River Restoration to Achieve a Stage 0 Condition

Summary of Workshop Held November 5-6, 2020

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Steve Wondzell, USDA Forest Service Pacific Northwest Research Station

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Oregon Watershed Enhancement Board

Institute for Natural Resources at Oregon State University

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Executive Summary

Restoration to achieve Stage 0 is a valley-scale, process-based (hydrologic, geologic and biological) approach that aims to reestablish stream depositional environments to maximize longitudinal, lateral, and vertical connectivity at base flows and facilitate development of dynamic, self-formed and self-sustaining wetland-stream complexes. The term *Stage 0* originally described complex multi-channel conditions and wider floodplains that evidence suggests were common when Euro-Americans arrived. Stage 0 is one stage in a 9-stage stream channel evolution model. Stage 0 is now also more broadly used to describe stream restoration projects aimed at changing the current condition and future evolution of incised, single-channel streams to achieve those multi-channel and wider floodplain conditions.

The Stage 0 approach has generated excitement among restoration practitioners and researchers. It is seen as an action on a scale commensurate with past impacts; potentially capable of putting streams and their floodplains on a trajectory to recovery that is sustainable with minimal future intervention. Projects that reset the valley surface elevation may include the transfer of large amounts of sediment into incised channels from adjacent terraces using heavy machinery, and placement of logs and boulders to create structure across the resulting floodplain. Recreating expanded, complex and resilient stream and floodplain habitats over the longer term may involve considerable short-term disturbance of existing stream environments. Because some of these streams currently support sensitive populations of focal or endangered species (most notably salmonids) projects designed to achieve a Stage 0 condition have raised some questions and concerns among land managers and regulators charged with recovering those species. The approach is relatively new, so there are also questions regarding terminology, implementation and monitoring approaches, and appropriate sites and scale for these projects.

In this science and policy context, a ***Stage 0 Stream Restoration Workshop*** was held on November 5-6, 2020 with the goal to *bring together practitioners, researchers, regulators and other stakeholders to discuss current topics and data gaps related to implementing and monitoring restoration projects intended to achieve a Stage 0 condition.* The online workshop included expert presentations, questions and discussions during plenary sessions, and smaller breakout groups. This document summarizes the workshop proceedings.

Core themes

Core themes that emerged over the course of the workshop include:

Stage 0 refers to a stream condition, not a restoration approach. More precise terms for projects to achieve Stage 0 include: *floodplain reconnection; valley reset; channel-floodplain-wetland corridor restoration/recreation.* A spectrum of methods exist to achieve Stage 0, from low-tech process based restoration techniques that use beaver dam analog (BDA) and post-assisted log structures (PALS), to large-scale valley reset approaches using heavy equipment to fill incised channels and grade the entire floodplain. Clarification of this spectrum – i.e. a framework for selecting and optimizing locations, appropriate scales and restoration methods for projects – is a key information need for both regulators and practitioners. Not all human-modified stream channels are suitable for restoration to Stage 0.

Initial results are promising, but projects restoring to Stage 0 require updated monitoring methods and long-term results to fully assess outcomes associated with these actions. Grid-based sampling could help map variation in water temperature across projects more effectively than linear samples above and below them. Remote sensing can be cost-effective for tracking geomorphological trends and other parameters. To aid with project scenarios and planning, the US Forest Service are assessing options for consistent monitoring data to parameterize a Stage 0 conceptual model. Key issues are salmonid habitat availability after project completion, how these more complex habitats evolve over time, and how fish utilize them. But there are limits to the ecological changes "fish-focused" monitoring can detect. A *synoptic* ("seeing everything together") approach to monitoring is most appropriate for the complex channel-floodplain-wetland systems these projects are intended to achieve.

Holistic, long-term monitoring requires sustained commitment and support. A robust and diverse restoration "community of practice" is emerging to implement and monitor projects to achieve Stage 0 in suitable PNW streams. Agencies, watershed councils and academia are coordinating to leverage available resources and efficiently acquire the additional monitoring data needed to inform adaptive management on these projects. Outreach is needed to demonstrate the need and generate public support for sustained monitoring efforts. But tradeoffs are inevitable when limited funds must be apportioned among new projects to address pressing, immediate environmental problems and sustained, long-term monitoring of projects already implemented.

There are numerous opportunities to "turn monitoring into science" through additional collaborative studies. Beyond the primary monitoring focus on salmonids, their habitats and channel geomorphology, there are also rich, untapped opportunities to investigate effects of projects on terrestrial species, e.g. anecdotal evidence of indirect "trophic cascade" benefits such as increased prey for apex predators. Also, of great interest are prospects for examining projects as whole systems by quantifying ecosystem services such as water quality and carbon storage, and to study how projects influence (and potentially mitigate) wildfire behavior and severity.

Discussions about uncertainties associated with restoration to Stage 0 should be reoriented. A single-thread, incised channel is more stable and predictable (less uncertain) but also less resilient and biologically productive than a multi-threaded channel that can access its floodplain. Future trajectories and arrangements of habitats in multi-threaded streams are less certain, but these systems are more resilient, diverse and biologically productive. Single incised channels provide fewer options for species of concern and thus more risk. We should focus on our (science-based) *confidence* in restoration to a Stage 0 condition to increase options for these species while acknowledging the risks and trying to minimize them.

Floodplain reconnection and restoration to Stage 0 may represent another "paradigm shift" in the evolution of stream restoration techniques, analogous to similar shifts away from the use of rip-rap and toward placements of large wood in a single channel. These changes were initially resisted but with experience, refinement, social learning and time became accepted as standard practice. There may also be analogies to dam removal where practitioners are increasingly adopting the view that incremental approaches focused on limiting short-term disturbances may risk delaying or preventing meaningful ecosystem uplift in the longer-term.

There is broad interest in an "information clearinghouse" to foster information sharing across agencies, practitioners and stakeholders regarding projects to achieve Stage 0 and supporting science.

The objective would be to facilitate the emerging Stage 0 *community of practice*, “a group of people who share a concern or a passion for something they do, and learn how to do it better as they interact regularly”. (There were suggestions that a name for the clearinghouse other than “Stage 0” could better clarify its purpose and scope, e.g. *channel-floodplain restoration*.)

The clearinghouse could include:

- A blog or chat group; perhaps moderated and with news updates, e.g. planning for future workshops, field trips, project updates, new publications etc.
- Summaries of existing projects, and summaries of projects in the planning pipeline
- Technical guidance
- Library of relevant peer-reviewed literature and “white” papers on related topics, e.g. design methods, construction practices, monitoring BMPs, contrasts/linkages between different approaches to achieving a Stage 0 condition
- Comparison of projects and reference sites in different areas
- Links to monitoring data as it becomes available

The “story” of Stage 0 in Oregon is still being written. Adoption of restoration to achieve a Stage 0 condition has considerable momentum among practitioners and scientists in Oregon, but their learning curve is still fairly steep. Restored areas are still evolving (as expected) and the ramifications for sediment transport and storage, wood movement, water quality, salmonid habitat availability, and fish passage and productivity are still being actively assessed. Effects on other species, resilience to wildfire, and carbon sequestration are mostly unknown but appear positive and potentially significant, and are beginning to be studied. For projects lower in watersheds, there are also questions regarding the potential for impacts on landowners and infrastructure. The effects of larger, less frequent high flows on project areas mostly remain to be seen.

Despite these knowledge gaps, scientists and practitioners at the workshop presented evidence that restoration toward a Stage 0 condition is conceptually sound, initial project results are generally positive, and coordination across the practitioner and science communities is strong. The risks of not taking significant action to restore human altered stream channels in Oregon are seen as quite serious. Some project proponents worry that current efforts may not be sufficient to forestall further declines in populations of salmonids. Expectations for the years ahead include a refined ability to identify appropriate sites for restoration toward Stage 0, and increasing clarity regarding how to tailor implementation methods to the range of opportunities and constraints at each site, in order to achieve maximum benefits and minimize risks.

Introduction and background for the workshop

For at least a century, humans have simplified Pacific Northwestern streams (e.g. removal of large wood and beavers), and disconnected rivers from their floodplains through channelization, road construction, dam installation and urban development. As a result, complex and multi-channel rivers and streams that seasonally interacted with their floodplains were converted into single-thread channels that commonly became incised. Since the 1990s, scientific understanding of how these changes impact stream ecosystems has continued to progress, concurrent with rising public concerns regarding such impacts and policy direction to aid endangered salmonid populations. The practice of stream restoration - mostly localized actions to stabilize streambanks, improve adjacent roads, maintain vegetated buffer strips, or place logs and boulders in stream channels to restore structural complexity – evolved in this context. Today, it is widely recognized that restoring physical and ecological functions of degraded waterways can help preserve endangered species and riparian ecosystems, and maintain ecosystem services including sediment storage and provision of clean drinking water.

Cycles of investment in stream restoration projects, research and monitoring to assess project effectiveness, and adaptive management to refine restoration methods have driven further evolution in the conceptual underpinnings for actions taken. One such shift is the emergence of a generalized approach to floodplain restoration often referred to as "Stage 0 [zero]" stream restoration. This term is commonly applied to actions designed to change the current condition and future recovery trajectory of incised, single-channel streams to more complex multi-channel (Stage 0) conditions that evidence suggests were common when Euro-Americans arrived. The term "Stage 0" was developed to describe a multi-channel stream condition. Stage 0 is one stage in a 9-stage stream channel evolution model. Stage 0 is now also often, though somewhat imprecisely, used to also describe projects aimed at achieving those conditions.

Moving streams to a Stage 0 condition is expected to increase their resilience and ability to sustain healthy salmonid populations and riparian ecosystems with minimal further human intervention. Because it is seen as action on a scale commensurate with past impacts and consistent with natural processes, restoration to Stage 0 appeals to many stream restoration practitioners. Projects may be intensive such as those that use methods to identify large amounts of sediment to be moved into incised channels from adjacent terraces using heavy machinery, and placement of logs across the resulting floodplain. In these projects, the goal of expanded, complex stream and floodplain habitat require short-term disturbance of existing stream and floodplain environments. Less intensive projects with the goal of restoration to Stage 0 conditions may be implemented using beaver dam analogs (BDAs) and post-assisted log structures (PALS). These low-tech, process-based restoration projects involve less extensive disturbance of the landscape and lower complexity and cost compared with more intensive applications using heavy equipment. However, the timeframe in which a Stage 0 condition is achieved is much longer.

Projects in Oregon designed to restore streams and their floodplains to a Stage 0 condition initially appear to be creating more dynamic, spatially complex and biologically productive river valleys. Practitioners and scientists are cautiously optimistic that these river systems will be more resilient and better able to support focal species such as salmon, trout, and lamprey. However, ecological and geophysical responses of floodplains to these projects unfold over time and have not yet been fully documented. Concerns exist that organisms may be negatively affected during and following project implementation, thus delaying or negating these predicted benefits. Shorter-term project outcomes appear promising but appropriate locations and impacts of projects to achieve Stage 0 conditions are still being debated, and questions remain surrounding their costs, unforeseen consequences and longer-term benefits.

As a major funder of stream restoration projects in the state, the Oregon Watershed Enhancement Board (OWEB) has a fundamental interest in helping to work through these issues and questions. The US Forest Service (USFS) also supports projects to restore streams to Stage 0 conditions. USFS researchers have been conducting a science review to clarify relevant concepts and synthesize existing knowledge to support a conceptual model and guide future restoration and monitoring efforts. Both agencies are committed to conducting projects to restore Stage 0 conditions in a science-based, adaptive management framework wherein projects and programs are informed by the integrated knowledge, experience and perspectives provided by applied scientists/practitioners, research scientists, and a broad range of social interests.

Since restoration to a Stage 0 condition is still relatively new, only recently have findings about project outcomes begun to be published, and robust monitoring and evaluation studies initiated. There is excitement about restoration projects to restore to a Stage 0 condition, but also discrepancies in understanding and viewpoints among restoration and fisheries science experts regarding methods and potential project effects. Some want to see projects designed to restore Stage 0 conditions ramped up, while others are more ambivalent and are urging caution until more data is available. The Stage 0 information "landscape" is evolving rapidly.

Workshop goal and objectives

In this context, OWEB staff decided to convene a ***Stage 0 Stream Restoration Workshop*** where practitioners, scientists and partners could share knowledge and perspectives in a social learning environment. OWEB enlisted the Institute for Natural Resources (INR) at Oregon State University (OSU) to assist with workshop planning and execution. The workshop was open to discussion of all types of restoration actions focused on restoring Stage 0 conditions, but was primarily focused on outcomes and monitoring of larger-scale projects that utilized heavy equipment to move large amounts of material into incised channels from adjacent terraces to reset the valley floor to increase floodplain connection.

The overall **goal of the workshop** was *to bring together practitioners, researchers, regulators and other stakeholders to discuss current topics and data gaps related to implementing and monitoring restoration projects intended to achieve a Stage 0 condition.*

Specific **objectives of the workshop** were to:

- Enable discussions that promote common understanding of the basic concepts and terminology related to implementing and monitoring restoration projects intended to achieve a Stage 0 condition and build upon the USFS science review.

- Share perspectives on the purpose, history, context, and evolution of restoration and monitoring methodologies, and lessons learned to achieve a Stage 0 condition in Oregon and Washington streams.

- Outline questions and concerns related to Stage 0 restoration projects by summarizing previously-identified uncertainties and soliciting information through pre-workshop surveys.

- Share monitoring results and describe approaches currently underway across Stage 0 restoration projects to understand the current state of knowledge around short-term outcomes emerging from these efforts.

- Identify other major questions and concerns or data gaps that remain and need to be addressed over time.

- Identify possible pathways for both addressing those questions and concerns or data gaps and sharing results and lessons learned as they emerge

Workshop planning, execution, and documentation

After preliminary discussions of workshop goals, OWEB recruited a workshop Steering Committee (SC) in the spring of 2020. See Appendix A for a list of SC members, OWEB staff, and INR support staff. The SC met monthly to discuss current science and issues related to projects in Oregon designed to achieve a Stage 0 condition, and to refine objectives for the workshop. These discussions were informed by the ongoing USFS Stage 0 science review and participation of a USFS researcher involved in that effort on the SC. The last two SC meetings focused primarily on the workshop agenda, presenters and format. In addition to the SC meetings, OWEB staff and a subset of the SC held a work session in early June to discuss details of how to present initial results from Stage 0 project monitoring.

With the onset of COVID-19 in spring of 2020, planning shifted to an online virtual workshop. The workshop date was moved from June 2020 to fall 2020, after the summer field season for stream restoration practitioners and researchers. The SC, OWEB and INR staff also developed a 10-question pre-workshop survey to solicit input from workshop invitees regarding their knowledge, questions and concerns regarding restoration to Stage 0 and project monitoring. By late summer 2020, the survey had garnered 64 responses, which were collated and used to further guide and refine the workshop agenda. The collated pre-workshop survey responses comprise Appendix B.

Workshop registrants are listed in Appendix C. The workshop was conducted online on November 5-6, 2021 utilizing INR staff and technical support from OSU Media Services. Plenary workshop presentations and question/answer sessions were video recorded and are available online. The links to these recordings are listed later in the report for each workshop session. Breakout sessions were held to allow participants to engage and discuss topics more in depth. These facilitated breakout sessions were not recorded, but notes were taken in each session. Notes for breakout sessions are compiled in Appendix D. Some key themes that emerged from Breakout Session II were compiled after the workshop and are included later in Session IV.

Plenary workshop sessions are also recapped in sections below. This recap includes short summaries of prepared presentations, and longer transcriptions of question and answer sessions. Readers of this document are also urged to view the video recordings via the links provided in each section, as there are the many graphics and photos in the Powerpoint presentations and explanations from the expert presenters that are not captured in the short presentation summaries below. Key points from plenary question and answer sessions and discussions are listed as bullet points.

After the workshop, OWEB solicited written responses to questions for which there was insufficient time to answer during the workshop sessions. Those questions and written responses are compiled in Appendix E.

OWEB also conducted a post-workshop survey of participants, soliciting their input to identify priority next steps and key contacts to further the communication network to share new information as it emerges. Responses to the post-workshop survey are compiled in Appendix F.

A short, annotated bibliography was compiled for the workshop from key literature related to Stage 0 suggested by SC members and cited in discussion during the workshop. The annotated bibliography appears in Appendix G.

Plenary Session I: Stage 0 Restoration Background and Overview

The following is a short summary of the presentations, and a transcription of the questions and answers that followed these presentations. For more detailed information, especially in the prepared Powerpoint presentations which contain images, graphics and expert interpretation, please watch the recording of this session. LINK to video of Session I: https://media.oregonstate.edu/media/1_1rg2om25

Presentation overview

Presentation 1: Stage 0: Description, Origin, Importance
Brian Cluer, National Oceanic and Atmospheric Administration (NOAA).

> Presenter Cluer describes how he and co-author Colin Thorne expanded upon established Channel Evolution Models to include a precursor, multi-threaded Stage 0, and the ecological benefits of stream channels in this condition, as described in their influential paper: A stream evolution model integrating habitat and ecosystem benefits.

Presentation 2: Stage 0 Overview and History: Practitioner Perspectives
Johan Hogervorst, U.S. Forest Service (USFS) Willamette National Forest.

> Presenter Hogervorst explains the history and effects of human disturbances in PNW stream valleys and how channel restoration concepts and approaches evolved through the 1980s-2000s. He then contrasts these approaches with the more recent recognition of, and efforts to emulate Stage 0 conditions.

Presentation 3: Ongoing Science Review and Monitoring of Stage 0 Restoration in Oregon
Becky Flitcroft, USFS Pacific Northwest (PNW) Research Station
Bill Brignon, USFS PNW Regional Office.

> Presenters Flitcroft and Brignon discuss recent USFS efforts to pull together science information regarding restoration to achieve a Stage 0 condition, along with relevant lines of research and monitoring approaches. They then describe progress the US Forest Service has made in data synthesis, and their collaborative approach to engage a wide range of practitioners and topic related experts to develop a conceptual model for programmatic, regional-scale monitoring of restoration projects to restore to a Stage 0 condition.

After Presentations 1, 2 and 3, workshop attendees were given the opportunity to pose questions to the various presenters.

Key points that emerged from this session

- The USFS presenters shared a definition they had refined through their collaborative process: "Stage 0 restoration" is a valley-scale, process-based (hydrologic, geologic and biological) approach that aims to reestablish depositional environments to maximize longitudinal, lateral, and vertical connectivity at base flows and facilitate development of dynamic, self-formed and self-sustaining wetland-stream complexes.

- The geologic record indicates a mosaic of valley zones with configurations that shifted over glacial, climatic or even tectonic timescales, with some areas in Stage 0 and others Stage 1 or even an incised stage, delivering sediment to deposition zones downstream.

- Disturbance and incision can occur on annual or decadal timescales, while recovery through the whole cycle of channel evolution to Stage 8 or backing up to Stage 0 involves processes over centuries or even millennia.

- Today, human impacts "drive" riparian ecosystems, having disturbed and put them in their current condition. Understanding variability in channel evolution stages over time helps guide restoration, but at what timescale should we manage for today?

- Restoration to Stage 0 can succeed in incised sedimentary and sand-driven systems, assuming that boundaries are erodible and the valley floodplain can be accessed, deposition takes over regardless of grain size and vegetation comes in with the water table to support it.

- USFS researchers aim to have a web-based Stage 0 conceptual model parameterized using consistent, relatively easy to gather monitoring data up and running by the end of 2021.

Q: In reference to Brian Cluer's slide on implementation approaches, what does the acronym "PALS" stand for?

Brian: PALS stands for "post-assisted log structure". So, it's related to beaver dam analogs (BDA) and other so-called low-tech techniques for adding small wood, roughness and deflection into stream channels.

Q: Regarding the timescale of Stage 0 processes, how do you reconcile the morphological evidence of Stage 0 in the geologic record - broad alluvial valleys with evidence of multiple channels- with the expectations of some implementing Stage 0 that Stage 0 systems should be actively rewetting and reshaping the entire valley bottom, or most of it, on a regular basis? Does geologic evidence really show full valley bottom occupation over short time scales, e.g. 1-3 years, especially in larger, wood dominated systems? Or is it more reasonable to expect Stage 0 systems to reshape their entire valley bottoms over longer time scales - decades and in some cases even centuries?

Brian: Great question. Cluer and Thorne (2014)* did not address timescales. Pollock and others' (2014)** had a simplified model focused on beaver and included a timescale which is quite useful, showing that incision is a really rapid process. Disturbance and incision can occur on annual or decadal timescales, while recovery through the whole cycle of evolution to Stage 8 or backing up to Stage 0 involves processes over centuries or even millennia.

Pollock and others (2014) also touched on the percentage of valley you might expect to be in Stage 0 at any given time or location. Geologic evidence shows that there is a shifting mosaic of areas in a valley that are in Stage 0 while other areas are in Stage 1 or even in some of the incised stages and delivering sediment to deposition zones downstream. [Patterns in this mosaic] are driven [and shift] on tectonic, glacial or even climatic timescales.

You posed a good question. Bouncing one back to you I'd ask us to think about: At what timescale do we want to manage our ecosystems [now]? Because frankly, we are driving these ecosystems now. We disturbed them; put them in the condition they're in now. We're now trying to figure out how to restore them and put them in a much more functional and productive condition. So, geologic timescale vs. the time scale we're managing for now, I think is really something different.

*Cluer, B. and Thorne, C. 2014. A stream evolution model integrating habitat and ecosystem benefits. *River Research and Applications*, 30(2), pp.135-154.

**Pollock, M. M., T. J. Beechie, J. M. Wheaton, C. E. Jordan, N. Bouwes, N. Weber and C. Volk. 2014. Using beaver dams to restore incised stream ecosystems. *BioScience* 64:279-290

Q: Can Stage 0 restoration be successful in sedimentary and sand-driven systems that are incised?

Brian: I'd say "yes". [Johan agrees.] If there are deposition processes, if the boundaries do relax, if the boundaries are erodible, the width constraint goes away, deposition takes over regardless of grain size. Then add vegetation to those physical processes, with the water table to support vegetation; then I think grain size doesn't matter at all. I don't think grain size is an issue.

Q: Could you [Bill Brignon] please describe the timeline to complete the next steps that you mentioned for the USFS model? [I.e. sensitivity analyses to ID parameters that are uncertain, work with practitioners to acquire monitoring data to address those uncertainties, then build a web-based app where practitioners can use the model]. How do you see the monitoring methods being developed over time to implement the monitoring plan?

Bill: Hopefully within the next year we can get the model up and running. My goal is to start coding it once we get a bit more feedback. We're going to define the [model] parameters, the states of those parameters, build up the code (however long that takes). Being a fish biologist and not a coder (I play coder on weekends) as soon as we can parameterize [the model] we'll get it up and running. Once we identify those parameters that need monitoring, the techniques we would actually use to monitor-we're kind of leaving that open-ended.

We know there's a lot of different ways to go about monitoring. We want practitioners to think about the best way to go about it. We want it to be simple. We don't want to cause a bunch of effort and cost a bunch of money to do a lot of high-tech monitoring for a programmatic type of approach. We know that a many important parameters are already being monitored intensively. How can we take that intensive information, pull out what we need and feed it into our monitoring plan? That's how we're looking at it right now.

Becky: The only thing that I'd add is that we're certainly very conscious of trying to make this something where the data will be usable, repeatable and consistent across different partners who would collect the data. We're also thinking through the issue of more specific guidelines and focus for monitoring approaches and how we would move on that. I agree with Bill that the timeline is sooner rather than later. We'll be focusing on this over the next year.

There were additional questions related to this session, but insufficient time for responses during the session. OWEB staff solicited written responses to these additional questions after the workshop was over. Those detailed responses, along with graphics and photos, are provided in Appendix E.

Plenary Session II: Uncertainties and Questions

The following is a summary of the presentations, panel discussion and questions and answers from the panel discussion. For more detailed information, especially in the prepared Powerpoint presentation, please watch the recording of this session. Link to video of Session II:
https://media.oregonstate.edu/media/1_n9qnuku8

Presentation and panel overview

Presentation 1: Questions & Uncertainties – Workshop Survey Summary
Jamie Anthony, Oregon Department of Fish and Wildlife (ODFW) Corvallis Research Station

Presenter Anthony provides an overview of findings from responses the pre-workshop survey of invitees that describes their top priority questions and concerns related to current approaches to restoration a stream channel to a stage 0 condition. Responses and findings from the survey are presented in more detail in Appendix B of this document.

Panel discussion: Uncertainties and Questions Regarding Restoration to Achieve a Stage 0 Condition
Moderator: Colin Thorne, University of Nottingham, UK.
Panelists: Jamie Anthony, ODFW; Bill Brignon, USFS; Janine Castro, US Fish and Wildlife Service; Johan Hogervorst, USFS; and Mathias Perle, Upper Deschutes Watershed Council (UDWC).

This was a panel discussion of priority uncertainties, questions, and information gaps regarding restoration to achieve a Stage 0 condition, and also opportunities to address those priorities. Moderator Thorne kicked off the session by asking panelists to summarize key questions and uncertainties as they saw them.

Key points that emerged from this session

- From the fisheries biology perspective, the key questions around restoration to achieve Stage 0 are: “Does it work, i.e. do we see more salmonids post-project, and if so what are the changes in habitat and water quality that can help explain this?”
- Questions regarding where restoration to achieve Stage 0 is most appropriate: What spatial criteria do we need to consider? Is there a minimum size area or valley width needed for the project to succeed? How much connectivity is needed between projects?
- The effects and potentially significant benefits to species other than fish, e.g. terrestrial species, and what happens to aquatic and terrestrial habitats and species during wildfires after restoration to achieve Stage 0 are poorly understood topics that are ripe for study.
- We need to start thinking about water quality and temperature monitoring in a spatial grid pattern, to identify cold and warm water sources across the project, expanding on traditional approaches using linear “above and below the project” monitoring.

- This is relevant because we're starting to see evidence that "food trumps temperature" for salmonids- exponentially greater food productivity in areas with higher temps may enable the fish to handle higher temps and metabolism because they have more food.
- There is also anecdotal evidence that areas restored to achieve Stage 0 are fine sediment sinks rather than sources; the question of whether these multi-channel systems are now depositional environments should be explored through monitoring.
- Stakeholders are hungry for data on salmonid habitat availability just after project completion, how these more complex habitats evolve over time, how salmonids utilize them, and in consistent, more holistic monitoring protocols to answer these questions.
- Uncertainty around projects to achieve Stage 0 stem from 1) incomplete knowledge about how stream channel ecosystems work, which we can address via research and; 2) inherent natural variability in these complex systems, which we can't do anything about.
- The restoration community should shift discussions about uncertainties around Stage 0 to what we are confident in, e.g. that incised single-channel systems are more predictable, but much less diverse, biologically rich and resilient than multi-channel systems.
- Uncertainty does not equal risk. We must avoid conflating the two terms and also note that higher uncertainty doesn't always entail higher risk. For example, a multi-threaded stream has more uncertainty, but less risk for salmonids because habitat is more diverse.
- One way to think about risk is "probability [of an unwanted event] times consequences [of that event]. Perceptions of risks (what they are and how serious) vary across different people in different roles, with different values.
- Risks associated with restoration to achieve Stage 0 can be addressed through monitoring, adaptive management, learning through doing, expanding options, keeping lines of communication open, and willingness to learn across partners and stakeholders.
- Whether a project to achieve Stage 0 could be too large and extensive, with potentially unacceptable impacts to fish populations is interesting academically but unlikely to be a practical concern because these large-scale projects are not implemented at once due to limitations in budgets, contractor availability and capacity, etc.
- These larger scale projects are implemented in phases over many years which allows adaptive management to be practiced to minimize impacts and maximize lessons learned to improve projects over time.
- The distinction between when a project to achieve Stage 0 stops evolving in response to the restoration actions and the point when natural processes "take over" is likely not a distinct temporal boundary and may be difficult to define, even with robust monitoring.
- The USFS conceptual model should prove useful in facilitating discussions around risk with stakeholders. Back and forth conversations about risk perceptions allow personal variations in them to be explored in a more open, nuanced way than written reports.

Bill: I'm a fish biologist so naturally I'm focused on fish, especially ESA-listed salmonid stocks- bull trout, steelhead, salmon. So, the biggest uncertainty for me is: Does [restoration to achieve a Stage 0 condition] work? With "work" defined, from a fish biologist perspective, as "are there more fish?" [Our primary goal.] If we see more fish, the next question is why? Is it related to redd abundance, spawning habitat, smolt survival, smolt condition, those types of components? In general, we know that more fish is an indicator of things like healthy habitat, good water quality, healthy aquatic macroinvertebrate communities, etc. So, in a nutshell my thought process is: Does it work? I.e., are we getting more fish? If so, what are the changes in habitat and water quality factors that can help explain this?

Janine: [As a USFWS employee] I often get questions focused on where to do [restoration projects to achieve a Stage 0 condition]. Are there spatial criteria we need to think about? Do we have enough space [in the location being considered]? Is there a minimum size for the project to be successful? How wide does the river valley need to be? Is there a minimum width, given flow volume we're expecting at the site? Tying it back into fisheries, we're also interested in how projects interact. If we have a large project, say 1000 acres, but then it's another 20 miles downstream to the next connected floodplain, do we need some smaller projects in between for connectivity? There are still uncertainties about that. At USFWS, we're responsible for all species. But we haven't thought explicitly much beyond fish, e.g. benefits to birds, terrestrial species. What happens during fires? Do [valley reset projects] provide refugia for a greater variety of species? We're starting to see some evidence of unforeseen, or at least not explicitly foreseen, benefits [to other species besides fish]. I think there are some real opportunities to look at these aspects of restoration to achieve a Stage 0 condition.

Johan: I'm a forest hydrologist, so my perspective is focused on water quality. Temperature is a common concern. Stage 0 projects offer the opportunity to think differently about temperature monitoring. Traditionally, we looked at this in a linear way. We'd set up two monitoring stations to assess: did temps change below the project, compared to above? For projects aimed at restoring to a Stage 0 condition, I believe we should think more on a grid, placing several monitoring points throughout the spatial extent of the project to identify locations of cold and warm water sources, and think more broadly. Where we have warm water, primary production will be much higher, with exponentially more food. We're starting to see literature out of California and elsewhere suggesting that "food trumps temperature", i.e. fish gravitate toward these food sources and can deal with the higher temps and higher metabolic rates because they have ample food. I think there's more complexity to the temperature question than can be addressed by linear [above/below] ways of thinking about it, and an opportunity to explore these issues via a grid pattern of monitoring.

Another issue is fine sediment, a perennial concern in single channel systems. In projects to achieve a Stage 0 condition, I'm seeing anecdotally and observationally that they are fine sediment sinks, rather than sediment sources. These multi-channel systems appear to be depositional environments where the water spreads and the sediment drops out. But I'd like to have more data to know if that is really what's happening.

Matthias: I look through lens of watershed council staff working on both public and private lands with diverse partners who wear multiple hats. We need to make sure we balance reintroduction and habitat development, while also making sure partners are on board with these newer approaches. Concerns with how we do the work, minimizing impacts and disturbance footprint while work is being done. Also, uncertainties with what [Stage 0 projects] accomplish and over what timeframes. There's potential for both negative (mostly short-term) and positive impacts over short and long-term.

We're seeing some good trends, but also questions about what habitat features are on the landscape just after we pull equipment out and how do these features evolve over subsequent high flow events and establishment of riparian and wetland vegetation as the water table is raised. We're hearing questions regarding sediment production, both onsite and downstream, and more recently about availability of spawning gravels, initially and over time.

Also, fish utilization questions- early data is positive, but it would be really valuable to have more data on how species utilize these more complex habitats. There's lots of interest and momentum among our partners in addressing these questions, getting partners on board with buy-in on how we gather data, helping gather data; and also in more holistic monitoring protocols to help us answer these questions.

Colin: These are legitimate and entirely understandable concerns that arise when a new [restoration] approach is set alongside existing approaches. I'm reminded of a question I got awhile back that really troubled me: "Is Stage 0 a fad?" I think what we're hearing today demonstrates that it is definitely not a fad. People appear to be taking a very close and deliberate look at Stage 0 before implementing it.

I want to deconstruct what we mean by uncertainty; what's it all about, and roll that into a question for the panel. Uncertainty is usually interpreted as a negative, but we shouldn't be scared of it. The flipside of uncertainty is confidence. Instead of worrying about uncertainty, we should be focused on building confidence in our restoration methods. Uncertainty comes from two sources: One is lack of knowledge. Our models are imperfect and our knowledge of the river systems we work in is imperfect. These are human issues. Another source of uncertainty is that these systems are complicated and have natural variability that causes uncertainty. These aspects are external to humans. We can reduce uncertainty related to imperfect knowledge, monitor and gather data, improve our science, learn by doing. But a lot of uncertainty comes from natural variability, which we can't control. It's an inherent property of the river. If we have a fully functional, multi-channel floodplain complex, we have piles of natural variability [and uncertainty] and that's what makes these systems resilient; gives them their buffering capacity.

Simplified systems reduce uncertainty by reducing natural variability, but also reduce ecosystem benefits and biodiversity. So this is a conundrum- we can reduce uncertainty by simplifying the system, going to a single channel system, but then we've sort of "lost the plot". Not all uncertainties involve higher risk. For example, consider a system with five anabranches that move around a lot. There's lots of uncertainty associated with this system, but odds of all channels being impassible for fish at the same time are far lower than for a single channel.

So [the take home point here is that] uncertainty does not equal risk. We should think about managing risk rather than uncertainty. So (posing question to panel) ***are we concerned about uncertainty when really we should be concerned about risk?***

Jamie: I agree that it's important not to conflate uncertainty with risk. I think the big challenges are beyond the science; in [the realm of] interpreting uncertainty and risk for the public. I've struggled with this. I've stumbled often in my career when trying to communicate uncertainty to the public and having it be interpreted as risk. So yes, I've "been there"!

Bill: That's a tough one! Uncertainty is inherent in natural ecosystems. Risk is a function of humans and their beliefs and how they behave and respond. Perception of risk varies across people. The best way forward is being willing to learn, don't be afraid to be wrong.

Janine: Risk is "probability times consequence". People have different tolerances of risk. Also different perspectives on likelihoods/probabilities, and different perspectives on how serious a particular consequence is. A private landowner my feel a particular outcome is unacceptable, whereas an agency person focused on fish may feel differently. Levels of perceived risk are going to be different across different partners and end users. The best you can do is keep lines of communication open, try to understand different perceptions, and be as transparent as possible.

Johan: When talking about risk, I jump to and think about what is the risk to our [focal, fish] species. The more options they have, the less risk that [populations] are going to "wink out". So I focus on giving them as many options as possible. That will help them to the greatest degree.

Matthias: I try to frame uncertainties and risks in terms of outcomes that our project partners are looking for. For a lot of different metrics, instead of trying to give a very precise estimate of the expected outcome, we talk about complexities in terms of ranges. For example, instead of saying we'll have "X" number of pools, we try to provide a range in number of pools. For key types of risk, for example problems with temperature or fish passage, we think in terms of triggers that would tell an agency something needs to be done, and address these through monitoring. So far, we haven't seen any rise to the level to trigger intervention, but it's still early.

Colin: The remedy to higher risk levels is monitoring and adaptive management. We need to have the capacity for adaptation, either hardwired into system or ability to step in and actively manage.

Chat-based questions

Q: "Is what we view as natural variability in aquatic systems really natural? How do we incorporate the rates of change to the water cycle and climate into project development?"

Colin: River restoration takes place in an "anthrome" [a biome] modified to a greater or lesser degree by humans. If you are working in a constructed urban environment, restoration is going to look very different than in a wildland, where you can "rewild" the system, where you can let the river be the architect of its own edifice. [That's the ideal] it's going to do a better job than we can. But very often, you cannot do this, don't have that option and we're not rewilding the stream. They are "used" spaces and therefore the river has to "work for living" as well as be an entity unto itself. That has to be taken into account, and I think that's OK.

Q: Janine mentioned the potential for a project to be too small; I wondered about the opposite, what scale of project is too large? Especially regarding sediment dynamics. I've observed upper reaches of Stage 0 projects being more dynamic than downstream reaches as depositional processes, especially with larger substrates dropping out in the upper reaches that haven't noticeably shifted downstream in over 4 years. Is it possible that some projects are biting off more than the system can chew? [Acknowledges that] it's possible that the answer to this question comes down to temporal uncertainty. How long will projects continue to develop?

Janine: I've also wondered about this. Fifteen years ago, running scenarios for programmatic biological opinions, we wondered what would happen if we put all available financial resources for river restoration in the PNW for a year into one watershed? Would that be too big of an impact from a construction standpoint? If we had many big projects in a single river, was there the potential to actually wipe out a population of fish by doing too much restoration work in one place?

This is definitely an extreme scenario. We've never gotten close to that because we work within certain constraints. We don't have that much money and there's only so much we can do during our "in water" work windows. There are also limits to equipment and contractor availability, so we usually see projects that are .5 to 1 mile of valley length, per year. This seems to generally be an upper limit, maybe exceeded a bit in some cases, but it's hard to imagine doing 10 miles in a year.

In regards to how long projects continue to develop, that's tough to answer definitively [not a distinct temporal boundary]. At what point is it still part of the project and at what point is it the system and natural processes taking over? There isn't some definite handoff, e.g. at 3 years you're [contractor, agency] off the hook because the vegetation has come back. It's a great question but I don't have a definite answer. [Along these lines] I'd like to share that many of these projects go through these programmatic biological opinions. One thing we built in is a 1-year monitoring window. Not from when you break ground. Many projects are multi-year, and phased. Some take as long 10 years. So it is from when the project wraps up. In terms of are people biting off more than they can chew, it isn't so much size of project as capacity of contractors, experience of personnel, other constraints. We've had situations where we planned to do a lot of work but had to scale it back or split into a couple of phases.

Q: Are there tools or techniques to communicate risk during planning and decision making? Could the USFS conceptual model help with that?

Bill: Communications and risk: Risk is a personal, human thing. How risk averse are you to something? We can run the model, vary parameters, look at the sensitivity analyses, use it to communicate what we think might happen, the uncertainty around e.g. sediment. [We can say] it may do this or it may do that, this is the range of predicted sediment response. [In short] we can use the model to demonstrate what we think may happen given our best available science. Then it's up to individuals to say whether or not it's too risky for them personally. But the model is good for promoting that communication. It helps us minimize uncertainty, understand it, embrace it, then [illuminate] how risk aversion varies among different people and try to come together on a plan of action.

Jamie: What I've seen during processes like development of the [Stage 0] conceptual model is that having a forum to facilitate discussions and open dialog enables us to explore perceptions of risk in a more [open, detailed and nuanced way] than just a written document where we don't have that "back and forth" capacity.

Colin: Uncertainty is fine to talk about and embrace among scientists, engineers and fellow practitioners. But when communicating with the public, I would just talk about confidence. If we talk about error bands or percentages of uncertainty, they're not going to hear us. If we say we're 90% confident that such and such is going to happen, that's a different message altogether. We'll get a much better reaction if we talk about our confidence level. I think folding uncertainty in, embracing it, but then speaking in terms of confidence could be the answer to the uncertainty issue.

Breakout 1: Challenges and Opportunities Related to Session II Uncertainties & Questions

The breakout group sessions were not videotaped or recorded. Note takers in each group captured key discussion points. These notes are compiled and listed below, as well as in Appendix D. The group note takers reported back to the full group in a 25-minute session that was videotaped. Link to video of the plenary recap of Day 1 Session II Breakout Groups: https://media.oregonstate.edu/media/t/1_iniz10se

Break out group participants were asked to discuss the following questions:

1. Based on what you heard and learned during the two sessions this morning, what do you think the most important uncertainty is to be addressed?
2. What opportunities exist to address it?
3. What challenges should we be mindful of when addressing this?

Combined responses from all breakout groups

Based on what you heard and learned during the two sessions this morning, what do you think is the most important uncertainty is to be addressed?

- The ability to communicate uncertainty regarding Stage 0 restoration to the general public.
- Uncertainty regarding where on the landscape it is appropriate, and where it is not. What is the natural analog? What does a "reference channel" look like? Are we really mimicking what is "natural"?
- Making people aware of just how pervasive anthropogenic changes to river channels are, and what pre-European contact channels actually looked like.
- I've been watching from the sidelines, perspective is from a regulatory standpoint. We need to make sure we are investing in monitoring. Are we really seeing the results we expected? We need to be able to show how Stage 0 projects can be effective.
- How does large wildfire affect our [Stage 0] treatments?
- Thinking about what Stage 0 looks like from a Tribal perspective…we are "resetting" the system. I think the greatest uncertainties are how treatments in the upper watershed (where there is less risk) might affect downstream reaches, and the potential for long-term impacts from larger projects.
- I think the greatest uncertainties lie less with where we undertake projects than with how we get the most "bang for the buck". Also, the degree to which these projects actually mimic historical conditions. Where do we have appropriate wood, sediment, flows to accomplish our goals? Are these conditions sustainable over time?

- We don't see smaller, process-based BDAs and PALS under the Stage 0 "umbrella". Where do these projects fit in?
- Timeframes - expectations for how much happens when we're still actively managing the project. For example, observations that the system is more dynamic in upstream project areas vs downstream areas (probably how this developed in nature) – learning more about that and being able to communicate the expectations.
- Timeframe of evolution of projects impacts like upstream irrigation withdrawals that affect current hydrology (no flushing flows in spring and early summer).
- Risk associated with our uncertainties being centered on an understanding of impaired systems (constrained channels). Stage 0 and Stage 8 valley bottoms are so different from current conditions. In current constrained channels, deep pools may be the only lower power areas for fish to hold out, but that is not necessarily true in a fully intact valley bottom where features other than deep pools can fill that low power habitat role. Similarly, we think of fine sediment deposition as a problem in constrained channels, but in a dynamic system there will be considerable sorting and a patchwork of habitats.
- What is at stake if we don't restore in this way – fish populations aren't responding to status quo, and the longer we wait there is a big risk. How do we communicate that risk (of not doing this work) and the uncertainty of the future (given current trajectories); that we have to try different things since we are running out of time and resources to recover these species. We know the answer if we do nothing. These species will be gone.
- Expectations of results quickly while we're still grappling with how to monitor these projects and define the results.
- How do we address other species (non-fish; wildlife)? How do we ask the right questions, etc. when reviewing or developing projects?
- How do we implement these projects on smaller parcels of land where appropriate, but where land uses or management in other nearby areas have significantly changed processes like hydrology (e.g., checkerboard land ownership/management)? How do we think about this in terms of the greater watershed?
- How can we better help practitioners scale these kinds of projects to areas of opportunities for restoration?
- Dynamic systems need movement of sediments (bedload and suspended) and large woody material. Do we know our budget of these materials from pre-project analysis; are those factored into the design and what is our budget of those materials over time?
- Does most of our mobilized sediment park at the upstream end of the project? Does the size of a project affect this? What monitoring do we need to answer this?
- Project scales are difficult to get our minds around and understand. How much connected floodplain is good enough?

- Mussels-has anyone looked at them and their needs for recovery in these environments?
- Coming in not having implemented but helping implement other restoration projects what hit home was understanding within your own organization or with others that clear communication coming to the table and understanding what partners' comfort level is and where they're uncomfortable so that a clearer presentation can be made [about what the project will entail, what habitat it will provide, on what timeline].
- Having taught from the beaver and LTPBR side, the biggest question is about fish and there's a lot of complicated work to be done there and it's hard to answer those questions.
- Uncertainty is most uncertain from a regulator's perspective. Getting regulators involved so we can start thinking less black and white more outside the box so we can permit more easily.
- Most curious about do [these projects) work and their longevity – what happens when a 100-yr flood impacts these projects? What happens to the wood, does it all get pushed to the side? Is there enough local recruitment of wood? What are the long-term outcomes?
- Have implemented Cole and Staley – how much do you implement without the monitoring results and how much do you implement within close proximity, how much time do you give between projects in close proximity?
- Fish bio standpoint: Will these projects provide long-term habitat? What does that habitat look like over time for juveniles, adults, spawning? How do you progress with Stage 0 approach- long term promise but short-term shock [of disturbance] is hard to deal with?
- Physical characteristics – hydrology with flow availability temperature, water depth
- Evaluation of appropriate sites - in particular with everyone being on the same page to evaluate outcomes
- Finances – how to fund these projects, and the long-term monitoring
- Evaluation – from a permitting perspective how to rate and compare stage 0 to other better understood types of projects
- Communication – need to be able to share the timeline with stakeholders, don't want to damage those relationships.
- Skeptics and uncertainty regarding response time from end of project to achieving goals – temperature and deep water are concerns
- Hydrologic uncertainties, how do dams affect SF McKenzie
- Don't agree on starting point to be able to identify the risks that we should be concerned about. Concern about loss of passage in a place where there already has loss of passage.
- What is the uncertainty about the transition between the stage 0 site and downstream unmodified channel?

- Uncertainty of landowner perspective about the look of a project when it's finished. Concern about long term relationship in restoration effort.
- How do you rate if there is enough benefit from stage 0 to justify the expenses of the project? State 0 functions a bit differently than other places.
- Big projects that are hard to fund.
- Public/partner communication/understanding
- ID and define success – consistent metrics/ range of parameters for focal species especially considering climate change
- Monitoring – macro/micro level, communicating results to partners/public
- Project management – when to intervene to address issues AND models/structures to continually learn about success or failure of individual project and allow for critical adaptive management
- Public buy in, keep rec going through a project. Boarder public stakeholder perspective.
- Are the desired results going to be meet with this project approach? More of a project by project approach and/or concept. Are going to meet goals?
- Parameter of capacity for species – i.e. temp ranges/sediment – range of parameters that focal species can tolerate. Natural geomorphic processes doing a better job of managing habitats – but is this going to be able to meet the challenges of climate change? Bio perspective
- Consistent metrics for measuring change to get at success of projects, more quantitative vs. qualitative.
- Example of post-pone on Whychus. Uncertainty of reaction of partners. Initial disturbance levels and reaction to that and short-term impacts. Setting expectations of partners and public. Developing monitoring goes hand in hand with this process of setting/understanding partner expectations. Monitoring data has a definitive help with this process.
- Success. Doing some good things on large scale monitoring level. But what about at project level to help PM's answer question am I doing this right. Also water is king. What are impacts to temperature and how do we share this information to stakeholders
- When to intervene with implemented project – i.e. fix elements- micromanagement vs. definite need.
- Old – is it working are we getting more fish? New; public uncertainty – structural uncertainty – how do we define success? Build models to develop structures to learn about success or failures – how we got there.
- Concerns as to how this type of restoration approach will work in working landscapes such as the forest industry (could lead to reduced harvest), agriculture areas (reduced surface area for yield) and in tidal areas.

- Potential landowner concerns linked to rivers/creeks that once released from their constraints could “take over” the entire valley floor. Would not be a good outcome for working lands and depending on communication with private landowners could lead to loss of trust.
- What are the long-term effects/benefits and how long will they last? How do we address these uncertainties so landowners can plan for long-term management?
- Provocative paradigm shift. Restoration through disturbance. How long will the disturbance last and what is the recovery trajectory? What if the site does not recover and gets stuck in the disturbance footprint? Once evolved to Stage 0 condition, does it stay there or can it move to other stages of evolution?

What opportunities exist to address the most important uncertainty (that you listed above)?

- Practitioners could be more open to dialog, and less defensive about the projects. We need to provide more opportunities for people to ask questions.
- We need to identify what a “natural” Stage 0 project looks like. We need to identify information sources for this.
- We could pursue a programmatic, streamlined process for getting Stage 0 projects approved, although it may be premature for this.
- Given the intense interest surrounding Stage 0 projects, I think there are opportunities for additional monitoring, which is always a challenge to get funded.
- Better communicating the risk associated with the current trajectories of the populations.
- Communicating across multiple audiences - practitioners through policy.
- To be able to implement these projects where opportunities exist (lower infrastructure); opportunities to learn more/communicate – decision support model, workshops like these.
- Understanding what the opportunities are on smaller areas
- Data from existing projects needs to be better shared to gain confidence in this restoration.
- One of the opportunities is that we have readily available drone-based imagery that we can collect relatively inexpensively – lots of monitoring issues, in these wetlands and flooded valley floors monitoring protocol is difficult – we see that individual projects have done their own kinds of things for monitoring and it’s difficult to compare [among projects], but drone-based sensing can help us solve the extensive nature of these systems.
- Remote sensing is one way to get at the question of uncertainty; there is also the question of Stage 0 as a reference condition v. stage 0 as a restoration approach. We have the ability to look at those places where Stage 0 exists [as a reference condition] and study those conditions and what’s happening with fish populations there. We don’t know how to inventory them.

- Are places where stage 0 exists mapped anywhere? [Opportunity to map reference Stage 0 systems and use to guide monitoring and provide information about fish populations and habitat use]
- Opportunities – continue ongoing monitoring and research
- Communication – more workshops to facilitate discussion and understanding of successes and failures. Monitoring critical for evaluation of projects and tracking outcomes.
- Biological opinion – can borrow from other applications such as using biological opinions/adaptive management templates to create common frameworks on goals/outcomes/ranges of benchmarks.
- Work with all landowners to make work as complete as possible.
- Solution is communication with one another, developing ideas to express stage 0 with people with work with and our community that we work with.
- Monitoring and tracking existing projects is important to understand comprehensive result of the work.
- Monitoring is important to educate about concerns. Workshops and general education really helpful to share knowledge.
- Even without Stage 0, still trying to restore systems to natural trajectory and process-based restoration. Really struggling to find a place to do this type of restoration. How to find a place without downstream infrastructure.
- Tool that's useful is biological opinion, monitoring and adaptive management template that brings stakeholders together. Common framework on goals/outcomes/ranges of benchmarks. What are the triggers or thresholds that brings group together to speak the same language?
- More environmental flows with dam releases. Need more monitoring as well to understand projects and communicate with the public and stakeholders.
- Communication about successes and failures is really important.
- MFWWC Outreach Grant for work at EBSP – board outreach and DEI principals
- McKenzie – fish-based work – i.e. Chinook redds. Create list of possible metrics and then see what is best for individual projects
- Application of monitoring data to pull partners together to share learnings. Helps build understanding. A need to build standardization into regional approaches with regional caveats,
- Beginning to get this to share information among PM and/or stakeholders, but also among practitioners so that community are speaking with consistent voice. How do we get that info out there?
- How do when id this opportunity? Need to watch and spend more time observing implemented projects. Experiment opportunity to understand need to intervention.

- Developing and supporting outreach to partners/public
- Creating consistency within monitoring across all project – a range of metrics
- Application/use of monitoring data – demonstrated value in increasing partner understand
- Speaking with consistent voice – structure to share info among PM's/stakeholders
- Identifying opportunities to adaptively manage project – opportunity to understand when to intervene in projects.
- Long term monitoring plan for both short term and longer-term habitat benefits. Project dependent on how long to monitor individual projects
- Better communication with partners during the planning process to allow enough time to provide input on the project and to plan for baseline monitoring to occur. 1 year of pre-project monitoring is not usually enough.
- Some felt that 6 years of pre-project monitoring would be needed, when compared to other long term paired watershed studies. Also, a need to establish a structure for long term monitoring to help address quality control, succession/turnover of staff etc.

What challenges should we be mindful of when addressing this uncertainty?

- Guidance for what stage 0 is, etc. for regulators, other practitioners so they know what Stage 0 is, etc.
- There are projects claiming to be stage 0 but not really stage 0 – so communicating the definition of Stage 0 and better informing practitioners, reviewers, regulators, etc. will be important.
- Challenges for monitoring – redesigning approaches are required given the complexity of these systems relative to a single thread channel; currently hard to answer all of the questions; more investment in monitoring funding and capacity is needed.
- Each system is unique and will have elements that are different from others.
- Existing paradigm is incapable of understanding the system. Are deep pools the right focus? Is fish passage the right focus?
- Also, what are the habitat attributes evolving within Stage 0 systems that are important for fish?
- Majority of work Helena has done has been salmonid-based, there are other species that use riparian areas – thinking about other organisms that don't get a lot of focus, non-game fish or aquatic species that might take advantage of Stage 0. What is the problem we're trying to solve and what are we trying to enhance, beyond salmonids.
- Managing people's expectations is going to be a huge challenge for these things, at local project level to larger scales, to the state investing in restoration projects, expectations to see increased size of salmon populations, which we know isn't controlled just by a few Stage 0 projects.

Salmon and salmon habitat have been impacted by a huge number of things. Stage 0 restoration might be some of most productive areas but they are a small proportion of the total area salmon use – expecting big impacts on salmon run sizes is unrealistic.

- Lesson learned from other systems, gaining reliable knowledge requires heavy investment in science, I don't think people realize [the amount of investment that is required]; monitoring has lots of different intensities – these are going to have to be deliberate, long-term experiments across geographies.
- Be realistic about what we can do in terms of intensive monitoring, harder to get funding for monitoring, a lot of things we'd like to see but the reality of getting that on the ground at all locations is a challenge.
- Communication – how to communicate dynamism particularly with stakeholders, between researchers and practitioners, Colin – stage 0 as a term is jargon and inherently exclusive for those that don't know what it is. Need to be inclusive as we evaluate different projects.
- Timeframe – need to convey that this is a long-term process. Also need to be mindful of challenges around downstream landowners.
- Prioritization of Stage 0 – compared to other projects, how to prioritize this work.
- Monitoring – avoid the kitchen sink approach and try and make sure that monitoring links specifically between objectives and data collection. Traditional monitoring often isn't a good fit.
- Prioritization of work – this doesn't work everywhere.
- How to convey a dynamic system that is messy, that is in a natural state. It's a state we haven't seen in 100 years. Easier to look for a location that's close by that's trending in the same direction as you'd expect with Stage 0 to show people an example. Need to teach about the processes. Need to have a time frame expectation of decades.
- These are large scale disturbances. Need to be able to explain the disturbance. Challenging.
- Stage O conditions/sites are really complex. Meaningful monitoring metrics that are feasible to collect over the long terms will be difficult. Consider potentially intensively monitoring projects in specific ecoregions and social settings to then use information from those to derive a simpler set of metrics that could be used over many sites, similar to the intensively monitored watersheds (IMWs)
- Communication between researchers and practitioners is a challenge. Lack of communication.
- Perception from the general public and landowners about what this is going to be and what this isn't. Need to be mindful of the language we use, and how we approach people. This is a challenge in restoration broadly, and very specifically with stage 0.
- Communication with landowners to bring folks on board, including downstream landowners. Prioritization of work – how does uncertainty fit in with uncertain Stage 0 compared with more traditional fish passage projects with known outcome.

- Monitoring a single thread is easy, harder in Stage 0. Judiciously line up monitoring with goals. Fearful of the kitchen sink approach to monitoring.
- Securing funding for monitoring is a problem. Also need funding for many years, not short term.
- Make sure that sites are landscape appropriate – don't push the technique where it should not be used.
- Terminology. Talk about functionality, not using term Stage 0, which is exclusive jargon.
- Perception from private landowners on this type of restoration if the site becomes "too" dynamic. So many private landowners are applying for projects such as bank stabilization which make streams/rivers stable. This approach is the opposite in that it promotes dynamism in the channel.
- Can't have appropriate places for Stage 0 everywhere.
- Even in very restricted area can have a more dynamic system, and neighbors can enjoy that.
- Making assumptions.
- Just getting oriented with concept and restoration projects
- Climate change. Tidal zones vs. non-tidal zones.
- Funding monitoring is hard. Need to show why monitoring is a priority. Establish this as a standard need.
- Unintended consequences on other species such as lamprey, mussels or frogs
- How best to have monitoring data collected to help inform where and what adaptive management should be performed on sites.

Plenary Session III: Monitoring Approaches, Challenges, and Evolving Knowledge of Stage 0 Restoration

This session was broken into two main parts. Part 1 addressed current monitoring approaches and findings via three presentations, followed by a panel discussion regarding monitoring challenges and information gaps. Part 2 looked at the evolving state of knowledge regarding restoration to achieve a Stage 0 condition by way of an additional presentation. Question and answer sessions followed the presentations in both parts.

Session III, PART 1: Current Monitoring Approaches

The following is a short summary of the presentations, panel discussion and questions and answers from the panel discussion. For more detailed information, especially in the prepared Powerpoint presentations which include photos of the projects, graphics and monitoring results, please watch the recording of this session. LINK to video for Day 2 Session III Part 1 - Current Approaches:
https://media.oregonstate.edu/media/t/1_y61ubwkf

Presentation overview

Renee Davis (OWEB) offers comments to frame the presentations. Session I aims to provide real-world examples of current monitoring being done as part of projects to achieve a Stage 0 condition. Experts will share how they approach monitoring from a range of perspectives- research, resource management and restoration science. Learning from both successful approaches and some of the challenges encountered helps facilitate adaptive management. The hope is that these presentations can inform subsequent discussions regarding future monitoring of projects.

Presentation 1: South Fork McKenzie River Stage-0 Restoration and Monitoring
Steve Wondzell, USFS Pacific NW Research Station

> Presenter Wondzell summarizes a very large process-based, valley-reset restoration project on the South Fork McKenzie River, just downstream from Cougar Reservoir. He then discusses various aspects of project monitoring including remote drone-based and transect-based approaches, and coordination of methods development with the Whychus Creek project partners.

Presentation 2: Phase I Stage 0 Restoration and Monitoring at Whychus Canyon Preserve, Whychus Creek, Oregon
Lauren Mork, Upper Deschutes Watershed Council

> Presenter Mork describes restoration to achieve a Stage 0 condition in Whychus Creek, a tributary of the Deschutes River in central Oregon. She then focuses on monitoring to assess whether the project is achieving a Stage 0 condition and providing abundant, diverse, high-

quality habitat for fish. She also discusses concerns related to water temperature, connectivity, deep pools, and fine sediment.

<u>Presentation 3:</u> **Monitoring Deer Creek Stage 0 Restoration using a Spatial Heterogeneity Framework**
Dan Scott, University of Washington

Presenter Scott reviews the restoration project on Deer Creek near its confluence with the McKenzie River, and describes monitoring to assess whether Stage 0 restoration sustainably reactivates desirable geomorphic processes such as avulsion; migration; wood and roughness-induce d erosion and deposition. Using geomorphic spatial heterogeneity to infer process activity, Dr. Scott and his colleagues sought to quantify the geomorphic "messiness" that this type of project is intended to restore.

<u>Presentation 4:</u> **Fish Habitat Development and Biological Response Time Following Stage 0 Implementation in the McKenzie River Sub-basin**
Kate Meyer, USFS Willamette National Forest

Presenter Meyer provides additional details regarding components of the South Fork McKenzie River restoration project and initial results of monitoring data to address the questions: Following project implementation, how long does it take for suitable habitat to form? Are there trade-offs in habitat type? How long does it take for communities to recolonize? How have they changed?

<u>Panel Discussion</u>**: Monitoring approaches and challenges panel discussion**
Moderator: Colin Thorne, University of Nottingham.

Panelists: Jamie Anthony, ODFW; Kate Meyer, USFS Willamette National Forest; Dan Scott, University of Washington; Steve Wondzell, USFS; and Lauren Mork, UDWC

Key points that emerged from this session

- Thinking in terms of restoration to achieve Stage 0 providing more sustainable, durable "neighborhoods" for fish: Both fish numbers and health, and also key ecosystem processes will be important to continue to monitor.
- Maintaining social support and funding for monitoring is an ongoing challenge, and will require ongoing communication with partners and stakeholders about the shift to, and importance of longer-term monitoring, and also communicating findings from it.
- Restoration to achieve a Stage 0 condition is usefully viewed as a spectrum from more process based to more process reset, from more of a lighter touch to nudge the system at one end of the spectrum to completely giving it a "kick" and resetting it at the other.
- A key information gap that research is addressing is the knowledge needed to target restoration actions along this spectrum to where they are most appropriate. Which actions work best under particular conditions, constraints, and locations?

- Maintaining institutional funding and "willpower" to monitor and adaptively manage can be difficult over the longer term and capacity for this varies, with federal agencies and watershed councils being perhaps better at it than local municipalities.
- Researchers in geomorphology, hydrology, and biology etc. have ideas about what might happen in response to projects to achieve Stage 0, but looking past near-term positive results and maintaining objectivity and skepticism over the long-term is critical.
- Parameters such as water temperature, wood movement and habitat attributes are important and can be measured on site. Changes in salmonid populations, and attributing them to restoration actions are arguably more important but much harder to measure.
- Monitoring objectives on the South Fork McKenzie restoration project focus on filling information gaps about the range of geomorphic and habitat conditions, and biological responses that are occurring, documenting conditions and complexity not present in more simplified systems.
- Specific knowledge gaps include lower velocity shallower, backwaters or margins, some which do have higher proportions of fines, and the importance of these types of features that are present in Stage 0 but not present in simplified channels for fish populations.
- A related gap is the need to develop a better understanding of the specific life-stage bottlenecks limiting fish populations and what is limiting recruitment into larger size classes.
- The USFS is defining monitoring questions and parameters using a conceptual model describing specific physical and biological responses we expected from restoration which became attributes that can be designated as project objectives and then measured.
- As an example, we expected the [S. Fork McKenzie] project to increase vertical hydrologic connectivity and selected groundwater depth as the measure of that.
- For future monitoring, we're continuing to work with partners to collect data to evaluate biological responses and use by all the life stages present for focal species to address questions about habitat quality. We also want to continue to track geomorphic evolution.
- There are also tremendous opportunities to look at these projects as whole systems and quantify their ecosystem benefits, beyond specific benefits for focal/target species. For example, carbon storage benefits- one of Ellen Wohl's grad students is studying this.
- There are many ways to "reset" a river channel and valley, or assist it to reset itself. A fundamental principle is to remove human caused impacts (e.g. levees) or channelization.
- In some cases, the system may just need to be "nudged", using low-tech approaches and nature's restorers. But in fully incised channels, we don't have enough time to wait for nature; we must use heavy equipment and fundamentally set the system on a new path.
- Attenuated peak flows, reduction or loss of sediment, nutrient and wood inputs and other effects of Cougar Dam are such that periodic augmentation of sediment and wood were part of the design plan to sustain the benefits of the S. Fork McKenzie project.

- Despite Cougar Dam, managers argue that the project is still highly valuable in providing for more lateral movement, sediment recruitment within the system, and maximizing the dynamism and connectivity that the river can possibly have now.
- Unless we're able to fully "rewild" an incised river, the design life of projects to achieve Stage 0 may be 30-50 years with the expectation that some periodic, post-project "after-care" adjustments and adaptive management may be needed to maintain their benefits.
- Regarding comparisons of different approaches (heavy equipment vs low-tech process based restoration) to achieve a Stage 0 condition, other projects across the USA are essentially moving to Stage 0 but not using either terminology. For effects and monitoring both, we need to better integrate with those researchers and practitioners.
- Another way to describe efforts to achieve Stage 0 is channel-floodplain-wetland corridor restoration/recreation.
- Monitoring after implementation of projects to achieve Stage 0 has required development of some new approaches to accurately describe the post-project ecosystem and effectively track ecological changes and trends that are occurring.
- For example, a traditional approach for macroinvertebrate monitoring (targeted riffle sampling) was augmented with a proportional multi-habitat sampling protocol that better represents the range of habitats present in addition to riffles.
- Pat Edwards (Portland State University) and coauthors have also published a paper on preliminary results for diatoms in restored compared to unrestored reaches.
- A synoptic ("seeing everything together") approach to monitoring may be most appropriate for the complex channel-floodplain-wetland systems that these projects are intended to achieve. We won't understand them by looking at one strand at a time.

<u>Colin:</u> Panelists: What are your initial reactions to information gaps we're trying to fill and how to go about answering monitoring questions discussed on Day 1 of the workshop? Looking to the future, what are your thoughts on the big issue of long-term monitoring and the sustainability of these sorts of restorations?

<u>Jamie:</u> [Building on the monitoring presentations.] I loved how Steve [Wondzell] described thinking about [monitoring] in terms of "neighborhoods" for fish: Does the neighborhood have better outcomes? [As an ODFW fisheries person I primarily look at these projects] through the lens of outcomes for fish. [So from that perspective the monitoring questions are] do we get more of them? Are they "fat & happy"? But I also like [Steve's] point regarding how this plays out over the long-term: it's one thing to get the fish to move in to the neighborhood; but we also hope to see that they're better off once they do.

Regarding the issue of how [projects to achieve a Stage 0 condition] play out over time, [those questions involve] the maintenance of that neighborhood. [A key outcome we're aiming for] is a more sustainable, durable system. So, looking to some of Dan's work, are we seeing the processes that maintain that neighborhood really being sustainable over time? These two areas [fish numbers and health; key ecosystem processes] are important to continue to monitor. I also want to note the challenge around sustaining long-term monitoring. Funders may be more used to seeing the expectation of shorter-term monitoring with an easier to define horizon. So, I think there will have to be a lot more communication with funders of monitoring that while there is some uncertainty about time horizons, we do have to think about the long haul.

Dan: I come at this from a research perspective trying to understand processes and foundations for these river systems. I work for and advise projects that are not reaching Stage 0 but shooting for it in more urbanized and more high-risk systems. Imagine trying to do restoration to Stage 0 where there are houses built the floodplain, and utilities and fiber optic lines that you have to avoid at all costs.

I take inspiration from people like Joe Wheaton who argue that we really need to be restoring a lot more of our watersheds than we currently are. We're just not hitting them hard enough, over a broad enough area to really have a big impact. What I see in Stage 0 is the opportunity to do that. The more we can target our restoration approach [appropriately, the more effective we'll be]. I really like [looking at restoration to achieve a Stage 0 condition] as a spectrum from more process-based to more process reset, from more of a lighter touch, helping the system to [at the other end of the spectrum] completely giving it a "kick" and resetting it. The gaps that I see and that I'm working to address include the knowledge we need to target [the appropriate scale of] our restoration in certain areas, and overcome constraints such as the highs risks of working in urbanized areas.

Also, is it [restoration to achieve a Stage 0 condition] sustainable not only from a process standpoint (e.g. do we have enough wood to support these systems) but also from a permitting and funding standpoint: Do we have the willpower and funding "attention" to do things like adaptive management? Organizations like the USFS and watershed councils have demonstrated that they can do an incredible job [at staying focused over time]. Municipalities tend to have a harder time. They often focus their attention like a spotlight for a couple of years, then it drifts away, so you need to make sure you can "do it right the first time". But I think a lot of the [expertise] that we'll develop over the longer term as we get better at this is how to do really targeted restoration that is very appropriate for the funding and the physical constraints that we face. [My hope is that] we'll be able to apply this over larger and larger areas that could really benefit.

Steve: When we were recruited for this panel one thing we were asked was to give an impression of the lens through which we view our monitoring efforts. My view got dramatically sharpened recently when Jared Weybright from the McKenzie Watershed Council contacted me by email because someone in the upper McKenzie valley had requested contact info for "the scientist who supported putting all that wood into the river".

Apologies for the "soapbox", but I want to make a point here that I think is really important. The word "support" that this person used is absolutely contrary to how I see my role as a scientist in these monitoring efforts. I have to be objective. If I'm just supporting Stage 0 restoration and looking for answers that show it is good, then I lose all credibility with a larger group. I can neither support Stage 0, but also I'm not contrary to it either. I have to be open to asking these monitoring questions and asking what will happen in the long run. I also have to be curious because these are really new restoration strategies that haven't been widely studied. In all reality, we don't know what's going to happen. Those of us with good backgrounds in geomorphology, hydrology, biology, etc. have hypotheses; we have ideas about what we think is going to happen, but we don't know those things for sure. So we have to be curious and open as we look at these projects.

For me at least, it's also important to be skeptical. It's easy to jump on initial, exciting results. But we also need to slow down, dig into those obvious answers, and take the time to [think about] what they really mean, how we interpret them and how we scale them up to larger basins or other things of interest. Finally, we have to be "data-based". We get that not through anecdote, but by doing the hard work of collecting and analyzing the data. We're doing that for a number of things. Kate did a great job of presenting initial results for salmon, and I agree those are super encouraging. I really hope that those kinds of trends continue into the future. But we have to be into this for the long-term to see what does happen, not just after 4 years, but what happens after a decade or two. What happens after we do see that really extreme flood?

In terms of what we should be monitoring, I see two alternative approaches. We can take the easiest things to measure- not necessarily easy, but easier. Things like water temperature, wood movement, habitat attributes, all of which are important. They're easier because they can be measured on site. Or, we can take things identified as perhaps the most important, e.g. what does Stage 0 contribute to salmon run size across the McKenzie Basin as a whole. But doing that kind of study is very difficult. We're building the foundations of trying to answer that question. But in the long run, questions about salmon run size in the McKenzie Basin aren't only determined by things that happen within the basin or our Stage 0 projects. They're also influenced by ocean conditions, harvest happening outside of the basin, etc. So these long term results are going to be difficult to interpret as we try to separate the effects of our Stage 0 restoration from that larger suite of processes.

<u>Colin:</u> Great to hear from another "militant agnostic"! Because when it comes to the future evolution of a scheme that's intended to change through time, we really don't know what's going to happen. That's why we have to be so watchful. I think that scientific objectivity is what will prevent Stage 0 from being a fad. Independent, objective, skeptical scrutiny is exactly what we need.

<u>Lauren:</u> For information gaps we're trying to fill, fundamentally it's been recognized that the conditions that result from Stage 0 in systems where we're implementing these projects have really not been described and documented. So our monitoring objective is to provide information about the range of geomorphic and habitat conditions, and biological responses that are occurring, recognizing that that entire range essentially started as an information gap.

Specifically, we want to better understand and quantify the conditions and complexity that are not present in more simplified systems. For example, lower velocity shallower backwaters or margins, some which do have higher proportions of fines, and then to segue, the importance of these types of features that are present in Stage 0 but not in simplified channels for fish populations. A related gap is the need to develop a better understanding of the specific life-stage bottlenecks limiting our fish populations, particularly on Whychus Creek. There we have resident red-band trout and introduced steelhead and chinook which have been returning as adults in relatively low numbers and so for those juvenile and resident fish we have data on spawning and on size classes. We're seeing that they're not recruiting into larger size classes, a very small [portion] of our redband density surveys are fish larger than 150mm. Collecting data to help understand what's limiting that recruitment in these systems would be helpful.

In terms of how we're going about answering these monitoring questions, we fundamentally worked from a conceptual model describing the specific physical and biological responses we expected to occur to our restoration design and those specific responses became attributes that we designated as project objectives and planned to measure. For example, we expected the project to increase vertical hydrologic connectivity and selected groundwater depth as the measure of that. For some metrics, data was already being collected. For other metrics, we needed to initiate separate monitoring efforts to generate those data.

As to future monitoring questions and data gaps, I'm continuing to work with our partners to collect that data to evaluate the biological responses and [habitat] use by all the life stages present for key species of interest. This will help us close the loop on questions about the quality of the habitat. We have data for one-year post project, but we do not have specific habitat data or, for example, macroinvertebrate data from shorter time frames- 0-3 months, 0-6 months, 0-1 year. By not having that data, we're not quantifying the habitats benefits that may be there. So that's a gap that we'd like to fill on future projects. [We also want to] continue to track geomorphic evolution as Dan described. There's a tremendous opportunity to look at projects as whole systems and quantify the ecosystem benefits, beyond specific benefits for the target species. One particular example is carbon storage. One of Ellen Wohl's grad students (Sara Hinshaw) implemented a study of carbon storage on Whychus Creek, and I believe the South Fork McKenzie and a number of other Stage 0 projects. So, beyond the carbon example, [there are additional opportunities to] measure the ecosystem benefits of the project.

<u>Colin:</u> *Moves to taking questions from workshop participants. Moderated by Andrew Dutterer.*

<u>Andrew:</u> Great discussion everyone. We have quite a few excellent questions. I'll go through them in order they came in. If we don't have time to answer all of them, the workshop planning team has indicated they are planning to help provide some written responses to those.

Q: Stage 0 restoration using the GGL approach seems to be getting conflated in this workshop with Stage 0 as a restoration reference condition. We need to back up a bit and acknowledge that Stage 0 or Stage 8 conditions exist on the land today and some have been studied. How are you incorporating what we've already learned from heavily monitored restoration projects such as the Bridge Creek IMW [Intensively Monitored Watershed] which achieved Stage 0 or Stage 8 conditions using BDAs and beavers?

<u>Colin</u> asks <u>Kate [Meyer]:</u> Not sure I'm the best person to answer that since I'm so focused on the McKenzie work. I'm sure there are Stage 0/Stage 8 projects/systems functioning naturally. I often look on Google Earth for those. But I don't think I've ever seen a natural system that is unimpaired by humans. As far as other projects making the claim that they have achieved Stage 0 conditions, I'm unaware of that happening, other than what I've [seen] touring as part of restoration assistance teams primarily on USFS land, so I can't really address that question.

<u>Colin:</u> I'll take a crack at it. Yes, Stage 0 is a condition, not a restoration technique or approach. There are many ways of resetting a system or assisting it to reset itself. The fundamental principle is to remove artificial constraints on the river and artifacts, especially if they are no longer needed. E.g. levees that were put in years ago for perfectly good purposes but which are now no longer necessary. If we put

something in the river that is no longer needed, we should take it away again. I think this is pretty hard to argue against. Unless you're like me and come from England where millraces that were constructed in the 1600s are now completely woven into the weft of what's "natural", where it would be crazy to go in and tear them out because nature has completely accommodated them. But if there's stuff in there that we don't use any more, don't need any more, and there's enough energy, sediment and life in the river to let it recover on its own, then sure we should allow that process, that's wonderful. But in many, many cases we can't wait that long. And yes, we have to be cautious but we know the risk of inaction and it's unacceptable. So we must move forward with caution, we must learn by doing, we must start with low-risk projects and then take on more ambitious projects as we gain confidence. But we can't wait because species will go extinct and things we want from our rivers will be lost.

Certainly if the river is in Stage 7 where it's not degrading anymore, in fact it's aggrading somewhat, its pushing out its shoulders, eroding the terraces and getting back to a fully connected floodplain itself, then I am shoulder to shoulder with Joe Wheaton and Michael Pollock that we can assist those processes, we can partner with nature's river restorers and we can achieve our goals. But if we're in Stage 3 – Stage 4 incised and widening [conditions] it's going to be very hard for nature to reverse that process. According to the Wheaton and Pollock timescales it may take 100 years. We don't have that long. That's where we should perhaps burn some diesel, with a heavy heart, use some machines and move things forward. And then, as soon as we can, take our hands back off the controls and the steering wheel, and let nature build resilience, build robustness because it [nature] does know how to do that.

Q: For the S. Fork McKenzie project, which is located downstream from a dam, are you monitoring sediment dynamics? How do you think the dam will affect process recovery in that project?

<u>Steve:</u> The dam obviously has a huge effect on discharges. We've seen a huge change in the size of the annual peak flow. Peak flows are averaging about 4000 cfs, with the highest peak flow recorded since the dam was in place being about 6000 cfs. Those discharges are really small for a river the size of the SFM. That has really big implications for the project. It increases the likelihood that the logs won't move. They can float; get moved small distances. But the chance of them getting catastrophically swept away in a 100-year flood is really minimal. There's also sediment movement, but again, sediment movement is limited by the lack of stream power. If preferential flows in the surface – we don't really have any place where we could preferentially call it a "channel" but there are places where water flows with more velocity or less. That can move the fines, certainly on the surface and we expect to see changes over time. In terms of monitoring sediment movement, we're not that I'm aware of. We are looking at sediment size class distributions in a variety of ways. The structure from motion digital surface models. We also have LIDAR- bathymetric LiDAR – so we have a variety of ways that we can look at surface elevations across the site to see if they change. Rather than specifically seeing sediment movement, we can see the effect of sediment movement, perhaps, over the long term.

<u>Kate:</u> Effects of the dam were an inescapable concern as we undertook this project. The cutting off of [peak] flows, sediment, wood, and nutrient input by the dam was huge. So the project design includes future augmentation of sediment and wood. We expect to retain a lot of the wood we put in initially, so it depends on decay rates. Thirty or so years down the road, we'll probably have to add more wood; probably using helicopters. So, wet and messy while we get back in there. We do also plan to do some level of sediment augmentation, possibly annually, or every 1-3 years. The quantity of sediment

augmentation would be based on monitoring. So we do have a plan for that. We have a stockpile of material and are seeking more as well. Possible sources include gravels dredged out of reservoirs lower in the McKenzie system. So material from within the McKenzie basin could be brought back up to use for sediment augmentation.

As far as the effectiveness of doing a project [like this] below a dam, there are definitely challenges but if you look at a different way, we're maximizing the connectivity, complexity and dynamism that that river can possibly experience now, below a dam. We've freed up sediments laterally, so even though we aren't getting inputs from above, we're recruiting sediment from within the valley itself. The river would not have done that without our intervention. I think it's perfectly suitable to do a project below a dam. Going into this we hoped that this project might serve as a model for other rivers below dams that are severely impaired.

Colin: I'm not an engineer but I've worked with them a lot. When river engineering projects are done and they have a design life 30-50 years, it's not expected that they're maintenance-free. If we do a full restoration and we rewild the river and the basin, then we don't have to do anything anymore. But [often] we're not able to fully rewild the river, such as in this case. Therefore, we have to expect that there may be maintenance and adaptive management needed and the project may have a design life, at the end of which we have to do something else. It's not fair to ask a restoration scheme to be "forever" in managed system, because nothing is forever in a managed system. We're responsible for maintenance and adaptive care- "after care" if you like.

Andrew: We have a comment from Ellen Wohl.

Ellen: I have a comment on the first question regarding Stage 0 projects vs BDAs. I think that's an important issue. There are various types of restoration projects being taken, certainly in the US and also elsewhere that are effectively going towards some things called Stage 0 but they're not using that terminology. This gets back to a comment yesterday saying that Stage 0 might be a little bit of jargon at this point. What I'm thinking of specifically is Big Spring Run in Pennsylvania, the wet meadow restoration that's been done in the upper Midwest, places like Michigan and Minnesota, the wet meadow restoration that's being done in California, and all the BDA restoration which is going on throughout the intermountain west. I think one of the things we need to do to really advance our understanding of both what's happening, and how to monitor, is to better integrate with people who are doing the same type of thing but not calling it Stage 0.

Colin: [Quoting Shakespeare] the Bard said, "A rose by any other name would smell as sweet." You don't have to call it Stage 0. You really don't. It's channel-floodplain-wetland corridor restoration/recreation. Call it by its name.

Q (for all panelists): Thank you panelists for the presentations on robust monitoring programs. In consideration of interactions across physical and biological parameters, have you been able to understand why your monitoring is working or why it's working less well on some parameters? Do you have a method for comparing success across different parameters?

Colin: Perhaps Lauren could jump in and respond to this? In the biogeomorphology area, she has been especially thoughtful.

Lauren: Sure. I can speak to that. We've modified our monitoring methods in order to better describe the biological response. In particular, for macroinvertebrates we historically have used a targeted riffle sampling methodology. With implementation of Stage 0 projects we have retained that targeted riffle sampling methodology in some key and index sites while adding a proportional multi-habitat sampling protocol to really be able to understand and capture and describe the macroinvertebrate community that we wouldn't expect to see in a riffle. The TRSP only collects macroinvertebrate samples in riffles, whereas the PMH approach samples proportionally to habitats within a sampling reach. So that's one way we've responded to monitoring metrics and methods not addressing what we want to be able to capture. We've also been fortunate to work with Pat Edwards at PSU on parasite sampling. Pat and coauthors recently published a paper of preliminary results of diatoms in restored compared to unrestored reaches. I'd wrap up by saying, we've had to take a step beyond the more traditional sampling and monitoring methods to be able to describe these systems.

Colin: Great answer. I think it closes with something slightly philosophical. I would recommend synoptic monitoring. Synoptic comes from the Greek word synoptikos; the literal translation of which is "seeing everything together". In Greek philosophy that meant recognizing and valuing the wisdom emerging from a coherent understanding of everything together. If we are going to understand these complex channel-floodplain-wetland systems, we're going to understand them synoptically. We'll never ever understand them if we try to do so one strand at a time. That isn't how they work. Think synoptic! Thank you.

Session III, PART 2: Evolving knowledge about Stage 0 Restoration Approaches

The following is a summary of the presentation and questions and answers after the presentation. For more detailed information, especially the Powerpoint presentation which includes images of the project area, monitoring results and expert interpretation, please watch the recording of this session. LINK to video for Day 2 Session III Part 2 – Evolving Knowledge:
https://media.oregonstate.edu/media/t/1_jj0xw8jm

Presentation overview

This session included one prepared presentation and an extensive question and answer session encompassing discussion material presented in both Session III Parts 1 and 2.

Presentation 1: Fivemile Bell Restoration Project: Vegetation Based Stage 0 Restoration in Coastal Oregon
Paul Burns, Siuslaw National Forest

Presenter Burns describes actions taken and lessons learned from a project to restore a Stage 0 condition in Fivemile Creek in Siuslaw National Forest in coastal Oregon. The waterway had been diked and straightened in the early 1900s, then incised downward.

Key points that emerged from this session

- In the Coast Range, post-project colonization by invasive reed canarygrass appears to be more related to percentage of the year that restored areas are wet than to water depth or velocity, with canarygrass favoring areas above the water table.
- Post-project monitoring at Deer Creek indicated that what was initially thought to be heavy wood loading was actually fairly light, resulting in lots of open spaces in logjams, and coarsening of sediment substrate and increases in flow velocity over time.
- Management was adapted using this information to significantly increase wood application on the S. Fork McKenzie project, which monitoring showed helped attenuate increased flow velocities and substrate coarsening.
- Heavy applications of wood appear to be serving as “proxies” for channel roughness until islands form and begin to provide their own roughness.
- Research and monitoring are also demonstrating the importance of including smaller wood sizes and slash to help fill interstitial spaces in logjams and increase retention of fine sediment and organic matter.
- These outcomes demonstrate the effectiveness of robust research, monitoring and adaptive management of projects to achieve Stage 0 in the McKenzie River watershed.

- There is some limited anecdotal evidence of indirect “trophic cascade” benefits resulting from projects to achieve Stage 0 (e.g. increased prey for apex predators) and significant but currently unrealized potential for studies to illuminate these effects.
- Recent wildfires in project areas also offer the potential to rigorously investigate anecdotal evidence that the projects helped mitigate wildfire effects by increasing patchiness and reducing fire severity and soil impacts in burned areas.
- Post-project analysis at Deer Creek using LiDAR data and the newly-developed Geomorphic Grade Line (GGL) tool showed that locations where the project succeeded in hitting the GGL had the most channel complexity and connectivity.
- While the wood regime is different in drier, east-side sites, there are also plans there to increase channel roughness by increasing the amount of smaller wood placed during those projects.
- Experience in the Coast Range suggests that GGL analysis work is a more reliable guide for restoration planning than relict channels for which the history is unknown and may reflect previous disturbance rather than “natural” conditions.
- It will be important to bring these types of “lessons learned” into guidelines for project reviewers and regulatory agencies to use when assessing and prioritizing projects, especially as the suite of approaches to achieving Stage 0 continues to grow and diversify.
- A key dilemma for stream restorers is how to allocate limited funds between taking action to address immediate environmental problems and the long-term monitoring necessary to answer important questions regarding the effectiveness of these projects.
- Remote sensing data may offer a more cost-effective alternative to fieldwork in meeting the challenge of scaling up and maintaining monitoring over larger scales and longer, ecologically and physically relevant timeframes associated with restoration to Stage 0.
- There are numerous opportunities to “turn monitoring into science” by funding graduate research projects that help meet monitoring information needs while also increasing scientific understanding of projects to achieve Stage 0.
- Effective monitoring programs for projects to achieve Stage 0 generally reflect the coordinated efforts of a “village” of project partners leveraging resources and deriving the maximum “bang for the buck” to answer questions.
- The stream restoration “community of practice” that has evolved in the PNW may be the most cohesive and robust in the world and with proper support has considerable potential to meet the challenges they face.

Chat-based questions

Q: On the S. Fork McKenzie, for the unrestored reach, was it meant to be a control? Or was it set aside because it wasn’t a good area to treat, i.e. more confined?

Kate: I think you might be referring to Deer Creek. There were various reasons we didn't treat that reach. For one thing, there's a powerline corridor that runs right up Deer Creek through that untreated reach. So that was one reason. We also had limited funding on that first round. But [that reach] is in the same valley type, the same valley width. It happens to be more heavily disturbed right there. There's a bridge that pinches the channel down and so there are some constraints that we'd have to work around, but it is in the same valley type.

Q: In the southern side channels of the S. Fork McKenzie are lamprey using the fine cohesive sediment that is still vegetated, even below the water surface, or do you see them preferentially using unvegetated fine sediment patches?

Kate: That's a tough one. We haven't done any specific lamprey monitoring other than frequently running our hands through fine sediment when we're out onsite, which we actually do across a pretty wide area of the project. So all I have is anecdotal information. There's definitely certain substrate that has to have a little more silt in it, can't be coarser sand. I haven't really been able to distinguish between a vegetated and unvegetated patch but I think they're pretty well distributed throughout the project. I don't really see any patterns of colonization in certain areas.

Q: I'm curious about your reed canarygrass control methods. What minimum water depth have you found is necessary to control canarygrass recolonization? Have you noticed that turbidity, velocity and/or depth correlate with canarygrass colonization?

Paul: From what we've seen so far, depth isn't that important. Just that it's kept wet at least through much of the year, not just for a short period of time. So it's more the extent of flooding and where we've seen the most reed canarygrass colonization is down in that first phase area where we had a lot of deposition the first year [post project?] and those depositional areas became even higher removed from the water and the reed canarygrass settled on them. As far as velocity differences for that, we haven't seen any of that because once you spread that water out, the velocities are so low out there that you don't see much difference across the valley.

Q: What are you learning about wood placement, distribution and loading across projects [and] over time?

Kate: Good question. We're learning a lot. As Dan Scott mentioned, in Deer Creek Phase I (2016) we had pretty light wood loading. We thought it was heavy at the time, but we learned through monitoring and observation that it was actually pretty light loading. There was a lot of open space in the log jams and we saw a general coarsening of substrate and an increase in [flow] velocities over time. So we saw the trajectory that was taking. In the meantime, we had implemented two phases on the South Fork where we increased the wood loading. So we had about 14 pieces per acre at Deer Creek and we basically doubled that on the South Fork. Through monitoring that project we realized we weren't seeing the sediment coarsening; or the increase in velocities as much and that we were getting closer to a desired roughness until the vegetation re-establishes. That's why we put so much wood in "up front". It's acting as a proxy until vegetation establishes and island formation takes off and provides its own roughness over time. Deer Creek is steeper gradient and a little more confined so going back in for the 2nd phase on Deer Creek we bumped up the wood density even more. We might even be at 50% higher than what we put on the South Fork; more like 35-40 pieces per acre. Time will tell how that will play out on Deer Creek Phase II.

We also learned about wood sizes. In Deer Creek Phase I we only put in large wood over 24" diameter. We didn't have much slash or smaller pieces so a lot of those interstitial spaces in the logjams didn't get filled in with finer woody material. Those [spaces] that did get filled in naturally functioned better; stored more sediment and organic matter, while those that didn't had less of a geomorphic impact. So, in the second phase we also utilized a lot more small wood pieces and slash. We're continually learning through all these projects and our design is continually evolving.

Q: Can either or both of you comment on the significance of apex predators and floodplain reconnection?

<u>Paul:</u> It's all about restoring the balance in the ecosystems. In some areas, apex predators are important for controlling ungulates. We've seen that in places like Yellowstone NP where the wolves have come back and the willows have taken off and provided for so much more function of those stream systems. Similarly, on the coast we deal with a lot of deer and elk – mostly elk – predation on our vegetation. Having cougars and other species are an important piece of bringing back the balance. So we're glad to see cougars [like we saw in the presentation] on our properties.

<u>Kate:</u> I second that. We don't know a lot about how these projects affect wildlife. We're totally missing the boat on that, and I find that very intriguing. In the aquatic world, our apex predator could be considered the bull trout, which do occupy both the South Fork and Deer Creek. We don't have any monitoring data [to support this] but in theory by increasing lower velocity foraging habitat, but also potentially increasing the abundance and size of prey, which in our system are primarily juvenile chinook, I think the bull trout will absolutely benefit. They are doing some monitoring on Staley Creek, another Stage 0 project in the Willamette basin where they're doing bull trout-specific monitoring and did not see bull trout in the project area before the project and now they are documenting several bull trout (don't know the numbers exactly) but bull trout are definitely utilizing the project area now.

Q: Can you [Kate] speak to some of the recent lessons learned regarding system resiliency to wildfire?

<u>Kate:</u> [Pulls up photos of burned areas in S. Fork McKenzie from her PowerPoint.] I was assigned as a resource advisor on the fires and did two 2-week stints, then transitioned into the Burned Area Emergency Response (BAER) team. So I saw a lot of the fire area and visited the [S. Fork McKenzie] project site several times, and also other areas. Some of my general observations [are that] there seem to be some differences in the patchiness of the burn mosaic that was created in the two different aquatic ecosystems [shown in the photos]. Our observations suggest that where we have hydrologic connectivity and habitat patchiness, we see more patchy burn patterns. We don't have actual data [yet] but Colin Thorne is coordinating a research project to address exactly this question. Based on our observations, we do see a difference in how wildfire moves through these [restored and unrestored]

areas, even though it was primarily wind-driven, there seems to be less burn severity and a more patchy burn in the project area. [Based on that] I'd say there's a good chance it [the project area] would show higher resilience and probably higher potential for the soils and metabiology within the soils to recover more quickly as well.

Q: Given what you're finding with your monitoring efforts and monitoring information that you are collecting, how might this help establish "standards of practice" for project planning and design? Specifically, in regards to the Deer Creek project (if that serves as a good example) what metrics and information were you finding there that led the team to go back in and take additional restoration actions? (Notes that Kate may have touched on this in her discussion of wood.)

Kate: Asks for clarification: Was the question "what monitoring metrics we would *recommend*?"

Andrew (chat moderator): I think it was more *what were you finding there from your monitoring that prompted you to go back and take additional adaptive management restoration actions? And, more broadly, for all panelists, what are you finding through monitoring that is informing Stage 0 planning and design, more generally?*

Kate: I can expand on what I already talked about regarding lessons learned on wood density and wood size. We learned another big lesson at Deer Creek regarding geomorphic gradeline. In 2016 we didn't have the geomorphic gradeline tool yet. We were just plodding along with general profiles and doing kind of a linear, valley slope based on that and then building target elevations based on that longitudinal profile. What we learned from subsequent LiDAR collected post-project, and when we were able to run the [GGL] tool is that we did hit the geomorphic grade line in some locations and where we did we saw the most complexity and connectivity. Where we didn't [hit the GGL] we saw more defined channels, less complexity, less connectivity. That was another reason we wanted to [do additional restoration actions]. [We decided], if we're going to add additional wood let's get the geomorphic grade line right and really do this project justice. So we did learn a lot from that project in terms of using the geomorphic grade line approach to design and evaluate the project.

Lauren: My expertise is primarily in monitoring. Our restoration program manager Matthias Perle primarily works with our design team. But I can comment on what we've learned in terms of [channel] roughness. One thing we've observed is related to what Kate described in terms of their project evolution and the amount of wood that they put on their site. At Whychus Canyon Preserve we had this beautiful network of relict channels and cottonwood galleries which we wanted to retain. But, post-project if you think about that existing vegetation and root structure that was left, those also served and acted as really high roughness. So one thing we'll be doing differently going forward is using much more roughness on the constructed floodplain, on the cut floodplain surface and really spreading out that roughness. While Kate described using slash, we have a very different wood regime on Whychus Creek compared to the S. Fork McKenzie and so some of that smaller wood is really what characterizes our system. We're really going to be increasing roughness on subsequent phases.

Jamie: I'd like to add to that. I have a little different tack on the questions because my lens is more on thinking in terms of project review, and from the perspective of permitting. Bringing these lessons learned into guidance for project reviewers and even permitters on the regulatory side is going to be really important. This is especially critical across the suite of approaches to restoring towards Stage 0 as that continues to grow and diversify among the practitioners out there doing this kind of work. It's going to be really important for project reviewers to have some benchmarks for thinking about how we review these projects [to help us assess]: What makes a good project? What makes a good monitoring design? Those kinds of things. Might be jumping ahead to the next session; just wanted to [make sure this got said].

Paul: One lesson I forgot to mention during my presentation was "don't let relict channels drive your restoration plan". That was a mistake we made in our 2nd phase. [The reason is] because you don't know the history of those relict channels. [The lessons is] "believe in your geomorphic grade line work". As you look at your geomorphic grade line don't look at a channel on the valley floor, just because it's there, as being a reference channel. Those are often disturbed channels.

Q: Can you say a bit about the cost of these monitoring efforts? At this point, do you feel like you're getting your return on investment, based on what you are learning from your efforts?

Dan: I can't speak to return on investment because I just do the monitoring and hope that other people benefit. But I can comment some on costs. For spatial heterogeneity and trying to infer geomorphic processes, ignoring wood, ignoring a lot of the biotic monitoring, I'd say that for a project like Deer Creek – 1.5 miles of stream – you want to monitor it annually; it's going to cost in the range of $2-5000/year, relatively cheap. On the scale of big monitoring efforts, you can do it with relatively few people and resources. Moving toward the more detailed, more field-oriented, resource intensive [types of monitoring] e.g. wood dynamics and especially biotic responses, for wood dynamics anyway it starts to get a lot more expensive and you start to face issues of scaling it up. It's been relatively easy to scale up remote sensing-based monitoring and you can do it relatively inexpensively. I'd argue that you can do a lot of remote sensing-based monitoring for very cheap, using publicly available imagery and databases. So one challenge I see is that if you want to do a lot of monitoring you need to figure out how to use these more inexpensive methods. Often, if you ask managers implementing the projects what their monitoring budget is, they'll tell you "somewhere between zero and zero dollars". So you need to figure out what you can do for nearly free.

[On the positive side], there's a lot of opportunity to turn [monitoring] into science by getting people like myself and Ellen Wohl involved and using the projects as opportunities for student learning. We're seeing a lot of that here in the Colorado Front Range. That can prove effective but it's not a long-term strategy. For longer term, we need to figure out what is the baseline monitoring we can do with limited resources; that's the reality for a lot of projects. I'd argue for Stage 0 there's quite a bit you can do with very little in the way of resources, at least from the geomorphic process side of things.

Kate: On S. Fork and Deer Creek we have two very different monitoring approaches. On S. Fork [monitoring is] huge scale, with many partners and funding sources involved. So we're undertaking a huge monitoring effort. Something like $1.2 million over 4 years. As Steve mentioned, that includes remote sensing, on-the-ground work, a huge variety of monitoring. On Deer Creek, it's much more minimal. Basically just doing our transect surveys which takes 2 field techs a few days, then the work that Dan Scott is doing and then our macroinvertebrate and spawning surveys. We do all want to figure out the priorities for monitoring and what we want to spend our [monitoring] funding on.

Steve: Tough question! The $1.2 million number that Kate mentioned doesn't surprise me. And such totals still don't reflect peoples' time and salary that go into collecting data, analyzing data, organizing the [monitoring] projects, etc. Undoubtedly the [monitoring] effort on the S. Fork McKenzie is very expensive. But I'd actually argue that it's not expensive enough. By that I mean, consider the numerous questions raised during this workshop and in the pre-workshop survey. They're good questions and deserve good answers. But we're only going to be able to provide decent answers to a small subset of them. If we really want to answer all the questions we're interested in, it will cost a lot more than we're currently investing in [monitoring]. As Dan Scott noted, the initial focus on implementing projects [to achieve a Stage 0 condition] often does not include much support for post-project monitoring. The [dilemma] as Kate noted is: "what do we want to invest our money in?" Do we want to focus on getting projects implemented on the ground to address immediate environmental problems? Or do we want to invest in long-term monitoring that might take years or even decades to provide good answers? That is way too slow for the kinds of problems we face now.

Lauren: Our experience on Whychus is that [monitoring; addressing questions; assessing outcomes] "takes a village". It requires all of our partners. All of the fish sampling data that we have is from PG&E, ODFW, and USFS. The aquatic inventory project surveys are contracted by ODFW. We've been very lucky to have the opportunity to leverage all of that data. We also work with universities- the University of Knottingham, Portland State. [These partnerships] have enabled us to make a relatively small monitoring budget go much farther in terms of the information that we're able to generate about outcomes [from the Whychus project.] I just wanted to note the effectiveness of this approach.

Colin: I work on river restoration projects in Europe, the US, New Zealand, Australia and river management in SE Asia. In the Pacific Northwest, you have a "community of practice" in river restoration that, in my experience, is unique. That's how you're going to move this forward- through the close coupling of monitoring, learning by doing, and "doing". If you folks can't pull this off, nobody on the planet can. So, no pressure! But we're really looking to you globally to show the way forward, help solve what is really a grand issue of our generation.

Plenary Session IV & Breakout Groups: Create a Communication Network or Process for Sharing Updates as New Information Emerges

For more detailed information, especially the prepared Powerpoint presentation, please watch the recording of this session. LINK to video of Session IV: Communication Network and Summary of Breakout Groups: https://media.oregonstate.edu/media/t/1_ir41hay6

This session addressed a key desired outcome for the workshop- the creation of a communication network, process or forum where Stage 0 practitioners, scientists and partners can share and acquire new information about Stage 0 projects and science as it becomes available.

The session opened with remarks by Renee Davis (OWEB) and Rose Wallick (USGS) who introduced and provided context for this goal. Ken Fetcho (OWEB) followed with a longer presentation on communication tools and strategies to help stimulate discussion in the breakout groups. After the breakouts, the group note takers reported back to the full workshop in a 25-minute session that was videotaped (link above). The breakout notes were compiled after the workshop, and are summarized below. The notes are also shown in Appendix D.

Following the breakout group reports, Brian Cluer, Colin Thorne and Janine Castro provided closing thoughts and comments and the workshop concluded.

Presentation overview

Presentation 1: Creating a Communication Network/Process for Sharing Information
Ken Fetcho, Oregon Watershed Enhancement Board

> Presenter Fetcho covered a range of options and strategies for information sharing among a "community of practice" consisting of Stage 0 practitioners, scientists, regulators and other interested partners. These included member organizations, professional societies, consortia, government agencies, and online communication tools. Mr. Fetcho discussed specific examples and pros & cons of each, along with some additional options including demonstration projects, email listservs, annual meetings, newsletters, project fact sheets, videos, and research summaries (e.g. USFS Stream Notes).

Breakout session

Breakout group participants were asked to address these four key questions:

1. What are you most interested in tracking and learning about following this workshop?
2. What are effective ways (e.g. annual workshop, online forum) for you to receive this information?
3. How will you use this information and/or how will it inform your work?

4. Is there other key information about Stage 0 restoration that you need to do your work and didn't hear about today?

After the workshop (November 2020), responses to the first 2 questions were synthesized to inform development of a post-workshop survey. Those summaries are listed below. Compiled responses to all 4 questions are provided in Appendix D.

What are you most interested in tracking and learning about following this workshop?

Theme 1: Opportunities & methods for information sharing – information clearinghouse

There is broad interest in seeking ways to facilitate greater sharing of information across agencies, practitioners and stakeholders regarding Stage 0-type projects and supporting science. Key to this would be some sort of online "information clearinghouse". The objective would be to facilitate a Stage 0 community of practice, *"a group of people who share a concern or a passion for something they do, and learn how to do it better as they interact regularly".* One challenge is to identify a "name" other than Stage 0 that could encompass BDA/PALS methods & approaches.

The clearinghouse could include:

- A blog or chat group; perhaps moderated and with news updates, e.g. planning for future workshops, field trips, project updates, new publications etc.
- Summaries of existing projects
- Summaries of projects in the planning pipeline (e.g. USFS)
- Technical guidance
- Library of relevant peer-reviewed literature and "white" papers on topics, e.g. design methods, construction practices, monitoring BMPs, contrasts/linkages between different approaches to achieving a Stage 0 condition
- Comparison of projects and reference sites in different areas (see Theme 2)
- Links to monitoring data as it becomes available (See Theme 3)

Theme 2: Comparison of and communication across Stage 0-type projects in different settings

This theme is explicitly focused on understanding how restoration to achieve a Stage 0 condition varies across different settings, encompassing comparison of practices used to implement projects (including contrasting the use of heavy equipment to fill incised channels and low-tech process-based restoration (BDA/PALS) approaches), methods used to monitor project outcomes and success, and variation in outcomes themselves. Respondents cited a related need for Stage 0 reference sites to help assess outcomes of completed projects, and to help guide future projects. Project funders and reviewers indicated a need for this information in order to help prioritize projects and compare Stage 0 with "traditional" projects.

The diversity of site types that were mentioned include:

- Flashy, bedrock systems
- Laterally-confined systems
- Semi-alluvial systems
- Fully alluvial systems
- Sites below dams
- Arid systems
- Systems with a Mediterranean climate
- Small steep streams
- Low gradient wet meadows
- East-side [Cascades] vs. west-side systems

<u>Theme 3:</u> Monitoring methods and results, effectiveness of existing projects, tracking change over time

This theme is explicitly focused on the acquisition and dissemination of monitoring data, results and "lessons learned" for projects intended to achieve a Stage 0 condition. Respondents cited the need for more information on Stage 0-specific methods and how to monitor efficiently, and also how to gain access to monitoring results more frequently and in a timely fashion. It was noted that the scale and goals of restoration projects to achieve a Stage 0 condition offer important opportunities to track ecological changes over time.

Specific monitoring needs that were cited include:

- Effects of Stage 0 projects on fish passage
- Effects of Stage 0 projects on fish habitat
- Effects of Stage 0 projects on sediment loads
- Tracking post-project wood dynamics to inform practices for wood placement
- Continuing to track change over longer time periods using consistent metrics
- Development of protocols that are repeatable across multiple projects
- Tailoring monitoring metrics to species of concern
- Looking for synergisms with broader post-wildfire monitoring efforts

What are effective ways (e.g., annual workshop, online forum) for you to receive this [Stage 0-related] information?

Workshops, webinars, annual meetings

- Continue holding workshops with more participants. Don't limit participants
- Both plenary & breakout sessions are very useful. Format works well. We need more of them
- Liked diversity of topics in the workshop. Interested in more workshops of this kind.
- Try to do more of this type of info sharing annually.
- Bring in the folks who don't agree into the workshop.
- Looking forward to report out from this workshop; share with other orgs like River Restoration NW.
- Example: Grande Ronde Model Watershed annual State of the Science meeting to share findings and formulate adaptive management actions
- Seminar Series – like the Association of Wetland Managers where 600 people from around the country
- can participate and listen to presentations
- Webinars have been used effectively to provide workshops on Stage 0 across the US and Europe.

Website, clearinghouse (for vetted, more formal info & documents)

- It would be nice to have a Stage 0 website; central clearinghouse- dual purpose for both practitioners and public outreach
- Stream notes (USFS) is a nice place to read about project developments.
- Clearinghouse of information
- Manual – like the beaver restoration guidebook, or large wood manual
- Oregon Explorer to aggregate info and make it accessible – more accessible than OGMS.
- Establish a website as a clearing house for information
- Fact sheets; updated annually, to condense pertinent info. Include contact info for further details etc.

Blog/forum (for more informal, ongoing, iterative discussion and sharing of info)

- [There is a] blog for sharing Stage 0 experiences. I find this very useful
- Forum that transcends regions
- Small groups that get together monthly (or more often) for talks or mini presentations.

- PNW mussel list serve example; PDX ecologist unit – another list serve example
- Email list serve or online forum.

Field trips; face-to-face interactions (not virtual)

- Field trips to Stage 0 sites with diverse viewpoints represented.
- A brief narrated video while walking a project provides a nice firsthand viewing opportunity.
- Project tours
- In addition to providing materials to people to read/review on the computer, people need to get out and spend time on these sites.
- Have to interact and listen to and learn from others with different viewpoints.

Building a Community of Practice

- Don't think virtual networks are the best way to establish community of practice (COP). Need time for people to spend together thinking and talking, sitting on logs, to learn the language of different individuals and different groups.
- Need a strong advocate to champion the COP- single entity, agency, etc. Need a unifying energy.
- Maybe what we need is a full-time Stage 0 communication position at USFS?
- For a COP we should start with the outcome we want, then back up and try to figure out how to get there. What about forming a subgroup to discuss a framework to build a COP?

Closing comments and workshop takeaway messages

Key points that emerged from this session

- Stage 0 is a *stream channel condition*, not a *restoration approach*.
- A spectrum of methods exists to achieve Stage 0, from “light-touch”, beaver dam analog and post-assisted logjam methods, to geomorphic gradeline, valley reset methods
- Clarification of this spectrum and which methods are suitable in a given location is a key information need.
- Not all human modified stream channels are suitable for restoration to Stage 0.
- A “successful” project to achieve Stage 0 sets the channel on a trajectory to evolve toward that, working with natural processes and the full range of “nature’s restorers”.
- Discussions around Stage 0 should shift from *uncertainties* to *confidences*, e.g. that single-channel streams are biologically limiting; not resilient whereas Stage 0 channels are less predictable but more resilient and biologically rich.
- Restoration to Stage 0 requires holistic, synoptic thinking; a coherent understanding of “everything together” as opposed to reductionistic focus on ecosystem components.
- Conceptual dynamic population models for fish are a potential alternative to address the challenges of accurately assessing fish responses to restoration projects.
- Restoration to Stage 0 may be analogous to dam removal in that an incremental approach focused on limiting short-term disturbances may risk delaying or preventing meaningful ecosystem uplift in the longer-term.
- Floodplain reconnection may represent another “paradigm shift” in the evolution of stream restoration, similar to ending the use of rip-rap, placement of large wood, and single-channel design with practitioners and stakeholders initially ambivalent but eventually accepting it.
- Compared to past conceptual shifts, there appears to be more extensive coordination between scientists and practitioners to research and monitor floodplain reconnection, with many potential benefits for river restoration

Colin: I have 5 things that I’ve heard over the past 2 days that I think are good “take-home” messages. First, Stage 0 is a *condition* not an *approach*. You can get there by “light-touch” process-based restoration, or by valley reset. There are multiple ways of getting there. It’s not for everywhere, and it’s not “forever”. We’re talking about what should be response reaches under Montgomery and Buffington (1997)* that is to say that sediment supply should be at least equivalent to sediment transport capacity and ideally exceeding it.

*Montgomery, D.R. and Buffington, J.M., 1997. Channel-reach morphology in mountain drainage basins**.** *Geological Society of America Bulletin*, 109(5), pp.596-611.

Secondly, we can't do this on our own. We have to work with nature's river restorers. I used to think that the outcome of a really good river restoration project was a fully functional, healthy floodplain wetland river ecosystem. I don't think that anymore. It is how you can achieve a really good river restoration project. We need not just beaver; we need all of nature's river restorers, "from bugs to bears", from microscopic algae all the way up to top predators. We need them all on our team.

Third, we have to embrace uncertainty and we have to stop talking about it to non-specialists so that we exude the confidence that we can legitimately feel because we will handle uncertainties in ways that avoid unacceptable risks. If we know what's going to happen at a [restoration] site, we're not doing [our restoration] right. These systems are not designed. They evolve. And they must evolve in the future because we don't know what stresses they're going to face from fires, from [peak] flows, from drought. We have to build in as much resilience as we can, and then trust nature to survive the future in exactly the way it's survived in the past. Rivers have been through much more cataclysmic changes than we can throw at them. If we give them a chance they can self-repair, they can recuperate, they can stop needing us to constantly tend to them.

Lastly, we have to think synoptically. If we parse out every process, every creature, every morphological feature and we try to measure everything that moves; everything that doesn't move; we'll never understand these [river] systems. But if we accept the philosophical view that wisdom comes from a coherent understanding of everything *together*, then we can understand those systems, we can wonder at them and we can benefit from them.

<u>Brian:</u> I want to emphasize that there's a spectrum of approaches to achieving a Stage 0 condition. There's not one part of that spectrum; no one "side" of it that's more valid than another. One breakout group said it would be useful to have guidance on what specific conditions would be more conducive to a particular end of the spectrum. I totally agree. Perhaps those people could reach out to me and we can work together on a diagram of that spectrum.

Stage 0 is just a term; a new term for floodplain restoration. As Becky pointed out [floodplain restoration?] is now a worldwide movement. We've recognized that the ecosystem is completely fractured and is no longer performing for humans if we don't have floodplains working. So I'd like to remind everyone that Stage 0 just a term. I guess it's kind of a nice "buzz" term and that's why it's being used. But I'm not hung up on it. At some point during the workshop I was thinking maybe we should never have called it that. But we did, so let's use it but not get hung up on it.

What Stage 0 and the Cluer & Thorne paper probably did was to redefine what a floodplain is in relation to its channel. We defined a floodplain-connected channel as a channel with very low capacity. That differs from the traditional definition of a floodplain channel, which is a bankfull channel; a 1.5-2 year capacity. Ecologically, those are [as different as] "night and day". I think that is what we really contributed to this floodplain conversation. Stage 0 [channels], if disturbed in some way, can and likely will evolve to a Stage 1. Recall that Stage 1 is also very rich and certainly richer than the former bankfull channel or incised channel members on the [Stream Evolution Model] diagram. So Stage 0 and Stage 1 should be talked about hand in hand. That might remove some questions or uncertainties about how much Stage 0 is needed. Some is better than none, and in almost every case we have no Stage 0 now. Start with some and hopefully we can get to where we ask "do we have enough".

There's no doubt we have monitoring challenges. Monitoring fish is particularly difficult. We have [ESA] listed fish, very low stock populations. They're hard to monitor even in enclosed channels. I think it's going to be impossible to get a "signal" out of the fish population [in response to restoration] at these sites. That's why NOAA Fisheries has largely turned to using population dynamic and conceptual models to guide management and restoration decisions. If we incorporated those in the way we think about how effective Stage 0 projects are, we would at least be asking more focused questions and be able to form better hypotheses.

[I'd also like to add to what Colin said] about uncertainty vs confidence: My take is that we have a lot of certainty in single thread, stable channels. We have a lot of uncertainty about the large, messy, dynamic floodplain systems that can replace them in the Stage 0 concept. Conversely, we have a lot of confidence in stable channels. We're confident that they are low productivity and that they're brittle, not resilient to disturbances; especially constructed habitat that has to be reconstructed frequently. So, where we do have confidence it's sort of misdirected. We also have a lot of confidence that floodplains are more productive and more resilient. I really liked the idea that Colin proposed that we should switch the conversation from our uncertainties to what we're confident in. I think that's a more productive conversation and engages more people in a productive way.

Lastly, I heard a lot of concerns about construction disturbance. That really interests me. We've managed habitat construction projects and channel rehabilitation projects in a very tight regulatory way, particularly around sediment. We force very expensive things on projects, e.g. dewatering, turbidity monitoring, putting up sediment screens and, more importantly, really limiting the scope and scale of projects to such small amounts that they're not going to result in any big ecosystem uplift. So I view valley restoration; Stage 0 restoration the same way I view dam removal. The guiding philosophy that community has adopted is: should we take these dams out incrementally over a series of years to minimize impacts? (The regulatory mindset.) Or is it better to rip them out as fast as humanly possible so that the ecosystem can begin to recover naturally and the species can begin to take advantage of that? The latter approach has become the most preferred and most often used. We can apply that same kind of thinking to floodplain restoration. The more we do faster, the more space the ecosystem has to begin its own natural recovery. After all, salmonids love disturbance. That's what the South Fork McKenzie project shows us- if you create new spawning gravel or just liberate spawning gravel, the salmon show up and use it immediately.

<u>Janine:</u> I want to talk about the context and history of [river] restoration. I think it's helpful to step back and look at [evolution in how we've gone about] restoring PNW rivers over time. When I started in this field we were trying to move people away from using rip rap and we were designing stream [borders? Bottoms?] Why did we do that? Well, it was a step in the right direction although there was a lot of controversy about it at the time. Next, we moved to a single channel, "natural" channel design approach or channel reconstruction. This was another big shift with a lot of questions. Then we started adding wood to rivers which was *very* controversial, with lots of concerns. We had the Wood in World Rivers conferences and a lot of research, which was great. Today, we put wood in almost all of our stream projects. It's no longer controversial. In fact, it actually would be strange to see a project that didn't include wood. It's become that acceptable in our restoration community.

Then we moved to beaver, not long ago. The focus shifted to BDAs and beaver reintroductions. Again, a lot of questions went along with that. So, I want to put this [current] floodplain reconnection approach within that context. I think where we're at is completely natural. We should be asking a lot of questions. Skepticism is good. We're seeing a really high potential that I think we need to explore. But we need to do our due diligence. We've gone through that with other restoration techniques. At least in my experience and career, for this floodplain reconnection I'm seeing more research, more monitoring than I've ever seen in other approaches and also closer connection between researchers and practitioners. I think that's fantastic. I really want to reinforce this idea of the importance of our community of practice. We have a lot to offer. We really do need to keep talking to one another. So I'll leave you with two challenges: There was a group of us many years ago who started an informal group called "Restoration Foresight". We'd speculate: "what's the next big thing? We'd ask: What could we do better?" I would encourage all of you to think about that. We can't assume what we're doing now is good enough. So how do we improve?

Secondly, I work with an amazing group of folks to put out the beaver restoration guidebook. It involved compiling all the information we had, with a $40k grant over two years and a series of workshops. It's been an amazing process of getting folks engaged. That could serve as a template for what we can do with this floodplain reconnection work we're all involved with. If someone could take this on, I could share all the things we did with the beaver restoration guidebook. That could be a great way forward.

Appendix A: Steering Committee member list

Steering Committee Members

Lauren Mork – Upper Deschutes Watershed Council

Mathias Perle – Upper Deschutes Watershed Council

Jared Weybright – McKenzie Watershed Council

Peg Boulay – University of Oregon/Oregon Watershed Enhancement Board

Jamie Anthony – Oregon Department of Fish and Wildlife

Stan van der Wetering - Confederated Tribes of Siletz Indians

Becky Flitcroft – PNW Research Station, US Forest Service

Paul Powers - Deschutes National Forest

Rose Wallick – US Geological Survey

OWEB Staff

Renee Davis - Oregon Watershed Enhancement Board

Ken Fetcho - Oregon Watershed Enhancement Board

Workshop Support Staff

Lisa Gaines - Institute for Natural Resources at Oregon State University

Jeff Behan - Institute for Natural Resources at Oregon State University

Appendix B: Responses to pre-workshop survey

Workshop:

River Restoration to Achieve a Stage Zero Condition

Synthesis of Responses to a

Pre-Workshop Survey of Registrants

Oregon Watershed Enhancement Board

Institute for Natural Resources at Oregon State University

December 2, 2020

Survey background and overview

This document compiles and synthesizes responses to a short survey of persons registered to attend a Stage 0 river restoration workshop sponsored by the Oregon Watershed Enhancement Board. The survey was conducted prior to the workshop to acquire more detailed understanding of the range of registrant knowledge, concerns and priorities regarding restoration intended to achieve a Stage 0 condition.

Survey respondents provided rich and nuanced feedback that proved very useful in helping to guide development of workshop sessions and content. This compiled feedback should also be of interest to workshop attendees in that it illuminates specifics and diversity of knowledge, expectations, questions and concerns among them regarding restoration to achieve a Stage 0 condition. As such, we hope that attendees will take the time to review this material prior to the workshop.

Methods for collating, interpreting and synthesizing survey feedback varied among the different questions posed. Responses were processed in greater depth for some questions than for others. “Raw”, verbatim responses are provided for each survey question. For a few key questions, responses were synthesized in several steps, ultimately pointing to core issues and topics to be addressed at the workshop.

Collated survey responses will also be included as an appendix in the workshop summary report.

OWEB STAGE 0 PRE-WORKSHOP REGISTRANT SURVEY:

COLLATED RESPONSES

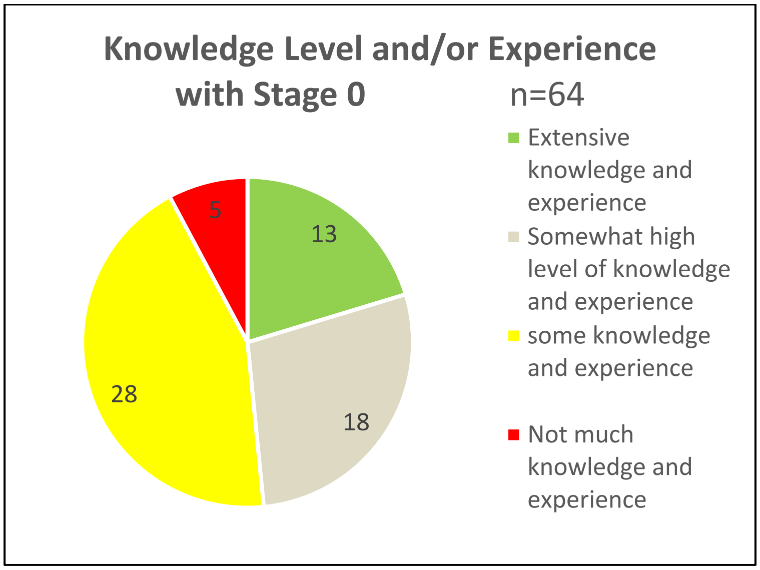
64 total responses (not all respondents answered all questions)

Summary of themes that emerged across all responses

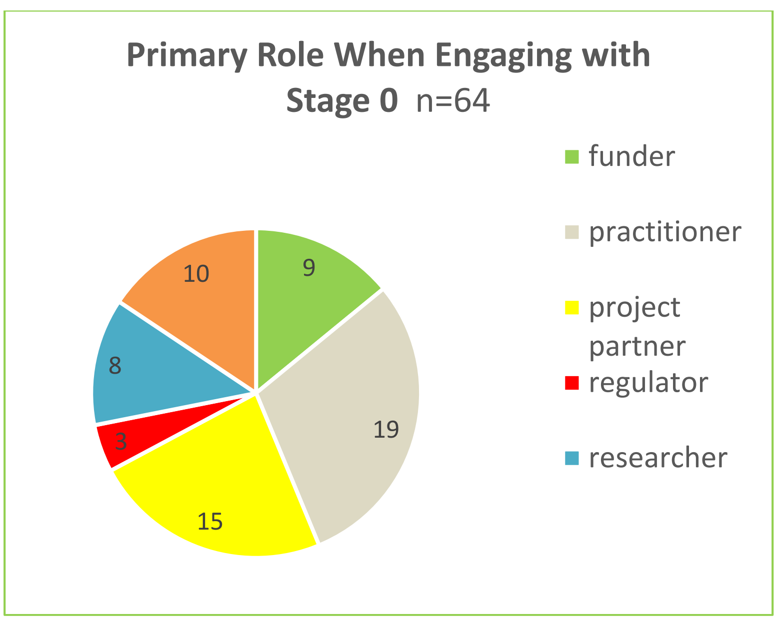
- Lots of excitement and interest in Stage 0 restoration. Many practitioners see it as a "paradigm shift", based on perceptions that it is more holistic, consistent with natural processes and larger-scale than traditional "band-aid" or piecemeal approaches focused on individual ecosystem components.
- A key aspect of this excitement and interest is the expectation that once the river system is "reset" to more resilient baseline conditions with greater connectivity, those conditions can be self-sustaining.
- There is a need for reliable monitoring evidence to confirm that Stage 0 restoration is achieving its primary goals, at least in the near-term, in some systems and for some parameters.
- There appears to be some confusion regarding what Stage 0 restoration is and what it is not, suggesting the need for more precise, consensus definitions of key aspects and components, and description of the Stage 0 "framework".
- Responses indicate that such a consensus framework should include a description of how Geomorphic Grade Line approaches compare and contrast with smaller-scale process-based restoration approaches (e.g. reintroducing beavers, beaver dam analogs, post-assisted log structures).
- There are wide variations in perceptions and many questions regarding timeframes for restoration benefits to emerge. A key aspect of this is that some ecosystem parameters respond immediately (water table) while others take years to decades to show change (e.g. large wood supply). But this uncertainty is also due to the relative newness of Stage 0 projects, lack consensus on what it entails, and lack of long-term monitoring results.
- Some respondents indicated that west side (wet) systems respond faster than east side (dry) systems. Others noted that response to Stage 0 restoration will be linked more strongly to occurrence of high flow events (which are stochastic) than to strict timelines.
- There are concerns that practitioners are jumping on a "bandwagon", and that Stage 0 is still largely experimental but is being implemented too broadly and quickly, in a one-size-fits-all manner. Some respondents suggested the need to slow down, increase monitoring, learn from current projects, and incorporate that knowledge before proceeding with more. But one respondent felt that Stage 0 is being applied too slowly.

- There is a need for more focused, site-specific guidance on designing and implementing Stage 0 projects. Consistent questions about how to prioritize and select sites, and implement Stage 0 restoration in different kinds of systems, e.g. small vs large, east-side (dry) vs. west-side (wet) different geomorphologies, soil types, vegetation types.
- There are consistent concerns about short-term impacts vs long-term benefits, primarily to fish production and fish habitat (including fine-grained sediment, temperature, deeper “holding” pools, etc.) but also other species, e.g. lamprey, invertebrates
- There are concerns about downstream effects of Stage 0 projects, e.g. supplies of large wood and sediment. There are also concerns regarding “unforeseen consequences”.
- There is a need to identify how Stage 0 monitoring should change from traditional methods, and to develop a consistent approach for monitoring Stage 0 projects, while taking into account the need to tailor monitoring to different systems and site-specific stakeholder concerns.
- A particular monitoring need is assessing effects on fish and fish habitat for all life stages.
- There is a lot of support for more monitoring, and ensuring that pre-project data is acquired. Some suggest explicitly viewing Stage 0 projects as experiments, and using BACI designs so that monitoring data can be used for project effectiveness.
- Some respondents noted the importance of maintaining long-term monitoring, since some ecosystem components may continue to evolve over long timeframes. Also, major changes may not occur until a high-flow event happens.
- Practitioners and experts often cited the need for more public education about Stage 0 restoration, why it represents a “paradigm shift” and the potential benefits, in order to increase public support. This will be especially important for projects lower in watersheds with more human infrastructure and land uses.
- Several respondents noted the need for disseminating monitoring information as it emerges and continuing to convene practitioners, regulators and researchers to discuss the questions and concerns that they have.

Survey question 1. What is your knowledge level and/or experience with restoration approaches to create a Stage 0 condition? (Please check one response.)



Survey question 2. What has been your primary role when engaging with restoration approaches to create a Stage 0 condition? (Please check one response.)



Survey question 3. What do you think the restoration approaches to create a Stage 0 condition are intended to achieve on the landscape, and over what time frames? (Please briefly describe.)

Raw Data

- Establish vegetation, allow the hydrology begin to form habitat features, sediment sorting and ecological processes begin to take place.
- To mimic to the extent practical historic floodplain structure and function as characterized by braided, anastomatizing channels through natural processes such as the interaction of high water events and large wood.
- Go back to a natural condition taking into consideration flow regime. It's not always clear how this differs from other restoration methods.
- Re-connection of a floodplain and re-creation of a wetland and stream complex over a shorter time frame than nature could cause change.
- The restoration is intended to promote valley-scale ecological processes (hydrologic, geologic and biological) that aims to reestablish depositional environments to maximize longitudinal, lateral, and vertical connectivity at base flows and facilitate development of dynamic, self-formed and self-sustaining wetland-stream complexes. The time scale is variable based on area geology, biota, and method of restoration. If I had to put a number on it, I'd say 10-50 years.
- Alluvial valley habitat where stream energy/unit area is low and floodplain access is high. Flows are spread across the landscape and allow processes to by dynamic. Where deposition is encouraged and where multiple channels are present at any moment in time. Time frame changes depending on State-0 restoration technique, USFS Geomorphic Gradeline Approach is quicker (2-3 years) than a beaver restoration approach (3-8 years).
- I think the main idea is to re-align the channel with adjacent and presumably now inaccessible flood plains. My understanding is that this should happen nearly immediately or at least within 1 season following implementation.
- Productive aquatic habitat over time periods of decades.
- Restoring the formative processes that created the valley deposit and its former ecosystem richness.
- There seems to be two approaches to Stage 0 restoration, and they represent book ends in approach. The valley re-grading approach is fast with immediate large-scale results and results mature as vegetation grows over the course of a few years. The accelerated erosion and sediment detention approach using BDA's is a small-scale approach that may achieve large results given enough many years and numerous interventions. The choice is primarily an institutional one: is there staff, funding, and permitting to support multiple interventions over many years, vs., one-time funding and permits to accomplish a large intervention.

- Restore degraded valley bottoms from simplified single-thread transport channels to depositional, anabranching, valley-spanning wetland-channel complexes.
- Restoration to Stage 0 resets the valley bottom, creating conditions for the river to process its native materials and restore natural process and function. Some things return immediately (i.e. water table, macroinvert populations) while others within a few years (substrate sorting, island formation, wetland vegetation, fish populations, beaver). Anthropogenic disturbance to these systems took decades to a century so years to a decade of recovery seem appropriate.
- Stage 0 should achieve a dynamic, wood and/or beaver-rich (as appropriate) valley bottom. The stream should be able to reshape its entire valley bottom, although it may not actively reshape its entire valley bottom all the time. Stage 0 should achieve a wood regime characterized by active bankside wood recruitment and dynamic jam formation and breakup; a sediment regime characterized by relatively low transport capacity relative to surrounding reaches, frequent redistribution of sediment, active bank erosion and avulsion, and maintenance of a diverse channel morphology; and a flow regime similar to that of other hydrologic buffers that retains water, recharges groundwater (if appropriate for the environment), and helps maintain a hydrologic regime suitable for native riparian vegetation, fish, and macroinvertebrates. Stage 0 restoration should achieve these conditions within a timeframe suitable for conserving existing native biota, but should focus more on creating conditions that will sustain desirable geomorphic, hydrologic, and biotic processes over longer timeframes.
- Higher natural process function, over centuries.
- To reset stream elevation and gradient to allow natural channel-forming processes to re-establish, with some impacts happening immediately and others much longer term.
- The ultimate desired outcome is dynamic, self-formed, self-sustaining stream and wetland complexes and the biota they support. Meaningful initial progress towards those desired outcomes are often likely to occur relatively quickly (e.g., one to a couple years or more). Timeframes needed to fully attain those outcomes likely differ substantially between sites, ranging from perhaps years to decade or so at some sites and decades to a century or more at others, depending on the dominant biophysical controls operating at landscape, watershed and reach scales. For example, systems wherein herbaceous vegetation, deciduous riparian shrubs and trees, and beaver dams govern key processes are likely to attain desired outcomes much faster than those systems wherein massive logjams associated with old forests do.
- Increased ecosystem improvements across hydrogeomorphic, ecologic and biologic process regimes through setting an environmental baseline where resilient benefits immediately accrue and compound through time.
- Ecological uplift through increased habitat quality, quantity, and complexity. Time frames are context dependent, and relative to watershed context.
- Significantly increased stream/floodplain interaction, benefiting not only instream and riparian habitat quantity/quality for native fish but also a wide range of native plants and wildlife inhabiting the river valley. Improved groundwater storage and hyporheic exchange to improve water temperature and increase resiliency to climate change.

- I believe that there is an assumption that Stage 0 restoration will create floodplains that create and maintain a "shifting mosaic" of aquatic and riparian habitats (e.g., a dynamic surface).
- The intention is to restore fluvial processes that create and maintain an anastomosing channel-wetland complex by reestablishing lateral, longitudinal, and vertical connectivity across all or much of the valley.
- The design and implementation methods intend to get to this dynamic, highly-connected state immediately, but vegetation recovery will take a few to several years, at which point becomes a primary driver of geomorphology.
- Revert the valley form back to the ice age. The glaciers just retreated. You have multiple thread channels that are highly dynamic. Erosion and bedloads are high. As channels figure themselves out (over several years), channels find a path(s) consistent with valley width and gradient. These "stable" streams quickly become vegetated, shaded, and less prone to bank failures. All of this is "better" than attempting to restore a stream without changing its geomorphology.
- I see 2 distinct approaches to creating a Stage 0 condition - (1)GGL/Valley Resetting and (2) biomic/process-based restoration.
- GGL - immediately create and retain in perpetuity a Stage 0 channel form by excavating topographically high areas of the river/floodplain system into topographically low areas of the river/floodplain system. Due to relatively long construction period per acre of habitat created, high level disturbance over a large footprint and reliance on heavy machinery, I am uncertain of the ability of this approach to scale up to a landscape level.
- Biomic/process-based - remove or relax human constraints on biologic and fluvial processes and work with processes to help these systems access a recovery trajectory and evolves the habitat to Stage 0.
- I assume this workshop is primarily regarding the former and the following answers reflect this assumption.
- Create better exchange with floodplains and more complex habitat. Some of this might take several years to develop.
- Naturally reconnect floodplains and help speed up balance of the hydrology.
- Development of sustainable floodplain/in-channel processes and ecological recovery in an expedited time frame. Restoration approach is process-based over greater area of treatment.
- Maximize wetted area and allowing the floodplain to become anastomosing once again.
- Restore the natural processes and functions of the both the river and floodplain. These include sediment transport and deposition, water storage and hyporheic flow, riparian vegetation regeneration and recruitment, food web, etc.
- Reconnecting channel(s) to the floodplain, raising the groundwater table, and creating a depositional environment.

- The aim is to remove artificial structures, landforms and constraints that are no longer needed from a depositional (response) reach and restore the valley floor to something approaching its pre-disturbance condition. If this is approached using earth moving equipment it can be achieved along about 1 km of stream in a single in-water work window. However, nature-based system recovery doesn't really start until the equipment leaves. Some elements of recovery are rapid - the hyporheic aquifer re-hydrates quickly. But it takes time for nature's river restorers to rebuild the full spectrum of habitats in the channel-wetland-floodplain complex. This is also true if heavy equipment is avoided and 'lite touch' or 'process-based' approaches are used instead. However long it takes, Nature delivers restoration outcomes that are more resilient and by most measures preferable to those constructed artificially.

- I think that Stage 0 restoration involves an initially intensive re-contouring of an entire valley, or a portion of the valley not constrained by infrastructure, to remove the impacts of historic human activities on the landscape. Re-contouring the valley allows for hydrologic changes, including reduced flow velocities, increased wetted area, and increase in the valley-wide water table. Those hydrologic changes drive vegetation changes. Once re-contoured, along with any other project actions such as placement of LWD and vegetation planting, the expectation is that conditions in the valley be allowed to change and evolve over time, on the order of decades or centuries, and that those ever-changing conditions would support a dynamic habitat development that in turn supports diverse populations of native flora and fauna.

- While I believe that the goals of Stage 0 restoration are to effect immediate change that supports long-term, natural evolution of habitat (without continued human interference), all Stage 0 sites exist with non-Stage 0 conditions upstream and downstream, and so the reality is that some attention and maintenance will be needed long-term to maintain desired conditions (though recognizing that desired conditions are actually being achieved through allowing for dynamic natural adjustments).

- Restoration of floodplain activation at all flow levels. Time frames depend on the site.

- A valley wide (or as much as you can achieve) connected river/floodplain system with dynamic flow path(s) formation and evolution, sediment deposition and sorting, healthy mature riparian and potentially wetland vegetation all associated with a shallow water table. Time frames for achieving this condition depend on restoration approach (GGL approach vs Low Tech PBR), climate (how quickly plants grow), hydrology and sediment supply in the system but can range from 5-10 years on the "fast" time frame to 10-30 years on the longer time frames.

- Floodplain connectivity / Lower stream velocities / Increase rearing habitats (Timeframes TBD based on higher flow events

- Goal- Natural conditions, Time frame- decades

- Stage 0 restoration approaches are used to restore highly degraded reaches of stream (usually exhibiting incised stream channels isolated from terraced floodplains) to a state where the floodplain and waterway regularly interact during normal rain events (so the floodplain can actually function like a floodplain). These approaches take a process that if left on its own, would take hundreds of years to correct itself, and accelerate it to only a handful of years.

- Stage 0 is a chance to somewhat start over and allow natural processes to guide the restoration of degraded areas and especially repair down or headcutting.
- To achieve a resetting of the valley which will take decades to recover fully
- Slowing water and raising the water table over a relatively short time frame. The slower water and elevated water table will have cascading effects on vegetation and wildlife.
- Increased floodplain connectivity, lateral flow, habitat heterogeneity for the first 5+ years post project, then moving to more defined flow paths over 10-30 years, and hopefully never reverting back to single thread incised condition.
- Valley-wide connectivity with rivers/streams, thereby creating conditions that allow for self-sustaining, unimpeded biological and physical stream processes to occur. This likely takes decades following project implementation, dependent on the hydrological setting.
- Create mobile, self-maintaining channel connected to floodplain with complex habitat, over life span of added LWD or with subsequent added LWD
- Fluvial and hydrological process and function, floodplain reconnection, complex and diverse habitat, water storage and improved water quality
    - Hydrologic connectivity at baseflow - immediately
    - Dynamic and diverse habitat conditions - immediately, and improving with time
    - Elevated water table - immediately, and improving with time
    - Appropriate wetland/riparian vegetation - after one growing season, and improving over the subsequent decades
- These approaches are intended to achieve the characteristics of Stage 0, foremost among them anastomosing channel networks and vertical hydrologic connectivity, and create abundant and high-quality fish habitat. Geomorphic complexity that supports dramatic increases in aquatic habitat quantity and quality can be achieved within one year following a GGL Stage 0 project. Some Stage 0 attributes, particularly establishment of a mature riparian vegetation community in high desert systems, are anticipated to require 5+ years to be fully realized.
- A complex, dynamic floodplain with good connection to groundwater, braided channels, diverse run/riffle/pool hydrology, low sediment load, high water quality, limited downcutting/bank erosion, a healthy riparian, ample fish/amphibian habitat, and diverse macroinvertebrate assemblages. I'm not sure about time frames but I've heard that results are relatively rapid (1-2 years) but I imagine it could take somewhat longer to establish robust riparian vegetation.
- From what I have gathered in attending workshops at AFS, the idea is to set back the riparian landscape to pre-contact and to do it quickly so that it kind of gives a jumpstart to the ecosystem.
- Restoration of a range of natural processes that create and maintain complex and diverse habitats over time. The types of natural processes enhanced will vary based on the

circumstances of a particular location, i.e. sites downstream of a dam will still have impaired sediment transport and flow regime processes. Within this context, the Stage 0 restoration approach seeks to maximize aquatic habitat enhancement across an entire valley bottom as opposed to defined channel or channel network.

- Stage 0 restoration aims to restore alluvial valley conditions to a state similar to that of conditions before Euro-American settlement over a much shorter time frame than traditional restoration strategies.
- Restoring hydrologic, sediment, nutrient, and organic matter connectivity between channel and floodplain; increasing attenuation of downstream fluxes; increasing abundance & diversity of aquatic & riparian habitat; increasing nutrient uptake; increasing biomass & biodiversity (aquatic & riparian).
- Typically, within the implementation time period of the restoration, but then continuing into the indefinite future.
- Reset stream floodplain to main channel connection and sediment transport processes to allow for a more natural channel migration over time
- These approaches are intended to create a highly functional ecosystem by resetting existing conditions to those before anthropogenic disturbances. This approach is meant to jump start these processes but may take many years before a balance is reached.
- Stage 0 has become short hand for anastomosing.... technically it is reconnecting a floodplain (usually with structural forcing) and having multi-threaded channels around vegetated floodplain islands across an entire valley bottom. The term also is used to describe efforts that achieve some connectivity and anastomosing (e.g. Stage 8) and aspire to Stage 0.
- Diverse habitat and restore fluvial processes.
- Restoration of the natural processes and functions of a system over a multi-year timeframe.
- [Restoration is intended to achieve] a more natural river system, potentially over decades.
- Restore floodplain connectivity and natural wood and substrate recruitment mechanisms. Time frame will be dependent on the magnitude and frequency of high flow events rather than calendar.
- The goal of Stage 0 restoration is the establishment of a pre-disturbance, dynamic and quasi-stable network of channels within a floodplain that includes vegetated islands in between those channels.
- Diverse habitat types across channel/floodplain. Some processes may happen quickly, others may take time. Time scale likely dependent on watershed precipitation and flood duration/stage. Likely quicker in high prec. zones (west cascades) than drier zones (east of cascades).
- The goal is to reset the fluvial geomorphic processes to achieve a pre-disturbance setting (not condition) in 1-5 flow seasons.

- Stage Zero projects in theory provide the greatest geomorphological and hydrological foundation for long-term development of habitat conditions.
- This approach intends to reset the geomorphologic and hydrologic context of a reach or multiple reaches to a state that more closely reflects conditions prior to human and/or natural disturbance, which led to simplified and constrained stream processes. The approach can provide immediate changes upon completion, but is intended to initiate a process of stream and habitat development over the next decade or more.
- Restore process & function at floodplain/valley scale. Time frames is likely somewhat dependent on location and design. Willamette sites have been pretty responsive in the short term.
- Restore river dynamism, improve and increase habitat, increase macroinvertebrate diversity and mass, and restore appropriate riparian vegetation. Each of these occur over different timeframes.

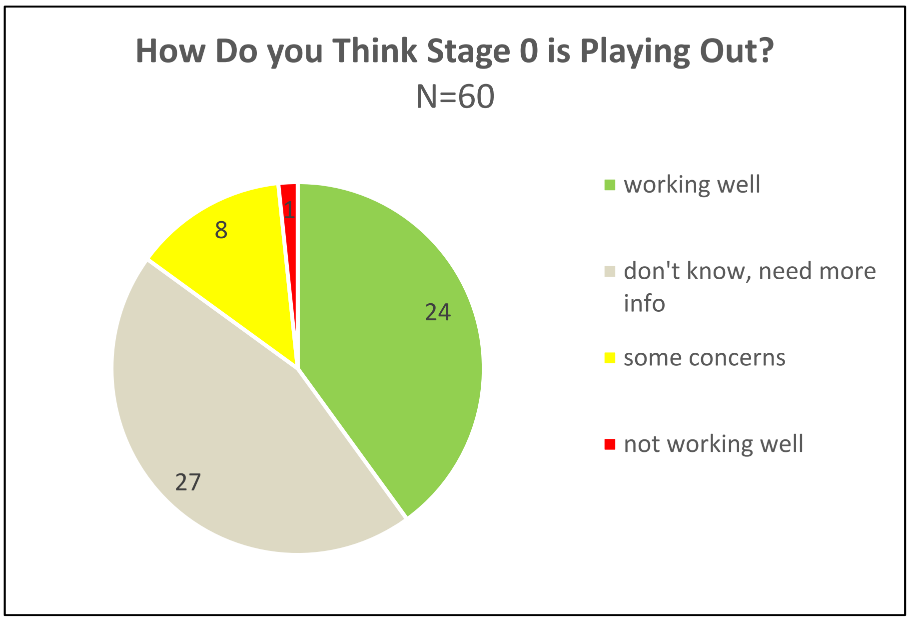
Responses and response clips that addressed timeframe question

- The time scale is variable based on area geology, biota, and method of restoration. If I had to put a number on it, I'd say 10-50 years.
- Time frame changes depending on State-0 restoration technique, USFS Geomorphic Gradeline Approach is quicker (2-3 years) than a beaver restoration approach (3-8 years).
- My understanding is that this should happen nearly immediately or at least within 1 season following implementation.
- Productive aquatic habitat over time periods of decades
- There seems to be two approaches to Stage 0 restoration, and they represent book ends in approach. The valley re-grading approach is fast with immediate large-scale results and results mature as vegetation grows over the course of a few years. The accelerated erosion and sediment detention approach using BDA's is a small-scale approach that may achieve large results given enough many years and numerous interventions. The choice is primarily an institutional one: is there staff, funding, and permitting to support multiple interventions over many years, vs., one-time funding and permits to accomplish a large intervention.
- Restoration to Stage 0 resets the valley bottom, creating conditions for the river to process its native materials and restore natural process and function. Some things return immediately (i.e. water table, macroinvert populations) while others within a few years (substrate sorting, island formation, wetland vegetation, fish populations, beaver). Anthropogenic disturbance to these systems took decades to a century so years to a decade of recovery seem appropriate.
- Stage 0 restoration should achieve these conditions within a timeframe suitable for conserving existing native biota, but should focus more on creating conditions that will sustain desirable geomorphic, hydrologic, and biotic processes over longer timeframes.
- Higher natural process function, over centuries.

- To reset stream elevation and gradient to allow natural channel-forming processes to re-establish, with some impacts happening immediately and others much longer term.
- The ultimate desired outcome is dynamic, self-formed, self-sustaining stream and wetland complexes and the biota they support. Meaningful initial progress towards those desired outcomes are often likely to occur relatively quickly (e.g., one to a couple years or more). Timeframes needed to fully attain those outcomes likely differ substantially between sites, ranging from perhaps years to decade or so at some sites and decades to a century or more at others, depending on the dominant biophysical controls operating at landscape, watershed and reach scales. For example, systems wherein herbaceous vegetation, deciduous riparian shrubs and trees, and beaver dams govern key processes are likely to attain desired outcomes much faster than those systems wherein massive logjams associated with old forests do.
- Increased ecosystem improvements across hydrogeomorphic, ecologic, and biologic process regimes through setting an environmental baseline where resilient benefits immediately accrue and compound through time.
- Time frames are context dependent, and relative to watershed context.
- The design and implementation methods intend to get to this dynamic, highly-connected state immediately, but vegetation recovery will take a few to several years, at which point becomes a primary driver of geomorphology.
- GGL - immediately create and retain in perpetuity a Stage 0 channel form by excavating topographically high areas of the river/floodplain system into topographically low areas of the river/floodplain system.
- Create better exchange with floodplains and more complex habitat. Some of this might take several years to develop.
- Restore the valley floor to something approaching its pre-disturbance condition. If this is approached using earth moving equipment it can be achieved along about 1 km of stream in a single in-water work window. However, nature-based system recovery doesn't really start until the equipment leaves. Some elements of recovery are rapid - the hyporheic aquifer re-hydrates quickly. But it takes time for nature's river restorers to rebuild the full spectrum of habitats in the channel-wetland-floodplain complex. This is also true if heavy equipment is avoided and 'lite touch' or 'process-based' approaches are used instead.
- Stage 0 restoration involves an initially intensive re-contouring of an entire valley, or a portion of the valley not constrained by infrastructure, to remove the impacts of historic human activities on the landscape. Re-contouring the valley allows for hydrologic changes, including reduced flow velocities, increased wetted area, and increase in the valley-wide water table. Those hydrologic changes drive vegetation changes. Once re-contoured, along with any other project actions such as placement of LWD and vegetation planting, the expectation is that conditions in the valley be allowed to change and evolve over time, on the order of decades or centuries

- I believe that the goals of Stage 0 restoration are to effect immediate change that supports long-term, natural evolution of habitat (without continued human interference), Time frames depend on the site.
- Time frames for achieving this condition depend on restoration approach (GGL approach vs Low Tech PBR), climate (how quickly plants grow), hydrology and sediment supply in the system but can range from 5-10 years on the "fast" time frame to 10-30 years on the longer time frames.
- Timeframes TBD based on higher flow events
- Goal-Natural conditions, Time frame-decades
- These approaches take a process that if left on its own, would take hundreds of years to correct itself, and accelerate it to only a handful of years.
- Time scale likely dependent on watershed precipitation and flood duration/stage. Likely quicker in high precipitation zones (west Cascades) than drier zones (east of Cascades).

Survey question 4. Based on what you know to date, how do you think Stage 0 in Oregon is playing out? (Please briefly describe.)



Positive: Working well, overall positive impression

- It is still very early but initial results seem promising as indicated by habitat types and use by fish for spawning in some projects.

- Very effective restoration that is hard to reproduce in many watersheds due to human encroachment on floodplains and numerous landowners adjacent to streams.
- I think the habitat that is being created is excellent, but I think many of these projects are becoming stable transport channels as they don't carry enough sediment to continue the aggradation and channel dynamism. I think the habitat being formed is great for rearing habitat, not as great deep pools holding habitat as the stream energy needed to scour deep pools is lost. I think the riparian habitat and associated water quality improvement are excellent.
- I think the results are very encouraging, although the regulatory community is slower to embrace the results.
- We are connecting valley bottoms at base flow. Restoration of water table has been immediate and biological responses have quickly followed. As a practitioner who has worked on and viewed several of these projects, recovery and use by native plant, macro invertebrate, fish, wildlife and amphibian species has far exceeded my expectations. Greatly reduced velocities and increased complexity have been the keys to project success and the biology on site has been confirming this. Social acceptance of this work has been variable due to long held beliefs about disturbance as well as a threat to "the way we have always done things" in alluvial valley bottoms with past anthropogenic disturbance. Change is hard. Honest discussion is needed.
- There have been some great projects that already resulted in important learning and that will likely continue to do so (S Fork McKenzie, Whychus Canyon, Five-mile Bell).
- Very well. People are asking better questions about the historic range of variability and intrinsic site potential across the full extent of the valley floor rather than just the existing channel.
- Monitoring results and observations from all Stage 0 projects are revealing dramatic improvements in restored processes, habitat, and biota. Although it is early, these results are very encouraging. This new approach is definitely gaining traction across Oregon and beyond.
- Incredibly well. The sites I've seen have responded "as nature intended" and have provided valuable habitat for listed species. The restoration approach is holistic and tackles everything from beaver to riparian plants to streamside roads. When you tackle the whole valley, you're addressing multiple limiting factors which is essential to success.
- More projects are being developed all the time. I think this is great progress in the field of floodplain (and/or estuary) restoration.
- Early-days, but the potential is clear and monitoring results from the S F McKenzie and Five Mile/Bell restorations are more than promising.
- The Stage 0 work that I have been involved with, visited, or seen reports from, has been impressive in its achievements. Through an active Stage 0 community, lessons learned from earlier projects are being applied to later projects, so I have seen greater success in later projects, or in later phases of the same project. The Stage 0 project that I am most familiar with has seen the habitat change from monoculture pasture, dry except for the single incised stream channel, to a wetted area with pockets of water of different depths and flow velocities, a

diverse native population of vegetation and the return of countless species of aquatic and terrestrial animals, all over the course of seven years.

- From the projects I've witnessed firsthand and others I've toured, Stage 0 restorations have been a resounding success. These projects do have a tendency to be expensive, but in my opinion, the suite of long term benefits they provide are worth every penny.
- Stage 0 is accomplishing the goals intended. Process-based restoration seems to be more effective in the long term than restoring individual habitat units with log jams and digging pools. I am hopeful that Stage 0 is providing a more resilient flood plain ecosystem than other restoration strategies, but needs to be evaluated on a case by case basis and is not a "one size fits all" approach.
- So far looks good on gravel-bed streams in western Cascades.
- Promotes process, functions, and ecological health noted above
- I think we need more of it! I think we need as much of it as we can get. Employing both low-tech process-based restoration and GGL design approaches in complement will accelerate recovery toward Stage 0 across the greatest area of geomorphically-appropriate reaches as possible.
- My understanding is that it has worked remarkable well with few drawbacks. I imagine the largest hurdle is the cost for initiating the Stage 0 process.
- Based on my knowledge of and experience with projects in the McKenzie I believe that Stage 0 projects are showing very positive immediate results, in particular when compared to more traditional form-based projects or highly engineer projects. Surveyed fish use, Chinook and trout, on the South Fork McKenzie has shown immediate increases in spawning and rearing. Macroinvertebrate sampling on Deer Creek has shown rapid recolonization of project areas that were highly disturbed during project implementation and increases in biodiversity. Vegetation regrowth on both Deer Creek and the South Fork has been immediate and sustain. Flow velocity has sharply decrease, even during high water events. Place large wood has shown some dynamic movement within the respective project areas, but has not mobilized out of the project areas and into the mainstem McKenzie River where is would cause safety concerns for boaters and the public. Fine sediment has also been largely retained with project areas, sorted by size class, and creating spawning habitats for a range of species not just salmonids (i.e. fines for lamprey).
- I’ve visited wood-based Stage 0 restoration sites (Deer Creek, South Fork McKenzie, Staley, Deep Creek) and meadow restoration sites (Whychus, Lost, Five Mile-Bell) and I think project goals are being achieved remarkably well at these sites.
- I am only aware of a few Stage 0 projects in Oregon, but they seem to be successful in achieving the intended goals
- As noted above, results on Willamette sites are compelling. Fish response and return to sites is telling a great story.

- In the McKenzie watershed, we have a 10-year plan to implement Stage 0 projects each year. The scale of our work is largely inhibited by funding and staffing resources. In areas where Stage 0 is appropriate, early monitoring results have shown that goals are being achieved. Monitoring resources are also limited by funding and staffing.

Neutral/Equivocal: Don’t know yet, need more information

- Too early to tell. S0 has been adopted quickly, several projects, takes time to unfold and there are many things we just don’t know yet. Current projects should be looked at as pilots or experiments
- Seems controversial
- Seems to work in some areas but not others

Too early to tell

- Still in experimental stage - hasn't been done long enough to know long term impacts or results.
- It seems pretty controversial, some love it, others have a lot of concerns.
- I think it's too early to tell.
- Way too early to know. It takes over a decade for vegetation to recover and much longer for the channel and water quality. If the water table is not connected to the surface recovery will take longer.
- It is absolutely no worse the status quo that has failed to restore viable populations of salmon, steelhead, and other native species.
- It's catching on and rapidly becoming the norm for restoring remote (i.e., low-risk), formerly anastomosing (or just those with wide valley bottoms) streams. Currently, there has been a lot of focus on the approach for restoration with insufficient consideration of how that approach could be tailored to restore more stream (i.e., be more cost effective) or how to effectively monitor Stage 0 outcomes to appropriately adaptively manage restored systems, although these things are being actively addressed.
- Working in some areas and not in others.
- Initial results look promising, particularly at sites wherein herbaceous vegetation, deciduous riparian shrubs and trees, and beaver dams govern key processes. Outcomes in bigger systems, wherein old forests strongly influence conditions are less certain because treatments are newer in those areas and the timeframes of ecosystem recovery/evolution are longer.
- IMO Valley Bottom Restoration is transitioning from a "boutique" approach into a more rigorous and codified method for approaching floodplain restoration.
- Some promising projects but the effectiveness and cost/benefit of the approach is largely still debated. There seems to be confusion across regions of the state about what Stage 0 means and how it is implemented. I find that it's often thought to be the GGL approach, but probably

should be considered a restoration result derived from a variety of different approaches. Many vocal proponents, including some blind enthusiasm; mixed with many others that are quietly skeptical.

- The Stage 0 restoration approach (literature supported) provides a broader, holistic context for practitioners and funders to consider when the opportunities are available to protect or enhance floodplains holistically. The CTUIR "Umatilla River Vision" document provides a vision of what a functioning, dynamic floodplain would look like. On a scale, Stage 0 restoration provides the greatest level of enhanced floodplain/river channel processes and ecological potential. However, in context, we have a greater need statewide for stakeholder restoration practitioners to maximize greatest restoration function and ecological potential within the constraints of any given project reach at various scales.
- The technique seems to be gaining acceptance and being applied more widely across the state. Partners are planning the first Stage-0 restoration project in the Grande Ronde Basin.
- It shows higher potential for recovery of aquatic species and habitats than any other restoration approaches that I've seen to date, but it needs rigorous monitoring an evaluation so we can learn from both the successes and failures. The Stage 0 approach is being held to a higher standard in terms of "proving biological uplift" when compared to other restoration approaches such as channel reconstruction and large wood placement.
- We are lucky to have many different projects in Oregon in different states of evolution from which to learn as they continue to evolve.
- Wetter Landscapes with Higher Run-off Flows - Evolution of restoration projects seem to be happening at a quicker rate. Dryer Landscapes with Lower Run-Off Flows & Irrigation Withdraws - Evolution of restoration projects will take considerable time to "evolve".
- It is a mixed bag but the hard part is that it may take longer than anticipated to achieve the desired outcomes.
- Feels like it's playing out at "light-speed." Meaning, there are multiple valley reset type of projects occurring annually with a lack of knowledge as to the long-term evolution of projects that are implemented with this method.
- I think we are continuing to learn with each project and adapt our designs and implementation methods to hone in on better practices.
- Some success stories... some well-intentioned efforts... some confusion..... tons of potential.
- I am unsure how it is playing out, though I have heard about it becoming more common.
- It's unclear from the current examples how applicable this technique will be to areas of mixed ownership in lower elevation streams.
- It is a patchwork of different techniques and experimental attempts to let a river reclaim some of its earlier channels and seasonally connected floodplain.
- Depends on where you are and what the projects goals are. I've only seen east of Cascades.

- At this time, my knowledge of the outcome of Oregon projects is limited.
- No idea
- No idea [2ND]
- Not sure

Some concerns

- Stage 0 is the new "trend", being rapidly adopted, maybe too quickly
- Need so slow down, learn from pilot projects before doing any more.
- Some projects are not being rigorously monitored to assess success
- People seem to be jumping on the Stage 0 "bandwagon"; some projects claiming to be Stage 0 but are not
- There is great interest and energy surrounding the projects. However, individual projects do not appear to have been examined rigorously to see if the Stage-0 restoration projects are meeting their goals.
- [Stage 0 restoration is playing out] interestingly and quickly.
- There are a very good number of GGL projects in a relatively short time period. At least one of the projects has some really great monitoring associated with it. Others have varying levels of monitoring. The community should recognize the need to continue these data sets.
- This is a very intensive and young approach. It seems the community should exercise caution before more rivers, floodplains and restoration funding are used for the implementation of this approach. We have enough pilot projects. Let's study them.
- In certain areas it is doing well and in others due to soil conditions it looks like a mess...although over time it might provide [prove?] to be great.
- So many opportunities out there but implementation not always meeting potential outcomes. Many projects occurring that claim Stage 0 that are not
- Everyone seems to be jumping on it quickly, as the new hot thing. I am a little worried about unintended effects.
- State 0 restoration seems to be a slow-moving process in Oregon, with State & Federal agencies often disagreeing on its efficacy.
- Too little, too slow, too cautious.
- I have knowledge of a number of Stage-0 projects in Oregon. The data thus far has not really shown strong advantages over more formal traditional methodologies, however, in the long-term it would seem that this methodology would have some ecological advantages.

Negative, skeptical, not working well

- From what I have seen and heard about from other Stage 0 is concerning. It seems projects have been implemented in areas where Stage 0 condition are not completely appropriate like moderately confined canyon streams. It seems like this was done just to get a Stage 0 project completed rather than choosing the best method or approach.

Survey question 5. What questions or concerns do you have related to Stage 0 restoration? (Please list your top three concerns or questions.)

Compilation Methods

- *Step 1* – Group responses into "questions" and "concerns". In some cases, the distinction between a "question" and a "concern" appeared to be simply a matter of phrasing. So where it made sense, a few "concerns" were re-phrased as "questions". In other cases, the "concerns" seemed well articulated and weren't really questions.
- *Step 2* – Group the questions & concerns by topic. The topics roughly track those identified for Question #6, monitoring priorities. Some questions and concerns could arguably fit into under more than one topic. A few seemed to add value to more than one topic, and are therefore listed more than once.
- *Step 3* – Organize the questions & concerns within each topic by similar sub-topics. E.g. "fish" within "Biological effects"; "landowner concerns" within "Social and policy issues".
- *Step 4* – Groups of similar questions were combined into a summary question, and associated concerns were grouped with summary questions. For each sub-topic, we provide the summary question and a summary of concerns for each, followed by the full survey responses grouped by summary question.

Please note a shortened summary of the responses to this question is included in Appendix A of this document.

Flora & Fauna

Summary of Questions & Concerns

- *What are the effects on fish during initial stages, and how do fish/fish production respond over the long term (timing/magnitude of response)?* Concerns about effects on fish include short-term negative impacts until longer-term benefits are realized.
- *How does restoration to Stage 0 effect fish at different life stages?* Concerns include whether there has been adequate consideration of short-term life history needs (0 to 5 years), lower base flows through time with decreasing channel-forming flows, whether practitioners are adequately considering adverse impacts (short and long term) to native fish and their life stages before implementation, and that some biologists don't see the opportunities with restoring to Stage 0 (i.e., narrow focus on deep pools and wood as primary habitat features; expectations that restoring a channel to Stage 0 needs to provide habitat for all life stages).

- *How is assessment of limiting factors considered when evaluating whether restoring to a Stage 0 condition is appropriate; what habitat limiting factors are Stage 0 projects best suited to address?* Concerns are that some Stage 0 projects have created habitat conditions that were not addressing primary limiting factors.
- *How does restoring to Stage 0 effect fish passage and migration?* Concerns are that fish passage could be compromised in some systems where anastomosing channels create too many shallow channels, and the potential to interfere with seasonal migrations (e.g., bull trout in summer).
- *What is the habitat response (fish habitat, vegetation) immediately after disturbance and over time; how long does it take to achieve desired habitat features for sensitive fish species?* Concerns are about near-term effects on deep pool habitats.
- *Does restoring to Stage 0 support primary production and create more complex food webs that are associated with more stable and resilient ecological systems?* No specific concerns.
- *How quickly do organisms, including freshwater mussels and other non-fish species, recover from the initial disturbance and over time (e.g., does fish and wildlife use increase)?* No specific concerns.

Survey Responses - Questions & Concerns

What are the effects on fish during initial stages, and how do fish/fish production respond over the long term (timing/magnitude of response)?

- How long does it take for fish production to return after the valley floor elevation is reset and water is returned to the floodplain/site?
- How has it [Stage 0 restoration] impacted fish during the initial stages?
- How have fish recolonized post Stage 0?
- How have fish responded to Stage 0 projects?
- Does it [Stage 0 restoration] produce more salmonids?

Concerns about Fish:

- I'm concerned that there can be short-term negative impacts to fish while longer term processes work out. In some cases, fish are threatened and waiting for natural processes to occur, etc. isn't a good option.

How does restoration to Stage 0 effect fish at different life stages?

- [Question developed by J. Anthony to summarize concerns below]

Concerns about Stage 0 effects on fish at different life stages:

- [I’m concerned that there has been] minimal consideration for the short-term (0-5 years) life history needs of anadromous/resident salmonids, mainly [in] stream systems that have low base flows and ever-decreasing frequency of "channel" forming flows.

- [I’m concerned about] biologists that don't see the opportunity and have their head stuck on 3 ft. deep pools with wood as the only habitat that matters. All streams reaches do not need to provide for all life stages.
- [I’m concerned] that all of the questions regarding potential adverse effects (short and long-term) to native fish and their life-stages are not being thought through by the practitioners prior to implementation.
- [I’m concerned about the] lack of consideration for fish life history needs.

How is assessment of limiting factors considered when evaluating whether restoring to a Stage 0 condition is appropriate; what habitat limiting factors are Stage 0 projects best-suited to address?

- [Question developed by J. Anthony to summarize concerns below]

Concerns about Limiting Factors:

- There have been some projects that perhaps created habitat conditions that were not the primary limiting habitat factor. Not really a concern on the approach, more on limiting factor assessment.

How does restoring to a Stage 0 condition effect fish passage and migration?

- [Question developed by J. Anthony to summarize concerns below]

Concerns about Stage 0 Effects on Fish at Different Life Stages:

- I worry that fish passage could be compromised in some systems where anastomosing channels create too many shallow channels.
- [I’m concerned about] implementation in areas where there are multiple listed species and timing the in-stream restoration to avoid interfering with seasonal migration (i.e. bull trout summer migrations).

What is the habitat response (fish habitat, vegetation) immediately after disturbance and over time; how long does it take to achieve desired habitat features for sensitive fish species?

- Are there impacts to fish habitat downstream right after water is returned to the site?]
- How long does it take for habitat features to form that are needed for sensitive fish species?
- Is the vegetation response what we expect/want?

Concerns about Habitat Response:

- [I have concerns about] immediate deep-water habitats.

Does restoring to a Stage 0 condition support primary production and create more complex food webs that are associated with more stable and resilient ecological systems?

- Does restoring to a Stage 0 condition create more complex food webs that are associated with more stable and resilient ecological systems?

- How much do Stage 0 projects influence and support primary productivity and the aquatic foodweb?

How quickly do organisms, including freshwater mussels and other non-fish species, recover from the initial disturbance and over time (e.g., does fish and wildlife use increase)?

- How quickly do organisms recover from short-term disturbance response?
- How does all of that fill affect mussel populations and other less fleshy wildlife?
- Does fish and wildlife use increase?

Physical (Hydrology and Geomorphology) Effects/Impacts

Summary of Questions & Concerns

- *Are background analyses of watershed hydrology adequately incorporated into project design?* Concerns are that there is a lack of background hydrologic analyses and subsequent effects on projects.
- *Does restoring to a Stage 0 condition result in dryer channels?* Concerns are that channels may become dryer after restoration due to not being connected to the water table and as fines are washed away.
- *What is the long-term durability/sustainability of Stage 0 restoration projects; will watershed processes (e.g., vegetation, hydrology, sediment and wood loading & transport; beavers) be able to sustain Stage 0?* Concerns are about response to large flow events (e.g., 20+year event), channels becoming unstable laterally and/or vertically over time, effects on downstream landowners, goals for wood loading and beavers (need to better understand these processes in Stage 0 to target monitoring and adaptive management).

Survey Responses - Questions & Concerns

Are background analyses of watershed hydrology adequately incorporated into project design?

- [Question developed by J. Anthony to summarize concerns below]

Concerns about Background Hydrologic Analyses:

- [I'm concerned about the] lack of background analyses regarding watershed hydrology and subsequent effects on projects.

Does restoring to a Stage 0 condition result in drier channels?

- [Question developed by J. Anthony to summarize concerns below]

Concerns about Channel Drying/Lower Flows:

- [I have concerns about] channels becoming drier after restoration due to not being connected to the water table and as fines are washed away.

What is the long-term durability/sustainability of restoring to a Stage 0 condition projects; will watershed processes (e.g., vegetation, hydrology, sediment and wood loading & transport; beavers) be able to sustain Stage 0?

- What is their long-term "durability" (i.e., will natural stream processes just shove the wood out of the channel, allowing new head cuts, down cutting, and reforming of simple, single-thread channels)? What are their long-term risks - releasing large amounts of in-stream wood to downstream transport in the next major flood?
- Since these are alluvial valleys and supposed to be dynamic, there needs to be a steady supply of sediment to maintain the processes. I think many of the projects are larger than they should be, where sediment deposition only occurs immediately downstream and then further downstream areas are starved of sediment. Without sediment or beaver for continued disturbance these downstream portions of projects see excellent riparian recovery that then armors banks with roots and vegetation, these low gradient low power systems then don't have the energy to do work on the banks and instead the channel incises.

Concerns about Long-Term Sustainability:

- I'm mildly concerned about what will happen to Stage 0 projects once we get a large flow event (20+ year event). There are challenges with such flows in regard to "standard" large wood and boulder restoration projects, but the cost of these projects is not even in the ballpark relative to Stage 0 projects.
- [I have concerns about] channels becoming laterally and/or vertically unstable.
- [I have concerns about] downstream impacts from project area instability.
- [I'm concerned about the] long term impact of projects, in particular large wood and boulder placements and effect on downstream landowners.
- I worry about goals for wood loading: they seem to be based on practitioner experience and historical wood loading, but we need to understand the relationship between wood load, wood characteristics, and wood function to better target monitoring and adaptive management hypotheses.
- I worry about goals for beavers: they seem to be based on practitioner experience and historical [beaver presence?] but we need to understand the relationship between [beaver & dam density, characteristics, functions?] to better target monitoring and adaptive management hypotheses. *[This comment was originally "same as for wood loading above, but for beavers" so I (Jeff) took a stab at trying to clarify it.]*

Water Quality Effects/Impacts (Temperature, Nutrients, Turbidity)

Summary of Questions & Concerns

- *How does restoring to a Stage 0 condition influence stream temperatures?* Concerns are centered on expectations of increased temperature due to slower, shallower water with less shade and whether increased heterogeneity of temperature and refugia can offset impacts.
- *How does restoring to a Stage 0 condition affect near-term nutrient and sediment loading to streams?* Specific questions are about effects on nutrient loading and sedimentation in the first year [post implementation] and the role of groundwater and geochemistry.
- *What are the effects of Stage 0 projects on turbidity and fine sediment transport; how can impacts be minimized?* Concerns are about minimizing impacts, controlling mobilization of fine sediment, accounting for upstream and downstream processes, and effects on local uses.

Survey Responses - Questions & Concerns

How does restoring to a Stage 0 condition influence stream temperatures?

- What are water temperature impacts after initial project is completed?

Concerns about Impacts to Water Temperatures:

- My biggest concern is increased stream temperature. I hope that we see a trend of decreasing stream temperature as water begins to "pick" more stable channels until there is another large flow event.
- [I have concerns about] short-term consequences such as increases in temperature [that] can occur.
- I think we need to answer the temperature question: Stage 0 in theory substitutes thermal heterogeneity and therefore temperature refugia for fast transport to keep water cool.
- [I'm concerned] that for GGL projects that completely reset floodplains there could be increases in stream temperatures and degradation of water quality. Slower water, spread thinner with less shade...

How does restoring to a Stage 0 condition affect near-term nutrient and sediment loading to streams?

- What does Stage 0 do in terms of nutrient loads to streams and direct impacts of sedimentation during the first year?
- What is the role of groundwater and geochemistry?

What are the effects of Stage 0 projects on turbidity and fine sediment transport; how can these impacts be minimized?

- How do we implement Stage 0 restoration projects with as little impact to natural resources (e.g. turbidity) as possible?

Concerns about Turbidity/Sediment Transport:

- [I'm concerned about] turbidity issues, taking into consideration upstream/downstream issues, local uses of the riverine system.

- [I have concerns regarding] fine sediment control.

Long-term effects & resilience, including to climate change

Summary of Questions & Concerns

- *What is the long-term durability/resilience of Stage 0 restoration projects (stream processes; climate change, sediment & geomorphic processes)?* Concerns are that projects seem to be based on historical conditions inferred from topography but could be improved by more explicit consideration of existing and future climate/hydrologic changes expected from climate change, determining if Stage 0 will be sustainable within the geomorphic context or controls, longevity in artificially stable environments (e.g., flows below dams), and stability of structures.
- *What are the short-term (months to years) and long-term (years to decades to centuries) trajectories of physical and ecological response to restoring to a Stage 0 condition; how do these trajectories vary based on environmental context (e.g., ecoregions; dry vs. wet areas)?* No specific concerns.
- *Can coordinated, system-wide restoration programs deliver Stage 0 projects so that restoration makes a difference at the watershed scale and in time to mitigate for impacts from climate change?* A concern is that there is risk associated with not restoring to Stage 0 given risks associated with climate change, low flows, and threatened anadromous populations.

Survey Responses - Questions & Concerns

What is the long-term durability/resilience of Stage 0 restoration projects (stream processes; climate change, sediment & geomorphic processes)?

- What is their long-term "durability" (i.e., will natural stream processes just shove the wood out of the channel, allowing new head cuts, down cutting, and reforming of simple, single-thread channels)?
- Is it [Stage 0 restoration] resilient to climate and sustainable from a sediment and geomorphic perspective?
- Is the connectivity across the floodplain/valley maintained into the future?
- Can these projects prove to be successful over long periods of time?
- Can there be consequences to existing fish habitat as climatic changes increase?

Concerns about Long-Term Durability/Resilience:

- Many projects seem based on historical conditions inferred from topography, but may be improved by a more explicit consideration of...existing and future climate. I rarely hear these things mentioned in Stage 0 planning efforts and I worry that some projects may suffer (i.e., require more heavy-handed adaptive management) due to a lack of planning for things like hydrologic changes expected due to climate change.
- Determining if the project is sustainable within the geomorphic context or controls is one concern.

- Questions remain about the longevity of the projects in stable environments (dams are the stabilizer).
- [I have concerns about the] stability of structures in different arrangements/concentrations.

What are the short-term (months to years) and long-term (years to decades to centuries) trajectories of physical and ecological response to restoring to a Stage 0 condition; how do these trajectories vary based on environmental context (e.g., ecoregions; dry vs. wet areas)?

- What are the short-term (months to years) and long-term (years to decades to centuries) trajectories of physical and ecological responses to Stage 0 restoration? How does environmental context influence those trajectories?
- I'm very interested to see how the approach is working in different climatic regions, specifically wetter west side systems versus dry east side systems.
- How long will the system take to reach a new dynamic equilibrium? Will it [this new dynamic equilibrium] last? Or will the channel return to a less dynamic single thread form?
- Do the long-term benefits truly outweigh the short-term disturbances, and if so, what sort of time frames should we expect?

Concerns about short-term and long-term trajectories of physical and ecological responses

- Depending on the site, the realized ecological function, while perhaps a bit larger in the long-term for Stage-0 projects, is often not realized for a number of years due to the natural hydrologic and vegetative processes that are necessary for the system dynamics to evolve.

Can coordinated, system-wide restoration programs deliver Stage 0 projects so that restoration makes a difference at the watershed scale and in time to mitigate for impacts from climate change?

- How can we deliver Stage 0 projects in the 'beads' in fluvial systems in coordinated system-wide programs, so that restoration makes a difference at the watershed scale and in time to mitigate climate change?
- What is the risk of not using a Stage 0 approach in this moment when low flows, climate change, and disturbances outside of the NRV [Natural Range of Variability] continue to threaten salmon populations?

Risks, Unforeseen Consequences, Levels of Disturbance

Summary of Questions & Concerns

- *What are the long-term risks for areas downstream from project areas (e.g., flood transport of placed wood, etc.)?* Concerns are about environmental and downstream impacts.
- *What are the possible unintended consequences or impacts from project failure over the long term (e.g., loss of near-project sources of large wood, downstream transport of wood placements, etc.)?* No specific concerns.

- *What is the risk of <u>not</u> restoring to Stage 0 (i.e., the decision to maintain status quo in terms of restoration approaches)?* A concern is that there is risk associated with not restoring to Stage 0 given risks associated with climate change, low flows, and threatened anadromous populations.
- *How do we balance the Stage 0 scale of restoration (large disturbance footprint) with impacts to existing fluvial and biological processes and potential to disturb culturally sensitive areas?* Concerns include that stakeholder practitioners, agencies, funders and public to consider the Stage 0 scale of restoration in context of addressing deficient constrained and incised channels across the landscape but also that this scale of restoration has potential to cause significant disruption to ecological processes and culturally sensitive areas like floodplain terraces.

Survey Responses - Questions & Concerns

What are the long-term risks for areas downstream from project areas (e.g., flood transport of placed wood, etc.)?

- What are their long-term risks - releasing large amounts of in-stream wood to downstream transport in the next major flood?
- What are the increased risks, and how can those be planned for?

Concerns about Risks:

- [I'm concerned about] environmental and downstream impacts.

What are the possible unintended consequences or impacts from project failure over the long term (e.g., loss of near-project sources of large wood, downstream transport of wood placements, etc.)?

- IF Stage 0 projects fail, at what time period is that acceptable and what are the costs (from an environmental perspective)? Logic track...Stage 0 projects heavily disturb the riparian area and typically utilize trees from the riparian area to be placed as grade controls and habitat features in the stream. If the project fails during a large flow event, have the future sources of large wood been mostly taken away? How long for recovery?
- What are their long-term risks - releasing large amounts of in-stream wood to downstream transport in the next major flood?
- What are the unintended consequences or potential failure modes?
- What are potential unintended consequences?
- Have there been any mistakes or unintended consequences as a result of Stage 0 projects?

What is the risk of <u>not</u> restoring to Stage 0 (i.e., the decision to maintain status quo in terms of restoration approaches)?

- What is the risk of not using a Stage 0 approach in this moment when low flows, climate change, and disturbances outside of the NRV [Natural Range of Variability] continue to threaten salmon populations?

How do we balance the Stage 0 scale of restoration (large disturbance footprint) with impacts to existing fluvial and biological processes and potential to disturb culturally sensitive areas?

- [Question developed by J. Anthony to summarize concerns below]

Concerns about the Initial Disturbance Footprint:

- [I'm concerned about the] disturbance footprint - huge! And generally in culturally sensitive areas. Example - Terraces on or near floodplains, which are commonly called out as 'cut' areas in the GGL approach, were often hot spots for Native Americans. The approach also disregards, disrupts or destroys any existing fluvial or biological recovery processes occurring at the restoration site.
- [I'm concerned about] excessive disturbance during construction.
- The Stage 0 scale of restoration is important for stakeholder practitioners, agencies, funders and public to think about restoration in context of addressing deficient constrained and incised channels across the landscape, and increasing water inundation more frequently on the floodplain for natural flood control and floodplain/channel restoration ecosystem improvements.

Site selection or prioritization; restoration design guidance; clarification of Stage 0 terms & methods

Summary of Questions & Concerns

- *How is Stage 0 defined – What is it, and what is it not?* Concerns include oversimplification of complex systems, restoration approaches that are erroneously termed "Stage 0", and differing views among restoration practitioners about what Stage 0 is and where restoration to Stage 0 can be implemented.
- *Where is it appropriate to restore to Stage 0 (stream size/order, alluvial vs bedrock systems)?* Concerns include whether an appropriate range of stream sizes for restoring to a Stage 0 condition has been defined, appropriate placement on the landscape considering geomorphic constraints, whether evaluation of site appropriateness based on historical conditions could be strengthened by including current or projected conditions (e.g., hydrology, sediment/wood regimes, climate), and attempts to restore to Stage 0 at inappropriate sites by practitioners eager to apply a new tool.
- *What approaches are available to restore to Stage 0?* Concerns about methods include a lack of definition of the various methods for restoring to Stage 0, conflating certain methods (e.g., GGL) with "Stage 0", applicability of different methods to different locations or ecoregions, and the challenge of adjusting expectations to a longer term, phased and adaptive restoration process.
- *What guidelines or guidance exist for determining site appropriateness and design (e.g., appropriate restoration approach, implementation methods; key design considerations)?* Concerns center on limited technical design and implementation guidance and opportunities for on-site training as well as how to consider connections of processes (e.g., wood and sediment transport) and unrestored reaches upstream and downstream of project areas.

- *What are the considerations for risk to infrastructure?* Questions involve site selection and design considerations for more developed locations lower in watersheds.

Survey Responses - Questions & Concerns

How is Stage 0 defined – What is it and what is it not?

- Is Stage 0 restoration just a new term for restoration of natural processes and functions?
- I would like more info about how it [Stage 0 restoration] is implemented and how it compares to other forms of restoration.

Concerns about Definitions:

- [I'm concerned about what I see as] over simplification and generalization of complex [river] systems.
- I'm concerned about] people conducting Stage 0 that are not really doing Stage 0.
- I believe practitioners have different views of what Stage 0 restoration is and where such work can be implemented.

Where is it appropriate to restore to Stage 0 (stream size/order, alluvial vs bedrock systems)?

- Is there a size of stream or a size range, etc. that Stage 0 should not be performed on? The only truly alluvial systems I have the ability to conduct restoration projects on my district are 4th or smaller streams. Is there any reason Stage 0 projects should only be done on the large systems they seem to be done on (from what I've seen)?
- Can it [Stage 0 restoration] only be applied to floodplain rivers? What about bedrock dominated systems?
- How can we deliver Stage 0 projects…in coordinated system-wide programs? Not Stage 0 everywhere - that's nonsensical - but taking advantage of floodplain reconnection where appropriate and in ways that create enough primary productivity hot spots linked by organism-passage transport reaches to resiliently power an abundant and diverse river ecosystem.
- Many projects seem based on historical conditions inferred from topography, but may be improved by a more explicit consideration of the existing flow, sediment, and wood regimes, as well as existing and future climate.

Concerns about Site Appropriateness:

- [I'm concerned that the] range of streams suitable for Stage 0 has not been determined yet.
- [I'm concerned about the] geomorphic appropriateness of project locations.
- [I'm concerned that] because it's new and exciting, practitioners are eager to employ the approach, including on sites where it may not be appropriate.

- Concern - appropriate placement on the landscape - unconfined or semi-confined alluvial valley - example - Threemile Creek in the Klamath project is placed in a reach that has a high degree of confinement by colluvium, high slope and intermittent side terraces.

What approaches are available to restore to Stage 0?

- What are the commonly used mechanisms to establish Stage 0 restoration?
- How should [practitioners] go about setting the stage for the river to restore all or some of its past area of influence?

Concerns about restoring to a Stage 0 condition approaches

- I am concerned that geomorphic gradeline is becoming conflated with Stage 0 restoration.
- For the most part, there seems to be the GGL approach or the BDA approach, and not much clearly defined in between. If the Stage 0 community could better define approaches that can achieve a Stage 0 result on sites with various constraints that preclude GGL (landowner concerns, infrastructure constraints, cost, etc.) then the Stage 0 restoration strategy/condition would be accessible and achievable for a much wider range of practitioners and project sites.
- [I have concerns regarding] the use of valley reset type of Stage 0 restoration using identical implementation methods regardless of ecoregion.
- There are a lot of ways to achieve anastomosing, but it is important to choose an appropriate riverscape based on hydrogeomorphic setting. It is important that different techniques (e.g. geomorphic grade line, low-tech process-based restoration, etc.) that can be used to achieve anastomosing are cast as complimentary and sometimes even a hybrid of the two is appropriate. My big question/concern is how to convince an industry too accustomed to this "one and done", "get in, get out" construction mentality that patience, phased treatments and adaptive management are what are necessary to get processes to either a) do the work for you, or b) play along with your work.

What guidelines or guidance exist for determining site appropriateness and design (e.g., appropriate restoration approach, implementation methods; key design considerations)?

- What guidelines will practitioners and backers use to know where this restoration approach is appropriate?
- Where can reliable [project?] design guidance be found?
- Where is [Stage 0 restoration] best implemented? Where is it not? What size stream best fits this scenario? Is it successful in low precipitation zones?
- What are the site characteristics of a project site that dictate the use of this practice?
- Is it [Stage 0 restoration] applicable to the project areas I can do work in?
- What are Best Management Practices for constructing in Chinook spawning reaches?

Concerns about Available Guidance:

- My top concern is practitioners with limited experience having sufficient guidance and knowledge on the appropriate context/location for application of this approach.
- As a practitioner who has been involved in at least seven Stage 0 projects, I understand the nuances of utilizing the tools, interpreting the data, and designing projects, particularly around constraints. My primary concern is that new practitioners will take on Stage 0 projects without experience in all of these components. There is a science and art to it that can only truly be learned through experience.
- [I'm concerned about the] limited availability of on-site training for practitioners and contractors.
- How well are we enumerating the processes of hydrology and wood - sediment transfer in the planning and design of these projects?
- [I have questions about?] interconnection to upstream and downstream connections to stage zero project, construction specifications.

What are the considerations for risk to infrastructure?

- As practitioners begin to "move down the watershed" to apply Stage 0 or similar methods to more developed areas, what are the site choice and design elements that need to be considered or modified?
- How [do we] determine candidate stream reaches given limitations of human alterations and infrastructure?

Monitoring & Project Assessment

Summary of Questions & Concerns

- *How can we comprehensively monitor (over the long term) a consistent suite of Stage 0 project objectives, across at least a subset of project sites, to adequately capture effects? Outcomes could include a standardized, replicable Stage 0 monitoring framework, "standards of practice" for Stage 0 projects, assessment of cost-benefit and rigorous quantification of outcomes and benefits.* Concerns are about needs for data collection and performance standards for project evaluation, design evaluation standards for assessing project risk and success, lack of robust biological/ecological monitoring relative to physical/geomorphic monitoring, maintaining sustained funding for long-term monitoring, and whether there has been sufficient review of implemented projects (e.g., lack of scientific evidence to support more widespread implementation).
- *What monitoring metrics are (1) most sensitive to restoring to a Stage 0 condition, (2) capture spatial and temporal heterogeneity (e.g., of temperature), and (3) can be measured and interpreted across a range of sites.* Concerns are the ability to provide rigorous monitoring results (e.g., temperature, substrate, macro abundance) to respond to criticism and issues of concern.
- *Will monitoring be able to provide a signal of success through the ecological noise (e.g., water transit time, predators, hydrosystem, and variable ocean conditions)?* Concerns are whether other

issues, described above, will mask the benefits of Stage 0 due to compensatory mortality of any demographic benefit from the restoration effort.

- *What are the expected timelines for ecological outcomes or impacts from restoration to Stage 0?* Concerns include uncertainty about how long will it take to see desired ecological outcomes, how and over what time scales projects [habitats] will evolve, lack of long-term research and monitoring data (important to continue monitoring at older sites), and actual long term responses.

Survey Responses - Questions & Concerns

How can we comprehensively monitor (over the long term) a consistent suite of Stage 0 project objectives, across at least a subset of project sites, to adequately capture effects? Outcomes could include a standardized, replicable Stage 0 monitoring framework, "standards of practice" for Stage 0 projects, assessment of cost-benefit and rigorous quantification of outcomes and benefits.

- How [can we] comprehensibly monitor these restorations in a manner that adequately captures their effects (ecological, water quality, etc.)? It would be great to develop a standardized, replicable Stage 0 monitoring framework.
- How does the industry establish a consistent suite of project objectives and criteria that lead to "standards of practice" that will stratify the approach from falling into a common vernacular? (When the inevitable occurs where a project results in controversy or is challenged as a failure, the approach should not be vulnerable to criticism that has impacted "Rosgen" or "BDA" [Beaver Dam Analog?] projects.)
- I consider it vital to have standardized, systematic, long-term (i.e., longer than 1-3 years) monitoring across at least a subset of the project sites. This will facilitate adaptive management, provide data that can be used to assess cost-benefit ratios for projects, and allow quantitative demonstration of project benefits that can be presented to observers who are critical of Stage 0 restoration.

Concerns about Standardization and Coordination:

- [There is a] need for data collection and performance standards to evaluate success.
- [There is a] need for design evaluation standards to assess risk and success of projects.
- The physical and geomorphic effects of Stage 0 are more easily understood. What is lacking to date is robust biological/ecological monitoring.
- My primary concern is maintaining funding and existing monitoring programs to document changes over time to support initial observations and monitoring data.
- [I'm concerned that there is] not enough review of implemented sites. Annual monitoring of channel formation, flood plain connection during flood events, and veg patterns would be my key questions for those projects that have been on the ground for at least a few seasons and have experience at least a 25 year event during those few seasons.

- [I'm concerned about the] lack of documented scientific evidence to support the more wide spread usage of Stage 0 restoration to enhance agencies' ability to plan and implement projects.

What monitoring metrics are (1) most sensitive to restoring to a Stage 0 condition, (2) capture spatial and temporal heterogeneity (e.g., of temperature), and (3) can be measured and interpreted across a range of sites?

- Which ecological metrics are most sensitive to restoring to a Stage 0 condition? Which metrics can be measured and meaningfully interpreted across a range of restoration sites?
- How do we measure temperature spatial and temporal heterogeneity?
- What are the metrics of success for these projects? Once agreed upon, let the data speak for itself.

Concerns about Monitoring Metrics:

- [I have concerns regarding] our ability to provide proven monitoring results (temperature, substrate, macro abundance) to respond to criticism and issues of concern.

Will monitoring be able to provide a signal of Stage 0 success through the ecological noise (e.g., water transit time, predators, hydrosystem, and variable ocean conditions)?

- [Question developed by J. Anthony to summarize concerns below]

Concerns about Signal Detection:

- I'm concerned that due to other issues in the migratory corridor (e.g., water transit time, predators, and other negative impacts of the hydrosystem) and variable ocean conditions that the benefit of stage-0 will not be noticed due to compensatory mortality of any demographic benefit from the restoration effort.

What are the expected timelines for ecological outcomes or impacts from restoration to Stage 0?

- It would be great to document the Stage 0 restoration process from pre to post, to map out expectations and associated timelines.
- How long do we have to wait to achieve those ecological conditions that are desired using this practice?
- [I have questions regarding] evolution timeframes.

Concerns about Timelines for Ecological Outcomes:

- [I have some concerns regarding] expectations and timeframes with those expectations. How long will it take to see results?
- The short-term effects and benefits of Stage 0 projects are becoming more and more understood, but no long-term data exists yet because the approach is so new. It will be very important to continue monitoring the older projects to learn about longer-term effects.
- [I have concerns about the] lack of long-term research on the effects of Stage-0 projects.

- [I'm concerned that] long term response not yet documented.

Social, Policy & Economic Issues; Information Synthesis, Sharing & Outreach

Summary of Questions & Concerns

- *How can restoring to a Stage 0 condition projects and regulatory permitting requirements be better aligned for improved efficiency, timelines, and project delivery?* Concerns include the need for fish passage to be a larger part of the initial communication between practitioners and regulatory agencies if providing fish passage is a necessity for the short term as well as concerns about permitting hurdles reducing efficiency of project implementation.

- *Is restoration to Stage 0 a cost-effective restoration approach?* Concerns are that Stage 0 restoration projects are high costs, whether there is/will be sufficient available funding, whether high project costs are justified without fully understanding long-term impacts or benefits, whether it is possible to do an analysis of costs vs. benefits or ecological return-on-investment, and the carbon balance of these projects.

- *What have restoration practitioners learned (water quality/quantity monitoring reports, direct and indirect effects to biota) from Stage 0 restoration projects; what are the pros & cons, and how can information be shared to communicate results and build social support?* Concerns are the multiple phases of projects have been funded and implemented on the basis of fish habitat restoration without reporting or sharing of monitoring results (water quality/quantity, effects on fish, lessons learned from previous phases, and that a robust monitoring program, combined with effective outreach may be necessary help to allay concerns from some potential project partners, funders, and permitting agencies.

- *How can concerns about infrastructure be addressed in areas of mixed land ownership and more developed valley bottoms; Is Stage 0 compatible with land uses and landowner expectations in these areas?* Concerns are that it is unclear whether restoration to Stage 0 will be in areas of mixed ownership (e.g., lower elevation streams; valley bottoms with significant infrastructure), that landowners or the public may have concerns about unconstrained river channels and sediment/wood accumulation, and that some will want to default to Stage 0 approaches everywhere.

- *What is needed to address the misalignment of expectations for post-restoration channel stability (i.e., conventional channel restoration) and the expectation of dynamic flow paths at Stage 0?* Concerns are that after restoration to Stage 0, some landowners may want to stabilize channels rather than leave the system dynamic and that some of the opposition comes from long-term perception of valley bottoms as transport reaches and wetlands as "ugly and messy" (how to shift some of the perception baseline on expectations for a healthy stream).

Survey Responses - Questions & Concerns

How can Stage 0 projects and regulatory permitting requirements be better aligned for improved efficiency, timelines, and project delivery?

- How does the industry approach a consistency in regulatory permitting and review so that efficiencies in schedule, timeline and project delivery can be secured?
- What to expect, or how to streamline the permitting process for Stage 0 restoration projects? It would be great to develop a standardized Stage 0 permitting process, so practitioners knew what to expect, and could plan accordingly.
- How do we get regulatory agencies on board?

Concerns about Regulatory Requirements:

- If fish passage is a necessity for the short term that should be a larger part of the communication between the practitioners and the agencies at the beginning.
- [I'm concerned about] permitting hurdles.

Is restoration to Stage 0 a cost-effective restoration approach?

- Is this the most efficient use of limited restoration dollars? The projects are expensive, can likely only be implemented in relatively few spots, and even if they work as well as is hoped - can they have a significant impact on the resources they are designed to support?
- How do we do the work more cheaply?
- Is it [Stage 0 restoration] worth the financial investment?

Concerns about Cost Effectiveness:

- [I'm concerned about] available funding for project work.
- [I'm concerned about the] high cost [of GGL projects] without fully understanding long-term impacts or benefits.
- How can we quantify benefits of these projects?
- Do the benefits really outweigh possible negative effects?
- [I'm concerned about the] overall cost of projects, in particular the cost at the design phase, including hydrological designs and modeling. Finding funding for this design can be difficult. This is often a necessary and expensive initial step to be able apply for implementation funding.
- Some grant reviewers ask understandable questions about cost in relation to habitat return. I think there is a case for cost-benefit but it would be helpful to be able to articulate more specific evidence of this.
- Concern - Carbon balance of project - lots of diesel burned in this project type - with the recent correlation of 1 ton of CO_2 emitted = 3 sq meters of permanent sea ice loss, the restoration community is confronted by the fact these projects trade Stage 0 habitat for permanent sea ice. How much so would be interesting to know.

What have restoration practitioners learned (water quality/quantity monitoring reports, direct and indirect effects to biota) from Stage 0 restoration projects; what are the pros & cons, and how can information be shared to communicate results and build social support?

- Is there social support for this work? Where there isn't, how can information be shared so informed decisions can be made?
- What have the practitioners of Stage 0 restoration learned? Pros and cons?
- How do we prevent Stage 0 from becoming the latest fad?

Concerns about Social Support/Information Sharing:

- Multiple phases of implementation keep getting funded and implemented in the name of fish habitat restoration without:

  a) reports of water quality/quantity monitoring results,

  b) direct and indirect effects to fish; and

  c) lessons learned from previous stages being shared or discussed.

- The initial implementation of Stage 0 projects involves massive disruption to the existing habitats. I don't really have concerns about that, as long as the project includes pre-project animal relocation and vegetation transplant, as appropriate. I see the increased post-project habitat extent and quality as justifying the disruption. I do see this being a major concern for some potential project partners, funders, and permitting agencies, though, as well as the public. I hope that a robust monitoring program, combined with effective outreach, will help to allay concerns.

How can concerns about infrastructure be addressed in areas of mixed land ownership and more developed valley bottoms?

- [Question developed by J. Anthony to summarize concerns below]

Concerns about Infrastructure:

- It's unclear from the current examples how applicable this technique will be to areas of mixed ownership in lower elevation streams.
- People must realize that there are valley bottoms where this strategy is not feasible (e.g., infrastructure considerations).
- Landowners/public have concerns with unconstrained river channels and sediment/large wood accumulation.
- [I'm concerned about] people thinking this should be done everywhere and jump to Stage 0 as their first objective.

What is needed to address the misalignment of expectations for post-restoration channel stability (i.e., conventional channel restoration) and the expectation of dynamic flow paths at Stage 0?

- [Question developed by J. Anthony to summarize concerns below]

Concerns about Expectations for Stability:

- [I'm concerned that] after restoration is complete, landowners upstream, downstream, or in the project area may want to "stabilize" the stream area rather than leaving it dynamic.
- I'm concerned that there has been a shift in the baseline for what is a "healthy" stream. For generations we have developed a belief that valley bottoms are transport reaches and wetlands are "ugly and messy" and this belief is the basis for much of the resistance to Stage 0.

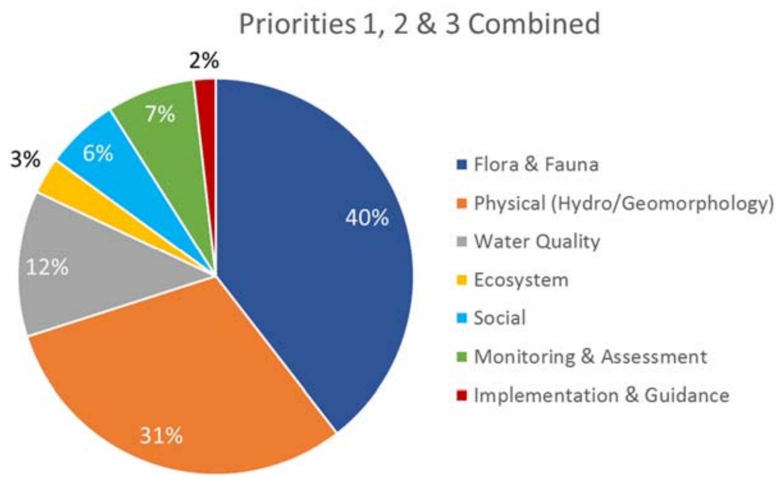
Survey question 6. Please list, in order of importance, your top three (3) monitoring priorities that would help address your concerns with Stage 0 restoration.

Compilation methods

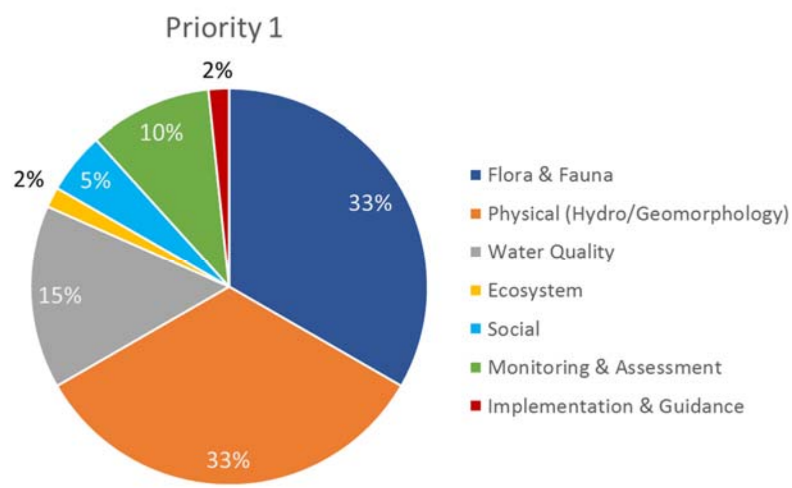
- *Step 1* – Responses were grouped into the following themes: Flora and Fauna; Physical (Hydrology and Geomorphology); Water Quality; Monitoring and Project Assessment; Social, Policy & Economic Issues; Information Synthesis, Sharing & Outreach; Ecosystem (responses addressing multiple outcomes or otherwise difficult to categorize); and Implementation and Guidance. In a few cases, a response fell into more than one theme.
- *Step 2* – Within three themes (Flora and Fauna; Physical [Hydrology and Geomorphology]; Water Quality) there were enough common sub-themes to further group responses.
- *Step 3* – Within each theme, responses were grouped by priority (1, 2, or 3)
- *Step 4* – Responses by theme and priority were summarized into pie charts based on percentages of responses. In the cases where further resolution of a theme was possible (Flora and Fauna; Physical (Hydrology and Geomorphology); Water Quality), further breakdowns are provided.

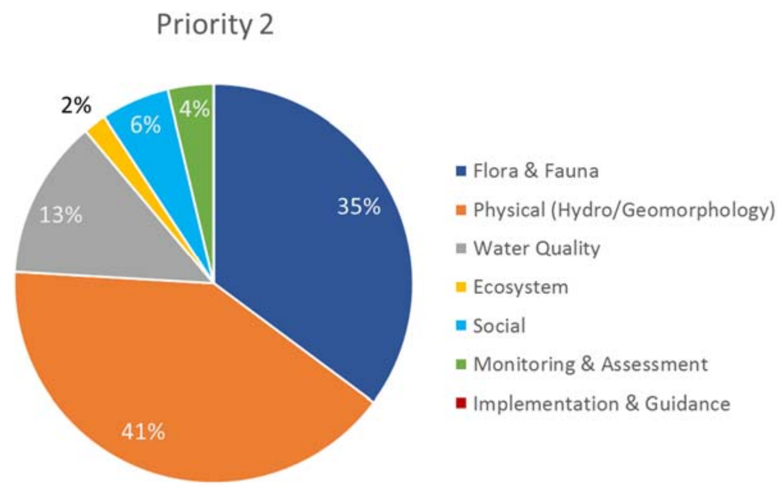
Summary

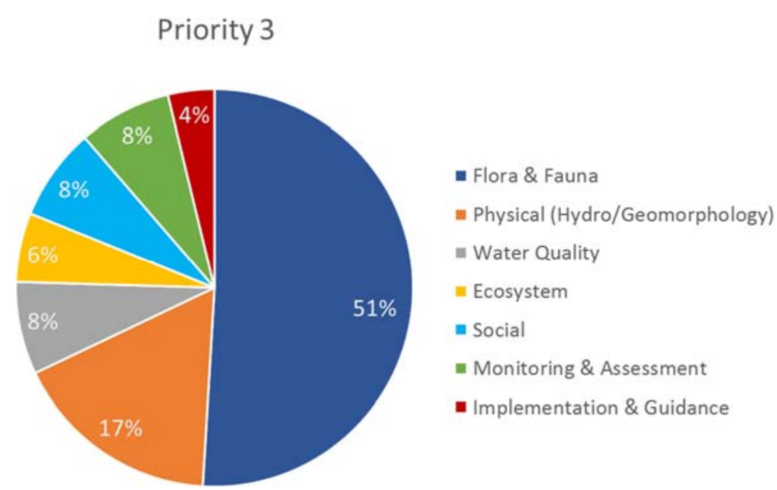
Summary of Responses by Category (Priorities 1, 2, and 3 Combined)



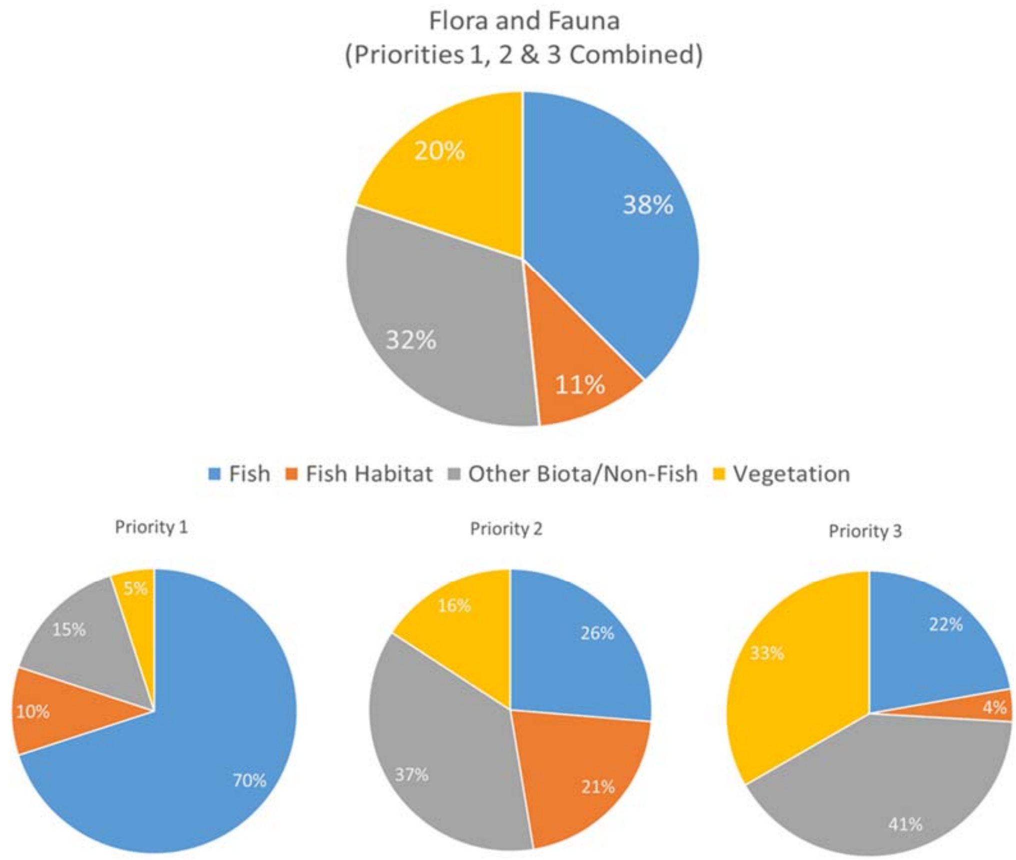
Summary of Responses grouped by Priority (1, 2 or 3) and Category



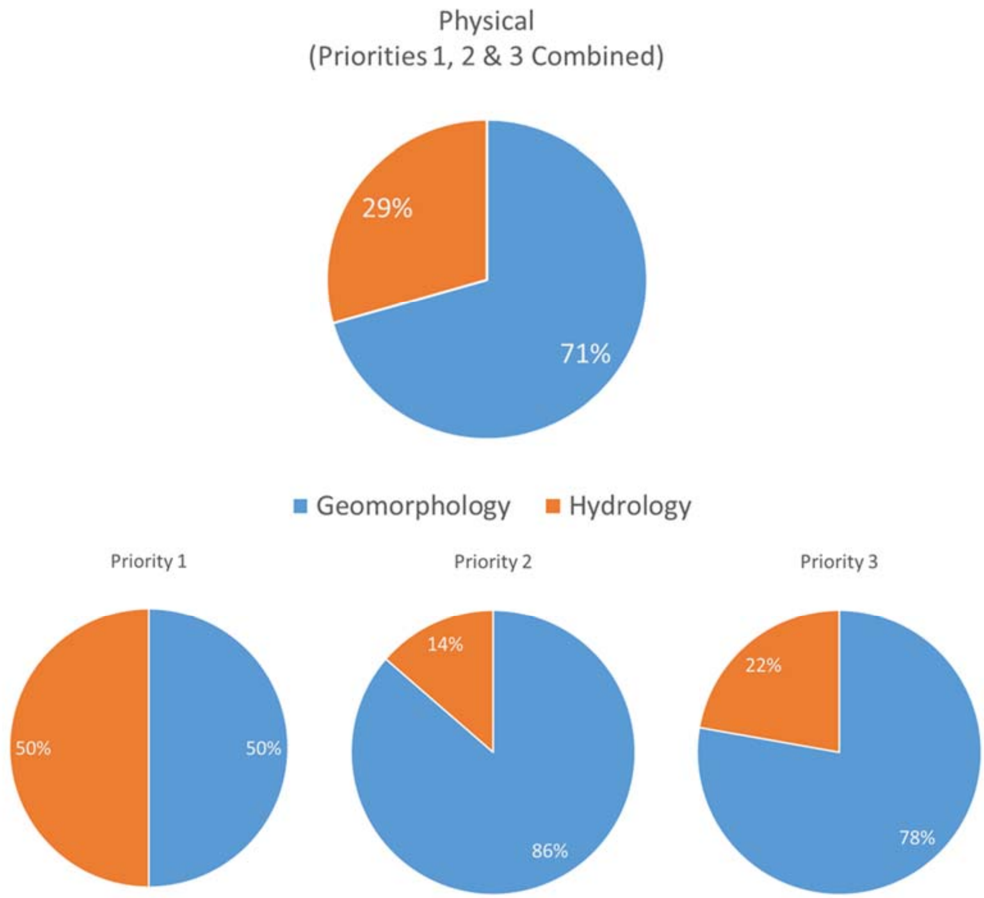

Priority 2
2%
6%
4%
35%
13%
41%
Flora & Fauna
Physical (Hydro/Geomorphology)
Water Quality
Ecosystem
Social
Monitoring & Assessment
Implementation & Guidance


Priority 3
4%
8%
8%
6%
8%
51%
17%
Flora & Fauna
Physical (Hydro/Geomorphology)
Water Quality
Ecosystem
Social
Monitoring & Assessment
Implementation & Guidance

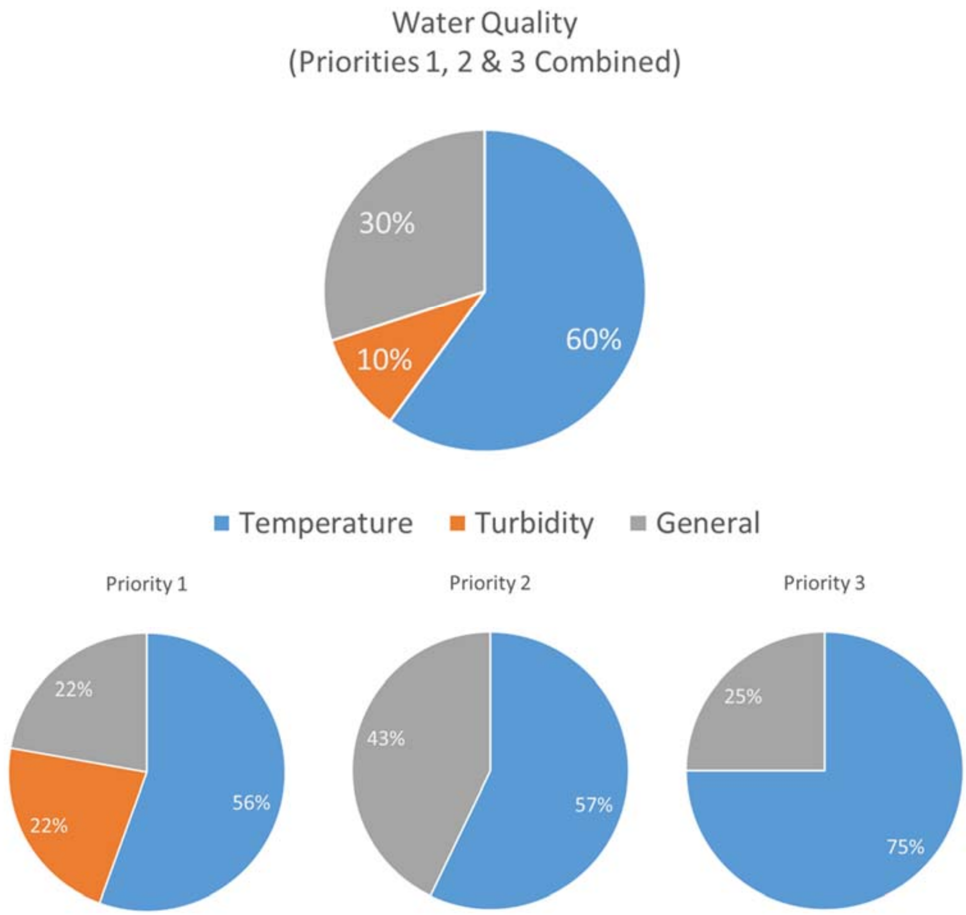
Breakdown of Responses within the Flora & Fauna Category



Breakdown of Responses within the Physical Category



Breakdown of Responses within the Water Quality Category



Flora & Fauna

Priority 1 – Biota & Habitat

Fish

- Fish passage
- Fish passage is a major concern
- Adult salmon migration through the site during low flow periods (i.e. spring Chinook)
- Over summer and over winter rearing survival and physical condition factors
- Fish reaction to restoration
- Fish response

- Fish use over time
- Fish population results
- Fish use and abundance (all life stages)
- Production measures fish and others
- Presence/absence of fish species
- I'd measure actual indicators of riverscape health indicative of the processes necessary for anastomosing to occur: Proportion of valley bottom active; dam & jam counts and densities; inundated proportion and flow types. Briefly:
    - Develop a comprehensive adaptive source management plan that links the physical components of the restoration to salmon and steelhead demographic characteristics known to be critical for species recovery (i.e., abundance, smolt to adult survival [SARS]).
    - Conduct sensitivity analyses on the above model to identify those parameters that have the greatest influence on abundance or SARS, and focus monitoring to minimize uncertainty with those influential parameters.
- Impact on other species outside of salmonids, in particular lamprey
- Larval lamprey response

Fish Habitat

- [Fish] habitat availability
- Clear understanding of salmon/steelhead habitat quantity/quality across all life stages as a result of stage 0 restoration, including the timeline of evolution of this habitat following implementation.

Other Biota/Non-Fish

- Biological response
- Biota monitoring
- Looking at a wide list of wildlife.

Vegetation

- Monitoring of vegetative response

Priority 2 – Flora & Fauna

Fish

- Fish passage and usage;
- Fish production

- Monitoring of native fish population responses
- Short term vs long term effects on native cold water species (salmonids, lamprey, densities and utilization during rearing/spawning, etc.)
- Larval lamprey response

Fish Habitat

- How fish are using the new habitat
- Monitoring of erosional and depositional areas within project locations in order to track incision and the presence/absence of spawning habitat
- Habitat monitoring- Is the habitat truly diverse? Or is it all shallow margins habitat? Did we lose all the deep pools?
- Long-term stream channel/aquatic habitat mapping, including stream/aquatic habitat distribution and abundance

Other Biota/Non-Fish

- Response of macroinvertebrates to Stage 0.
- Macroinvertebrate response
- Biological communities (macro-invertebrates, nutrient cycling, fish occupancy + population estimates)
- Robust biological/ecological monitoring such as changes in food webs and fish populations.
- The long-term biological response
- Biological monitoring
- Demonstrating a measurable response to in-basin productivity

Vegetation

- Flora diversity
- Post-project vegetation surveys
- Vegetation response

Priority 3 – Flora & Fauna

Fish

- Smolt production--Curious about potential impact of open area and avian predation
- Effects on ESA-listed species like spring Chinook and bull trout as well as Pacific lamprey and beaver.

- Fish use/species composition pre and post restoration
- Do they [Stage 0 projects?] lead to real increase in population size of fish species of interest as opposed to "attracting" individuals from other areas and concentrating them in a smaller area that is potentially riskier because the individuals are not spread out over a larger area?
- Biotic response variables (macroinvertebrate & *fish abundance & diversity*, with abundance quantified per unit length of valley) [Also included in Other Biota]
- *Fish* and wildlife surveys [Also included in Other Biota]

Fish Habitat

- Immediate habitat features for all life stages of fish

Other Biota/Non-Salmonids

- Fauna diversity
- Biological uplift and performance over time
- Ecological responses (both terrestrial and aquatic) to Stage 0 restorations
- Monitoring of long-term ecological production in regards to segments that have been restored with other methods.
- Biotic response variables (*macroinvertebrate* & fish abundance & diversity, with abundance quantified per unit length of valley) [Also included in Fish]
- Change in biotic, physical and vegetative attributes of the system over a longer time period post implementation than what is currently available
- Macro abundance
- Biological parameters
- Fish and *wildlife* surveys [Also included in Fish]
- Habitat changes
- Long term habitat complexity and cover

Vegetation

- Stage 0 restoration effects on wood recruitment and riparian vegetation succession.
- Revegetation time after demolition
- Vegetation recovery
- Vegetation reestablishment

- Frequency and duration of floodplain inundation and change in wetted area, and subsequent natural regeneration of native plants (to inform post-restoration planting plans, timing, and expense). [Also included in Physical – Hydro]
- Riparian vegetation
- Riparian response
- Primary productivity
- Primary productivity [extending to] inverts, fish, vegetation, wildlife (bugs to bears but especially apex predators)

Physical (Hydrology and Geomorphology)

Priority 1 – Physical

Geomorphology

- Sediment depositional area
- Long term topographic data including long pros [profiles?] and cross sections
- With regards to measuring healthy riverscapes, I would map the valley bottom (area that could plausibly flood in contemporary natural flow regime) and the proportion in active channel, active floodplain and inactive floodplain. A "stage 0" condition is when the active components are 100% of the valley bottom.
- Geomorphic performance over time
- Geomorphic monitoring
- Stability of installed structures in comparison to pre-project engineering analyses and modelling
- Physical parameters
- Long-term stream channel/aquatic habitat mapping
- The relationship between wood load and characteristics and the geomorphic processes Stage 0 targets.
- Large wood mobility

Hydrology

- Hydrologic connectivity (surface & subsurface)
- Mapping/monitoring hydrologic connectivity at baseflow
- What are the floodplain water storage benefits of Stage 0 restoration?
- Floodplain groundwater measurements

- Groundwater
- Depth of water table
- Hydrologic info like wetted area and groundwater depth
- Hydrologic monitoring including extent of wetted area, residual depth at different flows, temperature, groundwater/surface water exchange. [Also categorized in Water Quality]
- Monitoring of hydrology response
- Flow velocities, depths, and temperatures. [Also categorized in Water Quality]

Priority 2 – Physical

Geomorphology

- Reach scale stream geomorphology - such as width/depth ratios of both active channel and floodplain, stream profile, sediment sorting
- Channel forms pre and post restoration
- Channel incision
- Spatial heterogeneity or patchiness (channel and floodplain)
- The geomorphic trajectory of Stage 0 projects, especially in terms of channel morphologic change following a Stage 0 restoration that leaves a potential headcut at the downstream end of the site.
- Sediment transport
- Change over time, especially following major floods
- Long-term geomorphic responses
- Long-term channel and habitat monitoring.
- I think we need to figure out how the physical channel response may be context dependent (will the river respond differently in different locations?)
- In most anastomosing riverscapes, the splitting of flow around islands and the maintenance of higher degree of floodplain connectivity (even at low flow) is structurally forced (typically by beaver dam activity and/or wood accumulations). I would map and measure dams and jams, which are structurally forcing this multi-threaded anastomosing behavior.
- Sediment delivery downstream
- Physical processes monitoring (wood, sediments, etc.)
- Fine sediment inputs during and after implementation
- Sediment transport and flush.

- Channel stability
- Upstream and downstream connection points over time
- Substrate
- Morphological features (pools, riffles, runs, glides, dead zones, wetlands, ponds)

Hydrology

- Flow velocity monitoring
- Monitoring before and after large peak flow event. (Moved from uncategorized)
- Fines/embeddness,
- Extent and frequency of floodplain inundation and habitat feature creation (i.e., pools, riffles, etc.).

Priority 3 - Physical

Geomorphology

- Stream geometry over time
- Short and long-term geomorphic responses.
- The hallmark of a healthy riverscape is inefficiency. The inefficient conveyance of water is what you get in anastomosing systems, some anabranches are quick and free flowing, others are cluttered and pond up behind jams and dams, and some spill out onto otherwise dry bar and floodplain surfaces. A simple proxy for this is to map the inundated area (as proportion of valley bottom) at low flow, and use diversity of flow types (free flowing, overflowing, ponded) as proxy for diversification of residence time (i.e. inefficiency).
- Inundated area during/after floods and at base flows
- Physical uplift and performance over time
- Stability and evolution over time, any examples of problems with existing projects. (Moved from integrated)
- Pool development - How long does it take?

Hydrology

- Thalweg depth to bank height or OHW [ordinary high water?] ratio change over time.
- Frequency and duration of floodplain inundation and change in wetted area, and subsequent natural regeneration of native plants (to inform post-restoration planting plans, timing, and expense). [Also included in Flora & Fauna – Veg]

Water Quality

Priority 1 – Water Quality

Temperature

- Flow velocities, depths, and temperatures. [Also categorized in Physical - Hydro]
- Hydrologic monitoring including extent of wetted area residual depth at different flows, temperature, groundwater/surface water exchange. [Also categorized in Physical - Hydro]
- Stream temperature
- Water temperature pre and post restoration
- Temperature

Turbidity

- Extensive turbidity monitoring, monitoring far up and downstream of the restoration area, consider previous land use and upstream uses and monitoring for potential contaminants (for example- was there gold mining in the area at some point?)
- Turbidity monitoring during implementation

General Water Quality

- Water quality/quantity related to all anadromous life-stage uses in that particular system, pre and post-project implementation.
- Short term vs long term effects on water quality

Priority 2 – Water Quality

Temperature

- What are the summer and winter stream temperature benefits of Stage 0 restoration?
- Water temperature monitored in a spatially appropriate manner that shows the diversity of warm and cold water habitats.
- Downstream water temperatures
- Temperature

General Water Quality

- Water quality
- Chemical parameters
- Water quality

Priority 3 – Water Quality

Temperature

- Changes in stream water temperatures in a BACI study design.
- Stream temperature.
- Temperature monitoring

General Water Quality

- Water quality monitoring.

Monitoring & Project Assessment

Priority 1 – Monitoring & Project Assessment

- First, we need to figure out how to monitor these types of systems. Traditional approaches to stream monitoring (e.g., transects) may not be appropriate. Single species might also be difficult.
- Standardize approach to monitoring Stage-0 projects
- Coordinated long-term monitoring
- Intensive, long-term experimental studies (BACI designs) at a handful of sites in a range of biophysical environments.
- Un-train monitoring "scientists" from summer low flow single channel habitat unit feature quantification
- Integrating the assessment and planning efforts to clearly articulate project goals and objectives that guide the design process, and that are measurable to ascertain project effectives. Many developments in play right now with [Small Unmanned Aircraft System] SUAS derived assessment and effectiveness metrics. BPA has three separate M&E entities alone developing drone-based monitoring protocols. Remotely sensed M&E has to be developed and applied on a consistent and reproducible protocol especially on SZERO type where the implemented complexity is nearly impossible to measure using traditional methods.

Priority 2 – Monitoring & Project Assessment

- Develop spatio-temporal dynamics metrics for functioning floodplain systems
- Extensive monitoring across many sites of a modest, but meaningful set of ecological metrics using a combination of field-based and remote sensing methods. (Moved to monitoring)

Priority 3 – Monitoring & Project Assessment

- What do we measure, and what scientific protocols or tools do we use to monitor, cost effectively given the difficulty of monitoring projects at Stage 0 scale?
- New survey protocols that address anastomosing channels

- Prioritize monitoring on older Stage 0 projects to get longer-term results faster. (moved from uncategorized)
- Recurring, integrated (physical, biological) synthesis of results from [intensive long-term experimental studies (BACI designs) at a handful of sites) and [extensive monitoring across many sites of a modest but meaningful set of ecological metrics). (Moved to monitoring

Social, Policy & Economic Issues; Information Synthesis, Sharing & Outreach

Priority 1 – Social/Communication

- Social response
- There should be an oversight/review system set up to ensure Stage 0 projects are designed and implemented appropriately. (moved from uncategorized)
- I'm not sure that my concerns can be answered by monitoring because these projects have yet to be implemented. Instead, there will need to be additional thought, design, and stakeholder engagement to identify site specific methods, concerns and monitoring needs.

Priority 2 – Social/Communication

- Facilitated discussion among interested parties,
- Long term impacts on adjacent landowners and their level of comfort with stage zero before and after implementation
- Cost-benefit analysis.

Priority 3 – Social/Communication

- Recurring, integrated (physical, biological) synthesis of results from long-term studies and monitoring
- How to communicate with partners in order to implement these projects effectively (with less resistance)
- Need to monitor social perspectives associated with Stage 0 to better understand (and hopefully teach) the public and others who are resistant to change their biased baseline belief in what a valley bottom stream historically looked like.
- Opportunities for information sharing among restoration practitioners.

Ecosystem (Multiple Categories)

Priority 1 – Ecosystem

- What, if any, detriments are there to the short-term disturbances involved in Stage 0 work?

Priority 2 – Ecosystem

- Other bio/geo/chemical results. (Not Sure)

Priority 3 – Ecosystem

- Long-term viability. How does the ecosystem respond over short and long-time scales, and what mechanisms drive this response?
- Change in biotic, physical and vegetative attributes of the system over a longer time period post implementation than what is currently available
- Resilience

Implementation & Guidance

Priority 1 – Implementation and Guidance

- Evidence that can help us better describe cost-benefit of the approach to help grant reviewers compare these efforts with lower cost projects.

Priority 2 – Implementation and Guidance

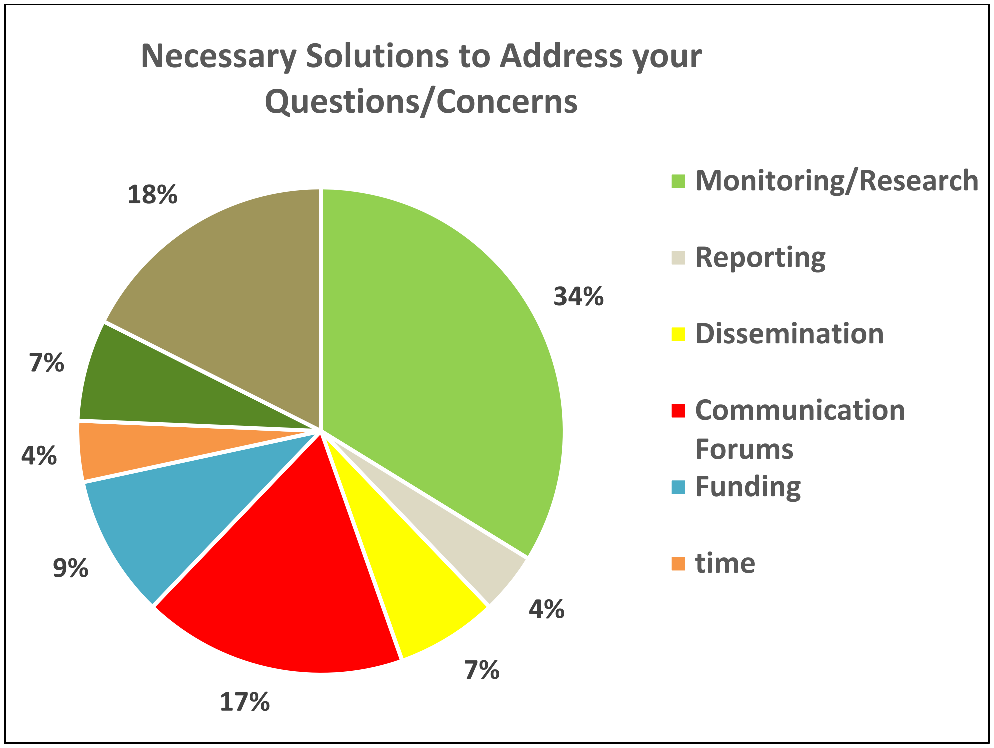
- Increase the suite of tools deemed acceptable to achieve stage 0 restoration.
- Diesel usage by heavy equipment.

Survey question 7. What do you think are the necessary next steps (solutions) to address your concerns or questions?

Compilation Method

Step 1 – Group the solutions by topic. Some responses suggested more than one solution and at times those responses were further organized into separate topics.

Breakdown (in percent) of Responses within each Topic



Necessary Solutions to Address your Questions/Concerns
18%
34%
7%
4%
9%
17%
7%
4%
Monitoring/Research
Reporting
Dissemination
Communication Forums
Funding
time

Monitoring and Research

Summary of Survey Responses

- OWEB should require all stage 0 projects to have effectiveness monitoring that follow a similar approach (if feasible) that is being developed by USFS in a collaborative fashion
- Perform a review of existing projects specifically looking at the area of deposition and how that relates to the size of the project, the stream and how it changes over time. Do channels stay at their as built elevations or higher as would be the goal of a Stage-0 project or do they incise over time? Longitudinal monitoring and valley cross sections should capture this. Stream temperature monitoring upstream, downstream, before and after the project should assess the impacts on stream temperature from these projects, the trick will be capturing before measurements and finding monitoring locations that are not altered by the project.
- A study design that is built to test these and other questions prior to implementation so that pre-data can be collected on these metrics (if needed).
- High quality monitoring using uniform and tested approaches that focus on the physical habitat and the populations of species of interest, backed up by rigorous sampling designs, data management, critical analyses, and peer-reviewed publications.
- Continued commitment to monitor various aspects of physical and biological change that occur in each of these sites.
- I'm a researcher, so I think my biased opinion is that more research is needed. Fortunately, the Stage 0 community is full of folks like me and research to address the concerns I raise above is ongoing.
- Combination of implementing and monitoring more projects
- Monitor various types of stage 0 restoration approaches to assess effectiveness and enhance technique (GGL is only viable in select cases where conditions are right; these cases are less common and typically not an option for most practitioners).
- Construct conceptual models that outline the physical and ecological mechanisms and feedbacks that are assumed to control responses, and then use the models to conduct thought experiments or even parameterize analytical models aimed at generating hypotheses about ecosystem responses. This exercise would help us hone in on what we should be monitoring and how long we might need to monitor it for. As well as determine where unexpected (or undesirably) outcomes may occur.
- Watershed assessments and baseline pre-project monitoring is necessary at the watershed, reach, and project level to inform project goals and objectives, and the associated design and treatment measures.
- Academic and scientific research and monitoring.
- Ensuring that both habitat and fish response are being measured in a controlled method.

- A monitoring protocol developed for complex channel-floodplain-wetland systems rather than the reliance on protocols developed for single thread channels.
- Monitoring, learning by doing, developing an academic body of knowledge.
- Continue a concerted effort to create a robust and commonly-used monitoring protocol.
- Comprehensive monitoring of several Stage 0 restorations, from pre to post implementation.
- Collect more pre-project data for a BACI approach and be dialed in on what the metrics are to be collected and being consistent post-project. Figuring out some way to effectively monitor fish populations/abundance in areas where there are not spawning salmon and steelhead (redd counts are not a monitoring technique that can be used in all locations that Stage 0 is implemented).
- I'm hoping to gather monitoring information from a project that we are involved with as well.
- Develop and implement a standardized monitoring protocol, which the USDA Forest Service is currently working on.
- Creating an adequate monitoring and assessment protocol for these sites to allow for unbiased evaluations. Making sure we create separate bins for sites where historic and or current habitat conditions were/are different – west slope cascades vs coast range vs Willamette valley floor, etc.
- More long-term monitoring
- These are the types of questions best answered through university research projects. There could be a number of very practical and applied M.S. theses to provide needed information. Expect to dedicate at least 5 years of substantial effort to obtain the insights necessary for broad application of this restoration technique.
- If there are a suite of monitoring metrics specific to this approach that can be consistently applied by any practitioner that chooses to use the Stage O approach, we may have a chance of evaluating its effectiveness more quickly.

Reporting of Monitoring Data and Information

Summary of Survey Responses

- Summarize existing data - especially turbidity monitoring. What levels have other projects reached? What kind of levels should regulators expect - for example, reaching 200 NTUs for two hours; 50 NTUs for 8 hours, etc. What effect does this have on aquatic species?
- The workshop is a great start. We need to treat stage-0 restoration as a research program and learn while doing and publish those findings so we can manage with the best available science.

Dissemination of Monitoring Data and Information

Summary of Survey Responses

- Dissemination of water quality/quantity monitoring results, and regular and ongoing sharing of information.
- Site visits to completed projects, information sharing.
- Seeing more data.
- Continue to generate and disseminate high-quality, data-based information about Stage 0 projects.

Communication Forums

Summary of Survey Responses

- Convene forums such as this one where everyone comes to the table for honest discussion.
- I'm really excited for workshops like this one to help bring active research to the forefront in informing ongoing Stage 0 restoration.
- Need forums such as this one to bring the keys players to the table and lay out the hot button issues, the state of the practice and develop strategies and work groups moving forward.
- Workshops such as these to promote and facilitate shared learning are critically important. Support stage 0 monitoring efforts for projects representing a diversity of landscapes around the state and PNW.
- Get state biologists on board
- Get regulatory agencies on board.
- More communication and participation for agencies, research organizations etc. and an openness to a new way, potentially more holistic way of seeing valuable habitat for fish and wildlife
- Develop a more robust communication campaign to funders about the importance of design work for stage zero projects
- Convincing my colleagues that the same old tired (i.e. blue hair metrics) that you were obsessed with measuring for the past 50 years is not that useful and that yes these really simple things are excellent indicators of a much more complicated suite of processes. Scientist are among the worst, and most closed-minded creatures of habit when it comes to changing their ways. We have gotten wrong for a lot of years focusing on counting pebbles, individual sticks and ignoring the forest (floodplain) beyond the trees (is that a qualifying piece of wood).
- Unsure. It currently seems like there was a large campaign to promote stage 0 projects very widely before any discussion on effectiveness occurred. As a funder, partner, and reviewer we have seen projects move forward that ultimately disregarded stakeholder input even after a large effort to communicate serious concerns. Addressing solutions at the regulatory and funding level may be the only option left.
- Attend the workshop
- Get more stakeholders (permit entities, funding entities, land management entities) in the middle of newly re-functioning reaches relative to their idea of successful (in actuality, non-functional) projects.
- I would prefer to hear what grantees & science communities recommend as next steps.

Funding

Summary of Survey Responses

- Continue to invest in monitoring Stage 0, especially large-scale, complex or potentially controversial projects.
- Prioritize funding for monitoring of Stage 0 projects.
- Get funders to prioritize big ticket, holistic restoration like this over smaller "bandaid" projects that don't necessarily address all limiting factors in a valley.
- Funding to develop a standardized monitoring approach.
- Funding of long-term monitoring projects at multiple projects sites in a range of habitats across the state (i.e. coastal, western Cascades, eastern Cascades, high dessert, etc.) on on-going opportunities for dialogue among interested parties are the most important next steps for this developing approach to river restoration.
- Larger allocation of funding to pre and post implementation monitoring
- Additional funding and staffing to support monitoring

Time – Temporal Components

Summary of Survey Responses

- Go slow
- Time
- To see these projects mature over time

Education

Summary of Survey Responses

- A guidebook with information on design standards and measurements of success.
- More education
- More statewide education is necessary to inform the public of floodplain functional benefits, both natural flood relief and protection and functional/ecological benefits at various scales. It is important to understand the Stream Evolution Model and how practitioners address various stages of channel function, particularly how restoration addresses typical constrained, incised channels across the regional landscape.
- I think it's probably as simple as learning more about projects that have already been done.
- More education about what stage 0 restoration is and how it can be applied in my geographic area.

Implementation and Adaptive Management

Summary of Survey Responses

- A combination of implementing and monitoring more projects

- Per Wohl (2015), to address my questions and concerns, project funders, project practitioners and researchers need to commit to planning, implementing and evaluating Stage 0 projects in a science-based, adaptive management framework that integrates knowledge, experience and perspectives provided by applied scientists/practitioners, research scientists, and a broad range of social interests.
- Show restraint when applying this technique. It does not belong everywhere.
- The Geomorphic Grade Line (GGL) project type seems more akin to a mitigation project, which the SF McKenzie project effectively is, and not a restoration project. The GGL/Valley Resetting project type should be classified and treated as mitigation technique rather than a restoration project type.
- Use the monitoring data to adapt project designs on future projects to ensure continued implementation improvements.
- Incorporate a "hybrid" approach in watersheds containing lower run-off flows and/or irrigation withdraws that create immediate habitat for all life stage of fish.
- BMP's that minimize fine sediments inputs during and after implementation.
- Monitoring and adjusting as new information is available. Keep the number of projects small until enough data is collected to determine what works and what doesn't.
- Becoming more familiar with project planning and design, design considerations for projects bracketed by private land/unwilling landowners, risks and risk management associated with downstream flooding.
- I think we need to make sure to critique our projects and listen to the data we are collecting, and not just give ourselves pats on the back for a job well done. In addition to what's good and what went well, what didn't work and how can we adapt in the future?
- A larger focus on land acquisition to be able to perform larger scale stage zero projects
- I think that the level of intervention at a restoration site will have to vary depending on the degree of human disturbance, degradation and stream incision already present at the site that is the target of this restoration approach. So, it is rather site specific and may range from "do nothing" to a low-tech process-based restoration effort.
- Implement more, diverse stage 0 projects. Avoid a narrow application and implementation definition.
- As with all new methodologies they often have a powerful niche of usefulness, but are not applicable for all sites and projects.
- Establish an oversight/review system and committee set up to ensure Stage 0 projects are designed and implemented appropriately.

- Higher level of review with a) reports of water quality/quantity monitoring results, b) direct and indirect effects to fish; and c) lessons learned from previous phases required before each phase of a multi-phased project gets funded.

Survey question 8. Is there anything else that you would like us to know?

Note: Many responses to this question expressed appreciation for the workshop, personal details such as job title, etc. These are not listed here. Other responses included substantive comments, questions or concerns directly related to Stage 0, which are compiled here.

- I think understanding the rate and areas of sediment deposition is critical to understanding the long-term effects and success of these projects.
- All the information I've seen so far has come from the project practitioners. I think a scientific peer-based approach and then replicates of that will be needed for me to feel more comfortable with the initially destructive nature and cost of Stage 0 projects.
- The monitoring budgets should be a substantial portion of the total project budget and monitoring should be put on equal priority with "getting the job done" (i.e., the heavy machinery part of the restoration implementation).
- It seems that the enthusiasm of proponents of stage 0 often overshadows and obscures the concerns of skeptics. It's important to be sure that those with concerns feel comfortable sharing and participating in the workshop discussions.
- The English Environment Agency (PoC John Phillips, john.phillips@environment-agency.gov.uk) and Scottish Environmental Protection Agency (PoC Roy Richardson, roy.richardson@sepa.org.uk) are both currently developing methods for nationwide 'Stage Zero Opportunity Mapping'. I suggest inviting them to give their opinions and join the event remotely.
- Need to realize the vast differences between types of Stage 0 areas.
- Stage 0 restoration is not the only tool in the toolbox but it sure seems that some restoration specialists only want to implement very narrow-minded restoration strategies.
- I believe that monitoring efforts conducted below dams are not an accurate representation of all Stage 0 projects, and results will always need to be with the caveat that it is not a natural system with natural flow, bedload transport and nutrient regimes.
- How to better incorporate climate change in to Stage 0 design given the amount of uncertainty to future hydrological patterns.

Shortened Summary of Responses to Question #5

Q5: What questions or concerns do you have related to restoring to a Stage 0 condition?

(Key Questions and Concerns related to restoring to Stage 0 Condition)

Flora & Fauna

- *What are the effects on fish during initial stages, and how do fish/fish production respond over the long term (timing/magnitude of response)?* Concerns about effects on fish include short-term negative impacts until longer-term benefits are realized.
- *How does restoration to Stage 0 effect fish at different life stages?* Concerns include whether there has been adequate consideration of short-term life history needs (0 to 5 years), lower base flows through time with decreasing channel-forming flows, whether practitioners are adequately considering adverse impacts (short and long term) to native fish and their life stages before implementation, and that some biologists don't see the opportunities with Stage 0 (i.e., narrow focus on deep pools and wood as primary habitat features; expectations that Stage 0 needs to provide habitat for all life stages).
- *How is assessment of limiting factors considered when evaluating whether a Stage 0 approach is appropriate; what habitat limiting factors are Stage 0 projects best suited to address?* Concerns are that some Stage 0 projects have created habitat conditions that were not addressing primary limiting factors.
- *How does restoring to a Stage 0 condition effect fish passage and migration?* Concerns are that fish passage could be compromised in some systems where anastomosing channels create too many shallow channels, and the potential to interfere with seasonal migrations (e.g., bull trout in summer).
- *What is the habitat response (fish habitat, vegetation) immediately after disturbance and over time; how long does it take to achieve desired habitat features for sensitive fish species?* Concerns are about near-term effects on deep pool habitats.
- *Does restoring to a Stage 0 condition support primary production and create more complex food webs that are associated with more stable and resilient ecological systems?* No specific concerns.
- *How quickly do organisms, including freshwater mussels and other non-fish species, recover from the initial disturbance and over time (e.g., does fish and wildlife use increase)?* No specific concerns.

Hydrologic & Physical (Geomorphic) Effects/Impacts

- *Are background analyses of watershed hydrology adequately incorporated into project design?* Concerns are that there is a lack of background hydrologic analyses and subsequent effects on projects.

- *Does restoring to a Stage 0 condition result in dryer channels?* Concerns are that channels may become dryer after restoration due to not being connected to the water table and as fines are washed away.

- *What is the long-term durability/sustainability of Stage 0 restoration projects; will watershed processes (e.g., vegetation, hydrology, sediment and wood loading & transport; beavers) be able to sustain Stage 0?* Concerns are about response to large flow events (e.g., 20+year event), channels becoming unstable laterally and/or vertically over time, effects on downstream landowners, goals for wood loading and beavers (need to better understand these processes in Stage 0 to target monitoring and adaptive management).

Water Quality Effects/Impacts (Temperature, Nutrients, Turbidity)

- *How does restoring to a Stage 0 condition influence stream temperatures?* Concerns are centered on expectations of increased temperature due to slower, shallower water with less shade and whether increased heterogeneity of temperature and refugia can offset impacts.

- *How does restoring to a Stage 0 condition affect near-term nutrient and sediment loading to streams?* Specific questions are about effects on nutrient loading and sedimentation in the first year [post implementation] and the role of groundwater and geochemistry.

- *What are the effects of restoring to a Stage 0 condition on turbidity and fine sediment transport; how can impacts be minimized?* Concerns are about minimizing impacts, controlling mobilization of fine sediment, accounting for upstream and downstream processes, and effects on local uses.

Long-term Effects & Resilience, Including to Climate Change

- *What is the long-term durability/resilience of Stage 0 restoration projects (stream processes; climate change, sediment & geomorphic processes)?* Concerns are that projects seem to be based on historical conditions inferred from topography but could be improved by more explicit consideration of existing and future climate/hydrologic changes expected from climate change, determining if Stage 0 will be sustainable within the geomorphic context or controls, longevity in artificially stable environments (e.g., flows below dams), and stability of structures.

- *What are the short-term (months to years) and long-term (years to decades to centuries) trajectories of physical and ecological response to restoring to a Stage 0 condition; how do these trajectories vary based on environmental context (e.g., ecoregions; dry vs. wet areas)?* No specific concerns.

- *Can coordinated, system-wide restoration programs deliver Stage 0 projects so that restoration makes a difference at the watershed scale and in time to mitigate for impacts from climate change?* A concern is that there is risk associated with not restoring to Stage 0 given risks associated with climate change, low flows, and threatened anadromous populations.

Risks, Unforeseen Consequences, Levels of Disturbance

- *What are the long-term risks for areas downstream from project areas (e.g., flood transport of placed wood, etc.)?* Concerns are about environmental and downstream impacts.

- *What are the possible unintended consequences or impacts from project failure over the long term (e.g., loss of near-project sources of large wood, downstream transport of wood placements, etc.)?* No specific concerns.

- *What is the risk of not restoring to Stage 0 (i.e., the decision to maintain status quo in terms of restoration approaches)?* A concern is that there is risk associated with not restoring to Stage 0 given risks associated with climate change, low flows, and threatened anadromous populations.

- *How do we balance the Stage 0 scale of restoration (large disturbance footprint) with impacts to existing fluvial and biological processes and potential to disturb culturally sensitive areas?* Concerns include that stakeholder practitioners, agencies, funders and public to consider the Stage 0 scale of restoration in context of addressing deficient constrained and incised channels across the landscape but also that this scale of restoration has potential to cause significant disruption to ecological processes and culturally sensitive areas like floodplain terraces.

Site Selection or Prioritization; Restoration Design Guidance; Clarification of Stage 0 Terms & Methods

- *How is Stage 0 defined – What is it, and what is it not?* Concerns included oversimplification of complex systems, restoration approaches that are erroneously termed "Stage 0", and differing views among restoration practitioners about what Stage 0 is and where restoration to Stage 0 can be implemented.

- *Where is it appropriate to restore to Stage 0 (stream size/order, alluvial vs bedrock systems)?* Concerns included whether an appropriate range of stream sizes for restoring to a Stage 0 condition has been defined, appropriate placement on the landscape considering geomorphic constraints, whether evaluation of site appropriateness based on historical conditions could be strengthened by including current or projected conditions (e.g., hydrology, sediment/wood regimes, climate), and attempts to restore to Stage 0 at inappropriate sites by practitioners eager to apply a new tool.

- *What approaches are available to restore to Stage 0?* Concerns about methods included a lack of definition of the various methods for restoring to Stage 0, conflating certain methods (e.g., GGL) with "Stage 0", applicability of different methods to different locations or ecoregions, and the challenge of adjusting expectations to a longer term, phased and adaptive restoration process.

- *What guidelines or guidance exist for determining site appropriateness and design (e.g., appropriate restoration approach, implementation methods; key design considerations)?* Concerns centered on limited technical design and implementation guidance and opportunities for on-site training as well as how to consider connections of processes (e.g., wood and sediment transport) and unrestored reaches upstream and downstream of project areas.

- *What are the considerations for risk to infrastructure?* Questions involved site selection and design considerations for more developed locations lower in watersheds.

Monitoring & Project Assessment

- *How can we comprehensively monitor (over the long term) a consistent suite of Stage 0 project objectives, across at least a subset of project sites, to adequately capture effects? Outcomes could include a standardized, replicable Stage 0 monitoring framework, "standards of practice" for Stage 0 projects, assessment of cost-benefit and rigorous quantification of outcomes and benefits.* Concerns are about needs for data collection and performance standards for project evaluation, design evaluation standards for assessing project risk and success, lack of robust biological/ecological monitoring relative to physical/geomorphic monitoring, maintaining sustained funding for long-term monitoring, and whether there has been sufficient review of implemented projects (e.g., lack of scientific evidence to support more widespread implementation).

- *What monitoring metrics are (1) most sensitive to restoring to a Stage 0 condition, (2) capture spatial and temporal heterogeneity (e.g., of temperature), and (3) can be measured and interpreted across a range of sites.* Concerns are the ability to provide rigorous monitoring results (e.g., temperature, substrate, macro abundance) to respond to criticism and issues of concern.

- *Will monitoring be able to provide a signal of success through the ecological noise (e.g., water transit time, predators, hydrosystem, and variable ocean conditions)?* Concerns are whether other issues, described above, will mask the benefits of Stage 0 due to compensatory mortality of any demographic benefit from the restoration effort.

- *What are the expected timelines for ecological outcomes or impacts from restoration to Stage 0?* Concerns include uncertainty about how long will it take to see desired ecological outcomes, how and over what time scales projects [habitats] will evolve, lack of long-term research and monitoring data (important to continue monitoring at older sites), and actual long-term responses.

Social, Policy & Economic Issues; Information Synthesis, Sharing & Outreach

- *How can Stage 0 restoration projects and regulatory permitting requirements be better aligned for improved efficiency, timelines, and project delivery?* Concerns include the need for fish passage to be a larger part of the initial communication between practitioners and regulatory agencies if providing fish passage is a necessity for the short term as well as concerns about permitting hurdles reducing efficiency of project implementation.

- *Is restoration to Stage 0 a cost-effective restoration approach?* Concerns are that Stage 0 restoration projects are high costs, whether there is/will be sufficient available funding, whether high project costs are justified without fully understanding long-term impacts or benefits, whether it is possible to do an analysis of costs vs. benefits or ecological return-on-investment, and the carbon balance of these projects.

- *What have restoration practitioners learned (water quality/quantity monitoring reports, direct and indirect effects to biota) from Stage 0 restoration projects; what are the pros & cons, and how can information be shared to communicate results and build social support?* Concerns are the multiple phases of projects have been funded and implemented on the basis of fish habitat restoration without reporting or sharing of monitoring results (water quality/quantity, effects on fish, lessons learned from previous phases, and that a robust monitoring program, combined with effective outreach may be necessary help to allay concerns from some potential project partners, funders, and permitting agencies.

- *How can concerns about infrastructure be addressed in areas of mixed land ownership and more developed valley bottoms; is Stage 0 compatible with land uses and landowner expectations in these areas?* Concerns are that it is unclear whether restoration to Stage 0 will be in areas of mixed ownership (e.g., lower elevation streams; valley bottoms with significant infrastructure), that landowners or the public may have concerns about unconstrained river channels and sediment/wood accumulation, and that some will want to default to Stage 0 approaches everywhere.

- *What is needed to address the misalignment of expectations for post-restoration channel stability (i.e., conventional channel restoration) and the expectation of dynamic flow paths at Stage 0?* Concerns are that after restoration to Stage 0, some landowners may want to stabilize channels rather than leave the system dynamic and that some of the opposition comes from long-term perception of valley bottoms as transport reaches and wetlands as "ugly and messy" (how to shift some of the perception baseline on expectations for a healthy stream).

Appendix C: List of workshop registrants

Stage 0 Restoration and Monitoring Workshop

Registrant List

First Name	Last Name	Organization
(Brian) SCOTT	Sheppard	Bureau of Land Management
Adrienne	Averett	Oregon Department of Fish and Wildlife
Alan	Henning	US Environmental Protection Agency
Alexandra	Holecek	Oregon Department of Environmental Quality
Allen	Childs	Confederated Tribes of the Umatilla Indian Reservation DNR Fisheries
Amy	Horstman	US Fish and Wildlife Service - CRFWCO
Andrea	Wagner	US Army Corps of Engineers
Andrew	Dutterer	Oregon Watershed Enhancement Board
Annie	Birnie	National Oceanic and Atmospheric Administration Fisheries
Audrey	Squires	National Forest Foundation
Ben	Ramirez	Oregon Department of Fish and Wildlife
Brandon	Haslick	Burns Paiute Tribe
Brian	Staab	US Forest Service, PNW Regional Office
Brian	Cluer	NOAA Fisheries West Coast Region
Bryan	Gillooly	Confederated Tribes of CLUSI
Callee	Davenport	US Fish and Wildlife Service
Carter	Crouch	Burns Paiute Tribe
Chris	Jordan	NOAA/NMFS/NWFSC
Christer	LaBrecque	McKenzie River Trust

Christopher	Claire	Oregon Department of Fish and Wildlife
Colin	Thorne	University of Nottingham
Daniel	Scott	University of Washington
Darin	Jarnaghan	Coquille Indian Tribe
Dirk	Renner	US Fish and Wildlife Service
Ellen	Hammond	Oregon Dept of Agriculture
Ellen	Wohl	Colorado State University
Eric	Williams	Oregon Watershed Enhancement Board
Erik	Moberly	Oregon Department of Fish and Wildlife
Greg	Apke	Oregon Department of Fish and Wildlife
Greg	Ciannella	Oregon Watershed Enhancement Board
Guillermo	Giannico	Department of Fisheries and Wildlife, OSU
Helena	Linnell	Coquille Indian Tribe
Herb	Winters	Gilliam SWCD
Irma	Lagomarsino	National Oceanic and Atmospheric Administration
James	Anthony	Oregon Department of Fish and Wildlife
Janine	Castro	US Fish and Wildlife Service
Jared	McKee	US Fish and Wildlife Service
Jared	Weybright	McKenzie Watershed Council
Jason	Gritzner	US Forest Service
Jason	Grant	Deschutes Land Trust
Jeanette	Smith	JE Smith Consulting; Member of the Washington SRFB Monitoring and Project Review Panel
Jeff	Behan	Institute for Natural Resources
Jeff	Ziller	Oregon Department of Fish and Wildlife
Jennifer	Weber	McKenzie Watershed Council
Jeremy	Maestas	Natural Resources Conservation Service

Jesse	Steele	Grande Ronde Model Watershed
Johan	Hogervorst	Willamette National Forest, US Forest Service
John	Spangler	Oregon Department of Fish and Wildlife
Jon	Souder	OSU Forestry and Natural Resources Extension
Jon	Germond	Oregon Department of Fish & Wildlife
Jonas	Parker	Bureau of Land Management
Joseph	Wheaton	Utah State University
Joy	Vaughan	Oregon Department of Fish and Wildlife
Kate	Meyer	US Forest Service
Kathryn	Frenyea	Nez Perce Tribe
Katie	Duzik	Oregon Watershed Enhancement Board
Ka-voka	Jackson	Middle Fork Willamette Watershed Council
Keith	Dublanica	Recreation and Conservation Office / Governors Salmon Recovery Office
Kelly	Coates	Cow Creek Band of Umpqua Tribe of Indians
Ken	Fetcho	Oregon Watershed Enhancement Board
Kregg	Smith	Oregon Department of Fish and Wildlife
Kris	Knight	Upper Deschutes Watershed Council
Kristina	Moore	Gilliam-East John Day Watershed Council
Lauren	Mork	Upper Deschutes Watershed Council
Lisa	Kurian	US Forest Service, Willamette National Forest
Lisa	Gaines	Institute for Natural Resources
Liz	Redon	Oregon Watershed Enhancement Board
Mackenzie	Keith	US Geological Survey
Mark	Richardson	US Forest Service, Willamette National Forest
Mathias	Perle	Upper Deschutes Watershed Council
Matt	Helstab	US Forest Service

Melody	Rudenko	Oregon Dept of State Lands
Michael	Lambert	Confederated Tribes of the Umatilla Indian Reservation
Mizu	Burruss	Siuslaw Watershed Council
Nicole	Merrill	University of Oregon
Olivia	Guthrie	US Forest Service
Pat	McDowell	University of Oregon
Paul	Burns	US Forest Service, Siuslaw National Forest
Paul	Powers	US Forest Service
Peg	Boulay	University of Oregon
Phil	Roni	Cramer Fish Sciences
Rebecca	Flitcroft	US Forest Service - PNW Research Station
Renee	Coxen	Oregon Department of Fish and Wildlife
Renee	Davis	Oregon Watershed Enhancement Board
Rose	Wallick	US Geological Survey
Ryan	Bellmore	US Forest Service - PNW Research Station
Sara	Slater	Oregon Department of Environmental Quality
Sarah	Hinshaw	Colorado State University
Sarah	Dyrdahl	Middle Fork Willamette Watershed Council
Scott	Turo	Warm Springs Tribes
Sean	Welch	Bonneville Power Administration
Seth	Mead	Siuslaw SWCD
Stan	van de Wetering	Confederated Tribes of Siletz Indians
Steve	Brink	Idaho Power
Steve	Wondzell	US Forest Service - PNW Research Station
Sue	Greer	Oregon Watershed Enhancement Board
Taylor	McCroskey	Oregon Department of Fish and Wildlife
Ted	Sedell	Oregon Department of Fish and Wildlife

Thomas	Segal	Oregon Department of Fish and Wildlife
Tim	Porter	Oregon Department of Fish and Wildlife
Timmie	Mandish	Natural Resources Conservation Service
Tom	Demianew	Oregon Department of Agriculture
Tracie	Nadeau	US Environmental Protection Agency, R10
Travis	Mackie	Cow Creek Band of Umpqua Tribe of Indians
Trevor	Taylor	Oregon Parks and Recreation Department
William	Brignon	US Forest Service
Winston	Morton	Oregon Department of Fish and Wildlife

Appendix D: Compiled breakout session notes

Day 1 Breakout Sessions: Combined Responses

Based on what you heard and learned during the two sessions this morning, what do you think is the most important uncertainty is to be addressed?

- The ability to communicate uncertainty regarding Stage 0 restoration to the general public.
- Uncertainty regarding where on the landscape it is appropriate, and where it is not. What is the natural analog? What does a "reference channel" look like? Are we really mimicking what is "natural"?
- Making people aware of just how pervasive anthropogenic changes to river channels are, and what pre-European contact channels actually looked like.
- I've been watching from the sidelines, perspective is from a regulatory standpoint. We need to make sure we are investing in monitoring. Are we really seeing the results we expected? We need to be able to show how Stage 0 projects can be effective.
- How does large wildfire affect our [Stage 0] treatments?
- Thinking about what Stage 0 looks like from a Tribal perspective…we are "resetting" the system. I think the greatest uncertainties are how treatments in the upper watershed (where there is less risk) might affect downstream reaches, and the potential for long-term impacts from larger projects.
- I think the greatest uncertainties lie less with where we undertake projects than with how we get the most "bang for the buck". Also, the degree to which these projects actually mimic historical conditions. Where do we have appropriate wood, sediment, flows to accomplish our goals? Are these conditions sustainable over time?
- We don't see smaller, process-based BDAs and PALS under the Stage 0 "umbrella". Where do these projects fit in?
- Timeframes - expectations for how much happens when we're still actively managing the project. For example, observations that the system is more dynamic in upstream project areas vs downstream areas (probably how this developed in nature) – learning more about that and being able to communicate the expectations.
- Timeframe of evolution of projects impacts like upstream irrigation withdrawals that affect current hydrology (no flushing flows in Spring and Early summer).
- Risk associated with our uncertainties being centered on an understanding of impaired systems (constrained channels). Stage 0 and Stage 8 valley bottoms are so different from current conditions. In current constrained channels, deep pools may be the only lower power areas for fish to hold out, but that is not necessarily true in a fully intact valley bottom where features

other than deep pools can fill that low power habitat role. Similarly, we think of fine sediment deposition as a problem in constrained channels, but in a dynamic system there will be considerable sorting and a patchwork of habitats.

- What is at stake if we don't restore in this way – fish populations aren't responding to status quo, and the longer we wait there is a big risk. How do we communicate that risk (of not doing this work) and the uncertainty of the future (given current trajectories); that we have to try different things since we are running out of time and resources to recover these species. We know the answer if we do nothing - these species will be gone.
- Expectations of results quickly while we're still grappling with how to monitor these projects and define the results.
- How do we address other species (non-fish; wildlife)? How do we ask the right questions, etc. when reviewing or developing projects?
- How do we implement these projects on smaller parcels of land where appropriate, but where land uses or management in other nearby areas have significantly changed processes like hydrology (e.g., checkerboard land ownership/management)? How do we thinking about this in terms of the greater watershed?
- How can we better help practitioners scale these kinds of projects to areas of opportunities for restoration?
- Dynamic systems need movement of sediments (bedload and suspended) and large woody material. Do we know our budget of these materials from pre-project analysis; are those factored into the design and what is our budget of those materials over time?
- Does most of our mobilized sediment park at the upstream end of the project? Does the size of a project affect this? What monitoring do we need to answer this?
- Project scales are difficult to get our minds around and understand. How much connected floodplain is good enough?
- Mussels-has anyone looked at them and their needs for recovery in these environments?
- Coming in not having implemented but helping implement other restoration projects what hit home was understanding within your own organization or with others that clear communication coming to the table and understanding what partners' comfort level is and where they're uncomfortable so that a clearer presentation can be made [about what the project will entail, what habitat it will provide, on what timeline].
- Having taught from the beaver and LTPBR side, the biggest question is about fish and there's a lot of complicated work to be done there and it's hard to answer those questions.
- Uncertainty is most uncertain from a regulator's perspective. Getting regulators involved so we can start thinking less black and white more outside the box so we can permit more easily.

- Most curious about do [these projects) work and their longevity – what happens when a 100-yr flood impacts these projects? What happens to the wood, does it all get pushed to the side? Is there enough local recruitment of wood? What are the long-term outcomes?
- Have implemented Cole and Staley – how much do you implement without the monitoring results and how much do you implement within close proximity, how much time do you give between projects in close proximity?
- Fish bio standpoint: Will these projects provide long-term habitat? What does that habitat look like over time for juveniles, adults, spawning? How do you progress with Stage 0 approach- long term promise but short-term shock [of disturbance] is hard to deal with.
- SUMMARY Physical characteristics – hydrology with flow availability temperature, water depth
- Evaluation of appropriate sites - in particular with everyone being on the same page to evaluate outcomes
- Finances – how to fund these projects, and the long-term monitoring
- Evaluation – from a permitting perspective how to rate and compare stage 0 to other better understood types of projects
- Communication – need to be able to share the timeline with stakeholders, don't want to damage those relationships.
- SPECIFIC COMMENTS Skeptics and uncertainty regarding response time from end of project to achieving goals – temperature and deep water are concerns
- Hydrologic uncertainties, how do dams affect SF McKenzie
- Don't agree on starting point to be able to identify the risks that we should be concerned about. Concern about loss of passage in a place where there already has loss of passage.
- What is the uncertainty about the transition between the stage 0 site and downstream unmodified channel.
- Uncertainty of landowner perspective about the look of a project when its finished. Concern about long term relationship in restoration effort.
- How do you rate if there is enough benefit from stage 0 to justify the expenses of the project. State 0 functions a bit differently than other places.
- Big projects that are hard to fund.
- Themes
- Public/partner communication/understanding
- ID and define success – consistent metrics/ range of parameters for focal species especially considering climate change
- Monitoring – macro/micro level, communicating results to partners/public

- Project management – when to intervene to address issues AND models/structures to continually learn about success or failure of individual project and allow for critical adaptive management
- Public buy in, keep rec going through a project. Boarder public stakeholder perspective.
- Are the desired results going to be meet with this project approach? More of a project by project approach and/or concept. Are going to meet goals?
- Parameter of capacity for species – i.e. temp ranges/sediment – range of parameters that focal species can tolerate. Natural geomorphic processes doing a better job of managing habitats – but is this going to be able to meet the challenges of climate change? Bio perspective
- Consistent metrics for measuring change to get at success of projects, more quantitative vs. qualitative.
- Example of post-pone on Whychus. Uncertainty of reaction of partners. Initial disturbance levels and reaction to that and short-term impacts. Setting expectations of partners and public. Developing monitoring goes hand in hand with this process of setting/understanding partner expectations. Monitoring data has a definitive help with this process.
- Success. Doing some good things on large scale monitoring level. But what about at project level to help PM's answer question am I doing this right. Also water is king. What are impacts to temperature and how do we share this information to stakeholders
- When to intervene with implemented project – i.e. fix elements- micromanagement vs. definite need.
- Old – is it working are we getting more fish? New; public uncertainty, parameters – structural uncertainty – how do we define success? Build models to develop structures to learn about success or failures – how we got there.
- Concerns as to how this type of restoration approach will work in working landscapes such as the forest industry (could lead to reduced harvest), agriculture areas (reduced surface area for yield) and in tidal areas.
- Potential landowner concerns linked to rivers/creeks that once released from their constraints could "take over" the entire valley floor. Would not be a good outcome for working lands and depending on communication with private landowners could lead to loss of trust.
- What are the long-term effects/benefits and how long will they last? How do we address these uncertainties so landowners can plan for long term management?
- Provocative paradigm shift. Restoration through disturbance. How long will the disturbance last and what is the recovery trajectory. What if the site does not recover and gets stuck in the disturbance footprint. Once evolved to Stage 0 condition, does it stay there or can it move to other stages of evolution.

What opportunities exist to address the most important uncertainty (that you listed above)?

- Practitioners could be more open to dialog, and less defensive about the projects. We need to provide more opportunities for people to ask questions.
- We need to identify what a "natural" Stage 0 project looks like. We need to identify information sources for this.
- We could pursue a programmatic, streamlined process for getting Stage 0 projects approved, although it may be premature for this.
- Given the intense interest surrounding Stage O projects, I think there are opportunities for additional monitoring, which is always a challenge to get funded.
- Better communicating the risk associated with the current trajectories of the populations.
- Communicating across multiple audiences - practitioners through policy.
- To be able to implement these projects where opportunities exist (lower infrastructure); opportunities to learn more/communicate – Decision support model, workshops like these.
- Understanding what the opportunities are on smaller areas
- Data from existing projects needs to be better shared to gain confidence in this restoration.
- SW: One of the opportunities is that we have readily available drone-based imagery that we can collect relatively inexpensively – lots of monitoring issues, in these wetlands and flooded valley floors monitoring protocol is difficult – we see that individual projects have done their own kinds of things for monitoring and it's difficult to compare [among projects], but drone based sensing can help us solve the extensive nature of these systems.
- Remote sensing is one way to get at the question of uncertainty; there is also the question of Stage 0 as a reference condition v. stage 0 as a restoration approach. We have the ability to look at those places where Stage 0 exists [as a reference condition] and study those conditions and what's happening with fish populations there. We don't know how to inventory them.
- Are places where stage 0 exists mapped anywhere? [Opportunity to map reference Stage 0 systems and use to guide monitoring and provide information about fish populations and habitat use]
- Opportunities – continue ongoing monitoring and research
- Communication – more workshops to facilitate discussion and understanding of successes and failures. Monitoring critical for evaluation of projects and tracking outcomes.
- Biological opinion – can borrow from other applications such as using biological opinions/adaptive management templates to create common frameworks on goals/outcomes/ranges of benchmarks.
- Work with all landowners to make work as complete as possible.
- Solution is communication with one another, developing ideas to express stage 0 with people with work with and our community that we work with.

- Monitoring and tracking existing projects is important to understand comprehensive result of the work.
- Monitoring is important to educate about concerns. Workshops and general education really helpful to share knowledge.
- Even without stage 0, still trying to restore systems to natural trajectory and process-based restoration. Really struggling to find a place to do this type of restoration. How to find a place without downstream infrastructure.
- Tool that's useful is biological opinion, monitoring and adaptive management template that brings stakeholders together. Common framework on goals/outcomes/ranges of benchmarks. What are the triggers or thresholds that brings group together to speak the same language.
- More environmental flows with dam releases. Need more monitoring as well to understand projects and communicate with the public and stakeholders.
- Communication about successes and failures is really important.
- MFWWC Outreach Grant for work at EBSP – board outreach and DEI principals
- Scott: not sure, have not explored.
- McKenzie – fish-based work – i.e. Chinook redds. Create list of possible metrics and then see what is best for individual projects
- Application of monitoring data to pull partners together to share learnings. Helps build understanding. A need to build standardization into regional approaches with regional caveats,
- Beginning to get this to share information among PM and/or stakeholders, but also among practitioners so that community are speaking with consistent voice. How do we get that info out there?
- How do when id this opportunity? Need to watch and spend more time observing implemented projects. Experiment opportunity to understand need to intervention.
- Developing and supporting outreach to partners/public
- Creating consistency within monitoring across all project – a range of metrics
- Application/use of monitoring data – demonstrated value in increasing partner understand
- Speaking with consistent voice – structure to share info among PM's/stakeholders
- Identifying opportunities to adaptively manage project – op to understand when to intervene in projects
- Long term monitoring plan for both short term and longer-term habitat benefits. Project dependent on how long to monitor individual projects

- Better communication with partners during the planning process to allow enough time to provide input on the project and to plan for baseline monitoring to occur. 1 year of pre-project monitoring is not usually enough.
- Some felt that 6 years of pre-project monitoring would be needed, when compared to other long term paired watershed studies. Also, a need to establish as structure for long term monitoring to help address quality control, succession/turnover of staff etc.

What challenges should we be mindful of when addressing this?

- Guidance for what stage 0 is, etc. for regulators, other practitioners so they know what Stage 0 is, etc.
- There are projects claiming to be stage 0 but not really stage 0 – so communicating the definition of Stage 0 and better informing practitioners, reviewers, regulators, etc. will be important.
- Challenges for monitoring – redesigning approaches are required given the complexity of these systems relative to a single thread channel; currently hard to answer all of the questions; more investment in monitoring funding and capacity is needed.
- Each system is unique and will have elements that are different from others.
- Existing paradigm is incapable of understanding the system. Are deep pools the right focus? Is fish passage the right focus?
- Also what are the habitat attributes evolving within Stage 0 systems that are important for fish?
- Majority of work Helena has done has been salmonid-based, there are other species that use riparian areas – thinking about other organisms that don't get a lot of focus, non-game fish or aquatic species that might take advantage of Stage 0. What is the problem we're trying to solve and what are we trying to enhance, beyond salmonids.
- Managing people's expectations is going to be a huge challenge for these things, at local project level to larger scales, to the state investing in restoration projects, expectations to see increased size of salmon populations, which we know isn't controlled just by a few Stage 0 projects. Salmon and salmon habitat have been impacted by a huge number of things. Stage 0 restoration might be some of most productive areas but they are a small proportion of the total area salmon use – expecting big impacts on salmon run sizes is unrealistic.
- Lesson learned from other systems, gaining reliable knowledge requires heavy investment in science, I don't think people realize [the amount of investment that is required]; monitoring has lots of different intensities – these are going to have to be deliberate, long-term experiments across geographies.
- Be realistic about what we can do in terms of intensive monitoring, harder to get funding for monitoring, a lot of things we'd like to see but the reality of getting that on the ground at all locations is a challenge.

- Communication – how to communicate dynamism particularly with stakeholders, between researchers and practitioners, Colin – stage 0 as a term is jargon and inherently exclusive for those that don't know what it is. Need to be inclusive as we evaluate different projects.
- Timeframe – need to convey that this is a long-term process. Also need to be mindful of challenges around downstream landowners.
- Prioritization of stage 0 – compared to other projects, how to prioritize this work.
- Monitoring – avoid the kitchen sink approach and try and make sure that monitoring links specifically between objectives and data collection. Traditional monitoring often isn't a good fit.
- Prioritization of work – this doesn't work everywhere.
- How to convey a dynamic system that is messy, that is in a natural state. It's a state we haven't seen in 100 years. Easier to look for a location that's close by that's trending in the same direction as you'd expect with Stage 0 to show people's example. Need to teach about the processes. Need to have a time frame expectation of decades.
- These are large scale disturbances. Need to be able to explain the disturbance. Challenging.
- Communication between researchers and practitioners is a challenge. Lack of communication.
- Perception from the general public and landowners about what this is going to be and what this isn't. Need to be mindful of the language we use, and how we approach people. This is a challenge in restoration broadly, and very specifically with stage 0.
- Communication with landowners to bring folks on board, including downstream landowners. Prioritization of work – how does uncertainty fit in with uncertain stage 0 compared with more traditional fish passage projects with known outcome.
- Monitoring a single thread is easy, harder in stage 0. Judiciously line up monitoring with goals. Fearful of the kitchen sink approach to monitoring.
- Securing funding for monitoring is a problem. Also need funding for many years, not short term.
- Make sure that sites are landscape appropriate – don't push the technique where it should not be used.
- Terminology. Talk about functionality, not using term stage 0, it's exclusive jargon.
- Can't have appropriate places for stage 0 everywhere.
- Even in very restricted area can have a more dynamic system, and neighbors can enjoy that.
- Making assumption
- Just getting oriented with concept and restoration projects
- Climate change. Tidal zones vs. non-tidal zones.

- Funding monitoring is hard. Need to show why monitoring is a priority. Establish this as a standard need.
- Unintended consequences on other species such as lamprey, mussels or frogs
- Stage O conditions/sites are really complex. Meaningful monitoring metrics that are feasible to collect over the long terms will be difficult. Consider potentially intensively monitoring projects in specific ecoregions and social settings to then use information from those to derive a simpler set of metrics that could be used over many sites, similar to the Intensively monitored watersheds (IMWs)
- How best to have monitoring data collected to help inform where and what adaptive management should be performed on sites.
- Perception from private landowners on this type of restoration if the site becomes "too" dynamic. So many private landowners are applying for projects such as bank stabilization which make streams/rivers stable. This approach is the opposite in that it promotes dynamism in the channel.

Day 2 Breakout Sessions: Combined Responses

What are you most interested in tracking and learning about following this workshop?

- Information sharing: how we can find pathways of sharing info across the state and PNW. There are a lot of projects in the hopper especially on federal land. It is hard to access that information. Being able to develop communication methods is important.
- Agree with communication, would like to know different ways of monitoring, what is working, what is not, how to make monitoring efficient
- Information, especially as reviewer for OWEB relying on own knowledge and network to bring knowledge to team. It would be good to see lessons learned, e.g., have a library of lessons learned to facilitate the discussions that help OWEB make investments.
- How are others brought to Stage 0 club? It has been exclusive. There is so much potential especially restoring towards Stage 0 but not Stage 0 itself. In the Umpqua, there is a lot of interest but no one was invited to this meeting and they are interested in learning.
- More data and monitoring about floodplain connectivity and groundwater. She reviews Stage 0 restoration across state, and sees a trend of projects moving towards Stage 0 but need more information sharing through workshops like this and other ways to share ideas.
- How all this monitoring will help us determine what is effective in long-term and what the data will look like down the line. It looks promising but we don't know what will happen over time, nor the sustainability of projects.
- Monitoring results, and hearing about what's going on with all these various projects.
- The efficacy of Stage 0 projects.

- These projects are expensive and high-impact, so we need to hear more about their effectiveness, especially regarding fish passage.
- From a project reviewer standpoint, how do Stage 0 projects fit into prioritization of projects. How do they compare with more traditional projects?
- Most interesting to me was comparison of projects in different ecosystems. [I'd like to see] more meta-analysis across different systems, and differentiation of practices in different types of systems.
- I'd like to see more people touring and taking field trips to Stage 0 sites. These groups should include people with different viewpoints on the projects.
- I'd like to see an increase in communication across different projects, and discussion of the "nuts and bolts" of different monitoring methods. "White" papers on Stage 0 monitoring methods [would be useful.]
- Would be nice to have clearinghouse for these types of projects.
- Interested in learning how to communicate and share monitoring findings across broader geography. She is using data from 6 sites in OR, and 3 in CO.
- [ ] is sharing her work next week in restoration community in CO – would be good to figure out how to link up these efforts in different state.
- I work in Rogue and Umpqua systems; flashy, bedrock systems, trying to find a place where I could implement Stage 0 in these systems, where I have enough space...low risk...where it is likely to be successful…"what I want to do with my restoration work is 'set things back to more natural system'"
- [ ] agrees – this data isn't published in literature…need a clearinghouse…[ ]'s input is so important: why we need to rollup, draw broader findings to apply in different settings…(what does Stage 0 look like in fully alluvial, below dams, semi-alluvial, arid systems, Mediterranean climate, small steep streams, low gradient wet meadows..)
- I face a lot of similar settings in Colorado (bedrock, flashy)..she is looking at lateral confinement (where valley is 6-8x wider than channel).
- a) how are low-tech approaches working out? He would like to see beaver dam analogs, PALS, hears more about the major valley-reset projects, not much about low tech. B) how will these projects evolve in future? Seeing streambanks get more stable as the vegetation comes in, so possible incision...how will project sites evolve without beaver or other disturbance?
- How are project implementers documenting and managing sediment loads after Stage Zero implementation? I know this is a big issue, but not discussed
- [ ] values sediment data because it is so important, and understands fish information hard to collect, will take longer time to see a change. Also thinking about landscape position of these projects.

- Tracking ecological response over decades is going to be very interesting. Investigating the biological response to physical changes. These projects provide an awesome opportunity to look at ecology.
- Tracking wood dynamics. Detailed look at jam formations, composition to help guide a more targeted placement of wood rather than the spread it all over approach.
- Most interested in tracking and helping with building a community of practice
- Integrating information and knowledge from reference Stage 0 systems with monitoring from Stage 0 restoration projects
- How the habitat, physical structure, template of these projects will evolve over time and how it may differ across sites; what can we learn about that diversity of sites and how they change
- Most excited about various metrics folks are using to quantify physical and biological changes – excited to dive into Deer Creek project report – looking for commonalities that can be used to track change over time; because coming from mitigation, need to document success, change, performance of projects.
- Really interested in seeing more about the way these projects have forced a change in methods used to monitor projects and how that has pushed thinking about rivers to understand whole environment – what she's most interested in seeing more of.
- Community of practice and communication – connection of people and sharing to broaden our perspectives and groups with work with.
- Monitoring results and techniques – sharing failures as well as successes.
- How to carry this work forward and share and learn across projects. Connect staff to others. Keep people out of their small boxes. Better with more connection to develop a community of practice.
- Monitoring techniques and results. More frequent updates. Invasive species results from other sites would have been helpful sooner for similar issues.
- This workshop is really important to bring people together and share our experiences. We're doing it, keep up these workshops.
- Harder to see signal from fish and aquatic organisms. Most interested in tracking biological response.
- Social side of utmost importance. Frustration regarding terminology, or having people feel excluded. Need to keep people reaching out and be as inclusive as possible.
- Food and foodwebs. Community of practice to broaden.
- Learn more about natural processes that could also achieve similar results – debris flows examples
- Post-fire how will debris flows impact Stage 0 and other projects

- Good reminder that nothing we do in floodplains will last forever – increase understand and ability to work with natural cycle
- Piggyback on post-fire impacts, tracking monitoring and longer-term results/success
- Long-term effects, especially impacts, on fish, how habitat is developed and maintained/evolved. East vs. west differences
- How to evaluate from a review POV, i.e. monitoring BMP's, budget design that can be compared across projects -
- Monitoring, sharing lessoned learned from implementation in a timely manner – practitioners
- Opportunities for receiving or sharing info linked to projects. Better connections and opportunities for communication to share monitoring information they are collecting and learn from others.
- Tracking what is being learned and what is being monitored. Network of reference sites and how common were these Stage 0 conditions across landscape.
- Establishing protocols to measure metrics and these protocols could be repeatable over many projects.
- Monitoring and metrics should be tailored to listed or species of concern needs.

What are effective ways (e.g., annual workshop, online forum) for you to receive this [Stage 0-related] information?

- This workshop was useful. It would have been nice not to limit number of participants, many people in her program could have benefited from main sessions. Continue holding workshops with more participants.
- Agree, don't limit participation; this workshop was good, a lot of people can benefit. She is in the loop so she can talk to people she knows, but not everyone has that network. It would be nice to have a Stage 0 website. Every organization struggles with communication to partners, publics, etc. It would be helpful to have central clearing house. Don't reinvent wheel, create something with dual purpose for also benefiting practitioners through different parts of website.
- Agree with website. It would also be nice to have a meta-database of similar data so can see. For example, rather than a yearly update, you look how storms affect results across projects. Acknowledge that not sure how open people will be to data sharing.
- Field trips to Stage 0 sites with diverse viewpoints represented.
- "SharePoint" type website to review presentations from this workshop. But there are some questions that need to be answered about how this might work: Will OWEB answer outstanding questions [that emerge at the workshop]? Who would host such a "SharePoint" site? There needs to be a champion for these efforts.

- Outreach is good, but from a practitioner perspective (watershed council?) it is almost overwhelming to try and find time for such efforts. We have all we can do just to meet our main responsibilities.
- Maybe what we need is a full-time Stage 0 communication position at USFS?
- [There is a] blog for sharing Stage 0 experiences. I find this very useful. We need [a more formal] place to house such a blog [and expand access]. Very useful for sharing the "art and science" of Stage 0.
- Clearinghouse of information
- Forum that transcends regions
- Manual – like the beaver restoration guidebook, or large wood manual
- Seminar Series – like the Association of Wetland Managers (?), where 600 people from around the country can participate and listen to presentations
- In addition to providing materials to people to read/review on the computer, people need to get out and spend time on these sites.
- Webinars have been used effectively to provide workshops on Stage 0 across the US and Europe.
- A brief narrated video while walking a project provides a nice firsthand viewing opportunity.
- Stream notes (USFS) is a nice place to read about project developments.
- This type of forum with both plenary and breakout discussion sessions is very useful and the format works well. We need more of them.
- A lot of excitement built up around topic but then we go back to day to day work and informal networks
- Very challenging: think of how many sectors are involved with supporting, implementing, monitoring, etc., habitat restoration
- Promise of virtual work for community of practice?
- I wonder how traditional approaches to habitat restoration evolved and were accepted? Would it be helpful to examine the past and how restoration evolved? Did it happen organically? We might learn something looking at the past. Also to approach the challenge of COP we should start with the outcome we want, then back up and try to figure out how to get there? What about forming a subgroup to discuss a framework to build a COP
- I don't feel virtual networks are the best way to establish community of practice – having a lot of time for informal communication – start to learn the language of different individuals and different groups, we often end up talking past each other, you spend two years dating, trying to figure out who each other are, before you can get around to work – time for people to spend together thinking and talking, sitting on logs, kicking rocks

- Project tours
- Have to interact and listen to and learn from others with different viewpoints
- Need a strong advocate to champion the community of practice whether a single entity, agency, etc. There has to be a unifying energy.
- Example of Grande Ronde Model Watershed annual State of the Science meeting to share findings and formulate adaptive management actions in response
- Appreciation of the surveys.
- Liked diversity of topics in the workshop. Interested in more workshops of this kind.
- Effective to boil down responses – liked the survey and the feedback about that. Follow up is talking about this, as we're doing in the break out groups. Pre-workshop survey brilliant.
- Give OWEB credit for putting this together to share info. Try to do more of this type of info sharing annually.
- Bring in the folks who don't agree into the workshop.
- Looking forward to report out from this workshop. Share this workshop with other organizations like River Restoration NW. Broaden that definition of Stage 0 to include other ecosystems like meadow restoration.
- Personal challenge – staying engaged in Stage 0 projects as it is a small percentage of the job. Struggle with diverse SOW – beyond emails that are easily deleted
- Small groups that get together on monthly or more for talks or mini presentations.
- Adrienne: PNW mussel list serve example – website, meetings – multiple ways to engage
- Oregon Explorer to aggregate info and make it accessible – more accessible than OGMS. PDX ecologist unit – another list serve example.
- Region meetings led to good discussions in the field. Annual meeting to encourage broader discussions
- Efforts to establish a website as a clearing house for information. Email list serve or Online forum. Monitoring on this style of restoration has been very intensive and surpasses monitoring on other types of monitoring projects.
- Use of fact sheets that could be updated every year and that could condense pertinent information. Make sure there is contact information for further details etc.

How will you use it [Stage 0-related information] and/or how will it inform your work?

- A website or accessible place to see project examples, especially successful or in-progress to share with applicants who could use assistance, guidance and additional resources.

- Partners can feel disconnected from other projects, Website useful if OWEB created somewhere people could see what is going on. RRNW is good but it will be helpful to have regional information to help plan projects.
- It would be helpful to have a bulleted list of lessons learned from beginning presentations at this workshop. The presentations had dimensionless graphic descriptions and were loose on applications. It would be good to have a place to look at lessons learned, mistakes, and adaptations. It would be helpful for OWEB review teams when members have different levels of experience and knowledge.
- Echo what [ ] said but relate lessons learned to monitoring: who is doing what methods, how is it working. Most examples of Stage 0 are in forested areas; it would be nice to find out how the concepts apply to the Great Basin (areas that don't rely on wood).
- As a researcher, seeing other data is needed so I can compare to my own findings
- She would use the information to help her bring a Stage Zero-like approach to bedrock streams (that naturally would not have had a Stage zero condition); so she would like to know what types of sites would be suitable.
- Would inform where different types of restoration approaches are appropriate and the different tools
- A big take home was a comment from Colin Thorne in regard to adaptive management. If we are going to work within managed systems, we might need adaptive management. Funders don't like to hear that we may need to re-enter a project area with maintenance at some point.
- Social communications to share topics with others.
- Social communication beneficial. Likes to see how others present and communicate information.
- To support other groups in those places where we can do this work. Can support collaboration in places where we can do this. Doesn't see this as likely in private areas.
- Seeing possibilities particularly with landowners adjacent to public land. Need to dial in the monitoring to share wins and losses.
- Social communication related to the survey.
- This has been a great base/background info
- Helpful for working with landowner's form working lands
- Challenges to implement, but help with reviewer process
- Clarity on Stage 0 as a condition not a restoration technique
- Are applicants bringing monitoring and lessons learned to bear on future projects? This will help when making funding decisions for new projects.

- Inform monitoring to be required as part of the permitting process, what to hear from others what is needed so they can incorporate that in the future projects.
- Are projects tracking with best information we have.
- Help inform whether we care collecting the right metrics
- Will help with public outreach

Is there other key information about Stage 0 restoration that you need to do your work and didn't hear about today?

- Carbon sequestration. We saw what was going on in California with diverse wetlands; it would be great to know if these projects were helping with carbon, if so how much and again what the lessons learned are.
- When we talk about projects, we talk about good things—what is increasing or being benefited—but we don't focus on critiques and lessons learned. We don't need to sell projects to each other; we need to learn from each other.
- Reference conditions – we need more and better examples to be able to compare projects to.
- I think we need a quantitative assessment of perceptions of risk, across various agencies, summarized by agency. These varying perspectives could help us mold our Stage 0 "story".
- Need to work toward a standard of practice. Develop a strategic plan for working across a landscape.
- Need guidance for planning and design purposes.
- How to recognize the real thing. There are already practitioners claiming Stage 0 restoration on projects that very clearly are not. They are simply the same thing as before, but adding the terminology.
- Should hear more about failures
- Language we are using to discuss restoration approaches could use crisping up and unifying
- Fish passage. Would like more discussion of this.
- Rise in flood elevations. Need county approval for changes in flood elevation. If over 1 foot must do a study that they are not impacting infrastructure. This can be incompatible with interpretations of results of Stage 0 restoration. Need to know more about how to communicate how this may actually not be an issue.
- Would like to know more about the remote sensing for monitoring.
- Monitoring right now is very much geared toward fish. Could we be focusing on bigger picture also such as carbon storage and climate change (future issues) and fire resiliency?

- Historic aspect of channel evolution in any one river system. Were different Stages present along any one channel? Concerns that this new technique is being applied where it is not appropriate. What would the natural frequency of these systems have been on the landscape? This would help provide context on is this the right thing here.
- What are the other tools to apply, if Stage 0 is not the right fit in a given location?
- How close do these types of projects need to be to one another?
- What will these types of projects mean for water rights? Should consider addressing this ahead of time before it becomes an issue.

Appendix E: Post-workshop responses to plenary session chat box questions not answered during workshop

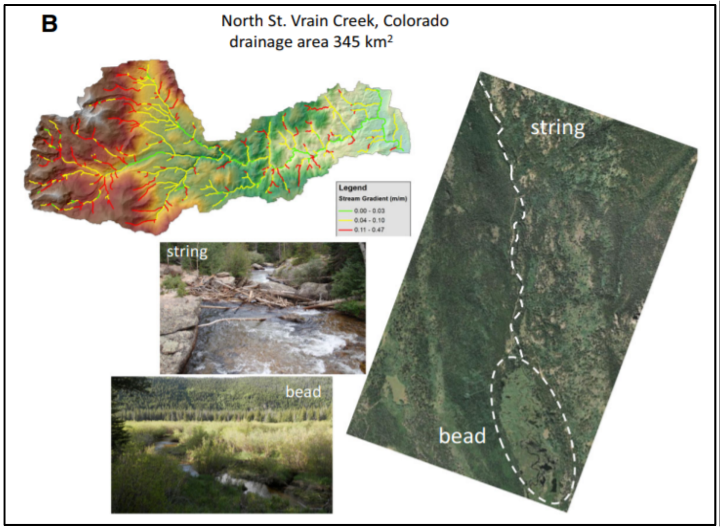
During the OWEB Stage 0 Workshop several comments or questions were raised that were not addressed during the workshop because we ran out of time. We targeted specific workshop speakers and panelists to respond to these comments or questions. The majority of comments or questions were answered by several workshop speakers and panelists and their compiled responses are attached here.

Session I chat questions/discussion

Question from Darin Jarnaghan, Coquille Indian Tribe: What is the smallest acreage or area stage 0 could/should be applied to, in general?

Answer from Kate Meyer: This depends on the site, the size of the stream and valley, the watershed context, and the project objectives. I would approach this in the following way (which is off the top of my head and has not been tested):

- Look at a digital terrain model of the HUC 12/6th Field sub-watershed
- Identify the "beads" (unconfined valley segments) on the "string" (confined valley segments) https://sites.warnercnr.colostate.edu/fluvial-geomorphology/wp-content/uploads/sites/53/2016/05/10.1007_s10533-017-0397-7.pdf
- Using the "bead" in the first image below (from Wohl et al 2017) as an example, I would think that treating ~10% of the "bead" (i.e. 2-3 meander bends of the incised stream) could provide some complex, productive habitat, but might not be enough area for meaningful connectivity, complexity, deposition, or reach-scale fluvial processes* to play out. In this example, 20-30% of the "bead" might be enough for that to start happening, and it might be enough to trigger upstream self-evolution to Stage 0 as well. Of the 3 "beads" that I've done Stage 0 projects in, if I could only treat 10-20%, then it would probably be considered a habitat enhancement project and not Stage 0. But every site and watershed are different. If your "bead" is massive, like the 6-million-acre San Luis Valley, then 10% would obviously be significant and ecologically meaningful.



It also depends on the objectives of the project. I could see a relatively small area being ecologically meaningful if, say, it would provide some of the only critical habitat available within the watershed for an at-risk species.

*Reach-scale fluvial processes from Roni and Beechie “Stream and Watershed Restoration”

- Shading
- Root reinforcement of banks
- Wood supply
- Sediment retention
- Litter fall
- Routing and stream flow
- Flood storage
- Sediment transport
- Sediment storage or retention
- Floodplain building
- Pool or bar formation
- Channel movement
- Pond formation
- Transport and storage of seeds, plant propagules, detritus

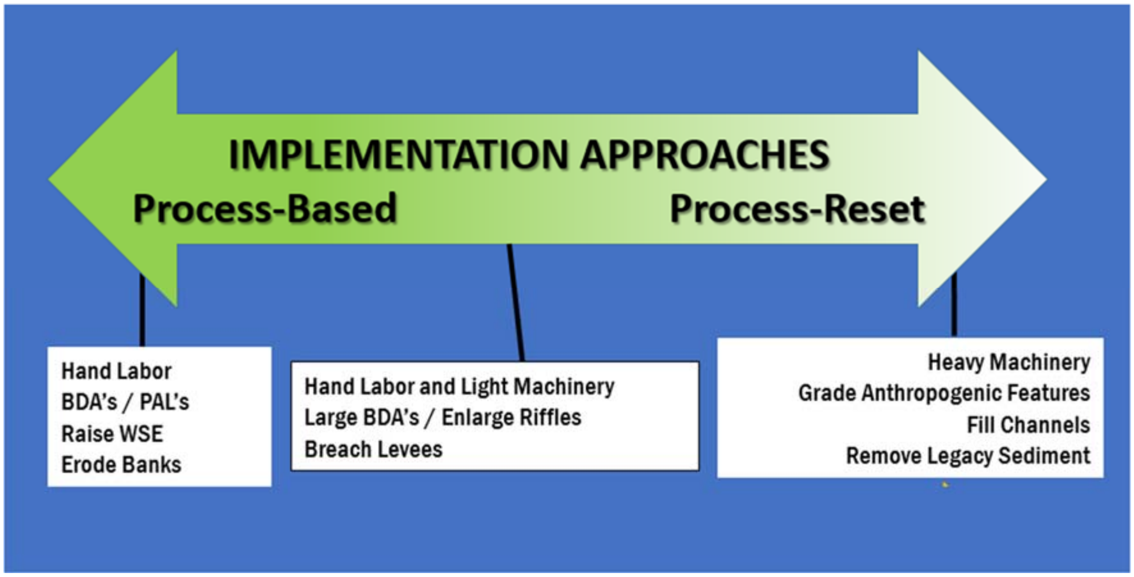
<u>Question from Phil Roni (CFS & UW):</u> I can think of few “reference stage 0 channels”. Brian Cluer showed one on Marsh Creek, can you think of others in Oregon?

<u>Answer from Brian Cluer:</u> There are many examples in Oregon, also located in the same types of settings where they are found in Idaho. Typically those areas are in climates too cold for farming. The Powder River in Oregon represents a large example. I suggest asking the OR USFS folks for examples in OR. There was a follow up question to this, "why are the channels in OR mountain meadows mostly

meandering single threads?" My response was, because all the mountain meadows have been grazed, lack apex predators, and have eradicated beaver for over a century; even those meadows that are now in wilderness areas and considered by us to be pristine; they are not.

<u>Question from Andrew Dutterer (OWEB):</u> In terms of implementation approaches, the 'reset' approach may not be available to some practitioners given certain conditions (e.g. funding, land ownership, etc.). Can you discuss restoration approaches that will achieve a stage 0 result that fall in between the process-based approach (BDAs, PALS) and the 'reset' approach that we commonly think of as Stage 0 restoration?

<u>Answer from Brian Cluer:</u> Yes, the spectrum of approaches (see figure below) that I showed at the end of my presentation vaguely covered the range of approaches from the low tech to the valley reset. In between these two end members are building up riffles, wood loading and relaxing banks using small machinery.



<u>Answer from Colin Thorne:</u> First, let's remember that 'Stage Zero' is a condition, not a process. Stage Zero is the pre-disturbance stage in the Cluer and Thorne 'Stream Evolution Model' (SEM) – nothing more, nothing less than that. In a restoration context, simply put, "Stage 0 restoration"[to use your term – I would say 'restoration to Stage 0, myself], involves removing artificial structures and fill, and reversing anthropogenically-driven channel changes (usually incision, but sometimes valley alluviation – like that described along the East Coast, in Walter and Merritts 2008 paper in 'SCIENCE'). That is possible in some places (probably more than is generally accepted at the moment) – but CERTAINLY NOT everywhere. Second, to answer your question directly, what we actually are talking about when we use the short-hand (jargon) term, Stage 0 restoration is full reconnection of a channel-floodplain-wetland that is currently disconnected due to past management/engineering/floodplain development. There are an infinite number of possible pathways along which natural processes can reconnect to its floodplain – the Stream Evolution Triangle shows that – freeing future recovery/evolution paths from that prescribed in the older Stream Evolution Model. Essentially, the valley flood reset takes the channel anti-clockwise

around the SEM, back to stage zero. The light-touch process-based approach can either take the channel anti-clockwise, back to stage zero (though this is usually only feasible if the channel is in stage 1, 2 or 3), or it can take a channel that's in stages 6 or 7 clockwise – around to stage 8, or if there's enough sediment supply, even to stage zero. Those are the 'book ends' of 'Stage 0 restoration'. BUT what the Stream Evolution Triangle shows us is that it is not predestined for a recovering or evolving channel to go around the SEM clock! In fact, events that happen DURING evolution or recovery (floods, droughts, human interventions) guide the pathway. Often recovery to the pre-disturbance condition or evolution to a new dynamically-stage condition like Stage 8 do tend to follow the SEM – that pathway is most trodden. BUT more often evolutionary pathways cut across the SEM or reverse it in response to new disturbances. In restoring a disconnected channel-floodplain-wetland system, working with natural processes means levering the power hydrology, sediment dynamics and biology to elicit the reconnection we desire. That's going to look different at each and every restoration site, depending on the catchment context, reach conditions AND events that actually happen before, during and after the restoration project. There really is no 'correct' or 'cook book' solution or design – the actions must be bespoke to the catchment, stream, reach, biota and people involved, including not only the science & engineering applicable, but also stakeholder values, goals and preferences.

<u>Answer from Johan Hogervorst:</u> Nature's approach to dissipating energy in broad alluvial valleys is to use the entire valley bottom and natural roughness elements (i.e. vegetation, wood, topography, etc). Once an incised channel is formed after various forms of disturbance, the fundamental ability of that valley bottom to dissipate energy has been altered and it will not function the same. Under the new transport regime, water uses bed and banks to dissipate energy, often leading to erosion and loss of water table. As Brian Cluer's last slide illustrated, Stages 3-5 of the Stream Evolution Model represent the incised condition with an entirely new energy regime. "Hybrid" approaches in Stages 3-5 that go halfway to restoring the proper energy dissipation almost always blow out in big storms…too much shear stress and stream power. They also tend to use hardened forms that are designed not to move, which goes counter to the dynamism that you want in this valley bottom environment. Stages 2 and 6 are not as severely incised and are more appropriate for BDAs, PALS and large wood placement that have higher potential to push depositional environments back to properly functioning. The GGL/REM model can produce a color-coded elevation map that helps determine degree of incision to help make decisions on which way to go.

If constraints prevent you from restoring proper energy dissipation and water table in what should be a depositional environment, move on to another location. Restoration to Stage 0 is not possible in every historically depositional environment, given the constraints you mention in your question. As a land manager looking at your watershed, prioritize valleys where constraints are not as forbidding and put your limited resources there. To start, consider investing in valleys higher up in watersheds where streams are smaller and investments are lower cost, looking for signs of ditching or head cutting that can be reversed cost effectively. We have worked on eastern Oregon sites with head cutting caused by overgrazing for as little as $1,500/acre. These examples exist everywhere.

A few important aspects to consider when deciding on an approach are "Which direction can we move through the stream evolution model and in what time frame?" "Do we have options to move forward, say from stage 3 to 8, or backwards from 3 to 0?" If we choose to advance to stage 8, this involves erosion and transport away from confining banks. While stage 8 is often a vast improvement over stage 3, we have accepted a lowered base elevation and transported away our native valley soils, a very valuable resource. The second part of that consideration is the time aspect. At the erosion and subsequent accretion rates observed in a particular valley, "Will it take years, decades, or centuries to reach the desired condition or can that be achieved more rapidly?" In deciding on a course of action, we need to weigh the monetary, ecological, time and opportunity lost costs. If it can't be done effectively because of outside constraints, punt and find another location where you don't have to make concessions.

Answer from Mathias Perle: The UDWC is working with the Deschutes Land Trust, US Forest Service and private consultants on a number of restoration projects in Whychus creek that use different "tools" or restoration approaches to help Whychus Creek move toward a Stage 0 condition. At the next phase of our Whychus Canyon Phase Restoration Project, we are not able to fully "reset" the entire valley floor due to cut/fill constraints on the property. We are exploring how we can potentially incorporate a combination of valley reset and low-tech process-based approach techniques to move the valley floor towards a Stage 0 condition. One technique is no more process based then the other per say but are differentiated by how quickly they short circuit certain processes over others in the stream evolutionary process. We expect that combining these approaches will lead to different parts of the project evolving at different rates where some portions of the valley floor may, for example, evolve more rapidly to a Stage 0 condition while others may first move to a Stage 8 condition (e.g. similar processes/benefits as Stage 0 but not connected all the way across the valley floor). We will also consider other methods or approaches if they hold promise in helping to achieve Stage 8 / Stage 0 conditions.

Session II chat questions/discussion

All questions were answered.

Session III chat questions/discussion

Question from Scott Sheppard, BLM: Can you speak to any hopes or fears for restoration projects located in burned areas? Specifically related to increased debris delivery and increased storm response peak flow rates.

Answer from Steve Wondzell: In my opinion, we really don't know what will happen post-fire. To start, let me say that I am not sure of how many of the Stage-0 restoration projects were in burned areas or are located downstream of severely burned areas. Certainly, the S. Fk. McKenzie R. project was in a severely burned area, with a substantial portion of the riparian area burned and many of the overstory trees killed. As of fall 2020, patches of green-canopied trees remain on site. The number of large, fire killed trees ought to lead to increased wood delivery over the next several years, followed by reduced delivery of large wood as the riparian forest regrows. Beyond that, the site is located below a major flood control reservoir so impacts from debris flows or increased peak flows would not be a concern.

More generally, we cannot yet be certain how the Stage-0 restoration sites will respond to extreme events such as 100+ year magnitude floods and major debris flows. We expect that the locations of the Stage-0 restoration projects—on segments of stream with lower gradients and wider valley floors—may make them less susceptible to channel reorganization during extreme events. Also, some portion of the large wood is generally buried into the streambed sediment and these pieces were intended to provide stability so that some large in-stream wood could move short distances as expected from natural processes in dynamic river systems, but limit the amount of large wood that could be transported out of the restored reach.

Debris flows have greater potential to impact the Stage-0 restoration sites, but this potential would depend on where the site is located within the stream network. Smaller and steeper-gradient streams can be entirely “reset” by debris flows, but for the most part, this is not where the Stage-0 restoration sites are located. Debris flows tend to “stall out” in larger, lower-gradient streams creating major deposition zones for large wood and sediment – creating portions of channel that in many ways resemble the immediate post-restoration conditions of the Stage-0 sites.

In the end, we will just have to wait and see. We know that the concept behind Stage-0 restoration comes from the 0th-stage in a natural channel evolution model. That is, major floods and debris flows drive scour, transport, and redistribution of both sediment and large wood, and thus reset the channel evolution back toward Stage-0. Further, we would expect these to occur more often in heavily disturbed areas like those burned this year along the west-slope of the Cascades. But we will also have to wait and see what this winter brings – a mild dry winter with no major storms will allow severely burned uplands more time to recover and grow herbaceous vegetation. The greater the recovery the lower the likelihood of post-fire increases in flood magnitude and debris flows when a major storm does occur. If this winter brings a rare, high magnitude and long-duration storm (the 100+ year magnitude), then channel-resetting floods and debris flows are more likely.

Answer from Kate Meyer: I have intimate experience with “hopes and fears” for our Stage 0 project on the South Fork McKenzie River in the 2020 Holiday Farm Fire. I knew that by restoring natural fluvial processes, heterogeneity, and hydrologic connectivity that the project area was in a more resilient state and in a better position to weather the literal fire storm that burned over 150,000 acres in 3 days. My biggest and really the only fear I had was that the 3,200+ pieces of large wood that were placed in the project burned up. That wood was placed in such high density to serve as important, relatively stable roughness elements – a proxy until island formation and vegetation recovery occurs – that reduces stream energy and potential for water to find concentrated flow paths that could lead to incision. Partial consumption of placed large wood likely would have been fine; that may have led to scattered areas of incision (which is natural), but overall the project area would have likely been maintained at its design geomorphic grade line (Powers et al 2018). Full consumption of placed large wood, however, would have changed the trajectory of the project dramatically without the development of islands, vegetation, and other roughness elements; stream energy would have increased likely leading to scour and incision, fewer channels and less hydrologic connectivity would follow, and without wood geomorphic and habitat complexity would be reduced.

Fortunately, <1% of the large wood within the project area burned and much of the vegetation survived (see Photo 1 below) in contrast to high vegetation mortality across most of the fire (see Photo 2 below). Although untested, we theorize that the restored river-floodplain-wetland system induced complex fire behaviors and a burn mosaic that, in turn, reduced the severity of damage to plants and soils, provided wildlife refugia during and after the fire, and altered floodplain-wetland patchiness in ways likely to facilitate post-fire recovery and increase future resilience.

Photo 1. South Fork McKenzie River project area a few weeks after the 2020 Holiday Farm Fire.

Photo 2. An un-restored side channel of the McKenzie River a few weeks after the 2020 Holiday Farm Fire.

Regarding resilience to sediment/wood delivery and increased peak flows, that isn't a concern on the South Fork because the project is below a flood control dam. On our other Stage 0 projects in free-flowing rivers, we welcome and look forward to disturbance events. Increased sediment/wood delivery and peak flows would help natural depositional processes unfold and maintain the dynamic and complex nature of the project. Through maximizing valley bottom connectivity, Stage 0 projects help attenuate floods and store sediment and wood onsite, reducing impacts downstream. The photo below illustrates the difference in flood water energy between the restored project area and an upstream un-restored reach on the South Fork McKenzie River.

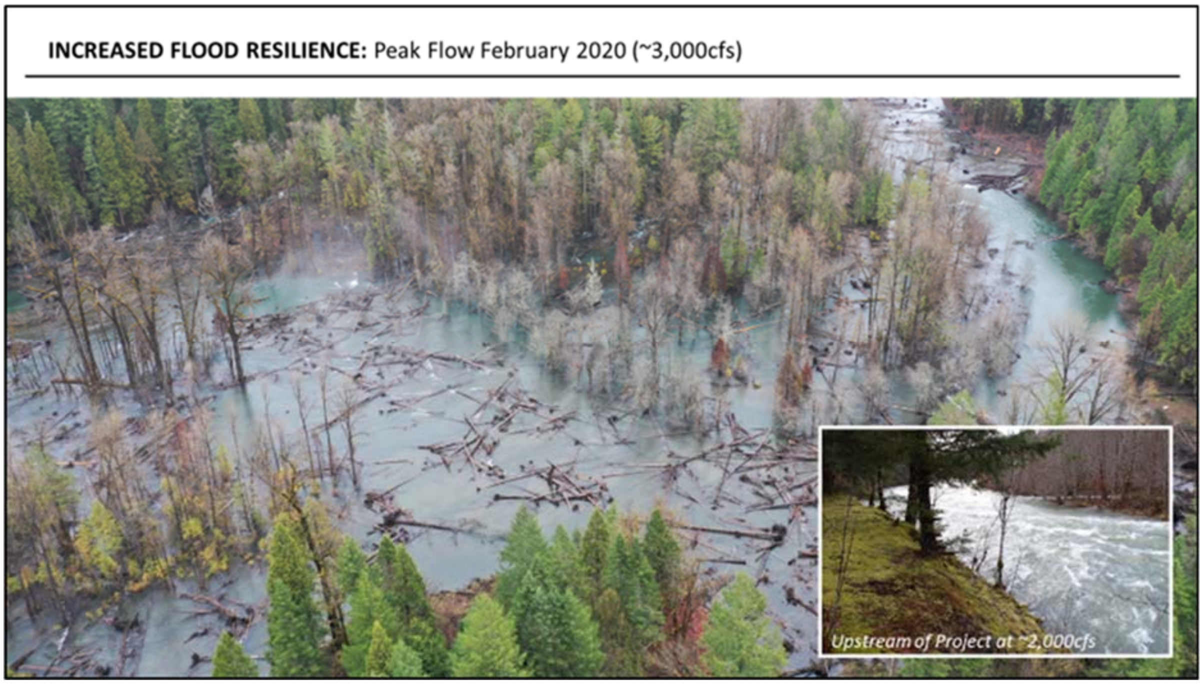


Photo 3. SF McKenzie River during flood event compared to insert at an unrestored reach upstream of the restoration project.

<u>Question from Sue Greer, OWEB:</u> How do upstream and downstream reaches that have not been restored factor in to the success of the project reach of Stage 0?

<u>Answer from Kate Meyer:</u> The reach directly upstream of a Stage 0 project is likely in a single-thread, high energy transport state, so the project reach design should consider this high energy as it enters the project. On the projects we've designed, the uppermost logjams are buried a bit more than the rest, knowing they will see very high energy. The upstream reach may see some level of self-evolution toward Stage 0 or 8 as deposition occurs and migrates upstream.

The reach directly downstream of a Stage 0 project is a critical consideration in design as it is the "tie-in" point typically back into an incised channel. This "tie-in" or transition needs to be carefully considered in assessment and development of the geomorphic grade line (GGL; Powers et al 2018). In most of the Stage 0 projects we've designed, the GGL includes a slightly higher gradient transition sub-reach to gradually tie in to the incised reach downstream without having large steps in gradient that may pose migration barriers to aquatic organisms. We have not engineered or constructed riffles to control the transition in a single-thread channel, but instead rely on spreading the flow out in an alluvial fan type of transition, often with multiple channels, that disperses energy rather than concentrates it.

<u>Answer from Johan Hogervorst:</u> Upstream and downstream conditions have a great deal to do with whether Stage 0 conditions will persist naturally. Use of LiDAR and modeling the geomorphic grade line (GGL) are essential to looking at the bigger picture for a stream valley and seeing where Stage 0 conditions would have occurred historically. LiDAR provides a way to look at geomorphic features that

created Stage 0 conditions in the past, and these features need to be accounted for in design. It also helps locate man-made features like ditches and berms that explain the current condition.

One example of an important geomorphic feature related to Stage 0 condition is an alluvial fan that comes into a valley bottom from a tributary drainage. These natural fans often cause main valley constriction that holds water on the up-valley side, forces subsurface flow and causes water to emerge as springs on the lower-valley side of the fan. Stage 0 is often associated with these fans and should be keyed into during design. If a location is being looked at for restoration to Stage 0 conditions, and there are no geomorphic or anthropomorphic features to act as tie-in points to maintain valley connection, the site has low potential for long term Stage 0 condition. Stage 0 conditions do not float in space with incised conditions above and below. There needs to be geomorphic context for the presence of Stage 0 conditions.

When a single valley must be restored in phases over multiple years, it is important to start the Stage 0 restoration at the downstream geomorphic control and work upstream during subsequent phases. Once the geomorphic control has been reestablished and a depositional environment has been restored, you can walk away from the site for a year or more without fear of degradation. The channelized segment immediately upstream of where the first phase ended will be a low energy environment and will actually self-heal in the interim between phases. Mobilized sediments entrained in the single thread/transport channel will be deposited at the upstream end of the project and "fill" some of the single thread channel.

In contrast, if you were to implement an upper reach in the first phase, the geomorphic control would remain degraded and therefore the restored segment of valley would be at risk. A restored segment of valley with a degraded geomorphic control downstream is the same as a headcut. We could expect to see ineffective alluvial aquifer recovery and the project site would be at risk of incision until the lower reach is restored

<u>Answer from Mathias Perle:</u> We have been designing our projects on Whychus Creek to function and stand on their own regardless of whether restoration occurs up or downstream of the projects. That being said, upstream and downstream conditions should definitely be considered when considering and designing a project reach to achieve Stage 0 conditions. Factors such a sediment/wood load, hydrology and hydrograph, dominant processes at play (e.g. transport or deposition dominated) are just some of the factors to consider both within the project reach but also up and downstream.

<u>From Ellen Hammond (ODA):</u> All the examples in this workshop seem to be in forested areas. What about Stage 0 restoration in Great Basin streams that are not "wood-heavy"? Is anybody doing it? How?

<u>Answer from Brian Cluer:</u> Yes, most of Joe Wheaton's projects are in the Great Basin, and all of Mark Beardsley's and Scott Gililan's projects are in the high desert Montana and Colorado basins. In both of these settings forests are not prevalent. Even the OR USFS staff have implemented Stage 0 projects in valleys without large wood.

<u>Comment from Ryan Bellmore, USFS:</u> There have been numerous statements yesterday and today about fish population responses—particularly salmonid species responses—as an indicator of stage 0 restoration success. However, it can be very difficult to quantify fish population responses (especially

anadromous fishes, as Steve alluded) to restoration even in relatively simple single-thread channels, let alone the wide and multi-thread nature that characterizes stage 0 channels. I'm wondering if monitoring at stage 0 sites may lend itself to more "holistic" monitoring metrics that examine the "heartbeat" of the ecosystem? Metrics such as primary production, secondary invertebrate production, and nutrient/organic matter cycling—all of which are associated with the capacity for rivers to support healthy fish populations. Similarly, monitoring metrics that focus on biodiversity may be insightful and easier to assess that population abundances. Metrics such as total species diversity, as well as the diversity of different life histories that species, such as salmonids, express. These diversity metrics may tell us something about the capacity of the ecosystem to both withstand and/or bounce back from environmental change and disturbances.

Response from Steve Wondzell: I think that Ryan Bellmore's comment reflects back to a part of the panel discussion in which OWEB asked the panelists to answer: "Based on your perspective and the survey responses you were provided, what future monitoring questions/data gaps do you think should be prioritized?" One cannot escape the fact that much of the larger societal goal driving public investment in stream restoration is focused towards maintaining and improving salmon stocks (run size, abundance, etc.) throughout their native range. As such, fish population responses make an obvious metric for monitoring. But a hugely problematic one – especially for anadromous fishes as I briefly mentioned in my response during the panel. I agree completely with Ryan's points, above, and would go even further. I think that we need to realistically manage expectation about what Stage-0 projects can accomplish. As of now, Stage-0 projects exist on a very small part of Oregon's rivers. Certainly, they are located in biologically important places – highly productive, wide, low-gradient valleys – so their impact should be greater than expected by just calculating the proportion of the stream network restored. But even though these are huge and expensive restoration projects, they cover very little of the stream network. A network that society has altered over the past 100+ years to meet specific societal goals. It will take a long time and many, many, many restoration projects before the influence of Stage-0 restoration would have a chance to be apparent in the numbers of salmon entering the Columbia River each year, or even passing over Willamette falls. We need to know, understand, and accept that reality.

Response from Mathias Perle and Lauren Mork: I really like where Ryan is going with this. As a paradigm shift, I find this more realistic and ultimately useful for monitoring these projects and what types of benefits we can achieve with them. Standard monitoring metrics are based on simplifying a system to a sum of its individual parts and making assumptions (based on data) that if a certain number of X then you will get a certain number of Y within individual boxes/silos. What this misses is how intricately interlaced so many of these metrics are and ultimately how they form a whole. Measuring components of the whole (e.g. how well a keystone species or process is doing) I agree is a better way of measuring system health and potential to support a range of species.

I agree that it is important to monitor more "holistic" metrics in Stage 0 restoration reaches as Ryan suggests, and including those he suggests. I'm guessing the relationships between these specific metrics and the capacity for rivers to support healthy fish populations have been demonstrated in the published literature, same thing with metrics that focus on biodiversity, but I think very clearly making that linkage to published literature is essential for using these types of metrics. What Ryan proposes is somewhat similar to the work done by Hall et al. (2018) to associate non-standard habitat metrics with fish production – I think we need that empirical relationship between these more holistic attributes and fish populations. I think there's also a need to have or as needed to collect the data to understand if those more holistic attributes are in place and we're not seeing a fish population response, why is that? In addition, I think there is a tremendous opportunity to start valuing and demonstrating the ecological benefits of these projects, e.g. water storage, carbon storage, increased resilience to fire and flooding, beyond the singular benefit of fish habitat.

Response from Dan Scott: I totally agree. From a geomorphic perspective, this is why I'm so interested in metrics related to landscape spatial heterogeneity, which may control biodiversity and biotic resilience. I and my collaborators are working to determine whether we can infer geomorphic processes and measure geomorphic complexity to determine if the foundation for biodiversity exists at a site. We're finding that while it's easy to derive geomorphic metrics that holistically reflect the processes active (or inactive) at a given site, knowing how to interpret those metrics is difficult, and there needs to be close tie-in between geomorphic measurements and biotic response. I think one frontier in improving our monitoring (and assessment, in support of planning and design) of river restoration that seeks to complexify valley bottoms, especially in high-risk settings (e.g., urban or developed rivers) is learning more about how geomorphic complexity actually reflects geomorphic processes, how complexity relates to geomorphic resilience and resistance to disturbance (e.g., under what conditions do multiple channels make a site more resistant to extreme incision during a flood, or how does a river's freedom to reshape its valley bottom control the timeframe over which it might adjust in response to a major sediment pulse, like a debris flow), and how geomorphic complexity translates to biotic diversity and resilience.

Question from Chris Jordan (NMFS/NWFSC): Very noble to put the process-based restoration methods under a research and monitoring lens. Why then do you not apply the same test to current form-based methods (ELJ, rock structures, "natural channel" design, etc.)? There is a +100yr history of demonstrating that these methods do nothing, yet the fad of using these approaches still dominates practice and the science of practice.

Answer from Brian Cluer: This question highlights the frustration of many of us in the field. It's a good question, but your workshop didn't set out to address that. It is very good perspective however on the current scrutiny of Stage 0 restoration.

Answer from Steve Wondzell: The point of this comment is unclear. While we appreciate that our monitoring effort is called "noble", the subsequent sentences seem critical of restoration monitoring and the scope of our efforts in particular. Maybe there is some confusion that the intent of our restoration monitoring might have been to monitor all types of restoration projects. That is not the case. Our monitoring project specifically focuses on Stage-0 type restoration as a relatively new restoration method. We certainly agree that much could be learned from a similar careful examination of other forms of restoration. We do not agree, however, with the claim that there is "a +100yr history of demonstrating that these methods do nothing", if for no other reason than the types of form-based restoration methods listed in the comment have only been widely employed in recent decades. There is no "+100 yr history" of such practices. Beyond that, there is some indication that form-based restoration methods do something, even if they have not fully met all the goals expected from the restoration projects. And finally, I hope we have learned the importance of evaluating new methods sooner rather than later, and thus it is now timely to evaluate Stage-0 restoration.

Answer from Colin Thorne: I read this as a soccer player yelling of 'bad call – that's unfair, referee!'. The inference is that those responsible for appraising restoration projects are applying double standards, with process-based restoration projects (as initiated and practiced by Chris Jordan and his doughty confederates including Michael Pollock and Joe Wheaton), being scrutinized and picked-at minutely, while channel-centric (Engineer Log Jam + rock = heavily structural/engineered) and Rosgen-style (natural channel design) approaches get a free pass or at least a lower less scrutiny. That is not, actually, true. Researchers like Margaret Palmer, Martin Doyle and Matt Kondolf have long studied engineering and 'form-based' restoration approaches and found them ineffective ecologically, and vulnerable to damage/instability during floods - even relatively low-magnitude events with return periods of ~10 years. I think what has happened is actually that the bar on what constitutes acceptable post-project monitoring and appraisal has been raised markedly since 2013/16 – when programmatic B.O.'s like HIP, SLOPES and ARBO began REQUIRING monitoring in order for a proposal to qualify for the programmatic process (instead of going through individual consultation). While the monitoring required focuses on listed species and the possibility of harm, I think the wider effect has been to attract attention to project-related risks, benefits and over-all performance more generally. That's why those granting state/federal permits AND the restoration community generally insist on more research and monitoring: (a) past projects haven't delivered, (b) risks of damage to species or project failure are taken more seriously these days and (c) expectations for VFM and project success (that is, demonstrable success) are much higher than in the past. In my view, the research and monitoring lens is being applied to process-based restoration because that approach has emerged in an era quite different to that which prevailed when structural and natural design methods were initiated and becoming established.

Question from Mike Lambert (CTUIR): For stage 0 restoration designs, is there a design methodology for wood placement? And, in monitoring wood numbers and location on a given site, how are the metrics interpreted as beneficial or failure (e.g. recruitment/loss, habitat complexity or sediment sorting, fish use, etc.)?

Answer from Steve Wondzell: We have no way to interpret a specific monitoring metric for large wood as a beneficial response or as a failure. For large wood, we are asking simpler questions: How much is there? Where is it located with respect to wetted channel areas, water depths, and flow velocities? And to what extent do these relationships change over time – either because of continued evolution of the site's morphology or because of wood movement itself? The monitoring data we are collecting today will provide the foundation for evaluating future changes and will help us to determine if the project is meeting its stated goals for amounts and distribution of wood. Other aspects of the project are evaluating macroinvertebrate abundance and diversity, site use by juvenile salmon and spawning adults, and several other aspects. But even these aspects of the project will only determine what happens—that is, has restoration led to greater macro-invertebrate biodiversity, greater productivity, more complex habitat, etc. To a great degree, determining if these changes might be beneficial or a failure, rests on the value system, and potentially competing priorities, of the person evaluating the change. As such, this sort of subjective evaluation lies outside the scope of our study.

Answer from Kate Meyer: There is not a design methodology because every site is different. On our projects in the Western Cascades, large wood plays a huge role in natural fluvial processes, particularly in unconfined valleys. Unconfined valleys were once depositional areas where wood, sediment, and nutrients from various tributaries and adjacent banks and slopes were deposited and stored for longer periods of time, so you can imagine how much wood once resided in these valleys.

Our “process-reset” Stage 0 approach sets the valley up for maximum connectivity, complexity, and dynamism and allows natural processes to play out over time. The design concept is to give the entire valley equal opportunity for evolution. By this I mean that flow and roughness elements (large wood, islands, vegetation) are fairly evenly (but randomly) distributed across the valley following construction and the river gets to decide where it wants to go – nothing is pre-determined or controlled, unless there is critical infrastructure to protect. The trick is to determine how much wood is enough, since wood is expensive and hard to obtain. Through our monitoring of various Stage 0 projects in the Western Cascades, we are constantly learning about wood density, size distribution, and placement types and techniques. Since it’s only been a few years, we don’t have answers, but general observations include:

- 15-20 pieces of wood (>12” diameter) per acre of peak flow wetted area is probably too little and 45-50 pieces per acre of peak flow wetted area is probably plenty in higher gradient valleys (1-2%)
- 25-35 pieces of wood (>12” diameter) per acre of peak flow wetted area seems about right in lower gradient valleys (0.5-1%)
- A more even distribution of wood sizes from slash to mature trees (~>24” diameter) seems to be preferable and pieces with rootwad are important; one project that used only mature trees didn’t have finer woody material to fill in spaces of logjams and seemed to have less of a geomorphic effect than logjams with various wood size
- Placement types and techniques vary across our projects, but a common theme is that about 30-40% of the wood is partially buried. Some projects scattered wood across the valley while other projects placed most wood in scattered logjams of varying size.

Project success or failure is typically determined by the project objectives. Typically the only wood-related project objective we use is something like: “Increase wood abundance by at least 1000% and retain at least 90% of project wood within project reach within 5 years of project completion”, but we’re also interested in the spatial patterns and how wood moves around within the project area. Metrics include: wood abundance (e.g. density, aerial cover, volume); proportion of project wood retained; spatial and temporal change in wood abundance; wood retention rates by placement style. Data is collected using a combination of remote sensing and transect or plot-based surveys.

We also conduct observational/qualitative monitoring, which has led us to theorize that too low of wood density and skewed size distribution of wood can lead to areas of incision, coarsening of substrates, and less connectivity and wetted area. These aren’t necessarily “failures” unless they drop below a certain threshold that you’ve included in the project objectives.

<u>Answer from Johan Hogervorst:</u> Speaking for reset projects, once flow is taken out of a transport channel that was acting as a highly efficient ditch, and put onto the entire valley floor, there is very little transport capacity. This allows us a great deal of flexibility for wood placement. Early projects on the Willamette National Forest in the West Cascades were placing large wood at about 14-16 pieces per acre. We are now closer to 35-40 pieces per acre of both large and smaller piece sizes. We have used latticed approaches where wood is spread across open surfaces uniformly with only a few pieces per

acre buried and we have also used more of a structure-based approach with pieces buried in each multi-piece structure and wood spread in between. In either approach, higher flows are allowed to shift wood and rack up smaller pieces to form bigger jams. Wood is placed to split flows and dissipate energy across the floodplain, while ensuring that linear flow paths that may concentrate flows are disrupted, creating the maximum amount of complexity in velocities, cover, spawning and rearing. We use wood not only for habitat elements for fish, amphibians and macroinvertebrates, but our wood placement creates short term roughness until sediments sort and vegetation responds to the recovered water table. Eventually, vegetation will become the dominate influence on channel and wetland formation, sediment storage and the dynamism on which native species thrive.

Wood metrics should help answer the following questions in our projects:

- Are wood pieces leaving our project sites? (so far, no)
- Is wood creating roughness on our valley floors, sufficient to scour, sort and deposit sediments within our sites? (early observations say yes, as soon as the first winter)
- Is the wood we are placing buying time for vegetation to become established under the new hydrologic regime with wetlands and high water table? (vegetation is responding immediately to increased water table as well as on islands that are forming around wood)
- Are pools forming and maintaining around the wood to provide optimal rearing habitat? (Some pools are forming and others filling, but overall, water is deeper on these sites post-project).
- Are wood-dependent macroinvertebrates keying in on our wood? (Yes, in some locations; TBD over time).
- Does the wood act as a dynamic element within the context of fluvial processes? Does it move and shift resulting in changes to flow paths? (Yes, in response to the higher flows in the first two years after construction, depending on the site)

This excerpt from Sedell and Froggatt (1984, p. 1830) describes how the Willamette River behaved when it was in stage 0 condition: "[the floodplain] during floods was covered with swiftly-running water to a depth of 1.5 to 3 m. Each year new channels were opened, old ones closed; new chutes cut, old ones obstructed by masses of drifts; sloughs became the main bed while the latter assumed the characteristics of the former; extensive [wood] rafts are piled up by one freshet only to be displaced by a succeeding one; the formation of islands and bars is in constant progress where the velocity of the current receives a sudden check only to disappear at the very next high water."

Our design for the South Fork McKenzie River project assumed the need to reassess wood needs on a 30-year basis, given that natural inputs will be limited by Cougar Dam. The recent Holiday Farm Fire will provide much more wood over the next 30 years. Given the redistribution of energy across a much broader template, leading to decreased stream power, no wood has left the 200-acre project site to our knowledge, even after a 5,000 cfs flow released from the dam.

<u>Answer from Mathias Perle and Lauren Mork:</u> Using the valley reset method using the Geomorphic Grade Line approach, the most recent iterations of design for wood placement has involved spreading out wood as diffusely as possible across all disturbed and unconsolidated surfaces as opposed to making wood aggregates or distinct log jams. The intent is to not allow water in any one flow path to gather too

much energy/velocity before it has to "interact" with roughness (wood in this instance) in the early phases following valley reset in these unconsolidated/disturbed areas. Over time, establishing riparian vegetation and associated root mass along with future wood recruitment will help achieve this roughness that placed wood is providing in the short term. Our most recent design calls for approximately 1/3 of total wood placed to be partially buried (approximately 1/3 of the piece). The assumption being that 2/3 of wood placed will not be buried and could be mobilized by higher flows. We want some of the wood to adjust and move around and "rack" up in areas of the project based on what flows and sediment dynamics dictate. That is we expect some of the wood to be "stable" and some of it to mobilize but don't necessarily need to dictate exactly which pieces and where.

Using low tech process-based restoration (LTPBR) approaches with PALS and BDAs, the wood is placed and locked into place using posts. However, it is fully anticipated that stream energy during higher flow events will likely dislodge or "unlock" some of these smaller wood structures given that they are built by and we do not have the option to bury wood. LTPBR design on our projects involve building structures in complexes made up of 4-8 individual structures. As wood from any one structure is dislodged and becomes mobile, it then can interact/rack up with other downstream structures/complexes. Our LTPBR design incorporates monitoring and adaptive management over multiple years and high flow events that include continued either maintenance or construction of new wood structures or complexes until processes and wood recruitment are self-sustaining.

From a monitoring perspective, we are examining how much of the wood placed on site remains on site and how well it is interacting with flows to create geomorphic and habitat complexity. While wood is one factor in the development of geomorphic and habitat complexity, it is in of itself not the only factor dictating habitat evolution. We are moving toward establishing numerical objectives for wood and other metrics within ranges as opposed to fixed numbers to reflect that dynamic nature of any one metric and how dependent it is on other metrics we are monitoring (e.g. vegetation establishment, groundwater table, wetted area etc.) We rarely discuss/interpret metrics as failing if we fall outside these ranges but more from the perspective of how we can adaptively manage the existing project or better design the next project. Failure if one needs to use this term would be return to the pre-project condition. For the wood metric, this would be little to no wood on site. We have not even come close to observing this on any of our projects as even though wood may mobilize within a project reach, the spreading of energy that these projects achieves (no single thread channel with concentrated energy) means that when wood does move, it cannot move as far.

With regard to interpreting wood numbers as beneficial or failure: We are comparing post-project wood metrics, including number of pieces, number of jams, volume, and area of LWD, to pre-project values where they exist and to untreated reaches on Whychus Creek where pre-project values aren't available. We consider any natural recruitment a habitat benefit while recognizing that in the near term (10+ years) recruitment of large wood in project reaches through tree mortality is most often a direct result of project implementation and a changed hydrologic regime rather than evidence of the natural process of recruitment through natural tree mortality being re-established. We consider increases in wood or wood jams particularly within active channels to be an asset and habitat benefit, knowing from literature that wood serves multiple process and habitat functions including promoting scour, deposition, and the creation of geomorphic units which contribute to habitat complexity, as well as providing cover for fish and habitat for benthic macroinvertebrates; we don't have a minimum value at which we consider wood to provide additional benefit, we consider any increase in wood to improve habitat. However, for some Chinook and steelhead life stages the HabRate model (Burke et al 2010) does provide specific value thresholds for pieces of wood, key pieces of wood per pool, and pieces of wood per pool, that differentiate habitat into good, fair, or poor (in combination with a number of other metrics), and these criteria could be applied to wood numbers in project reaches.

Answer from Dan Scott: This depends on the goals for the restoration and the local and downstream risks specific to the site. I tend to avoid using words like "failure", other than to describe a complete failure to meet project goals - everything else is just a situation that does or does not trigger adaptive management. Generally, I approach evaluating wood impact on a site from the geomorphic perspective (I'm a geomorphologist), but I try to make sure whatever I'm measuring has meaning in terms of reflecting desirable (related to goals) or undesirable (related to risks) geomorphic processes. If I can estimate or derive a proxy for geomorphic processes, I can then work with biologists and/or ecologists to help understand how those processes relate to biotic response. One example: I might track wood morphologic impact (e.g., I could measure what proportion of wood jams create pools across a site and the spatial distribution of that impact) as a measure of wood function (wood load doesn't always relate to wood function), then contextualize that measurement by thinking about what factors actually limit aquatic species on the site. Maybe pool habitat isn't all that important, or maybe bed elevation complexity was a key goal of the project, since it is judged to be key to the ecosystem. If pool habitat is identified as a key limiting factor, then seeing that a lot of the wood on site is creating pools, or bed elevation heterogeneity, would be interpreted as a good sign, and if not, that might suggest that we should be doing more investigation to figure out why and then consider adaptive management.

Question from Kelly Coates, Cow Creek Band of Umpqua Tribe of Indians: Have any of the panelists used or thought about using structure from motion (SfM) to track Large Woody Debris (LWD) movement?

Answer from Steve Wondzell: We are using structure from motion to create digital surface models of the S. Fk. McKenzie River. Some of the observed site roughness is clearly caused by large wood, but this has not been used to track wood movement. Matt Barker, an OSU graduate student working on the project has developed a semi-automated process to map wood at the site using drone-based multi-spectral imagery. As we collect more imagery, over time, I expect to use the semi-automated classification process to track wood movement.

Answer from Lauren Mork: We have imagery and a SfM product derived from it, but we haven’t specifically planned to use SfM to track LWD movement. This is for two reasons. LWD movement has been a lower-priority monitoring parameter for us both because of the remote, rural setting with no bridges or paved roads downstream of the project down to the confluence with the Deschutes, and because we haven’t focused specifically on the mechanistic, local deposition and scour associated with wood. We would also need to acquire a subsequent SfM product to support a time series and be able to track movement. But, it’s a good idea and I would be surprised if it wasn’t being done elsewhere.

Answer from Dan Scott: SfM produces a snapshot in time, and wood pieces may be difficult to reliably identify based on their shape alone (the data product derived from SfM is a 3D point cloud), or even their shape plus spectral characteristics. I haven't tried using SfM to track wood movement, but I definitely use it (i.e., a SfM derived surface plus the imagery used for the SfM) to look for wood jams that likely won't pass wood, then infer whether wood is leaving a site. It's much harder to track individual pieces without some sort of physical tagging (e.g., RFID chips, paint, metal tags, etc.), as far as I know, but perhaps that's changing.

Question from Amy Horstman, USFWS: Can they project the length of that design life for the South Fork McKenzie River restoration project and other sites?

Answer from Kate Meyer: Our "process-reset" Stage 0 projects are designed to restore natural fluvial processes and let those processes recreate a dynamic anastomosing system. If all the components of a functioning system are in place (unaltered flow, sediment, and wood delivery regimes, etc.) then the design life is indefinite – we should be able to walk away. If there are, however, impaired processes within the watershed (due to dams, roads, logging, grazing, etc.), then future maintenance may be needed. This is the case on the South Fork McKenzie River, which is below a dam that alters the flow regime and interrupts the sediment and wood supply. The project plan is to augment sediment and wood as needed based on monitoring. We expect sediment augmentation to occur every 1-3 years and wood augmentation every 20-50 years. Deer Creek, Staley Creek, and Coal Creek sub-watersheds are functioning quite well and it's likely that no maintenance will be needed to sustain a Stage 0 condition indefinitely.

Question from Amy Horstman, USFWS: I would love a recap of the definition. Please provide a recap of the approach of synoptic monitoring in the follow up Q/A responses to better understand it.

Recap of the definition: *"Stage 0 restoration" is a valley-scale, process-based (hydrologic, geologic and biological) approach that aims to reestablish depositional environments to maximize longitudinal, lateral, and vertical connectivity at base flows and facilitate development of dynamic, self-formed and self-sustaining wetland-stream complexes.*

Answer from Colin Thorne: Greek philosophy teaches us that when monitoring what happens (as well as trying to forecast what will happen – as in the synoptic weather forecast for the path of a hurricane), we should recognise that 'wisdom emerges from a coherent understanding of everything together'. That means that while we are measuring numerous, KPIs (key performance indicators) relevant to a wide range of different project aspects and beneficiaries, we should still recognise and value the benefits of 'seeing everything together': that is we take a synoptic view of the river-floodplain-wetland corridor as a whole that is far, far more than the sum of its parts. In practice, synoptic monitoring involves an interdisciplinary expert (or more likely a panel of subject matter experts) periodically compiling together the monitoring information (not just the data, but useful information generated by analysis of the individual monitoring activities) and evaluates the overall performance of the channel-floodplain-wetland system. This should be done in the context of its contribution to the functions within and outside the restored area, of course. For example, a fully functional 'response' reach is a valuable 'capacitor' for water, sediments and nutrients moving through the fluvial system – slowing their passage, provisioning wildlife and smoothing out some of the variability in fluxes that characterises fluvial systems dominated by source and transport reaches. A synoptic view takes all this into account when judging the performance and success of a river restoration project and build wisdom with respect to the science and practice of river restoration.

Appendix F: Post-workshop survey responses

Workshop:
River Restoration to Achieve a Stage Zero Condition

Synthesis of Responses to a

Post-Workshop Survey of Registrants

Oregon Watershed Enhancement Board

January 15, 2021

Survey background and overview

This document compiles and synthesizes responses to a short survey of persons registered to attend a Stage 0 river restoration workshop sponsored by the Oregon Watershed Enhancement Board. The survey was conducted following the workshop to identify priority next steps and key contacts to further the communication network to share new information as it emerges.

Survey respondents provided their name, organization and email address for future communication, but the survey respondent's personal information is not reported here. This summary includes responses to two close ended questions and additional feedback provided to one open ended question. This information is intended to help inform development of a communication network to share emerging information in the future. No single agency alone can implement this. A partnership approach will help achieve communication success over the long term.

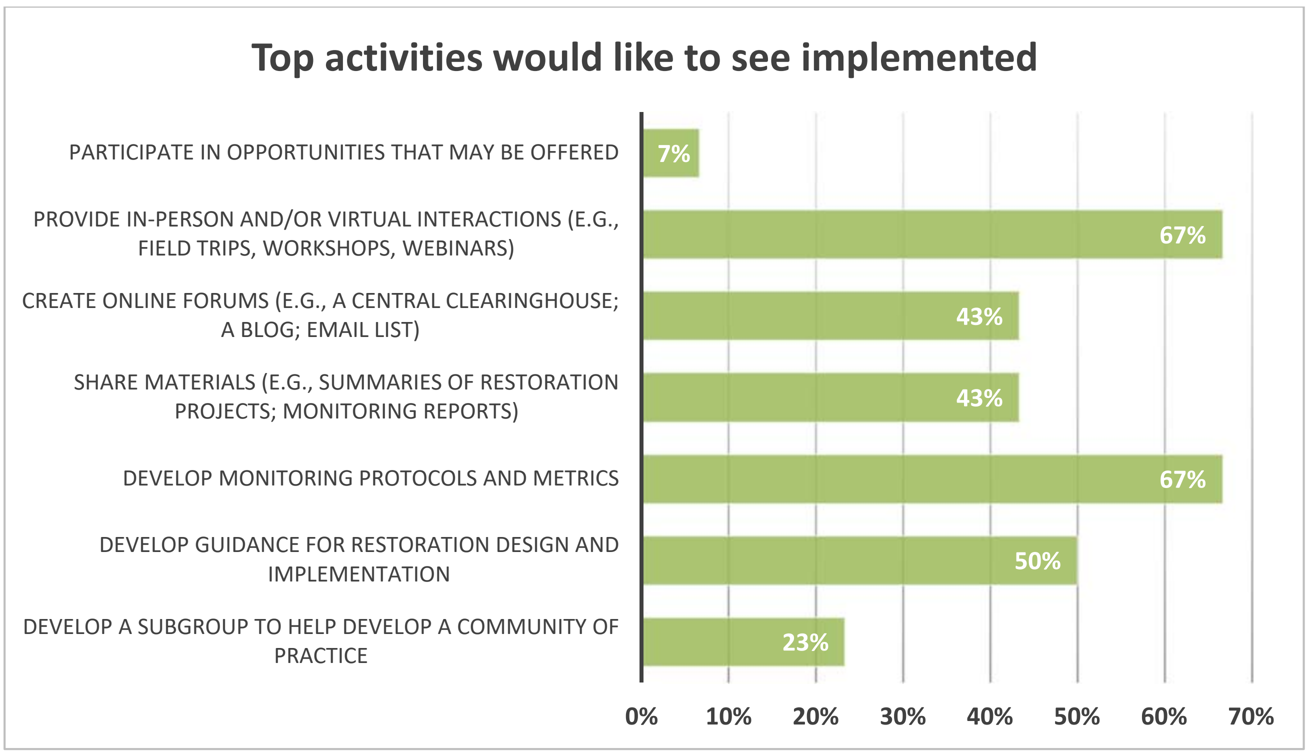
OWEB STAGE 0 POST-WORKSHOP SURVEY:

COLLATED RESPONSES

30 total responses (not all respondents answered all questions)

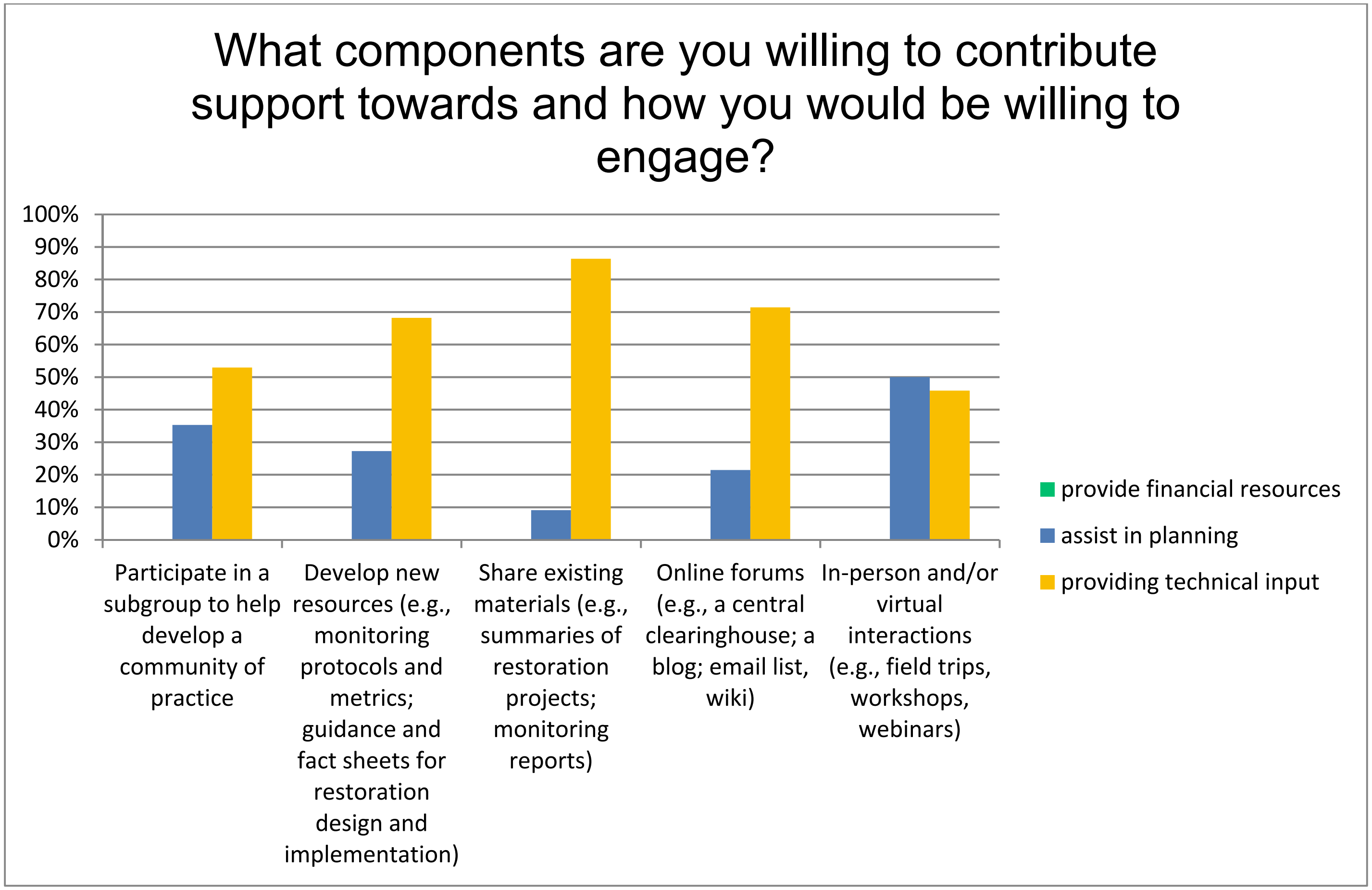
Survey Question 1. Select the top 3 activities associated with a communication network and/or information sharing that you would like to see implemented. (Only select 3)

30 answered, 0 skipped



Survey Question 2. What components are you willing to contribute support towards and how you would be willing to engage [i.e., financial, logistical, technical]? (Select as many as you like)

28 answered, 2 skipped



Survey Question 3. In the intervening weeks since the workshop occurred, do you have any additional thoughts on how to develop a communication network or process to share new information as it emerges?

6 Answered, 24 skipped

Raw Data

I would suggest that an annual meeting each year with information from the various stage-0 projects would be valuable for practitioners.

Community of practice, you keep using that phrase. I do not think it means what you think it means.

I really like the idea of a central place where people can go to get the latest information on implementation and monitoring of restoration to stage 0 conditions.

Share information by email and Instagram

I think attempting to organize a Stage 0 State of the Science workshop following the Grande Ronde State of the Science annual meeting, that updates the information shared at the November 2020 workshop could be one component of a communication plan; having a Stage 0 repository for Stage 0 designs, protocols, and publications, possibly housed under PNAMP, could be another effective element; creating an annual call for data, plans, and reports also might capture new information.

I think making sure it's accessible to all users is important. For example, it's difficult for me to get documents off of dropbox and google docs due to work security settings. Also, during the workshop since I used the zoom browser option (work won't let me download zoom) it would kick me out of the meeting when put into breakout groups and I could not see the poll options.

Appendix G: Stage 0 Annotated Bibliography

This bibliography compiles references and materials related to river restoration targeted at achieving a Stage 0 condition. Included are peer-reviewed papers, reports, workshop and educational materials, and other documents.

Entries were identified primarily through communications with sponsors and practitioners involved with preparation for a workshop on Stage 0 restoration on November 5-6, 2020, as well as some limited literature searches. A few additional references cited during the workshop were added afterwards.

Most annotations are abstracts or executive summaries; some entries include additional comments from various sources.

This bibliography is not complete or exhaustive. Rather, it is intended to provide a starting point for individuals interested in learning more about the rationale and methods for projects aimed at restoring rivers to a Stage 0 condition.

Suggestions for additional, directly relevant entries or annotations for may be submitted to: jeff.behan@oregonstate.edu

Cluer, B. and Thorne, C. 2014. A stream evolution model integrating habitat and ecosystem benefits. *River Research and Applications*, 30(2), pp.135-154.

Tells the Stage 0 "story". Regarded by practitioners as a seminal paper in the Stage 0 literature.

Abstract: For decades, Channel Evolution Models have provided useful templates for understanding morphological responses to disturbance associated with lowering base level, channelization or alterations to the flow and/or sediment regimes. In this paper, two well-established Channel

Evolution Models are revisited and updated in light of recent research and practical experience. The proposed Stream Evolution Model includes a precursor stage, which recognizes that streams may naturally be multi-threaded prior to disturbance, and represents stream evolution as a cyclical, rather than linear, phenomenon, recognizing an evolutionary cycle within which streams advance through the common sequence, skip some stages entirely, recover to a previous stage or even repeat parts of the evolutionary cycle. The hydrologic, hydraulic, morphological and vegetative attributes of the stream during each evolutionary stage provide varying ranges and qualities of habitat and ecosystem benefits. The authors' personal experience was combined with information gleaned from recent literature to construct a fluvial habitat scoring scheme that distinguishes the relative, and substantial differences in, ecological values of different evolutionary stages. Consideration of the links between stream evolution and ecosystem services leads to improved understanding of the ecological status of contemporary, managed rivers compared with their historical, unmanaged counterparts. The potential utility of the

Stream Evolution Model, with its interpretation of habitat and ecosystem benefits includes improved river management decision making with respect to future capital investment not only in aquatic, riparian and floodplain conservation and restoration but also in interventions intended to promote species recovery.

Powers, P.D., Helstab, M. and Niezgoda, S.L. 2019. A process-based approach to restoring depositional river valleys to Stage 0, an anastomosing channel network. *River Research and Applications*, 35(1), pp.3-13.

Describes the Geomorphic Gradeline (GGL) approach to restoring to achieve a Stage 0 condition.

Abstract: Stream restoration approaches most often quantify habitat degradation, and therefore recovery objectives, on aquatic habitat metrics based on a narrow range of species needs (e.g., salmon and trout), as well as channel evolution models and channel design tools biased toward single-threaded, and "sediment-balanced" channel patterns. Although this strategy enhances perceived habitat needs, it often fails to properly identify the underlying geomorphological and ecological processes limiting species recovery and ecosystem restoration. In this paper, a unique process-based approach to restoration that strives to restore degraded stream, river, or meadow systems to the premanipulated condition is presented. The proposed relatively simple Geomorphic Grade Line (GGL) design method is based on Geographic Information System (GIS) and field-based analyses and the development of design maps using relative elevation models that expose the relic predisturbance valley surface. Several case studies are presented to both describe the development of the GGL method and to illustrate how the GGL method of evaluating valley surfaces has been applied to Stage 0 restoration design. The paper also summarizes the wide applicability of the GGL method, the advantages and limitations of the method, and key considerations for future designers of Stage 0 systems anywhere in the world. By presenting this ongoing Stage 0 restoration work, the authors hope to inspire other practitioners to embrace the restoration of dynamism and diversity through restoring the processes that create multifaceted river systems that provide long-term resiliency, meta-stability, larger and more complex and diverse habitats, and optimal ecosystem benefits.

Wheaton J.M., Bennett S.N., Bouwes, N., Maestas J.D. and Shahverdian S.M. (Editors). 2019. Low-Tech Process-Based Restoration of Riverscapes: Design Manual. Version 1.0. *Utah State University Restoration Consortium.* Logan, UT. 286 pp. http://lowtechpbr.restoration.usu.edu/manual/

Describes restoration using beaver dam analogues (BDAs) and post-assisted log structures (PALS).

Executive Summary: Stream and riverine landscapes or riverscapes are made up of a series of interconnected floodplain, groundwater, channel habitats, and their associated biotic communities that are maintained by physical and biological processes that vary across spatial and temporal scales. An over-arching goal of riverscape restoration and conservation is to improve the health of as many miles as possible, while ensuring those systems achieve and maintain their potential in self-sustaining ways. This design manual is intended to help the restoration community more efficiently maximize efforts to initiate self-sustaining recovery of degraded riverscapes at meaningful scales. Structural-starvation of wood and beaver dams in riverscapes is one of the most common impairments affecting riverscape

health. At a basic level, a riverscape starved of structure drains too quickly and efficiently, lacks connectivity with its floodplain and has simpler more homogenous habitat. By contrast, a riverscape system with an appropriate amount of structure provides obstructions to flow. What follows in the wake of structurally-forced hydraulic diversity are more complicated geomorphic processes that result in far more diverse habitat, resilience, and a rich suite of associated ecosystem services. The purpose of this design manual is to provide restoration practitioners with guidelines for implementing a subset of low-tech tools—namely post-assisted log structures (PALS) and beaver dam analogues (BDAs)—for initiating process-based restoration in structurally-starved riverscapes. While the concept of process-based restoration in riverscapes has been advocated for at least two decades, details and specific examples on how to implement it remain sparse. Here, we describe 'low-tech process-based restoration' as a practice of using simple, low unit-cost, structural additions (e.g., wood and beaver dams) to riverscapes to mimic functions and initiate specific processes. Hallmarks of this approach include:

- An explicit focus on the processes that a low-tech restoration intervention is meant to promote
- A conscious effort to use cost-effective, low-tech treatments (e.g., hand-built, natural materials, non-engineered, short-term design life-spans)
- Letting the system do the work', which defers critical decision making to riverscapes and nature's ecosystem engineers

Importantly, the manual conveys underlying principles guiding use of low-tech tools in process-based restoration in systems impaired by insufficient structural complexity. Although intended to be simple, low-tech restoration still requires some basic understanding of watershed context, riverscape behavior and channel evolution, and careful planning. The manual provides interested practitioners with sufficient conceptual and applied information on planning, design, permitting, construction and adaptive management to get started, as well as references to additional information and resources. Detailed design and construction guidance is provided on two effective low-tech tools: 1) beaver dam analogues (BDAs) for mimicking beaver dam activity, and 2) post-assisted log structures (PALS) for mimicking wood accumulation in riverscapes. Throughout the manual, readers are reminded that the structures themselves are not the solution, but rather a means to initiate specific, desirable processes. Ultimately, embracing the design principles will help practitioners better understand the 'why' behind structural interventions and allow for more efficient and effective riverscape restoration.

Pollock, M. M., T. J. Beechie, J. M. Wheaton, C. E. Jordan, N. Bouwes, N. Weber and C. Volk. 2014. Using beaver dams to restore incised stream ecosystems. BioScience 64:279-290

A key paper in support of BDA and PALS approaches. Also includes a stream evolution timeline.

Abstract: Biogenic features such as beaver dams, large wood, and live vegetation are essential to the maintenance of complex stream ecosystems, but these features are largely absent from models of how streams change over time. Many streams have incised because of changing climate or land-use practices. Because incised streams provide limited benefits to biota, they are a common focus of restoration efforts. Contemporary models of long-term change in streams are focused primarily on physical characteristics, and most restoration efforts are also focused on manipulating physical rather than ecological processes. We present an alternative view, that stream restoration is an ecosystem process, and suggest that the recovery of incised streams is largely dependent on the interaction of biogenic structures with physical fluvial processes. In particular, we propose that live vegetation and beaver dams or beaver dam analogues can substantially accelerate the recovery of incised streams and can help create and maintain complex fluvial ecosystems.

Castro, J.M. and Thorne, C.R. 2019. The stream evolution triangle: Integrating geology, hydrology, and biology. *River Research and Applications*, 35(4), pp.315-326.

Abstract: The foundations of river restoration science rest comfortably in the fields of geology, hydrology, and engineering, and yet, the impetus for many, if not most, stream restoration projects is biological recovery. Although Lane's stream balance equation from the mid-1950s captured the dynamic equilibrium between the amount of stream flow, the slope of the channel, and the amount and caliber of sediment, it completely ignored biology. Similarly, most of the stream classification systems used in river restoration design today do not explicitly include biology as a primary driver of stream form and process. To address this omission, we cast biology as an equal partner with geology and hydrology, forming a triumvirate that governs stream morphology and evolution. To represent this, we have created the stream evolution triangle, a conceptual model that explicitly accounts for the influences of geology, hydrology, and biology. Recognition of biology as a driver leads to improved understanding of reach-scale morphology and the dynamic response mechanisms responsible for stream evolution and adjustment following natural or anthropogenic disturbance, including stream restoration. Our aim in creating the stream evolution triangle is not to exclude or supersede existing stream classifications and evolutionary models but to provide a broader “thinking space” within which they can be framed and reconsidered, thus facilitating thought outside of the alluvial box.

Wohl, E., Lane, S.N. and Wilcox, A.C., 2015. The science and practice of river restoration. *Water Resources Research*, 51(8), pp.5974-5997.

Abstract: River restoration is one of the most prominent areas of applied water-resources science. From an initial focus on enhancing fish habitat or river appearance, primarily through structural modification of channel form, restoration has expanded to incorporate a wide variety of management activities designed to enhance river process and form. Restoration is conducted on headwater streams, large lowland rivers, and entire river networks in urban, agricultural, and less intensively human-altered environments. We critically examine how contemporary practitioners approach river restoration and challenges for implementing restoration, which include clearly identified objectives, holistic understanding of rivers as ecosystems, and the role of restoration as a social process. We also examine challenges for scientific understanding in river restoration. These include: how physical complexity supports biogeochemical function, stream metabolism, and stream ecosystem productivity; characterizing response curves of different river components; understanding sediment dynamics; and increasing appreciation of the importance of incorporating climate change considerations and resiliency into restoration planning. Finally, we examine changes in river restoration within the past decade, such as increasing use of stream mitigation banking; development of new tools and technologies; different types of process-based restoration; growing recognition of the importance of biological-physical

feedbacks in rivers; increasing expectations of water quality improvements from restoration; and more effective communication between practitioners and river scientists.

Wohl, E. 2019. Forgotten legacies: Understanding and mitigating historical human alterations of river corridors. *Water Resources Research*, 55(7), pp.5181-5201.

Highlights the legacy human impacts to rivers and how we as a society have normalized them and no longer recognize those impacts.

Abstract: Legacies are persistent changes in natural systems resulting from human activities. Legacies that affect river ecosystems can result from human alterations outside of the river corridor, such as timber harvest or urbanization, or from alterations within the river corridor, including flow regulation, river engineering, and removal of large wood and beaver dams. Human alterations of river ecosystems have been occurring for thousands of years in some parts of the world and are now ubiquitous, yet both river scientists and the public may be unaware of the persistent effects of historical activities. Failure to recognize the legacy of historical activities that no longer occur can skew perceptions of river process and form and the natural range of variability in river ecosystems. Examples come from rivers of the Mid-Atlantic Piedmont and the Pacific Northwest regions of the United States. Mid-Atlantic Piedmont streams in which legacy sediment accumulated behind now-abandoned mill dams experienced a complete transformation from wide, shallow, marshy valleys to sinuous rivers lined with tall cutbanks, but the existence and the cause of this river metamorphosis was not widely recognized until the first decade of the 21st century. Rivers of the Pacific Northwest from which large wood was removed have changed during the past century from spatially heterogeneous, multichannel systems closely connected to their floodplains via frequent channel avulsion and lateral migration to single-thread channels with more homogeneous floodplains and less lateral connectivity. Again, this river metamorphosis has only been recognized within the past two decades. In each of these regional examples, river process and form have changed so substantially that the river ecosystems can be described as having assumed an alternative state. In these and many other examples, the alternative state provides lower levels of ecosystem services such as habitat, biodiversity, and attenuation of downstream fluxes of water, sediment, organic carbon, and nutrients. River management designed to enhance and restore these ecosystem services can be more effective if the continuing effects of these historical legacies are recognized. The grand scientific challenges resulting from historical human alterations of river ecosystems include the following: (1) to recognize the existence of a legacy that continues to affect river ecosystem process and form; (2) to understand the source of the legacy with respect to chronology, type, spatial extent, and intensity of human activities; (3) to understand the implications of the legacy regarding how river process and form and river ecosystem services have changed; and (4) to design management or restoration strategies that can mitigate the loss of river ecosystem services. In summary, the existence of forgotten legacies challenges river scientists to recognize the continuing effects of human activities that have long since ceased and also poses challenges for the application of scientific understanding to resource management. Societal expectations for attractive, simple, stable rivers are commonly at odds with scientific understanding of rivers as dynamic, spatially heterogeneous, nonlinear ecosystems. Knowledge of how human actions, including historical actions that have long since ceased, continue to alter river ecosystems can help to bridge the gap between societal and scientific perceptions of rivers.

Brown, A.G., Lespez, L., Sear, D.A., Macaire, J.J., Houben, P., Klimek, K., Brazier, R.E., Van Oost, K. and Pears, B. 2018. Natural vs anthropogenic streams in Europe: history, ecology and implications for restoration, river-rewilding and riverine ecosystem services. *Earth-Science Reviews*, 180, pp.185-205.

Abstract: In Europe and North America the prevailing model of "natural" lowland streams is incised-meandering channels with silt-clay floodplains, and this is the typical template for stream restoration. Using both published and new unpublished geological and historical data from Europe we critically review this model, show how it is inappropriate for the European context, and examine the implications for carbon sequestration and Riverine Ecosystem Services (RES) including river rewilding. This paper brings together for the first time, all the pertinent strands of evidence we now have on the long-term trajectories of floodplain system from sediment-based dating to *seda*DNA. Floodplain chronostratigraphy shows that early Holocene streams were predominantly multi-channel (anabranching) systems, often choked with vegetation and relatively rarely single-channel actively meandering systems. Floodplains were either non-existent or limited to adjacent organic-filled palaeochannels, spring/valley mires and flushes. This applied to many, if not most, small to medium rivers but also major sections of the larger rivers such as the Thames, Seine, Rhône, Lower Rhine, Vistula and Danube. As shown by radiocarbon and optically stimulated luminescence (OSL) dating during the mid-late Holocene c. 4–2 ka BP, overbank silt-clay deposition transformed European floodplains, covering former wetlands and silting-up secondary channels. This was followed by direct intervention in the Medieval period incorporating weir and mill-based systems – part of a deep engagement with rivers and floodplains which is even reflected in river and floodplain settlement place names. The final transformation was the "industrialisation of channels" through hard-engineering – part of the Anthropocene great acceleration. The primary causative factor in transforming pristine floodplains was accelerated soil erosion caused by deforestation and arable farming, but with effective sediment delivery also reflecting climatic fluctuations. Later floodplain modifications built on these transformed floodplain topographies. So, unlike North America where channel-floodplain transformation was rapid, the transformation of European streams occurred over a much longer time-period with considerable spatial diversity regarding timing and kind of modification. This has had implications for the evolution of RES including reduced carbon sequestration over the past millennia. Due to the multi-faceted combination of catchment controls, ecological change and cultural legacy, it is impractical, if not impossible, to identify an originally natural condition and thus restore European rivers to their pre-transformation state (naturalisation). Nevertheless, attempts to restore to historical (pre-industrial) states allowing for natural floodplain processes can have both ecological and carbon offset benefits, as well as additional abiotic benefits such as flood attenuation and water quality improvements. This includes rewilding using beaver reintroduction which has overall positive benefits on river corridor ecology. New developments, particularly biomolecular methods offer the potential of unifying modern ecological monitoring with the reconstruction of past ecosystems and their trajectories. The sustainable restoration of rivers and floodplains designed to maximise desirable RES and natural capital must be predicated on the awareness that Anthropocene rivers are still largely imprisoned in the banks of their history and this requires acceptance of an increased complexity for the achievement and maintenance of desirable restoration goals.

Walter, R.C. and Merritts, D.J. 2008. Natural streams and the legacy of water-powered mills. *Science,* 319(5861), pp.299-304.

Does an excellent job of highlighting misinterpretation of channel evolution, which led to the whole Natural Channel Design approach.

Abstract: Gravel-bedded streams are thought to have a characteristic meandering form bordered by a self-formed, fine-grained floodplain. This ideal guides a multibillion-dollar stream restoration industry. We have mapped and dated many of the deposits along mid-Atlantic streams that formed the basis for this widely accepted model. These data, as well as historical maps and records, show instead that before European settlement, the streams were small anabranching channels within extensive vegetated wetlands that accumulated little sediment but stored substantial organic carbon. Subsequently, 1 to 5 meters of slackwater sedimentation, behind tens of thousands of 17th- to 19th-century milldams, buried the presettlement wetlands with fine sediment. These findings show that most floodplains along mid-Atlantic streams are actually fill terraces, and historically incised channels are not natural archetypes for meandering streams.

Wohl, E., 2014. A legacy of absence: wood removal in US rivers. *Progress in Physical Geography*, 38(5), pp.637-663.

Abstract: The historical removal of accumulations of wood on medium to large rivers in the continental United States caused a fundamental change in river corridors that has received relatively little attention in the scientific literature. Although scientific literature discusses the natural wood rafts present on the Red and the Atchafalaya Rivers in the southeastern United States, there is little awareness that similar extensive masses of wood are documented in the historical record from forested river catchments as diverse and widespread as those in the northeast, southeast, Texas Gulf Coast, Pacific Northwest, and upper Great Lakes regions of the country. While present, these natural wood rafts decreased channel conveyance, increased channel-floodplain connectivity, and facilitated anastomosing channels and floodplain lakes. Removal of natural wood rafts began in the 17th century in the eastern United States and proceeded westward with the movement of European settlers, accelerating during the 19th-century era of steamboats and floating of cut timber. Removal of the natural wood rafts likely forced many rivers from a multi thread planform with high channel-floodplain connectivity into an alternative stable state of single-thread channels with substantially reduced overbank flow, sedimentation, and avulsions. There is now widespread recognition among the geomorphic community of how upland clearance increased sediment yields and floodplain aggradation. I propose that widespread removal of instream wood for steamboat routes, timber rafts, and flood control was equally significant in decreasing floodplain sedimentation and river complexity, and in causing a fundamental, extensive, and intensive change in forested river corridors throughout the United States.

Wohl, E., Kramer, N., Ruiz-Villanueva, V., Scott, D.N., Comiti, F., Gurnell, A.M., Piegay, H., Lininger, K.B., Jaeger, K.L., Walters, D.M. and Fausch, K.D., 2019. The natural wood regime in rivers. *BioScience*, 69(4), pp.259-273.

Abstract: The natural wood regime forms the third leg of a tripod of physical processes that supports river science and management, along with the natural flow and sediment regimes. The wood regime consists of wood recruitment, transport, and storage in river corridors. Each of these components can be characterized in terms of magnitude, frequency, rate, timing, duration, and mode. We distinguish the natural wood regime, which occurs where human activities do not significantly alter the wood regime, and a target wood regime, in which management emphasizes wood recruitment, transport, and storage that balance desired geomorphic and ecological characteristics with mitigation of wood-related hazards. Wood regimes vary across space and through time but can be inferred and quantified via direct measurements, reference sites, historical information, and numerical modeling. Classifying wood regimes with respect to wood process domains and quantifying the wood budget are valuable tools for assessing and managing rivers

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Pfeiffer, A. and Wohl, E. 2018. Where does wood most effectively enhance storage? Network-scale distribution of sediment and organic matter stored by instream wood. *Geophysical Research Letters*, 45(1), pp.194-200.

Abstract: We used 48 reach-scale measurements of large wood and wood-associated sediment and coarse particulate organic matter (CPOM) storage within an 80 km2 catchment to examine spatial patterns of storage relative to stream order. Wood, sediment, and CPOM are not distributed uniformly across the drainage basin. Third- and fourth-order streams (23% of total stream length) disproportionately store wood and coarse and fine sediments: 55% of total wood volume, 78% of coarse sediment, and 49% of fine sediment, respectively. Fourth-order streams store ~0.8 m3 of coarse sediment and 0.2 m3 of fine sediment per cubic meter of wood. CPOM storage is highest in first-order streams (60% of storage in 47% of total network stream length). First-order streams can store up to 0.3 m3 of CPOM for each cubic meter of wood. Logjams in third- and fourth-order reaches are primary sediment storage agents, whereas roots in small streams may be more important for storage of CPOM. We propose the large wood particulate storage index to quantify average volume of sediment or CPOM stored by a cubic meter of wood.

Polvi, L.E. and Wohl, E., 2013. Biotic drivers of stream planform: implications for understanding the past and restoring the future. *BioScience*, 63(6), pp.439-452.

Abstract: Traditionally, stream channel planform has been viewed as a function of larger watershed and valley-scale physical variables, including valley slope, the amount of discharge, and sediment size and load. Biotic processes serve a crucial role in transforming channel planform among straight, braided, meandering, and anabranching styles by increasing stream-bank stability and the probability of avulsions, creating stable multithread (anabranching) channels, and affecting sedimentation dynamics. We review the role of riparian vegetation and channel-spanning obstructions—beaver dams and logjams—in altering channel–floodplain dynamics in the southern Rocky

Mountains, and we present channel planform scenarios for combinations of vegetation and beaver populations or old-growth forest that control logjam formation. These conceptual models provide understanding of historical planform variability throughout the Holocene and outline the implications for stream restoration or management in broad, low-gradient headwater valleys, which are important for storing sediment, carbon, and nutrients and for supporting a diverse riparian community.

Wohl, E., Brierley, G., Cadol, D., Coulthard, T.J., Covino, T., Fryirs, K.A., Grant, G., Hilton, R.G., Lane, S.N., Magilligan, F.J. and Meitzen, K.M. 2019. Connectivity as an emergent property of geomorphic systems. *Earth Surface Processes and Landforms*, 44(1), pp.4-26.

Abstract: Connectivity describes the efficiency of material transfer between geomorphic system components such as hillslopes and rivers or longitudinal segments within a river network. Representations of geomorphic systems as networks should recognize that the compartments, links, and nodes exhibit connectivity at differing scales. The historical underpinnings of connectivity in geomorphology involve management of geomorphic systems and observations linking surface processes to landform dynamics. Current work in geomorphic connectivity emphasizes hydrological, sediment, or landscape connectivity. Signatures of connectivity can be detected using diverse indicators that vary from contemporary processes to stratigraphic records or a spatial metric such as sediment yield that encompasses geomorphic processes operating over diverse time and space scales. One approach to measuring connectivity is to determine the fundamental temporal and spatial scales for the phenomenon of interest and to make measurements at a sufficiently large multiple of the fundamental scales to capture reliably a representative sample. Another approach seeks to characterize how connectivity varies with scale, by applying the same metric over a wide range of scales or using statistical measures that characterize the frequency distributions of connectivity across scales. Identifying and measuring connectivity is useful in basic and applied geomorphic research and we explore the implications of connectivity for river management. Common themes and ideas that merit further research include; increased understanding of the importance of capturing landscape heterogeneity and connectivity patterns; the potential to use graph and network theory metrics in analyzing connectivity; the need to understand which metrics best represent the physical system and its connectivity pathways, and to apply these metrics to the validation of numerical models; and the need to recognize the importance of low levels of connectivity in some situations. We emphasize the value in evaluating boundaries between components of geomorphic systems as transition zones and examining the fluxes across them to understand landscape functioning.

Roni, P., Hall, J.E., Drenner, S.M. and Arterburn, D. 2019. Monitoring the effectiveness of floodplain habitat restoration: A review of methods and recommendations for future monitoring. *Wiley Interdisciplinary Reviews: Water*, 6(4), p.e1355.

Abstract: Floodplains are some of the most ecologically important and human-impacted habitats throughout the world. Large efforts are underway in North America, Europe, Australia, and elsewhere to restore floodplain habitats, not only to increase fish and aquatic biota but to restore ecological diversity. As the scale, number, and complexity of floodplain restoration projects has increased, so has the need

for rigorous monitoring and evaluation to demonstrate effectiveness and guide future floodplain restoration efforts. Moreover, technological advances in remote sensing, genetics, and fish marking have been evolving rapidly and there is need to update guidance on the best methods for monitoring physical and biological response to floodplain restoration. A comprehensive review of the restoration literature located 180 papers that specifically examined the effectiveness of various floodplain restoration techniques. The various methods that were historically and currently used to evaluate the physical (channel and floodplain morphology, sediment, flow, water quality [temperature and nutrients]) and biological (fish, invertebrates, and aquatic and riparian plants) effectiveness of floodplain restoration were reviewed and used to provide recommendations for future monitoring. For each major physical and biological monitoring method, we discuss their importance, how they have historically been used to evaluate floodplain restoration, newer methodologies, and limitations or advantages of different methodologies and approaches. We then discuss monitoring the effectiveness of small (<2 km in main channel length) and large (>2 km of main channel length) floodplain projects, with recommendations for various study designs, parameters, and monitoring methodologies.

Entwistle, N., Heritage, G. and Milan, D. 2019. Ecohydraulic modelling of anabranching rivers. *River Research and Applications*, 35(4), pp.353-364.

Abstract: In this paper we provide the first quantitative evidence of the spatial complexity of habitat diversity across the flow regime for locally anabranching channels and their potential increased biodiversity value in comparison to managed single-thread rivers. Ecohydraulic modelling is used to provide evidence for the potential ecological value of anabranching channels. Hydraulic habitat (biotopes) of an anabranched reach of the River Wear at Wolsingham, UK, is compared with an adjacent artificially straightened single-thread reach downstream. Two-dimensional hydraulic modelling was undertaken across the flow regime. Simulated depth and velocity data were used to calculate Froude number index, known to be closely associated with biotope type, allowing biotope maps to be produced for each flow simulation using published Froude number limits. The gross morphology of the anabranched reach appears to be controlling flow hydraulics, creating a complex and diverse biotope distribution at low and intermediate flows. This contrasts markedly with the near uniform biotope pattern modelled for the heavily modified single-thread reach. As discharge increases the pattern of biotopes altered to reflect a generally higher energy system, interestingly however, a number of low energy biotopes were activated through the anabranched reach as new subchannels became inundated and this process creates valuable refugia for macroinvertebrates and fish, during times of flood. In contrast, these low energy areas were not seen in the straightened single-thread reach. Model results suggest that anabranched channels have a vital role to play in regulating flood energy on river systems and in creating and maintaining hydraulic habitat diversity.

Introduction to Stage 0 Restoration. Workshop, October 22-24, 2019 Black Butte Ranch, Sisters, Oregon. Sponsored by River Restoration North West & Portland State University. https://lowtechpbr.restoration.usu.edu/workshops/2019/Stage0/materials.html

Workshop materials archived by the Utah State University Restoration Consortium. Materials include PowerPoint slides from presentations by Colin Thorne ("Stage 0: Genesis & Theory"), Brian Cluer

("Western Streams: Evidence for Stage 0 & Using Stream Evolution Model to guide restoration approaches"), Paul Powers ("Stage Zero Valley Types") and Joe Wheaton ("Introduction to Low-Tech Process-Based Restoration to Stage 0"), as well as images from the South Fork McKenzie River project and field trip.

Scott, D.N. and B.D. Collins. 2019. Deer Creek Stage 0 Restoration Geomorphic Complexity Monitoring Report. Presented at the 2020 River Restoration Symposium, Feb. 6, 2020, Stevenson WA. River Restoration Northwest. https://www.mckenziewc.org/wp-content/uploads/2020/04/Scott-Collins-2019-Deer-Creek-Stage-0-Restoration-Geomorphic-Complexity-Monitoring-Report.pdf

Executive Summary: Stage 0 restoration is a relatively new technique of restoring wide, depositional valley bottoms to an anastomosing state, and existing monitoring has not yet demonstrated its long-term efficacy. The Deer Creek Stage 0 restoration sought to increase valley bottom geomorphic complexity by adding large wood, removing anthropogenic channel confinement, and reshaping the existing channel. Existing monitoring techniques may not adequately capture these processes that Stage 0 restoration seeks to influence. To develop and test appropriate metrics for monitoring Stage 0 restoration, we used a combination of post-restoration field surveys and remote imagery to measure spatial heterogeneity and to observe wood jam characteristics and channel lateral migration. Specifically, to determine the impacts of Stage 0 restoration along Deer Creek, we evaluated: (1) how the restoration directly altered valley bottom spatial heterogeneity; (2) the variability, or dynamism, of valley bottom morphology and spatial heterogeneity before and after restoration; (3) the trajectory of valley bottom spatial heterogeneity before and after restoration in the context of estimated flow history; and (4) wood dynamics. We also compare methods for quantifying geomorphic complexity and collecting relevant monitoring data.

The Stage 0 restoration substantially increased the ratio of active channel area to valley bottom area of the treated reaches of Deer Creek and increased valley bottom patch diversity in the upstream of the two treated reaches. This direct impact has provided the river more room to erode and deposit sediment across its valley bottom and, in the upstream treated reach, created a more diverse assemblage of geomorphic units that may provide the basis for a more diverse fluvial ecosystem. While the restored reaches are not uniformly more dynamic than pre-restoration, they show no trend towards a return to their pre-restoration, less complex state after two years of low to moderate flows. However, the absence of high flows post-restoration prevents determination of whether these short-term impacts will be sustained. The lack of high flows and field surveys of wood or channel morphology similarly limit our ability to quantify wood dynamics and sediment erosion and deposition post-restoration. However, we observed complex and likely relatively stable wood jams that substantially interact with channel margin landforms and living trees and that could induce substantial geomorphic change when high flows that can reshape the channel occur in the future.

To characterize valley bottom spatial heterogeneity, we determine: (1) the ratio of channel length to valley bottom length; (2) the number of vegetated islands per valley bottom length; (3) the ratio of channel to valley bottom area; and (4) the Shannon equitability index, a measure of the relative abundance of morphologic patches across the valley bottom. We found the ratio of channel to valley bottom area and the Shannon equitability index to be most robust to mapping errors and provide information directly relatable to ecogeomorphic processes such as channel migration, avulsion, widening, vegetation establishment on deposited sediment, and vegetation recruitment from eroded surfaces. Thus, we recommend these indices or similar ones (e.g., channel to floodplain area, or Shannon diversity index) as robust measures of valley bottom spatial heterogeneity that can be used to monitor Stage 0 restoration effectiveness. However, we caution that these metrics of spatial heterogeneity are sensitive to the selection and definition of valley bottom patch types.

The observations needed to measure geomorphic complexity can be made using a variety of methods, ranging from expensive and time-consuming (e.g., bathymetric LiDAR) to cheap and rapid (e.g., field transects of patch abundance). We recommend a combination of field measurements of valley bottom patch abundance and mapping of freely available imagery as a cost-effective means of measuring spatial heterogeneity. We also recommend direct observation of wood jam dynamics (e.g., repeat surveys to determine how wood jams change after high flows) and channel morphological change (e.g., tracking lateral erosion in imagery, noting bar deposition during field surveys) to contextualize measurements of spatial heterogeneity.

Erős, T., Kuehne, L., Dolezsai, A., Sommerwerk, N. and Wolter, C. 2019. A systematic review of assessment and conservation management in large floodplain rivers–Actions postponed. *Ecological Indicators*, 98, pp.453-461. http://real.mtak.hu/103777/2/ErosT_etal_EI_ms.pdf

Abstract: Large floodplain rivers (LFRs) are currently threatened by high levels of human alteration, and utilization is expected to grow. Assessments to determine ecological condition should address the specific environmental features of these unique ecosystems, while conservation management requires balancing maintenance of good ecological condition with the ecosystem services provided by LFRs. However, a systematic evaluation of the scientific literature on assessment of ecological condition of LFRs and trade-offs to guide conservation management is currently lacking. Here, we reviewed 153 peer reviewed scientific articles to characterize methodological patterns and trends and identify knowledge gaps in the assessment of LFRs. Our review revealed that most approaches used classical biotic indices for assessing ecological condition of LFRs. However, the number of articles specifically addressing the peculiarities of LFRs was low. Many studies used watershed level surveys and assessed samples from small streams to large rivers using the same methodological protocol. Most studies evaluated the status of main stem river habitats only, indicating large knowledge gaps with respect to the diversity of river-floodplain habitat types or lateral connectivity. Studies related to management were oriented toward specific rehabilitation actions rather than broader conservation of LFRs. Papers relating to ecosystem services of LFRs were especially few. Most importantly, these studies did not distinguish the different functional units of river-floodplain habitat types (e.g. eupotamon, parapotamon) and their role in ecosystem services provision. Overall, the number of articles was too low for meaningful analyses of the relationships and tradeoffs between biodiversity conservation, maintaining ecological condition, and use of ecosystem services in LFRs. Our review highlights research gaps and emphasizes the importance of developing more holistic indicators of ecosystem condition, which better reflect landscape level changes in structure and functioning of LFRs. As human use of water and land increases, the need to develop more effective spatial conservation prioritization tools becomes more important. Empirical research in

this field can aid in solving conflicts between socio-economic demands for ecosystem services and nature conservation of LFRs.

Scagliotti, A. 2019. Quantifying the Geomorphic Response of Stage 0 Stream Restoration: A Pilot Project on Whychus Creek. MS thesis, Oregon State University. https://ir.library.oregonstate.edu/concern/graduate_projects/9w032849z

"The goal of this pilot project was to develop a replicable and robust monitoring protocol that quantifies substrate heterogeneity conditions among four priority reaches in Whychus Creek."

It is generally accepted in stream ecology that habitat heterogeneity and patchiness at multiple scales increases ecosystem resilience through niche diversification. Heterogeneous stream habitats include a complex mosaic of hydraulic features, large woody debris, anabranches, substrata and channel forms - this complexity tends to increase as streams progress towards later stages based on the Stream Evolution Model. Recent restoration work on Whychus Creek in Central Oregon has sought to create complex, late-stage systems in order to improve the ecological function of artificially simplified reaches. One way to measure and track lotic system habitat complexity is through substrate analyses because a heterogeneous patchwork of substrata can act as a proxy for diversity of aquatic habitat types. The goal of this pilot project was to develop a replicable and robust monitoring protocol that quantifies substrate heterogeneity conditions among four priority reaches in Whychus Creek. To do this, I developed a monitoring protocol that utilizes three methods to capture substrate heterogeneity on four, 500-m reaches of the creek. Each sample reach included a nested sampling design of 12 floodplain-wide transects that allowed me to quantify micro, meso or macro-level substrate heterogeneity. I collected data using standard pebble counts, two-dimensional areal plot estimates and one-dimensional patch width measurements. I used the data from each of these three methods to calculate habitat heterogeneity using four metrics – Simpson's Diversity Index, Shannon's Evenness Index, Lloyd's Index of Patchiness and Fortin's Spatial Diversity Index. The results indicated that the two recently restored reaches were on average, 38% more heterogeneous than the untreated reach while the older, more established project reach was on average, only 15% more heterogeneous. The chi-square test for independence for the pebble count indicated significant differences between all the reaches and substrate classes (X2 (18, N = 1865) = 210.23, p <.001) except one – which signaled that the untreated reach requires a slightly larger sample size in future years. For the plot method, the differences among the reaches were more significant with X2 (18, N = 2306) = 836.57, p <.001. The plot method resulted in the highest Cramer's V value of 0.35 (p < 0.001) – indicating a strong relationship between substrate composition and individual reach. These results illustrate that the three methods were robust enough to represent stream substrate conditions. Recommendations include foregoing the pebble count in order to prioritize larger sample sizes of the plot method and the transect patch method.

McKenzie Watershed Council. 2019. Stage 0 Design Approach to Floodplain Restoration. https://www.mckenziewc.org/wp-content/uploads/2020/04/Figure-3.-Stage-0-Design-Approach-Flyer.pdf

Two-pager with visual schematics summarizing Stage 0 rationale and approach in layperson terms.

Meyer, K. 2018. Deer Creek: Stage 0 Alluvial Valley Restoration in the Western Cascades of Oregon. *StreamNotes*, May 2018. USDA Forest Service, National Stream and Aquatic Ecology Center Fort Collins, Colorado. https://www.fs.fed.us/biology/nsaec/assets/streamnotes2018-05.pdf

Six-page project summary with photographs and management implications.

Bianco, S.R. 2018. A novel approach to process-based river restoration in Oregon: Practitioners' perspectives, and effects on in-stream wood. Thesis completed in partial fulfillment of the degree of M.S. in Water Resources Engineering, Oregon State University, Corvallis, OR. May 30, 2018.

Abstract: The widespread fragmentation, channelization, and simplification of river ecosystems has had acute environmental impacts, including degradation of water quality and habitat and biodiversity loss (Vörösmarty et al., 2010). These concerns have incited an increased focus on reestablishing ecological and hydrogeomorphological functions and improving habitat that has been lost in riverine ecosystems. The broad set of activities aimed at improving the environmental health of rivers, referred to collectively as river restoration, has become a multi-billion dollar industry (Bernhardt et al., 2005), and one of the most active areas of applied, contemporary water resources research (Wohl, Lane, & Wilcox, 2015). An innovative approach to process-based river restoration has recently emerged in Oregon, and is being implemented across the state by a small group of U.S. Forest Service (USFS) fisheries biologists and hydrologists. The development and dissemination of this practice – termed Stage 0 restoration – may mark an important shift in the approach to river restoration in the Pacific Northwest, yet the phenomenon remains undocumented in the literature. This research presents Stage 0 practitioners' perspectives and a case study of the impacts of this restoration on large in-stream wood. Qualitative semi-structured interviews and participant observations were conducted with seven USFS fisheries biologists and hydrologists to characterize what inhibits and enables the implementation of Stage 0 restoration. Interviewees cited stakeholders' fears about fish, sedimentation, and an unfamiliar morphology as serious challenges; they also noted that scientists have been crucial enablers by "bridging the gap" through advocacy and participation in stakeholder meetings. The most salient catalyst for the Stage 0 practice, however, is the interviewees' commitment to building relationships through peer-review, mentorship and outreach. The findings from this study point to the importance of Stage 0 stakeholders engaging in transparent dialogues about values, and exploring perspectives of other groups to identify opportunities for building stronger collaborations. Continued monitoring to assess the impact of Stage 0 restoration on biophysical processes is also critical. Given the broad effects of in-stream wood on important riverine processes, a case study on this important ecosystem constituent was conducted on Deer Creek in the Western Cascades of Oregon. This research explores the effects of the experimental placement of unknown quantities of large in-stream wood in the floodplain, and the response of that wood to one year of flows after restoration. The abundance, size and spatial distribution of large in-stream wood were estimated from repeat unmanned aerial vehicle (UAV)-captured, high resolution aerial imagery of a 500-m transect of Deer Creek before (April 2016), after (September 2016), and one year following completion (September 2017). Data were compared with a 2002 field inventory from a 500-m transect of Lookout Creek in the H.J. Andrews Experimental Forest (HJA). The abundance of wood in Deer Creek more than tripled as a result of the restoration activities (from 428 to 1,560 pieces), but decreased by 25% over the year following restoration. Most of this change involved wood in small size classes (<30 cm diameter, <10 m length), which apparently was rearranged by 2016-17 winter peak flows (~1.5-year recurrence interval). The restoration efforts sharply increased wood of a particular larger size class (>60 cm diameter, 10 to 20 m length), though after restoration, Deer Creek only had about 40% as many large diameter class (>60 cm) pieces per unit stream channel length as Lookout Creek. More wood was contained in accumulations in Lookout Creek, and the accumulations were larger and more widely spaced, due to fluvial rearrangement during high flow events. Uncertainty in wood diameter and length and location of logs in repeat drone-based imagery was high. Thus, if wood monitoring using drone-mounted cameras continues in Deer Creek, it should include field verifications of sizes and establishment of a ground control network. The response seen at Deer Creek points to the importance of promoting long-term wood recruitment processes at Deer Creek, and continuing to study the stability of wood. There are opportunities for research partnerships between Stage 0 practitioners and HJA scientists, who have collectively conducted decades of research on large in-stream wood.

Johnson, M.F., Thorne, C.R., Castro, J.M., Kondolf, G.M., Mazzacano, C.S., Rood, S.B. and Westbrook, C., 2019. Biomic river restoration: A new focus for river management. *River Research and Applications.* https://s3-us-west-2.amazonaws.com/etalweb.joewheaton.org/Workshops/Stage0/2019/Reading/Johnson+et+al.+2019+Biomic+River+Restoration_RRA.pdf

Abstract: River management based solely on physical science has proven to be unsustainable and unsuccessful, evidenced by the fact that the problems this approach intended to solve (e.g., flood hazards, water scarcity, and channel instability) have not been solved and long-term deterioration in river environments has reduced the capacity of rivers to continue meeting the needs of society. In response, there has been a paradigm shift in management over the past few decades, towards river restoration. But the ecological, morphological, and societal benefits of river restoration have, on the whole, been disappointing. We believe that this stems from the fact that restoration over relies on the same physical analyses and approaches, with flowing water still regarded as the universally predominant driver of channel form and structural intervention seen as essential to influencing fluvial processes. We argue that if river restoration is to reverse long-standing declines in river functions, it is necessary to recognize the influence of biology on river forms and processes and re-envisage what it means to restore a river. This entails shifting the focus of river restoration from designing and constructing stable channels that mimic natural forms to reconnecting streams within balanced and healthy biomes, and so levering the power of biology to influence river processes. We define this new approach as biomic river restoration.

Jones, K., Poole, G., Quaempts, E.J., O'Daniel, S. and Beechie, T., 2008. Umatilla River vision. Retrieved April, 29, p.2016. http://www.ykfp.org/par10/html/CTUIR%20DNR%20Umatilla%20River%20Vision%20100108.pdf

Summary: Sound river management and restoration are predicated upon the need to develop a systemic and holistic vision of a functional river. Such a vision provides a framework for planning management or restoration efforts and an initial benchmark for assessing management success or failure. Similarly, a river vision provides the context necessary for understanding the role of any specific management decision or action in the context of other decisions or actions. In this report, we outline a vision for desired ecological characteristics of the Umatilla River's water quality and water resource management, which will facilitate the sustained production of First Foods within the Umatilla Basin. We then present a "river vision" by highlighting attributes of the Umatilla River's hydrology, geomorphology, habitat and network connectivity, riverine biotic community, and riparian vegetation that are essential in the sustained production of First Foods for tribal consumption.

Hall, J.E., Greene, C.M., Stefankiv, O., Anderson, J.H., Timpane-Padgham, B., Beechie, T.J. and Pess, G.R. 2018. Large river habitat complexity and productivity of Puget Sound Chinook salmon. *PloS one*, 13(11).

Describes salmon use in Puget Sound Rivers and what attributes are strongly associated with healthy populations.

Abstract: While numerous studies have shown that floodplain habitat complexity can be important to fish ecology, few quantify how watershed-scale complexity influences productivity. This scale mismatch complicates population conservation and recovery strategies that evaluate recovery at regional or multi-basin scales. We used outputs from a habitat status and trends monitoring program for ten of Puget Sound's large river systems to examine whether juvenile Chinook salmon productivity relates to watershed-scale habitat complexity. We derived habitat complexity metrics that quantified wood jam densities, side and braid to main channel ratios, and node densities from a remote sensing census of Puget Sound's large river systems. Principal component analysis revealed that 91% of variance in these metrics could be explained by two principal components. These metrics revealed gradients in habitat complexity across Puget Sound which were sensitive to changes in complexity as a result of restoration actions in one watershed. Mixed effects models revealed that the second principle component term (PC2) describing habitat complexity was positively related to log transformed subyearling Chinook per spawner productivity rates from 6–18 cohorts per watershed. Total subyearling productivity (subyearlings per spawner) and fry productivity (subyearling fry per spawner) rates were best described by models that included a positive effect of habitat complexity (PC2) and negative relationships with log transformed peak flow recurrence interval, suggestive of reduced survival due to egg destruction during floods. Total subyearling productivity (subyearlings per spawner) and parr productivity (subyearling parr per spawner) rates were best described by models that included a positive effect of habitat complexity (PC2) and negative relationships with log transformed spawner density, suggestive of density dependent

limits on juvenile rearing habitat. We also found that coefficient of variation for log transformed subyearling productivity and subyearling fry productivity rates declined with increasing habitat complexity, **supporting the idea that habitat complexity buffers populations from annual variation in environmental conditions.** Therefore, we conclude that our watershed-scale census based approach provided habitat complexity metrics that explained some of the variability in productivity of subyearling juveniles among Chinook salmon populations. Furthermore, this approach may provide a useful means to track and evaluate aggregate effects of habitat changes on the productivity of Endangered Species Act (ESA) listed Chinook salmon populations over time.

Lennox III, P.A. and Rasmussen, J.B., 2016. Long-term effects of channelization on a cold-water stream community. *Canadian Journal of Fisheries and Aquatic Sciences*, 73(10), pp.1530-1537.

[Provisionally included; addresses impacts on stream biota of anthropogenic modifications that reduce stream access to floodplains.] *"Stream channelization is defined as the artificial straightening of streams…and is an effective method to impede water from accessing the flood plains adjacent to rivers…"*

Abstract: Stream channelization is a common form of anthropogenic disturbance, whose impacts on cold-water biological communities have received little attention in comparison with the body of work demonstrating its negative effects on lowland, warm-water systems. Furthermore, it has been suggested that physical stream processes, given sufficient temporal scale, are capable of restoring channelized reaches to their natural state; however, empirical evidence of this is lacking. Here, we examine the effects of stream channelization on fish and invertebrate communities and their habitats in disturbed and undisturbed cold-water mountain streams in southern Alberta, 80 years postchannelization. Our results show that negative impacts associated with channelization, such as a significant reduction of deep pools and loss of flow refugia, remain prevalent along impacted reaches, inhibiting the reestablishment of native species across multiple trophic levels. While these findings are applicable for a range of cold-water salmonid populations, we suggest that they may be of special importance to the management of mountain whitefish (Prosopium williamsoni) populations, which may be more sensitive to channelization than other cold-water species.

Medel, I.D., Stubblefield, A.P. and Shea, C., 2020. Sedimentation and erosion patterns within anabranching channels in a lowland river restoration project. *International Journal of River Basin Management,* pp.1-11.

Abstract: Anabranching channel designs are seldom utilized for river restoration projects despite their potential for efficient hydraulic conveyance and robust floodplain habitat. We evaluated a stream restoration project that concentrates base flows within a single deep, narrow channel overflowing into secondary channels and an alternating series of higher elevation active benches at flood stages. The design represents an implementation of a Cluer and Thorne SEM Stage 8 anastomosing system aimed at increasing transport efficiency of water and sediment through low gradient river reaches to alleviate flooding on adjacent properties. We investigated the performance of the project's hydraulic conveyance

and the general utility of anabranching channels as a restoration alternative by assessing the distribution and magnitude of deposition and erosion response patterns. High-resolution survey indicate aggradation is not occurring within the main channel. Between summer 2016 and summer 2017, reaches experienced mean elevation decreases between 0.08 and 0.29 m indicating effective discharge rates transported dominant grain sizes. Along some reaches, bed scour was sufficient to undercut banks, producing slumps, which may affect long-term conveyance capacities. Lateral bank scour was limited to reaches exposed to daily tidal flows. Variable deposition patterns were observed within secondary channels, depending on cumulative precipitation, dominant hydrology, and channel entrance orientation. Isolated tidal flows resulted in deposition, while long duration flood flows produced intertidal floodplain scour. Within fluvially-dominated benches, uniform longitudinal deposition of fine-grained sediments was associated with low channel entrance flow rates. Higher entrance flow rates resulted in concentrated deposition of coarse-grained particles, up to 0.21 m, and a longitudinal gradient of decreasing sediment sizes and magnitude. This study builds upon previous work by providing a high-resolution assessment of a constructed anabranching channel system and confirms its suitability for efficient hydraulic conveyance within fluvial reaches of lowland rivers and provides general recommendations for future designs.

Scott, D.N. and Wohl, E., 2020. Geomorphology and climate interact to control organic carbon stock and age in mountain river valley bottoms. *Earth Surface Processes and Landforms*. 45, 1911–1925

Briefly discusses potential linkages between Stage 0 restoration and terrestrial carbon storage: "…where valley bottoms are wide and floodplains can develop, restoration aimed at increasing soil retention (e.g. Stage 0 restoration; Powers et al., 2019) shows potential to increase valley bottom OC stocks. However, we stress that more work on the turnover time of floodplain soil OC, interactions between groundwater hydrology and OC mineralization, and the source of OC in floodplain soils is necessary before such restoration can be used as a predictable method of increasing terrestrial OC storage." (p. 1922.)

Abstract: Organic carbon (OC) in valley bottom downed wood and soil that cycles over short to moderate timescales (101 to 105 years) represents a large, dynamic, and poorly quantified pool of carbon whose distribution and residence time affects global climate. We sought to quantify this potentially important OC pool at the watershed scale to estimate its magnitude and age, as well as determine the controls on its variability within watersheds. To do this, we compared four disparate mountain river basins to show that mountain river valley bottoms store substantial estimated OC stocks in floodplain soil and downed wood (median OC of urn:x-wiley:01979337:media:esp4855:esp4855-math-0001 MgC/ha, n = 178). Although soil OC is generally young (exhibiting a median radiocarbon fraction modern value of urn:x-wiley:01979337:media:esp4855:esp4855-math-0002, n = 121), geomorphic processes regulate soil burial and processes that limit microbial respiration, preserving aged OC in especially deep, unconfined, wet, and/or high-elevation floodplain soils. We statistically modeled OC stocks to show that valley bottom morphology and hydrology regulate variability in floodplain soil retention and resulting variability in OC stock and age in floodplain soil throughout river networks. Comparing the distribution of OC stocks between wood and soil, we find that where floodplain soils are present, their OC stocks are generally greater than OC stocks stored in wood. Our results suggest that although mountain rivers may accumulate large OC stocks relatively rapidly, those stocks are highly

sensitive to alterations in soil and wood retention, implying that human alterations to either disturb or restore floodplain wood and soil storage may have substantial impacts on OC storage in river corridors.

Plain Language Summary: Carbon stored on the land has the potential to be released to the atmosphere and act as a greenhouse gas, influencing global climate. To predict future climate, it is imperative to understand where and how much carbon is stored across the landscape to understand how much carbon might be released to and/or sequestered from the atmosphere in the future. We quantify carbon storage in downed wood and soil in mountain river valley bottoms, finding that mountain river valley bottoms are high magnitude carbon storage zones on the landscape, and that the legacy of past glaciation, climate, and modern erosional and depositional processes regulate the age and quantity of stored organic carbon. Our results imply that human actions can change how much carbon is stored in mountain river valley bottoms, and how it is stored there. Understanding the distribution of carbon across the landscape, especially in carbon-rich zones such as valley bottoms, requires an understanding of both the historic and modern processes shaping the landscape and vegetation.

Montgomery, D.R. and Buffington, J.M., 1997. Channel-reach morphology in mountain drainage basins. Geological Society of America Bulletin, 109(5), pp.596-611.

Channel reach morphologies described in this paper in which sediment supply is equal to or exceeds transport capacity have been suggested as one possible criterion to use when assessing the potential or suitability of a stream reach for restoration to Stage 0.

Abstract: A classification of channel-reach morphology in mountain drainage basins synthesizes stream morphologies into seven distinct reach types: colluvial, bedrock, and five alluvial channel types (cascade, step pool, plane bed, pool riffle, and dune ripple). Coupling reach-level channel processes with the spatial arrangement of reach morphologies, their links to hillslope processes, and external forcing by confinement, riparian vegetation, and woody debris defines a process-based framework within which to assess channel condition and response potential in mountain drainage basins. Field investigations demonstrate characteristic slope, grain size, shear stress, and roughness ranges for different reach types, observations consistent with our hypothesis that alluvial channel morphologies reflect specific roughness configurations adjusted to the relative magnitudes of sediment supply and transport capacity. Steep alluvial channels (cascade and step pool) have high ratios of transport capacity to sediment supply and are resilient to changes in discharge and sediment supply, whereas low-gradient alluvial channels (pool riffle and dune ripple) have lower transport capacity to supply ratios and thus exhibit significant and prolonged response to changes in sediment supply and discharge. General differences in the ratio of transport capacity to supply between channel types allow aggregation of reaches into source, transport, and response segments, the spatial distribution of which provides a watershed-level conceptual model linking reach morphology and channel processes. These two scales of channel network classification define a framework within which to investigate spatial and temporal patterns of channel response in mountain drainage basins.