Large Wood Research Workshop Summary Report

February 2012, Seattle, Washington
Report Number: SRH-2012-20

U.S. Department of the Interior
Bureau of Reclamation

U.S. Army Corps of Engineers

June 2012

Mission Statements

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Large Wood Research Workshop Summary Report

Recommended Citation: Reclamation and U.S. Army Corps of Engineers, 2012, Large Wood Research Workshop Summary Report, workshop held February 14 to 16, 2012, Seattle, Washington.

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ACKNOWLEDGEMENTS

This workshop was a success because of the dedicated participants that not only took the time to attend but actively engaged in developing the product presented in this report. Without the participants' involvement and dedication during the workshop, this product would not have been possible. We would also like to thank all of the participants who provided presentations. The staff from King County Department of Natural Resources and Parks, especially the River and Floodplain Management Section, who planned and hosted the field trip for the workshop did an amazing job and we greatly appreciate all the effort that went into exposing participants to multiple large wood project examples. A special thanks goes to four doctoral students working in the field of large wood who did an incredible job capturing all of the discussions from the workshops while also concurrently engaging in discussion so participants could benefit in knowing ongoing research progress: Michael Stanley Gallisdorfer (University at Buffalo), Jane Atha (University of Oregon), Sarah Davidson (University of British Columbia), and Claire Ruffing (Kansas State University). We would like to thank the Reclamation Science and Technology Office and USACE's Ecosystem Management and Restoration Research Program (EMRRP) and Seattle District for providing funding and staff support to accomplish the workshop. We would also like to acknowledge Dr. Catherine Petroff (University of Washington, USACE) for facilitating the workshop and keeping us all on course!

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Thank you to all of the workshop participants whose contributions made this effort a success!

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Introduction

The historical legacy of anthropogenic removal of large wood (LW) from river valleys is commonly cited as a contributor for the disruption of river environments and decline of their dependent native species. As a result, regulatory agencies and the fisheries community often recommend the reintroduction of large wood, including the use of engineered logjams, for reestablishment of fluvial processes, habitat enhancement, and species recovery. Bureau of Reclamation (Reclamation) and United States Army Corps of Engineers' (USACE) roles in protecting native and listed species while meeting water delivery and managing flood risk and navigational needs has become increasingly apparent over the past few decades.

Background

The importance of large wood in fluvial environments had until recent decades been largely overlooked (Bisson et al, 1987). Consider the high complexity of wood itself – it spans the biological, physical, and social sciences. Trees grow, and in the right circumstances eventually enter rivers, whereby they float, sink, deposit, decay, and in the certain circumstances form channel spanning, valley spanning, or smaller but significant jams. A multitude of mechanisms can deliver wood to a river or stream, some largely chaotic and unpredictable (Benda et al, 2003). Thus proper study of wood recruitment and transport dynamics at watershed scales was virtually impossible until the recent advent of computers and geographic information systems. Societal factors also played a major role.

In most parts of the world, and until recently throughout the United States, river simplification has been used as a primary flood risk management tool. Since mobile wood creates complexity (which counters simplification), and can damage improperly planned infrastructure and property, it has been removed systematically for centuries (Montgomery et al, 2003; Lave, 2009; Petts and Welcomme, 2003).

Pioneering studies in the 1970s and 1980s began to establish the importance of large wood on stream health through regulation and distribution of energy, nutrients, sediment, and water, which play integral roles in aquatic species abundance and diversity (Bisson et al, 1987). In the 1980s and 90s, efforts to mitigate for past or impending impacts to streams through "enhancement" and "restoration" began to grow dramatically (Bisson et al, 1987, Gregory 2003, Reich et al, 2003).

In the mid 1990s the concepts of channel classification, dynamic equilibrium, natural channel design, and "bio-engineering" also began to take hold as the practice of stream restoration became formalized. Many of these early restoration projects perpetuated the idea of streams as simple systems that could be manipulated for narrowly targeted outcomes, often aesthetic (Petts and Welcomme, 2003). Some of these methods have been criticized for their narrowly defined goals, over-reliance on stable forms, and relatively high rates of failure (Lave, 2009). In recognition, the restoration community is increasingly shifting from structural solutions to reestablishment of natural processes, complexity, and dynamics (Abbe and Brooks, 2011;

Beechie et al, 2010; Magilligan et al, 2008). Typical methods include stressor removal, or re-establishment of more normative hydrology, sediment, and wood supply.

Large Wood Workshop Origins

In May 2011 an interagency workshop was held with the two largest federal water management agencies, Reclamation and USACE, to discuss opportunities to improve collaboration in the broad and complex field of river restoration. One of the products of the workshop was a list of emerging science areas that would benefit from new and innovative interagency research efforts. Participants noted that the practice of using large wood in river restoration has been increasing throughout the nation, and even more intensely in western river systems. It is not uncommon to hear of projects installing hundreds or thousands of wood pieces, with a priority goal to improve habitat conditions for salmonids and often secondary goals of managing river stage and habitat maintenance, affecting transport rates and deposition patterns of background wood supply, and reducing bank erosion. The river restoration workshop participants recommended a follow-up workgroup be convened to discuss the current state of practice and research needs for the use of large wood in river restoration projects. An interdisciplinary team of people working in the field of river restoration from Reclamation and USACE was put together to plan and implement the large wood workshop. Funding for the workshop was provided by the Research and Development Office of Reclamation with in-kind support from USACE staff and ERDC's Ecosystem Management and Restoration Research Program.

Purpose of Large Wood Workshop

Various federal and state agencies are increasingly advocating that more wood be used as a "soft", cost-effective, and ecologically beneficial engineering approach in restoration and mitigation projects to meet environmental mandates and endangered species requirements while maintaining traditional agency missions.

Reclamation and USACE have missions that span the United States. Staff tasked with developing designs for projects, or providing technical design assistance and reviews must ensure projects will meet habitat improvement goals, and in some cases population improvement metrics. As public stewards, Reclamation and USACE are also tasked with ensuring due diligence with design of these projects to prevent unanticipated harm to private landowners, infrastructure, or recreationalists on the river. Based on Reclamation and USACE's shared missions, mandates, and broad geographic focus, it was recognized that a cooperative effort to better understand existing practice, develop collaborative research opportunities, and improve standards for wood-based restoration engineering was needed.

Large Wood Workshop Goal

The goal of the Large Wood Workshop (Workshop) was to provide an opportunity for individuals and agencies actively working in the engineered placement of large wood field to collectively develop a road map for future large wood research needs and priorities. Research is defined for this Workshop as a hypothesis-driven approach that includes testing of defined variables with the objective of improving understanding of large wood roles and processes in riverine environments so better tool sets can be developed.

Large Wood Workshop Overview

The Workshop was held in Seattle, Washington from February 14-16, 2012 at the Center for Wooden Boats on Lake Union. Individuals who currently are researching, designing, and/or implementing large wood roles and placement in river restoration projects were invited. Participants from across the U.S. were invited to attend the workshop to provide as much geographic diversity as possible. However, because of the workshop location and a concentration of wood-oriented research and restoration in the region, representation from the northwestern U.S. was greatest (see workshop attendee list at beginning of report). Effort was also made to have interdisciplinary representation from the physical and biological sciences working in river restoration, and a range of both practitioners and researchers, including academics and students, actively working on research projects at the time of the workshop.

The Workshop opened with a discussion of recent legal developments in the State of Washington related to large wood augmentation efforts on rivers. The first talk by David Eckberg from Skellenger Bender, P.S. included discussion of relevant case law, current legislative efforts, roles of designers, clients, public agencies, and environmental managers relating to placement of wood in rivers. Katy Vanderpool from the River and Floodplain Management Section of King County Department of Natural Resources and Parks provided a discussion of the ongoing challenges using large wood projects to achieve flood risk reduction and salmon recovery goals where river recreational use creates competing risk management and public safety needs.

A field trip was co-hosted by USACE Seattle District Office and King County, Washington to explore a range of implemented wood projects (Figure 1). The projects varied from remote locations to urban sites right within the city of Seattle metropolitan area. Field trip hosts offered lessons learned from the projects, and thoughts on data gaps and ways to improve design and implementation. Workshop attendees had a chance throughout the day to interact and pose questions to the field trip hosts to begin formulating possible research ideas.

The remaining days were spent in sessions focused on three key areas: System and Reach Scale Analysis, Local Design Scale, and Implementation, Monitoring & Adaptive Management. Each session kicked off with invited speakers to begin exploring the topic, followed by break-out groups where participants were tasked with collectively developing answers to the following questions:

(1) What is the current state of science and engineering in the field of large wood restoration projects within riverine environments?

(2) What are pertinent science and technology gaps in the field of large wood design and implementation in riverine areas?

(3) What are potential research concepts that could be explored to improve the knowledge base for agencies and practitioners working in this field?

Figure 1. North Wind's Weir site where King County, Washington and USACE have been placing earth-anchored log clusters in fine-grained soil to improve tidal backwater conditions at an urban site near Seattle that has local cultural significance. Photograph taken by Connie Svoboda, Bureau of Reclamation on February 14, 2012.

The break-out groups then reported back to the larger group on their findings and recommendations. Comments and recommendations were provided by the larger group to expand upon and clarify break-out group findings. A final group discussion closed out the workshop. The purpose of the discussion was to summarize identified research priorities and explore potential collaborations and information sharing mechanisms among participants.

Report Overview

This report documents the outcomes from the workshop. The report is limited to presenting a compilation of the discussions that occurred at the workshop, and it is recognized that gaps will exist in certain topics. This report is not intended to act as a policy document or a comprehensive literature review of the field of large wood. Rather, the intent is to provide a research roadmap developed from a representative sample of technical experts working in the field of large wood that can serve as a platform to build upon for exploring future research proposals and collaborations.

State of the Science

Science on the roles of wood in lotic ecosystems and its utilization in river restoration is currently in a state of exponential growth. While the same can be said for river restoration science more broadly, wood-focused efforts have lagged the general field. There are multiple possible reasons for this delay, including broad land use patterns (wood removal), stream crossing designs, and reservoir placements and operations that have severely limited historic or "normative" rates and patterns of wood recruitment and transport through river systems; explicit or implicit foci on channel and bank stabilization rather than restoration of dynamic forms and processes; the influence of zero-risk engineering standards; an early focus and familiarity with rock and its suitability for engineering specifications and standards; and the overall roles of precedent and inertia.

That has changed, beginning in areas of the U.S. Pacific Northwest where relatively wild and narrow valley, steep sideslope headwater sub-basins continue to deliver large wood supplies, often through colluvial processes, to their drainage networks. Current foci for basic and applied wood research include the following areas:

- Hydraulic and hydrologic effects of wood
- Effects on hyporheic exchange
- Geomorphic roles of wood at site, reach, and system scales
- Effects on stream and river biochemistry and metabolism
- Habitat formation and maintenance roles
- Habitat utilization by varying age cohorts, species, and guilds
- Cumulative effects
- Interactions between engineered, active restoration and background sediment, wood, and ice regimes
- Roles for assisted and passive restoration techniques
- Implications for riparian restoration and management
- Recreational and safety issues
- Implications for stream crossing design and reservoir operations
- Roles in estuarine, intertidal, and near-shore zones

The workshop noted that the rate of scientific advance will continue to be rapid, but that there are clear needs at present for robust and more standardized assessment protocols, guidelines for project design, implementation, and improved distribution of efforts in other hydrophysiographic regions and varying channel and valley types.

Workshop Session 1 Overview: System and Reach Scale Issues and Contexts in Planning Wood-based Restoration

Wood regimes have varying characteristics and play differing roles in abiotic and biotic processes in various hydro-physiographic regions, valley types, and even points in a single system's channel continuum. Site-scale work must account for these variations in articulating project objectives, in specific design formulation, in monitoring plans, and in assessing the responses to and benefits of restoration actions. This workshop session focused on developing research goals for the hydrologic, geomorphic, biological, and even social contexts and responses to wood regimes and wood-based restoration at a reach scale. A reach scale was defined for this session as a length of stream that represents a consistent set of physical, chemical, and/or biological conditions and drivers. In the context of large wood, typically a reach would incorporate multiple large wood features, whether naturally occurring, constructed, or both (Figure 2).

Figure 2. Photograph of large wood structures placed on Upper Green River in Washington State. Photograph courtesy of Zachary Corum, USACE.

The session began with presentations from researchers and designers of large wood. Tim Abbe, of Natural Systems Design, Inc, talked about abiotic responses to wood and influence of scale. Dana Warren from Oregon State University discussed biogeochemistry, lotic metabolism, and food web roles of wood in aquatic ecosystems. George Pess from NOAA's Northwest Fisheries Science Center presented fish and habitat analyses for planning large wood applications at a reach and watershed scale.

Following the presentations participants were divided into four breakout groups to discuss the following topics related to large wood research at the reach scale:

- Group #1 topic: Geomorphic, fluvial processes and habitat context
  Example discussion topics: normative regime assessment (how impacted is the system?), background/historic wood load calculation methods, cumulative effects.
- Group #2 topic: Integrating project with current supply and transport dynamics
  Example discussion topics: recruitment mechanisms, use of stochastic hydrology in pulsed loading estimates, designing crossings for debris passage, large wood management at reservoirs, reach-scale layout/spacing of wood features.
- Group #3 topic: Effects and benefits
  Example discussion topics: cost-benefit and risk-reward profiles of various restoration techniques, multi-criteria benefit assessment techniques, limiting factor analyses.
- Group #4 topic: The social context
  Example discussion topics: public perception of risk and value, avoiding infrastructure damage from debris deposition and altered flood recurrence, utilization of wood debris after major floods.

Each breakout group discussed existing analysis methods, data gaps, and proposed research ideas. A summary of the key findings are listed below while a more detailed documentation of the discussions can be found in Appendix A.

Existing Methods

Several existing methodologies are being used to aid in planning or evaluating wood-based restorations at a reach scale. To establish background wood loads and set restoration objectives on the types and number of wood features per stream reach, participants often use a regionally-based reference condition approach based on available watershed assessments and historical accounts of wood. Participants noted that the incorporation of first return and bare earth LiDAR and remote sensing evaluation techniques are becoming more common and provide increased resolution for documenting wood and stream morphology characteristics at a reach scale. This information is used to estimate how wood features function in a natural or high integrity setting to help guide design of the types, size, and spacing of wood features. To predict the effects of large wood on reach scale hydraulics and river morphology, participants typically use numerical and/or empirical models. To evaluate the benefit of installing wood features at a reach scale, participants rely on cost-benefit tools or environmental benefits assessments such as looking at biological utilization by fish species (example in Pess et al, 2011). To evaluate hydraulic resistance of existing wood features or monitor installed features, participants noted high water marks and stage recorders are often used. Among the tools used for reach scale analyses of wood loading on infrastructure, a new manual has been completed that provides approaches on evaluating effects of large wood loading on bridge piers and the associated scour in NCHRP report 653 "Effects of Debris on Bridge Prier Scour" (Lagasse et al, 2010).

Data Gaps and Proposed Research

Data gaps and research needs were also discussed by each of the breakout groups. In summary, current approaches to adding large wood to rivers vary widely and include three schools of thought: 1) add large wood to the stream to supplement depressed natural loading through passive or active techniques and allow the wood to be transported and deposited as a function of natural river processes; 2) add large wood to the stream but secure it so that it does not move (at least not very much) but allow local channel adjustments (scour and deposition if not avulsion) to occur; or 3) secure the large wood in the channel to never move and limit potential channel change. Research at the reach scale is needed on wood rating curves and wood budgeting to assist with projects implementing dynamic wood that can be transported by the system and become incorporated to the natural wood load. Research is needed on design loads to accommodate background wood loads when only local channel change is acceptable. A highlight of the more specific foreseen research needs is synthesized below.

- More sophisticated numerical models with improved representation of large wood features to support design and analysis
- Development of tools to evaluate risk of potential consequences to infrastructure and public safety as a result of constructed or naturally occurring large wood features
- How large wood loading and recruitment on constructed large wood features affects structure spacing
- Better understanding of role and density of wood in undisturbed or historical settings as a guide for design
- Establish methods to develop relationships between discharge, sediment, and large wood loads to better inform design approaches
- Development of large wood rating curves to better understand magnitude of large wood supply associated with varying discharge; account for regional and local variability along with natural variability; account for differences in small streams or headwater areas (Figure) versus larger streams
- Efficacy of passive and assisted techniques (e.g., passive restoration of supply through stream corridor protections and large wood recruitment through existing or restored lateral dynamism) or combined approaches
- How to best define benefits, risks, and liability issues of wood-based restoration designs and practices and how to best communicate these to the larger public
- Better predictions of temporal design components such as when will project be self-sustaining and expected lifespan
- How to incorporate climate change predictions and sensitivity analysis into large wood design and benefit analysis
- How to better manage and utilize wood for restoration after large floods occur in cases where the wood may be otherwise cleared from river systems
- How to utilize wood captured in reservoirs for restoration or downstream river loading that may be otherwise removed from the system or destroyed when released over dams

Figure 3. Natural large wood features on Trail Creek in the Snowy Range of the Medicine Bow Mountains, WY, forming a hydraulic control (photo on left) and being used in a beaver dam (photo on right). Photographs courtesy of Claire Ruffing from Kansas State University.

Workshop Session 2 Overview: Designing at a Local Scale

In this session, the group discussed research needs relating to designing large wood structures at a local scale (example shown in Figure 4). This includes the design of physical structural components, the effect the structure has on local hydraulics and sediment processes, and the stability of the structure. The group focused on how the structure architecture is determined, such as number of wood pieces and their orientation, and other parameters, such as extent and magnitude of the backwater, that need to be considered before construction. Tools for predicting changes near the structure (within several channel widths) were also discussed.

The session began with presentations from researchers and designers in the field of large wood. Doug Shields from the ARS National Sedimentation Laboratory presented results of field and large scale flume studies of hydrodynamic forces acting on wood of variable sizes, including drag, lift, and failure modes. Vivian Leung from the University of Washington discussed her current field and laboratory research relating to flow fields around natural large wood emplacements. Melinda Daniels from Kansas State University discussed the local hydraulic and geomorphic effects of naturally occurring large wood structures.

Figure 4. Photograph of constructed wood feature on John Day River in Oregon on November 5, 2008 provided by Kendra Russell, Reclamation.

Participants were divided into breakout groups to discuss the following four topics relating to designing at the local scale:

- Group #1 topic: Structural characteristics of large wood
  Example discussion topics: Wood size, rootwad size, number pieces, orientation, vertical extent, debris recruitment, architecture, burial and angle of logs
- Group #2 topic: Morphological changes produced by large wood
  Example discussion topics: Bank erosion, bed erosion, deposition, scour hole production, numerical and/or physical modeling to predict changes
- Group #3 topic: Hydraulic and habitat changes produced by large wood
  Example discussion topics: Backwater effects, debris recruitment, changes in sediment sizing, habitat value and benefit, methods to predict changes such as modeling
- Group #4 topic: Stability of large wood
  Example discussion topics: Ballast material, depth to key in members, loose vs. tied-in, factor of safety, drag, and anchoring

Each breakout group discussed existing analysis methods, data gaps, and proposed research ideas. A summary of the key findings are listed below while a more detailed documentation of the discussions can be found in Appendix B.

Existing Methods

Several existing technologies are currently used to design large wood features. To establish an appropriate design that fits the context of the river system, watershed characteristics and trends are identified and historical photos and data, such as written accounts of travelers and survey records, are analyzed. Survey data, particularly LiDAR, is an important tool in selecting a location where the large wood structure can produce the desired river modifications. Numerical simulation models (1D and 2D hydraulics), physical models (Figure), and empirical observations are used to predict hydraulic and geomorphic response of designed structures. Literature continues to emerge that provides tools to better analyze the hydraulic forces on large wood to assist with design parameters (Shields and Alonso, 2011). Emerging tools also include 3D hydraulics and incorporation of dynamic bed and channel banks. Participants used reference books and guidelines such as NRCS Technical Supplement 14J and applied research from other disciplines (ex. risk/stability assessment for ballast or simulations of bed scour for design of highway crossings to guide design decisions). Habitat suitability criteria and limiting factors analysis are used to determine the type of large wood structure that can achieve habitat goals for target species.

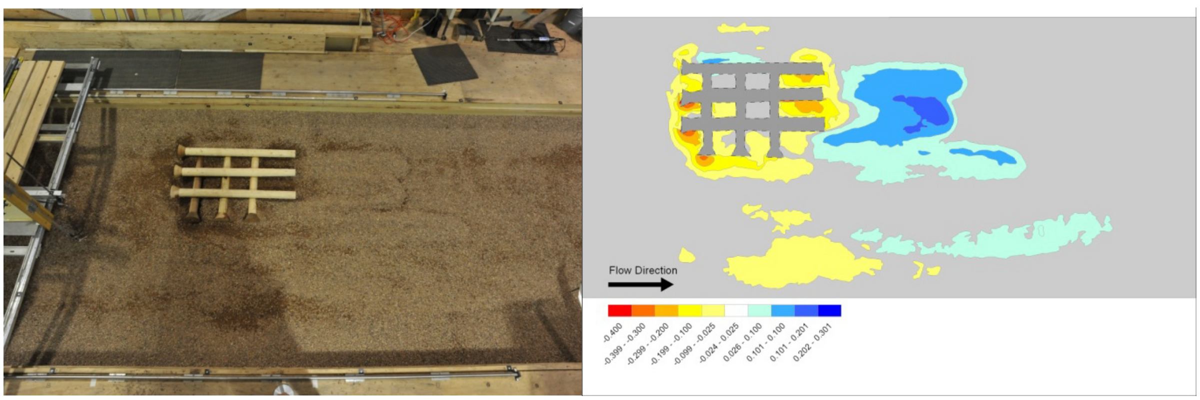

Figure 5. Example physical model study looking at scour effects on various large wood configurations. Photograph taken June 2010 by Connie Svoboda, Reclamation.

Data Gaps and Proposed Research

Data gaps and research needs were discussed by each of the breakout groups. In all four groups, several concepts were independently listed. These research needs are synthesized below. There were several examples of overlap in research needs among the breakout groups.

- Guidelines, principles and standards for design and implementation
- Cost/benefit analysis
- Better understanding of interactions between multiple wood structures
- Need for field demonstrations (e.g. flume/numerical/field comparison study, long term monitoring efforts, instrument large wood with sensors, experiments in low-risk environments)
- Engineering for desired habitat suitability/habitat effects

- Better understanding of large wood and floodplain interaction
- Risk assessment tool
- Effect of large wood structures on side channel connectivity and evolution
- Stability and failure mechanisms
- Improved understanding of scour and scour prediction specific to large wood debris and engineered log jam implementation
- Improved understanding of porosity by predicting structure evolution/recruitment

Several concepts and data gaps were identified in individual breakout groups that were not repeated among the other groups. Below is a list of topics that were discussed unique to the individual group. The topics were organized by individual groups because of the uniqueness of each category.

Additional needs from topic 1: Structural characteristics of large wood

- Database of projects (objectives, materials, cost, fate, geomorphic response, habitat effects)
- Design guidelines and standards (streamline equations/practices to more universal model)
- Value engineering tool
- Application of existing understanding of stability and failure mechanisms , such as discussed in Sutherland, 2010, into development of safety and risk design criteria

Additional needs from topic 2: Morphological changes produced by large wood

- Design guidelines for different types of river systems
    - Account for similarities and differences between large versus small river systems
    - Incorporate how sand -bed versus gravel-bed channels respond differently to wood.
- Long term integrated monitoring efforts
- Improve understanding of multiple LWD structures (spacing, number, geomorphic response)
- Understand structure-scale effects for different size rivers
- More communication/information connectivity within technical community and with public
- Understand effects of blockage ratio on geomorphic response
- Understand ability of channel to retain wood (“sticky river”)
- Advance 3-D river corridor modeling technology
- Predict watershed trajectories

Additional needs from topic 3: Hydraulic and habitat changes produced by large wood

- Design specific criteria for side channels versus main channels
- Improve understanding of multiple LWD structures (spacing, backwater)
- Low cost design tools for small projects
- Improve recirculation effects understanding
- Improve bed material size sorting predictions
- Efficacy of different structures

Additional needs from topic 4: Stability of large wood

- Balancing risk vs. ecological benefits tool
- Improve understanding of interactions between LWD structures (spacing, spatial)
- How to maintain stability using best engineering practices
- Better understanding of hydraulics and stability of LWD in bends
- Define best engineering to achieve hydraulic and habitat objectives
- Define what is considered a success or failure
- Bank erosion mitigation tool
- Better understanding of morphological response to obstructions in gravel bed systems
- Analysis of deformable vs. rigid structures benefits
- Experiments needed in low-risk environments

Workshop Session 3 Overview: Implementation, Monitoring, and Adaptive Management of Large Wood

In this session, the group focused on research needs related to the post-design phase of large wood projects including the three topic areas of implementation, monitoring, and adaptive management. Implementation was focused on applied construction techniques and addressed key issues that need to be considered when installing large wood designs. Monitoring included aspects of both biological and physical responses related to large wood projects. Adaptive management looked at both the aspects of implementation and monitoring and linked them together through the adaptive management framework and applied learning process. Example guidelines have been developed such as the recent U.S. Department of Interior Adaptive Management Implementation Guide.

The presentations during Session 3 were structured into the three topic areas of implementation, monitoring, and adaptive management. Each of the distinct themes was introduced by key presenters addressing various technical aspects of their respective topics. Rocco Fiori, Engineering Geologist and consultant with the Yurok Tribe in Northern California, presented on the implementation topic and used many examples from his role as a heavy equipment operator constructing large wood projects. Roger Peters, Fisheries Biologist with the U.S. Fish and Wildlife in Washington presented on monitoring biological responses to large wood, using many examples from his extensive work throughout the state of Washington on various river systems. Zac Corum, hydraulic/design engineer with the Corps of Engineers Seattle District tied implementation and monitoring together with a discussion of the adaptive management framework applied to multi-year large wood projects near Seattle.

After presentations, participants were divided into breakout groups to discuss four topics relating to implementation and monitoring:

- Group #1 topic: Applied techniques of large wood implementation
  Example discussion topics : practical stabilization methods (e.g., piles vs. posts, ballasting methods, etc), constructability challenges, factor of safety, longevity in relation to installation, cost-benefit considerations, permeability relative to habitat and public safety.

- Group #2 topic: Monitoring the biological response of large wood
  Example discussion topics: methods of measuring fish under log jams, monitoring the utilization of other species, quantifying secondary ecologic effects (side channels, hyporheic, forest/riparian development), advancing predictive tools in relation to biological monitoring, radio frequency technology to track habitat usage, photo documentation methods.

- Group #3 topic: Monitoring the physical response of large wood
  Example discussion topics: documenting bed texture and morphological change, advancing predictive tools in relation to physical monitoring, radio frequency technology to track scour production, field measuring hydraulics around the wood structures, photo documentation methods, bathymetric surveying techniques around wood jams, tracking the mobilization and transport of wood during floods, and the pros/cons of marking large wood for monitoring.

- Group #4 topic: The adaptive management process for large wood projects
  Example discussion topics: addressing maintenance needs relative to stability and function, applying monitoring data back to the design cycle, reporting monitoring/analysis results to stakeholders and managers, refining risk assessment from monitoring, addressing liability issues over time, documenting the evolution of structure size and function, effective and practical inspection and reporting strategies, strategies of conveying the use of large wood to the public

Each breakout group discussed existing analysis methods, data gaps, and proposed research ideas. A summary of the key findings are listed below while a more detailed documentation of the discussions can be found in Appendix C.

Existing Methods

IMPLEMENTATION: Existing techniques for the implementation of large wood projects were discussed (Figure). The design of many projects is “outside-in”, that is designs are influenced as much by costs, permits, safety, access, and other site constraints as they are by relevant geomorphic or biological contexts and goals. Accounting for scour has created challenges for water control and water quality protection, as well as structural stability. Practitioners assess liability and safety concerns for specific sites before installing large wood structures, especially in recreational settings. Practitioners identified several common issues that are impacting the effectiveness of completed projects. Accounting for the availability (or lack thereof) and condition of large sized wood pieces during construction was a critical issue. For proper wood placement, necessary construction equipment should be selected and transport procedures should be identified. Contracting methods and field changes were other important issues. The U.S. Forest Service and Federal Highway Administration are currently producing a stream restoration implementation manual that can be used in the future for implementation guidance.

Figure 6. Example of large wood implementation on Trinity River, California. Photography courtesy of USBR Trinity River Restoration Program (taken by Kenneth DeCamp).

MONITORING: There are several existing technologies and methods currently being used to monitor the physical and biological performance of natural and placed large wood. Some of the most commonly used techniques identified by the group are:

- Photographic monitoring
  - Photo points, photogrammetry, web-cams
- Topographic mapping
  - Sonar/ADCP bathymetric surveys
  - Total station surveys
  - Aerial or terrestrial LiDAR
  - Cross-sectional/transect surveys
  - Scour pins/chains
- Geographic surveys (GIS/GPS) of geomorphic and vegetation change
- Tracking movement of fish, wood, gravel (RFID tracers, radio tags, GPS tags)
- Modeling based monitoring (prediction/comparison)
- Bed texture (grain size) monitoring

- Hydrologic (stage/flow) and sediment transport monitoring
- Limiting factors analysis
- Before-after-control-impact (BACI) studies such as monitoring for changes in temperature variations and groundwater contributions

Literature on large wood monitoring data continues to emerge but can vary by location and project type of how protocols and density of information are represented. Documentation where multiple projects are evaluated with similar approaches can provide comprehensive data sets on lessons learned (Washington State example in Southerland, 2010).

ADAPTIVE MANAGEMENT: During discussions about adaptive management processes, several existing techniques were identified. Monitoring is a requirement – this is typically begun early in order to establish baseline conditions, prior to implementation. Once performance metrics are established, monitoring locations, frequency, and methodologies follow. Adaptive management strategies often include a communication plan and collaboration protocols, to ensure stakeholders can stay abreast of the project and provide timely input. Identifying performance metrics and documenting progress are critical to establishing a firm basis for changing an implementation strategy. Other current techniques include developing (and reformulating) hypotheses, evaluating alternatives for implementation, and developing a conceptual model with different trajectories. Reference sites can be used to set targets for actions or baselines for comparison with project responses. Conceptual modeling holds promise for identifying different possible trajectories and communication to stakeholders.

Data Gaps and Proposed Research

Data gaps and research needs were discussed by each of the breakout groups. In all four groups, several concepts were independently listed. Below is a summary of the key research needs that were compiled and synthesized from the original notes taken during Session 3 break-out group discussions.

Data Gaps:

- Centralized project database of completed projects for independent evaluations of effectiveness
- Lessons learned compilation
- Literature review database
- Long term monitoring data sets
- Higher resolution data sets
- Modeling linkages between biology and geomorphology
- More sets of monitoring data to understand before and after project completion changes from installation of a large wood restoration project with the potential of using a control reach for comparison

Needs:

- Scalable success metrics
- Standard monitoring protocols and unification
- Decision framework for monitoring

- Experimental project areas & full scale test beds
- Tools for measurement of variability
    - Index of biological integrity (IBI) and habitat indices
- Monitoring tools for storage, transport, and recruitment dynamics
- More robust/refined 2D/3D models related to large wood
- Sediment transport models (morphological evolution based)
- Data interpolation tools
- Education/outreach/communication tools for stakeholders
- Refined limiting factor analysis tools
- Constructability assessment tools
- Implementation guide and technique compilation for construction
- Training tools for regulators, implementation and monitoring
- Peer-reviewed journal articles to provide quality control of data

Workshop Synthesis Session

In this final session, workshop participants reviewed results from each of the three focused sessions and discussed four key topics that had come to the forefront: a river corridor concept to assist with large wood implementation, communication among the large wood community, documentation of monitoring results, and better understanding of risk.

There was a general consensus among workshop participants on the idea of supporting the idea of river corridors within watersheds. The concept was based on defining a corridor for the river within which physical processes would be encouraged including large wood implementation, vegetation restoration, floodplain connectivity, and natural channel dynamics. A platform for generating this type of statement was not identified but it was noted it would be stronger if supported by multiple agencies and technical practitioners.

Communication ideas to continue information exchanges on large wood included using web-hosted lists among technical groups such as the ASCE task committee on river restoration and expanding upon the email list generated for the workshop. The idea was posed to hold additional large wood workshops in the Midwest and East Coast to increase geographic diversity and representation. An additional idea was to hold a workshop specific to tasking participants with developing components of large wood design guidelines. Additional communication ideas included partnering with floodplain managers and regulating agencies such as the Federal Emergency Management Agency (FEMA), participating in social media, partnering with non-profit organizations, creating public education pamphlets on the role of large wood and example project outcomes.

Documentation and funding of monitoring following implementation was noted as a significant limiting factor in acquiring performance and follow-up lessons learned data on large wood. One suggestion was to look at existing databases maintained by funding agencies to see if there are opportunities to add monitoring data and make them publically accessible. Agencies such as U.S. Forest Service and U.S. Fish and Wildlife were noted as good resources to look into for monitoring data, along with organizations specifically geared at monitoring such as the Pacific Northwest Aquatic Monitoring Partnership (PNAMP; www.pnamp.org).

Because risk of downstream impacts from large wood structures came up in multiple session discussions, participants discussed the idea of intense monitoring at low-risk sites where large wood is implemented to better understand what impacts actually occurred, if any, and how to evaluate them. It was discussed that sites where supplemental wood is allowed to be mobilized and transported through the system would offer a great opportunity for learning. Participants offered several locations as possible sites for consideration including long-term or intensively monitored watershed sites, examples in Washington State such as the Upper Green River, the Entiat River, the Quinault River, and the Klamath tributaries in California. It was discussed that having a highly disturbed site in addition to more remote areas would be valuable.

Workshop Recommendations

The goal of the large wood workshop was to provide an opportunity for individuals and agencies actively working in the field of large wood to collectively develop a road map for future large wood research needs and priorities. Three sessions were held where break-out groups were tasked with collectively documenting science and technology gaps and potential research goals for various topics. Session 1 addressed the hydrologic, geomorphic, biological, and social contexts and responses to wood regimes and wood-based restoration in various regions and settings at a reach scale. Session 2 addressed designing wood structures at a local scale and included how the structure architecture and other parameters, such as extent and magnitude of the backwater, need to be considered before construction. Session 3 topics included monitoring and assessing both biological and physical responses to large wood projects. Additional discussion occurred in a wrap-up session where broader research and management questions related to large wood were posed and discussed.

From each of the three focused sessions and the workshop synthesis session, key research needs were developed. Several of these data gaps were mentioned in multiple sessions. While all needs are important, ideas that were referenced in multiple sessions or strongly supported by the general group of participants in the large group sessions were deemed to be priorities. Priority research ideas fell into two categories: technical information needed to support design and implementation and resource management information needed to evaluate and communicate effects of large wood projects.

The priority technical research needs include:

- Guidelines, principles and standards for design, implementation and monitoring
- Develop a better understanding of interactions between multiple wood structures, such as how large wood loading affects structure spacing
- Develop more refined or robust techniques to represent large wood in numerical models
- Conduct detailed performance assessments of treatment techniques at prototype scales, to resolve outstanding technical data gaps, in low-risk settings

The priority resource management research needs include:

- Develop a benefits/effects assessment tool
- Determine how to best define risks and liability issues of wood-based restoration designs
- Determine how to best document and communicate the value of large wood and risks through education and outreach with stakeholders and the public
- Enhance communication between agencies of lessons learned from large wood projects
- Support a collaborative development of a river corridor concept to improve understanding of natural river dynamics and restoration concepts

The goal of this report is to provide a platform for exploring future research proposals and collaborations. As such, the workshop has already been a success. Design guidelines for large wood structures were listed as one of the priority research needs. Reclamation and USACE are currently working together to produce a manual of large wood design standards, and a contract was awarded in May 2012. This work will be developed and evaluated by teams of interdisciplinary practitioners to ensure a robust and useful framework is produced. Other guidelines were also noted to be in progress by participants on the topics of stream restoration and monitoring protocols that could offer opportunities to incorporate large wood information.

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Appendix A: Reach Scale Detailed Notes

<u>Group #1: Geomorphic, fluvial processes and habitat context</u>

- Existing Methods
  - Watershed assessments
    - Structural vs. functional objectives
    - Planning at multiple scales
  - LiDAR and remote sensing (photogrammetry) products
  - Historical accounts
  - Reference condition approach
  - Numerical modeling to simulate dynamic/complex river
- Data Gaps and Proposed Research
  - Better understanding of fate of wood placed in river systems
  - More sophisticated numerical models
    - Wood routing models (utilizing large wood input rates)
    - Vegetation colonization model
  - Biogeomorphology (at what assessment level is this important?)
  - Connecting physical and biological processes
  - Benefits and limitations of using non-wood material in design structures
  - How to apply watershed and reach scale information into design and prediction analysis
    - What processes/conditions are we trying to restore with wood?
    - What is the relevance of the pre-historic wood budget?
    - How can wood related to watershed processes or conditions be restored?
  - To what extent is restoration guided by design/analysis and to what extent is it situational based on current and local features within a reach
  - Re-think assessments for wood
    - Assess recruitment, routing, deposition mechanisms
    - 3D riparian structure
    - Addressing wood and nitrogen and phosphorus (N&P) dynamics
    - Develop better assessment tools for effects quantification
  - Consequences for infrastructure and safety
  - How to evaluate quantify the beneficial effects of wood predicatively
  - Prediction of the recurrence of riparian species
  - Multi-tiered framework for national application with regional tools
    - Assess if large wood is good for a particular project

Group #2: Integrating projects with current supply and transport dynamics

- Existing Methods
    - Large wood designs are currently static. This practice leads to the racking of wood in these systems along with initiating recruitment mechanisms and other processes there. These processes are influenced by windfall, rate of large wood decay, and the residence time of large wood in the system, for example. In CA, river systems are far off-track, because they do not receive inputs of conifer logs, and large wood recruitment to those systems is absent. This influences sediment dynamics there. It is important to note that large wood species decay rates influence the results of projects. Conifer species will decay at a different rate than Alder, for example.
    - Large wood budgets and loading rates estimated in river systems with dams located downstream (through utilizing reservoir studies)
    - Empirical models for wood delivery
    - Determine the effects of large wood load on flood heights for design purposes.
        - High water marks
        - Stage recorders
    - Fluvial floodplain design
- Data Gaps and Proposed Research
    - There is a need to account for the transport of large wood in river systems and with respect to river restoration projects.
        - There is a need to monitor and estimate the load of large wood contributed to a project and the upstream and downstream impacts of that project on the river system where it is conducted.
        - There is a need to address uncertainty in large wood loading analogues through examining current and historical conditions in river systems.
        - There is a need to develop data-driven models that account from sediment transport, large wood transport, and large wood input rates.
        - In-channel large wood pieces as well as those pieces found on and along bar surfaces should be accounted for. The amount of large wood should be counted in both cases. GIS analysis of remotely-sensed data could be used to collect data on large wood, for example.
        - Documenting the amount of large wood pulled out of reservoirs gives an idea of large wood budgets and input rates to river systems. Data are collected on how much large wood is stopped at the reservoir. This data indicates a loading rate, which is, perhaps, the natural loading rate. It may be possible to develop analogues for other watersheds using this data by

comparing watershed area and channel discharge, and the applying regression analyses to the results of these comparisons.

  - Investigate the problem of estimating the background load of large wood to rivers.
  - How can we track large wood transport in river systems?
  - Study the effects of large wood loading on bridge piers and associated scour.
  - Identifying the natural variability of large wood loading in a river system
  - Understand the differences between background large wood loading rates versus episodic, stochastic, and extreme loading rates
  - Understand how large wood loading affects log jam spacing
    - Develop thresholds and criteria for log jam spacing and large wood input rate
  - Observe and quantify interactions between natural and engineered jams
  - Investigate the effects of wood jams on river dynamics and properties such as roughness, width, and depth. Information is needed to determine the effects of large wood loads on flood heights for design purposes.
    - This requires data gathered from stream gauges, data on precipitation, and data on low return interval events.
    - Data must also be gathered on stochastic events. Available equipment and techniques can be used to document stochastic events in river systems. During flood events nails and flagging may be placed along the margins of flow to record water surface elevation and the longitudinal water surface profile up and downstream of an engineered log jam, and could be useful in evaluating floodplain reconnection resulting from the installation of that engineered log jam.
  - How are discharge, sediment, and large wood load related?
    - How often does a river system experience conditions that could lead to the transport of large wood in that system?
    - What does a large wood rating curve look like? Is this curve regionally applicable and is it similar to other regional regimes?
  - Are regional design templates really applicable across regions?
    - Large wood is multifunctional. Compartmentalized understandings of river system manipulations are predicted to breakdown, with multidisciplinary work becoming common.
- Recommendations
  - The number of pieces of large wood in the river and in jams should be tracked
    - If not tracking pieces of large wood, then the amount of large wood entering the river should be estimated
  - There is a need to create and implement designs in a more cooperative fashion among agencies and partners

- Infrastructure must be replaced with attention given to how that infrastructure affects large wood transport dynamics; a more holistic design is needed
  - Large wood in river systems, sediment budgets, channel mobility rates, channel lateral migration rates, and instability functions must be considered.
  - Having a clearer idea of large wood budgets allows for the creation of a better design.
- Encourage use of a probabilistic prediction model for large wood transport in rivers
- Encourage bridge replacements to follow a new design standard that eliminates the large wood problems often encountered with older bridge designs
- Beyond fish passage alone, restoration designs should account for broad aquatic organism passage across a wide variety of life stages in addition to accommodating fluvial processes
- Important to consider the role of climate change and its impact on project time scales and design life spans
- It's good to have an idea of what the local policies are on the recruitment rate of large wood
- With any restoration design, you should engage with non-engineers to consider other factors that could have an influence on design
- There is a need to fill data gaps in the social understanding of large wood in river systems and to develop an appropriate regulatory framework for large wood in these systems.
- There is a need to address social and regulatory concerns respecting large wood in river systems.
- Discuss and recognize the place and role of restoration in projects with other primary goals
  - Beyond fish passage alone, designs should account for broad aquatic organism passage across a wide variety of life stages in addition to accommodating fluvial processes

<u>Group #3: Effects and benefits</u>

- Existing Methods
  - Cost: Benefit tools
    - Cost: structure, risk/liability, flood
    - Benefit: fish, labor/job
    - Alternatives analysis
- Data Gaps and Proposed Research
  - Quantification of project objectives involving large wood

- How large of a scale must restoration efforts be in order to detect increases in fish populations? (look at IMW efforts on Entiat River in eastern Washington as an example - http://www.ecy.wa.gov/programs/eap/imw/index.html)
    - Mechanistic linkages of effects – how do activities work through the system?
    - Examples of success
    - Establish systematic definitions of benefits/effects
    - Establish a standard of practice for benefits/effects assessment
    - Numerical fish habitat modeling (with linked large wood processes)
    - Improve experimental design
- Recommendations
    - Define explicit objectives (based on limiting factors for fish productivity) and do benefit: risk analysis based on these
    - Create contingency plan
    - For restoration projects, look at the change in habitat (e.g. quality and amount). Usually easier to quantify than fish
    - Need to prioritize (spend less money for less area or more money for more area)
        - Potential non-linear effects of increasing expenditure
    - Should first determine the limiting factor(s) to make sure we are working at the appropriate scale
    - Establish systematic monitoring (rather than assemblage of case studies)

<u>Group #4: The social context</u>

- Existing Methods
    - Awareness/outreach (public meetings, YouTube, Face book, school curriculum, etc.)
- Data Gaps and Proposed Research
    - How do we communicate the issues of wood in rivers?
    - How do we define risk and liability?
    - People's perception of what they want with reality
- Recommendations
    - Appoint an action committee to implement workshop recommendations
    - Provide input/information to change current FEMA policies
    - Team up with non-profits and professional organizations
    - Work with both river users and local community
    - Write up a corridor policy statement signed by the large wood community
    - Need a common vision
        - Corridors
            - More effective restoration
            - Wood in rivers
            - Benefits people (flooding), fish, and ecology

- Roadmap to get there
    - Education
        - Social media, newspaper articles, school curriculum, documentaries, etc.
        - Community service
    - Policy/legal
        - FEMA
        - Zoning (undeveloped)
        - Risk and liability
        - Watershed districts
    - Incentives
        - Land trusts
        - Conservation easements
        - Emergency response
        - Stewardship
        - Mitigation banking

Appendix B: Local Scale Detailed Notes

<u>Group #1: Structural Characteristics of LWD</u>

- Existing Methods
  - Survey
  - Hydrology and hydraulic models
  - Read the stream
  - Placement and size based on objectives, constructability
  - Risk/stability assessment for ballast

- Data Gaps and Proposed Research
  - What flow rate do you design for?
  - How do we go from agency specific equations and practices to a more process-based universal model? (e.g. ballast)
  - More research on accumulation mechanism
  - Jam stability with less complicated analysis
  - Porosity – How do we predict (based on internal structure)?
  - Predicting structure evolution from racking, slash, etc.
    - Jam transitions from a few pieces to many pieces?
  - Design factors of safety – drag, porosity, lateral loading, density, species, height, length
  - Cost /benefit analysis – Design to implementation aspects – What are “efficient” designs?
  - Failure mechanism (with respect to architecture, lateral loading, foundation, sedimentation/scour, buoyancy, flanking, hydraulics)
  - Maintenance
    - Timing of “adjustments’
    - Project Life
  - Stability, foundation structure
  - Needed tools
- Database of projects
  - Materials database
  - What has been done?
  - Cost?
  - Fate? Geomorphic response?
  - Objectives?
  - Habitat effects?
- Design guidelines and standards

- Risk assessment tool
    - Appropriate placements for experimental design
- Value engineering tool
- Instrument structure with sensors (e.g. Demonstration Erosion Control (DEC))
- A linked full scale real and numerical model (flume, numerical, field)
    - Reach scale modeling of system

- General Discussion
    - Existing Design Considerations
        - Quantitative objectives (e.g. reduce low flow width-to-depth ratios)
        - Design discharge – baseflow
            - Consider designing for 100 yr flow and bankfull
        - Cross section encroachment
        - Geomorphic analysis – planform location
        - Meander patterns, scour frequency
        - Predicting scour, empirically
        - Design elevation
        - Klingeman equations
        - Site measurements (empirically)
        - Set proper scale – topography, hydrology, match LWD to channel type
        - Ballast - no one standard, empirical

    - Limiting Factors
        - Liability Issues
        - Inter-agency coordination (information sharing)
        - Lack of monitoring
        - Training & mentoring
        - Size and availability of wood
        - Variability of site conditions
        - $$$ cost
        - Computational powers
        - Going from flume/model to the field
        - Interest
        - Lag time between design and implementation
        - Availability and transportation of wood
        - Environmental compliance permits
        - Water management during construction – dewatering, turbidity

<u>Group #2: Morphological Changes Produced by LWD</u>

- Existing Methods

- Hydraulic modeling of LW/sediment transport models
    - Numerical simulations models (e.g. IBM hydro and bed morphodynamic models)
- Empirical field studies; should include monitoring
- Physical models (e.g. Froude-scaled river models)
- Analysis of historical photos and data, such as written accounts of travelers and survey records
- Applied research from others (simulations of bed scour and some information on the permeability and other characteristics of structure related to LW/ELJ structures, such as spur dikes)
- Watershed characteristics/trends
- LiDAR could be used to evaluated channel migration zones

- Data Gaps and Proposed Research
    - Develop principles to guide restoration design in river systems. Principles should not be strict rules, but guidelines for thinking on how to design.
    - Develop a logical framework to ask the right questions and identify the right or most important factors in design work (e.g. wood behaves differently in bedrock channel). Sediment load, lateral migration potential, etc. are variable.
    - Long term integrated monitoring efforts.
    - Improve scour prediction technology by using threshold equations for bridge scour, for example.
    - Better understand structure-scale effects in river systems.
    - How do structures function as a group? How should structures be spaced, and how would this vary across systems? How many need to be deployed in a river system to achieve the desired results? What are the associated channel migration rates?
    - Communicate knowledge between levels, increase “information connectivity” (e.g. there is a disconnect between academia, practitioners, municipal engineers at the state, county, and local level)
    - Scale – Local/Reach/Spacing
    - What are the morphological effects of blockage ratio? How much of the channel should be blocked?
    - What are the attributes of a channel that make it “sticky” for wood?
    - 3D numerical models using supercomputer corridor modeling
    - How do we predict watershed trajectories? Will LW installed now work in 25 years?
    - Better model LWD structures/floodplain interaction
    - Better predict side channel connectivity
    - Cost/benefit analysis
    - How to articulate the results of this analysis and communicate them to the public

Group #3: Hydraulic and habitat changes produced by LWD

- Existing Methods
    - 1D, 2D models
    - Physical models
    - Different tools for large vs. small streams
    - Reference books/checklists
    - Habitat suitability criteria
    - Empirical observations
    - Design for complexity
    - Take advantage of opportunities (e.g. levee rebuild, emergencies)
        - Potential for larger scale projects

- Data Gaps and Proposed Research
    - Efficacy of different structures
    - Improved understanding of scour
    - Low cost design tools for small projects
        - Accessible (cheap) models and/or standards of practice for small streams
    - Side channel design/evolution
    - Habitat suitability and relation to seasonal preferences, variability in flow
        - Questionable habitat suitability curves – better to emulate 'natural'?
    - Backwater objectives
        - Floodplain connectivity; flood elevation (rule of thumb?, relation between blockage ratio and afflux, distance between jams)
        - How close should we put jams (will backwater effects of downstream jams cancel out upstream)?
        - Lose riffles with too much wood?
        - Effects on habitat
            - Many assumptions
            - What if backwater extends to riffles?
    - Recirculation (velocity)
    - Size sorting (cobbles for spawning)
    - Guidelines for implementation/design

Group #4: Stability of LWD

- Existing Methods
    - Modeling – 1D, 2D, and 3D (less available)
        - What about bank erosion?
    - Reference conditions based on species
    - Integrated steam bank protection guidelines (Washington State)
    - Habitat restoration guidelines
    - NRCS Tech 14J
- Data Gaps and Proposed Research
    - What is the definition of success or failure?
        - Hinges on funding, liability, risk
        - Depends on the objective of the structure
        - What is best engineering to achieve hydraulic (or habitat) objectives?
    - Analysis of hydraulics & stability of jams in bends
    - Balancing risk vs. ecological benefits
        - Placement and mobility
    - Relationship between porosity, flow-through, habitat
    - How to deal with bank erosion?
    - Engineering required to maintain stability
    - Better understanding of morphological response to obstructions in gravel dominated systems
    - Interactions between wood structures
        - Implication for spacing
        - Organization (spatial)
        - Geomorphological
        - Biological/ecological
        - Reach-scale vs. local Scale treatment
    - Biological/geomorphological benefits of deformable vs. rigid structures
    - Experiments in low-risk environments (design)

Appendix C: Implementation & Monitoring Detailed Notes

Group #1 topic: Applied techniques of large wood implementation

- Existing Methods
    - Outside-In Design: Design for Liability/safety, wood availability, costs, site and regulatory constraints
    - Issues with construction: wood properties, choice of equipment, transport, size of materials
    - Forest service & Federal Highways producing manual on stream restoration implementation
    - Issues affecting construction:
        - Wood species/size/condition/moisture content
        - Expected Scour – how to get account for it and complications with water control
        - Contractors choice of equipment/methods
        - Variability of contractor capabilities/experience
        - Ability to do field modifications
        - Roles of designer/owner
        - Transport of materials (rock/wood) in sensitive locations
        - Acquisition methods and planning

- Data Gaps and Proposed Research
    - Expedite permitting through outreach and education of regulatory community
    - Manual of wood properties such as wood decay rates as a function of species, climate, submergence, etc,
    - Training manual for construction (for contractors)
    - Artificial wood-type elements
    - Compile different implementation techniques
    - Assess cost/benefits of different treatment techniques
    - Identify contracting methods best suited to large wood projects

- Recommendations/Questions
    - Describe regulatory response (specify which techniques fit into which programmatic)
    - Are there economies of scale?
    - Constructability-what does it take to build?
    - What techniques go where?
    - Easy to train? Training manual? (designers, contractors, regulators)
    - Lessons Learned Compilation (what happened, where, when, why, how)
    - Stream restoration implementation Manual (U.S. Forest Service, Federal Highway Administration)

  - Peer review of Programmatics; peer review of project design
  - Concentrated monitoring/testing/experimentation on Green, Quinault, Trinity, Entiat Rivers
    - Write-up report about each site (long term ecological research (LTER) like Knapp also possible);
    - Also need 'bombed out' spots with low risk for infrastructure damage to experiment

Group #2 topic: Monitoring the biological response of large wood

- Existing Methods
  - Before After Control Impact (BACI) important but adds a lot of cost -> Roger Peters is going to attempt just control-impact instead
  - Collaboration; most research/monitoring is tucked away in technical reports

- Data Gaps and Proposed Research
  - Streamline and standardize monitoring guidelines where possible
    - e.g. Roger Peters monitoring protocols
    - Stream restoration implementation handbook
    - River Rat project (NOAA)
  - Fill in knowledge gaps regarding effects on fish
  - Difficult to standardize (though desirable) between regions
  - Need core set of scale-able metrics accompanied by locally-specific metrics
  - Background data by region: processes; natural variability
  - Limiting Factors Analysis – what do we need to measure? What scale should be measured? How to track change over time and deal with variability?
  - Ties from biology to geomorphology; bridging scales between modeling capabilities and output to what scale monitoring is occurring at; fish measured often at reach scale but geomorphic may be at smaller scale
  - Behavior of biota; how long in what habitat?
  - Temporal Scales – limiting factor

- Recommendations
  - Consider measuring stream metabolism instead of fish number
  - Consider measurements of capacity (e.g. bioenergetic models, food web analysis)
  - Very hard to quantify fish and understand behavior
  - Need to move towards process-based metrics (e.g. population structure through time)
  - Need measures of variability: index of biological integrity, index of habitat indices
  - Improve communications with public and stakeholders – are there more fish? Are funds showing success and meeting objectives?
  - Maintain a food web perspective
  - Scale of use: much of work done on smaller streams; need to better understand role of wood in big river ecology
    - Measuring local process

        - Accounting for habitat connectivity; what is cumulative benefit of multiple wood features
        - Quantifying biota in a way that allows typing discipline objectives

    - NEEDED TOOLS
        - Population life cycle model: find bottlenecks/limiting factors
        - Community/guild scale: e.g. integrated index of biologic integrity (IBI's)
        - Can we come up with an IBI that works with geomorphic metrics?
        - A process based tool: space and time; using age class to determine how effective wood structures are
        - Monitoring with restoration responses in mind
        - Good literature reviews/meta-analysis: disseminate available literature
        - What is best sampling design?

    - WHAT SHOULD WE MEASURE
        - Standardization (pros and cons)
        - Core set of scalable metrics within cost limits; units that can be combined (modular)
        - Decision Framework for what and how to monitor – scalable; modular network of monitoring metrics; get this out to community to make data comparable and maximize efficiency with limited funds; what are things to measure first, during, and after
        - BACI use – sense of before and after conditions
        - Integrated teams from start to finish
        - Need to do a better job of relating importance of long-term monitoring to funders and decision makers

<u>Group #3 topic: Monitoring the physical response of large wood</u>

- <u>Existing Methods</u>
    - Existing Tools for Monitoring:
        - ADCP (acoustic Doppler Current Profiler): used to monitor topography, can collect data in the whole reach: flow, bed type
        - LiDAR, site-scan sonar, hyper-spectral for bed topography
        - PIV, digital camera mounted to a mast, coordinates surveyed – able to get velocity coordinates of the "peanuts"
        - Scour chains, tracers, accelerometers
        - Radio frequency identification tags (RFIDs), can detect maximum scour
        - Grain size analysis
        - Cross-sections, long profiles
        - Interpolation tools
        - Repeat photography
        - Stereo photo point clouds

    - Ground based GIS/GPS mapping
  - Low tech
    - Grain size analysis
    - Cross-sections, long profiles
  - High tech
    - ADCP – flow; bed type
    - Lidar – terrestrial, aerial, hyper-spectral
    - Side scan, sonar
    - Scour chains, tracers, RFID, accelerometers
    - Interpolation tools
    - Digital camera photogrammetric point clouds
  - Log-jam growth/changes
  - Physical environment
    - Changing grain size
    - Bed changes
  - Bathymetry mapping
  - Max scour depths
    - Couple hydro-dynamics with scour
  - Velocity measurements – limiting factor
    - Side channels are important; how can you measure side channels?
    - Triage: high water marks
    - Quantify eddy viscosity for example and verify with field investigations
    - What else can be monitored – like bedload measurement tools – to calibrate models
    - What are the limitations of equations, can build sediment load rating curve based on morphological data from the field
- <u>Data Gaps and Proposed Research</u>
  - Model improvements (for hydraulics? Stream response? Biological response?)
  - Interpolation tools
  - 2D/3D models; what field data is needed?
  - Sediment transport models
    - Especially gravel/cobble transport/morphologic change
  - Money for monitoring
    - Timeframe for partnership
    - WSDOT
  - Centralized monitoring (database) to develop "regional response curves"
  - Long-term data-sets
  - Timeframes of monitoring projects exceed the length of a graduate student
  - Data quality and standardization issues
  - Which locations among reaches were most effective for Engineered Log Jams (ELJs)
    - Certain channel types that would benefit more for example?

    - Density or frequency of structures?
    - Experimental design
- Recommendations
  - Should have a contingency plan
  - Decide if you are going to tag wood and how
  - Before and after reach-scale aerial photos at extreme low and high water to see how things are responding
  - Regionally pool resources, targeting monitoring, what is successful, what isn't…
  - Establishing the right kind of partnerships
  - Find a place where monitoring can be invested to set a gold standard for what can be expected for fish population increases/show it's more widely applicable
  - Low to high technology to gather field inputs for monitoring
  - Data inputs needed for 2D, 3D models
  - Sediment transport models (especially for gravel/cobbles)
  - Timescales of funding
    - Consortium between agencies to extend funding
  - Centralized monitoring
  - Long-term data sets (which sites are most effective?)
  - Monitoring objectives to meet the needs of ELJ type
  - What are the goals of the project and how will that direct monitoring?
  - River surveys
  - Need more data as input to models
  - Different partnerships that could be utilized to collect better data both immediately afterwards and long-term
  - Tie specific objectives better to monitoring plan development and techniques
  - Physical objectives
  - How jam grows and changes over time (local and reach scale effects)
    - Physical environment around jam: flow regime, ADCP; cross-sections; grain size; bed (RFID, scour)
    - Decay rates, function of climate change
  - Multi-discipline coupling of physical, biological, ecological important
  - Higher resolution data sets for future modeling efforts
  - SOCIAL project scale objectives
    - What is effectiveness of project; good return on investment? How to manage when put in; ecology and fish response and geomorphology; whether goals are set for project and how they fit to monitoring objectives
    - Contingency plans as part of monitoring plan
    - Importance of tying monitoring regionally: focus on example projects within a region to show effects of structures to get more details and focus rather than spreading out monitoring at lower resolution over multiple sites
  - LIMITATIONS
    - 2D/3Dmodels – what field data is needed for boundary conditions?

        - Sediment transport models – especially for gravel/cobble transport, morphologic change; improvements needed
        - Economic: funding for monitoring; timeframe for how funding works with large wood projects; money not currently extended over long time scales; partnering to get long-term monitoring; consortium between agencies; (example with oil company consortium)
        - Integrate disciplines more
        - Centralize monitoring at regional or national scale to allow comparison between sites/project/structure/stream types
        - Importance of having a database to cover range of failures and successes
        - Set up to consider types of projects for varying site types/conditions
        - Common monitoring protocols – non-profit collaboration

<u>Group #4 topic: The adaptive management process for large wood projects</u>

- <u>Existing Methods</u>
    - Tools
        - Monitoring approaches (pre and post)
        - Developing hypothesis
        - Evaluating alternatives
    - Identifying sites for experimentation reference sites similar to LTER
    - Communication and collaboration
        - Communication protocol
        - Performance metrics
        - Documenting progress at regular time scales (annual reports)
    - Appropriate time/spatial scales
    - Adaptive management is a tool itself
    - Conceptual model up front and identify different trajectories: communicate to modelers up front and see what is possible to predict; iterative process
    - Where are experimental areas? Could reference sites be setup and could we get funding, possibly through NSF?
    - Communication protocols: identify questions up front; repeatedly come back and answer questions and use answers to redirect monitoring for next phase; make sure all parties are involved; need to have bridge and consistency among participants in different stages of project (planning, implementation, monitoring)
    - Are there other reaches beyond project area that can be used to compare response in project?

- <u>Data Gaps and Proposed Research</u>
- Getting data for completed projects and making it accessible to research community
- Peer review – QA/QC of completed projects and outcomes
- Storage, transport and recruitment dynamics
- Project and practitioner database
- Data compilation: get data out to help with conceptual model development
- Peer review: QA/QC, What is quality? Who collected?

- Unified monitoring protocols for physical and biological (economy of scale)
- Evaluate effects at reach scale
- Using watershed management practices: flood protection, water control, can this be used to streamline metrics and level of data collected; can one area be used to provide indicators of another with same management practices
- Monitoring database/list-serve: mechanism to disseminate new literature and information on projects
- Place to store reports and share information
- Journal papers offer good mechanism now: quality controlled; accessible
- ACOE Regulators review and approve thousands of in-water projects in US. Could require baseline data collection as permit condition; if we could establish protocols for baseline – follow-up could more readily happen; type and level of data and quality; need to identify common methods would help get monitoring data if you can show it could be used by others
- For example, ACOE has national levee database; effort not trivial
- Would be valuable to store GIS data without analysis to limit QA/QC issues
- Quinault Nation has example of establishing GIS database
- Can we identify big funders for this: BPA?
- Don't necessarily need database for every project; perhaps a representative sample to represent overall population and major categories
- What is life cycle of a designed structure?; need more information/research of how structures function over time
- If there is a recreation component, can we incorporate them into monitoring of how features are working to evaluate whether risk and liability are issues or working OK?
- Trinity example – citizen science to build trust and bring in users to team
- Could BOR or ACOE support a database to share information? Challenges with quality control and commitment for long-term support

- <u>Recommendations</u>
    - Education/outreach/communication
        - Public broadcasting spots for LW (e.g. David Suzuki on CBC Radio-Canada)
        - Pamphlets, radio
        - Use existing organizations
    - Getting on the same page about adaptive management
        - Science based approach
    - Objective driven
        - Questions and hypotheses
    - Short, intermediate, and long term goals
    - Defining success and failure
    - Handling uncertainty
    - Adaptive management goals should be established up front
    - Break out into short and long-term goals: geomorphic response might happen quickly; fish population might be longer term