Welcome, Agenda Review

Moderators Laura Weatherly, Fisheries & Oceans Canada (DFO) & Jason Hwang, Pacific Salmon Foundation.

Laura welcomed everyone, noting this was the 7th workshop in the series co-hosted by DFO and PSF, with support from the Washington Governor's Salmon Recovery Office.

Following a territorial acknowledgement and outline of the focus of today's workshop, she noted a record number of workshop participants, with over 1,000 individuals attending virtually from across BC, Canada and the US. Presentations, recordings and summaries from past workshops in the series can be accessed here.

Jason noted the goal of these workshops is to share the latest science, knowledge and practitioner experience. The intent is not to be prescriptive but to provide opportunity to come together, learn from experts, and exchange information. He reviewed the agenda and explained how to use the virtual Slido feature to share questions.

Greer Maier, Washington Governor's Salmon Recovery Office

Greer noted the value of transboundary collaboration and knowledge sharing, so it is exciting to see the growing interest in these workshops. She looked forward to sharing lessons learned and to exchange information.

Effective Use of Wood in River Restoration

Tim Abbe, Natural Systems Design

Presentation highlights included (See PPT for details):

- Presentation will focus on benefits of using wood, how it supports different aspects of physical habitat, with impacts on water and alluvium of particular relevance for fish.
- To prioritize projects, we consider how wood can play a role in restoring alluvial beds and trapping desired sediments.
    - We start with wood, then determine where, how and how much. Project goals help us answer these questions.
- In contrast to the historical context, few places today have natural wood loading, even in remote areas (millions of pieces of wood removed from small streams.)
- Wood function: Diagram illustrating channel complexity in relation to wood loading.
    - Pool frequency in response to wood loads.
- Bed aggradation associated with log jams — Alta Creek example.
    - When this happens over spatial and temporal scales, you can get a very complex landscape: complex valley bottoms in the Alta Creek example.
    - Removal of wood has simplified these things.
- The other key thing is natural processes and how wood removal has affected those.

- Engineered log jams provide stress partitioning, with higher stresses on the wood, and therefore less elsewhere, which reduces sediment transport.
    - Sullivan Creek example: Fine gravel accumulated in cobble stream bed after the addition of wood.
    - Lower Elhwa example: response to engineered log jams (ELJs)
- ELJs: Influence of channel form (single to anabranching to braided) similar at low flow but looks very different at bankfull flow. Reducing substrate grain size can change channel planform.
- Process based restoration: How will adding wood change fundamental processes driving physical parameters of the stream and floodplain.
    - 1995 European study on effects of pulling log jams from a small stream found the frequency of bedload mobilization increased three fold, and duration increased 14-fold. This explains how loss of riparian (passive) and active wood removal affects stream incision.
    - Another study illustrating grain size decrease in relation to wood density (it affects not just grain size but scour depth).
    - Critical shields stress increases with morphologic drag (critical shear stress increases, scour depth goes down).
    - Scour model results, Lower Hoko River, Washington, showed significantly improved egg survival from adding wood.
- Project examples: Upper Dungeness River, Olympic Peninsula (very steep river, historic loss of wood).
    - Did helicopter wood placement. Results included recruitment of smaller wood, sand bars, fine gravels, and eventually returning Chinook.
- Restoring incised channels: the longer you let it continue, the more costly it is to fix.
- Development of new tools: DEM models.
- Shale Creek project raised the stream bed 1.5 metres. They found 1.7 metre bundles wrapped in manila rope very useful for helicopter placement and saw a rapid response in a stream that was subject to very rapid flows.
    - It’s about reducing the velocity of water, and retaining water in our watershed.
    - Before/After pictures of water storage in these systems.
- South Prairie Creek: Incised channels. Rock and wood structures supported a process-based response.
- Little River: Helicopter/ground based work.
    - Little River response: 105 mm to 15-40 mm substrate — a significant improvement for spawning salmon.
    - Increased proportion of substrate that is movable for Trout, Pink and Chinook.
    - Number of wood forced pools doubled, less space between pools.

    - Little River summary of results.; 1,000 Pinks returned (spawning upstream of the structures); Captured 45,000 out-migrating Spring smolts (10-15% of total). Improved response due to habitat improvements.
- Importance of comprehensive projects to restore the large wood cycle:
    - Results of different levels of work: significant scale needed to achieve ecosystem effects and affect population levels.
- Elhwa: increased wetted area despite lower flows after project completion.
- Upper Quinault River Valley Restoration: Long-running project led by the Quinault Nation (plan to publish results in the coming year), involved 103 log jam structures built since 2008.
    - Used piles to stabilize existing natural wood structures and work to protect property from erosion.
- Alder Creek Reach: Aerial photos showing development of multiple channels.
    - Hydraulic modelling shows complexity of hydraulics around these structures.
    - Forested islands also emerging on these structures.
- Most ELJs are forming pools, recruiting wood. Most are associated with pre-existing or new channels, most are trapping alluvium (retaining more sediment), and most are forming forested islands.
- Building ELJs: They use all types of forest products, including root wad, boles, slash.
    - Illustration of logjam design.
    - Hardware notes: Avoiding hardware is preferred, but it's sometimes needed for stable structures.
    - Structural elements of an ELJ; and failure mechanisms.
- Conclusions: Summary of ecosystem benefits of using wood.
    - Alluvium is key to keeping wood stable; rock may also be needed.
    - Physical complexity is good and we're still underestimating how much wood is needed.
    - Lots of racking wood is a good thing.

Discussion

- Are these designed to be dynamic?
    - The core is designed to be stable, but racking material to be dynamic (shedding, accumulating). The river may also evolve to move around it. Provide a mosaic of structures so that wherever the river moves, it will interact with some of them.
- So if it's the system that's effective, do you wait for enough money or what do you start with?
    - In some cases, you can be effective with just one or two structures. Ideally you start with a master plan and prioritize but some of these were built over many years. You can definitely do it incrementally and not all sites need a full array of structures,

    - although it's more important in some, e.g. the Elhwa focus was on building more in a short stretch.
- How do you do this in areas where flooding is a risk for surrounding areas?
    - In another reach of the Elhwa, there was important surrounding infrastructure so what we built was designed to actually support the municipal water withdrawal system, and in compliance with flood ordinances. Another approach is to build low profile structures that would be submerged at very high flows. It's typically more expensive in such situations.
- Is sediment retention ever too much of a good thing?
    - Good question, though we haven't ever seen that yet. We see some sand, but locally, and for some species, that may be a good thing. But it's a good question to ask in your design.

Nooksack River Restoration: Lessons Learned from Almost 20 Years of Log Jam Projects

Lindsie Fratus-Thomas, Nooksack Tribe Natural Resources

Presentation highlights included (See PPT for details):

- Overview of the Nooksack river system.
    - Two at-risk Chinook populations with habitat degradation as a leading cause of declines.
- Over 700 log jam installations were built between 2001 and 2024, in projects led by the Nooksack and Lummi tribes.
    - These projects increased in size and complexity over time, as they learned from earlier work.
- Overview of the key limiting factors being addressed in this work in the South, Middle and North Forks.
    - Projects guided by work planning (minimum 4 years from conception to execution) and using qualified engineering consultants.
    - Overview of key goals for the different areas.
- Nessets Reach, South Fork: 2 phases, 25 log jams, 1.1 miles mainstem habitat, total cost $2 million. They use pile-driven logs as the base for structures.
- North Fork, Farmhouse Reach: 5 phases to restore stable side channel habitat, with 127 log jams, 2.2 miles of habitat, and total cost of $6.9 million.
- How do we build these in large dynamic river systems:
    - Construction access: many are remote sites, with frequently shifting channels.
    - Had to construct a road through DNR/State lands and build temporary bridges (using old 40-foot long rail cars) to access islands and gravel bars (bridge building can be a key task in these projects).

    - Water management: water deflectors and diverters. Crews onsite to monitor and avoid fish stranding (they try to avoid work during spawning time).
    - Installing isolations: Choosing experienced contractors is important; also careful planning, monitoring and communication to ensure they follow design specs.
    - Fish exclusion: Seine nets to remove fish in the isolation areas before digging/construction.
    - Dewatering to install logs.
- Different types of installation (pile drivers, excavation). Chain lashings used to attach horizontal logs.
    - Jams are designed to be self-settling; we have seen some of them move.
- Lessons learned; Manila rope replaced with chain (did not last); incorporate other learning from past designs and refining plans with engineers. You need contractors with in-water experience. Also expect that you will need to adapt so include contingency for that in the budget. Managing log inventory is always more difficult than expected.

Discussion

- What are short term risks of going big to save at risk populations?
    - We're always guided by the long-term vision and goals. When things are serious, you need to crack a few eggs to do what's needed.
- How did ELJs respond to the 2021 atmospheric river?
    - There was some loss, particularly of older structures following the major flood, but overall, the great majority remain intact and functional. Over the years, we increased the depth of vertical piles and added root wad. Elsewhere, too much wood racks up and the tops have broken off, but it remains functional. We increased pile diameter (to 18 inch) to address that and also lowered profiles to reduce how much racks up.
- How did you build up contractor experience?
    - It's important to include the specific requirements in the requests to bid, and we have refined those over the years. We don't always have to go with the lowest bidder, which has been helpful. Contractors often have to start small to build up the necessary experience. Having contractors who are patient, communicate well, etc is important.

A Holistic Approach to Watershed Restoration

Tom Balfour, Redd Fish Restoration Society

Presentation highlights included (See PPT for details):

- Overview of the Tla-o-qui-aht First Nation's long-term, holistic approach; partners.
- Tranquil Creek area overview: Significant past watershed logging impacts; extreme climate and landscape, where the big native trees would have played a key role in stability.

- Project focus was four kilometres of very productive salmon habitat that had been very aggressively logged, resulting in a massive input of sediment, rapid widening and simplification of stream features.
    - Second growth monoculture forest planting did not function like the original old growth.
    - Buried creek issues: wide, flat very hot, featureless systems.
- Top down approach: First step involved looking up to address sediment, with bio-engineering to stabilize slopes.
- Forest riparian floodplain had inappropriate second growth planting, resulting in a super dense forest of skinny trees that don't have the same function, so the focus was on how to restore old growth characteristics (e.g. by thinning)
- Tranquil Creek project has been a valuable learning experience: one of the biggest and most dynamic projects we'd taken on.
    - Gravel bar project: a once-productive spawning area had become a hot dry moonscape.
    - Built many different wood structures through trial and error, along with bioengineering (willow stakes, grass seeds, relying on the natural succession of plant species in replanting).
    - Plan is to continue monitoring and building over the long term.
- Recent work on a different reach, matching the scale of structures with the needs of the river.
    - Hydraulic flow modelling: Featureless, single channel, lacking complexity. Goal was to restore natural watershed functions.
    - Area is boat access only, so all equipment and wood had to be barged in.
    - Heavy bundles flown in using helicopter.
    - Isolation, foundation construction. They try to minimize steel, but longevity is important.
    - Built large structures, designed to function at both high and low flows.
    - A series of structures was built over time, but it was designed to work as a package.
- 2022-24: 400 metres of channel, 500+ pieces of wood added, 13 ELJs.
- Overflight showing results: habitat mosaic; increased pool density and depth; plus they saw salmon using it right away.
- In the atmospheric river, the structures took a beating but also accumulated new pieces.

Discussion

Jessica Hutchinson and Luke Swan of Inter-Fluve joined Balfour for the Q&A

- Q/A: Overall project cost was about $1 million, plus costs for the riparian work.
- What are you doing to help sediment move through the system while upland areas are recovering from logging?

    - It's a multi-pronged strategy, with racking, willow stakes, plus the log jams. It's like a big ooze of sediment coming in, so the idea is to ensure it spreads unevenly.
    - We have a major slide issue, which creates a large pulse but then it continue to bleed sediment, so a lot of the work is to stem that. There is also road deactivation to prevent future slides and work to accelerate recovery of large trees and healthy ecosystems.
- Are all these things guided by a master plan or is it more about the philosophy?
    - It's both. There is the core concept that everything in the watershed is connected; although there are individual plans for different pieces of work, they all work together.
- What are key take-aways?
    - Each river and situation will have a slightly different application. There are many different functions of using wood, so we really try to think about what we want the large wood to do and how to design it for that.
- Q/A: The scale of restoration needs to match the scale of the industrial logging that occurred, so we need a commitment to a holistic approach and adequate scale.

Wood: The Original Influencer

Al Jonsson, Kerr Wood Leidal Associates

Presentation highlights included (See PPT for details):

- How we got here: widespread wood removal was motivated by flooding, infrastructure and an aversion to "untamed nature" (which views wood in rivers as "messy" or dangerous).
- Forestry practices led to widespread perceptions that wood is deleterious to aquatic habitat and needed to be cleaned up.
- The tide turned in the 1990s with the watershed restoration program and publication of *Tech Circ 9*, a pivotal publication on restoration practices. The role of debris trapping was recognized at that time, but that understanding fell out of consciousness, leading to a highly regressive view of the role of wood in BC.
    - We're dealing with many factors holding things back, including technical stove piping (not seeing the collaborative practices needed), and a lack of mentors and professional development. Most work is focussed on offsetting (measured in square metres) so we've lost the system-wide perspective needed. So we need a lot of work in BC to get to where Washington and Oregon are.
    - The focus here is on singular pieces and large woody debris (LWD) predominantly viewed as a structure, so how do we get from one-offs to really get this going.
    - The solution involves understanding LWD as an influencer and a key factor in river geomorphology.
- Case study: Indian River, North Vancouver project led by the Tseil-Waututh Nation.
    - Very steep, flashy river, with destabilization due to past logging and clearance for a BC Hydro corridor. Results include fish stranding.

- Initial work done in 2017 but much of it was lost with high water that fall.
- Further work undertaken in 2024, thanks to an alignment of factors (funding, wood supply, opportunity to share contractors).
- Site considerations; construction overview. Work was done over 5 days.
- Results/next steps: Observed geomorphic responses, live staking pilot, LiDAR scan/analysis, and potential future works planned downstream.
- Side benefits: Inspiration for other ELJ projects in the valley.

Discussion

- What is different now from the old Watershed Restoration Program on the use of wood for restoration.
    - Tim Abbe has been a trailblazer. He has set the standard and understanding of the need to go beyond the standards in *Tech Circ 9*. There was some understanding back then, so it's not clear why it went off the rails.
- How has the shift to process-based systems influenced the current approach?
    - It goes back to geomorphology and looking at how the entire river system will respond to the changes instead of focus on a singular placement of LWD to impact fry holding.
- Speak to the cultural values around this work.
    - The important thing is the common vision, holistic outlook and seeing salmon as a keystone species. I bring the technical know-how and we see the cross-over to those traditional values.

Panel Discussion

- What are pivotal actions we can take to start catching up regarding the scale of the large wood projects that we need, as is happening in Washington and Oregon?
    - We need stable, predictable, long term funding to build the necessary experience and knowledge base amongst practitioners. So more government support and getting the agencies fully on board. Forestry is such a huge issue, yet we're still permitting logging in steep areas, and road commissioning — things that everyone know will come back to bite us.
    - Agree re long-term, stable funding. Challenges include working against preconceived notions, so maybe some DFO education about why we should be doing some of these things. We also need to incentivize development of high-end local expertise.
- What are some of the important recent design changes and why?
    - There is important new tech for mobile pile drivers; also guidelines for allowing un-anchored loose wood vs. transitioning to more engineered structures. Also low tech solutions for small, low-gradient systems and the value reset around Stage Zero and the importance of when you can do that. There is also emerging science on wood and its functions, including new work from Europe, and work on water rights and storing more water in stream systems.

    - Increased stability is important. Lots of money goes into these projects, so we don't want to see them fail, especially in places that are hard to access — e.g. our use of chain instead of manila rope. We're working more with partners on lower profile log jams, and more affordable solutions.
    - The biggest change is around use of wood to achieve restoration goals, which has helped us design structures that achieve process-based goals, especially to address limiting factors. Our thinking has really evolved. There is so much more discussion about design, about getting bigger and more aggressive and how to use wood to achieve these goals.
- What are applications for the broader community of restoration practitioners, or those guiding/investing in such. How do you do this in a valley bottom with wall to wall agriculture or perhaps in an urban area — are there different design concepts and approaches?
    - We do get asked to restore rivers without changing anything, so maybe we need more education and understanding of the trade-offs, and some of these projects do happen in urban areas.
    - Compromise is key. We need to give rivers some space to help salmon recovery and restore riparian corridors. We have worked with farmers whose banks were eroding to do bank protection that was fish-friendly, so the idea of green infrastructure. Sometimes it requires farmers giving up some riparian land. Where it works best includes, for example, in Seattle where we purchased some houses so we could restore complexity. It's more expensive but it's important for people to see this working in the places they live. Infrastructure is expensive, so the more we can integrate this, e.g. with road building, the better.
    - There are ways to find compromise with land owners, for example one who was previously not interested in working with us. His bank started eroding in 2017 so we used bank protection as an incentive to get them to sign on to a larger project (1 mile of riparian restoration). We also used funding conditions to encourage sign on. You can't ask people to give up their land without incentives. We're also doing our first Fish Flood program, combining flood risk reduction goals with our habitat restoration goals, so more focus on projects with multi-benefits to get landowners on board. Also community outreach is very important to build trust. We're also thinking more about future conditions in our designs (so things we may not be able to do now but that are potential future opportunities).
- Is there a risk of over-engineering in building large wood structures or promoting silver bullet thinking — what else needs to be considered?
    - You can't make it too strong. In terms of stability, it needs to be proportional to the risk (e.g. more in urban areas). There is absolutely a risk of this being a sliver bullet or flavour of the day seen as the answer to everything. Every tool needs to be properly used where it's most appropriate and modified appropriately to fit the situation.
    - There are very few places where we have the large stable trees. But there are risks of these large structures, for example if there are bridges downstream. So we try to be conservative to ensure longevity but without over engineering. It's important to

keep asking if you're over/under engineering. It is like open heart surgery but it's amazing how quickly the fish comes back given the extent of construction activity.

- Is there a point when it's too early to intervene (e.g. Tranquil) so where it's best to wait for things to stabilize?
    - The places where logging left old growth buffers, it created old growth log jams and it looks very healthy. If you wait for stability, you'd wait forever. Having all this wood in the channel helps to manage these large intermittent sediment pulses. I have yet to see a project where the log jams were too big — it always feels like we don't do enough, not too much.
    - Something that's under-appreciated is Pacific salmon live in a disturbance landscape but it needs to be a mix of stability and disturbance. So it's about building islands of stability in disturbed reaches. In other places, we need to re-introduce that periodic disturbance regime.
    - Agree with the argument for not waiting because we will always have disturbances. The log jams helped manage sediment pulses after a dam removal. Having these structures helps to build resilience to these changes and with climate change it will be even more important to provide features that help to handle these disturbances.
- Is wood used differently in different circumstances (e.g. increasing/decreasing alluvium)?
    - My work is primarily in buried streams and the assumption that we are replacing lost log jams. There are tweaks, e.g. my focus is trapping sediments.
    - It's good to understand what is your sediment budget. Usually it's not a shortage of sediment, it's just flushing through. But the strategy for both extremes is similar. You're creating diverse substrates and conditions and fish prefer that diversity.

Large Wood as a Driver and Feedback of River Corridor Spatial Heterogeneity

Anna Marshall, University of Tennessee

Presentation highlights included (See PPT for details):

- The broader term "river corridor" is used to include the associated components.
- Spatial heterogeneity refers to patchiness: Key natural drivers are geology and climate.
- River corridor spatial heterogeneity is important for resilience.
- Historical removal of wood has shaped societal expectations around stable, simple river channels.
    - Scientific understanding has highlighted the importance of dynamic, spatially heterogeneous systems.
- Swan River, Montana: one of a handful of systems that remains naturally unaltered. Marshall's work there focusses on the interactions of channel dynamism, log jams and spatial heterogeneity, and metrics for such.

    - Mapping natural log jams using satellite imagery (presence, persistence and distribution density).
    - Beavers as ecosystem engineers.
    - Total sinuosity.
    - Distribution of distinct patches in the river corridor and how those change over time.
- Reaches with more log jams and channel dynamism have higher spatial heterogeneity.
    - They also see feedback patterns — e.g. contributing to building secondary channels, islands, and trapping more wood.
- Reaches with more physical complexity attract beavers, and we see more spatial heterogeneity there.
    - The spatial heterogeneity persists even after the log jams are no longer present. So large wood can be the initiator, but it doesn't have to remain in place.
- Two patterns:
    - Logjam as a trapping mechanism, then vegetation takes hold and it continues to grow upstream.
    - Log jam creates avulsion that persists (from a decade to over a century).
- It takes about 200 years to return to natural wood load after logging. Log jams can speed up that time scale.
- Prioritizing wide wood-rich retention zones is important for fostering spatial heterogeneity. These zones can also help to jump start heterogeneity after fires.
- Spatial heterogeneity persists after log jams are not longer present.
    - Reintroduced wood does not have to be anchored in place to facilitate heterogeneity. You need anchoring to limit hazards for good reasons, but also think about places where you can let it move.
    - Considering the geomorphic context of a river is very important. In some contexts, e.g. delta where there is no natural wood, other processes can create heterogeneity.

Discussion

- What can we communicate to regulators about solutions that permit wood to move around in systems?
    - Context matters in terms of constraints on restoration and the options available to work with. For un-anchored wood to successfully sustain heterogeneity, it requires a complete picture of the wood regime, including recruitment. You also need to define whether wood moving is actually a failure or not. So monitoring to learn, bridging the academic/practice boundary, gathering and sharing the info.
    - Solutions are site specific. In some contexts, anchoring is the right solution, but there are also situations of where there is value in allowing wood to move, so they are complementary strategies.

- Q/A: Context is critical to determining what strategies make sense, e.g. sedges and rushes in a marshy setting or meadow. There are many factors to consider, including the geomorphic context. There is a great resource on this that Anna can share.

The Middle Entiat Project: Process-based Restoration at the Reach Scale

Allison Lutes, Chelan County

Presentation highlights included (See PPT for details):

- This was a process-based restoration project, with multiple partners.
    - Watershed background and description; the project focussed on 4 miles assessed as having the most potential impact for salmonids (focus on juvenile overwintering habitat gap).
    - Project came 20 years after the listing of Upper Columbia Spring Chinook, Bull Trout and Steelhead, so there was lots of documentation/background work to establish the foundation.
    - The Chelan Douglas Land Trust acquired 536 acres and 5.2 miles of habitat and was key to being able to undertake this project.
- Work involved not just installation of large wood, but also plans to improve lateral complexity (levee removal).
    - Large wood was key to re-establishing side channels.
    - Mechanism used for planting in gravel bars with Stinger equipment.
    - 143 ELJs, many designed in concert with other habitat features.
    - Different kinds of jams built, bank enhancement, side channel structures.
- Lessons learned:
    - Importance of landowner agreements and civil liability; they followed strict design guidelines, e.g. building to 100-year flood standards.
    - Log procurement and sorting requirements.
    - Used pile driving and bolted connections (with cosmetic finishing work to make it look more “natural”).
    - Isolations: needed less with the pile driving.
    - Post-project monitoring: Very limited funding, but you can accomplish a lot with drones and remote loggers.

Evaluating Large Floodplain Restoration Projects

Reid Camp, Snake River Salmon Recovery/Cramer Fish Sciences

Presentation highlights included (See PPT for details):

- Unique features of this project; very large areas, thus an important role for remote sensing.

    - Tools/methods for effectiveness evaluation.
    - Work done pre-project, as it was built and post-project.
- Whole project results: the value of a continuous data set is it's inherently scalable.
- Intent was to see if the project achieved the design objectives.
    - Examples, e.g. Apex jams and Bank-attached jams, and value of the monitoring data in demonstrating what was achieved.
- Takeaways: Physical responses.
    - Magnitude of response for wood jams depends on flow, sediment flux and jam size (better to go big to get an initial strong response).
    - Interaction between jams is also key.
    - Helicopter jams worked very well.
    - Pinned log structures mostly worked well — limit temporal response.
    - Decreased porosity produces a stronger response.
- Side channels: extremely difficult to build stable side channels in a dynamic resilient system.
    - Mimic natural side channels.
    - Bed aggradation is most effective for connection (wood alone likely won't maintain connection).
    - Design for low flows.
- Levee removal:
    - Design lower elevation than the models suggest.
    - Use more wood to spread flows and aggrade the channel bed.
    - Also model flow duration for the flood plain areas to maximize fish benefits (not much benefit if there are only flows for a few days).
- Fish habitat: Seeing improved habitat for Chinook and Steelhead; seeing more fish returning.
- Monitoring doesn't need to look like this: take a picnic at an old project to see how it's doing.

Discussion

Nic Truscott, Chelan County, joined for the Q&A.

- If you can't afford the full array, what should a small group prioritize?
    - Hobby drones, multi-spectral camera, green LIDAR is great and it's getting cheaper, also cheaper low tech (stick and tape).
    - Traditional LIDAR uses red wavelength, green LIDA uses blue green laser wavelengths to get ground surface and water underneath.
    - Some of the funding for this monitoring was made possible by the Salmon Recovery Board selecting this project for intensive monitoring.

- What are the trade offs between investing in such intensive monitoring projects vs spreading it around?
    - Most important is having clear objectives and just going out there to check if it's happening.
    - New tech offers low cost solutions, e.g game(?) cameras and time lapse videos
- Unpack the variety of different log jams discussed and how would those be used for different project goals.
    - Depends on the goals, e.g. you can use a bunch of jams to slow flows, to create habitat, etc.
- Q/A: The riparian plan called for addressing reed canary grass. We looked at different treatments for it, but it's very aggressive. Putting in larger stock is important to outcompete reed canary grass, and also shading it.

Helicopter LWD – An Evolution in Cost-Effective Process-Based Restoration Approaches

Derek Marks, Tulip Tribes

Presentation highlights included (See PPT for details):

- Presentation focusses on value of helicopter work.
- Overview of Deer Creek site description and project goals; force analysis.
- Pilot project installation and analysis: we learned a lot about anchoring technique by tracking the fate of a large log anchored to a boulder in the pilot.
- Key project steps: Identified key sites, acquired large logs, helicopter contractor (lifting capacity of 3,200 - 3,500 pounds). Also backpacked in a small generator for anchoring/installation.
- Tracking: the log jams accumulated additional wood and have persisted for years.
- Lessons learned:
    - LWD weights are difficult to estimate remotely, especially with root wads.
    - Anchoring method vital to structure strength.
    - Larger helicopter could have helped.
    - Chain anchors are effective as long as porpoising can be minimized.
- South Fork Tolt Project: Overview and key take-aways:
    - 2006 pilot was designed for 10-year flood events but survived 20- and 90-year events; most logs dislodged were caught by jams further downstream.
    - Used normal LIDAR and a relative elevation model to help identify potential side channel locations.
- Steps to success:
    - Rootwads are key: they provide stability, and increase future wood recruitment.

    - Using full length trees (> 100-120 feet). This reduces transport capacity if they do break free, as they tend to get hung up.
    - Stacked wood at least above flood plain elevation.
    - Significant biological response with Summer Steelhead spawning around the jams.
- Pilchuck River helicopter project:
    - Implementation strategy flipped conventional wisdom, using smaller wood at the bottom and ballasting with the larger pieces.
    - Anchoring techniques: boulders, entanglement.
    - Iterative design process
- Pilchuck specifics
    - Example jam stability calculation: partial channel spanner (free spreadsheet tool from USFS).
- Lessons learned so far:
    - Detailed engineering is not always necessary when risks are appropriate; hydraulic modelling is a valuable tool for addressing stability.
    - Methods for jam stability: work with gravity, against buoyancy.
    - Mobile woody debris is a necessary ingredient.
- Conclusion: Helicopter projects can be very cost effective: total costs of $300,000 plus staff time for installation of about 30 jams.

Discussion

- Q/A: For non-engineered design — mimic nature, with design standards, and field fitting. These rivers tend to be steeper, high energy spawning/rearing areas for salmon, with widths of 100 feet or less.
- Q/A: So it’s about not embedding wood but rather dropping and anchoring it. On longevity, it has to be tailored to the risks. Some are transient and that’s OK. The intent of this approach is to kickstart process-based evolution in a more cost-effective manner.
- Why choose this approach?
    - It’s more nimble, with less riparian replanting, and it’s not feasible to get heavy equipment into some of these areas. Helicopters sound expensive but can be done affordably with a lean design.
- What did it cost?
    - South Tolt was about half a million, so about the same, for 300 pieces of wood. They used the helicopter twice, with trees having a diameter of 36 to 40 inches. Land based would have been more expensive.

Panel Discussion

- What are the key limitations on what we can and can’t achieve, and on situations where we will have success or not?

    - Regulatory restrictions mean we have to trade stability over effectiveness, so it would be useful to have more information to inform regulatory reform.
    - Permitting frameworks have become more complex in recent years. Also the climate change needle is happening faster than we can respond. We need more focus on reconnecting rivers to floodplains so they can work more like sponges, and on using wood to reactivate flood plains to address low flows, etc.
- Are there times and places where these solutions are not recommended?
    - A single piece of wood sticking in a bank isn't going to be as effective. There are places where wood is not the most effective method to achieve your goals (example of using rock instead to avoid boating hazard). How long will the wood last is important. Sometimes you may choose materials that simulate wood but that will last longer. Agree that helicopter projects can be very effective. We need to ensure they raise water elevations. It's important to exchange learning and learn from our mistakes.
- Several questions relate to considerations for recreational users.
    - We've built thousands of log jams and we haven't had many such situations. But rivers are dangerous places, so public education is important. Recreational signage has been important in Washington but it's something that designers should always be cognizant about.
- Looking ahead, what exciting ideas do you see for using wood differently?
    - We're seeing more risk in channel spanning or more focus on doing these more aggressively in the centre of the channel.
    - We are seeing terrific response with such approaches and they really hit the mark with more water and sediment storage.
    - We have a lot more options for monitoring tools to demonstrate values and outcomes.
    - We're seeing more focus on headwaters, prioritizing water quality and quantity and ways to work where there is less infrastructure. So thinking more holistically about the whole watershed, not just a focus on habitat.
- Looking ahead, with increased wildfires, are there things we should be thinking about regarding sediments, wood supply, etc.?
    - This relates to the importance of looking ahead and climate resilience, and of considering all the benefits in our projects, not just restoring species habitat — but of reconnecting flood plains, raising water table, storing sediments.
    - There is interesting new research on the value of riparian corridors in mitigating wild fires.
    - We can view these as an opportunity to seize the moment and prioritize projects to take advantage of future sediment flows expected.
- We really see a role for wood as a tool in supporting riparian systems and riparian recruitment.

    - That is a fundamental goal of the Tulalip projects. Our work is all about pursuing the same goals of kickstarting natural processes that pay back dividends and that we don't need to stay hands on.
    - In the Western US, we used to have an excess of sedimentation, then we went the other way so maybe we need to re-think.
- Closing thoughts?
    - Long-term monitoring, continued evaluation and learning how wood responds over time, then sharing data, successes and failures.
    - Restoration is a relative new discipline, so continued learning. And we need to be comfortable knowing we don't have all the answers.
    - Share your knowledge with others. There are lots of misperceptions and public fear of rivers, based on past damaging flood events. So we need a better public understanding of the value of what we do.
    - Importance of understanding that if you build it, they will come, in some cases very quickly, and that you need to take some risks to get those big rewards.
    - To the practitioners, keep doing it. We have a long way to go, and this is work that never ends. It's about a lot more than salmon — it includes water supply, etc.
    - I'm excited to see the trend to looking at entire watershed resilience, moving from single structures to more strategic approaches that use wood to recover salmon.
    - One of the big challenges is aligning our planning and work and collaboration. This deep dive has been effective in connecting individual projects into restoring watershed processes.
- Co-hosts thanked everyone, noting links would be provided to all the talks, including session recording.

Adjourned: 3:40 pm