ASOTIN CREEK
INTENSIVELY MONITORED WATERSHED
ANNUAL PROGRESS REPORT

2008-2019 Data Summary and

Adaptive Management Update

Submitted To:
Recreation and Conservation Office, Olympia, Washington

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EXECUTIVE SUMMARY

The Asotin Creek Intensively Monitored Watershed (IMW) project was established in 2008 in southeast Washington. Asotin Creek is managed as a wild steelhead refuge and summer run steelhead are the focal species of the IMW. The IMW is implemented in three Asotin Creek tributaries: Charley Creek, North Fork Asotin Creek (North Fork), and South Fork Asotin Creek (South Fork; hereafter referred to together as "study creeks"). The study creeks cover a range of sizes, gradients, and flow regimes but all have a similar condition we refer to as structural starvation (i.e., low wood frequency). Lack of large wood accumulations limits instream complexity, overbank flow, and properly functioning floodplain and riparian conditions. The goal of the IMW is to increase channel complexity with large wood additions and eventually ***promote and sustain*** overbank flow, floodplain connection, riparian expansion and health, and riverscape physical and biological processes. We are using an alternative restoration strategy we call low-tech process-based restoration of riverscapes to cost-effectively add wood and protect recovering riparian habitat.

We have been successful in partnering with local stakeholders, seeking input from the Regional Technical Team, and selecting a good location for an IMW (i.e., meets criteria conducive to conducting an experiment; Bennett et al. 2016). This was the critical first step to implementing the IMW. We have since been able to develop a robust experimental design, implement a large and cost-effective series of restoration actions, conduct inexpensive "phased" maintenance and enhancement of the original restoration actions, consistently monitor fish and habitat attributes directly related to the goals and objectives of the project, develop analysis methods and tools to analyze the data, and we are beginning to observe significant habitat and fish responses. We have done all this within a well-articulated Adaptive Management Plan where we detailed hypothesized responses and are now systematically testing these hypotheses. To date, we have built almost 700 LWD structures over 14 km (39% of study area) and added several thousand more pieces of LWD to maintain and increase wood density in treatment areas using our Adaptive Management Plan. Total costs of restoration to date are ~$550,000 total or $39,000/km.

In this report which incorporates data from 2008-2019, we document positive habitat responses to restoration actions based on an increase in the frequency of large woody debris, pools, and bars in treatment sections compared to control sections. The habitat responses have generally i) increased since our last significant data summary (2008-2017) and ii) continue to vary in magnitude and timing between the three study creeks. We also document positive responses in juvenile steelhead abundance in both summer and fall estimates and similar to the habitat responses, fish abundance appears to be increasing since our last data summary. The positive abundance responses equate to an increase of 128-745 juvenile steelhead/km in treatment sections compared to control sections after restoration based on stream size (North Fork > South Fork > Charley). We have provided results for juvenile steelhead survival, capacity, production, and productivity measures for 2008-2017 in previous reports and plan to update these analyses in 2020.

Results from the Asotin IMW are particularly applicable to wadeable (order 1-5) streams which typically make up 90% or more of the perennial stream network. We see huge potential for this approach to help buffer the imminent threats of climate change. There are tens of thousands of miles of wadeable streams that are structurally starved in the Pacific Northwest and traditional engineering approaches cannot scale up to the scope of the problem due to their high cost and potential damage to recovering riparian areas. Applying low-tech process-based restoration could help slow water leaving watersheds, recharge groundwater, reconnect disconnected floodplains creating more storage opportunity, and perhaps provide higher base flows, and limit impacts of climate change.

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1. INTRODUCTION

Restoration of the freshwater habitat of anadromous salmonids has been occurring for decades with little evidence that restored habitat has led to an increase in salmonid populations at the watershed scale (Bernhardt et al. 2005, Roni et al. 2008). The lack of demonstrating a fish response may in part be due to the limited size of many restoration actions and high natural spatial and temporal variability in environmental conditions and population abundance (Roni et al. 2002, Wagner et al. 2013). Recently a series of Intensively Monitored Watersheds (IMWs) have been established in the Pacific Northwest to assess the effect of different restoration actions on populations of salmonids at the watershed scale (Bilby et al. 2005, Bennett et al. 2016). IMWs use an experimental framework to increase the probability of detecting a population level response to restoration actions, should one exist. A population level response can be defined as any increase in fish freshwater production or productivity due directly or indirectly to a restoration action. Freshwater production can be measured by summation of salmonid abundance, growth, and survival over a defined area and period of time (Almodóvar et al. 2006, Horton et al. 2009, Bouwes et al. 2016a), whereas freshwater productivity can be measured by calculating the recruits from one life stage to another such as smolts/spawner (Crawford and Rumsey 2011, Ward and McCubbing 2007). For practical purposes, it is assumed a population level response will need to be large (i.e., > 20%) to be detected by most monitoring efforts (Hinrichsen 2010, Roni et al. 2010). The main goals of IMWs are to assess how restoration actions alter stream habitat conditions, and to understand the casual mechanisms between stream habitat restoration and changes in salmonid production at the watershed scale. ***Ideally, insights gained from IMWs that are based on robust experimental designs, detailed and lengthy (e.g., spanning several generations pre- and post-restoration) monitoring, and inherently expensive programs can inform and improve restoration effectiveness across a wide range of stream types and regions where funding for such monitoring is not available***.

1.1 BACKGROUND

Asotin Creek was chosen as the site of an IMW in southeast Washington through a process coordinated by the Snake River Salmon Recovery Board (SRSRB). Washington Department of Fish and Wildlife (WDFW) designated Asotin Creek as a wild steelhead refuge in 1997 and steelhead are the focus of the Asotin IMW (Bennett and Bouwes 2009, Herr et al. 2018). We are implementing the IMW experiment within an Adaptive Management framework and have revised aspects of the experimental design, restoration plan, and monitoring based on the iterative evaluation process of Adaptive Management (Wheaton et al. 2012, Bouwes et al. 2016b). An experimental study design has been developed and refined for the Asotin Creek IMW that includes treatment and control sections within the Asotin Creek tributaries of Charley Creek, North Fork Asotin Creek (North Fork), and South Fork Asotin Creek (South Fork; hereafter referred to together as "study creeks"; Appendix A). The study creeks cover a range of sizes, gradients, and flow regimes (Table 1). The study creeks generally exhibit homogenized and degraded habitats, with poor riparian function and low frequencies of large woody debris (LWD) and pool habitat which is thought to be limiting salmonid production (SRSRB 2011). A detailed Restoration Plan was developed that proposed long-term riparian enhancement and short-term LWD additions as restoration treatments in the Asotin Creek IMW (Wheaton et al. 2012). The restoration plan was updated as part of our Adaptive Management Plan (Bennett et al. 2015) and we continue to add more LWD to maintain high densities of LWD in the treatment compared to control sections as needed.

Table 1. Basic watershed characteristics for the three Asotin Creek IMW study creeks.

Stream	Basin area (km^2)	Bankfull width (m)	Gradient (%)	Average annual discharge (cfs)	2 Year return interval (cfs)
Charley	58	4.8	3.0	9.5	292
North Fork	165	9.8	1.7	60.0	674
South Fork	104	6.3	2.6	11.5	448

The Asotin Creek IMW is funded from NOAA's Pacific Coastal Salmon Recovery Fund (PCSRF) and the Pacific States Marine Fisheries Commission (PSMFC). The NOAA funds are used to support the ongoing fish and habitat monitoring and data collection and analysis. These funds are administered via the Governor's Salmon Recovery Office. Funding for the restoration actions has primarily come from Pacific Coast Salmon Recovery Fund (PCSRF) through the State of Washington's Salmon Recovery Funding Board (SRFB) and donations of wood from US Forest Service, along with accommodation and equipment from WDFW and SRSRB. Eco Logical Research Inc. is the primary contractor that manages the Asotin Creek IMW and implements the restoration.

A separate project funded by the Bonneville Power Administration (BPA) and implemented by the Washington Department of Fish and Wildlife (WDFW) provides fish-in, fish-out monitoring for the Asotin watershed (Herr et al. 2018). The WDFW fish-in fish-out monitoring collects annual steelhead population abundance and life history data that is critical for the Asotin IMW to fully assess restoration effectiveness.

The goal of this progress report is to provide an update on the status of the Asotin IMW (what has been done to date), and what are the next steps based on our Adaptive Management Plan. Specifically, we i) describe and summarize ongoing IMW and WDFW fish and habitat monitoring for project context, ii) link goals and objectives to monitoring indicators, iii) describe the extent and timing of restoration actions, iv) geomorphic responses to restoration actions, v) juvenile steelhead abundance and growth responses to restoration, and iv) provide responses to the Salmon Recovery Funding Board and the Monitoring Panel's IMW project questions.

2. PROJECT CONTEXT

The Asotin Creek IMW began in 2008 and was implemented in Asotin Creek partly because of the ongoing WDFW fish-in fish-out monitoring that began in 2004. Below we provide a summary of some the WDFW ongoing monitoring efforts along with trends in IMW fish abundance and some basic habitat, flow, and water temperature as context for the project. For further information see Herr et al. (2018) for a detailed summary of the fish-in fish-out monitoring and Bennett et al. (2015) for study design and methods for the Asotin IMW.

2.1 STEELHEAD MONITORING TRENDS

Each year the IMW monitoring program conducts a 2-day mark-recapture survey at 12 fish sites in the summer (July) and fall (late September to mid-October). All unmarked juvenile steelhead > 70 mm are PIT tagged and the Chapman estimator is used to calculate a population estimate for the site (Seber 1992, Krebs 1999). WDFW capture and PIT tag emigrating juvenile steelhead at a rotary screw trap near the mouth of Asotin Creek in the spring and fall and estimate the total annual emigrant steelhead for Asotin Creek including the mainstem of Asotin Creek, Charley, North Fork, and South Fork Asotin Creek.

2.1.1. Tagging Summary

Capture and tagging rates were relatively normal at the WDFW smolt trap and the IMW mark-recapture fish sites after a record-setting year in 2018 for PIT tagging juvenile fish (Table 2). Location of the WDFW smolt trap, IMW fish capture sites, and other monitoring infrastructure are provided in Appendix A.

Table 2. Summary of total annual steelhead passive integrated transducer (PIT) tagging by WDFW at the smolt trap near the mouth of Asotin Creek and the Asotin IMW fist sites in Charley, North Fork, and South Fork Asotin Creeks.

Stream	2005	2006	2007	2008	2009	2010	2011	2012	2013*	2014*	2015*	2016*	2017	2018	2019	Total
Asotin (WDFW)	2,462	1,552	1,895	1,862	946	2,605	4,002	4,679	3,944	5,607	2,334	4,339	3,178	6,346	4,968	**50,719**
Charley	-	-	-	424	1,296	1,955	1,283	1,136	1,246	1,180	1,048	1,086	1,208	1,174	675	13,711
North Fork	-	-	-	372	470	1,397	906	931	1,800	1,549	2,035	2,245	1,793	2,376	1,583	17,457
South Fork	-	-	-	549	737	1,862	1,276	1,499	1,939	1,848	1,892	1,784	1,810	3,142	1,579	19,917
IMW subtotal	-	-	-	1,345	2,503	5,214	3,465	3,566	4,985	4,577	4,975	5,115	4,811	6,692	3,837	**51,085**
Total	**2,462**	**1,552**	**1,895**	**3,207**	**3,449**	**7,819**	**7,467**	**8,245**	**8,929**	**10,184**	**7,309**	**9,454**	**7,989**	**13,038**	**8,805**	**101,804**

** includes 620, 362, 222, and 217 juveniles PIT tagged on mainstem and captured with hook and line in 2013, 2014, 2015, and 2016 respectively.*

2.1.2. Asotin Steelhead Adult Returns and Juvenile Emigration

WDFW continues to limit the contribution of hatchery steelhead to the spawning population by operating the adult weir for the majority of the spawning season and removing all hatchery adults captured at the weir (Herr et al. 2018). It is estimated that over the last 14 years hatchery steelhead have made up 3.4% of spawners and in the last five years < 1%. Adult returns have dropped from a high in 2010 and 2019 appears to have the lowest adult returns to Asotin Creek since 2005 (Figure 1; estimates for 2019 escapement will be available in early 2020). Returning natural origin adults exhibit a large number of life history pathways spending 1-4 years in freshwater and 1-4 years in the ocean based on 9,806 scales collected by WDFW as of 2018 (Herr et al. 2018).

The dominant life history since 2005 has been fish that spend two years in freshwater and one or two years in the ocean, making up over 65% of natural origin returning adults (Herr et al. 2018).

Since 2010 returning adults have been captured at the adult weir and PIT tagged. PIT tagged adults can be detected if they enter study creeks. On average, 60% of the returning adults appear to spawn in the mainstem Asotin Creek, 17.2% in North Fork Asotin Creek, 6.9% in South Fork Asotin Creek, and 6.6% in Charley Creek based on PIT tag detections. As the adult escapement has declined it appears that the proportion of adults spawning in the mainstem Asotin Creek has increased and the proportion of spawning in the IMW study creeks has decreased, which could impact the abundance of juveniles in the study creeks.

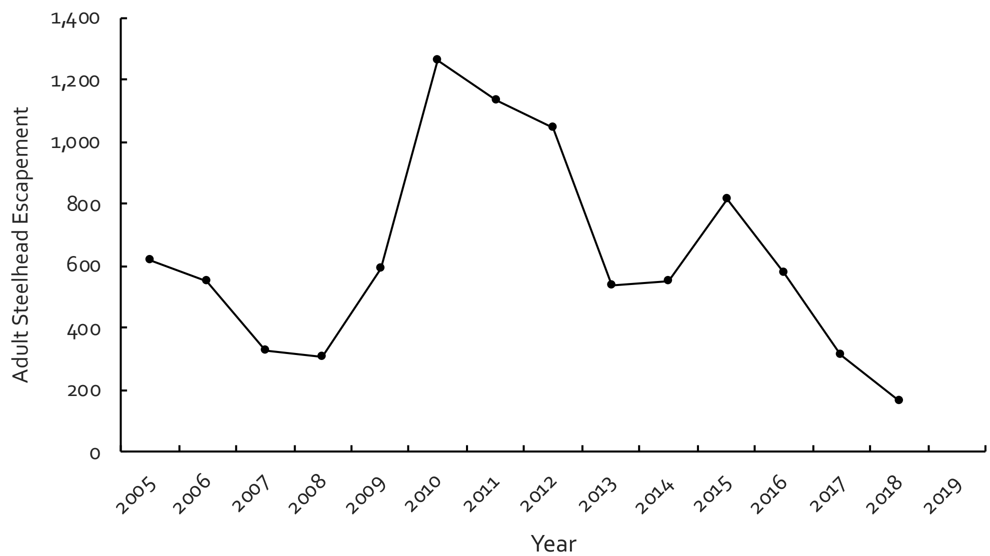

Figure 1. Adult steelhead escapement in Asotin Creek mainstem as determined by WDFW fish-in fish-out adult weir captures and PIT tagging: 2008-2018 (Herr et al. 2018). Note – 2019 adult escapement likely to be lowest since WDFW fish-in fish-out monitoring began in 2005).

The majority of juvenile steelhead emigration occurs in the spring with a second smaller pulse in fall (Figure 2). Age 2 juveniles dominate the spring emigration and age 1 juveniles dominate the fall emigration. Emigration in 2018 and 2019 were the highest observed since 2004 and are generally attributed to density dependent effects related to low adult abundance. A very low emigration rate in 2015 combined with low adult escapement in the last few years appears to have led to higher growth and survival of juvenile steelhead across all of Asotin Creek.

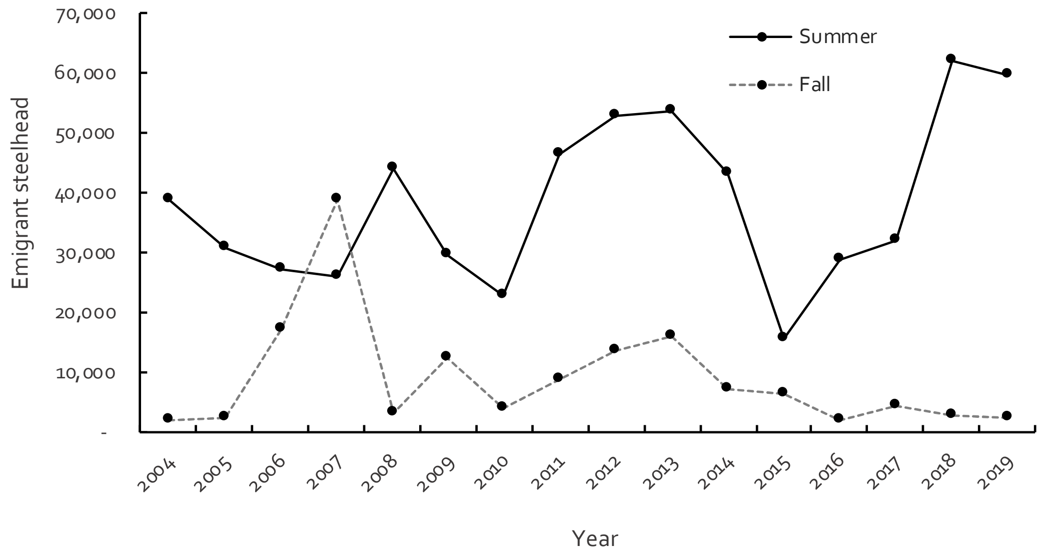

Figure 2. Juvenile (≥ 70 mm steelhead emigrants from Asotin Creek as determined by WDFW rotary screw trap captures, PIT tagging, and population estimates (Herr et al. 2018 and M. Herr pers. Comm. 2019). Estimates include emigration from Asotin Creek above George Creek confluence from 2004-2010 and estimates of Asotin Creek below George Creek confluence from 2011 onward (see Appendix A - maps of the watershed).

2.2 DISCHARGE AND TEMPERATURE SUMMARY

As reported previously, the average peak flows in the mainstem Asotin Creek pre-restoration were much larger than the average peak flows post-restoration (Figure 3). The peak 7-day maximum stream temperatures tend to be higher when peak flows are lower; however, we have observed complex relationships between flows (prior years and current years), air temperature, and stream temperature that may in part be due to significant contributions of springs to summer base flows. We have also observed that the timing and form of peak flows range widely from year to year. Peak flows have occurred from December through June and peak stream temperatures have occurred from June through August. The 2017 flow was the largest since restoration began and we observed significant geomorphic change and overbank flow as a result.

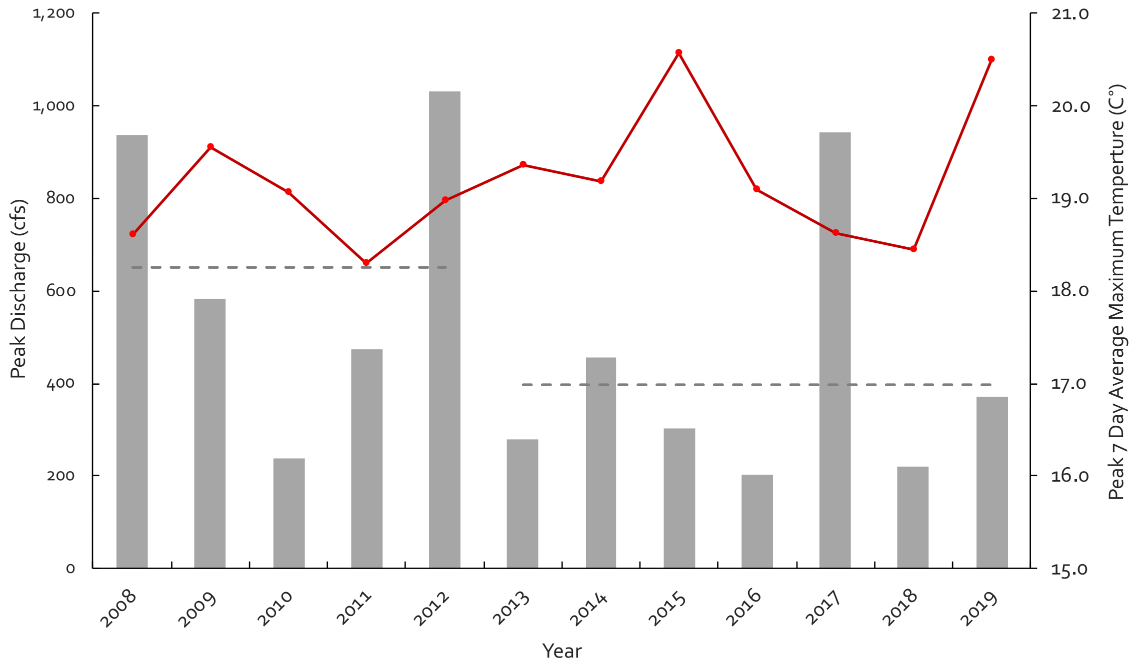

Figure 3. Asotin Creek mainstem peak discharge (bars) and peak 7-day maximum temperature by year (red line). Discharge data compiled from USGS gauge #13334550 and temperature data from Washington Department of Ecology flow gauge 35D100. Grey dashed line indicates the average peak flow prior to restoration (2008-2012) and post-restoration (2013-2019).

3. GOALS AND OBJECTIVES

The over-arching goal of the Asotin Creek IMW restoration is to mimic natural wood accumulations, promote the creation of natural wood accumulations, and ultimately attain self-sustaining processes of wood recruitment, wood accumulations, dynamic and complex channel and floodplain conditions. We use the term "wood accumulation" deliberately here because it is a process that we are trying to restore. Large woody debris is important, but ultimately it is the movement of LWD and its accumulation in log jams that produce most of the ecological benefits (Wheaton et al. 2019). In our original restoration plan (Wheaton et al. 2012), we described the steps to accomplish these goals: namely addition of high densities of post-assisted log structures (PALS; called dynamic woody structures or DWS in Wheaton et al. 2012), seeding and trees (non-secured), implementation of an Adaptive Management Plan to determine when and how more LWD should be added, and riparian planting as a future source of LWD. We also described a lengthy set of hypotheses in our restoration plan related to the overall goal of the IMW. These hypotheses are captured in conceptual diagrams we have developed for both the addition or large woody debris and introduction or promotion of beaver activity (Bouwes et al. 2016a; Figure 4, Appendix B). In the remaining sections we will describe the restoration actions we have implemented and the responses we are observing based on indicators we are using to track progress and restoration responses (Table 3).

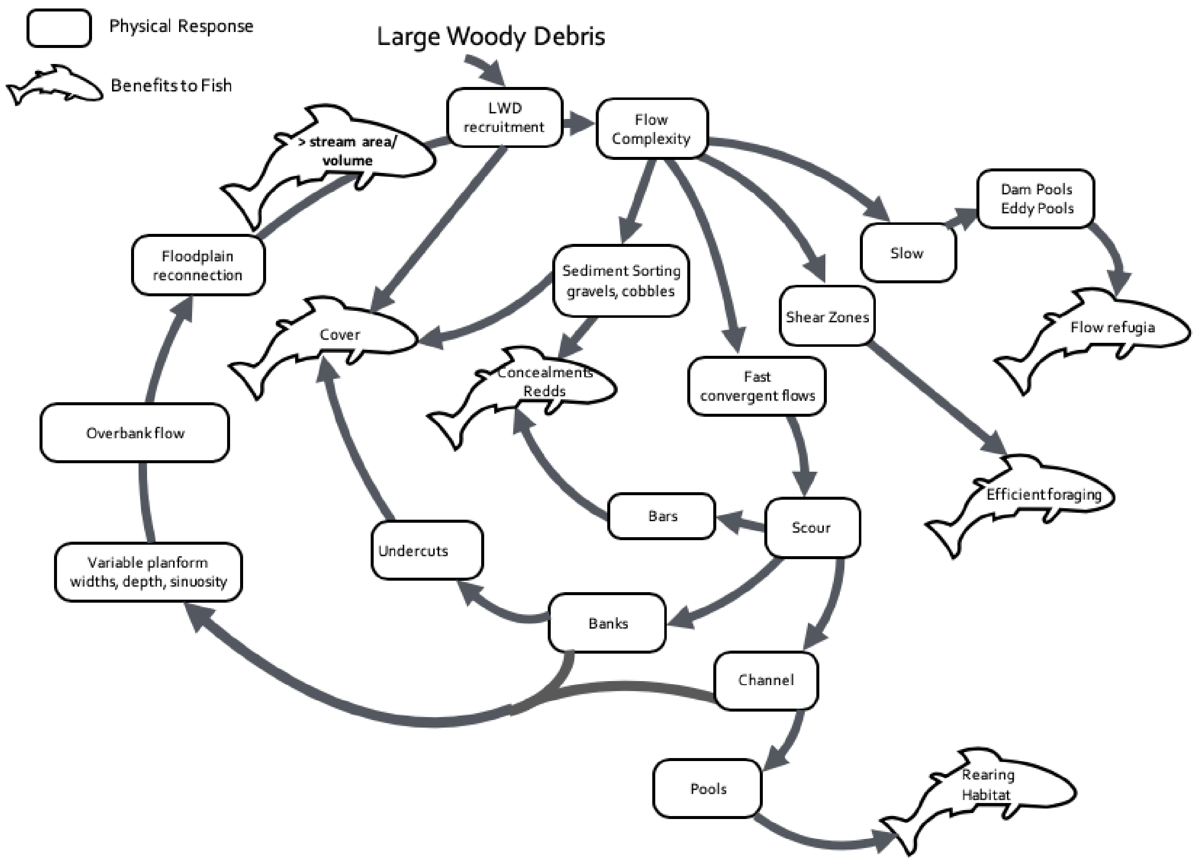

Figure 4. Conceptual diagram of hypothesized physical and fish responses to the addition of large wood. The right side of the diagram captures increases in channel complexity and the left hand side captures increase in floodplain connection which ultimately increases the available habitat for fish per km of valley bottom and can lead to greatest increases in fish production.

Table 3. Asotin Intensively Monitored Watershed project goals, objectives and monitoring indicators.

Specific Goals	**Objectives**	**Monitoring Indicators**
Increase channel hydraulic and geomorphic complexity	1. Install 654 post-assisted log structures (PALS)	1a. Wood accumulations (log jams and LWD frequency) 1b. Hydraulic diversity (visual estimates; constriction jets, shunting or splitting flows, etc.) 1c. Geomorphic unit frequency and area (bars, pools, planar features) 1d. Fish habitat complexity (cover, undercut banks, off-channel, riffles) 1e. Thalweg depth and channel variability
Maintain/Increase channel hydraulic and geomorphic complexity, promote LWD recruitment	2. Add more woody debris in form of PALS, brush, unsecured LWD, and whole trees to maintain or increase wood accumulations and force more hydraulic and geomorphic complexity as per the Adaptive Management Plan	2a. Wood accumulations (log jams and LWD frequency) 2b. Hydraulic diversity (visual estimates) 2c. Geomorphic unit frequency and area (bars, pools, planar features) 2d. Fish habitat complexity (cover, undercut banks, off-channel, riffles) 2e. Thalweg depth and channel width variability 2g. Tree recruitment/LWD frequency

Table 3 continued

Specific Goals	Objectives	Monitoring Indicators
Increase overbank flow, floodplain connectivity, and riparian extent	3. Wood additions as needed, and natural recruitment to force more frequent overbank flows	3a. Area of inundation at low flow and high flow 3b. number of off-channel, side-channels, beaver dams 3c. Riparian extent/stage of treatment sections (i.e., Stage 0; Cluer and Thorne 2014) 3d. Normalized difference vegetation index (NDVI) to assess riparian productivity pre- and post-restoration in treatment and control sections (Silverman et al. 2018)
Increase the quality and eventually the amount of juvenile rearing and adult spawning habitat leading to increased freshwater capacity, production, and productivity of juvenile steelhead	4. Increase juvenile feeding efficiency (i.e., more shear zones), flow, predation, and/or temperature refugia, and sediment sorting (i.e., improved spawning sites and egg survival), more habitat per km of valley, and ultimately self-sustaining Stage 8 (some inaccessible floodplain still exists) or Stage 0 (full floodplain connection)	4a. abundance 4b. growth 4c. survival (within treatment section and during outmigration) 4d. age at migration (length of time in treatment stream and mainstem) 4e. Production (g/g/100m^2), Productivity (smolts/spawner), Capacity (fish capacity/100 m; Net Rate of Energy Intake [NREI]; Wall et al. 2016a,b)

4. RESTORATION ACTIONS

It is important to stress that the Asotin Creek IMW has borrowed from the experience and conclusions of the Bridge Creek IMW that was managed by ISEMP and implemented by Eco Logical Research, Inc., NOAA Fisheries, and Oregon Department of Fish and Wildlife. We use a similar experimental design, survey methods, analyses, and most importantly, the same philosophy and approach to restoration as Bridge Creek that we call ***low-tech process-based restoration of riverscapes***. We developed and refined the low-tech approach from the combined lessons of historic low-tech approaches (going back over a century), experience form Bridge Creek and Asotin IMWs, dozens of smaller low-tech restoration projects across the west (Appendix C), and workshops (http://lowtechpbr.restoration.usu.edu/workshops/). Low-tech process-based restoration actions are not new but we integrated the actions into the process-based approach to restoration, and developed a set of riverscape and restoration principles to help guide practitioners in designing, implementing, and assessing low-tech restoration (Wheaton et al. 2019). We briefly describe the restoration actions we have taken and the low-tech approach we have used in the Asotin IMW, and encourage readers to review the manual for more details.

4.1 RESTORATION DESIGN AND APPROACH

The Asotin Creek IMW has a hierarchical-staircase experimental design which includes the lower 12 km of three tributaries: Charley Creek, North Fork Asotin Creek, and South Fork Asotin Creek (hereafter the study creeks; Appendix A). Each study creek is divided into three 4 km long sections and one section of each creek was treated (i.e., restoration applied) consecutively from 2012-2014. Part of another section of South Fork Asotin Creek was treated in 2016 to increase the total restoration area to 14km of the 36 km study area (i.e., ~ 39% of study area is treated). Large wood restoration treatments were chosen as the main restoration action. Riparian areas are generally recovering throughout Asotin Creek (Bennett et al. 2018), but where riparian recovery is limited in the IMW study area (mainly lower parts of Charley Creek), riparian planting is being implemented to provide LWD recruitment in the future (see ACCD project in PRISM 13-1405).

The addition of LWD to streams to improve habitat complexity and quality is not a new restoration strategy (Thompson 2005). However, we argue that most projects place undue focus on the size and stability of LWD with frequent attempts to anchor LWD in place. From a stream or watershed perspective, we think that the low density of LWD is a much bigger problem than the size, and streams with healthy rates of LWD recruitment see much more dynamic behavior in their LWD (i.e., it moves regularly). Therefore in the Asotin IMW we are attempting to produce a population-level response in steelhead in the Asotin Creek Watershed by treating over 14 km of stream in three study creeks with almost 700 hand-built LWD structures. We expect this to fundamentally alter the complexity of habitat of four treatment sections inducing an increase in steelhead production and productivity at the stream scale.

Achieving the desired LWD densities with traditional treatment methods would be extremely expensive, highly disruptive to the existing riparian vegetation, and logistically and financially infeasible over the broad range of steelhead habitat in the Columbia Basin. Therefore, we are testing the effectiveness of a simple, cost-effective method of installing LWD we call post-assisted log structures (PALS; low-tech process-based restoration; Wheaton et al. 2019). Post-assisted log structures that mimic wood accumulations (i.e., log jams) and are constructed using LWD that can be moved by hand and pinned in place by driving untreated wooden posts into the streambed using a hydraulic driver. The structures are designed to produce an immediate hydraulic response by constricting the flow width (Camp 2015). Like natural wood accumulations, alteration of the flow creates more hydraulic heterogeneity and increases the number of shear zones (i.e., areas with swift flow that abut areas of slow flow providing fish places with low swimming cost next to places with high rates of invertebrate drift). Moreover, the increase in hydraulic diversity produced by PALS is likely to promote aggradation, scour, sediment sorting, and the creation a diversity of bars and fish habitat (cover, spawning areas, etc.).

The fate of an individual structure is not as critical as the overall density of structures. A high density of PALS (e.g., 3-5 structures/100m) will increase the large-scale roughness of the stream creating much more variability in flow width and opportunities to build, alter, and maintain complex assemblages of active bar and pool habitat. Ideally, the high density of PALS will eventually initiate a more regular exchange of materials (sediment, water, LWD, etc.) with the adjacent riparian area and floodplain as PALS promote overbank flow, side-channel reconnection, aggradation, and slowing and attenuation of high flows. We have articulated these predicted responses into a series of explicit design hypotheses, which are guiding our monitoring efforts (see Section 3 for a summary and Wheaton et al. 2012 for more details).

4.2 RESTORATION ACTIONS

We built 196 structures in South Fork section 1, 207 in Charley Creek section 2, 135 in North Fork section 1, and 116 in South Fork section 1 in 2012-2014, and 2016 (Figure 5, Table 4). The approximate number of pieces of LWD added to each treatment section was 2,000 pieces in the South Fork (section 1 and 2), 1,000 pieces in Charley Creek, and 750 pieces in North Fork. Approximately 5-10 times more small woody debris (<0.1 cm dbh) was added to the structures. The majority of structures built were deflector PALS in all streams. The total length of stream restored with LWD is 14 km which equates to 38.9% of the IMW study area (i.e., 14/36 km). On average the LWD structures are approximately 21 m apart or 4.7 LWD structures/ 100 m. Figure 6 shows an example of a stream reach before treatment and after treatment and Figure 7 shows examples of the common structure types we built.

The restoration actions we have implemented were relatively low cost compared to average stream restoration projects that add wood to streams. The initial restoration treatment of 14 km cost ~ $550,000 or ~$39,000/km. Further maintenance and enhancement of the 14 km treatment area between 2016-2019 cost ~ $12,000. During the maintenance we added several hundred more pieces of LWD, rebuilt ~20 PALS, added ~ 100 whole trees, and hundreds of pieces of small woody debris. We plan to implement further maintenance and enhancement in 2020 with a budget of $30,000 from the SRFB. These treatments are done with donated wood from the USFS and WDFW and we are combining forest thinning with wood collection to increase the efficiency of the treatments by providing a thinning service and reducing local fire risks. We anticipate one more $20-40,000 maintenance round could push much of the treatment area to Stage 8 or Stage 0 (near to complete floodplain connection) for a total cost of below $650,000 or $44,500/km.

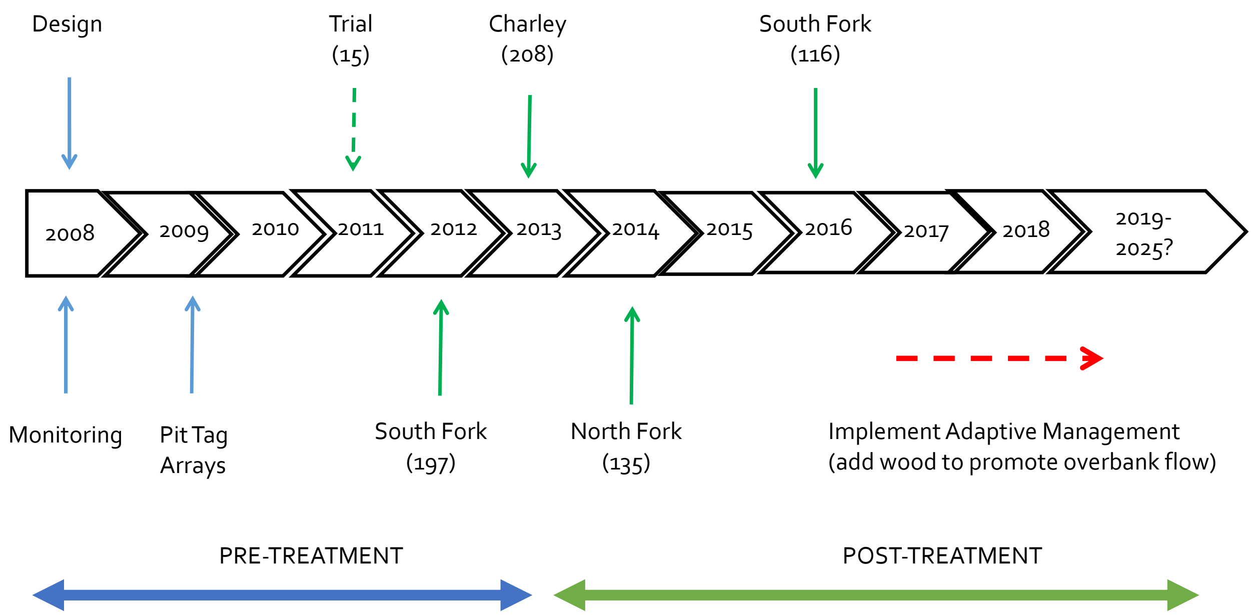

Figure 5. Timeline of design, implementation of monitoring infrastructure, and restoration actions by year and stream, pre- and post-treatment in the Asotin Creek Intensively Monitored Watershed.

Table 4. Summary of the type and count of large woody debris (LWD) structures built in each stream by year constructed. PALS = post-assisted log structure, Seeding = unsecured LWD placed in channel, Key LWD = LWD too large to move by hand (e.g., > 10 m long and > 0.4 m diameter).

Type	**South Fork (2012)**	**Charley (2013)**	**North Fork (2014)**	**South Fork (2016)**	**Total**
Bank-attached	115	129	75	67	386
Mid-channel	17	38	31	17	103
Debris Jam	2	10	15	18	45
Seeding	50	30	14	14	108
Key LWD	12	0	0	0	12
Total	**196**	**207**	**135**	**116**	**654**

Figure 6. Example of treatment section before restoration (left) and as-built restoration (right) in South Fork Section 1.

Figure 7. Example of the three post-assisted log structure types (PALS) built in the Asotin Creek IMW. Top left = series of Bank-attached, top right = Mid-channel, and bottom picture = Debris Jam PALS.

5. RESULTS AND INTERPRETATION

We have completed a high-level summary of the IMW results/outcomes, data sources, conclusions and our current interpretations of the data related to the goals and objectives outlined in Section 3 (Table 3). The following section provides some details related to the data summaries, analysis, and high-level summary. We have also summarized and analyzed some habitat and fish data collected for the entire project period (2008-2019) related to LWD frequency, geomorphic units, structure status, and juvenile steelhead abundance and growth to help support the high-level results. The following section is divided into three parts: i) high-level results, and ii) supporting habitat analysis, and iii) fish analysis.

5.1 HIGH-LEVEL RESULTS SUMMARY

We have been successful in partnering with local stakeholders, seeking input from the Regional Technical Team, and selecting a good location for an IMW – this was the critical first step to implementing the IMW. We have since been able to develop a robust experimental design, implement a large and cost-effective series of restoration actions, conduct inexpensive maintenance and enhancement of the original restoration actions, consistently monitor fish and habitat attributes directly related to the goals and objectives of the project, develop analysis methods and tools to analyze the data, and are beginning to observe significant habitat and fish responses. We have done this all within a well-articulated Adaptive Management Plan where we detailed hypothesized responses and are now systematically testing these hypotheses. Table 5 summarizes the high-level results and interpretations as of December 31, 2019 related to the original goals and objectives, and the data available to make such conclusions as requested by the Monitoring Panel.

Table 5. Goals, results/outcomes, which variables have measures before and after restoration actions, and conclusion/interpretation of the responses to date.

Specific Goals	Result/Outcome*	Data Available**	Conclusions/Interpretation
Increase channel hydraulic and geomorphic complexity	1a. Installation of 654 post-assisted log structures (PALS) resulted in increased wood accumulations and LWD frequency in all treatment sections 1b-c. Hydraulic and geomorphic diversity is higher in all treatment sections (more pools and bars, less planar habitat) 1d-e. Thalweg and width variability had minimal change in 2017	1a. CHaMP and rapid wood surveys pre and post restoration 1b-c. CHaMP, CHaMP Lite, rapid pool surveys 1d-e. CHaMP topographic data; future rapid surveys of control and treatment sections to collect depth and width profile (post–treatment only)	1a. Wood additions (PALS, brush, trees, and natural tree recruitment) have increased LWD frequency 260% 1b. pools frequency is 63% greater, bars have increased substantially but are still being reviewed 1d-e. Thalweg depth and channel width variability likely increasing in treatment sections but needs further assessment
Maintain/Increase channel hydraulic and geomorphic complexity, promote LWD recruitment	2. Added approximately 2,000 pieces of LWD (0.1-0.3 cm DBH, 3-6 m long), over 100 trees, and thousands of SWD (brush) since completing the final treatment in 2016. The wood additions have helped maintain high wood density in treatments and continue to help restore natural processes (e.g., sediment sorting, overbank flow, aggradation, scour, and lateral erosion)	2a-e. Same data as above	2a-e. Because the wood additions are strategic (replace wood where densities are low, force more change where change is already trending positive), the maintenance/ phased restoration approach is successfully increasing the overall treatment responses; however, the responses are variable and greater in areas of greater floodplain access

Table 5 continued

Specific Goals	Result/Outcome*	Data Available**	Conclusions/Interpretation
Increase overbank flow, floodplain connectivity, and riparian extent	3. Have observed significant overbank flow in South Fork Section 1 during high flows in 2017 (video), and to a lesser extent in the other treatment sections in Charley and North Fork. Overbank flow is almost always confined to high spring flow periods (i.e., no sustained flows outside the main channel during low flow periods).	3a-c. Google, drone (inconsistent), and aerial imagery, LiDAR, field surveys, CHaMP (topographic data, auxiliary data, site maps) ** We are developing a simple monitoring protocol to better assess changes in overbank flow, floodplain connectivity, and riparian extent	3a. Area of inundation at low flow and high flow 3b. We have seen a number of new side-channels develop in treatment sections, especially South Fork Section 1; beaver activity has remained low but there are some signs (feeding and sightings) in the treatment reaches that suggest beaver activity may be increasing 3c. We plan to classify each section based on stream evolution stage pre- and post-restoration as a way to see if there has been significant changes at the reach scale in riverscape condition (i.e., Stage 0 as per Cluer and Thorne 2014)

Table 5 continued

Specific Goals	Result/Outcome*	Data Available**	Conclusions/Interpretation
Increase the quality and eventually the amount of juvenile rearing and adult spawning habitat*	4a. Increase juvenile feeding efficiency (i.e., more shear zones), flow, predation, and/or temperature refugia, and sediment sorting (i.e., improved spawning sites and egg survival)	4a-e. Summer and fall mark-recapture surveys (4 sites/stream, 2 treatment, 2 control), winter and spring mobile PIT tag surveys (same sites as mark-recapture), four PIT tag interrogation sites (at mouth of each study creek, and two on mainstem Asotin Creek), PTAGIS database, scale samples (~10% of all PIT tagged fish), age determination using Bayesian model based on known length/age relationship), adult redd counts and PIT tag detections, Net Rate of Energy Intake (NREI; Wall et al. 2016a,b)	4a. Abundance increased in all treatment sections ranging from 12.5-42.2% which equates to 128-745 juvenile steelhead/km increase in treatment compared to controls. This is an increase from 2017 and appears to be due to flow driven habitat changes (i.e., geomorphic change) and benefits of LWD (i.e., cover and flow refugia). 4b. Growth decreased in all but one growth period and one stream ranging from -42.2-13.7%. This is consistent with the uniform increase in fish abundance and demonstrates density dependence 4c. Survival as of 2017 showing positive treatment responses; running updated analysis in early 2020 4d. Age at migration to assess in early 2020 4e. NREI showing positive treatment responses; Production (g/g/100m^2) and Productivity (smolts/spawner) to be updated in 2020 (2018 report showed compilation of productivity through 2016 as it takes several years to establish brood year productivity)

* all results are based on pre and post surveys in treatment and control sections unless otherwise stated

** numbers refer to goals and objectives from Table 3

5.2 HABITAT

5.2.1. Large Woody Debris

Annual trends

Across all streams, LWD frequency is almost 260% higher in treatment than control sections after treatment (59.1/100 m in treatment, 16.5/100 m in control; Figure 8). In general LWD frequency was lower or similar in treatment sections prior to restoration and shows a steady increase after the initial restoration treatment and various levels of maintenance and enhancement. LWD added to a treatment section was not counted until the following year because it was added in the late summer after high spring flows. We continue to observe variability at the individual fish and habitat site level with some sites in treatment sections having low LWD frequency and some control sites having large LWD frequency (Appendix D - Figure 19). This is likely due to wood movement, natural wood recruitment, variable effectiveness of structures, site specific conditions (i.e., site is in a narrower valley setting and may naturally short residence times for LWD), and a trend in all study creeks where the furthest upstream section (i.e., Section 3 which is a control in all three creeks) started in better condition and is trending towards recovery more than the downstream control sections.

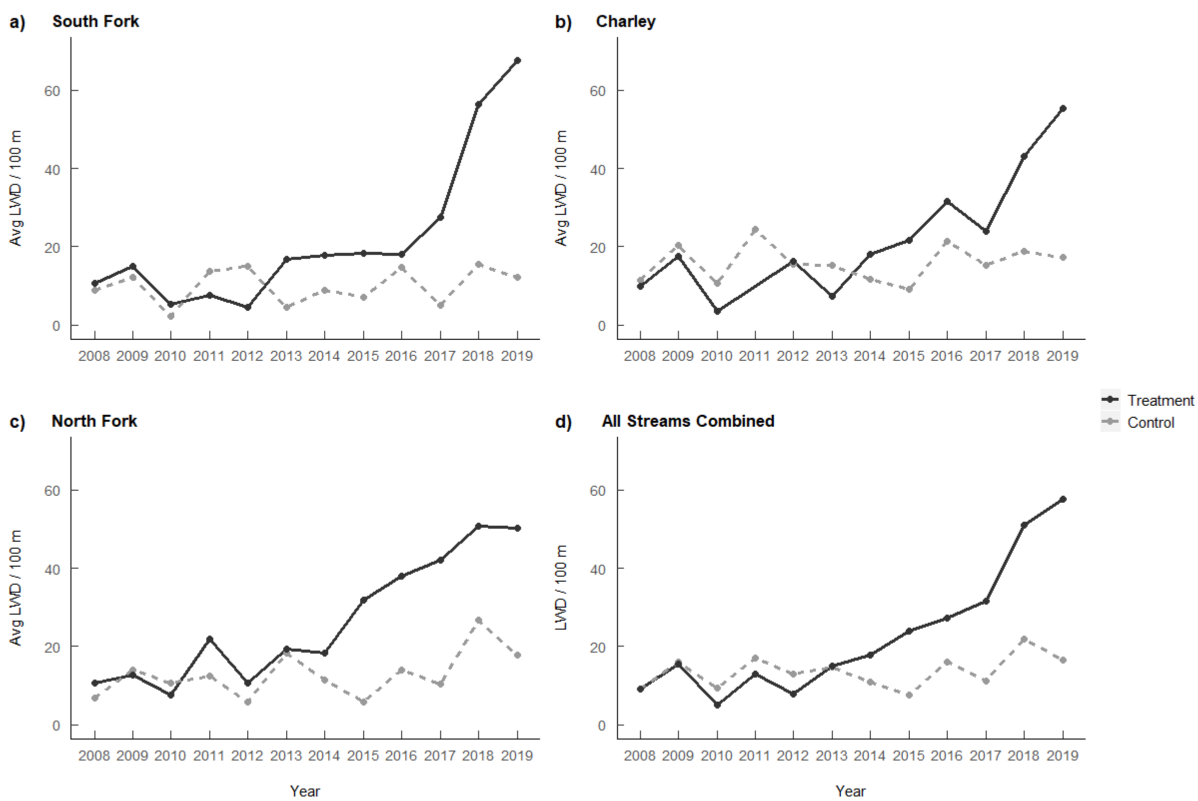

Figure 8. Trend in LWD frequency in treatment and control sections from in a) South Fork, b) Charley Creek, c) North Fork Creek and d) all streams combined: 2008-2019. Streams are ordered from first to last restoration implementation.

Pre- versus post-restoration comparisons

We compared changes in LWD frequency by stream and fish site by plotting the LWD frequency in the last pre-treatment year, the last post-treatment year (2019), the difference between post-restoration and pre-restoration, and calculating the % change (Appendix D - Figure 20-22). We observed large % increases in LWD frequency in treatment sections post-treatment and smaller change or decreases in control sites. To determine how much treatment sections changed relative to control sections we subtracted the % change observed in controls from the percent change in treatments and found that LWD frequency in treatments increased between 280-2,275% since pre-treatment period.

5.2.2. Pools

Annual trends

Across all streams pool frequency is almost 63% higher in treatment than control sections (7.5/100m in treatment, 4.6/100 m in control; Figure 9). In general pool frequency was lower or similar in treatment sections compared to control sections prior to restoration and shows a less consistent trend than LWD frequency. South Fork has a steep increase in pool frequency after the final treatment and maintenance in 2016 with little change in the control section. In Charley there is an increase in pool frequency in the treatment section after restoration but the pool frequency is increasing at a similar rate. In the North Fork there is no difference between treatment and control, with both increasing after treatment. We continue to observe variability at the individual habitat site level with some treatment sites having low pool frequency and some control sites having large pool frequency (Appendix E - Figure 23). This is likely due to wood movement, natural wood recruitment, variable effectiveness of structures, site specific conditions (i.e., site is more or less prone to creation of scour pools based on bed conditions or stream power), and a trend in all study creeks where the furthest upstream section (Section 3 which is a control in all three creeks) started in better condition and is trending towards recovery more than the downstream control sections.

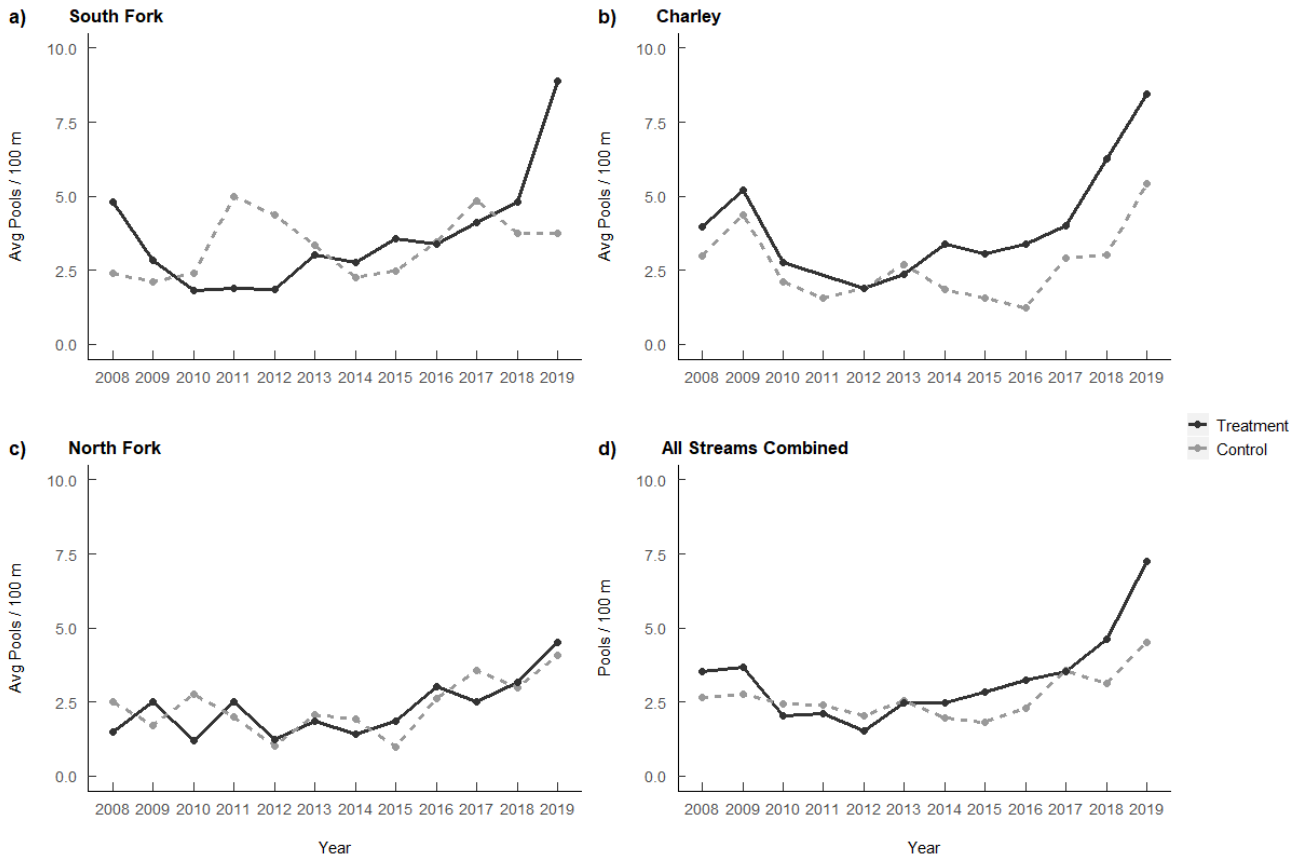

Figure 9. Trend in pool frequency in treatment and control sections in a) South Fork, b) Charley Creek, c) North Fork Creek and d) all streams combined: 2008-2019. Streams are ordered from first to last restoration implementation.

Pre- versus post-restoration comparisons

We compared changes in pool frequency by stream and fish site by plotting the pool frequency in the last pre-treatment year, the last post-treatment year (2019), the difference between post-restoration and pre-restoration, and calculating the % change (Appendix E – Figure 24-26). We observed large % increases in pool frequency in treatment sections post-treatment and little change to some decreases in control sites. To determine how much treatment sections changed relative to control sections we subtracted the % change observed in controls from the percent change in treatments and found that pool frequency in treatments increased between 125%-391% since pre-treatment period.

5.2.3. Bar Development

Unlike LWD and pools, we have not been surveying bars since the beginning of the IMW. We began assessing geomorphic units explicitly after we co-developed and implemented the Columbia Habitat Monitoring Protocol (CHaMP) in 2011 (Bouwes et al. 2011). During a CHaMP survey the topography of the stream channel is mapped and is used to derive a digital elevation model of the channel. From the elevation model we either delineate geomorphic units by hand or use the Geomorphic Unit Tool (GUT; http://gut.riverscapes.xyz; Appendix F - Figure 27). The tool is still in development but has been tested extensively on CHaMP data and is based on a geomorphic classification approach developed by Wheaton et al. (2015). Geomorphic units are delineated in Tiers. Tier 1 determines if a geomorphic unit is in-channel or on the floodplain. Tier 2 units are in-channel geomorphic units that are delineated by their topographic signature: convex = bar, concave = pool, and flat = planar (e.g., run, rapid). The size (topographic change, area, etc.) of units GUT delineates can be controlled with model settings (e.g., delineate only units > 2 m^2) .

We stopped using CHaMP after 2017 because of budget constraints and lack of support, and now use rapid habitat surveys to visually delineate geomorphic units. To assess changes in bar development we are currently comparing GUT output from 2011-2017 to our rapid surveys. The settings of our original GUT run delineated smaller bars than we delineated using rapid surveys so we cannot directly compare these surveys. We will be rerunning GUT on the 2011-2017 data to make it more comparable to 2019 data. However, we can still compare relative change between treatment and controls.

We compared changes in bar frequency by stream and fish site by plotting the bar frequency in the last pre-treatment year, the last post-treatment year (2019), the difference between post-restoration and pre-restoration, and calculating the % change (Appendix G - Figure 28-30). *Note* we manually reduced the bar frequency in all pre-restoration sites by 50% to make changes positive because GUT delineated more bars than our visual surveys and to make the % changes positive since we are observing increases in bars around many of the restoration structures. We observed net increases in bar frequency in treatment sections post-treatment. We cannot determine the true increase at this time due to the limitations outlined above but based on CHaMP, rapid, and structure effectiveness surveys (where we map geomorphic change around each structure; see 5.2.4 below) we are confident that there is a positive increase in bars in treatment sections compared to controls. Re-running GUT and potentially conducting more CHaMP surveys in the future are also being considered.

5.2.4. Restoration Effectiveness and Integrity

Short-term hydraulic and geomorphic changes

We have conducted detailed short-term assessments of our predictions of hydraulic and geomorphic changes around the restoration structures (PALS) in South Fork Section 2 (196 PALS) and Charley Creek Section 2 (207 PALS) and documented them in a Master's thesis (Camp 2015). In general, we observed many of the hydraulic and geomorphic responses we predicted including creation of constriction jets that increase scour and lateral migration, eddies and shear zones that provide resting areas near areas of high food delivery for juvenile fish, and a conversion of planar features (e.g., runs, rapids) to more pools and bars. We have almost 2,000 surveys over multiple years of hydraulic and geomorphic attributes around structures that we will be summarizing in 2020.

Long-term structure effectiveness and integrity

A concern of the PALS restoration actions was that the structures would only last 1-2 years and then wash downstream. However, we predicted that using wooden post to secure the LWD would create a relatively stable log jam and installing high densities of structures would ensure that any structures that moved or LWD that washed off a structure would get caught on structures downstream. We tested these predictions by annual surveys of the structures. In general, the majority of PALS are intact or mostly intact and many structures have grown in size as they accumulate natural LWD and IMW wood from other structures (Figure 10). Approximately the same proportion of new log jams are forming as are structures that wash downstream (~10-20% depending on stream). We are also seeing that much of the wood that does move only moves 3-5 structures downstream (Sutherland Pers. Comm., ongoing PhD thesis on wood movement in Asotin Creek IMW). We have also not observed or heard of any large wood accumulations downstream of the treatment sections in either the IMW control sites or outside the study area. We attribute this partly to the density of structures in the treatments and to the relatively small pieces of LWD we are using which are less likely to cause damage if they move outside of the IMW.

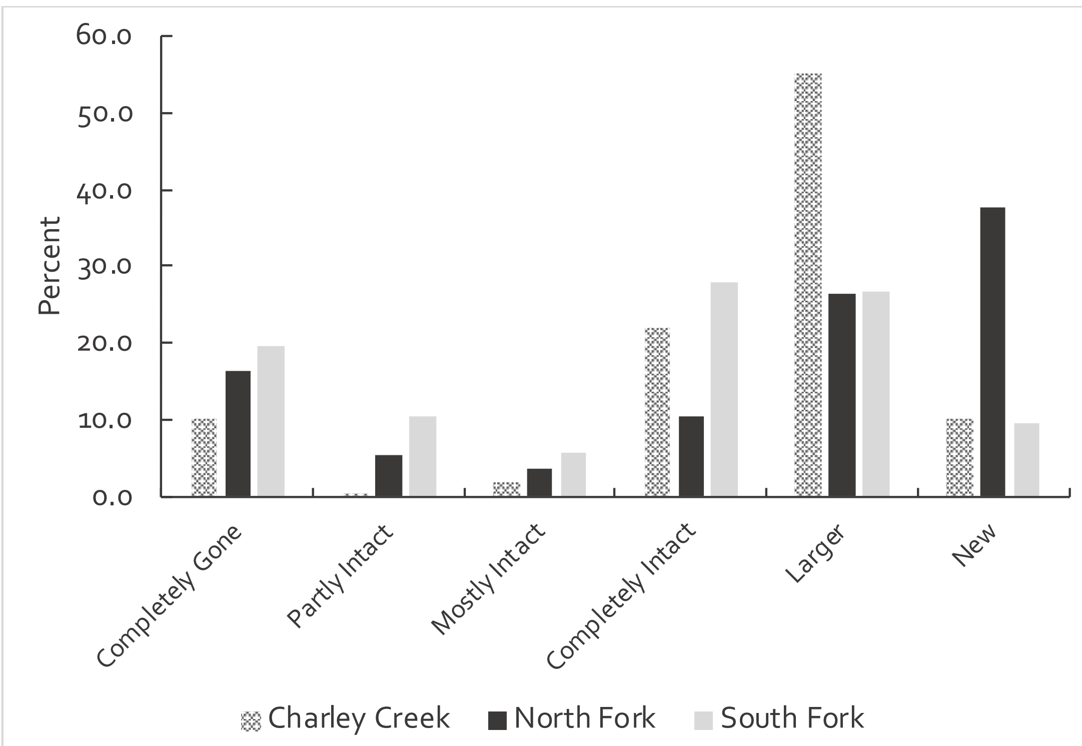

Figure 10. Percent of structures by category describing their integrity. Larger refers to structures that have increased 25% in volume due to wood accumulation and New refers to wood accumulations that have developed since the original restoration treatment from IMW wood, natural recruitment or both (Total number of wood accumulations now = 750 in 14 km treatment area).

5.3 JUVENILE STEELHEAD RESPONSE

5.3.1. Summer and Fall Abundance

We have conducted mark-recapture estimates in the summer and fall at 3-4 fish sites in each study creek (2 controls and 1-2 treatment sites) and have an almost uninterrupted data series from 2008-2019 (Figure 11). Fish abundance has averaged 1,041 in Charley Creek, 1,880 in North Fork, and 1,463 in South Fork Creek across all treatment and control sites. Fall abundance estimates are typically larger than summer because young-of-year are generally too small to tag (< 70 mm) in the summer but often attain tagging size (> 70 mm) by fall. There is limited annual variability despite large differences in the number of returning adults. More variability is evident between fish sites within the same stream (Figure 12). It is hard to distinguish any patterns from the data without using a statistical model.

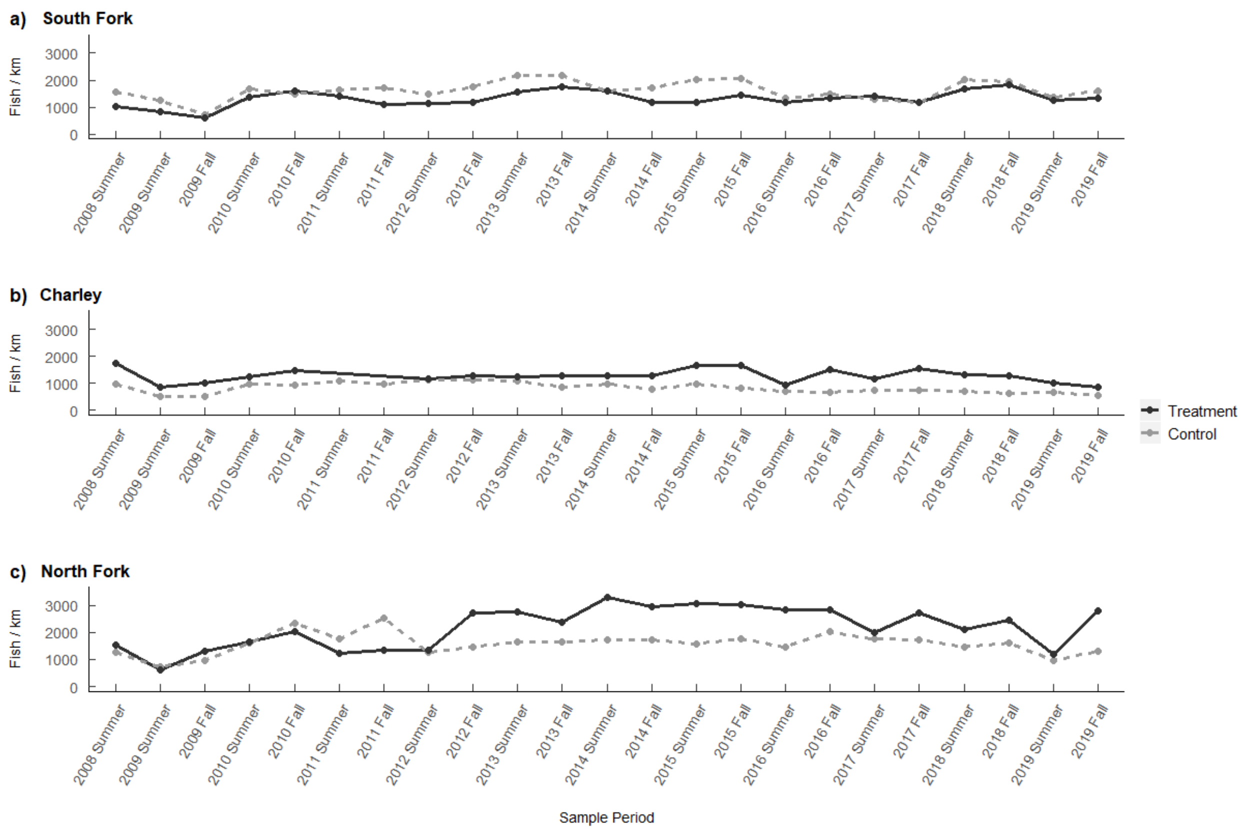

Figure 11. Average fish abundance by stream and treatment control: 2008-2019. Sample periods include one 2-day mark-recapture survey per fish site in the summer (July) and fall (late September to mid-October) every year except 2008 when only a summer survey was conducted.

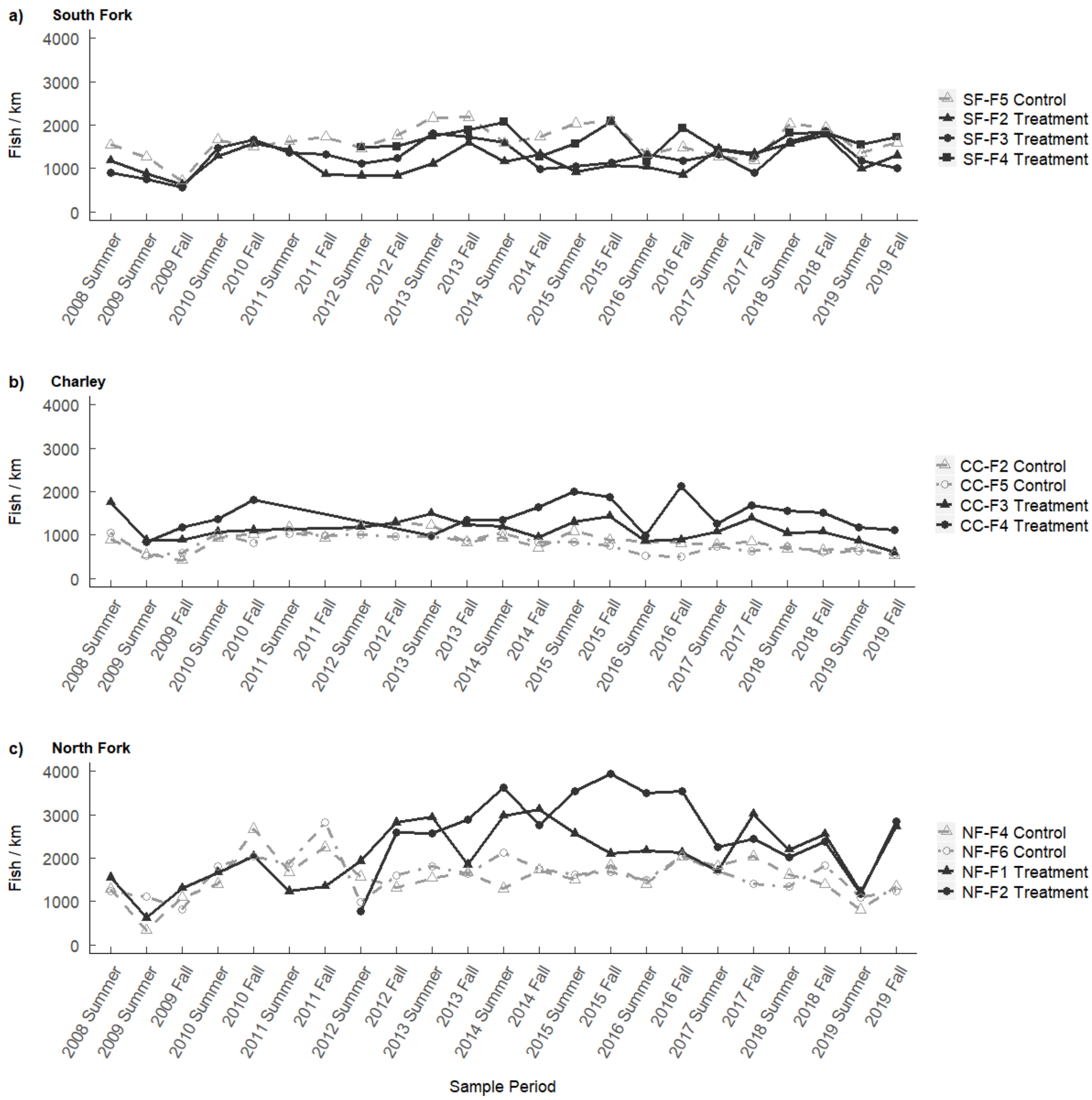

Figure 12. Average fish abundance by fish site and treatment and control: 2008-2019. Sample periods include one 2-day mark-recapture survey per fish site in the summer (July) and fall (late September to mid-October) every year except 2008 when only a summer survey was conducted.

Staircase Model

In 2017 after 5, 4, 3, and 1 years of post-treatment conditions in SFS2, CCS2, NFS1, and SFS1 respectively, only the North Fork treatment section had a significant increase in summer juvenile steelhead abundance based on mark-recapture populations estimates and analysis using the staircase model (Loughin et al. 2018 [resubmitting]; Bennett et al. 2018). We reran the same analysis using data from 2008-2019 and found a significant increase in juvenile abundance in both the North Fork and South Fork treatments (Figure 13). All treatment responses in summer and fall for all streams were positive ranging from 12.5 – 42.2% with larger increases occurring in the fall and in larger streams (i.e., North Fork > South > Charley).

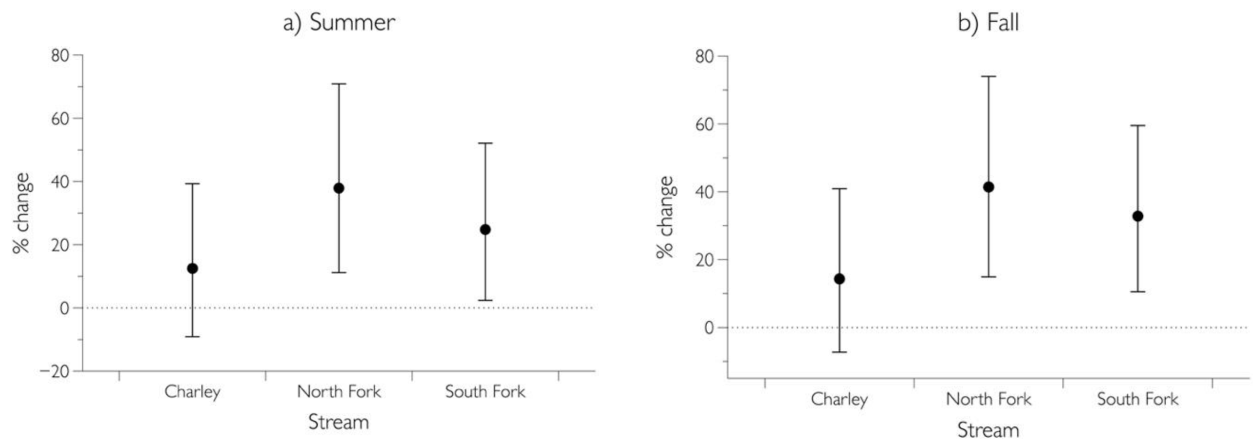

Figure 13. Results from the staircase model analysis comparing change in juvenile steelhead abundance in the treatments compared to the controls before and after restoration based on a) summer and b) fall mark-recapture surveys. Estimates are the percent change in juvenile steelhead abundance (fish/km) by each study creek in the Asotin Creek IMW: 2008-2019. Confidence intervals are 90% (α = 0.1). Summer estimates for Charley Creek = 12.5% (p = 0.19), North Fork = 37.9 (p = 0.016), and South Fork = 24.8% (p = 0.067); Fall estimates for Charley = 14.3% (p – 0.291), North Fork = 41.4% (p = 0.008), South Fork = 32.8% (p = 0.013).

We back-calculated the difference in juvenile steelhead/km from pre- to post-restoration by subtracting the mean pre-abundance from the mean post-restoration abundance (Table 6). We estimate that there are an additional 128-745 juvenile steelhead/km in the treatment sections post-restoration. Larger increases occurred in the fall and in larger streams (i.e., North Fork > South > Charley).

Table 6. Mean juvenile steelhead abundance (fish/km) pre-restoration, post-restoration, and difference (post-restoration – pre-restoration) for a) summer and b) fall mark-recapture abundance estimates: 2008-2019.

a) Summer	**Steelhead/km**		
Stream	Mean pre-	Mean post-	Difference
Charley	959	1,087	128
North Fork	1,429	2,026	598
South Fork	1,254	1,572	318

b) Fall			
Stream	Mean pre	Mean post	Difference
Charley	874	1,013	139
North Fork	1,766	2,511	745
South Fork	1,361	1,616	254

5.3.2. Growth

We calculated relative growth (mm/mm/day) of PIT tagged juvenile steelhead over two periods based on when we conduct our mark-recapture surveys: summer to fall (approximately 50-70 days) and fall to the next summer (approximately 240-270 days). We collected 25,305 measures of individual growth between 2008-2019. We found a decrease in relative growth in all streams over the two periods except in Charley Creek during the fall to summer period (Figure 14). It appears that the increase in juvenile steelhead abundance in treatment sections has led to fairly strong density dependent growth in the summer to fall period when flows are very low and temperatures are highest. Less density dependence occurs in the fall to summer period which likely reflects increases in flows, and decreases in temperature during this period which spans fall, winter, and spring. Charley Creek has flows that are more spring dominated and hence it is warmer in the winter months than the other study creeks. It appears that the spring influence in Charley Creek may be leading to generally positive growth in the fall to summer period. Growth estimates will be combined with abundance estimates and survival to determine production (g/area/time) in future analyses.

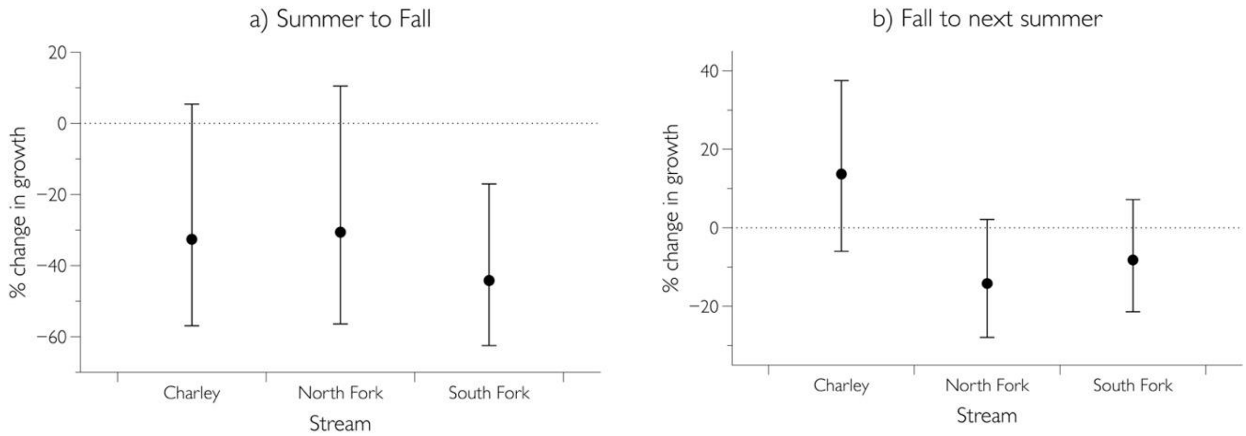

Figure 14. Results from the staircase model analysis comparing change in juvenile steelhead growth in the treatments compared to the controls before and after restoration based on a) summer and b) fall mark-recapture surveys. Estimates are the percent change in juvenile steelhead relative growth (mm/mm/day) by each study creek in the Asotin Creek IMW: 2008-2019. Confidence intervals are 90% (α = 0.1). Summer estimates Charley Creek = -32.6% (p = 0.145), North Fork = -30.6 (p = 0.194), and South Fork = -44.2% (p = 0.0.018); Fall estimates for Charley = 13.7% (p = 0.263), North Fork = -14.2% (p = 0.146), South Fork = -8.2% (p = 0.362).

6. SRFB ANNUAL REPORT QUESTIONS

Below we answer a series of "questions to be addressed" as requested by the SRFB monitoring panel. We provide supporting data above and in the Appendices.

6.1 IMPLEMENTATION SCHEDULE

a. What restoration actions remain to be implemented and when do you anticipate completing them?

We have completed all the main restoration actions (i.e., added wood to 14 km or 39% of study area); however, the low-tech restoration approach we applied explicitly assumes that to recover physical and biological processes, a phased approach to restoration will likely be required. We are implementing restoration in phases using a simple Adaptive Management Plan that relies on annual assessments of restoration actions. We do a complete survey of the restoration sections and decide if more wood is needed to 1) promote geomorphic complexity and 2) promote overbank flow and improved floodplain connection. We have added wood to treatments in 2016-2018 in small strategic efforts costing ~ $10,000 (original restoration treatments for 14 km was $500,000). We have a $30,000 wood addition planned for 2020 (funded by SRFB) which we will use to add wood based on our structure surveys.

b. Do you anticipate having to perform maintenance on existing projects and what is the justification for doing so?

Yes. See above. But by maintenance we mean "phases" of the restoration because the structures we built were not engineered structures. We built almost 700 structures assuming that some wood would move and that the structures may break down over time. We also hypothesized that because of the high density of structures, wood that moved would be trapped by downstream structures and/or form new wood accumulations (see Figure 10). Our approach can be captured in three of the restoration principles of low-tech process-based restoration (Wheaton et al. 2019 – Chapter 2):

Strength in numbers – a large number of small structures working together can mimic and promote natural wood accumulations and geomorphic processes more than a few expensive, large, stable structures.

Let the system do the work – providing the riverscape with the tools (i.e., LWD) and letting stream power promote processes is a more efficient way to scale to the scope of stream habitat degradation.

Defer decision making to the stream – by avoiding precisionism (Hiers et al. 2016) and a focus on structure stability we are deferring some of the decision making to the stream and not trying to impose a specific form on the stream.

6.2 SPECIES OF CONCERN

a. What are your focal species and their associated listing status?

The Asotin Creek IMW focal species are summer steelhead which is listed as threatened under the Endangered Species Act (ESA). Asotin steelhead are summer "A" run fish that generally migrate up the Columbia River and past Bonneville Dam before August 25 (ACCD 2004). Asotin Creek steelhead are part of the Snake River Evolutionary Significant Unit (ESU) based on genetic characteristics that distinguish the Snake River steelhead from other Columbia River Basin steelhead (ACCD 2004, SRSRB 2011). The Asotin Creek steelhead are further grouped into the Lower Snake Mainstem Tributaries Major Population Grouping (MPG) which includes the Tucannon River and nine small tributaries that flow directly into the Lower Snake River (SRSRB 2006). Asotin Creek and the following six tributaries are considered a ***subpopulation*** of the Lower Snake River MPG: Almota, Alpowa, Couse, Steptoe, Tenmile, and Wawawai Creeks. The Asotin Creek steelhead subpopulation is further divided into major spawning aggregations (MSA) and minor spawning aggregations (mSA) based on the intrinsic viability of spawning populations which is primarily determined based on the geographic complexity of spawning distributions and the number of discrete spawning populations within a watershed. The Asotin Creek Watershed and Alpowa are considered MSAs because they are thought to have been able to support at least 500 spawners historically. All other tributaries within the Asotin Creek subpopulation of steelhead are considered mSAs, which indicates they historically supported between 50-500 spawners. However, recent attempts to estimate what population capacity of some streams suggest that Asotin could have had two orders of magnitude higher adult steelhead (Table 7).

Table 7. Estimates of historic fish abundance based on run reconstruction from habitat availability and spawning densities (Pess et al. in review). Abundance estimates presented are one third of full capacity.

Stream	Summer/Fall	Spring	Coho	Steelhead
Asotin		1,435	-	15,362
Tucannon	89,772	116,297	141,757	71,087
Walla Walla	-	120,507	276,423	133,808

6.3 EFFECTIVENESS

a. What are the limiting factors believed to be in your watershed?

The primary limiting factors are:

- Structurally starved (i.e., low density of LWD, low inputs/recruitment of LWD, and low residence time of wood due to simple channel form and low roughness)
- Low hydraulic and geomorphic diversity (e.g., channel is incised, channelized, low sinuosity, dominated by planar features and coarse substrate)
- Low frequency of overbank flow, floodplain inundation, and disconnection of portions of the floodplain

b. How were completed restoration actions tied to limiting factors?

The restoration actions are tied directly to the limiting factors. We detailed the restoration actions in Wheaton et al. (2012), and created a conceptual diagram of response hypotheses (Figure 4, Appendix B), and sum up here:

- The riparian habitat in Asotin Creek is recovering and made up of predominately 20-40 year old alder which are locking in the stream and not providing much recruitment of LWD
- Successive floods and channelization has left much of the study area with simplified flow conditions and low diversity of geomorphic units and fish habitat; these are symptoms of structural starvation (i.e., low LWD frequency)
- Addition of hundreds of post-assisted log structures increase hydraulic diversity
- Increased hydraulic diversity leads to increased geomorphic diversity
- Increased geomorphic diversity leads to increased habitat diversity, sediment sorting, residence time of LWD and sediment, aggradation and scour, and overbank flow
- Increased overbank flow leads to increase in the extent and health of riparian habitat, side-channels and backwaters, floodplain connectivity, and ground water storage

- Increased riparian extent and health leads to greater LWD recruitment and self-sustaining processes
- *** Specific to ESA listed salmonid recovery, returning of a single thread channel with limited hydraulic and geomorphic diversity to a riverscape with a fully connected floodplain can significantly increase the available fish habitat per kilometer of valley bottom by increasing sinuosity and sustaining multiple channels (i.e., an anastomosing stream evolution stage); it is becoming more evident based on results from the Bridge Creek IMW, the Asotin IMW, and other research that providing more stream miles/valley length will provide the greatest benefits to freshwater fish production

c. Are the findings of this IMW applicable to other watersheds? Be specific about what findings are transferable and where? Specify criteria by which the findings translate to other watersheds (e.g. geomorphic conditions, climate regimes, land cover, ESUs, etc.).

Yes.

Scope of the problem - In our publication "Low-tech process-based restoration of riverscapes" we document the scope of degradation of North American streams and highlight that many thousands of stream miles are structurally starved (see Wohl et al. 2013, 2014). At an average cost of $200,000-500,000/km to add LWD it seems clear that it is not feasible to restore enough stream miles to recover ESA listed species at the current rate of restoration. The restoration action we are implementing and testing in Asotin creek provides an alternative and potentially more cost-effective approach to restoring structurally starved streams. We can use small pieces of wood from thinning operations and help with lowering wildfire risk to build structures and expand the restoration community because the approach does not require engineers and fancy models to implement. This approach to addressing structural starvation is applicable across the entire western US and we have examples across many different climates and landscapes – essentially wherever LWD played a role in riverscape health and function – this approach is applicable (Appendix B,C).

Wadeable streams and climate change – the findings from the Asotin IMW are particularly applicable to wadeable (order 1-5) streams which typically make up 90% or more of the perennial stream network (Colvin et al. 2019). The low-tech structures have withstood flows of ~1000 cfs and are still functioning after nine years. We see huge potential for this approach to help buffer the imminent threats of climate change because the approach can be applied in headwater streams where tradition engineering approaches would cause too much damage to riparian areas (and be too costly). Treating hundreds or thousands of miles of headwater streams could help to slow water from leaving watersheds, recharge groundwater, reconnect disconnected floodplains creating more storage opportunity, and perhaps provide higher base flows, and limit impacts of climate change (Justice et al. 2017). These results could be especially applicable on the eastside of the Cascades where predictions for snow dominated hydrologic regimes are expected to shift towards rain dominated regimes due to climate change (Liermann et al. 2012).

Restoration response – our decision to treat all three streams in the study area is providing us with a greater opportunity to expand the results to a broader range of streams types and may also help to prioritize restoration actions. Charley Creek is relatively small and spring fed, South Fork is medium sized and has more variation in flow, and the North Fork is large and has flows similar to the mainstem Asotin Creek (Table 1). Each of these streams seem to be responding differently to restoration. The North Fork, despite being treated last, had the first fish response and more dramatic geomorphic responses. South Fork, treated first, had a lower fish response and more variable geomorphic response. Charley Creek appears to be slow to respond both in fish and geomorphology. And the streams respond differently – as an example, fall-summer growth was only positive in Charley. These results suggest that flow is a key driver of physical responses, and flow and temperature are key drivers of biological responses, and that larger rivers with bigger flows will likely respond more rapidly all other things being equal. It also highlights that past studies of restoration effectiveness on smaller streams may have inaccurately concluded that there was no restoration response when it could have been because of lack of sufficient flows. Our expectations for responses need to match the local conditions and underlying timing and magnitude of flows that control formation and condition of stream habitats and their distribution.

Benefits of partial restoration – we were focused on increasing in-channel complexity when the IMW was initiated because that is a leading limiting factor identified in many streams in southeast Washington (SRSRB 2011). We also wanted to promote overbank flow and floodplain restoration but we recognized that it may take time due to the degraded channel, lack of wood, and erosion resistant banks (i.e., banks comprised of coarse substrate and held together by roots from dense stands of alder). Like many wadeable streams with narrow valleys, the floodplain extent in the study creeks is limited and often discontinuous (one side or the other of the stream but not both), or found in isolated pockets. However, just like larger streams in more alluvial valley settings, overbank flows are less common and much of the floodplain is functionally disconnected in the study creeks. However, because we are implementing the IMW on WDFW in the mid-upper watershed there is limited infrastructure or risk to fully connecting the floodplain.

This is a long-winded way of saying, the IMW will be able to demonstrate the physical and biological benefits of moving from Stage 5-7 to 8 (Cluer and Thorne 2014, Figure 15). Stage 8 may be a common stage to target restoration because complete floodplain connection may not be feasible due to development. However, we have the opportunity to push some or all of the treatment sections to Stage 0 and quantify the **benefits** and the **costs** of reaching this stage. These results could then be used to prioritize restoration based on cost/fish which has been recommended by the ISRP but is rarely if ever done. Our current results are very similar to the % increase in benefits between Stage 6-7 and Stage 8 articulated by Cluer and Thorne (Figure 15, ~30-40%). We may also get lucky and have beaver populations expand as the condition of the study creeks improve, providing more predation cover and food resources. Then we may be able to document the fish responses as beaver push the system from Stage 8 to Stage 0 (for a lot less cost).

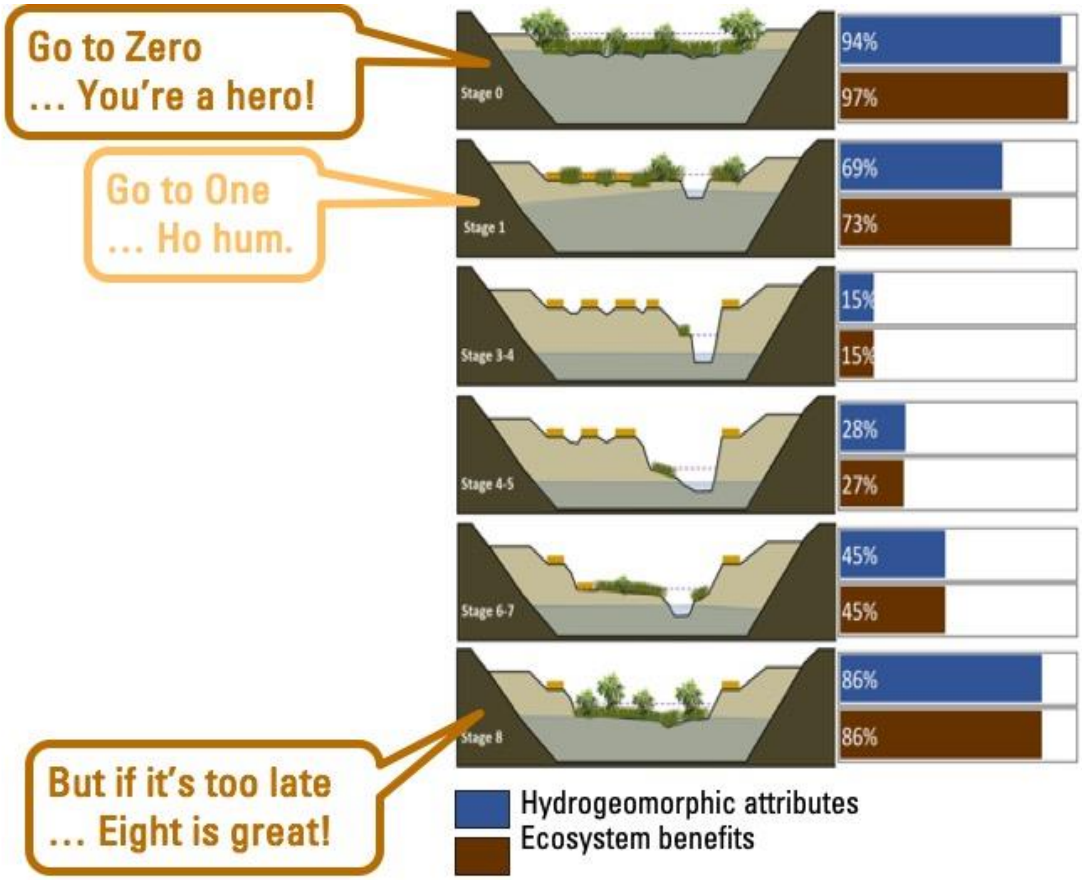

Figure 15. Stages of stream evolution and percent of potential hydrogeomorphic/ecosystem benefits adapted from Cluer and Thorne (2014) and borrowed from M. Beardsley. Study Creeks in Asotin IMW started in stage 6-7 and are moving towards Stage 8 due to restoration actions. More phases of LWD additions could move some treatment sections to Stage 8 and potentially Stage 0 (especially if beaver populations expand).

6.4 COLLABORATION AND COMMUNICATION

a. **Cite examples of how your program has collaborated with monitoring partners (including project sponsors, lead entities, and local, state, tribal, and federal agencies). The purpose of this is to demonstrate the depth and breadth of collaboration that is occurring; a comprehensive list of every communication with your partners is not necessary.**

The Snake River Salmon Recovery Board has coordinated the Asotin IMW from its inception in 2007. The selection of the location for the IMW was a collaborative effort that took over 6 months to complete. Meetings were held with the Regional Technical Committee (RTT) and selection criteria for choosing a location for the IMW were established. The RTT is made up of project sponsors, lead entities, local, state, tribal, and federal agencies. The RTT provided data and input into the scoring and ranking of different watersheds which led to Asotin Creek being selected as the location for the IMW. Since then, we have presented experimental designs, monitoring approaches, and preliminary data to RTT and local stakeholders for review and input at 3-6 meetings annually. We have also hosted several tours of the IWM for project sponsors and stakeholders throughout the Snake River Salmon Recovery region. And we continue to work with WDFW via maintenance of the PIT tag interrogation sites, monitoring and tagging of juvenile steelhead and general project management.

b. **List reports and other technical products (e.g. presentations, maps, graphics, videos, etc.) that have been produced and where they can be obtained by the public. The purpose of this is to document public access to the results of your work; a comprehensive list of all materials is not necessary.**

We have published several papers on the IMWs, Adaptive Management, our restoration actions, survey methods, modeling approaches, and supported graduate theses on the IMW (Appendix H). We have also developed numerous newsletters and landowner/stakeholder tours and presentations of the IMW as well as presented aspects of the IMW at Salmon Recovery symposiums, American Fisheries Society meetings, and other science gatherings. We share our presentations with RCO, and SRSRB posts our reports on their website (http://snakeriverboard.org/wpi/library/). We have also worked with RCO to develop a story map for the IMW. And we post our reports and research on personal ResearchGate sites (Stephen Bennett), University website (Fluvial Habitat Center; https://restoration.usu.edu), company websites (Anabranch Solutions; Eco Logical Research), restoration manual (https://lowtechpbr.restoration.usu.edu/#), and data hub for all the models we develop and use (https://www.riverscapes.xyz).

c. **Provide examples of conferences/meetings in which your program presented or participated; a comprehensive list of every presentation is not necessary.**

See Appendix H for a list of presentations and outreach.

6.5 ADAPTIVE MANAGEMENT

a. **Please identify any specific changes made in your methodology over the reporting period.**

We have not made any changes to our methodology over the current reporting period. The main changes we have made to the Asotin IMW is previous reporting periods were to go from implementing a traditional BACI design with one treatment stream and two control streams to a staircase design where we treated one 4 km long section in each of three streams and implemented the restoration over three years. We did this because an extensive modeling exercise and statistical comparisons revealed that the power to detect a treatment response would be greater in the staircase design, especially when variance is high. We are currently revising a paper on the staircase design to resubmit for publication. Other minor changes to the IMW include switching from the PIBO habitat protocol to the CHaMP habitat protocol, and suspending CHaMP protocol to free up budget for more analysis and to wait for more geomorphic changes. CHaMP may be conducted again to get topography before wrapping up the IMW. We have previously documented changes to IMW in Bennett et al. (2015).

b. What challenges have you encountered in implementing your monitoring program?

Generally, the Asotin IMW is an ideal situation for an experiment because there is only one landowner (WDFW), one species (steelhead), a relatively healthy population of wild fish with very limited hatchery influence, and fairly identifiable and specific type of habitat degradation (lack of wood). A key issue with the IMW is that the budget precludes having a full time person in charge of data collection and management. We had support by ISMEP to develop and manage data – we no longer have that support as ISMEP was mostly discontinued. Managing data is a constant struggle as the data streams are almost continuous. We have been lucky and not had too many missing data points (e.g., fail to get population estimate for a fish site). Maintaining temperature and flow monitoring programs (which are necessary to use as explanatory variables) is difficult because of data loss (probes wash away or fail). Luckily some of the lost data can be recreated using regressions with data from other sites, but this is time consuming and difficult to manage. By scaling back some of our habitat sampling we are able to spend more time on data management, synthesis, and summarization which should allow us to more efficiently analyze data and publish our findings.

The most challenging field surveys have been identifying specific steelhead spawning locations and we or WDFW no longer do spawning surveys. Flows and visibility are unpredictable and spawning sites are in low densities (i.e., far apart), making it costly to survey. We now rely on PIT tag arrays and tagging adults at the WDFW weir to estimate adult escapement at the stream scale.

c. How will the findings of this IMW inform future salmon recovery (broad answers are appropriate)?

Test and document a more process-based and cost-effective restoration approach that can expand the restoration community (it is relatively easy to train people to do low-tech) and lead to more miles of stream being restored.

Provide a more appropriate restoration philosophy and approach to restoring wadeable streams that focuses less on stability and creating form and more on mimicking, promoting, and sustaining physical and biological processes. More flexible and cost-effective project and structure design and implementation (no requirement for flow and sediment models).

Provide insight and contrast on the cost-benefit of Tonka toy restoration versus low-tech; we cannot restore thousands of miles of riverscape at $500,000 – 1,000,000/mile.

Expectation management – restoration needs to be done in phases (it will be rare that we can fix 200 years of degradation with one treatment); there has been an implicit assumption that restoration is one-and-done.

This project could provide an example and guidance on how to set more realistic expectations and implement cost-effective phased restoration using a simple Adaptive Management approach.

Clear demonstration and quantification of the physical and biological responses to LWD restoration which can aid in prioritization of future restoration actions. *** Specific to ESA listed salmonid recovery, returning of a single **thread** channel with limited hydraulic and geomorphic diversity to a riverscape with a fully connected floodplain can significantly increase the available fish habitat per kilometer of valley bottom by increasing sinuosity and sustaining multiple channels (i.e.**,** an anastomosing stream evolution stage); it is becoming more evident based on results from the Bridge Creek IMW, the Asotin IMW, and other research **that the providing more stream miles/valley length will provide the greatest benefits to freshwater fish production.**

7. PLANS FOR 2020 AND BEYOND

We have provided results for juvenile steelhead survival, capacity, production, and productivity measures for 2008-2017 in previous reports and plan to update these analyses in 2020. It is a slow and time consuming process to gather the data to measure survival, capacity, production, and productivity over time scales that are needed to understand population responses. However, these are critical components to developing a greater understanding of restoration effectiveness and the reason that IMWs were developed (Bilby 2005, Bennett et al. 2016).

We plan to maintain current monitoring levels, compile data sets on geomorphic conditions, fish abundance, growth, movement, survival, capacity, production, and productivity. We also plan to map floodplain connection pre- and post-restoration to document the effect on fish. We will use aerial imagery, LiDAR, and site maps developed during PIBO and CHaMP surveys to assess pre-restoration floodplain conditions and surveys in the spring of 2020 to assess post-restoration conditions in treatment and control areas. We also plan to develop manuscripts on short (< 5 years) and long-term (> 5 years) geomorphic responses to LWD additions, a life history paper for Asotin steelhead, and begin to develop models to help us understand factors controlling juvenile steelhead abundance, growth, movement (i.e., age at migration), and production.

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APPENDIX A – EXPERIMENTAL DESIGN AND MONITORING MAPS

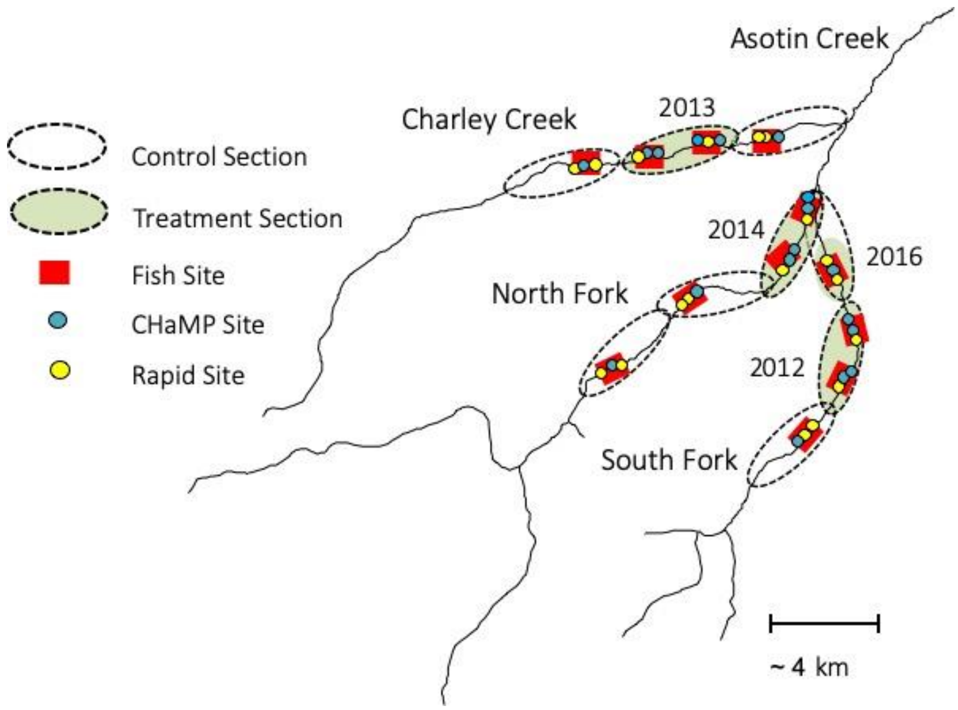

Figure 16. Experimental design and sample sites for juvenile PIT tagging and habitat surveys for the Asotin Creek Intensively Monitored Watershed project. Each study creek has three 4 km long sections. One section in each stream was restored each year (staircase design) using post-assisted log structures (shaded green): South Fork (2012), Charley Creek (2013), and North Fork (2014). An additional section was restored in South Fork (lower section) in 2016 at part of the Adaptive Management plan. All other sections not colored are controls. Fish sites and habitat survey sites are nested within each section. CHaMP = Columbia Habitat Monitoring Protocol, Rapid = custom rapid habitat survey.

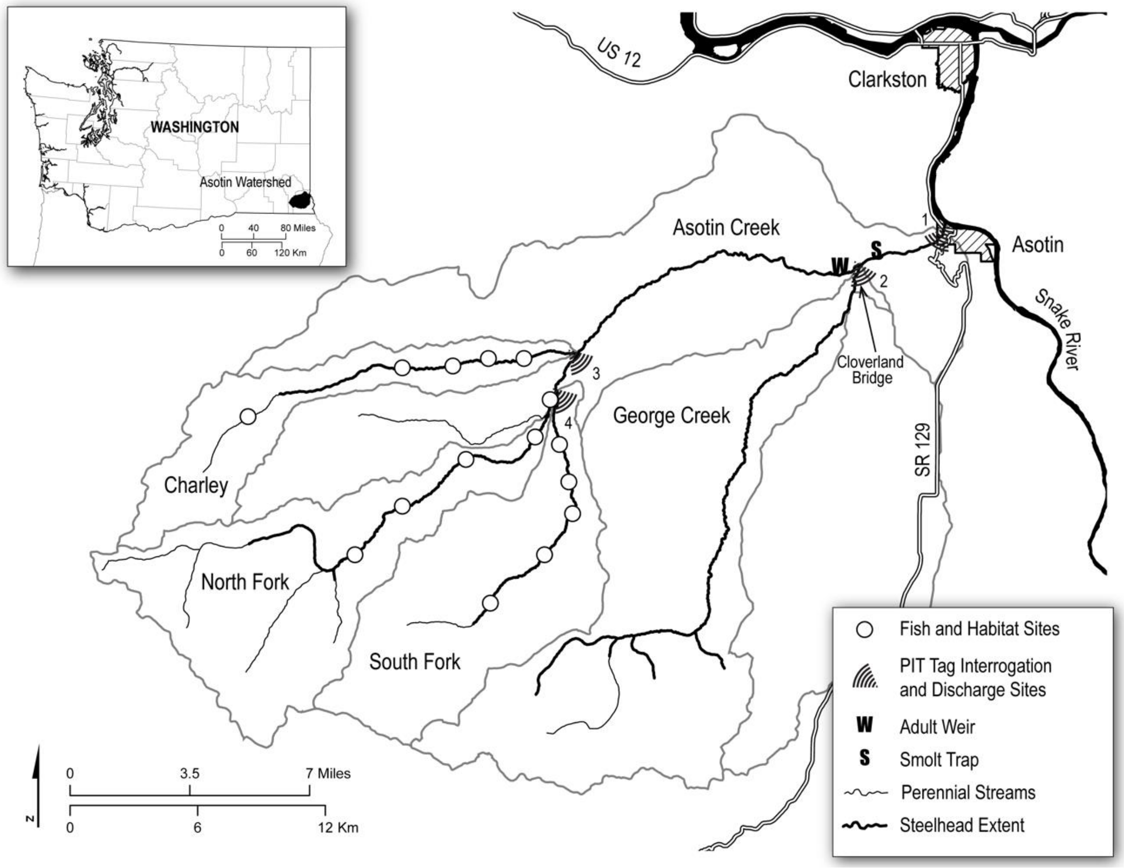

Figure 17. Monitoring infrastructure including fish and habitat sites in Charley Creek, North Fork, and South Fork Creek, discharge gauges, passive integrated transponder (PIT) tag interrogation sites, and the WDFW adult weir and smolt trap for fish-in fish-out monitoring. Water temperature is monitored at each fish site and entering and leaving treatment and control sections. Discharge is measured at the mouth of Charley, North Fork, South Fork, and Asotin Creeks. The Columbia Basin PIT Tag Information System (PTAGIS) PIT tag interrogation sites are: ACM – mouth of Asotin Creek, ACB – Asotin Creek mainstem at Cloverland Bridge, AFC – confluence of North Fork and South Fork Asotin Creek, and CCA – near mouth of Charley Creek.

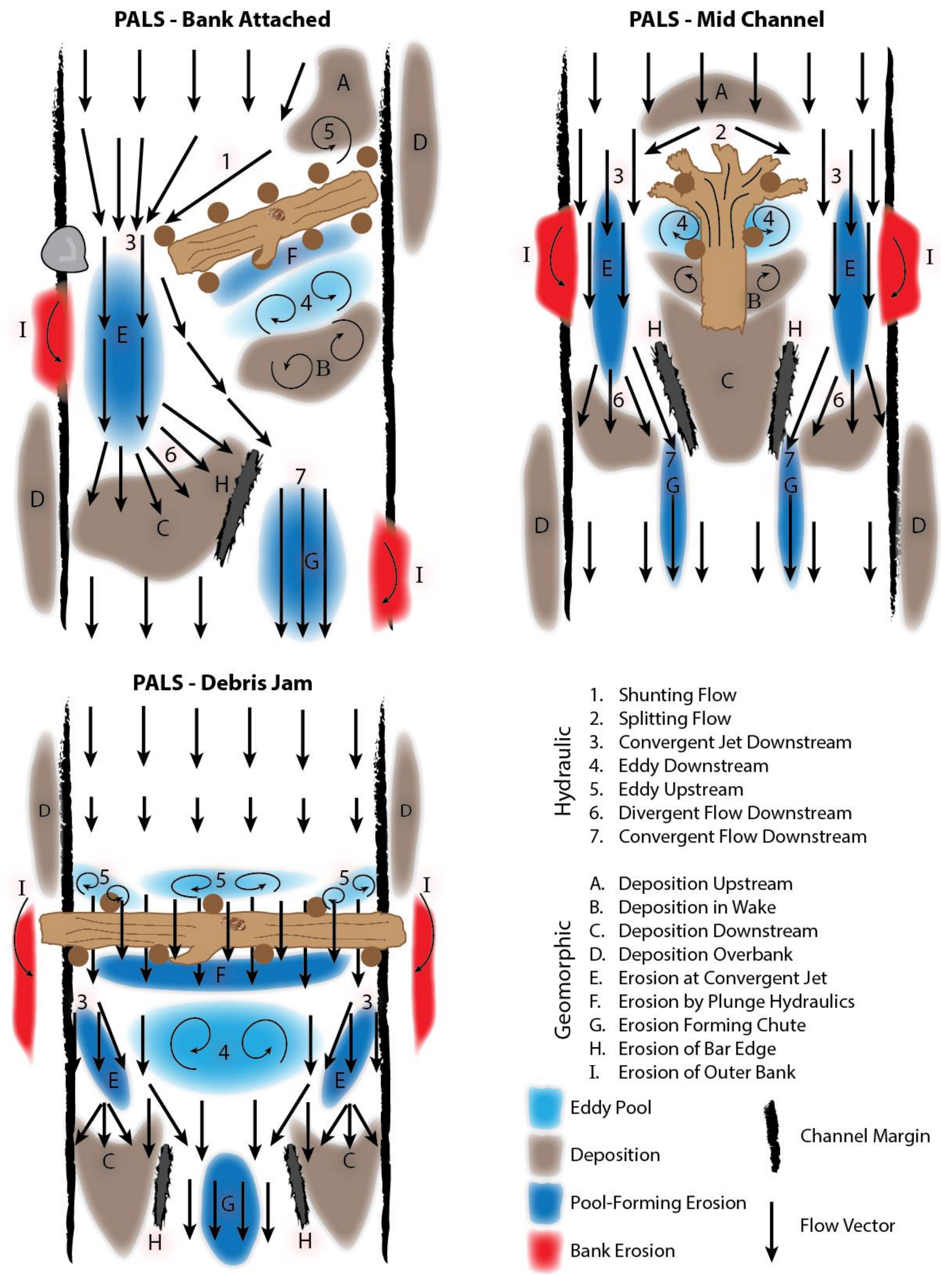

Figure 18. Design and expected responses of the three post-assisted log structure types: Red indicates bank erosion, blue indicates scour, brown indicates deposition, and arrows indicate flow direction and velocity

APPENDIX C – EXAMPLES OF LOW-TECH PROCESS-BASED PROJECTS

Little Tucannon River, WA - Post-assisted log structures (PALS)

Designed and assisted in construction of over 50 PALS over 2 km of lower river. Goal of the project was to improve steelhead rearing and spawning habitat and assist conservation district to apply Cheap and Cheerful restoration technique. Funding from the Snake River Salmon Recovery Board.

Alpowa Creek, WA - Post-assisted log structures (PALS)

Extrapolation of the low-tech process-based restoration approach from Asotin Creek IMW. Goal is to improve juvenile steelhead habitat and potentially increase summer base flows. Over 900 PALS installed from 2014-2019. Several large landowners partnering with Conservation Districts to implement.

Pataha Creek, WA - Beaver Dam Analogues (BDAs) and post-assisted log structures (PALS)

Pilot implementation of 8 BDAs installed in 2015 and scaled up to full implementation of 140 BDAs and PALS in 2016-2107. The project is to restore a steelhead habitat in a heavily incised channel (20-30' incision) and encourage recolonization by beaver. Beaver are currently limited by lack of food and the structure of inset floodplain. Main partner is the Pomeroy Conservation District. Project covered over 4 km and included planting of over 3000 willows to try and control invasive reed canary grass.

Birch Creek, ID - Beaver Dam Analogues (BDAs)

Forty BDAs (and 2 lodges) installed from 2014-2016, beaver reintroduced into ponds created by BDAs in 2015. Beavers have now built 150 dams and are expanding upstream and downstream from the release site. Visual observations of flow over past decade and plotting when the stream goes dry related to the snowpack suggest beaver dams are increasing summer base flows and producing perennial flows which have not existed for several decades. We have also demonstrated increases Bonneville Cutthroat trout abundance in beaver influenced areas compared to degraded sections of stream. Partners: Rancher (allotment permittee), USFS, IDFG.

Pine Creek, OR - Beaver Dam Analogues (BDAs)

Pilot project constructed in 2014, Design and Scoping Reports delivered. The project is targeted at improving steelhead habitat and riparian habitat in an incised channel with a much less competent flow regime than Bridge. Main partner is Confederated Tribes of Warm Springs and the Oregon Natural Desert Association.

SF Crooked River, OR - Beaver Dam Analogues (BDAs)

Project is to restore ~8km of stream by adding BDAs to reconnect floodplain, recruit riparian vegetation, increase water storage, and create suitable beaver habitat. Pilot structures implemented in 2015 and larger implementation in 2016-2018.

Basin Creek, UT - Beaver Dam Analogues (BDAs)

30 pilot structures on 2 km of one stream installed in 2014 and maintained in 2015. This one is primarily targeted at improving foraging for cattle, improving instream habitat for Yellowstone Cutthroat Trout, and brood rearing habitat for sage-grouse. Partners are two ranchers (it's private property) and UDWR. Two beaver were translocated into the upstream restoration reaches in Fall 2015, however there were no signs of beaver activity in spring 2016. Currently, we are hoping to live trap and translocate more beaver in order to leverage benefits provided by the existing BDAs.

San Rafael River, UT - Beaver Dam Analogues (BDAs)

Pilot treatment using BDAs implemented in spring 2015 consisting of 40 channel spanning structures. The restoration goal is to improve instream habitat complexity for three native and threatened fish species. The San Rafael represents a new setting for the use of cheap and cheerful restoration techniques. Ongoing maintenance of structures and construction of new structures has been undertaken by Anabranch Solutions with help from Utah State University, Utah Division of Wildlife Resources, and the Bureau of Land management. Ongoing monitoring efforts by USU are assessing the geomorphic response to restoration treatments in order to inform future restoration and management decisions.

Grouse Creek, UT - Beaver Dam Analogues (BDAs) and Beaver Relocation

Restoration efforts began in the upper Grouse Creek watershed in 2016, funded by the Watershed Restoration Initiative. In spring 2017, a complete restoration proposal and restoration design was completed by Utah State University and Anabranch Solutions LLC, based on observations of the pilot treatment. In June 2017, 114 BDAs were built along Pine Creek, Kimbell Creek, and Cotton Creek along 8+ stream miles. All BDAs were designed and built to achieve specific restoration objectives that reflect the restoration goals for each stream, including channel incision recovery, increased channel-floodplain connectivity, and providing immediate habitat for beaver translocation. An important aspect of the Grouse Creek restoration is the translocation of beaver. While BDAs may produce short term benefits for stream and riparian health, continued benefits of restoration require maintenance of BDAs that is best achieved by translocating beaver. In early September 2017 the Utah Division of Wildlife Resources revised the Utah Beaver Management Plan, allowing UDWR personnel to live trap and translocate beaver into the Grouse Creek Watershed. Currently, UDWR and USU are working together to live trap and translocate beaver into the Pine Creek and Kimbell Creek where BDAs were built in order to provide deep water habitat for beaver translocation.

Spring Creek, UT - Adaptive Beaver Management Plan

This is the Walmart 'Living with Beaver' project. The purpose is to mitigate potential flooding and harvest impacts of beavers in an urban area. Partners are Bear River Watershed Council, Walmart, City of Logan.

Birch Creek, UT - Beaver Dam Analogues (BDAs) and post-assisted log structures (PALS)

Demonstration project along 3 km of stream designed to compare and contrast a variety of cheap and cheerful structures including Beaver Dam Analogs (BDAs), Post Assisted Log Structures (PALS) as well as different construction techniques (i.e., structure that utilize posts and post-less structures). Project is funded by a Watershed Restoration Initiative grant to BLM. In addition to cheap and cheerful methods, UDWR personnel will be using heavy equipment to provide additional examples of restoration structures. As part of the demonstration, a site 'atlas' and signage will be constructed at the restoration site.

APPENDIX D – LARGE WOODY DEBRIS FREQUENCY SUMMARIES

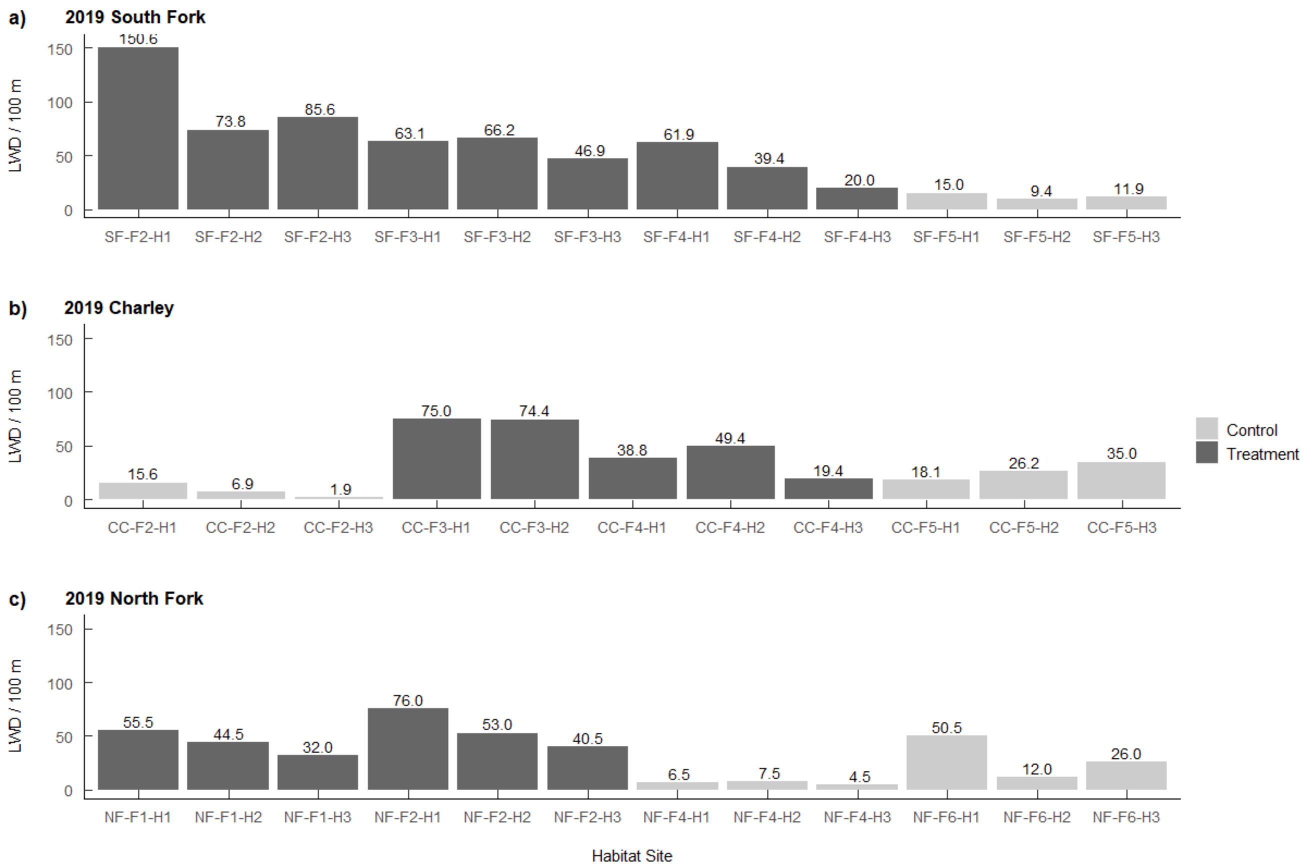

Figure 19. Frequency of large woody debris (LWD) in 2019 by habitat site and control and treatment sections for a) South Fork, b) Charley, and c) North Fork Creeks. Each fish site has three associated habitat sites. Habitat sites are 160 m long in South Fork and Charley Creek, and 200 m long in North Fork. SF-F2-H1 = South Fork fish site 2, habitat site 1. All fish sites are numbered from downstream to upstream.

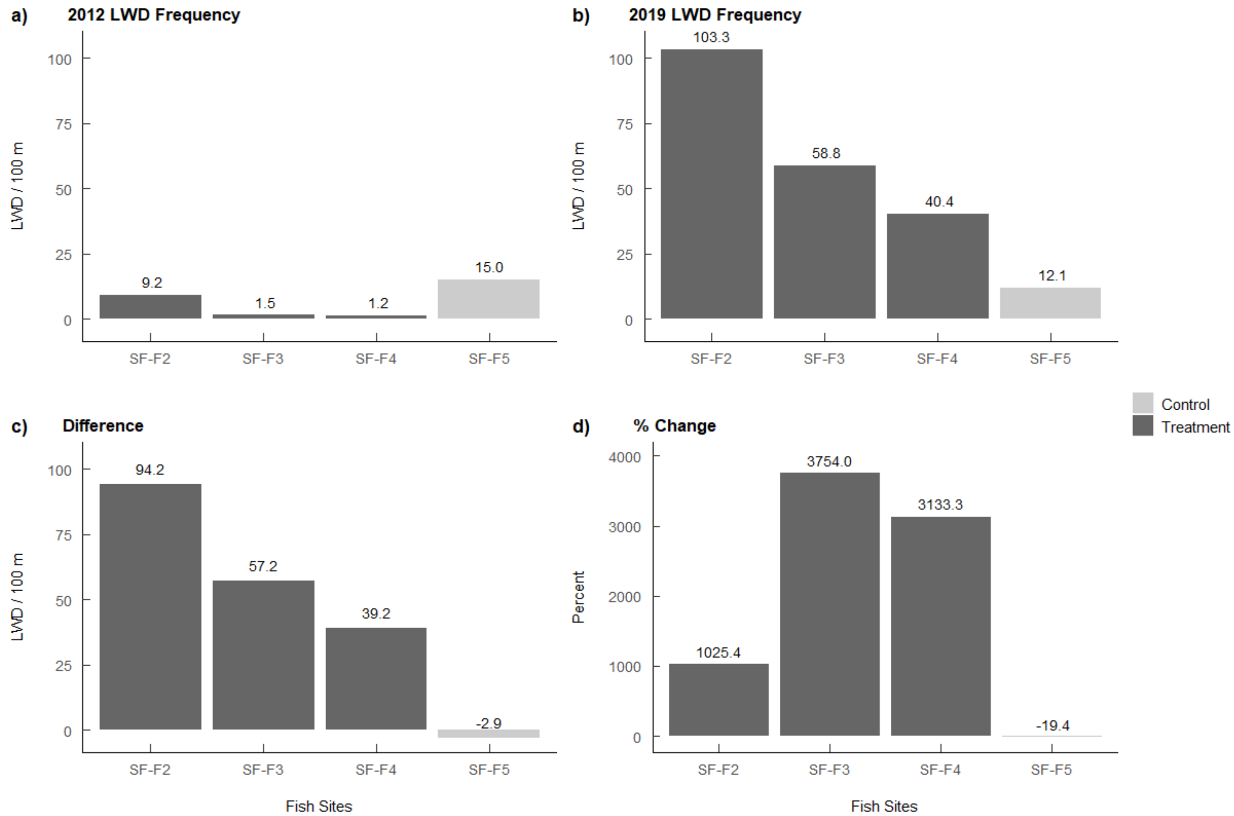

Figure 20. Frequency of large woody debris (LWD) in a) 2012, b) 2019, c) the difference (treatment – control), and d) the percent change in South Fork by fish site (average of three associated habitat sites). SF-F2 = South Fork fish site number 2. All fish sites are numbered from downstream to upstream.

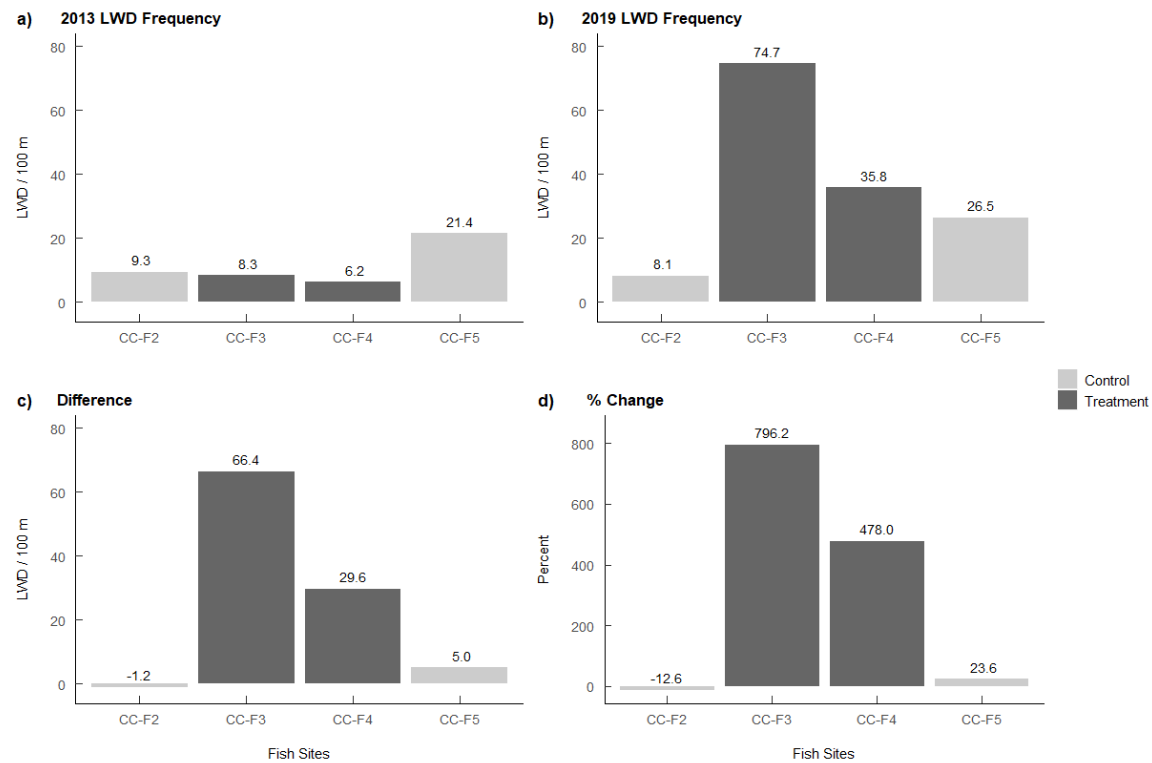

Figure 21. Frequency of large woody debris (LWD) in a) 2013, b) 2019, c) the difference (treatment – control), and d) the percent change in Charley Creek by fish site (average of three associated habitat sites). CC-F2 = Charley Creek fish site number 2. All fish sites are numbered from downstream to upstream.

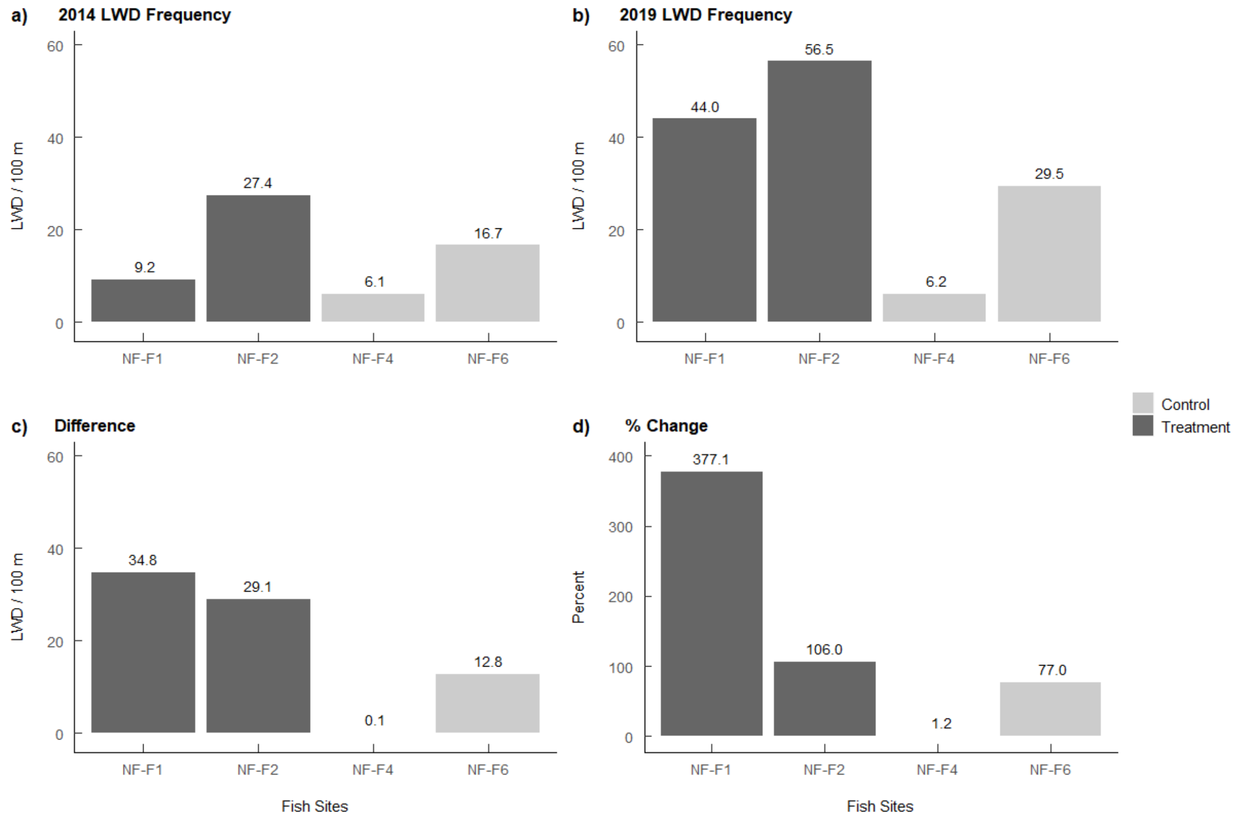

Figure 22. Frequency of large woody debris (LWD) in a) 2013, b) 2019, c) the difference (treatment – control), and d) the percent change in North Fork by fish site (average of three associated habitat sites). NF-F2 = North Fork fish site number 2. All fish sites are numbered from downstream to upstream.

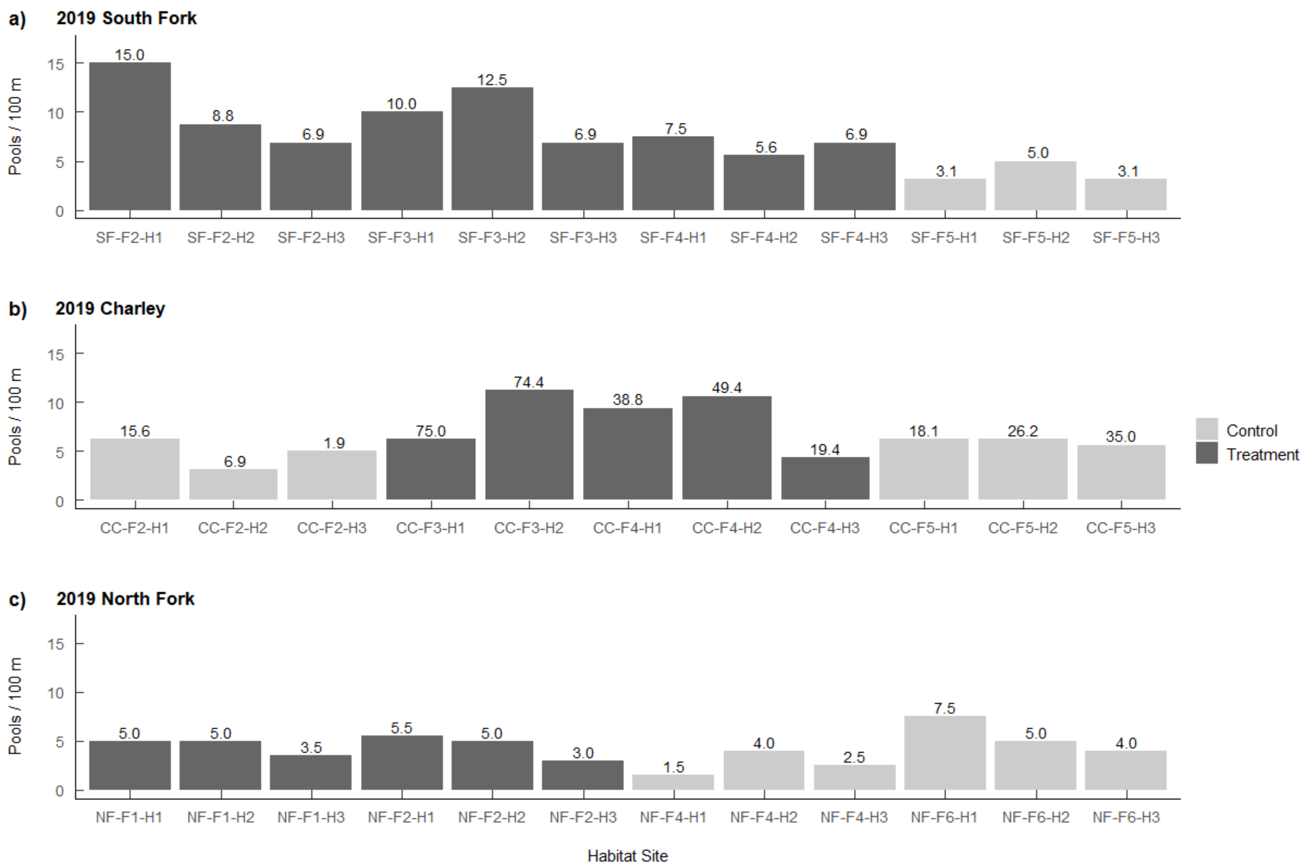

Figure 23. Frequency of pools in 2019 by habitat site and control and treatment sections for a) South Fork, b) Charley, and c) North Fork Creeks. Each fish site has three associated habitat sites. Habitat sites are 160 m long in South Fork and Charley Creek, and 200 m long in North Fork. SF-F2-H1 = South Fork fish site 2, habitat site 1. All fish sites are numbered from downstream to upstream.

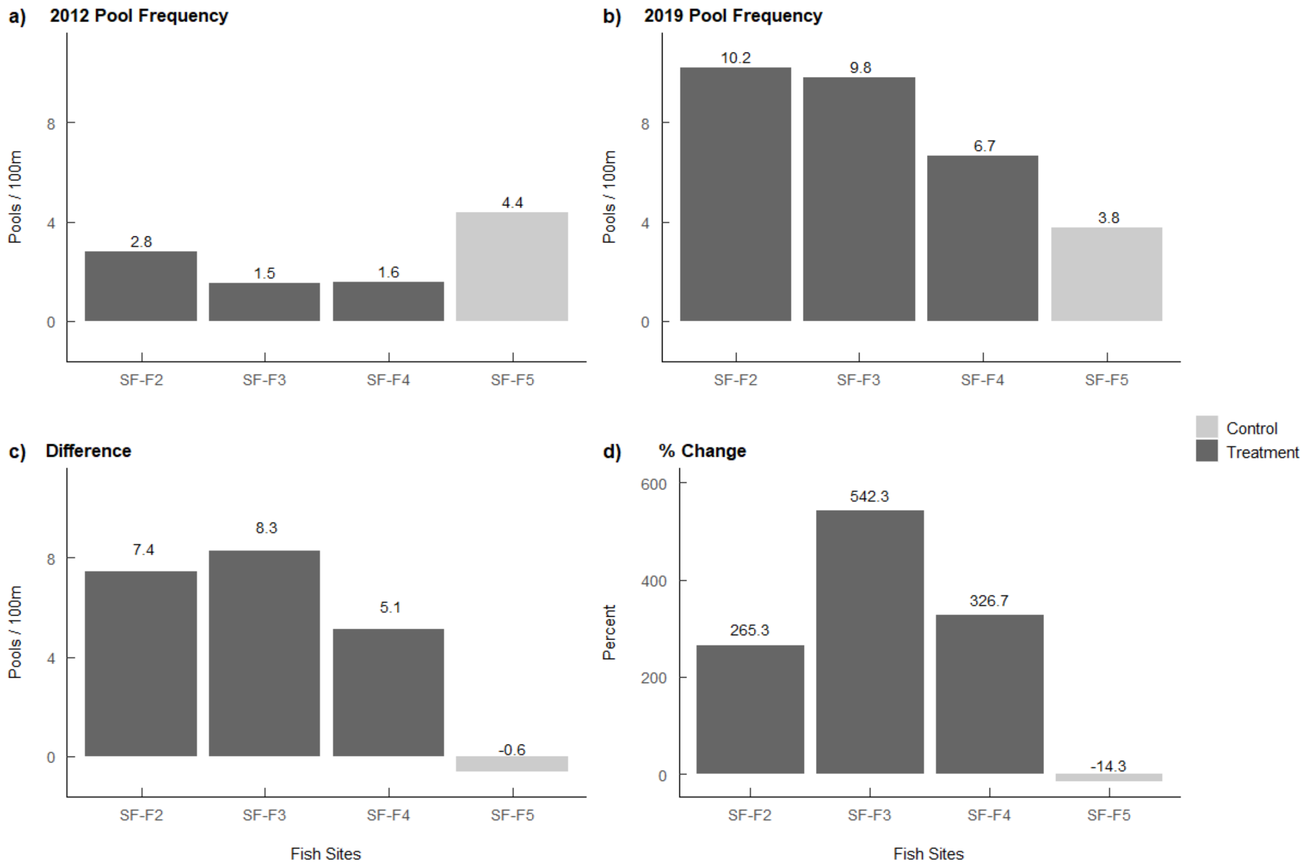

Figure 24. Frequency of pools in a) 2012, b) 2019, c) the difference (treatment – control), and d) the percent change in North Fork by fish site (average of three associated habitat sites). SF-F2 = South Fork fish site number 2. All fish sites are numbered from downstream to upstream.

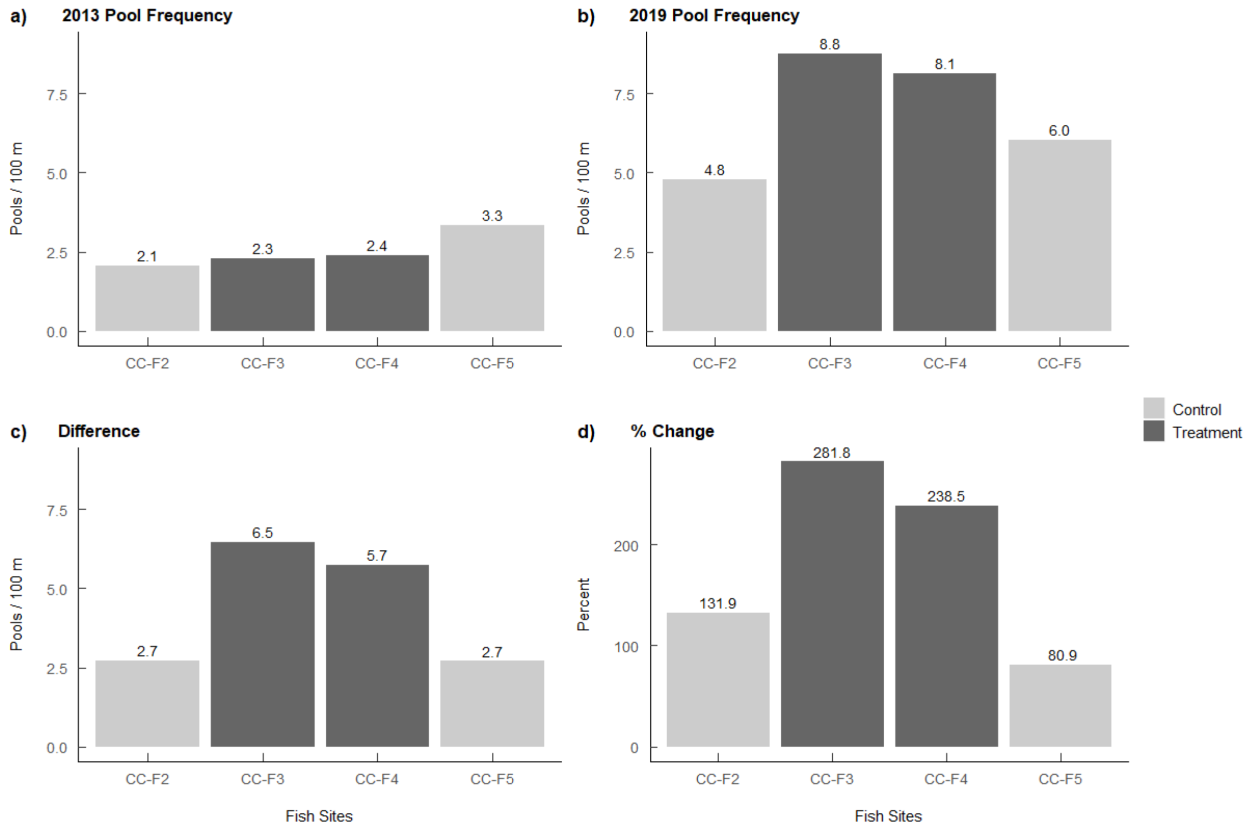

Figure 25. Frequency of pools in a) 2013, b) 2019, c) the difference (treatment – control), and d) the percent change in Charley Creek by fish site (average of three associated habitat sites). CC-F2 = Charley Creek fish site number 2. All fish sites are numbered from downstream to upstream.

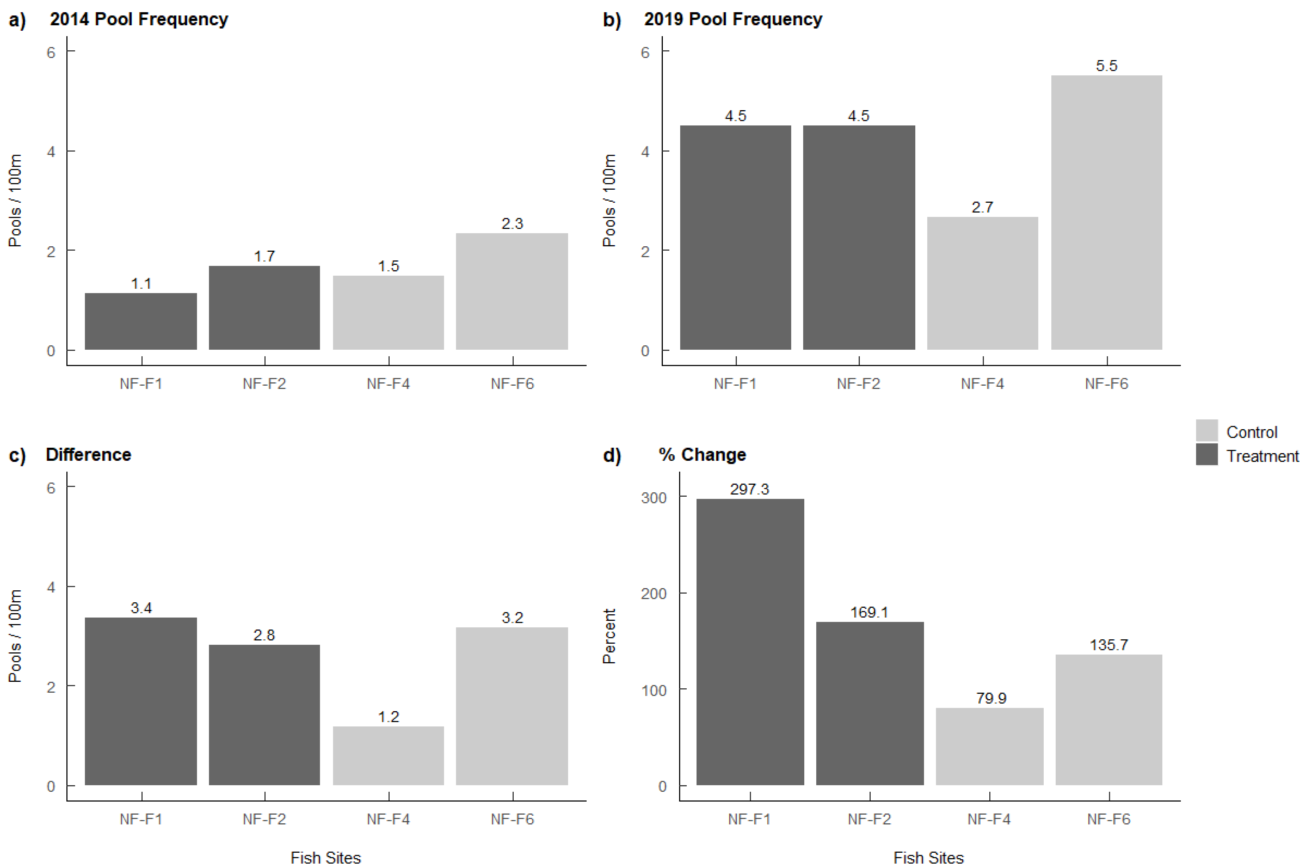

Figure 26. Frequency of pools in a) 2014, b) 2019, c) the difference (treatment – control), and d) the percent change in North Fork by fish site (average of three associated habitat sites). NF-F2 = North Fork fish site number 2. All fish sites are numbered from downstream to upstream.

APPENDIX F – EXAMPLE OF GEOMORPHIC UNIT DELINEATION

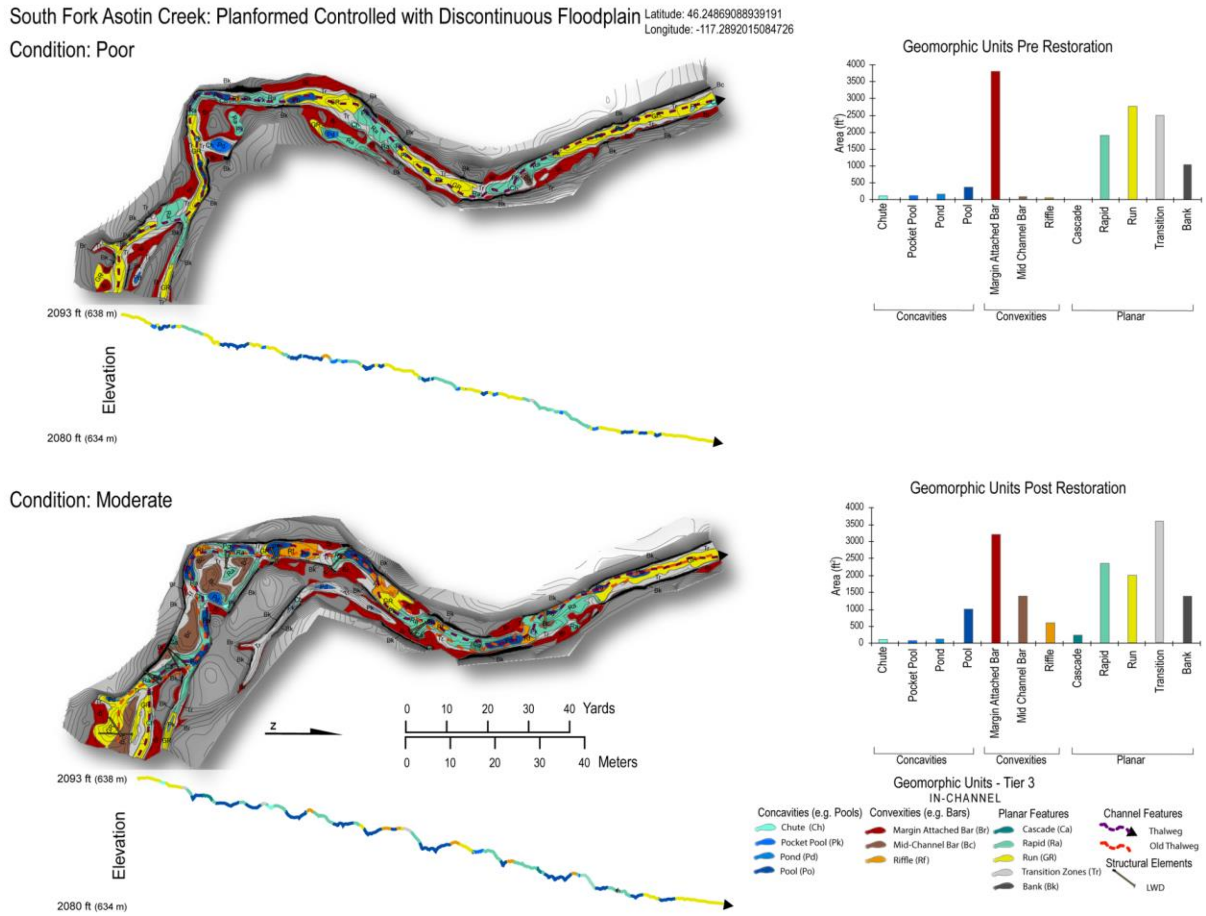

Figure 27. Example of geomorphic unit delineation pre-restoration (2012) and post-restoration (2017) in South Fork Asotin Creek. Geomorphic units were delineated and quantified (area, count, type) using the Geomorphic Unit Tool (http://gut.riverscapes.xyz).

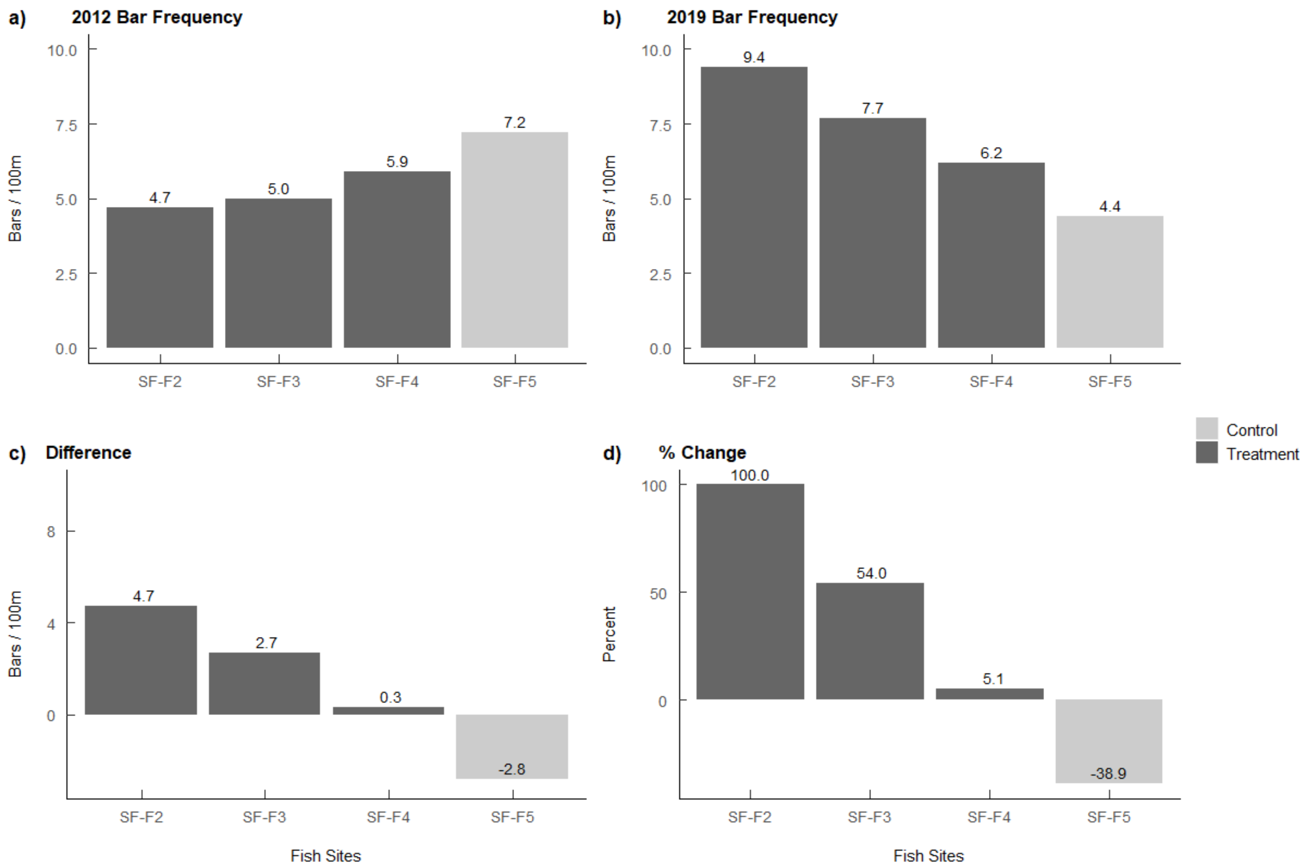

Figure 28. Frequency of bars in a) 2012, b) 2019, c) the difference (treatment – control), and d) the percent change in North Fork by fish site (average of three associated habitat sites). SF-F2 = South Fork fish site number 2. All fish sites are numbered from downstream to upstream.

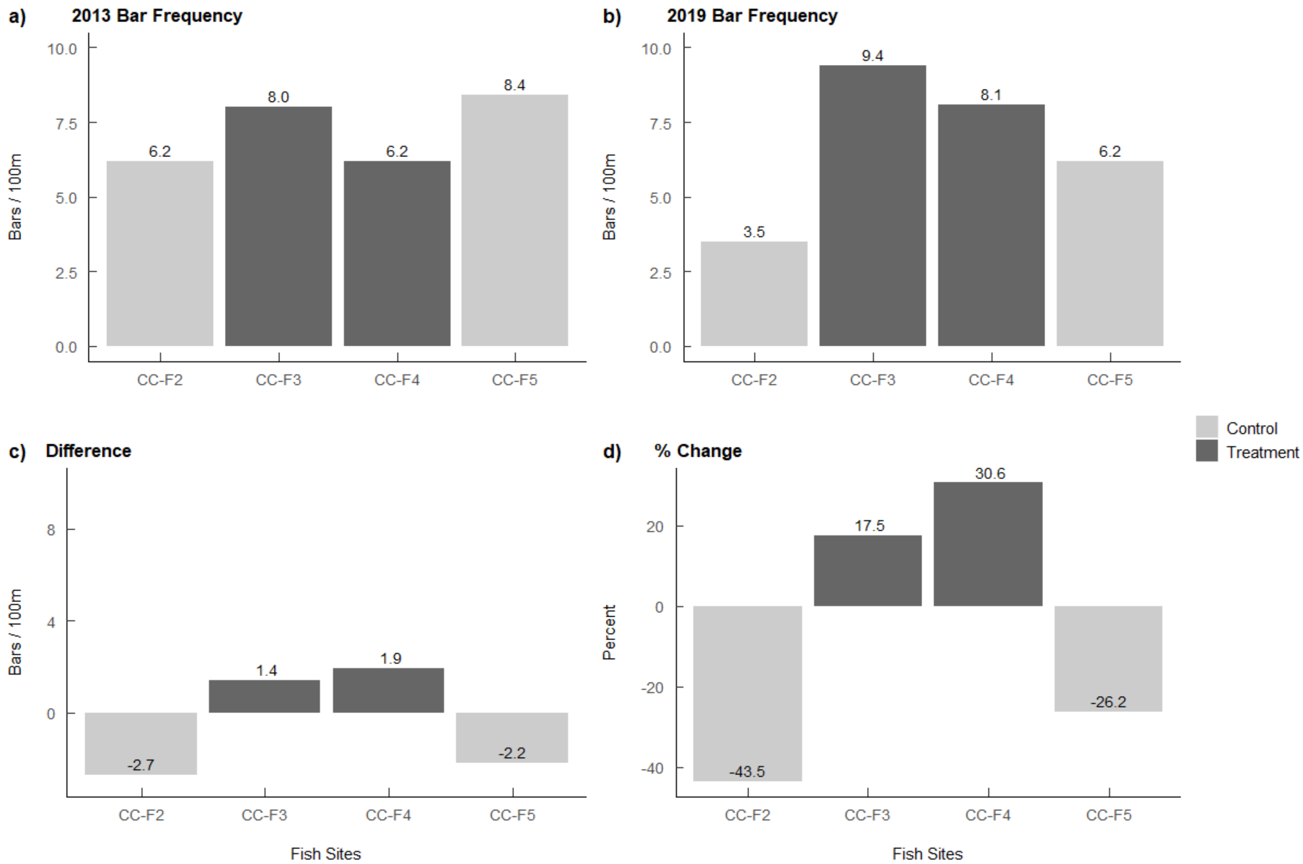

Figure 29. Frequency of bars in a) 2013, b) 2019, c) the difference (treatment – control), and d) the percent change in Charley Creek by fish site (average of three associated habitat sites). CC-F2 = Charley Creek fish site number 2. All fish sites are numbered from downstream to upstream.

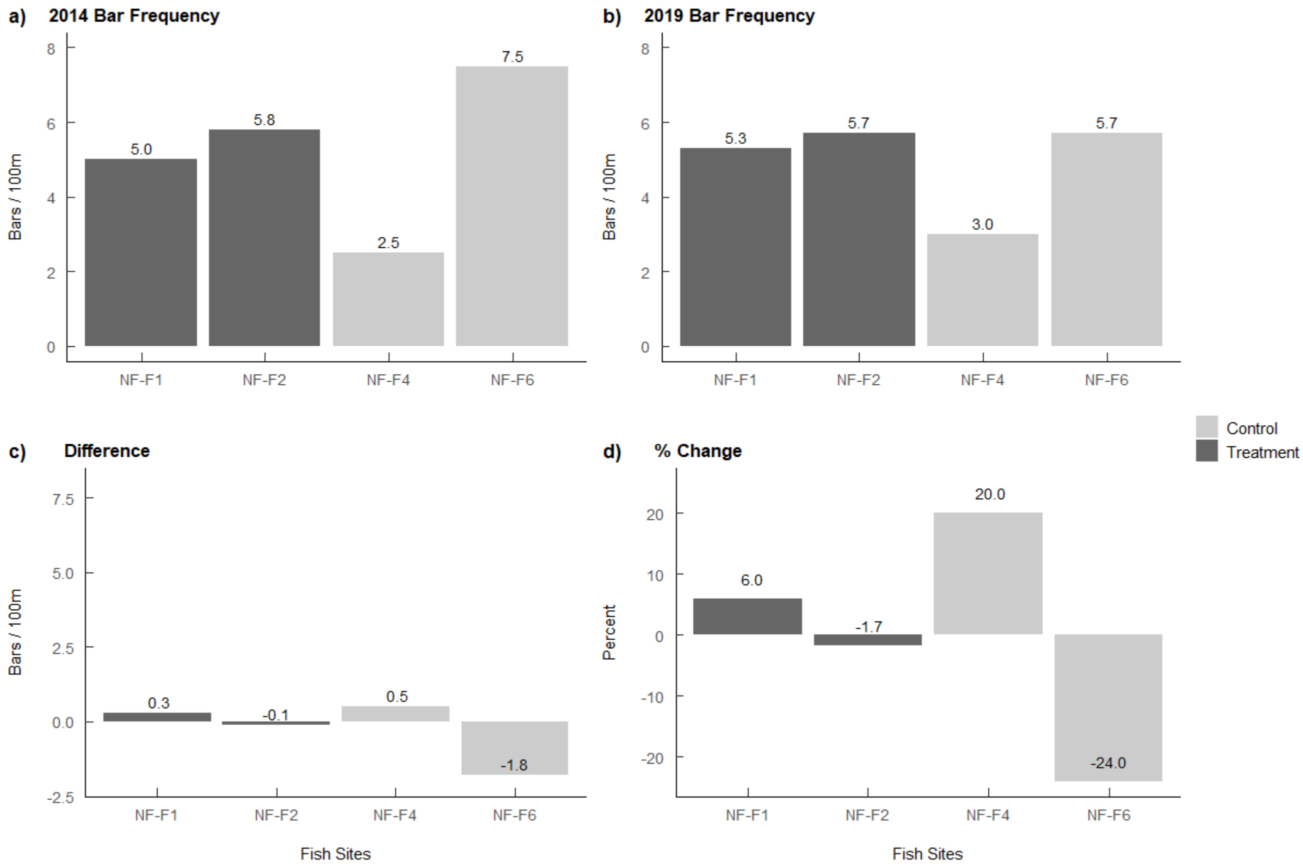

Figure 30. Frequency of bars in a) 2014, b) 2019, c) the difference (treatment – control), and d) the percent change in North Fork by fish site (average of three associated habitat sites). NF-F2 = North Fork fish site number 2. All fish sites are numbered from downstream to upstream.

APPENDIX H – PUBLICATIONS, PRESENTATIONS & PUBLIC OUTREACH

The Asotin Creek IMW coordinator has supported and helped co-author a variety of publications related to the design, monitoring and results of the IMW. We strongly believe in the importance of publishing results of the IMW and are planning to develop publications for all aspects of the restoration response and the implications for recovering ESA listed salmonids, and managing and restoring riverscape productivity.

Publications

Bennett, S., Pess, G., Bouwes, N., Roni, P., Bilby, R.E., Gallagher, S., Ruzycki, J., Buehrens, T., Krueger, K., Ehinger, W., Anderson, J., Jordan, C., Bowersox, B., and Greene, C. 2016. Progress and Challenges of Testing the Effectiveness of Stream Restoration in the Pacific Northwest Using Intensively Monitored Watersheds. Fisheries 41(2): 92-103.

Bouwes, N., Bennett, S., and Wheaton, J. 2016. Adapting Adaptive Management for Testing the Effectiveness of Stream Restoration: An Intensively Monitored Watershed Example. Fisheries 41(2): 84-91.

Bouwes, N., Moberg, J., Weber, N., Bouwes, B., Beasley, C., Bennett, S., Hill, A., Jordan, C., Miller, R., Nelle, P., Polino, M., Rentmeester, S., Semmens, B., Volk, C., Ward, M.B., Wathen, G., and White, J. 2011. Scientific protocol for salmonid habitat surveys within the Columbia Habitat Monitoring Program. Prepared by the Integrated Status and Effectiveness Monitoring Program and published by Terraqua, Inc., Wauconda, WA.

Camp, R.J. 2015. Short-term effectiveness of high density large woody debris, a cheap and cheerful restoration action, in Asotin Creek. Master's thesis. Utah State University, Logan, Utah.

Camp, R.J., and Wheaton, J.M. 2014. Streamlining field data collection with mobile apps. Eos, Transactions American Geophysical Union 95(49): 453-454.

Conner, M.M., Bennett, S.N., Saunders, W.C., and Bouwes, N. 2014. Comparison of Tributary Survival Estimates of Steelhead using Cormack–Jolly–Seber and Barker Models: Implications for Sampling Efforts and Designs. Transactions of the American Fisheries Society 144(1): 34-47.

Loughin, T., Bennett, S., and Bouwes, N. 2018. A comparison of asymmetric before-after control impact (aBACI) and staircase experimental designs for testing the effectiveness of stream restoration. Revising based on peer review.

Wall, C.E., Bouwes, N., Wheaton, J.M., Saunders, C., and Bennett, S. 2016. Net rate of energy intake predicts reach-level steelhead (Oncorhynchus mykiss) densities in diverse basins from a large monitoring program. Canadian Journal of Fisheries and Aquatic Sciences 73: 1081–1091.

Wheaton, J.M., Bennett, S.N., Bouwes, N., Maestas, J.D., and Shahverdian, S.M. 2019. Editors. Low-tech process-based restoration of riverscapes: design manual. Utah State University Restoration Consortium. Logan, UT. Available at: http://lowtechpbr.restoration.usu.edu/manual.

Bangen et al. in prep – Use of the Geomorphic unit delineation tool to quantify geomorphic change based on restoration with large woody debris.

Kramer et al. in prep – Estimating changes in juvenile steelhead capacity due to geomorphic changes forced by large wood restoration.

Sutherland et al. in prep – Estimating wood movement and accumulation in a restoration treatment with high density post-assisted log structures compared to control reaches without restoration structures.

Presentations and Public Outreach

We coordinate and receive input from the Snake River Salmon Recovery Board (SRSRB), the SRSRB Regional Technical Team (RTT), Washington State Recreation and Conservation Office (RCO), Salmon Recovery Funding Board (SRFB), SRFB Monitoring Panel, and Pacific States Marine Fisheries Commission. We also collaborate with the US Forest Service, Washington Department of Fish and Wildlife for monitoring and restoration efforts. We meet and present to these groups and other interested parties in southeast Washington multiple times a year at the SRSRB RTT meetings in Dayton, WA. To date we have presented at least 30 times on the Asotin IMW to the SRSRB and its partners. It is through this venue in particular, that we have received valuable feedback from local groups, provided updates on the IMW progress, and sought funding when necessary to make the Asotin IMW a success. The following partial list outlines other venues we have presented Asotin IMW designs, methods, restoration approaches, results, and lessons learned.

Bouwes, et al. 2009. Presentation. Oregon Chapter of the American Fisheries Society. Bend OR. Evaluating Cormac-Jolly-Seber and Barker mark-resight models when passive instream antennae are used to collect resight data.

Bouwes et al., 2010. Presentation. American Fisheries Society 2010 Western Division. Overcoming challenges to estimating survival, movement and habitat use of fickle salmonids that may choose to emigrate, immigrate or stay at home.

Bouwes, et al. 2010. Presentation. Advances in the population ecology of stream salmonids symposium. Luarca, Spain. Large-scale stream restoration experiments: investigating what fish need in an uncertain environment.

Loughin et al. 2011. Presentation. American Fisheries Society 2011 Western Division - Development of the Asotin Creek Intensively Monitored Watershed Project with specific emphasis on experimental design and implementation considerations

Bennett et al. 2011. Presentation. American Fisheries Society 2011 Western Division - Characterizing juvenile steelhead abundance, growth, and survival at multiple spatial and temporal scales during the pretreatment period of large restoration experiment: Asotin Creek Intensively Monitored Watershed.

Bouwes, et al. 2011. Presentation. Spring Runoff Symposium. Logan, UT. Watershed restoration experiments: maximizing learning while trying to recover endangered species.

Bouwes, et al. 2011. Presentation. Pacific States Marine Fisheries Council PITTag Workshop. Stevenson WA. Using mobile and passive antennas to improve estimates of survival, tracking of movement, and habitat use of salmonids.

Camp et al. 2011. Presentation. American Fisheries Society 2011 Western Division - Rapid assessment of reach scale movement and habitat associations of juvenile steelhead using portable pit-tag antennas and low-cost geographic positioning system

Wall et al. 2011. Presentation. American Fisheries Society Annual Meeting. Seattle, WA - September 4-8, 2011. Giving fish more energy without giving them more food: Can streambed topography influence a fish's net rate of energy intake?

Wall and Bouwes. 2011. Presentation. Utah State University Water Initiative Spring Runoff Conference, Logan, UT. Can we give fish more energy without giving them more food?

Bennett et al. 2012. Presentation. Asotin County Annual Meeting. Asotin Creek Intensively Monitored Watershed: Updates and insights into restoration effectiveness.

Bennett et al. 2013. Presentation. Pacific Northwest Aquatic Monitoring Partnership, Portland, OR. Intensively Monitored Watersheds Coordination Workshop. Asotin Creek Intensively Monitored Watershed, southeast Washington: summary of approach, design, and preliminary findings.

Wall et al. 2013. Presentation. American Fisheries Society Western Division Annual Meeting. Boise, ID. Assessing the predictive ability of a process-based net rate of energy intake model for drift-feeding salmonids.

Bennett et al. 2014. Presentation. Washington State University, Pullman, WA. Does stream restoration work? How the Asotin Creek Intensively Monitored Watershed Project intends to find out.

Bennett et al. 2014. Presentation. Joint Aquatic Sciences Conference, Portland, OR. Restoration of wadeable streams with high-density large woody debris (HDLWD).

Camp, et al. 2014. Presentation. Characteristics of Benthic Winter Concealment Locations for Juvenile Steelhead (Oncorhynchus mykiss). Western Division of American Fisheries Society, Mazatlán, Sinaloa, Mexico.

Bennett et al, 2015. Presentation. Snake River Salmon Recovery Data Symposium, Dayton, WA. Asotin Creek Intensively Monitored Watershed Snake River Data Symposium Update

Bennett et al. 2015. Presentation. Asotin County Annual Meeting. Asotin Creek Intensively Monitored Watershed: Updates and insights into restoration effectiveness.

Bennett et al. 2015. Presentation. Salmon Recovery Conference, Vancouver, Washington. Intensively Monitored Watersheds: An approach towards determining restoration effectiveness

Camp, et al. 2015. Presentation. American Fisheries Society, Portland, OR. Presentation. Asotin Creek Intensively Monitored Watershed: Lessons Learned from Three Years of Restoration.

Camp, et al. 2015. Presentation. Rapid Assessment Monitoring Strategies. Snake River Salmon Recovery Board Data Symposium, Walla Wall, WA.

Wall et al. 2015. Presentation. American Fisheries Society Annual Meeting. Portland, OR. Using large-scale application of a foraging model in the interior Columbia River Basin to help understand patterns of habitat use in salmonids.

Bennett et al. 2016. Presentation. Pacific Northwest Aquatic Monitoring Partnership, Portland, OR. Intensively Monitored Watersheds Coordination Workshop. Intensively Monitored Watersheds: ideal elements, implementation challenges, and progress towards determining restoration effectiveness.

Bennett et al. 2017. Presentation. Asotin County Annual Meeting. Asotin Creek Intensively Monitored Watershed: Updates and insights into restoration effectiveness.

Bennett et al. 2017. Presentation. Salmon Recovery Conference, Wenatchee, Washington. Asotin Creek Intensively Monitored Watershed: An emerging story of restoration effectiveness

Bennett, Wheaton, and Camp. 2017. Workshop. Snake River Salmon Recovery Board Cheap and Cheerful Restoration Workshop, Dayton, WA. Sharing lessons learned and providing hands on experience in constructing post-assisted log structures (PALS) and beaver dam analogs (BDAs) developed in Asotin Creek and Bridge Creek Intensively Monitored Watersheds.

Bennett, Bouwes, Shahverdian, Maestas, Weber, and Wheaton. 2018. NRCS Workshops. Low-low process-based riverscape restoration. John Day, OR; Hailey, ID, Cedar City, UT; Lander, WY; Elko, Nevada.

Bennett, Bouwes, Wheaton, and Shahverdian. 2019. Salmon Recovery Conference, Tacoma, Washington. Low-tech process-based restoration: what is it and why do we need more of it?

Bennett, S. 2019. Landowner tour of Asotin Creek lead by Asotin County Conservation District to view post-assisted log structures and discuss low-tech restoration with landowners.

Bennett, Bouwes, Shahverdian, Maestas, Weber, and Wheaton. 2019. NRCS Workshops. Low-low process-based riverscape restoration. Gunnison, CO; Lewiston, MT, Hailey, ID; Logan, UT.

Bennett, S. 2019. Presentation. American Fisheries Society and the Wildlife Society, Reno, Nevada. Low-tech process-based restoration – Beaver Restoration Symposium.