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Lessons learned from 30 years of implementing Intensively Monitored Watershed studies: aligning the science with partners, policy, and funding

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Intensively Monitored Watershed (IMW) studies are one of the largest and most audacious programs in our effectiveness monitoring toolbox. During the past 30 years, we have learned not only about the science of large-scale restoration but also about the social aspects of these programs. Although the focus of previous IMW reviews has been largely on scientific methods and results, we argue that an equally important emphasis should be placed on the relationships and processes needed to successfully implement restoration and monitoring programs at a watershed scale. This study uses a qualitative, practitioner-informed synthesis to identify recurring themes shaping IMW outcomes. Our conclusions are based on interviews with policy staff, restoration practitioners, and scientists working in IMWs across the Pacific Northwest, USA. These interviews highlight the coupled social-ecological nature of IMWs and provide a common framework that links scientific inquiry, restoration implementation, and policy decision-making. Results demonstrate that a strong commitment to planning, collaboration, and the ability to embrace change are as critical to success as study design or analytical rigor. Documenting best practices and lessons learned from IMWs will help others successfully plan, implement, and manage long-term monitoring and restoration programs. We argue that adhering to these best practices is essential for meeting local restoration objectives and ensuring the information leads to new insights, continual adaptation, and ultimately more successful restoration in the long-term.

KEYWORDS

adaptive management, collaboration, habitat restoration, IMWs, Intensively Monitored Watersheds, long-term monitoring, salmon recovery

Introduction

During the past 30 years, a massive effort has been undertaken to recover salmon populations across the Pacific Northwest. Recovery efforts are intended to reduce factors that contributed to the decline in naturally spawning salmon. These factors typically include the loss and modification of habitat, overfishing, detrimental impacts from hatchery production, and blockage of migration corridors (NRC, 1996; Ruckelshaus et al., 2002). In many cases, these impacts have occurred for decades, leading to full-scale change in watershed condition and fundamental changes to salmon populations (Stouder et al., 1997; Tschaplinski et al., 2025). Salmon also are being impacted by changes in the ocean and other ecosystem-scale changes (Brodeur et al., 2019; Scannell et al., 2020; Welch et al., 2020). Long-term monitoring allows us to detect changes in watershed conditions and fish populations amid the background of annual variability and large-scale factors affecting salmon outside of restored watersheds (e.g., Larsen et al. 2004; Anderson et al., 2025; Tschaplinski et al., 2025).

Core salmon recovery strategies focus on the protection and restoration of freshwater, estuary, and near-shore habitats. Common restoration actions aim to increase in-stream flow and water quality, remove migration barriers, restore estuaries and floodplains, add in-stream wood, and replant lost riparian vegetation. Although this effort has been underway for decades, several recent publications pointed to a widespread lack of evidence that restoration has led to an increase in wild fish abundance (Bilby et al., 2024; Jaeger and Scheuerell, 2023; Booth et al., 2016; Lackey, 2022). The need to provide evidence for the link between restoration and fish production led to the establishment of Intensively Monitored Watershed (IMW) studies across Washington, Oregon, Idaho, and California in the early 2000s. The establishment of the IMWs occurred as many salmon and steelhead populations were protected under the federal Endangered Species Act and habitat restoration was determined to be a key strategy for recovery. IMW watersheds were chosen based on factors such as their size, priority for recovery, and restoration potential. Due to the costs and effort to implement IMW programs, only a small number of watersheds were chosen for these studies (Roni et al., 2015; Bennett et al., 2016).

An IMW is an experiment in one or more catchments with an extensive, long-term monitoring program to determine watershed-scale fish and habitat responses to restoration actions (Bilby et al., 2005). The basic premise of the IMW study design is to concentrate restoration treatments and monitoring resources together at a watershed scale to maximize the ability to detect fish and habitat responses, if they occur. The IMWs in the Pacific Northwest generally were designed to determine the effectiveness of restoration at increasing salmon and steelhead productivity, determine the causal mechanisms behind the response to restoration, and extrapolate the results to other watersheds (Bilby et al., 2005; McDonald et al., 2007).

There is an opportunity to learn from the IMWs as scientific findings continue to provide new insight into restoration effectiveness. However, the relationships and processes needed to successfully implement restoration and monitoring programs are equally important to the generation of new and relevant information to inform future restoration and conservation efforts. Each IMW study had similar goals to start with but varied widely in how they were set up, structured, and evolved over time, and how effective they were in implementing their studies and generating useful information (Bisson et al., 2023). This variety provides the scope for learning about social aspects.

This paper builds on past efforts to communicate lessons learned from IMWs (Meyer et al., 2024; Bennett et al., 2016; Peters et al., 2024; Bisson et al., 2024; Haskell et al., 2019; Hillman et al., 2019; Roni et al., 2015). However, these reviews were from the viewpoints of the scientists and the barriers they faced in implementing their studies. Understanding social contexts and challenges arguably may do more to improve restoration outcomes than fine-tuning study designs (Anderson et al., 2003). The primary goal of this paper is to present a series of lessons learned and recommendations from the perspectives of scientists, managers, and policymakers involved in implementing IMW studies in the past 30 years. The results point to three key lessons learned that could be applied to future long-term restoration and monitoring efforts and will help maximize learning opportunities.

Materials and methods

Case studies

We interviewed people associated with nine IMWs across Washington, Oregon, and Idaho for this study (Figure 1). These IMWs represent a diversity of variables such as watershed context, land-use history, landownerships, restoration treatments being tested, species of interest, collaborative frameworks used, funders, and implementers (Bilby et al., 2022; Hillman et al., 2019). The IMWs share common monitoring goals related to testing hypotheses about restoration treatments at a scale relevant to the population of interest. A wide range of restoration approaches are being employed in these IMWs, including wood supplementation, floodplain reconnection, fish passage, and riparian enhancement. One IMW is concerned with estuary restoration while the others focus on spawning and rearing habitats in freshwater. Despite differences in restoration treatments, there are common monitoring strategies and approaches in use across the case studies to measure change in freshwater productivity (e.g., spawning surveys, parr tagging, and smolt traps). Details of restoration strategies and study design are given by Hillman et al. (2019) and responses to treatments are summarized in Haskell et al. (2019) and Bilby et al. (2022).

The IMWs mentioned in this study span a variety of ecoregions including the Coast Range (Strait of Juan de Fuca and Lower Columbia River), Puget Lowland (Hood Canal and Skagit River), Blue Mountains (Bridge Creek and Middle Fork John Day River), Columbia Plateau (Asotin River), Northern Rockies (Potlatch River), and Middle Rockies (Lemhi River). All IMWs are focused on anadromous salmonids including steelhead (*Oncorhynchus mykiss)*, Chinook salmon (*Oncorhynchus tshawytscha)*, and coho salmon *(Oncorhynchus kisutch)*. A few also are concerned with resident salmonids such as bull trout (*Salvelinus confluentus*), cutthroat trout (*Oncorhynchus clarki*) and resident rainbow trout (*Oncorhynchus mykiss*).

Interviews with IMW participants

We conducted virtual interviews with policy staff, scientists, and restoration practitioners in the nine case studies to understand their professional perceptions and experiences from implementing the IMWs. Policy staff develop and implement programs, policies, and

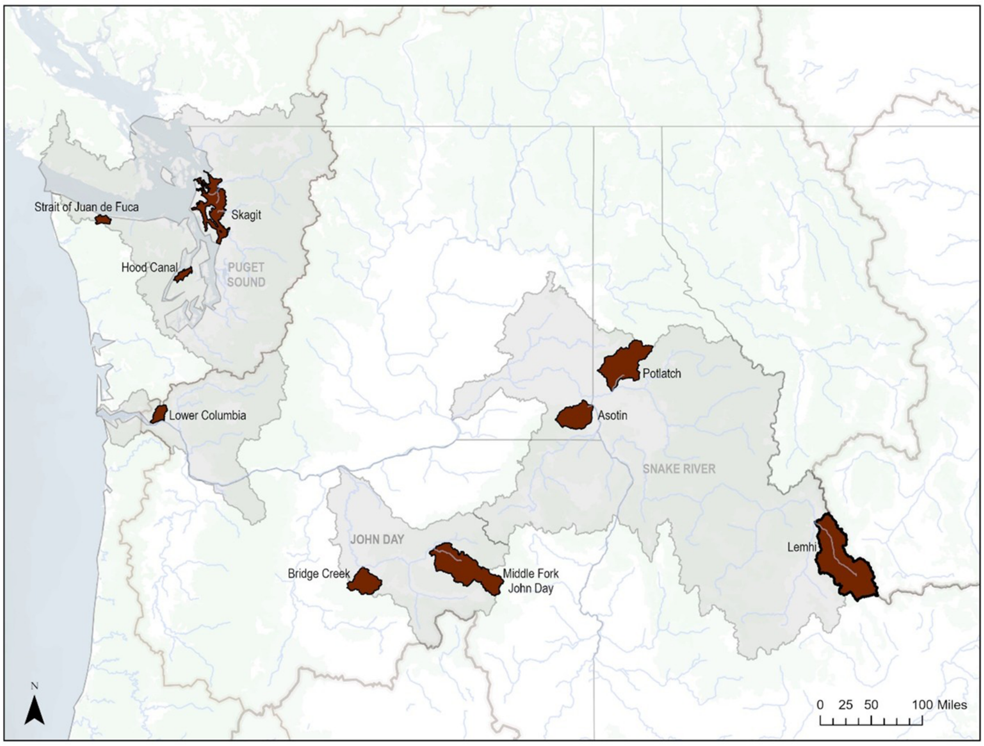

FIGURE 1
Map showing Intensively Monitored Watershed case studies (dark areas) where individuals were interviewed. Shaded areas show larger watershed boundaries.

strategies to support recovery and conservation of salmon and steelhead. They ensure funding and support for restoration and monitoring efforts. Restoration practitioners develop and implement habitat restoration and conservation plans and strategies to improve and protect watershed conditions. They work with landowners, community members, and salmon recovery program managers to identify, design, and construct restoration and conservation projects. Scientists (biologists, hydrologists, ecologists, etc.) design and oversee monitoring efforts including habitat and fish data collection, analysis, and assessment efforts at watershed and population scales. Scientists also analyze data, provide technical information, and communicate findings to multiple audiences using a variety of products. The interviewees were chosen based on their roles, histories, and relevance to the study. Most had been involved in their IMWs since their studies began, but some were brought in more recently with less than five years of experience. The 30 practitioners interviewed had diverse backgrounds in policy (n=12), restoration (n=11), and monitoring (n=14). Interviewees worked for a range of agencies, organizations, and tribes including state agencies (n=14), federal agencies (n=4), tribes and tribal organizations (n=4), salmon recovery organizations (n=4), private sector (n=2), and state funding boards (n=5). This assessment did not include local community members or landowners, although we acknowledge the importance of these perspectives in understanding the success of IMWs.

We informed participants about the purpose of the interviews, their rights to decline participation, their rights to remain anonymous, and that interviews were being recorded. Interviews were semi-structured and followed a set of 20 questions specifically written and delivered based on the role of the interviewee (policy, monitoring, or restoration). Questions were aimed at collecting information on the history of the IMW itself and the person's background, history, role in IMW implementation, and perspectives on challenges, lessons learned, and recommendations. Some interviewees had multiple roles in an IMW and therefore answered questions from multiple lists. All interviews were recorded to supplement notes taken during the interview. Recordings were later deleted to preserve anonymity.

Analysis of responses

We employed the Microsoft Copilot tool to initially help analyze interview responses. Copilot is an Artificial Intelligence-powered tool that offers contextual assistance, automation of routine tasks, and narrative analysis. Copilot was asked to generate codes, themes, and lessons learned and summarize interviews based on interview notes. Analyses were run on individual interviews, all interviews in each IMW, interviews in specific roles (policy, restoration, and monitoring), and across all IMWs. Experience showed that summaries developed by Copilot were repeatable and accurate, although exact wording changed somewhat with a new iteration. Results from the Copilot analysis were vetted and validated by the authors through review of interview notes and transcripts. A subset of the results was reviewed by the relevant interviewees to ensure the summaries accurately captured their responses. Results from Copilot were used as an aid in our analysis to help identify themes and codes and all results were discussed and refined by the authors. Codes, themes, and lessons learned that were repeated across interviews became the focus of our results.

Results

Policy staff

Overall, the interviews with policy staff collectively highlight the complexity and multifaceted nature of IMW programs, emphasizing the importance of collaboration, a shared strategy, and effective communication among stakeholders. Several policy staff members reiterated that long-term commitment to monitoring is necessary to evaluate restoration impacts and build confidence in restoration actions.

> *"Because of the investment in information collection, we need to continue to get long-term data. We need trend analyses. Because of the fish life cycle, we need multiple generations, 10+ years. Build on top of the current information."*

Translating progress and scientific findings into actionable policy recommendations was a fundamental need for policymakers. Using scientific data and rigorous methodologies is essential for guiding restoration efforts, understanding causal mechanisms, and evaluating the effectiveness of different restoration techniques. Policy staff noted the need to reduce uncertainty through information about how restoration improves watershed condition and leads to fish responses.

Policy perspectives emphasized accountability for investments, scientific rigor, and long-term data to reduce uncertainty. Key challenges included funding stability, aligning expectations with realities, and improving communication with scientists and policymakers. Strategic prioritization and adaptive management were cited as critical improvements needed (Table 1). Collaboration among scientists and restoration practitioners was seen as essential for successful implementation of the IMW. As one policy staff member noted,

> *"The greatest strength of IMWs is linking restoration practitioners with those doing the fish monitoring so they can learn from one another."*

TABLE 1 Generalized needs, challenges, and areas of improvement for Intensively Monitored Watersheds from the standpoint of policy staff.

Needs for IMWs	Challenges	Suggested areas for improvement
• Accountability for investments • Evidence for decision-making • Scientific rigor • Long-term data sets • Reducing uncertainty	• Funding and resource allocation • Limitations on methods • Expectations vs. reality • Communication with scientists • Long-term nature of IMWs	• Strategic prioritization • Coordination and collaboration • Adaptive management • Communication strategies • Funding stability

Effective communication is also important. Regular and strategic workshops and meetings to discuss monitoring priorities and findings were suggested as a way to improve communication along with better outreach to policymakers and the public. Lastly, policy staff highlighted the importance of setting realistic expectations and timelines to ensure all stakeholders understand the scope of restoration and monitoring needed to achieve the goals of the IMW. "*There needs to be a strategic target for work and reasonable expectations.*"

Restoration practitioners

Interviews with restoration practitioners underscore the need for collaboration, adaptive management, and access to actionable information. Although restoration practitioners were generally supportive of long-term monitoring and the IMW approach, it was clear from their responses that some restoration practitioners did not feel like active partners in the IMW studies. They rarely were asked to provide input into IMW monitoring and some were not even aware of results. As one person stated, *"I didn't learn much from the IMW…. They are smart people but disconnected from watershed partners. Not sure how the design was created (it was before me) and I haven't been asked to provide input."*

This highlights a disconnect between the monitoring and restoration communities in some IMWs. In IMWs where restoration practitioners felt actively involved in the study, there was clear support for the collaboration that occurred and a recognition of the importance of the IMW results to their work. As one person shared,

> *"The biggest question we have is whether the work we are doing is succeeding and the IMW tells us if we are doing the right thing. That is critical because the funders and policymakers need to know we are using the science and we are being adaptable in our work. We have taken criticism over that in the past and been pushed to be more strategic."*

Interviewees highlighted the significance of having a clear vision for the IMW and a common understanding of the magnitude of work needed to be successful. This includes developing a detailed plan and ensuring that all stakeholders are aligned with the project's goals and objectives. As one participant noted,

> *"One of the keys is to have a plan, know the limiting factors. The plan should be detailed in scope versus seat-of-the-pants restoration."*

Developing a clear vision for the restoration in IMWs, including specific goals and objectives, can help align data collection with restoration program goals. Effective communication and advocacy for this vision and goals are crucial for securing funding and building support for implementation on the ground. This step involves educating communities, landowners, funders, and policymakers about the importance of restoration projects and the long-term benefits they provide. Regularly relaying information to these groups can help build support for the projects over the long term.

Lastly, implementing adaptive management practices based on monitoring results allows for continuous learning and improvement. This approach can help demonstrate the effectiveness of restoration efforts and justify the need for continued funding. Regular synthesis and analysis of data can provide valuable insights and support funding requests. Table 2 summarizes the needs of restoration practitioners, the challenges they face, and opportunities for improvement in IMWs.

Scientists

Interviews revealed that scientists from different IMWs shared many of the same views despite differences between their studies. They highlighted adaptation, collaboration, and meaningful communication of results to restoration practitioners as key factors for success. Furthermore, interviews emphasized the complexity of ecosystem restoration and the necessity for collaboration, funding, and adaptive management to achieve long-term success in monitoring responses of fish populations and their habitats. Based on their findings to date, nearly all scientists mentioned the need to fully understand and address limiting factors and implement large-scale, process-based restoration approaches to produce a fish response. Themes identified from interviews underscore the technical and social complexity of these IMW studies.

Those doing monitoring in IMWs noted the need for clear study plans and the need to adapt to new information, new technology, and changing conditions because of the long-term nature of these studies. Comments suggest that the study plans should be more hypothesis-based and include multiple techniques to test restoration effects. Implementing monitoring at the scale required by IMWs is incredibly challenging and there is still a lot to learn about how to make these studies work effectively. One participant captured this sentiment in their statement:

> *"It is hard to know what we need to monitor. We need to be adaptive and have the space and time to figure that out. That flexibility has been the key to success. We don't always know at the start and need to change over time in our monitoring approach."*

Scientists acknowledged the importance of regular updates and the need to communicate results in a meaningful way to restoration practitioners. During planning and implementation, stakeholders should understand the scope of restoration needed and the expected monitoring outcomes. This understanding can help avoid temporal and spatial mismatches between restoration and monitoring and helps maximize the likelihood that restoration will lead to a detectable fish response. As one participant stated,

> *"IMWs are as much a social experiment as they are a scientific one."*

Lastly, interviews emphasized the importance of adaptive management through regularly sharing results and updating plans and strategies. Interviewees provide valuable insights into the needs, challenges, and opportunities faced by scientists in implementing IMWs (Table 3).

Cross-cutting themes

Planning, restoration, collaboration, communication, long-term commitments, and adaptive management were themes that arose across all three interview groups (Table 4). Below are more detailed descriptions of each cross-cutting theme. These themes have been consolidated to form the foundation of the three lessons discussed in the next section—planning, collaboration, and adaptability.

Planning approaches varied by IMW with some plans developed by scientists while others were collaboratively developed by interdisciplinary teams composed of policy, monitoring, and restoration partners. Interviewees emphasized the need for long-term, robust monitoring tied to strategic restoration plans and collaborative, adaptive planning. As one participant stated,

> *"We need to work together and work off a long-term vision … avoid getting locked into ideas and approaches, need to be open-minded and flexible."*

Interviewees also highlighted the importance of developing goals and objectives and considering out-of-basin factors, limiting factors,

TABLE 2 **Needs, challenges, and areas of improvement for Intensively Monitored Watersheds from the standpoint of restoration practitioners.**

Needs	Challenges	Suggested areas for improvement
• Actionable information • Fish & habitat status and trends • Information on limiting factors • Understanding restoration effectiveness • Information for communications	• Long-term funding • Landowner willingness • Community support • Permitting • Capacity limitations • Communication with scientists • Lack of coordination • Political will	• Process-based restoration • Strategic planning • Collaboration • Communication • Adaptive management • Holistic watershed management

TABLE 3 **Needs, challenges, and areas of improvement for Intensively Monitored Watersheds from the standpoint of scientists.**

Needs	Challenges	Suggested areas for improvement
• Long-term data sets • Key hypotheses • Understanding restoration effectiveness • Scientific rigor	• Stable funding • Restoration timeline • Out-of-basin factors • Variability • Scale and focus of restoration • Sample size • Study design • Communication • Collaboration • Political will	• Adaptive management • Strategic planning • Collaboration • Data management and analysis • Goals and objectives • Monitoring methods • Understanding watershed processes

TABLE 4 Coded interview results showing common, cross-cutting themes and the number of people that mentioned the topic.

Code	Theme	Number of interviews that mentioned theme
Planning	Restoration planning	15
	Goals and objectives	10
	Landowner willingness	12
	Watershed and species priority	14
	Out of basin factors	8
	Density dependence	9
	Habitat limiting factors	17
Monitoring	Strategic and scalable monitoring	15
	Consistency	7
	Study design	18
	Methods	8
	Analysis planning and funding	6
	Causal mechanisms	11
	Nested questions	6
	Clear hypotheses/monitoring questions	8
Restoration	Scale of restoration	17
	Transferability/exportability	12
	Ecosystem and process-based restoration	12
	Permitting/regulatory	4
Collaboration	Interdisciplinary teams	7
	Strategic leadership and facilitation	9
	Trust and Relationships	9
Communication	Public outreach and landowner engagement	7
	Communication with funders and policy makers	10
	Managing expectations	15
	Key messages	6
	Regular, consistent communication	16
Long-Term Commitment	Political will	6
	Long-term data	16
	Stable funding	13
	Accountability for investments	9
Adaptive Management	Adapting restoration over time	13
	Adapting study plans	14

density dependence, watershed priority, and landowner willingness early in the planning process. Planning using focused hypotheses, nested questions, and scalable monitoring designs also were suggested as solutions to some of the challenges faced in IMWs.

Restoration tactics and scale were frequently discussed by those interviewed, both in terms of challenges and solutions. Many interviewees emphasized the need for adaptation and flexibility in restoration strategies and techniques given the length of IMW studies and the opportunities for learning and evolving. As an example, restoration practitioners in the lower Columbia IMW changed their approach to restoration based on monitoring results. They increased their focus on overwinter habitat for coho and designed more intensive and extensive process-based restoration treatments, using wood to increase off-channel habitat. Many interviewees focused on the large scale of restoration needed and the use of natural processes and an ecosystem approach to restoration in IMWs.

Collaboration was one of the most frequently mentioned themes across all interviews. Interviewees noted that consistent collaboration was critical to the success of several IMWs, as was trust and relationship building in the core teams, the communities, and with landowners. As one person interviewed observed,

> *"IMWs require tight collaboration … This collaboration helps relationships grow and get better and increases efficiency."*

Collaboration helped ensure that all parties had input and were working toward common goals. The Middle Fork John Day IMW was highlighted in policy staff interviews as an example of effective collaboration where restoration practitioners worked closely with scientists and policy leads to implement a coordinated IMW program and apply learning from results.

Communication among researchers, practitioners, and decision-makers was emphasized by interviewees as a core factor in the success of IMWs. Landowner outreach, community engagement, and communication with policy staff also were discussed as critical for building support for large-scale, long-term restoration programs. Despite its importance, many interviewees mentioned a lack of time and funding to build this support and suggested changes to improve communication. It was clear that creating space for collaboration between researchers and restoration practitioners was important and that talking with community members at site visits and regular meetings helped build trust and relationships. Other aspects of communication that were raised across interviews included managing expectations and establishing key messages. As one participant described,

> *"Communication is key to success. We need to communicate results that are meaningful to the restoration work and make sure it gets in the hands of the practitioners. This needs to be a key goal for the work."*

Long-term commitment to both monitoring and restoration is critical to meet study objectives in all IMWs. Many interviewees highlighted issues with inconsistent or inadequate funding, the burden of having to submit proposals for annual funding, the need for dedicated and stable funding, the impacts of funding delays, and the importance of consistent political will and dedicated staff to support IMWs over the long term. One interviewee noted,

> *"We should have been much more proactive about securing commitments for long-term funding. As staff changed, our respective roles in the study became unclear and the IMW scientists were seen as competing for funds rather than helping address priority questions being asked by the funding and review staff."*

Adaptive management was seen by all groups as crucial for success, both in the study and in broader decision-making about funding and restoration programs. Adaptive management allowed for adjustments in IMWs based on new information and changing conditions, such as delays, evolving technologies, funding cuts, and discoveries. Effective adaptive management often tied to effective collaboration among partners. As one person stated,

> *"It is hard to know what to monitor. We need to be adaptive and have the time and space to figure that out. That flexibility has been key to success."*

Several examples of adaptive management in IMWs were shared in interviews. For example, the Lemhi IMW changed restoration direction based on monitoring results. At first, restoration focused on reconnecting smaller tributaries in the upper watershed, but emphasis shifted to restoring side channels, particularly in downstream reaches. In another example, a continued lack of large wood in the treatment watersheds of the Straits IMW led to a secondary wood treatment to meet restoration goals.

Discussion

Ecosystem restoration programs are inherently broad in time and often in space. Success often depends on long-term relationships and extended learning. The results of this study build on past efforts to document the importance of knowledge co-production and collaboration in monitoring and restoration (Piczak et al., 2022; Cooke et al., 2021; Gonzalo-Turpin et al., 2008; Lovett et al., 2007). We acknowledge that this assessment did not include the local community perspective, something that also is important to consider when developing IMW programs and something that should be considered as a follow-up step in future studies (Koontz, 2022; Christoffersen, 2011; Roni et al., 2015). In the following, we discuss the three main social lessons from IMW programs distilled from the synthesis of policy, implementation, and monitoring perspectives. These apply broadly to any watershed restoration program.

Build a shared strategy

Watershed restoration warrants a collaborative, strategic approach to planning because of the scope of restoration, funding, time, and necessary high level of partner and community support. As one participant stated,

> *"It is key that the folks planning and implementing the [IMWs] are in sync with the decision-makers."*

As many of those interviewed discussed, planning is a critical step in the restoration process. Careful thought should be put toward where long-term monitoring and restoration programs should occur (Larsen et al., 2004). Consideration should be given to a watershed's importance to recovery, social and political support for funding and implementation, and sufficiency of information for planning (Wissmar and Bisson, 2003). Given the amount of restoration that needs to occur in these watersheds over decades, community and political support is particularly important (e.g., Gann et al., 2019; DeAngelis et al., 2020). Without adequate landowner support (whether it be public or private), restoration will fall short of expectations. For this reason, the focus ideally should be on selecting high-priority areas with high potential to fully implement restoration.

Also important to consider in planning is the current and expected future condition of the watershed. Restoration in less impaired systems is more likely to show good returns on investments than in greatly degraded watersheds (Whelan, 2025). It is difficult to detect a response from restoration in watersheds with out-of-basin impacts, lack of freshwater density dependence, low escapement, or restoration needs with long-term lags between restoration and response (Bilby et al., 2022; Anderson et al., 2019; Krall et al., 2019; Anderson et al., 2025). Locations with high production potential can be rare but restoration treatments should focus on locations that intrinsically can support high salmon production and in populations with high fish abundance to maximize effectiveness (Anderson et al., 2019; Bilby et al., 2023). Bilby et al. (2022) found that locations where watershed processes were relatively intact appeared to have a higher probability of generating a more rapid fish response to habitat treatments and that some restoration strategies have shown a greater response than others. Furthermore, they found that failure to identify the priority limiting factor(s) was a major cause for the poor fish response at many IMWs in the Pacific Northwest.

An explicit plan with a common vision and a defined collaborative framework is the foundation for a deeper partnership and level of understanding (Krall et al., 2019; DeAngelis et al., 2020; Piczak et al., 2022). Interviews highlighted the importance of having a clear vision and strategic goals and objectives in IMW plans, one of the tenets of good restoration practice (Krall et al., 2019; Whelan, 2025). Some interviewees suggested having goals and nested, hypothesis-oriented questions focused on testing specific restoration approaches and strategies that are pertinent to restoration practitioners. Objectives should be specific to a limiting factor and restoration approach, be measurable so progress is clear, achievable with the available resources, relevant to broader watershed goals, and have a reasonable timeline for results (Gann et al., 2019).

Ideally, planning should include facilitation of interdisciplinary teams toward a clear vision and goals, to be revisited and re-evaluated at appropriate intervals (Gonzalo-Turpin et al., 2008; Cooke et al., 2021; Canfield et al., 2022; Kapoor et al., 2025). Regular assessment of limiting factors and restoration priorities and approaches throughout implementation helps ensure the most effective restoration (Bilby et al., 2022; Bliesner et al., 2026). Plans also should describe a process for how partners will work together and respond to change along the way.

Study designs need to be flexible. Practitioners working in IMW studies with a before-after, control-impact (BACI) approach noted particular challenges such as inherent differences among control and treatment watersheds, implementation of restoration in control watersheds, and restoration timelines continuing past the treatment period (Kerr et al. 2019; Krall et al., 2019). As one person observed,

> *"BACI was not the best study design. Control [watersheds] had restoration done and restoration imperative overrode the study design. The intention was there but it was difficult to implement."*

Most IMWs had to adjust or add to their study designs as results yielded new knowledge or unexpected issues arose. Adopting new technology, remote sensing, and modeling for some data sets could allow scientists to more easily cover an entire watershed over an extended time period. Creative thought may uncover alternative sources to provide needed information. Regardless of the location, study design, or method adopted, all partners involved in the study should understand the plan and be fully supportive of implementation.

Embrace change

One of the most ubiquitous experiences of all IMW practitioners and partners was change. Although monitoring and restoration practitioners are accustomed to responding to unexpected environmental changes, the social context can make adaptation particularly challenging. Most IMWs experienced significant environmental events (e.g., fire or flooding) and all experienced challenges that affected restoration and monitoring efforts (e.g., staff turnover, funding shortfalls, delays, and lack of landowner or permitting support). Without a robust adaptive management process, flexibility in the study, communication, and a strong collaborative relationship among key partners, long term restoration and monitoring programs face significant challenges in responding to change. This is consistent with other studies that have cited adaptive management as a critical component of salmon recovery and restoration programs (e.g., Bliesner et al., 2026; Bouwes et al., 2016; Maas-Hebner et al., 2016).

Regular analysis of monitoring data, tracking progress, and communication of progress and results (Lovett et al., 2007) is important to robust adaptive management and maintaining public and political support. Information flow can allow restoration practitioners to learn from the monitoring and adjust restoration approaches and designs; for scientists to change aspects of the study design, methods and analyses, or communication approach; and for policy staff to modify their expectations, timelines, and funding approaches (Jellinak et al., 2021). Many interviewees noted the importance of being open to change and accepting failure as part of the learning process. Several of those interviewed mentioned the importance of change. One person interviewed reflected, *"we should have been more experimental in the beginning, and been okay with failure as we went along."*

A key lesson from the IMWs is that restoration and response at the population scale is complex, often building over time or operating in fits and starts as change occurs. Long-term monitoring is essential to track progress over multiple generations and identify areas for improvement (Larsen et al. 2004; Bilby et al., 2024). Continuously adapting to new information and being willing to change plans based on what is learned is vital (Maas-Hebner et al., 2016; Bliesner et al., 2026; Bouwes et al., 2016). This adaptive management approach helps ensure that restoration efforts remain effective and relevant. As one interviewee stated,

> *"These watersheds were broken in ways we didn't anticipate."*

As this statement implies, there is a continuing need to test and address limiting factors. Watersheds with intensive monitoring and restoration and testable hypotheses should be hubs of learning and adaptation with broad application.

Foster collaboration

Two of the most common themes across interviews were communication and collaboration. These traits often were cited as the keys to success or failure in IMWs. The social aspects of IMW programs can be just as important as the technical aspects, starting with building strong relationships and trust among the interdisciplinary team members, stakeholders, communities, and landowners (Bliesner et al., 2026; Gonzalo-Turpin et al., 2008; DeAngelis et al., 2020; Piczak et al., 2022). As many of those interviewed reiterated, it is not just about communicating information regularly but building teams that have regular conversations about what the information tells us and whether and how to act on it. One interviewee said, *"communicate 'til it hurts."* Clear and structured communication of results is essential to ensure that the information is understandable and actionable and reaches the right people (Jellinak et al., 2021). This communication may look different depending on whether one is talking to landowners, scientists, funders, or restoration practitioners. Building a collaborative framework for restoration programs involves thinking about the connections between how we communicate, what we communicate, and what we expect could happen as a result of that communication (Kapoor et al., 2025). Robust collaborative processes allow groups to respond and adapt over time while informing restoration and monitoring programs. Facilitating trust, fostering dialogue, and creating opportunities for collaboration can enhance understanding and cooperation. Effective partnership also leads to the sharing of ideas and responsibilities and helps people work effectively together, especially when facing challenges.

Collaboration in IMWs usually involved monitoring and restoration practitioners, sometimes including landowners and the local community. Rarely, it extended to policy and funding partners as well. Collaboration with policy staff is critical to long-term funding support. Funders and policy staff have an interest in findings and scientists need to communicate with them, so they are aware of the most impactful restoration actions. If policy staff can apply findings to their decision-making through adaptive governance, they are more likely to commit long-term funding to sustain the long-term monitoring efforts. For example, a lack of sufficient restoration effort, communicated through a review by Lando et al. 2013, led to a policy decision by the Salmon Recovery Funding Board to dedicate additional funding to implementation in several Washington IMWs. Similarly, the Oregon Watershed Enhancement Board used results from the Middle Fork John Day IMW as rationale for why it is important to support adaptive management actions in a watershed (MFIMWWG, 2024).

Collaborative frameworks have been shown to be highly effective at connecting people, producing novel information, and generating informed decisions (Piczak et al., 2022; Christoffersen, 2011; Lauber et al., 2011; Thomas and Mendezona Allegretti, 2019). Because of the extended time of these studies, relationships cannot depend on individuals alone but instead must be built on a robust collaborative framework that creates and maintains trust among partners over time through effective leadership and facilitation (White et al., 2023). Effective collaboration involves open communication, teamwork, extended dialog, and shared decision-making, which allows a restoration program to adapt to change and produce relevant outcomes. Figure 2 provides an example of the type of collaborative framework that could be employed by others to successfully plan, implement, and manage long-term monitoring and restoration programs. This framework focuses on a core project team that works together to build a plan and make decisions that respond to interests, information, and change over time. As this study highlights, these elements are critical to long-term success.

In conclusion, several social aspects of the IMW experience are exportable to other restoration and monitoring programs. These include: 1) planning processes, including where to focus work; 2) the relationships and collaborative processes that support effective implementation and learning, and 3) lessons about the development, flow, and use of information. Larger watersheds with ongoing restoration will require long-term monitoring and ongoing adaptive management. Challenges remain in linking monitoring data to decision-making and prioritization of projects, programs, and funding. To help address this challenge, we recommend the establishment and funding of robust collaborative processes that allow learning and adaptation over time. These improvements will gain importance as restoration becomes more complex and challenging, requiring more information, long-term support, and collaboration.

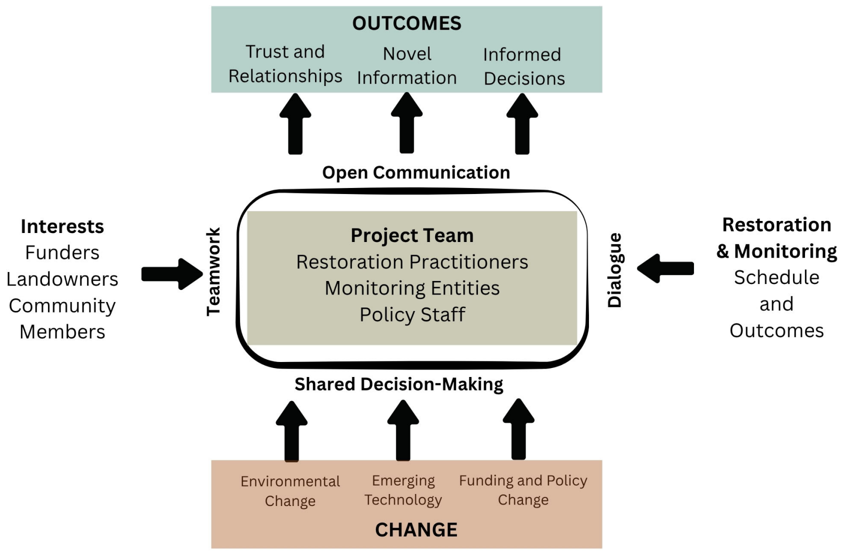

FIGURE 2
Example collaborative framework and collaborative process that could be employed by long-term monitoring and restoration programs.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

GM: Writing – original draft, Writing – review & editing. TC: Writing – original draft, Writing – review & editing. KF: Writing – original draft, Writing – review & editing.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declared that generative AI was used in the creation of this manuscript. As stated in the methods section, we employed the Microsoft Copilot tool to help analyze interview responses. Copilot is an Artificial Intelligence-powered tool that offers contextual assistance, automation of routine tasks, and narrative analysis. Themes, unifying elements, trends, and relationships were developed in Copilot using the responses to questions from interviewees. Analyses were run on individual interviews, on all interviews in each IMW, and on all interviews in roles (policy, restoration, and monitoring) across all IMWs. Copilot was asked to identify themes, unifying elements, challenges, lessons learned, and recommendations from the interviewees' responses. Results from the Copilot analysis were vetted, validated with a subset of interviewees, and used in development of the themes and lessons learned. Experience showed that summaries were repeatable, although exact wording changed somewhat with a new iteration. Therefore, we developed a set of five primary themes and four to six key takeaways for each role.

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Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fevo.2026.1731965/full#supplementary-material

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