FISH DISTRIBUTION, RELATIVE ABUNDANCE, AND HABITAT ASSOCIATIONS IN NEVER SAMPLED JAMES RIVER WATERSHEDS

FINAL REPORT

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PROJECT OVERVIEW:

Fish assemblage structure and local habitat characteristics were quantified at representative stream reaches from watersheds (HUC10) within the James River Basin that have never been previously sampled (M. Wagner, *pers. comm.*; Figure 1). Because many watersheds within the James River Basin (n = 22; 31.4% of the basin by area) were yet to be sampled, distribution models for species are currently misleading and regional species pools are poorly understood. In addition, fisheries sampling in the James River Basin have rarely included rigorous habitat assessments thereby limiting the ability to characterize and predict fish assemblage structure throughout the James River Basin. During the summer and fall of 2015, fish assemblage structure and instream habitat was measured at a single stream reach from each un-sampled watershed (n = 22; Figure 1) using standardized sampling methodologies. Sampling of lotic assemblages alleviated large gaps in the known distribution of South Dakota stream fishes and allowed initial relation of fish occurrence patterns to habitat availability throughout the James River Basin as a prerequisite for future conservation activities. Given the immense resource demand required to regularly sample stream reaches, these now updated distribution records and preliminary habitat-based modeling exercises will be instrumental in prioritizing future sampling efforts, conservation activities, and afford public entities valuable information about fish assemblage structure throughout the region. In addition, the surveys occurred within the potential range of fish species identified as rare by the South Dakota Heritage Program (e.g., Topeka Shiner, *Notropis topeka* & Plains Topminnow, *Fundulus sciadicus*). Sampling further delineated areas occupied by one at-risk species and will make widespread predications of each species occurrence probability more robust. High quality fish sampling data for this large river drainage obtained by this comprehensive standardized survey has generated better understanding of occupancy patterns of lotic fishes in eastern South Dakota.

PROJECT OBJECTIVES:

Objective (1): Describe the fish assemblage structure at stream reaches within 22 un-sampled James River watersheds (HUC10) using standardized methods

Objective (2): Relate fish species occurrence patterns to habitat availability throughout the James River Basin

PROJECT METHODS:

Study area.—Twenty-two (22) stream reaches from watersheds within the James River Basin that have never previously been sampled were selected for surveys of fish assemblage structure and habitat availability. Local sampling reaches were delineated as 40 times the average wetted stream width at five randomly selected points; however, a minimum of 150 m and maximum of 300 m were established to insure sufficient numbers of individuals were captured, rare habitats were encountered, and riparian conditions did not fully determine channel morphology (Lyons 1992).

Fish sampling.—Fish were captured using single-pass backpack electrofishing conducted in an upstream direction; however, catch rates for individual species were adjusted to estimate species density using methods described by Kauth et al. (*in prep*). Using widespread multiple-pass depletion estimates, regression relationships for single- and multiple-pass catch-per-effort abundance for prairie fish species were developed that predict densities of individual species at each stream reach (Kauth et al. *in prep*). Prior to sampling, block nets were installed at the upstream and downstream ends of the sampling reach to prevent fish movement out of the site during the sampling period. As fish were captured by netters during electrofishing, fish were placed into a net pen within the sampling reach but outside the electrical field. At the conclusion of the electrofishing pass, all fish were removed from the net pen, identified to species and counted prior to release. At each site a limited number of individuals were selected as voucher specimens (not to exceed two per species) and fixed in 10% formalin. All individuals were later preserved in 70% ethyl alcohol and are maintained within the Natural Heritage Fish Reference Collection for South Dakota at South Dakota State University.

Water chemistry.—Measurements of instantaneous chemical and physical characteristics were conducted at the midpoint of each stream segment to describe the relationship between water chemistry variability and fish occurrence. Temperature (°C), dissolved oxygen (mg/L), conductivity (µS), salinity (ppt), pH, and turbidity (NTU) were measured instantaneously at all sites.

Physical habitat.—To measure a subsample of the available physical instream habitat, each delineated stream reach was divided into 11 equally spaced transects. Aquatic cover density and substrate coarseness was quantified along each transect at 15 distinct points. Substrate coarseness was visually estimated in cross sections by the percentage composition of silt/muck (< 0.5 mm), sand (0.5-2 mm), fine gravel (2-16 mm), coarse gravel (16-64 mm), and cobble (64-240 mm). The wetted width (m), bankfull width (cm), bankfull height (cm), riparian width (m), bar width, and estimates of instream cover (i.e., percent of filamentous algae, macrophyte, woody debris, and overhanging vegetation cover) were also be recorded along each transect. At five equally spaced points along each transect depth (cm) and water velocity (cm/s) were measured to characterize the stream reach. Two measurements of current velocity were recorded at each point, at the surface and at 60% of the depth, to be averaged.

RESULTS (OBJECTIVE 1):

Twenty-two (22) stream reaches from watersheds within the James River Basin that have never previously been sampled were randomly selected for surveys of fish assemblage structure, water chemistry, and habitat availability (Figure 1). Three alternate sites were selected from each

watershed in the event that the selected site was inaccessible or was not representative of the watershed (i.e., impounded, dry, or access was denied). Permission was granted to sample within each watershed; however, three alternate sites were substituted given their proximity to impoundments (n = 1) and inclusion of dugout, cattle ponds (n = 2). No fish sampling occurred within five watersheds (Table 1) in which the originally selected site and all alternatives were found to be dry. In each case, indigenous knowledge from local landowners suggested that water is rarely present. These sites were therefore classified as *ephemeral*; an important distinction from *intermittent* (occupancy probability [ψ] > 0]) when applied to future predictive modeling because the probability of fish occupancy of ephemeral systems approximates zero ($\psi = 0$). Repeat sampling visits are planned in spring to further assess the intermittency of those systems. Twelve watersheds were distinctly dominated by *intermittent* stream reaches characterized by isolated runs and pools and dry reaches (Table 1). Five watersheds were *perennial* in which water of substantial discharge was present throughout the year (Table 1).

Fish sampling.—A total of 7,444 fish of 20 species (Appendix A) were captured from the 17 sampled reaches at which relative abundance varied considerably (Mean ± Standard Error [SE]: 452.3 ± 141.64; Table 1). Despite water availability, no fish species were captured at four intermittent sites (Table 1). Species richness, at sites with water, ranged from 0 to 14 species (3.6 ± 0.83; Table 1). Sampled sites were generally dominated by particular species (Dominance [d]: 0.68 ± 0.076), often Fathead Minnow [*Pimephales promelas*], with uneven distributions of abundance among species (Evenness: 0.55 ± 0.056) and lacked substantial diversity (Shannon H': 0.66 ± 0.158). Perennial sites were generally occupied by a greater number of species with more evenly distributed abundances, lacked dominant species, and were more diverse than intermittent systems (Table 1).

Variation in assemblage structure among watersheds was substantial in most cases (Jaccard similarity coefficient; Figure 2). However, notable exceptions exist as the assemblages of site 4, 11, 15, and 19 overlap considerably (Figure 2). In general, fish assemblage structure was more similar within than between hydrologic status designations (i.e., intermittent and perennial. Several species were unique to particular sites: Bigmouth Buffalo [*Ictiobus cyprinellus*], Creek Chub [*Semotilus atromaculatus*], Red Shiner [*Cyprinella lutrensis*], Largemouth Bass [*Micropterus salmoides*], River Carpsucker [*Carpiodes carpio*], Tadpole Madtom [*Noturus gyrinus*], Yellow Perch [*Perca flavescens*], Yellow Bullhead [*Ameriurus natalis*]) driving the extensive divergence in fish assemblage structure among watersheds. These species likely have specific niche requirements that are disproportionately available throughout the James River Basin (Figure 1). Fathead Minnow and Black Bullhead [*Ameiurus melas*] were widespread and occurred at nearly all sites occupied by fish. Although fish sampling methods targeted species of conservation concern, only one South Dakota Heritage species was captured (Plains Topminnow [*Fundulus sciadicus*]). This previously undiscovered population is near the most northern extent of the species' known range (Figure 1; Pasbrig et al. 2012). The majority (n = 18) of species represent little sport fishery value; however populations of Largemouth Bass and Yellow Perch were present at one site in close proximity to a cattle pond.

RESULTS (OBJECTIVE 2):

Fish occurrence, paired with instream habitat measurements are instrumental to further characterization and development of a predictive framework for fish assemblage diversity

throughout the James River Basin. Given the resource demand necessary to regularly sample stream reaches throughout the State of South Dakota, such habitat based predictive models will be instrumental in prioritizing future sampling efforts, conservation activities, and to generate knowledge of lotic fish life history.

Variation between fish assemblage structure and seven local or riverscape scale variables was described using the collected data: hydrologic status (intermittent or perennial), salinity (ppt), turbidity (NTU), dissolved oxygen (mg/L), mean wetted width (cm), maximum depth (cm), and agricultural damage. Incorporated independent variables were selected from numerous candidate variables and were metrics that limited redundancy and correlation. For all habitat associative analyses the response variable was species relative abundance. Sufficient capture events (i.e. occurrence at > 2 sites) were available for Fathead Minnow, Brook Stickleback [*Culaea inconstans*], Green Sunfish [*Lepomis cyanellus*], Iowa Darter [*Ethostoma exile*], Black Bullhead, Common Carp [*Cyprinus carpio*], and Orangespotted Sunfish [*L. humilus*]. Canonical correspondence analysis (CCA) was used to divide assemblage variance into independent components relative to the seven habitat variables (Angermeier and Winston 1999). This analysis provides artificial axes that maximize the separation among the distinct niche space of each species assuming that associations with environmental variables represent the species optimal habitat. Close proximity to the endpoint of a habitat vector indicates an intimate species-habitat relationship.

Preliminary exploration of fish-habitat associations in the James River Basin using CCA explained a sizeable amount of the cumulative variance in species abundance among watersheds (62.2%; Table 2). Establishing relationships between vectors (i.e., habitat variables) and fish species using CCA was highly subjective; so conservative inferences of meaningful relationships are presented (Figure 3). However, the CCA model provided substantial evidence indicating that the amount of animal damage to the riparian area was related to Green Sunfish abundance (Table 2; Figure 3). Mean width and turbidity were associated with catch rates of Orangespotted Sunfish (Figure 3). Salinity was identified to potentially contribute to changes in abundance of both Black Bullhead and Common Carp (Figure 3).

DISCUSSION:

Standardized sampling of lotic assemblages alleviated large gaps in the known distribution of South Dakota stream fishes and helped to relate fish occurrence patterns to habitat availability. These now updated distribution records and preliminary habitat-based modeling exercises will be instrumental in prioritizing future sampling efforts, conservation activities, and afford public entities valuable information about fish assemblage structure throughout the region. In addition, preliminary evaluations of potential fish-habitat relationships allow understanding of life history characteristics of poorly understood species. In addition, the surveys occurred within the potential range of fish species identified as rare by the South Dakota Heritage Program (e.g., Topeka Shiner, *Notropis topeka* & Plains Topminnow, *Fundulus sciadicus*). Sampling further delineated areas occupied by one at-risk species and will make widespread predications of each species occurrence probability more robust. High quality fish sampling data for this large river drainage obtained by this comprehensive standardized survey has generated better understanding of occupancy patterns of lotic fishes in eastern South Dakota.

LITERATURE CITED

Angermeier, P. L., and M. R. Winston. 1999. Characterizing fish community diversity across Virginia landscapes: prerequisite for conservation. Ecological Application 9(1):335-349.

Pasbrig, C. A., K. D. Koupal, S. Schainost, and W. W. Hoback. 2012. Changes in range-wide distribution of plains topminnow *Fundulus sciadicus*. Endangered Species Research 16:235-247.

Table 1. Hydrologic status assigned and measures of fish assemblage structure at previously un-sampled watersheds (HUC10) in the throughout the James River Basin, South Dakota.

Site ID	Watershed	Hydrologic Status	Richness	Total Abundance	Dominance D	Shannon H'	Evenness
1	Upper Wolf Creek	Intermittent	3	232	0.983	0.055	0.352
2	Lost Creek	Ephemeral (Dry)	NA	NA	NA	NA	NA
3	Cain Creek	Intermittent	4	1190	0.439	0.954	0.649
4	Medicine Creek	Perennial	6	434	0.814	0.419	0.253
5	Lower Preachers Run-Scatterwood Lakes	Intermittent	4	362	0.693	0.546	0.432
6	Dry Run	Ephemeral (Dry)	NA	NA	NA	NA	NA
7	Lower North Fork Snake Creek	Perennial	14	884	0.309	1.55	0.337
8	Hamak Lake	Intermittent	0	NA	NA	NA	NA
9	Upper Preachers Run	Ephemeral (Dry)	NA	NA	NA	NA	NA
10	Upper Snake Creek	Ephemeral (Dry)	NA	NA	NA	NA	NA
11	Elm Lake	Intermittent	4	1858	0.644	0.657	0.482
12	Dry Branch	Intermittent	0	0	NA	NA	NA
13	Dry Run	Intermittent	0	0	NA	NA	NA
14	Crow Creek Drainage Ditch	Perennial (Channelized)	2	1587	0.999	0.005	0.503
15	Crow Creek	Perennial	5	191	0.607	0.727	0.414
16	Foster Creek	Perennial	9	65	0.209	1.79	0.669
17	Crandon Creek	Ephemeral (Dry)	NA	NA	NA	NA	NA
18	Jim Creek	Intermittent	1	3	1	0	1
19	School Section Lakes	Intermittent	5	26	0.326	1.33	0.753
20	Newport/Weston Ditch	Intermittent	2	25	0.923	0.168	0.591
21	Antelope Creek	Intermittent	0	0	NA	NA	NA
22	Broadland Creek	Intermittent	5	832	0.923	0.439	0.776
		Mean	3.76	480.56	0.682	0.665	0.555
		Standard Error	0.859	147.647	0.076	0.158	0.056
		Mean: Intermittent	2.33	411.64	0.741	0.519	0.629
		Mean: Perennial	8.50	393.50	0.485	1.122	0.418

Table 2. Canonical Correspondence Analysis (CCA) results for the James River Basin watersheds (HUC10) that had previously been un-sampled.

	Axis 1*	Axis 2	Axis 3
Eigenvalue	0.329	0.082	0.319
Cumulative Variance Explained	46.6	57.8	62.2
Species-Environment			
Animal Damage*	0.771	0.084	0.265
Salinity	0.279	0.341	-0.477
Turbidity	0.354	-0.465	0.451
Dissolved Oxygen	-0.678	-0.662	-0.001
Mean Width	0.529	-0.579	-0.441
Max Depth	0.494	-0.012	-0.596

Total Inertia	0.712

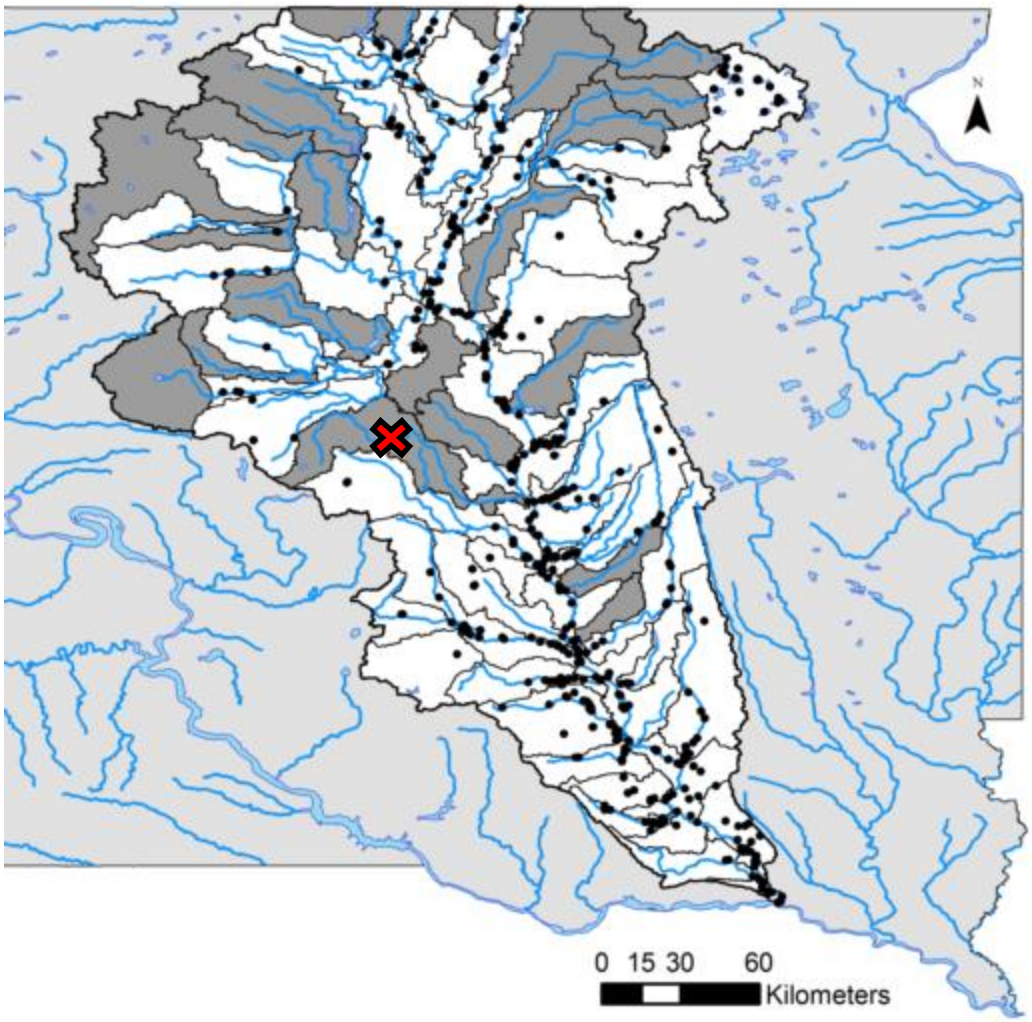

Figure 1. Previously un-sampled watersheds (Gray; HUC10) that occur throughout the James River Basin, South Dakota. Black dots indicate sampling records have yet to be sampled and red 'X' indicates approximate captured location for Plains Topminnow [*Fundulus sciadicus*].

Site Number	1	3	4	5	7	11	14	15	16	18	19	20	22
1	1	0.17	0.33	0.40	0.21	0.40	0.25	0.33	0.20	0.33	0.33	0.25	0.33
3	X	1	0.29	0.14	0.13	0.33	0.20	0.29	0.08	0.25	0.13	0.50	0.29
4	X	X	1	0.29	0.38	0.80	0.17	0.67	0.27	0.20	0.25	0.40	0.43
5	X	X	X	1	0.29	0.14	0.20	0.13	0.30	0.25	0.80	0.20	0.50
7	X	X	X	X	1	0.29	0.14	0.27	0.35	0.07	0.36	0.14	0.27
11	X	X	X	X	X	1	0.20	0.80	0.18	0.25	0.13	0.50	0.29
14	X	X	X	X	X	X	1	0.17	0.10	0.50	0.17	0.33	0.17
15	X	X	X	X	X	X	X	1	0.17	0.20	0.11	0.40	0.29
16	X	X	X	X	X	X	X	X	1	0.11	0.27	0.10	0.40
18	X	X	X	X	X	X	X	X	X	1	0.20	0.50	0.20
19	X	X	X	X	X	X	X	X	X	X	1	0.17	0.38
20	X	X	X	X	X	X	X	X	X	X	X	1	0.17
22	X	X	X	X	X	X	X	X	X	X	X	X	1

Figure 2. Jaccard Similarity Index comparing watersheds at which fish were captured in previously un-sampled James River Basin watersheds (HUC10). Index values range between 0 (entirely different fish assemblage) and 1 (equal assemblage structure).

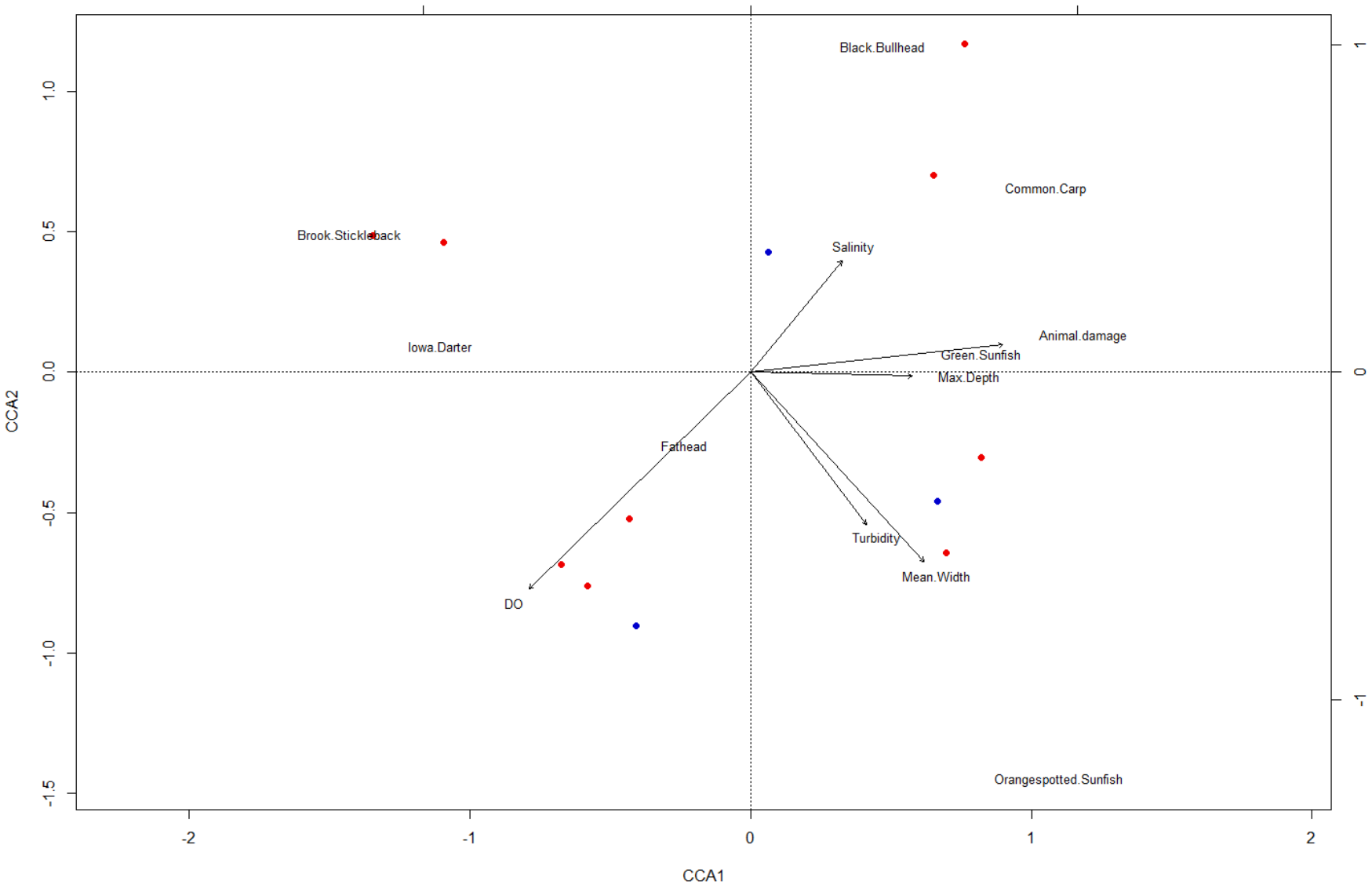

Figure 3. Canonical Correspondence Analysis (CCA) biplot (axes 1-2) for watersheds in the James River Basin that had been previously un-sampled showing approximate fish-habitat relationships.

Appendix A. Fish species captured at each sampling location within 22 previously un-sampled James River Basin watersheds (HUC10).

Site ID	Watershed	Hydrologic Status	Fish species captured
1	Upper Wolf Creek	Intermittent	Fathead Minnow, Brook Stickleback, Green Sunfish
2	Lost Creek	Ephemeral (Dry)	NA
3	Cain Creek	Intermittent	Fathead Minnow, Brassy Minnow, Plains Topminnow, Iowa Darter
4	Medicine Creek	Perennial	Fathead Minnow, Brook Stickleback, Green Sunfish, Iowa Darter Black Bullhead, Common Carp
5	Lower Preachers Run-Scatterwood Lakes	Intermittent	Fathead Minnow, Green Sunfish, Common Carp, Orangespotted Sunfish
6	Dry Run	Ephemeral (Dry)	NA
7	Lower North Fork Snake Creek	Perennial	Fathead Minnow, Brook Stickleback, Green Sunfish, Iowa Darter, Bigmouth Buffalo, Bluegill, Common Carp, Orangespotted Sunfish, Red Shiner, River Carpsucker, White Sucker, Yellow Bullhead
8	Hamak Lake	Intermittent	Zero
9	Upper Preachers Run	Ephemeral (Dry)	NA
10	Upper Snake Creek	Ephemeral (Dry)	NA
11	Elm Lake	Intermittent	Fathead Minnow, Brook Stickleback, Iowa Darter, Black Bullhead
12	Dry Branch	Intermittent	Zero
13	Dry Run	Intermittent	Zero
14	Crow Creek Drainage Ditch	Perennial (Channelized)	Fathead Minnow, Bluegill
15	Crow Creek	Perennial	Fathead Minnow, Brook Stickleback, Iowa Darter, Black Bullhead Creek Chub
16	Foster Creek	Perennial	Fathead Minnow, Green Sunfish, Black Bullhead, Common Carp, Largemouth Bass, Sand Shiner, Tadpole Madtom, White Sucker, Yellow Perch
17	Crandon Creek	Ephemeral (Dry)	NA
18	Jim Creek	Intermittent	Fathead Minnow
19	School Section Lakes	Intermittent	Fathead Minnow, Green Sunfish, Common Carp, Orangespotted Sunfish
20	Newport/Weston Ditch	Intermittent	Fathead Minnow, Iowa Darter
21	Antelope Creek	Intermittent	Zero
22	Broadland Creek	Intermittent	Fathead Minnow, Green Sunfish, Brassy Minnow, Black Bullhead, Common Carp