Free Round of PBR: The Future for Research, Monitoring, and Implementation of Process-Based Restoration

Photo: M. Blazewicz.

The Free Round of PBR symposium was organized to bring together students, land and fisheries managers, biologists, and restoration practitioners to review the state of science around process-based restoration (PBR). Moreover, the goal was to review contemporary information and critical knowledge gaps with respect to PBR. The full-day symposium was held in Boise, Idaho on May 10th, 2023 at the annual meeting of the Western Division of the American Fisheries Society. Fifteen speakers contributed talks on topics ranging from principles and practices of PBR to tools for prioritizing and monitoring PBR. Included herein are full abstracts from all of the contributed talks.

Program overview from the PBR symposium at the 2023 annual meeting of the Western Division of the American Fisheries Society.

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Corsi and Hodge	Closing Comments: Reflections from Two Days of PBR

Opening remarks

Free Round of PBR: The Future for Research, Monitoring, and Implementation of Process-Based Restoration (opening remarks)

Brian Hodge (Brian.Hodge@tu.org), Daniel Dauwalter, and Helen Neville; Trout Unlimited

Caroline Nash, CK Blueshift, LLC

Scott Miller, Bureau of Land Management

Matthew Steinwurtzel, University of Idaho

Abstract.—Process-based restoration (PBR) has garnered a great deal of interest across the West and PBR tactics (e.g., beaver mimicry) are being implemented with increasing frequency in hopes of reinstating processes considered central to riverscape health. The rapid expansion of PBR is generating new insights and opportunities but also revealing new challenges for those charged with managing and conserving aquatic ecosystems. For instance, how does restoring beaver-related processes influence sediment storage, streamflow, and stream temperature, and what are the implications for fish? Could beaver dams or their analogs have the unintended consequence of restricting fish movement or of favoring invasive fishes and pathogens? Answers to such questions are still few in number, and underlying these questions is a potential divergence between managing for ecosystem services and managing for individual species. Deliberate monitoring, data collection, and reporting will improve our abilities to manage adaptively and predict the effects of PBR on riverscapes and the fishes therein. This symposium will bring together managers, scientists, and practitioners to make sense of a shifting landscape and discuss how best to navigate emergent and potentially competing priorities. Presenters will reveal recent insights and recommend avenues for future research on the efficacy and complexity of process-based restoration.

What should streams look like? How does the concept of reference condition relate to the practice of stream restoration?

Steve Wondzell, U.S. Forest Service, Pacific Northwest Research Station,
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Abstract.—The practice of river restoration requires that practitioners set goals – and those goals are a statement of "What Streams Should Look Like". The concept of reference condition attempts to provide an objective basis for setting those restoration goals. However, as Dufour and Piégay (2009) argue, the concept of reference condition is too often based on the "Myth of Paradise Lost". My talk explores the limitations of this concept and is primarily based on my own experience trying to develop models to project historical conditions and potential future conditions for riparian zones in the upper Middle Fork John Day River, OR. I take a historical retrospective of major events influencing land-use in the Pacific Northwest, starting today and traveling backwards through time to Lewis and Clark who spent the winter of 1805-06 at the mouth of the Columbia River. I argue that history is too easily forgotten, and despite widespread general knowledge of the last two-hundred years of Euro-American settlement, historical legacy is not sufficiently considered when attempting to define a reference condition. This retrospective suggests that it is impossible to pick a time period that represents a reasonable reference condition.

Process-based riverscape restoration - Now or never

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Brian Cluer, National Oceanic and Atmospheric Administration: National Marine Fisheries Service, West Coast Regional Office

Joe Wheaton, Utah State University

Abstract.—The overwhelming majority of riverscapes across the continental US are dramatically impaired due to current or legacy land and water use. The mode of impairment is predominantly structural starvation, resulting in, or resulting from, overly efficient conveyance channels that are vertically and laterally separated from their adjacent floodplain volumes. The scope and scale of the impairment is so pervasive as to have long been accepted as the normative condition of North American streams, rivers, and floodplains. But, because this shifted baseline sees channels where riverine wetland corridors once ran and continuous forests where successional patches once thrived, our management models maintain, perpetuate, and even restore to this degraded, reduced function state. Therefore, it is time to act. It is time to reawaken the biofluvialgeomorphic mess that functional riverscapes were, and can be, again. It is time to undrain the drained land, unforest the plantation hillslopes, unsimplify the straightened and cleaned channels, unchannelize the ghost of anastomosing floodplain connected streams and rivers. Process-based riverscape restoration is the simple conceptualization of functional riverscapes being valley bottoms with space, structural complexity, and flow inefficiency, all forced by connections to dynamic hillslopes, that together yield a resilient natural system made more productive and robust by perturbation and movement of energy and materials. A century of biological, hydrological, geological science, and the science adjacent practice of stream restoration have reinforced the pastoral ideals of static stream, river, and floodplain conditions and enabled an environmental compliance industry based on the premise of no net loss. As such, introducing the natural state of riverscapes as dynamic, laterally and vertically connected systems dependent on landscape scale "disturbance" runs contrary to a deeply seated premise that the natural world is static and pristine. However, if we expect to achieve the fire resilient, climate change adapted, drought and flood resistant, and protected species recovering riverscapes our management programs claim, we must first accept, allow, and foster the messy, dynamic nature of nature. The scientific results and conclusions, as well as any views or opinions, expressed herein are those of the authors, and do not necessarily reflect the views of NOAA or the Department of Commerce.

New models of evaluation and communication for processing uncertainty in process-based restoration

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Abstract.—Since its inception, process-based restoration has attracted attention as a more “nature based” approach to stream and wetland restoration. By aiming to either directly harness, induce or mimic natural processes, the expectation is that these projects will restore degraded ecosystems at a fraction of the cost of traditional, form-based approaches. Common expectations include that projects will increase water availability, improve water quality, enhance biodiversity, and increase forage quality of surrounding floodplains with minimum long-term maintenance. These lofty expectations have fueled considerable interest and increasing amounts of funding towards its use by both private landowners and public land managers. However, as is often the case in restoration, the practice has greatly outpaced science, due in part to the fundamental nature of process-based restoration. How do we balance flexibility and objectivity as we evaluate projects that are, by definition, built on inducing process rather than generating specific measurable outcomes? How can we, as land managers and practitioners, rigorously learn from these projects to improve long-term outcomes? These uncertainties are driving challenges not only for practitioners seeking to acquire funding and support for projects, but also for regulators at every level of government seeking to uphold their statutory requirements while facilitating what are often experimental approaches. This presentation will introduce the concept of process-based evaluation, which combines contingency-based process-pathway charts and trend-based monitoring. This evaluation model seeks offer a flexible approach to monitoring and adaptively managing projects across a range of landscapes, project types and budgets. In demonstrating this model of evaluation, we will explore persistent uncertainties in the science documenting commonly expected outcomes of process-based stream restoration.

Can you have your water and use it, too? The persistent, pernicious issue of downstream water availability

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Caroline Nash, CK Blueshift

Abstract.—Natural distributed storage has been posited as key strategy to improve resilience in the face of drought and climate change. As such, process-based restoration projects aiming to slow streamflow and increase floodplain aquifer recharge are increasing in popularity on public and private lands. Natural distributed storage projects are designed to increase the area and duration of floodplain inundation through both low-tech (e.g., beaver dam analogs, low-head dams) and heavy equipment (e.g., Stage 0 restoration) approaches. While this work has many potential ecological benefits, changes to annual streamflow patterns, including flood attenuation and increased baseflows, are often an explicit project goal. Meanwhile, given the potential water rights implications of these changes, a growing group of practitioners also claim that flow impacts of aquifer recharge projects are negligible. All of this begs the question, can you have your water and use it too? As process-based restoration has become more common, research of its effects on factors like riparian productivity and depth to groundwater have followed. However, its effects on streamflow are still poorly described. The issue of how these projects influence stream flows for aquatic resources and downstream water rights is complicated, in part because of persistent uncertainty in our hydrologic understanding of these systems. Namely, these changes can vary considerably across site conditions and can be difficult to capture with standard monitoring equipment, raising the question of which impacts are statistically vs. practically significant and whether case studies can be extrapolated to other landscapes. This presentation will provide an overview, with support from peer-reviewed research, of how process-based restoration tactics influence natural distributed storage and streamflow.

Wood you believe it? Experimental nonnative wood addition enhances in-stream habitat for native desert fishes

Benjamin Miller (benjamin.miller@usu.edu), Casey A. Pennock, and Phaedra Budy; Utah State University

Abstract.— Habitat simplification is contributing to the decline of native fishes in the Colorado River basin, including the San Juan River (SJR), where flow regulation, water overallocation, and nonnative riparian vegetation (primarily Russian olive *Elaeagnus angustifolias*) are major contributing factors. We conducted an experiment to investigate the potential effectiveness of enhancing native fish habitat by using an abundant resource, namely, Russian olive branches. In this experiment, we constructed a total of 155 woody structures over the course of two years at 19 paired treatment and reference (no wood added) reaches within the main channel of the SJR. To evaluate responses of wood addition, we sampled fishes and macroinvertebrates, measured habitat characteristics (depth, velocity, dominant substrate type, and geomorphic features), and deployed portable PIT tag antennas. To date, we have captured a total of 1,264 fishes in treatment reaches (17% native species) and 1,153 fishes in reference reaches (10% native). Densities of native fishes and macroinvertebrates were 72% and 160% higher, respectively, on average in treatment reaches than in reference reaches. Habitat characteristic variability (CV) was higher on average in treatment than in reference reaches (depth: 21%, velocity: 50%, dominant substrate size: 28%). After the addition of wood, the number of geomorphic features in treatment reaches increased by 7.3x on average, whereas in reference reaches, the number of geomorphic features remained unchanged. Our preliminary results suggest that addition of nonnative woody structures is an effective management action for enhancing native fish habitat by facilitating hydraulic and geomorphic diversity. While flow management has been the primary tool used by managers to improve habitat conditions for native desert fishes, this approach is increasingly less effective with water overallocation, increased aridity, and riparian vegetation encroachment. Managers might consider pairing flow management with non-flow, process-based, alternatives, such as wood addition, to enhance habitat for native fishes.

Food-web dynamics in a river-floodplain mosaic overshadow effects of engineered logjams: Consequences for salmon and process-based restoration

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J. Ryan Bellmore, U.S. Forest Service, Pacific Northwest Research Station

Joseph Benjamin, U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center

Abstract.—Process-based restoration (PBR) of river-floodplains is aimed at re-expression of shifting habitat mosaics, in contrast to more engineered habitat treatments involving installation of features such as large wood or pools. Yet, empirical studies are generally lacking that assess how the structure and productivity of patch-scale food webs that sustain fishes like salmon change through time in natural river-floodplains, such that relationships underpinning the assumptions of PBR remain untested. Moreover, such natural process dynamics have not been compared to effects of restoration efforts like engineered wood jams or pools. We quantified changes in secondary production, organic matter flow, and food-webs across a mosaic of main-channel and side-channel habitats of the Methow River, WA, USA over two periods (2009-2010 and 2015-2016), and we compared the natural process dynamics (that would, in many cases, be a goal of PBR) to change in a side-channel treated with engineered logjams and pools. Organic matter flows through food webs varied among untreated habitats, ranging from minimal change over time in the main-channel, to ~4-fold shifts in side-channel webs. In the side-channel whose habitat was manipulated, production of benthic invertebrates and juvenile salmonids increased by 2X and 4X, respectively, but these magnitudes of change did not surpass temporal variation observed among untreated habitats of the mosaic. For instance, juvenile salmonid production rose 17-fold in one untreated side-channel habitat, and natural aggregation of large wood in another untreated side channel coincided with community and food-web dominance by juvenile salmonids. Our findings suggest natural dynamism across floodplain habitat mosaics is linked to patchiness in food-web characteristics that may exceed ecological responses to localized habitat manipulation, complexity that may buffer salmon and biodiversity in the long term. As such, the results also support efforts to preserve or restore (via PBR) the processes that create and maintain this dynamic food-web mosaic.

Measuring channel response to Process-Based Restoration

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Abstract.—There are few tools available for resource managers to evaluate short-term geomorphic changes related to low-tech, process-based restoration (LTPBR). This lack of information reduces our ability to determine whether a project is on the desired trajectory, which can impede development of adaptive management plans to correct actions gone awry or maintain and improve processes working as intended. To investigate this problem we outline a cost-effective, highly accurate, and easily repeatable monitoring approach using unmanned aerial vehicle (UAV) technology coupled with structure-from-motion (SfM) photogrammetry to evaluate two LTPBR projects in central Idaho. Our approach builds off previous work using SfM photogrammetry and digital-elevation models (DEMs) to detect channel response to LTPBR. Instead of DEMs, we used a point cloud analysis tool, developed specifically for detecting change of rough, complex surfaces in three dimensions. Change detection using point cloud analysis provides greater accuracy because small surface complexities, such as point bar aggradation, can be lost through interpolation when generating DEMs. This improved accuracy allows managers to track geomorphic change over shorter temporal scales, providing a monitoring solution to inform adaptive management within a relevant time frame. Working with point clouds also eliminates the need to generate DEMs, simplifying the analysis process. Our results demonstrate the ability to detect small, short-term changes in stream geomorphology, specifically deposition upstream and downstream of LTPBR structures and areas of erosion adjacent to structures where streamflow is directed. We also outline best practices for UAV data collection to optimize point cloud change detection and offer a data processing workflow that provides flexibility to overcome data collection shortfalls and discrepancies. Finally, because our two project sites vary across physical and temporal scales and restoration objectives, we demonstrate the utility of our approach across a spectrum of LTPBR projects.

Quantifying and mapping the thermal and hydrologic retention capacity of beaver habitat and beaver restoration analogs with UAS

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Wesley Keller, Nez Perce Tribe

Abstract.—Historically, beaver-mediated habitat would have been a ubiquitous and multifunctional aspect of Idaho's river and riparian ecosystems. Beaver impacts on river systems include the maintenance of surface-water storage during drought or low flows and the creation of cool-water refugia through increasing groundwater exchange. Throughout the Columbia River Basin, the loss of these ecosystem services has resulted in widespread, but difficult to quantify, impacts on salmonid populations. As forecasts for climate change impacts in our region include less predictable flow and warmer surface waters, the implementation and monitoring of restoration activities that mimic historical beaver impacts and facilitate cold-water refugia for imperiled salmonids is critical. In this study, we combine state-of-the-art unmanned aerial systems (UAS, or 'drone') imagery to produce red-green-blue band (RGB) and thermal infrared (TIR) models in both a pristine river with abundant beaver impacts and a comparative restoration context. TIR models are verified through the deployment of in situ temperature loggers. Photogrammetry modeling techniques are used to illustrate and quantify the effects that both a network of beaver ponds has on ~0.75km2 of a Wilderness stream and the impacts of implemented Beaver Dam Analogs (BDAs) on a stretch of river that provides habitat for ESA-listed salmonid stocks. We hypothesize that the spatial proximity of beaver ponds to main-channel habitats dampens main-channel diurnal temperature ranges through measured thermal maxima. Additionally, to test the prediction that beaver-mediated stream sites increase riparian water-surface elevations, we use Digital Elevation Models (DEM) to quantify temporal changes of beaver dam reservoirs and the post restoration effects on surface water elevations. We discuss the scale at which these habitat effects may have implications for the bioenergetics and growth of juvenile salmonids. We also discuss the broader application of this instrumentation to address the research limitations encountered in other watersheds.

Resist-accept-direct for restoration: Landscape-scale prioritization of floodplain reconnection in Lahontan Cutthroat Trout habitat using remote sensing and GIS

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Kenneth McGwire, Desert Research Institute

William (Wally) Macfarlane and Cashe Rasmussen, Utah State University

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Abstract.—Applying tools to prioritize restoration, such as using process-based restoration (PBR) efforts, effectively at a landscape scale is increasingly important in fisheries conservation. Riverscapes, which include the floodplain (i.e., valley bottom), riparian corridor, and instream habitat, provide crucial ecological and socioeconomic function. However, riverscapes have been extensively altered by anthropogenic activities, which resulted in reductions in valley bottom connectivity, riparian condition, and instream habitat condition. Assessing riverscape health requires an understanding of connectivity between the active channel and the valley bottom. Prioritizing actions may be best achieved by understanding capacity for recovery, which could be contextualized relative to valley bottom area; larger valley bottoms are likely to have greater capacity for riparian production or water storage. While remote sensing methods can effectively characterize riparian vegetation, documenting inundation extent can provide a more complete depiction of floodplain connectivity. Here, we provide examples of how remote sensing and geospatial products can help prioritize restoration for riverscapes within the resist-accept-direct (RAD) framework, with specific focus on Lahontan Cutthroat Trout (LCT) habitat. We used Sentinel-2 normalized difference vegetation index (NDVI), a field-informed likelihood raster of the proportion of active valley bottom (AVB; frequently flooded surfaces), and a composite NDVI-AVB status ranking to prioritize where restoration in relation to floodplain connection could occur at a landscape scale. We show that the status inference when using the NDVI-AVB composite differs from inferring status using NDVI alone. Within the RAD framework, we show that considering the effort and capacity of restoration simultaneously can further prioritize where actions to increase or maintain floodplain connection could exist on the landscape. Riverscape restoration using PBR presents a key opportunity to bolster aquatic ecosystems given changing climatic conditions. Our approach shows that using multiple data sources will provide more context in directing efforts to enhance LCT habitat and riverscapes.

A Watershed Pyramid Scheme – RAD-ical perspectives from Central Oregon streams

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Abstract.—Many historically perennial streams in Central Oregon have become more intermittent in recent years, requiring managers to reconsider prioritizing fish-habitat focused projects against those intending to improve overall geomorphic and ecological function. In many streams, the loss of persistent water presence and/or increasing water temperatures creates greater limitations on fish presence that form-based physical habitat components alone cannot address. Climate change and shifting precipitation patterns in this region may have fundamentally changed what the restoration potential is in some of these systems. Even the best-designed restoration project may not feasibly return any of these systems back to a "historic" condition. This presentation will share an applied use of the Resist-Accept-Direct (RAD) concept for setting objectives for process-based restoration on the Ochoco National Forest. Here, managers have prioritized resetting the site conditions so that physical and ecological "process" can move forward to provide the desired riparian conditions and sustainable habitat. Specifically, managers are shifting primary objectives to floodplain reconnection that increases recharge and retention capacity in valley floors, with objectives around habitat-specific features for fish and amphibians becoming secondary. The overarching goal of this approach is to create riparian conditions that increase the ability of these systems to withstand extreme climatic events with the expectation that this approach will create a diversity of both aquatic and terrestrial habitat in most settings. Emphasizing focus on the foundational components of a watershed "pyramid" (hydrology and geomorphology) that can set the stage for processes that inform the physicochemical and biological conditions for proper ecological function.

Integrating data from multiple tools for monitoring riverscapes and prioritizing restoration actions

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Kenneth McGwire, Desert Research Institute

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Abstract.—Habitat serves as the template for biological processes. However, anthropogenic-related activities have degraded riparian and stream habitat, contributing to the declines of native fishes. Given that habitat restoration remains one of the plausible mechanisms for increasing the capacity and resilience of fish populations, particularly in the context of climate change, improving our approaches for habitat assessments is becoming increasingly important. Here, we demonstrate how using multiple monitoring approaches can enhance our ability for assessing habitat status, characterizing the capacity of these ecosystems (i.e., restoration targets), and prioritizing restoration for imperiled fishes. We merge data from remote sensing approaches, drones, and field sampling to overcome spatial heterogeneity common in habitat along stream networks and assist in the recovery of Lahontan Cutthroat Trout *Oncornhychus clarkii henshawi*, a subspecies of cutthroat trout listed as Threatened across the current distribution in the Great Basin (NV, OR, CA). Our results indicate considerable portions of stream networks are disconnected from floodplains—a pattern further supported by metrics indicating excessive levels of fine sediments and low channel diversity. Our data further suggest a paucity of available structure (i.e., large woody debris) for reconnection to floodplains—likely driven by historic land management practices and the aridity of the Great Basin. Our results also highlight the need for active, process-based restoration methods to reconnect habitats to floodplains, allowing for greater resilience of habitats to increasing frequency and severity of droughts. However, through these efforts we acknowledge uncertainty in the capacity of different landscape types and the long-term effectiveness of restoration methods in the Great Basin.

Using a landscape-scale approach to prioritizing LTPBR sites through partnerships and collaboration

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Abstract.—To achieve landscape-scale low-tech mesic and wet meadow restoration across the Northern Great Plains, practitioners need a consistent standard of practice. This includes spatiotemporal scales at which we mimic, promote, and sustain desired processes. With the development of a Watershed Analysis Framework, the opportunity to replicate and expand this practice at a landscape scale is ripe. Approximately 45,400 miles of intermittent/ephemeral stream and 1,100 miles of perennial stream on BLM administered lands in Montana, North Dakota and South Dakota could be improved by low-tech process-based restoration activities. With increased interest from local watershed groups in Montana and partnerships with additional land managers such as The Nature Conservancy this project addresses the need for producing a replicable, watershed-scale assessment and prioritization for low-tech restoration on both public and private lands across the West.

How to keep the PBR flowing: Perspectives from Tribal, NGO, and land management practitioners

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Abstract.—Federal legislation investing in ecosystem restoration combined with increased social awareness present generational opportunities to invest in riverscape health. The dynamic in part has shifted from questions of how to plan and fund small-scale projects to how to implement a series of coordinated actions among partners to make transformational, watershed-scale impacts. In this session we bring together diverse practitioners, including representation from the Nez Perce Tribe, Trout Unlimited, and the Bureau of Land Management, to discuss bottlenecks and opportunities to increase the geographic scope and pace of process-based restoration. Through a series of case studies, we outline opportunities to improve restoration prioritization, design, implementation, assessment, and adaptive management. We highlight unprecedented funding opportunities and the challenges to seizing them, including competing perspectives regarding healthy rivers, agency mandates, and state and federal regulations. Lastly, we highlight the importance of partnerships to restoring riverscapes at meaningful spatial scales, and the need for increased research and monitoring of process-based restoration outcomes to inform and improve future projects.

Reflections from Two Days of PBR

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Two days prior to the Free PBR symposium (on May 8, 2023) a group convened the Idaho Stream Summit, a one-day meeting designed to build a diverse network of restoration practitioners experienced with process-based techniques. Meeting objectives were to 1) grow a network in Idaho and beyond to better deliver mesic and riparian restoration across jurisdictional boundaries and at meaningful scales, 2) identify the biggest gaps in science and monitoring related to the applicability and implementation of process-based restoration, and 3) develop a collective path forward and follow-up action items for small stream restoration. The facilitated Summit was attended by 103 participants from multiple sectors, including state and Federal government, non-profit organizations, private companies, landowners, and special interest groups. Participants were expected to engage and complete active work to achieve the objectives. Several gaps in science and monitoring were identified, and primarily emerged as perceived risks associated with work in process-based restoration. Risks associated with the proliferation of invasive species (especially Brook Trout), surface water loss downstream of projects, and shifting temperature gradients emerged as essential avenues for empirical research. Social challenges to expansion of process-based restoration included damaged stakeholder relationships and setbacks in perception of process-based approaches when projects go awry. By design, process-based restoration leads to emergent and evolving outcomes that add substantial complexity to definitions of effectiveness, evaluation of results, and dissemination of findings. We encourage researchers in this field to define their questions by emergent risks and to speak to the potential losses of stakeholders with their evaluations to advance and improve process-based restoration in both science and practice.

Brian Hodge, Trout Unlimited, Brian Hodge, Brian.Hodge@tu.org

One of the stated goals of the Free PBR symposium on May 10th was to identify questions that need to be answered before we can consistently make good, responsible decisions around process-based restoration. Two of the fundamental questions raised during the course of the symposium were *what should streams look like?* and *do we need to redefine the boundaries of PBR in light of the fact that form is explicitly used to initiate process and implicitly referenced in evaluations of project success?* Other questions posed included: *where do we start [implementing PBR]?* and *what data can we leverage to help prioritize riverscapes for PBR?* Whereas one speaker asked *what is the best way to quantity the benefits of floodplain reconnection?* another queried *how does PBR influence a water budget and hydrologic regime?* Within these questions lie potential avenues for future research and monitoring of process-based restoration; answers to these and other questions can inform the ways in which we prioritize and implement PBR.