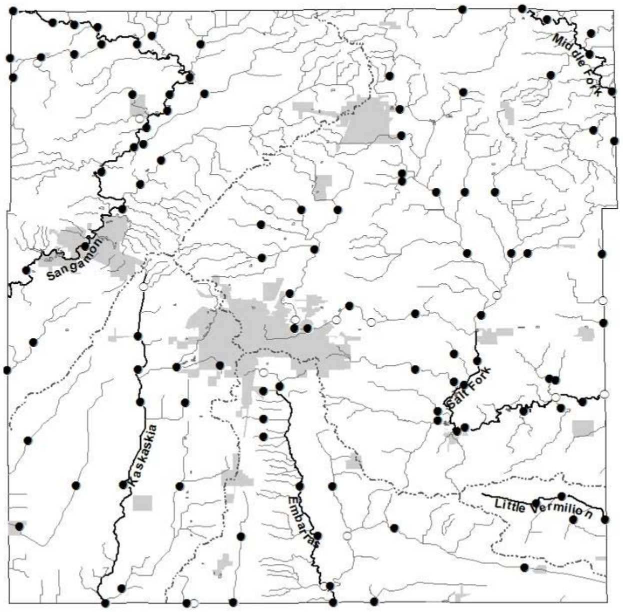
Sherwood & Stein (2012 – 2015)

Phenacobius mirabilis, Suckermouth Minnow

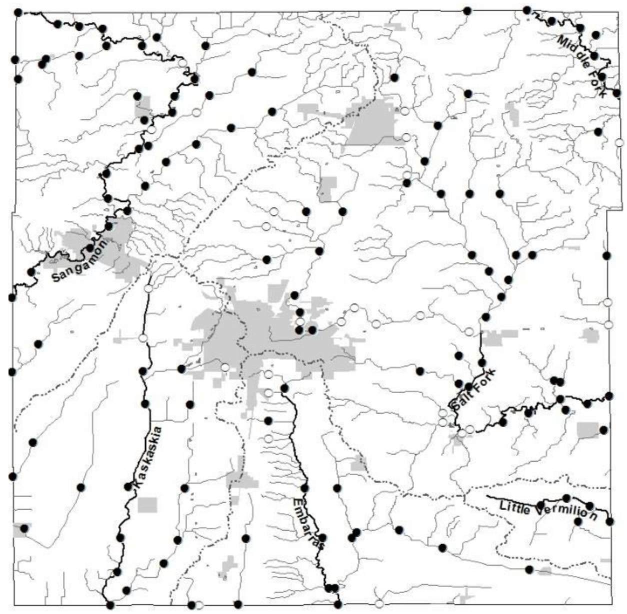
O = species absent

● = species present

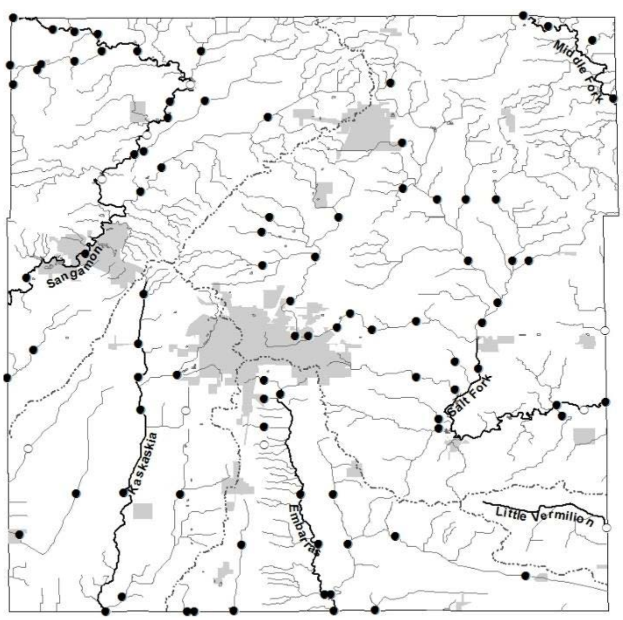
Figure 16



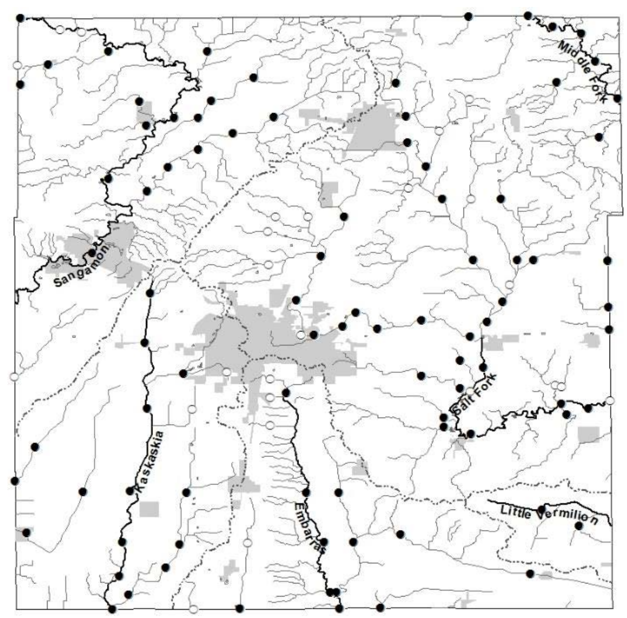
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



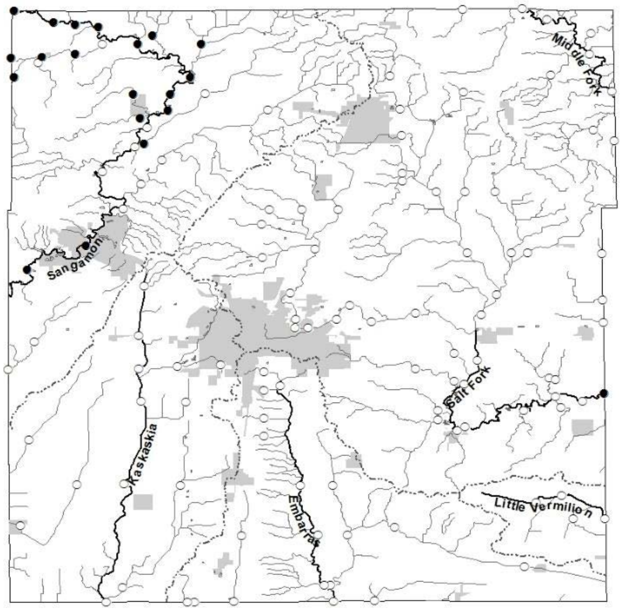
Sherwood & Stein (2012 – 2015)

Pimephales notatus, Bluntnose Minnow

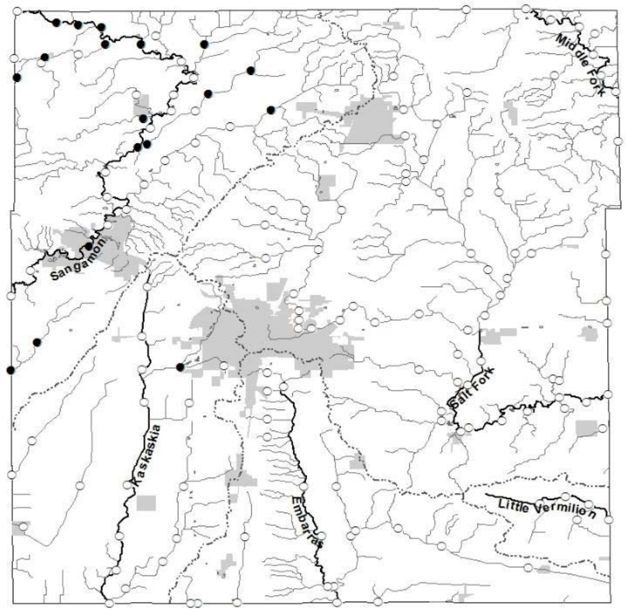
○ = species absent

● = species present

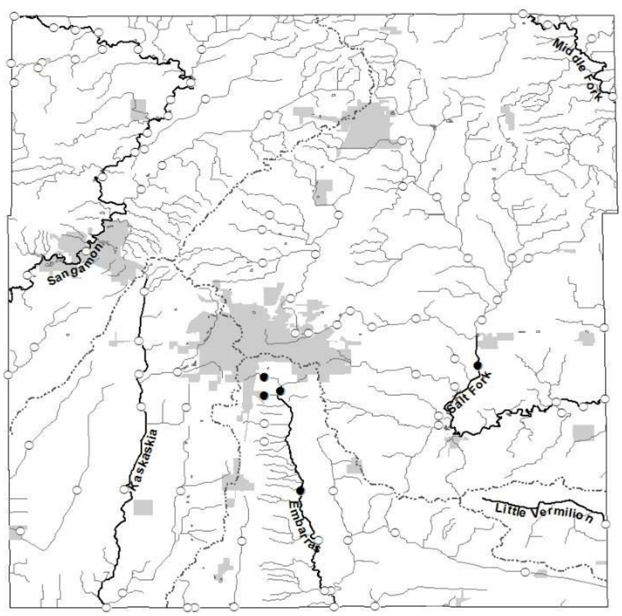
Figure 17



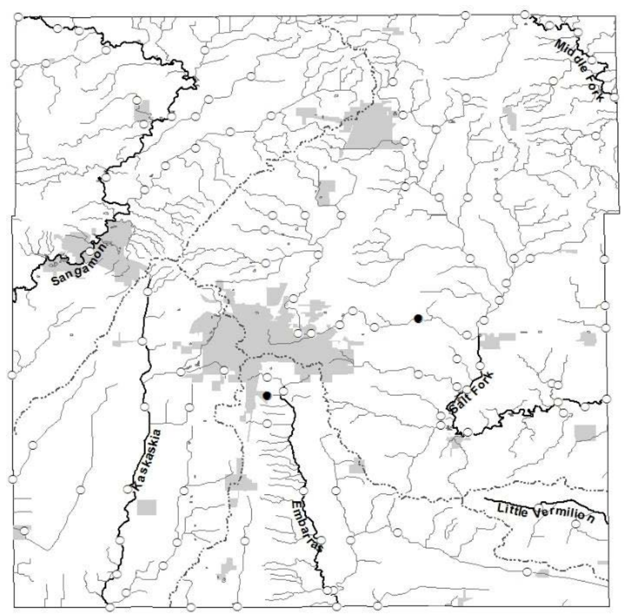
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



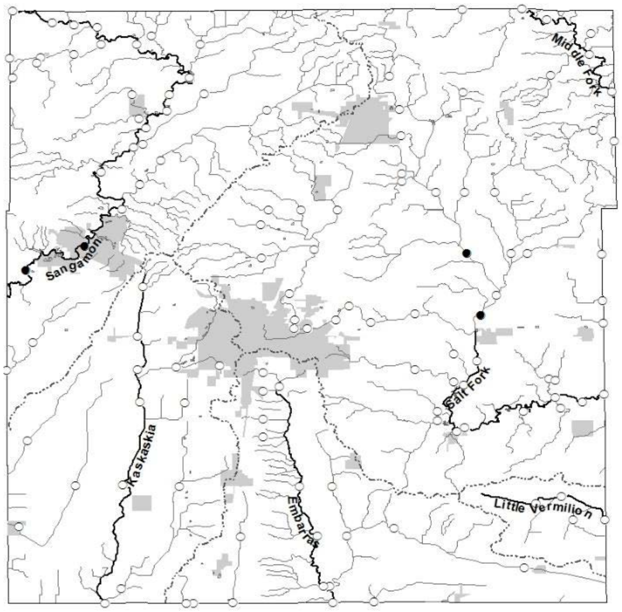
Sherwood & Stein (2012 – 2015)

***Pimephales promelas,* Fathead Minnow**

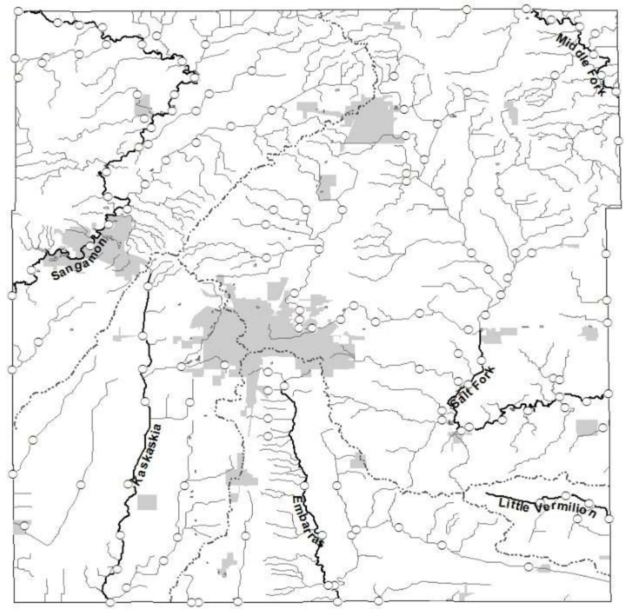
O = species absent

● = species present

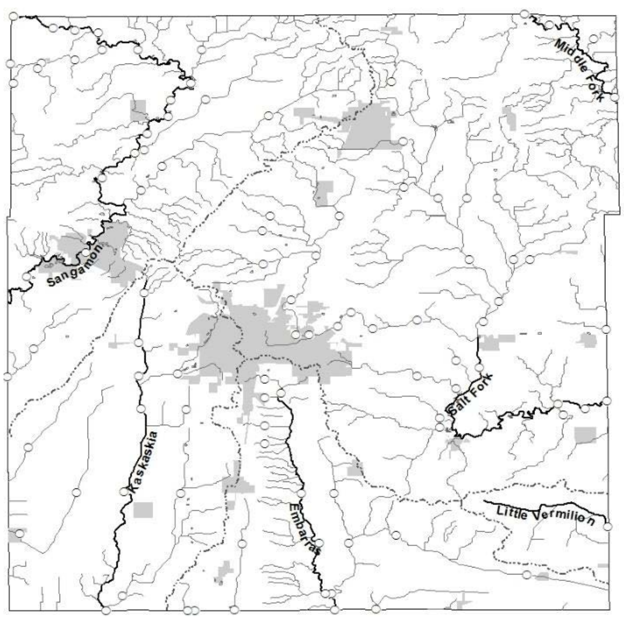
Figure 18



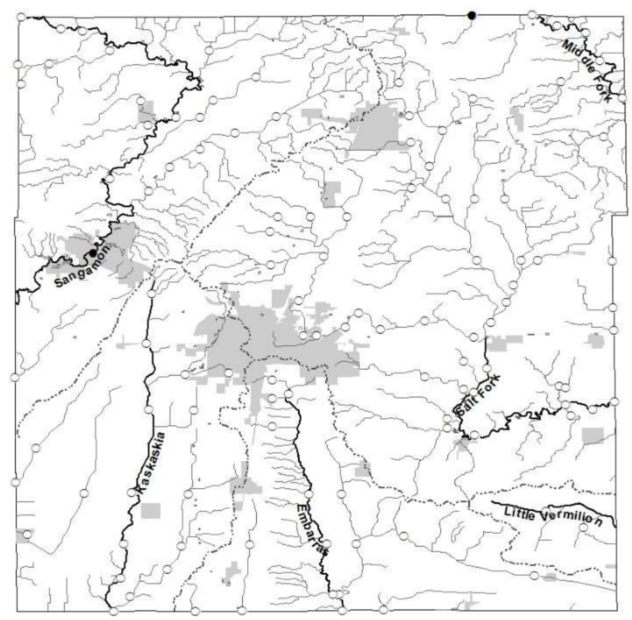
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



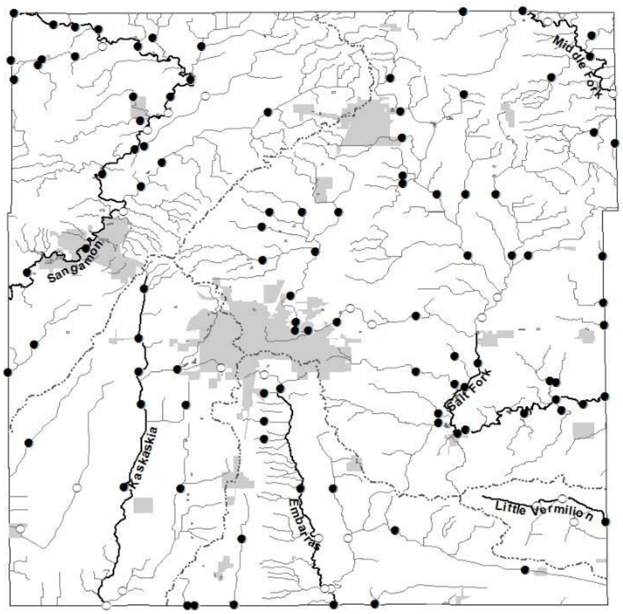
Sherwood & Stein (2012 – 2015)

Pimephales vigilax, Bullhead Minnow

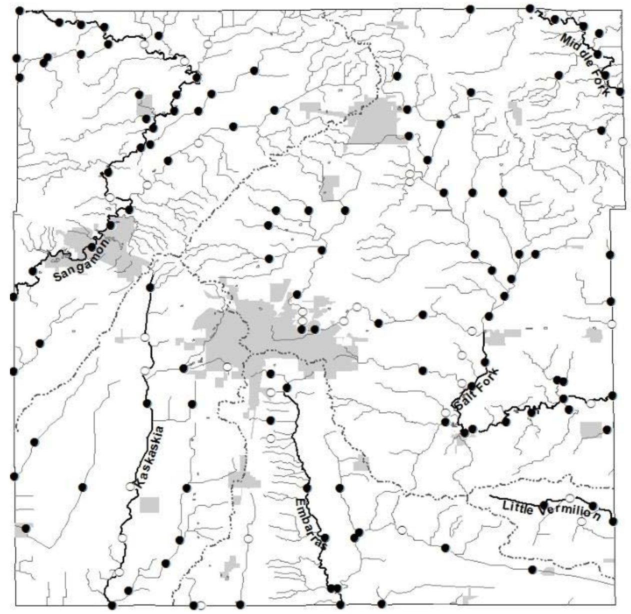
○ = species absent

● = species present

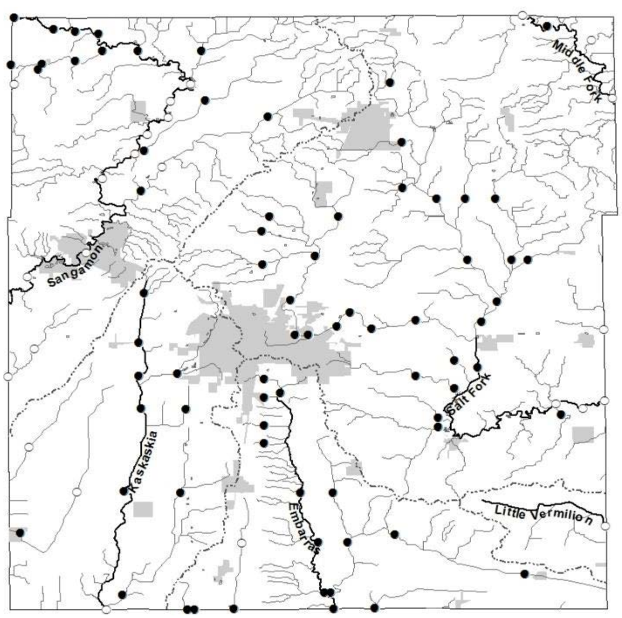
Figure 19



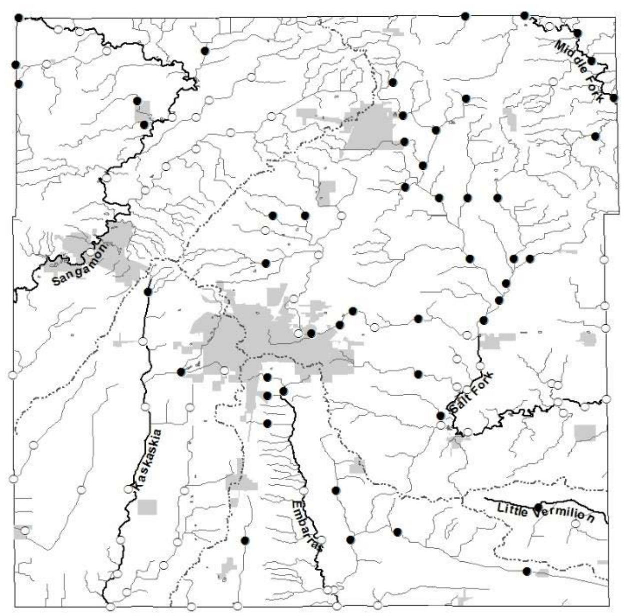
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



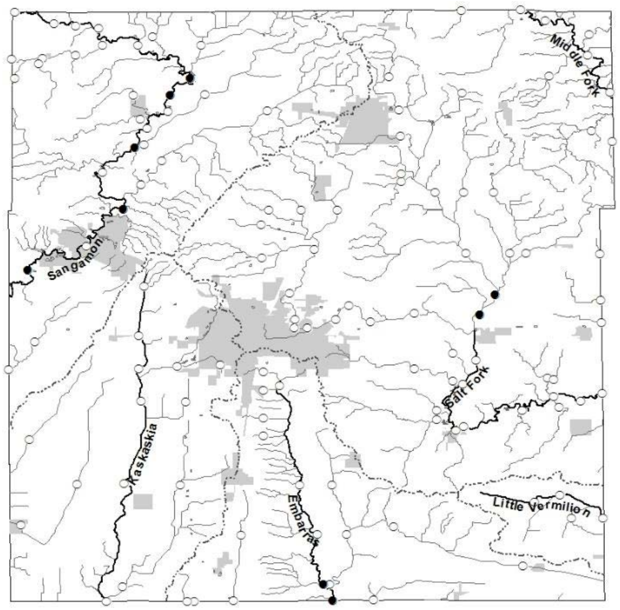
Sherwood & Stein (2012 – 2015)

***Semotilus atromaculatus,* Creek Chub**

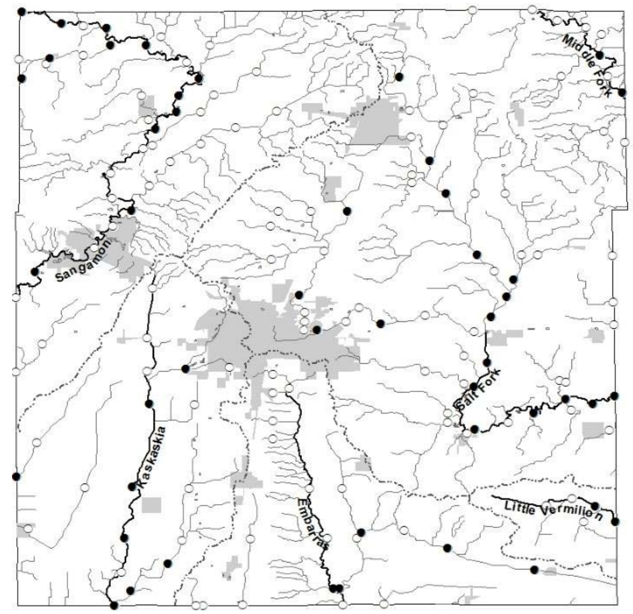
○ = species absent

● = species present

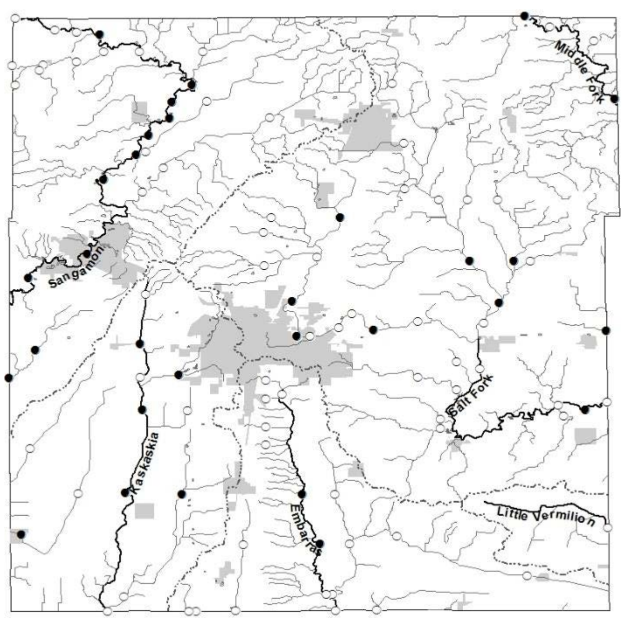
Figure 20



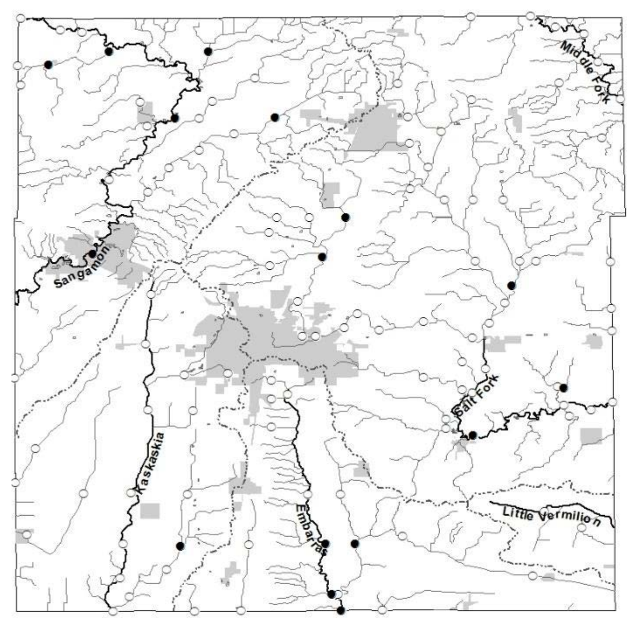
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



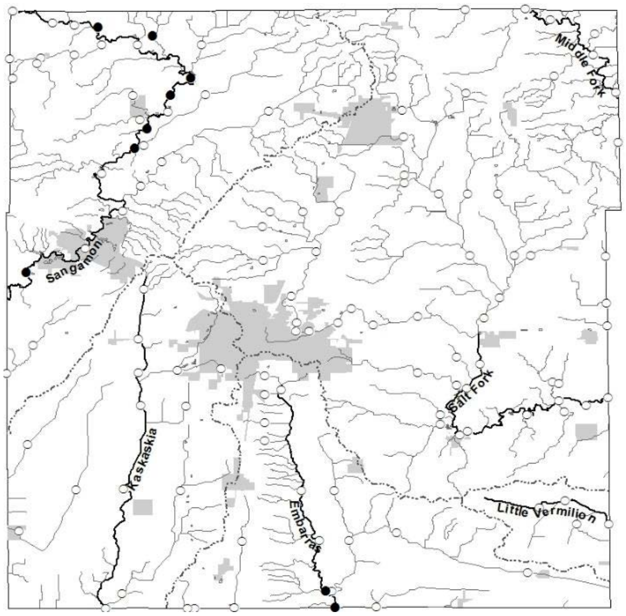
Sherwood & Stein (2012 – 2015)

Cyprinus carpio, **Common Carp**

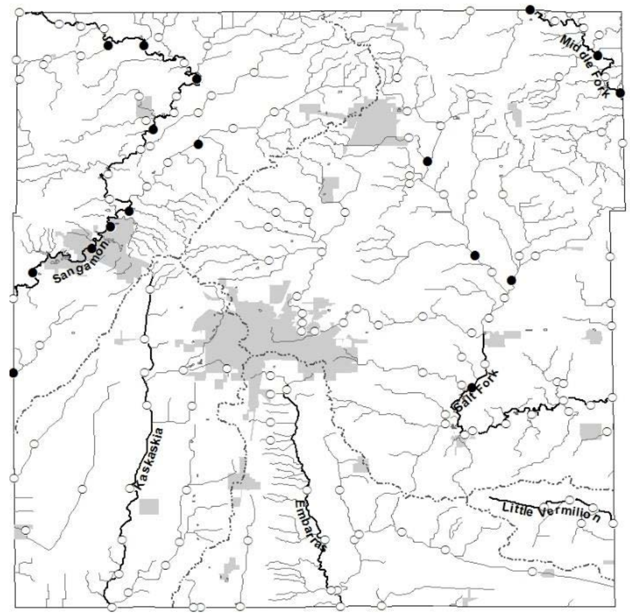
○ = species absent

● = species present

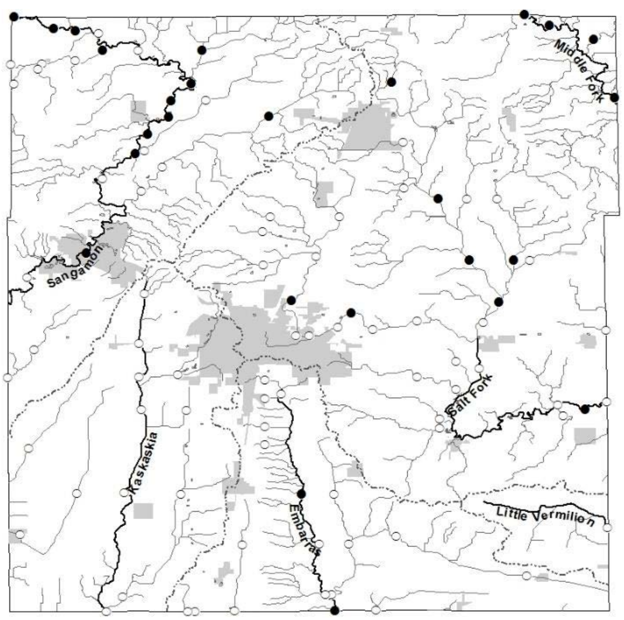
Figure 21



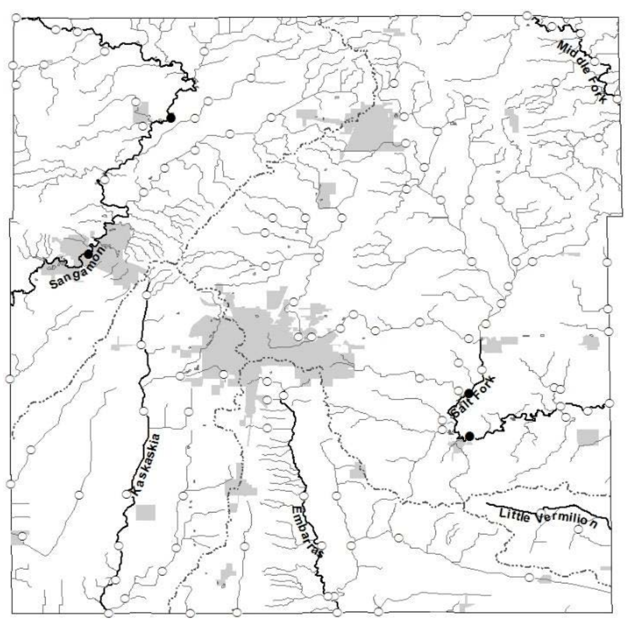
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



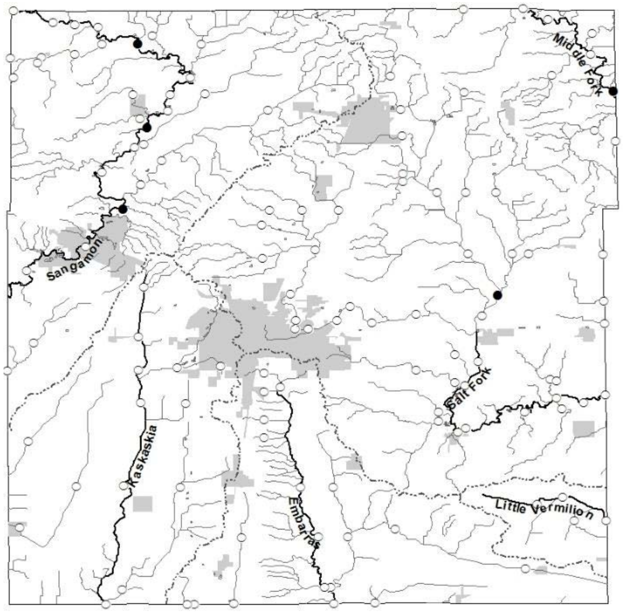
Sherwood & Stein (2012 – 2015)

***Carpiodes cyprinus,* Quillback**

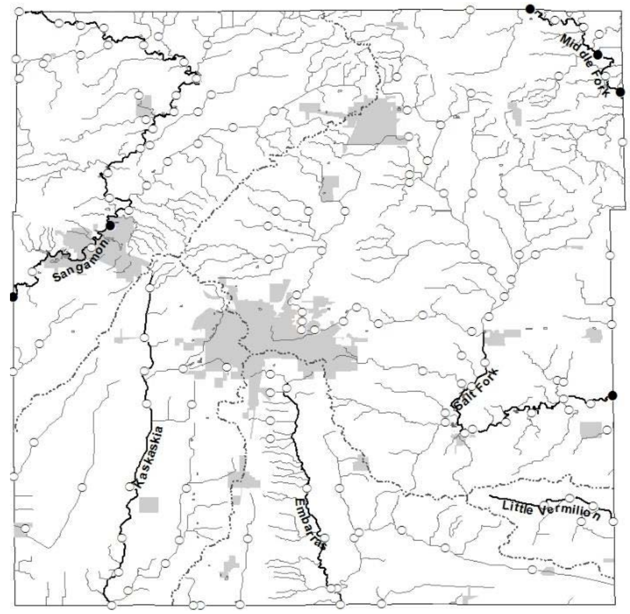
O = species absent

● = species present

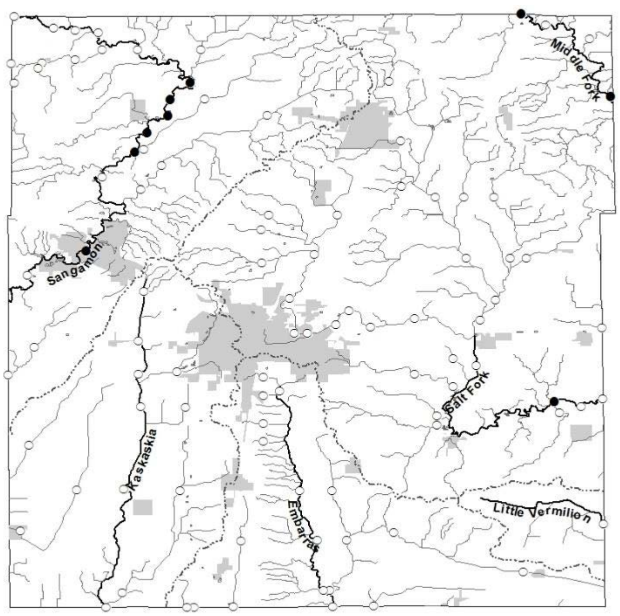
Figure 22



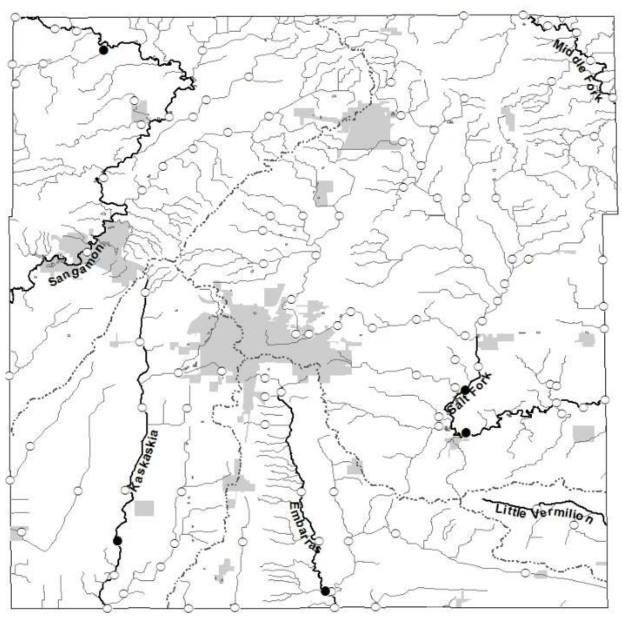
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



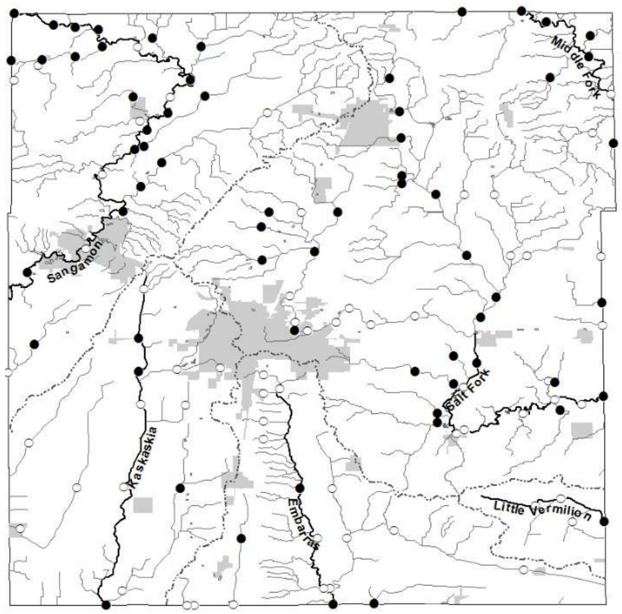
Sherwood & Stein (2012 – 2015)

Carpiodes velifer, **Highfin Carpsucker**

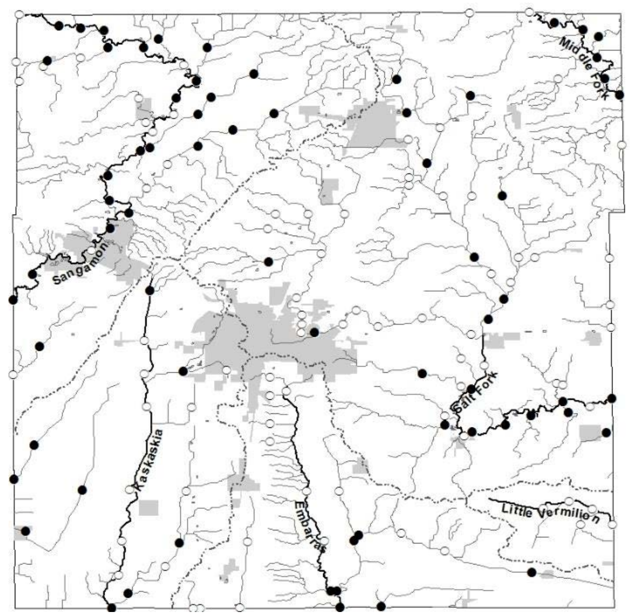
○ = species absent

● = species present

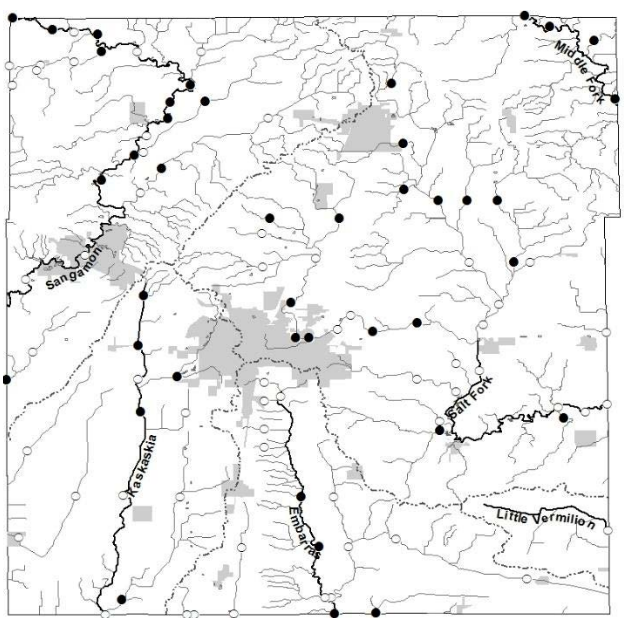
Figure 23



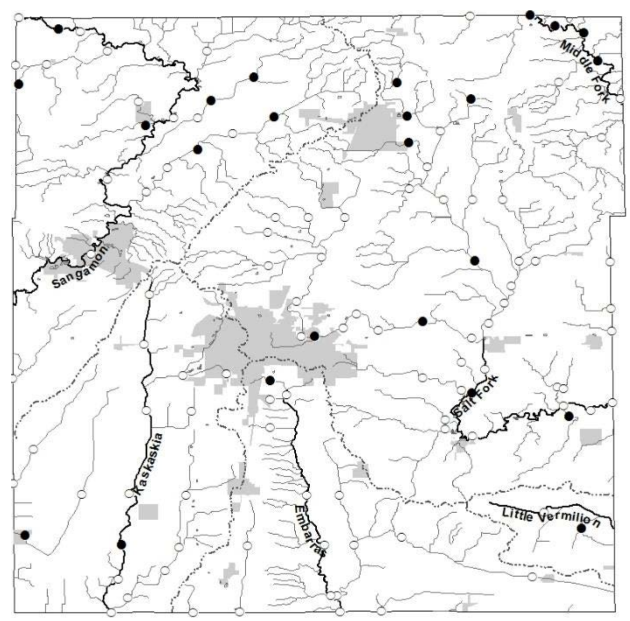
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



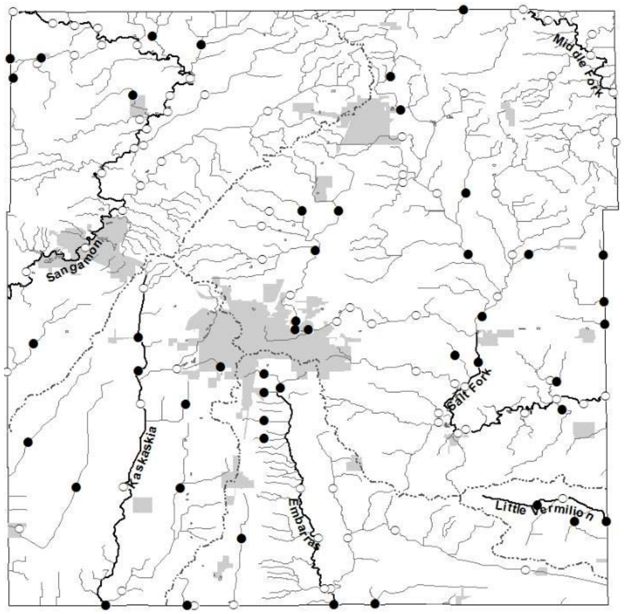
Sherwood & Stein (2012 – 2015)

***Catostomus commersonii,* White Sucker**

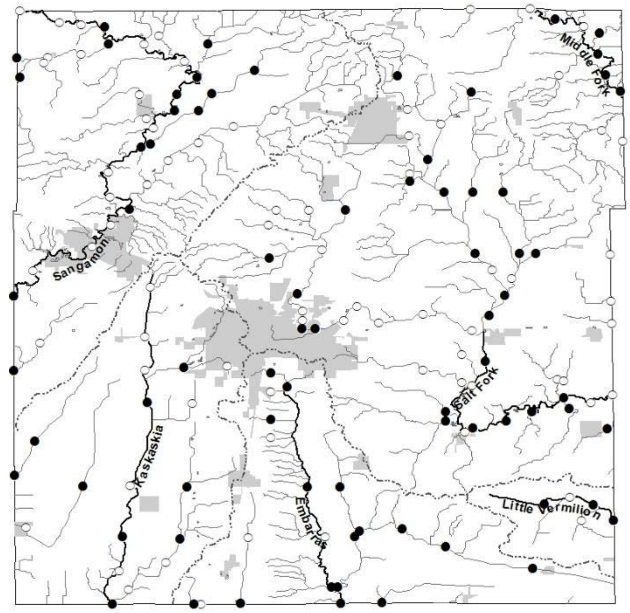
○ = species absent

● = species present

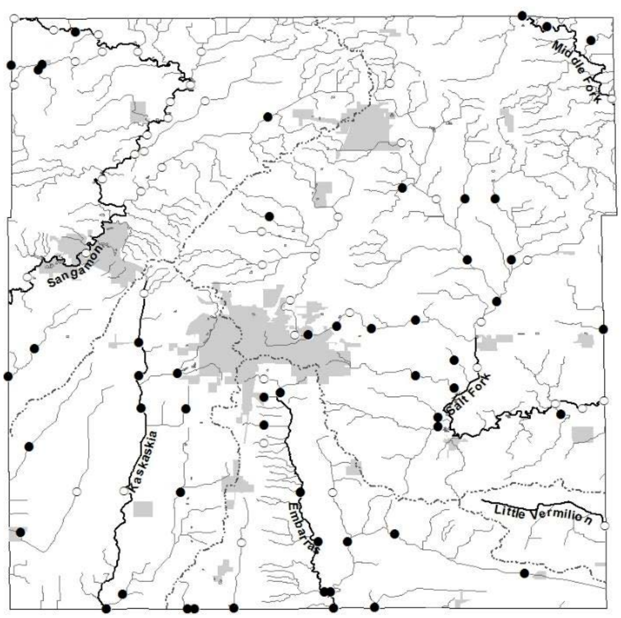
Figure 24



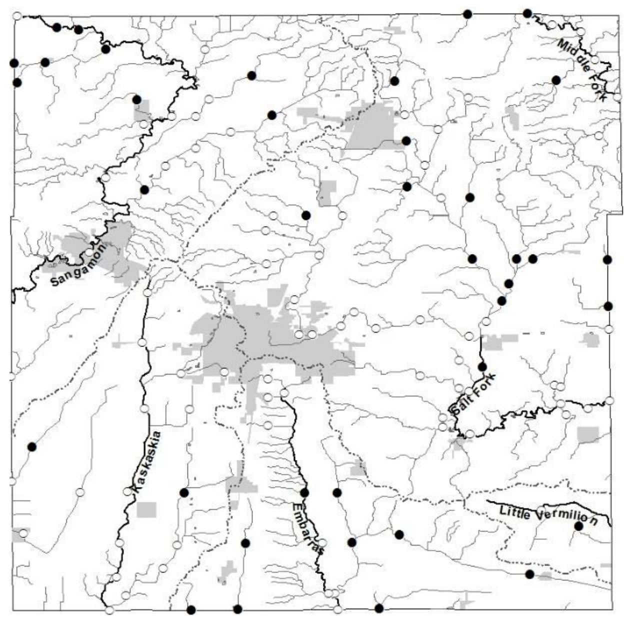
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



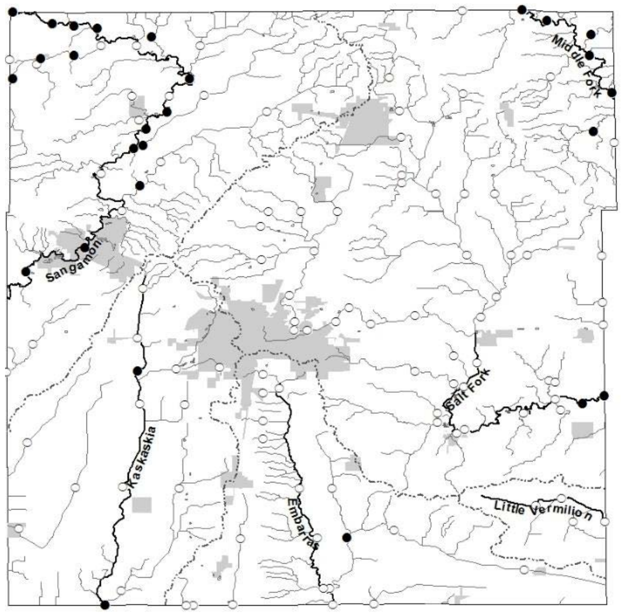
Sherwood & Stein (2012 – 2015)

***Erimyzon claviformis,* Western Creek Chubsucker**

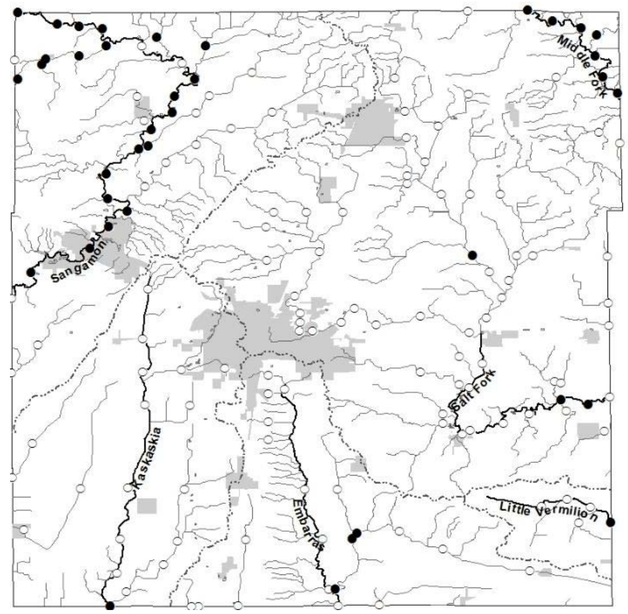
○ = species absent

● = species present

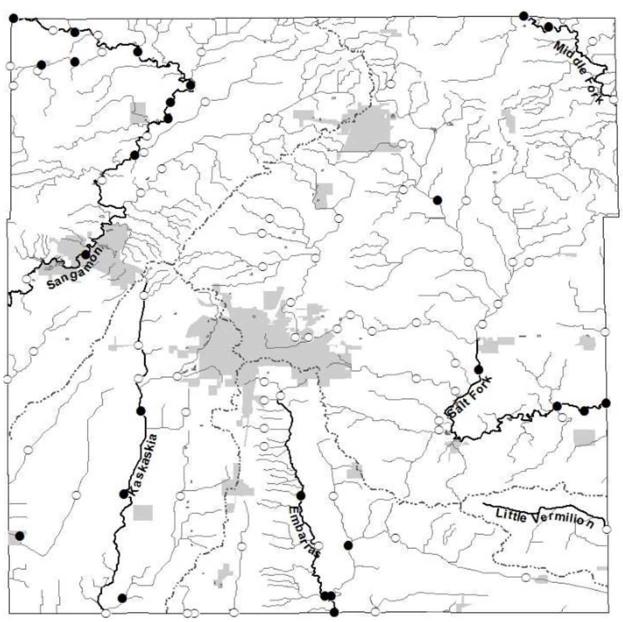
Figure 25



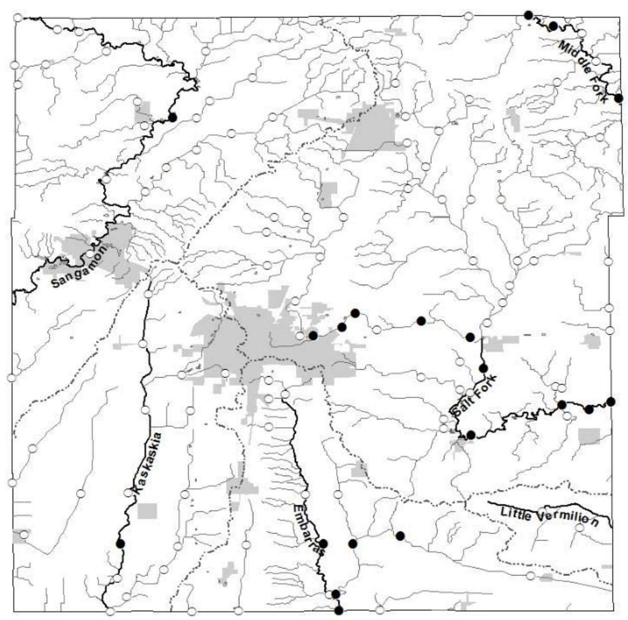
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



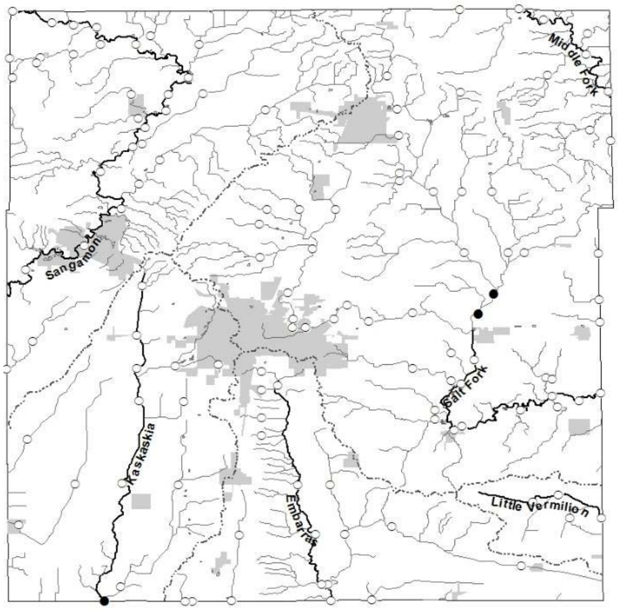
Sherwood & Stein (2012 – 2015)

***Hypentelium nigricans,* Northern Hog Sucker**

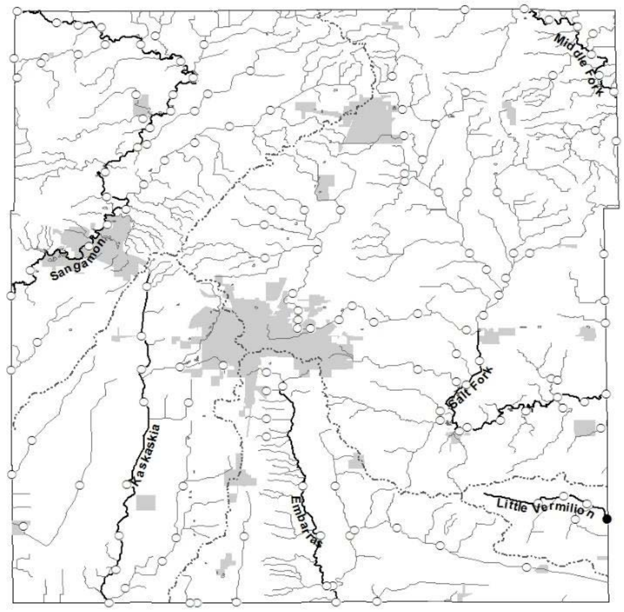
○ = species absent

● = species present

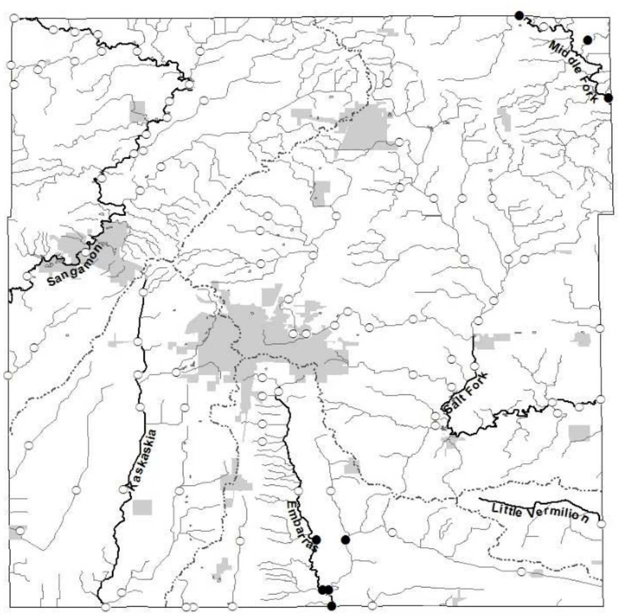
Figure 26



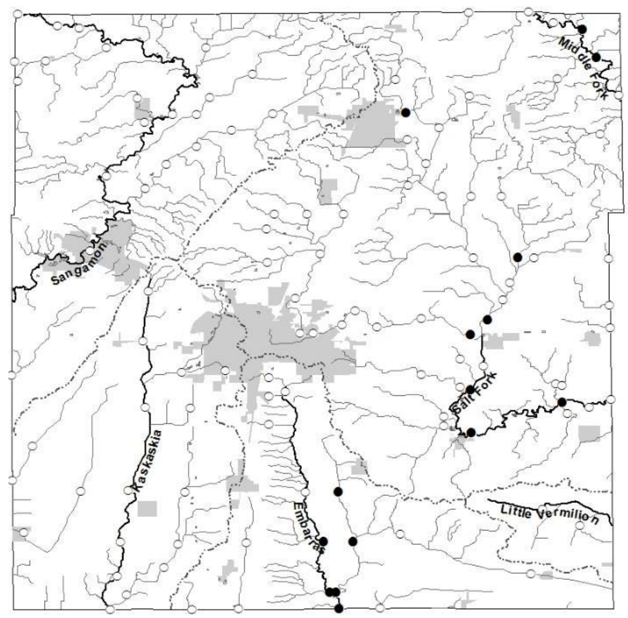
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



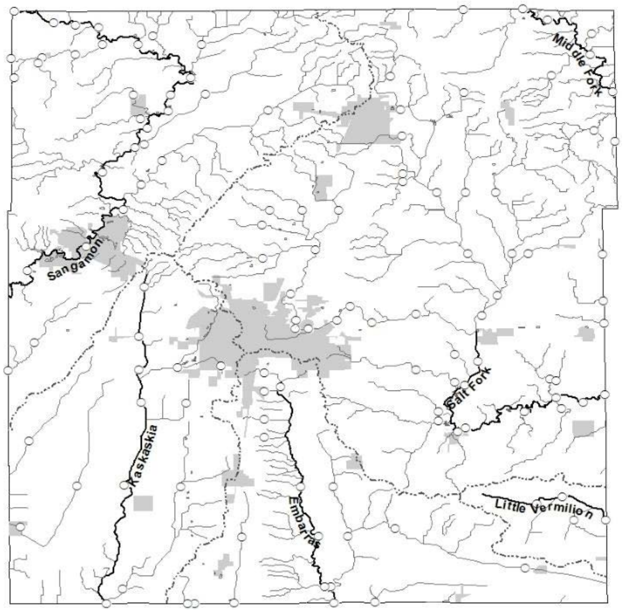
Sherwood & Stein (2012 – 2015)

Minytrema melanops, Spotted Sucker

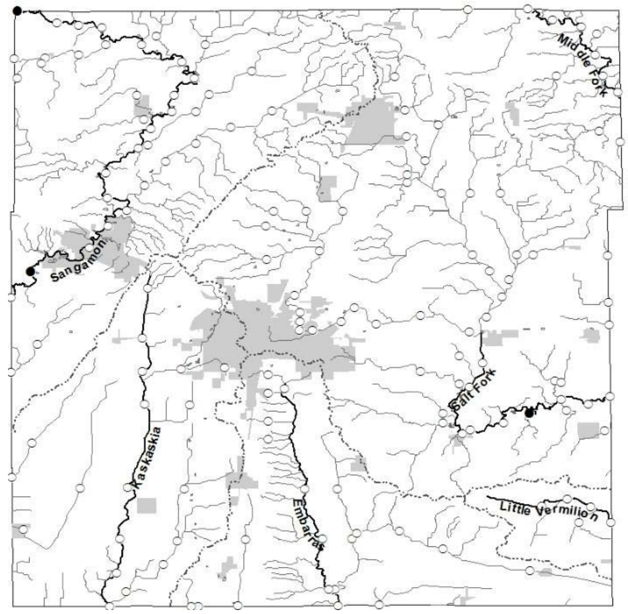
O = species absent

● = species present

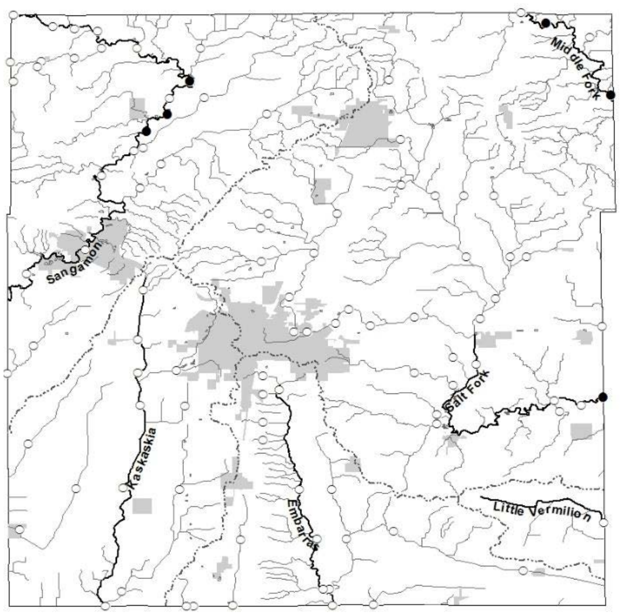
Figure 27



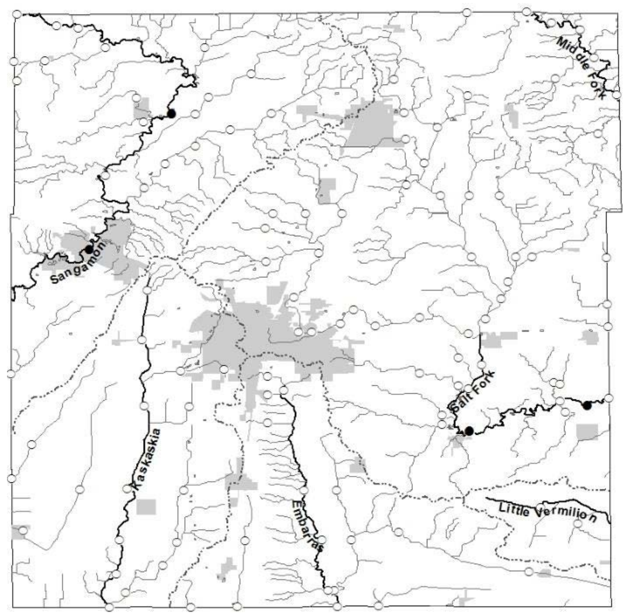
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



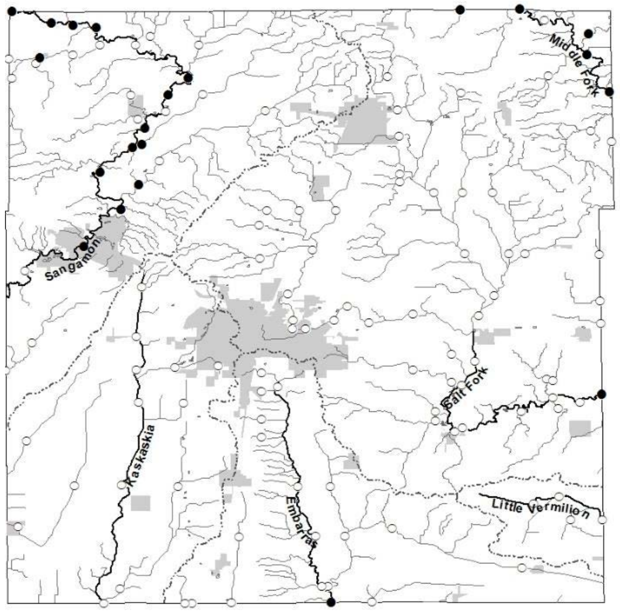
Sherwood & Stein (2012 – 2015)

Moxostoma anisurum, Silver Redhorse

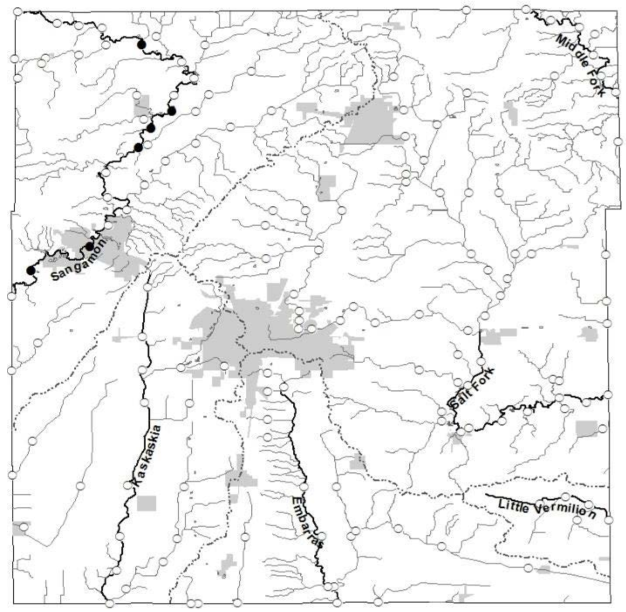
○ = species absent

● = species present

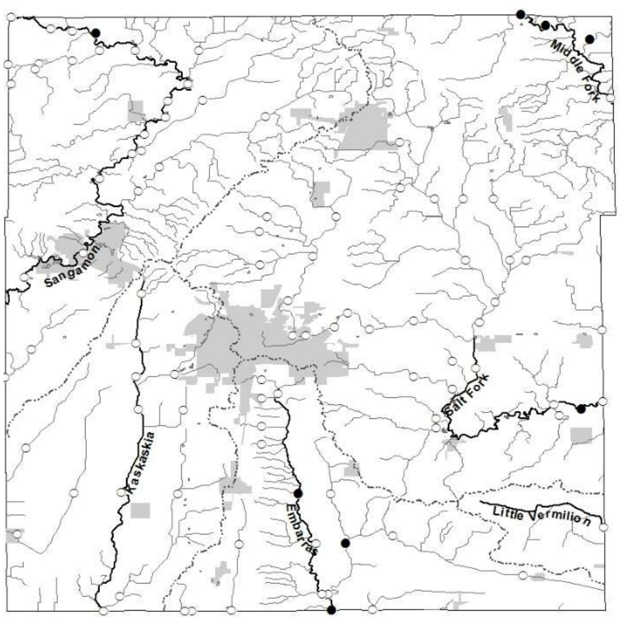
Figure 28



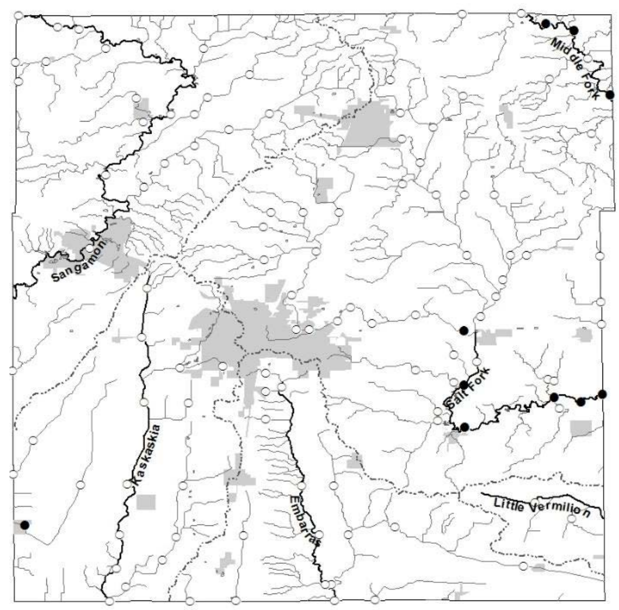
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



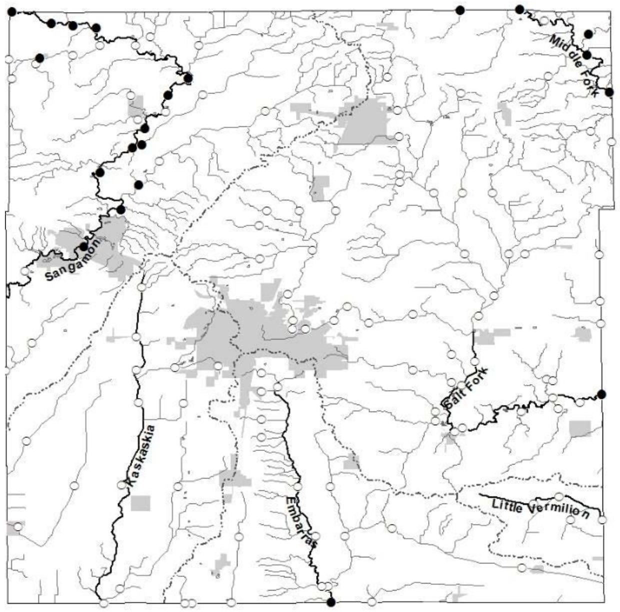
Sherwood & Stein (2012 – 2015)

Moxostoma duquesnei, Black Redhorse

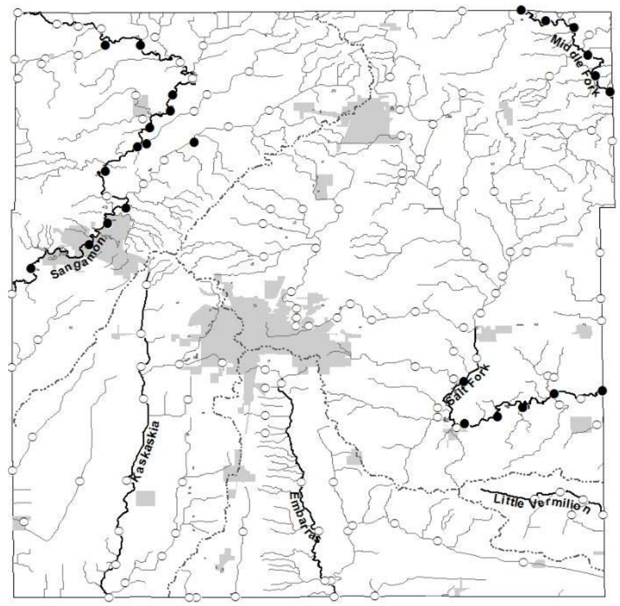
○ = species absent

● = species present

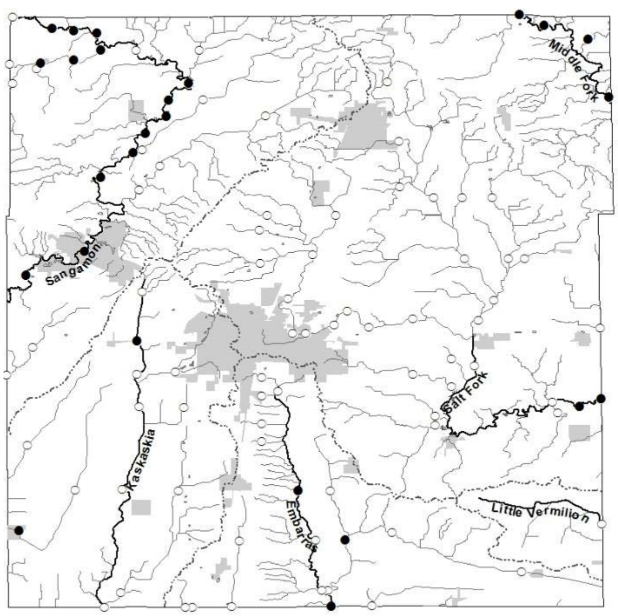
Figure 29



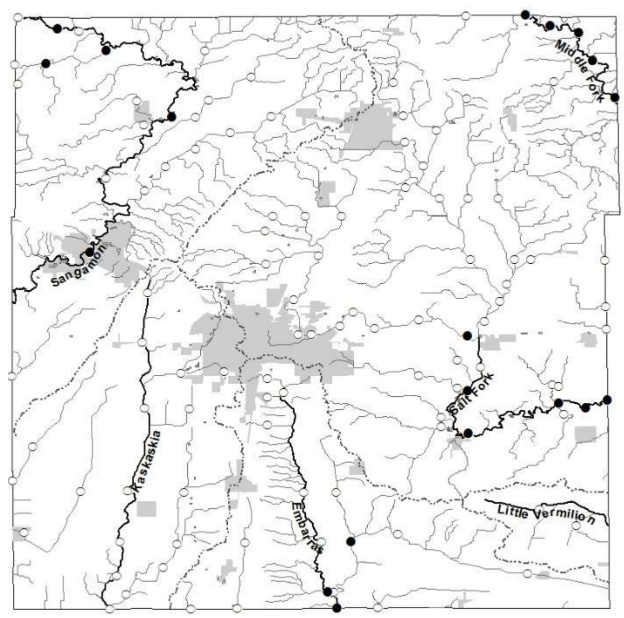
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



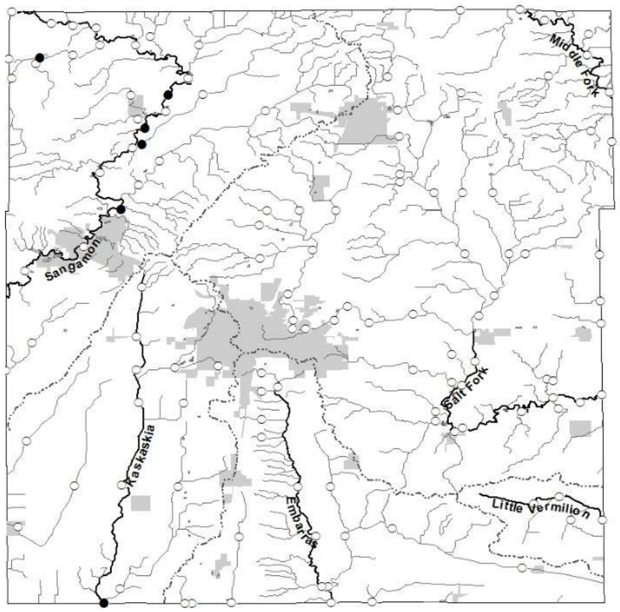
Sherwood & Stein (2012 – 2015)

Moxostoma erythrurum, **Golden Redhorse**

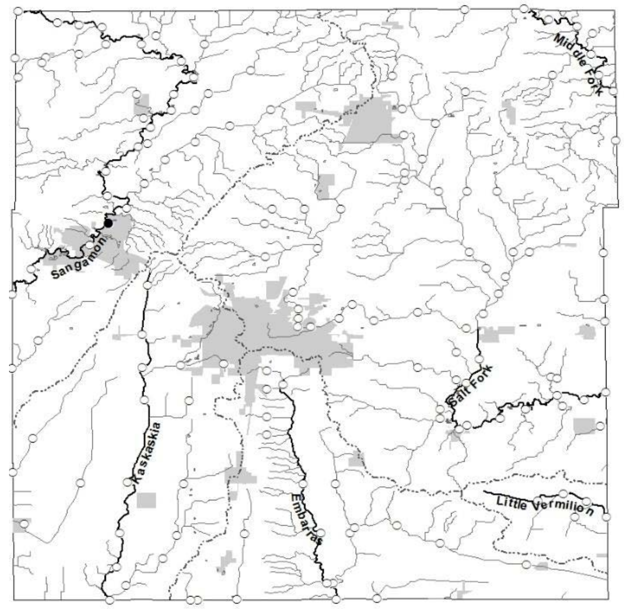
○ = species absent

● = species present

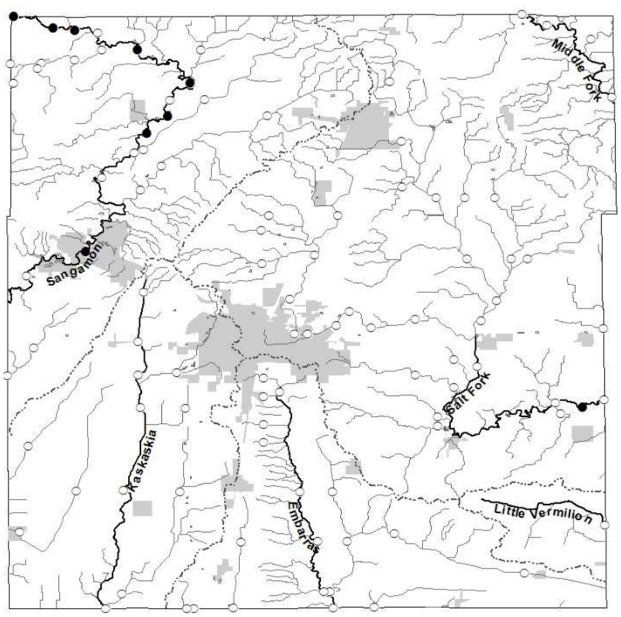
Figure 30



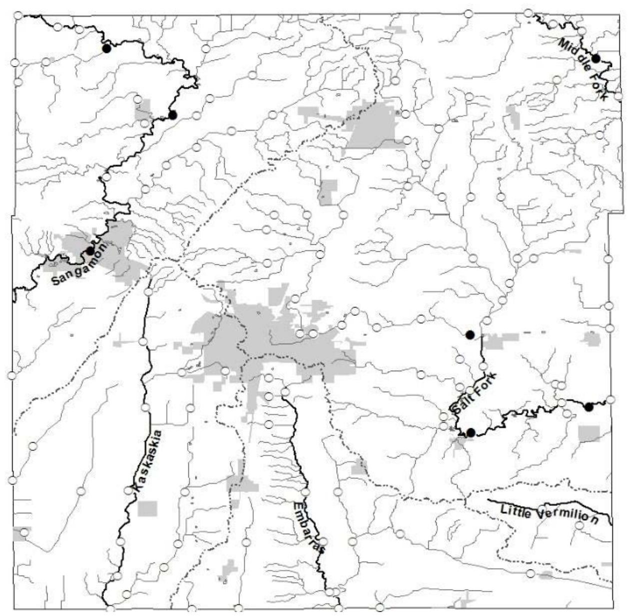
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



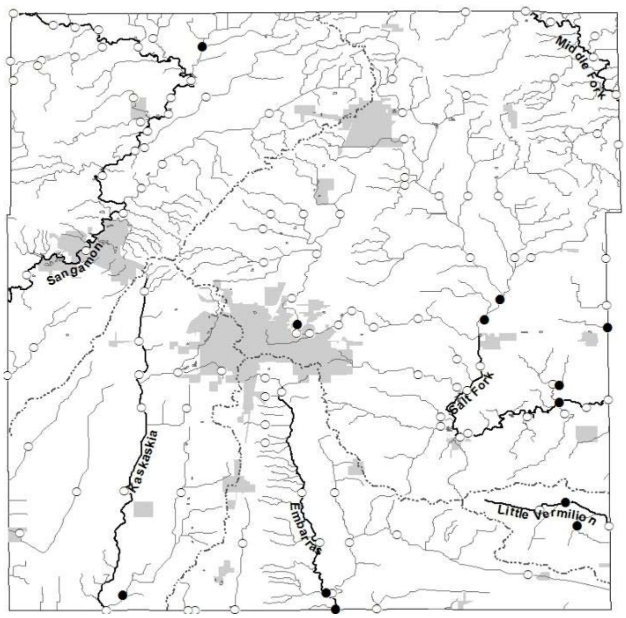
Sherwood & Stein (2012 – 2015)

***Moxostoma macrolepidotum,* Shorthead Redhorse**

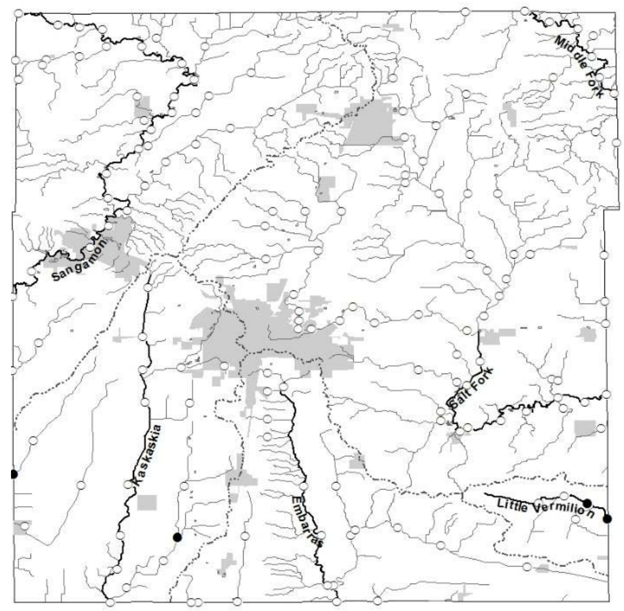
O = species absent

● = species present

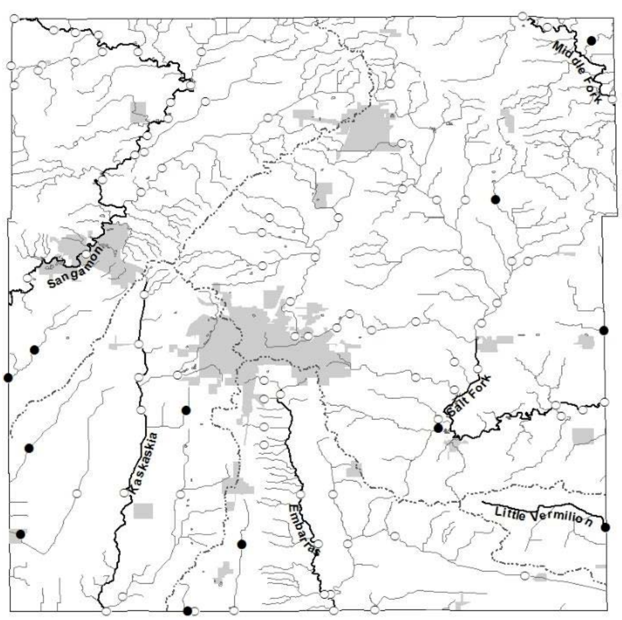
Figure 31



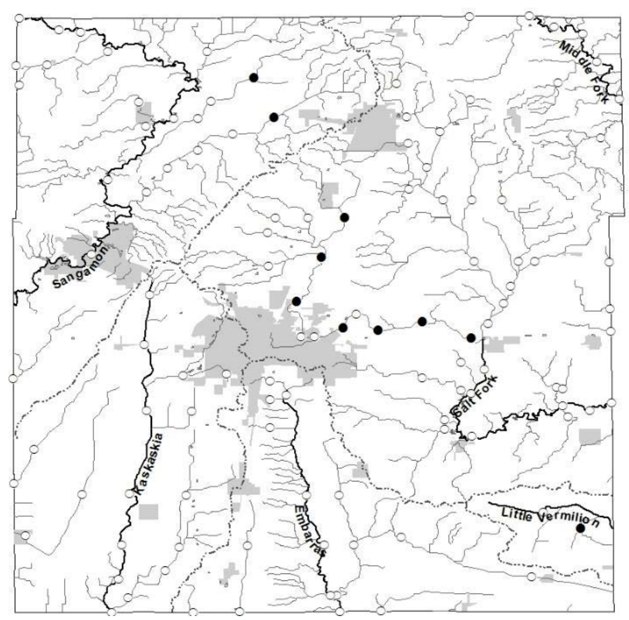
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



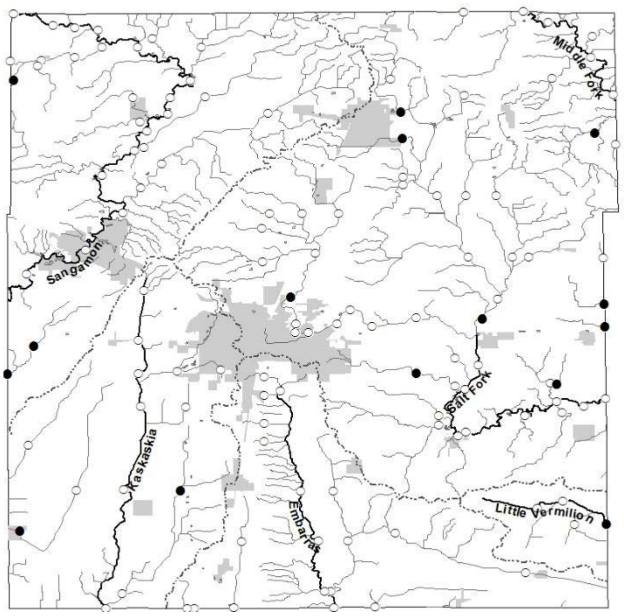
Sherwood & Stein (2012 – 2015)

***Ameiurus melas,* Black Bullhead**

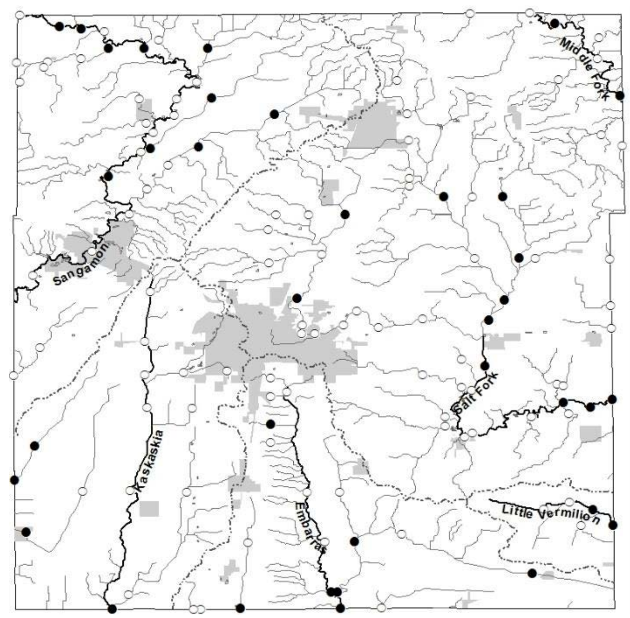
○ = species absent

● = species present

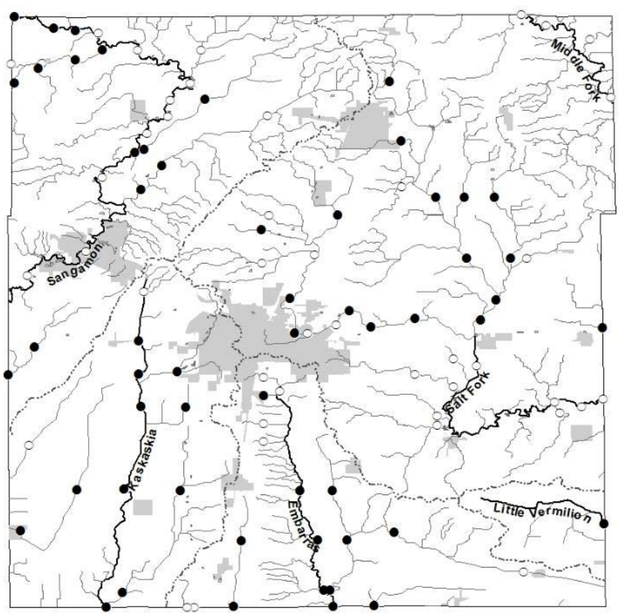
Figure 32



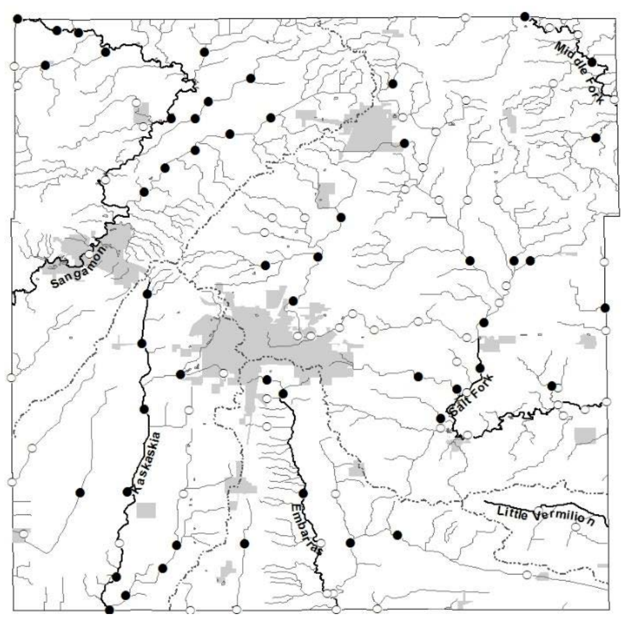
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



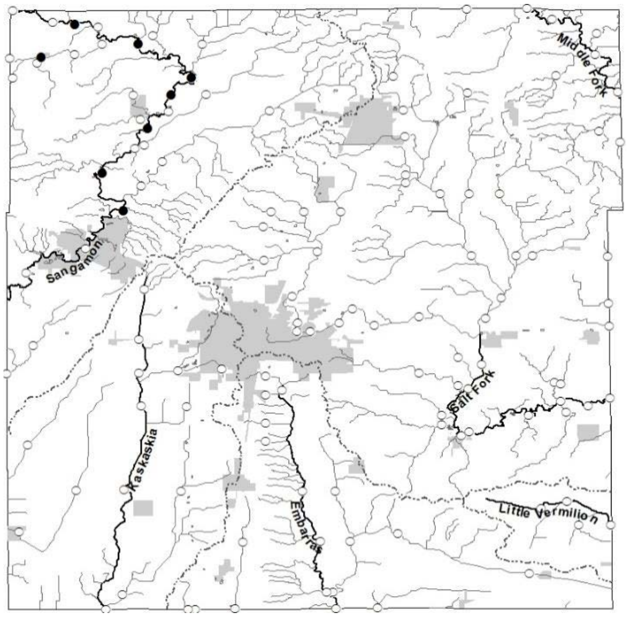
Sherwood & Stein (2012 – 2015)

***Ameiurus natalis,* Yellow Bullhead**

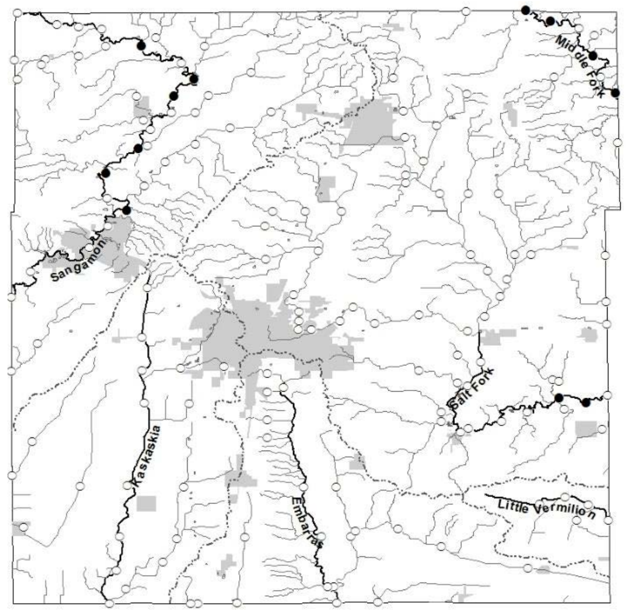
○ = species absent

● = species present

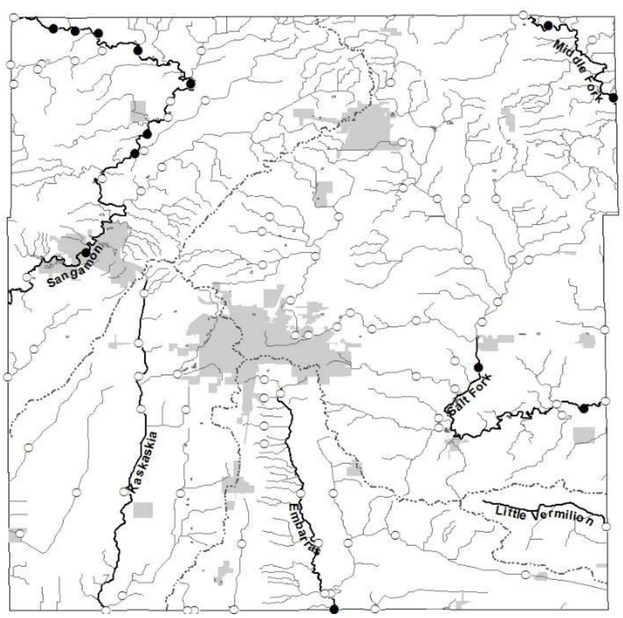
Figure 33



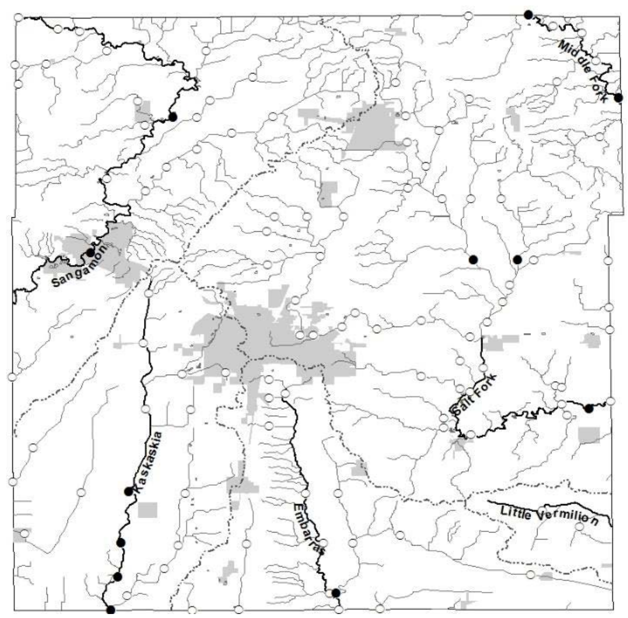
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



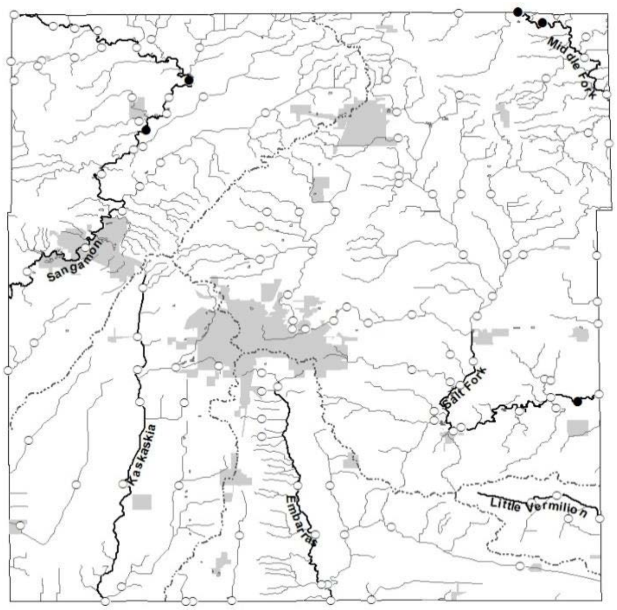
Sherwood & Stein (2012 – 2015)

Ictalurus punctatus, Channel Catfish

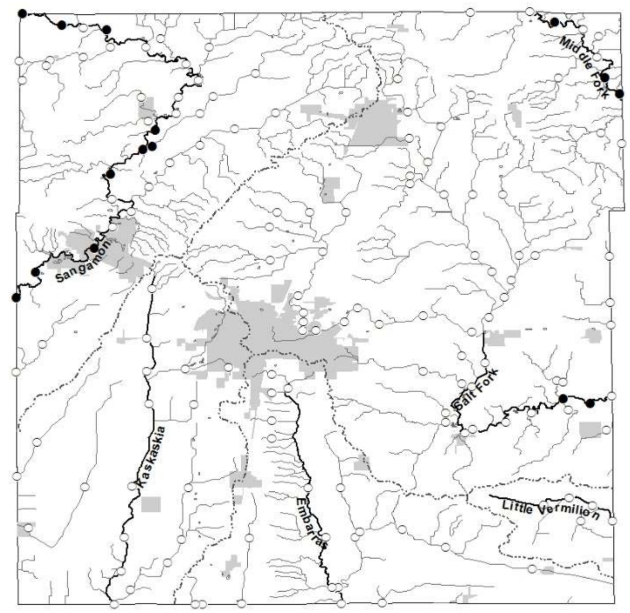
○ = species absent

● = species present

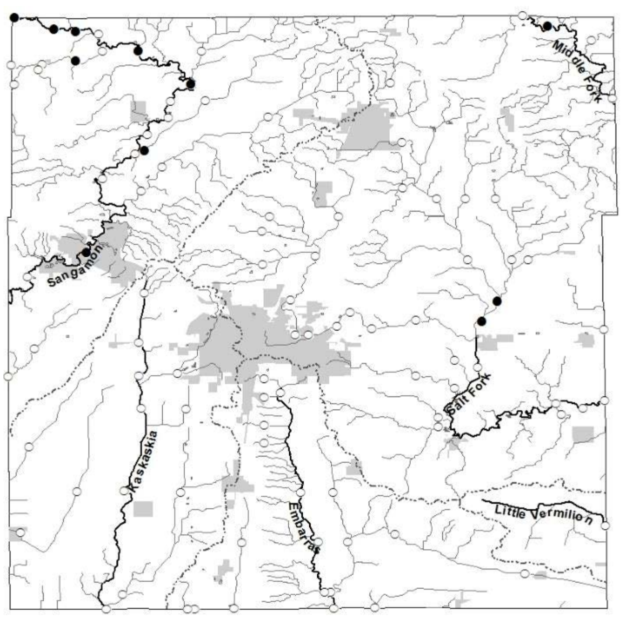
Figure 34



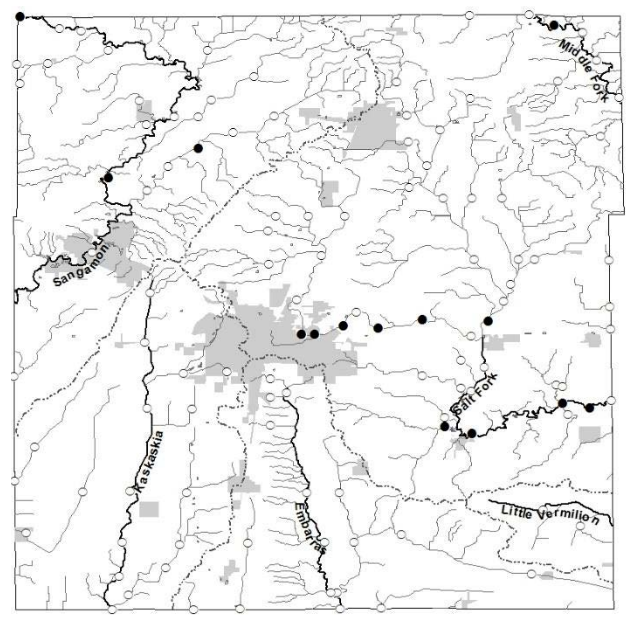
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



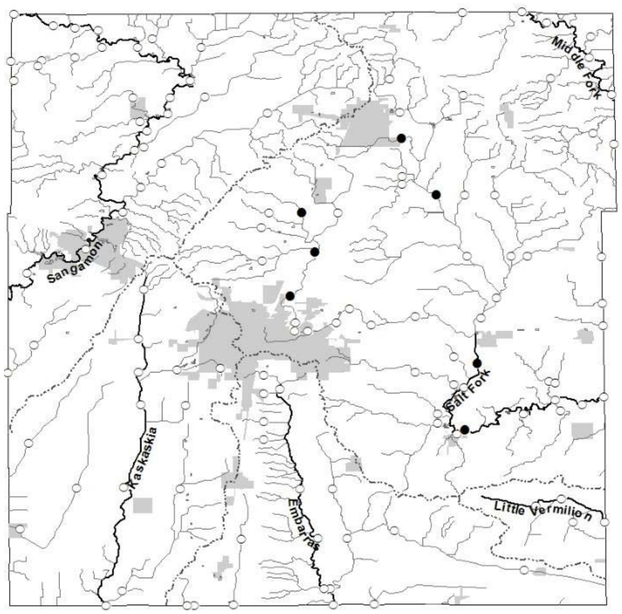
Sherwood & Stein (2012 – 2015)

***Noturus flavus*, Stonecat**

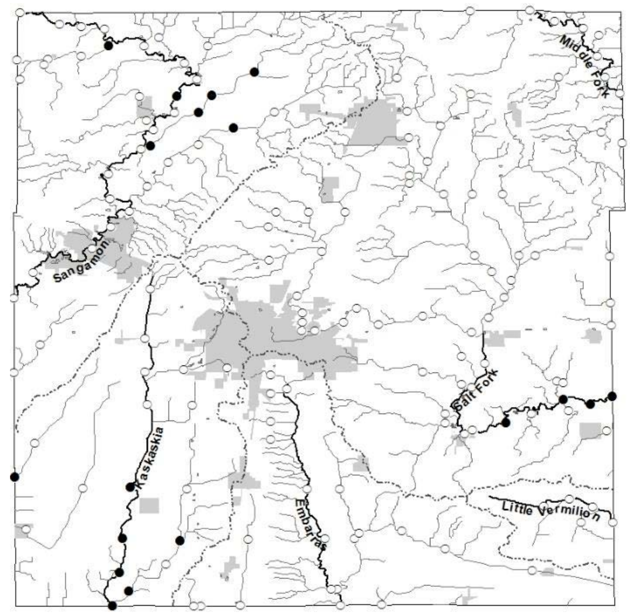
O = species absent

● = species present

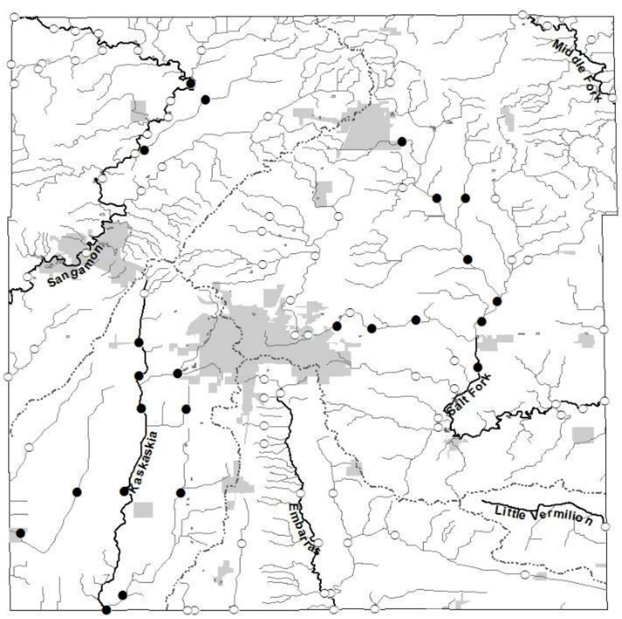
Figure 35



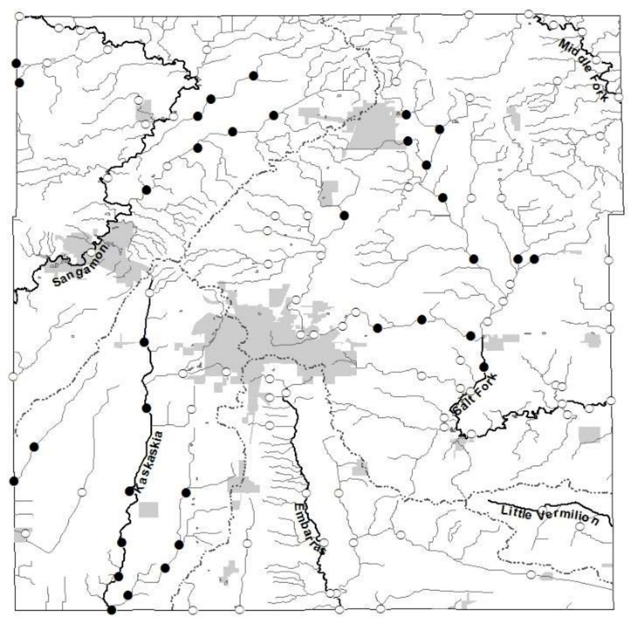
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



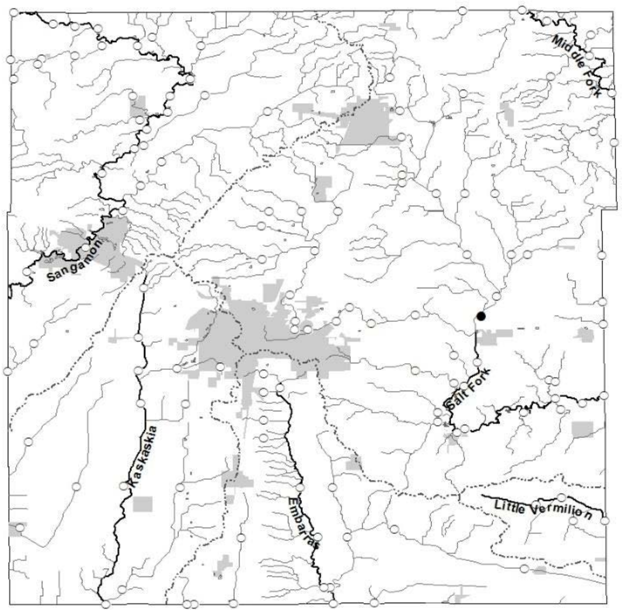
Sherwood & Stein (2012 – 2015)

Noturus gyrinus, **Tadpole Madtom**

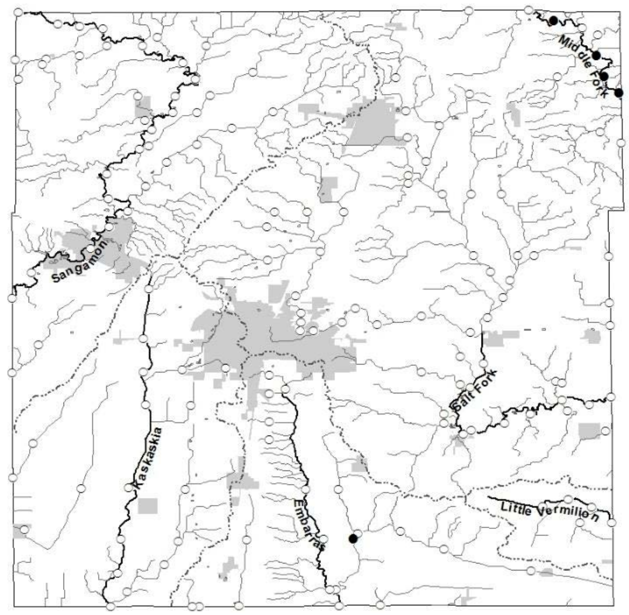
○ = species absent

● = species present

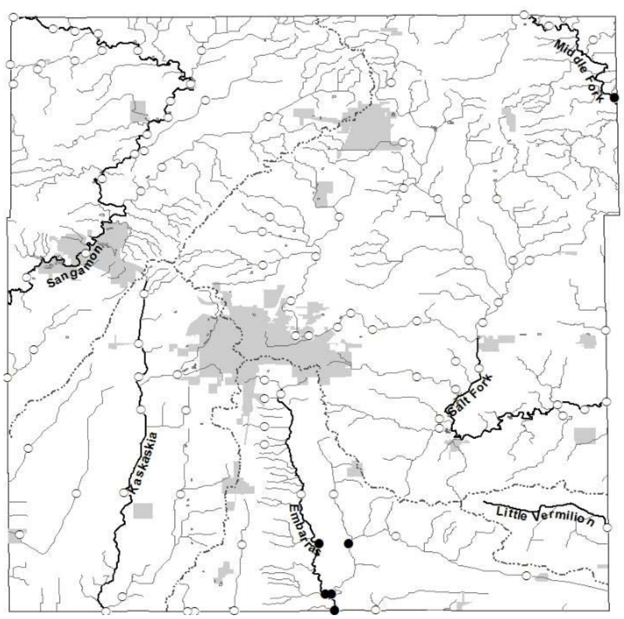
Figure 36



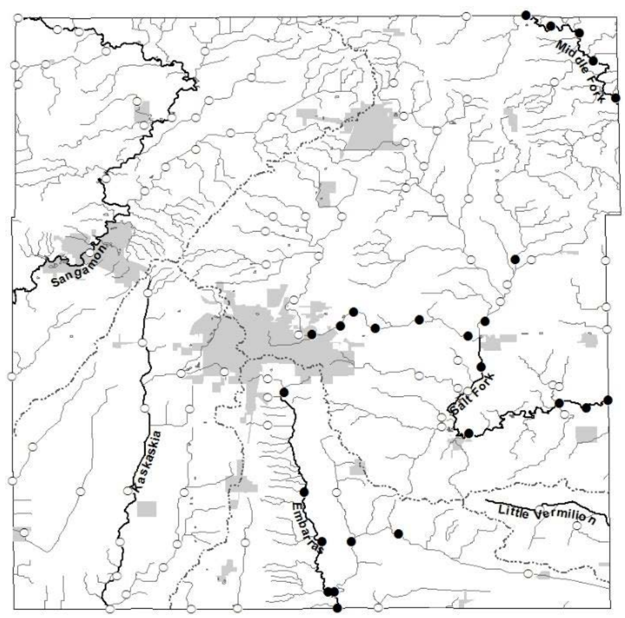
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



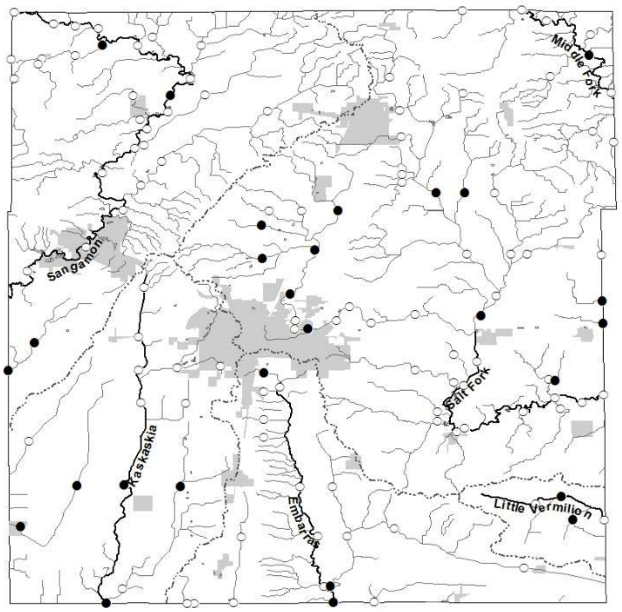
Sherwood & Stein (2012 – 2015)

Noturus miurus, Brindled Madtom

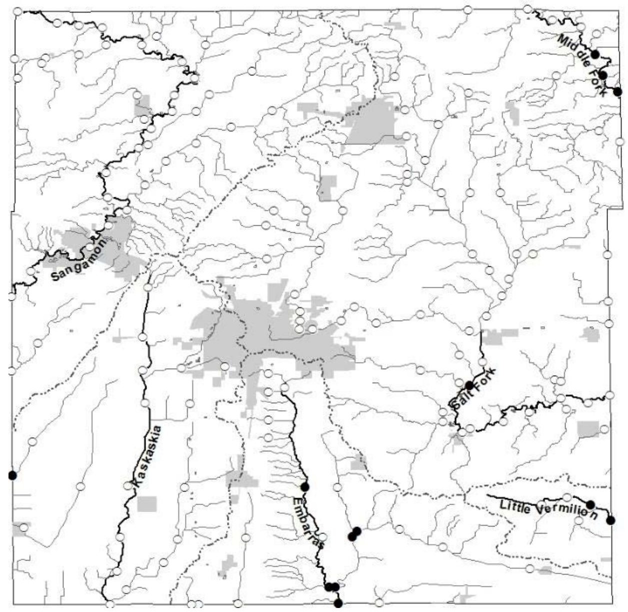
○ = species absent

● = species present

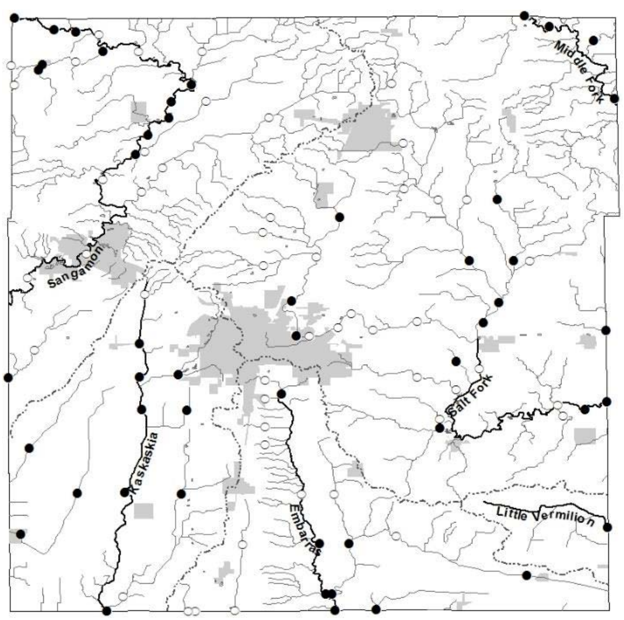
Figure 37



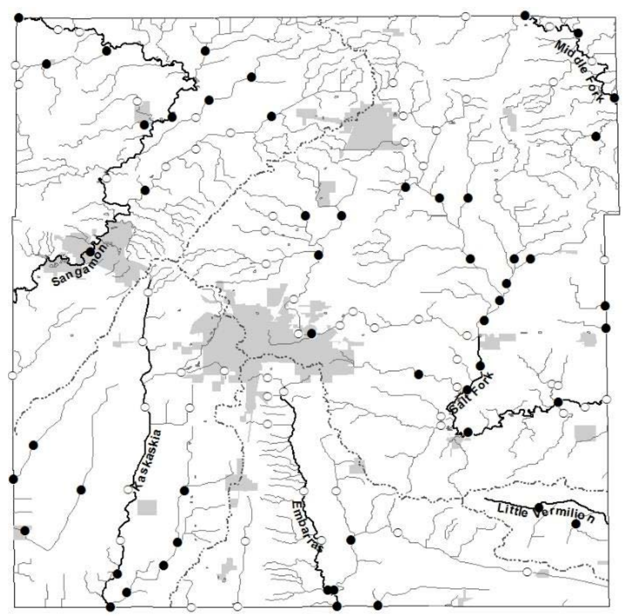
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



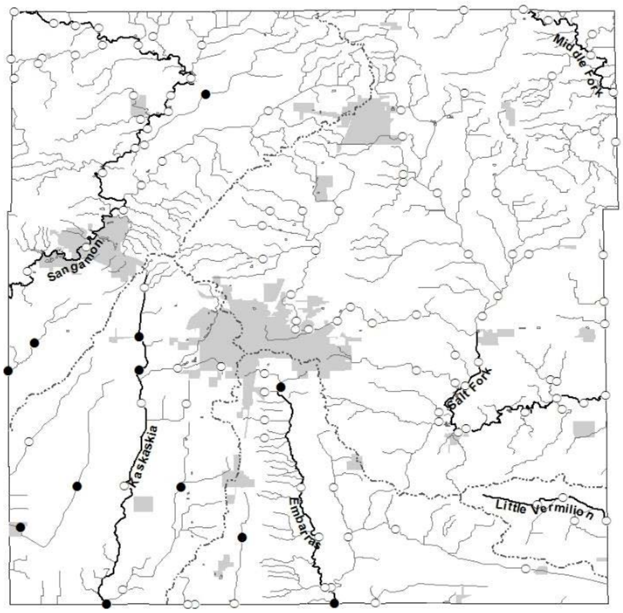
Sherwood & Stein (2012 – 2015)

Esox americanus, Grass Pickerel

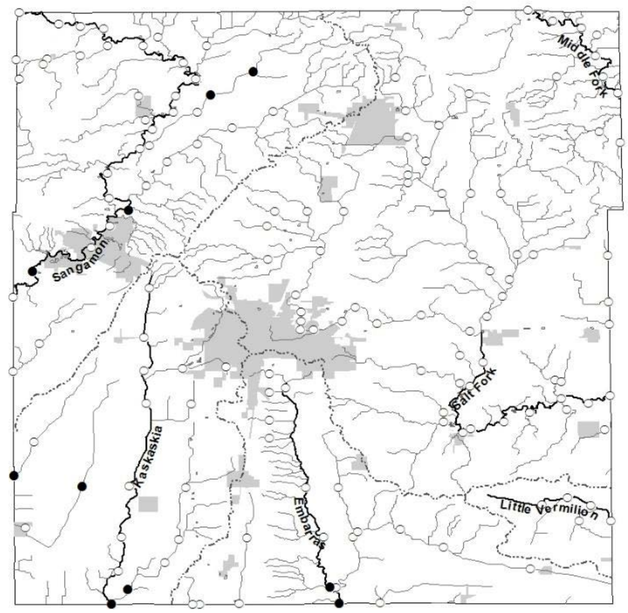
○ = species absent

● = species present

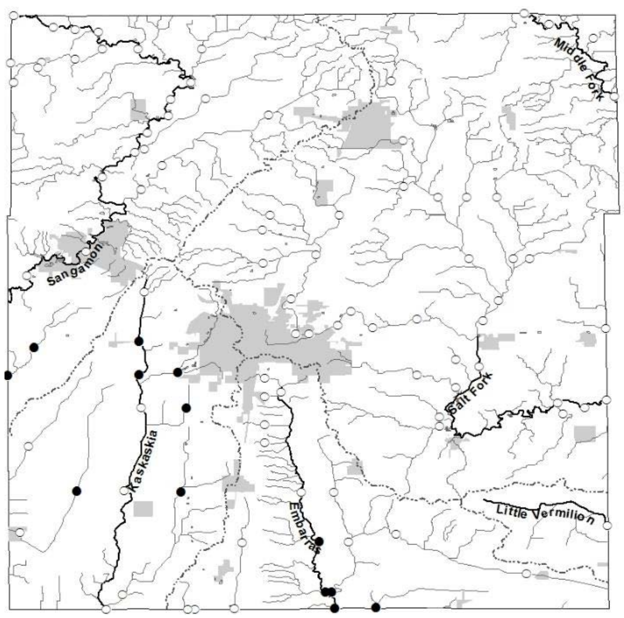
Figure 38



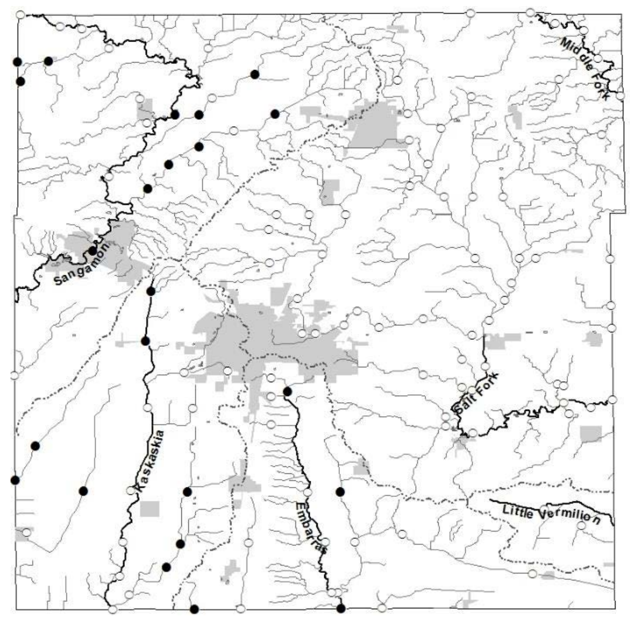
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



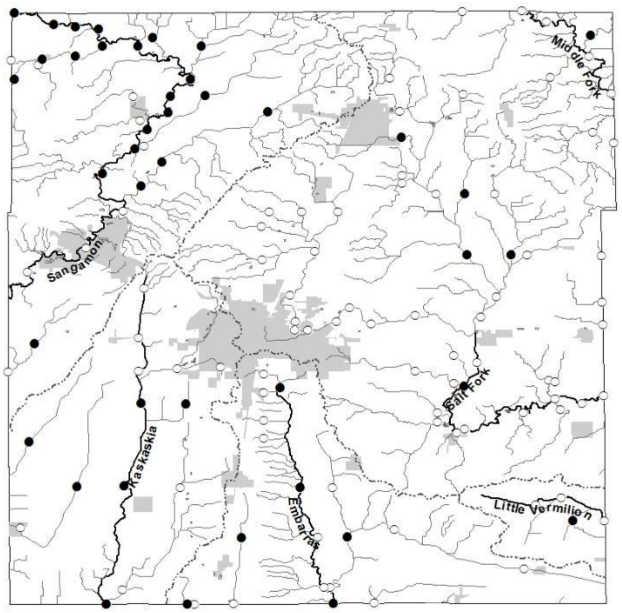
Sherwood & Stein (2012 – 2015)

***Aphredoderus sayanus*, Pirate Perch**

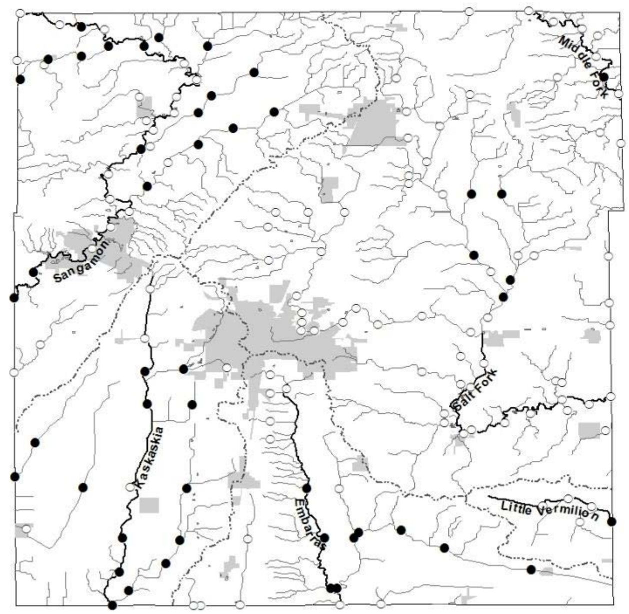
○ = species absent

● = species present

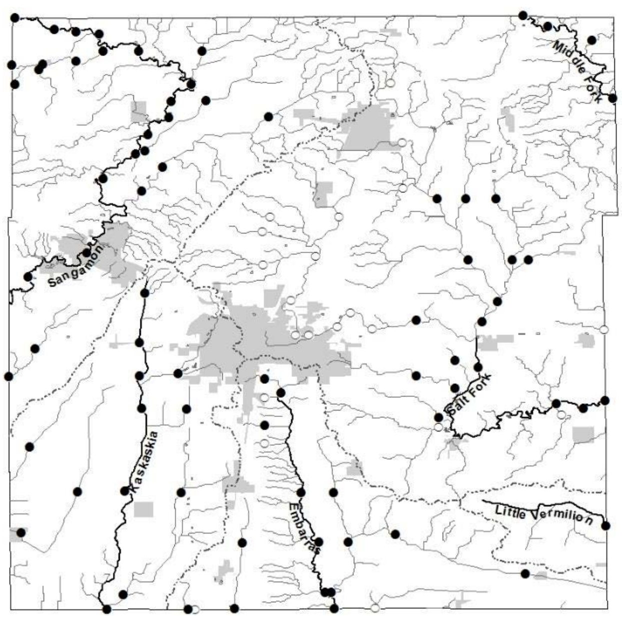
Figure 39



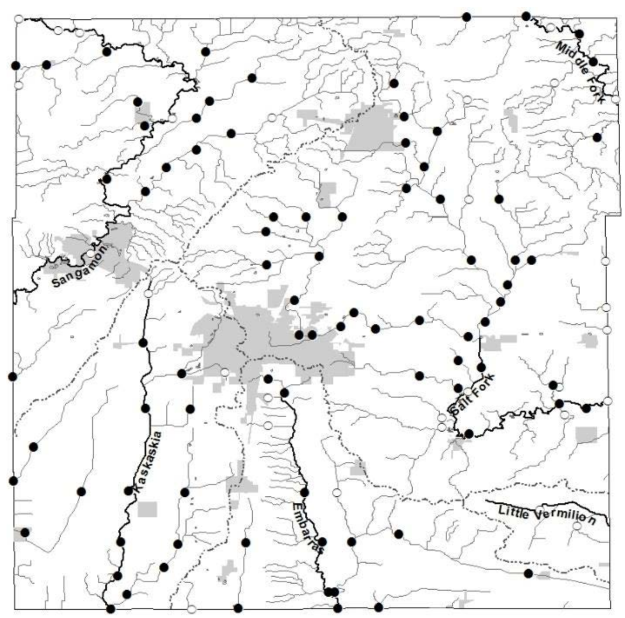
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



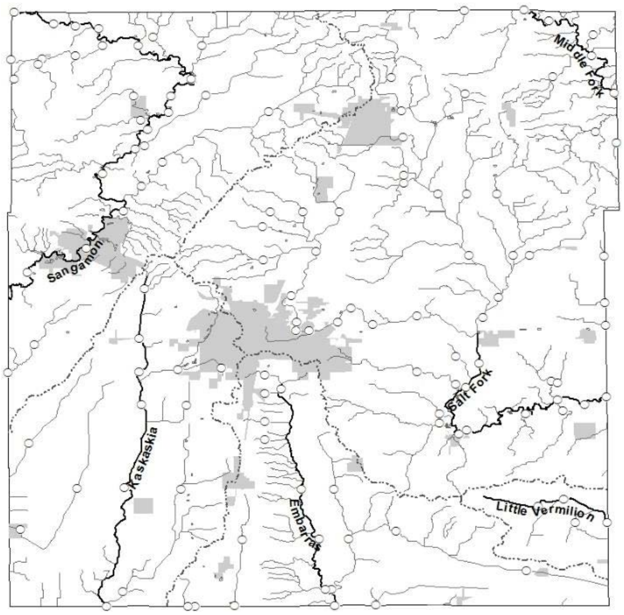
Sherwood & Stein (2012 – 2015)

***Fundulus notatus*, Blackstripe Topminnow**

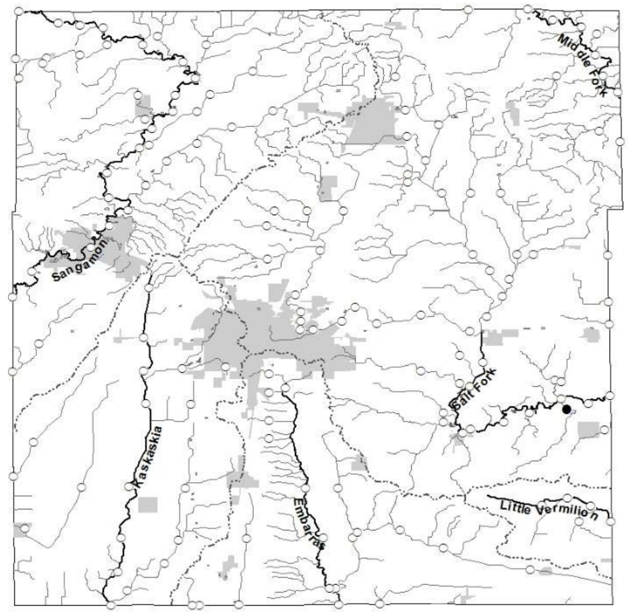
○ = species absent

● = species present

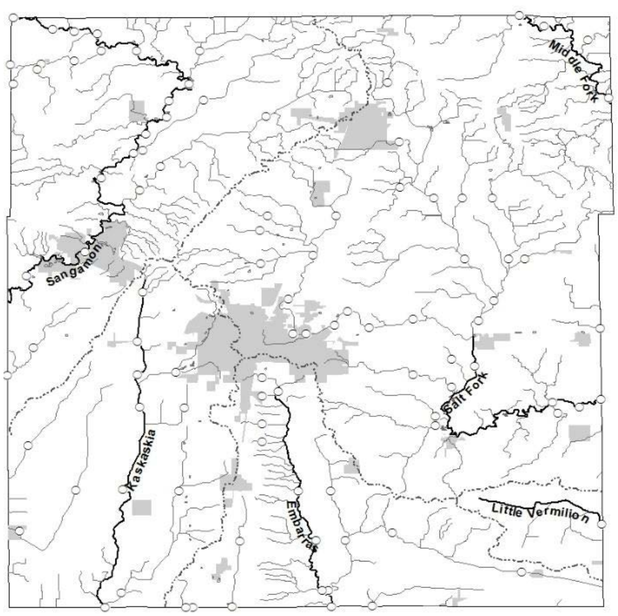
Figure 40



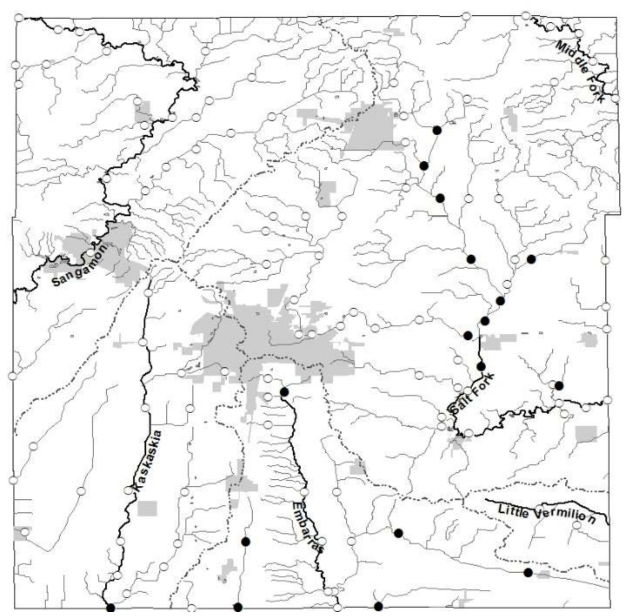
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



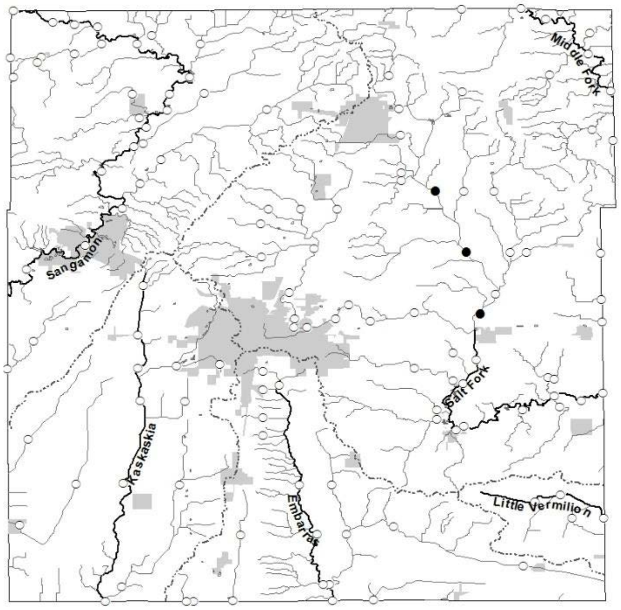
Sherwood & Stein (2012 – 2015)

***Gambusia affinis,* Western Mosquitofish**

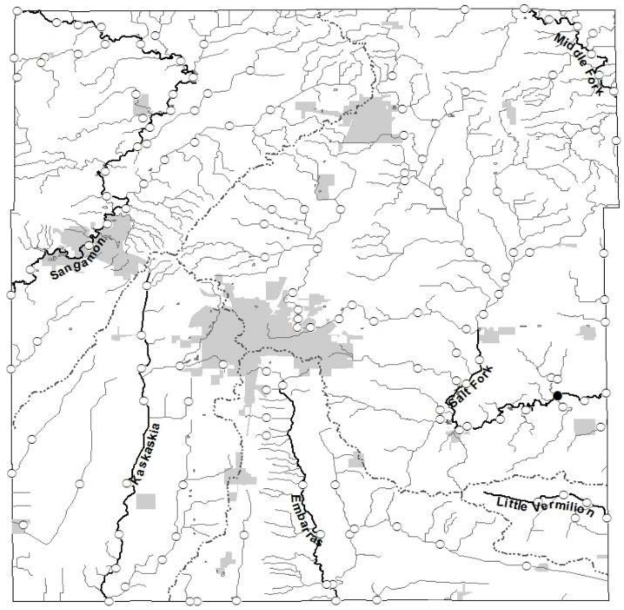
○ = species absent

● = species present

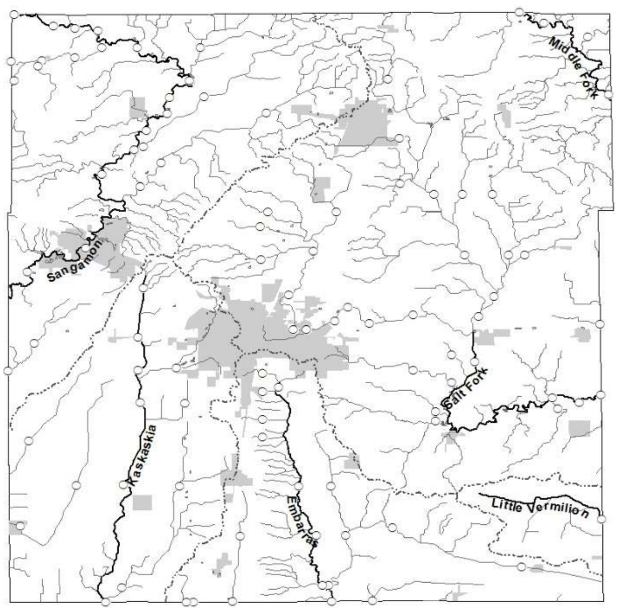
Figure 41



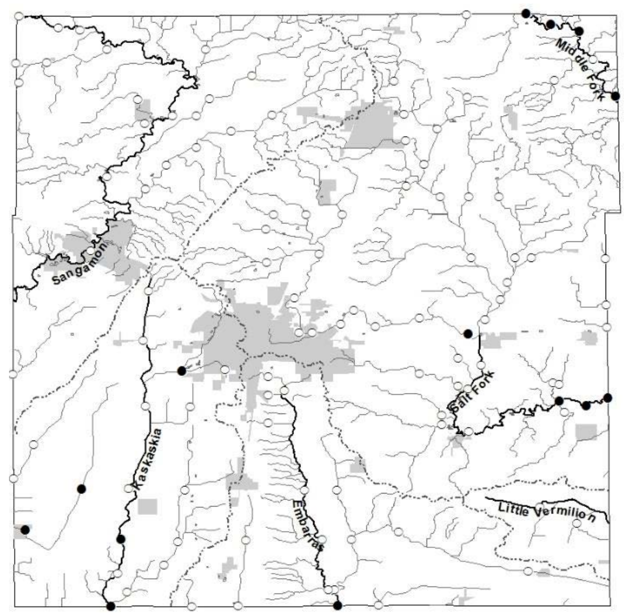
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



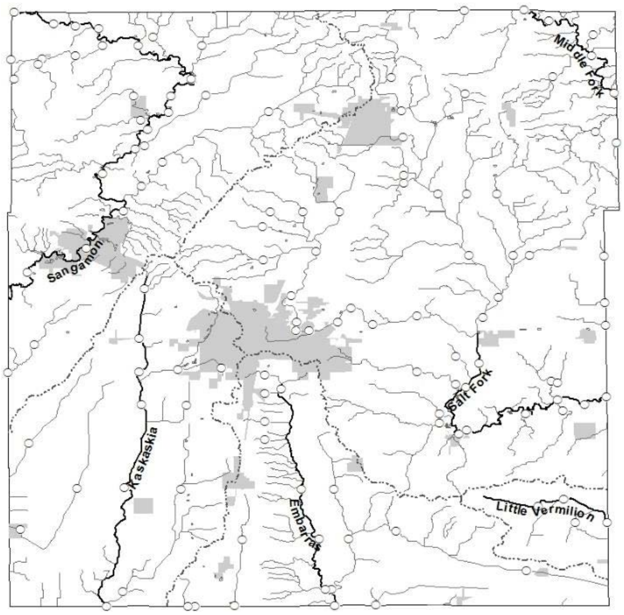
Sherwood & Stein (2012 – 2015)

Labidesthes sicculus, **Brook Silverside**

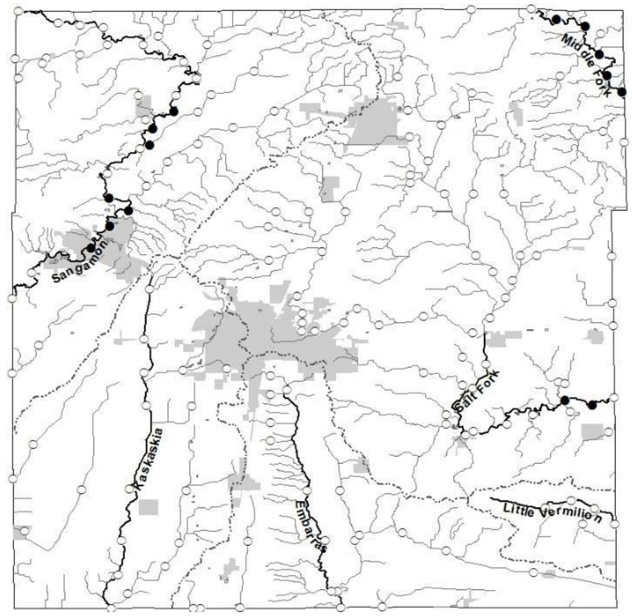
○ = species absent

● = species present

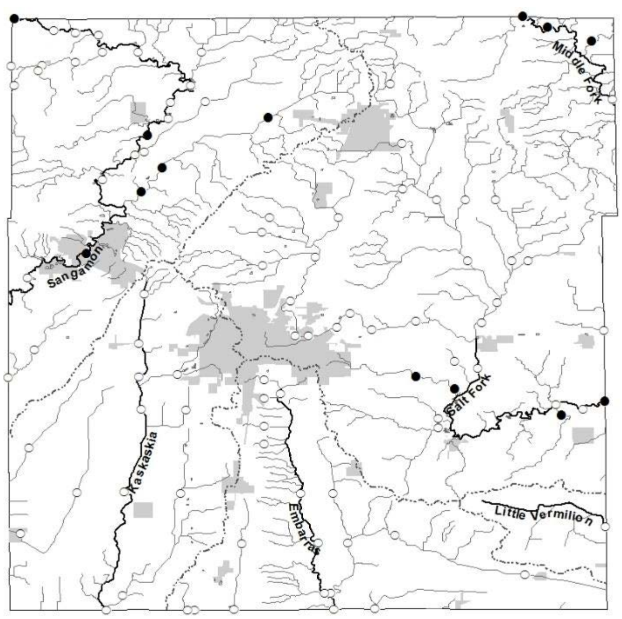
Figure 42



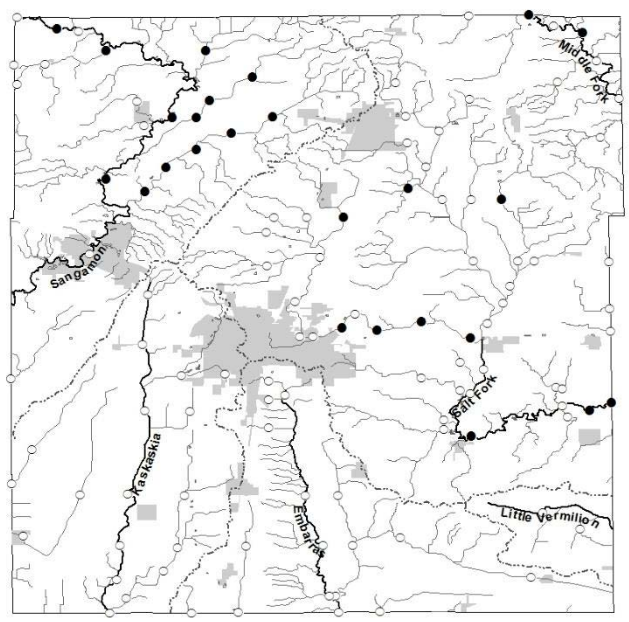
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



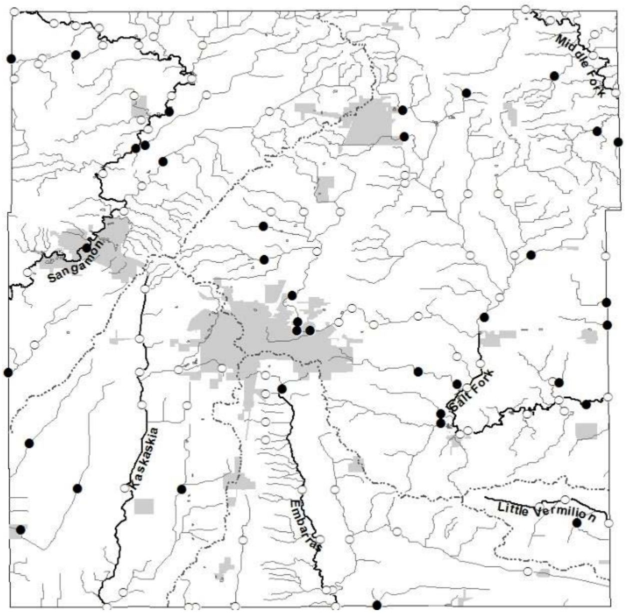
Sherwood & Stein (2012 – 2015)

***Ambloplites rupestris*, Rock Bass**

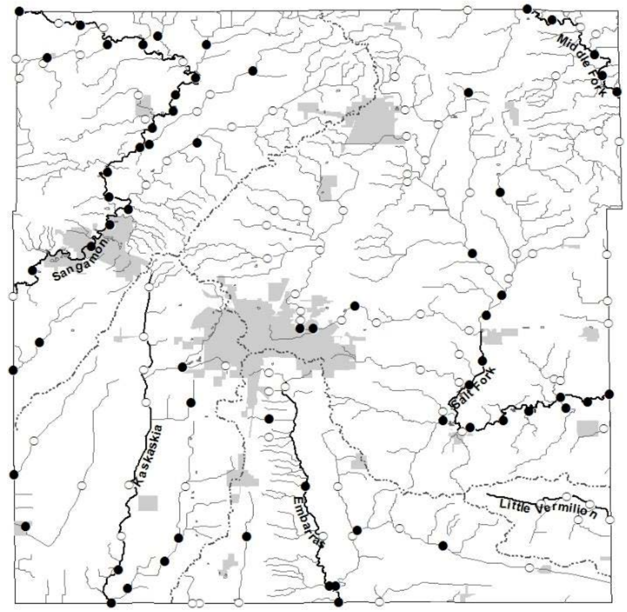
○ = species absent

● = species present

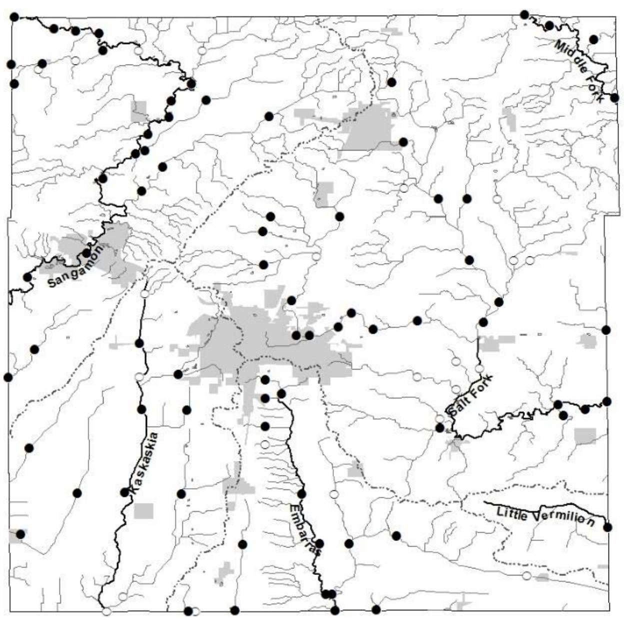
Figure 43



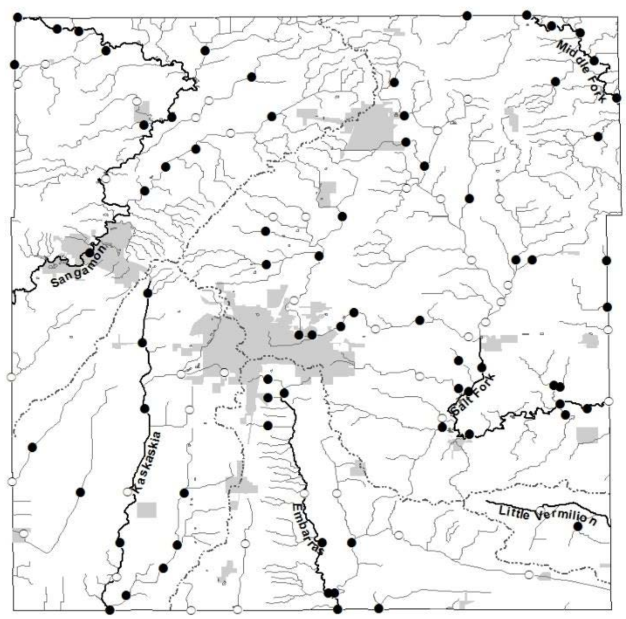
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



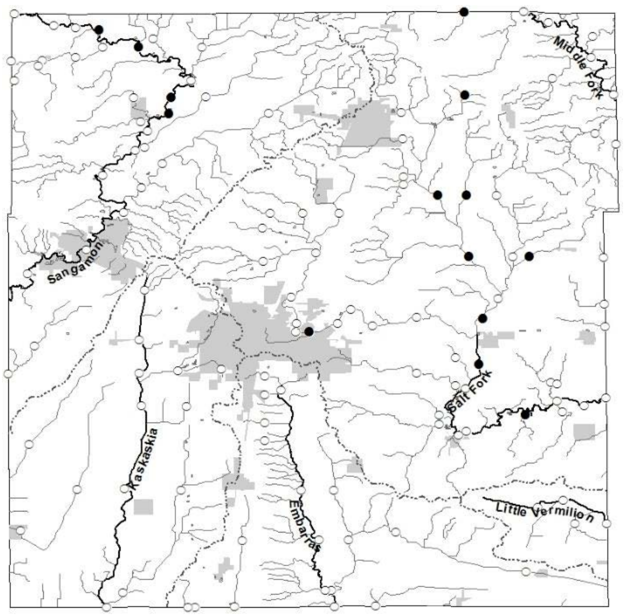
Sherwood & Stein (2012 – 2015)

Lepomis cyanellus, Green Sunfish

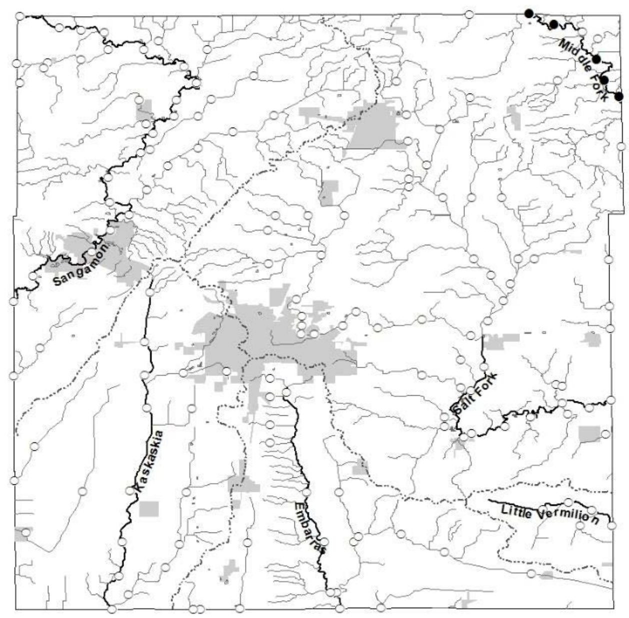
○ = species absent

● = species present

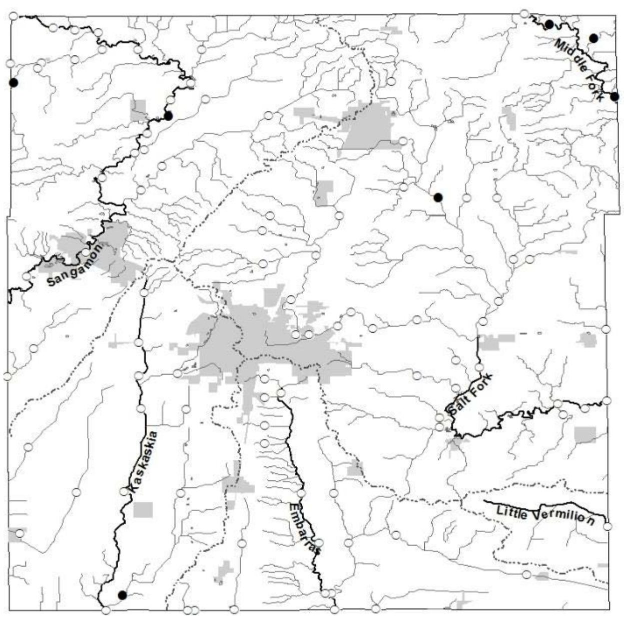
Figure 44



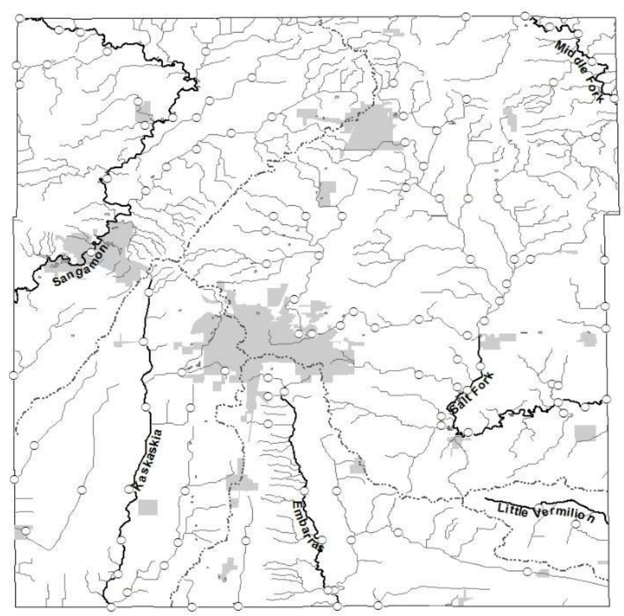
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



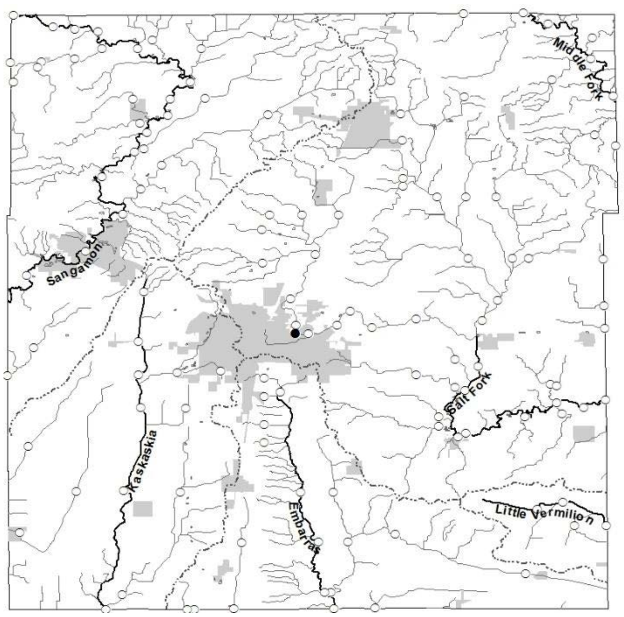
Sherwood & Stein (2012 – 2015)

Lepomis humilis, Orangespotted Sunfish

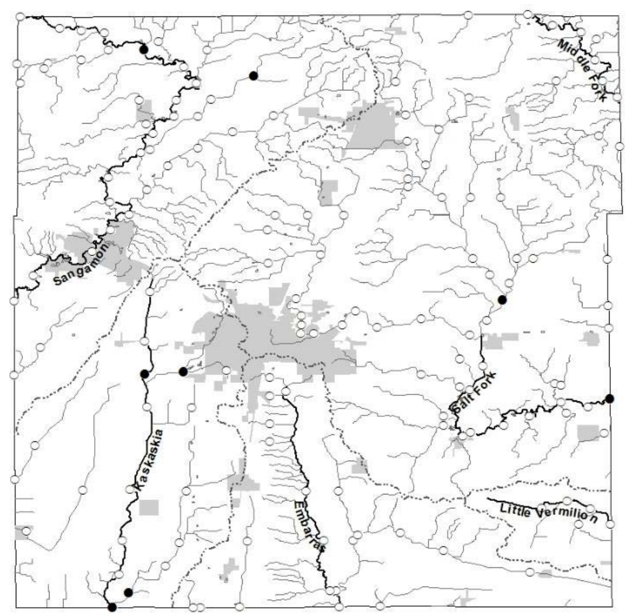
○ = species absent

● = species present

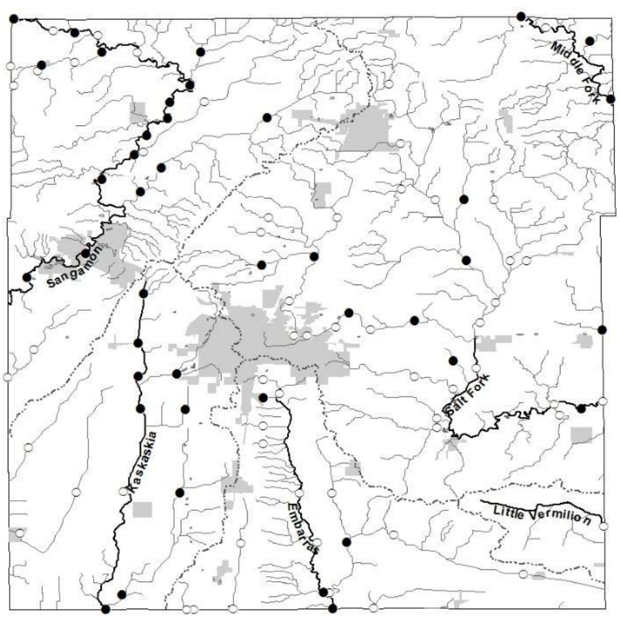
Figure 45



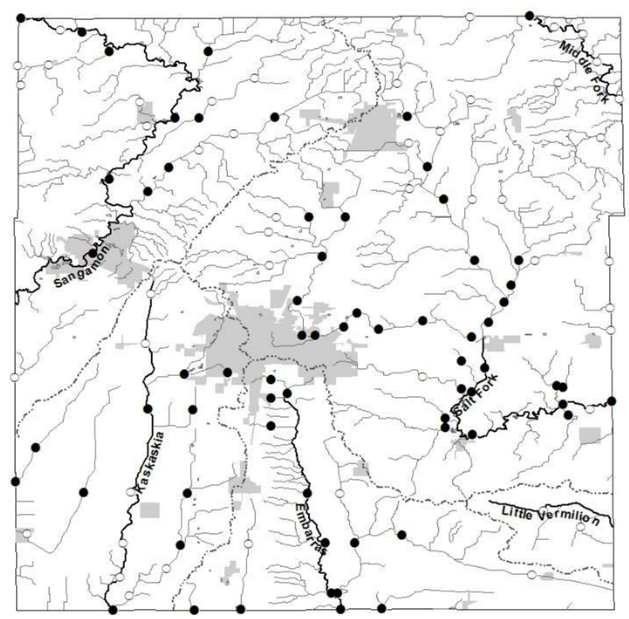
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



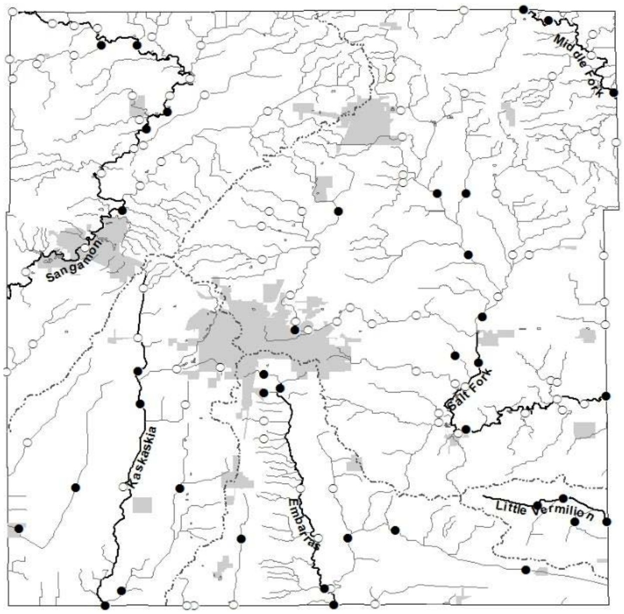
Sherwood & Stein (2012 – 2015)

Lepomis macrochirus, **Bluegill**

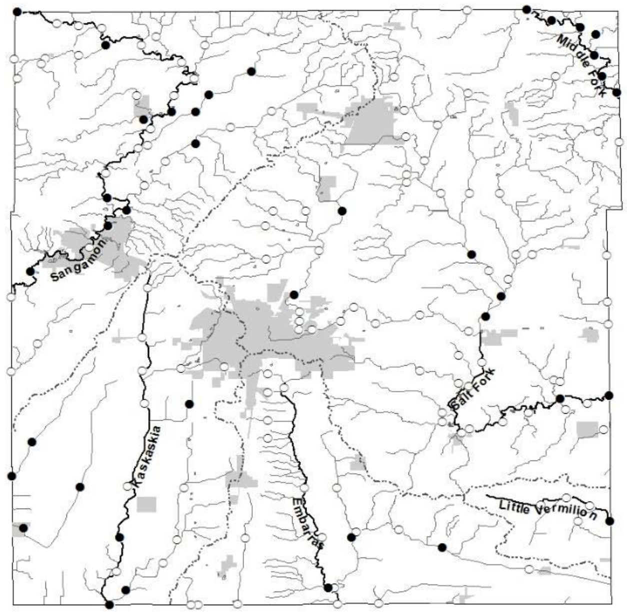
○ = species absent

● = species present

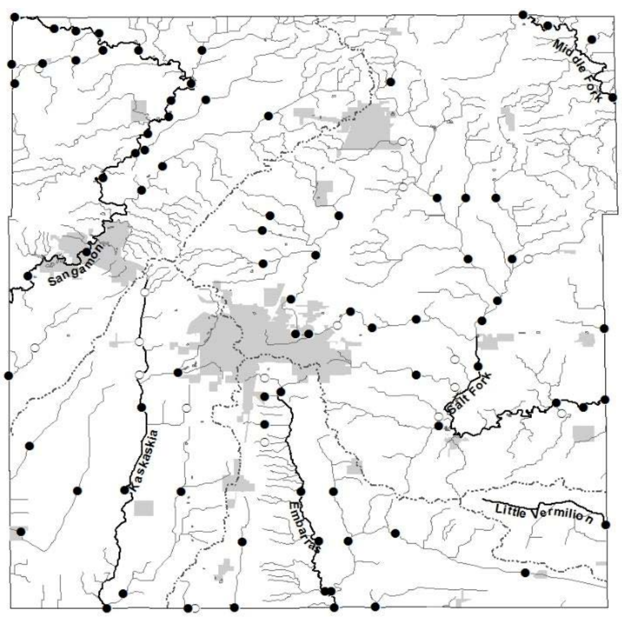
Figure 46



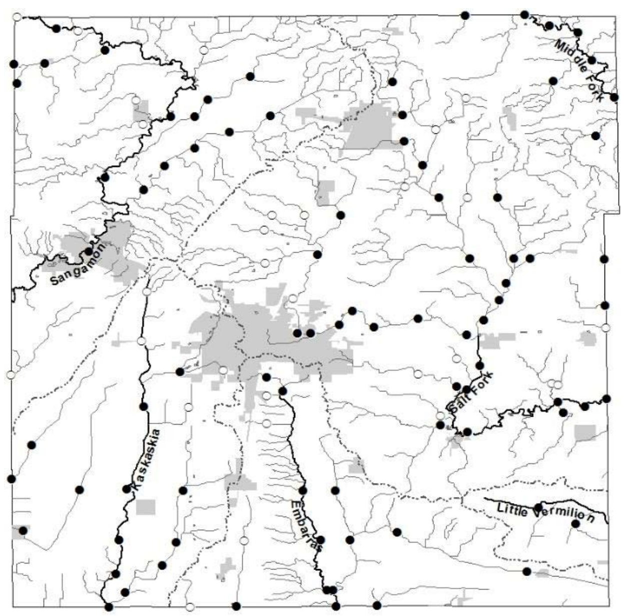
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



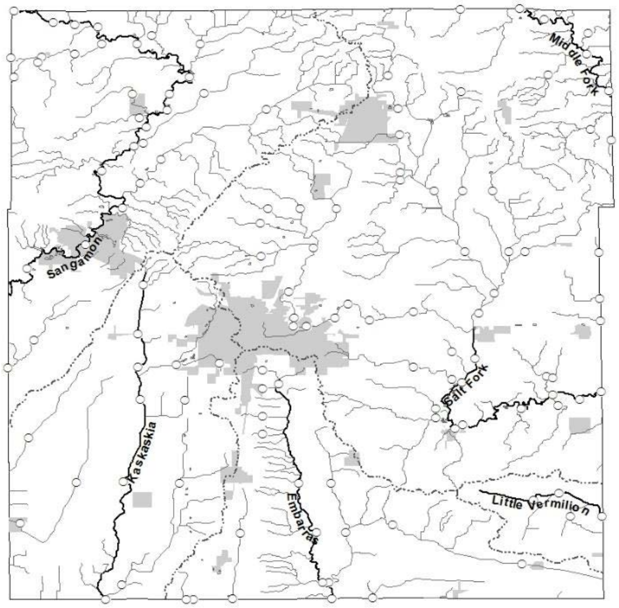
Sherwood & Stein (2012 – 2015)

***Lepomis megalotis*, Longear Sunfish**

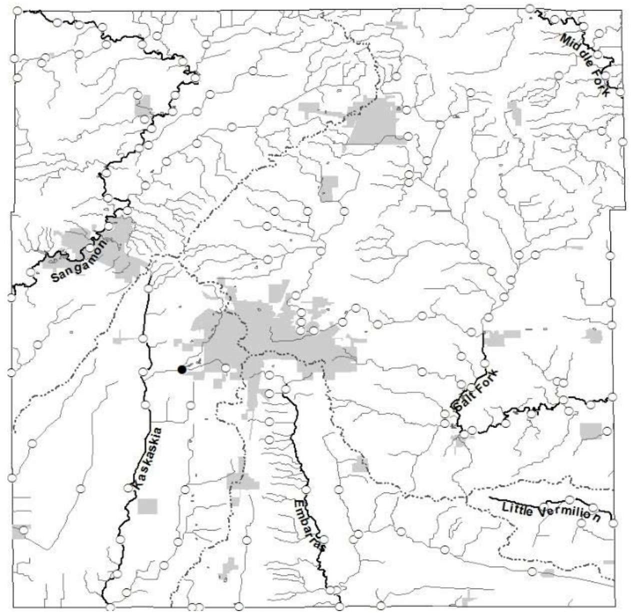
O = species absent

● = species present

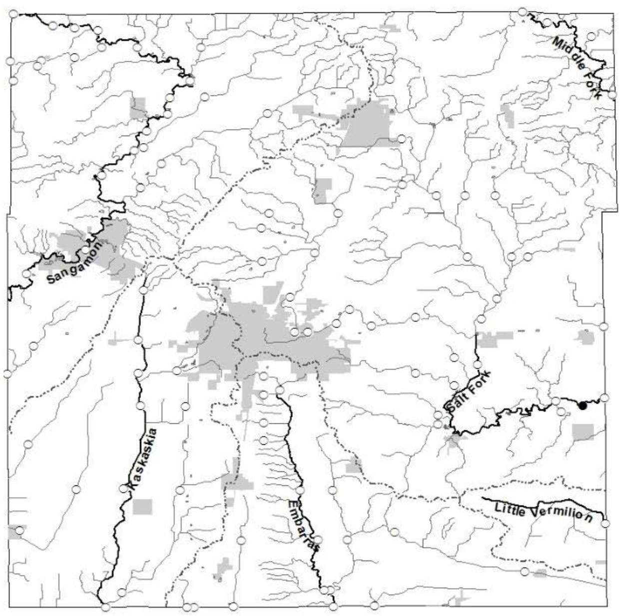
Figure 47



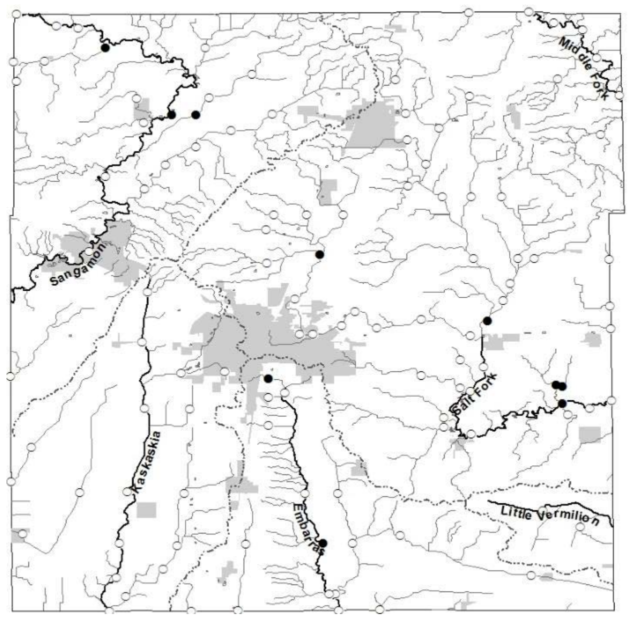
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



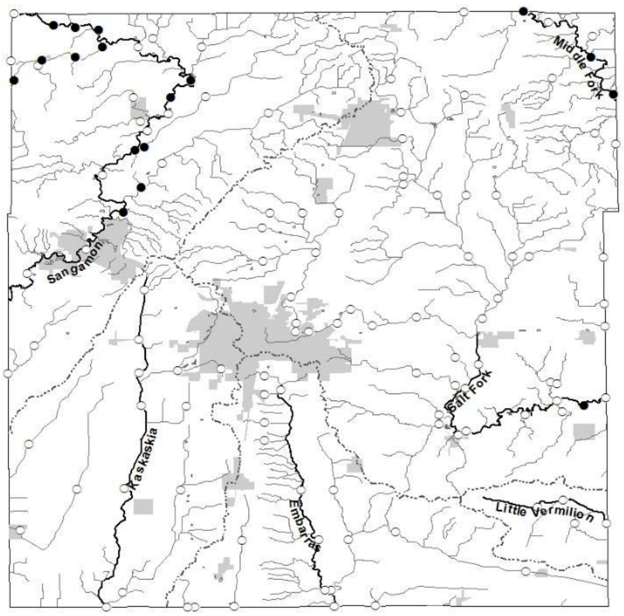
Sherwood & Stein (2012 – 2015)

Lepomis microlophus, Redear Sunfish

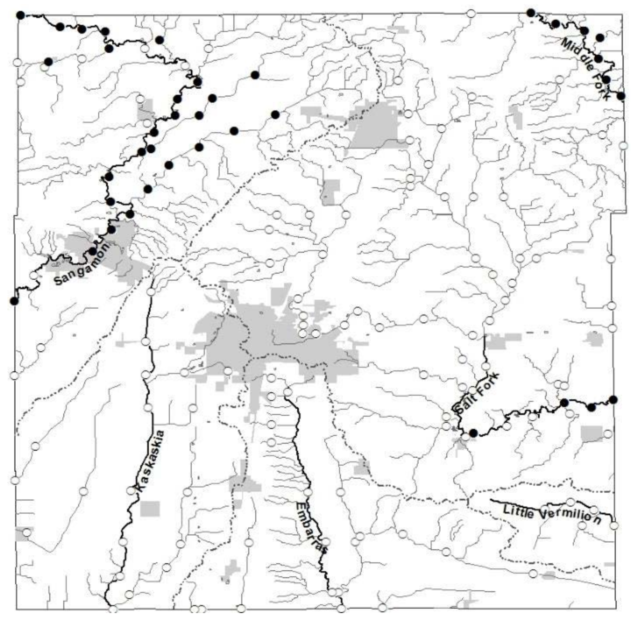
○ = species absent

● = species present

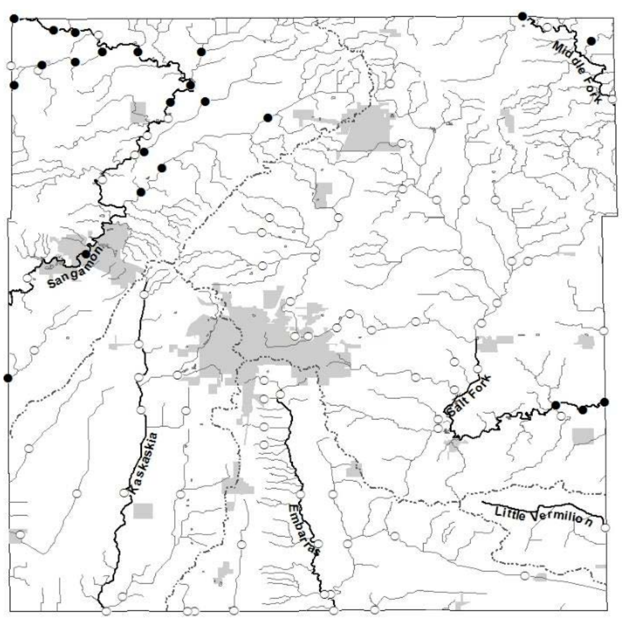
Figure 48



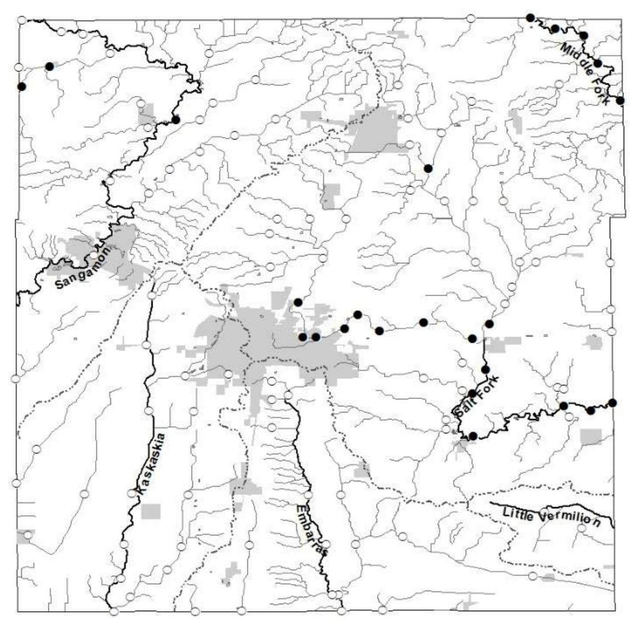
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



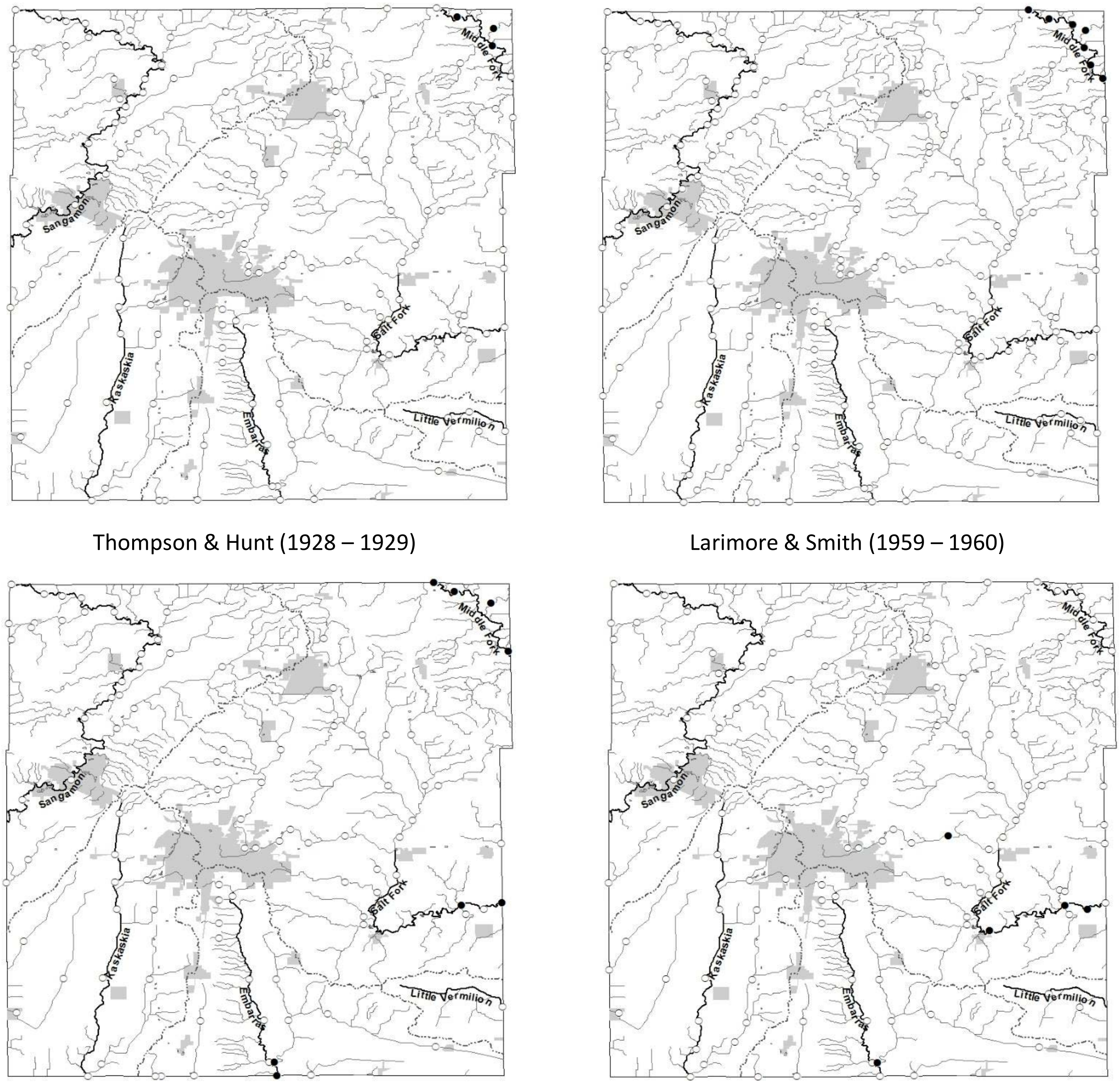
Sherwood & Stein (2012 – 2015)

Micropterus dolomieu, Smallmouth Bass

○ = species absent

● = species present

Figure 49



Thompson & Hunt (1928 – 1929)

Larimore & Smith (1959 – 1960)

Larimore & Bayley (1987 – 1988)

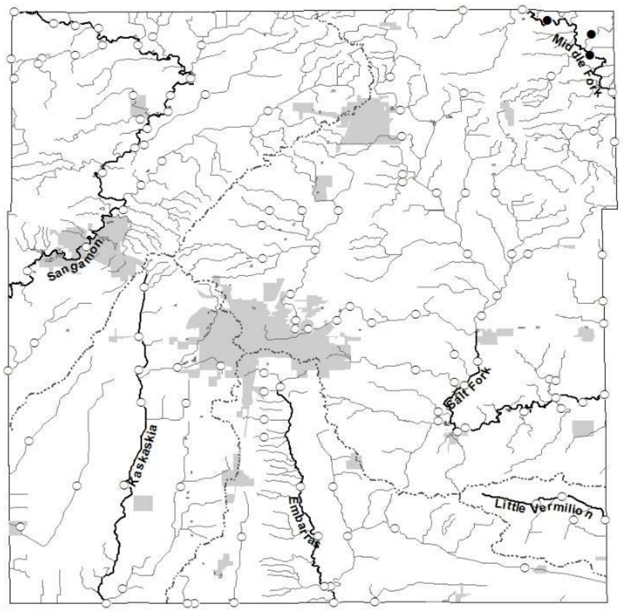
Sherwood & Stein (2012 – 2015)

Micropterus punctulatus, Spotted Bass

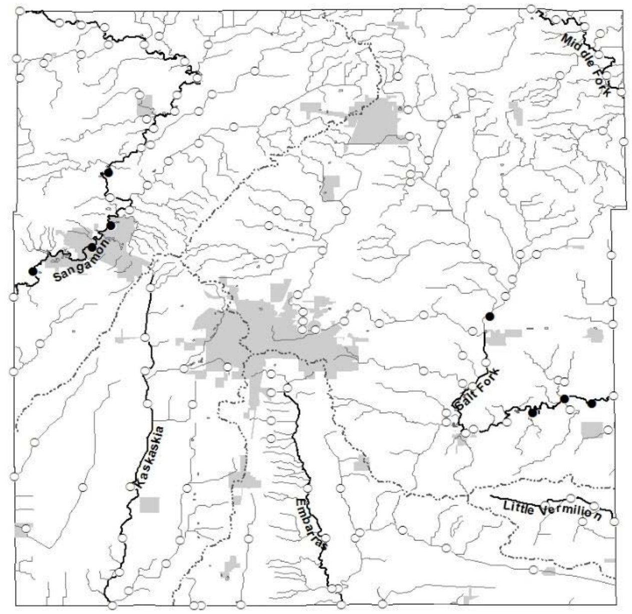
○ = species absent

● = species present

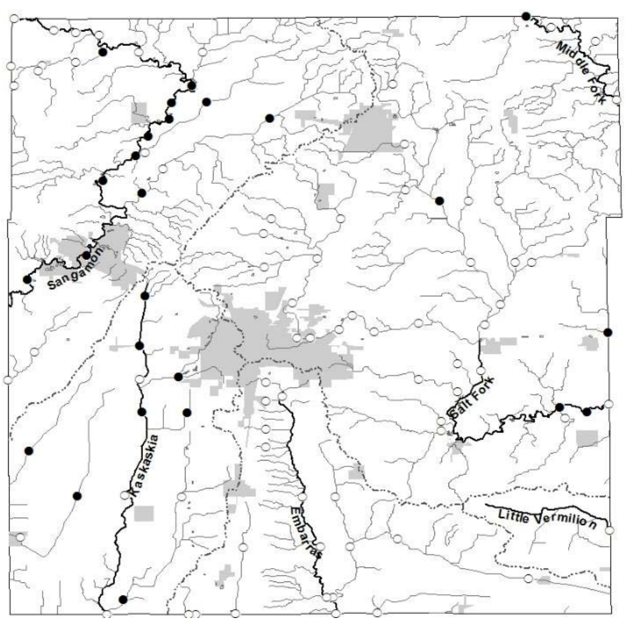
Figure 50



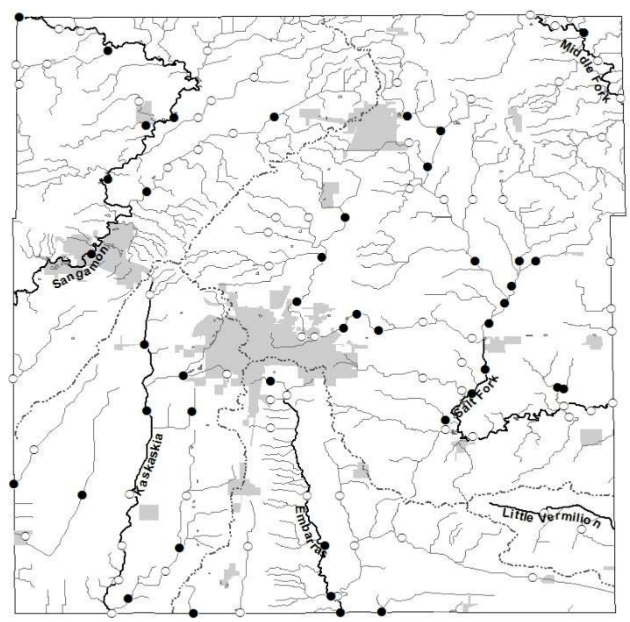
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



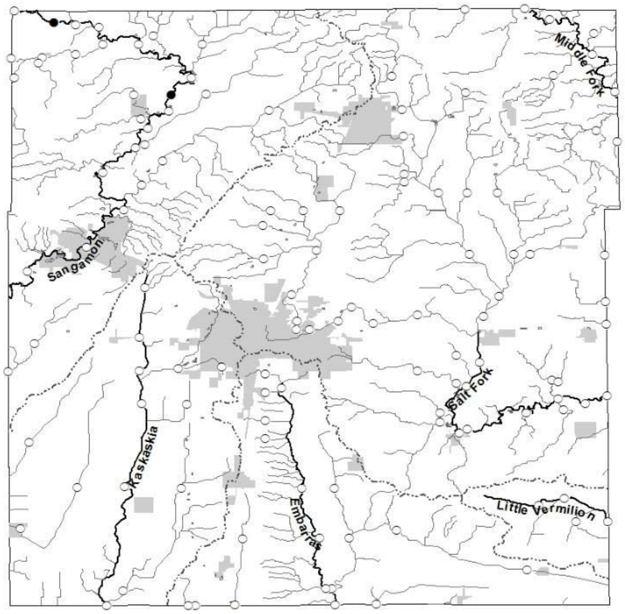
Sherwood & Stein (2012 – 2015)

***Micropterus salmoides,* Largemouth Bass**

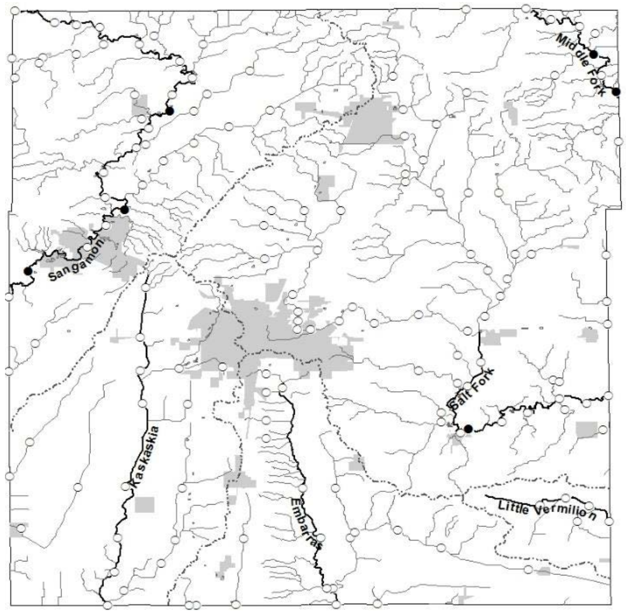
○ = species absent

● = species present

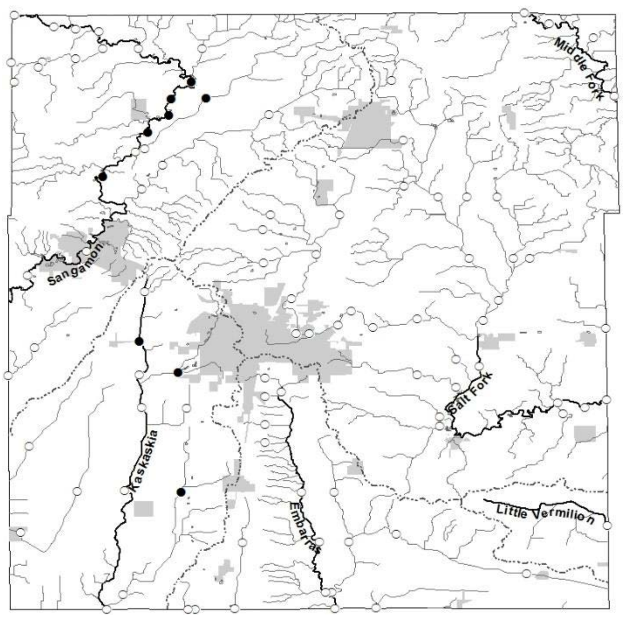
Figure 51



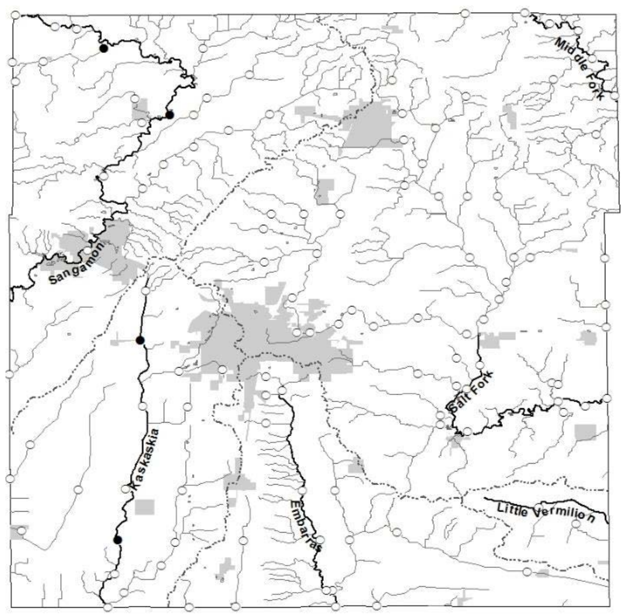
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



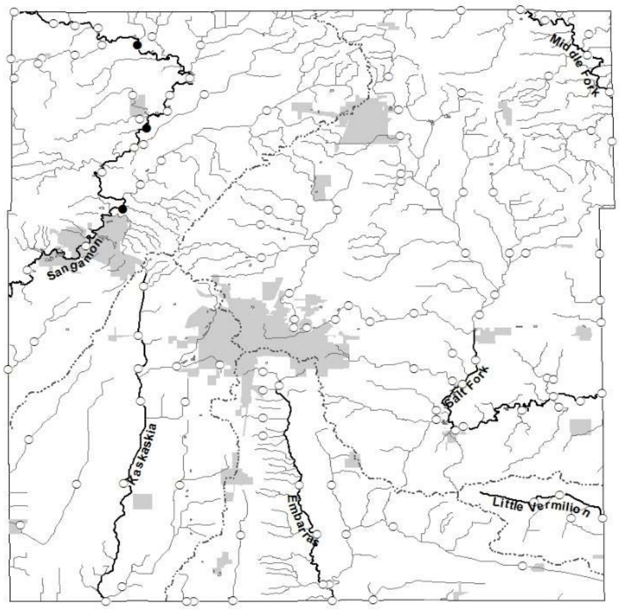
Sherwood & Stein (2012 – 2015)

Pomoxis annularis, White Crappie

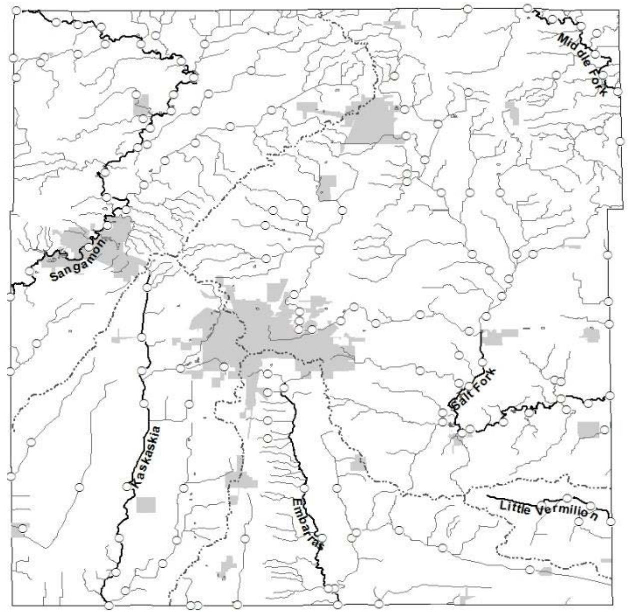
○ = species absent

● = species present

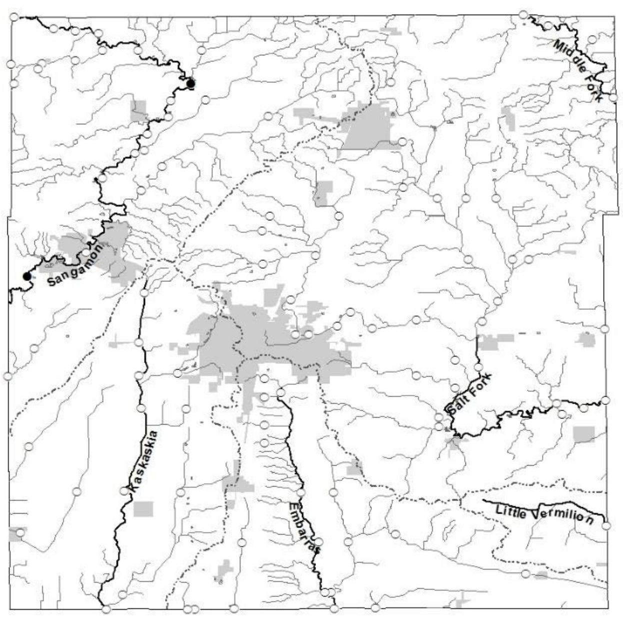
Figure 52



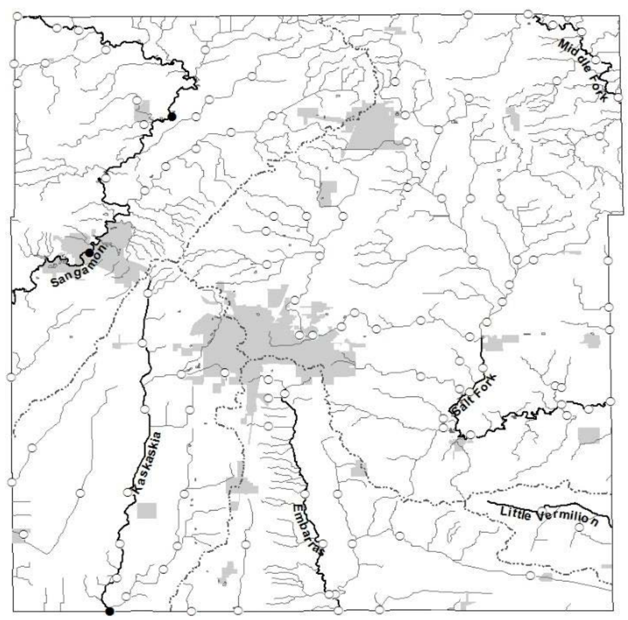
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



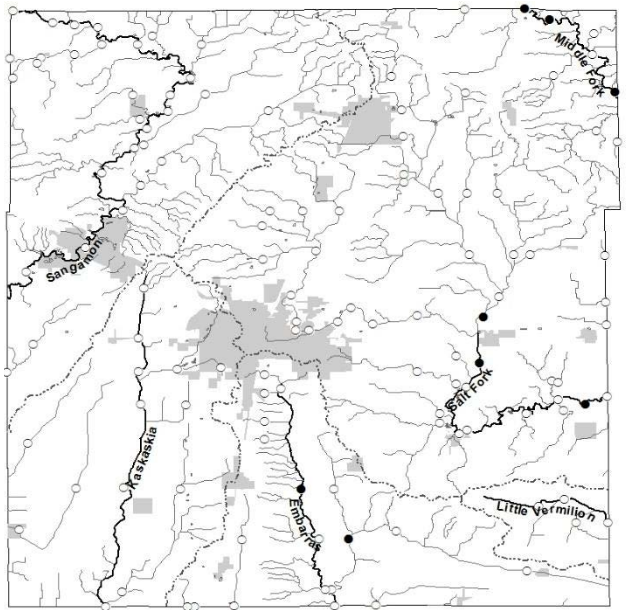
Sherwood & Stein (2012 – 2015)

Pomoxis nigromaculatus, Black Crappie

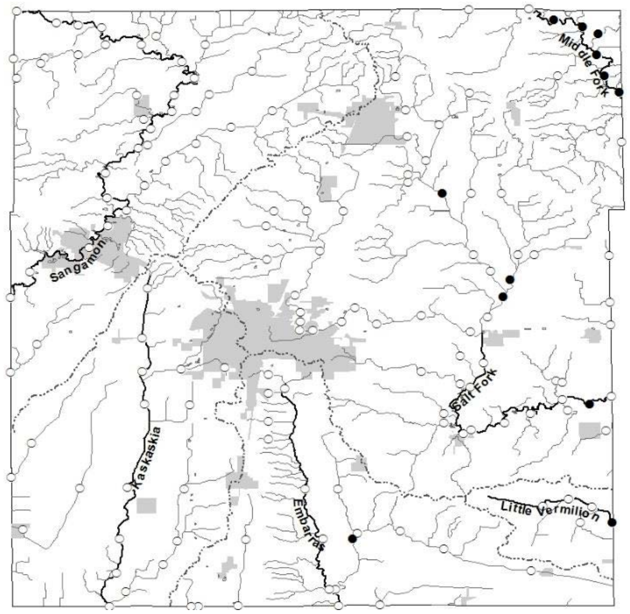
○ = species absent

● = species present

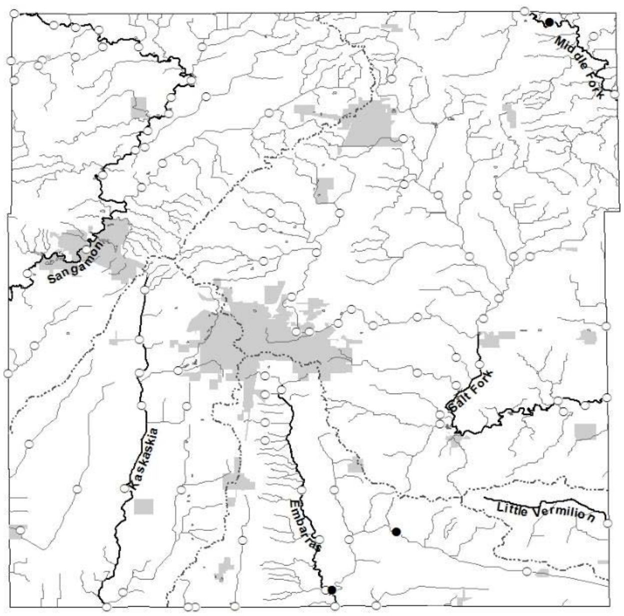
Figure 53



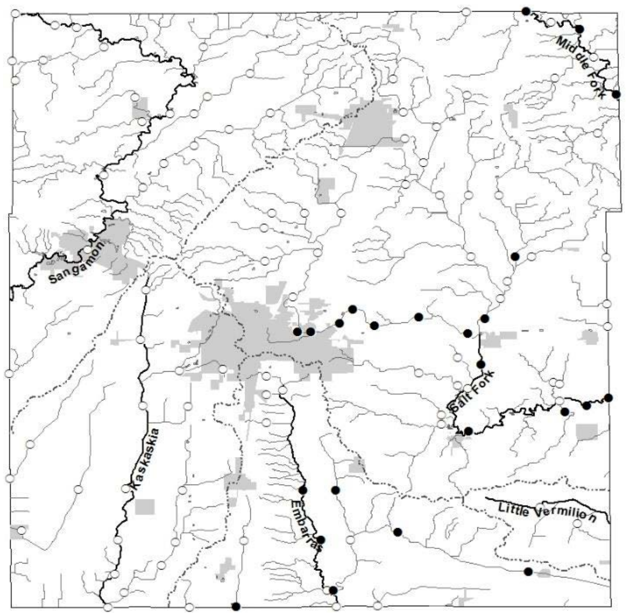
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



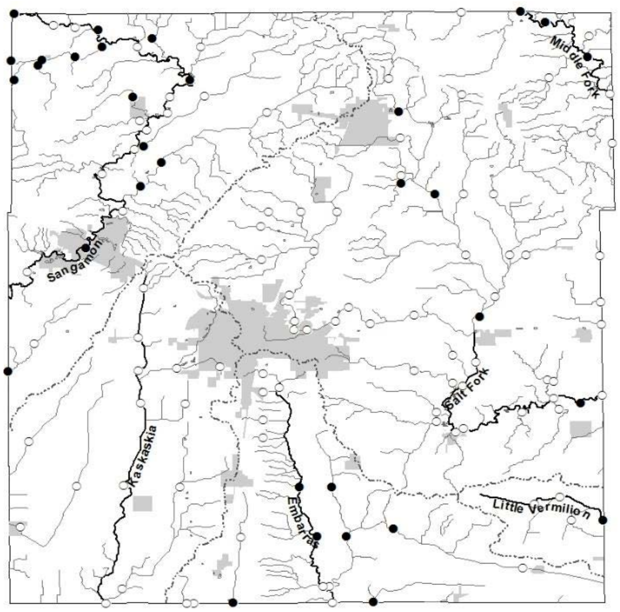
Sherwood & Stein (2012 – 2015)

Etheostoma blennioides, Greenside Darter

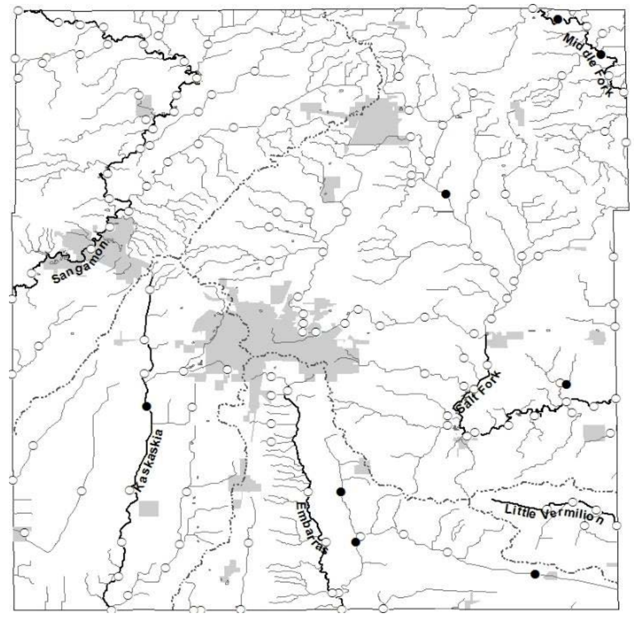
○ = species absent

● = species present

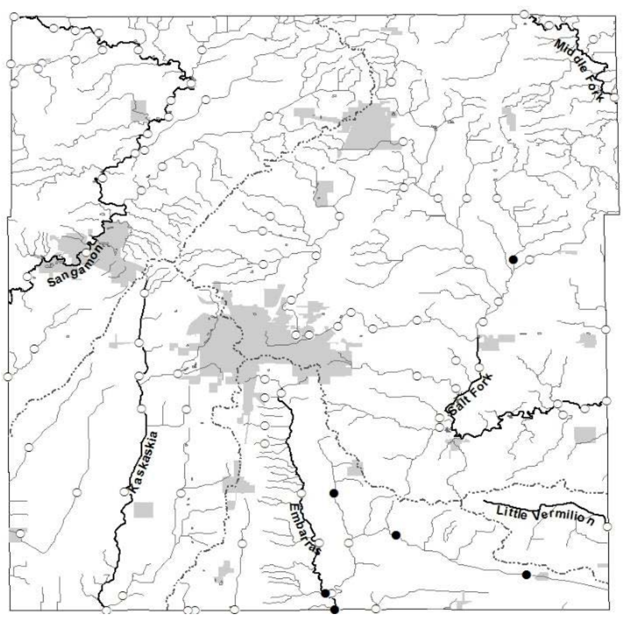
Figure 54



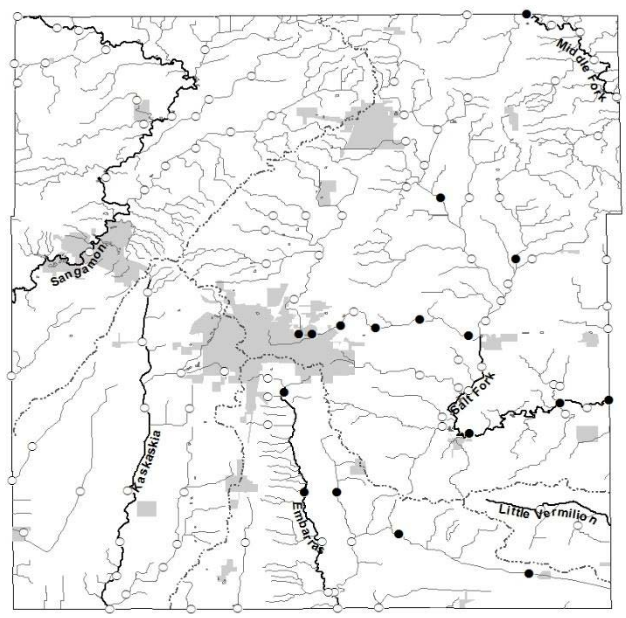
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



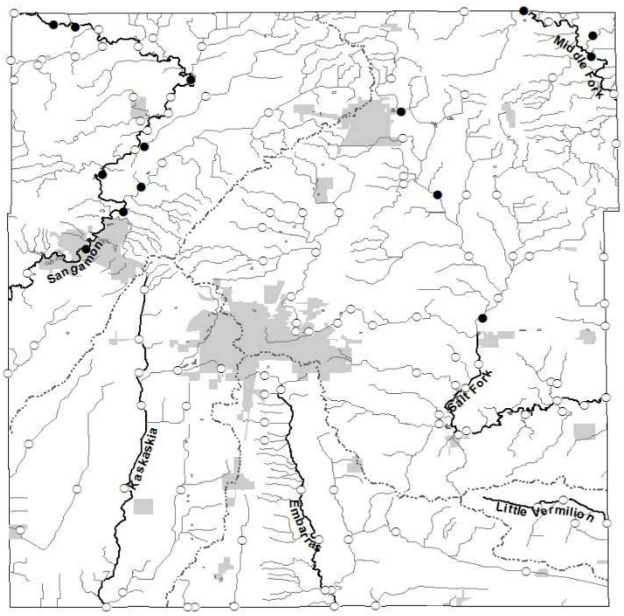
Sherwood & Stein (2012 – 2015)

***Etheostoma caeruleum,* Rainbow Darter**

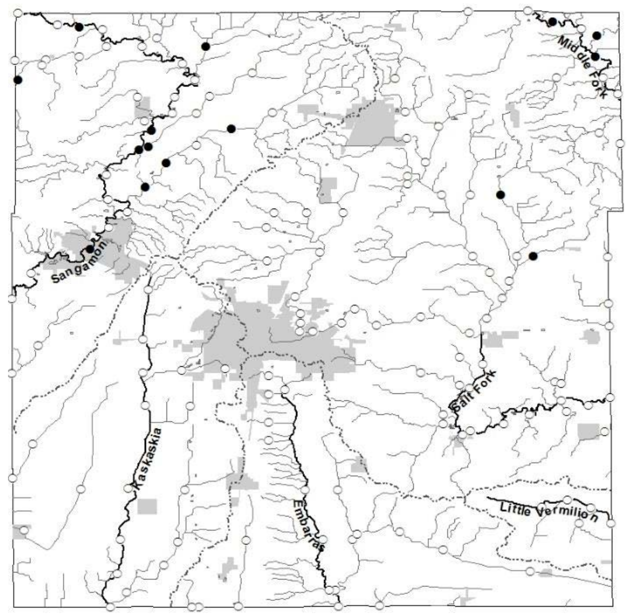
○ = species absent

● = species present

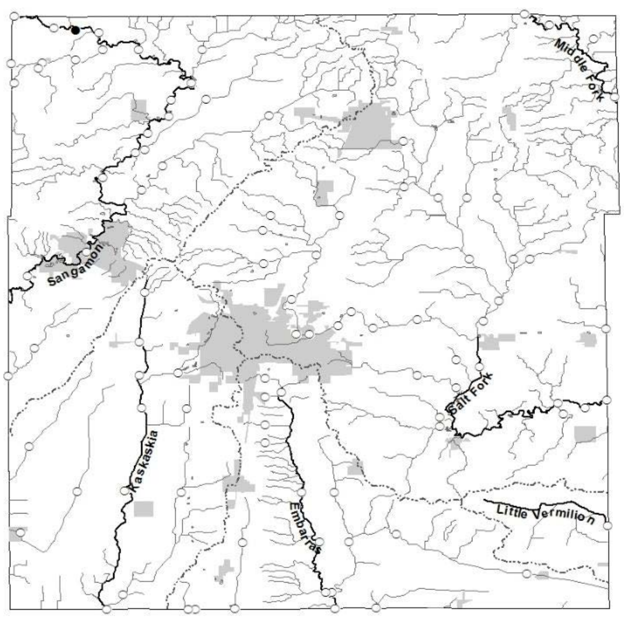
Figure 55



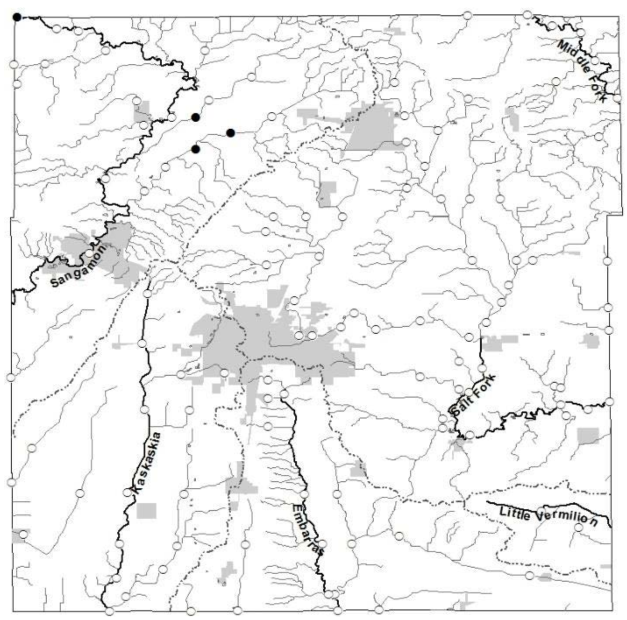
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



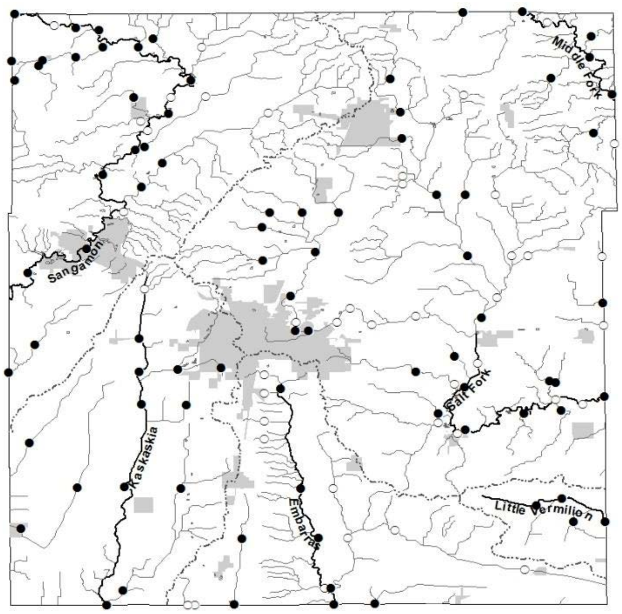
Sherwood & Stein (2012 – 2015)

Etheostoma flabellare, Fantail Darter

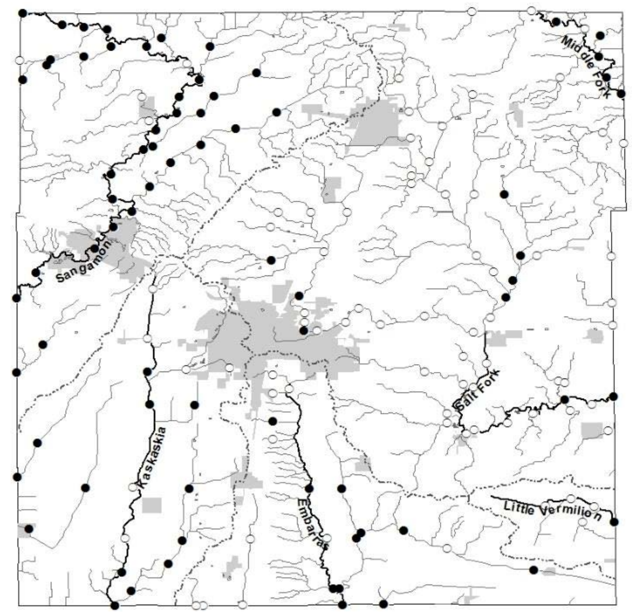
○ = species absent

● = species present

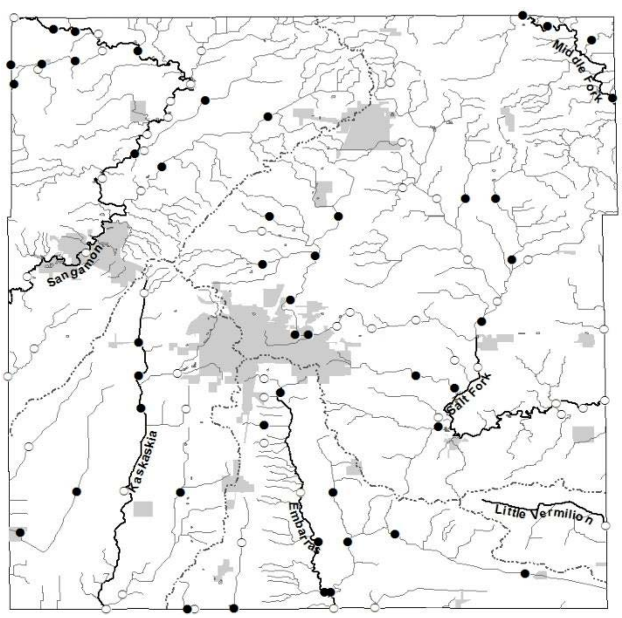
Figure 56



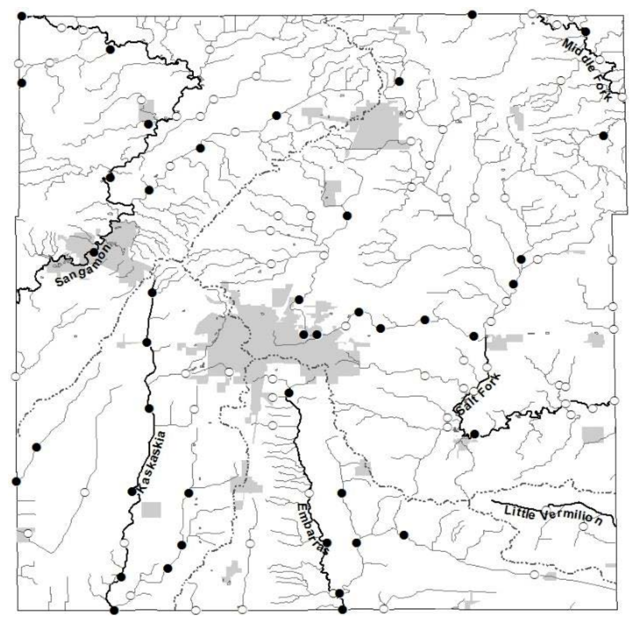
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



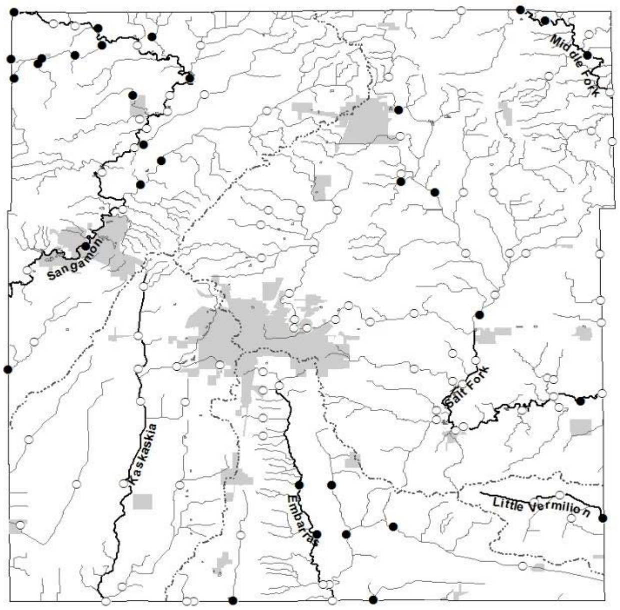
Sherwood & Stein (2012 – 2015)

Etheostoma nigrum, Johnny Darter

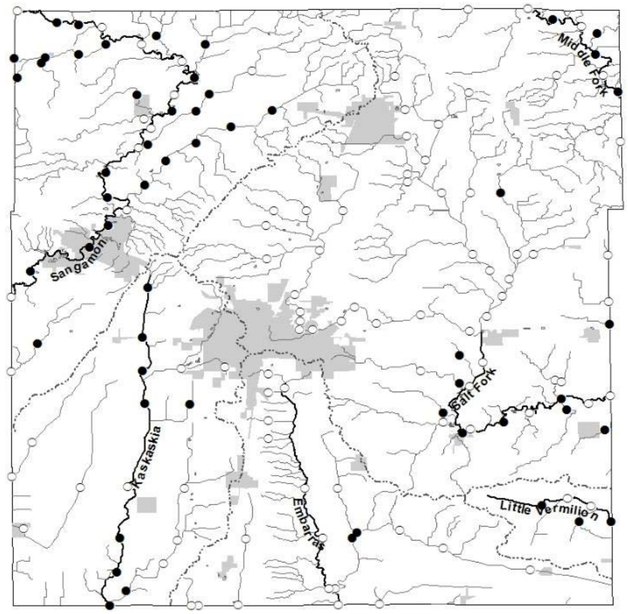
○ = species absent

● = species present

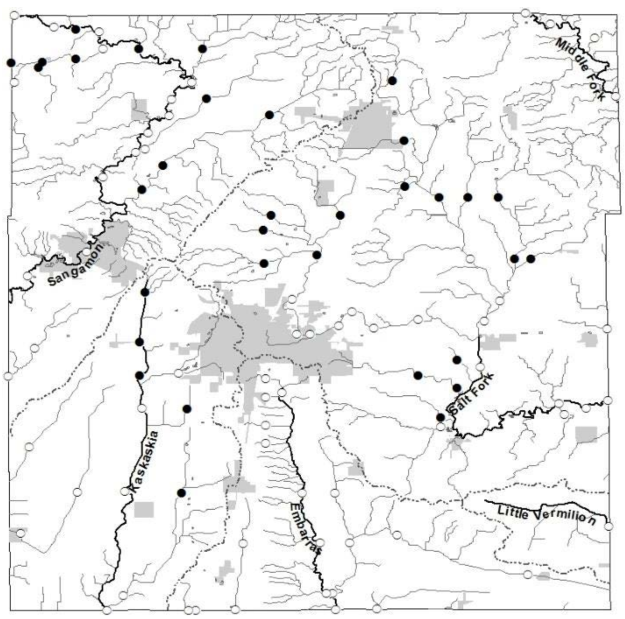
Figure 57



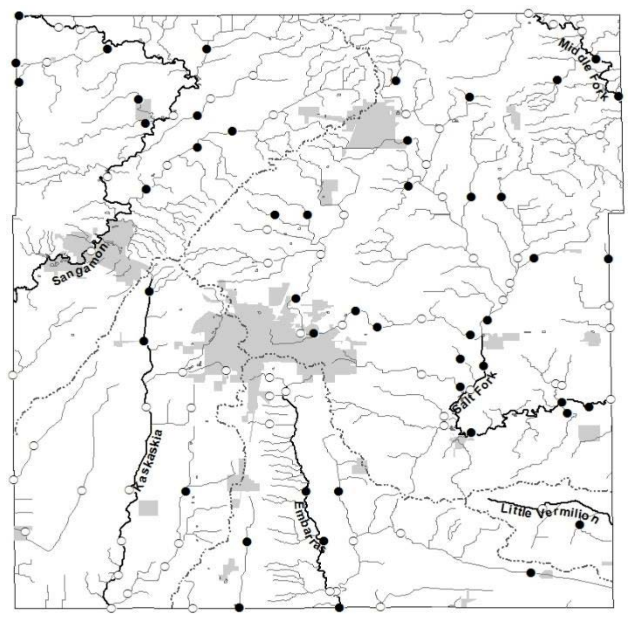
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



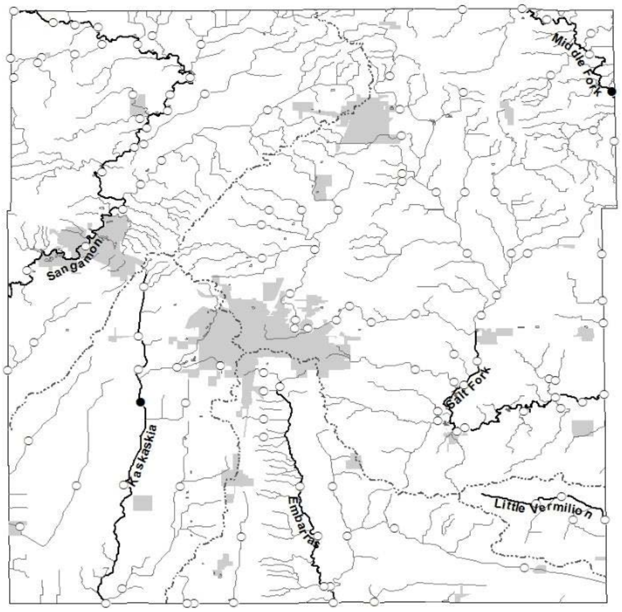
Sherwood & Stein (2012 – 2015)

Etheostoma spectabile, Orangethroat Darter

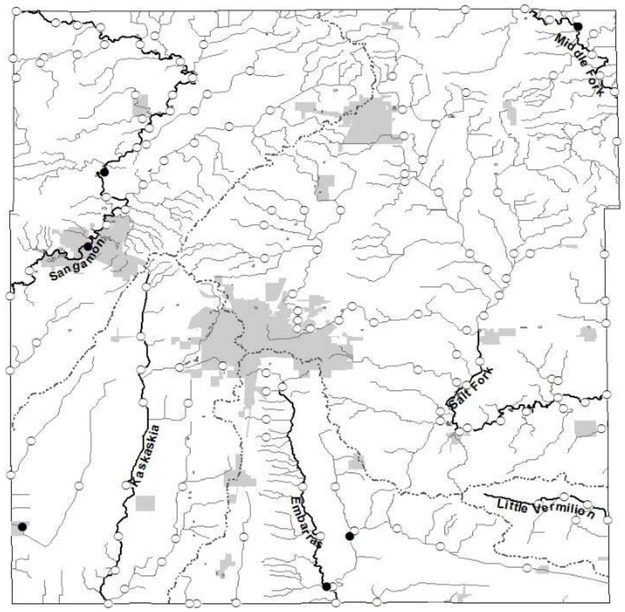
○ = species absent

● = species present

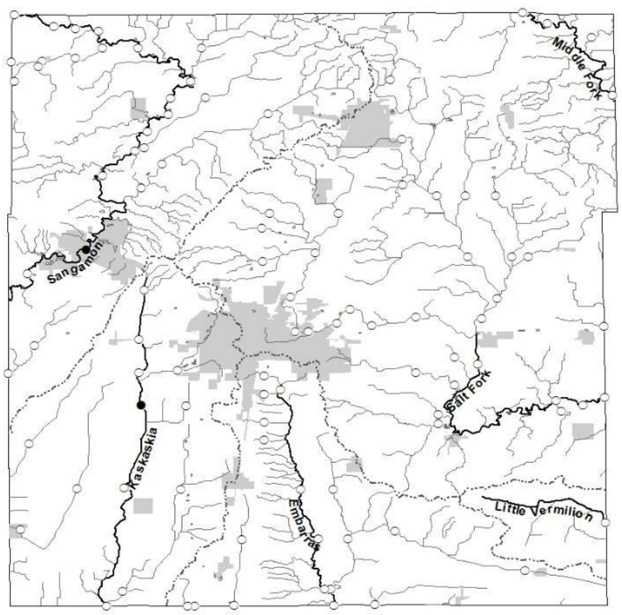
Figure 58



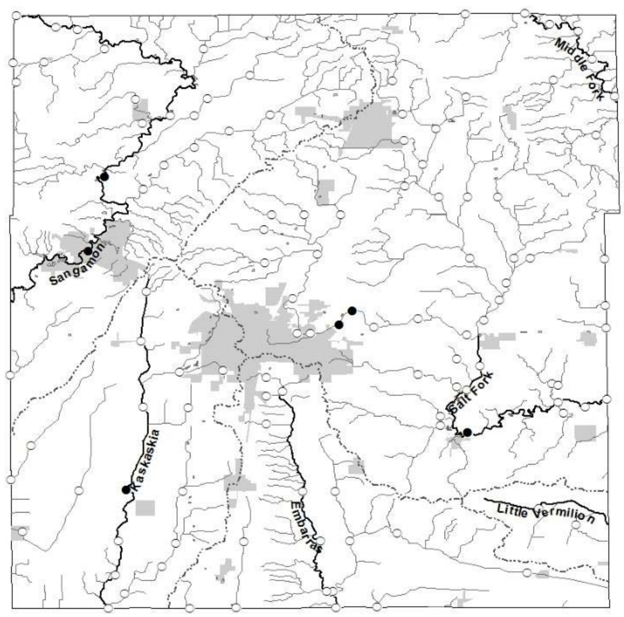
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



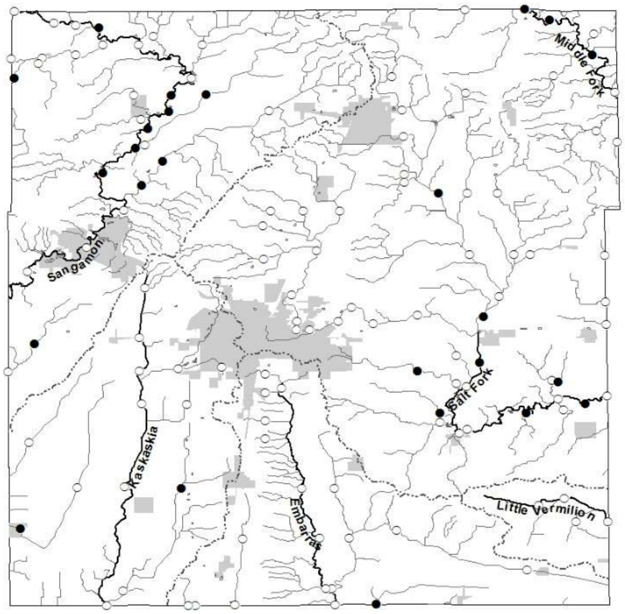
Sherwood & Stein (2012 – 2015)

Percina caprodes, **Logperch**

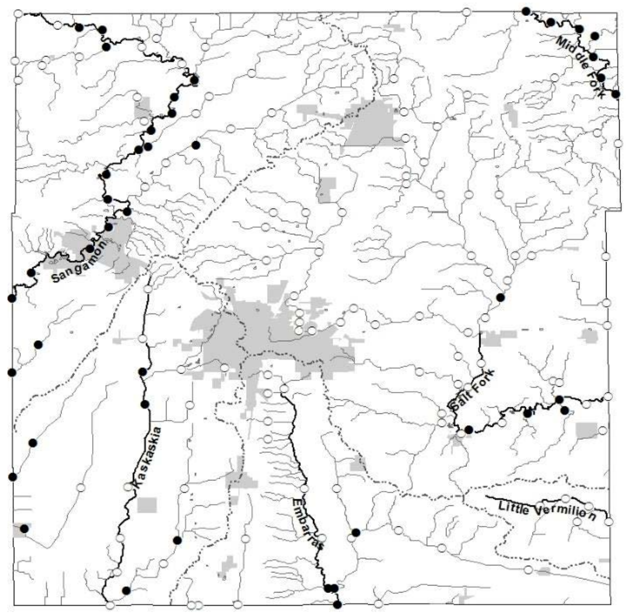
○ = species absent

● = species present

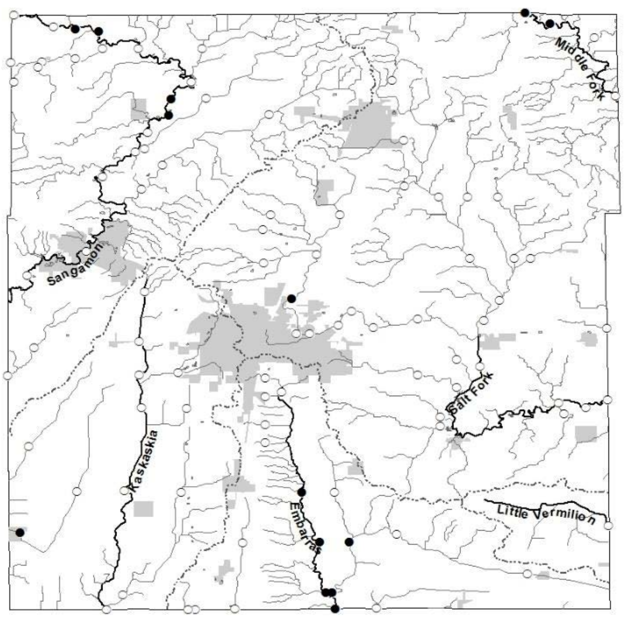
Figure 59



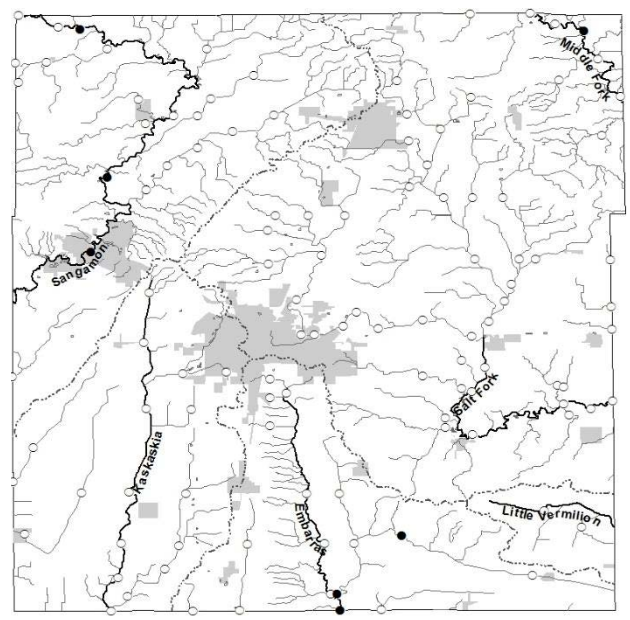
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



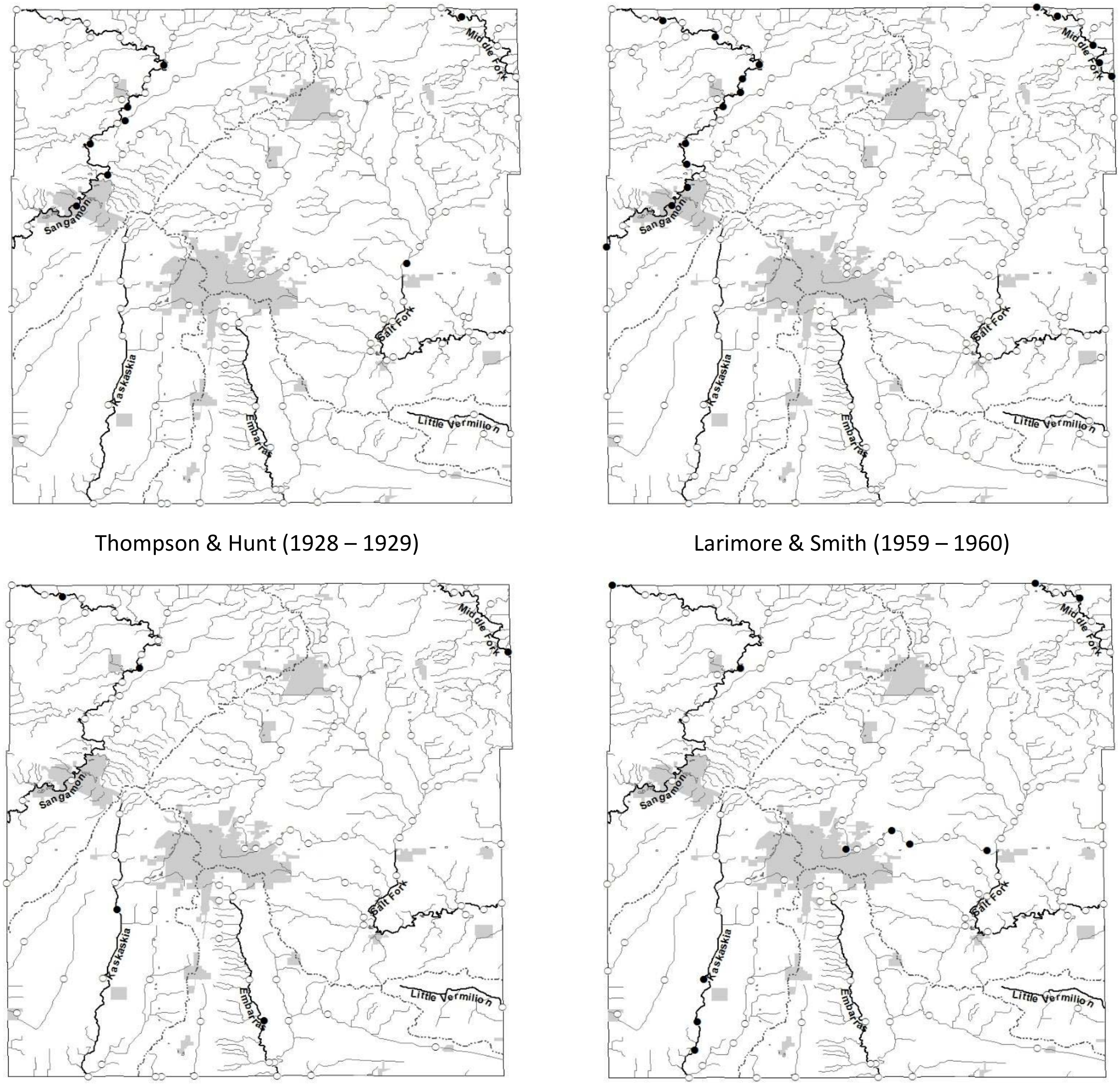
Sherwood & Stein (2012 – 2015)

***Percina maculata,* Blackside Darter**

○ = species absent

● = species present

Figure 60



Thompson & Hunt (1928 – 1929)

Larimore & Smith (1959 – 1960)

Larimore & Bayley (1987 – 1988)

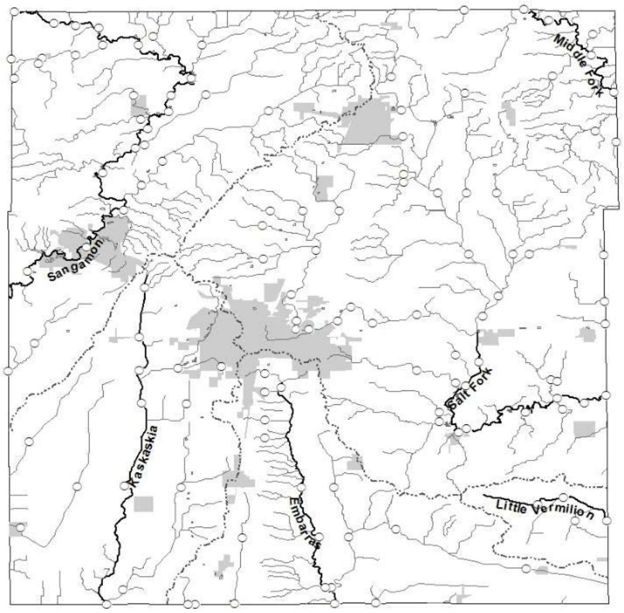
Sherwood & Stein (2012 – 2015)

***Percina phoxocephala,* Slenderhead Darter**

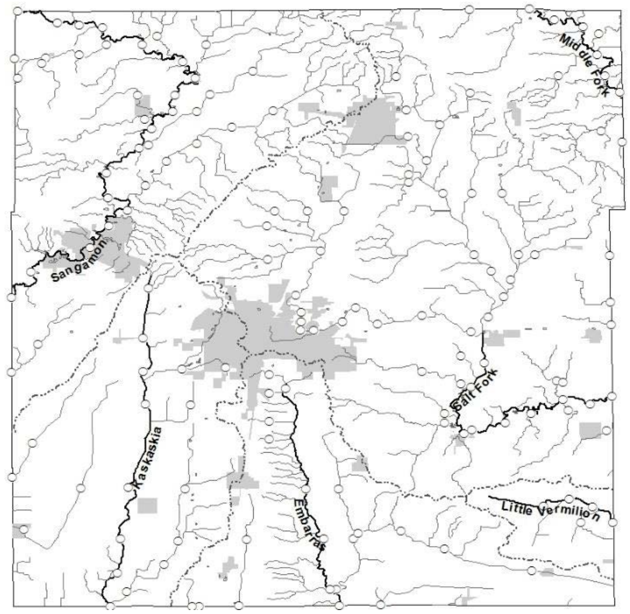
○ = species absent

● = species present

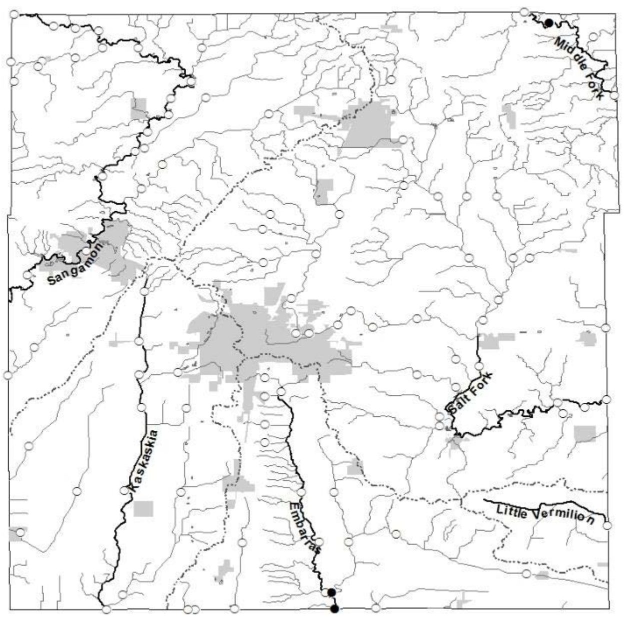
Figure 61



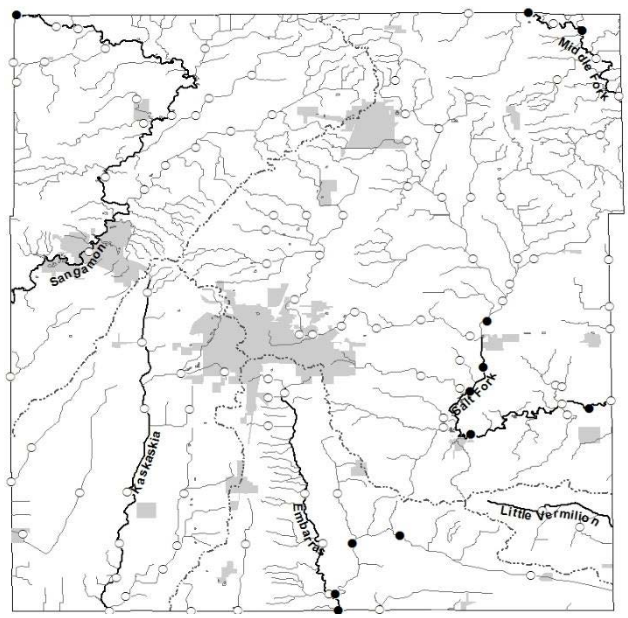
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



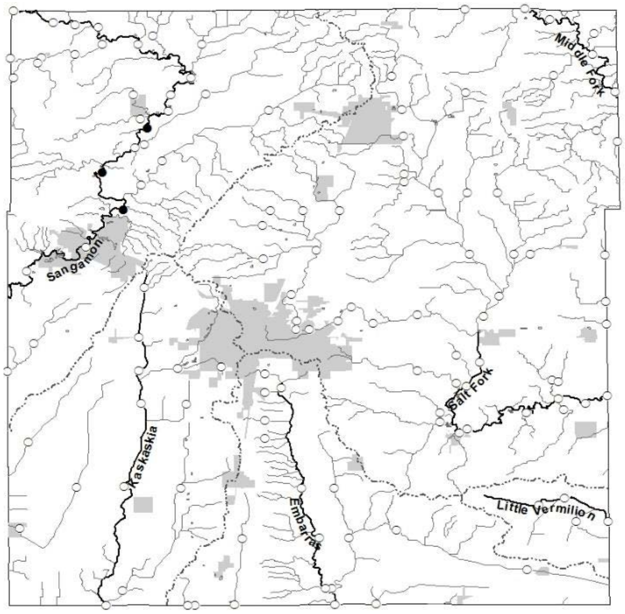
Sherwood & Stein (2012 – 2015)

Percina sciera, **Dusky Darter**

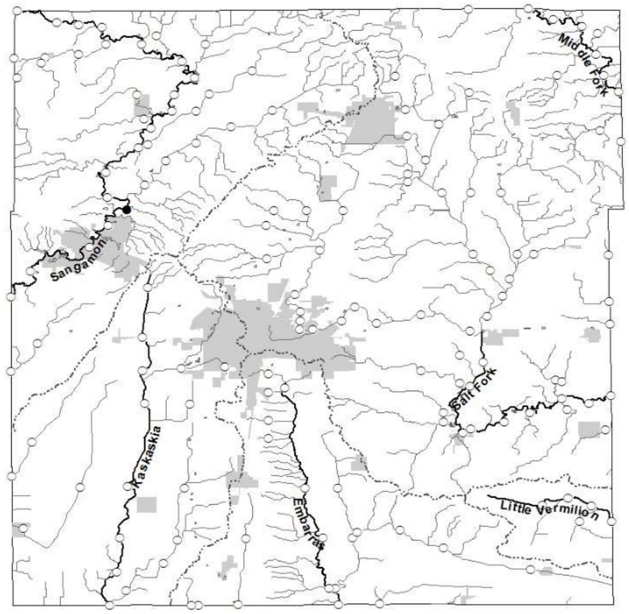
○ = species absent

● = species present

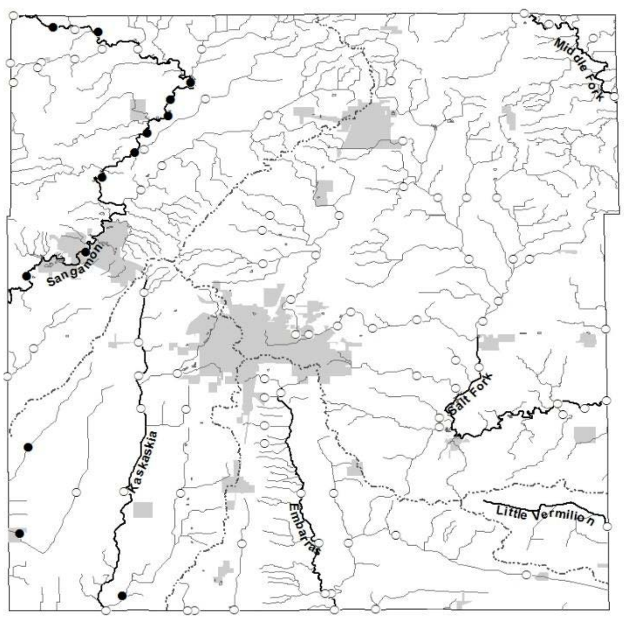
Figure 62



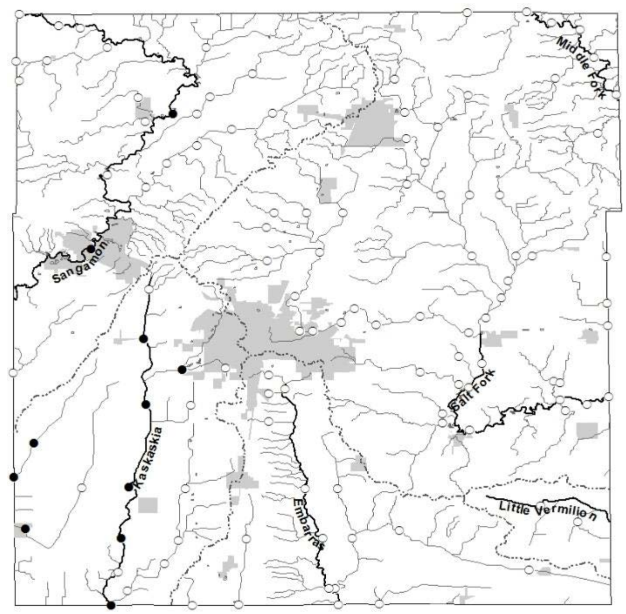
Thompson & Hunt (1928 – 1929)



Larimore & Smith (1959 – 1960)



Larimore & Bayley (1987 – 1988)



Sherwood & Stein (2012 – 2015)

Aplodinotus grunniens, **Freshwater Drum**

○ = species absent

● = species present