Lessons Learned in Salmon Habitat Restoration
from Intensively Monitored Watersheds of the Pacific Northwest

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Management Implications from Results of Intensively Monitored Watersheds (IMW)

Robert Bilby, Science Advisory Panel, Salmon Recovery Funding Board

Q&A

Q: In heavily impacted watersheds, what we can do is greatly limited by these issues. In BC, we're ramping up resources to support restoration but we're 15-20 years behind Washington State. If you were where we are now, what would you prioritize?

A: I don't agree that you're that far behind us. In terms of the science, BC has been in many ways a leader. But to your question, I would pay attention to trying to understand what factors are truly important in salmon production. In the US, we've focused mostly on physical attributes like stream channels, and woody debris in stream channels. And that is important but where we haven't done as well is in understanding some of the non-physical attributes like nutrient dynamics, whereas in BC you've done considerable work on this as far back as the '70s and '80s showing that we can generate a sizable response with small amounts of nutrients. This in turn raises questions about how we can manipulate watersheds to increase nutrient availability. This has not been a consideration in the way we've done things in the US. I suggest you consider these attributes as well as physical attributes and try to fully understand the range of processes for producing a dynamic nutrients environment.

Q: If there's no evidence of density dependence, what can we do to reduced density-independent mortality?

A: A key indicator would be predation, and we may be able to address that with treatments that produce cover. Another factor would be serious water-quality problems like high levels of sedimentation or toxic substances. So restoration actions that address these issues could be effective.

Q: Are any studies planned to help us understand why some coho migrate in fall when it could be better for them to wait until spring?

A: To my knowledge, no, but it could be a genetic component that drives them to fulfil a different life history strategy. However, so many are now migrating early that they're probably driven by competition for some limited resources and the fish that are migrating early are the losers in that competition. There's some work from the early '90s on "Larry's floaters" that's crucial to understanding premature migration and that includes important points regarding

highly productive watersheds. A better understanding of that could be a key factor to incorporate in our restoration strategies.

Lessons Learned from 25 years of Habitat Restoration in the Skagit River Estuary
Correigh Green, Northwest Fisheries Science Center
Mike LeMoine, Skagit River System Cooperative

Q&A

Q: You have been really effective at implementing habitat restoration at landscape scales, which appear to shift how the Skagit River and Estuary function to benefit salmon. What are the top 2 or 3 factors that have been critical to realizing your success to date?

A: First, putting the effort together to follow through with monitoring. Monitoring provides us with information that ensures we're not shooting in the dark. Second, working alongside restoration practitioners and helping them stick with the objectives we began with over time. There are many demands for use of public lands, like hunting and agriculture, and as regulators trying to address everyone's needs, our objectives can get watered down. Having a biologist there helps remind restoration practitioners of the original objectives and continue to stick with them.

Q: Given the need to monitor over the long term and over a large area, how do you ensure that support and funding is available to continue monitoring over a timescale that may transcend funding cycles, people's careers, and so on?

A: We develop collaborations as much as possible by reaching out to stakeholders in the community. In Skagit, we've had some relationships break down, so it takes a lot of effort to see whether our work has been successful. For example, a lot of farmers may think restoration efforts cause a lot of productive land to be wasted. So then we have to work at rebuilding those relationships, so we can tell them that we may not be growing potatoes, but we are growing salmon so it's not being wasted. It takes work to build and maintain those relationships, but they're important.

Patterns of Density Dependence Affect Ability to Detect a Restoration Response
Joseph Anderson, Washington Department of Fish and Wildlife

Q&A

Q: What are some strategies for measuring population resilience in relation to restoration projects?

A: There are different ways to think about it. We can think of productivity in terms of smolt per spawner; how quickly does low abundance bounce back? You might think about how stable a

population is over the long term; do we see a lot of ups and downs, or does it tend to show stability? We can also think about proxies for resilience, like life history diversity and growth movement pathways, scale analysis, microchemistry, habitat types: generally, life history diversity spreads eggs out in multiple baskets so that it works as a metaphor for overall resilience.

Q: One assumption in monitoring for restoration effectiveness is that the rate of restoration should outpace the rate of habitat impact. Did you attempt to also account for habitat degradation within these systems to consider net habitat improvement?

A: We didn't talk about a habitat monitoring program that's been ongoing in these IMWs, but we have a host of measurements that show a lot of variation in size and frequency of pools. I have considered stepping away from channels and think about landscape-level attributes. For example, some areas are subject to private timber harvests. Another issue is water use in these streams owing to private wells. And these can all have impacts.

Q: What methods and study designs have you found to be most effective for quantifying the change in juvenile fish abundance and habitat use pre- and post-restoration, for example, coho salmon rearing abundance pre- and post-BDA installation.

A: The IMW approach focuses on population-scale metrics in that it captures everything that's happening within these watersheds. That helps address thoughts like maybe fish are just moving toward restoration sites and leaving other habitats. We should be able to see whether there are population improvements overall rather than just movements from one point to another. We're using techniques that intercept fish at their point of egress from the watershed and we're taking a census as they do. We try to use techniques that estimate abundance and at the precision of our estimates. Those mark-recapture approaches allow us to gauge the quality of our estimates and not just the quantity.

Q: When looking at density dependence, have you evaluated life-stage specific limitations and then designed the restoration to directly address the shortfalls rather than using catch-all approaches?

A: No we haven't done that yet. Our hope is that habitat monitoring data would allow us to get into some of those mechanisms, but it hasn't been that precise yet. One of my lessons here is thinking it's hard to pinpoint and identify a bottleneck that's going to affect populations the same way year after year. The conditions are going to change and we're learning that it's hard to identify limiting factors with a level of precision that will target specific life-stage transitions.

Q: At Big Beef, did you use particular metrics to monitor connectivity between the wetland and the stream (connectivity of water, or of fish)?

A: Not really. We did address multiple channels, but we didn't develop a specific metric to qualify how connectivity changes from before to after restoration projects.

Q: You mentioned resilience as an important but hard-to-measure metric. Are you planning to take advantage of our now-frequent extreme weather events to attempt to measure some aspects of resilience of salmon, or of habitat?

A: We're not modifying the study design but we're positioned to see from consistent year-after-year measurements whether the population bounces back from a period of low survival. Fortunately, we haven't experienced catastrophic fires or anything of that nature yet.

Q: Most effectiveness monitoring seems to be related to fish population and physical habitat. What sorts of hydrogeology and water quality data sets would best aid effectiveness monitoring in the ranch/agriculture-dominated headwaters of the Pacific Northwest?

A: I've wondered about the status of the aquifer and its impacts. That summer low flow does seem to affect salmon habitat and survival. But there's not much knowledge about how surface waterflow interacts with and affects fish. It's an area with a lot of room for collaboration.

Panel Discussion: Dr. Bob Bilby, Correigh Green, Mike LeMoine, and Joe Anderson

Q: Is there evidence that estuary habitat modifications in the Skagit have resulted from invasive species such as green crab or Spartina, or bird species that damage habitats through grubbing? If so, what restoration techniques would you recommend?

Mike LeMoine: A hybrid form of cattail has invaded the estuary along with reed canary grass. These are the two primary non-native vegetation species. Washington Fish and Wildlife has been mowing and applying herbicides. We have to internally tailor our practices to deal with them. There is currently some monitoring work on how they modify food webs and chinook diets, and it shows shifts in the benthic community. An additional species of interest is the New Zealand mud snail. There is potential for synergistic effects that does influence food webs but it's still an emerging science.

Correigh Green: There are outbreaks of Spartina in Skagit Delta within Puget Sound and they're best dealt with by establishing other vegetation to establish, that can break their spread. There's also an issue with respect to grazing by geese, especially snow geese but also Brandt Canada geese. They can extensively consume eel grass and our goal is not to change that but to make sure more habitat is available that the birds can use.

Q: If limited capacity in non-estuary marine areas explain the lack of positive responses in fish is it reasonable to expect a good response from habitat restoration and is this the best use of taxpayer money?

Joe Anderson: It's a fair question. We're learning from IMWs that implementing restoration doesn't guarantee the fish will respond with greater numbers. However, we need to make habitat optimal so the fish can take advantage of it. That doesn't mean they will because there are a lot of factors outside of our control. But if we want salmon recovery to be successful in the long term, we need to restore freshwater habitat. That habitat won't guarantee a good fish response, but at the same time we can't ignore that and expect a good fish response in the long run.

Mike LeMoine: Another point about taxpayer dollars is that, here in the US, we have a legal obligation to recover species under the Endangered Species Act. Extinction is not an option. I represent tribal communities, and the federal government has a trust responsibility to maintain tribal access to fish for cultural and subsistence needs. So while it seems hard and there are factors we can't control, it's also a legal/moral/treaty responsibility that we have to meet.

Correigh Green: Whether in non-estuary, estuary, or other habitats in comparison, we have investigated nearshore food availability on a density dependent signal. There's evidence of density dependence at other life stages like marine, but they are much more subtle than what we've seen in the Skagit. The density dependent signals are dominant in both estuary and stream environments in the Skagit. And that's where you seen fish together at high densities where they're constrained by the geomorphology of the habitat.

Q: For Dr. Bilby: Have you looked into groundwater interactions and how they may be affecting the overwintering potential of sites where early emigration is occurring?

Bob Bilby: No, we haven't but there's a lot of evidence in the literature that floodplain habitats have a capacity for high-level salmon production.

Q: I'm a bit concerned with the recommendation that restoration in watersheds with density dependence should focus only on capacity. Wouldn't we expect similar productivity responses with reduced density-independent mortality with and without density dependence? If so, wouldn't focusing on both be the best long-term strategy?

Bob Bilby: I didn't imply that we wouldn't implement projects in watershed where we're seeing density-independence. If the watershed has other problems (eg 6qppd-quinone), regardless of density dependence, we should be correcting that too because that problem is very likely to be having an impact, and addressing both issues is very likely to help.

Correigh Green: A lot of what we might do will also likely benefit density-independent productivity. For example, wood shelters improve density dependence but also improve issues with volume of flow.

Q: Dr. Bilby mentioned that promoting positive fish responses may require more targeted restoration efforts. Is there any anticipated trade-off between highly targeted projects and the increasing unpredictability associated with climate change?

Bob Bilby: Some common elements in watersheds are having disproportionate effects and we can't help that. We need to do better at identifying families of issues. We're much more likely to promote a positive fish response that way than by implementing random responses without a full understanding of what we're doing.

Joe Anderson: Many restoration projects have focused on hydrology, geomorphology, and other constraints and we haven't given as much attention to food webs and their dynamics. We need to get a better handle on capacity constraints around food and the forage base and how the food web interacts with population abundance. We have tremendous data on growth and fish size at every life stage, so the potential is there to give a more detailed treatment on food availability and growth, but we haven't done the work yet.

Q: Dr. Bilby, was there much work done to monitor low-level nutrients (N and P primarily) across watersheds that could explain variation in coho production across watersheds? Nutrient enrichment, in nutrient-poor systems, might provide a crutch to physical restoration, such as with woody debris.

Bob Bilby: Yes, we have those data monitoring N and P levels in all IMWs. But no, we haven't used it to help us understand fish response. So that is a "to-do", and would be a good thing to do. It's an aspect of habitat that we don't pay much attention to on this side of the border. The only work we've done in our area is salmon carcasses or carcass-analogs (processed tissue) that are added to streams as a treatment (Germany Ck). There has been work in northern California that we can learn from, showing caracasses don't have fundamental effect on productivity in the long-term, which may be due to physical deficiencies in the watershed (habitat simplification, lack of retention). That is, some habitats may have been so simplified by man-made changes that they can't retain the nutrients to affect fish production. There has been a lot more work on that on the BC side of the border than the Washington side on understanding nutrient levels and how they affect fish production.

Q: What are some key lessons learned on the social dimension of habitat restoration projects? Any advice for project promoters, sponsors, and managers?

Mike LeMoine: In Puget Sound and nearby areas there are different strategies. For example, land acquisition is a key tool to implement restoration. In Skagit, we've been using volunteerism to identify public landowners like the state, but we run into a wall when we run out of land to conduct restoration. This is coming up in our Skagit project. If we use this model, public outreach is crucial in understanding who the stakeholders are and what their needs are and

giving them a sense of place in the project and an understanding of the importance of salmon recovery. It's important to leverage this as an education tool and to show, for example, where we've learned from a project 20 years ago that didn't go the best way possible, but now we're doing better. We need to tell people what we plan to do when we do outreach and education.

Q: For every dollar spent, how much do you think we should be spending on land acquisition versus restoration project implementation?

Bob Bilby: I think we should look at acquisition only when a particular piece of land is critical for salmon and there's no other way to deal with it. Generally, buying land is not necessarily going to be effective because we lack the money to buy enough land and to put it back into a precontact state. A better approach is to look at existing land use and ensure it's compatible with salmon health, and they key factor in this is regulatory systems to ensure it happens.

Mike LeMoine: I don't disagree, but I'm aware of some areas that started restoration work later but through land acquisition they're catching up and surpassing us. It' not an either/or proposition. It's both acquisition and other approaches, whatever is most appropriate in each individual situation.

Correigh Green: Where land uses are on the edge because of climate change, for example, it can provide a big carrot for land-use transfers. It's challenging because of climate change skeptics, but if we're thinking about restoring fish populations we have to think about where to put resources to best use.

Q: Given the resource intensity of the IMW approach, do you have alternative suggestions for restoration monitoring that might be more feasible if fewer resources are available?

Mike LeMoine: The cost of monitoring seems huge, but it actually only runs to about 5-10% of the total project budget. In our sentinel sites, we can stretch that IMW investment a long way. Even at that, when considering our overall objectives, it's still not that much. My entire field team of six individuals is costs than it would to bring an excavator onsite.

Joe Anderson: I think about setting up a system with areas of higher intensity monitoring. That was the idea behind IMWs—in the lowlands and small streams there were a lot of lost connections, so we chose a few areas of higher intensity. It's essentially an indicator approach.

Q: Within these watersheds, have you been examining the potential climatic impacts with climate change (e.g., snowpack levels feeding into the systems or drought conditions)? How would you address the longer-term threats to the systems?

Correigh Green: We've looked at a couple of factors, such as private impacts, water temperatures, and storms. In some respects, they're a lot of the impacts we might expect over time. Several investigations are ongoing right now as well as monitoring wetlands regarding

changes due to sea level rise. It's a starting point for examining how these impacts are going to play out. We know that temperature has a negative impact on fish abundance because in high temperature years, fish disappear quickly. But high temperatures can also contain migration and lead to the highest years of return.

Joe Anderson: The climate impacts research I'm involved with has focused less on abundance and more on life history. Juveniles tend to migrate earlier. The concern is that earlier migration does not match other factors and affects long-term survival, and yet we have seen evidence of changing migration patterns over time.

Q: Many of the approaches discussed in IMWs are more appropriate for coastal rain-dominated hydrographs. For highly disturbed snow-dominated systems, tributary to large rivers like the Fraser, salmonids exhibit complex life history variations with rearing in natal and non-natal areas, where do you start?

Bob Bilby: Most of our IMWs are in rain-dominated wet-side ecosystems. There are multiple IMWs in snow-dominated systems so there is some information on that, but I will admit we have more data on rain than snow-melt hydrology.

Joe Anderson: In snow-dominated areas we rely more on pit tags. There are surveys and smolt trapping and fisheries biology techniques can open up more information about life history pathways in these areas.

Correigh Green: These systems need to be monitored locally and you get out of it whatever you give it. If monitoring size changes, that's critically important. Monitoring outmigrants is also important locally. That's the way these local watersheds are impacting larger processes.

Q: Dr. Anderson, you noted that limiting factors for populations are difficult to identify and may change yearly. Can you speak to the initial groundwork for how we can generate IMWs that improve life histories of salmon while retaining a research program that has clear research objectives?

Joe Anderson: I suggest a phased research approach that looks at abundance and then using that information to design a project that complements restoration plans. A focal point of the message is not to get too focused on a narrow range of restoration techniques or life history strategies. When you design the program, you need to give yourself time and space to learn and allow for the kinds of surprises Correigh mentioned in his talk.

Mike LeMoine: Our original chinook study started as a coho project in early '90s but it documented a lot of chinook use of the estuary. We then took another step toward looking at density-independent or -dependent effect on the population. The next step was to parse out how to implement a project. So we're looking at parr within the flood plain to figure out what to do and we can then further design our restoration planning as connected with those factors.

Q: I'm wondering what the most valuable pre-restoration assessment work and information gathering you've done has been and how that information has been used to inform the best decisions on type and area of habitat restoration. In other words, how have you translated information into targeted restoration decisions?

Mike LeMoine: The first question any restoration practitioner asks me is about distribution of fish—that is, do they occur at this site. In Skagit, we don't have great fish distribution information and we need to work on that, but that's always where the restoration work starts.

Joe Anderson: I agree and that's what I was alluding to in my answer to the previous question about factors. When we can identify target species that are crucial to overall salmon population health, that's where we're likely to find our greatest chance for ROI.

Let the System Do the Work: What We Know About Low-Tech, Process-Based Restoration
Stephen Bennett, Watershed Sciences Department, Utah State University

Q&A

Q: Have you been involved in any projects that resulted in "excessive" aggradation, such as transforming an incised stream into a wetland with only seasonal surface inundation, to the extent that fish passage is impacted?

A: It depends, but you have more landslides here and bad roads that produce lots of sediment. The dynamic part of low-tech is that these structures fail and BDAs fill up with sediment. The more wood and beaver dams you have in a system the more you get sediment sorting. Our group has developed habitat protocols to monitor bars and their development and sorting – we see a huge amount of sorting from fine silt to boulders. So yes, I believe this could work in BC.

Q: After BDAs are installed and the surrounding habitat is adjusting to wider and more complex channel paths, have there been concerns with juvenile fish stranding in the smaller side channels that are then developing?

A: There are 20+ dams on the Snake and Columbia Rivers that are bigger problems than beaver dams will ever be. For a lot of species, stranding happens naturally. I don't see this as a big problem. If you want more fish, you need a healthy riverscape. Beaver and lots of wood are crucial parts of that. I study cutthroat in a stream called Spawn Creek in Northern Utah that has tons of beaver and wood. The stream got its name for a reason. Low-flow beaver dams can be less passable, that's true, but I'd like to see more information on that. Beavers often make secondary dams below their main dams and fish often use those dams to get through.

Q: Is there a maximum channel bed slope and bank full width that are appropriate for BDAs?

A: I've heard 6%, above which beaver dams are rare. I think that's too low because if we look at it from a wildlife perspective, a low density of animals is usually in the most preferred habitat. Where there's a high density of beavers, they're building dams in higher gradient areas. Width is not a concern; it's more about stream power. The wider the stream, the less the stream power. We build wide dams up to 40 metres across, so we don't worry too much about that. There's a natural one somewhere in Canada that's 1.5 km long.

Q: How do you manage concerns regarding liability if/when beaver dam analogues break and release water to downstream communities or assets? This is a concern for my area and is a hinderance to implementing analogues.

A: We do a risk assessment wherever we work but most of the time the risk is over inflated. If there's a culvert downstream that could get plugged up it could be a problem, but we can keep the culvert clean or replace it with an appropriate bridge. I live in the US, where liability is a real concern, but most of the places we've implemented BDAs are not heavily urban, so the risk is minimal.

Q: How did the habitat respond to drought? With more side channel habitat, were there issues with water depth or passage during low flow periods or did it balance out with better groundwater connection and slower flows?

A: We had an example in Bridge Creek where vegetation is still doing well despite severe drought. With steelhead populations, as with many other species, their timing is connected to changes in flow. During the summer months, the fish are not moving. The juveniles only move in the fall with higher rain. And in the spring, the higher out-migration is tied to flow, and adults return inn the spring, too. So there's not a lot of concern. During low flow conditions, there could be problems for species that try to travel, but steelhead don't and that's what we're studying.

Q: Were there controls/reference sites associated with the Bridge Creek site to demonstrate that the increased productivity was unique to the BDA project?

A: Yes, both sites were set up as a staircase design. We worked with Tom Logan, a statistician at SFU, and created controls at both Bridge Creek and Asotin that allowed us to see significant increases in comparison with the control sites.

Lessons Learned from the Lower Columbia IMW Program
Jamie Lamperth and Eli Asher, Washington State Department of Fish and Wildlife

Q&A

Q: Many restoration projects have limited resources and budgets that may preclude large scale wood replacement. Is it worth doing smaller scale projects?

A: That question is up to the project funder. If you're planning a population-level response where value is represented by a statistical measurement in value, maybe not. But if your goal is to improve habitat and fish use, then it's totally worth it. It may not be enough to push an entire population back from the edge but if you can make a local improvement, that might be enough for that funder.

Q: What are your thoughts on the need for cabling and or ballasting wood structures?

A: When possible, we like to avoid this. In Abernathy Creek, we took a blended approach. Where we had critical infrastructure like logging bridges or we were working in urban areas, we added those supports to provide a catcher's mitt in case of a 50- or 100-year event happened. As it is, we've seen some wood movement but not a lot given that we've had some pretty good-sized events. A few pieces have moved a couple hundred feet. So where you have to use cables and ballast, it makes sense to do it. But if you can avoid it by finding locally sourced material that's big enough to stay in place, it's better to do so.

Q: You made an interesting point about slash piles. In BC, these are typically burnt after logging season, in the fall. But it sounds like creating slash piles at or near a riparian zone within the logged area might be a better application.

A: We burn slash piles here, too; that's a pretty standard forestry approach. We're at odds with some policy on DNR land about onsite burning, but an important issue is that every time you touch slash, or every time a machine grabs it, it gets a bit smaller, so it becomes less optimal. If you can get loggers to form slash piles close to riparian areas, that's the best thing. Slash is important but it's hard to move it without destroying it.

Q: What time scale is needed for this sort of natural IWD recruitment into the system and what rate of input needs to occur to maintain this amount of wood in the system?

A: We have a lot of red alder, but alder is not going to sustain the work we do. The work requires conifers. How long will it take to see natural input of that type? A long time because a lot of those conifers take 100-300 years to mature. We do have Douglas fir that are good for this work when they reach 40-60 years old. Once they fall in, they'll last much longer in the water. So, it depends on what's there and what your time scale is.

Q: There are often challenges in sourcing enough quantities of high-quality wood suitable for these projects in BC. Have you had similar challenges and what solutions have worked for you?

A: It's crazy that we live in such a wood-rich region, but we have a hard time finding the best wood for these projects. We started working with private timber owners early on because they're easier to work with than public owners. Private owners tend to be very willing to sell a timber sale. I don't know about Canada but in the US, you can buy a timber sale of 40-120

acres, push those trees over to ensure you retain good root wads, and hire a helicopter to transport the wood to your site. It takes a lot of advance work like applying for grants to fund the timber purchase and hire the helicopter. But the overall costs end up being vastly lower, the quality of material is better, and the work gets done faster.

Q: Have you worked in systems with debris flows?

A: Yes, in a very steep coastal system with lots of marine sediments. It can be a challenge to work with and an opportunity. It can be context changing.

Q: Have you ever run into navigation water restriction in main stems? I'm thinking of tubers, boaters, and so on.

A: Yes.

Q: Have you used engineered log jams (ELJs) as alternatives to large wood? Do you have any thoughts on their value across larger areas?

A: ELJs are carefully constructed and secured so they are more appropriate in large mainstem rivers. I can't really comment on value because they're an entirely different proposition. They bring completely different problems, and they require a lot of public outreach and managing ways for boaters to get around them safely. And there are huge liability issues. It's easier to do this intensity of treatments in watersheds where you don't have a lot of public access or use by boaters.

Q: Are there any negative implications of using large burnt wood from forest fire salvages?

A: We've only used legacy wood, so we've never dealt with charcoal or char.

Learning from Long-Term Restoration and Monitoring in the Strait of Juan de Fuca IMW
George Pess, NOAA - Fisheries

Q&A

Q: How do we best maximize and measure life history diversity, how can we best incorporate into restoration design?

A: There are a couple of ways to do this. First, document what you have because every watershed is a bit different. For example, in some smaller watersheds I've seen up to 18 different life history strategies. Second, note whether you see these life history differences in different parts of the watershed. Are there unique characteristics with these strategies? How do they prioritize certain kinds of habitats? Also, when I consider climate change, I think of basic changes to the watershed, like when do we get peak and low flows and how do animals respond, and what are the life history diversity links as well.

Q: Did you find that adding smaller wood and brush was needed or did it happen naturally?

A: In our case, it was the latter, most of small debris was caught by the large debris, so a completely different dynamic extends out of the flood plain.

Q: Did the fall emigration you mentioned mean fish moved among watersheds, or were they migrating to the sea and then beyond?

A: Fall emigration is when young fish are moving out to the marine environment and not coming back until they're adults, whereas others are smolting in different watersheds and sometimes back to their original watersheds.

Q: Have any of the IMWs looked at managing young forests, or using reforestation as techniques to modify water flows and help recover the hydrological regime? If not, what is the potential for this, especially in dry interior ecosystems?

A: That was not part of our restoration process, but there are reforestation techniques that can be used to recover stands near streams, and know hydrologic metrics like stand age, and ask how that will change with restoration actions. One thing in our watershed is road decommissioning and trying to improve the hydrology, which can have a profound impact in smaller areas.

Q: Given we can't restore everything everywhere, what should we focus on to set us up for long-term success?

A: I saw this concept in terms of retention and connection that if restoration actions are retaining things that are part of the natural system—that is, if you have a natural connection between tributaries and main stem—the concept of reconnection and retention is important to success and to the changes we see these days. And getting to scale now regarding connection with floodplain, that's important to success.

Q: How are you accounting for fish moving from control to treatment watersheds and vice versa?

A: We measure this with pit tags. We try to put out the same number in each of the watersheds. We haven't thought about why they go from on to another. We're just counting and later will hypothesize why. It would be great to come up a series of nice hypotheses, as so much of what we're doing with monitoring is learning.

Panel Discussion: Dr. Stephen Bennett, Jamie Lamperth and Eli Asher, and Dr. George Pess

Q: Has anyone had success installing BD analogues in areas with little beaver food, or with planting food for beavers?

Eli Asher: A lot of beaver food grows quickly so if the end goal is to attract more beaver than you need to plant willows and vine maples. If you plant it, they will come.

Stephen Bennett: There are likely as many people out planting trees as doing other projects. I see so many people planting in disconnected floodplains and I think it's backward—we need to connect first and then plant.

Q: Would it be appropriate to use ELJs in smaller streams where large wood is not abundant? Eli mentioned that ELJs are typically used in larger streams, but in BC there are many small/mid-sized streams that lack complexity and natural LWD recruitment.

Eli Asher: ELJs exist to replicate old growth log jams. Anytime we need a log jam, but we lack old growth, we bring in an ELJ. So the appropriateness of an ELJ will depend on site conditions. Abernathy Creek is small, and we did use ELJs, so they're not only used in large systems—it just depends on site conditions. But it is cheaper and more effective in smaller streams to find local stuff, and funders also feel better about not putting a lot of steel in the water.

Q: Within systems where you've introduced BDAs, do you notice that wildfire effects have been dampened on the vegetation within the regions of the analogues?

Stephen Bennett: There have been some studies of fire and the ability of wet landscapes to minimize fire, with the theory that more flood plain reduces the likelihood that fires will hop to the other side.

Q: BC has a restoration fund to be disbursed to actors such as First Nations, NGOs, and so on. How can we avoid lots of small-scale well-meaning projects that don't add up to a whole-watershed response?

Eli Asher: If you look around our regions, a lot of watershed-scale restoration efforts are being done by a single non-profit, or a single tribe, or a single person who assumes the responsibility. The result is that there's no way to coordinate work to be done on a whole, large watershed.

Stephen Bennett: We need to re-enact the Forest Practices Code and spread the money out better. If we add more money, we could go bigger in more places. For example, instead of spreading small sums around, why not put all the money for five years into one watershed, and then the next five years it could all go to another watershed, and so on.

Q: Knowing that hydrology is more challenging in smaller streams than larger rivers, from a hydrometric perspective, what level of effort is required for salmon restoration? What uncertainties in discharge or flow is acceptable?

Stephen Bennett: We don't do any modelling and flow is just low, medium, or high. Most of the streams we work in don't have flow gauges. Our approach doesn't need that kind of information because basic observation tells us enough.

Eli Asher: In larger river systems, it's different. In smaller streams I agree with Stephen that it's a matter of dealing with high, medium, and low flows. The differences in elevation over one flood event would render those models pointless. In our work, where we had to modelling, we did it, but we don't have a lot of faith in it.

Q: Interspecies interaction in systems with multiple species of concern and targeting population level response and what are the challenges of trying to meet the needs of different species in these restoration projects?

Jamie Lamperth: In general, a lot of the work we do is going to benefit multiple species. So if we're looking at restoring coho overwintering habitat, that work will benefit steelhead as well. If we see a benefit, we'll monitoring that. We might not see a change for chinook, but we'll continue looking for it and if we see it, we'll monitor it.

Q: What about ELJs in larger flows? Do fish move into them to feed?

Eli Asher: I have installed a lot of ELJs in larger rivers and done lots of monitoring of those projects and I've seen results in the way chinook use these structures. But no one currently in the room can answer the science questions there.

Q: We began this knowledge series with a workshop on the stage-zero approach. Hearing about your approach today around BDAs, could you speak to the stage-zero approach and how it and low-tech process restoration mesh together? Are they two ways of achieving the same thing?

Stephen Bennett: It's a process-based continuum from low tech to stage zero. Extreme low tech is just changing management while stage zero is a control-delete kind of approach. In Asotin, there were multiple large floods over decades as well as adjustments with bulldozers so even though the flood plain was changed and altered, we lost connection. We can support adjusting the flood plain when needed but I don't think the stage-zero approach scales up well over miles and miles of stream and flood plain. But if low-tech works well in a particular situation, you can move up to a higher-tech approach.

Eli Asher: I didn't attend the stage-zero workshop, but as I understand it addressed two things. Stage zero in an evolutionary model says that in some depositional areas we need to get away from single-thread channels. So there's a channel condition known as stage zero with low energy spread across numerous deep channels. But then there's also a shorthand stage-zero approach around levelling hydromodifications and resetting an entire valley at a calculated grade, reintroducing water, and letting it rip. It's incredibly invasive and it can be effective. But

it's at the other end of the spectrum from what we do. In each of those situations, Bridge Creek and Abernathy, the desired future condition is similar. The stage-zero approach wouldn't have worked in Abernathy because it wouldn't have gotten past regulations or landowners. It's a very site-specific approach for getting to a desired future condition. It's tough to decouple the desired future condition from stage zero as a restoration approach.

Stephen Bennett: The stage-zero paper is good in linking the stage of the river with environmental benefits. But one thing that may not have come across in my talk is context dependence. That paper refers only to wide valley alluvial depositional conditions. People think that's a model for all streams. It isn't. Every stream has its stage zero; it's just not always the same.

Q: If watershed restoration is viewed over the long term, how can we protect the restoration work we do now from future land-use changes? For example, can we put a covenant on a piece of land?

Eli Asher: That's a policy level discussion. In Washington state under certain funding, projects must be maintained for 10 years post-implementation with the that the work won't be undone. There is a requirement for that to go along with the project. There have been a lot of cases that Stephen and I have worked on in the past, whether on private or public timber land, where the projects are de facto protected by the nature of the land ownership. But if you're going into smaller projects, you need to find another mechanism to make sure your project doesn't just go away.

Stephen Bennett: It's a policy decision. If you think about all the talks today, we're talking about envisioning a different way of managing rivers. Process-based restoration is to let the river adjust and move and that hasn't even been brought up let alone put into practice. Bottom line, we have to think of rivers differently. Rivers are going to move. I've seen national parks changing things in anticipation of climate change and maybe we need to catch up with that. We've been trying to control things for far too long.

Q: In your experience, what factors have been driving the prioritization of restoration projects? How often have ecosystem services, benefits to other species, and relational ecosystem values—such as cultural/legacy values—come up in the prioritization process?

Stephen Bennett: Funding in the US is a well-oiled machine for divvying out money but we're not as good as we think we are at prioritizing. We focus often on these wide alluvial valleys as targets because we think we'll get the most benefits there. But that's debatable because it's the upstream infrastructure that's feeding those areas and if they're not healthy, those valleys won't be either. I tend not to get hung up on that. We tell ourselves it's about the fish but that's

going to take a long time. The focus has to be on building the most continuously healthy habitat possible, so building out from good areas seems like about the best idea I've heard>

Eli Asher: If I were to be czar, I'd prioritize areas where you can do extensive, intensive, contiguous treatment and disregard everywhere else. I've seen too much money go into small projects that don't make the biggest overall change.

Stephen Bennett: I'd get rid of all the barriers to continuous connectivity and integration and instead take the riverstyles approach. A group in southwest BC is looking at that this year.

Q: If funding and expertise were no obstacle, what sort of hydrologic, water quality, or sediment studies would you most like to see to best evaluate habitat quality in spawning areas?

Stephen Bennett: I like studying and there's plenty to learn but our group is moving toward what we can detect with satellite imagery. I don't want to see a 1% change, I want to see a 100% change, and that means something I can see from space. So we're trying to develop simple rapid monitoring. We've all collected so much data, a lot of which we don't end up using or even looking at, so the route we're trying to go is to spend money, so others won't have to, by making big change with simple tools.

Q: You indicated that beaver dams do not tend to impact fish passage, but when conducting stock assessment surveys, I have observed beaver dams limiting upstream migration to all spawning areas (fish milling below and zero fish above). How should technicians proceed in response to these observations?

Stephen Bennett: This is the sort of thing I've hinted at. The people who offer these observations don't describe what happens to the fish that didn't pass. In most cases, they spawn below the dam. Too many people are ripping out dams when they don't need to.

Eli Asher: Fish might continue milling around below a dam without making it above the dam until you get a good shot of rain. The fact that they're milling doesn't mean they won't go upstream or they won't find suitable habitat where they are. The literature is very clear that beaver dams are a net benefit.

Stephen Bennett: It's the same thing with stranding fish. We have this idea that if you create a side channel and fish get stranded there, we shouldn't create side channels. It's a wild world and fish die for all types of reasons. I don't think these approaches are having a net negative effect.

Q: Can you describe examples of successful BDAs and PALs that have occurred in places where residential properties are in close proximity to the project?

Stephen Bennett: In Park City, which is a really expensive residential development, houses sit four to five feet above the stream and it's no problem. If you can assess risk and you know where the floodplain is, you can proceed.

Q: BDA work seems to range from placing the sound of running water to encourage beavers to move in, to semi-permanent structures with posts drilled into the ground and woven wood added through the posts. Any advice on how "engineered" a structure should be?

Stephen Bennett: Not very. We don't design anything before we get out into the field and then we just mimic natural structures.

Q: Can you give a stab at a stream evolution model for steep, flashy coastal watersheds in BC?

Stephen Bennett: I'm a fish biologist who hangs out with geomorphologists. I'm not going to tackle that.