Prairie Stream Surveys on BLM Public Lands in Eastern Montana and South Dakota 2012 Surveys

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November 2013

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Cover photo: Cedar Creek R5, Wibaux County, Montana. June 5, 2012.

Introduction

Prairie streams are an essential resource in the Northern Great Plains eco-region for many aquatic and terrestrial wildlife species. These streams and adjacent riparian areas provide spawning, rearing, feeding, transient, and cover habitat. Prairie streams do not receive as much attention as their mountain stream counterparts, probably in large part due to a lack of angling opportunities. Additionally, it is common folklore to assume that many prairie streams do not contain fish because they are muddy, too warm, not enough water, etc. However, organisms that exist in the prairie stream ecosystem have adapted to turbid water, extremes of hot and cold temperatures, and perennial pools of intermittent streams (Matthews 1988).

The BLM manages prairie stream habitat across central-eastern Montana and the western Dakotas. This project focuses on four field offices: Billings, (BiFO), Miles City (MCFO), North Dakota (NDFO), and South Dakota (SDFO), with the majority of prairie streams located in MCFO and SDFO. The BLM has never completed a thorough inventory of the streams that cross through BLM surface in this larger area. Surveys have been performed as the need arises, with varying methodologies, and across a wide temporal spectrum. This is a concern when resource managers are responsible for preserving aquatic wildlife habitat, stream function, and the native biodiversity within these systems. It is also difficult to determine the impacts of land-use activities without a quantitative monitoring system that specifically targets a basic understanding of stream habitat and the biota within.

In 2009 prairie stream surveys began on BLM public lands, and will be complete in 2013. In 2012 BLM continued inventory of prairie streams in MCFO and SDFO with four main objectives:

(1) Inventory streams on BLM surface including small streams typically assumed non-fish bearing and those streams far from roads.

(2) Conduct surveys that are repeatable, quantitative, and efficient; design the surveys so they are spatially explicit and will expedite future monitoring efforts.

(3) Identify and record locations where streams are degraded and would be enhanced with future stream restoration projects.

(4) Continue to build a database (general and GIS) that stores all this data. This will assist BLM resource managers by having similar, current, and spatially explicit data across this larger area.

Methods

Site Selection

Prairie streams dissecting more than a half mile of BLM public lands were inventoried and surveyed when water was present. Fish in prairie streams are known to tolerate warm temperatures in disconnected-perennial pools in intermittent streams. However, based on previous years experience we assumed a stream was non-fish bearing when disconnected pools were less than 0.25m deep and we could walk and visually search for fish. The non-fish bearing designation is considered a dynamic term where the status can change annually, bi-annually, or even with a particular storm event. Further, the absence of fish in a particular stream reach does not preclude the possibility of fish presence upstream or downstream of the surveyed reach.

In this region BLM public lands have a predominant checkerboard pattern. Streams that crossed less than a half-mile of BLM lands were typically not sampled.

When visiting a site the entire stream reach was walked to determine if water was present and to make some general qualitative notes (overall condition of stream, anthropogenic impacts, visually look for fish, etc). An actual sampling location was determined by choosing a 300 meter sampling reach that was representative of the longer BLM stream reach. The 300m reach geographical data was captured with GIS (see Figure 1). Multiple reaches were set up on an individual stream when necessary.

Three streams (Pumpkin, Cherry, and Cedar) are monitoring sites that began in 2010. These sites will be monitored twice annually after this initial sampling effort across BLM streams is complete. This will give a long (years) and short (seasonality) temporal perspective of prairie streams managed by BLM. This will also give the potential to monitor potential stream restoration projects.

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 species 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. In rare cases voucher samples were collected to verify identification in the lab.

Habitat data were collected following Bramblett (2005). 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. For this method substrate size is a categorical ranking including sand, silt, fine gravel, coarse gravel, cobble, boulder, bedrock, wood, hardpan, and an other category. 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 temp (˚C) recorded with an YSI Pro2030 water quality meter (YSI Inc. Yellow Spring, OH), pH recorded with an Extech meter (Extech Instruments, Waltham MA), and air temp was recorded with a handheld thermister.

Stream Cross Sections

In addition to fish and habitat surveys, cross sections with benchmarks were set-up at sites where the streamcrossed one mile or more of BLM public lands (Figure 1). The 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). An electronic data monitor or total station (Sokkia Co. Ltd) was used to survey elevation changes between each benchmark. Measurements were taken at two to five 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. A Trimble GeoXT GPS unit was used to store point geographical data for the benchmarks. The GPS point data was differentially corrected in the office to provide the most accurate point data possible for locating benchmarks during future monitoring.

Pumpkin, Cedar, and Cherry Creeks are primary sites that are sampled twice a season in early summer and fall. There are 13 reaches total, with four at Pumpkin Creek, six at Cedar Creek and three at Cherry Creek. All reaches dissect more than a mile of BLM public lands and had permanent benchmarks installed in 2010 except for Cedar Creek R1 and R2a. The cross sections at the primary sites were surveyed again in 2012 to allow for comparison across years in this report.

Figure 1. Aerial image of Pumpkin Creek R1. Red dots indicate rebar benchmarks installed on either side of the channel for each of 3 cross-sections. The blue line indicates the 300m sampling reach where fish and habitat surveys were conducted.

<u>Database & Data Analysis</u>

A database specific to this project was built in 2010 and continues to be upgraded. The database will allow easy extraction of data for resources 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. Initial GIS data was derived from NHD, whereas our GPS data will provide exact locations of our study reaches and benchmarks. Additionally, raw fish data was 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).

Stream cross section raw data from 2010 to 2012 were entered into Excel. The data were corrected (for X, Y and Z coordinates of each benchmark and each point recorded between the benchmarks) and uploaded to Global Mapper (a topographic mapping software program) to compare elevation changes between years at each cross section.

Results

<u>Sites</u>

In 2012, approximately 94 stream miles (45 sites) were inventoried on BLM public lands across two BLM field offices. We sampled 24 of the 45 sites that were inventoried. All 24 sampling reaches were fish-bearing. One site, Lone Tree Creek R2, was re-surveyed at all three cross sections, but was not sampled for fish because it was dry at the time of site visit. Of the 24 sampling reaches, 13 were sampled twice (Primary sites: Pumpkin, Cherry, and Cedar Creeks) which yields a total sample size of n=37. The remaining 20 sites, out of the 45 inventoried, were assumed to be non-fish bearing, based on visual examination. The sites, dates, type of sampling conducted, stream reach length, watershed area, and IBI scores are listed in Table 1.

Table 1. Streams sampled in 2012, arranged by field office then alphabetically by Hydrologic Unit Code (HUC) 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 or non-fish bearing reach. IBI scores calculated according to Bramblett (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	**Big Dry**						
	Santo Arroyo Creek	8/2/2012	N	1	1.12	193	N/A
	Woody Creek R1	8/6/2012	F	1,2	2.33	36,669	61
	Big Porcupine						
	Big Porcupine Creek R1	6/13/2012	F	1,2,3	2.23	8,082	67
	McGinnis Creek R1	6/8/2012	F	1,2	1.53	32,969	50
	Box Elder Creek (Little Missouri River)						
	Lone Tree Creek R1	7/31/2012	N	1	1.28	4938	N/A
	Lone Tree Creek R2	7/31/2012	N	1,3	0.86	3033	N/A
	Lone Tree Creek R3	7/30/2012	F	1,2,3	0.85	2841	67
	Fort Peck Reservoir						
	Bear Creek R1	8/8/2012	F	1,2	0.53	2,773	72
	Coal Creek	8/7/2012	N	1	4.03	4,105	N/A
	Flat Creek	8/14/2012	F	1	5.15	13,324	N/A
	Rough Prong Creek	8/8/2012	N	1	4.07	2,843	N/A
	Snow Creek R1	8/14/2012	F	1,2,3	4.26	17,699	64
	Unnamed Tributary (T21NR41E Sec 3)	8/14/2012	N	1	1.42	5,831	N/A
	Unnamed Tributary (T21NR42E Sec 29,30)	8/14/2012	N	1	1.52	777	N/A
	Little Dry						
	Phillips Creek	8/2/2012	N	1	1.17	363	N/A
	Taylor Creek R1	8/6/2012	F	1,2	1.44	744	78
	Lower Belle Fourche						
	Owl Creek R3	6/21/2012	F	1,2,3	5.29	1,785	72
	Lower Tongue						
	Pumpkin Creek R1	5/9/2012	F	1,2,3	0.81	179,019	60

Field Office	HUC Name Stream Reach	Date	Fish Present	Survey Type (1,2,3)	Miles of stream	Watershed Area (ha)	IBI Score
MCFO	Pumpkin Creek R1	9/5/2012	F	1,2		179,019	56
	Pumpkin Creek R2	5/10/2012	F	1,2,3	3.2	178,434	56
	Pumpkin Creek R2	9/5/2012	F	1,2		178,434	53
	Pumpkin Creek R3	5/10/2012	F	1,2,3	2.58	165,910	50
	Pumpkin Creek R3	9/6/2012	F	1,2		165,910	56
	Pumpkin Creek R4	5/11/2012	F	1,2,3	1.57	164,040	53
	Pumpkin Creek R4	9/6/2012	F	1,2		164,040	58
	Lower Yellowstone						
	Cedar Creek R1	5/21/2012	F	1,2	0.33	54,473	58
	Cedar Creek R1	9/4/2012	F	1,2		54,473	54
	Cedar Creek R2	5/21/2012	F	1,2,3	2.37	45,488	63
	Cedar Creek R2	8/29/2012	F	1,2		45,488	57
	Cedar Creek R2a	5/22/2012	F	1,2	0.55	44,455	66
	Cedar Creek R2a	8/29/2012	F	1,2		44,455	56
	Cedar Creek R3	5/24/2012	F	1,2,3	4.38	42,807	63
	Cedar Creek R3	8/28/2012	F	1,2		42,807	55
	Cedar Creek R4	5/25/2012	F	1,2,3	9.9	41,471	51
	Cedar Creek R4	8/28/2012	F	1,2		41,471	53
	Cedar Creek R5	6/5/2012	F	1,2,3	1.06	30,279	61
	Cedar Creek R5	8/27/2012	F	1,2		30,279	55
	Cherry Creek R1a	5/16/2012	F	1,2,3	0.76	58,674	53
	Cherry Creek R1a	8/30/2012	F	1,2		58,674	63
	Cherry Creek R1b	5/15/2012	F	1,2,3	1.26	58,503	58
	Cherry Creek R1b	8/30/2012	F	1,2		58,503	62
	Cherry Creek R2	5/16/2012	F	1,2,3	1.51	56,579	59
	Cherry Creek R2	8/31/2012	F	1,2		56,579	62
	Middle Little Missouri						
	Cannonball Creek R1	7/2/2012	F	1,2,3	1.37	3,818	76
	South Fork Cannonball Creek	7/3/2012	N	1	2.11	1,307	N/A
	Middle Powder River						
	Hell Creek	6/7/2012	N	1	2.29	466	N/A
	Little Powder River						
	Pine Creek Little Powder River	6/7/2012	N	1	2.33	1,036	N/A
	Upper Little Missouri						
	South Beaver Dam Creek R1	6/20/2012	F	1,2,3	1.99	4,209	70

Field Office	HUC Name Stream Reach	Date	Fish Present	Survey Type (1,2,3)	Miles of stream	Watershed Area (ha)	IBI Score
SDFO	**Bad River**						
	Ash Creek	7/16/2012	N	1	2.67	5,712	N/A
	Willow Creek R1	7/18/2012	F	1,2	0.51	25,848	70
	Lower Lake Oahe						
	Foster Creek	7/18/2012	N	1	2.12	3,950	N/A
	Mission Creek	7/17/2012	N	1	1.75	2,640	N/A
	Unnamed Tributary (T9NR26E Sec 24)	7/17/2012	N	1	1.44	489	N/A
	Upper Moreau River						
	Big Cedar Creek	6/26/2012	N	1	1.48		N/A
	Lower Belle Fourche River						
	East Badlands Creek	6/27/2012	N	1	1.5	4,336	N/A
	Middle Badlands Creek	6/28/2012	N	1	0.9	3,290	N/A
	Second Bull Creek	6/27/2012	N	1	0.78	992	N/A
	West Badlands Creek	6/27/2012	N	1	1.2	3,787	N/A

Fish and Habitat Surveys

A total of 47,621 fish were sampled in 2012, making up 6 families and 24 individual species (Table 2). The catch was dominated by native fishes, with 83.7% of the total catch comprised of native individuals; 39,871 native individuals and 7,750 exotic individuals. The most widely distributed species observed was the fathead minnow, occurring at all sampled sites (n=37 sampling events on 24 sampling reaches). The fathead minnow was also the most common species sampled with 13,402 individuals, comprising over 28% of all recorded individuals. We found plains killifish at 65% of our sampled sites, making the plains killifish the most widely distributed exotic species. Plains killifish was the most numerous exotic species as well, with 4,532 individuals. The number of species recorded at a site ranged from 1 to 16, while the number of individuals ranged from 68 to 6,964. The highest species richness, 16, and highest native species richness, 12, were recorded at Pumpkin Creek R1 (May sampling event). The highest exotic species richness recorded was 5 species at Cherry Creek R2 (August sampling event). There was an average of 8.5 species per site, and an average of 1,287 individuals per site. 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.

The size of streams generally decreased from spring to fall which likely affected the amount of available habitat. For example, Over 75% of our thirteen primary sites had flowing water or continuous standing water throughout the sampling reach in the spring while only 15% of the primary sites had flowing water on the return visit in the fall. At primary sites, species richness generally increased from spring to fall sampling events, while total individual counts primarily decreased from spring to fall (Table 3). Over 60% of all sampling events (n=37) had interrupted standing pools of water. Sampled streams had a mean wetted width of 2.9 m and an average center depth of 28.3 cm. General habitat and water quality characteristics are presented in Appendix C and D.

Table 2. Individual species count and origin arranged alphabetically by species common name.

Species	Native (n) or Exotic (e)	Count	% of Total Count
Black bullhead	e	540	1.13%
Black crappie	e	16	0.03%
Brassy minnow	n	8	0.02%
Channel catfish	n	181	0.38%
Common carp	e	147	0.31%
Creek chub	n	1,165	2.45%
Fathead minnow	n	13,402	28.14%
Flathead chub	n	6,594	13.85%
Green sunfish	e	2,479	5.21%
Lake chub	n	151	0.32%
Longnose dace	n	247	0.52%
Longnose sucker	n	86	0.18%
Plains killifish	e	4,532	9.52%
Pumpkinseed	e	1	< 0.01%
Plains minnow	n	10,879	22.84%
Red shiner	n	172	0.36%
River carpsucker	n	478	1.00%
Sand shiner	n	5,176	10.87%
Shorthead redhorse	n	21	0.04%
Smallmouth buffalo	n	6	0.01%
Stonecat	n	3	0.01%
Western silvery minnow	n	1,123	2.36%
White sucker	n	179	0.38%
Yellow perch	e	35	0.07%
Total	**e = 7 n = 17 Total = 24**	**47,621**	**100%**

Table 3. Species richness and total individuals observed at Pumpkin, Cedar and Cherry Creeks in 2012.

	Spring		Fall	
Stream Name	**Species Richness**	**Total Individuals**	**Species Richness**	**Total Individuals**
Pumpkin Creek R1	16	1861	13	327
Pumpkin Creek R2	11	1260	12	558
Pumpkin Creek R3	9	168	10	391
Pumpkin Creek R4	11	1250	12	884
Cedar Creek R1	10	4536	6	166
Cedar Creek R2	11	4344	8	549
Cedar Creek R2a	12	2408	7	740
Cedar Creek R3	11	1686	7	237
Cedar Creek R4	6	2362	7	1389
Cedar Creek R5	7	109	8	518
Cherry Creek R1a	8	160	10	250
Cherry Creek R1b	9	294	11	425
Cherry Creek R2	11	1688	12	1013

Discussion

Since 2009, approximately 625 stream miles have been inventoried on BLM public lands. These surveys completed by the BLM, and stream surveys completed by Montana Fish, Wildlife, and Parks (MFWP) from 2003-2006 (Ostovar, 2007) have begun to improve our baseline understanding of distribution and abundance of prairie stream fishes and their habitat. Prairie streams are very unpredictable when it comes to water and flow (Matthew 1988). Prairie stream biota move across a landscape that includes drying, flooding, and iced-over conditions. Throughout the summer a lack of precipitation can decrease the amount of habitat, subsequently reducing available resources. The loss of habitat may allow other local driver variables, such as competition, to decrease the abundance of aquatic wildlife. For example, the total individuals sampled at our primary sites generally decreased from spring to fall sampling events (Table 3). The amount of water available decreased as well during the course of a very hot and dry summer. Over 75% of the stream reaches at our primary sites had flowing or continuous standing water in the spring, while only 15 % had flowing water during the return visit in the fall. Similarly, the average wetted width at our primary sites was 3.8 m in the spring and only 1.9 m in the fall. This may be a mechanism for density-dependent and density-independent interactions at a local scale. For example, fish species will become trapped in intermittent pools as streams dry up due to a lack of precipitation and extreme temperatures. Fish species in shallower pools will die off as the water dries up (density independent). In larger refuge-pools, smaller 'prey fish' may experience increased predation with decreased cover habitat (density dependent).

Some prairie streams inventoried on BLM lands were recorded as non-fish bearing (Table 1). However, this classification only means the section of stream crossing BLM land was dry at that time. It is possible for a pool of water, large enough to support aquatic wildlife, to be further upstream or downstream of the BLM portion of the stream. For example, Taylor Creek was dry and looked like an ephemeral stream along the entire length of BLM land except for one 60 m long pool. When sampled we only found one species, fathead minnow, but there were over 4,000 individuals sampled in this one pool. Had this pool been further upstream on private land, we would have labeled the stream non-fish bearing and moved on. The time of year when a site is sampled can also affect whether a stream is classified as fish bearing or not. The amount of water in prairie streams can change not only from year to year, but also from season to season and sometimes even from day to day (Matthews 1988). For example, stream inventory in the summer of 2011 occurred during a very wet year with 65 inventoried sites recorded as fish bearing streams with water present. 45 additional sites were found to be non-fish bearing. Of these 45 sites, 80% of them were inventoried in July, August, or September. Had we inventoried these sites earlier in the year, we might have found some sites to have water and fish present. Furthermore, a local rancher mentioned Taylor Creek had been connected and flowing once in the spring of 2011 for about a month. These data show how important refuge-pools are in sustaining aquatic wildlife throughout the year. That one pool at Taylor Creek, sampled in August 2012, held enough water to sustain aquatic wildlife during a drying stage, since late summer 2011. During the next high rainfall or spring snow melt event, Taylor Creek may return to a flowing stage once again which would allow fish to re-distribute up and downstream. A stream that we have labeled as non-fish bearing this year has the potential to be an ephemeral pool, and hence important fish habitat, in the future. In-stream habitat constantly changes in prairie stream systems and the fish and other aquatic species are adapted to and respond favorably to these changes (Matthews 1988).

Despite the apparent hardiness of prairie streams, Dodds et al. (2004) describes prairie streams as fragile systems on the brink of collapse in many cases due to a legacy of varied land use disturbances. Overall, we have found low IBI scores, with an average of 58 out of 100, from all sites sampled since 2010 (n=158). In 2012 the average IBI score was 60 out of 100 (Table 1). IBI scores from the primary sites (Pumpkin Creek, Cherry Creek, Cedar Creek), which have been monitored annually since 2010, have increased each year. The average IBI score from all primary sites sampled were 53, 55, and 57 in 2010 (n=23), 2011 (n=20), and 2012 (n=26) respectively. At the time of this report, a detailed analysis of IBI scores has not been conducted. Likely there are multiple factors affecting IBI scores, species richness, etc. 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.

Nonnative species may also be a factor in the distribution and abundance of prairie stream fishes (Ostovar 2007). Exotic species were common, occurring in 89% of our sampling events. There are many sport-fish reservoirs (or prairie fishing ponds) in this region. They were historically or currently stocked (both to encourage angling opportunities and illegally) with various exotic fish species which probably contributed to the number of exotic species on the prairie stream landscape. Out of four regions inventoried in Montana, Ostovar (2007) found the greatest number of nonnative fishes to be in this southeastern region of Montana. Additionally, large rivers such as the Yellowstone, Missouri, and Tongue Rivers are also a constant source of exotic species to the smaller streams.

Stream Cross Sections

All cross section data from 2010 to 2012 have been entered into the BLM database. BLM is in the beginning stages of entering cross section data in Global Mapper and linking this data with benchmarks (from GPS points) in a GIS framework. We can compare the cross section data across different years at each site to observe the amount of erosion or deposition that occurs along each cross section. At the time of this report a detailed analysis of the stream morphology has not been conducted. A detailed analysis would be improved with multiple years of data. Consistent survey work (e.g. every 2-5 years) at our cross section locations would provide an important understanding of physical processes and the effects of land-use through time in prairie streams. With the two years of data there is evidence of erosion at some sites, most notably Pumpkin Creek R1. Surveys for Pumpkin Creek were completed in 2010 and 2012. In 2011 Eastern Montana experienced high and later than usual spring runoff that caused extensive flooding across eastern Montana and the Dakotas. Some of the banks eroded away along Pumpkin Creek, which is evident from the survey data taken before and after the flooding event in 2011 (Figure 2). Our photo point surveys provide good visual evidence as well on how quickly geomorphic features of prairie streams can change (Figure 3). Consistent survey work would give resource managers an understanding of how streams change physically and how land-use or restoration activities may influence the geomorphology of streambeds.

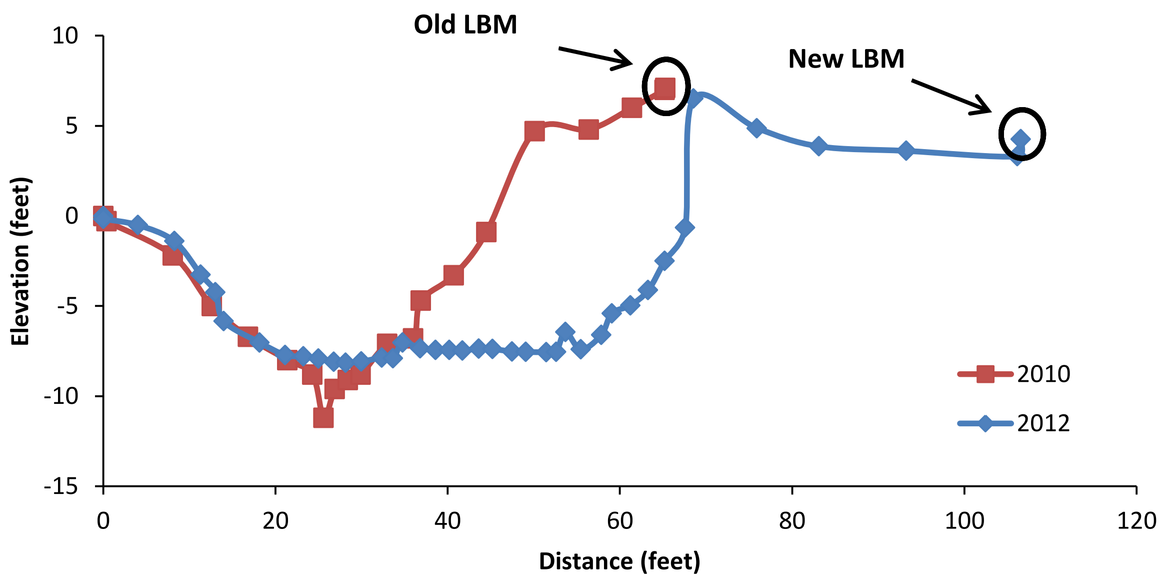

Figure 2. Cross sections (300 m) from 2010 and 2012 at Pumpkin Creek R1. Left benchmark (LBM) from 2010 was washed away when the stream bank eroded away to the current profile depicted by the 2012 survey data. New LBM was installed 40 feet away from previous benchmark.

Figure 3. Photographs of 300 m cross section facing upstream at Pumpkin Creek R1, pictures were taken in 2010 (left) and 2012 (right) standing in the same location in the stream.

Stream Restoration

A central premise for this project was that inventory would lead to identification of impaired streams and identify locations for future restoration projects. Since 2010, several stream restoration projects have been initiated, and several more identified for the near future. Provided are a few examples.

Pumpkin Creek, which flows into the Tongue River, is one of our core sampling locations that BLM plans to monitor bi-annually even after this inventory effort is over. Pumpkin Creek is just 15 miles south of Miles City, a perennial stream system stretching nine miles through BLM public lands. The BLM acquired and traded for lands in 2006 that left 9.2 stream miles, and over 1700 acres of riparian area and adjacent uplands, in federal ownership. Historically, this stream reach had been channelized in order to accommodate and irrigate intense hayfield conversion of the riparian area and adjacent uplands. Additionally, it was intensely grazed as winter pasture. Currently, the BLM is in the process of working on restoration projects and recreation/management planning for the area is also planned for the near future. There has been no land-use on this area, including grazing, since 2006. In 2011 a 4 year riparian-shrub planting project was undertaken. In April 2011 around 3000 willow and cottonwood cuttings were planted in the furthest upstream reach (Pumpkin Creek R4). Additionally, approximately 75 buffaloberry seedlings were planted in this reach with small enclosures. As of August 2011 the plantings overall had high survival. This spring, April 2012, the second phase of the planting project was carried out along Pumpkin Creek R3, the next downstream reach. There were about 7000 willow cuttings and a total of 1,640 rooted stock plants: 766 buffaloberry, 413 golden currant, 171 boxelder, 180 sandbar willow and 110 redosier dogwood seedlings. The majority of the seedlings were planted with small enclosures to help protect the seedlings. In 2013 BLM will continue to plant willows, cottonwoods, and buffaloberry in the downstream 4 miles of Pumpkin Creek. Another phase of Pumpkin Creek restoration is to consider bank stabilization projects. If permitting and NEPA can be accomplished and additional funds are secured, BLM may consider beginning a bank stabilization project on Pumpkin Creek in 2014. Starting in summer 2014 adjacent uplands on BLM public lands will also undergo a native prairie restoration/habitat improvement project. This project will replace non-native vegetation with native shrubs and grasses that will greatly improve habitat for a suite of wildlife species. This habitat improvement project will not only benefit migratory and upland game birds, but also big game species and other small mammals. All told this will be a 1700 acre habitat improvement project with a restored prairie stream running through the middle of it. Finally, with benchmarks and monitoring locations in place BLM will monitor the geomorphology and biota of this prairie stream through the restoration process and beyond.

Harris Creek, which empties into the Yellowstone River several miles east of Miles City, was an inventory site in 2009 and 2010 for this project. In 2012 restoration projects began here. This project included riparian fencing and water gaps to decrease livestock use on the stream and incorporated willow and cottonwood plantings.

Lone Tree Creek is a small ephemeral/intermittent system south of Ekalaka, MT. This stream was inventoried in 2011. Lone Tree Creek was fish-bearing but habitat fragmentation, due to reservoirs, probably does not allow fish and other aquatic species to migrate up and down the system. One large reservoir with a retention dam on BLM lands that blocks this creek has failed. Rather than rebuild it the BLM is in the process of planning for dam removal and stream rehabilitation. This will be a unique project on a prairie stream in the Northern Great Plains eco-region. This project should provide a model for similar projects across the Northern Great Plains in the future. The Northern Great Plains has many, probably hundreds of thousands, of dams/reservoirs blocking streams. If the reservoir is not used for sport-fishing, livestock water, or waterfowl production then dam removal may be a viable option for resource managers across the region to consider. Additionally, these reservoirs are often a source of mosquitos that could harbor the West Nile virus. Finally, dam repair and maintenance is costly and will continue to be costly as long as the dam is there, whereas once the dam removal and stream rehabilitation project is complete the stream system can be left to its natural processes.

A large focus of prairie stream restoration should be the implementation of fish passable devices on road and trail crossings. BLM has partnered with the Montana, Fish, Wildlife, and Parks to build a fish passable culvert along a county road crossing the Redwater River, which was a stream inventory site in 2010. The culvert would be installed just upstream of 2010 site Redwater River R1. In the Pacific Northwest, Intermountain West, and into the Rocky Mountains, the consideration of fish and wildlife passage has become customary when building roads and culverts across streams. The common practice of using fish passable devices has primarily been driven by declining populations of anadromous salmon, migratory inland trout, and other freshwater species. In the Northern Great Plains eco-region, intentional fish passable devices are almost nonexistent. Technology has improved greatly where now these devices are not only good at passing fish, but perhaps equally important they decrease erosion that culverts have been known to cause. For example, arch culverts or natural stream bottom culverts allow the stream to function semi-naturally, are large enough to let material (sticks, logs, etc.) pass, and allow fish and aquatic/riparian organisms to pass.

The data collected from this prairie stream project will greatly improve baseline understanding and resource management decisions on these unique and important prairie stream systems. This information has already been incorporated into various NEPA documents, help guide restoration projects, and will provide a monitoring framework for various resource/land-use activities. Prairie streams and their adjacent riparian areas are a valuable resource to many aquatic and terrestrial species across the Northern Great Plains Eco-region. Additionally, prairie streams can provide ecosystem services such as clean water and hunting opportunities. Finally, with the potential impacts of climate change it is ever more important to further our knowledge on these delicate systems and when possible enhance and conserve prairie streams.

Acknowledgments

Funding for 2012 field work was provided by BLM and the Great Plains Fish Habitat Partnership. Sarah DeNitto and Mariel Maxted, of Miles City BLM, were a great prairie stream crew. Additional field help was provided by Brandee Wills, Kimberly Stocks, Merle Blankenship, and Ryan Hoenke. GIS/GPS work and database development and support was provided by Scott Kichman and Jennifer Nagy of the Miles City BLM. Constructive reviews were provided by Melissa Dickard and Robert Bramblett that helped improve this report. Various private landowners gave access to cross their land to reach some of the BLM public land sites. Scientific collectors permit #16-2012 was issued by the Montana Department of Fish, Wildlife, and Parks. Scientific collectors permit #2012-25 was issued by South Dakota Department of Game, Fish and Parks. Reference to trade names does not imply endorsement by the U.S. government.

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Appendix A. Species richness and total number of individual fish caught at each site in 2012.

Field Office	HUC & Stream Name	Date	Species Richness	Total Individuals
MCFO	**Big Dry**			
	Woody Creek R1	8/6/2012	11	174
	Big Porcupine			
	Big Porcupine Creek R1	6/13/2012	5	389
	McGinnis Creek R1	6/8/2012	4	169
	Box Elder			
	Lone Tree Creek R3	7/30/2012	3	3324
	Fort Peck Reservoir			
	Bear Creek R1	8/8/2012	2	83
	Snow Creek R1	8/14/2012	7	1906
	Little Dry			
	Taylor Creek R1	8/6/2012	1	4401
	Lower Belle Fourche			
	Owl Creek R2	6/21/2012	3	68
	Lower Tongue			
	Pumpkin Creek R1	5/9/2012	16	1861
	Pumpkin Creek R1	9/5/2012	13	327
	Pumpkin Creek R2	5/10/2012	11	1260
	Pumpkin Creek R2	9/5/2012	12	558
	Pumpkin Creek R3	5/10/2012	9	168
	Pumpkin Creek R3	9/6/2012	10	391
	Pumpkin Creek R4	5/11/2012	11	1250
	Pumpkin Creek R4	9/6/2012	12	884
	Lower Yellowstone			
	Cedar Creek R1	5/21/2012	10	4536
	Cedar Creek R1	9/4/2012	6	166
	Cedar Creek R2	5/21/2012	11	4344
	Cedar Creek R2	8/29/2012	8	549
	Cedar Creek R2a	5/22/2012	12	2408
	Cedar Creek R2a	8/29/2012	7	740
	Cedar Creek R3	5/24/2012	11	1686
	Cedar Creek R3	8/28/2012	7	237
	Cedar Creek R4	5/25/2012	6	2362
	Cedar Creek R4	8/28/2012	7	1389
	Cedar Creek R5	6/5/2012	7	109
	Cedar Creek R5	8/27/2012	8	518
	Cherry Creek R1a	5/16/2012	8	160
	Cherry Creek R1a	8/30/2012	10	250

Field Office	HUC & Stream Name	Date	Species Richness	Total Individuals
MCFO	Cherry Creek R1b	5/15/2012	9	294
	Cherry Creek R1b	8/30/2012	11	425
	Cherry Creek R2	5/16/2012	11	1688
	Cherry Creek R2	8/31/2012	12	1013
	Middle Little Missouri			
	Cannonball Creek R1	7/2/2012	6	214
	Upper Little Missouri			
	South Beaver Dam Creek R1	6/20/2012	6	356
SDFO	**Bad River**			
	Willow Creek R1	7/18/2012	13	6964

Appendix B. Number of individuals per fish species caught at individual sites, arranged by field office then alphabetically by HUC name. Date of 2012 sampling event in parenthesis next to reach name. Number caught arranged longitudinally in cell.

Sampling Reach (Date)	Black bullhead	Black crappie	Brassy minnow	Channel catfish	Common carp	Creek chub	Fathead minnow	Flathead chub	Green sunfish	Lake chub	Longnose dace	Longnose sucker	Plains killifish	Pumpkinseed	Plains minnow	Red shiner	River carpsucker	Sand shiner	Shorthead redhorse	Smallmouth buffalo	Stonecat	Western silvery minnow	White sucker	Yellow perch
MCFO																								
Big Dry																								
Woody Creek R1 (8/06)	34	16		1	14	13	11			3					47		2	1						32
Big Porcupine Creek																								
Big Porcupine Creek R1 (6/13)							145		171	6		49			18									
McGinnis Creek R1 (6/8)	10						102		56	1														
Box Elder																								
Lone Tree Creek R3 (7/30)	390						1030		1904															
Fort Peck Reservoir																								
Bear Creek (8/08)							78																5	
Snow Creek (8/14)							912	190		43	46				194			478					43	
Little Dry																								
Taylor Creek R1 (8/06)							4401																	
Lower Belle Fourche																								
Owl Creek R2 (6/21)	31				2		35																	

Sampling Reach (Date)	Black bullhead	Black crappie	Brassy minnow	Channel catfish	Common carp	Creek chub	Fathead minnow	Flathead chub	Green sunfish	Lake chub	Longnose dace	Longnose sucker	Plains killifish	Pumpkinseed	Plains minnow	Red shiner	River carpsucker	Sand shiner	Shorthead redhorse	Smallmouth buffalo	Stonecat	Western silvery minnow	White sucker	Yellow perch
Lower Tongue																								
Pumpkin Creek R1 (5/9)			1	70	1		1096	91	1	4	14		2		163		5	243			1	141	26	2
Pumpkin Creek R1 (9/5)					13		97	15	7		2	3	4		27			153			1	3	1	1
Pumpkin Creek R2 (5/10)				11	2		667	84	1		11				11		1	367				96	9	
Pumpkin Creek R2 (9/5)	1			1	34	1	164	21	41		10		9				1	274				1		
Pumpkin Creek R3 (5/10)							43	48		3	6		2		3			56				5	2	
Pumpkin Creek R3 (9/6)				18		2	98	36	21		3				9			199	4			1		
Pumpkin Creek R4 (5/11)	1				5		758	21		4	54		16		81			303				1	6	
Pumpkin Creek R4 (9/6)				8	10	1	186	76	109		10	4	15		35			415				15		
Lower Yellowstone																								
Cedar Creek R1 (5/21)						10	224	2598			6		24		594		192	116				718	54	
Cedar Creek R1 (9/4)				19			2	18					3		12		112							
Cedar Creek R2 (5/21)						98	106	1410		6	28		138		1550		102	836				68	2	
Cedar Creek R2 (8/29)				3	1		69	201					130		42		33	70						
Cedar Creek R2a (5/22)					1	20	126	711		18	41	3	326		899		5	257					1	

Sampling Reach (Date)	Black bullhead	Black crappie	Brassy minnow	Channel catfish	Common carp	Creek chub	Fathead minnow	Flathead chub	Green sunfish	Lake chub	Longnose dace	Longnose sucker	Plains killifish	Pumpkinseed	Plains minnow	Red shiner	River carpsucker	Sand shiner	Shorthead redhorse	Smallmouth buffalo	Stonecat	Western silvery minnow	White sucker	Yellow perch
Cedar Creek R2a (8/29)						3	59	124					522		14		3	15						
Cedar Creek R3 (5/24)						9	167	570	1	15	7		352		394		8	161					2	
Cedar Creek R3 (8/28)							142	49		1			16		14		1	14						
Cedar Creek R4 (5/25)							49	169		5			2002		5			132						
Cedar Creek R4 (8/28)							306	88		1			738		71			115				70		
Cedar Creek R5 (6/5)						2	34	10		24		1	2		36									
Cedar Creek R5 (8/27)					4	8	63	49		16			6		370			2						
Cherry Creek R1a (5/16)						78	12		1		1		13		1			53		1				
Cherry Creek R1a (8/30)					1	40	87						3		9		1	104	1	3	1			
Cherry Creek R1b (5/15)					6	155	16	1					42		19			49	3				3	
Cherry Creek R1b (8/30)	8				19	148	67	2			2	3	29		21			125	1					
Cherry Creek R2 (5/16)			4		4	414	1100		22				20		10			82	10			4	18	
Cherry Creek R2 (8/31)	23				26	135	246		15		1	22	118	1	12			412	2					
Middle Little Missouri																								
Cannonball Creek R1 (7/2)							82	10		1	5	1			115									

Sampling Reach (Date)	Black bullhead	Black crappie	Brassy minnow	Channel catfish	Common carp	Creek chub	Fathead minnow	Flathead chub	Green sunfish	Lake chub	Longnose dace	Longnose sucker	Plains killifish	Pumpkinseed	Plains minnow	Red shiner	River carpsucker	Sand shiner	Shorthead redhorse	Smallmouth buffalo	Stonecat	Western silvery minnow	White sucker	Yellow perch
Upper Little Missouri																								
South Beaver Dam Creek R1 (6/20)	20		3				188		127						17								1	
SDFO																								
Bad River																								
Willow Creek R1 (7/18)	22			50	4	28	434	2	2						6086	172	12	144		2			6	

Appendix C. Physical habitat characteristics of sites arranged alphabetically by HUC 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						
Big Dry						
Woody Creek R1	8/6/2012	1.4	4.0	16.3	4.2	20.3
Big Porcupine						
Big Porcupine Creek R1	6/13/2012	1.8	15.1	31.5	9.5	30.5
McGinnis Creek R1	6/8/2012	1.1	5.6	18.0	6.1	22
Box Elder						
Lone Tree Creek R3	7/30/2012	9.2	5.4	43.0	7.0	44.9
Fort Peck Reservoir						
Bear Creek R1	8/8/2012	0.4	0.5	4.4	1.4	7.6
Snow Creek R1	8/14/2012	9.0	18.1	46.8	12.5	46.8
Little Dry						
Taylor Creek R1	8/6/2012	1.1	1.2	8.0	1.1	10.2
Lower Belle Fourche						
Owl Creek R2	6/21/2012	0.4	4.2	10.8	3.9	16
Lower Tongue						
Pumpkin Creek R1	5/9/2012	7.6	14.3	94.5	14.1	101.3
Pumpkin Creek R1	9/5/2012	4.9	14.1	74.5	16.5	69
Pumpkin Creek R2	5/10/2012	4.3	32.7	96.7	34.0	95.5
Pumpkin Creek R2	9/5/2012	4.1	19.7	70.6	31.6	65.5
Pumpkin Creek R3	5/10/2012	2.8	16.7	71.0	19.9	66.7
Pumpkin Creek R3	9/6/2012	1.4	5.5	21.4	7.5	21.5
Pumpkin Creek R4	5/11/2012	4.9	9.0	42.8	10.5	51
Pumpkin Creek R4	9/6/2012	2.3	5.8	15.7	6.6	26
Lower Yellowstone						
Cedar Creek R1	5/21/2012	5.0	8.7	19.1	3.5	21.1
Cedar Creek R1	9/4/2012	1.9	4.5	10.2	1.0	8.6
Cedar Creek R2	5/21/2012	3.6	12.3	19.4	7.4	22
Cedar Creek R2	8/29/2012	0.7	1.7	6.7	4.4	9.8
Cedar Creek R2a	5/22/2012	3.2	11.9	25.5	17.4	25.2
Cedar Creek R2a	8/29/2012	1.4	3.6	10.9	2.6	11.6
Cedar Creek R3	5/24/2012	3.3	7.6	29.3	10.4	29.8
Cedar Creek R3	8/28/2012	0.7	2.3	6.4	3.2	9.5
Cedar Creek R4	5/25/2012	3.0	4.8	9.5	5.8	15.9
Cedar Creek R4	8/28/2012	2.8	4.9	7.0	4.1	15.6

HUC Stream Name	**Date**	**Wetted Width (m)**	**Left Bank (cm)**	**Center (cm)**	**Right Bank (cm)**	**Thalweg (cm)**
Cedar Creek R5	6/5/2012	1.7	9.6	65.7	19.0	65.5
Cedar Creek R5	8/27/2012	1.1	6.9	31.8	8.7	36.2
Cherry Creek R1a	5/16/2012	2.5	2.1	10.5	1.8	12.2
Cherry Creek R1a	8/30/2012	0.4	2.8	2.4	0.5	2.2
Cherry Creek R1b	5/15/2012	3.6	6.5	15.0	4.2	23.5
Cherry Creek R1b	8/30/2012	0.1	0.2	0.6	0.4	2.7
Cherry Creek R2	5/16/2012	4.4	6.5	19.5	9.9	33.2
Cherry Creek R2	8/31/2012	2.5	7.4	16.5	5.0	22.7
Middle Little Missouri						
Cannonball Creek R1	7/2/2012	1.7	9.8	27.4	10.3	35.2
Upper Little Missouri						
South Beaver Dam Creek R1	6/20/2012	1.5	10.5	34.3	8.9	46.3
SDFO						
Bad River						
Willow Creek R1	7/18/2012	4.5	9.2	21.9	10.6	27.5

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

HUC Stream Name	**Date**	**Conductivity (µS/cm)**	**pH**	**DO (% sat)**	**Air Temp (°F)**	**Water Temp (°C)**
MCFO						
Big Dry						
Woody Creek R1	8/6/2012	1704	8.78	125.8	96	31.1
Big Porcupine						
Big Porcupine Creek R1	6/13/2012	13870	8.37	99.7	75	19.1
McGinnis Creek R1	6/8/2012	2495	8.98	92	82	20.2
Box Elder (Little Missouri River)						
Lone Tree Creek R3 Boxelder Creek	7/30/2012	728	8.23	99.8	86	26.2
Fort Peck Reservior						
Bear Creek R1 Fort Peck Reservoir	8/8/2012	717	8.1	44.6	80	24
Snow Creek R1	8/14/2012	1694	8.61	89.5	61	10.04
Little Dry						
Taylor Creek R1	8/6/2001	1499	9.44	164.9	84	25.1
Lower Belle Fourche						
Owl Creek R2	6/21/2012	3446	7.9	66	80	18.8
Lower Tongue						
Pumpkin Creek R1	5/9/2012	4490	8.77	88.2	68	13.4
Pumpkin Creek R1	9/5/2012	5829	8.53	24.5	50	16.1
Pumpkin Creek R2	5/10/2012	5350	8.5	111.79	83	18.6
Pumpkin Creek R2	9/5/2012	10396	8.52	31.7	78	18.7
Pumpkin Creek R3	5/10/2012	4970	8.76	97.1	72	18
Pumpkin Creek R3	9/6/2012	11971	8.53	25.6	58	15.1
Pumpkin Creek R4	5/11/2012	4750	8.66	83.4	64	12.7
Pumpkin Creek R4	9/6/2012	13585	8.72	23.6	65	18.1
Lower Yellowstone						
Cedar Creek R1	5/21/2012	8710	8.4	83.9	80	18
Cedar Creek R1	9/4/2012	10739	8.6	31.57	68	18.5
Cedar Creek R2	5/22/2012	12160	8.53	132.19	89	27.3
Cedar Creek R2	8/29/2012	1590	8.82	139.5	98	28.3
Cedar Creek R2a	5/22/2012	11010	8	95.7	82	20
Cedar Creek R2a	8/29/2012	16590	8.18	90.8	86	21.5
Cedar Creek R3	5/24/2012	7760	8.58	96	62	16.7
Cedar Creek R3	8/28/2012	4205	8.84	70	98	22.4
Cedar Creek R4	5/25/2012	8260	8.33	69.9	46	9.2
Cedar Creek R4	8/28/2012	4006	8.56	63.8	79	17.7
Cedar Creek R5	6/5/2012	1871	8.03	73.1	85	21.2

HUC Stream Name	**Date**	**Conductivity (µS/cm)**	**pH**	**DO (% sat)**	**Air Temp (°F)**	**Water Temp (°C)**
Cedar Creek R5	8/27/2012	3661	8.47	80.1	80	16.2
Cherry Creek R1a	5/16/2012	4270	7.94	77	79	15.2
Cherry Creek R1a	8/30/2012	10632	8.73	72.2	66	18.5
Cherry Creek R1b	5/15/2012	3394	7.98	60.9	64	11.6
Cherry Creek R1b	8/30/2012	9930	8.43	92.3	82	22.2
Cherry Creek R2	5/16/2012	5290	9.6	94.19	94	20.2
Cherry Creek R2	8/31/2012	16062	8.24	92.2	84	22.4
Middle Little Missouri						
Cannonball Creek R1	7/2/2012	2975	9.1	7.9	96	24.3
Upper Little Missouri						
South Beaver Dam Creek R1	6/20/2012	335.8	7.41	64.2	72	17.6
SDFO						
Bad River						
Willow Creek R1 Bad River	7/18/2012	7280	8.81	30.6	68	22.7