Appendix B. Watershed Restoration Effectiveness Monitoring, FY2014 Progress Report

Summary

The Watershed Restoration Effectiveness Monitoring (WREM) Project is an 8-year monitoring project designed to evaluate the success of in-stream restoration projects by detecting trends in channel conditions and aquatic biota in select stream reaches. In Fiscal Year 2014, we completed year 2 of the expanded sample design of forest-wide restoration projects. Under this expanded design we sampled 17 reaches (18 targeted) in one of three categories (reference, managed control, and treatment [restoration]) grouped into three channel-size ranges. The total sample size for the first 2 years is 37 reaches.

We sampled physical habitat parameters, fish composition and reach complexity in each of the 17 reaches following published methods discussed below. We held a scientific review of our methods in Fall 2013 with a combined interagency and stakeholder group and a more focused field review in September 2014 with PNW research geomorphologist, John Buffington and retired Tongass hydrologist, Steve Paustian. The latter review produced a final document that details the strengths and weaknesses of our monitoring program and makes recommendations for improvements (Buffington 2015). We will begin to implement the recommendations in FY2015.

Restoration Objectives

The objectives of effectiveness monitoring are to detect trends in channel condition and abundance, condition, and diversity of aquatic biota that are attributable to stream restoration. The specific monitoring questions (Table 1) are focused on the hypothesis that channels affected by historical riparian harvest have seen an interruption in the supply of large wood. Over time, lack of large wood input led to decreased pool frequency and quality, and a simplification of the stream channel. This is often accompanied by a lack of stream bank stability as legacy riparian root masses decay. Restoration efforts use a combination of instream large wood placement and riparian treatment as a means to improve channel and riparian function. While specific goals vary with each project, large wood is often used to improve pool habitat and increase the overall complexity of the channel.

WREM Progress Report Table 1. Monitoring questions and the metrics used to answer them

Monitoring Question	Metrics
Does large wood placement increase frequency, areal extent, and quality of pools?	Relative pool area (pool area per total wetted area), pool frequency (pools per km), and average residual pool depth per average channel bed width
Does large wood placement increase channel complexity?	Mean squared error (MSE) of thalweg profile (topographic variation about the mean slope; complexity)
Does large wood placement improve stream bank stability?	Length of undercut bank/m
What are the fish characteristics (composition, relative abundance, diversity, and condition) in restored reaches?	Species counts expressed as percent of total (composition), fish per m^2 (relative abundance or density), number of species (diversity), and Fulton's K (condition)

Reach Locations

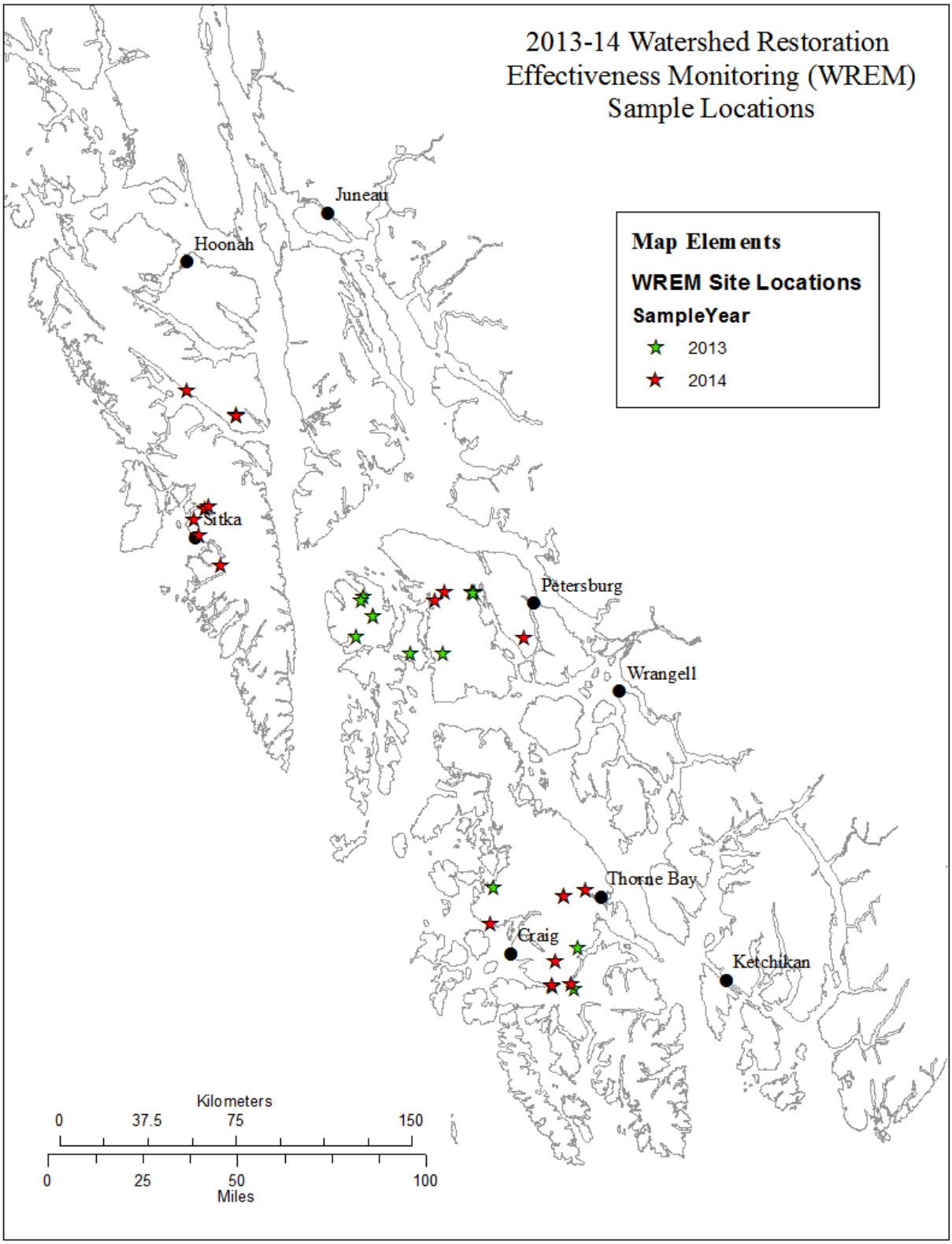
Reaches are located in low-gradient alluvial channels that provide freshwater spawning and rearing habitat for a number of anadromous and resident fish species. The reaches are primarily located on National Forest lands, but adjacent private lands will be used if no suitable sites can be identified elsewhere.

During the 2014 field season, we surveyed 17 streams reaches across the Tongass National Forest. Survey reaches were located on Chichigof, Baranof, Kupreanof, and Prince of Wales Island (Figure 1).

The reaches ranged between 100 and 355 m in length and represent small and medium floodplain (FP) and moderate mixed (MM) channels (Paustian 1992) (Table 2). The reaches were either reference, managed control, or treated, depending upon the management history. The treated reaches were restored between 1995 and 2013.

WREM Progress Report Table 2. Characteristics of the 2014 WREM surveyed reaches. Reaches are grouped by management category and ordered by increasing width.

Reach Name	Channel Type	Management Category	Average width (m)	Reach Length (m)	Gradient (%)	Notes
Falls Ck Trib.	MMS	Managed Control	2.7	105	3.7	
Spike Buck	MMS	Managed Control	3.9	105	2.39	
Suntaheen	FPS	Managed Control	7.0	143	0.5	
Sitkoh Ck	FPM	Managed Control	10.4	200	1.74	
Otter/Cable	FPM	Managed Control	12.5	250	0.8	
Yellowlegs	MMS	Treatment	3.3	100	2.8	Restored 2011
Hemloop	MMS	Treatment	3.8	100	2.9	Restored 2013
Starrigavan	FPS	Treatment	4.2	100	2.1	Restored 1995
Katlian	FPS	Treatment	9.1	180	0.5	Restored 2003
Sitkoh Ck	FPM	Treatment	10.3	206	2.2	Restored 2003
Fubar Phase 1	FPM	Treatment	15.8	320	1.2	Restored 2006
Indian R. Trib.	FPS	Reference	2.6	100	2.2	
Last Ditch	MMS	Reference	4.0	100	3.4	
Fairyland	MMS	Reference	5,8	114.5	1.92	
Newlundberry 2	FPS	Reference	6.8	140	1.4	
Salmon Creek	FPM	Reference	15.6	200	0.05	
Elevenmile	FPM	Reference	17.4	355	0.9	



WREM Progress Report Figure 1. WREM sample locations

Methods

The treatment reaches were selected randomly from the set of restoration projects implemented over the last 20 years that met minimum criteria of treatment intensity and documentation. Control and reference reaches were chosen based on location, management history, similarity of channel type and accessibility. The focal reaches are low-gradient alluvial channels that are important salmon spawning or rearing habitat. We define a managed channel as having adjacent riparian harvest and a reference channel as having no harvest adjacent or upstream of the reach. Treated channels are managed channels that have undergone restoration treatments consisting of instream large wood placement. The distinction between treated and restored is that the projects rely on channel forming events to act on placed wood and achieve the restoration goals. We expect that the channels will adjust for years after the implementation.

We followed the Alaska Region Survey Protocol (USDA Forest Service 2001) to complete physical habitat surveys in all 17 reaches. Reach lengths were approximately 20 times the average channel bed-width. Reaches were sampled using the tier three protocol with the following exceptions:

- Large wood was split into twelve categories (three widths and four lengths) following the tier four criteria.
- Longitudinal profiles were measured along the deepest part of the channel (thalweg) using an auto-level to evaluate channel complexity.

Methods for collection of aquatic biota follow published methods as described by Thurow (1994) and an adaptation of Bryant (2000). Summer relative juvenile fish data collection methods are dictated by channel size. For small and medium channels, a single pass 90-minute soak using a sufficient number of 1/8-inch mesh minnow traps and disinfected egg baits placed either in perforated whirlpaks or film canisters. Block nets with 1/8-inch mesh are deployed on either end of the reach to prevent fish movement into or out of the sample reach. Total number of minnow traps used is dependent on the complexity of the sample reach and stream conditions but typically no less than 40 and upwards of 75 traps are used in a reach given that reach lengths are 20 times channel bed width. Based on work by Bryant (2000), probabilities of capture in the first sample occasion of a multiple (3 to 4 passes) sequential removal method range from 50-65 percent. Further analysis of this probability of capture will be conducted using the current forest MIS dataset to provide a better comparison of what we consider relative abundance versus the more traditional full population estimate derived from a multiple pass depletion methodology.

For large channels where it would be difficult if not impossible to saturate the wetted channel sufficiently with minnow traps, underwater observation with snorkeling gear is used to estimate relative fish abundance in pool habitat within a sample reach. Thurow (1994) generally outlines procedures. A two-person snorkel crew counts the number of fish broken out by species and size categories at all or a portion of pool habitat units within the sample reach. Snorkel methodology involves a single upstream pass through a designated pool. After snorkeling, the underwater visibility of each pool during the snorkel count is ranked using a specific scale and pools with a high amount of hiding cover or poor water clarity are dropped from any analysis. To quality check the snorkel data, a subset of pools (10-20 percent) are resampled during the same sample event but leaving sufficient time for fish to settle prior to resampling. By having at least one regular diver conducting all surveys we hope to limit variability. Habitat unit surface area is calculated by measuring total length of the unit and measuring wetted width at three or more equally spaced or best representative intervals. Densities of fish are calculated using an area measure of m^2 or 100 m^2. For replicated counts, the mean (average density) and variance are calculated, and confidence limits placed around the mean value.

To gather fish length-weight data on the large channels, ten 1/8-inch minnow traps are placed within the reach, after snorkel crews have passed through so as not to bias snorkel counts. Traps are set for 90

minutes using disinfected egg baits.

Fish condition, denoted as K, are calculated using the Fulton condition factor equation (Anderson and Neumann 1996) and comparisons made on a species basis stratified by management types and channel size. The value of K is influenced by a variety of physical and environmental factors including sex, gut fullness and season. We hope to minimize variability of these influences by sampling at the same time of year and under similar conditions (low flows). Species composition is based on sampling.

Analysis

The final product of this project will consist of several types of comparisons. These comparisons include trend analysis at individual and group sites, comparative analysis of individual sites to Tongass-wide metrics, and comparative analysis of groups of sites. We expect to improve our analysis methodology through refinement of the study plan over the course of this project.

- Trend analysis will measure the change in specific metrics over time. As this is the second year of a 4-year rotating panel design, we do not have sufficient data for establishing trends at the majority of sites.
- Comparison to Tongass-wide metrics. The Tongass maintains a database of reference sites that is our best estimate of the natural range of variation (NRV) for our habitat objectives. We will compare data collected for this project with the (NRV) to assess the relationship of individual sites to the natural ranges.
- Comparison of group means. We will compare means for specific variables using standard statistical techniques (probably a t-test), developed in consultation with a statistician.

Preliminary Results

The preliminary results are summarized by reach into a standard suite of metrics known as fish habitat objectives (USFS, 2008). A subset of the fish habitat objectives are the focus of this project and these metrics will be compared over time to reference data for similar channel types.

WREM Progress Report Table 3. Summary metrics for the 2014 sample set

Reach Name	Key Wood	Complexity (MSE method)	Pool Spacing	AveRPD/CBW	Undercut Banks	Relative Pool Area
Units	**Piece per meter**	**Average deviation (mean square error) from a linear interpolation of bed slope**	**Number of channel bedwidths per pool**	**n/a**	**Length per meter**	**Pool area per total wetted area**
Falls Creek Tributary	0.13	0.03	2.77	0.09	0.14	0.32
Spike Buck	0.05	0.02	6.77	0.10	38.00	0.26
Suntaheen	0.07	0.03	2.54	0.07	0.22	0.72
Sitkoh Creek	0.06	0.10	1.93	0.05	0.17	0.51
Otter/Cable	0.06	0.04	1.83	0.04	0.20	0.51
Yellowlegs	0.34	0.03	3.79	0.07	0.41	0.28
Hemloop	0.09	0.03	4.39	0.07	25.00	0.19
Starrigavan	0.26	0.03	7.94	0.07	0.24	0.18
Katlian	0.07	0.01	0.00	0.00	0.18	0.00
Sitkoh Creek	0.06	0.07	0.95	0.04	0.16	0.41

Reach Name	Key Wood	Complexity (MSE method)	Pool Spacing	AveRPD/CBW	Undercut Banks	Relative Pool Area
Units	**Piece per meter**	**Average deviation (mean square error) from a linear interpolation of bed slope**	**Number of channel bedwidths per pool**	**n/a**	**Length per meter**	**Pool area per total wetted area**
Fubar Phase1	0.09	0.11	4.06	0.05	0.00	0.38
Indian River Tributary	0.12	0.03	3.88	0.13	0.80	0.57
Last Ditch	0.07	0.03	4.17	0.07	0.28	0.21
Fairyland	0.11	0.08	3.30	0.05	0.33	0.71
Newlundberry 2	0.06	0.10	3.41	0.46	0.07	0.64
Salmon Creek	0.10	0.07	1.07	0.04	0.36	0.87
Elevenmile	0.06	0.10	1.70	0.03	0.29	0.55

Biotic metrics will be compared over time as trend analyses (shift over time looking at frequency) and compared to reference and control reach data for similar channel types. Non-parametric statistical analyses will be best suited for use in this case since it is unlikely that the data will have a normal distribution. Again, statistical techniques will be developed in consultation with a statistician. Below in table form are general fish characteristics derived from each sampling event. These are preliminary numbers and further analysis and figure development is underway. Standard deviations calculations as well as other descriptive length and weight stats are forthcoming.

WREM Progress Report Table 4. Fish characteristics in the 2014 WREM surveyed reaches

Reach	Mgmt catagory[1]	Species	Relative density (fish/m^2)	Biomass (g/m^2)	Mean length (mm)	Mean weight (g)	Condition (K)
Falls Ck Trib.	MC	Coho	--	0.003	29	0.85	--
		Dolly Varden	0.07	0.32	74	4.35	1.00
		Cutthroat	0.92	0.56	82	6.11	1.02
Spike Buck	MC	Coho	0.03	0.11	65	3.66	1.20
		Dolly Varden	0.02	0.30	110	15.18	0.84
		Cutthroat	0.03	0.64	111	19.97	0.98
Suntaheen	MC	Coho	0.09	0.20	53	2.23	1.19
		Dolly Varden	0.07	0.40	83	5.79	0.94
		Sculpin	0.03	0.11	--	--	1.19
Otter Cable	MC	Coho	0.04	0.16	67	4.17	1.67
		Dolly Varden	0.01	0.12	102	10.38	0.94
		Steelhead	0.01	0.16	105	12.96	1.03
		Sculpin	0.02	0.16	81	--	1.11
		Cutthroat	0.00	0.01	121	17.09	0.96
Sitkoh Ck	MC	Coho	0.28	0.29	45	2.03	1.12
		Dolly Varden	0.04	0.22	80	6.33	0.97
		Sculpin	0.01	0.10	--	--	--
		Cutthroat	0.01	0.04	87	7.02	0.98

Reach	Mgmt catagory[1]	Species	Relative density (fish/m^2)	Biomass (g/m^2)	Mean length (mm)	Mean weight (g)	Condition (K)
Yellowlegs	T	Coho	0.07	0.21	59	2.92	1.19
		Dolly Varden	0.003	0.03	95	10.21	1.19
		Sculpin	0.003	--	--	--	--
Hemloop	T	Data summary unavailable at time of progress report					
Starrigavan	T	Coho	0.18	0.28	50	1.58	1.12
		Dolly Varden	0.18	0.67	67	3.64	1.05
Katlian	T	Coho	0.05	0.67	47	1.45	1.07
		Dolly Varden	0.05	0.15	63	2.76	1.01
Sitkoh Ck	T	Coho	0.51	--	46	2.58	1.14
		Dolly Varden	0.06	0.27	80	5.05	1.00
		Cutthroat	0.003	0.03	94	9.49	1.00
Fubar Phase1	T	Coho	0.05	0.11	56	2.37	1.11
		Dolly Varden	0.03	0.15	81	4.96	0.89
		Steelhead	0.001	0.12	117	16.65	1.00
Indian R Trib.	R	Coho	0.70	0.89	45	1.29	1.13
		Dolly Varden	0.32	1.89	82	5.99	0.96
Last Ditch	R	Coho	0.02	0.04	54	1.92	1.15
		Dolly Varden	0.27	1.41	80	5.31	0.94
		Sculpin	0.02	--	--	--	--
Fairyland	R	Data summary unavailable at time of progress report					
Newlundberry 2	R	Coho	0.04	0.09	57	2.40	1.16
		Dolly Varden	0.03	0.16	79	5.01	0.96
		Steelhead	0.01	0.07	78	5.27	1.12
		Cutthroat	0.01	0.17	101	11.90	0.99
Salmon Creek	R	Coho	0.46	--	59	3.85	1.12
		Dolly Varden	0.20	--	80	6.16	0.56
		Steelhead	0.02	--	84	6.20	0.99
		Cutthroat	0.004	--	89	7.36	0.98
		Sculpin	0.002	--	--	4.64	--
Elevenmile	R	Coho	0.10	0.52	75	5.17	1.19
		Dolly Varden	0.07	1.14	114	15.44	0.97
		Steelhead	0.01	0.18	95	12.48	1.09

[1] Management categories are as follows: MC=Managed Control; T=Treatment; R=Reference

Preliminary Results and Discussion

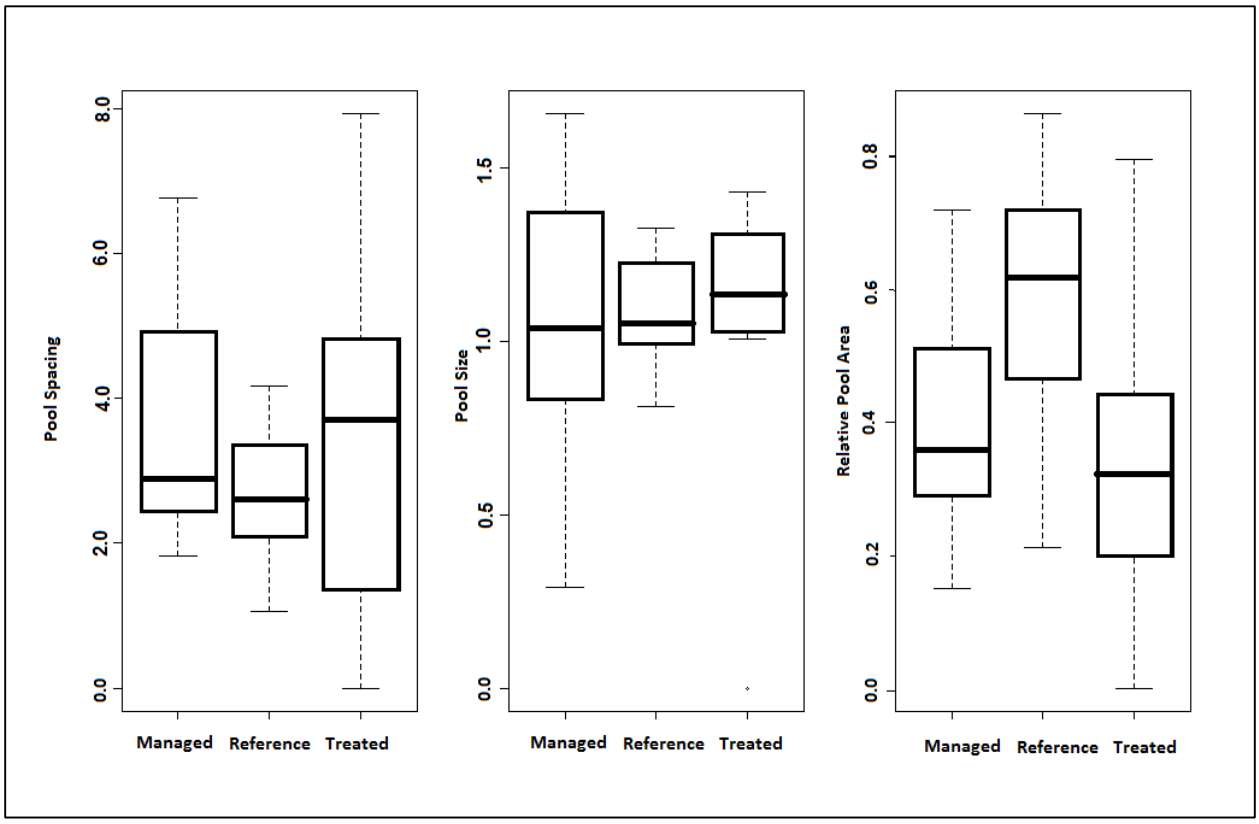
Pools

The distribution and quality of pool habitat is one of the key areas for the project and are core parameters of the Alaska Region habitat survey. Figure 2 shows the reach summaries for pool spacing, pool size and relative pool area for all WREM reaches (n=37) sorted by treatment.

Pool spacing illustrates the distribution of pools throughout the reach in units of channel widths per pool. Higher values indicate fewer, more widely spaced pools (Montgomery 1995). Pool size is a measure of pool quality – average residual pool depth scaled by the reach average bankfull depth. Relative pool area shows the percentage of the wetted stream channel that is in pool habitat.

In each of these summary variables, we hypothesize that we will see differences between the reference condition and that of the managed and treatment categories and over time. The data to date show high variability and no obvious trends. While there appears to be a higher relative pool area in the reference

reach compared to the managed and treated reaches, there remains overlap in all categories. There is less variability in pool size amongst categories than pool spacing or relative pool area; however, the managed reaches remain variable.



WREM Progress Report Figure 2. Pool summary metrics by management category

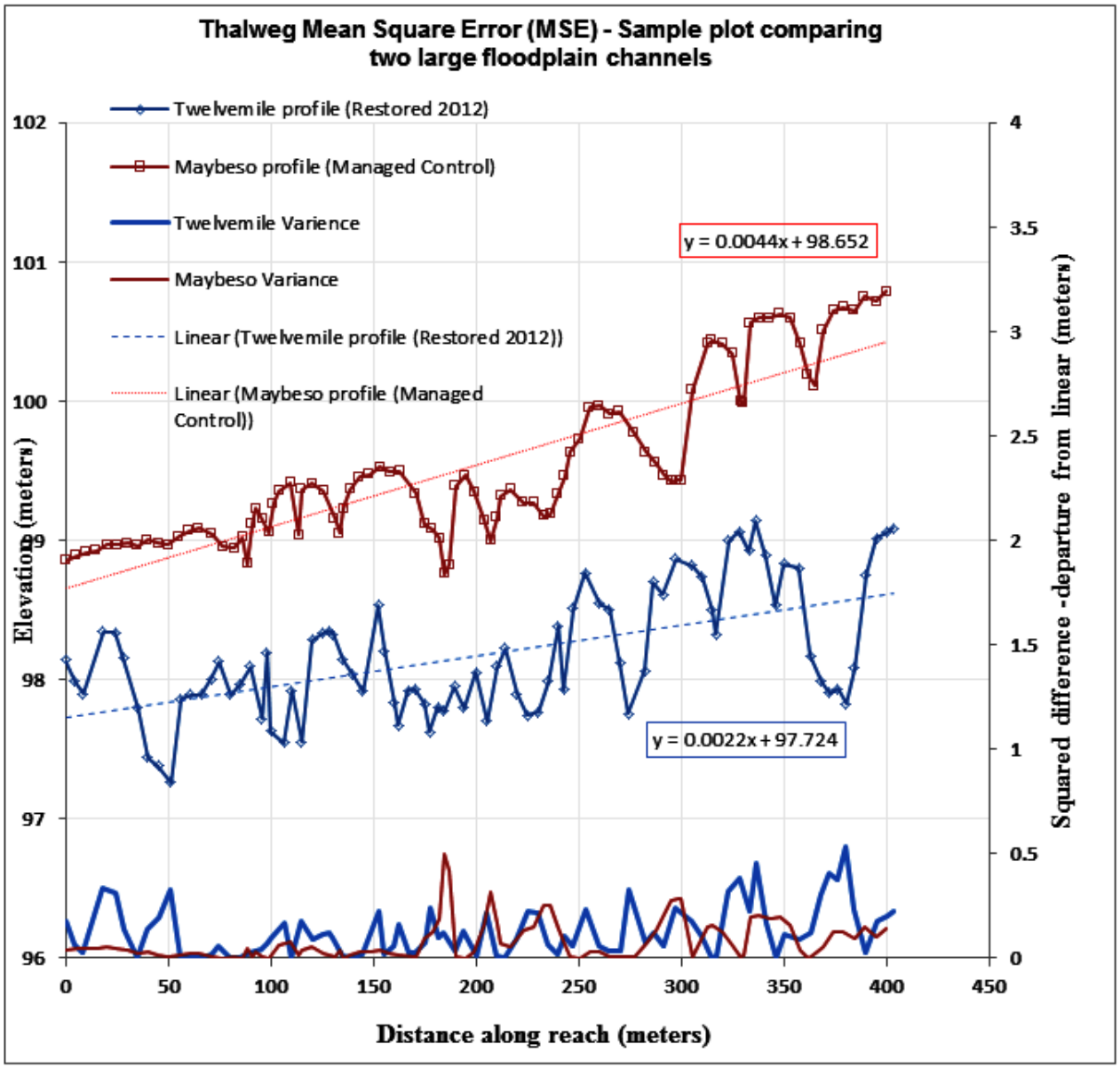
Channel Complexity

We use a thalweg profile to evaluate vertical channel complexity. One method of complexity evaluation is the mean square error (MSE) method (Mossop and Bradford 2006). It defines complexity as the absolute amount of variation in the bed profile (Figure 3) and summarizes this variable as the average of the squared differences between the data and a best-fit line for each data point. Differences in the mean among channels of similar size and gradient (Figure 4) indicate that this technique has promise in differentiating between managed and reference reaches.

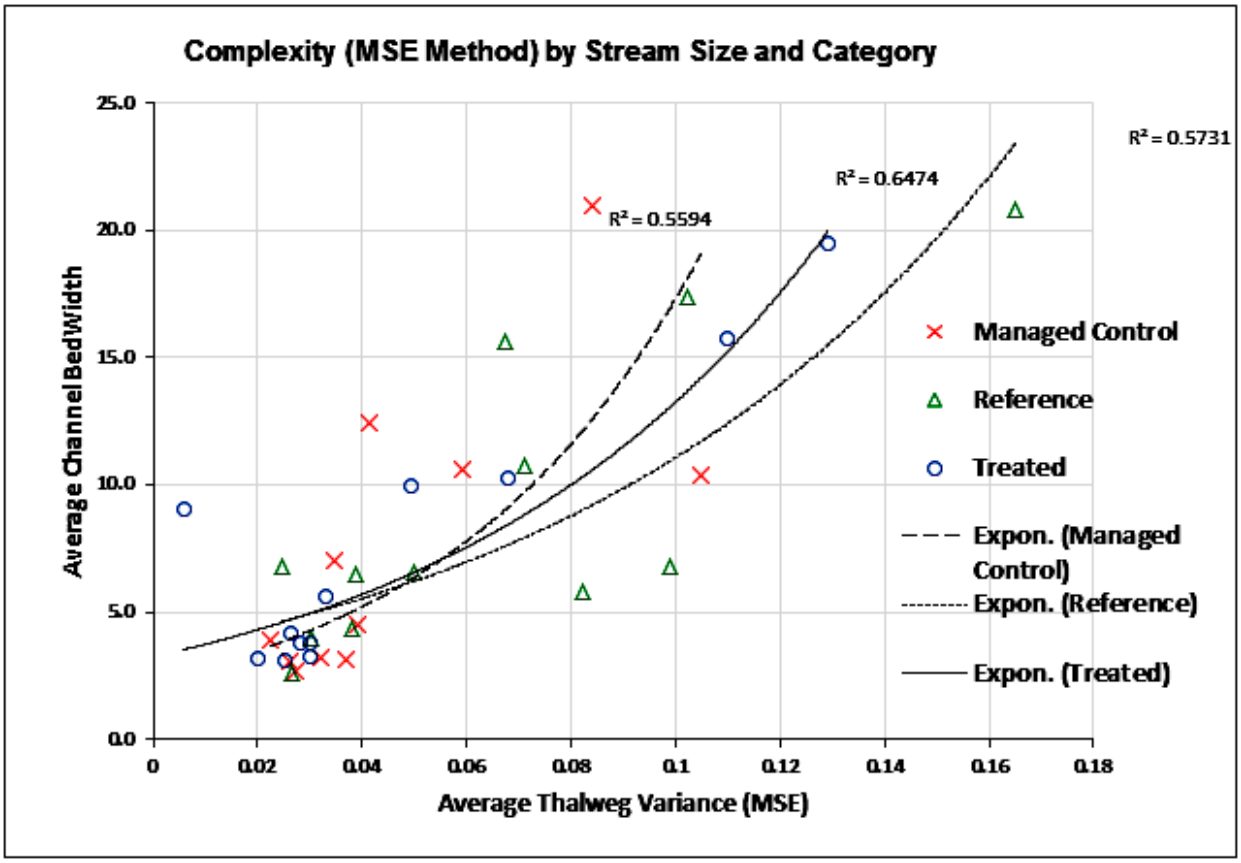
The MSE ranged between 0.01 and 0.11 (Table 3). In all channel sizes and categories there was an increase in MSE with an increase in channel size. The small dataset shows no significant trends at this point however there does appear to be greater MSE per average channel bed width in the reference reaches compared to the managed control and treated reaches.

Stream Bank Stability

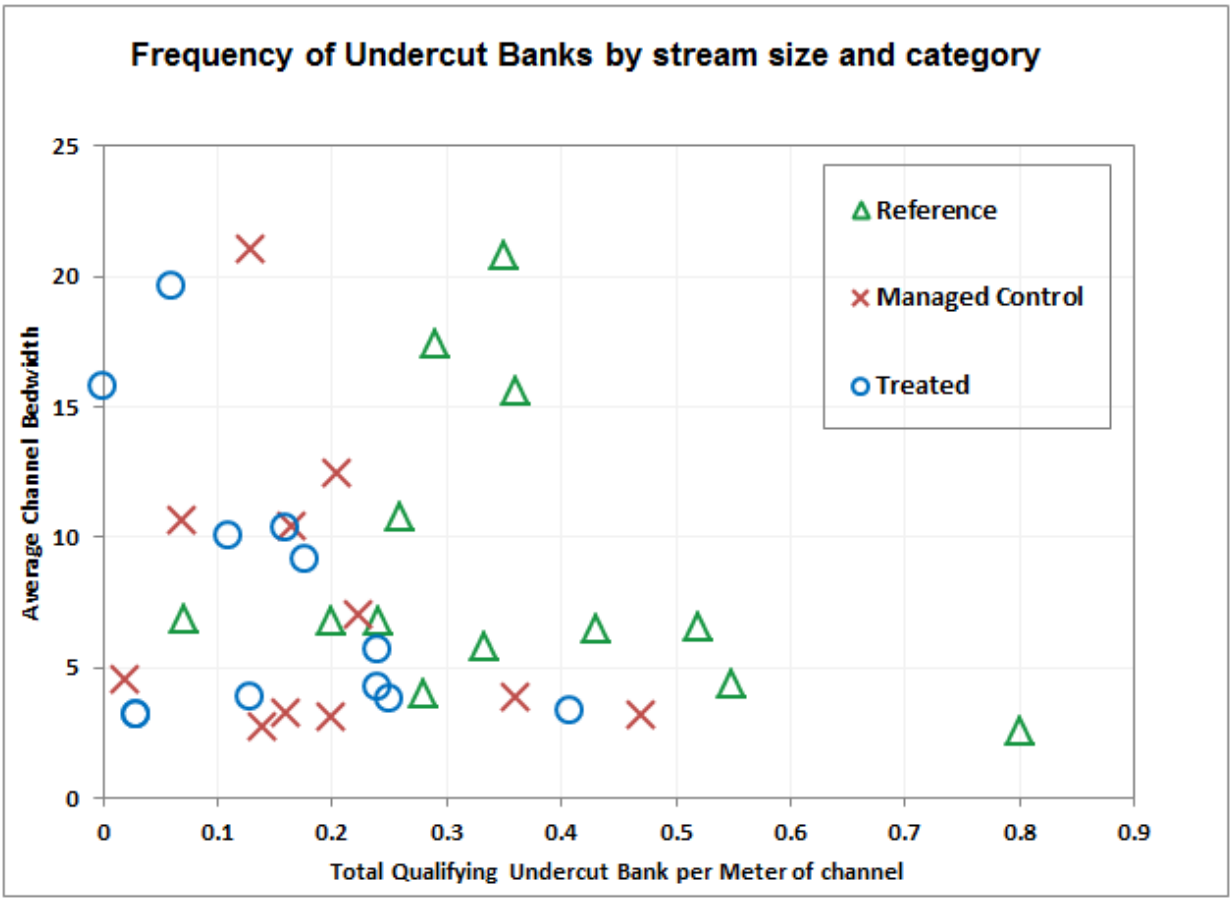
The presence of undercut banks can be used as an indicator of channel stability. We hypothesize that undercut banks are more likely to occur where the channel banks are vegetated and stabilized by roots. Under such stable conditions the stream can erode under the banks without causing bank failure. Reference conditions would have higher values and restored channels would trend towards higher values. This measurement is currently under analysis for feasibility of measurement and sensitivity over the course of the restoration monitoring cycle (Figure 5).



WREM Progress Report Figure 3. Detail of the channel complexity metric. The upper two line graphs depict the measured thalweg profiles while the lower lines show the squared deviation from the dotted trend lines. Each site is summarized to a single value representing the average of the deviations.



WREM Progress Report Figure 4. Complexity measured as the mean squared deviation to a best fit linear trend of the bed profile. This figure emphasizes the difference in total magnitude based on channel width and the differences between different categories.



WREM Progress Report Figure 5. Undercut banks 2013-2014

Citations

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