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PRACTICE INSIGHTS

BRITISH ECOLOGICAL SOCIETY Ecological Solutions and Evidence

Lessons learned from a co-produced field experiment comparing aquatic vegetation removal methods in recreational waters

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Abstract

1. Freshwater ecosystems are facing many complex stressors, from climate change to invasive species, and addressing these issues requires an interdisciplinary, collaborative approach to understand them and develop strategies to mitigate ecosystem harm. Knowledge co-production is an increasingly common approach, where researchers, practitioners and local collaborators (e.g. community members) co-develop a research project that produces actionable outcomes.
2. Here, we demonstrate how this approach was applied to a current ecological and management issue in waterways in Ontario, Canada. Researchers from four academic institutions, practitioners from two agencies and local community collaborators co-developed the Trent-Severn Aquatic Plant Experimental Removal (TAPER) project in the Trent-Severn Waterway, Ontario, Canada, to better understand the ecosystem impacts of aquatic plant removal methods.
3. We identified and applied guiding principles from previous environmental co-production research, which were grouped into six themes: funding, trust building and power sharing, communication, flexibility, skill development and reflection. In this paper, we evaluated the importance of each theme and provided examples of challenges faced regarding each theme and our approach to overcome them.
4. We found that building on pre-existing relationships, consistent communication and having a flexible research team resulted in the ability to overcome many of the major challenges that were encountered during this community-engaged,

co-production project. Including community collaborators contributed to a more robust study design because of the inclusion of place-based knowledge.

5. *Practical implication*. This work builds on previous co-production literature and provides a case study that reveals how challenges were overcome while yielding best practices for future work. We recommend that future projects apply these practices, including building on existing relationships, appointing a designated communication facilitator and setting realistic project expectations early.

KEYWORDS
challenges, community collaboration, co-production, ecosystem approach, guiding principles, macrophyte removal

1 | INTRODUCTION

Knowledge co-production is 'an iterative and collaborative process that brings together diverse actors to create integrated, context-specific and goal-oriented knowledge through mutual learning' (Cooke et al., 2024, p. 2). Involving practitioners (policymakers and resource managers) and community members in research, from planning and goal setting through to analysis and interpretation, increases the actionability of project findings and narrows the knowledge–action gap (Beier et al., 2017). As co-production grows in environmental research, we are learning its benefits, which include increased relevance and applicability of the work, increased uptake of knowledge by practitioners, reduced waste of effort in applied research, increased inter-personal trust between partners and broadened perspectives of all participants (Chambers et al., 2021; Cooke et al., 2021; Nel et al., 2016). However, as with any approach, there are unique challenges with co-production. Co-production is resource intensive; it requires specific skill sets; the academic incentive structures are not optimal for knowledge co-production; and it may induce bias from inclusion of practitioners in the study design (Beier et al., 2017; Cooke et al., 2021; Djenontin & Meadow, 2018). Thus, there is a need to contribute to 'lessons learned' and conditions that enable co-production to support alleviating existing challenges (van Maurik Matuk et al., 2023). Previous work on environmental co-production reflects on various projects and identifies guiding principles, recommended practices and major challenges associated with this work. Here, we highlight practical lessons and enablers for co-production categorized into six themes: funding, trust building and power sharing, communication, flexibility, skill development and reflection.

2 | THE CO-PRODUCTION CASE

Nearshore habitat and freshwater life hold essential cultural and social value and thus cannot be managed without considering impacts on local communities (Lynch et al., 2023). Managed and artificial lakes, in particular, are experiencing accelerated shoreline development, especially since the COVID-19 pandemic (Peiman et al., 2024; Weeden, 2020). Waterfront property owners and other users are important stakeholders to consider in environmental decision-making and research, as lake/river conditions affect recreational opportunities, nutrition from fish and property values (Calderón-Arrieta et al., 2019; Clapper & Caudill, 2014). Excluding property owners' priorities and perspectives may result in negative perceptions of environmental practitioners and researchers and, ultimately, outcomes that are not socially robust (Davis & Andrew, 2017). In some cases, these negative feelings can manifest in property owners taking adverse actions such as removing aquatic plants, which can have negative impacts on the aquatic ecosystem (Mistry et al., 2023; Thiemer et al., 2021). Alternatively, community involvement in research and decision-making can increase compliance with environmental regulations and involvement with local environmental organizations (e.g. lake associations, stewardship groups, Hsu et al., 2019; Toomey & Domroese, 2013).

The Kawartha Lakes are a set of mostly interconnected lakes in the Trent-Severn Waterway (TSW) National Historic Site of Canada, a waterway that connects Lake Huron at Port Severn in Georgian Bay to Trenton in central Lake Ontario, Canada (Figure 1). Several Indigenous communities have lived in harmony with the land and waters of the Kawartha Lakes region for millennia. The area and connectivity of these lakes were increased through construction of a series of locks and dams in the late 19th and early 20th centuries, but since the mid-1950s, they were primarily developed for recreation, including seasonal cottages and resorts, as a key part of the local tourism economy (City of Kawartha Lakes, 2021). In recent years, there has been a substantial increase in the year-round resident population of the Kawartha Lakes (Kawartha Conservation, 2014, 2015, 2016), and this trend is expected to continue as the southern Ontario population ages and retires outside of major cities, including Toronto which is approximately 90 min away (Weeden, 2020).

Increasing shoreline development will likely impact the health of these lakes with detrimental impacts, such as eutrophication and reduced biodiversity, already apparent in many locations (Smith et al., 2021; Smith & Kirkwood, 2022). Aquatic plants (macrophytes), which grow in abundance in many of these shallow, meso-eutrophic lakes, are an element of special concern in this region. Although macrophytes play a key role in the ecosystem for nutrient cycling and providing habitat for various species, they are negatively perceived

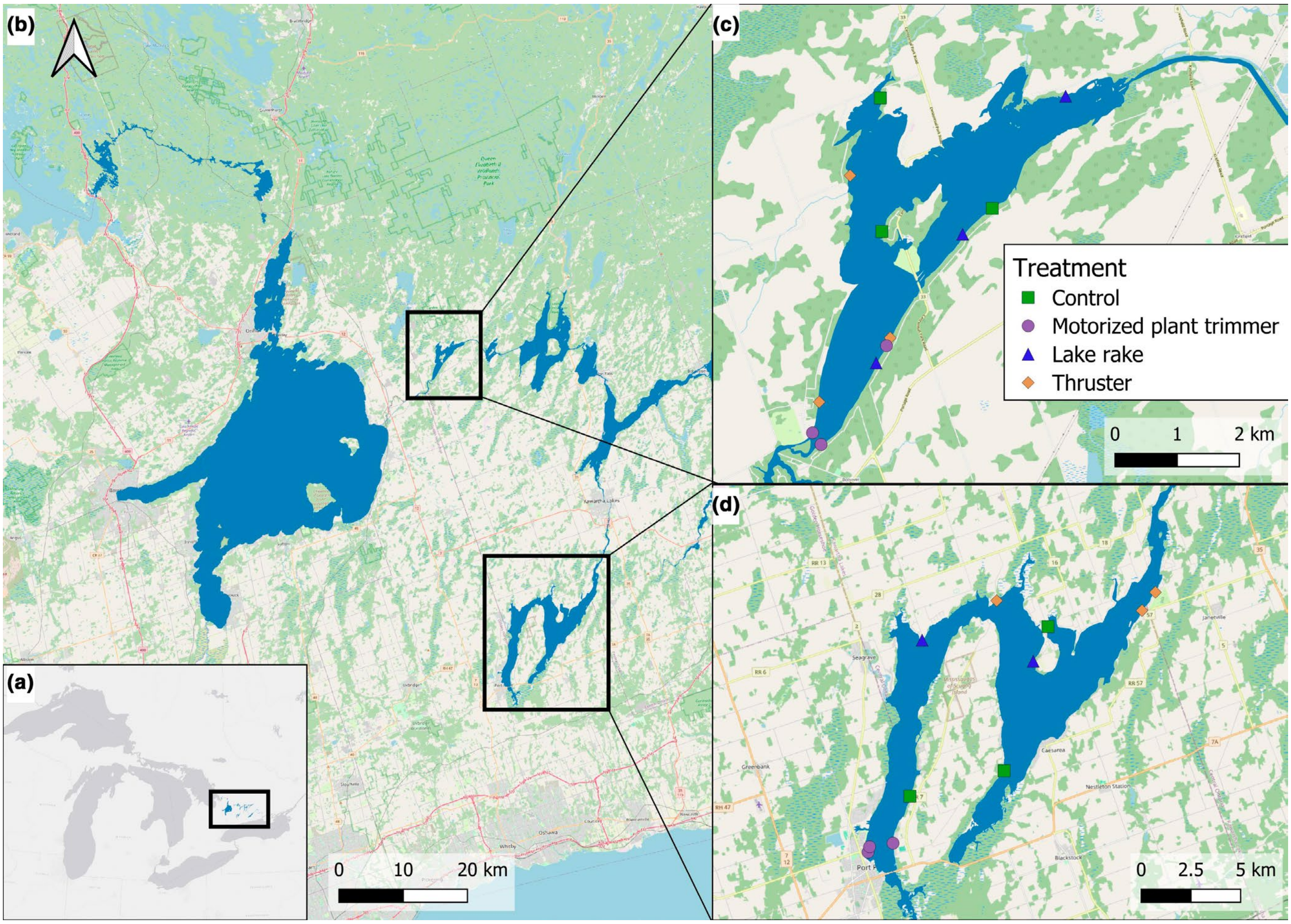

FIGURE 1 Map of (a) the location of the Trent-Severn Waterway within the Great Lakes region and (b) the lakes and canals of the Trent Severn Waterway, and sampling sites for (b) Canal Lake and (c) Lake Scugog with treatments (control, motorized plant trimmer, lake rake and thruster) labelled per site. Basemap panel (a) from ESRI (2024), basemaps panel (b–d) from OpenStreetMap (2024).

by many residents because of their impacts on boating and swimming. The increasing abundance of invasive macrophytes is also impacting lake ecosystem structure and function (Harrow-Lyle & Kirkwood, 2022; Hicks & Frost, 2011). With a growing population of residents motivated to remove aquatic plants, it is essential to better understand their role in nearshore lake ecosystems and how various plant removal methods may impact the nearshore ecosystem as this knowledge will help inform environmentally sustainable practices.

3 | PROJECT OVERVIEW: TRENT-SEVERN AQUATIC PLANT EXPERIMENTAL REMOVAL

The Trent-Severn Aquatic Plant Experimental Removal (TAPER) research project involved academic research groups, federal and municipal regulatory agencies (practitioners) and community collaborators (Figure 2). The project concept was developed by building on previous conversations between partner organizations on shared concerns about property–owner macrophyte removal methods and gaps in understanding ecosystem effects of such methods. The researchers and practitioners co-developed an application for and received a Natural Science and Engineering Research Council (NSERC) Alliance Missions Grant to monitor ecosystem impacts to an experimental plant removal in two Kawartha Lakes. Once the grant was received, local practitioners and researchers reached out to engage community members (community science volunteers and members of lake societies) for interest in having their waterfront included in the experiment which was expressed through an interest form. The interest form was distributed after the grant was received in the spring of 2023 and included nine questions with four subquestions about water access, submerged aquatic cover and previous removal efforts at their property (Appendix A). Practitioner and researcher partners (principal investigators and early career researchers) worked together to develop methodology for the project, settling on a before-after control-impact (BACI) design (Underwood, 1992) to best isolate the impacts of experimental plant removal methods. Community collaborators provided researchers with access to sites and provided site background information on macrophyte abundance and previous aquatic plant maintenance. Using information from property owners and local researchers and practitioners, sites were selected to ensure the appropriate distribution of experimental plant removal methods and control sites within each lake (Figure 1).

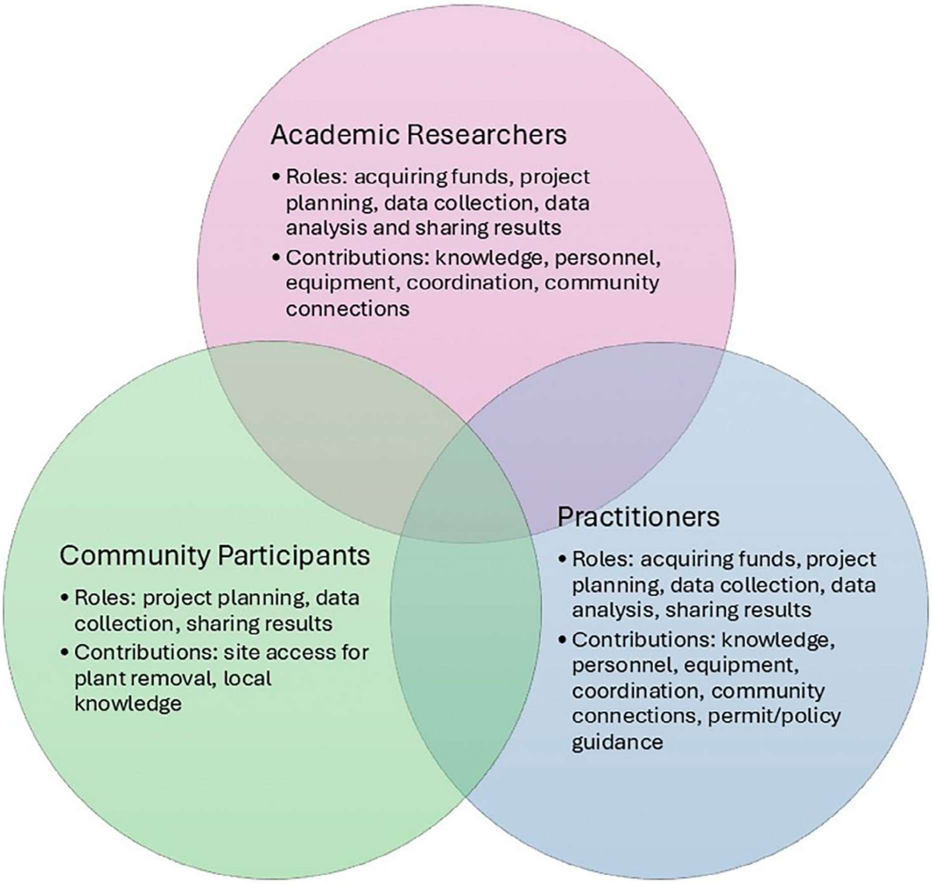

FIGURE 2 Roles and contributions for each type of partner involved in the Trent-Severn Aquatic Plant Experimental Removal (TAPER) project.

During the summer of 2023, researchers conducted four sets of biweekly monitoring before and after plant removal and surveyed various ecosystem components including water quality, bioacoustics and phytoplankton, zooplankton, macroinvertebrate, macrophyte and fish communities. The fieldwork component of the project was primarily led by graduate students and post-doctoral fellows. Plant removal was a collaborative activity involving joint equipment purchasing and vegetation removal by practitioners and researchers. Following completion of the fieldwork, practitioners continued to collaborate with researchers compiling and sharing findings to extract novel research findings and policy implications. Through reflection on this collaborative project, some key lessons learned for implementation of applied knowledge co-production were identified that build on previous work in aquatic co-production research, and these lessons are shared here, categorized in six emerging themes from our experiences.

4 | RESULTS AND DISCUSSION

4.1 | Theme 1: Funding

Funding is one of the top barriers to knowledge co-production and difficult to overcome because it requires systemic changes in academic reward structures. Traditional funding streams often favour theoretical advancements with short-term investments in individual projects. Incentive structures are also misaligned with co-production, favouring academic publications and presentations as key performance indicators. These structures are not well aligned with knowledge co-production, which is often applied research that takes additional time for relationship building and where dissemination of results to stakeholders and integration of findings into policy action are the key outcomes (Cooke et al., 2021; Djenontin & Meadow, 2018; Rölfer et al., 2022).

This project was a component of a larger project titled 'Generating actionable science to inform sustainable freshwater ecosystem use and shoreline development in Canada in the face of increasing human pressure' that was funded through an NSERC Alliance Missions grant. Alliance grants specifically fund collaborative research between a Canadian academic institution and private, public or not-for-profit partner organizations, with the goal to bring together diverse skill sets and perspectives for economic, environmental or social benefit (Natural Sciences and Engineering Research Council of Canada, 2025). The grant application benefitted from pre-existing relationships between the practitioners and research groups. Due to communication pathways and trust built from previous projects, the partners were able to collaborate on writing the application and develop novel research questions that addressed priorities from all partners. Access to this dedicated fund for building partnerships allowed for effective project budgeting over an appropriate timeline for knowledge co-production. While the NSERC Alliance grant is a Canada-specific funding example, more generally, grants that prioritize collaboration, especially with local partners, are recommended as funding pathways. Additionally, funds that allow for flexibility on timelines and allow for engagement metrics as key performance indicators better fit with co-production research approaches.

4.2 | Theme 2: Trust building and power sharing

When involving academic researchers, governmental agencies and community members, there are often conflicting interests and power imbalances that complicate relationships (Beier et al., 2017; Cooke et al., 2021; Reed & Abernethy, 2018; Rölfer et al., 2022). Each party may have unique goals, values and uses of the environment for various ecosystem services: when these do not align, there is potential for negative interactions and a breakdown in communication. Previous work identified trust building as a mechanism to avoid these challenges (Cooke et al., 2020; Djenontin & Meadow, 2018). Trust building requires open and honest conversations and can also involve building on pre-existing relationships, spending time with communities and participating in community activities unrelated to the research (Campbell et al., 2016).

In this project, each group approached the work with different motives. The academic researchers aimed to understand the impacts of aquatic plant removal on nearshore ecosystem health. Practitioners wanted to understand the impacts of current plant management strategies relative to new technologies. Based on volunteer registration form responses and previous discussions, most community members were interested in learning how best to limit excessive plant growth. While these objectives may conflict with each other, we followed advice from previous reflections on co-production to be open and honest about the goals of each group (Beier et al., 2017; Cooke et al., 2020). An open communication resulted in outlining potential benefits for all groups and agreement on study design among the partners.

In practice, maintaining this trust and open communication depended on a foundation of credibility with the community collaborators. Kawartha Conservation (the local conservation authority) and the Kirkwood Lab (local research group) had over 10 years of experience with community collaborators maintained through consistent communication (Kawartha Conservation, 2015, 2023; Smith et al., 2021). Many of these local practitioners and researchers were also residents of the region or have personal connection to the region and were able to act as boundary spanners, building trust as evidenced by continued requests for talks, plain language summaries and research on the lakes (Neal et al., 2023; Nel et al., 2016). This trust allowed the TAPER project to bring in new partners and investigate emerging questions about the nearshore habitat in these lakes. This was especially important because of existing negative perceptions of regulatory agencies, whose role is to manage the system and enforce limits on aquatic plant removal by community members. To reduce perceived power dynamics, researchers engaged with both community collaborators and practitioners when developing project methods, throughout sample collection, and to disseminate results (Beier et al., 2017; Cooke et al., 2021; Djenontin & Meadow, 2018). Practitioners and community collaborators were especially involved with the development of methodology as it relied on practitioners' knowledge of macrophyte removal restrictions, local context for removal and property-owners information about past removals and macrophyte abundance. Based on this work, it is recommended that future projects engage boundary spanners and build on pre-existing relationships to build trust between partners. Boundary spanners are organizations or individuals that work with partners from both sides of the boundary (i.e. academic and community member) and can be found by mapping the organizations working in the area of interest and identifying those with overlapping interests, often these are non-profit organizations or community groups with strong local connections (Neal et al., 2023). Additionally, if pre-existing relationships do not exist, we recommend taking time before initiating a project to connect with organizations of interest, attending their events and finding ways to support and understand their priorities.

One limitation of the TAPER project was the lack of Indigenous engagement. One of the local environmental organizations works with the Mississauga's of Scugog Island First Nation, and researchers have shared information through that connection; however, there was not a true co-production engagement. As such, we recommend that future co-production build relationships and engage with interested Indigenous communities early in development of co-production projects to ensure respectful relationships and trust is established (Cooke et al., 2021; Grimm et al., 2025).

4.3 | Theme 3: Communication

Communication is consistently mentioned as a best practice for knowledge co-production (Beier et al., 2017; Cooke et al., 2021; Djenontin & Meadow, 2018; Reed et al., 2014); however, it can be a challenge as researchers are primarily trained for technical communication that may not reach or be accessible to non-academic audiences. As such, two pathways to overcome these types of issues have been suggested: (1) use facilitators to improve intergroup communication and (2) better training in science communication and collaboration (Cooke et al., 2020; Grimm et al., 2025; Reed & Abernethy, 2018).

Regular engagement with community collaborators and practitioners was necessary for project success and benefitted the study design. A member experienced in working with community collaborators and practitioner partners was designated as the project facilitator to streamline communication. The consistent voice from the research team likely eased community members' apprehensions about working with the researchers and practitioners, allowing for multi-directional communication (Neal et al., 2023;

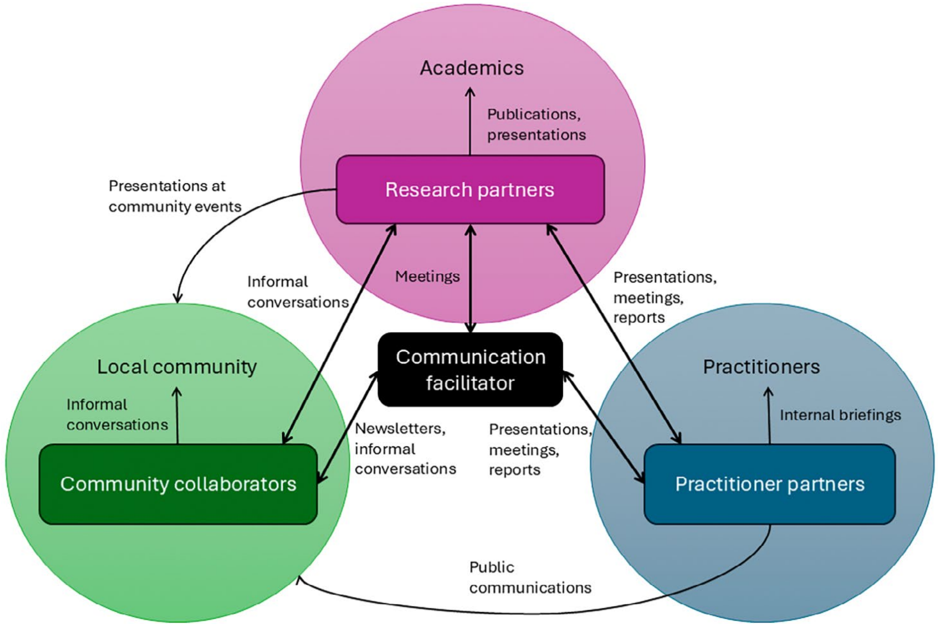

FIGURE 3 Communication pathways connecting Trent-Severn Aquatic Plant Experimental Removal (TAPER) project partners and their broader communities; arrows demonstrate the direction of information flow with labels as examples of how this information is exchanged.

Figure 3). This trust was evidenced in the response of community collaborators to an unexpected schedule change due to logistical issues. When the facilitator informed community collaborators of the schedule change, they all responded positively, allowing access to their property at the rescheduled date. Additionally, practitioner partners expressed interest in continuing to collaborate with researchers on research to follow up on research questions that came from the TAPER project.

This clear communication pathway also allowed community collaborators that were long-term residents of the lake to give researchers valuable insight into past patterns on the lake, which helped to inform sampling design. For example, some community collaborators informed the researchers that their site commonly received severed and washed up macrophyte stems from other locations on the lake. This insight supported researchers in the quantification of aquatic vegetation so that they could exclude any macrophytes that appeared uprooted, cut or dead as likely originating from other sites on the lake. The collaboration with community members and openness from researchers to local knowledge improved the study design, highlighting the benefits of a transdisciplinary approach. Thus, we recommend that future co-production projects assign a dedicated person, ideally with previous experience in co-production, to coordinate communication between partners.

4.4 | Theme 4: Flexibility

Flexibility can be a mechanism to overcome some of the major challenges to knowledge co-production related to funding structures, timelines and research methodologies (Beier et al., 2017; Djenontin & Meadow, 2018). Funding barriers were overcome with a specialized, collaborative funding stream as described above, but other issues arose that required flexibility, including study design.

For this project, there were many unknowns about applying the proposed plant removal methods, as multi-method aquatic plant removal projects are not common (Thiemer et al., 2021). One planned plant removal method, the aquatic plant harvester treatment, required hiring a commercial harvesting company with appropriate insurance and fees within the project budget. Initially, the service was secured through a contract with a local service provider, but issues regarding timelines and insurance resulted in the loss of that provider a few weeks prior to the planned treatment application. However, due to the consistent communication between project partners and engagement with local knowledge holders, an alternative plant removal method was quickly acquired. One of the researchers was a property owner on an adjacent lake and suggested using a motorized aquatic plant trimmer. While plant removal had to be delayed by a week and this plant removal method likely had different impacts than the aquatic plant harvester, using the trimmer fit within timeline and budget constraints—and importantly—trimmers are used by local community members. This highlights one of the advantages of a transdisciplinary approach, where researchers and partners contribute knowledge to develop solutions to real-world issues (Wickson et al., 2006). Along with the transdisciplinary approach, flexibility and effective communication provided a pathway to overcome a major challenge to project implementation. In the future, we recommend that partners set expectations early that changes to plans are likely and that partners should remain open minded to new ideas throughout the project.

4.5 | Theme 5: Skill development

There are specific challenges associated with co-production research that requires skills that are not usually prioritized in academic training (Djenontin & Meadow, 2018; Rölfer et al., 2022). The primary challenges cited are a lack of time to invest in important relationships with project partners and a lack of skills for working collaboratively with non-academic partners. Although these challenges are real, involvement in co-production research, connection with mentors and formal training provide opportunity to learn these skills (Beier et al., 2017; Cooke et al., 2021).

Given the short study timeline (i.e. one field season), this project benefitted from principal investigators and practitioner partners that had extensive experience working with each other and others on co-production projects. These experienced project leaders allowed those without previous experience, especially early career practitioners (ECPs; students and post-doctoral fellows), to learn from mentors, especially in their approach to project planning and communication. The collaborative approach to project design provided insights on how to co-develop research approaches that consider knowledge from academics and practitioners with management and local knowledge. Most researchers had some experience in science communication through previous involvement in community-engaged research, which they built-upon by learning from examples from mentors and local practitioner partners. The interdisciplinary project also provided opportunities to learn new technical skills. Researchers from the various academic institutions had the opportunity to work together in the field to collect a diverse array of data types while learning about the use and implications of each sampling methodology. Along with the opportunities for skill development, we also identified challenges with working in a large team, specifically with the need to consider objectives of multiple researchers and logistical constraints when adjusting study design. Some of these challenges were overcome with supervisors setting clear expectations for ECPs about project outcomes and timelines. While this project benefitted from the involvement of mentors that provided training and examples, it is recommended that future work seek formal training opportunities, such as science communication or project management workshops or micro-credentials. Additionally, we found that informal learning opportunities such as involvement in local environmental events provided a chance for researchers to improve their science communication skills and build relationships with the local community and practitioner partners.

4.6 | Theme 6: Reflection

Reflection is a key element of knowledge co-production which requires evaluation of processes and outcomes at key points in the project (Chapman & Schott, 2020; Cooke et al., 2021). Internal reflection during the project should focus on partner interactions and the impacts of the work to ensure that the research contributes to building relationships and meeting project goals (Djenontin & Meadow, 2018; Mach et al., 2020). Sharing these reflections widely is an important way to provide guidance for others looking to follow the approach and to improve the practice of knowledge co-production itself (Beier et al., 2017).

The TAPER project team reflected on progress and shared lessons learned through various means at different points in the project. Following the highly collaborative fieldwork component of the project, researchers followed up with partners to share progress and receive feedback on data analysis through virtual team meetings where each researcher provided updates on their progress, and practitioners and researchers discussed next steps. Second, progress was also shared with the wider community through a virtual mini-symposium day where regional practitioners, community members and researchers were invited to hear about the TAPER project and associated research projects. This event proved to be of interest to community members as ~175 people from the region attended the hybrid event. Researchers also shared reflections on the TAPER co-production process at an academic conference, Society of Canadian Aquatic Sciences (SCAS) in 2025, with multiple project members sharing their lessons learned from the project. Finally, this manuscript represents a compilation of those reflections by partners to share lessons learned from this work with the scientific community. Based on this approach, we recommend booking meetings with dedicated time for reflection on progress and actively finding avenues to share reflections from the process, such as conference sessions or journal special issues dedicated to co-production.

5 | CONCLUSION

We demonstrate how six common themes in environmental co-production research were applied to an experimental plant removal project that involved community collaborators. We found that some themes presented more challenges than others and overall, the project benefitted most from building on pre-existing relationships, consistent communication, and flexibility. We exemplified some of the broader benefits of this approach, including increased collaborative networks, trust building and skill development. Additionally, by involving local community collaborators, we gained insights because we were given access to both the environment of interest and place-based knowledge. Future work would benefit from early consideration (i.e. at project initiation) of these six themes within the context of other potential challenges that may arise: developing strategies to overcome the main challenges can begin by applying these and previously identified best practices. Specifically, we recommend building on pre-existing relationships, engaging boundary spanners and setting realistic project expectations early and with all partners. As co-production is increasingly accepted as a scientific approach for environmental research, best practices will continue to improve the process and maximize the benefits for research and management.

AUTHOR CONTRIBUTIONS

Erin D. Smith, Valerie Minelga, Chantal Vis, Brett Tregunno, Robert Bailey, Vivian M. Nguyen, Colin Rennie, Stephanie J. Melles, Steven J. Cooke and Andrea E. Kirkwood conceived the ideas and designed the methodology. Erin D. Smith, Flavia Breje, Alana Tyner, Sarah Rijkenberg and Husnah Azmi conducted the investigation. Erin D. Smith led the visualization. Erin D. Smith, Flavia Breje, Alana Tyner, Sarah Rijkenberg, Husnah Azmi, Steven J. Cooke and Andrea E. Kirkwood led the writing of the manuscript. Valerie Minelga, Chantal Vis, Brett Tregunno, Robert Bailey, Vivian M. Nguyen, Colin Rennie, Stephanie J. Melles, Steven J. Cooke and Andrea E. Kirkwood provided resources, supervision and funding acquisition. All authors contributed critically to manuscript drafts, reviewed and edited the manuscript and gave final approval for publication.

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CONFLICT OF INTEREST STATEMENT

The authors declare that there are no competing interests regarding this work.

PEER REVIEW

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DATA AVAILABILITY STATEMENT

No data were used in this article.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Supporting Information S1. Volunteer shoreline property owner questionnaire.

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