Prairie Stream Surveys on BLM Public Lands in Eastern Montana 2014 Surveys

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Cover photo: Cherry Creek R1b, Prairie County, Montana. September 2, 2014.

Introduction

Prairie streams are an endangered yet valuable resource in the Northern Great Plains Eco-region (Samson and Knopf 1994). Previous studies on prairie streams in the Northern Great Plains have shown that prairie stream systems are very unpredictable, constantly changing from drying to flooding stages between seasons, sometimes even in a matter of days (Matthews 1988, Ostovar 2007), and shown the need for multiple spatial and temporal sampling to occur along each stream for an adequate understanding of prairie stream assemblages (Ostovar 2007). An inventory effort to survey all prairie streams intersecting Bureau of Land Management (BLM) administered public lands in eastern Montana and western North and South Dakota occurred from 2009 to 2012. Permanent benchmarks were installed along prairie streams that dissected one mile or more of BLM lands to allow for future monitoring in hopes of gaining a better understanding of the distribution and abundance of fishes that inhabit these prairie streams. The goal for prairie streams with permanent benchmarks is to establish a plan which aims to monitor these streams every five years or in combination with any land use planning. Three primary streams (Pumpkin, Cedar, and Cherry Creek) intersect large contiguous pieces of BLM lands and have been monitored annually or bi-annually since 2010 (Chaffin 2011 a, b, Stuart and Chaffin 2013 a, b). Pumpkin Creek intersects nine miles of BLM lands and has four sampling reaches along the nine mile stretch of BLM with benchmarks that were installed in 2010. Cedar Creek intersects 19 miles of BLM lands and has six sampling reaches, four of which have benchmarks that were installed in 2010. Cherry Creek intersects three and a half miles of BLM lands and has three sampling reaches with benchmarks that were set up between 2009 and 2010.

Methods

Site Selection

In 2014 sites were selected by reviewing all projects occurring within the Miles City Field Office (MCFO) that overlapped with locations of sampling reaches with permanent benchmarks. The review of projects turned up one restoration project and two grazing allotment reviews that overlapped with sampling reaches set up with permanent benchmarks. Lone Tree Creek has two sampling reaches, R2 and R3, which were set up with permanent benchmarks in 2011 (Chaffin 2011 b). Blackfoot reservoir, just upstream of Lone Tree Creek R3, was removed in 2013 and a stream rehabilitation project was begun (Stuart and Chaffin 2013 a, b). Lone Tree Creek R2 and R3 were surveyed in 2014 to monitor stream morphology and species composition through the restoration process. Whitney Creek R1 and Owl Creek R3 were set up with permanent benchmarks in 2011 and 2012 respectively and are located on two separate grazing allotments which were being reviewed for renewal in 2014. Whitney Creek R1 and Owl Creek R3 were sampled in 2014 to monitor fish, habitat, and geomorphology data along with grazing habits on those allotments. Pumpkin, Cedar, and Cherry Creeks are primary sites that were established between 2009 and 2010 (Chaffin 2011 a) and were sampled twice (spring and fall) in 2014. There are 13 sampling reaches set up on the three primary creeks, with four at Pumpkin Creek, six at Cedar Creek and three at Cherry Creek.

Fish and Habitat Surveys

This work followed an Index of Biological Integrity (IBI) protocol developed by Bramblett et al. (2005) with specific field methodology outlined in Bramblett (2003). Block nets were positioned at the upstream and downstream ends of the 300 m sample reach, except when natural barriers like dry channels or shallow riffles were present, to prevent fish movement outside the sample area. An appropriate sized seine net, based on the stream width to be sampled, was used to seine the sampling reach moving downstream. Fish were collected at appropriate intervals and held in five gallon buckets. Next fish were anesthetized, identified to the species

taxonomic level using Holton and Johnson (2003) and taxonomic keys (Professor Bob Bramblett, MSU, unpublished data), enumerated, and released. A subsample of 20 individuals per species was measured (TL) to the nearest millimeter.

Habitat data were collected following Bramblett (2003). Eleven individually labeled pin flags were placed every 30 m along the 300 m sampling reach. Each flag location was a transect site where wetted width, depth and substrate size were recorded. Depth and substrate were recorded at five locations (left bank, left center, center, right center, right bank) at each transect within the wetted width. A thalweg profile was recorded by measuring ten thalweg (deepest part of channel) depths evenly spaced between each transect. A member of the crew walked along the stream bank of the entire sampling reach carrying a Trimble GPS unit collecting linear geographical information in order to store stream sinuosity and allow for future monitoring to take place at the exact same location.

Water quality parameters collected at each sampling site included dissolved oxygen content (percent saturation and mg/L or ppm), conductivity (µS/cm), and water temperature (˚C) recorded with an YSI Model Pro 2030 water quality meter (YSI Inc. Yellow Spring, OH), pH recorded with an Extech meter (Extech Instruments, Waltham MA), and air temperature (°F) was recorded with a handheld thermister.

Within the 300 m sampling reach we recorded qualitative observations such as riparian vegetation: native and exotic trees, shrubs, and grasses; evidence of land-use activities and anthropogenic influences; and wildlife observations to help assess stream condition. We also recorded percent of habitat type (run, riffle, pool, dry channel, backwaters, secondary channels, etc.), percent of vegetation consumed by livestock, percent of sample reach covered by vegetation, occurrence of large woody debris in the stream and stream bank condition (incisement, floodplain development, active down-cutting).

Stream Cross Sections

All sites sampled in 2014 had permanent benchmarks installed during the inventory effort that took place between 2009 and 2012 (Chaffin 2011 a, b, Stuart and Chaffin 2013 a) except for Cedar Creek R1 and R2a. Benchmarks (rebar or fence posts) were installed outside the perceived flood-prone boundary on either side of the stream at the beginning, middle, and end of the 300 m sampling reach (0, 150, and 300 meters) (Figure 1). An electronic data monitor or Total Station (Sokkia Co. Ltd) was used to survey elevation changes between benchmarks. Measurements were taken at two to ten foot intervals between the benchmarks and at one foot intervals within the bank-full width. Two digital photos were taken at each cross-section standing in the middle of the stream, one looking up and the other down-stream so that photo-point surveys, alongside cross-section data, can be compared with future monitoring.

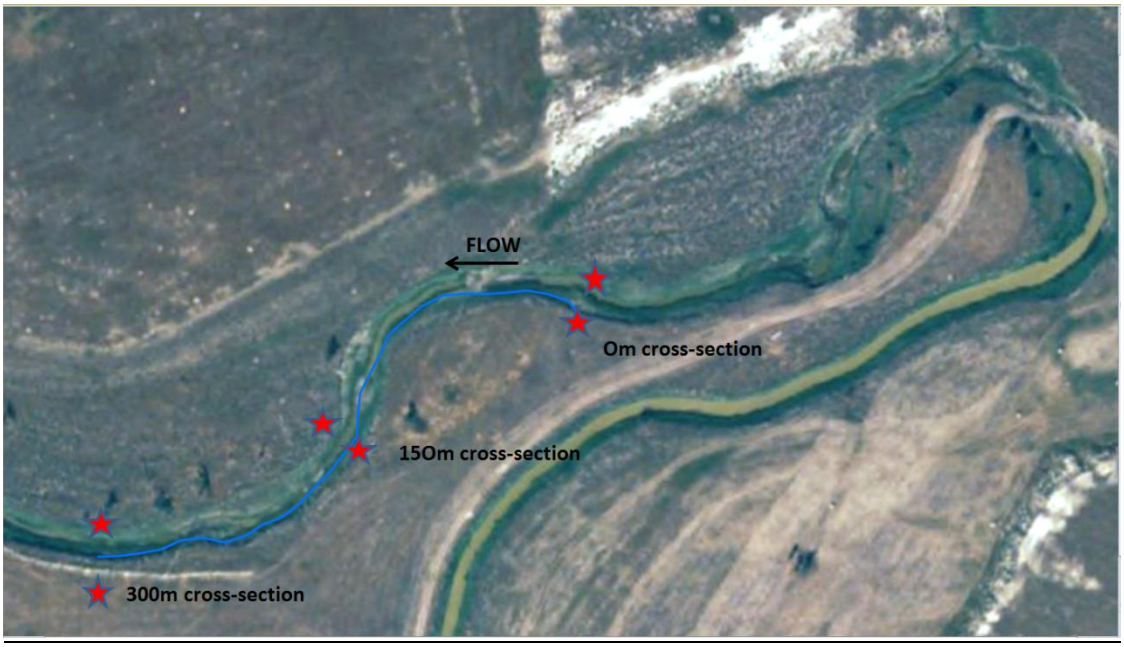

Figure 1. Aerial image of Pumpkin Creek R1. Red stars indicate permanent benchmarks (rebar for 0 and 300m, fencepost for 150m cross-section) installed on either side of the channel for each of three cross-sections. The blue line indicates the 300m sampling reach where fish and habitat surveys were conducted.

Database & Data Analysis

A database specific to this project was built in 2010 and continues to be upgraded. The database will allow easy extraction of data for resource managers within the BLM. The data will also be used to generate reports and can be shared with other agencies or researchers. The data will also be linked to GIS/GPS data so that everything is spatially explicit. Additionally, raw fish data will be sent to state agencies through requirements of their scientific collectors permit.

IBI scores were calculated following Bramblett et al. (2005). Watershed area calculations were conducted in GIS using ArcMap (ESRI, 2009) with Arc Hydro (ESRI, 2009) tools. Digital elevation models (DEM) were of 10 m resolution from USGS NED (National Elevation Dataset, accessed December 2012).

Results

Sites

In 2014 a total of 17 sampling reaches were re-visited to continue monitoring efforts on BLM administered public lands. Of the 17 sites, 16 were re-sampled for fish and habitat data. Lone Tree Creek R2 was not sampled for fish or habitat data because R2 was dry at the time of the site visit, only benchmarks were re-surveyed at Lone Tree Creek R2. Of the 16 sites re-sampled, all the primary sites were sampled twice, once in the spring and once in the fall, except for Cedar Creek R5 (Table 1). Cedar Creek R5 was only sampled once in the fall due to extremely high flows occurring from late spring through summer. Whitney Creek R1, Owl Creek R3, and Lone Tree Creek R3 were all sampled once, mid-summer. Total number of sites sampled in 2014 was 16 with 28 sampling events (12 primary sites sampled twice). The sites, dates, type of sampling conducted, stream reach length, watershed area, and IBI scores are listed in Table 1.

Table 1. Streams visited in 2014, arranged alphabetically by Hydrologic Unit Code (HUC) name then by stream name. F=fish bearing, N=non-fish bearing; 1= Stream walked and inventoried along BLM public lands, 2=IBI Fish and Habitat Protocol, 3=Surveyed cross sections with benchmarks. Miles of stream refers to the stream length occurring on BLM public lands. Watershed area refers to all contributing land above the bottom point of the sampling reach. IBI scores calculated according to Bramblett et al. (2005) range from a 0-100 scale, 100 being of highest biological integrity.

Field Office	HUC Name Stream Reach	Date	Fish Present	Survey Type (1,2,3)	Miles of stream	Watershed Area (ha)	IBI Score
MCFO	**Box Elder Creek (Little Missouri River)**						
	Lone Tree Creek R2	8/18/2014	N	1,3*	0.86	3033	N/A
	Lone Tree Creek R3	7/16/2014	F	1,2,3	0.85	2841	65
	Lower Belle Fourche						
	Owl Creek R3	7/15/2014	F	1,2,3*	5.2	1,785	10**
	Lower Tongue						
	Pumpkin Creek R1	5/28/2014	F	1,2,3	0.81	179,019	45
	Pumpkin Creek R1	9/3/2014	F	1,2		179,019	55
	Pumpkin Creek R2	5/28/2014	F	1,2,3	3.2	178,434	56
	Pumpkin Creek R2	9/4/2014	F	1,2		178,434	54
	Pumpkin Creek R3	5/28/2014	F	1,2,3	2.58	165,910	52
	Pumpkin Creek R3	9/3/2014	F	1,2		165,910	48
	Pumpkin Creek R4	5/27/2014	F	1,2,3	1.84	164,040	54
	Pumpkin Creek R4	9/4/2014	F	1,2		164,040	49
	Lower Yellowstone						
	Cedar Creek R1	6/3/2014	F	1,2	0.33	54,473	53
	Cedar Creek R1	9/15/2014	F	1,2		54,473	54
	Cedar Creek R2	5/29/2014	F	1,2,3	2.37	45,488	69
	Cedar Creek R2	9/9/2014	F	1,2		45,488	65
	Cedar Creek R2a	6/2/2014	F	1,2	0.55	44,455	61
	Cedar Creek R2a	9/9/2014	F	1,2		44,455	55
	Cedar Creek R3	6/2/2014	F	1,2,3	4.38	42,807	58
	Cedar Creek R3	9/10/2014	F	1,2		42,807	55
	Cedar Creek R4	7/2/2014	F	1,2,3	9.9	41,471	58
	Cedar Creek R4	9/18/2014	F	1,2		41,471	59
	Cedar Creek R5	9/18/2014	F	1,2,3	1.06	30,279	59
	Cherry Creek R1a	6/9/2014	F	1,2,3	0.76	58,674	56
	Cherry Creek R1a	9/2/2014	F	1,2		58,674	63
	Cherry Creek R1b	6/9/2014	F	1,2,3	1.26	58,503	59
	Cherry Creek R1b	9/2/2014	F	1,2		58,503	55
	Cherry Creek R2	6/12/2014	F	1,2,3	1.51	56,579	59

Field Office	HUC Name Stream Reach	Date	Fish Present	Survey Type (1,2,3)	Miles of stream	Watershed Area (ha)	IBI Score
MCFO	Cherry Creek R2	9/8/2014	F	1,2		56,579	66
	O'Fallon Creek						
	Whitney Creek R1	6/25/2014	F	1,2,3	1.94	33,275	62

* Only surveyed two cross sections at these sites, 0 m cross section was not surveyed

** IBI manually lowered to 10 due to fewer than 10 individual fish caught

Fish and Habitat Surveys

A total of 5,336 fish were sampled in 2014, making up seven families and 24 individual species. The catch was dominated by native fish (92%) with 4,912 native individuals and 424 exotic individuals. The percent of native species recorded at all sampled sites ranged from 0% (Lone Tree Creek R3 and Owl Creek R3) to 100% (Cedar Creek R1 spring and fall) (Table 2). The most abundant species sampled was the sand shiner, a native species, with 1,237 individuals sampled. The most abundant exotic species observed was the plains killifish, with 172 individuals (Table 3). The most widely distributed species observed were the plains minnow and fathead minnow, both native species, occurring at 14 of the 16 sampling sites. The most widely distributed exotic species was the plains killifish, occurring at 68% of our sampled sites (Table 4). The number of species recorded at a site ranged from 1 to 13 (Owl Creek R1 and Cedar Creek R2 respectively), while the number of individuals recorded at a site ranged from 5 to 523 (Owl Creek R1 and Cedar Creek R3 respectively). The highest native species richness, 11, was recorded at Cedar Creek R2 and highest exotic species richness, 4, was recorded at Pumpkin Creek R3 and R4. Appendix A has the species richness and total fish caught at each site, while Appendix B has the species count at each site for the different sampling events.

All sampled sites (n=28) had a mean wetted width of 5.3 m and an average center depth of 45 cm. All sampled sites had flowing water except for Owl Creek R3 (interrupted standing pools of water) and Lone Tree Creek R3 (continuous standing water). General habitat and water quality characteristics are presented in Appendix C and D.

Table 2. Species richness and total number of individual fish (separated out by natives and exotics) caught at each site in 2014, arranged alphabetically by HUC name then by stream name.

			Species Richness		Total Individuals	
Field Office	**HUC &** Stream Name	**Date**	**Native**	**Exotic**	**Native**	**Exotic**
MCFO	**Box Elder Creek (Little Missouri River)**					
	Lone Tree Creek R3	7/16/2014	0	2	0	55
	Lower Belle Fourche					
	Owl Creek R3	7/15/2014	0	1	0	5
	Lower Tongue					
	Pumpkin Creek R1	5/28/2014	6	1	38	1
	Pumpkin Creek R1	9/3/2014	9	3	337	56
	Pumpkin Creek R2	5/28/2014	10	1	27	1
	Pumpkin Creek R2	9/4/2014	6	3	154	8
	Pumpkin Creek R3	5/28/2014	6	3	19	7
	Pumpkin Creek R3	9/3/2014	4	4	29	21
	Pumpkin Creek R4	5/27/2014	9	1	40	1
	Pumpkin Creek R4	9/4/2014	7	4	313	30
	Lower Yellowstone					
	Cedar Creek R1	6/3/2014	7	0	120	0
	Cedar Creek R1	9/15/2014	7	0	87	0
	Cedar Creek R2	5/29/2014	10	1	210	1
	Cedar Creek R2	9/9/2014	11	2	361	29
	Cedar Creek R2a	6/2/2014	8	1	215	3
	Cedar Creek R2a	9/9/2014	7	1	284	29
	Cedar Creek R3	6/2/2014	8	2	290	5
	Cedar Creek R3	9/10/2014	7	1	512	11
	Cedar Creek R4	7/2/2014	6	2	45	4
	Cedar Creek R4	9/18/2014	8	1	224	34
	Cedar Creek R5	9/18/2014	6	2	149	4
	Cherry Creek R1a	6/9/2014	6	1	25	8
	Cherry Creek R1a	9/2/2014	10	2	137	4
	Cherry Creek R1b	6/9/2014	9	2	122	12
	Cherry Creek R1b	9/2/2014	5	1	122	22
	Cherry Creek R2	6/12/2014	9	3	480	19
	Cherry Creek R2	9/8/2014	10	2	479	21
	O'Fallon Creek					
	Whitney Creek R1	6/25/2014	8	3	93	33

Table 3. Individual species count and origin arranged alphabetically by common species name.

Species	Native (n) or Exotic (e)	Count	% of Total Count
Bigmouth buffalo	n	1	0.02%
Black bullhead	e	136	2.55%
Brassie minnow	n	125	2.34%
Burbot	n	1	0.02%
Channel catfish	n	76	1.42%
Common carp	e	57	1.07%
Creek chub	n	337	6.32%
Emerald shiner	n	32	0.60%
Fathead minnow	n	834	15.63%
Flathead chub	n	1,019	19.10%
Goldeye	n	1	0.02%
Green sunfish	e	59	1.11%
Lake chub	n	12	0.22%
Longnose dace	n	90	1.69%
Longnose sucker	n	39	0.73%
Plains killifish	e	172	3.22%
Plains minnow	n	759	14.22%
River carpsucker	n	34	0.64%
Sand shiner	n	1,237	23.18%
Shorthead redhorse	n	16	0.30%
Smallmouth buffalo	n	4	0.07%
Stonecat	n	2	0.04%
Western silvery minnow	n	236	4.42%
White sucker	n	57	1.07%
Total	**e = 4 n = 20 Total = 24**	**5,336**	**100%**

Table 4. Number of sampled sites and sampling events (12 sampled twice) each species were observed at, along with the number of individuals recorded for each species, arranged alphabetically by common species name. Asterisk (*) indicates an exotic species.

Species	Count	# of sampling events spp observed in	# of sites spp observed at
Bigmouth buffalo	1	1	1
Black bullhead*	136	12	10
Brassie minnow	125	5	4
Burbot	1	1	1
Channel catfish	76	12	9
Common carp*	57	9	7
Creek chub	337	14	9
Emerald shiner	32	6	4
Fathead minnow	834	24	14
Flathead chub	1,019	20	12
Goldeye	1	1	1
Green sunfish*	59	13	9
Lake chub	12	2	2
Longnose dace	90	15	9
Longnose sucker	39	5	3
Plains killifish*	172	16	11
Plains minnow	759	21	14
River carpsucker	34	8	6
Sand shiner	1,237	24	13
Shorthead redhorse	16	6	5
Smallmouth buffalo	4	2	2
Stonecat	2	2	2
Western silvery minnow	236	20	12
White sucker	57	10	8
Total	**5,336**	**n = 28**	**n=16**

Stream Cross Sections

Of the 17 sites re-visited in 2014, 15 had permanent benchmarks installed between 2009 and 2012. All cross sections were re-surveyed in 2014 except for the 0m cross sections of Lone Tree Creek R2 and Owl Creek R3. The left bench mark on Lone Tree Creek R2 and the right bench mark on Owl Creek R3, both at the 0m cross sections, could not be located and at this time new bench marks have not been installed. We found the cross section data to be very similar to previous data for most sites, other than a few spots that show some erosion or deposition. For example, from the cross section data at Cherry Creek R1b 0m you can see a new pool has recently been scoured out on the right side of the cannel since 2013 (Figure 2). The cross section data from Owl Creek R3 300m shows a small dip on the left bank in 2012 that is now filled in (Figure 3).

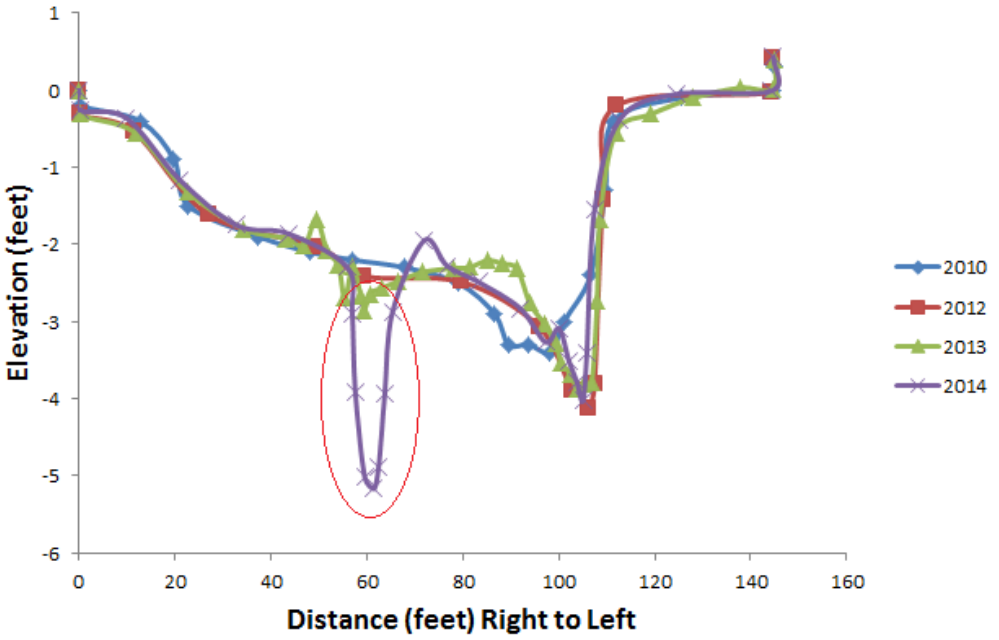

Figure 2. Cross section data from 2010 to 2014 of Cherry Creek R1b 0m. From the graph you can see a new pool, almost three feet deep, has been scoured out (red circle) on the right side of the channel since 2013.

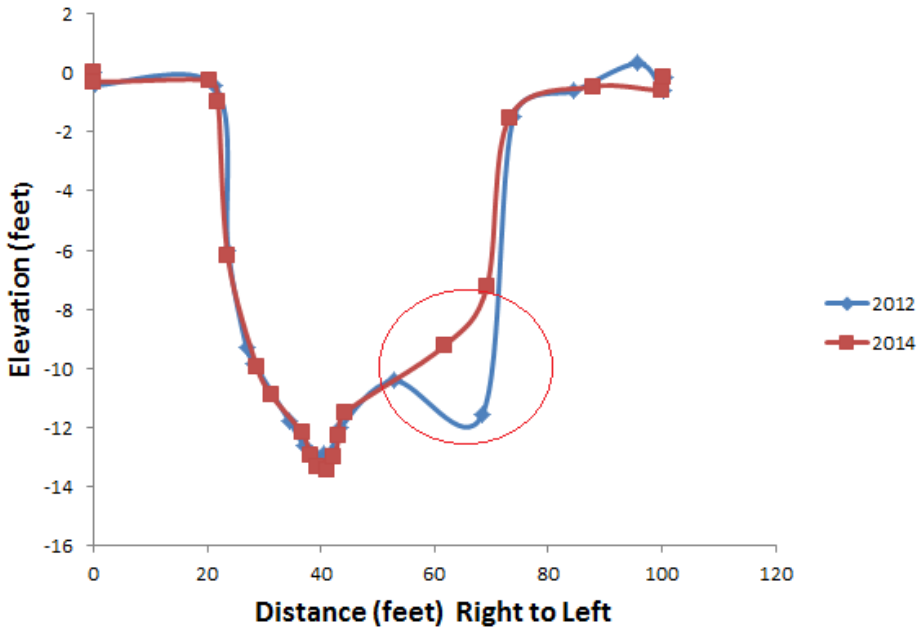

Figure 3. Cross section graph showing some deposition (red circle) that has occurred at the 300m cross section of Owl Creek R3 sometime between 2012 and 2014.

Discussion

All primary sites were re-sampled, including surveying benchmarks, once in the spring and once in the fall of 2014 (except for Cedar Creek R5) to continue monitoring efforts to gain a better understanding of the distribution and abundance of fishes that inhabit prairie streams on BLM administered public lands. Cedar Creek R5 was only sampled once in the fall due to two significant rain events (4 - 6 inches) that occurred in late spring and summer of 2014 which kept water depths in the R5 area anywhere from eight to ten feet deep. Therefore sampling did not occur on Cedar Creek R5 until fall of 2014 when water levels receded.

Overall, IBI scores for primary sites were consistent with previous years with an average of 57 out of 100 for 2014 (Table 5). Since 2010, IBI scores have averaged anywhere from 52 to 57 (Table 5). At the time of this report a detailed analysis of IBI scores has not been performed. Some variables that might explain patterns in aquatic wildlife and their habitat include grazing history, other various land-use impacts (e.g. oil and gas development), number or percent of reservoirs/ water pits blocking the natural flow regime in a watershed, roads and particularly non fish-passable culverts, and climate change. A more detailed statistical analysis may help elucidate driver variables affecting stream bio-integrity and presence or absence of species.

Table 5. IBI scores for Pumpkin, Cedar, and Cherry Creeks from 2010 to 2014, arranged alphabetically by HUC name then by stream name. Asterisk (*) indicates sampling reaches that were not sampled during that year or season, N/A indicates sampling occurred but no IBI calculated due to no catch.

HUC Name Stream Reach	**2010 spring**	**2010 fall**	**2011 Summer**	**2011 Fall**	**2012 Spring**	**2012 Fall**	**2013 Fall**	**2014 Spring**	**2014 Fall**
Lower Tongue									
Pumpkin Creek R1	59	47	58	40	60	56	49	45	55
Pumpkin Creek R2	49	47	49	50	56	53	47	56	54
Pumpkin Creek R3	45	42	48	52	50	56	45	52	48
Pumpkin Creek R4	51	43	50	53	53	58	57	54	49
Lower Yellowstone									
Cedar Creek R1	*	51	*	59	58	54	60	53	54
Cedar Creek R2	67	62	*	65	63	57	N/A	69	65
Cedar Creek R2a	54	63	*	65	66	56	62	61	55
Cedar Creek R3	52	55	*	60	63	55	66	58	55
Cedar Creek R4	55	55	*	56	51	53	54	58	59
Cedar Creek R5	56	*	*	57	61	55	56	*	59
Cherry Creek R1a	52	53	56	61	53	63	50	56	63
Cherry Creek R1b	48	46	57	63	58	62	62	59	55
Cherry Creek R2	*	60	*	60	59	62	69	59	66
Average IBI Score:	53	52	53	57	58	57	56	57	57

Lone Tree Creek R2 and R3 were re-visited in July to continue monitoring efforts alongside a stream rehabilitation and bank stabilization project. Lone Tree Creek was first inventoried in 2011 and was found to be fish-bearing but with habitat fragmentation, due to multiple reservoirs, credibly obstructing fishes from migrating up and down stream (Chaffin 2011 b). The BLM began planning to remove the Blackfoot reservoir, just upstream of Lone Tree Creek R3, and for stream restoration in 2011 (Chaffin 2011 b), which were completed over the summer of 2013. Lone Tree Creek R3 and R2 were sampled and cross sections surveyed in 2014 to continue monitoring species composition and stream morphology through the restoration process.

Lone Tree Creek R2 has always been dry or non-fish bearing (some water present but less than one foot deep) in the past (2011 and 2012) during site visits therefore sampling for fish has not occurred at R2. What once was a dry, bare stream bed in 2012 (Figure 4a) was found to be lush and green with an abundance of cattails, prairie cordgrass, and soft stem bulrush in 2014 (Figure 4b). Standing water was present throughout the cattails, about a foot deep, although we did not visually observe any fish therefore sampling for fish did not occur. The R2 area may be able to hold water better and longer now with so many cattails and other riparian vegetation present that are crucial for bank stabilization. Future monitoring of the area will provide invaluable data showing temporal changes in stream type, either positive or negative.

Cross section data recorded from R2 and R3 are facsimiles of geomorphic features observed in 2012 and 2011. On the other hand, species composition data from Lone Tree Creek R3 are very interesting, given the extent of habitat fragmentation in the area. In 2011 only two species were found in the R3 area, black bullheads and fathead minnows. Two things of note happened between 2011 and the return visit in 2012. First the number of individuals sampled increased drastically, from 51 individuals in 2011 to 3,324 in 2012. Second, there was a new species observed, green sunfish (exotic), which dominated the total catch (57%) (Table 6). The sudden presence of green sunfish in the area raises some questions. Was the green sunfish always present yet entirely missed during the sampling effort in 2011, denoting a sample not representative of the entire population in the R3 area, or was the green sunfish introduced into the area between 2011 and 2012, either through some anthropogenic act or adequate temporal flows allowing movement of aquatic species up and down stream? The species composition observed in 2014 was similar to that of 2011, in terms of number of species and individuals (Table 6); however, there were no fathead minnows, only black bullheads and green sunfish both of which are exotic species. Once again these data raise questions about the presence, or lack, of species. One point worth mentioning is there were two Cyprinid individuals observed in 2014. The two Cyprinid individuals were too small to identify beyond family level and were not large enough (>35mm) to be selective to the gear being used, therefore were not recorded. Perhaps the fathead minnow were outcompeted by non-native species, which made up 69% of the total catch in 2012. Future data collection and monitoring of the Lone Tree Creek area can help answer these and other questions.

(a) (b)

Figure 4. Lone Tree Creek R2 150m looking downstream in 2012 (a) and 2014 (b).

Table 6. Species and number of individuals of each species recorded as well as IBI scores for Lone Tree Creek R3 in 2011, 2012, and 2014.

	Lone Tree Creek R3		
Date	**Species**	**Individuals**	**IBI**
6/16/2011	Black Bullhead	8	58
	Fathead Minnow	43	
7/30/2012	Black Bullhead	390	67
	Fathead Minnow	1030	
	Green Sunfish	1904	
7/16/2014	Green Sunfish	2	65
	Black Bullhead	53	

Whitney Creek R1 and Owl Creek R3 were both re-sampled and surveyed in 2014 to begin monitoring stream morphology as well as species composition along with grazing habits. The IBI score at Whitney Creek R1 went down by 5, from 67 in 2011 to 62 in 2014. Eleven species were recorded in both 2011 and 2014. However, three species present in 2011 were not in 2014, thus there were three new species observed in 2014 that were not in 2011. The number of exotic individuals decreased from 88 found in 2011 to 33 found in 2014, then again the total number of individuals decreased considerably as well from 2011 to 2014 (Table 7). When calculating an IBI for Owl Creek R3, the score had to be reduced to 10 due to less than ten individuals recorded at the sampling site per IBI design following Bramblett et al. (2005). In 2012 there were only three species observed in Owl Creek R3, two of which were exotic species, and 68 individuals. In 2014 there were only five individuals, all of which were black bullheads, an exotic species. Owl Creek R3 had interrupted standing pools of water at the time of the survey; however, from observations of the immediate area it is evident the creek can be connected and flowing at times of high precipitation which would allow for movement up and down stream by aquatic species. With only two years of data for both Whitney Creek and Owl Creek, there is not enough data to draw any conclusions or show any trends between land management activities, in this case grazing, and the integrity of prairie streams. The cross section data recorded for both Whitney Creek and Owl Creek in 2014 compared to previous data do not show any major changes in stream morphology. However, as previously stated two years of data is inadequate to show trends and would be rash to draw any conclusions at this time. A detailed analysis of the stream morphology would be improved with multiple years of data. Consistent survey work (e.g. every 2-5 years) at our cross section locations would allow for observations in the amount of erosion and deposition at each cross section, providing an important understanding of physical processes and the effects of land-use through time in prairie streams.

Table 7. Species and number of individuals of each species recorded at Whitney Creek R1 in 2011 and 2014. Species with an asterisk (*) are exotic species, the last three species in each column are species that were observed in one year but not the other.

Whitney Creek R1

2011		**2014**	
Species	**Individuals**	**Species**	**Individuals**
Common Carp*	77	Common Carp*	5
Creek Chub	90	Creek Chub	45
Fathead Minnow	178	Fathead Minnow	15
Green Sunfish*	1	Green Sunfish*	17
Longnose Dace	6	Longnose Dace	3
Sand Shiner	46	Sand Shiner	6
Western Silvery Minnow	37	Western Silvery Minnow	1
White Sucker	58	White Sucker	21
Northern Plains Killifish*	10	Black Bullhead*	11
River Carpsucker	10	Brassy Minnow	1
Stonecat	1	Plains Minnow	1
Total Spp:	**514**	**Total Spp:**	**126**
IBI:	**67**	**IBI:**	**62**

Stream Restoration

The riparian-shrub planting project that was started on Pumpkin Creek in 2011 (Chaffin 2011 b, Stuart and Chaffin 2013 a, b) was completed in the spring of 2013, with over 4000 willow cuttings planted along with 1,150 rooted stock plants. So far we have a 56% survival rate of all rooted stock plants planted since 2011, survival rates calculated during monitoring efforts in 2014. A native prairie restoration project was started in 2013 on the surrounding uplands adjacent to Pumpkin Creek to remove non-native crested wheatgrass and make room for native shrubs and grasses that will greatly improve habitat for migratory and upland game birds, big game species, and other small mammals.

The removal of Blackfoot reservoir, on Lone Tree Creek, was completed in 2013 (Stuart and Chaffin 2013 b). Part of the reservoir was channeled to rout water through the breached section of the dam and four structures were installed downstream of the dam to stabilize the banks. The four structures installed are temporary, meant to hold in place long enough for native riparian vegetation to move in and stabilize the banks. A mix of native seeds (upland and riparian) were scattered throughout the location to reclaim disturbed areas with native vegetation. Monitoring of the area in 2014 showed 70% of seeded areas with vegetative growth, and three structures in good working conditions. One structure was slightly damaged in the spring of 2014 during high flows. The BLM plans to repair this structure and reseed the banks and uplands in 2015.

With permanent benchmarks in place in locations such as Lone Tree Creek and Pumpkin Creek where major restoration/habitat improvement projects are currently ongoing, the BLM can monitor the geomorphology and biota of these stream systems through the restoration process and beyond. From consistent survey data collected at cross section locations we can also gain a better understanding of how restoration activities may influence the geomorphology of streambeds. Prairie streams and their adjacent riparian areas provide spawning, rearing, feeding, transient, and cover habitat for many aquatic and terrestrial species across the Northern Great Plains Eco-region. With prairie grasslands and prairie streams being one of the most endangered resources in North America (Samson and Knopf 1994, Dodds et al. 2004) and the potential impacts of climate change, it is ever more important to expand our knowledge of prairie streams and enhance and conserve these fragile systems when possible.

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Appendix A. Species richness and total number of individual fish caught at each site in 2014, arranged alphabetically by HUC name then by stream name.

Field Office	HUC & Stream Name	Date	Species Richness	Total Individuals
MCFO	**Box Elder Creek (Little Missouri River)**			
	Lone Tree Creek R3	7/16/2014	2	55
	Lower Belle Fourche			
	Owl Creek R3	7/15/2014	1	5
	Lower Tongue			
	Pumpkin Creek R1	5/28/2014	7	39
	Pumpkin Creek R1	9/3/2014	12	393
	Pumpkin Creek R2	5/28/2014	11	28
	Pumpkin Creek R2	9/4/2014	9	162
	Pumpkin Creek R3	5/28/2014	9	26
	Pumpkin Creek R3	9/3/2014	8	50
	Pumpkin Creek R4	5/27/2014	10	41
	Pumpkin Creek R4	9/4/2014	11	343
	Lower Yellowstone			
	Cedar Creek R1	6/3/2014	7	120
	Cedar Creek R1	9/15/2014	7	87
	Cedar Creek R2	5/29/2014	11	211
	Cedar Creek R2	9/9/2014	13	390
	Cedar Creek R2a	6/2/2014	9	218
	Cedar Creek R2a	9/9/2014	8	313
	Cedar Creek R3	6/2/2014	10	295
	Cedar Creek R3	9/10/2014	8	523
	Cedar Creek R4	7/2/2014	8	49
	Cedar Creek R4	9/18/2014	9	258
	Cedar Creek R5	9/18/2014	8	153
	Cherry Creek R1a	6/9/2014	7	33
	Cherry Creek R1a	9/2/2014	12	141
	Cherry Creek R1b	6/9/2014	11	134
	Cherry Creek R1b	9/2/2014	6	144
	Cherry Creek R2	6/12/2014	12	499
	Cherry Creek R2	9/8/2014	12	500
	O'Fallon Creek			
	Whitney Creek R1	6/25/2014	11	126

Appendix B. Number of individuals per species caught at individual sites in 2014, arranged alphabetically by HUC name then by stream name. Numbers arranged longitudinally (e.g. 112 sand shiners caught at Pumpkin Creek R1 9/3).

Sampling Reach (Date)	Bigmouth buffalo	Black bullhead	Brassie minnow	Burbot	Channel catfish	Common carp	Creek chub	Emerald shiner	Fathead minnow	Flathead chub	Goldeye	Green sunfish	Lake chub	Longnose dace	Longnose sucker	Plains killifish	Plains minnow	River carpsucker	Sand shiner	Shorthead redhorse	Smallmouth buffalo	Stonecat	Western silvery minnow	White sucker
MCFO																								
Box Elder																								
Lone Tree Creek R3 (7/16)		53										2												
Lower Belle Fourche																								
Owl Creek R3 (7/15)		5																						
Lower Tongue																								
Pumpkin Creek R1 (5/28)									5	6		1					1	2	16				8	
Pumpkin Creek R1 (9/3)		23			40	31			54	45		2					16	19	112	3			47	1
Pumpkin Creek R2 (5/28)					1				5	6		1		1			2	2	7			1	1	1
Pumpkin Creek R2 (9/4)					14	1			34	10		4				3			89				5	2
Pumpkin Creek R3 (5/28)		3			1	3				4	1	1					8		4					1
Pumpkin Creek R3 (9/3)		13				4			7			3				1			20				1	1
Pumpkin Creek R4 (5/27)				1	1	1			4	5				7			7	1	5				9	
Pumpkin Creek R4 (9/4)		14			4	4			54	6		5		12		7	1		231				5	
Lower Yellowstone																								
Cedar Creek R1 (6/3)			24		1			3	1	64							22						5	
Cedar Creek R1 (9/15)	1						1	4		59								2	4				16	

Sampling Reach (Date)	Bigmouth buffalo	Black bullhead	Brassie minnow	Burbot	Channel catfish	Common carp	Creek chub	Emerald shiner	Fathead minnow	Flathead chub	Goldeye	Green sunfish	Lake chub	Longnose dace	Longnose sucker	Plains killifish	Plains minnow	River carpsucker	Sand shiner	Shorthead redhorse	Smallmouth buffalo	Stonecat	Western silvery minnow	White sucker
Cedar Creek R2 (5/29)		1	84		3				1	40				5			56	5	7	1			8	
Cedar Creek R2 (9/9)					8	7		5	62	142				10		22	6	2	98		2		25	1
Cedar Creek R2a (6/2)					1		1		19	90				12		3	58		30				4	
Cedar Creek R2a (9/9)							1		76	88				13		29	49		41				16	
Cedar Creek R3 (6/2)		1			1		1		22	181				3		4	49		29				4	
Cedar Creek R3 (9/10)							2		30	205				12		11	189		72				2	
Cedar Creek R4 (7/2)		1							4	19				3	2	3	10		7					
Cedar Creek R4 (9/18)					1		2		44	21				1		34	129		25					1
Cedar Creek R5 (9/18)						1	7		36	26			10	1		3	69							
Cherry Creek R1a (6/9)							7	2	2						3	8			9	2				
Cherry Creek R1a (9/2)							34	14	3	1		1			1	3	4		24	3			52	1
Cherry Creek R1b (6/9)							35	4	3	1		1		4		11	7		64	2			2	
Cherry Creek R1b (9/2)							42		3					3		22			73			1		
Cherry Creek R2 (6/12)		5	5				30		230			6	2		21	8	23	1	161				7	
Cherry Creek R2 (9/8)		6	11				129		120			15			12		52		103	5	2		18	27
O'Fallon Creek																								
Whitney Creek R1 (6/25)		11	1			5	45		15			17		3			1		6				1	21

Appendix C. Physical habitat characteristics of sites arranged alphabetically by HUC name then by stream name. Left and right bank depths were measured 5 cm from the water's edge. Wetted width, left bank, center, and right bank are the average of 11 individual measurements. Thalweg is an average of 100 individual measurements.

HUC Stream Name	**Date**	**Wetted Width (m)**	**Left Bank (cm)**	**Center (cm)**	**Right Bank (cm)**	**Thalweg (cm)**
MCFO						
Boxelder Creek (Little Missouri R)						
Lone Tree Creek R3 Boxelder Creek	7/16/2014	12.8	14.9	124.0	33.9	126.1
Lower Belle Fourche River						
Owl Creek R3	7/15/2014	0.6	10.8	14.9	6.9	27.2
Lower Tongue River						
Pumpkin Creek R1	5/28/2014	9.6	15.4	77.3	17.5	82.2
Pumpkin Creek R1	9/3/2014	9.1	6.9	56.9	4.3	79.4
Pumpkin Creek R2	5/28/2014	4.5	44.4	90.7	30.0	89.3
Pumpkin Creek R2	9/4/2014	4.4	13.1	78.5	21.7	76.3
Pumpkin Creek R3	5/27/2014	2.8	16.2	66.8	32.4	66.0
Pumpkin Creek R3	9/3/2014	2.2	8.2	39.9	10.5	37.0
Pumpkin Creek R4	5/27/2014	4.6	21.1	49.9	10.1	60.3
Pumpkin Creek R4	9/4/2014	4.3	9.3	36.4	11.2	40.9
Lower Yellowstone River						
Cedar Creek R1	6/3/2014	10.3	9.4	65.5	9.2	68.3
Cedar Creek R1	9/15/2014	7.0	4.5	17.1	7.5	23.3
Cedar Creek R2	5/29/2014	5.8	22.5	34.1	21.6	41.8
Cedar Creek R2	9/9/2014	3.6	26.5	30.6	20.0	33.6
Cedar Creek R2a	6/2/2014	3.1	15.8	25.3	19.4	26.9
Cedar Creek R2a	9/9/2014	3.9	13.9	25.1	22.3	35.5
Cedar Creek R3	6/2/2014	3.6	13.6	34.1	20.8	43.4
Cedar Creek R3	9/10/2014	3.9	11.9	36.6	23.1	46.3
Cedar Creek R4	7/2/2014	6.0	10.4	47.4	21.9	59.0
Cedar Creek R4	9/18/2014	4.4	19.2	29.6	14.2	34.7
Cedar Creek R5	9/18/2014	1.4	19.9	50.2	17.0	42.1
Cherry Creek R1a	6/9/2014	7.2	3.6	27.0	9.7	37.5
Cherry Creek R1a	9/2/2014	7.9	8.5	20.7	7.7	33.9
Cherry Creek R1b	6/9/2014	5.0	6.5	18.8	8.4	31.1
Cherry Creek R1b	9/2/2014	6.0	7.5	23.5	9.8	28.7
Cherry Creek R2	6/12/2014	5.0	18.4	41.6	15.6	53.8
Cherry Creek R2	9/8/2014	5.4	15.5	45.6	6.7	51.2
O'Fallon Creek						
Whitney Creek R1	6/25/2014	5.1	7.7	53.0	15.3	54.3

Appendix D. Water quality characteristics of sites arranged alphabetically by HUC name then by stream name.

HUC Stream Name	Date	Conductivity (µS/cm)	pH	DO (%sat)	Water Temp (°C)	Air Temp (°F)
MCFO						
Boxelder Creek (Little Missouri R)						
Lone Tree Creek R3 Boxelder Creek	7/16/2014	2741	6.95	40.8	19.4	88
Lower Belle Fourche River						
Owl Creek R3	7/15/2014	3119	6.94	64.0	19.5	80
Lower Tongue River						
Pumpkin Creek R1	5/28/2014	6163	8.08	98.1	26.7	84
Pumpkin Creek R1	9/3/2014	1845	8.25	84.8	19.6	88
Pumpkin Creek R2	5/28/2014	7317	8.36	91.8	24.0	85
Pumpkin Creek R2	9/4/2014	2082	8.38	82.0	14.9	N/A
Pumpkin Creek R3	5/27/2014	7145	8.03	91.5	26.4	78
Pumpkin Creek R3	9/3/2014	1361	8.56	70.5	15.2	71
Pumpkin Creek R4	5/27/2014	3685	8.14	81.0	20.9	72
Pumpkin Creek R4	9/4/2014	1572	8.59	79.6	13.9	52
Lower Yellowstone River						
Cedar Creek R1	6/3/2014	3524	8.46	97.5	19.9	69
Cedar Creek R1	9/15/2014	3729	8.50	95.5	10.8	59
Cedar Creek R2	5/29/2014	5362	7.84	85.4	23.9	79
Cedar Creek R2	9/9/2014	6516	8.56	82.0	15.6	48
Cedar Creek R2a	6/2/2014	3534	9.02	122.8	22.2	66
Cedar Creek R2a	9/9/2014	6268	8.54	94.7	14.5	50
Cedar Creek R3	6/2/2014	2851	8.50	96.2	16.8	59
Cedar Creek R3	9/10/2014	4754	8.52	91.3	12.2	38
Cedar Creek R4	7/2/2014	3241	8.36	93.3	20.4	81
Cedar Creek R4	9/18/2014	4634	8.40	100.0	19.7	80
Cedar Creek R5	9/18/2014	4533	7.75	86.1	14.3	72
Cherry Creek R1a	6/9/2014	3645	8.05	82.1	17.1	71
Cherry Creek R1a	9/2/2014	3499	8.25	77.5	22.1	79
Cherry Creek R1b	6/9/2014	4085	8.29	86.4	21.4	84
Cherry Creek R1b	9/2/2014	3075	8.27	88.7	17.0	74
Cherry Creek R2	6/12/2014	3734	8.20	72.2	14.4	62
Cherry Creek R2	9/8/2014	3795	8.07	76.7	15.4	71
O'Fallon Creek						
Whitney Creek R1	6/25/2014	5250	7.67	51.2	20.0	79