Appendix A: Response to CMER comments on Final Study Design

This appendix is the byproduct of a CMER participant meeting held on March 23, 2018 to document the TWIG's response to CMER's review of the ISPR-approved ENREP Study Design document. It provides information on the history of the project development, consideration of different research approaches, site selection and site grouping process, and directly addresses a set of concerns expressed by one or more CMER voting members at the March 23 meeting. The last section includes a bullet-list of text changes made to the study design in direct response to CMER member suggestions at the March 23 meeting.

Potential research approaches

In November 2013, the initial ENREP Technical Writing and Implementation Group (TWIG) presented the TWF Policy committee a set of research alternatives for the ENREP study. The objectives included quantify the magnitude of change in stream flow, canopy closure, water temperature, suspended sediment transport and wood loading. The potential research approaches included meta-analyses, decision support systems, physically-based modeling, and empirical research. The empirical research section included comparisons of Before-After/Control Impact (BACI) designs, before-after designs, and observational designs. After considering the alternatives and TWIG recommendations, Policy approved moving forward with a watershed-scale BACI study design similar to the two ongoing westside study designs (Hard Rock and Soft Rock) focused on Type Np basins with spatially continuous stream flow (a.k.a., 'wet'); and to collect follow-up information on, and develop a design for, Type Np basins with spatially discontinuous summer surface flow (a.k.a., 'dry').

In November 2016, CMER voted to send the 'wet' study design out for Independent Science Peer Review (ISPR) and in the spring of 2017, a 'dry' TWIG was convened.

Site selection process

In the summer of 2017, just as the 'wet' study design was coming back from ISPR and the 'dry' TWIG was getting started, detailed information about site availability and site conditions became available. ISPR participants had raised several questions and expressed concerns about potential sites, and in the June 6, 2017 video meeting, the TWIG explained that site details were just becoming available and more information would be added once information on summer streamflow permanence was available.

The following images were shared with ISPR on June 6.

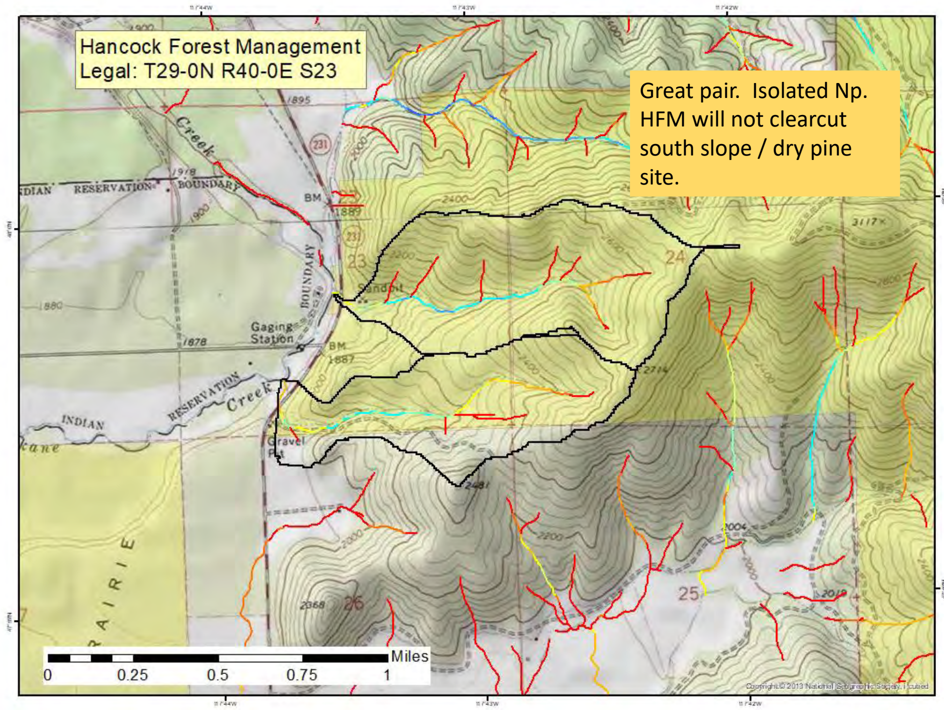


Figure 1: Site selection is tough, but we are finding sites. We had 26 potential N basins and these look like some of the better pairs. The stream layer is the probability of perennial water based from the Forest Hydrology Study (FHS).

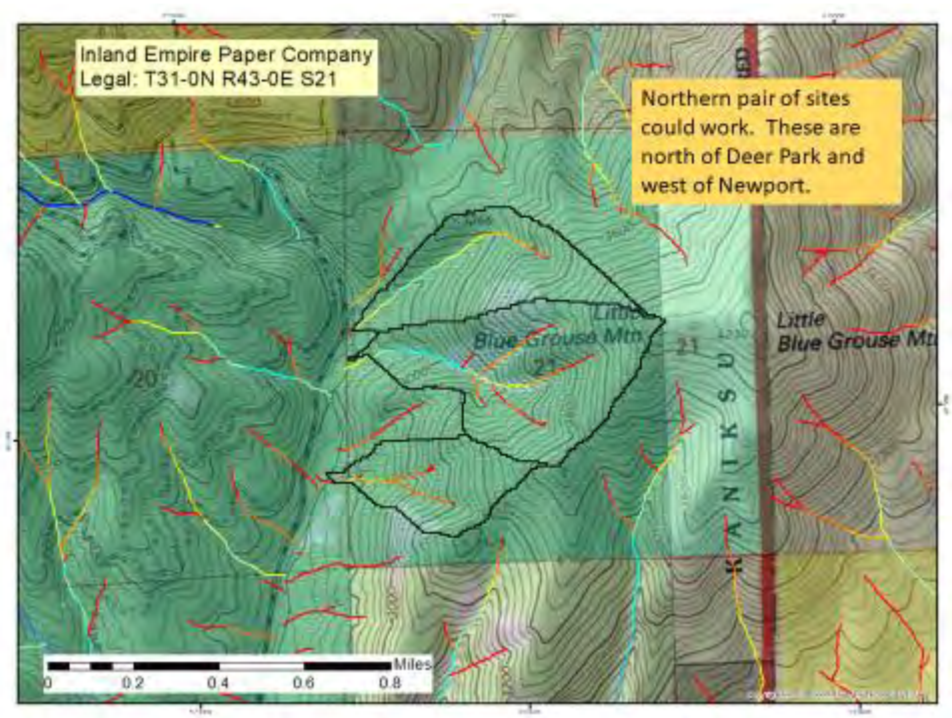


Figure 2: Another potential pair.

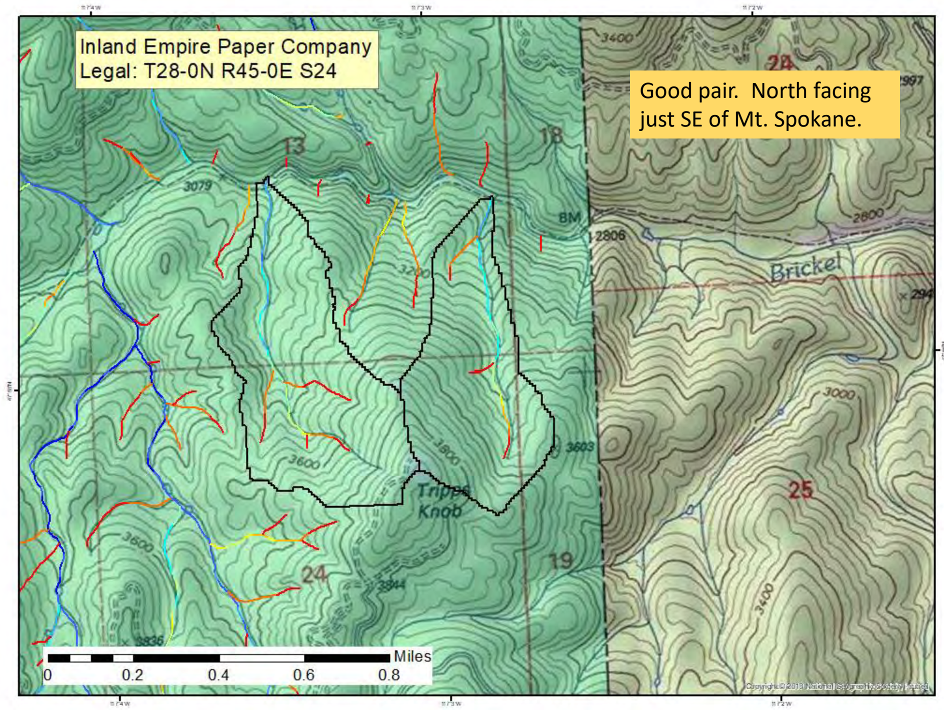


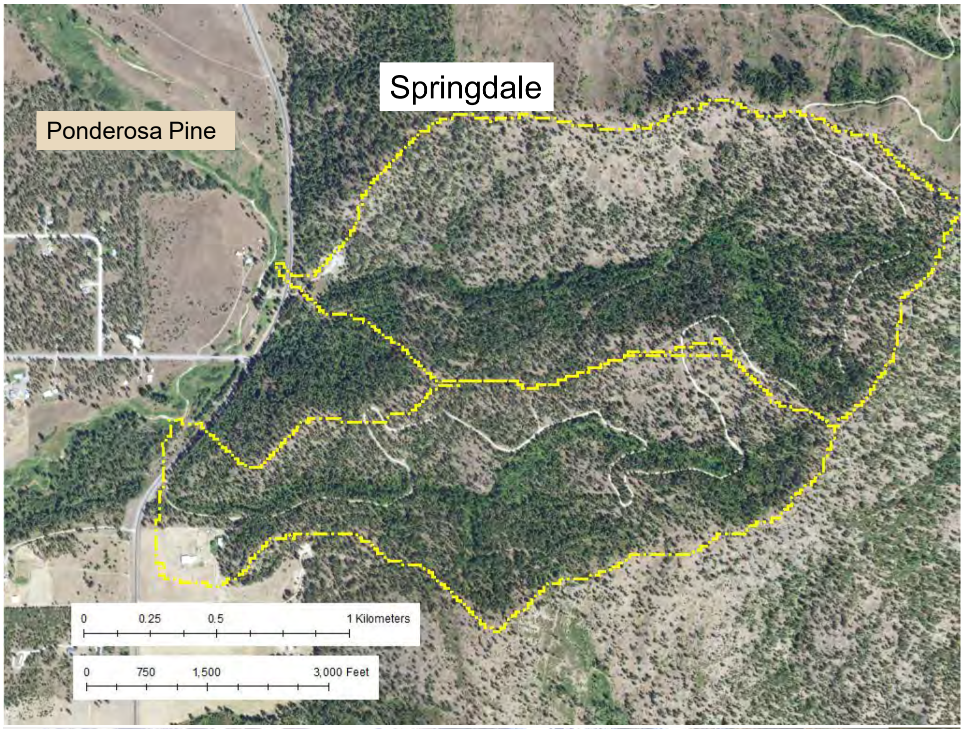
Figure 3: ISPR was told that this site is wetter and that we were seeing a potential gradient in terms of precipitation and summer surface water extent. ISPR were told that we were collecting information on surface water extent and temperature correlations and that those data would be available in September and that we would provide information on how representative candidate sites might be to the area of inference.

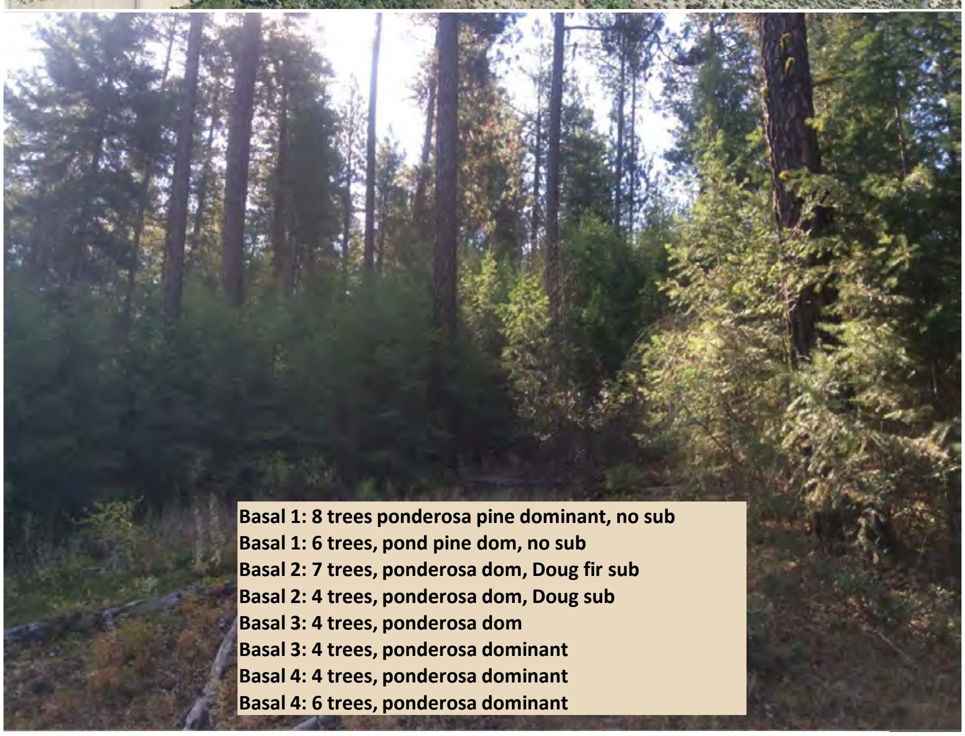
In September and October 2017, the 'wet' and 'dry' TWIGs reviewed available data, visited the 2 driest of the 3 potential sites, and recommended that the two studies be merged. During the October 24, 2017 teleconference between CMER and the TWIGs, CMER approved combining the wet and dry studies based on the understanding that the sites spanned a gradient of hydrologic conditions and that the design could accommodate the range of conditions present across forested landscapes of eastern Washington. CMER directed the TWIG to incorporate elements of the "dry" study plan into the existing "wet" study plan document, continue to work with ISPR to address existing comments, and provide feedback on the revised study plan document. The merged study plan document and completed comment matrix was submitted to the ISPR on December 8, 2017. A teleconference between the TWIG and ISPR was held on January 3, 2018 to discuss the TWIG's response to the ISPR review, and to discuss remaining minor issues that the ISPR wanted to have resolved prior to approval of the study plan. The final revised ENREP Study Plan was submitted to the ISPR AE on January 18, 2018, and approved by the AE on January 23, 2018 with the statement from the AE that "this revised document constructively and cogently addresses all of the concerns raised in review and that were subsequently identified as important in conference call discussions".

The following slides were part of the September TWIG discussion and were shown to the Scientific Advisory Group Eastside (SAGE).

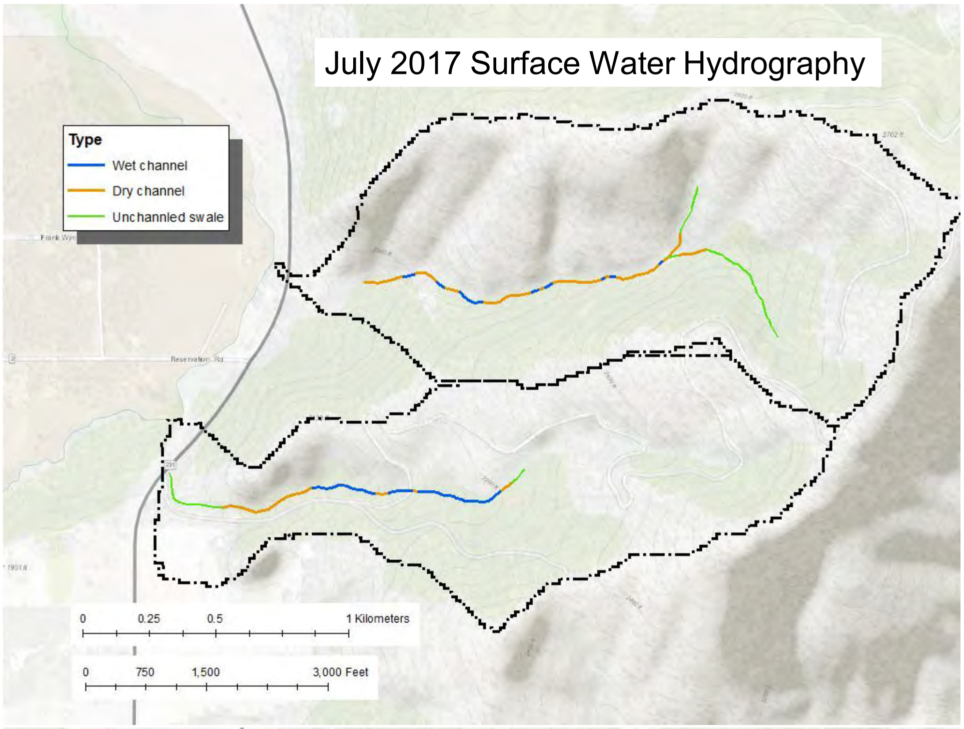
We can't recall whether any of these slides were shown on a Jan 3, 2018 video conference with ISPR. The purpose of that video conference was for ISPR to indicate where additional edits were warranted prior to formal approval of the study design. If these slides were shared with ISPR, they may have affected ISPR's opinion of the study design document, so they are incorporated here as part of the formal record.

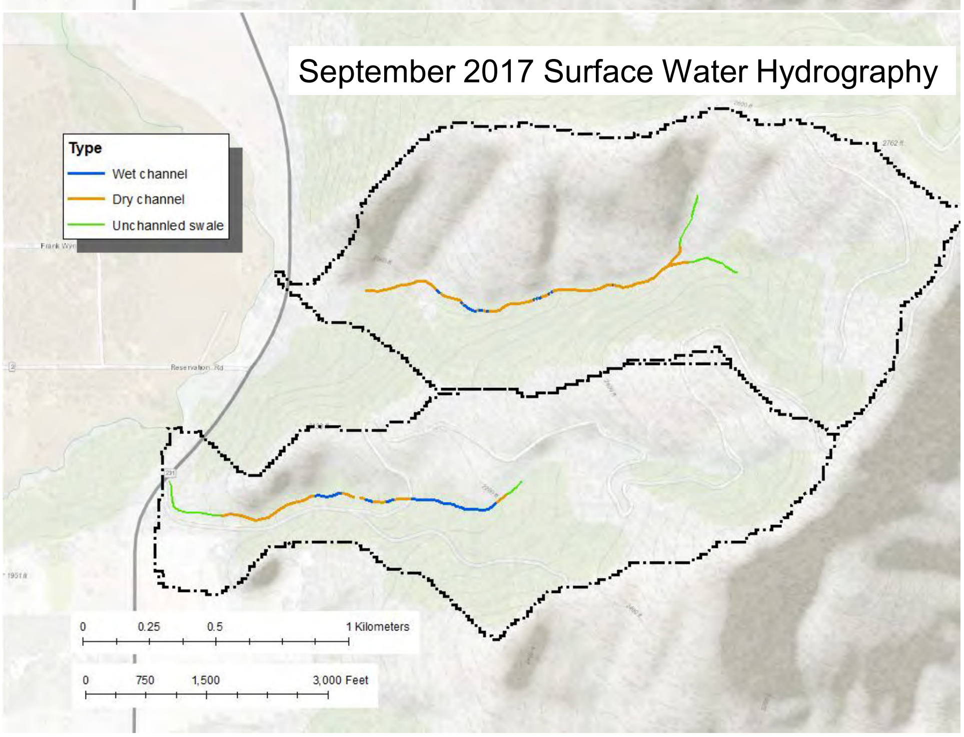
Figure 4: These are the sites we have.





Springdale is a relatively dry site dominated by ponderosa pine.





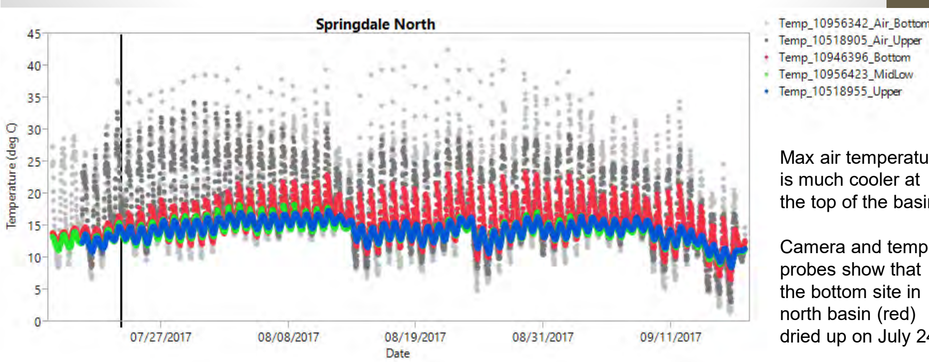
Stream hydrology was surveyed in July and September 2017. The northern basin would be the treatment and we would clearcut approximately 50% of the reaches that were classified as Np in July.

July	Springdale_N		Springdale_S	
	Length (ft)	Proportion	Length (ft)	Proportion
DryChan	2460	77%	1055	41%
WetChan	723	23%	1492	59%
Grand Total	3183		2547	

September	Springdale_N		Springdale_S	
	Length (ft)	Proportion	Length (ft)	Proportion
DryChan	2717	88%	1345	55%
WetChan	366	12%	1113	45%
Grand Total	3084		2458	

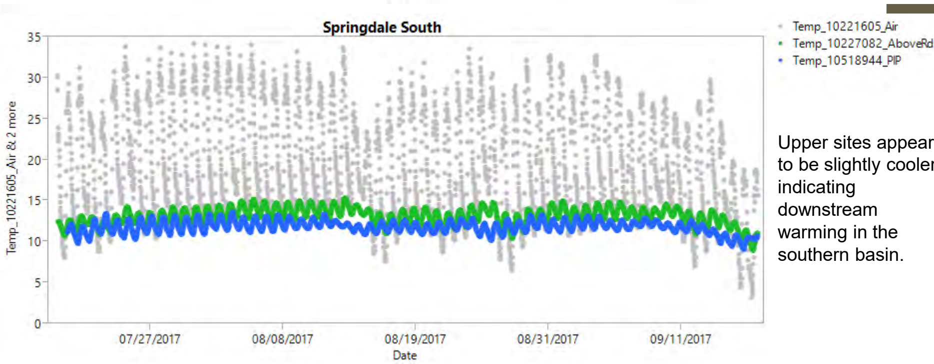
Mid-July to Mid-Sept	Springdale_N	Springdale_S
Dried up between surveys (ft)	390	393

Length is probably slightly underestimated because it only includes reaches mapped as either dry or wet in both surveys.



Max air temperature is much cooler at the top of the basin.

Camera and temp. probes show that the bottom site in north basin (red) dried up on July 24



Upper sites appear to be slightly cooler indicating downstream warming in the southern basin.

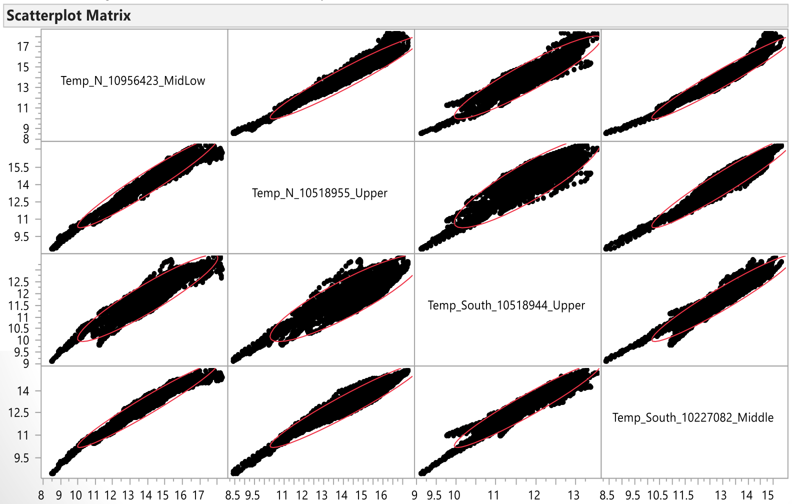
This shows both the length of dry and wet channel and change in condition. Temperature data were used to make sure the basins had similar pre-treatment temperature profiles.

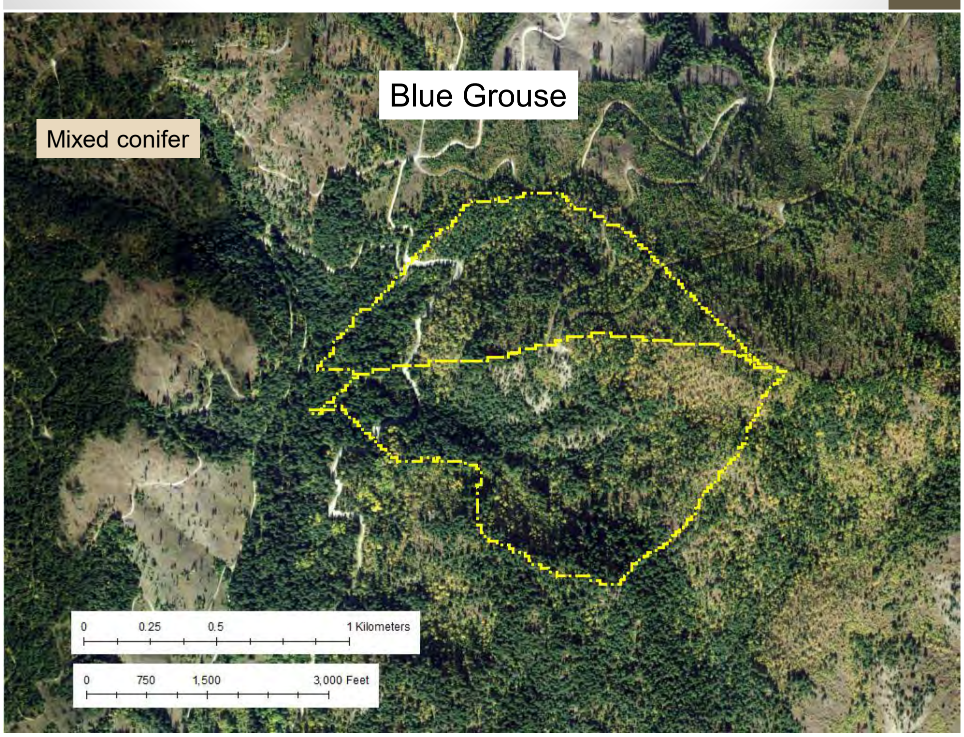
Correlations

	Temp_N_10956423_MidLow	Temp_N_10518955_Upper	Temp_South_10518944_Upper	Temp_South_10227082_Middle
Temp_N_10956423_MidLow	1.0000	0.9642	0.9306	0.9718
Temp_N_10518955_Upper	0.9642	1.0000	0.8861	0.9615
Temp_South_10518944_Upper	0.9306	0.8861	1.0000	0.9586
Temp_South_10227082_Middle	0.9718	0.9615	0.9586	1.0000

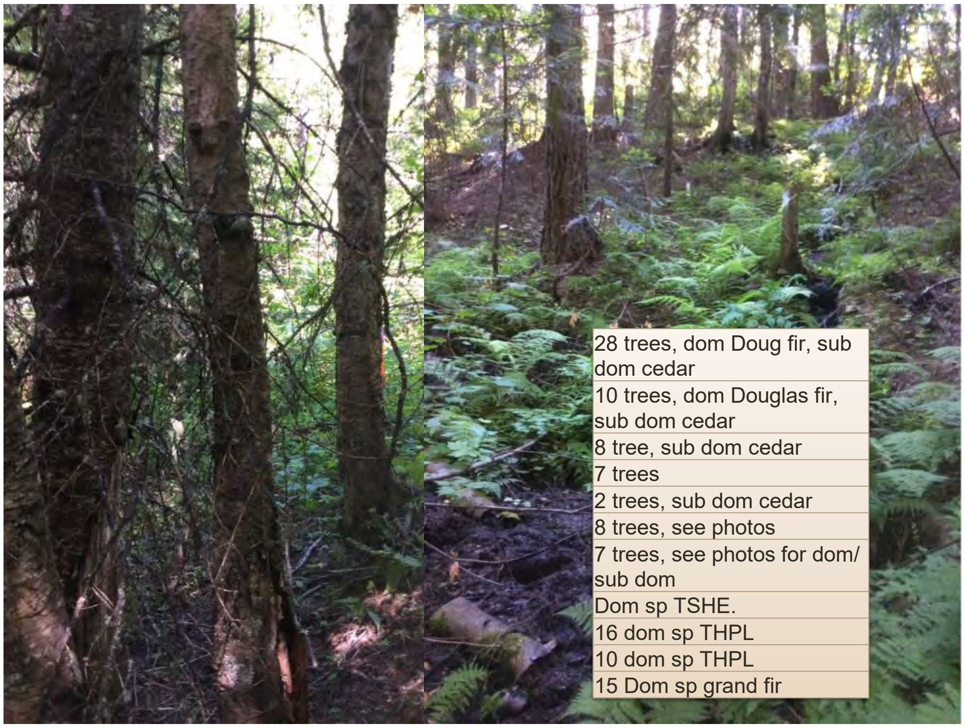
There are 50 missing values. The correlations are estimated by REML method.

Scatterplot Matrix

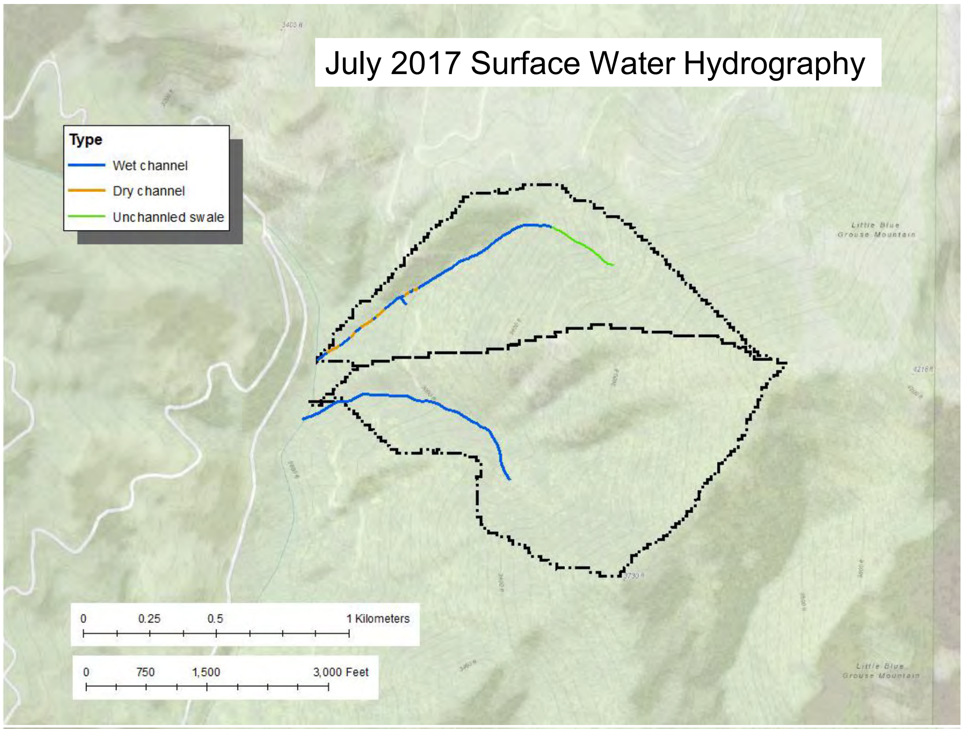


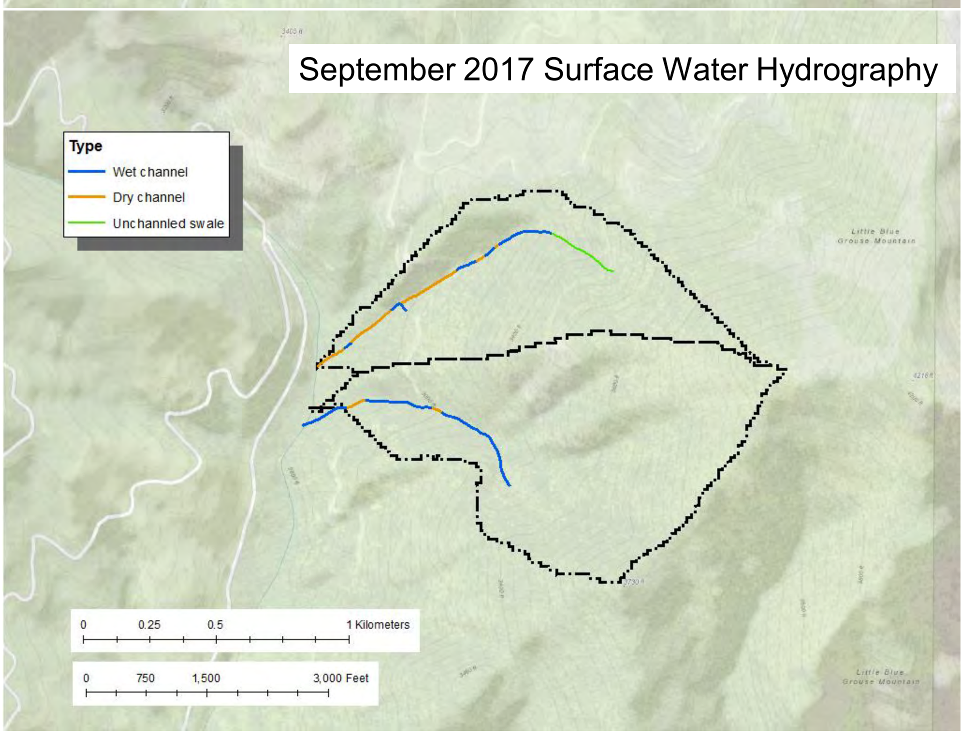


Top graph shows that temperature within and between sites is strongly correlated. The next site is Blue Grouse.



Blue Grouse is a true mixed conifer site.





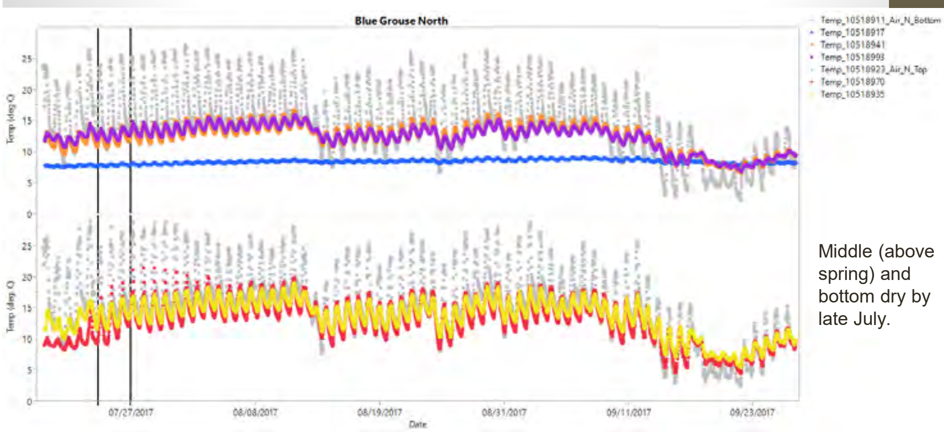
Both basins were largely wet in July, but by September the lower half of the northern basin was dominated by dry stream channel. The northern basin would be the treatment and at least 50% of the September dry reach would be clearcut harvested.

July	BlueGrouse_N		BlueGrouse_S	
	Length (ft)	Proportion	Length (ft)	Proportion
DryChan	490	21%	0	0%
WetChan	1878	79%	2115	100%
Grand Total	2368		2115	

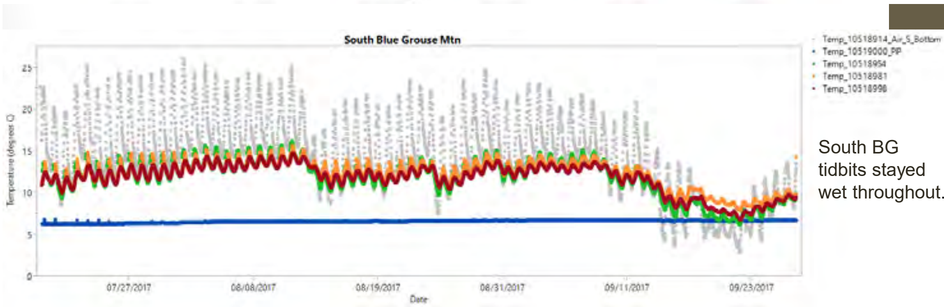
September	BlueGrouse_N		BlueGrouse_S	
	Length (ft)	Proportion	Length (ft)	Proportion
DryChan	1359	54%	263	12%
WetChan	1175	46%	1853	88%
Grand Total	2534		2115	

Mid-July to Mid-Sept	BlueGrouse_N	BlueGrouse_S
Mapped wet and then dry	877	263

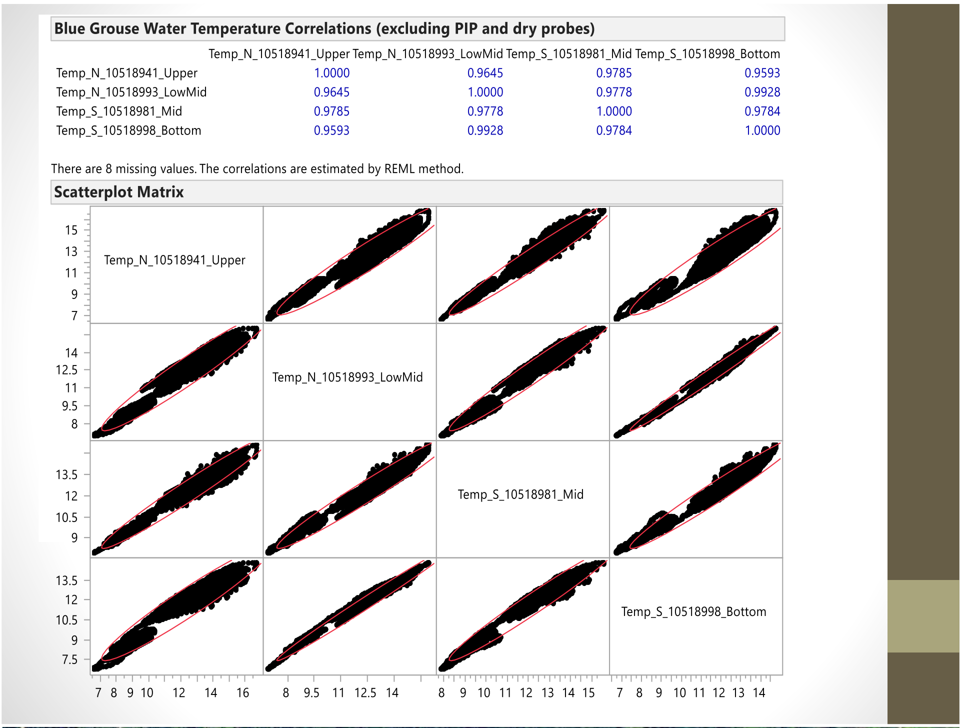
Length is probably slightly underestimated because it only includes reaches mapped as either dry or wet in both surveys.



Middle (above spring) and bottom dry by late July.

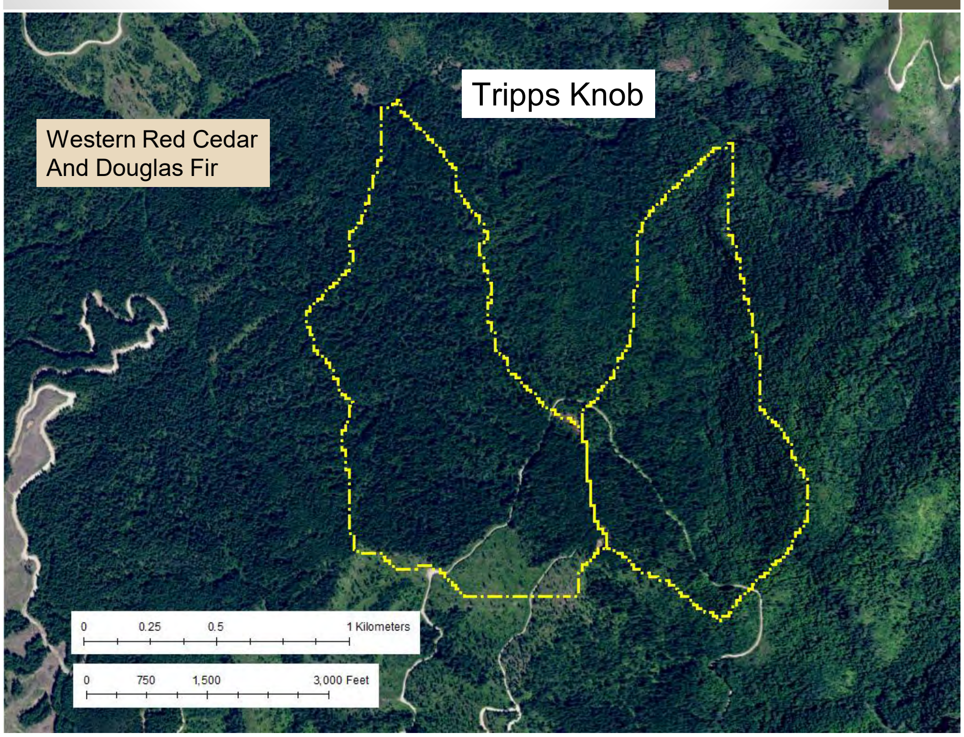


South BG tidbits stayed wet throughout.

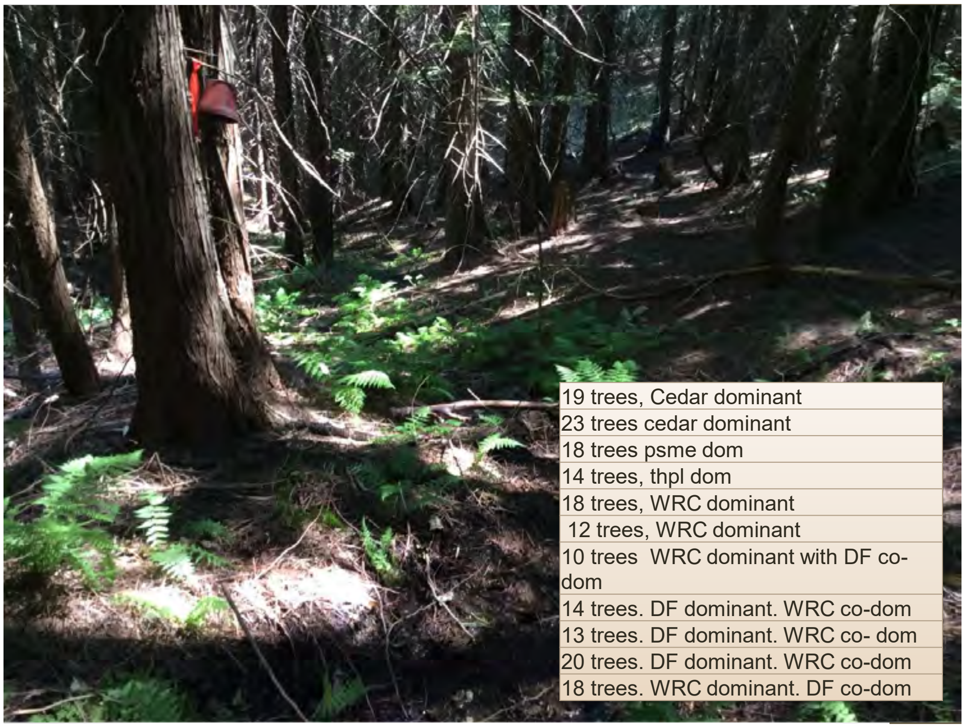

Blue Grouse Water Temperature Correlations (excluding PIP and dry probes)

	Temp_N_10518941_Upper	Temp_N_10518993_LowMid	Temp_S_10518981_Mid	Temp_S_10518998_Bottom
Temp_N_10518941_Upper	1.0000	0.9645	0.9785	0.9593
Temp_N_10518993_LowMid	0.9645	1.0000	0.9778	0.9928
Temp_S_10518981_Mid	0.9785	0.9778	1.0000	0.9784
Temp_S_10518998_Bottom	0.9593	0.9928	0.9784	1.0000

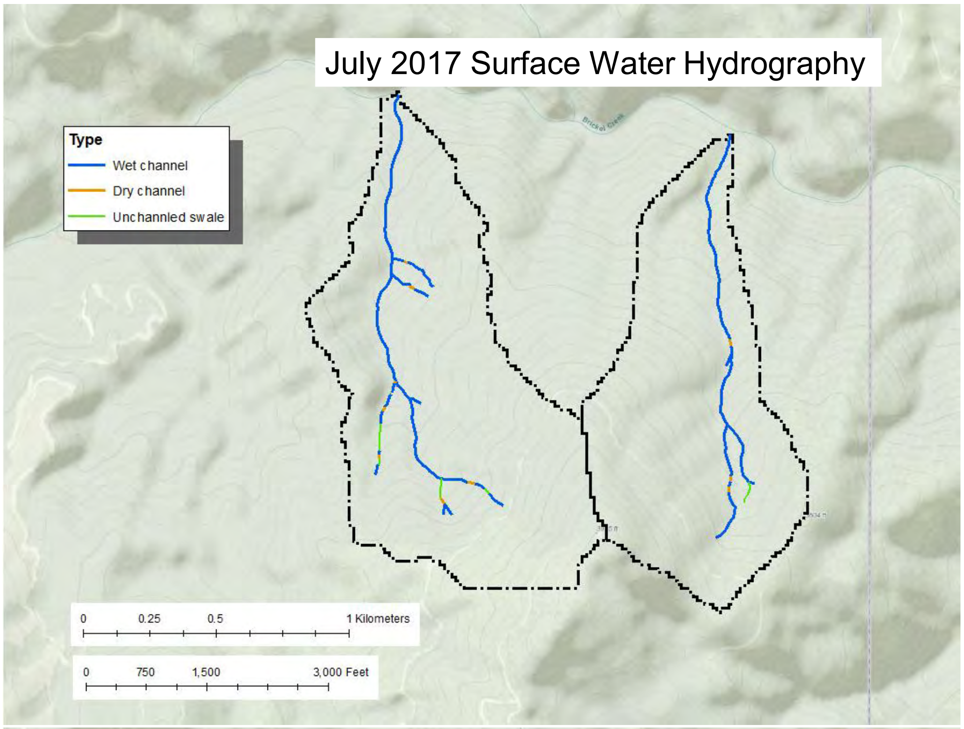
There are 8 missing values. The correlations are estimated by REML method.

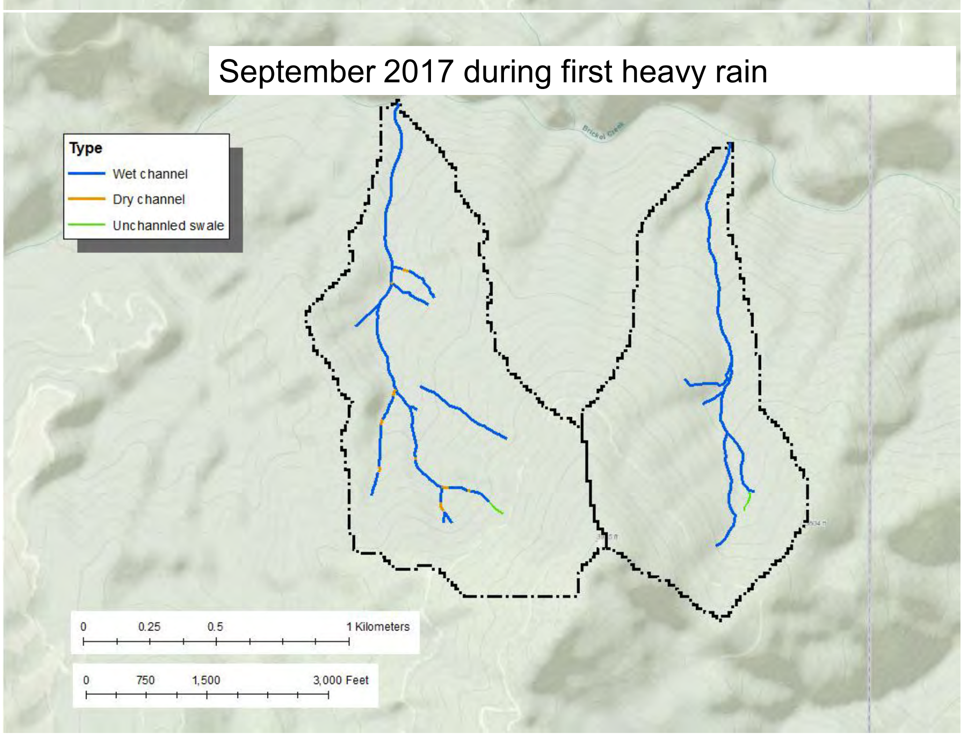


Trips is the wettest of the three basins.



Tripps is dominated by cedar and Douglas fir.



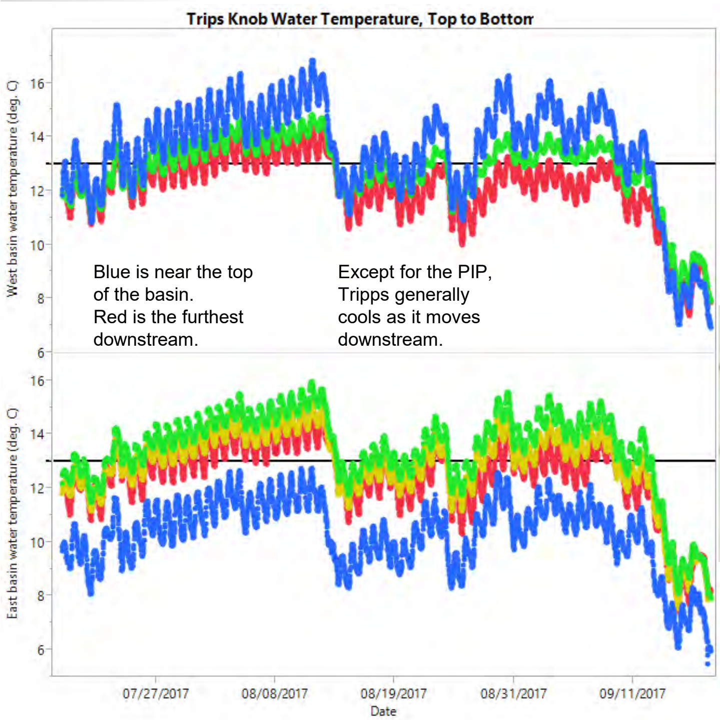


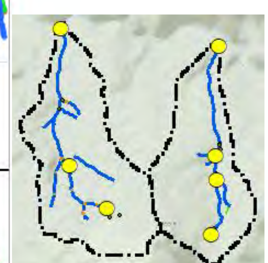
Tripps is a wet site.

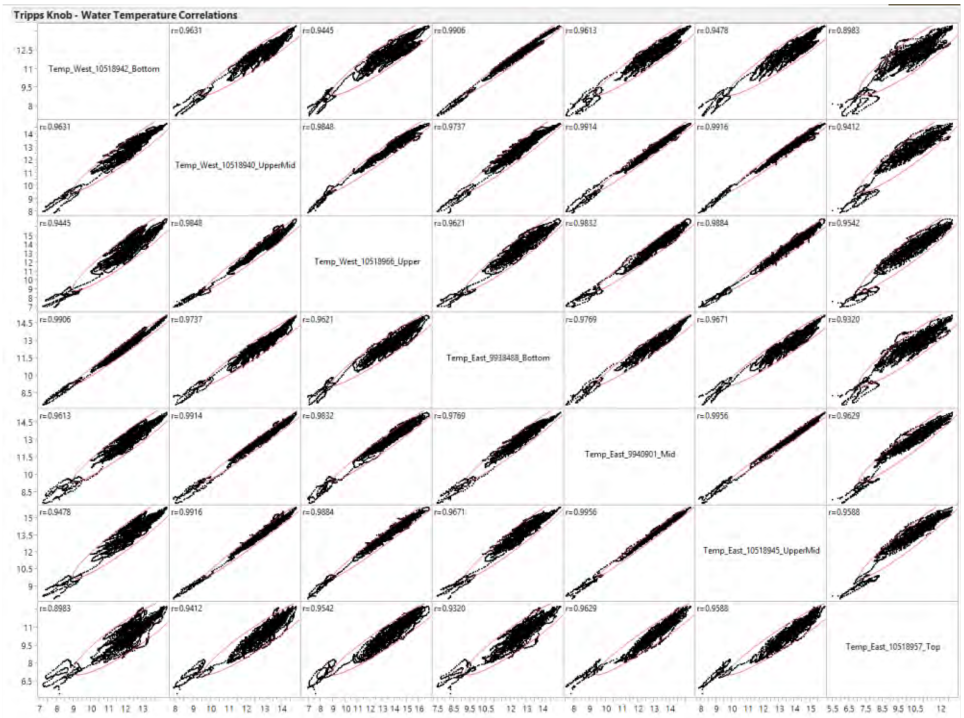
July	Tripps_West		Tripps_East	
	Length (ft)	Proportion	Length (ft)	Proportion
DryChan	284	5%	135	3%
WetChan	5363	95%	3993	97%
Grand Total	5647		4128	

September	Tripps_West (Rain)		Tripps_East (Rain)	
	Length (ft)	Proportion	Length (ft)	Proportion
DryChan	419	6%	0	0%
WetChan	6187	94%	4327	100%
Grand Total	6606		4327	

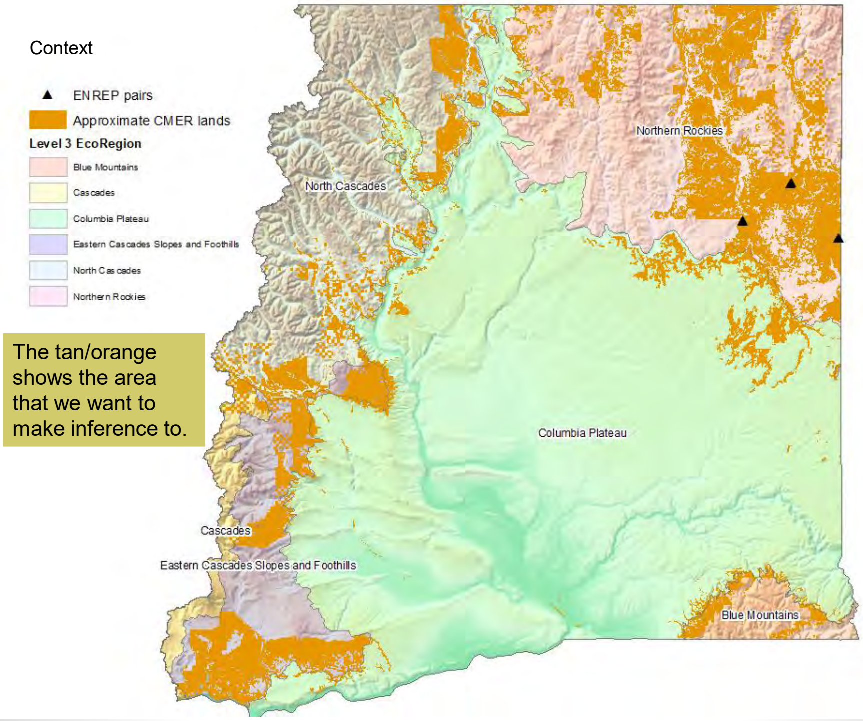
Length is probably slightly underestimated because it only includes reaches mapped as either dry or wet in both surveys.

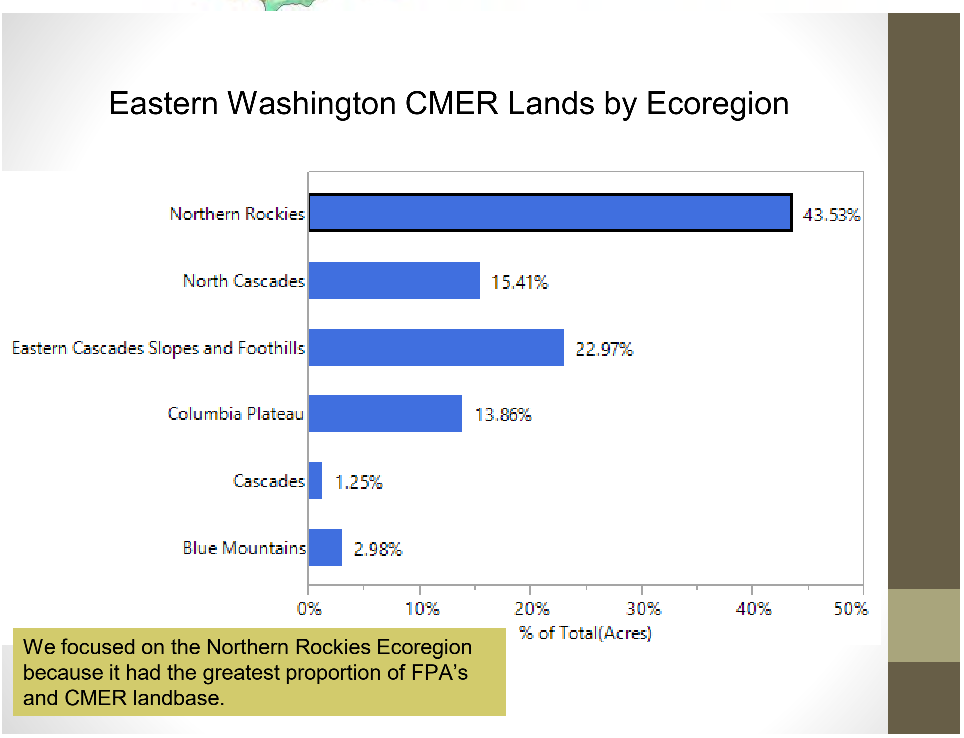




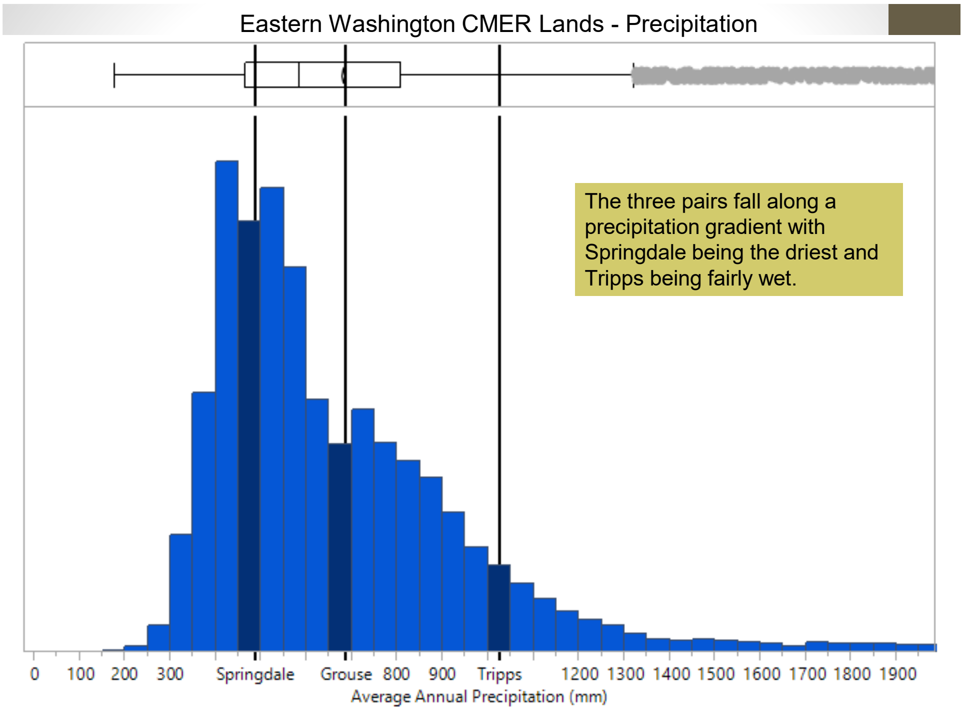


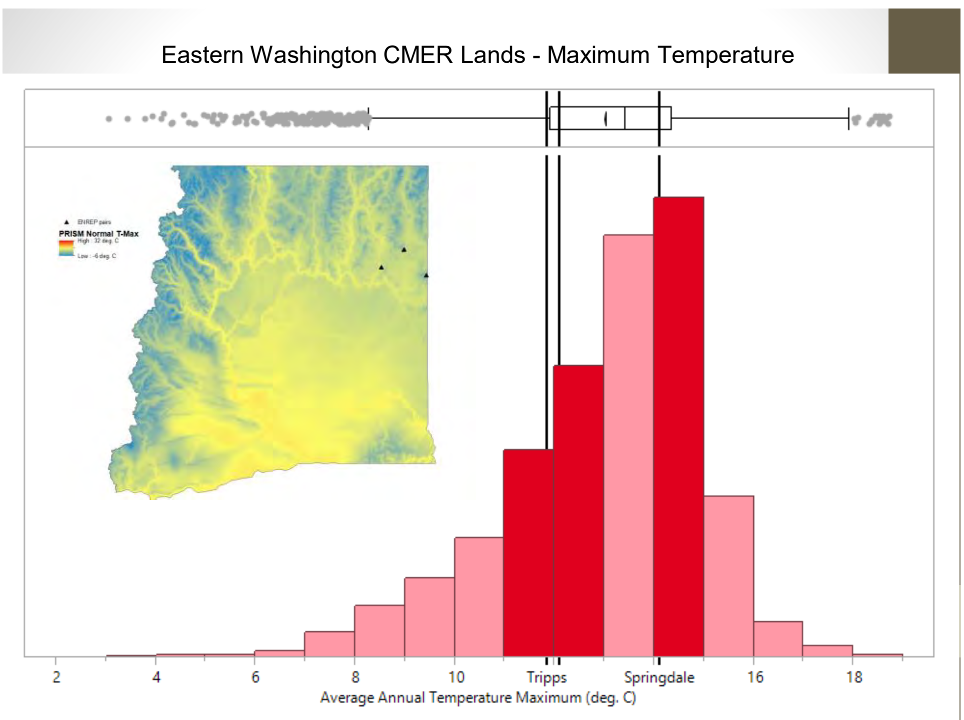
Again, the temperatures are correlated across and between basins.



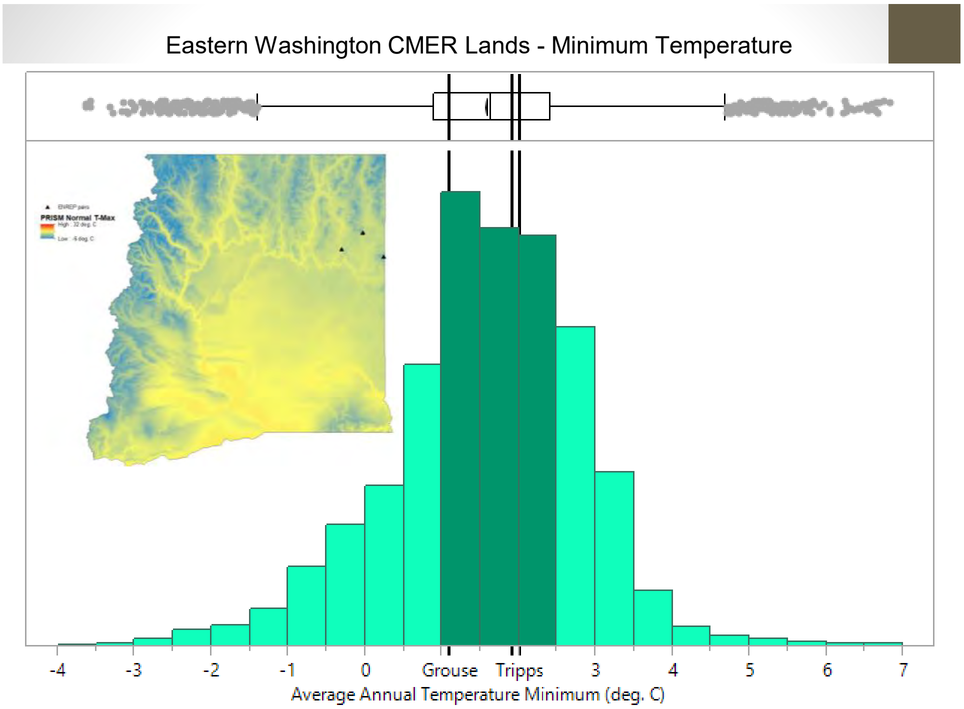


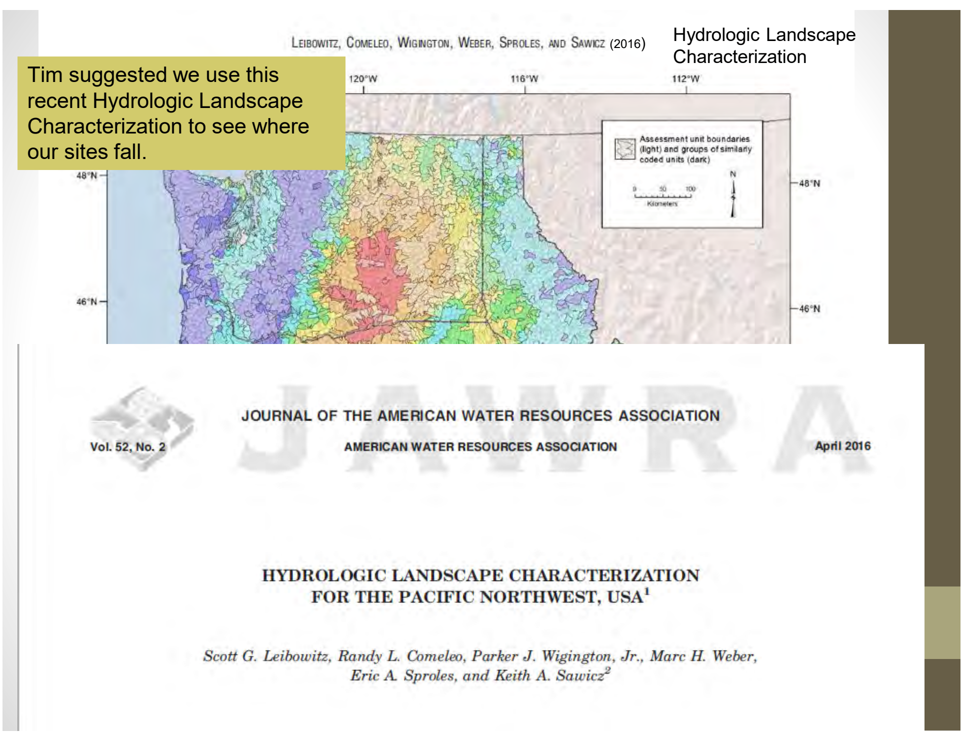
These graphs give some idea of the context of the sits we have relative to the areas we want to make inference. The top graph shows eastern Washington CMER lands and the lower graph shows the proportion of CMER land area by ecoregion.





The top graph shows that the three sites span a gradient of precipitation. The next couple show that the sites are not outliers in terms of maximum or minimum annual temperature.

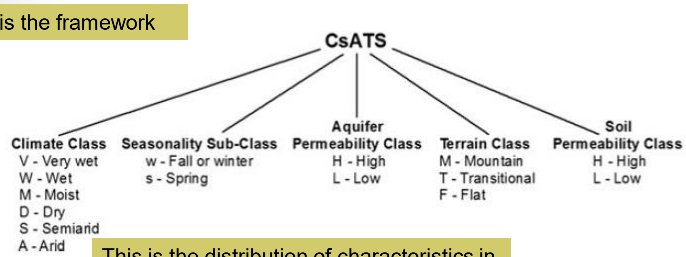




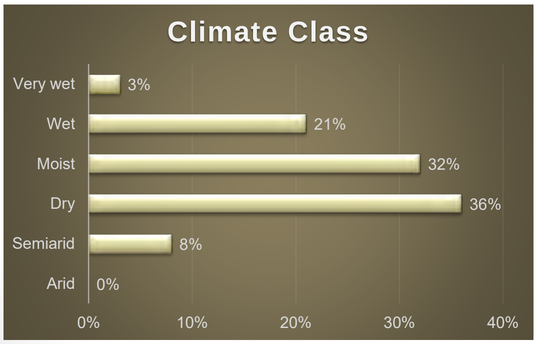
Use used a recent paper by Leibowitz et al. (2016) to look at how the three sites we have compare with the hydrologic landscape within CMER lands. We see that for most metrics, the sites are fairly representative.

Hydrologic Landscape Characterization

Here is the framework



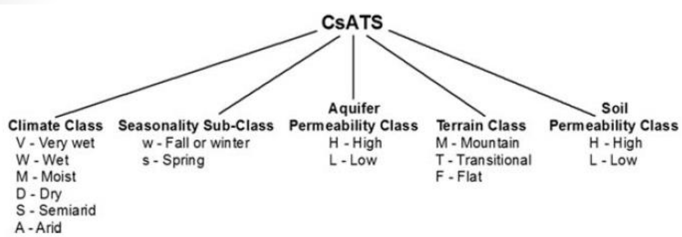
This is the distribution of characteristics in eastside CMER lands.



Site characteristics

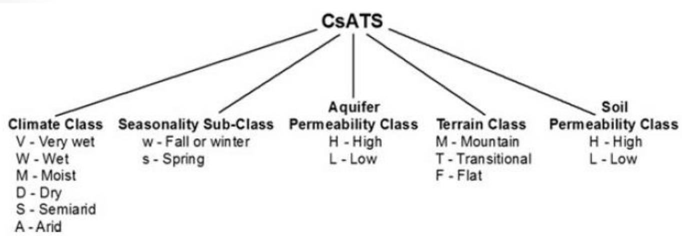
Site	Climate
Tripps	Wet
Blue Grouse	Moist
Springdale	Dry

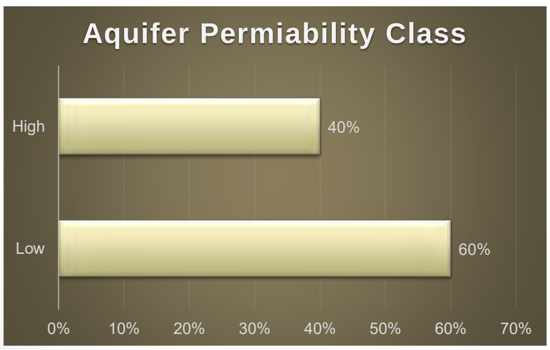
Hydrologic Landscape Characterization



Site	Hydro Season
Springdale	Winter
Blue Grouse	Spring
Tripps	Spring

Hydrologic Landscape Characterization





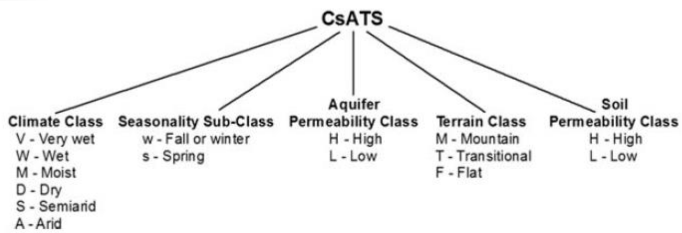
Site	Aquifer Perm.
Springdale	Low
Blue Grouse	Low
Tripps	Low

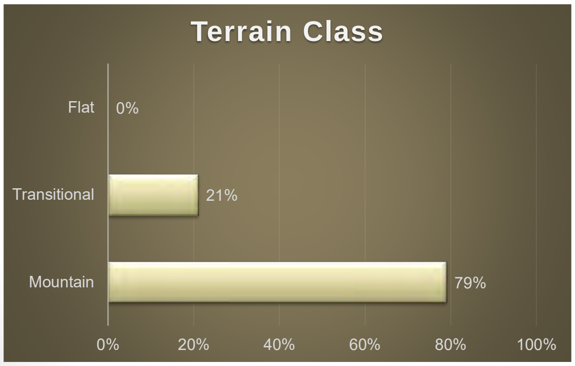
Eastern Washington CMER Lands Aquifer Permeability by Ecoregion

	Aquifer Permiability	
Ecoregion	**High**	**Low**
Blue Mountains	3%	0%
Cascades	0%	1%
Columbia Plateau	8%	5%
Eastern Cascades Slopes and Foothills	22%	1%
North Cascades	1%	14%
Northern Rockies	6%	38%

The one place where the three existing sites were not representative was in terms of aquifer permeability. All three sites near Spokane are classified as having low aquafer permeability while 45% of eastside CMER lands have high aquifer permeability. To pick up sites with higher aquifer permeability we should look at the eastern Cascades slopes and foothills.

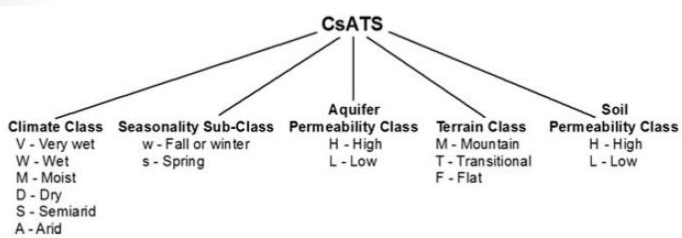
Hydrologic Landscape Characterization

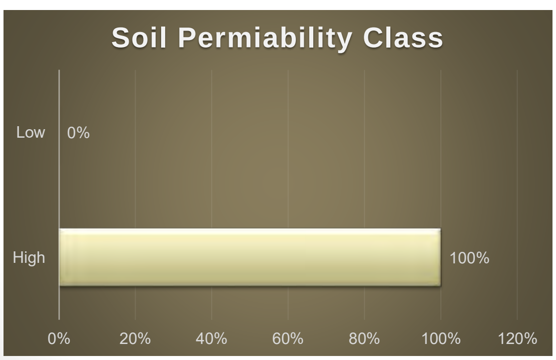




Site	Terrain
Springdale	Transitional
Blue Grouse	Mountain
Tripps	Mountain

Hydrologic Landscape Characterization





Site	Soil Perm.
Springdale	High
Blue Grouse	High
Tripps	High

Additional concerns

Harry Bell, Jenny Knoth, and Doug Martin, and Chris Mendoza each raised concerns regarding the ISPR approved study design or study design document. The March 23, 2018 meeting was intended to give the TWIG the opportunity to clarify for CMER members how the discussions between the ENREP team and ISPR reviewers transpired, and how those discussions affected the final study design. The purpose of this section is not to comprehensively document CMER member concerns, but rather to capture some of the TWIG perspectives that may not be captured in the text of the study design.[1]

Changes made to the study design following the March 23, 2018 meeting

The following is a list of changes made to the study design in direct response to CMER comments received at, or in preparation for, the March 23 meeting:

- Title page: Version changed from ISPR to Final. Date updated with correct year.
- Replaced text in the abstract regarding potential for additional monitoring with text from the body of the document which states that "longer-term monitoring will be required to determine the overall trajectory of the response and to capture a broader range of climate conditions and greater potential for episodic changes with less frequent recurrence intervals."
- Corrected performance target in Table1.
- Replaced the clarifying language in Critical Question 3 with the text that was approved by Policy. The original critical question read: "What is the relationship between observed changes in resource condition and forest management activity?" During ISPR it was re-written to be more explicit. The revised text had read: "What is the relationship between aquatic life (and their supporting resources) and observed changes in hydrology, sediment, and temperature associated with forest management activity?"
- Added the Hard Rock reference (e.g., McIntyre *et al.* 2017) to the statement that although the degree of inference will be limited by the relatively short pre and post-treatment phases, this has been shown to be adequate for quantifying the initial changes associated with harvest.

Discharge as a confounding factor

Doug Martin questioned the ability of the study design to identify the mechanisms causing potential observed changes in temperature because he thought changes in shading would be confounded with changes in hydrology (discharge). He stated that he thought increased discharge would swamp or mask effects of stream buffers on shortwave radiation loading of the stream surfaces.

[1] This document was written on Sunday following a Friday meeting for distribution on Monday and is therefore not as complete as it otherwise might be.

As noted in the background section, forest management simultaneously influences a large number of processes and functions including watershed hydrology, extent and duration of surface water, stream thermal processes, wood and sediment dynamics, benthic invertebrates, and other aquatic life. It is the opinion of the TWIG, that the integrated watershed design is one of the study's strengths because it allows us to deconvolve relative contributions and interactions, if needed. In fact, integrating multiple processes was a design requirement from the project's inception as dictated by both CMER and Policy, which is why a variety of relevant internal watershed data (e.g. forest maturity, hydrometeorological gradients, stream shading, lateral and longitudinal extent and duration of surface water, channel morphology, surface and subsurface water temperature, sediment and sediment delivery pathways, large wood, functional small wood, and aquatic life) will be collected at multiple locations, rather than selected response variables at limited downstream locations. As for the concern that changes in discharge will overwhelm changes in temperature, the data do not support that hypothesis. Temperature changes were documented in all of the hard rock study sites despite overall annual increases in water yield. One reason that shade and discharge are not likely to have significant confounding effects on stream temperature is that the temporal dimensions of their changes are different. Discharge increases are most likely to occur during the winter and spring while temperature increases are most extreme during late summer (McIntyre *et al.* 2017). Moreover, reach-scale observations within and across basins will allow us to estimate the relative effects of changes in shade and discharge on stream temperatures.

Downstream Impacts

Multiple reviewers had questions about identifying potential effects of buffer treatments on reaches downstream of the study basins, and assessing their implications for fish. The TWIG acknowledges these concerns and had previously agreed to evaluate whether downstream impacts could defensibly be addressed given the sites available to this Type Np study. As discussed at the March 23, 2018 meeting, these sites are not appropriate for evaluating effects on fish and have limited utility for assessing even downstream effects on temperature given that the adjoining higher-order streams the study basins discharge to are influenced by land uses both upstream and immediately downstream of their confluences with the study streams.

However, the TWIG did agree to perform temperature monitoring in downstream connected F reaches (per the study plan), not to extend past the first downstream tributary junction.

Harvesting along dry reaches

One of the design goals of the 'dry' study was to evaluate the effect of buffering or not-buffering dry reaches. In all the sites where we have over 1000' of stream that is predominately dry for more than 2 months (e.g., Springdale, BlueGrouse, and their eastern Cascade analogs), we will be working with landowners to clearcut harvest a portion of the dry stream network. This was always a design goal for the 'dry' component of the study that was communicated to landowners of those sites, but not well articulated in the approved study design document.

We recognize that there was interest by certain members to also see clearcut harvest in perennially wet reaches, and this was discussed as an option in the March 23, 2018 meeting. At this meeting, TWIG members also brought up that having a large number of clearcut reaches would weaken our ability to relate shade-loss to temperature change across less pronounced differences in shade and thus and make inferences regarding the effects of different buffering practices. Clearcut harvest along perennially wet reaches has not been discussed with the landowners, and the decision on where and how perennial reaches are treated will need to be resolved at a later date with the involvement of landowners and their harvest implementation teams to ensure that experimental treatments both meet their management objectives and are practically feasible.

ISPR concerns and how they were addressed

Most of ISPR's concerns were addressed directly through the comment matrix and text changes, but a few of their comments and our responses were resolved or changed during the January 3, 2018 conference call with ISPR.

On March 23, 2018, one or more reviewers asked for clarification regarding how some of these comments were resolved. Explanations to some of these were provided at the meeting, but they are captured here as part of the record. The bullet points are concerns raised by ISPR that were addressed through text changes or conversation.

- **The specific objectives and metrics to be generated in the cross-sectional survey methods are unclear and warrant further explication.**

ISPR wanted to know why we were surveying channel cross-sections and they wanted more detail in the methods. We explained that the cross-sections were to show channel aggradation/degradation and migration, and we updated the description of both the goal and methods under Sampling Scheme and Field measurements.

- **The methodological and design basis for assessing impact of Type N stream responses on adjoining type F waters is unclear, and certain to be complicated enough that it justifies more rigorous treatment if it is to be included in the study.**

This conversation was similar to the one that occurred during the March 23, 2018 CMER meeting. We explained that given these site conditions it would be hard to make any inference regarding effects on downstream fish and that inferences regarding even temperature were likely to be problematic once an upstream or downstream tributary is reached.

- **We are uncertain that the proposed frequency pairing framework for evaluating flow changes is statistically appropriate for low flow comparisons, especially where low flow variation is large and qualitative change from low flow to no flow, or the reverse, are likely. This should be resolved, considering that biota, and probably water quality, are likely strongly controlled by low flow dynamics in these systems.**

We agreed to drop the frequency pairing language from the study design. We can always use the technique later if it makes sense, but we concluded this level of detail was not needed in the proposal.

- **"I also question whether MBACI is the best design to attack the study goals and objectives, given the complexity of watershed-stream responses, and often high variability." "As NC rightly points out here, the BACI affords no firm inferential basis for interpreting cause and effect, especially when outcomes are highly variable." "careful site pairing to minimize uncontrolled variation is crucial if MBACI is to be successfully implemented and not wholly confounded by variations not affected by the riparian logging treatments."**

During the discussion that occurred with the ISRP on January 3, 2018, it became clear that they wanted to know why we had not considered also employing physics-based models (e.g., DHSVM) to help discern cause and effect relationships. With physics-based models, one can explore the sensitivity of variables of interest to forcing data and parameterizations. In this sense, models can be used in conjunction with empirical data to both explore direct mechanistic relationship sensitivities and assess a broader range of biophysical conditions with virtual watershed experiments in numerical simulations. We explained that we had run that alternative past Policy but that Policy wanted the study to be empirically-based. As soon as we focused on empirical research, their previous concerns were dropped and ISPR came to the conclusion that an observational BACI study with supporting internal watershed data was appropriate despite the challenges required to infer cause and effect relationships in this experimental framework.

- **"Describe what power represents in the context of MBACI and how is going to be interpreted, given the potentially large number of site pairings. Explain why the proposed statistical methods are best suited to discriminate cause and effect. They may be able to detect the change, but given the complexity of the systems, it is not clear how the main cause of the change is going to be identified" "How is data interpreted as a function of general precipitation and temperature patterns? The connection between streamflow and changes in stream temperature is missing from the statistical tests."**

Again, in this case, the ISPR reviewer's perspective was whether inclusion of a physically-based model, rather than the collection and analysis of empirical data, would be the most effective approach to discern cause and effect relationships. We discussed the merits of physically-based models as well as some of the challenges in having model output accepted in the adaptive management context for making decisions regarding policy. In the end, the questions were less about the power of MBACI and more about the relative strengths and weaknesses of empirical, modeling, and hybrid approaches. Again, given the objective of this study is to inform policy decisions, the ISRP ultimately agreed that the study design was acceptable to meet both the scientific and policy objectives of assessing the effectiveness of management practices on non fish-bearing streams.