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# Mobilizing practitioners to support the Emergency Recovery Plan for freshwater biodiversity

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## Abstract

Freshwater biodiversity loss is one of the greatest environmental threats in our changing world. Although declines have been reported extensively in the literature, much less attention has been devoted to solving the freshwater biodiversity crisis relative to other ecosystems. The recently proposed Emergency Recovery Plan for Freshwater Biodiversity (Tickner et al., 2020, BioScience, *70*(4), 330–342) outlines an ambitious but necessary set of overarching actions that can help "bend

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the curve" for freshwater biodiversity declines. This plan is timely given the present opportunity to adjust freshwater biodiversity targets in international biodiversity agreements and to encourage meeting targets of relevant Sustainable Development Goals. Yet, relying solely on a trickle down from such agreements to national and local scales will likely take too long, given the immediate urgency of the situation. Here, we advocate for a broader, concerted effort from all actors to ensure the Emergency Recovery Plan meaningfully influences the actions of practitioners at a local scale. We outline the roles and responsibilities of actors involved with policy, research, professional bodies and societies, advocacy, and industry, as well as practitioners themselves, in achieving this goal. It is our hope that this overview facilitates the real-world actions needed to execute the Emergency Recovery Plan so that we can indeed "bend the curve" for freshwater biodiversity.

**KEYWORDS**
ecosystems, environmental flows, fish, fisheries, knowledge action gap, migration, policy, practice, sustainable development goals

## 1 | INTRODUCTION

Freshwater ecosystems are among the most threatened on Earth, with ~25% of all freshwater fish species, ~8% of all freshwater invertebrate species, and 41% of amphibian species classified as imperiled on the IUCN Red List (IUCN, 2020; Strayer, 2006). Freshwater species are declining more rapidly than their marine and terrestrial counterparts (Reid et al., 2019). Recent estimates from the Living Planet Index suggest a mean decline of 84% in freshwater vertebrate populations from 1970 to 2016 compared to an overall population decline of 68% across all vertebrate populations (WWF, 2020), although re-analyses of these data have shown that these mean declines are driven by extreme cases (Leung et al., 2020). Many of Earth's major threats (e.g., climate change, pollution, overharvest, invasive species) have disproportionately higher effects in freshwater habitats (Dudgeon et al., 2006). For instance, it is expected more rivers will become "temporary" in response to climate change, land-use, and water extraction, with flow restricted to certain periods of the year (Steward, von Schiller, Tockner, Marshall, & Bunn, 2012). It is the proliferation of dams worldwide (particularly from hydropower development), however, that remains one of the greatest threats to freshwater ecosystems. It is estimated that just 37% of large rivers over 1,000 km in length remain free flowing (Grill et al., 2019), and many of the world's largest, most biodiverse rivers (e.g., Mekong, Congo, Amazon) are slated for new or intensified hydropower development in the coming years or decades. In addition to the known threats facing freshwater ecosystems, a number of recently recognized or emerging threats have been identified that can further degrade aquatic habitats worldwide (e.g., salinization of freshwater, microplastic and nanoparticle pollution; Reid et al., 2019; Pérez-Jvostov et al., 2020). Regardless of the mechanisms, the global decline of freshwater ecosystems is compromising the many services they provide to humans (Dodds, Perkin, & Gerken, 2013).

Concern surrounding the decline of freshwater ecosystems is not new (Dudgeon et al., 2006; Reid et al., 2019), but frameworks identifying steps to reverse these declines are only just coming to light. An Emergency Recovery Plan for Freshwater Biodiversity (henceforth, ERP) was recently published by a team of freshwater conservation experts and is a major step toward prioritizing actions to reverse declines in freshwater biodiversity (Tickner et al., 2020). United Nations (UN) Water, in its input to the Convention of Biological Diversity (CBD), led consultations on the post-2020 global biodiversity framework and built on this plan with more detailed suggestions for targets and indicators, in hopes of creating a legal framework to protect freshwater biodiversity (United Nations (UN) Water, 2020). Many forward-thinking papers have since been published to identify means of "bending the curve" for freshwater biodiversity (Harper et al., 2021; Maasri et al., 2021; van Rees et al., 2020) including an outline of strategic activities that are critical to enacting the ERP (Arthington, 2021). Recommendations within the ERP to bend the curve for freshwater biodiversity comprise six core actions: (a) accelerating the implementation of environmental flow protections; (b) improving water quality; (c) protecting and restoring critical habitats; (d) managing exploitation of freshwater species and their habitats; (e) preventing and controlling non-native species invasions; and (f) safeguarding and restoring freshwater connectivity. Indeed,

there is a clear acknowledgement that actions must be taken to reverse declines, while also addressing climate change concerns and improving human well-being (IUCN, 2019; Mace et al., 2018).

The recommendations identified by Tickner et al. (2020) are global in scope and identify big-picture approaches to bend the curve. Their recommendations focus on reshaping international agreements that overlooked freshwater biodiversity (CBD, 2019; HLPW, 2018), particularly the CBD and the Sustainable Development Goals (SDGs), as well as national policies (Dickens et al., 2020). By re-shaping these high-level agreements and policies, the hope is that these recommendations will influence regional decision-making and individual actions at the river basin level (discussed in Abell et al., 2019). Ultimately, however, there is a need to translate these approaches to bend the curve into tangible actions that are adoptable by various practitioners—many of whom are over-extended and thus struggle to keep up to date on the latest scientific literature (Cook, Mascia, Schwartz, Possingham, & Fuller, 2013; Sunderland, Sunderland-Groves, Shanley, & Campbell, 2009). Relatedly, there may be instances where actions to bend the curve are already being undertaken by practitioners, but experiences (success stories or failures) are not shared broadly with others who may face similar challenges. This disconnect between knowledge and action is a widely acknowledged problem (i.e., the knowledge–action gap; Nguyen, Young, & Cooke, 2017), but efforts can be made to mobilize knowledge to ensure that it reaches those with the ability to act on this information (Cvitanovic, McDonald, & Hobday, 2016).

Given the critical state of freshwater biodiversity and the need for immediate action to reverse declines, it is now more important than ever to implement the recommendations laid out in the ERP. Here, we show that these recommendations must be scaled down for real progress to be achieved, and to ensure that recommendations are accessible to practitioners and facilitate their engagement in the process of bending the curve of freshwater biodiversity loss. We outline the roles and responsibilities of various actors, including (but not limited to) those involved in policy, research, professional bodies and societies, advocacy, and industry, and practitioners themselves, in facilitating practitioner engagement. It is our hope that this paper will promote real-world actions that can be taken to facilitate the ERP so that we can indeed bend the curve for freshwater biodiversity.

## 2 | WHO ARE PRACTITIONERS?

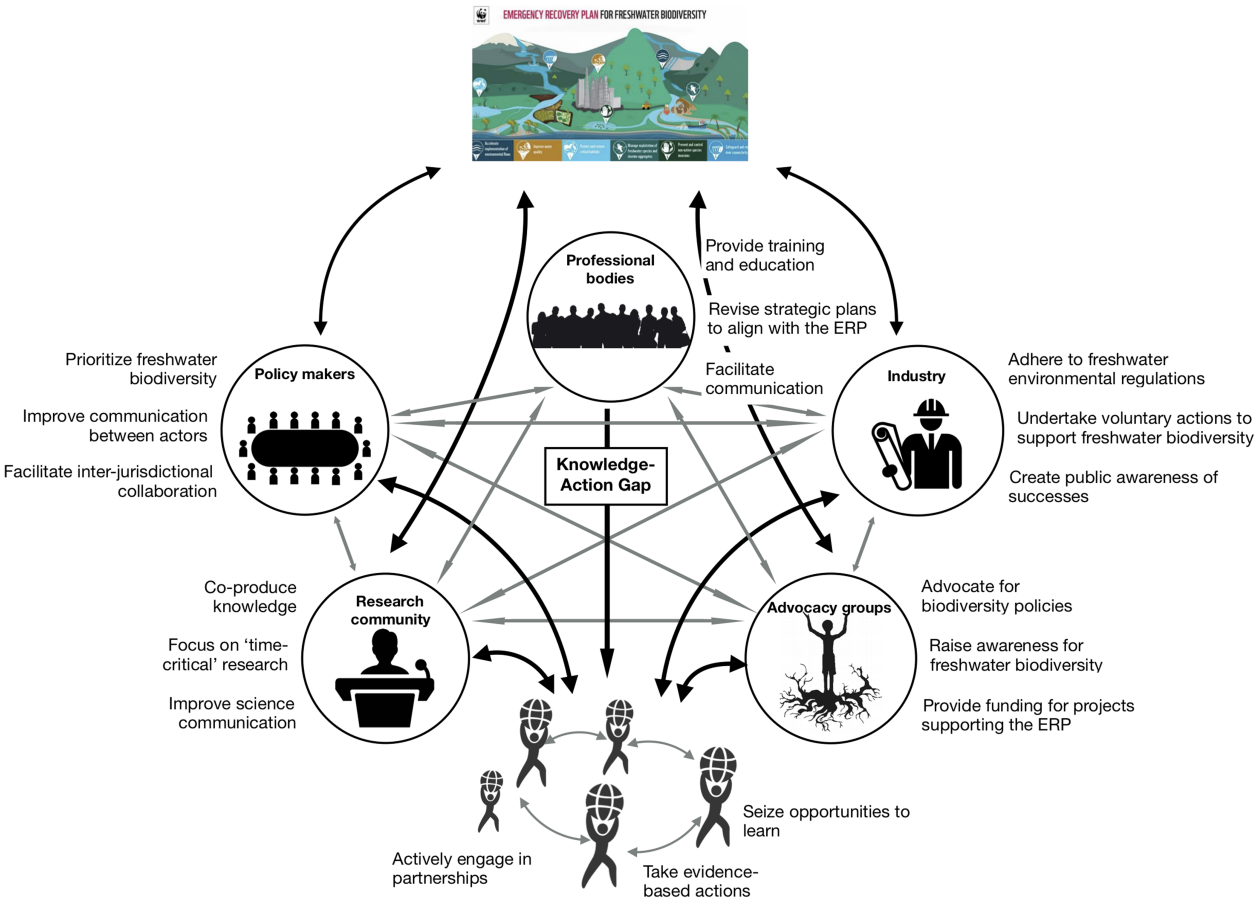
We consider freshwater biodiversity practitioners to be on-the-ground actors whose main occupation is the implementation of conservation actions to protect and manage natural resources (as per Gossa, Fisher, & Milner-Gulland, 2015), including those responsible for designing, managing, and monitoring freshwater biodiversity projects (similar to Margoluis & Salafsky, 1998). A freshwater biodiversity practitioner could be, for example, a biologist at an energy corporation, a restoration ecologist at a non-governmental organization (NGO), an Indigenous Guardian or steward for an Indigenous community or government, or a stock-assessment technician for a fishery. That being noted, we also consider the importance of engaging allied environmental practitioners who may not work with biodiversity issues on a daily basis, but may influence freshwater biodiversity issues indirectly (e.g., water managers, land managers, dam operators, spatial planners, engineers). These allied practitioners are similarly important to engage if we are to collectively carry out the ERP. Practitioners make critical decisions at localized scales, and their role in enacting the ERP must not be overlooked. For every recommendation or decision made at the international or national level, manifold decisions are made by practitioners, and although many have the technical ability and authority to make decisions at local scales, they need support in scaling down and potentially adapting the ERP to local actionable items. This includes recognition that good monitoring, science and restoration takes time (and sustained cooperation between organizations, institutions and other partners), and that consistent funding and policy support is needed despite changing or competing priorities. Over time, the knowledge of practitioners, combined with insights from science and wider values in society, can have substantial influence on conservation paradigms, which in turn can influence higher-level policy decisions (Bednarek et al., 2018). Hence, there are important knowledge feedbacks within the policy-practice-science system.

## 3 | SCALING ACTIONS TO THE LEVEL OF THE PRACTITIONER

Concerted effort from a diversity of actors will be necessary to mobilize the ERP and facilitate practitioner-level decisions that will bend the curve for freshwater biodiversity locally (Box 1). For instance, what actions can a practitioner undertake at a localized scale to protect and restore critical habitat to support freshwater biodiversity (see Box 2 for an example in the Canadian context)? Here, we outline the roles and responsibilities of actors involved in five key areas central to enabling the practitioner: policy, research, professional bodies and societies, advocacy, and industry, as well as practitioners

## BOX 1 From knowledge to actions that bend the curve

The "knowledge-action gap" describes the lack of implementation to address various issues despite having the evidence base to do so (Nguyen et al., 2017). This has been observed for myriad conservation issues including those related to freshwater ecosystems (e.g., Hart et al., 2010). As per the Emergency Recovery Plan (ERP), recommendations for targets and indicators are made at the international level, but there is a need to influence the actions of those working at all levels (e.g., practitioners working at a local scale) if we are to sufficiently respond to the urgency of this crisis. However, effective knowledge mobilization will be needed to ensure the actions of the ERP are effectively communicated and facilitated through this chain-of-command. Achieving this will require a conscious effort from a wide range of actors from the level of international and national bodies (policy makers) down to the practitioners themselves. Policy makers will need to propose policies that align with the ERP and provide direction and capacity for practitioners so they can implement those policies. Members of the research community need to prioritize research related to "curve-bending actions" and co-produce science with practitioners to ensure research is relevant. Members of professional bodies and societies can take on a greater role in facilitating communication between practitioners and providing education and training opportunities. Advocates are well positioned to influence policies in line with the ERP, and rally public support. Industrial decision-makers, often strongly influenced by public opinion, can set voluntary standards or engage in projects that support the ERP as a way to communicate their company's values to their customers, or increase the long-term sustainability of their operations. Finally, practitioners themselves need to seize opportunities to adopt a collaborative, evidence-based approach to freshwater biodiversity issues. We encourage all actors to take a moment for self-reflection (discussed in Sandbrook, Adams, Büscher, & Vira, 2013) to consider the scope and scale of their profession and what decisions and actions they can carry out to mitigate impacts to freshwater biodiversity.




*Direct connections between actors and practitioners (black) and between actors (grey)*

themselves. We acknowledge that individual actors can take on multiple roles in support of the ERP. For instance, a Senior Biologist working at an NGO could advocate for policy changes, conduct research, and be part of a professional body or society. We by no means see this list of actors as exhaustive, recognizing that many other actors have important roles, and that funding is critical (Box 3). Nonetheless, assigning accountability to, and enabling, these actors in their role in "bending the curve" for freshwater biodiversity will be key if we are to address this wicked problem (i.e., a complex problem with conflicting interests among stakeholders and no straightforward solution; Sharman & Mlambo, 2012).

## 3.1 | Policy

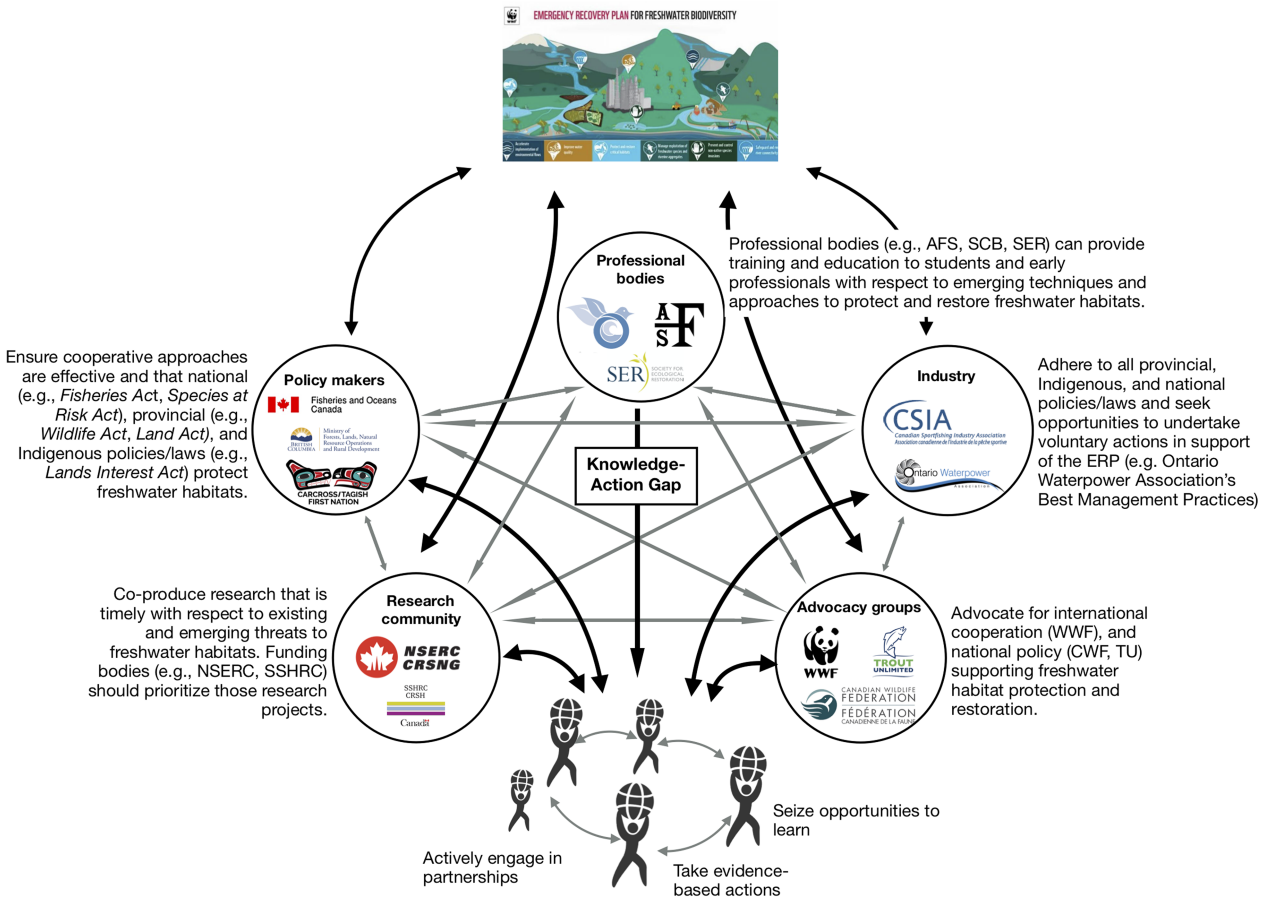
Policy makers are the actors (e.g., national, regional, or Indigenous governments) that provide efficient and effective conditions for practitioners to carry out the ERP through policy, legislation, funding, authority, capacity, and guidelines. To reach stated policy objectives, governments implement various policy instruments that are broadly categorized as commands, incentives, capacity building, and system transformation instruments (McDonnell & Elmore, 1987). It can be difficult to ascertain which policy instrument(s) will be most effective for various aspects of the ERP, but what is clear is that policy instruments need to be properly supported. A primary challenge for policy makers is providing sufficient resources (e.g., ensuring adequate oversight and enforcement) to implement policies, recognizing that freshwater biodiversity issues are just one of the many important and pressing issues facing our society. Another challenge is resistance from politicians and lobby groups to implementing legislative frameworks that adequately protect freshwater resources. It is clear that prioritization of high-level initiatives like the ERP at the level of

**BOX 2 Operationalizing practitioners to "protect and restore critical habitat (strategy 4)" for the benefit of freshwater biodiversity—A Canadian context**

Despite having some of the longest stretches of free-flowing rivers on Earth (Grill et al., 2019), Canadian freshwater systems face a number of threats (e.g., dams, pollution) that risk freshwater biodiversity (Pérez-Jvostov et al., 2020). Here, we outline a conceptual diagram highlighting the main actors and the roles they must play to achieve strategy 4 ("protecting and restoring critical habitat") of the Emergency Recovery Plan for freshwater biodiversity (ERP) in Canada. We recognize that actors can be involved with more than one group (e.g., research institutions and professional bodies), and that organizations can contribute in multiple different ways to the ERP (e.g., through research and advocacy).

The ERP has the potential to influence international agreements such as the Convention on Biological Diversity. Policy makers (e.g., national, regional, and Indigenous policy actors) must then evaluate whether current legislation meets the freshwater biodiversity expectations set out in international agreements. For example, as per strategy 4 of the ERP, is sufficient effort being made to protect and restore critical habitat? In Canada, the *Fisheries Act* and *Species at Risk Act* have provisions for the protection of fish habitat, though development can often proceed if effort is taken to avoid, mitigate, and compensate for any damage to aquatic habitat. Policy makers within the Government of Canada, provincial/territorial, and Indigenous governments need to ensure that policies align with the ERP, satisfy the diverse range of actor perspectives, and provide direction and capacity to practitioners so they can implement those policies. It will be important to form these policies through collaborative processes involving researchers, members of professional bodies, advocacy groups, industry, and practitioners themselves, and ensure effective collaboration during policy development. We envision an important role for NGOs, such as the Canadian Wildlife Federation and World Wide Fund for Nature, in advocating for policy changes that support the ERP, as well as in influencing public support. Canadian research funding agencies can prioritize research related to "curve bending actions" (e.g., through the Natural Sciences and Engineering Research Council of Canada funding priorities) and then researchers can co-produce science with practitioners to ensure that research supports the protection and restoration of critical habitat. Decision-makers within professional bodies and societies could take on a greater role facilitating communication between practitioners and providing education and training opportunities. A potentially useful initiative to build from is the Canadian Aquatic Resources Section of the American Fisheries Society that has a current focus on raising awareness and supporting student scholarships. Industry actors can encourage development that is in line with the ERP and provide conditions for practitioners to work in a more sustainable manner. For instance, the Ontario Waterpower Association has published several "Best Management Practices" guidelines that encourage sustainable hydropower development

and, over time, they could become an industry standard for allied practitioners to follow. Finally, it is then up to the practitioner to adapt their approach to freshwater biodiversity projects based on the opportunities provided by various actors.

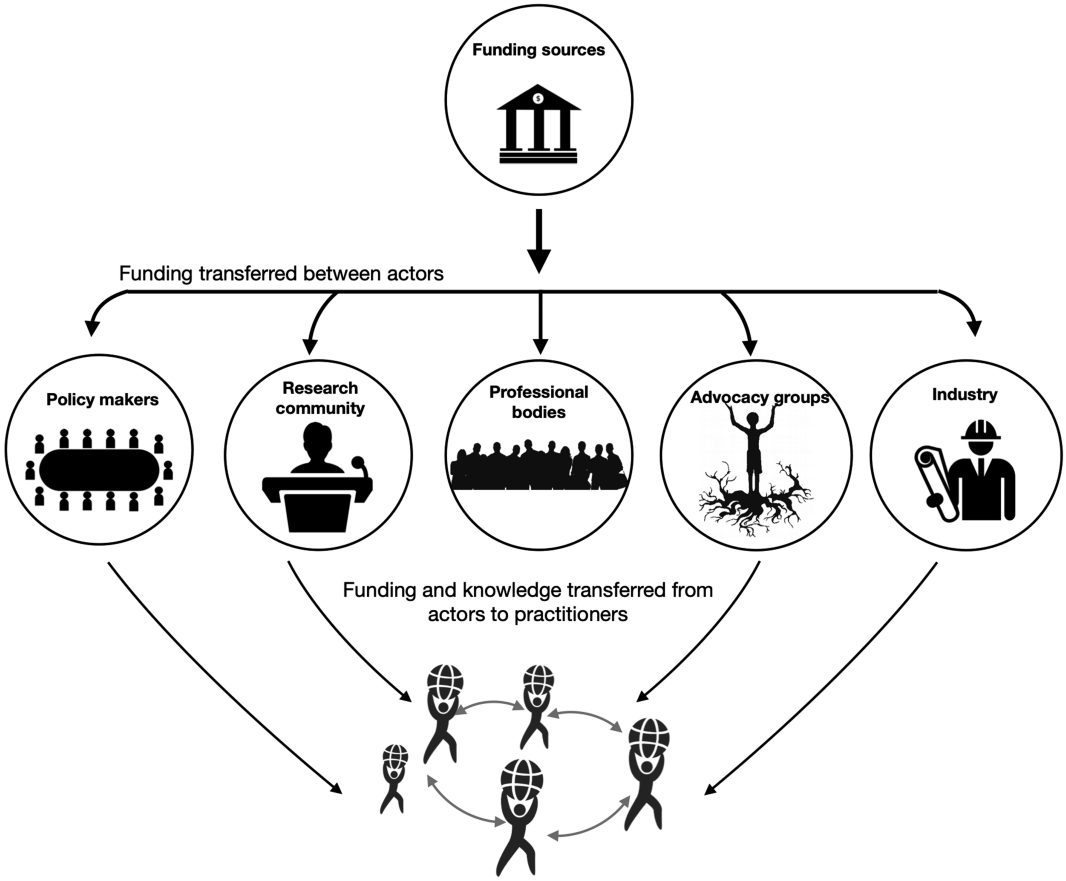



*A conceptual diagram showing the flow of information (arrows) from the Emergency Recovery Plan for freshwater biodiversity to various actors and ultimately practitioners*

**BOX 3 Underlying actors—Funding sources. Central to the mobilization of freshwater biodiversity practitioners in support of the ERP is the need for appropriate funding and support**

Research funding agencies, banks, governments, the public, and other bodies provide funding to various groups, and this funding is often passed between groups. Actors within these groups then use this funding to produce research, undertake restoration projects, advocate for conservation, share codes of practice, undertake development, and engage in other activities that ultimately shape the way that practitioners operate. Funding sources play an important role in supporting those actors and specific initiatives that closely align with the ERP, and that will ultimately lead to tangible on-the-ground actions by the practitioner. For instance, research funding agencies have an important role in supporting the ERP. Calls for funding should prioritize the six recommendations set forth in the ERP and must support projects with high likelihood of influencing policy and practice related to these recommendations (discussed in Rose et al., 2019; Mach et al., 2020). Reform to current funding models will be needed to amplify the impact of research (Holmes, Scarrow, & Schellenberg, 2012; Mach et al., 2020) and freshwater biodiversity projects; successful examples of which already exist (e.g., the National Estuarine Research Reserve System funding program; Trueblood et al., 2019). Specifically, there needs to be a focus on co-production, interdisciplinary teams, and "follow-up" to see how research findings or freshwater biodiversity projects have been integrated into society (Arnott, Neuenfeldt, & Lemos, 2019; Mach et al., 2020) and ultimately contribute to bending the curve for freshwater biodiversity. There is also a need for funding

institutions (e.g., World Bank) to ensure that funded development projects are designed to minimize harm to freshwater biodiversity. For example, funding institutions could make it mandatory that the hydropower projects they support are following "proven best practices" outlined by the Hydropower Sustainability Assessment Protocol.




*A conceptual diagram showing the role of funding in supporting various actors and practitioners seeking to carry out the Emergency Recovery Plan for freshwater biodiversity*

national policy has a great influence on outcomes of that initiative. In comparing drivers behind the improved implementation of the SDGs in Japan and South Korea versus China, it was concluded that both countries tended to focus policy more so on social and ecological sustainability while social and economic sustainability were prioritized in China (Xie, Wen, & Choi, 2021). We argue however, that this top-down approach is insufficient to ensure policies are applied and integrated at multiple scales and across jurisdictions such that they influence actions at the local scale. Here, we describe holistic changes that can be made by policy makers to mobilize and support the practitioner working "on the ground" on freshwater biodiversity issues.

Stronger partnerships are needed between policy makers and various actors to approach the freshwater biodiversity crisis in a more inclusive manner (Tallis & Lubchenco, 2014). Policy makers should systematically include practitioners (including allied practitioners) in water resource management decisions to minimize the disconnect between overarching objectives and the practicalities of implementation. In some cases, the concept of decentralizing decision-making can be explored (i.e., distributing decision-making authority to a broader group of practitioners). Decentralizing decision-making has led to more cost-effective conservation and improved conservation outcomes in certain circumstances (Campos-Silva & Peres, 2016; Somanathan, Prabhakar, & Mehta, 2009), but it does come at the expense of potentially slower decision-making. Transitioning from top-down management approaches to bottom-up participatory river-basin-management approaches is also likely to better connect practitioners with the tenets of the ERP and how these tenets can be scaled down to the local level. A positive example of this is the Consorcio Intermunicipal Lagos Sao Joao that brought together local

non-governmental organizations, companies, academics, and municipal governments to improve water management and overcome pollution problems (Pereira et al., 2009). While changes to governance systems will not always be possible, creating opportunities for improved communication will be critical.

One means of improving communication is to create forums where these actors can communicate and share ideas on freshwater biodiversity that will ultimately shape policy (Fischer & Leifeld, 2015). Forums could include symposia, meetings (e.g., with a practitioner advisory board), expert panels, interdisciplinary journals (e.g., *Conservation Science and Practice*), among other avenues. The Intergovernmental Panel on Climate Change (IPCC) and Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) are examples of high-level international forums, convened and resourced by policy makers, that have the specific purpose of synthesizing current policy-relevant science to inform decisions. Downscaled versions of these initiatives will be needed to facilitate collaboration between policy makers and practitioners at smaller spatial scales (e.g., national, regional, local). These forums can also provide opportunities for practitioners to communicate the support they require (e.g., resources, training) to effectively contribute to the ERP. It is then the responsibility of the policy maker to provide practitioners with support, including the mandate and funding to carry out policies related to freshwater ecosystems (Lapointe et al., 2014). Practitioners are challenged by the fact that conservation takes time (often years or decades), and government priorities often change on much shorter timescales, leaving practitioners with inconsistent time, funding, and mandate to successfully complete projects in support of the ERP. Longer term government supports that are resilient to changes in political shifts are needed to provide adequate support to practitioners over the timescales relevant to supporting the plan. Similarly, when funding is provided, barriers to implementation issues must be recognized and overcome to ensure on-the-ground implementation is effective (e.g., appropriate timing of funding, use of funding, timing of employment programs/hiring).

Conservation is a crisis discipline with limited resources (Bottrill et al., 2009), so efforts must be made by governments to facilitate inter-jurisdictional collaboration and coordination related to shared interests and assessments to efficiently work toward shared endpoints. This may be facilitated by putting a stronger emphasis on river basin and system-scale thinking (e.g., the supply and demand of ecosystem services; Langhans et al., 2019) that align with the recommendations and indicators put forward by the ERP and CBD/SDGs. For example, system-scale water-infrastructure planning can weigh trade-offs in river-management objectives at the infrastructure portfolio scale, rather than project-by-project (Opperman et al., 2020). Emphasizing such ecosystem-based principles will help shift the mindset of conservation practitioners from focusing on a single species to thinking about the ecosystem as a whole (Braunisch, Home, Pellet, & Arlettaz, 2012).

A particularly troubling shortcoming is the lack of monitoring capacity for freshwater communities in many of the most biodiverse regions on Earth (Dickens et al., 2020). Improved monitoring will be critical if we are to prioritize actions across freshwater systems (Holland, Darwall, & Smith, 2012) and track progress towards freshwater biodiversity goals. The lack of regularized monitoring is often the result of insufficient long-term resources to document wildlife and habitat or population trends with necessary statistical rigor. To build capacity in these regions, policy frameworks must provide support for monitoring initiatives, and training is needed to mobilize field teams to support monitoring (e.g., Indigenous Guardians; Schmeller et al., 2017). Establishing strong community-based monitoring and science networks (e.g., GEOBON) will likely be critical in areas where resources are limited.

## 3.2 | Research

The research community includes all actors (e.g., researchers, funding agency decision-makers) that facilitate the creation of knowledge used to support decision-making processes at various scales, from international policy agreements to specific and localized actions undertaken by practitioners. Unfortunately, much of the knowledge produced by the conservation research community never actually leads to conservation action (Cook et al., 2013; Nguyen et al., 2017). Reasons for this disconnect are manifold (Cvitanovic et al., 2016; Rose et al., 2018), but it is partly due to a lack of science communication and practitioner consultation on behalf of the researcher, perhaps due to a lack of training and incentives to do so (Knight et al., 2008; Sunderland et al., 2009). Complicating the issue further, many subdisciplines of conservation research (e.g., ecological restoration) have a weak evidence base to support many actions that could be undertaken by practitioners (Cooke et al., 2018), while in other subdisciplines, extensive research and monitoring appears to be poorly linked with biodiversity outcomes (Buxton et al., 2020).

To overcome this knowledge–action gap, research co-produced with practitioners is needed to ensure that research questions, experimental designs, results, and how these results are communicated are relevant (Gordon et al., 2014; Lapointe, Tremblay, & Barna, 2016;

Latulippe & Klenk, 2020; Laurance et al., 2012). Identifying motivations, strategies, and outcomes will be necessary to minimize the costs and risks associated with this co-production process (Oliver, Kothari, & Mays, 2019). For example, researchers surveyed Swiss conservation practitioners to identify and prioritize research questions of both general practical relevance and of specific regional importance to bridge the gap between conservation science and action (Braunisch et al., 2012). This research must be time-sensitive to influence actions of the practitioners (i.e., completed and shared over the span of months, not years). Funding institutions can help achieve this by funding pressing research, and researchers can help achieve this by sharing findings with practitioners before the completion of the peer-review process which can take years to navigate. This will require researchers to present findings cautiously to make it clear they are preliminary and subject to further review. There must also be recognition that simply having better ecological knowledge will never be enough to turn the tide—we need powerful insights on how to mobilize groups in society (e.g., allied practitioners) to champion, or at least support, conservation efforts. Part of the solution will be raising appreciation that there are multiple benefits of freshwater systems and gaining a greater understanding on how these benefits accrue to different groups in society (Anderson et al., 2019; Tickner et al., 2017).

Sharing knowledge with and among practitioners (Sutherland, Dicks, Ockendon, Petrovan, & Smith, 2018) on which actions are successful in "bending the curve" at a local scale and under what circumstances is essential (Bennett et al., 2016; Jeanson et al., 2021). Communication between researchers and practitioners on conservation objectives (e.g., targeted meetings, professional society conferences, and magazines) has been touted as one key way to have research inform practitioner action (Lauber, Stedman, Decker, & Knuth, 2011). Providing research summaries to practitioners is another effective means of transitioning research into action (Walsh et al., 2015). These methods of knowledge transfer are often more effective than simply publishing in an academic journal given that practitioners may not have access to this research (Gossa et al., 2015) or may not have the time or skills to search for, read, and synthesize these papers (Sutherland, Spiegelhalter, & Burgman, 2013). Sutherland et al. (2019) suggested that evidence-based websites that allow users to query for key locations, problems, or species, could be a more accessible format for practitioners to glean and contribute information. Indeed, there are journal outlets that are tailored to making information accessible to practitioners or have dedicated sections for practitioners to publish (e.g., *Environmental Management*, *Conservation Science and Practice, Case Studies in the Environment*, *Ecological Solutions and Evidence*). For example, *Conservation Evidence* is a promising resource that provides free evidence summaries of scientific literature that can be accessed through a query tool (https://www.conservationevidence.com/) and encourages practitioners to publish monitoring results following various interventions. *Case Studies in the Environment* is another recently established peer-reviewed outlet that publishes case study articles with slides and teaching notes aimed to inform best practices for students, faculty, educators, professionals, and policy makers on many topics related to the ERP including "ecology and biodiversity conservation," "climate change mitigation and adaptation," "energy and the environment," "water management, science and technology," and "sustainability" (Burns, 2019). These outlets also provide the opportunity for researchers to learn from practitioners about their successes and failures, and to then build a formal understanding of the research designs that are useful to informing actions. This is not to discount conventional forms of publishing scientific information; for example, evidence syntheses (e.g., systematic reviews) can be robust decision-support tools given that they compile information from many different sources (e.g., The Collaboration for Environmental Evidence; https://www.environmentalevidence.org). Additionally, publications highlighting successful actions and case studies putting successful practices into action (i.e., "bright spots") can help move knowledge into action (Bennett et al., 2016). Recently, several papers have published "bright spots" on topics related to the ERP including freshwater biodiversity (Flitcroft, Cooperman, Harrison, Juffe-Bignoli, & Boon, 2019), inland fish (Jeanson et al., 2021), and environmental flows (Harwood et al., 2017), but these will only be applicable in some circumstances. Ultimately, if researchers are to help support the role of practitioners in carrying out the ERP, a much greater focus will be needed on sharing findings through direct and simple lines of communication.

### 3.3 | Professional bodies and societies

Decision-makers within professional bodies and societies are those actors that provide oversight for a given profession and aim to advance the knowledge, skills, and practice of its practitioners (e.g., Society for Conservation Biology, American Fisheries Society). These organizations have important roles in providing training and certification, connecting practitioners within and among specialities, facilitating professional communication, and bridging science and practice (Parker, 2006). To influence practice, professional bodies and societies must

first incorporate curve-bending activities into their program of work (e.g., by revising their strategic plans). Practitioners need guidance as to what actions are effective at supporting freshwater biodiversity goals (Cooke, Bennett, & Jones, 2019). Guidance could occur through training and professional development opportunities such as workshops, seminars, certifications, or codes of practice that cater to local landscapes and freshwater biodiversity issues. This guidance will need to be based on available science so that the limited resources available to achieve the ERP recommendations are used effectively (Sutherland, Pullin, Dolman, & Knight, 2004). Many of the organizational structures to facilitate this type of training already exist and can benefit from greater funding and prioritization. For instance, the American Fisheries Society has several sections in line with the ERP including "fish habitat," "fish management," "invasive and introduced species," and "water quality," among others (https://fisheries.org/about/units/sections/). Members within each of these sections gain access to research updates and training opportunities. Another positive example includes the Certified Ecological Restoration Practitioner Program from the Society for Ecological Restoration. Professional bodies can also help train practitioners to become better decision-makers by putting problems in context, specifying alternative actions, and assigning criteria to select an action (Johnson, Eaton, Williams, Jensen, & Madsen, 2015). In most cases, these training opportunities will be targeted towards freshwater biodiversity practitioners, but it will be similarly important to design and target these opportunities towards allied practitioners that may be less familiar with the principles underlying the ERP.

Another important role for professional bodies is the facilitation of communication. Professional societies need to further encourage connections between practitioners and scientists. Science communication should be short, simple, and direct (e.g., infographics). Other communication channels could be as simple as having a call for short case study submissions for a given freshwater biodiversity topic and sharing these with constituents through weekly updates. Communication channels can be used to promote diversity, inclusivity, and equity within the discipline, recognizing that diverse voices will be needed to address the biodiversity challenges outlined in the ERP (Foster, Blair, Bennett, Bynum, & Sterling, 2014). For example, the Strategies for Ecology Education, Development, and Sustainability (SEEDS) program hosted by the Ecological Society of America introduces underrepresented students from different disciplines to professional ecologists (Herrick & Sarukhán, 2007). This is one means of allowing practitioners with diverse backgrounds to share lessons learned from common freshwater biodiversity problems.

### 3.4 | Advocacy

Actors involved with advocacy include a broad spectrum of individuals, often working with non-governmental organizations (NGOs) or community groups with the aim of supporting freshwater biodiversity issues. In many cases, actors within the research community, professional bodies and societies, as well as industry can also act as advocates for certain topics related to the ERP. Advocacy groups may operate at various scales from international (e.g., World Wide Fund for Nature), to national (e.g., Trout Unlimited Canada), or even local (e.g., Friends of the Lower Mekong). In many instances, organizations may have advocacy as part of their mandate, and may also employ practitioners themselves.

Advocates have a unique opportunity to influence the actions of other key actors including policy makers, members of the research community, and ultimately, practitioners. Advocates can play an important role in influencing environmental policy (discussed in Lane & Morrison, 2006) or research in support of the ERP. Advocates may work with politicians directly to influence legislation, regulation, policy, and implementation, and can also engage with bureaucrats, either as lobbyists or as invited experts, or through formal consultation processes. Advocates may also attempt to sway public opinion in support of a certain policy position through a range of communications, outreach, marketing, and media actions, designed to inform and motivate the public to put pressure on decision-makers (Guo & Saxton, 2014). By helping shape policy to reflect the principles of the ERP, advocates can indirectly influence practitioner action. Similarly, advocates may provide funding to support practitioners completing projects in line with the ERP. Moving forward, it will be important that advocates ensure that the messages they share are in line with the best available science and the key messages of the ERP for freshwater biodiversity.

### 3.5 | Industry

The primary goals of industrial decision-makers may not be shaped around the recovery of freshwater biodiversity, but industrial operations can indeed contribute to "bending the curve." Given that industry goals are often unrelated to (or are in opposition of) freshwater biodiversity (e.g., natural resource development), positive environmental actions in support of freshwater ecosystems are often done to comply with legislation or to benefit from financial incentives (which emphasizes the importance of the role of policy makers and related actors). However, there is also an opportunity for industry actors

to undertake voluntary actions to support freshwater biodiversity. Such actions will most likely be taken up when there is strong public support for such an action, and often such actions are necessary to obtain a "social license" for an industrial project. Similarly, voluntary actions can improve business opportunities because customers want a certain standard of environmental responsibility. For instance, Patagonia contributes substantially to environmental restoration projects that support their "environmental branding" and, in theory, their clothing sales (Rattalino, 2018). Regardless of the motivation, both individual industry actors (e.g., a decision-maker at a single corporation) and industry associations can help mobilize freshwater biodiversity practitioners (and perhaps more importantly allied practitioners) to act in a way consistent with the ERP. Industry actors and associations can help to ensure that these practitioners act based on the best available science, and thereby contribute to meaningful change for freshwater biodiversity rather than "green washing" consumers (Delmas & Burbano, 2011).

Industry-based practitioners may require additional training to learn these supportive actions. Creating conditions that allow industry-based practitioners to engage in open and transparent collaborations with other actors (e.g., policy-makers, researchers, members of professional societies, advocates, and other practitioners) will be central to supporting the ERP. Positive examples exist of grants available to support collaborations between research and industry partners like MITACS and NSERC Alliance in Canada. However, a shift to more sustainable industry operations is still likely to be limited by the financial burden to individual companies associated with these actions. As such, voluntary actions may be more easily adopted when standardized across an industry (e.g., an industry certification program). Successful examples of this exist including the Hydropower Sustainability Assessment Protocol (created in partnership with industry, civil society, donors, developing country governments, and financial institutions) and the Alliance for Water Stewardship (a collaboration between industry, NGOs and the public sector). As these certification programs gain recognition, they can be used to determine market access and price premiums that provide financial incentives for adoption of good practices (e.g., Aquaculture Stewardship Council). Industry should encourage practitioners to monitor the success of "curve-bending actions" and create public awareness of these successes as a means of fostering positive brand identity, ideally increasing industry market share, and ultimately creating a positive feedback cycle whereby promoting practitioners in support of the ERP is mutually beneficial to the industry actor.

### 3.6 | Practitioners

Mobilizing actions to bend the curve is also the responsibility of the practitioners themselves. As researchers, policy makers, and members of professional bodies create opportunities for training and collaboration related to freshwater biodiversity (e.g., forums, workshops, research projects), it will be the responsibility of the practitioner to seek out these opportunities and actively engage in them. When relevant science has been effectively communicated to or co-produced with the practitioner, the practitioner should use this evidence base to inform actions, even if it means conventional practices may have to change (Walsh, Dicks, & Sutherland, 2015). Practitioners are well positioned to comment on freshwater biodiversity issues at a local scale, and to bring forward realistic opportunities (e.g., restoration projects) to decision-makers that align with the ERP.

## 4 | CONCLUSIONS

The biodiversity crisis is a so-called "wicked problem" that requires a multidisciplinary approach for improvement (Sharman & Mlambo, 2012). This is of particular urgency for freshwater ecosystems, which are facing much greater declines than the terrestrial and marine realms (WWF, 2020). An ambitious Emergency Recovery Plan (ERP) has been put forward identifying steps we must take to reverse declines in freshwater biodiversity globally. To be successful, this plan will require adoption from the level of international agreements (e.g., the Convention on Biological Diversity) to the local practitioner working on restoring native species in a small stream. While the scale of action of the practitioner is much smaller than that of other actors, practitioners make manifold decisions for every large decision made at the national or international level. It is of utmost importance that the principles behind the ERP shape the smaller-scale actions of the practitioner if we are to be successful in bending the curve for freshwater biodiversity loss. Additionally, it will take a concerted effort from all actors, spanning from policy makers to members of local community groups, to mobilize practitioners (including those working on the periphery of freshwater biodiversity issues) in support of the ERP. The roles, responsibilities, and mechanisms of action to achieve this goal will differ across the various actors, but ultimately practitioners need consistent and suitable time, funding, mandate, training, and collaborative opportunities to be successful. This will undoubtedly mean greater prioritization of freshwater biodiversity issues by governments globally, though we view this as absolutely essential given

humanity's dependence on freshwater ecosystems to survive, and the alarming biodiversity declines being observed in these systems.

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## CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

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**William M. Twardek:** Conception of the idea; writing; review. **Elizabeth A. Nyboer:** Review. **David Tickner:** Conception of the idea; review. **Constance M. O'Connor:** Review. **Nicolas W. R. Lapointe:** Review. **Mark K. Taylor:** Review. **Irene Gregory-Eaves:** Review. **John P. Smol:** Review. **Andrea J. Reid:** Review. **Irena F. Creed:** Review. **Vivian M. Nguyen:** Review. **Amanda K. Winegardner:** Review. **Jordanna N. Bergman:** Review. **Jessica J. Taylor:** Review. **Trina Rytwinski:** Review. **André L. Martel:** Review. **Andrew R. Drake:** Review. **Stacey A. Robinson:** Review; **Jerome Marty:** Review. **Joseph R. Bennett:** Review. **Steven J. Cooke:** Conception of the idea; review.

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