EASTSIDE TYPE N RIPARIAN EFFECTIVENESS PROJECT (ENREP)

Contents

OCTOBER 2019

Site Update From Project Team: The update from the Project Team is intended to provide a comprehensive synopsis of the information gathered and evaluated by the Project Team in association with their June investigatory visit to the three site pairs in the Eastern Cascades Slopes & Foothills and Northern Cascades ecoregions.

ENREP Questions Relevant For Policy Evaluation: TWF Policy requested the ENREP Project Team and CMER answer four Policy relevant questions. These questions were delivered by the AMPA, as requested by Policy, to CMER, the SAGE Chair, and the ENREP Project Team on August 9, 2019. At the August 27, 2019 meeting, CMER directed the ENREP Project Team to answer those questions relevant to their contracted expertise and implementation of the project. To date, the ENREP Project Team has responded to questions #2 through #4, with question #1 reserved for CMER. CMER has formed a subgroup which is intended to address Question #1, and a response will be sent to Policy for review at a future meeting.

Budget Details: The spreadsheet provided depicts the following project budget line items:

1. MPS approved fiscal year estimated expenditures for 6-basin pairs,
2. September 2019 Project Team estimated fiscal year expenditures for 5-basin pairs,
3. Cost per basin pair for aquatic life component,
4. Potential cost savings estimate if the aquatic life component is removed from the Eastern Cascades Slopes & Foothills and Northern Cascades ecoregion sites (2-basin pairs),
5. Cost per basin pair for the sediment component, and
6. Potential cost savings estimate if the sediment component is removed from the Eastern Cascades Slopes & Foothills and Northern Cascades ecoregion sites (2-basin pairs).

(Note: Line items 3. through 6. correspond to Question #3 from Policy.)

EASTSIDE TYPE N RIPARIAN EFFECTIVENESS PROJECT (ENREP)

August 2019

Site Update From Project Team

This update, drafted by the Project Team, is intended to provide a comprehensive synopsis of the information gathered and evaluated by the Project Team in association with their June investigatory visit to the three site pairs in the Eastern Cascades Slopes & Foothills and Northern Cascades ecoregions.

EASTSIDE TYPE N RIPARIAN EFFECTIVENESS PROJECT (ENREP)

PROJECT UPDATE

Oversight Committee: Scientific Advisory Group – Eastside (SAGE)

Project Team Members: Timothy Link, Charles Hawkins, William Ehinger, Paul Robinson, Ian Hellman, Donald Benkendorf, Eastside CMER Scientist (TBD), Emily Hernandez

---

Purpose Statement

This Project Update, drafted by the Project Team, provides a comprehensive synopsis of the information gathered and evaluated by the Project Team in association with their June investigatory visit to the three site pairs in the Eastern Cascades Slopes & Foothills and Northern Cascades ecoregions:

Rattlesnake Ridge | Sedge Ridge | Coxit Mountain

August 2019

Brief Summary of Eastern and Northern Cascades June Site Visit

Timothy Link (UI) and Bill Ehinger (ECY) visited potential ENREP watershed pairs from June 24-27, 2019. Four watersheds that would comprise two potential pairs (Sedge Ridge and Rattlesnake) in the Eastern Cascades Slopes and Foothills ecoregion, and three adjacent watersheds that would comprise one pair (Coxit) in the North Cascades ecoregion were evaluated. Specific objectives of the trip were to:

1. Evaluate site conditions to determine if watersheds are viable to support research objectives.
2. Evaluate summer and winter access logistics, both vehicular and via foot.
3. Identify reach breaks and install water temperature.
4. Evaluate thermal matching in Coxit watersheds.
5. Identify potential flume locations
6. Estimate work needed to develop access trails for flume/SedEvent system installation.
7. Identify any other strengths, weaknesses, and/or concerns.
8. Look for additional cost efficiencies within the approved Study Design.

Available geospatial data was used to determine the approximate climate regime and geologic conditions for each watershed pair. Water temperature data from the Eastern Cascades Slopes and Foothills ecoregion sites (Sedge and Rattlesnake) that were collected by ECY only during the summer of 2018 and removed in the fall of 2018 were evaluated to assess the adequacy of the sites for the study.

General Summary of Findings

- The three site pairs identified for inclusion purposefully span a gradient of precipitation and channel wetness. The approximate range of precipitation is not as wide as the sites in the Northern Rockies ecoregion that span the 30th to the 90th percentile of approximate annual precipitation in the target population. The Eastern Cascades Slopes and Foothills sites span a precipitation gradient from approximately the 55th to the 90th percentile of annual precipitation for the target population and include a relatively dry (Coxit), mesic (Sedge), and wet (Rattlesnake) site.

- None of the Np streams appear to have spatially intermittent reaches and all appear to connect to larger receiving bodies.

- The geology of all the sites is comprised of volcanic bedrock, in contrast to the metamorphic and intrusive igneous geologies of the Northern Rockies watershed pairs. The distinctive geology is an important feature of the Cascade regions, and in particular the volcanic flow dominated Eastern Cascade Slopes and Foothills ecoregion because these hydrological landscapes are likely to have larger flow contributions from deep groundwater.

- The vegetation at the sites is comprised of Douglas fir/subalpine fir/Engelmann spruce (Coxit), grand fir/Douglas fir/ponderosa pine (Sedge), and mountain hemlock/lodgepole pine/ Engelmann spruce (Rattlesnake) which differs from the ponderosa pine, mixed conifer, and Douglas fir/western red cedar dominated watersheds in the Northern Rockies ecoregion.

- Analysis of 2018 stream temperature data indicate that both the Sedge and Rattlesnake pairs exhibit acceptable thermal correlations to address the study objectives for stream temperatures.

- Snow-free season foot access is excellent at Sedge and Coxit and acceptable (requires 2-3 stream crossings) at Rattlesnake. Snow-free season motorized access is viable at Sedge and Coxit but will necessitate some limited trail improvements. Rattlesnake access has significant challenges due to necessary stream crossings and wet meadow traverses. Winter access is very viable at Sedge, reasonable at Coxit, and not recommended at Rattlesnake due to dangerous steep terrain and numerous stream crossings.

Specific Findings and Issues:

Issue #1: DNR State Lands, Southeast Region cannot allow Rattlesnake basin pair to be used in the ENREP study due to the presence of Northern Spotted Owl dispersal habitat.

Impact on the Study

- Loss of the Rattlesnake Ridge basin pair will reduce the ability of the study to infer responses of streams located in wetter and colder regions underlain by more permeable volcanic bedrock.

- Reducing the monitored watersheds from 12 to 10 will reduce the upcoming project costs by approximately $233k over the duration of the project. In addition, previously purchased equipment (SedEvent and hydrometeorological systems) valued at approximately $78k will be available for other projects.

Discussion

- The Project team will continue to work with DNR foresters to explore options that could permit harvesting in the watersheds to occur, but at this time indications are that the site will not be available for harvest.

- Other site options have been pursued in this region, but have either been eliminated from consideration due to other HCP issues (e.g. Teanaway State Forest) or operational and harvest timing concerns that are expected to delay instrumentation (e.g. Yakama Nation). An assessment of other potential sites in the region could be re-initiated. If this option is of interest, potential site evaluation and landowner outreach should proceed as soon as possible.

Proposed Alternative(s)

1. The inferential power of the study to the Northern Rockies ecoregion could be further increased by adding a fourth basin pair to this subregion. Advantages include increased inferential capacity for the region that produces a large proportion of timber on the eastside and potentially a budget reduction if the identified sites are close to existing sites and free of significant access issues. If this option is of interest, potential site evaluation and landowner outreach should proceed as soon as possible.

2. The loss of one pair of basins should not significantly affect the ability of the study to identify and quantify environmental and biological response to treatments. The original six-basin-pair design was a compromise between statistical power (more is always better), representativeness of landscape conditions (coverage across the full gradient is ideal), and cost (less is the goal). Statistical power to detect responses of ecological importance with a five-basin-pair design will not be markedly affected because of the overall ability of BACI designs to isolate the effect on response variables of interest by rigorously controlling for factors that can confound inferences in synoptic survey designs. The loss of a wet, high aquifer permeability volcanic portion of the eastside geoclimatic gradient will prevent direct inference to ~8% of the eastside landscape, but it will also

result in cost savings, which we have been asked to pursue. Overall, the design should still allow us to infer how streams in ~92% of the eastside landscapes that comprise the target population respond to riparian buffer treatments. Note that the loss of the Rattlesnake basins will not affect coverage of the precipitation gradient (Fig. 1), and these basins had similar, although higher estimated precipitation levels and are both higher elevation and colder relative to the Sedge Ridge basins (Table 1).

Issue #2: Postponing East Cascade flume installations and data collection to summer 2020

Impacts on the Study

- ENREP utilizes a before-after, control-impact (BACI) study design, therefore climatic differences between the specific monitored periods at the various study basins are not of concern because the analyses only depend on having an adequate control basin. The study specifies at least two years of both pre- and post-harvest data to help understand the effects of different climate conditions and provide a hedge against anomalous years on response variables.

- This delay will concomitantly delay the final comprehensive analysis of project data.

- The instrumentation delay will reduce project funding needs during the current biennium, but will extend the current budget projection by an additional year, but at a reduced level if data collection at the Northern Rockies sites ceases when currently scheduled in 2023.

Current East Cascade Field Activities

- Reach breaks in all potential Cascades watershed pairs were identified and surface water temperature loggers were installed during the reconnaissance trip. The installations are intended to both provide the data needed to assess the thermal matching in the Coxit pair and provide an additional one to two years of pre-treatment water temperature data if the sites are integrated into ENREP.

- A second reconnaissance trip later in the summer is planned with Phil Peterson from WestFork Environmental and local DNR foresters to finalize potential flume locations, determine necessary access improvements for his equipment, and identify potential sites for hydrometeorological stations.

- WCC field crew time has been reserved for this fall to initiate access improvements at the Sedge and/or Coxit sites if sites are integrated into the study.

- Addressing habitat and other site specific matters associated with the Coxit sites:

    - A goshawk nest was discovered is on the other side of a prominent ridge on Coxit Mountain. It is at least ¾ of a mile from the edge of the potential unit identified to

study the stream in pre/post-harvest. A biologist will need to see if any other nests are discovered, but the study area isn't significantly impacted at this point.

- Active cattle grazing lease in the basin area. Working with State Lands to address fence maintenance/repair issues.

- Located within a lynx travel corridor. Requires additional evaluation and coordination with Northeast Region DNR Forestry division.

- Two conflicting water type modification forms are currently in place for the lower reach of the streams within this basin, one calling this reach of stream Type N and the other calling it Type F. The discrepancy in the forms is most likely due to the standard default physical classification efforts that took place in 2003. Though the reach in question is most likely Type N, a downgrade/reclassification is not permissible during a state-wide drought designation. To mitigate this issue we have two options: 1.) Verification and reclassification of the F/N break during next year's water typing window (~July-August), or 2.) Conduct an interim water-type assessment for FP Board review/approval.

Winter Access

Sedge Ridge Sites

Roads are plowed to within several miles of the sites, and access with winter vehicles appears to be very feasible at both sites. Approximately ½ miles of trail improvements are needed to provide motorized access to the western site. There are no significant access concerns at this site.

Coxit Sites

Winter access to the Coxit sites may be challenging due to the overall travel distance (16+ miles) and several steep sidehill traverses that look to potentially be hazardous during deep and/or soft snow conditions. Despite these concerns, winter access appears to be very feasible based on well-developed and maintained forest roads in the area. Both watersheds also have good potential for solar charging due to nearby clearcuts at the base of the watersheds which would reduce the number of necessary winter trips.

If conditions prevent winter access and/or there is inadequate solar radiation to maintain battery voltages through the winter, some flow, turbidity, and suspended sediment data could be lost. However, the plan to reduce potential impacts on the study will be to include extra batteries and solar panels with the automated sampling installations and to access the site and swap batteries prior to the onset of seasonal melt to reduce winter transport hazards.

Timeline & Budget Outlook

Required species and habitat surveys and approvals of potential plan modifications for the eastern Cascades sites will result in equipment installations (Flumes and SedEvent systems) during the summer of 2020 rather than late 2019 as planned. This will reduce anticipated personnel and travel costs in FY2020 and FY2021 but will increase costs in FY2024 and FY2025 due to shifting field crew activities forward in time. This will also delay the initiation of the out-year final data analyses for the Cascades sites to late 2025. One advantage is that the delay will enable two additional summers of pre-treatment stream temperature data collection.

	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26 ??
Budget	$250,000	$777,135*	$907,968	$723,434	$686,719	$626,609	$366,695	$152,267	TBD
Spent to Date	$172,865	$579,101	--	--	--	--	--	--	--
Adjustments	--	--	-$42,251**	--	--	--	--	--	--
Unspent Funds	+$77,135*	$198,034***	$865,717	--	--	--	--	--	--
Potential Change in Budgeted Amounts	--	--	$ ↓	$ ↓	$ ↓	$ ↓	$ ↑	$ ↑	$ ↑

*FY18 unspent biennium funds that rolled over to FY19

**FY20 equipment purchased with available FY19 funds

***Awaiting final invoicing

Appendix

Critical Questions. The ENREP addresses the following non-fish-bearing (Type N) Riparian Prescriptions Rule Group questions from the CMER work plan (CMER 2019-2021 Biennium Work Plan):

- *Are riparian processes and functions provided by Type (Np) non-fish buffers maintained at levels that meet resource objectives and performance targets for shade, stream temperature, large woody debris (LWD) recruitment, litter fall, and amphibians?*
- *Do different types of Type N channels explain the variability in the response of Type N channels to forest practices?*
- *What is the effect of buffering or not buffering spatially intermittent stream reaches in Np streams?*

The critical questions developed by the Study Design team for ENREP are:

- *What is the magnitude of change in water temperature, canopy closure, and stream cover of Type N channels in the first two years after harvest?*
- *What is the magnitude of change in stream flow and suspended sediment export from the Type N basins in the first two years after harvest?*
- *What is the relationship between aquatic life (and their supporting resources) and observed changes in hydrology, sediment, and temperature associated with forest management activity?*

Table 1. Basin characteristics for all six sites.

	East Cascades						Northeast Washington					
	Sedge Ridge		Rattlesnake Ridge		Coxit Mountain		Springdale		Blue Grouse		Tripps Knob	
	West	East	West	East	North	South	North	South	North	South	West	East
Basin Area (acres)	87	173	88	93	230	139	223	169	65	103	126	97
Elevation Range (min-max, ft)	3906-5108	3283-4623	4751-5500	4750-5379	4704-6235	4726-6286	1884-2922	1880-2688	2857-4069	2832-4088	3032-3970	2866-3967
Approx. Channel Length (ft)	920	940	2000	1800	1400	1300	3100	2500	2400	2100	6100	4200
Precipitation (mm)*	886	855	932	932	602	621	484	485	685	685	1022	1028
Temperature Min (deg. C)*	0.8	1.2	0.1	0.1	-1.8	-2.0	1.9	2	1.1	1.1	2.1	2.2
Temperature Max (deg. C)*	10.6	11.0	8.7	8.7	8.2	7.8	14	14.3	12.1	12.1	11.9	11.8
Geology	Tertiary volcanics		Tertiary volcanics		Tertiary fragmental volcanic rocks		Tertiary intrusive		Precambrian metamorphic		Mesozoic orthogneiss	
Forest Type	Mixed conifer (grand fir, Douglas fir, ponderosa pine)		Mixed conifer (mountain hemlock, lodgepole pine, Engelmann spruce)		Mixed conifer (Douglas fir, subalpine fir, Engelmann spruce)		ponderosa pine		Mixed conifer		Douglas fir & western red cedar	

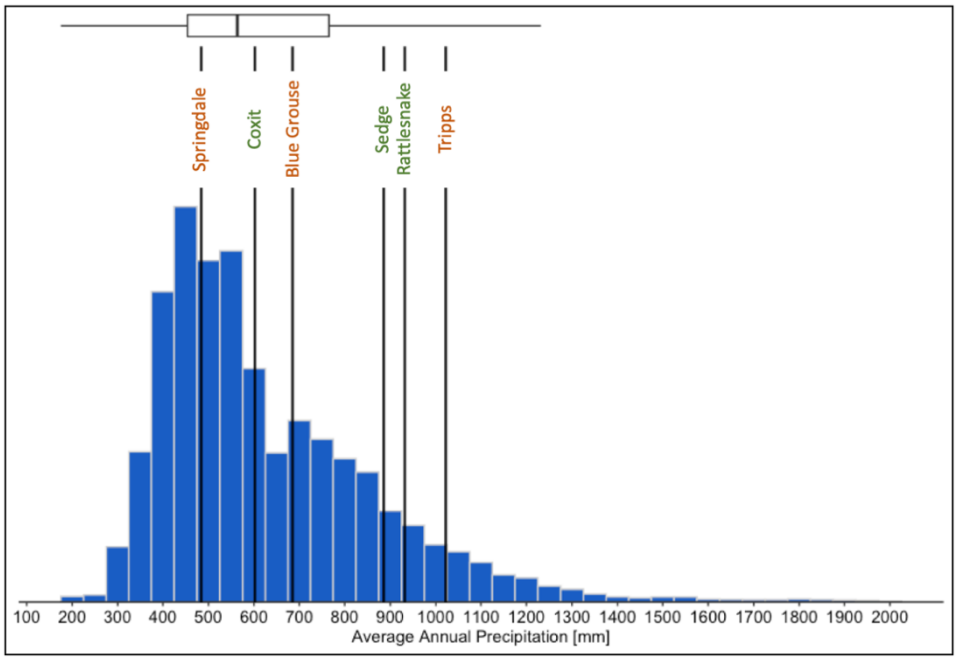
*30 yr annual PRISM climate normals (1981-2010)

Table 2. Distribution of target population land area and paired sites by the Hydrologic Landscape Characterization for the Pacific Northwest (Liebowitz et al., 2016)

Class	Categories	Proportion of Population Area	Northeast Washington	East Cascades
Climate	Very wet	3%		
	Wet	21%	Tripps	Coxit, Sedge, Rattlesnake
	Moist	32%	Bluegrouse	
	Dry	36%	Springdale	
	Semiarid	8%		
	Arid	-		
Seasonality	Fall or winter	62%	Springdale	
	Spring	38%	Bluegrouse, Tripps	Coxit, Sedge, Rattlesnake
Aquifer Permeability	High	40%		Sedge, Rattlesnake
	Low	60%	Springdale, Bluegrouse, Tripps	Coxit
Terrain	Mountain	79%	Bluegrouse, Tripps	Coxit, Sedge, Rattlesnake
	Transitional	21%	Springdale	
	Flat	-		
Soil Permeability	High	100%	Springdale, Bluegrouse, Tripps	Coxit, Sedge, Rattlesnake
	Low	-		

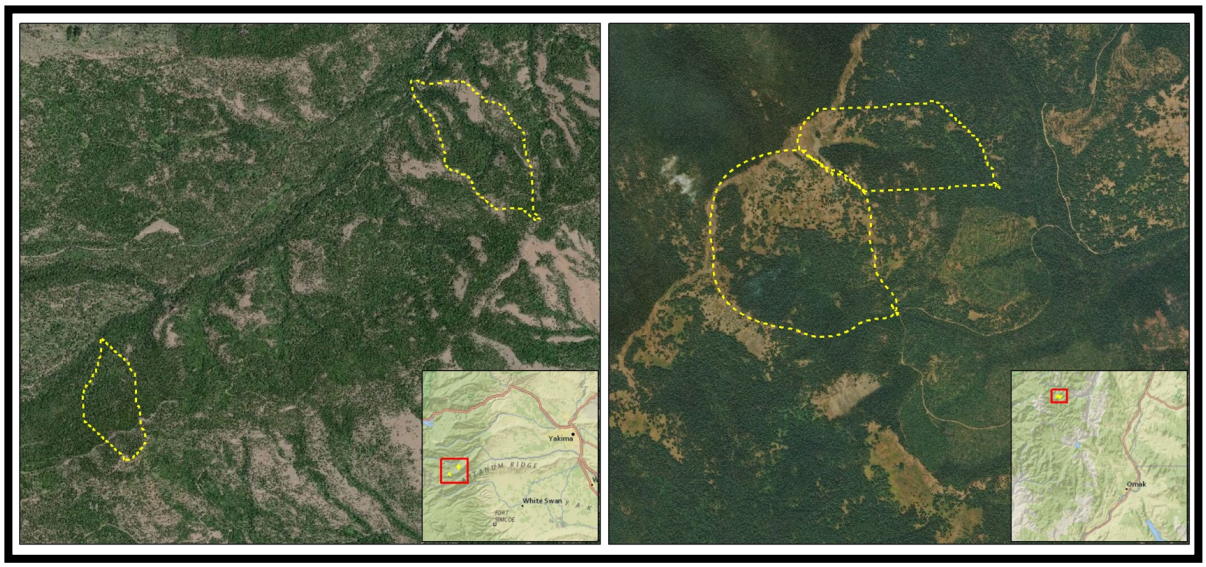
Note: The climate class for each site was determined by a modified version of the Feddema Moisture Index based on a combination of PRISM-estimated precipitation and potential evapotranspiration (PET) based on latitude and mean monthly solar declination.

Figure 1. Annual PRISM estimated precipitation normal for all ENREP proposed sites compared with the population of interest. Precipitation domain restricted to <2000mm



Note: Average annual precipitation is estimated for each site based on PRISM data which can have large errors over small scales in complex terrain and therefore should be used as a general indication of precipitation regime for site comparisons.

EASTSIDE TYPE N RIPARIAN EFFECTIVENESS PROJECT (ENREP)



September 2019

ENREP Questions Relevant For Policy Evaluation

TWF Policy has requested the ENREP Project Team and CMER answer four Policy relevant questions. Policy has asked for this information to better understand the scientific tradeoffs pertaining to the possible elimination or modification of select/proposed project elements.

These questions were delivered by the AMPA, as requested by Policy, to CMER, the SAGE Chair, and the ENREP Project Team on August 9, 2019. At the August 27, 2019 meeting, CMER directed the ENREP Project Team to answer those questions relevant to their contracted expertise and implementation of the project.

The ENREP Project Team has responded to questions #2 through #4, with question #1 reserved for CMER to address.

EASTSIDE TYPE N RIPARIAN EFFECTIVENESS PROJECT (ENREP)

PROJECT TEAM RESPONSE TO QUESTIONS FROM POLICY

Oversight Committee: Scientific Advisory Group – Eastside (SAGE)

Project Team Members: Timothy Link, Charles Hawkins, William Ehinger, Paul Robinson, Ian Hellman, Donald Benkendorf, Eastside CMER Scientist (TBD), Emily Hernandez

---

Questions

1. Please review the Project Team's assessment of the site-review from summer 2019 and provide Policy with CMER's position on the inference ability of the research project as currently sited.
2. Are the secured/proposed paired basins sufficient in order for Policy to infer effects to the whole east side per the original study design? If not, what are the limitations of inference? How does that inference change with elimination of the east Cascades sites or the Coxit site?
3. How can findings related to the following study factors be used to inform the adaptive management process and/or rulemaking or rule validation? Are there indicators in the HCP or current rule that would provide a basis for decision making for Policy? What are the information tradeoffs to keeping versus removing a study factor? What does this factor cost?
    a. Macroinvertebrates
    b. Sediment output
    c. Disconnected Np streams
4. Are there ways to answer the questions with a less frequent sampling regime?

September 2019

Question #1: Please review the Project Team's assessment of the site-review from summer 2019 and provide Policy with CMER's position on the inference ability of the research project as currently sited.

As currently designed, CMER position on the inferential strength of the ENREP research project is that, for each research parameter examined, the treatment response of each basin pair of sites will contribute to the estimate of average treatment response for the group of east side landscapes they represent. Accuracy and precision of each estimate depends on the number of basin pairs (sites) that are included in the study. Adding sites tends to narrow the confidence intervals of estimated responses (i.e. resulting in less uncertainty), whereas omitting sites tends to broaden the confidence intervals (i.e. resulting in greater uncertainty). As indicated on page 5 of the September 2019 site-review report, the original six basin-pair design was based on a need to achieve an acceptable balance of statistical power, landscape representation, and cost.

In terms of the strength of inference: As stated on page 5 of the September 2019 site-review, the loss of the Rattlesnake basin-pair "should not significantly affect the ability of the study to identify and quantify environmental and biological response to treatments." This means that the current five basin-pair study design will still be able to detect statistically significant treatment effects for both individual study sites and for the group of study sites as a whole. It will simply do so with less replication.

In terms of the spatial scope of inference: As noted on page 5 of the site-review report, the loss of the Rattlesnake basin-pair reduces the scope of spatial inference since each pair represents a certain combination of geographic attributes, and each combination of geographic attributes represents a certain proportion of the east side of the state. As the Rattlesnake basin-pair was representative of roughly 8% of the landscape, its loss will diminish landscape representation by roughly that amount.

The ENREP project team report proposes adding another basin-pair in the Northern Rockies Ecoregion (instead of seeking an alternative basin-pair in the Eastside Cascades Ecoregion) because it can increase the inferential power for distinguishing important effects in the Northern Rockies region. Moreover, the report also suggests that it would be more difficult to find a replacement basin-pair in the Eastside Cascades than in the Northern Rockies. Further, because the Northern Rockies Ecoregion produces a larger proportion of the timber than does the Eastside Cascades Ecoregion, selection from the Northern Rockies will have the potential for the selected pair to increase the size of the represented landscape. CMER agrees with the ENREP team that it would be worthwhile to both maintain inferential power by adding a site in the Northern Rockies Ecoregion, and conduct the trade-off between an increased spatial scope of inference in the Northern Rockies while reducing it in the Eastside Cascades. Hence, CMER recommends that the project team pursue the addition of an alternative basin-pair in the Northern Rockies.

Question #2: Are the secured/proposed paired basins sufficient in order for Policy to infer effects to the whole east side per the original study design? If not, what are the limitations of inference? How does that inference change with elimination of the east Cascades sites or the Coxit site?

Candidate sites in the Cascades ecoregions and Northern Rockies ecoregion were specifically selected to span a gradient of precipitation and channel wetness and the distinct primary geologies that comprise the eastside region to evaluate the effectiveness of riparian buffers across the range of conditions that encompass the target population of sites. See Tables 1 and 2 for a concise summary of all study site conditions. The identified watershed pairs in the Cascades ecoregions span a gradient of estimated precipitation, similar to the Northern Rockies sites, but are within a slightly narrower range, from roughly the 50th to the 85th percentile of the target population. Areas in the lower precipitation percentiles have few perennial streams, therefore the truncation of the lower precipitation percentiles should have a minor impact on the level of inference provided by the study. The Sedge Ridge and Rattlesnake basins are in the Eastern Cascade Slopes and Foothills ecoregion, and the Coxit basins are in the North Cascades ecoregion. The first pair of basins (Sedge Ridge) is approximately 26 miles west-southwest of Yakima, average 130 acres in size, are northwest-facing and consist of mixed conifers dominated

by grand fir, Douglas fir, and ponderosa pine. Both basins are connected directly to fish-bearing waters. The second pair of basins (Rattlesnake) is approximately 35 miles west-southwest of Yakima, average 91 acres in size, are northwest-facing and comprised of mixed conifers dominated by mountain hemlock, lodgepole pine, and Engelmann spruce. Both basins are connected directly to fish-bearing waters. The third pair of basins (Coxit) is approximately 23 miles northwest of Omak, average 185 acres in size, are south and southeast-facing, comprised of mixed conifers dominated by Douglas fir, subalpine fir, and Engleman spruce and flows into downstream fish-bearing waters.

Scope of Inference

Experimental studies, such as Hard Rock and Soft Rock, are done not because there is any great interest in the specific streams but to infer how the overall population of streams will respond to similar treatments. Statistics of the treatment effect, e.g., mean and 95% confidence intervals, are estimates describing the expected response of the population of streams. They are not predictions of the response of any individual stream to a given treatment.

The population of streams to which one can infer is defined by the criteria used to select streams for the study and ENREP sites pairs were selected along a gradient from low to high precipitation to capture streams with substantial lengths of dry channel to those with no dry reaches. If the range of precipitation is reduced by eliminating the driest or the wettest site pairs, the scope (range of streams) of inference is reduced accordingly.

Loss of the Rattlesnake Ridge basin pair as a viable experimental unit reduces the ability of the study to infer responses of streams located in wetter and colder regions underlain by more permeable volcanic bedrock. The loss of this site in the wet, high aquifer permeability volcanic portion of the eastside geoclimatic gradient prevents direct inference to ~8% of the target area of interest in the eastside landscape.

Question #3: How can findings related to the following study factors be used to inform the adaptive management process and/or rule making or rule validation? Are there indicators in the HCP or current rule that would provide a basis for decision making for Policy? What are the tradeoffs to keeping versus removing a study factor?

a. **Macroinvertebrates** - All waters of the State of Washington are protected for aquatic life. WAC 173-201A-200(1) states "Aquatic life uses. Aquatic life uses are designated based on the presence of, or the intent to provide protection for, the key uses identified in (a) of this subsection. It is required that all indigenous fish and nonfish aquatic species be protected in waters of the state in addition to the key species described below."
See: https://apps.leg.wa.gov/wac/default.aspx?cite=173-201A-200.

   Aquatic macroinvertebrates are the dominant (and sometimes only) animal aquatic life component in small headwater streams. Moreover, they are used to assess and monitor overall biological integrity by most state and federal water resource management agencies in the United States, including Washington. Eliminating the macroinvertebate component from the study would prevent our ability to directly infer whether aquatic life uses are being

protected by the riparian buffer treatments. Directly assessing aquatic life can thus help ensure that waters of the state are meeting their biological protection objectives.

b. **Sedimentation** - The second critical question in the study design specifically addresses harvest effects on suspended sediment export following harvest: "What is the magnitude of change in stream flow and suspended sediment export from the Type Np basin in the first two years after harvest?" Removing suspended sediment will therefore not allow this question to be addressed or potentially to be used to understand how sediment may be related to aquatic life responses.

   Removal of suspended sediment from the study will reduce the overall study cost. Currently suspended sediment analyses and associated University of Idaho overhead costs are budgeted at approximately $25k/year based on the volume of samples generated by the Hardrock study. To date, ENREP is generating a smaller volume of samples, so the budget savings would be proportionally less. Winter travel costs would also be reduced due to reduced power requirements needed to drive sampling pumps and associated maintenance activities to swap in fresh batteries during the winter.

   We could retain suspended sediment in the study, but reduce costs by reducing the intensity of sample collection (the number of samples collected per storm event). This could reduce laboratory analyses and winter travel costs. Turbidity measurements that are part of the original study design are recommended to be retained because they require minimal resources to maintain and are a water quality variable of interest.

c. **"Orphaned" Np Streams** - The final ENREP study plan merged previous study plans that were in development specifically for "wet" and "dry" eastside channels, and another one of the critical questions specifically addresses how harvest and riparian buffers affects different types of Type N channels and spatially intermittent stream reaches. The latter types of reaches are present in four of the basins. The Springdale site pair do not have a defined channel connection with downstream Type F waters, likely because of the road/highway crossing. Springdale is the lowest precipitation site pair and was specifically selected to address concerns voiced by the timber industry caucus, through the TFW Policy review process, about the effects of buffering spatially intermittent streams. Removing the Springdale basin pair from the study will reduce the ability of the study to address the critical questions related to spatially intermittent stream reaches, and hence will decrease the overall scope of inference of the study. The Springdale site is the only site below the median precipitation of the candidate area and falls within the 2nd lowest precipitation quartile, and is estimated to affect inference to approximately 15% to 25% of the target area based on connection to downstream waters and precipitation range.

   Removal of the one "orphaned" Np pair (Springdale) will reduce personnel, travel, and analytical costs associated with data collection and management. Monitoring of the two watersheds has been ongoing for approximately one year, hence the investments associated with the infrastructure (flumes, SedEvent systems, longitudinal meter markers, access trail construction), automated data collection (water level, turbidity, distributed water temperature, and hydrometeorological variables), manual surveys and laboratory analyses

(wetted channel extent, stream shade, aquatic life, habitat, large wood, riparian forest mensuration, stream cross-sections), and landowner outreach will effectively be negated.

Question #4: Are there ways to answer the questions with a less frequent sampling regime?

Most variables (e.g. wetted channel extent, large wood, channel cross sections, stream shade) are collected one or two times per year and are important to assess interannual variations and the frequency should not be reduced in order to address the critical questions.

We employ Turbidity Threshold Sampling to collect water samples for the analysis of suspended sediment during discharge events across a range of turbidity values. We then construct and empirical model, i.e., SSC= f(turbidity), to estimate suspended sediment concentration for the entire pre and post-harvest periods. Currently, a single discharge event may trigger the collection of up to 24 samples for SSC analysis. Reducing the winter time sampling events would reduce the cost for the laboratory analyses (fewer analyses) and could reduce the need for winter time site maintenance. This would reduce the confidence in the suspended sediment transport estimates for the un-sampled discharge events, but still allow us to estimate annual suspended sediment transport.

Aquatic macroinvertebrates are the only measure of aquatic life being used in the study. Reducing the frequency of macroinvertebrate sampling would likely result in biased estimates of aquatic life conditions because we would inadequately estimate overall aquatic life diversity and composition. We are currently sampling three times a year (spring, summer, and fall). Macroinvertebrate species in streams have temporally staggered life histories, which means multi-season samples are needed to comprehensively describe the identity and diversity of species present. One-season sampling is often used by state water-quality agencies to place assessed waters into coarse condition categories, but such sampling cannot describe aquatic life conditions with the resolution needed in this project.

We are also conducting two types of sampling: traditional benthic netting and eDNA samples. We are doing both because of the unique features of small headwater streams. These streams have limited channel bottom that can be sampled, and too intensive of sampling over space and time could alter both macroinvertebrate abundance and composition and thus confound assessment of treatment effects. These streams are also physically difficult to sample without severely damaging habitats. We are therefore sampling only a small percent of each stream each season, which allows sampled patches of the channel to recover before we sample again. As mentioned above, the seasonal samples will provide a much more robust estimate of aquatic life than will be possible from the smaller number of samples collected in any given season. These samples are also habitat-specific, which will allow us to assess if the macroinvertebrates inhabiting some types of habitats are more or less sensitive to treatment than those inhabiting other types of habitats. We are also collecting eDNA via filtered water samples. This method will allow for a more comprehensive assessment of the diversity and composition of species inhabiting these streams than traditional benthic sampling will because the water samples will contain DNA shed from all species within the basin. However, we will not be able to infer habitat-specific responses from the eDNA samples because the eDNA we collect could originate far upstream. We will analyze both types of samples in parallel to inform us if aquatic life is

affected by the riparian buffer treatment. The traditional (net) samples will allow us to make habitat-specific inferences about potential shifts in core (common) species, whereas the eDNA samples will allow us to make stronger inferences about overall biodiversity at the basin scale.

Table 1. Basin characteristics for all six sites.

	East Cascades						Northeast Washington					
	Sedge Ridge		Rattlesnake Ridge		Coxit Mountain		Springdale		Blue Grouse		Tripps Knob	
	West	East	West	East	North	South	North	South	North	South	West	East
Basin Area (acres)	87	173	88	93	230	139	223	169	65	103	126	97
Elevation Range (min-max, ft)	3906-5108	3283-4623	4751-5500	4750-5379	4704-6235	4726-6286	1884-2922	1880-2688	2857-4069	2832-4088	3032-3970	2866-3967
Approx. Channel Length (ft)	920	940	2000	1800	1400	1300	3100	2500	2400	2100	6100	4200
Precipitation (mm)*	886	855	932	932	602	621	484	485	685	685	1022	1028
Temperature Min (deg. C)*	0.8	1.2	0.1	0.1	-1.8	-2.0	1.9	2	1.1	1.1	2.1	2.2
Temperature Max (deg. C)*	10.6	11.0	8.7	8.7	8.2	7.8	14	14.3	12.1	12.1	11.9	11.8
Geology	Tertiary volcanics		Tertiary volcanics		Tertiary fragmental volcanic rocks		Tertiary intrusive		Precambrian metamorphic		Mesozoic orthogneiss	
Forest Type	Mixed conifer (grand fir, Douglas fir, ponderosa pine)		Mixed conifer (mountain hemlock, lodgepole pine, Engelmann spruce)		Mixed conifer (Douglas fir, subalpine fir, Engelmann spruce)		ponderosa pine		Mixed conifer		Douglas fir & western red cedar	

*30 yr annual PRISM climate normals (1981-2010)

Table 2. Distribution of target population land area and paired sites by the Hydrologic Landscape Characterization for the Pacific Northwest (Liebowitz et al., 2016)

Class	Categories	Proportion of Population Area	Northeast Washington	East Cascades
Climate	Very wet	3%		
	Wet	21%	Tripps	Coxit, Sedge, Rattlesnake
	Moist	32%	Bluegrouse	
	Dry	36%	Springdale	
	Semiarid	8%		
	Arid	-		
Seasonality	Fall or winter	62%	Springdale	
	Spring	38%	Bluegrouse, Tripps	Coxit, Sedge, Rattlesnake
Aquifer Permeability	High	40%		Sedge, Rattlesnake
	Low	60%	Springdale, Bluegrouse, Tripps	Coxit
Terrain	Mountain	79%	Bluegrouse, Tripps	Coxit, Sedge, Rattlesnake
	Transitional	21%	Springdale	
	Flat	-		
Soil Permeability	High	100%	Springdale, Bluegrouse, Tripps	Coxit, Sedge, Rattlesnake
	Low	-		

Note: The climate class for each site was determined by a modified version of the Feddema Moisture Index based on a combination of PRISM-estimated precipitation and potential evapotranspiration (PET) based on latitude and mean monthly solar declination.

Budget Details

ENREP BUDGET DETAILS - SEPTEMBER 2019

	FY 20 July 1, 2019- June 30,2020	FY 21 July 1, 2020- June 30,2021	FY 22 July 1, 2021- June 30,2022	FY 23 July 1, 2022- June 30,2023	FY 24 July 1, 2023- June 30,2024	FY 25 July 1, 2024- June 30,2025	FY 26 July 1, 2025- June 30,2026	**Total**
TWF APPROVED MASTER PROJECT SCHEDULE (7.11.2019)								
1. MPS Approved Project Total (6-Basin Pairs)	$907,968	$723,434	$686,719	$626,609	$366,695	$152,267	--	**$3,463,692**
ESTIMATED PROJECT TOTALS - SEPTEMBER 2019								
2. September 2019 Project Team Estimated Total (5-Basin Pairs)	$748,921	$637,546	$683,263	$699,442	$642,664	$517,640	$366,588	**$4,296,064**
UTAH STATE UNIVERSITY: AQUATIC LIFE								
3. Per Basin Pair Cost Estimate	$92,418	$95,170	$107,607	$110,655	$113,876	$101,979	$105,378	**$727,083**
4. Potential Cost Savings Estimate: Removal of Aquatic Life Component in E-Cascade Sites (2-Basin Pairs)	($184,837)	($190,339)	($215,215)	($221,310)	($227,752)	($203,957)	($210,757)	**($1,454,167)**
UNIVERSITY OF IDAHO: SEDIMENT								
5. Per Basin Pair Cost Estimate	$3,931	$4,088	$4,211	$4,337	$4,468	$4,602	$2,370	**$28,007**
6. Potential Cost Savings Estimate: Removal of Sediment Component in E-Cascade Sites (2-Basin Pairs)	($7,862)	($8,177)	($8,422)	($8,675)	($8,935)	($9,203)	($4,740)	**($56,014)**