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PRACTICE AND TECHNICAL ARTICLE

Dimensions of effective volunteer restoration techniques in North America

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Key voices in ecological restoration are advocating for participatory, community-based practices to lower costs, enhance resilience, and improve outcomes by engaging volunteers in restoration practice. We reviewed methods from 19 studies that focused on techniques that specifically involved volunteers. Our review identified metrics of success (e.g. establishment, cost savings) and limitations (e.g. ability to scale) to understand what attributes constitute an effective restoration technique in the context of community-led efforts. The results from a survey of practitioners ($n = 82$) validate and expand the findings by identifying important criteria that are not studied in the literature (safety), by clarifying modes of technique transmission (e.g. word-of-mouth) and by highlighting key areas of work where volunteer capacity is often directed (e.g. invasive species removal, planting). We conclude with a set of criteria that can be applied to develop and evaluate techniques for evidence-based ecological restoration by volunteers. This work helps managers choose scientifically sound techniques and further accumulate evidence for volunteer-driven restoration.

Key words: conceptual framework, evaluation, implementation, knowledge mobilization, restoration techniques, volunteer engagement

Implications for Practice

- When describing techniques that are appropriate for volunteers in restoration, safety should be emphasized or at least discussed.
- Impact, effort, safety, cost, cultural fit, and mobilization are factors that should be evaluated and considered when assessing or studying volunteer ecological restoration techniques.

Introduction

Ecological restoration as a practice engages both trained professionals and community volunteers to assist in the recovery of ecosystems that have been degraded, damaged, or destroyed (Keenleyside et al. 2012; Gann et al. 2019). This involves diverse actions such as planting, removing invasive species, and creating abiotic landscape changes to achieve restoration goals. There are myriad ways for volunteers to be involved, but there are no general guidelines based on the available literature.

Volunteer techniques are employed in a vast range of ecosystem types – from aquatic systems to terrestrial, temperate, and arid. Volunteers have been engaged in activities from interventions like building and deploying buoys containing eelgrass (*Zostera marina L.*) (Pickerell et al. 2005) to monitoring grassland recovery (Schulze et al. 2009). Volunteer engagement in ecological restoration has the potential to help achieve ecological and social goals, spread ecological knowledge and awareness, and also address social factors, such as power imbalances, which can potentially inhibit restoration success (Fox & Cundill 2018). However, while techniques are widely deployed among volunteers, it is not clear which criteria make one technique more "effective" at achieving these ecological and social goals. Broad guidelines for effective volunteer restoration techniques could ensure that ecological effectiveness is balanced with concerns related to the potential for the use of the technique by volunteers. These guidelines could inform future studies of the effectiveness of volunteer techniques and provide more clarity around what exactly constitutes an effective technique and on which metrics techniques are to be evaluated on.

The effectiveness of ecological restoration is a frequent subject of study (e.g. Haskell et al. 2018; Gerwing & Plate 2019; Nolan et al. 2021); however, in large-scale studies that evaluate whether restoration achieved its goals, little consideration is given to whether restoration is implemented by paid staff or volunteers (Jones et al. 2018). "Effectiveness" can be understood as the degree to which a restoration project achieves its goals. There is limited consideration of social goals and volunteer

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engagement among restoration practitioners (Walpole et al. 2020). Practitioner-oriented resources (e.g. Short 2018; Wheaton et al. 2019; Mueller et al. 2021) provide instructions for volunteers to use a technique, but the peer-reviewed literature has lagged behind in studying the potential of such techniques to both engage volunteers and restore ecosystems. When volunteer restoration techniques are studied and documented in the peer-reviewed literature, criteria beyond ecological measures are examined, but not rigorously so (Schulz et al. 2012; Haight et al. 2017). A framework of criteria for volunteer restoration techniques would help researchers rigorously examine the contribution of volunteer techniques to social goals and, more broadly, to the effectiveness of restoration. Additionally, this framework will clarify what exactly constitutes an effective volunteer restoration technique by examining criteria other than biological efficacy.

This paper reviews existing literature evaluating ecological restoration techniques used by volunteers and surveys volunteer managers to create a framework that describes criteria for effective and suitable volunteer ecological restoration techniques. These criteria consider both practitioner and researcher perspectives by combining a literature review with a survey. The resulting criteria can be used to communicate and research volunteer restoration techniques.

Methods

We conducted a survey that solicited the perception of volunteer managers on the criteria that are considered when implementing restoration techniques and also their experience with information transmission. A web-based survey was chosen because the population being surveyed is dispersed across North America, and web-based surveys allow for rapid deployment and effective response gathering (Rea & Parker 2014). North America was chosen because the practice of volunteering is similar in Canada and the United States, but may vary in other countries (Hustinx et al. 2010). The survey was designed and administered using the online survey platform Qualtrics. This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Board (REB 44185).

Recruitment

Participants for the survey were recruited electronically using targeted distribution and snowball sampling (i.e. asking participants to circulate the survey among other volunteer managers) (Parker et al. 2020). The Society for Ecological Restoration sent recruitment materials through its mailing list, and large volunteer-driven organizations—such as the Audubon Society, Nature Conservancy, and Ducks Unlimited—were targeted directly through publicly listed employees. Participants were also asked to forward the survey to other conservation professionals.

Survey Development

Studies of ecological restoration techniques that can be used by volunteers emerged as a secondary result from a systematic scoping review of volunteer motivation (Alamenciak & Murphy 2024). A corpus of 22 articles was extracted from the original review that describes the techniques employed by volunteers in ecosystem restoration projects. The original review searched Web of Science, Scopus, Google Scholar, and ProQuest Dissertations and Theses Global for the following search terms:

> "restoration ecology" OR "eco* restoration" OR "environment* restoration" OR "habitat restoration" OR "eco* remediation" OR "environment* remediation" OR "habitat remediation" OR "eco* reclamation" OR "environment* reclamation" OR "habitat reclamation" OR "eco* rehabilitation" OR "environment* rehabilitation" OR "habitat rehabilitation" OR "rewild*" OR "re-wild*" OR "reforest*" OR "re-forest*" OR "conservation") **AND** "motiv*" **AND** ("participation" OR "volunt*" OR "engagement" OR "citizen."

The searches yielded 2,058 unique results, which were reviewed. While the primary objective was to retrieve studies that examined volunteer motivation, studies that focused on volunteer techniques were also extracted for analysis.

Several key themes emerged during the literature review that informed the design of the survey (Table 1). Additional themes (e.g. safety) were added by the authors based on their experiences managing volunteers in restoration projects. Questions for the survey were developed by the authors and piloted with individuals who have experience managing volunteers in ecological projects. The survey consists of multiple choice, Likert, and short answer questions (Table 1).

Results

Literature-Derived Criteria

The literature review revealed five core criteria that were highlighted when researchers studied volunteer ecological restoration techniques: training required, after-care required, physical effort required, cost, and cultural linkages (Table 2). Studies indicated that volunteer managers prefer techniques that require minimal advanced knowledge (e.g. Chiu et al. 2020). The studies also revealed that techniques that require little maintenance were preferred, since those should involve less of a time commitment from volunteers (e.g. Haigh et al. 2015).

Ecological restoration can be labor-intensive, with techniques like invasive species removal sometimes requiring the use of heavy tools. Volunteer-appropriate techniques discussed in the literature emphasized the need to minimize the intensity of labor (e.g. Haight et al. 2017). It was also important that techniques be low-cost for the community and use common materials (Cruz et al. 2014).

Finally, several studies discussed the role that cultural linkages could play in volunteer techniques. For instance, a study of coppicing described the technique as promising because of

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Table 1. Survey questions.

Question Number	*Question*	*Possible Responses*
1	Which type of organization do you belong to? (Select all that apply)	Non-governmental organization, Government, Consulting company, Land trust, University/College, Other
2	In which country do you primarily work?	Free text
3	In which province/state do you primarily work?	Free text
4	On average, how many volunteers do you manage per project?	Free text
5	In which ecosystem types do you most frequently conduct restoration projects? (Select all that apply)	Forest, grassland (e.g. prairie, meadow, savannah), wetland (e.g. bog, swamp, fen, peatland), freshwater river, freshwater lake, ocean/coastal, other
6	On average, what percentage of tasks are completed by volunteers in an ecological restoration project?	Percentage slider
7	Which tasks do volunteers typically participate in on restoration projects? (Select all that apply)	Planting nursery stock, seeding, invasive species removal, monitoring (e.g. citizen/community science), restoration design and planning, outreach, trail maintenance, other
8	Which factors are important to consider when designing volunteer restoration activities?	From Very Unimportant (0) to Very Important (5): Accessibility, Cost, Ecological effectiveness, Educational opportunity, Visible impact, Physical effort required, Safety, Supervision needs, Time commitment, Training required, Other
9	Which sources are important for planning volunteer restoration activities?	From very unimportant (0) to very important (5): Advice of peers and mentors, government documents, history of use, organizational policy, peer-reviewed journals, personal experience, traditional ecological knowledge, other
10	Are restoration projects evaluated after completion?	Yes, no, sometimes, other
11	If yes to the above, does the project evaluation measure the success of restoration activities performed by volunteers?	Yes, no, other
12	How do you measure success in volunteer restoration activities? (Select all that apply)	Ecological indicator (e.g. number of trees planted), project-specific indicators, number of volunteers, number of returning volunteers, feedback forms, informal feedback from volunteers, other
13	Is there anything you wish to add about the use of volunteers or designing restoration techniques?	Free text

its connection to cultural values in the community where it was used (Terada et al. 2010).

Survey Results

We received a total of 87 complete survey responses. We removed 5 surveys for originating outside North America, leaving 82 responses for the final analysis.

Responses were submitted by volunteer managers working at nongovernmental organizations (NGOs) ($n = 31$; 38%), government ($n = 23$; 28%), universities/colleges ($n = 13$; 16%), consulting companies ($n = 8$; 10%), and conservation authorities ($n = 8$; 10%). Responses were geographically distributed, with 62.2% ($n = 51$) of respondents reporting they work primarily in the United States and 37.8% ($n = 31$) of respondents working primarily in Canada. Respondents reported they used an average of 11 volunteers per project and predominantly worked in forest ($n = 49$), grassland ($n = 35$) and wetland ($n = 32$) ecosystems. On average, volunteers completed 40% of the tasks in a given project. Those tasks most frequently included invasive species removal ($n = 63$), planting nursery stock ($n = 58$) and monitoring ($n = 42$) (Table 3).

We surveyed volunteer managers on the criteria derived from the literature (Table 2) and additional possible criteria that were identified by the study authors. The Likert scale responses for Question 8 (Which factors are important to consider when designing volunteer restoration activities?) tended to be high for all factors (i.e. somewhat important or very important) (Fig. 1).

Safety emerged as a primary factor that was not revealed by the literature review. The majority of respondents ($n = 62$; 76%) rated safety as "very important." Both safety and supervision needs (i.e. how much supervision is required for a given technique) had a median rating of 5, while the remaining factors had a median rating of 4 (Table S1).

When responding to the question "Which sources are important for planning volunteer restoration activities?" Most volunteer managers rated their own personal experience of a given technique as "very important" ($n = 41$; 50%) or "somewhat important" ($n = 29$; 35%) (Fig. 2). Personal experience received the highest median score (5) of all the information sources.

Other information sources, such as advice from peers and mentors and history of use, had a median score of 4. Traditional ecological knowledge and organizational policy also had

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Table 2. Literature-derived criteria.

Criteria	*Example quote*	*References*
Training required	"We present a simple procedure to collect, transport, sort, pretreat, and germinate Wigeongrass seeds. The users of the protocol need minimal preknowledge, skills, or special equipment" (Cho & Biber 2010)	Pickerell et al. 2005; Cho & Biber 2010; Forrester et al. 2011; Chiu et al. 2020
After-care required	"The objective, therefore, is to develop forestation strategies that are efficient, effective, reliable, low maintenance and fit for purpose" (Haigh et al. 2015)	Haigh et al. 2015; Schulz et al. 2012
Physical effort required	"Due to the similar impacts of cutting and rhizome removal treatments on knotweed abundance, we recommend that cutting alone be used as a mechanical management technique, and that the hard-work of digging out roots and rhizomes may not be necessary" (Haight et al. 2017)	Haight et al. 2017; Pickerell et al. 2005
Cost	"Because the methods tested are simple and cheap, they could be used by volunteer recreational divers to restore locally extirpated A. palmata populations or to enhance reefs where natural recovery is slow" (Forrester et al. 2011) "In conclusion, rehabilitation intervention is likely to succeed when reef-users are involved (as also observed in related studies, e.g. Meñez et al., 1998, 2012) and when it is affordable and cost-effective for the community" (Cruz et al. 2014)	Forrester et al. 2011; Toh et al. 2017; Cruz et al. 2014
Cultural linkage	"Our research, as well as that of Nielsen and Møller (2008), confirms that coppicing is a promising direction for urban forestry that weaves together historic and current socio-cultural values" (Terada et al. 2010)	Terada et al. 2010; Rossi-Snook et al. 2010; Schmidt et al. 2019

Table 3. General question responses.

Question	*Response summary*
Which type of organization do you belong to?	NGO—31 Government—23 Other—14 ("conservation authority"—8) University/college—13 Consulting company—8 Land trust—4
In which country do you primarily work?	Canada—31 United States—51
In which province/state do you primarily work?	Top responses: Ontario (22), California (8), Wisconsin (6)
How many volunteers do you manage per project?	Average: 11 (range: 0–40)
In which ecosystem types do you most frequently conduct restoration projects?	Forest—49 Grassland—35 Wetland—32 Freshwater river—25 Other—17 Freshwater lake—9 Ocean/coastal—6
On average, what percentage of tasks are completed by volunteers in an ecological restoration project?	Average: 40% (range: 0–100%)
Which tasks do volunteers typically participate in on restoration projects?	Invasive species removal—63 Planting nursery stock—58 Monitoring (e.g. citizen/community science)—42 Seeding—34 Trail maintenance—26 Outreach—25 Other—15 Restoration design and planning—4

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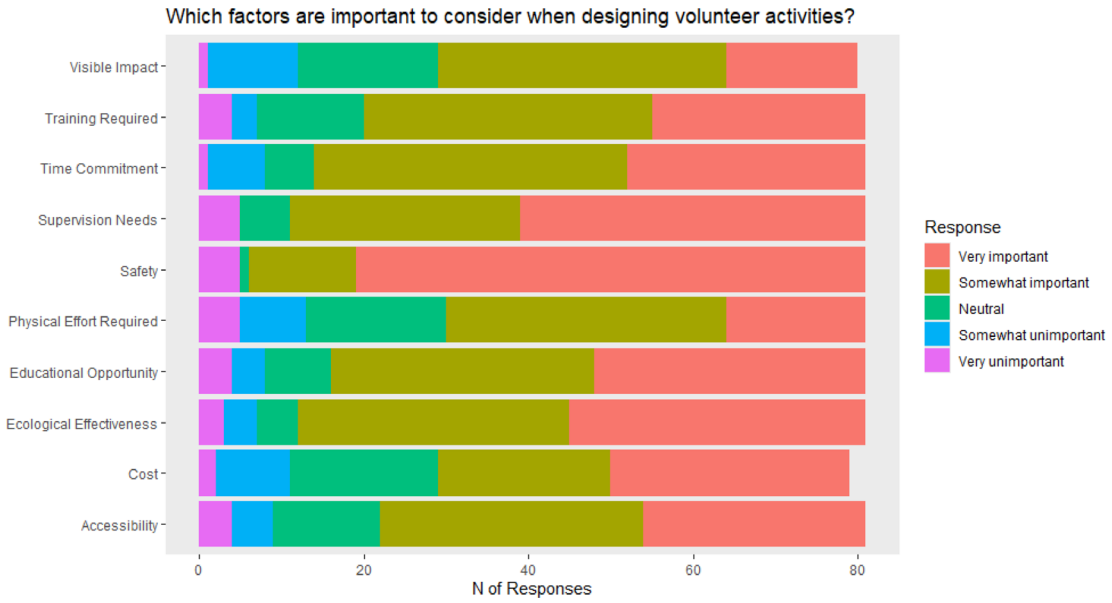

Figure 1. This chart shows how highly participants rated the importance of different elements of volunteer restoration techniques from 0 (not important at all) to 5 (very important).

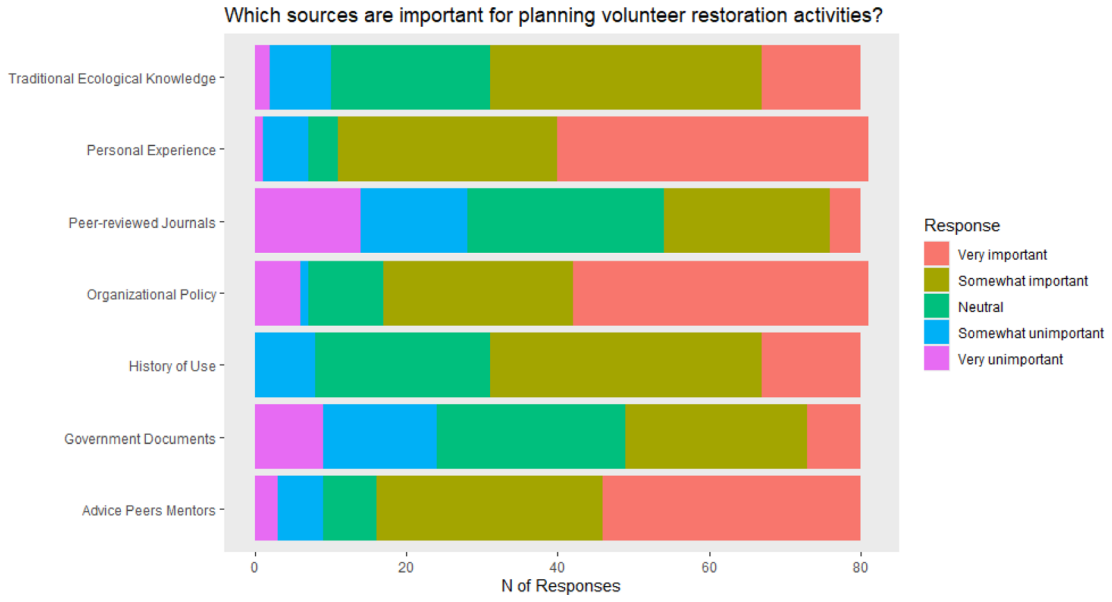

Figure 2. This chart shows how highly participants rated the importance of different elements of volunteer restoration techniques from 0 (not important at all) to 5 (very important).

median scores of 4. Government documents and peer-reviewed publications received the lowest score as sources of information, with a median of 3 (Supplement S2; Fig. 3).

Discussion

A Framework for Volunteer Restoration Techniques

The survey and literature review taken together inform a framework for the study and description of volunteer ecological restoration techniques. Authors found no significant direct disagreement between the results of the survey and the literature review. The framework includes elements of labor (i.e. safety, physical effort required), cost (i.e. material supplies), training, cultural fit (i.e. whether the technique reflects or contributes to local traditional practices), and mobilization (i.e. the capacity for the technique to be shared).

In contrast to professional restoration ecologists, volunteers are not paid, and restoration work is not their primary activity; yet, they can conduct effective restoration that is often a good fit with

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Figure 3. This concept map shows an interconnected set of criteria that may be used to analyze and evaluate volunteer techniques for ecological restoration. The criteria include impact, effort, safety, cost, cultural fit and mobilization.

local cultural and economic concerns (Fox & Cundill 2018). This literature review and survey revealed how the design and selection of restoration techniques (e.g. planting methods, invasive species removal techniques) can be planned and evaluated when volunteers are conducting the work. Collectively, the results of the survey and literature review inform a framework that gives an overview of important dimensions of the effectiveness of volunteer restoration techniques.

The framework outlines five criteria that can be used to analyze and describe volunteer restoration techniques: impact (e.g. Is the impact visible? Is the technique ecologically effective? Is it educational?), effort (e.g. How much training is required? How much time commitment is needed?), safety (e.g. Is it safe for volunteers to perform? Is it accessible? How physically taxing is it?), cost (e.g. Are the materials costly? How much supervision is needed?), cultural fit, and mobilization (e.g. Does the technique work with local practices? Could it apply elsewhere?). This framework could be applied to the analysis and design of volunteer ecological restoration techniques and to the communication of those techniques both in the peer-reviewed and gray literature.

Restoration ecologists agree that restoration techniques should be effective to optimize outcomes (Suding et al. 2015; Gann et al. 2019). However, what is most ecologically effective may not be the most effective in the context of volunteers. There may be techniques or situations that are not appropriate for volunteers because they use heavy equipment or special materials. The framework discussed in this paper provides clear criteria for evaluating whether a technique is effective in the context of volunteer-led restoration and whether it is appropriate for volunteers.

The framework proposed by this study holds cost and safety as part of the core criteria for effective volunteer ecological restoration techniques. This fits with the broader discussion on volunteering, which positions the practice as a more cost-effective alternative to professionalized restoration (Armsworth et al. 2013). The value that volunteers can bring to an organization can be increased by designing techniques that are low-cost, which could reduce the costs of the overall endeavor, though administrative costs may increase (Daniels et al. 2014). For example, Buoy-deployed seeding of eelgrass for marine restoration was highlighted as a cost-effective restoration technique (Pickerell et al. 2005). It appears that it is both important that the technique itself is low cost and that the use of volunteers lowers the cost through efficient scaling (Toh et al. 2017). While cost was identified as important, volunteer engagement can be compromised by a focus on the use of volunteers as supplemental, low-cost labor (Pages et al. 2018). It is therefore important that volunteer managers consider the goals and motivations of volunteers, which can range from emotional needs to career aspirations (Alamenciak & Murphy 2024).

Restoration is often a labor-intensive undertaking. The three main activities conducted by volunteers in this survey tend to require outdoor work, digging, lifting, and moving (e.g. removing invasive species, planting plugs, monitoring species). While the intensity of labor may be alleviated by using large machines, volunteers often do not have access to such labor-saving devices. Research into techniques appropriate for volunteer use should therefore consider how physically taxing a technique and how safe a particular technique is when advocating for one approach over another. For example, a study comparing cutting and rhizome removal in *Reynoutria japonica* (Japanese Knotweed) control found that the less labor-intensive method (cutting) was just as effective as rhizome removal (Haight et al. 2017). While Haight et al. (2017) discussed the intensiveness of labor, there was little discussion of safety. Our study provides a conceptual framework that can be used to consider all aspects of a technique that may be relevant to volunteers.

Simple techniques that require minimal training can be lower cost to administer and easier for volunteers to understand. For example, researchers and practitioners have developed a simple approach to monitor the health of grassland restoration projects that can be executed in "a few minutes" (Schulze et al. 2009). Such an approach is far easier to train volunteers on than typical scientific approaches such as Vegetation Sampling Protocol. Well-designed community science approaches can be beneficial for conservation and restoration efforts (McKinley et al. 2017). Ease of training means that more volunteers will be able to use the method and there is less room for error.

Mobilization and cultural fit are two closely related criteria in the framework. Restoration methods that can be transferred to the community reduce the cost of implementation and labor (Cruz et al. 2014). Community practices such as coppicing and other traditional land management approaches can persist without organizational supervision (Terada et al. 2010). This cultural approach toward restoration resonates with literature calling for the consideration of culture and context in restoration design (Cooper 2013; Cross et al. 2019).

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Guidelines for Mobilization of Volunteer Restoration Techniques

Knowledge mobilization is a significant challenge in conservation and restoration ecology. Research that is not appropriate for deployment in the field risks wasting valuable resources (Buxton et al. 2021). The framework provides insights on how researchers can examine the effectiveness of restoration techniques for volunteer use through the mechanisms identified in this study.

This survey also identified key pathways to mobilize knowledge developed by researchers. Scholarly publishing and government documents were ranked very low by respondents, yet those remain the main modes of communication for restoration researchers. Peer-reviewed publishing in restoration is on a significant upward trajectory (Alamenciak et al. 2023) and governments routinely release or endorse guidance on restoration practice (Parks Canada & Canadian Parks Council 2008; Keenleyside et al. 2012). However, practitioners responding to this survey rated personal experience very highly, which suggests that researchers may need to do additional knowledge mobilization beyond publishing in peer-reviewed journals if they want practitioners to use their research (Gornish et al. 2023). It also stands in contrast with the growing call for evidence-based conservation action (Cooke et al. 2018). Mobilization among conservation practitioners faces similar challenges (Lemieux et al. 2018). The framework proposed in this study would be useful for translational ecology practitioners seeking to build capacity across the researcher–practitioner divide (Enquist et al. 2017).

This study provides some insights for people seeking to mobilize the results of a study on volunteer restoration techniques and a potential basis on which to evaluate techniques. While safety emerged as a key criterion in the survey research, it did not appear in our literature review but was added by the study authors who have experience managing volunteers. It would be helpful to discuss safety in both peer-reviewed and non-peer-reviewed publications on volunteer restoration techniques.

Given that personal experience is an important source of information about techniques, a productive strategy to mobilize knowledge would be to partner with community champions who will use techniques and share them with their colleagues (Patnaik 2019). A community champion approach has been used to build resilience and leadership in communities experiencing poverty (Worthy et al. 2016). The use of "knowledge brokers" and community champions has been suggested to bridge research and policy (Cooke et al. 2021), and here we suggest a similar approach can bridge research and restoration volunteering.

Directions for Future Research

This study used a Likert scale to evaluate the perceptions of restoration volunteer managers. This is a subjective measure, and future studies could improve by incorporating quantitative measures, such as time or cost, to assess the relationships between elements of the framework. For instance, Are more labor-intensive techniques less costly? Additionally, the limitations of a Likert scale could be counteracted by using alternative question formats, such as ranking the factors. While our literature review was extensive, it would be beneficial to further analyze the articles selected and conduct a systematic scoping review to determine which ecosystem types have documented volunteer restoration techniques and which do not. Such a study would highlight gaps for ecological research. Finally, the framework discussed in this study should be further validated through a consultative process engaging both practitioners and researchers. This framework should be validated and extended through interviews and surveys with volunteer participants in ecological restoration initiatives. Additionally, while our survey of volunteer managers captured a wide range of perspectives, it may be valuable to engage in further study of a broad solicitation of guidelines from organizations conducting restoration. Finally, this study and its results should be further explored and developed outside of a North American context.

Volunteer engagement has the capacity to create restoration outcomes that are ecologically effective and socially mobilizing. By considering the cost, labor, and training involved in a given volunteer restoration technique, researchers and managers can ensure their technique is likely to be used in the field. By harnessing local cultural knowledge and considering the mobilization capacity of a technique, managers can ensure that best practices are easy to share and continue to be undertaken.

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Supporting Information

The following information may be found in the online version of this article:

Table S1. Median scores for Question 8.
Table S2. Median scores for Question 9.

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