Boone River Watershed Stream Fish and Habitat Monitoring, IA

2017 Annual Progress Report to:

Fishers and Farmers Partnership
U.S. Fish and Wildlife Service
Boone River Watershed
The Nature Conservancy
Iowa Department of Natural Resources

Submitted by:

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Background

Historically, Iowa's landscape consisted of prairies, forests, and wetlands with meandering streams integrated throughout (Hewes 1950). The arrival and subsequent settlement of European immigrants began a long process of altering the landscape to help meet human needs. Cultivating row crops in Iowa became a popular and successful venture for many as the flat, fertile ground of the Midwestern United States provided a great opportunity for farmers (Easterlin 1976). Early Iowa farmers began to drain wetlands, cut down forests, remove prairies, and replace them with crop fields (Gallant et al. 2011). As the technology of farming practices improved and operations became larger, streams were altered to aid in irrigation, removal of excess water from fields, and flood control (Iowa Department of Natural Resources 2015b). Portions of streams that once meandered through the forest were straightened and redirected between crop fields. Across Iowa, fast moving riffles and slow pools were replaced by stretches of run habitat (Iowa Department of Natural Resources 2015b). These habitat alterations negatively impacted many fish species (Hughes et al. 1990; Gallant et al. 2011).

One fish species that has been negatively affected by habitat degradation in Iowa is the Topeka shiner (*Notropis topeka*). The Topeka shiner is a small cyprinid identified by its silver to olive color with a dusky stripe along its side and a black chevron shaped wedge at the base of the caudal fin. Mature males develop red-orange fins during breeding season (Pflieger 1997). Once an abundant resident of streams in Iowa, Kansas, Minnesota, Missouri, Nebraska, and South Dakota (Lee et al. 1980), the Topeka shiner has experienced declines over recent decades and was listed as a federally endangered species in 1998 (USFWS 1998). This species is most commonly found in slow moving runs and pools of small, clear headwater streams (Pflieger 1997). A factor contributing to the decline of Topeka shiners is the straightening, or channelizing, of the small streams it inhabits (Wall et al. 2004; Missouri Department of Conservation 2012; Panella 2012). Channelizing often removes pool habitats, increases stream velocity, and increases sedimentation (Brookes et al. 1983) which decreases available habitat in which Topeka shiners are commonly found (Pflieger 1997). Channelization also removes, or makes inaccessible, off-channel oxbow habitats and reduces the likelihood of new oxbows forming through a stream's natural meandering process (Kenney 2013). Because Topeka shiners are often found in oxbows, these habitats are considered important for the species' success (Dahle 2001; Hatch 2001).

Several studies have been conducted in the last two decades building our understanding of landscape and habitat level factors and their effects on fish assemblages of small wadeable Iowa streams. Rowe et al. (2009a, b) studied landscape and land use factors, their effect on physical habitat, and the resulting effects on fish assemblages. They determined that landscape factors directly affect physical habitat which, in turn, directly affects fish assemblages. However, they conclude that landscape factors tended to have an indirect relationship with fish assemblages. Another study by Sindt et al. (2012a, b) evaluated the habitat associations of seven of Iowa's stream fish species of greatest conservation need (SGCN; Iowa Department of Natural Resources 2015b). They determined that the most influential habitat variables for predicting presence are species specific and that measuring variables at multiple spatial scales provided the best results for their model. Bakevich et al. (2013, 2015) examined habitat and fish assemblage associations of Topeka shiners. They determined that the presence of fathead minnows (*Pimephales promelas*), submerged vegetation, oxbows, and fish assemblages comprised of lentic species were positively associated with Topeka shiner presence and abundance.

The Boone River Watershed (BRW) has been highly modified over many decades to improve crop production and control flooding (Blann 2008). The alteration of streams and surrounding riparian areas has led to decreases in the abundance and ranges of several fish species on Iowa's SGCN list, some of which occur in the BRW (Sindt et al. 2012; Iowa Department of Natural Resources 2015b). Following the listing of the Topeka shiner as a federally endangered species in 1998, efforts began in a number of watersheds, including the BRW, to prevent further decline. To increase the chances of a Topeka shiner recovery, multiple institutions including the United States Fish and Wildlife Service (USFWS), Iowa Department of Natural Resources (IDNR), The Nature Conservancy (TNC), Iowa Soybean Association (ISA), Sand County Foundation (SCF), and the USDA Natural Resources Conservation Service (NRCS) have been restoring old, silted-in oxbow remnants in areas of central and western Iowa. To date, 22 oxbows have been restored, and an additional 137 potential restoration sites have been identified in the BRW.

The restoration process involves dredging out soil down to the level of the old stream bed, which allows for a groundwater reconnection from the stream to the oxbow and creates a deeper oxbow with greater potential to hold water in drought periods and support fish (Kenney 2013). Although anecdotal information suggests that Topeka shiners use restored and naturally occurring, unrestored oxbows, little is known regarding what characteristics of oxbows and their surrounding areas are associated with their presence and survival. A better understanding of associations between Topeka shiners and oxbow characteristics could help guide the restoration process to improve suitability and increase the chance of utilization by Topeka shiners. A better understanding of associations between Topeka shiners and in-stream characteristics is also important, as the species can potentially move between oxbows, requiring the use of a nearby stream. Furthermore, oxbow restoration may not only benefit Topeka shiners, but also other SGCN. Thus, a better understanding of these same associations for other rare species would be beneficial as well.

Work in the BRW to enhance understanding about the federally endangered Topeka shiner (*Notropis topeka*) has been occurring for several years and includes contributions from many agencies including: the United States Fish and Wildlife Service (USFWS), Iowa Department of Natural Resources (IDNR), The Nature Conservancy (TNC), Iowa Soybean Association (ISA), Sand County Foundation (SCF), the USDA Natural Resources Conservation Service (NRCS), Iowa State University (ISU), and the Iowa Cooperative Fish and Wildlife Research Unit (ICFWRU) among others. Much of this work involves the restoring of off-channel oxbows to potentially increase the amount of suitable Topeka shiner habitat in the watershed. Iowa State University and Iowa Cooperative Fish and Wildlife Research Unit personnel have monitored these efforts in the past and continue their research with the current project, carried out by graduate student Nick Simpson. Nick's thesis work will include sampling fish assemblages and measuring habitat characteristics of in-stream and oxbow habitats in the BRW (Appendix 1).

Objective 1: Monitor fish assemblages and habitat conditions in two streams in the Boone River Watershed (BRW); White Fox Creek and Eagle Creek.

Fish Sampling

Fishes were sampled with two gear types: electrofishing and seining. At stream sites, we first made a single pass upstream with DC electrofishing using enough power to sufficiently stun fish. All fish were netted and placed in the live well. A generator powered barge electrofishing unit (ETS Electrofishing Systems LLC, Madison, WI USA) was used in larger streams and a backpack electrofishing unit (Smith Root Inc., Vancouver, WA USA) was used in smaller, shallower streams too small for a barge unit. Following electrofishing, portions of each stream site were seined (4.6 x 1.8m or 10.7 x 1.8m, 6.35mm mesh). The two collection methods help increase the probability that all species present were detected.

Oxbows were sampled via bag seine only (10.7 x 1.8m or 17.1 x 1.8m, 6.35mm mesh), following the protocol of Bakevich et al. (2013). Oxbows tended to have soft, mucky substrates and no flow. Thus, electrofishing would not be an efficient method for sampling oxbows due to high turbidity caused by walking in them. When possible, three passes were made through the whole wetted area of the oxbow with the bag seine in an attempt to collect all fish present.

At both stream and oxbow sites, total lengths were taken of any Topeka shiners and game fish (as determined by the Iowa DNR: Black crappie (*Pomoxis nigromaculatus*), White crappie (*Pomoxis annularis*), Bluegill (*Lepomis macrochirus*), Pumpkinseed (*Lepomis gibbosus*), Rock bass (*Ambloplites rupestris*), Largemouth bass (*Micropterus salmoides*) Smallmouth bass (*Micropterus dolomieu*), Channel catfish (*Ictalurus punctatus*), Flathead catfish (*Pylodictis olivaris*), Walleye (*Sander vitreus*), Yellow perch (*Perca flavescens*), and Northern pike (*Esox lucius*)). All fish were identified to species in the field, if possible, and counted. Voucher specimens were collected for individuals unable to be identified in the field and preserved in 90% ethanol to be identified in the lab. Any abnormalities to fish (referred to as DELTS: deformities, eroded fins, lesions, tumors, parasites, etc.) were noted.

When analyzing the fish community at all sites, catch per unit effort (CPUE) was calculated for each species as number of individuals caught per $100m^2$ of sampled area. For stream sites, electrofishing and seining abundances were combined to calculate total relative abundance for each species as well as combined sunfish (green and orangespotted sunfish), predators (Smallmouth and Largemouth bass, Black and White crappie, Channel and Flathead catfish, Rock bass, Northern pike, Walleye, Yellow perch, Shortnose gar), and SGCNs. To account for instances when three seine passes could not be completed in oxbows, only individuals captured during the first seine pull were used when calculating relative abundance in all oxbows.

Stream fish community data was put into the IDNR-created BioNet software available on their website. BioNet calculates 12 metrics describing the fish community such as native species richness, sensitive species richness, proportion of sucker species, and an overall community tolerance index (1-10 scale) based on fish community as a whole. The program then uses those metrics and site location information to calculate an overall fish index of biological integrity (FIBI), which is meant to provide a community-level assessment of stream biological conditions. FIBI scores correspond to excellent (71-100), good (51-70), fair (26-50), or poor (0-25) conditions. Because this program was only designed to be used on stream data, these indices were only calculated for stream sites.

Water Quality and Habitat Sampling

Water quality measurements for both stream and oxbow sites consisted of temperature (°C), dissolved oxygen (mg/L), conductivity (mS/cm) (Yellow Springs Instruments, Professional Series model 2030), and pH (Thermo Fisher Scientific, model pHTestr 10). Turbidity (NTU) was measured using a Hach 2100Q portable turbidimeter. These measurements were taken before any fish or habitat data were collected to minimize contamination.

Habitat characteristics were measured following a slightly modified version of the Iowa Department of Natural Resources wadeable streams procedure (Iowa Department of Natural Resources 2015a). At stream sites, each sampling reach consisted of ten equally spaced transects where measurements were taken (Figure 1A). At each transect, a tape measure was stretched across to obtain a wetted width (Figure 1B). Next, depth (m), velocity (m/sec), and substrate type were determined at 10, 30, 50, 70, and 90% of the width (Figure 1C). Stream velocity was measured using a Marsh McBirney Flow-mate 2000 flow meter at 60% of the depth if <0.75m or 20% and 80% of the depth and averaged if ≥0.75m. Measurements taken at each bank of each transect include bank angle by clinometer and percent bare stream bank by visual estimate (Figure 1D) as well as canopy cover by spherical densitometer facing upstream (Figure 1E). Density of in-stream cover (i.e., macrophytes, filamentous algae, woody debris, tree roots, boulders, over-hanging banks, under-cut banks, and artificial structure) was estimated within an area 5m upstream and 5m downstream of each transect line. Estimates were recorded as either absent (0%), sparse (<10%), moderate (10-40%), heavy (40-75%), or very heavy (>75%; (Figure 1F).

Two mini-transects were located at 33% and 67% of the distance between two transects (Figure 1G). At mini-transects, thalweg depth was measured and presence of soft or small sediment (e.g., fine gravel, sand, silt, clay, and muck) was determined. Macrohabitat was characterized at each transect and mini-transect as pool, riffle, or run. For the purposes of this study we used the following definitions for each macrohabitat as described by Sponholtz and Rinne (1997). Pools are described as typically being the deepest sections of a stream and having little or no surface velocity. Pools tend to have fine gravel, sand, and silt substrates. Riffles are defined as shallow, swift areas with a large amount of surface turbulence. Riffles tend to have larger gravel and cobble substrates with boulders commonly present. Runs are typically described as being deeper and slower than riffles and shallower and swifter than pools. Gravel, cobble, and sand are common substrates of run macrohabitats.

Riparian vegetation was visually estimated at transects 1, 5, and 10 in an area 5m upstream and downstream and 10m out into the riparian area from each transect (Figure 1H). Type (i.e. deciduous, coniferous, broadleaf evergreen, mixed, or none) and density of vegetation was estimated for the canopy (>5m), understory (0.5-1.5m), and ground cover (<0.5m) on each bank and recorded as either absent (0%), sparse (<10%), moderate (10-40%), heavy (40-75%), or very heavy (>75%).

At oxbow sites, three transects were located at 25, 50, and 75% of the length of the oxbow (Figure 1A). The same measurements and bank characteristics were taken at oxbow transects as were at stream transects with the exception of velocity. There were no mini-transects at oxbows because they are generally uniform in depth and substrate (Bakevich 2012). The same riparian vegetation estimates were also recorded at oxbow sites.

When analyzing habitat characteristics of streams and oxbows, many variables were either averaged across the whole site (width, depth, riparian vegetation estimates) or presented as a proportion of the site (substrate and macrohabitat types). Several other characteristics were only measured once per site (water quality, minimum and maximum depth). These values were then used in an effort to determine habitat associations of Topeka shiners.

Accomplished to Date

During the 2016 and 2017 field seasons, 101 fish and habitat surveys were conducted at 95 sites throughout the BRW (Figure 2). This includes 66 in-stream sites and 29 oxbows. In addition to 23 sites in the White Fox Creek HUC10 and 20 sites in the Eagle Creek HUC10, 52 sites were sampled throughout other sub-basins of the watershed (Table 1). A total of 145,887 fish including 55 species were sampled. The five most abundant species were common shiner, fathead minnow, black bullhead, orangespotted sunfish, and green sunfish. The five most commonly occurring (# sites present/total # sites) species were common shiner, creek chub, green sunfish, white sucker, and bluntnose minnow. Abundance and percent occurrence of all species sampled are listed in Table 2. Of 66 stream sites, three had excellent FIBI scores (Max=81), 30 had good scores, 32 had fair scores, and one had a poor score (Min=22). Habitat assessments were also performed at each of these sites. Many habitat variables were measured or visually estimated in each habitat assessment (Table 3). Each habitat variable along with several variables describing the fish community are considered when evaluating which characteristics are associated with the presence of Topeka shiners to be included in thesis analysis. Side by side boxplots show the distribution of variables over three types of sampling site: stream, unrestored oxbow, and restored oxbow. Appendix 2 shows boxplots describing habitat variables while appendix 3 shows boxplots describing fish community variables. When viewing these plots, the bold horizontal lines represent the sample median and the box represents the interquartile range (IQR). The “whiskers” on either end of the box represent the smaller value between the most extreme value or 1.5*IQR. Values greater or smaller than 1.5*IQR are considered outliers. To improve clarity of these plots, outliers are not shown.

To be Completed

Fish and habitat sampling has been completed for this project in the BRW. We are currently working through analyzing our data and selecting models to accurately describe habitat and fish community associations of Topeka shiners and other SGCNs. Variable selection for any multivariate analysis is an important step when there are dozens of variables that could potentially describe variation between sites. Building random forests is a method that can be used to order the significance of variables. We have been working with random forests to aid in selecting which variables should be included in a multivariate logistic regression. The goal of logistic regression is to determine which variables are significantly different between sites with Topeka shiners and sites without Topeka shiners and to what extent.

Objective 2: Assess these streams' potential as Topeka shiner population sources and conduits for associated oxbow habitat.

Accomplished to Date

Of the 95 total sites sampled in the BRW, Topeka shiners were sampled at 32 (34%). This includes 19 in-stream reaches and 13 oxbows. Topeka shiners were not sampled at any White Fox Creek sites but were present at 6 Eagle Creek sites. In addition to Eagle Creek, Topeka shiners were sampled in the Boone River, Middle Branch Boone River, East Branch Boone River, Prairie Creek, Otter Creek, Drainage Ditch 4, and Drainage Ditch 94. Topeka shiner abundance at sites where they were sampled ranged from 1-453 individuals with a mean of 57 and median of 16 individuals per site. Overall, 2010 Topeka shiners were sampled in the BRW in 2016-2017, making them the 16th most abundant and 19th most commonly occurring species in our sampling (Table 2).

Topeka shiner presence and abundance was most consistent in Prairie Creek and its associated oxbows. Fourteen of 32 (43.7%) positive Topeka shiner sites and 1633 of 2010 total Topeka shiners sampled were in Prairie Creek or one of its oxbows. Topeka shiners were sampled at 14 of 17 (82.4%) sites in the Prairie Creek HUC10 compared to 18 of 78 (23.1%) sites throughout all other HUC10s of the BRW. This was surprising because there were only two detections of Topeka shiners in this HUC10 in two previous Iowa State University stream fish studies since 1997 (Menzel and Clark 2002; Bakevich et al. 2015).

Reviewing past detection locations of Topeka shiners in the BRW is important when considering the status and current distribution of the species. Figure 3 shows the BRW partitioned into its seven HUC10 sub-watersheds with points representing Topeka shiner detection locations from the present study, two previous stream fish studies (Menzel and Clark 2002; Bakevich et al. 2015), and a historical database also complied at Iowa State University (Loan-Wilsey et al. 2005). Table 4, more generally, lists the presence or absence of Topeka shiners in each HUC10 across these four study periods and also includes a qualitative status label based on their presence over time. To alternately view this, Figure 4 shows the BRW HUC10 watersheds colored by individual qualitative status label. It is noteworthy that what appeared to be a precipitous decline in Topeka shiner occurrence in BRW HUC10 watersheds in the 2010-11 study may have slowed or even reversed, although the objectives of that study did not allow for such intensive sampling of the watershed as the present study did. It is also noteworthy that we have documented the occurrence of Topeka shiners in both the Otter Creek and Headwaters HUC10s for the first time in over two decades. It had been previously reported that these areas were within the historical distribution of the species but without any explicit published locations.

Preliminary analyses have focused on three sets of variables (habitat variables, fish community variables, and all variables combined) and two habitat types (streams and oxbows). Random forest tests consistently rank species richness as well as fathead minnow, green sunfish, and orangespotted sunfish CPUEs highly among important variables to predict presence of Topeka shiners. Each of these variables shows a positive relationship with Topeka shiner presence for all models, although not always statistically significant (alpha=0.05). After running variables through a preliminary logistic regression, Topeka shiners appear to be positively associated with yellow bullhead CPUE and species richness while being negatively associated with woody riparian vegetation and cobble at stream sites. At oxbow sites, Topeka shiners display a positive relationship with species richness, black bullhead CPUE, and deeper minimum depths while being negatively associated with the wetted length of oxbows.

To be Completed

We will continue analysis of data from 2016-2017. Manuscripts will be written and submitted to appropriate journals.

Products

Four short popular-type articles were submitted to newsletters for publication in early 2017:

Simpson, N. 2017. Working with an endangered Iowa fish. Boone River Watershed Newsletter.

Simpson, N., Zambory, C., and A. Bybel. 2017. A team effort in Topeka shiner research. Fishers & Farmers Partnership Newsletter.

Bybel, A. and N. Simpson. 2017. Working with an endangered Iowa fish. Field Notes, Department of Natural Resource Ecology and Management, Iowa State University.

Zambory, C., A. Bybel, and N. Simpson. 2017. A multifaceted approach to Topeka shiner research in Iowa. Getting Into Soil and Water 2017, Iowa Water Center and Soil & Water Conservation Club, Iowa State University.

Anticipated activities for 2018

Presentations are being prepared for conferences upcoming in early 2018. We are planning on presenting at the Midwest Fish and Wildlife Conference and the Iowa Water Conference which are both holding sessions focusing on the benefits of oxbow restorations. In addition, we are also planning to present at the Iowa Chapter of the American Fisheries Society meeting

Nick Simpson is expected to complete his master's program at Iowa State University in 2018. He will defend his work and submit a thesis to the university, followed by publication of manuscripts.

References

Bakevich, B.D. 2012. Status, distribution, and habitat associations of Topeka shiners in west-central Iowa. Graduate Theses and Dissertations. Paper 12269.

Bakevich, B.D., C.L. Pierce, and M.C. Quist. 2013. Habitat, fish species, and fish assemblage associations of the Topeka shiner in West-Central Iowa. North American Journal of Fisheries Management 33: 1258-1268.

Bakevich, B. D., C. L. Pierce, and M. C. Quist. 2015. Status of the Topeka shiner in west-central Iowa. 2015. American Midland Naturalist 174: 350-358.

Blann, K. 2008. Boone River Watershed Conservation Action Plan. The Nature Conservancy, Iowa Chapter, Des Moines.

Brookes, A., K.J. Gregory, and F.H. Hansen. 1983. An assessment of river channelization in England and Wales. The Science of the Total Environment 27: 97-111.

Easterlin, R.A. 1976. Population and farm settlement in the Northern United States. The Journal of Economic History 36(1): 45-75.

Dahle, S.P. 2001. Studies of the Topeka shiner (*Notropis topeka*) life history and distribution in Minnesota. University of Minnesota, St. Paul, MN, Masters thesis.

Gallant, A.L., W. Sadinski, M.F. Roth, and C.A. Rewa. 2011. Changes in historical Iowa land cover as context for assessing the environmental benefits of current and future conservation efforts on agricultural lands. Journal of Soil and Water Conservation 66(3): 67A-77A.

Hatch, J.T. 2001. What we know about Minnesota's first endangered fish species: the Topeka shiner. Journal of the Minnesota Academy of Science 65: 31-38.

Hewes, L. 1950. Some features of early woodland and prairie settlement in a Central Iowa county. Annals of the Association of American Geographers 40(1): 40-57.

Hughes, R.M., T.R. Whittier, C.M. Rohm, and D.P. Larsen. 1990. A regional framework for establishing recovery criteria. Environmental Management 14(5): 673-683.

Iowa Department of Natural Resources. 2015a. Biological sampling and physical habitat assessment standard operating procedure for Iowa wadeable streams and rivers. Revision 2.0.

Iowa Department of Natural Resources. 2015b. Securing a future for fish and wildlife: a conservation legacy for Iowans. The Iowa Wildlife Action Plan. Third Edition.

Kenney, A. 2013. The Topeka shiner: shining a spotlight on an Iowa success story. Endangered species bulletins and technical reports (USFWS).

Lee, D.S., C.R. Gilbert, C.H. Hocutt, R.E. Jenkins, D.E. Mcallister, and J.R. Stauffer, Jr. 1980. Atlas of North American freshwater fishes. North Carolina Museum of Natural History, Raleigh: 867.

Loan-Wilsey, A.K., C.L. Pierce, K.L. Kane, P.D. Brown, and R.L. Mcneely. 2005. The Iowa aquatic gap analysis project: final report. Iowa Cooperative Fish and Wildlife Research Unit, Iowa State University, Ames, IA.

Menzel, B.W. and S.J. Clark. 2002. Final Report to Iowa Department of Natural Resources on agreement for consultant services for refinements to a habitat model of the Topeka shiner, Ames, IA.

Missouri Department of Conservation. 2012. Topeka shiner (Notropis topeka) best management practices. Missouri Department of Conservation, Jefferson City, MO, USA.

Panella, M.J., 2012. Topeka shiner (*Notropis topeka*) a species conservation assessment for the Nebraska natural legacy project. Nebraska Game and Parks Commission, Lincoln, NE, USA.

Pflieger, W.L., 1997. The fishes of Missouri. Missouri Department of Conservation, Jefferson City, MO, USA: 154-155.

Rowe, D. C., C. L. Pierce, and T. F. Wilton. 2009a. Fish assemblage relationships with physical habitat in wadeable Iowa streams. North American Journal of Fisheries Management 29:1314-1332.

Rowe, D.C., C.L. Pierce, and T.F. Wilton. 2009b, Physical habitat and fish assemblage relationships with landscape variables at multiple spatial scales in wadeable Iowa streams. North American Journal of Fisheries Management 29:1333-1351.

Sindt, A.R., C.L. Pierce, and M.C. Quist. 2012a. Fish species of greatest conservation need in wadeable Iowa streams: current status and effectiveness of aquatic gap program distribution models. North American Journal of Fisheries Management 32: 135-146.

Sindt, A.R., M. C. Quist, and C.L. Pierce. 2012b. Habitat associations of fish species of greatest conservation need at multiple spatial scales in wadeable Iowa streams. North American Journal of Fisheries Management 32: 1046--1061.

Sponholtz, P.J. and J.N. Rinne. 1997. Refinement of aquatic macrohabitat definition in the Upper Verde River, Arizona. Hydrology and Water Resources in Arizona and the Southwest.

U.S. Fish and Wildlife Service (USFWS). 1998. Endangered and threatened wildlife and plants; final rule to list the Topeka shiner as endangered. Endangered species bulletins and technical reports (USFWS).

Wall, S.S., C.R. Berry, Jr., C.M. Blausey, J.A. Jenks, and C.J. Kopplin. 2004. Fish-habitat modeling for gap analysis to conserve the endangered Topeka shiner (*Notropis topeka*). Canadian Journal of Fisheries and Aquatic Sciences 61(6) 954-973.

Tables and Figures

Table 1. Total number of oxbows and stream reaches sampled in each HUC10 of the Boone River Watershed and how many sites had Topeka shiners (TS) present in 2016-2017.

	Oxbow Sites		Stream Sites		Combined Sites	
HUC10	**Sampled**	**TS present**	**Sampled**	**TS present**	**Sampled**	**TS present**
Eagle Creek	7	3	13	3	20	6
Headwaters Boone River	0	0	6	5	6	5
Lower Boone River	4	0	10	0	14	0
Middle Boone River	1	1	8	3	9	4
Otter Creek	2	2	4	1	6	3
Prairie Creek	8	7	9	7	17	14
White Fox Creek	7	0	16	0	23	0
Total	29	13	66	19	95	32

Table 2. Abundance (total number of individuals collected) and percent occurrence (# sites present/total # sites sampled) of each fish species sampled in streams and oxbows in the BRW during 2016-2017, sorted from most to least abundant. Common and scientific names of Iowa Species of Greatest Conservation Need are in bold.

Species	Scientific Name	Abundance	% occurrence
Common shiner	*Luxilus cornutus*	33784	89.47
Fathead minnow	*Pimephales promelas*	33169	53.68
Black bullhead	*Ameiurus melas*	13654	47.37
Orangespotted sunfish	*Lepomis humilis*	9089	54.74
Green sunfish	*Lepomis cyanellus*	8282	84.21
Creek chub	*Semotilus atromaculatus*	6747	87.37
Brook stickleback	*Eucalia inconstans*	5248	30.53
Bluntnose minnow	*Pimephales notatus*	4299	81.05
White sucker	*Catostomus commersoni*	4021	84.21
Blacknose dace	*Rhinichthyes atratulus*	3490	56.84
Sand shiner	*Notropis stramineus*	2807	67.37
Central stoneroller	*Campostoma anomalum*	2585	71.58
Bigmouth shiner	*Notropis dorsalis*	2580	68.42
Hornyhead chub	***Nocomis biguttatus***	2287	69.47
Common carp	*Cyprinus carpio*	2236	22.11
Topeka shiner	***Notropis topeka***	2010	33.68
Johnny darter	*Etheostoma nigrum*	1891	71.58
Golden shiner	***Notemigonus crysoleucus***	1201	7.37
Rosyface shiner	*Notropis rubellus*	1057	52.63
Golden redhorse	*Moxostoma erythurum*	784	44.21
Brassy minnow	*Hybognathus hankinsoni*	692	25.26
Bluegill	*Lepomis macrochirus*	613	32.63
Spotfin shiner	*Cyprinella spiloptera*	570	35.79
Largemouth bass	*Micropterus salmoides*	397	22.11
Northern rock bass	***Ambloplites rupestris***	358	50.53
Smallmouth bass	*Micropterus dolomieu*	338	30.53
Northern hogsucker	*Hypentelium nigricans*	226	30.53
Banded darter	***Etheostoma zonale***	181	29.47
Fantail darter	*Etheostoma flabellare*	129	17.89
Stonecat	*Noturus flavus*	125	22.11
Channel catfish	*Ictalurus punctatus*	114	18.95

White crappie	*Pomoxis annularis*	109	3.16
Blackside darter	***Percina maculata***	97	27.37
Shorthead redhorse	*Moxostoma macrolepidotum*	86	15.79
Yellow bullhead	*Ameiurus natalis*	80	31.58
Suckermouth minnow	***Phenacobius mirabilis***	73	21.05
Black crappie	*Pomoxis nigromaculatus*	70	6.32
Tadpole madtom	***Noturus gyrinus***	62	17.89
Quillback carpsucker	*Carpiodes cyprinus*	61	12.63
Hybrid sunfish	*Lepomis spp.*	59	11.58
Gizzard shad	*Dorosoma cepedianum*	57	8.42
Highfin carpsucker	*Carpiodes velifer*	56	5.26
River carpsucker	*Carpiodes carpio*	35	8.42
Emerald shiner	*Notropis atherinoides*	24	1.05
Northern pike	***Esox lucius***	15	7.37
Slenderhead darter	***Percina phoxocephala***	11	4.21
Bigmouth buffalo	*Ictiobus cyprinellus*	8	2.11
Silver redhorse	***Moxostoma anisurum***	5	3.16
Yellow perch	*Perca flavescens*	3	2.11
Bullhead minnow	*Pimephales vigilax*	3	1.05
Freshwater drum	*Aplodinotus grunniens*	3	2.11
Slender madtom	***Noturus exilis***	2	2.11
Speckled chub	*Macrhybopsis aestivalis*	2	1.05
Walleye	*Sander vitreus*	1	1.05
Silver chub	*Macrhybopsis storeriana*	1	1.05

Table 3. Definitions of habitat and fish community variables measured.

Variable (All-site types)	Definition
Temperature	Temperature reading measured once at each site
Conductivity	Conductivity reading measured once at each site
pH	pH reading measured once at each site
DO	Dissolved oxygen reading measured once at each site
Turbidity	Turbidity reading measured once at each site
Avg Transect Width	Wetted width (m) at each transect averaged per site
Avg Thalweg Depth	Thalweg depth at each transect/minitransect averaged per site
Min depth	Minimum depth measured at a site
Max depth	Maximum depth measured at a site
Filamentous	Filamentous algae long enough for fish cover; transect estimates averaged
Macrophytes	Submerged macrophytes providing fish cover; transect estimates averaged
Woody debris	Woody debris (>0.3m diam.) in the water; transect estimates averaged
Small brush	Woody debris (<0.3m diam.) in the water; transect estimates averaged
Trees/roots	Tree branches or roots in water; transect estimates averaged
Overhanging banks	Cliff-like eroded banks ; transect estimates averaged
Undercut banks	Banks that extend out over water near surface; transect estimates averaged
Boulders	Rocks larger than a basketball; transect estimates averaged
Artificial structure	Non-natural structure (tire, barrel); transect estimates averaged
Bank Angle	Average of all bank angles at a site
Bare Bank	Average of all bare bank percentage estimates at a site
Canopy Cover	Percentage of site with canopy cover based on densitometer readings at each transect
Woody riparian veg.	Density of woody riparian vegetation around transects averaged per site
Non-woody riparian veg.	Density of non-woody riparian vegetation around transects averaged per site
Bare riparian ground	Density of bare ground around transects averaged per site
% bedrock	Percentage of bedrock substrate records per site
% rip rap	Percentage of rip rap substrate records per site
% boulder	Percentage of boulder substrate records per site
% cobble	Percentage of cobble substrate records per site
% gravel	Percentage of gravel substrate records per site
% sand	Percentage of sand substrate records per site
% silt	Percentage of silt substrate records per site

%clay	Percentage of clay substrate records per site
% muck	Percentage of muck substrate records per site
CPUE of each species	CPUE for each of 55 species collected in the BRW
Sunfish CPUE	Combined CPUE of Green and Orangespotted sunfish (nest associates of Topeka shiner)
Predator CPUE	Combined CPUE of potential predators of Topeka shiner
SGCN CPUE	Combined CPUE of all SGCNs sampled per site
Total CPUE	Combined CPUE of all individuals present per site
Species Richness	Total number of fish species present at a site
SGCN Richness	Total number of SGCN species present at a site
Stream-specific variables	
Flow	Average flow velocity reading per site (m/sec)
% pool	Percentage of pool macrohabitat records per site
% riffle	Percentage of riffle macrohabitat records per site
% run	Percentage of run macrohabitat records per site
% soft/small present	Percentage of soft/small sediment present per site
Watershed Area	Area that drains to a site
FIBI	Fish Index of Biotic Integrity
Native Species Richness	Total number of native species present at a site
Sucker Species	Total number of sucker species present at a site
Sensitice Species	Total number of sensitive species present at a site
Benthic Invertivore	Total number of benthic invertivore species present at a site
Top 3 Abundance %	Proportion of the top 3 most abundant species to the total catch at a site
Benthic Invertivore %	Proportion of benthic invertivore species at a site
Omnivore %	Proportion of omnivorous species at a site
Top Carnivore %	Proportion of top carnivores at a site
Lithophilous spawner %	Proportion of lithophilous spawner species at a site
Tolerance Index	Tolerance value assigned to the fish community at a site as calculated by BioNet
Adjusted CPUE	CPUE adjusted for only length of a site
DELT % Adjustment	Adjustment of FIBI as a result of DELTs
Oxbow-specific variables	
Restored or Unrestored	Restored oxbow or unrestored, natural oxbow
Distance to stream	Shortest distance to stream (oxbows only)
Age	Years post restoration (0 for unrestored oxbows)
Length	Wetted length of the oxbow

Table 4. Collections of Topeka shiners over time in HUC10 watersheds of the Boone River Watershed. Historic data (collections prior to 1997) come from Loan-Wilsey et al. (2005), 1997-2000 data come from Clark (2000), 2010-2011 data come from Bakevich (2013), and 2016-2017 data are from the present study. Status is determined based on presence of the species through the four time periods. Topeka shiner populations in HUC10s are considered “stable” if collected in all study periods. Populations are considered “possibly stable” if collected in all but one time period. Populations are considered “possibly recovering” if historically present but not collected again until the present 2016-2017 study. Populations are considered “at risk” if not collected in the two most recent studies. Populations are considered “possibly extirpated” if not collected since historic records.

		Topeka Shiners Collected				
HUC10	HUC8	Historic	1997-2000	2010-2011	2016-17	Status
Eagle Creek	Boone	Yes	Yes	Yes	Yes	Stable
Headwaters Boone River	Boone	Yes	No	No	Yes	Possibly Recovering
Lower Boone River	Boone	Yes	Yes	No	No	At Risk
Middle Boone River	Boone	Yes	Yes	No	Yes	Possibly Stable
Otter Creek	Boone	Yes	No	No	Yes	Possibly Recovering
Prairie Creek	Boone	Yes	Yes	No	Yes	Possibly Stable
White Fox Creek	Boone	Yes	No	No	No	Possibly Extirpated

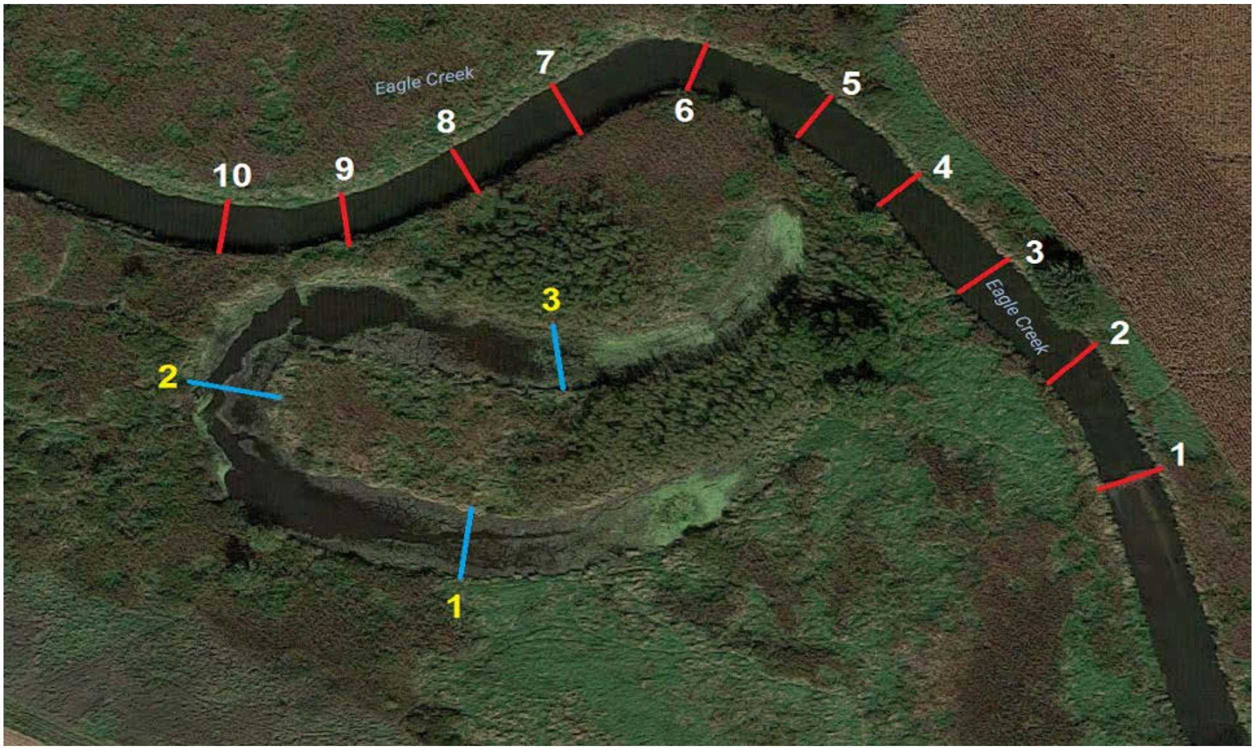


Figure 1A. Example of site layouts and transect positions of stream sites (red lines) and oxbow sites (blue lines).

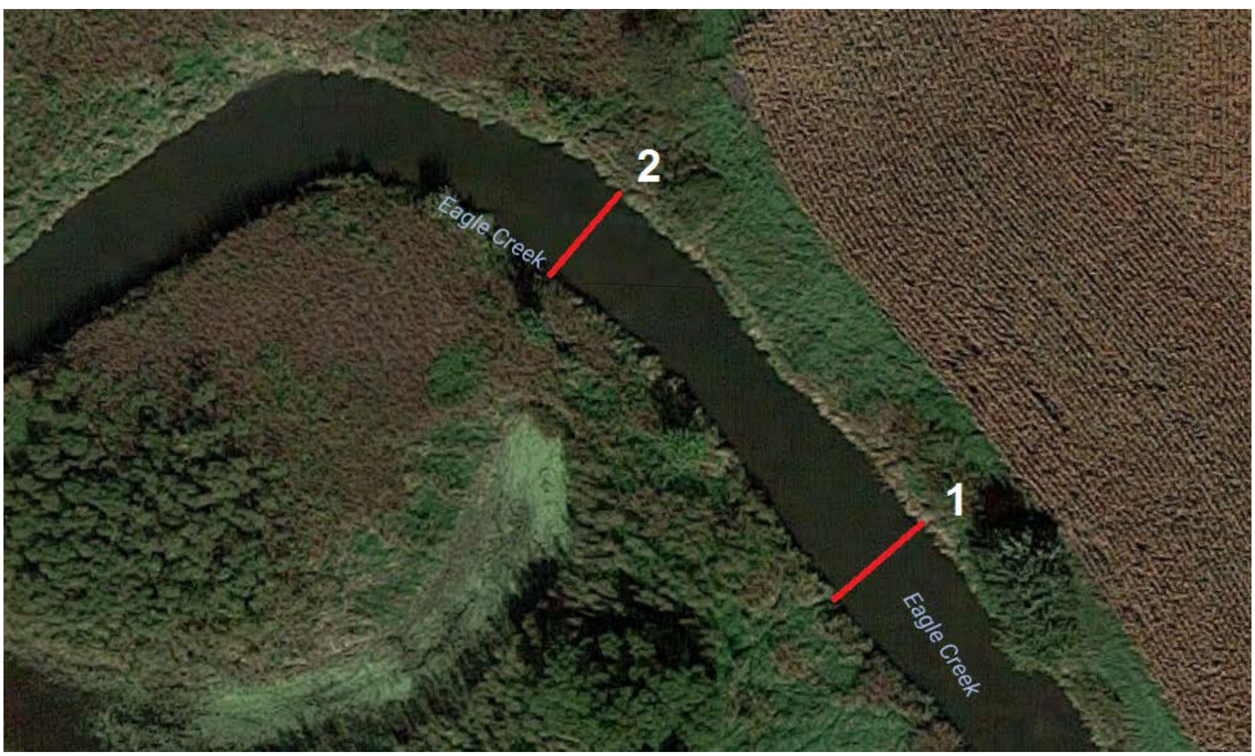


Figure 1B. Width measurements (m) were taken at each transect (red line).

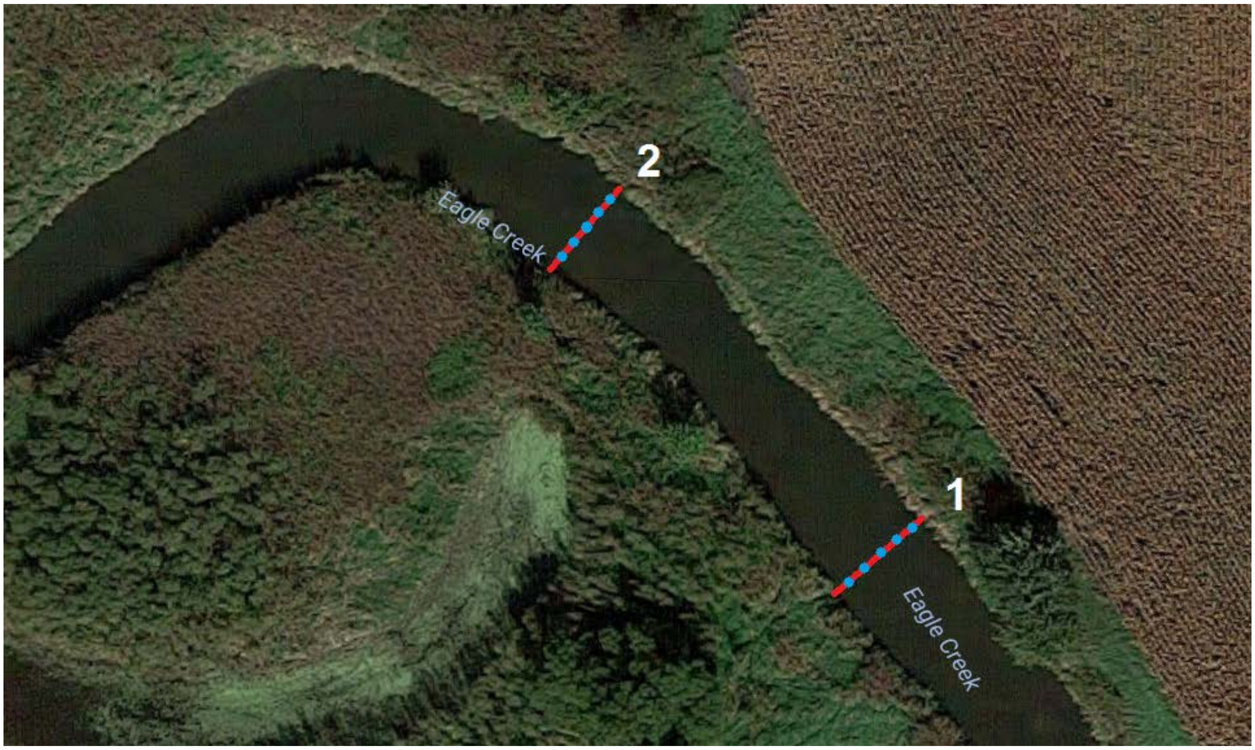


Figure 1C. Depth (m), velocity (m/sec), and substrate type were recorded at each blue dot.

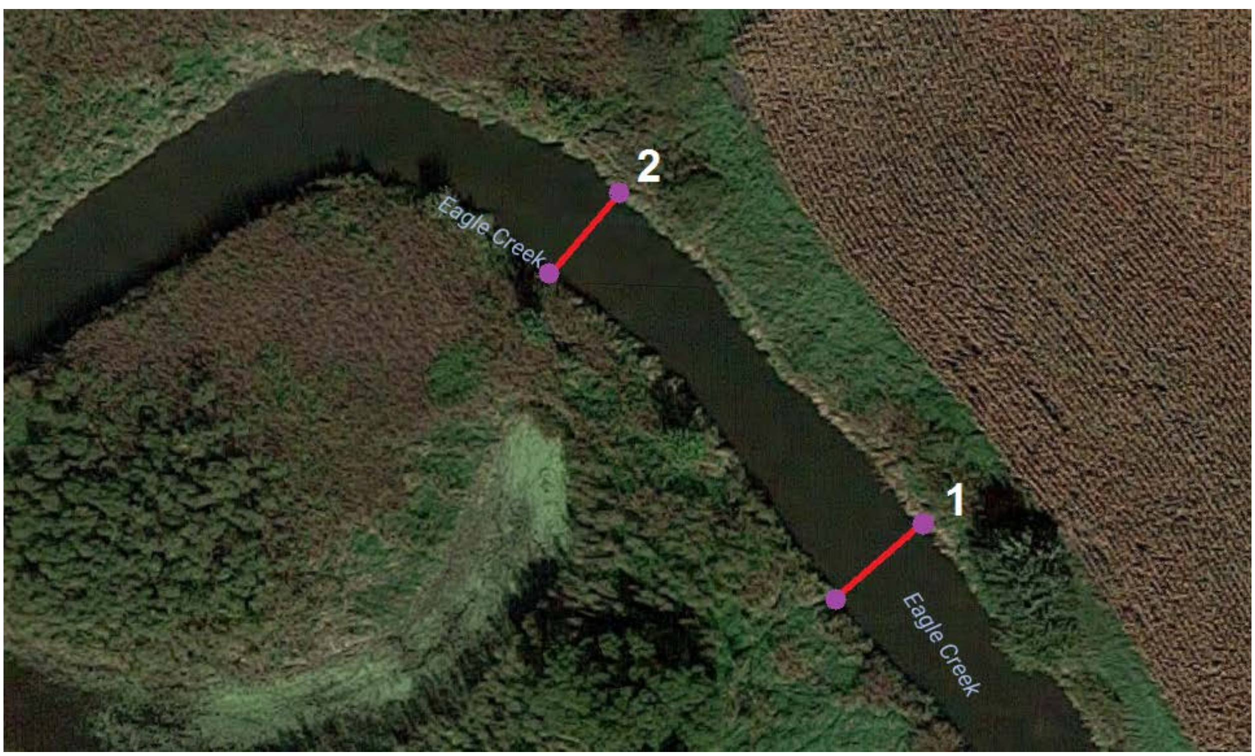


Figure 1D. Bank angle (°) and estimated bare bank (%) were recorded at each purple dot.

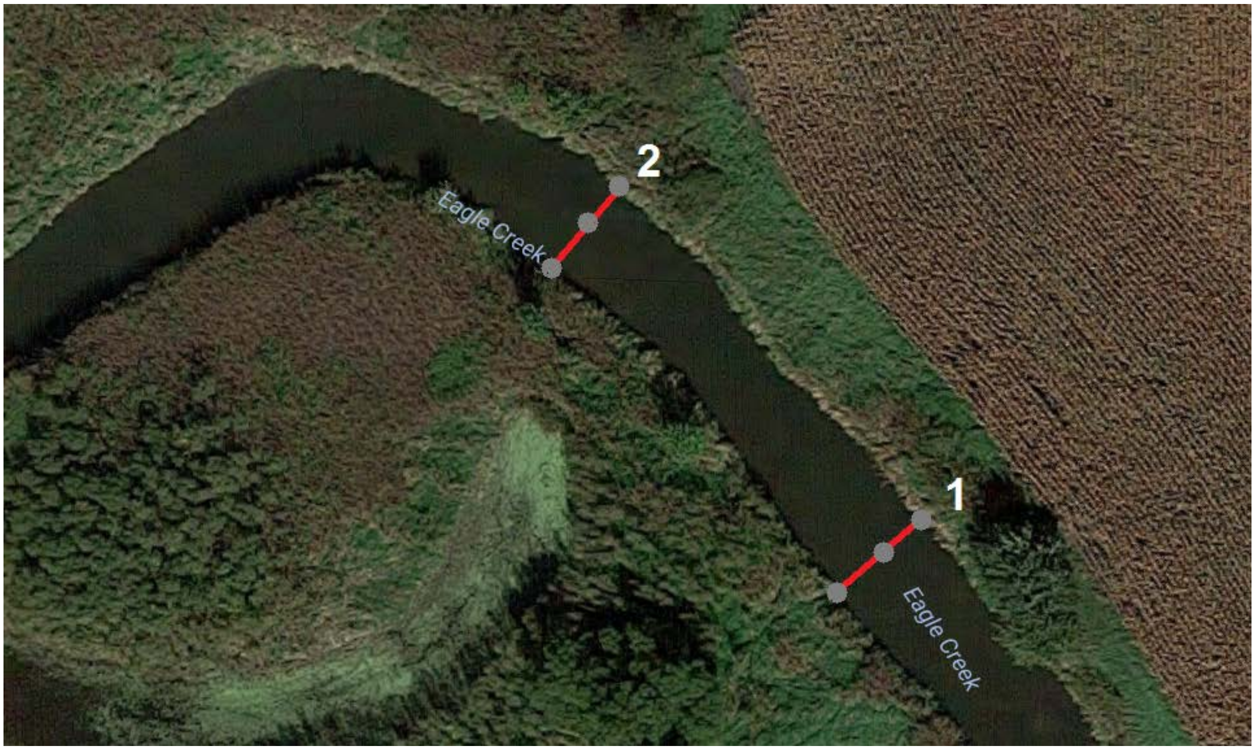


Figure 1E. Canopy Cover was measured at each grey dot.

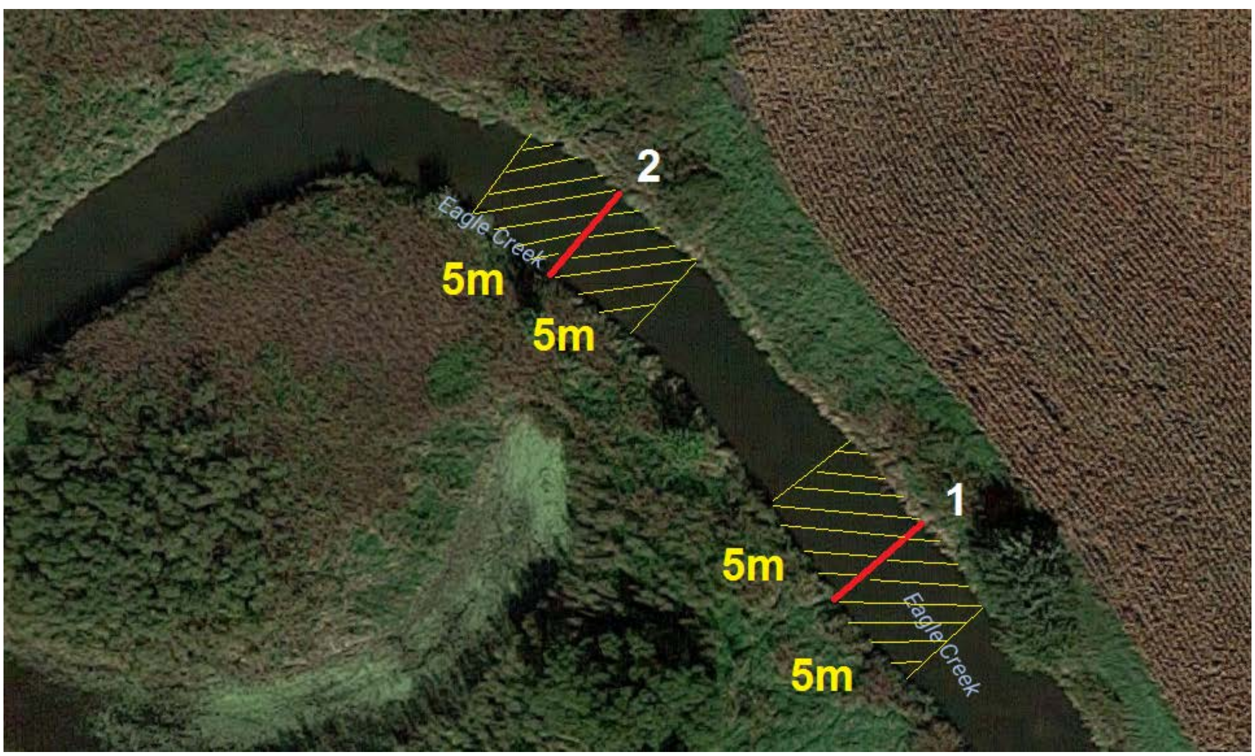


Figure 1F. Fish cover type and estimated densities were recorded at each transect (yellow area).

Figure 1G. Macrohabitat type, thalweg depth, and presence of soft/small sediment were recorded at each mini-transect line (pink dashed line) and each transect line (red line).

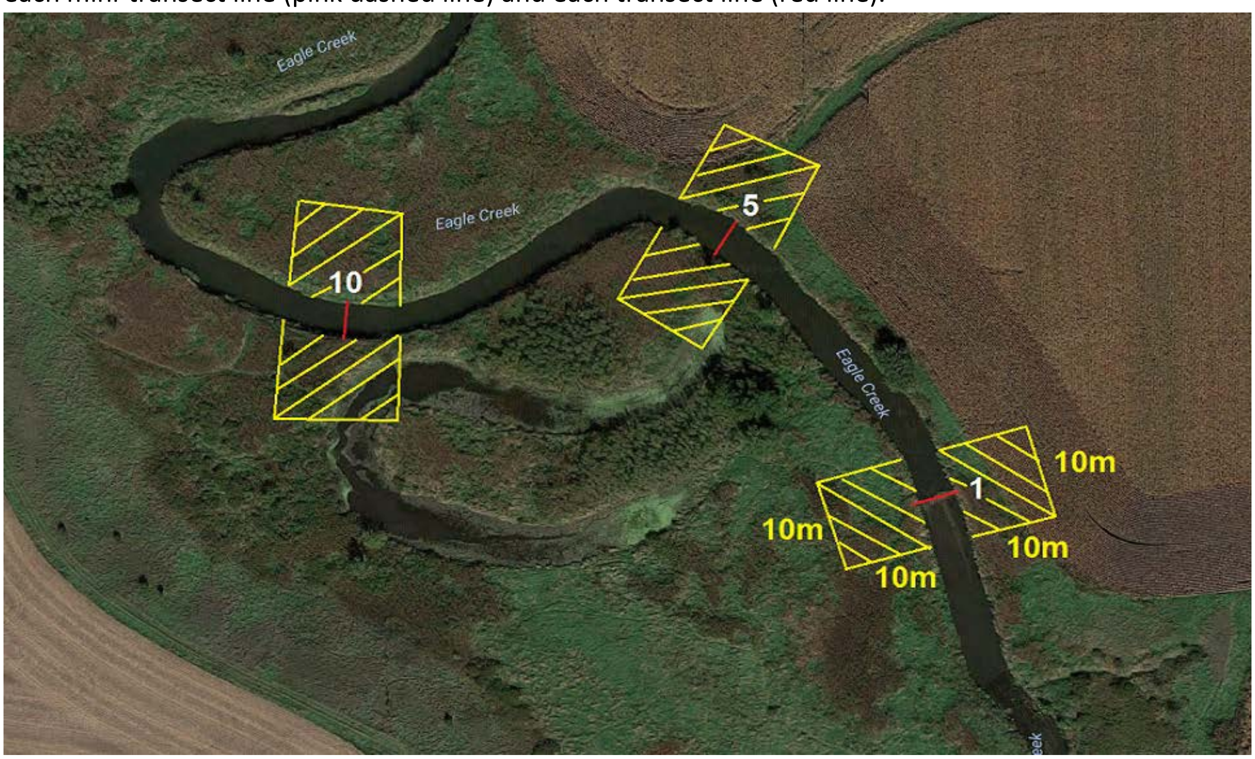


Figure 1H. Riparian vegetation type and estimated densities were recorded at the canopy (>5m), understory (0.5-5m), and ground cover (<0.5m) levels at transects 1, 5, and 10 for stream sites in the yellow areas.

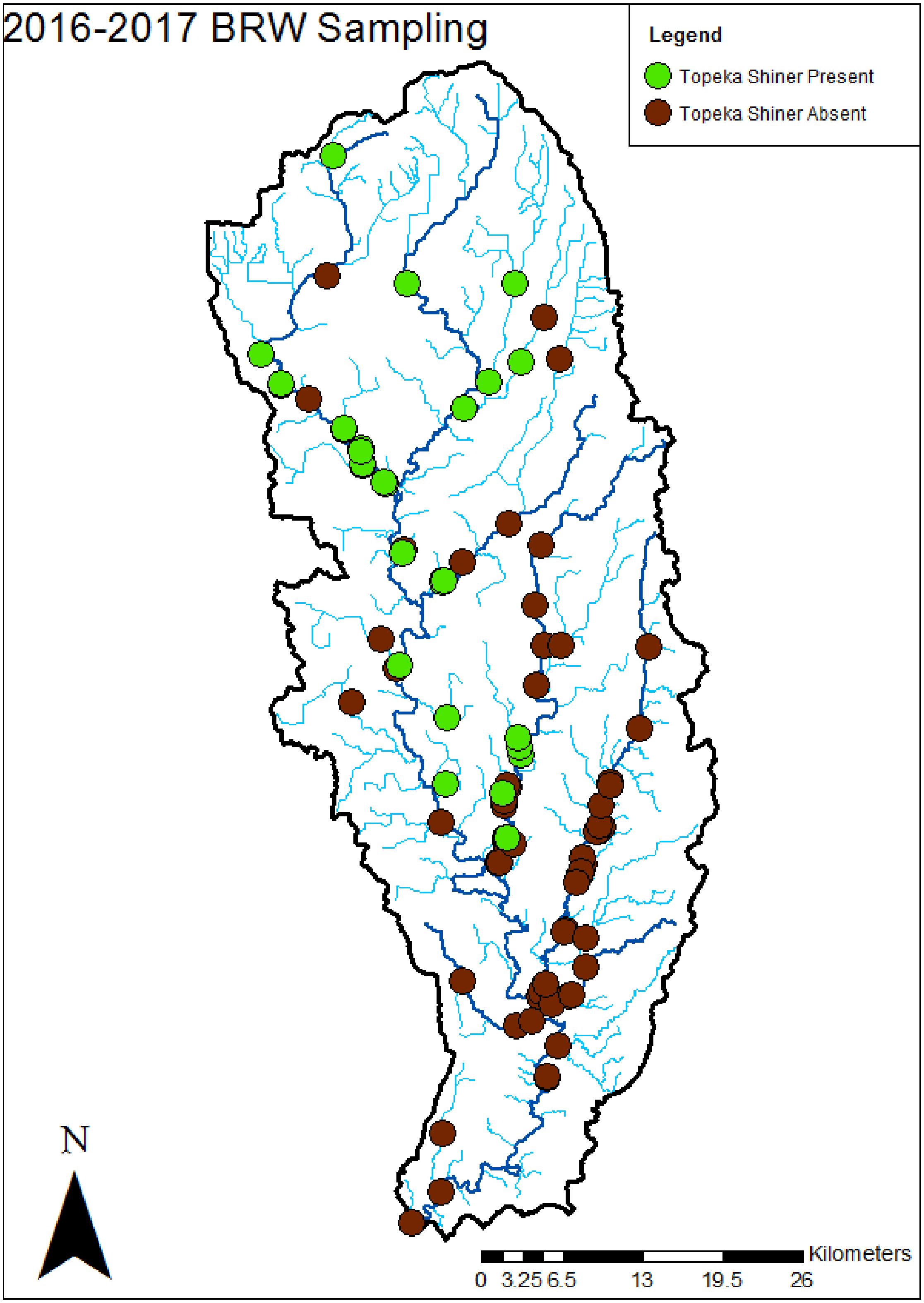


Figure 2. 2016-2017 stream and oxbow sampling sites in the BRW showing Topeka shiner presence (green) and absence (brown).

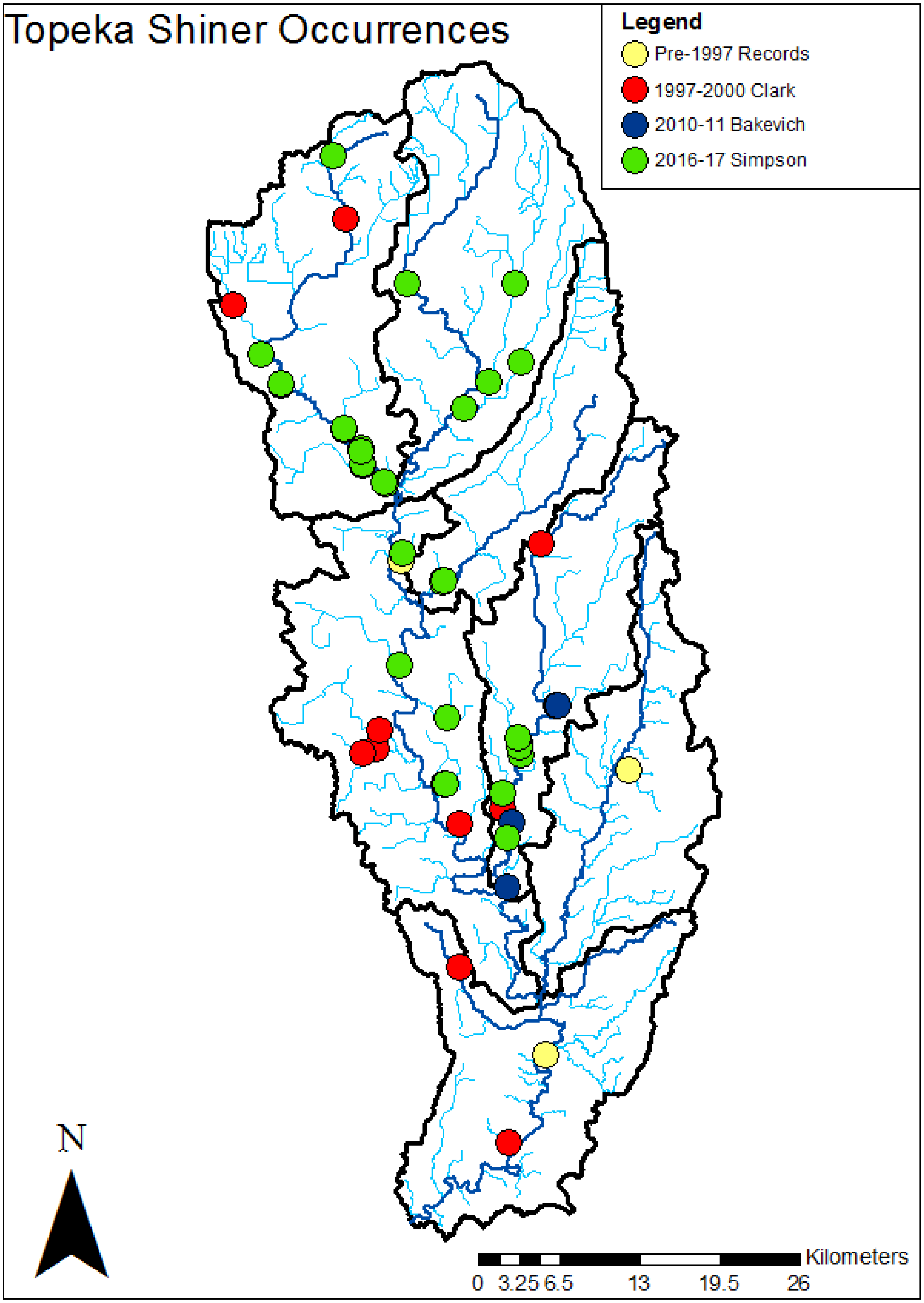


Figure 3. All published Topeka shiner occurrences in the Boone River Watershed from prior to 1997 (Loan-Wilsey et al. 2005; Yellow), 1997-2000 (Menzel and Clark 2002; Red), 2010-2011 (Bakevich et al. 2015; Blue), and from 2016-2017 (Simpson et al.; Green).

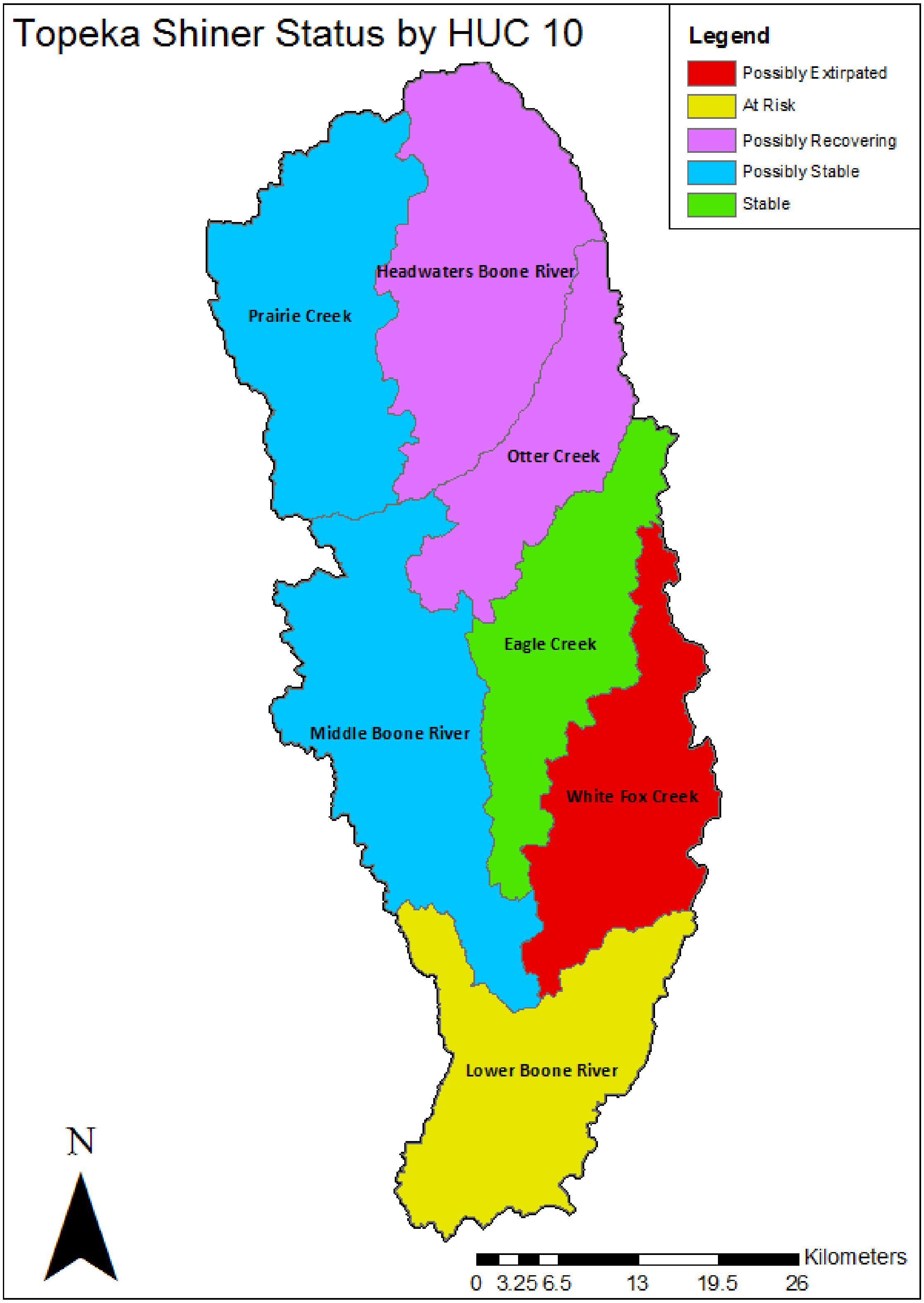


Figure 4. Potential status of Topeka shiners in the BRW in each HUC10 based on presence or absence over time as seen in Table 4. Categories shown in legend are described in Table 4.

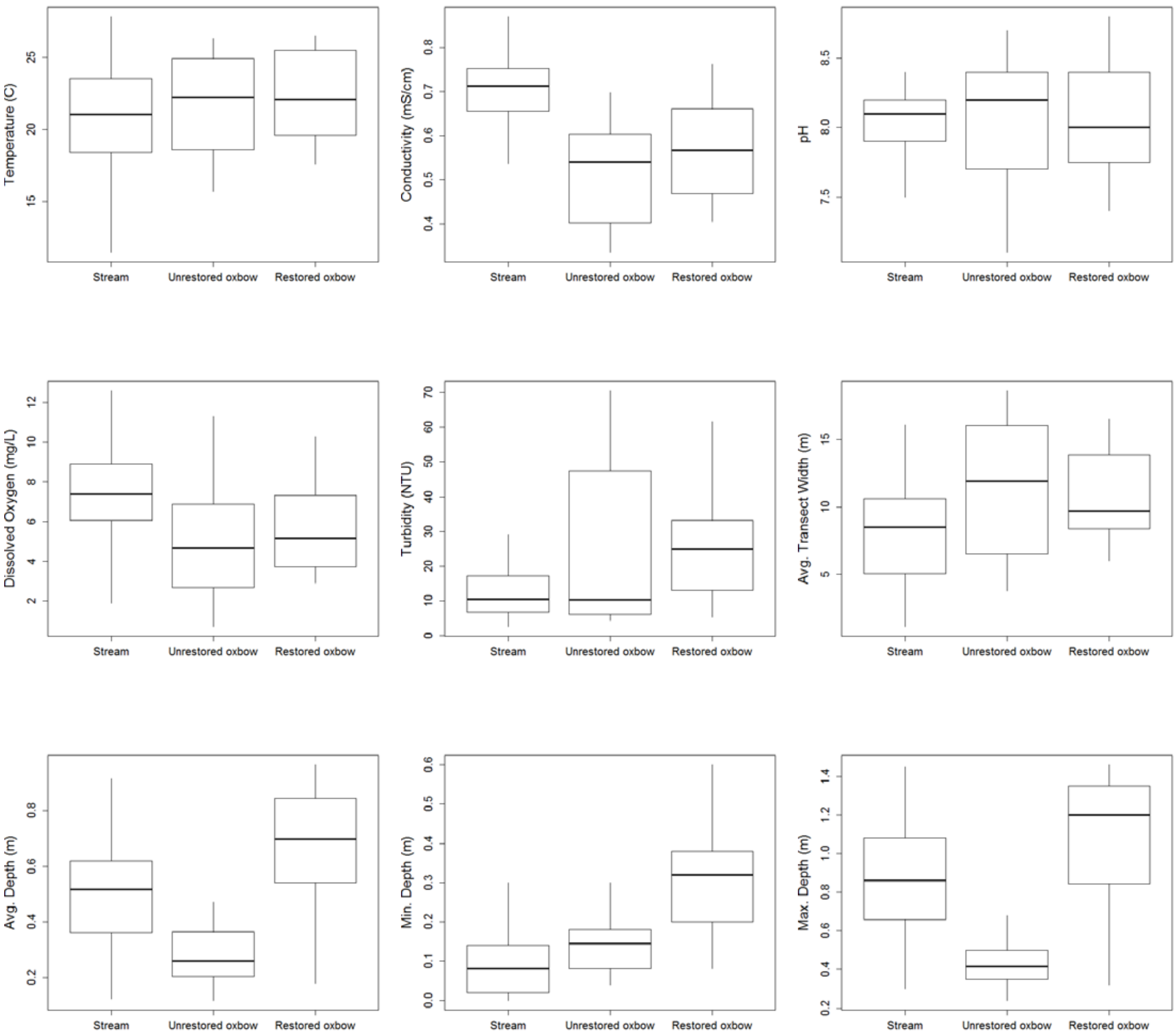
Appendix 1– Relationship of this project to Nick Simpson's thesis project

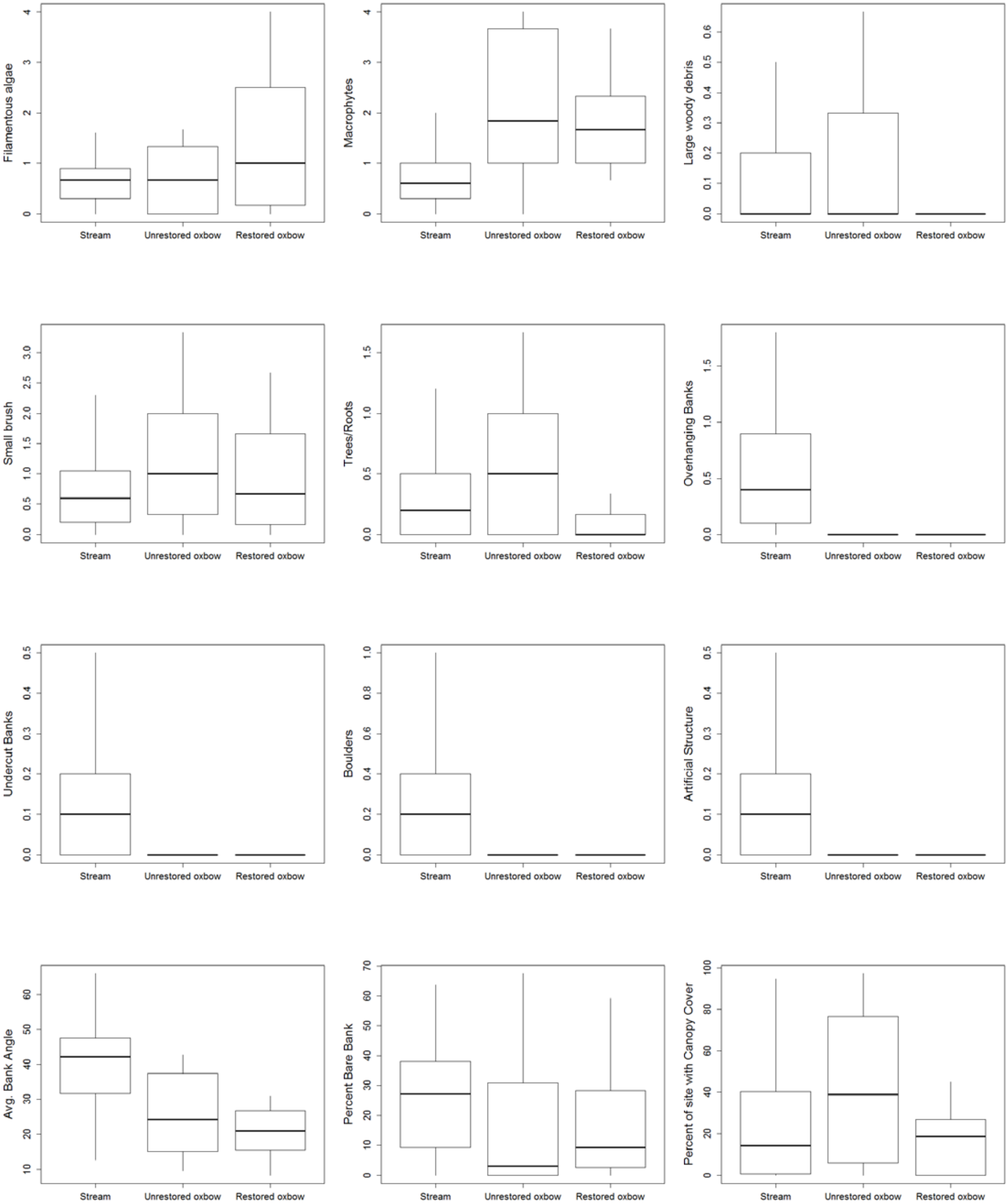
Nick Simpson will use data collected under this project from the Boone River Watershed as well as similar data from the North Raccoon River, Rock River, and Big Sioux River Watersheds from a concurrent stream fish project at Iowa State University in his thesis analysis. Nick's thesis addresses the following objectives:

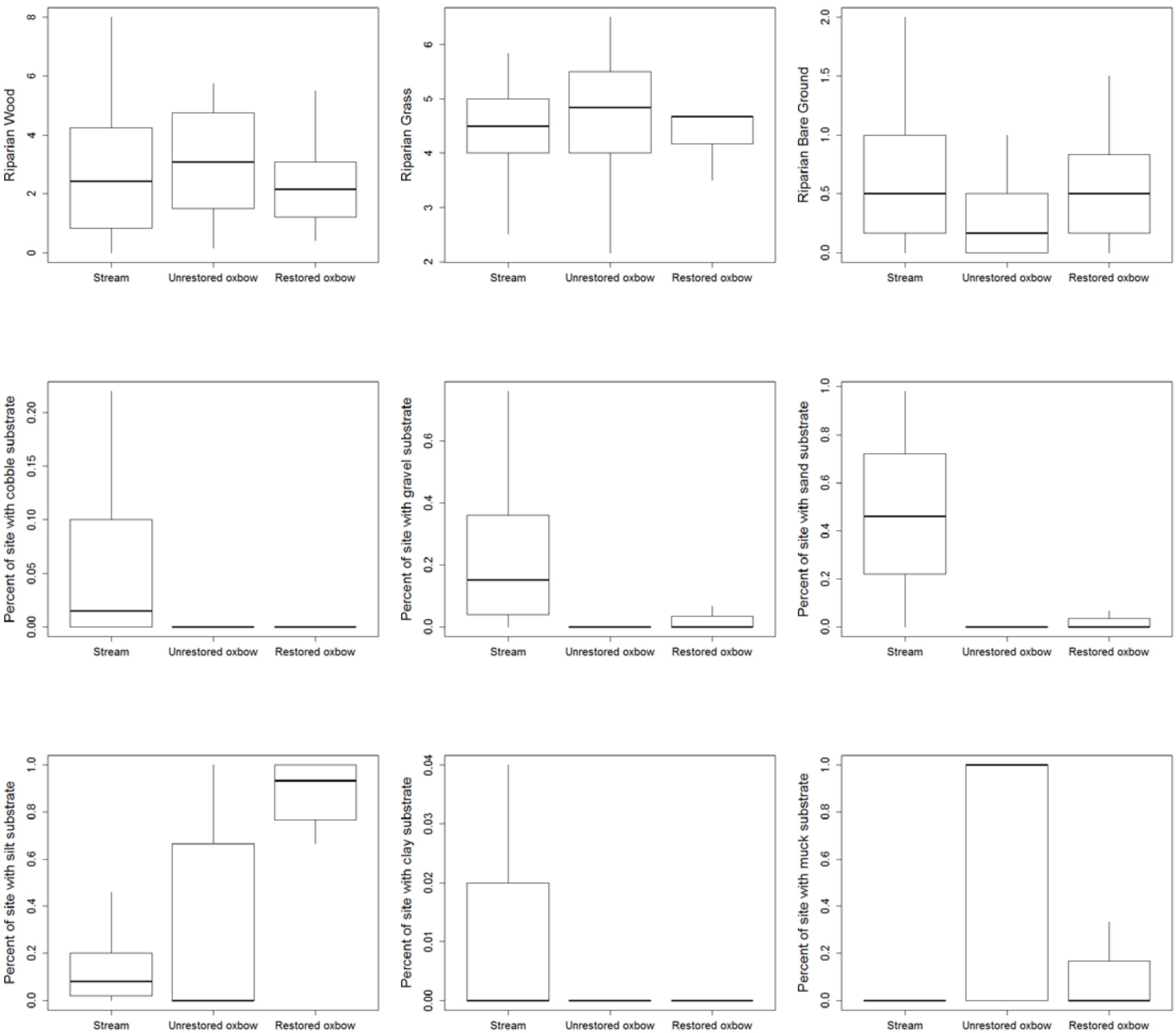
1. Assess the presence and abundance of Topeka shiners in streams and associated oxbows in the Boone River, North Raccoon River, Rock River, and Big Sioux River Watersheds.
2. Evaluate biotic and abiotic characteristics of oxbows and streams and their association with the presence of Iowa's stream fish Species of Greatest Conservation Need.
3. Assess oxbow restorations and how restored oxbows can differ from natural oxbows in habitat characteristics and fish assemblages.

By addressing these broader objectives, we aim to contribute the best possible information to BRW stakeholders to help inform their decisions. For the purposes of this annual report, only the results obtained from BRW in 2016-2017 was included.

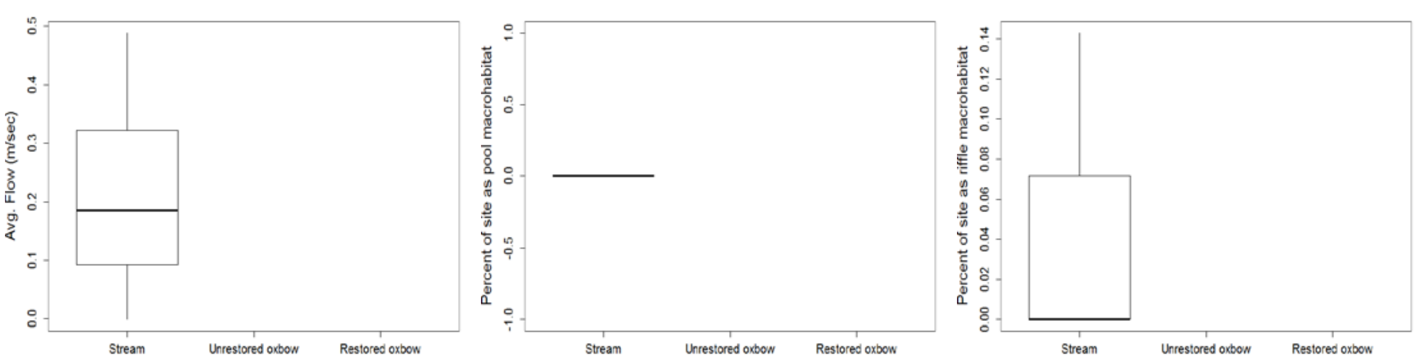
Appendix 2. Box plot distributions of habitat variables in streams, unrestored oxbows, and restored oxbows in the Boone River Watershed in north central Iowa, USA. Bold horizontal lines in boxes indicates the median, the box represents the interquartile range (IQR), and "whiskers" on either end of the box represent the smaller value between the most extreme value or 1.5*IQR. Values greater or smaller than 1.5*IQR are considered outliers and are not shown for clarity.

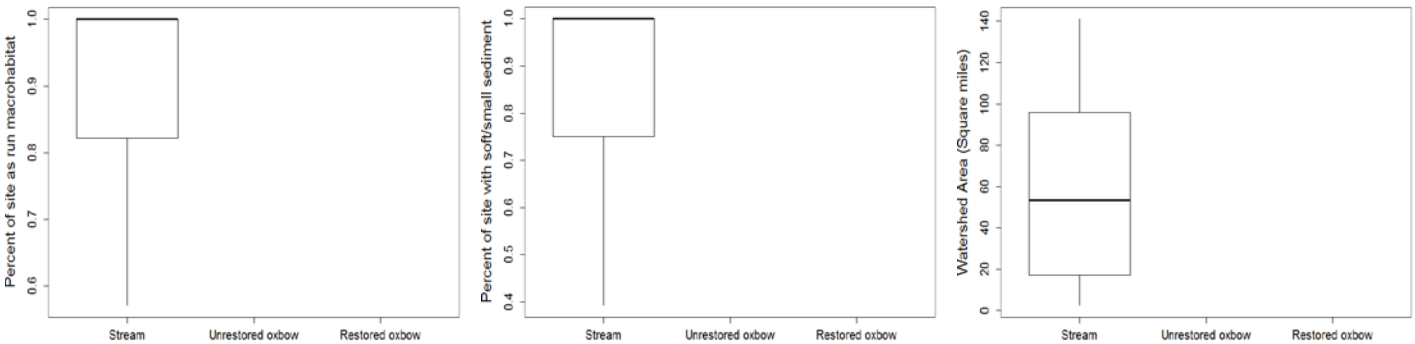



Filamentous algae
Macrophytes
Large woody debris
Small brush
Trees/Roots
Overhanging Banks
Undercut Banks
Boulders
Artificial Structure
Avg. Bank Angle
Percent Bare Bank
Percent of site with Canopy Cover
Stream
Unrestored oxbow
Restored oxbow

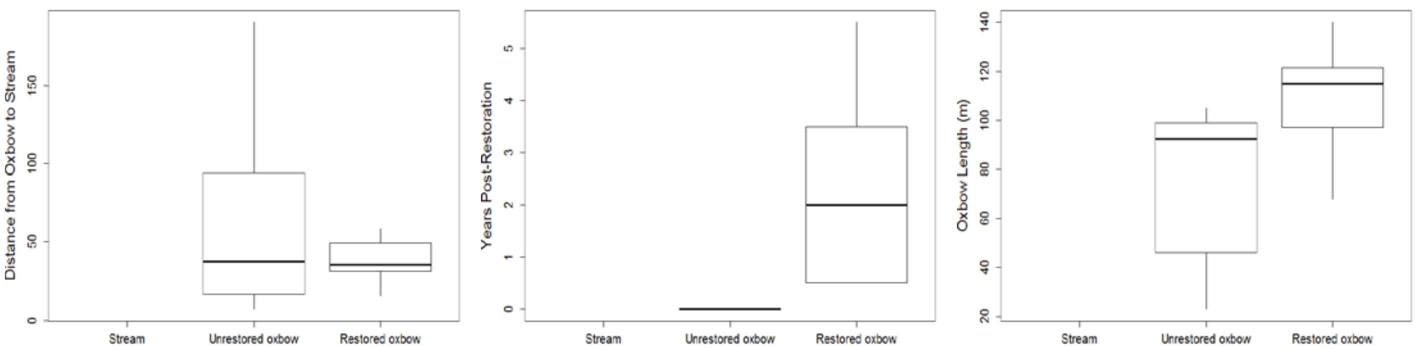


Stream-specific Variables

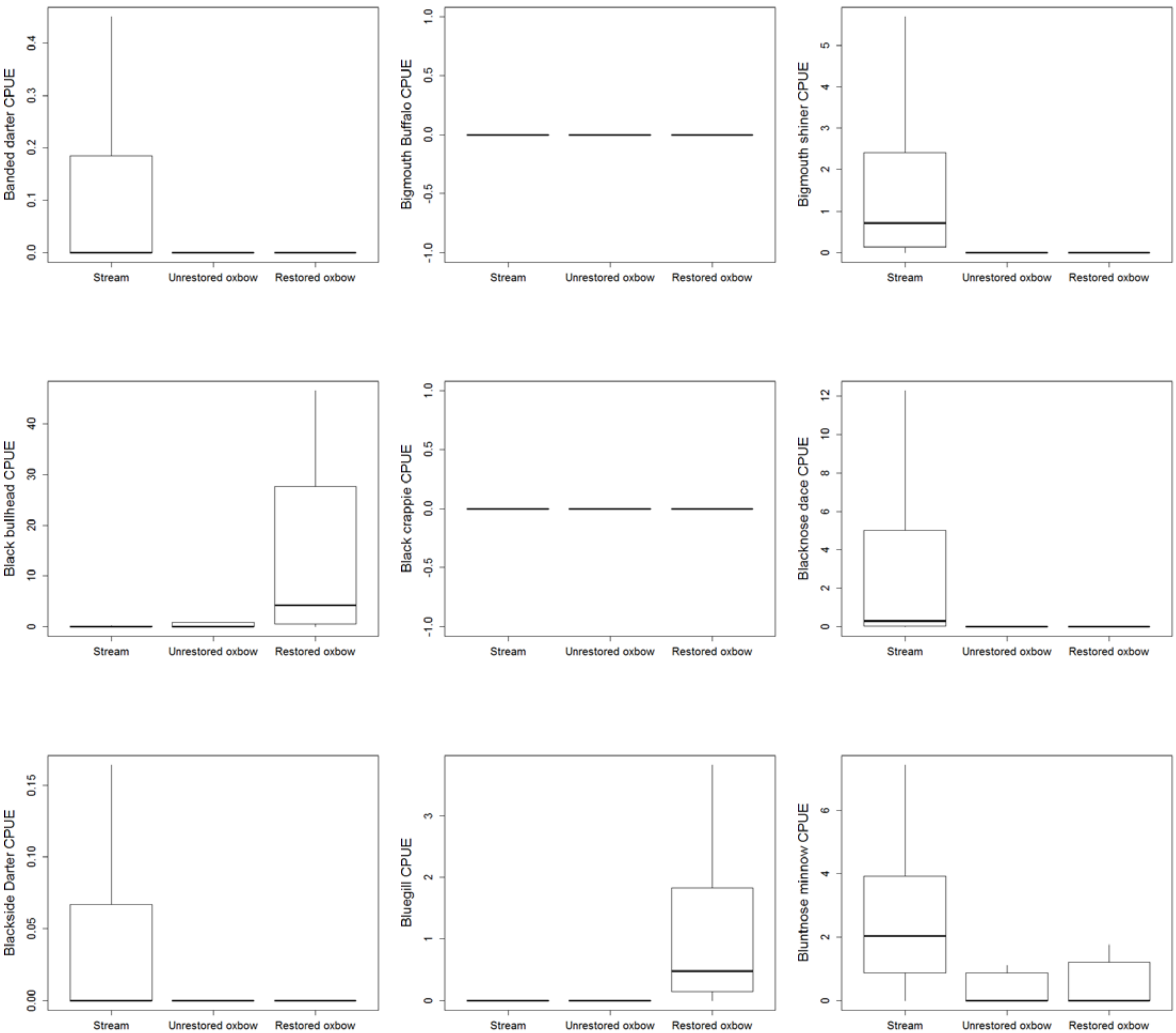


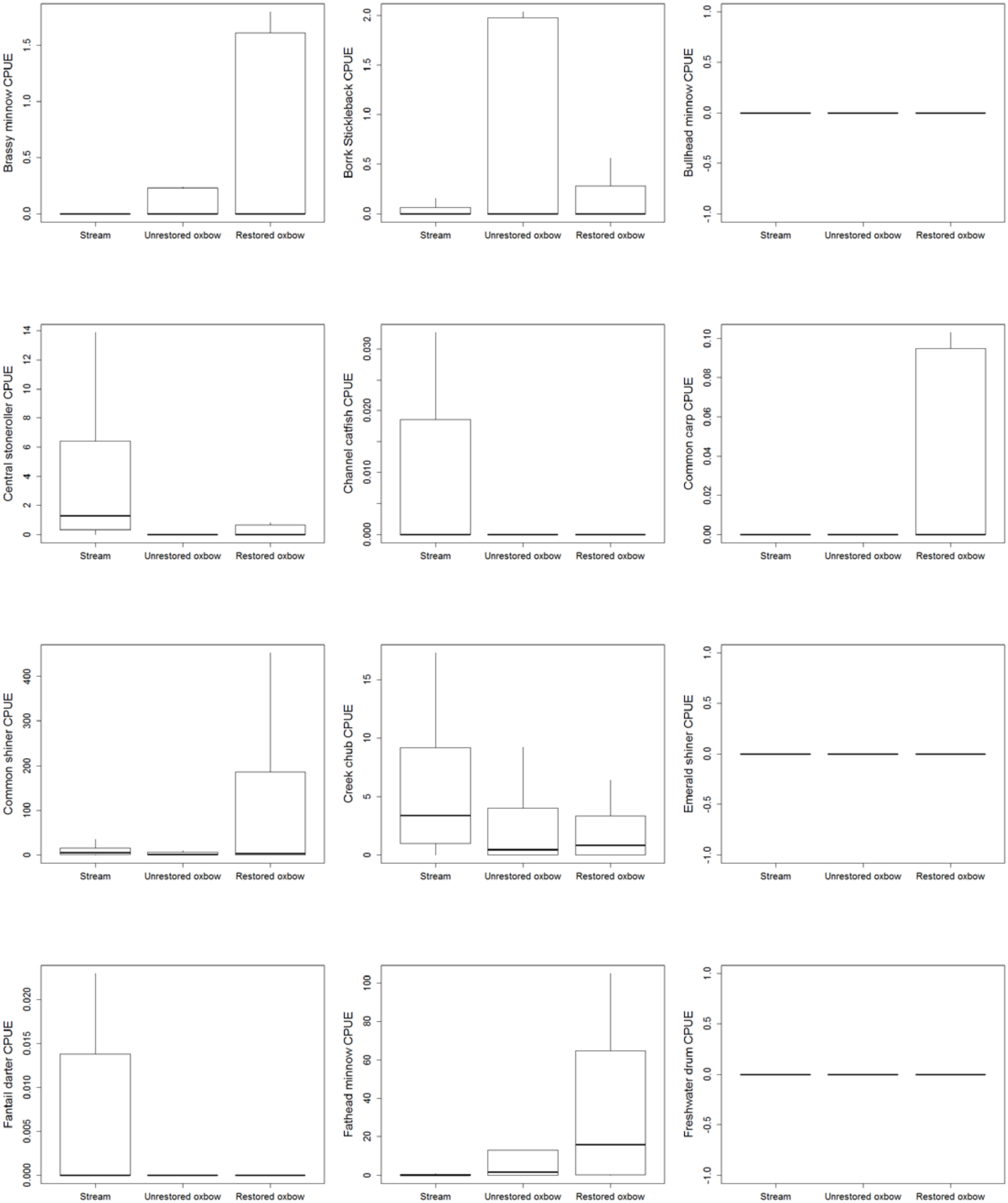


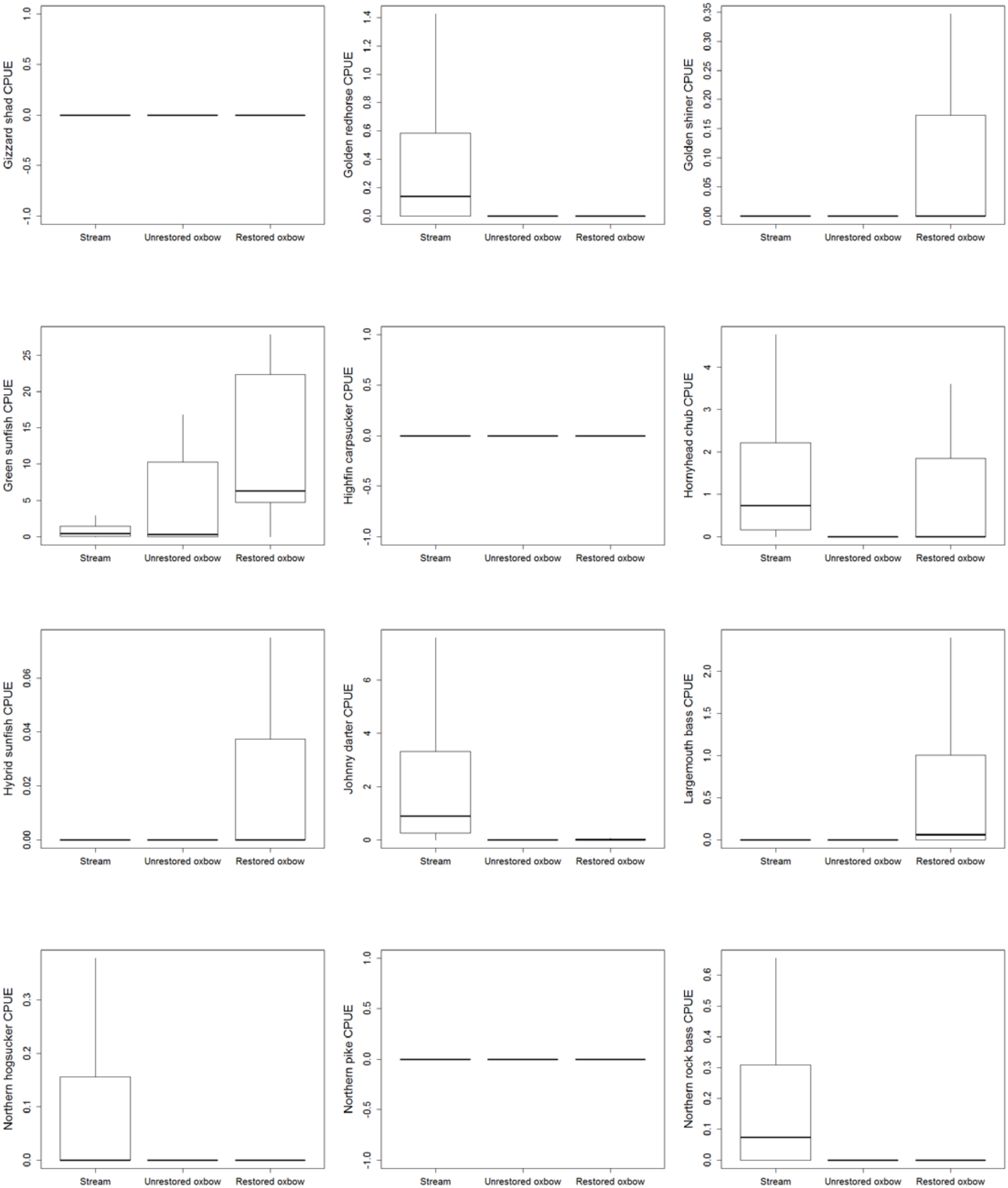
Oxbow-specific Variables

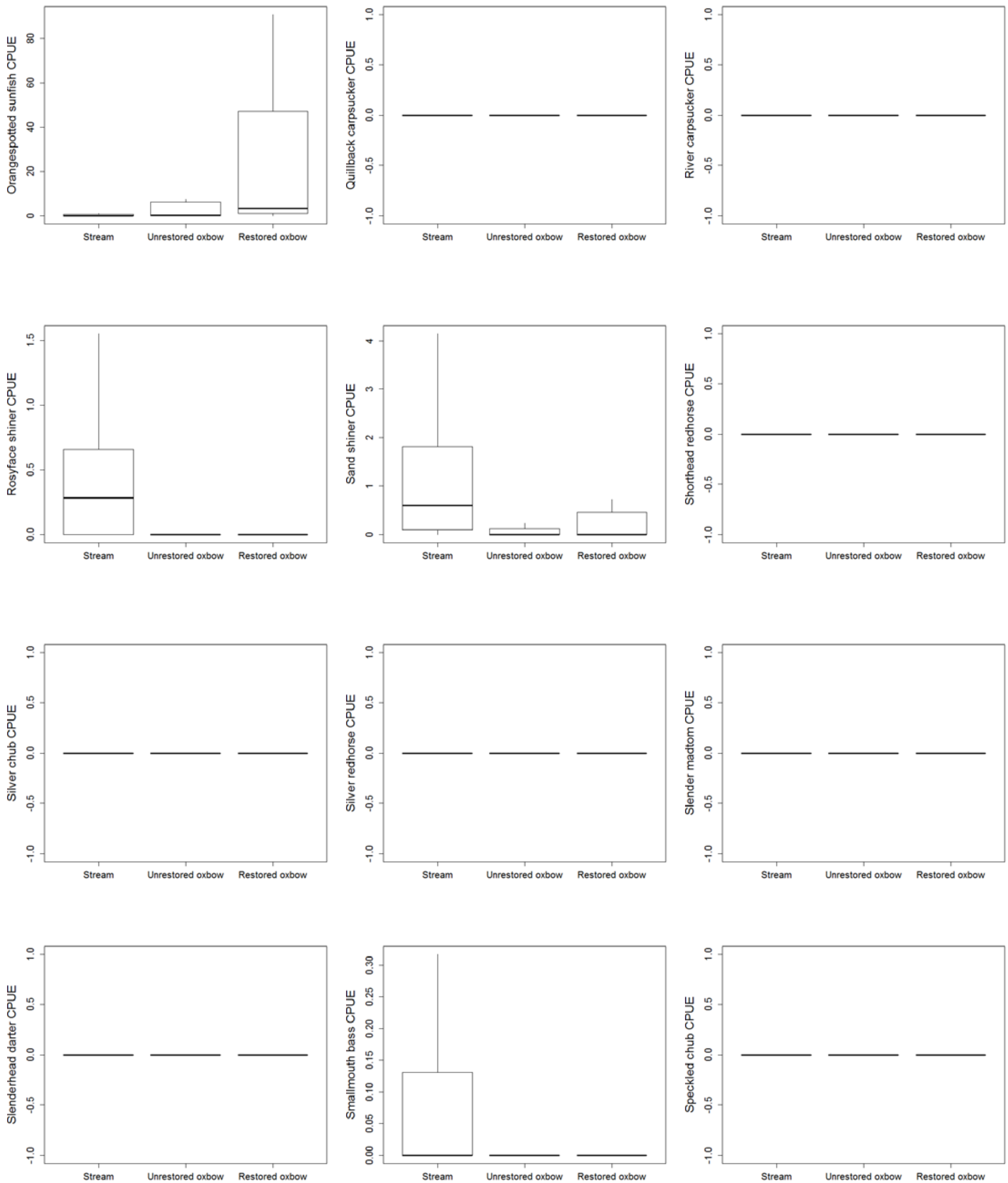


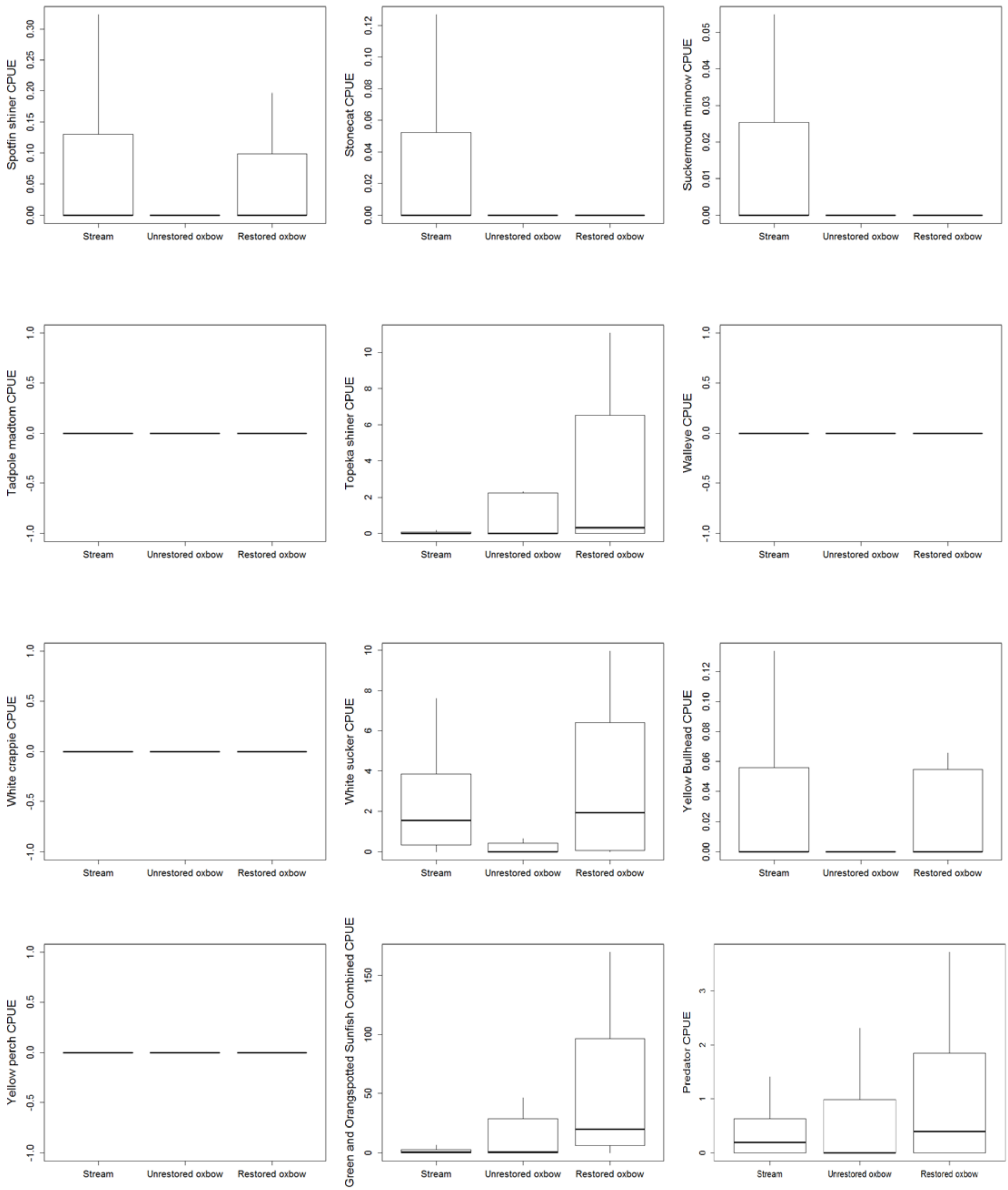
Appendix 3. Box plot distributions of fish variables in streams, unrestored oxbows, and restored oxbows in the Boone River Watershed in north central Iowa, USA. Relative abundances shown were calculated as # fish sampled per 100m^2 of sampled area. Stream CPUEs reflect combined electrofishing and seining per site, while oxbow CPUEs reflect only the first seine pass made in each oxbow. Bold horizontal lines in boxes indicates the median, the box represents the interquartile range (IQR), and “whiskers” on either end of the box represent the smaller value between the most extreme value or 1.5*IQR. Values greater or smaller than 1.5*IQR are considered outliers and are not shown for clarity.



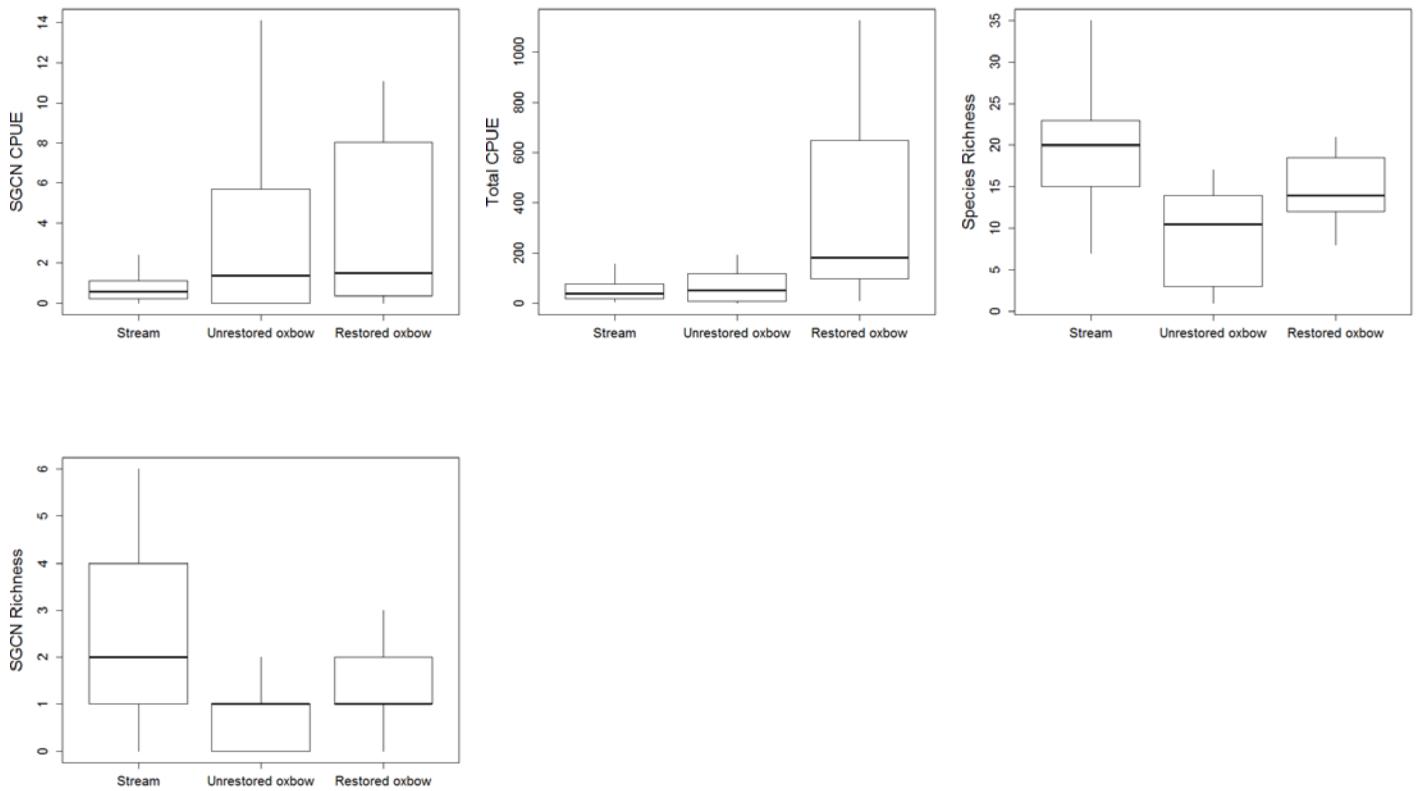

Brassy minnow CPUE
Borrk Stickleback CPUE
Bullhead minnow CPUE
Central stoneroller CPUE
Channel catfish CPUE
Common carp CPUE
Common shiner CPUE
Creek chub CPUE
Emerald shiner CPUE
Fantail darter CPUE
Fathead minnow CPUE
Freshwater drum CPUE
Stream
Unrestored oxbow
Restored oxbow


Gizzard shad CPUE
Golden redhorse CPUE
Golden shiner CPUE
Green sunfish CPUE
Highfin carpsucker CPUE
Hornyhead chub CPUE
Hybrid sunfish CPUE
Johnny darter CPUE
Largemouth bass CPUE
Northern hogsucker CPUE
Northern pike CPUE
Northern rock bass CPUE
Stream
Unrestored oxbow
Restored oxbow

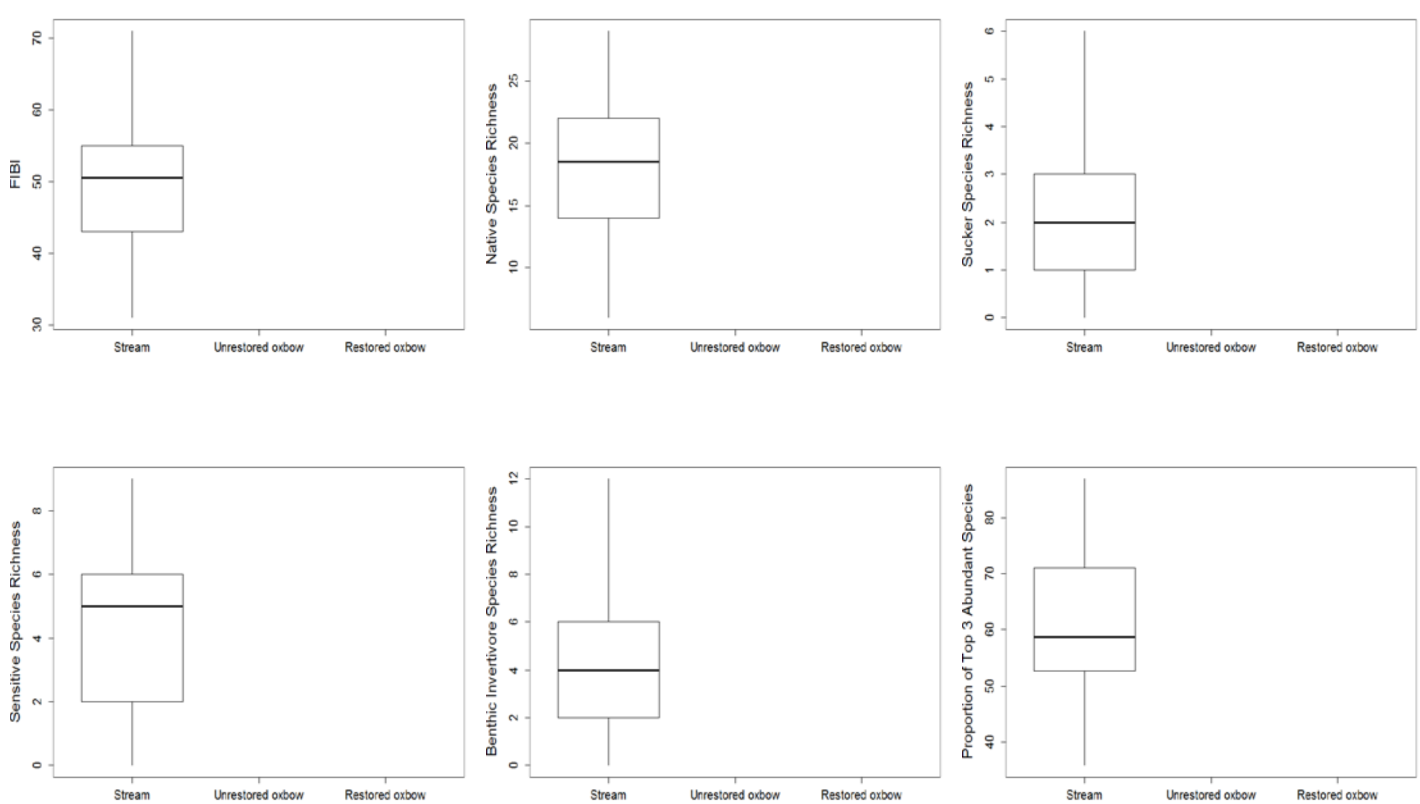

Orangespotted sunfish CPUE
Quillback carpsucker CPUE
River carpsucker CPUE
Rosyface shiner CPUE
Sand shiner CPUE
Shorthead redhorse CPUE
Silver chub CPUE
Silver redhorse CPUE
Slender madtom CPUE
Slenderhead darter CPUE
Smallmouth bass CPUE
Speckled chub CPUE
Stream
Unrestored oxbow
Restored oxbow

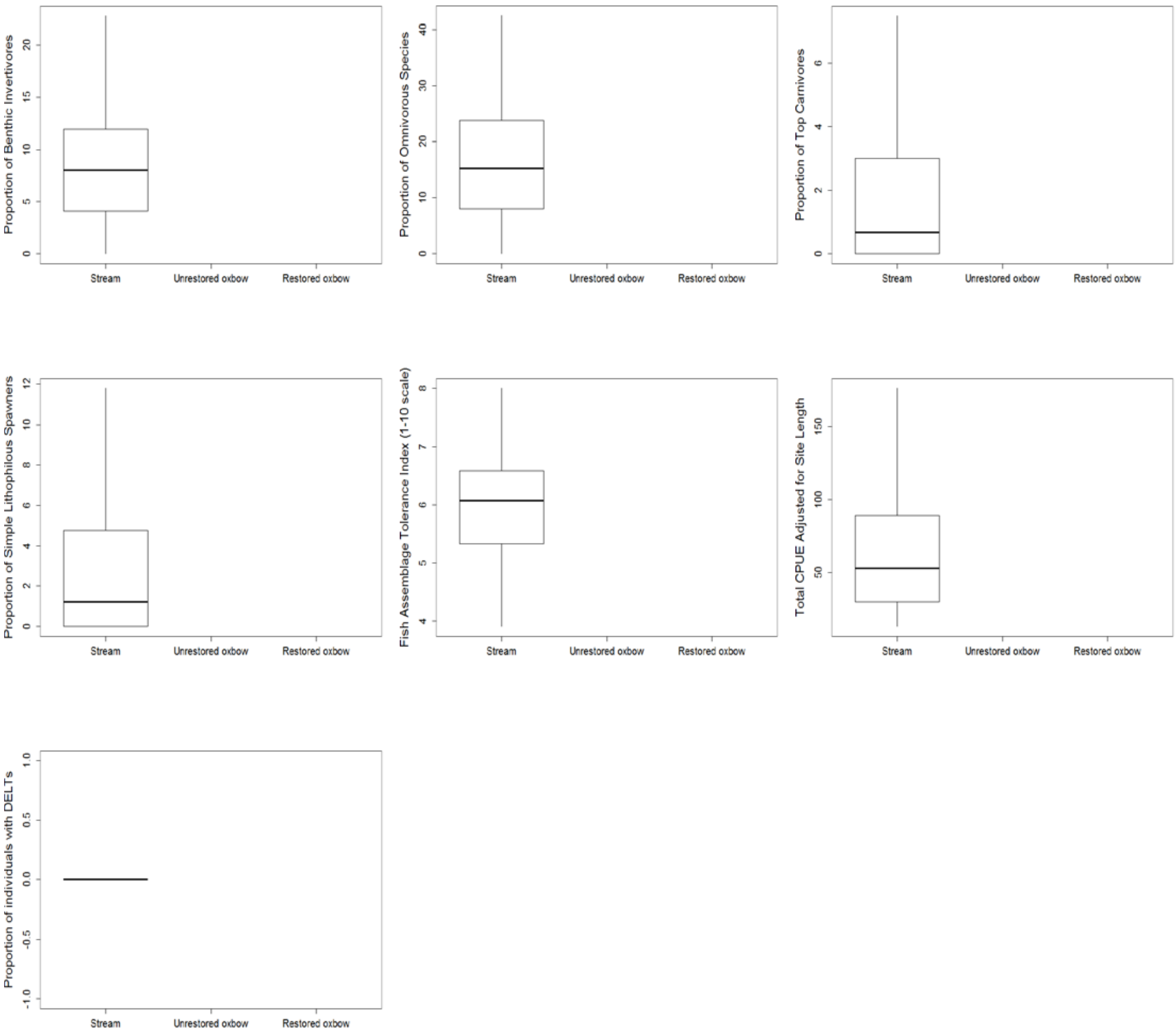


Spotfin shiner CPUE
Stonecat CPUE
Suckermouth minnow CPUE
Tadpole madtom CPUE
Topeka shiner CPUE
Walleye CPUE
White crappie CPUE
White sucker CPUE
Yellow Bullhead CPUE
Yellow perch CPUE
Green and Orangspotted Sunfish Combined CPUE
Predator CPUE
Stream
Unrestored oxbow
Restored oxbow



Stream-specific Variables





Proportion of Benthic Invertivores
0
5
10
15
20
Stream
Unrestored oxbow
Restored oxbow
Proportion of Omnivorous Species
0
10
20
30
40
Stream
Unrestored oxbow
Restored oxbow
Proportion of Top Carnivores
0
2
4
6
Stream
Unrestored oxbow
Restored oxbow
Proportion of Simple Lithophilous Spawners
0
2
4
6
8
10
12
Stream
Unrestored oxbow
Restored oxbow
Fish Assemblage Tolerance Index (1-10 scale)
4
5
6
7
8
Stream
Unrestored oxbow
Restored oxbow
Total CPUE Adjusted for Site Length
50
100
150
Stream
Unrestored oxbow
Restored oxbow
Proportion of individuals with DELTs
-1.0
-0.5
0.0
0.5
1.0
Stream
Unrestored oxbow
Restored oxbow