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RESEARCH

Identifying practitioner and researcher collaboration needs to improve ecosystem restoration in Canada

Tim Alamenciak[1,2] · Nancy Shackelford[3] · Logan Rehberg[2] · Ash Baron[4] · Catherine Febria[5] · Alina Fisher[3] · Tina Heger[6,7] · Eric Higgs[3] · Stephen Murphy[8] · Ryan Stephenson[9] · Bruno Travassos-Britto[10]

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Abstract
Ecological restoration practitioners should have access to relevant science on which to base their plans, and restoration researchers should ground their science in real-world needs — but the gap between science and practice frustrates this integration. Organizations are working to bridge that gap, and practitioners and researchers want to work together, yet specifically what each group needs to effectively collaborate is less clear. We hosted two in-person workshops that brought together ecological restoration practitioners and researchers to investigate the collaboration needs of practitioners and researchers. We conducted two facilitated dialogue-based exercises at RE3 (Reclaim, Restore, Rewild) 2023 conference in Quebec City, Quebec, and two at the Society for Ecological Restoration North American Conference 2024 in Vancouver, British Columbia. We analyzed responses from both events using qualitative coding and extracted six themes (connections, engagement, targets, resources, data and uncertainty) and 23 sub-themes that informed three core needs shared by both researchers and practitioners. The first core need was communication, particularly around project experiences and failures. The second need was tools, suggesting the current landscape of collaborative platforms is insufficient. The third need was greater engagement with adaptive management and goal setting in restoration science and practice. We synthesize the findings from four collaborative exercises and identify future areas to build bridges between restoration research and practice, such as co-training workshops on funding opportunities, which could lead to co-designed actions with mutual value for researchers, practitioners and Indigenous and local communities.

Keywords Restoration ecology · Science-practice gap · Knowledge-action gap · Theory-practice gap · Knowledge mobilization

1 Bridging the science-practice gap in restoration ecology

Ecological restoration has gained global significance in recent years. Propelled by the Sustainable Development Goals (Goal 15), the UN Decade on Ecosystem Restoration (2021–2030), and Target 2 of the COP15 Global Biodiversity Framework (GBF), the world has committed to "[e]nsure that by 2030 at least 30 per cent of areas of degraded terrestrial, inland water, and marine and coastal ecosystems are under effective restoration" (UN Environment Program). While ecological restoration has consistently improved biodiversity and ecosystem functions globally, it is still a relatively young field with often unpredictable outcomes that may not reflect ideal project success (Benayas et al. 2009, p. 1122). Scientists and practitioners globally have responded by ramping up research on restoration methods, needs, and processes to enhance our worldwide ability to restore ecosystems effectively, but a gap between research and practice persists.

In an ideal world, restoration researchers and practitioners would be able to quickly and easily share knowledge, experiences, and resources with one another. In the real world, however, researchers and practitioners often occupy separate realms of restoration. Academic researchers focus on understanding the mechanisms and patterns involved in restoring degraded socioecological systems, while practitioners focus on effectively implementing restoration actions.

Extended author information available on the last page of the article

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This gap has been referred to as the knowledge-action gap (Buxton et al. 2021), the theory-practice gap (Cooke et al. 2021), or the science-practice gap (Clark et al. 2019). Here we are broadly concerned with the gap between scientific research and practice and so use the term "science-practice gap." Ideally research would be done with a translational approach wherein researchers work with local communities and practitioners to design research that is more easily translated into appropriate and successful action on the ground (Murphy 2018; Reyes-García et al. 2019; Levine 2020; Di Sacco et al. 2021; Gornish et al. 2024). Practice ideally would be evidence-based and reflexive, sharing insights with researchers and critiquing research directions (Cooke et al. 2018, p. 204; Buxton et al. 2021, p. 3).

The broad motivations differ between researchers and practitioners, however. Researchers prioritize publishable findings that advance general scientific knowledge and academic careers. Published scientific literature is not a valued source of information for practitioners (Alamenciak et al. 2025, p. 5). For the practitioner, the major motivations are to get project-specific results and to satisfy local partners, clients, or stakeholders by achieving value-based restoration outcomes. However, the resulting actions are not always compatible with the structure, resources, and time needed for scientific research. While this supports a persistent gap between research and practice, finding ways of bridging that gap by reducing time to adoption of innovative and demonstrably useful approaches (Dickens and Suding 2013, p. 135; Sutherland et al. 2004, p. 306) can benefit both practitioners and researchers. However, the fact that such collaboration does not frequently occur suggests there are unmet needs on either side, presenting an opportunity for boundary-spanning organizations to enable collaboration.

An example where the connection between researchers and practitioners is vital is the decades-long rise in the integration between ecological restoration projects and the process of planning and development in construction projects (e.g., the Toronto & Region Conservation Authority's ecological compensation framework mandate). Historically positioned as mitigation or offsets in development projects, there is ample evidence that these types of development-driven restoration efforts are not as successful as they should be (zu Ermgassen et al. 2019, p. 13). Collaboration between researchers and practitioners has the potential to enhance the success of mitigation or offset projects by facilitating the sharing of knowledge and data across actors or projects (Ladouceur et al. 2022, p. 6). Given the high cost of failure in these cases, there is significant incentive for collaboration between researchers and practitioners.

Communication between scientists as they produce research outputs and practitioners as they encounter questions or uncertainty can facilitate a quicker pace of research evidence becoming integrated into practice (Buxton et al. 2021). This quickness is vital in response to the related crises of human-caused climate change and socioecological degradation. Effective restoration has the potential to limit and mitigate climate change impacts (Intergovernmental Panel on Climate Change 2022, p. 20), but the rapid pace of global change needs to be matched by rapid responses that arise from deeper research-practitioner-stakeholder coalitions. The goal of these coalitions is to enable higher quality information transfer for more rapid, more effective large-scale restoration action (Cooke et al. 2018, p. 203). While some fundamental differences between researchers and practitioners in restoration ecology may persist (Bertuol-Garcia et al. 2018, p. 1050), closer integration is possible.

Boundary-spanning knowledge brokers and organizations that bridge researchers and practitioners have been found to be effective at creating bi-directional knowledge flows in some contexts (Clark et al. 2019, p. 1249; Doehring et al. 2024, p. 449). Canada's diverse resource economy, rich restoration practice landscape and broad representation of ecosystems make it an ideal case with lessons transferrable internationally (Cooke et al. 2016, p. 7). The co-operative extension model in the United States has been suggested as a model for how boundary-spanning organizations can create this bridge (David et al. 2016, p. 411), but areas without a history of extension (such as Canada and many other nations) need to start from scratch. To do this, the first step is to understand the collaboration needs of both communities.

To understand what is needed to build collaboration, this paper addresses the following research question: What are the collaboration needs of restoration practitioners and researchers? We used a series of in-person workshops using facilitated conversation exercises to answer this question. The exercises were designed to elicit ideas of *how* practitioners and researchers envision working together, which would provide insight into the needs that a boundary-spanning organization could fulfill, thereby connecting researchers with boots on the ground.

2 Workshops on collaboration needs

This study used qualitative coding to analyze materials produced during two in-person workshops that brought together practitioners and researchers to understand their needs. The first workshop was a series of structured question sessions held at the Reclaim, Restore, Rewild (RE3) 2023 conference in Quebec City, Quebec, Canada (Table 1). The second was a collaborative scenario exercise and data prioritization activity held at the Society for Ecological Restoration[1]

[1] The Society for Ecological Restoration is an international professional organization that includes restoration practitioners and

Table 1 Detailed description of the exercises conducted during two in-person workshops

Exercise	Description	Questions
Speed dating (RE3)	Researchers and practitioners were paired up with one another and given a series of questions to collectively answer.	Q1. Do you see any point in practitioners and researchers engaging with one another? If yes, what does the engagement bring to a project? If no, would anything change your mind?
	Output: notes taken by individual participants	Q2. What are the most uncertain things in a new project? How do you deal with that uncertainty?
		Q3. What do you want to learn from other projects or from research? What do you want to share from your own work? What do you need to make this kind of sharing possible?
		Q4. Would you like to see (and participate in) more situations where researchers engage in co-designing their research projects with practitioners and other partners? What would it take to motivate you to participate?
Group work (RE3)	Groups consisting of roughly equal portions of researchers and practitioners worked through a series of questions.	GW1: Do you feel there is a gap between restoration scientists and practitioners? If yes, do you have ideas how to bridge this gap?
	Output: Notes taken by organizer(s) listening in on groups.	GW2: What is your preferred method of creating dialogue amongst practitioners and researchers?
		GW3: You have infinite money, infinite resources and infinite time from any researcher who has been studying whatever fields are relevant to your restoration practice. What tools and knowledge would you ask be develop to support your work?
Restoration scenario (SERNAC)	Participants brainstormed how best to engage researchers, practitioners and land-based knowledge holders during a fictional restoration scenario that focused on three time periods: diagnosis, implementation and post-implementation (per Cooke et al. 2024).	How would you meaningfully engage with (practitioners/researchers/land-based knowledge-holders) during the diagnosis, implementation and post-implementation phases of a restoration project?
	Output: Posters with notes and illustrations co-created by group participants.	
Data dotmocracy (SERNAC)	Participants voted on important indicators of restoration success derived from the Restoration Project Information Sharing Framework.	Which indicators are most important during the diagnosis, implementation and post-implementation phases of a restoration project?
	Output: Table with tallied votes from each group.	

North American Conference 2024 in Vancouver, British Columbia, Canada (herein SERNAC).

Both conferences brought together a diverse group of stakeholders from a variety of institutions including academic organizations, governmental agencies, and non-governmental organizations (NGOs) from within Canada and internationally. This diversity ensured a wide range of perspectives on the challenges and opportunities related to collaboration in ecological restoration. All discussions were recorded through written notes from the research team, written responses to research questions, chart-paper brainstorming materials and voting sheets.

2.1 Workshop formats

The exercises were designed to first allow participants to generate ideas for modes of collaboration through structured conversations. The first of these sessions, held at RE3, was structured as a "speed dating" session, where practitioners and researchers were partnered with one another to discuss collaboration. Each pair were given specific questions to guide their conversations and instructed to take notes in response. At the same workshop, groups of practitioners

scientists. See https://ser.org for more information.

and researchers collaborated on answering three additional questions, each with one organizer sitting in to take notes on the conversation points (Table 1).

In the SERNAC workshop, participants were asked to respond to a scenario describing the need to implement a recovery program for a fictional species (cozy-toed turtle) in a fictional place (**Supplementary Material 1**). For the exercise, the restoration project was split into three time periods characterized as "diagnosis," "implementation" and "post-implementation" after Cooke et al. (2024, p. 6). Participants were instructed on the contents of each step. Diagnosis refers to all preparation steps short of physically intervening in the ecosystem. Implementation refers to the steps in which ecological interventions are conducted. Post-implementation refers to the time after major work has concluded, though additional maintenance interventions may be conducted.

Each table was assigned one of three time periods, and participants were alternately told to assume the perspectives of researchers, practitioners, and land-based knowledge holders. They stayed with the same time period for each role and wrote down important elements of collaboration at their assigned time period in the fictional scenario. Participants were given chart paper and markers and instructed to be creative in their depictions. Each group presented to the workshop after each role change.

The second SERNAC activity presented participants with a series of metrics described in the Restoration Project Information Sharing Framework (RPISF) (Gann et al. 2022, pp. 9–11). The metrics are designed to structure reporting on restoration projects. We used a sticker voting, often referred to as "dotmocracy", to evaluate the information needs of restoration practitioners and researchers. This is a facilitation method that allows participants to vote on their preferred options using a limited number of stickers to visually identify group priorities (Diceman 2010). Participants were given a set number of stickers to represent research priorities, and another set to represent practice priorities. This approach encouraged participants to prioritize the most relevant information points while acknowledging and thinking through the differences between science and practice.

2.2 Qualitative coding analysis

The chart paper and transcribed discussions were analyzed using qualitative coding, a method chosen for its effectiveness in systematically identifying and exploring patterns, themes, and meanings within textual data (Saldaña 2013, pp. 1–24). We used an initial inductive coding strategy to analyze the results of all exercises (Saldaña 2013, pp. 100–105). Inductive reasoning involves allowing themes to form from the data itself rather than applying existing theory. Initial coding used in vivo codes, which involves using the words of the participants as the codes themselves when inductively determining themes. The codes that emerged from the speed dating and group work during the first workshop at RE3 were then grouped together thematically in a process known as "axial coding" (Saldaña 2013), compiled into a codebook and applied to the results of the SERNAC workshop to gain clarity on how they emerged in "real world" restoration scenarios or monitoring priorities.

The inductive analysis to arrive at codes and themes proceeded in two phases. In the first phase, all RE3 workshop outputs were reviewed multiple times to ensure a deep understanding of the content. During this process, codes were created from the text and applied using *Nvivo 15*. In the second phase, the initial codes were clustered into broader thematic categories, allowing for the exploration of relationships and interactions between different themes.

This second phase of the analysis involved applying the codes and themes from RE3 to the SERNAC scenario planning results by tagging the chart paper filled in by participants with the developed codes. The dotmocracy results were analyzed as a simple vote-counting exercise.

3 Emergent needs in researcher-practitioner collaboration

3.1 Connections and knowledge-sharing (RE3)

Overall, 23 codes across 6 themes were identified from the speed dating and group work at RE3 **(**Fig. 1**).** A total of 28 restoration professionals participated in the RE3 workshops (Industry: 11; Academia: 7; Government: 5; NGO: 4; First Nation: 1). The six themes were connections, uncertainty, resources, data, engagement and targets (Fig. 1). The 23 codes were derived from participant statements.

The connections theme included the codes "build a community," "needs for effective communication," "communication methods," "compare experiences," "sharing different knowledge types," and "field visits". The engagement theme was applied to statements that discussed the need to engage people in restoration projects and included the codes "participation," "perception," and "policy development." The data theme was applied to statements that discussed data and included "access to data," "data for decision making" and "site information and history." The uncertainty theme was applied to statements that referenced the role of uncertainty in restoration projects and included the codes "challenges," "coping strategies," and "learning from mistakes." The resources theme was applied to statements that referenced the need for greater support and included the codes "budget spending," "funding," "training," "resource sharing," and

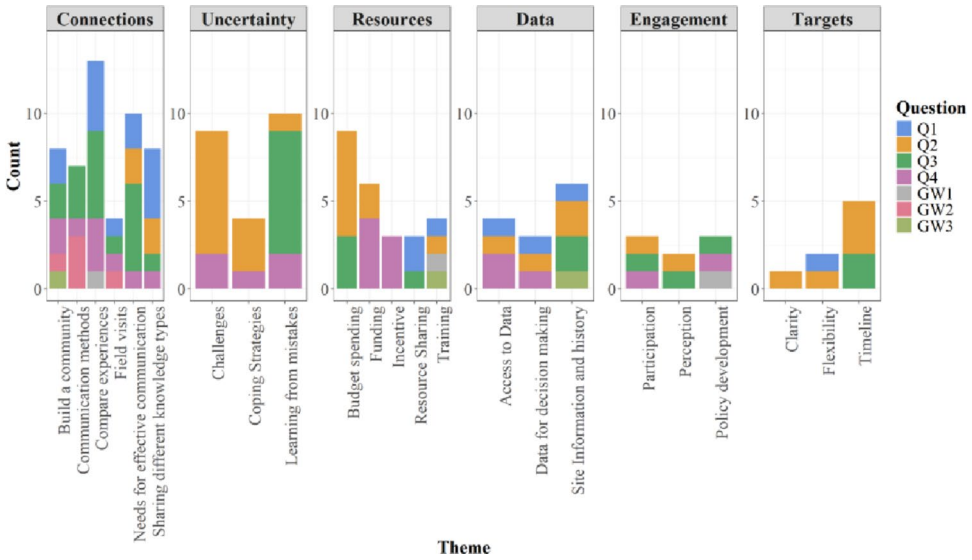

Fig. 1 The most common themes that emerged from the RE3 workshop centered on the need for stronger connections between practitioners and scientists. Overall, responses were diverse and additionally included (from left to right) themes of dealing with uncertainty, resource constraints, needs for data sharing pathways, supports for public and stakeholder engagement, and needs for better defined and usable targets in restoration. We created the themes from individual codes, which are identified on the X axis of the above chart. Questions were: **Q1.** Do you see any point in practitioners and researchers engaging with one another? If yes, what does the engagement bring to a project? If no, would anything change your mind? **Q2.** What are the most uncertain things in a new project? How do you deal with that uncertainty? **Q3.** What do you want to learn from other projects or from research? What do you want to share from your own work? What do you need to make this kind of sharing possible? **Q4.** Would you like to see (and participate in) more situations where researchers engage in co-designing their research projects with practitioners and other partners? What would it take to motivate you to participate? **GW1.** Do you feel there is a gap between restoration scientists and practitioners? If yes, do you have ideas how to bridge this gap? **GW2.** What is your preferred method of creating dialogue amongst practitioners and researchers? **GW3.** You have infinite money, infinite resources and infinite time from any researcher who has been studying whatever fields are relevant to your restoration practice. What tools and knowledge would you ask be developed to support your work?

"incentive." Finally the targets theme included the codes "clarity," "flexibility" and "timeline."

The workshop at the RE3 conference was designed to discuss the interface between science and practice, and responses reflected that in their focus on community building and knowledge sharing. All questions resulted in at least one mention of the need for deeper connections through community building, communication, comparing experiences, or sharing different perspectives and knowledge types (Fig. 1, "connections"; **Supplementary Material 2**). Mentions of knowledge sharing fell under the theme of "connections." Responses highlighted that effective knowledge sharing can shorten the gap between research and practical application, ensuring innovations are implemented sooner.

In identifying sources of uncertainty, there was acknowledgement that the driving challenges may not be known ahead of time, but that they stem from both ecological and social dimensions. Socio-political changes that could represent fundamental uncertainties in a project were assigned the theme "uncertainty." Some recommendations to work with uncertainty included early and meaningful consultation with stakeholders, setting clear goals, and scenario planning.

Resource availability and funding constraints were consistent both in the challenges that might be faced within a project, and in participating in knowledge sharing exercises between science and practice. Consistent mentions of resource availability and funding were grouped under the theme "resources." Funding was a significant motivator mentioned for participation in co-designing research projects.

There was a consistent appetite to share failures and learn from mistakes across almost all questions. This even included a recommendation for a "mistakes database", and multiple answers showed overlap between wanting to share failures and seeing gaps in communication tools and pathways. Participants suggested creating platforms and opportunities for open dialogue, mentorship, and collaborative projects to bridge this gap. This could encourage a culture of sharing experiences, both successes and failures, and foster mutual understanding and collaboration.

3.2 Prioritizing engagement and metrics (SERNA)

A total of 36 participants attended the workshop and participated in the two facilitated exercises. Participants generated

13 chart-paper responses as part of the scenario exercise, and 6 completed dot-voting sheets as part of the dotmocracy exercise.

3.2.1 Scenario planning: diagnosis to implementation

We applied code categories generated from the RE3 workshop (Table 2; **Supplementary Material 2**) to the chart-paper responses. A total of 23 codes across 6 themes were applied to 143 sections of the responses. The documents were coded by ANONYMIZED. All counts in figures and tables refer to the number of times each code was applied across the whole set of documents.

The themes connections ($n=67$) and engagement ($n=27$) were most strongly represented by the responses (Table 2). Participants tended to emphasize both themes most strongly in the diagnosis stage. The themes targets ($n=15$), resources ($n=13$) and data ($n=11$) appeared less frequently in the scenario exercise, and the theme of uncertainty ($n=5$) only occurred in the implementation and post-implementation phases.

The two most common themes – connections and engagement – were emphasized by participants most often in the diagnosis stage. Participants covered more codes during diagnosis ($n=59$) than either implementation ($n=39$) or post-implementation ($n=40$).

Within the themes, participants highlighted most often the need to build a community ($n=21$) throughout the entire phase of a project. Comparing experiences – the second-most common code – was mentioned most in the diagnosis stage ($n=14$), as was participation ($n=7$). Several codes that emerged from the RE3 workshop were not explored by participants in the scenario exercise. These included budget spending, challenges, coping strategies, flexibility and incentives (all $n=0$).

During the workshop, participants rotated through adopting the perspective of different roles to address the scenario. The resulting scenario responses were coded by role (Table 2). When the group took roles as researchers and practitioners, their responses focused on building a community (Researchers n (Rn)=10; Practitioners n (Pn)=7) and comparing experiences (Rn=10; Pn=8), while those who took the land-based knowledge holder role focused on participation (Land-based knowledge holder n (Ln)=10) and sharing different knowledge types (Ln=8).

3.2.2 Metric prioritization through dotmocracy

Rightsholder and stakeholder engagement was voted as the most important metric ($n=51$; Fig. 2; **Supplementary Material 2**), with slightly more votes from practitioners ($n=33$) over researchers ($n=18$). While it was rated highly throughout, most voted for this metric during the diagnosis

Table 2 Codes and associated themes applied to the scenario exercise

Code	Theme	Land-based knowledge holder	Practitioner	Researcher	Totals
Build a community	Connections	4	7	10	21
Compare experiences	Connections	1	8	10	19
Participation	Engagement	10	5	2	17
Sharing different knowledge types	Connections	8	2	1	11
Clarity	Targets	4	3	2	9
Communication methods	Connections	4	3	1	8
Field visits	Connections	2	4	1	7
Training	Resources	3	1	3	7
Learning from mistakes	Uncertainty	3	2	1	6
Perception	Engagement	3	2	1	6
Timeline	Targets	1	2	3	6
Access to data	Data	0	3	2	5
Policy development	Engagement	3	1	1	5
Site information and history	Data	1	3	1	5
Funding	Resources	1	1	2	4
Needs for effective communication	Connection	3	0	0	3
Resource sharing	Resources	1	1	0	2
Data for decision-making	Data	1	0	0	1
Budget spending	Resources	0	0	0	0
Challenges	Uncertainty	0	0	0	0
Coping strategies	Uncertainty	0	0	0	0
Flexibility	Targets	0	0	0	0
Incentives	Resources	0	0	0	0
Totals		53	48	41	142

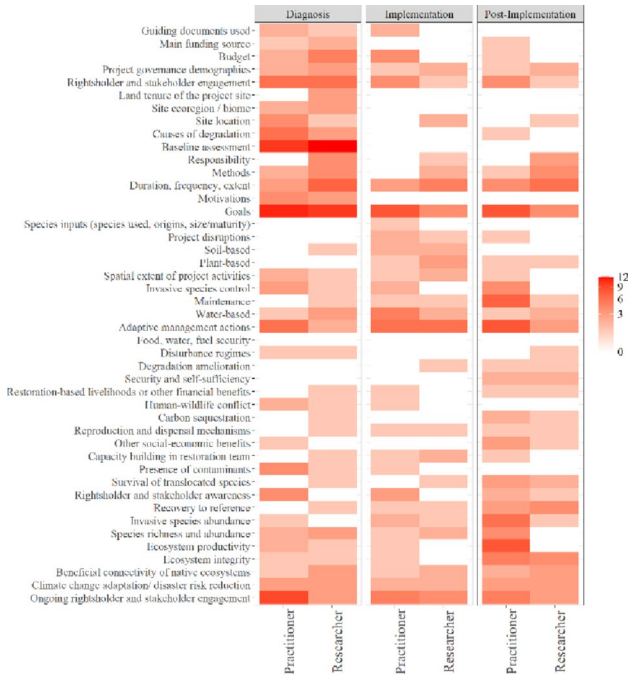

Fig. 2 This heatmap shows the metrics (y axis) voted on by participants during the SERNA Dotmocracy exercise. The affiliation of the voter (e.g. practitioner or researcher) is described on the x axis. The shade of the square corresponds to the number of votes each metric received during the exercise. See Supplementary Material 2 for a full table of results

stage ($n=24$) as opposed to implementation ($n=14$) and post-implementation ($n=18$).

Project goals emerged as the second most important metric from both researchers ($n=18$) and practitioners ($n=27$). It was most voted for in the diagnosis stage ($n=21$) as opposed to implementation ($n=12$) or post-implementation ($n=12$) (Fig. 2; **Supplementary Material 2**). This overlaps with a desire for clarity on targets expressed in the scenario exercise ($n=9$).

Adaptive management actions ($n=31$) emerged as the most important metric in the framework's restoration actions section. Monitoring details, particularly the duration, frequency and extent of monitoring, were voted the next most important metric ($n=28$). Rightsholder and stakeholder engagement ($n=29$) and the baseline assessment ($n=22$) completed the top five metrics according to votes. Site conditions, knowledge sources, and financial metrics were all emphasized as priorities at the diagnosis stage and then faded in importance in later stages. All other categories of metrics were shown to be consistent priorities across participant groups and project stages.

Table 3 Summary of recommendations for collaboration needs

Collaboration need	Key recommendations
Communication	Direct communication between researchers and practitioners is important, but so is engaging stakeholders, partners and other community members.
	Deeper two-way connections are an important solution.
	Improving communication is not only about information exchange but also trust-building, shared understanding and co-producing usable knowledge.
	Communication about failures should be encouraged.
Tools	There is a need for better digital and organizational tools to support collaboration.
	Tool creation should be grounded in collaboration with practitioners and researchers from the beginning.
	Tools should share resources and not operate in silos.
Adaptive management	Clear and well-documented goals are important.
	Measures of success must reflect individual project goals.
	Monitoring against clear benchmarks is important to share project information.

4 Synthesizing collaboration needs for effective restoration

Our study solicited the collaboration needs of practitioners and researchers through facilitated exercises. The most consistent and continuous message from both workshops was the need for more effective communication. This emerged both as a priority for direct communication between researchers and practitioners, and as a need to engage stakeholders, partners, and other community members who are affected by restoration work. Communication served as a key factor across project elements: fostering collaboration, setting clear goals, managing uncertainty, and implementing adaptive management. These interconnected elements were each emphasized at different stages of restoration projects and across participant roles, underscoring their universal importance.

Rather than viewing the science-practice gap as a unidirectional problem in which science should inform practice (Bertuol-Garcia et al. 2018, p. 1050), participants emphasized that deeper two-way connections were a key solution (Table 3). Responses discussed how engagement between practitioners and researchers is essential for creating a cohesive and supportive community. According to participants, one of the ways through which these interactions foster better engagement is by allowing the sharing of stories, both successes and failures, which contributes to a collective pool of knowledge. Such a community can validate each

other's data, verify findings, and support helpful consistency in practices across different projects. Growing "communities of practice" can foster the exchange of different perspectives and knowledge systems—a bidirectional flow that helps overcome persistent barriers of transferability and applicability (Jellinek et al. 2021, p. 211; Dickens and Suding 2013, p. 135). Participants also pointed out that knowledge sharing between researchers and practitioners ensures that the latest research findings are not only accessible but also practically applicable (Table 3). This two-way exchange allows researchers to understand the constraints and needs of practitioners, while practitioners can stay updated on new developments and methodologies that could enhance their work.

Our results reveal that scientists and practitioners agree that the knowledge deficit view is flawed. This view assumes that the lack of scientific knowledge among non-scientists is the main factor causing the distancing between science and other societal sectors (Fisher et al. 2025, p. 10). Under this view, the solution would be to communicate scientific results better. Even though the inability of scientists to discuss their work without the language of scientific jargon has been pointed out as a problem (Cook et al. 2013, p. 673), the main solution points towards better ways to collaborate through all stages of knowledge production. This result is in complete alignment with a recent analysis that puts the knowledge deficit model into question (Fisher et al. 2025, p. 10) and with decades of literature calling for practically applicable science and resonates with scholarship emphasizing relational and place-based knowledge systems (Cooke et al. 2018, p. 204; Long et al. 2020, p. 71) and working with Indigenous knowledge systems (e.g., two-eyed seeing) (Reid et al. 2021, p. 249).

Participants spoke about the need for more opportunities to connect with one another, particularly to share failures and learn from past mistakes (Table 3). While the publication bias towards success in conservation is well documented (Catalano et al. 2019, p. 3), despite consistent calls for disseminating failures (Hobbs 2018, p. 803; Nilsson et al. 2016, p. 7), similar dynamics appear to inhibit reflection in restoration practice. Practitioners expressed a desire for tools to share and access failure case studies, including the idea of a "mistake database" which would enhance large-scale sharing of factors that can go wrong in projects. Drawing on tools from conservation, such as taxonomies of failure (Dickson et al. 2023), could provide a scaffold for shared learning. These insights were most prominent in the diagnosis and planning phases, when projects are shaped by lessons from the past and the uncertainties of the future (Cooke et al. 2024, p. 5). Participants' desire to learn from one another reflects a shared recognition that anticipating common pitfalls and errors (Nilsson et al. 2016, p. 5) can lead to more resilient and adaptable project planning.

Interactive communities that connect partners may be an opportunity for creating meaningful ecological science that is then applied directly to environmental challenges. In this context, the need for communication expressed by the participants was not only about information exchange but about trust-building, shared understanding, and co-producing actionable knowledge. An understanding of the importance of co-production is central to translational ecology – a research orientation which considers both science and practice (Enquist et al. 2017; Hallett et al. 2017). Translational ecology may be a fruitful discipline for operationalizing the mechanisms identified in this research.

Many of the themes that arose in the workshops centered on communication tools that work between researchers and practitioners, practitioners and practitioners, and through sincere engagement with rightsholders, stakeholders, and partners (Table 3). The idea of communication extended beyond person-to-person interactions to digital and organizational tools. Participants described the need for better platforms to support practitioner-researcher communities, despite the existence of many such tools at global (e.g., the Society for Ecological Restoration International's Conversations chat forum), national (e.g., the Suzuki Foundation's Butterfly Way Rangers program), and regionally ecosystem specific (e.g., the Coastal Prairie-Oak Partnership in the Pacific Northwest of North America) scales (for a non-exhaustive list, see **Supplementary Material 3**). Thus, there is a question about exactly what kind of tool is needed, and how dissemination should occur to ensure its accessibility and usefulness. Creating an accessible tool (e.g., databases of successes, failures, and best practices) that documents the outcomes of restoration can theoretically support shared learning (Fabian et al. 2019, p. 96; Heger et al. 2022, p. 6), but the need for such a tool should be grounded in an assessment of the ways in which researchers and practitioners want to collaborate (Beier et al. 2017, p. 293). Existing platforms often operate in silos, with limited integration or user uptake. This suggests a missed opportunity to leverage digital infrastructure more effectively; for example, the Global Restoration Observatory on which the dotmocracy study was based has yet to be integrated into even the largest (and likely best funded) global restoration reporting platform (Google's *Restor*). Participants' needs suggest that future tool development must prioritize accessibility, co-creation, and interoperability, perhaps borrowing more deliberately from the principles of successful commercial product design.

Beyond communication and tools, participants emphasized the need for clear and well-documented goal setting to enhance learning and efficacy in restoration (Table 3).

Unclear or shifting goals were cited as a key source of project uncertainty, which has been argued is a widespread, long-standing issue in restoration ecology globally (Brudvig and Catano 2021). Well-crafted goals have been identified in many domains as important foundations for project planning and successful outcomes (Abrahamse et al. 2007, p. 266), yet they are often unstated or poorly monitored in restoration projects (Prach et al. 2019, p. 920). This challenge echoes long-standing issues in restoration ecology, where diverse motivations and vague objectives complicate the evaluation of success (Ehrenfeld 2000, p. 5). There is such a large diversity of project motivations in restoration (Bayraktarov et al. 2019, p. 3) that measures of success must reflect the specifics of individual project goals. Aligning monitoring efforts with explicitly stated goals would support adaptive management, creating a feedback loop where changing site conditions prompt timely, informed interventions. Participants' prioritization of adaptive management and stakeholder engagement in the dotmocracy exercise reflects this need for clarity and responsiveness. Monitoring against clear benchmarks can allow adaptive management when things begin to veer away from the project targets and can create an early warning system for changing site conditions (Simonson et al. 2021, p. 307). Effective restoration, then, depends not only on sound ecological methods but also on robust processes of goal-setting, reflection, and revision.

Underlying each of these themes — communication, tools and adaptive management (Table 3) — is the inescapable challenge of limited resources. Resource limitations shape who gets to participate, what kinds of questions are asked, and how knowledge is shared. In this sense, co-production of knowledge is not just a methodological choice but a resourcing challenge. Participants suggested holding co-training workshops on funding opportunities, as well as developing resource-sharing mechanisms to reduce duplication and support collective action. Tight connections between people in differing restoration roles are required to effectively "bridge the gap" (Clark et al. 2019, p. 1242), with time needed to exchange knowledge, concerns, co-develop research projects, and tailor general scientific knowledge to context-dependent applications (Jellinek et al. 2021, p. 210). The act of bridging the science-practice gap requires time, trust, and investment—conditions that must be actively cultivated through institutional and financial support. Fundamental barriers to this lofty goal still exist given that some institutions like universities still reward research over application, and practitioner or government groups are often over-stretched and unable to commit the needed time and resources to relationship building.

These findings agree with much of the work that has been done on this topic in the past (e.g., Bertuol-Garcia et al. 2018; Clark et al. 2019), pointing insistently to the need for knowledge sharing grounded in relationship-building as essential to "bridging the gap". There was consistent value placed on boundary-spanning roles—individuals or organizations that facilitate translation, connection, and mediation across research and practice (Gornish and Roche 2018; Cooke et al. 2021, p. 246). Participants' calls for sustained dialogue, shared language, and mutual learning echo the functions typically attributed to knowledge brokers. The emphasis on building communities and aligning perspectives suggests that the social infrastructure of collaboration may be just as important as technical tools or data repositories. The land-based knowledge holder role in the scenario exercise revealed unique priorities, including a focus on participation and sharing diverse knowledge types. These priorities challenge dominant narratives of evidence-based practice and highlight the need for more inclusive, equity-focused approaches to restoration (Dudney et al. 2024, p. 6). Co-design must expand to include co-governance arrangements, recognizing that meaningful engagement with Indigenous and local knowledge systems requires relational approaches, structural changes within and between organizations and communities, and not simply invitations to participate.

5 Towards a relational approach to collaboration in restoration

Participants in both workshops offered a vision of restoration practice grounded in relationships, responsiveness, and mutual respect. They emphasized that bridging the science-practice gap is not only a matter of more data or better models, but of cultivating the conditions under which knowledge is co-created, shared, and acted upon. From communication and goal clarity to adaptive management and equitable participation, these themes form a reinforcing system. Addressing one lever — such as tool development or goal setting — can help shift others, but meaningful progress will require coordinated attention across the system. The science-practice gap is not simply a failure of communication, but a call for transformation in how we work, learn, and restore together.

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Author contributions T.A. and N.S. conceptualized the research and

wrote the main manuscript text; N.S. prepared figures; T.A. and L.R. analyzed transcripts from the exercises. All authors reviewed, edited and revised the manuscript.

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Declarations

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Tim Alamenciak is a translational ecologist working on engagement, open knowledge systems and communities of practice. He has a PhD in Social and Ecological Sustainability with a focus on socio-ecosystem function and renewal from the University of Waterloo. He is a postdoctoral fellow in the Bennett Lab at Carleton University and an adjunct associate professor at the University of Waterloo and a research scientist with the Restoration Futures Lab at the University of Victoria.

Nancy Shackelford is an ecological restoration researcher and educator based at the University of Victoria, where she serves as Academic Director of the Restoration of Natural Systems program. Her work bridges community-driven stewardship, knowledge synthesis, ecological theory, and practical restoration science. She teaches and mentors students across field, classroom, and partner-based projects, supporting collaborative, place-rooted approaches to ecosystem recovery and environmental decision-making.

Logan Rehberg Logan Rehberg's academic background consists of a Bachelor of Science (Honours) in Biology with a specialization in Biodiversity, Natural History, and Conservation Science from Carleton University. Interests include how policy frameworks, land-use practices, and ecological monitoring strategies influence conservation outcomes. Additional interests include wildlife ecology, as well as the development of practical tools for improving environmental management. Experience includes environmental assessment and program support within federal initiatives involving species at risk, invasive species management, hazardous materials management, and ecosystem protection.

Ash Baron Ash Baron holds a bachelors of Environment and Resource Studies and a Certificate of Excellence in Ecological Restoration and Rehabilitation from the University of Waterloo. Her professional private consulting practice focuses on natural heritage planning, terrestrial and aquatic systems, ecological restoration, and climate change adaptation. Ms. Baron has served on the board of the Ontario chapter of the Society for Ecological Restoration since 2012.

Catherine M. Febria (she/her/siya) is an Associate Professor at the University of Windsor and holds a Canada Research Chair in Freshwater Restoration Ecology. She conducts multidisciplinary research on stream restoration, ecosystem ecology and science-policy work at local to global levels. She invests in land-based learning, knowledge co-production and capacity-strengthening among youth and early career practitioners. She serves as a Multidisciplinary Expert Panel with IPBES and Co-Chair of the Indigenous and Local Knowledge Task Force..

Alina Fisher is an ecologist and science communicator focused on conservation and wildlife issues. Her research examines how social media shapes science communication and the barriers that limit its uptake. She writes and speaks on ecology, wildlife, and research methods for academic and public audiences. Alina is Research Manager in UVic's School of Environmental Studies, Associate Faculty at Royal Roads University, and a PhD candidate whose dissertation links wildlife conservation with science communication..

Tina Heger is an ecologist focusing on knowledge synthesis and conceptual research on global change effects and nature conservation. Based at IGB in Berlin, Germany, she is teaming up with computer scientists, philosophers and others to work towards a digital "atlas of knowledge" in which scientific knowledge would be accessible in an actionable form at no cost. She was recently awarded a honorary professorship at Leuphana University Lüneburg, and an adjunct professorship at Technical University of Munich..

Eric Higgs is a professor in the School of Environmental Studies at the University of Victoria and former chair of the Society for Ecological Restoration..

Stephen D. Murphy is a Professor in the School of Environment, Resources & Sustainability at the University of Waterloo. He is the Editor-in-Chief of *Restoration Ecology*. He has helped mentor 200+ graduate students & 1000+ undergraduate students on restoration ecology, ecological restoration, conservation, ecological indicators, ecological monitoring & management for private and public lands. He has led or collaborated on over 300 peer reviewed publications and strategic plans at national and international levels.

Ryan Stephenson is Senior Project Manager for Toronto and Region Conservation Authority with a bachelor's degree in Environment and Resource Studies and a Diploma of Restoration and Rehabilitation from the University of Waterloo. Professional focus on wetland, stream erosion, natural channel design, riparian and aquatic emergent buffer, and upland forest ecological restoration projects in urban and near-urban settings.

Bruno Travassos is a biologist with a PhD in Ecology and a Postdoc in Education. Interested in how research practices and new technologies affect scientific theories, teaching of science at university level, and how theoretical syntheses can be used to close the research-practice gap in Ecology. Currently teaching research practice, community ecology, data science, data analysis related courses at the University of Toronto, Toronto Metropolitan University, and York University in Canada.

Authors and Affiliations

Tim Alamenciak[1,2] · Nancy Shackelford[3] · Logan Rehberg[2] · Ash Baron[4] · Catherine Febria[5] · Alina Fisher[3] · Tina Heger[6,7] · Eric Higgs[3] · Stephen Murphy[8] · Ryan Stephenson[9] · Bruno Travassos-Britto[10]

✉ Tim Alamenciak
tim.a@uwaterloo.ca

✉ Nancy Shackelford
nshack@uvic.ca

Logan Rehberg
rehberg.logan@gmail.com

Ash Baron
ash@terrastoryenviro.com

Catherine Febria
catherine.febria@uwindsor.ca

Alina Fisher
alinaf@uvic.ca

Tina Heger
t.heger@tum.de

Eric Higgs
ehiggs@uvic.ca

Stephen Murphy
stephen.murphy@uwaterloo.ca

Ryan Stephenson
Ryan.Stephenson@trca.ca

Bruno Travassos-Britto
bruno.travassos@gmail.com

[1] School of Environment, Resources and Sustainability, University of Waterloo, Waterloo, Canada

[2] Institute for Environmental and Interdisciplinary Sciences and Department of Biology, Carleton University, Ottawa, Canada

[3] School of Environmental Studies, University of Victoria, Victoria, Canada

[4] Terrastory Environmental, Guelph, Canada

[5] Great Lakes Institute for Environmental Research, Department of Integrative Biology, University of Windsor, Windsor, Canada

[6] Leibniz Institute of Freshwater Ecology and Inland Fisheries, Berlin, Germany

[7] Institute of Biology, Freie Universität Berlin, Berlin, Germany

[8] School of Environment, Resources and Sustainability, University of Waterloo, Waterloo, Canada

[9] Toronto and Region Conservation Authority, Vaughan, Canada

[10] University of Toronto, Toronto, Canada