FISH RESEARCH PROJECT
OREGON

STEELHEAD ESCAPEMENT MONITORING IN THE UPPER GRANDE RONDE RIVER AND JOSEPH CREEK BASINS

ANNUAL TECHNICAL REPORT

CONTRACT PERIOD: February 1, 2012 to January 31, 2013

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Contract Number: IGC 56105

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Objectives

1. Estimate redd density and spawner escapement of summer steelhead in the Upper Grande Ronde River watershed.
2. Estimate redd density and spawner escapement of summer steelhead in the Joseph Creek watershed, a tributary to the Lower Grande Ronde River.
3. Estimate spawners/redd above adult weir collection points.

Accomplishments and findings

We conducted 170 surveys in the Upper Grande Ronde River (UGRR) watershed and 111 surveys in the Joseph Creek watershed from 12 March through 27 June 2012 to determine summer steelhead *Oncorhynchus mykiss* redd abundance and adult escapement for these two populations. We sampled 30 random, spatially-balanced sites throughout the UGRR basin encompassing 60.7 km (6.8%) of an estimated 897 km of available steelhead spawning habitat. In Joseph Creek, we surveyed 30 sites encompassing 58.4 km (15%) of the 384 km of available spawning habitat. During these surveys we observed 70 steelhead redds and 21 live steelhead in the UGRR watershed and 67 redds and 13 live steelhead in the Joseph Creek watershed. In Joseph Creek, data was collected on five carcasses observed during surveys, no carcasses were observed in the UGRR watershed.

On 18.5 km of Deer Creek, 22 redds and 9 live steelhead were observed during six survey visits. A total of 69 wild-origin adult steelhead were passed above a permanent weir on Deer Creek, resulting in a 3.14 fish/redd ratio for the 2012 spawning season. Using the fish/redd ratio extrapolated from Deer Creek surveys, adult steelhead escapement estimates for the UGRR and Joseph Creek basins were 3,261 (95% C.I.: 2,184 – 4,336) and 1,357 (95% C.I.: 977 – 1,736) respectively.

Management recommendations

1. Using the current data of steelhead spawning distribution and geographic landscape variables, refine the sampling universe for the Upper Grande Ronde River and Joseph Creek populations to improve our knowledge of steelhead spawning distribution.
2. Estimate the biologically and statistically significant level of change in steelhead escapement for determining short- and long-term population changes.
3. Improve current methods for standardizing escapement estimates.
4. Continue to manage the Upper Grande Ronde River and Joseph Creek populations exclusively for wild-origin steelhead and determine the extent and distribution of hatchery steelhead in the basin through observations of hatchery fish during the spawning season.

ACKNOWLEDGEMENTS

We would like to acknowledge the assistance and cooperation of the many private landowners throughout the area who allowed us access to their property. The cooperation of private landowners was essential in meeting our project objectives. Additionally, we would also like to thank the Confederated Tribes of the Umatilla Indian Reservation for providing data from weir collections on Catherine Creek and the UGRR. Nez Perce Tribe provided data from weir collections on Joseph Creek. Further, we would like to acknowledge our field crew members Caitlin Ecklund, Michaela Satter, Tiffany Spaulding and Shannon Skinner for their assistance as well as Nadine Craft, Jeff Yanke, and Bill Knox for their expertise and assistance.

INTRODUCTION

Summer steelhead in the Grande Ronde River basin fall within the Snake River Distinct Population Segment (DPS) and are listed as threatened under the Endangered Species Act (62 FR 43937; August 18,1997). The Upper Grande Ronde River (UGRR) and Joseph Creek watersheds support two of the four Major Population Groups (MPG) in the Grande Ronde River basin. These populations are segregated based on topographic, genetic, and behavioral evidence of interactions. Historically, the Grande Ronde River was one of the more significant anadromous fish producing rivers in the Columbia River Basin. Despite recovery efforts, these populations remain depressed relative to historic levels.

The goal of this project is to annually evaluate summer steelhead population abundance for the UGRR, and recently Joseph Creek, by conducting surveys of redds and spawning activity. These surveys provide the data needed to estimate adult steelhead escapement, improve our understanding of habitat utilization, and contribute to productivity and survival estimates for these populations.

Study area

The Grande Ronde River flows generally northeast 341 km from its origin in the Elkhorn Mountain range to join the Snake River at river kilometer (rkm) 271, about 32 rkm upstream of Asotin, WA and 793 rkm from the mouth of the Columbia River. The UGRR watershed (Figure 1) includes the Grande Ronde River and its tributaries from the headwaters to the confluence with the Wallowa River (rkm 131). Major tributaries of the UGRR include Sheep Creek (rkm 312), Meadow Creek (rkm 290), Catherine Creek (rkm 225), and Lookingglass Creek (rkm 138). The UGRR drains approximately 4,200 km^2 and contains 1,475 km of streams (897 km of anadromous salmonid habitat). Elevations in the watershed range from 705 m at the confluence of the Grande Ronde and Wallowa rivers to over 2,646m in the headwater mountains. Stream physiography in headwater areas is similar to other western, inter-mountain systems, with forested uplands, perched meadows, and high to moderate stream gradients. However, the mid-portion of the UGRR flows through large historic wetland complex (approximately 56 x 24 km at its greatest extent), bounded by a geologic pinch point at the downstream end (Rinehart Gap). The main portion of this valley is extremely flat (stream gradient <0.1%), leading to increased stream sinuosity and decreased water velocity. Gradient increases after the UGRR passes downstream through Rinehart Gap (near town of Elgin) and enters a canyon-dominated landscape. Land use in the headwaters is a mix of timberlands and cattle grazing, while the main valley is in irrigated crop production. Land use is relatively light downstream of Elgin.

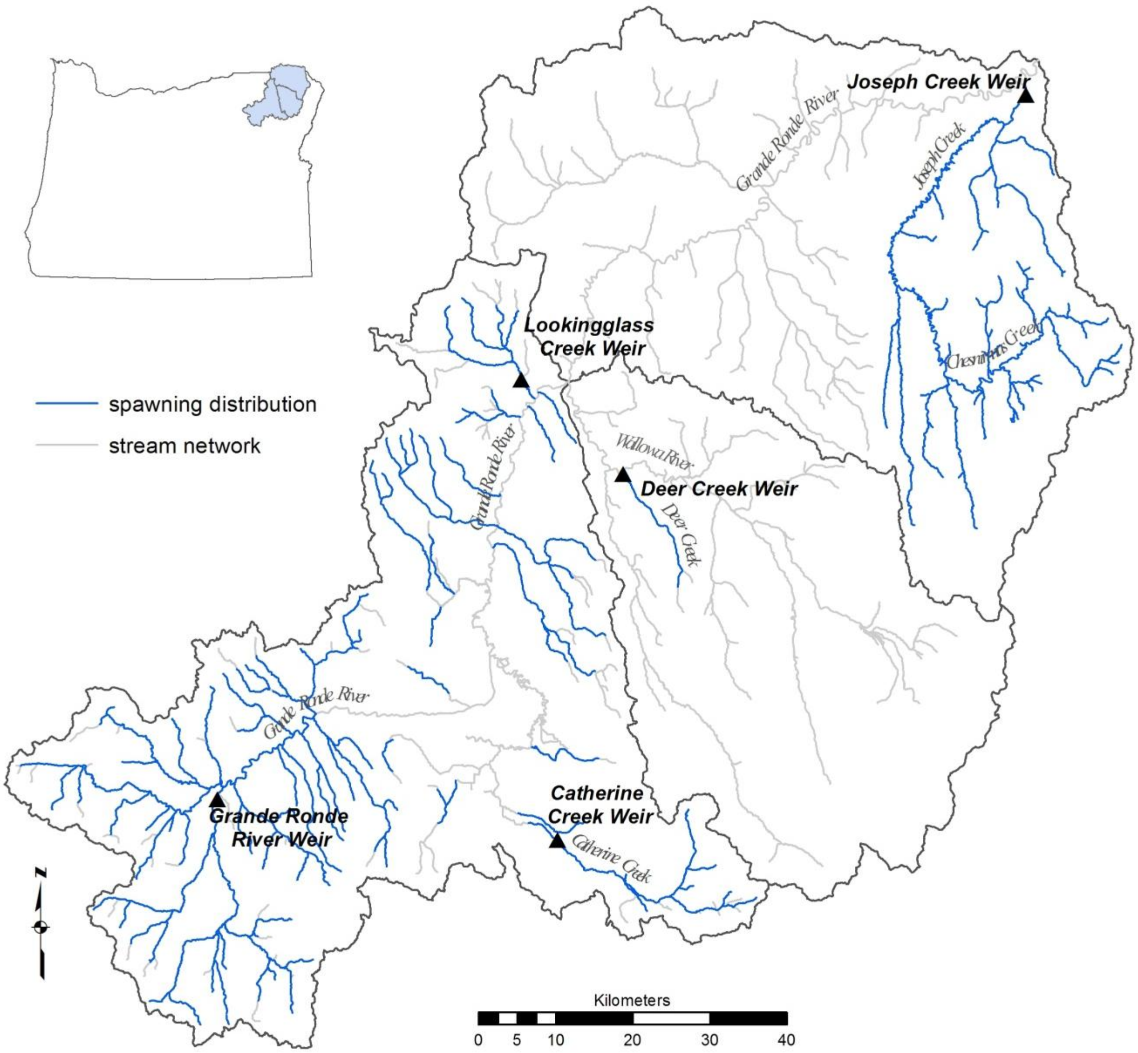

Figure 1. Our sampling domain falls within the current spawning distribution of summer steelhead (blue) in UGRR and Joseph Creek watersheds. Deer Creek and pertinent weir locations are also shown.

Joseph Creek is the most downstream tributary of the Grande Ronde River, entering approximately 7 km upstream of its mouth. Joseph Creek and its tributaries drain 1420 km^2 originating on a plateau north of the upper Wallowa River valley, and flowing generally north into Washington (Wallace 2011). The Joseph Creek watershed contains 536 km of streams, 384km of which are estimated to be part of steelhead spawning distribution (Figure 1). Major tributaries include Crow and Chesnimus creeks (which meet forming Joseph Creek at rkm 79), Swamp Creek (rkm 54), and Cottonwood Creek (rkm 7). Elevations in the watershed are substantially lower than the UGRR basin, and range from 273 m at its confluence with the lower Grande Ronde River to around 1673 m in the headwater areas. Physiography within the drainage is a mixture of hills and valleys in the upstream end, and canyon lands in the downstream portion (Figure 1). Land use is primarily cattle grazing in the upper reaches, especially upstream of the origin of Joseph Creek. Some grazing occurs in the lower reaches and tributaries but most of lower Joseph Creek flows through federal (US Forest Service) and Nez Perce Tribal property. No significant municipalities exist in the Joseph Creek watershed.

Deer Creek flows north from its origin in the Wallowa Mountains until reaching the Wallowa River at rkm 18. It is a narrow, elongated drainage, covering 79 km^2 with elevations ranging from 2259 m to 787 m. Approximately 18.5 km of stream are considered anadromous fish spawning habitat, and all 18.5 are surveyed annually. A concrete fish acclimation facility (Big Canyon), with a permanent weir, is located approximately 0.25 km from the mouth of Deer Creek. Wild-origin adult steelhead were marked with an opercle punch and passed above the weir during their spawning migrations. The known number of adult steelhead allowed into the spawning areas enable us to determine the adult fish/redd ratio for extrapolation to the larger UGRR and Joseph Creek populations (Flesher et al. 2005; Gee et al. 2008; James Ruzycki, ODFW, unpublished data). Land use is almost entirely timberlands upstream of the permanent weir.

METHODS

Sampling domain and site selection

Steelhead were monitored using a probabilistic sampling approach that incorporates a sample-site selection procedure created for the Environmental Protection Agency's environmental monitoring and assessment program (EMAP). The Generalized Random Tessellation Stratified (GRTS) design achieves a spatially balanced distribution of sites selected at random from the available spawning habitat to extrapolate an estimate of spawner abundance (Jacobs et al 2009). This method follows the Oregon Plan for Salmon and Watersheds Monitoring Program approach (Stevens 2002).

This GRTS design was first implemented in the UGRR in 2008 and newly implemented in 2012 for Joseph Creek. Sample sites were limited to the current steelhead spawning distribution, which was defined by redd and fish counts from previous spawning ground surveys and barriers identified during habitat surveys for summer steelhead. This information is annually updated to include newly identified barriers as well as new reaches of spawning habitat. All reaches upstream of known barriers to anadromous fish passage were eliminated from the potential sampling area. Thirty sample sites were targeted in both basins for this year.

For 2012, a new survey design implementing sites selected from the Columbia Habitat and Monitoring Program (CHaMP) was integrated into the legacy design that includes the following components for the UGRR:

- 10 sites repeated every year (annual)
- 11 sites repeated once every 3 years on a staggered basis
- 4 sites from UGRR CHaMP frame to be repeated once every 3 years.
- 5 sites new every year (once-only)

and for Joseph Creek:

- 18 sites repeated every year (annual)
- 12 sites repeated once every 3 years on a staggered basis

There were no sites in the Joseph Creek basin integrated from CHaMP because the program is not implemented in that watershed. Under the new survey design, stream segments were stratified into three classifications (source, transport, and depositional) and sites were evenly distributed among those three strata (logistics allowing). Stream segments were classified using Geographical Information System (GIS) by several attributes including valley width, stream gradient and bankfull width (Tim Beechie, unpublished data). In stratifying the universe, we attempted to identify and isolate areas of habitat differentially utilized for spawning, thereby increasing the precision of future adult escapement estimates.

Incorporating a 1:100,000 digital stream network, GIS was used to insure an unbiased and spatially balanced selection of sample sites. The GIS site selection process generated geographic coordinates (i.e. latitude and longitude) for each candidate site (Table 1). A two kilometer reach was established encompassing each candidate site. Topographic maps were produced showing the downstream and upstream end of each survey reach, along with the included GRTS sample point. In the field, crews used a handheld Global Positioning System (GPS) to locate the established survey reaches which encompassed the selected GRTS sample points. Some candidate sites were not sampled due to denial of permission from private landowners or because sites were located upstream of previously unknown fish passage barriers. In such events, replacement sites were drawn from a pre-selected list of over-sample sites.

Steelhead redd surveys

Steelhead redd surveys were based on standard ODFW methods (Susac and Jacobs 1999; Jacobs et al. 2000; Jacobs et al. 2001) and were conducted from March through June, 2012. Individual sites were surveyed up to nine times to quantify the number of redds constructed at each site, with approximately three week intervals between successive surveys to account for the temporal variation in spawning activity. Normally, a two week interval is attempted, but snow and high discharge sometimes prevented the desired interval. Generally, surveyors walked upstream from the bottom of each sample reach and counted all redds, live fish, and dead fish observed. In some cases the larger streams were surveyed in a downstream direction for safety.

New redds were flagged and locations were marked with a handheld GPS unit. During each visit, surveyors recorded the number of new redds as well as previously identified flagged redds. Redd visibility was rated 0 for new redds discovered and ranged from 1 (clearly visible) to 5 (least visible) for previously observed redds. To reduce bias of surveyor observations, surveyors were rotated through sites and partners if logistics allowed.

Steelhead carcasses were examined to obtain population and life history information by recording fork length (mm), MEPS (middle of the eye to posterior scale) length, sex, egg retention (females), origin determined by presence (wild) or absence (hatchery) of an adipose fin. For all carcasses, surveyors also collected scale samples from the key scale area (Nicholas and Van Dyke 1982) for age determination. Additional details of the survey protocol can be downloaded from the PNAMP, Monitoring Methods website (https://www.monitoringmethods.org/Protocol/Details/757).

Spawning timing

Weir Counts

Five weirs located on the UGRR, Joseph Creek, and Deer Creek (Figure 1) were used to evaluate timing of steelhead entering the watersheds prior to spawning. The UGRR weirs, operated by the Confederated Tribes of the Umatilla Indian Reservation (CTUIR), are located on the mainstem Grande Ronde River (rkm 291), Catherine Creek (rkm 32), and Lookingglass Creek (rkm 3). The weir on Deer Creek, operated by ODFW, is located 0.25 rkm upstream of its confluence to the Wallowa River. Wild adult steelhead trapped at the weirs were marked with an opercle punch and released upstream of the weir to spawn naturally. All hatchery adult steelhead are removed at these weir sites.

The Nez Perce Tribe (NPT) operates the weir on Joseph Creek just upstream of its confluence to the Grande Ronde River. All adult steelhead (wild- and hatchery-origin) were captured and passed above the weir unmarked to spawn naturally (Paul Kucera, NPT, unpublished data).

Discharge and temperature

We attempted to relate redd observations to discharge and site specific temperature for the UGRR, Joseph Creek, and Deer Creek. We used discharge measurements taken by Oregon Water Resources Department (OWRD) on the mainstem Grande Ronde River (station ID 13318960) by Perry (rkm 263) and measurements on Joseph Creek (station ID 35G060) upstream of the mouth (rkm 3) taken by Washington Department of Ecology (DOE).

We took five discharge measurements from Deer Creek through the season using a Marsh-McBirney Flowmeter and correlated them to measurements taken by the US Geological Survey (USGS) on the neighboring tributary Bear Creek (station ID 13330500). We then used the regression trendline formula to interpolate daily discharge on Deer Creek (D) from the Bear Creek (B) station as:

$$D = 1.118 + (0.11 \cdot B) \quad (1)$$

Prior to the start of each survey, we recorded the temperature to the nearest 0.5 °C using a handheld thermometer. Newly discovered redds were associated with these site specific morning (prior to 12:00PM) temperatures in an attempt to identify a relationship between spawning activity and stream temperature. Because temperature was not recorded for every reach on Deer Creek, only redds directly relating to reach-specific temperatures were used for comparison.

Estimating escapement

A locally weighted neighborhood variance estimator (Stevens and Olsen 2004), which incorporates the pair-wise dependency of all points and the spatially constrained nature of the design, was used to estimate a 95% confidence interval of the escapement estimate using SP Survey for R statistical software (R Development Core Team 2005). The statistical test was ran both with a single weighting value for the total spawning distribution and broken into a matrix of three strata by classification (source, transport, depositional) with weighting values depending on distance and number of surveys for each category (3).

Total escapement of adult steelhead (E_s) was determined by summing the product of the weight value (W), number of redds observed/km surveyed at each site (*i*), and fish to redd ratio determined from Deer Creek Surveys as:

$$E_s = \sum_{i=1}^{n} W_s \left(\frac{\text{Redds}}{\text{km}}\right)_i \left(\frac{\text{Fish}}{\text{Redd}}\right) \quad (2)$$

Weight equals the distance of available spawning habitat in km (determined from GIS layer) divided by the number of sites surveyed as:

$$W = \left(\frac{km\ avail.}{no.sites}\right) \quad (3)$$

The proportion of hatchery to wild-origin steelhead was calculated by dividing the total number of fin marked fish by all fish that could be observed for marks (live fish only). The number of hatchery fish straying to the basin was then estimated by multiplying this proportion of hatchery and wild-origin steelhead by our estimate of steelhead escapement.

Table 1. Steelhead spawning ground survey characteristics, location and stream classification for sites in the UGRR basin, 2012.

Site ID	Stream	Survey Frequency	Stream Classification	Survey Distance (km)	GRTS point		Downstream point of survey		Upstream point of survey	
					Latitude	Longitude	Latitude	Longitude	Latitude	Longitude
079752	Grande Ronde River	Annual	Depositional	1.94	45.1834	-118.3883	45.1793	-118.3894	45.1934	-118.3947
177134	East Phillips Creek	Annual	Source	1.97	45.6280	-118.0615	45.6345	-118.0557	45.6230	-118.0722
147928	Five Points Creek	Annual	Depositional	2.02	45.4047	-118.2171	45.4108	-118.2017	45.4032	-118.2229
120904	Burnt Corral Creek	Annual	Source	1.90	45.1807	-118.5073	45.1740	-118.5167	45.1804	-118.5071
118408	West Chicken Creek	Annual	Source	2.32	45.0318	-118.4058	45.0250	-118.4052	45.0445	-118.4039
059352	Clark Creek	Annual	Depositional	1.95	45.5155	-117.8297	45.5003	-117.8202	45.5157	-117.8297
018904	Spring Creek	Annual	Transport	2.07	45.3393	-118.2893	45.3472	-118.3075	45.3379	-118.2863
125832	Meadow Creek	Annual	Depositional	1.89	45.2637	-118.5514	45.2637	-118.5515	45.2714	-118.5331
101102	Phillips Creek	Annual	Depositional	1.95	45.5671	-117.9746	45.5697	-117.9935	45.5670	-117.9733
101560	Meadow Creek	Annual	Transport	1.86	45.2832	-118.6023	45.2922	-118.6120	45.2834	-118.6022
125256	Waucup Creek	Once	Transport	2.06	45.2547	-118.6487	45.2547	-118.6490	45.2702	-118.6435
119868	Beaver Creek	Once	Source	2.06	45.1702	-118.2175	45.1587	-118.2169	45.1737	-118.2202
010990	Little Phillips Creek	Once	Source	1.99	45.6297	-118.0173	45.6450	-118.0202	45.6278	-118.0155
094600	Fly Creek	Once	Source	1.83	45.1347	-118.5813	45.1280	-118.5906	45.1372	-118.5726
022844	Little Clear Creek	Once	source	2.16	45.0376	-118.3013	45.0372	-118.3011	45.0518	-118.3122
170478	Little Lookingglass Creek	Panel 2	Depositional	2.03	45.7635	-117.8836	45.7676	-117.8879	45.7544	-117.8780
149464	Middle Fork Clark Creek	Panel 2	Source	1.96	45.4976	-117.7913	45.4963	-117.7899	45.5089	-117.8061
111960	Pelican Creek	Panel 2	Transport	2.22	45.4090	-118.3091	45.4088	-118.3094	45.3951	-118.2937
130030	Clark Creek	Panel 2	Depositional	2.25	45.5435	-117.8733	45.5426	-117.8716	45.5498	-117.8910
006894	Dry Creek	Panel 2	Transport	2.29	45.5665	-118.0795	45.5776	-118.0935	45.5648	-118.0766
159368	Chicken Creek	Panel 2	Transport	1.92	45.0562	-118.3959	45.0471	-118.3924	45.0471	-118.3924
057838	Duncan Canyon Creek	Panel 2	Source	1.84	45.6964	-117.8087	45.6970	-117.8086	45.7088	-117.8232
065720	Spring Creek	Panel 2	Transport	2.03	45.3652	-118.3442	45.3659	-118.3459	45.3579	-118.3250
077704	Burnt Corral Creek	Panel 2	Source	2.11	45.2202	-118.4767	45.2060	-118.4916	45.2209	-118.4762
049208	Camp Creek	Panel 2	Source	1.99	45.3868	-117.7483	45.3904	-117.7377	45.3865	-117.7585
108270	Little Phillips Creek	Panel 2	Transport	2.00	45.5972	-118.0118	45.6107	-118.0163	45.5940	-118.0079
095642	McCoy Creek	Panel 2*	Transport	2.02	45.3511	-118.5653	45.3517	-118.5674	45.3399	-118.5491
000001	North Fork Catherine Creek	Panel 2*	Depositional	2.04	45.1221	-117.6432	45.1317	-117.6288	45.1197	-117.6476
000168	North Fork Catherine Creek	Panel 2*	Depositional	1.99	45.1527	-117.6170	45.1675	-117.6056	45.1521	-117.6175
000205	Grande Ronde River	Panel 2*	Depositional	2.04	45.3150	-118.2757	45.3118	-118.2771	45.3221	-118.2599

*CHaMP annual sites integrated into the steelhead draw.

Table 2. Steelhead spawning ground survey characteristics, location and stream classification for sites in the Joseph Creek basin, 2012.

Site ID	Stream	Survey Frequency	Stream Classification	Survey Distance (km)	GRTS point		Downstream point of survey		Upstream point of survey	
					Latitude	Longitude	Latitude	Longitude	Latitude	Longitude
002175	Crow Creek	Annual	Transport	2.02	45.7033	-117.1550	45.7045	117.1527	45.6905	117.1500
040895	Davis Creek	Annual	Transport	2.07	45.7837	-117.2322	45.7841	117.2298	45.7717	117.2435
051026	Unnamed Creek	Annual	Source	1.61	45.6945	-117.0136	45.7043	117.0226	45.6908	117.0113
112130	Devils Run Creek	Annual	Source	2.02	45.7842	-116.9856	45.7808	116.9855	45.7823	116.9692
141826	Basin Creek	Annual	Source	1.50	45.9138	-117.0579	45.9327	117.0583	45.9190	117.0590
150018	Cottonwood Creek	Annual	Source	1.76	45.8842	-116.9856	45.8977	116.9963	45.8846	116.9856
167426	Chesnimnus Creek	Annual	Depositional	2.05	45.7536	-117.0031	45.7507	117.0191	45.7544	116.9984
169810	Chesnimnus Creek	Annual	Transport	2.03	45.6978	-116.9229	45.6976	116.9230	45.7114	116.9119
240130	Broady Creek	Annual	Source	1.83	45.9535	-117.0725	45.9586	117.0648	45.9480	117.0815
263762	Swamp Creek	Annual	Transport	2.04	45.5533	-117.2259	45.5656	117.2245	45.5516	117.2257
288594	Chesnimnus Creek	Annual	Depositional	2.10	45.6968	-117.1113	45.6974	117.1169	45.7030	117.1015
301570	Cottonwood Creek	Annual	Source	1.80	45.9375	-117.0616	45.9433	117.0599	45.9336	117.0524
351746	Joseph Creek	Annual	Depositional	2.04	45.7338	-117.1676	45.7419	117.1657	45.7327	117.1605
389055	Joseph Creek	Annual	Depositional	2.08	45.7800	-117.1784	45.7810	117.1805	45.7686	117.1757
389247	Chesnimnus Creek	Annual	Depositional	1.94	45.7053	-117.1373	45.7067	117.1380	45.6980	117.1204
411474	Salmon Creek	Annual	Transport	2.01	45.6893	-117.0526	45.7029	117.0492	45.6875	117.0538
493394	Salmon Creek	Annual	Transport	1.90	45.7092	-117.0513	45.7186	117.0502	45.7040	117.0496
515586	Chesnimnus Creek	Annual	Depositional	1.99	45.7331	-117.0400	45.7319	117.0509	45.7367	117.0332
012802	Cottonwood Creek	Panel 1	Source	1.92	45.9008	-117.0016	45.9118	117.0077	45.8978	116.9964
043522	Broady Creek	Panel 1	Source	1.70	45.9421	-117.1010	45.9480	117.0815	45.9431	117.0999
045183	Elk Creek	Panel 1	Transport	2.01	45.6875	-117.1887	45.6947	117.1855	45.6789	117.1922
089602	Joseph Creek	Panel 1	Depositional	2.01	45.7277	-117.1561	45.7315	117.1581	45.7185	117.1597
116562	Alder Creek	Panel 1	Transport	2.00	45.7034	-117.0258	45.7053	117.0508	45.7033	117.0260
128514	Chesnimnus Creek	Panel 1	Transport	1.95	45.7239	-116.9448	45.7276	116.9505	45.7159	116.9348
237503	Swamp Creek	Panel 1	Depositional	2.02	45.8108	-117.2291	45.8225	117.2319	45.8085	117.2293
258175	Chesnimnus Creek	Panel 1	Depositional	2.07	45.7095	-117.1446	45.7144	117.1556	45.7067	117.1380
318978	Chesnimnus Creek	Panel 1	Depositional	2.02	45.7276	-117.0624	45.7219	117.0653	45.7319	117.0509
394754	Devils Run Creek	Panel 1	Source	2.02	45.7721	-116.9144	45.7729	116.9325	45.7708	116.9119
487551	Crow Creek	Panel 1	Source	1.98	45.6786	-117.1414	45.6904	117.1500	45.6769	117.1397
509778	Pine Creek	Panel 1	Transport	1.95	45.6773	-117.0297	45.6898	117.0387	45.6774	117.0297

RESULTS

Sampling domain and site selection

We surveyed 30 sites on the UGRR (Figure 2) encompassing 60.7 km of an estimated 897 km (6.5%) available steelhead spawning habitat (Table 1). Stream classification for the 30 sites was distributed as evenly as possible while retaining previously-surveyed sites: 11 sites in source classification, 9 in transport, and 10 in depositional. Four of the sites were located above the Grande Ronde River weir, two above the Catherine Creek weir, and one above the Lookingglass Creek weir. One site on Mill Creek (runs through town of La Grande) was surveyed and removed due to a lack of spawning habitat and a culvert impeding upward migration.

Thirty sites were surveyed in Joseph Creek and tributaries (Figure 3), encompassing 58.4 km of an estimated 384 km (15.2%) available spawning habitat (Table 2), all of which were above the weir. Sites were evenly distributed across the three stream classifications. One survey was dropped and replaced due to inability to survey (extremely thick hawthorns on very small stream). This section of stream was retained in escapement calculations. One survey in upper Swamp Creek was completed, and deemed unsuitable spawning habitat due to its wetland characteristics. This section of stream was removed from the spawning distribution and the site cancelled for future years' surveys.

We conducted six surveys on Deer Creek encompassing 18.5 km of what is believed to be all available spawning habitat from the weir to the USFS road 8270 bridge. In previous years, additional surveys were conducted upstream of these 18.5 km, and no redds or adult steelhead were observed.

Steelhead redd surveys

We conducted 170 surveys in the UGRR basin in 2012, with a mean interval of 17 d between surveys. A total of 70 steelhead redds were observed at 21 of the 30 sites (Table 3). Redds were not evenly distributed amongst the stream classifications: 23 redds (33%) were found in source areas, 31 (44%) in transport, and 16 (23%) in depositional reaches (Figure 2). A total of 21 live, adult steelhead were also observed at seven of the 30 sites in the basin (Table 5). Two of those had no adipose fin, indicating hatchery origin.

A total of 111 surveys were completed in the Joseph Creek watershed. We found 67 steelhead redds at 22 of the 30 sites (Table 4). More redds were found in the depositional stream classification (n=33, 49%), than source or transport reaches (17 redds each, 25%, Figure 3). Water visibility was more challenging in Joseph Creek than UGRR, and surveys had a mean interval of 20 d once conditions allowed for access. Thirteen live, adult steelhead were seen at six of the sites (Table 6), while five dead, adult steelhead were found at four sites (Table7). All live and dead steelhead in the Joseph Creek watershed surveys retained an adipose fin and were considered wild-origin.

We observed 22 redds on our visits to Deer Creek, 17 (77%) of which were discovered in the lower 9.6 km.

Spawning timing

Weir Counts

The Catherine Creek and the Grande Ronde River weirs were operable 1 March and the Lookingglass weir was continually operated (permanent structure). During the spring of 2012, 275 wild-origin adult steelhead were passed at the Lookingglass Creek weir, 329 at the Catherine Creek weir, and 13 at the Grande Ronde River weir. The first adult steelhead were passed on 12 March at the Lookingglass Creek and the Grande Ronde River weirs and 14 March at the Catherine Creek weir.

One adult hatchery steelhead was trapped and removed at the Lookingglass weir. The last fish were passed on 29 May at the Grande Ronde River, 2 June at Lookingglass Creek and 5 June at Catherine Creek (CTUIR, unpublished data).

Adult steelhead were captured at the weir operated by Nez Perce Tribe (NPT) near the mouth of Joseph Creek and all fish (wild- and hatchery-origin) were passed above for natural spawning. High flows, ice and debris rendered the trap inoperable for 17 days during the months of February through April. The first adult steelhead were passed 27 January and the last was passed 24 May. During the spring of 2012, 264 wild adult steelhead and 12 hatchery adult steelhead were passed above the weir (Paul Kuchera, NPT, unpublished data).

At the Deer Creek weir, 69 adult wild-origin steelhead were passed upstream to spawn naturally. The weir was installed and operating 13 February trapping the first fish on 18 May. The weir was removed 29 May, 10 days after the last wild-origin fish was passed. One adult hatchery male was found in the weir without an opercle punch, the mark signifying it was trapped and handled at the weir on its upward migration. This fish was suspected to have migrated upstream prior to the installation of the weir panels. No additional hatchery or wild-origin unmarked adult steelhead were observed above the weir.

Discharge and temperature

Spawn timing, based on our redd observations, was similar among the surveyed watersheds. We observed the first redds on 2 April in the UGRR (Figure 4), 3 April in Deer Creek (Figure 5) and 12 April in Joseph Creek. The last redds were observed on 13 June in the UGRR, 11 June in Deer Creek , and 27 June in Joseph Creek. By the third survey on 17 April, 55% of the total redds were observed on Deer Creek. By 10 May, 51% of the total redds were observed in the UGRR and 49% were observed in Joseph Creek.

Most redds in the UGRR basin were first observed during the descending hydrographs of early April and late April to late May (Figure 4). The six visits to Deer Creek coincided with low discharge periods. In Joseph Creek, few redds were discovered until flows declined below 500 cfs in late April.

New redd observations were associated with morning temperatures in all three basins. The majority of redds in the UGRR and Deer Creek were first observed with morning temperatures 2 - 8ºC (Figure 6). Joseph Creek redd observations occurred when temperatures were significantly higher than in UGRR or Deer Creek (χ^2= 351.7, 28 d.f., $p<0.001$), most >10 ºC.

Estimating escapement

A fish to redd ratio of 3.14 (69/22) was generated using the number of fish passed above the weir at Deer Creek and the number of redds observed there in 2012. Using this ratio and a single weight value for all stream classifications (29.9), an **estimated 3,261 adult steelhead (95% CI, 2,184 – 4,336)** escaped into the UGRR watershed and naturally spawned (Table 8). Two hatchery steelhead were observed, one in Spring Creek and the other in West Chicken Creek. The hatchery fraction was 0.09 which expanded to approximately 293 hatchery fish that strayed into the UGRR.

Using this same method with a weight value of 12.8, **an estimated 1,357 adult steelhead (95% CI, 977 – 1,736)** escaped into the Joseph Creek watershed. No adipose-clipped hatchery fish were observed during surveys on Joseph Creek.

Stratifying surveys by stream classification resulted in a similar escapement estimate for both basins, but did little to improve confidence intervals. Using the weight values for each strata, source

(41.1), transport (27.3), and depositional (19.9), we estimated that **3,264 (95% CI, 2,008 – 4,520)** adult steelhead for the UGRR population (Table 9). For Joseph Creek, using the weight values for each strata, source (15.9), transport (11.5), and depositional (11.1), we estimate that **1,316 (95% CI, 957 – 1,675)** adult steelhead returned to spawn (Table10).

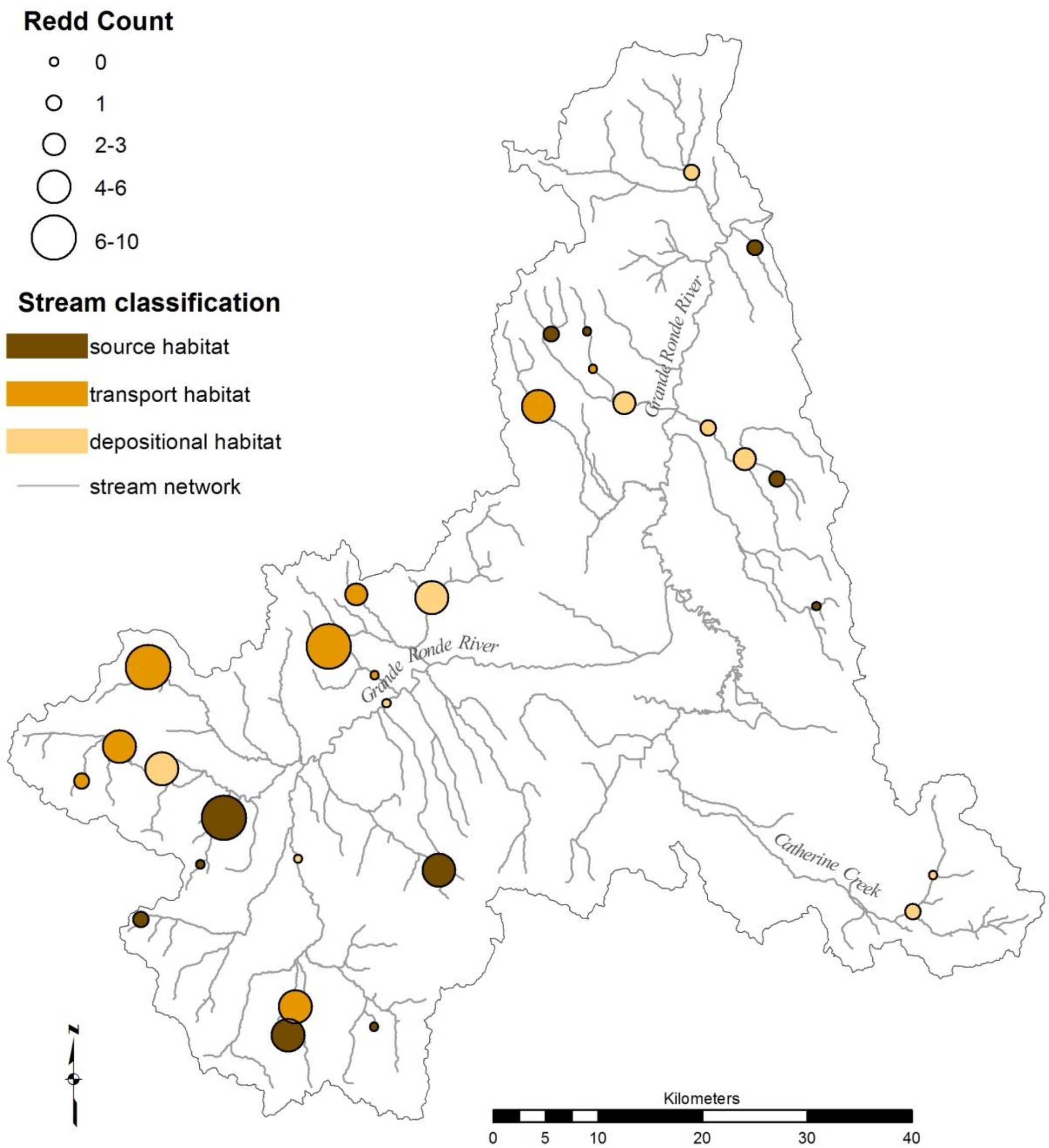

Figure 2. Map of the Upper Grande Ronde River watershed showing density, locations, and stream classification of redds observed in 2012.

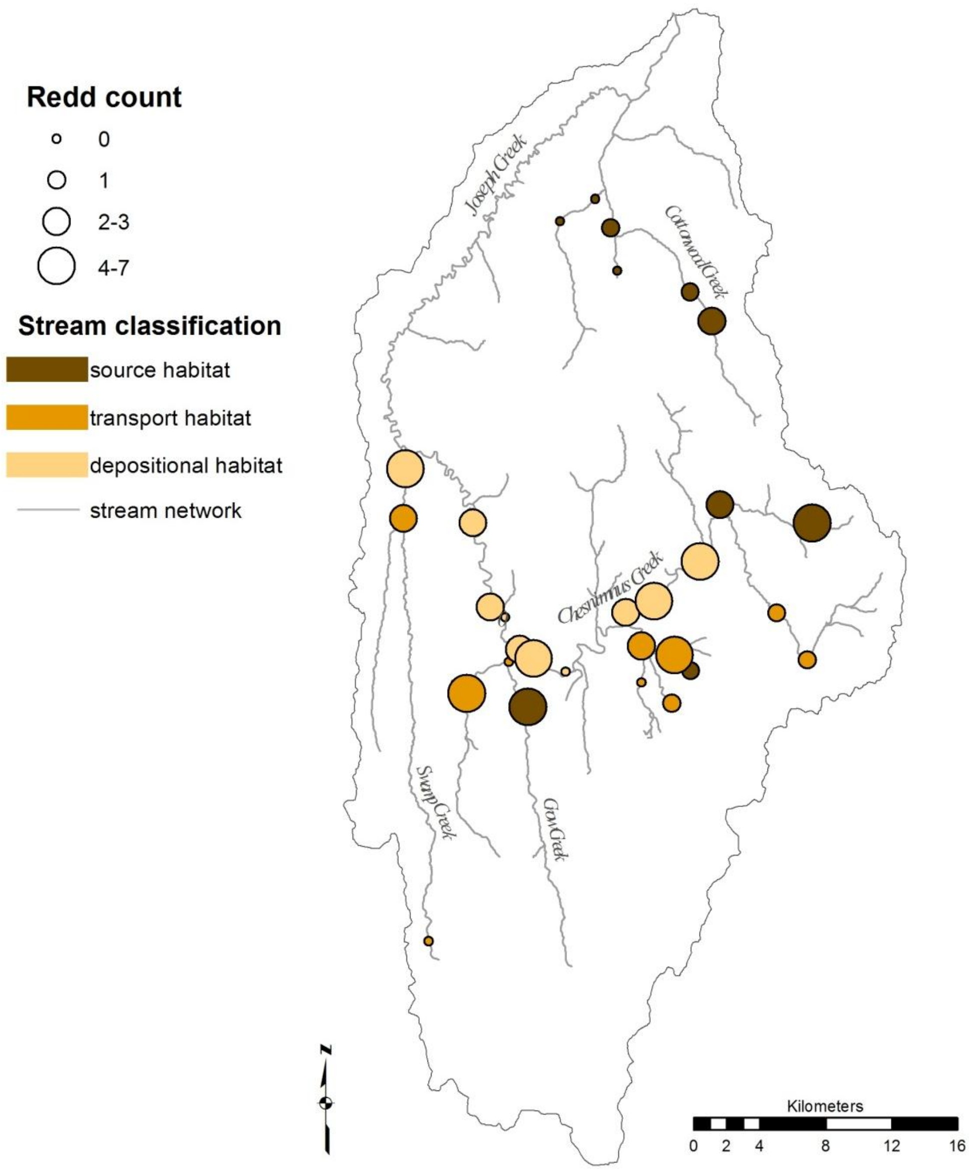

Figure 3. Map of the Joseph Creek watershed showing density, locations, and stream classification of redds observed in 2012.

Table 3. Completion dates and general results for surveys in the Upper Grande Ronde River watershed and Deer Creek,2012.

Site ID	Stream	No. of surveys completed	Mean no. of days between surveys	Redd count	1st Survey Date	2nd Survey Date	3rd Survey Date	4th Survey Date	5th Survey Date	6th Survey Date	7th Survey Date	8th Survey Date	9th Survey Date
079752	Grande Ronde River	5	25	0	3/13	3/29	4/9	5/30	6/19				
177134	East Phillips Creek	4	15	1	4/30	5/15	5/29	6/14					
147928	Five Points Creek	4	22	4	3/26	4/11	5/8	5/31					
120904	Burnt Corral Creek	5	15	0	4/9	4/24	5/9	5/22	6/6				
118408	West Chicken Creek	7	14	5	3/27	4/9	4/25	5/8	5/22	6/5	6/19		
059352	Clark Creek	7	16	2	3/12	4/2	4/16	5/2	5/14	5/31	6/18		
018904	Spring Creek - Hilgard	8	14	0	3/13	3/27	4/10	4/23	5/8	5/23	6/4	6/25	
125832	Meadow Creek	8	13	5	3/14	3/29	4/10	5/1	5/17	5/30	6/11	6/13	
101102	Phillips Creek	9	13	2	3/12	3/22	4/2	4/16	5/2	5/15	5/29	6/11	6/25
101560	Meadow Creek	6	13	4	4/9	4/19	5/1	5/15	5/30	6/12			
125256	Waucup Creek	5	14	1	4/19	5/1	5/16	5/30	6/12				
119868	Beaver Creek	3	13	4	5/18	5/29	6/13						
010990	Little Phillips Creek	8	14	0	3/12	3/30	4/11	4/30	5/16	5/29	6/8	6/20	
094600	Fly Creek	5	15	1	4/16	5/3	5/16	5/30	6/13				
022844	Little Clear Creek	4	14	0	4/25	5/7	5/22	6/6					
170478	Little Lookingglass Creek	6	18	1	3/20	4/10	5/7	5/29	6/8	6/20			
149464	Middle Fork Clark Creek	5	17	1	4/10	4/30	5/14	5/31	6/18				
111960	Pelican Creek	5	15	3	4/16	5/1	5/17	5/30	6/13				
130030	Clark Creek	5	17	1	4/10	5/2	5/14	5/31	6/18				
006894	Dry Creek	8	13	5	3/22	4/2	4/6	4/25	5/7	5/23	6/4	6/20	
159368	Chicken Creek	8	13	4	3/19	4/2	4/12	4/24	5/7	5/22	6/5	6/19	
057838	Duncan Canyon Creek	5	22	1	3/12	4/11	4/30	5/16	6/7				
065720	Spring Creek	8	15	7	3/15	3/28	4/10	4/23	5/8	5/23	6/4	6/25	
077704	Burnt Corral Creek	7	14	10	3/14	3/27	4/10	4/24	5/9	5/22	6/6		
049208	Camp Creek	3	24	0	5/10	6/14	6/27						
108270	Little Phillips Creek	7	14	0	3/30	4/11	4/30	5/15	5/29	6/8	6/20		
095642	McCoy Creek	5	14	7	4/16	5/1	5/15	5/30	6/12				
000001	North Fork Catherine Creek	5	25	1	3/14	3/29	4/18	5/29	6/20				
000168	North Fork Catherine Creek	3	38	0	4/5	4/18	6/20						
000205	Grande Ronde River	2	27	0	5/23	6/19							
N/A	Deer Creek	6	16	22	3/21	4/3	4/17	5/2	5/21	6/11			

Table 4. Completion dates and general results for surveys in the Joseph Creek watershed, 2012.

Site ID	Stream	No. of surveys completed	Mean no. of days between surveys	Redd count	1st Survey Date	2nd Survey Date	3rd Survey Date	4th Survey Date	5th Survey Date
002175	Crow Creek	5	22	0	3/15	4/5	4/19	5/8	6/11
040895	Davis Creek	2	34	3	4/12	5/16			
051026	Unnamed Creek	4	19	1	4/10	4/24	5/15	6/5	
112130	Devils Run Creek	4	19	3	4/9	4/23	5/14	6/4	
141826	Basin Creek	5	20	0	3/12	4/3	4/16	5/7	5/30
150018	Cottonwood Creek	4	25	2	3/14	4/18	5/8	5/29	
167426	Chesnimnus Creek	5	19	5	3/20	4/9	4/26	5/21	6/4
169810	Chesnimnus Creek	5	18	1	3/27	4/11	4/23	5/14	6/5
240130	Broady Creek	3	22	0	4/17	5/9	5/31		
263762	Swamp Creek*	1	0	0	5/23				
288594	Chesnimnus Creek	3	20	0	5/3	5/21	6/11		
301570	Cottonwood Creek	5	20	1	3/12	4/3	4/17	5/9	5/30
351746	Joseph Creek	2	15	3	5/22	6/6			
389055	Joseph Creek	2	15	2	5/22	6/6			
389247	Chesnimnus Creek	3	14	7	5/10	5/21	6/7		
411474	Salmon Creek	4	19	0	4/10	4/24	5/15	6/5	
493394	Salmon Creek	4	21	2	4/5	4/24	5/15	6/6	
515586	Chesnimnus Creek	5	19	5	3/19	4/9	5/1	5/15	6/4
012802	Cottonwood Creek	4	25	1	3/14	4/18	5/8	5/29	
043522	Broady Creek	4	26	0	3/13	4/17	5/9	5/31	
045183	Elk Creek	5	19	4	3/19	4/4	4/25	5/17	6/4
089602	Joseph Creek	2	15	0	5/22	6/6			
116562	Alder Creek	4	21	5	4/5	4/24	5/15	6/6	
128514	Chesnimnus Creek	4	18	1	4/11	4/23	5/14	6/5	
237503	Swamp Creek	2	42	7	5/16	6/27			
258175	Chesnimnus Creek	3	14	2	5/10	5/21	6/7		
318978	Chesnimnus Creek	5	19	2	3/19	4/9	5/1	5/15	6/4
394754	Devils Run Creek	3	24	5	4/25	5/14	6/11		
487551	Crow Creek	5	22	4	3/15	4/5	4/19	5/8	6/11
509778	Pine Creek	4	19	1	4/10	4/24	5/15	6/5	

*determined to be unsuitable spawning habitat, more marsh/wetland than stream, removed from sample frame for future years

Table 5. Locations, dates, and characteristics of live steelhead observations the UGRR watershed, 2012.

Site ID	Stream	Date observed	Fin clip	Origin	Near redd
077704	Burnt Corral Creek	4/10/2012	NA	Unknown	No
059352	Clark Creek	4/2/2012	NA	Unknown	NA
059352	Clark Creek	4/2/2012	NA	Unknown	NA
101560	Meadow Creek	4/9/2012	NA	Unknown	Yes
101560	Meadow Creek	4/9/2012	NA	Unknown	Yes
147928	Five Points Creek	5/8/2012	NA	Unknown	No
065720	Spring Creek	5/8/2012	AD	Hatchery	No
118408	West Chicken Creek	5/7/2012	None	Wild	Yes
118408	West Chicken Creek	5/7/2012	NA	Unknown	No
118408	West Chicken Creek	5/7/2012	None	Wild	No
077704	Burnt Corral Creek	5/9/2012	None	Wild	No
170478	Little Lookingglass Creek	5/7/2012	None	Wild	Yes
170478	Little Lookingglass Creek	5/7/2012	None	Wild	Yes
118408	West Chicken Creek	5/22/2012	None	Wild	No
118408	West Chicken Creek	5/22/2012	AD	Hatchery	No
077704	Burnt Corral Creek	5/22/2012	NA	Unknown	No
077704	Burnt Corral Creek	5/22/2012	NA	Unknown	No
077704	Burnt Corral Creek	5/22/2012	NA	Unknown	No
101560	Meadow Creek	5/30/2012	None	Wild	No
101560	Meadow Creek	5/30/2012	NA	Unknown	No
101560	Meadow Creek	5/30/2012	NA	Unknown	No

Table 6. Locations, dates, and characteristics of live steelhead observations the Joseph Creek watershed, 2012.

Site ID	Stream	Date observed	Fin clip	Origin	Near redd
045183	Elk Creek	3/19/2012	None	Wild	No
045183	Elk Creek	4/4/2012	NA	Unknown	No
045183	Elk Creek	4/4/2012	NA	Unknown	No
167426	Chesnimnus Creek	4/9/2012	NA	Unknown	No
167426	Chesnimnus Creek	4/9/2012	NA	Unknown	No
167426	Chesnimnus Creek	4/9/2012	NA	Unknown	No
318978	Chesnimnus Creek	5/1/2012	NA	Unknown	No
318978	Chesnimnus Creek	5/1/2012	NA	Wild	No
112130	Devils Run Creek	5/14/2012	None	Wild	No
112130	Devils Run Creek	5/14/2012	None	Wild	No
112130	Devils Run Creek	5/14/2012	NA	Unknown	No
318978	Chesnimnus Creek	5/15/2012	NA	Unknown	No
515586	Chesnimnus Creek	5/1/2012	NA	Unknown	Yes

Table 7. Locations, dates, and characteristics of dead steelhead observations the Joseph Creek watershed, 2012.

Site ID	Stream	Date observed	Sex	Fork length	Fin Clip	Origin
389247	Chesnimnus Creek	5/10/2012	Male	620	None	Wild
112130	Devils Run Creek	5/14/2012	Male	560	None	Wild
389247	Chesnimnus Creek	5/21/2012	Male	700	None	Wild
351746	Joseph Creek	5/22/2012	Male	730	None	Wild
389055	Joseph Creek	5/22/2012	Male	500	None	Wild

Table 8. Annual results of steelhead spawning ground surveys, 2008−2012. Available spawning habitat was refined yearly based on previous surveys

Year	No. of sites	Spawning habitat (km)	Weight value	Redds observed	Distance surveyed (km)	Fish/redd ratio	Spawner escapement	SE	95% CI	CI as % of escapement
UGRR basin										
2008	29	1301	44.9	24	64.2	4.07	2096	583	±1142	54.5%
2009	30	1178	39.3	42	59.9	3.81	3148	534	±1047	33.2%
2010	29	934	32.2	109	56.4	1.60	2876	457	±897	31.2%
2011	28	929	33.2	44	59.5	4.75	3275	524	±1028	31.4%
2012	30	897	29.9	70	60.7	3.14	3261	549	±1077	33.0%
Joseph Creek basin										
2012	30	384	12.8	67	58.4	3.14	1357	193	±380	28.0%

Table 9. Survey characteristics and results, grouped by stream classification type for UGRR basin, 2012.

Stream Classification	No. of sites	Spawning habitat (km)	Weight value	Distance surveyed (km)	Total redds observed	Spawner escapement	Standard error	Lower 95%CI	Upper 95% CI
Source	11	452.3	41.1	22.1	23	1413	514	406	2419
Transport	9	245.8	27.3	18.5	31	1346	312	735	1956
Depositional	10	198.6	19.9	20.1	16	505	155	202	809
Total	**30**	**896.7**	**29.9**	**60.7**	**70**	**3264**	**641**	**2008**	**4520**

Table 10. Survey characteristics and results, grouped by stream classification type for Joseph Creek basin, 2012

Stream Classification	No. of sites	Spawning habitat (km)	Weight value	Distance surveyed (km)	Total redds observed	Spawner escapement	Standard error	Lower 95%CI	Upper 95% CI
Source	10	159.0	15.9	18.1	17	440	84	275	606
Transport	10	114.7	11.5	20.0	17	306	93	125	488
Depositional	10	110.5	11.1	20.3	33	569	133	308	831
Total	**30**	**384.2**	**12.8**	**58.4**	**67**	**1316**	**183**	**957**	**1675**

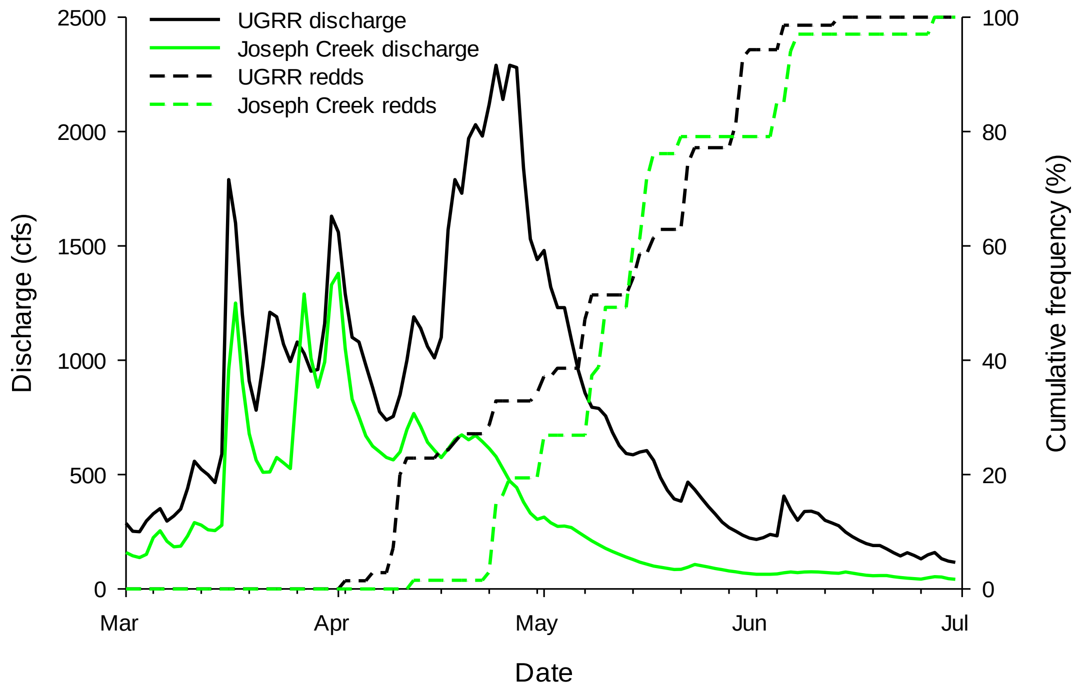

Figure 4. Cumulative frequency of observed redds and mean daily discharge during the spawning period for the UGRR (USGS station #13318960) and Joseph Creek (WA DOE station ID 35G060) watersheds in 2012.

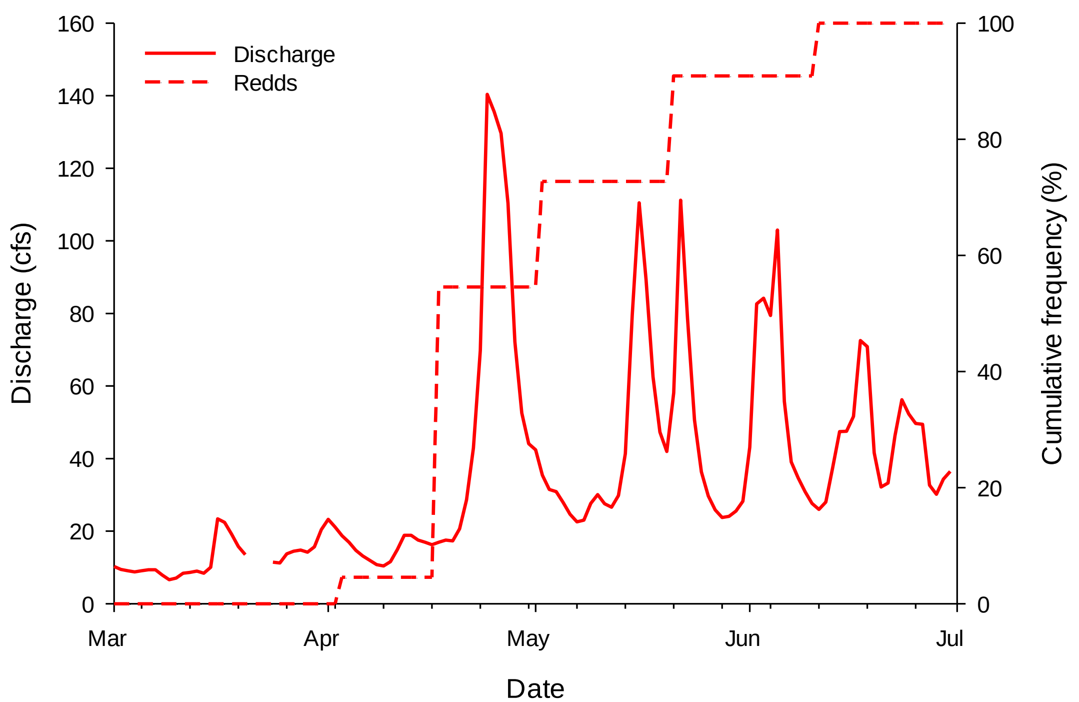

Figure 5. Cumulative frequency of observed redds and mean daily discharge during the spawning period for Deer Creek in 2012.

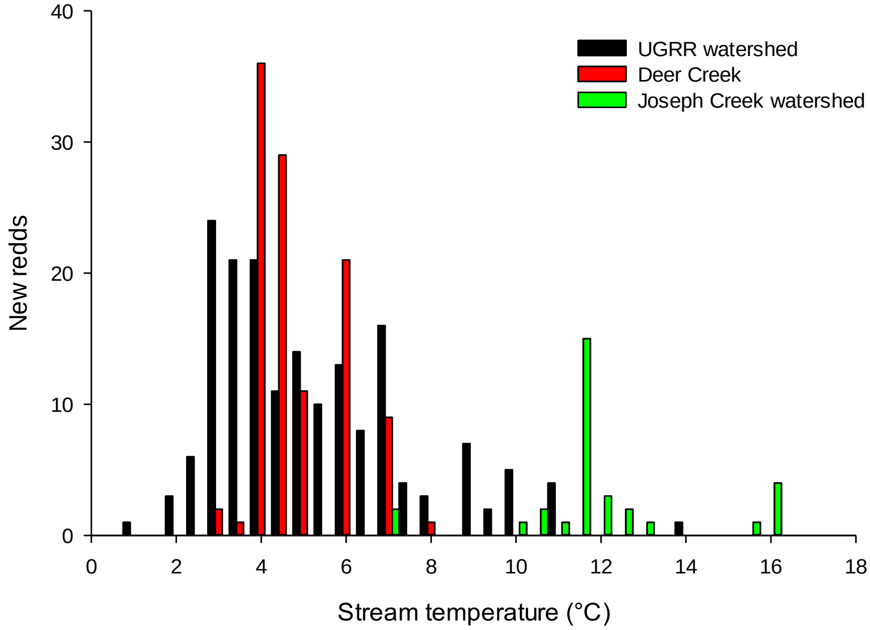

Figure 6. Morning stream temperatures (before 12:00pm) at sites where new redds were observed on surveys of the UGRR and Deer Creek during 2008−2012 and Joseph Creek during 2012. Morning temperatures were significantly higher in Joseph Creek than Deer Creek or UGRR (Chi-square= 351.713, 28 d.f., P <0.001).

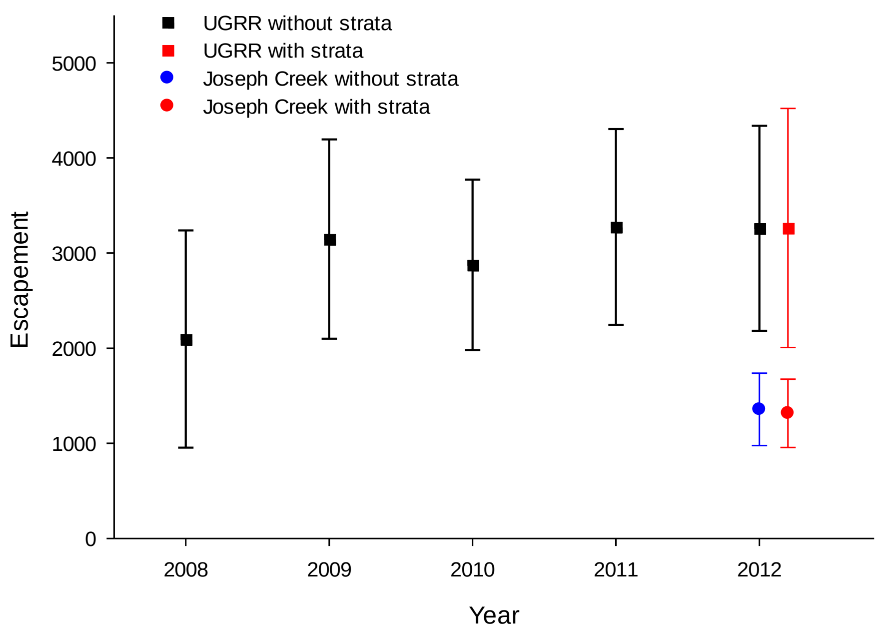

Figure 7. Escapement estimates with 95% confidence intervals for steelhead in the Upper Grande Ronde River watershed using a single weight value, 2008−2012 and using strata weights for the three classifications of stream type for UGRR and Joseph Creek, 2012.

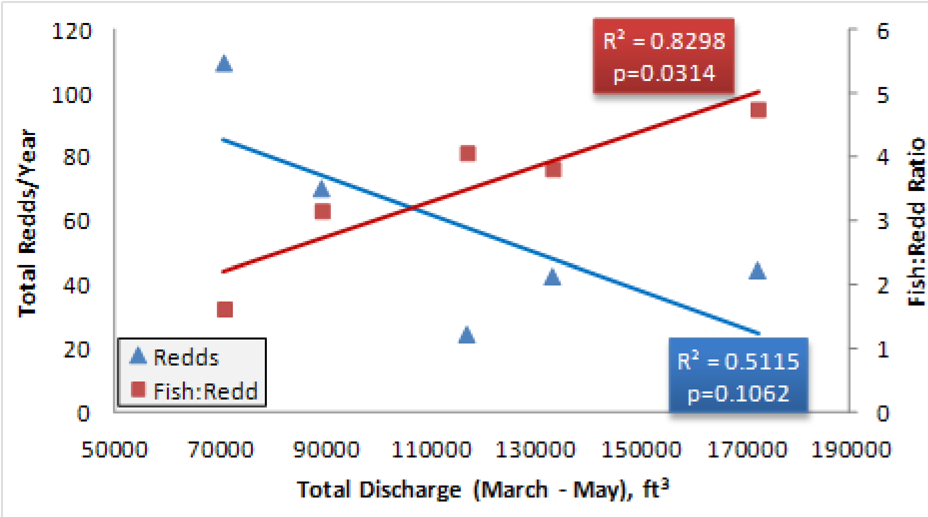

Figure 8. Relationships between total number of redds observed and cumulative stream discharge, and fish:redd ratio and discharge, UGRR 2008 - 2012. Discharge measured at UGRR Perry Station.

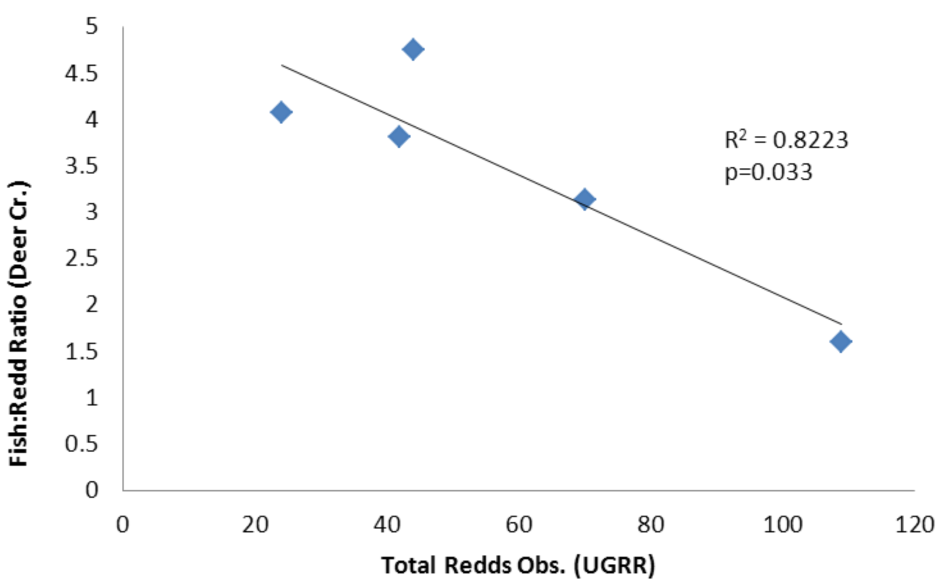

Figure 9. Relationship between the fish:redd ratio calculated on Deer Creek, and total redd observations from the UGGR basin, 2008 - 2012.

DISCUSSION

Steelhead redd surveys

Water clarity during surveys was marginal to good in both the UGRR and Joseph Creek watersheds throughout most of the season. Water clarity and our ability to observe redds generally improved as the season progressed, especially after April. Restriction of snow to higher elevations, relatively low precipitation, and moderate to low flows in May resulted in early access to most sites and good visibility. Flows were generally higher, and persisted longer in Deer Creek, Catherine Creek, and other tributaries flowing from the Wallowa Mountains due to their high elevation headwaters. Although our protocol indicates that surveys be conducted at two week intervals, flow conditions often increased the time between visits.

This was the initial year of surveys in the Joseph Creek drainage and there was concern about our ability to survey throughout the spring season. The upper portion of the basin had generally poor water visibility and high turbidity at moderate flows. As a result, the total number of surveys completed at the various sites was generally less than in the UGRR basin. That said, our crews were able to survey multiple times at sites, and spread surveys throughout the season. A year with higher snow quantity will likely make this more of a challenge, but we have demonstrated that implementing the sampling regime was feasible, despite periodic high water turbidity.

Water volume appears to play a significant role in our ability to observe redds. Total water volume correlated strongly with our annual redd observations in the UGRR (figure 8). However, this relationship appears to be mitigated by using the fish:redd ratio from deer creek. Fish:redd showed the opposite relationship with total discharge, and also correlated strongly with the total number of redd observations from the UGRR (Figure 9). This all suggests that the use of fish:redd is an appropriate method to compensate for our ability to successfully observe redds throughout the basin based on water conditions. It also helps explain why escapement estimates, which incorporate both values, have been similar across all years, despite substantial differences in total redd counts (Table 8).

Spawning timing

Most redds were first observed during descending limbs of the hydrograph, in both UGRR and Joseph Creek basins. However, this tells us little about the relationship of spawning to stream flow. Our ability to observe redds is strongly influenced by water clarity, which is generally better on the descending limb of hydrographs than on rising limbs. Even though our observations of redds were during these descending periods, they do not indicate exactly when the redd was made. Deer creek surveys illustrate this point. We were only able to survey during the low water periods between peaks in the hydrograph (Figure 5). However, redds were likely built during the high water periods between surveys. Our surveys cannot determine or estimate when redds were built, limiting our ability to infer a relationship between flow and spawning activities.

Timing of initial redd observations was similar across both basins and in Deer Creek. However, the temperatures during which those observations were made varied significantly (Figure 6, Chi-square, 28 d.f., $p<0.001$). Stream temperatures in Joseph Creek and tributaries were several degrees higher during the spawning season, especially in May and early June. Most redds found in the Joseph Creek drainage were first discovered when morning temperatures were >10ºC (Figure 6).

Estimating escapement

We were able to provide population-scale escapement estimates with relatively good precision (95% CI < 34% of the estimate). However, this is no better than in past years. Confidence intervals have consistently been 30 – 35% of the UGRR escapement estimate since 2009 (Table 8). This is despite our refinement of known steelhead spawning distribution, which has been reduced in length by 31% since 2008. It appears that the variable distribution of redds throughout the spawning distribution inflates the confidence intervals. In particular, observations of zero redds substantially increase the confidence interval, and certain streams are not likely to produce redds regardless of the number of adults returning. With continued observations of zero redds at some survey sites, it seems unlikely that precision will improve unless some other method of identifying appropriate spawning habitat can be found.

We attempted to improve our estimate precision and isolate areas of differential use by stratifying survey reaches by stream classification (source, transport or depositional). Each strata of sites was given a different GRTS weight based on length of streams available for spawning that fall within that strata. Results were mixed. In the UGRR basin, stratification resulted in a 5% increase in confidence intervals around the escapement estimate. Conversely, the Joseph Creek basin confidence intervals decreased by about 5% when stratified (Figure 7). These small changes in precision are likely the result of spatial scale. The stream classes used in our analyses were estimated in GIS at intervals of 200 linear meters. Steelhead are not likely choosing appropriate spawning areas at this scale. Thus, our inability to associate observations of redds based on stream classification is possibly due to the coarseness of scale for those stream classes. We will continue to explore analysis and stratification of spawning habitat, attempt to increase the precision of our escapement estimates at the watershed scale, and associate spawning use with specific stream characteristics that can be predicted/measured and used to refine the spawning distribution further. Preferably, habitat measures could be estimated using GIS, rather than intensifying measurements taken during field surveys.

We will continue to define the extent of these identified stream reaches unsuitable for spawning and locate similar reaches when they are selected in our sample draw. As the spawning distribution is refined, precision in our escapement estimates should increase. We will also continue to monitor trends of both methods and relate redd locations to immediate habitat to gain better understanding of how spawning habitat is utilized.

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