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A freshwater perspective on the United Nations decade for ecosystem restoration

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Abstract

Globally, ecosystems have suffered from anthropogenic stressors as we enter the sixth mass extinction within the Anthropocene. In response, the UN has declared 2020-2030 the Decade for Ecosystem Restoration, aiming to mitigate ecosystem degradation and biodiversity loss. Freshwater ecosystems are disproportionately impacted relative to marine or terrestrial systems and ecological restoration is needed to preserve biodiversity and ecosystem services. Paradoxically, freshwater is among Earth's most vital ecosystem services. Here we identify meaningful considerations from a freshwater perspective that will lead to progression toward the restoration of freshwater ecosystems: work across terrestrial and freshwater boundaries during restoration, emulate nature, think and act on a watershed scale, design for environmental heterogeneity, mitigate threats alongside restoration, identify bright spots, think long term (a decade is not long enough), and embrace social-ecological systems thinking. Further, we reflect upon the three implementation pathways identified by the UN to translate these considerations into practice in hopes of "bending the curve" for freshwater biodiversity and ecosystems. Pathway 1, building a global movement, could create a network to share experiences and knowledge promoting vicarious learning, ultimately leading to more effective restoration. Pathway 2, generating political support, will be necessary to institutionalize ecosystem protection and restoration by demonstrating the value of freshwater ecosystems and biodiversity. Pathway 3, building technical capacity, aims to improve

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the current and often ineffective restoration toolbox by incorporating evidence syntheses (i.e., appraisal of evidence base) and Indigenous ways of knowing (i.e., two eyed seeing). Given that freshwater ecosystems are in dire need of repair, it is our hope that these considerations and implementation pathways will contribute to an actionable and productive Decade for Ecosystem Restoration.

K E Y W O R D S

decision making, diversity, freshwater, rehabilitation, restoration ecology

1 | INTRODUCTION

We have just begun the United Nations Decade for Ecosystem Restoration (UN DER, 2021-2030) with much hoorah (see https://www.decadeonrestoration.org/; Mills et al., 2020). Such focused attention and effort are certainly needed given the manifold effects that humans have had on the planet. Ecosystems have been altered by pollution, habitat alteration and loss, the introduction of invasive species, and over exploitation which have collectively contributed to the loss of biodiversity indicating the start of the sixth mass extinction (Cowie et al., 2022). All of the aforementioned threats and impacts are being amplified by climate change (Dodson et al., 2020). These effects on ecosystems and biodiversity are also having direct and indirect effects on human well-being, health and prosperity (Naeem et al., 2009). The level of human impact on the planet has been so extreme that it is now widely accepted that we are in a new epoch period called the Anthropocene (Steffen et al., 2011). Quite simply, we live on a damaged planet that is in dire need of repair (Banks-Leite et al., 2020; Jones et al., 2018). Although ecosystem degradation and biodiversity loss occur in all regions and ecosystem types, effects are perhaps most extreme in freshwater ecosystems (Harrison et al., 2018). Paradoxically, freshwater is among the most vital ecosystem services on Earth-without freshwater, most life cannot persist.

Freshwater ecosystems have been transformed such that freshwater biodiversity is in crisis (Harrison et al., 2018; Reid et al., 2019). Many of the ecosystem services that are provided by wetlands, rivers, and lakes have been impaired (Postel & Carpenter, 1997) to a point that there is much need for ecosystem restoration. Although the premise of the DER is timely, progressive, and lofty, a number of challenges still exist for its benefit to be fully realized (Cooke et al., 2019; Young & Schwartz, 2019). That is particularly the case for freshwater ecosystems, which are often forgotten when it comes to both conservation and restoration (Arthington, 2021). It is assumed that freshwater is encompassed by terrestrial restoration efforts, given the connection between land use and freshwater ecosystem health. Recently there have been articles published on the UN DER in the context of both terrestrial (Abhilash, 2021; Dudley et al., 2020) and marine (Waltham et al., 2020) systems with no treatment specific to freshwater. It is evident that freshwater specific restoration solutions are needed.

Here we provide a freshwater perspective on the UN Decade for Ecosystem Restoration. First, we identify specific considerations for achieving meaningful progress in the restoration of freshwater ecosystems during the UN DER. Second, we reflect on the three UN DER implementation pathways and consider how they are salient to a freshwater context. This perspective article is intended to help ensure that we emerge from the UN DER with strategies for the restoration of freshwater ecosystems. The authorship team comprised primarily of members of the leadership team of the Freshwater Working Group (FWWG) of the Society for Conservation Biology (SCB), who are based in six countries spanning a diversity of latitudes. As such, we also approach this exercise from diverse perspectives, with the aim of identifying what the FWWG could do to help ensure that the UN DER is as impactful as possible when it comes to restoring freshwater ecosystems and bending the curve for freshwater biodiversity (Tickner et al., 2020).

This paper is intended for several audiences including knowledge generators (i.e., researchers), on-the-ground practitioners and stewards (i.e., those engaging in restoration activities ranging from trained professionals to volunteers), and policy-makers and/or agency leads (i.e., those who set the directions of their organizations and allocate resources). We acknowledge that individuals may occupy roles that crossover among these target audiences. Different actors within the freshwater restoration "ecosystem" have different roles and thus the ways in which they interface with the UN DER will vary considerably. As such, in Table 1 we have provided examples of

Roles Policy-makers and **Opportunities for** engagement **Knowledge generators** Practitioners and stewards organizational leads Considerations Work across terrestrial and -Conduct research to -Collaborate with terrestrial -Enable processes and freshwater boundaries understand the effectiveness practitioners to develop structures that of restoration actions that integrated restoration plans institutionalize the concept of have the potential to benefit integrated terrestrialmultiple realms freshwater planning Emulate nature -Conduct research to evaluate -Embrace inspiration from -Support initiatives that the effectiveness of various nature when engaging in consider nature-based restoration actions intended restoration solutions as part of broader to emulate nature conservation and protection programs Think and act on a -Conduct research to -Develop restoration plans that -Embrace governance watershed scale understand the benefits/ are strategic and are applied structures and projects that disbenefits of current efforts from headwaters to estuaries are focused on watershed that tend to be site specific and beyond scale as it relates to planning. with more holistic restoration management and restoration approaches Design for environmental -Conduct research to -Partner with engineers and -Resource programs and heterogeneity understand the types of fluvial geomorphologists to projects at levels that allow restoration initiatives that are ensure that restoration for performance across most resilient and effective in initiatives incorporate different environmental dynamic environmental principles that are resilient to conditions that will most conditions dynamic environmental certainly be experienced over conditions long time scales Mitigate threats alongside Conduct research to understand Work in partnership with other Invest in organizations, restoration the best methods of environmental professionals programs and projects that mitigating threats/stressors to identify and mitigate are comprehensive and and identify the most threats prior to or while combine threat mitigation appropriate time to engage in engaging in restoration (protections) with restoration restoration activities Identify bright spots -Develop rigorous approaches -Share bright spots (and dark -Share bright spots with for quantifying bright spots spots) with others to enable politicians and broader and evaluate methods for uplearning from practitioner publics to build support for and down-scaling experience restoration and to show what is possible Think long term-a decade -Engage in long-term research -Realize that restoration of -Create a restorative culture in is not enough to understand how different some systems will require a organizations and ensure restoration actions perform long time horizon so ensure they are well-funded with across years and decades that there is a lucid plan and long time horizons to repair implement it damaged freshwater ecosystems Embrace social-ecological -Conduct research to quantify -Engage with local -Develop structures and systems thinking the value of restoration to communities and programs that provide society (in economic, social, rightsholders to prioritize, opportunities for diverse cultural and health contexts) plan and engage in actors to engage in ecological freshwater restoration restoration Pathways Pathway I. Building a -Conduct research on the -Network with restoration -Adopt and embrace global movement human dimension of practitioners from around the international policy restoration to identify how instruments and programs

TABLE 1 Audience-specific opportunities for engaging with the UN DER related to freshwater ecosystems

4 of 12 WILEY-

TABLE 1 (Continued)

Opportunities for engagement	Roles		
	Knowledge generators	Practitioners and stewards	Policy-makers and organizational leads
	diverse human values can be respectfully included in restoration programs and projects	globe to learn about successes and failures	(like the UN DER) and develop regional and national programs that support global initiatives
Pathway II. Generating political support	-Quantify value of degraded and restored ecosystems to create the value proposition for restoration for decision makers	-Create opportunities for diverse publics to engage in all facets of restoration so they can build an appreciation for freshwater ecosystems and the need/ potential for restoration	-Embrace opportunities for assembling cross-sectoral working groups to collaborate and plan freshwater use, protection, and restoration to identify win-win-win scenarios and ensure that relevant governance structures are in place that embrace the concept of "restoration governance"
Pathway III. Building technical capacity	-Engage in rigorous evidence synthesis to ensure that restoration approaches are based upon the best available evidence	-Incorporate monitoring components into all restoration projects to ensure learning opportunities are not lost	-Adopt a two-eyed seeing approach that respectfully bridges traditional Western science with Indigenous knowledges and science to inform restoration planning and practice

Note: The items listed in the first column align with topics discussed in this paper. This table is not intended to be exhaustive but rather provide examples of how individuals that hold different roles could engage in or otherwise support the UN DER with a specific focus on freshwater ecosystems.

audience-specific guidance to complement the narrative aspects of the paper.

2 | CONSIDERATIONS FOR ACHIEVING PROGRESS ON THE RESTORATION OF FRESHWATER ECOSYSTEMS

Here we present considerations for achieving meaningful progress toward the restoration of freshwater ecosystems during the UN DER.

2.1 | Work across terrestrial and freshwater boundaries

There is an implicit assumption that the protection and restoration of watersheds will result in tangible benefits for freshwater ecosystems. Whereas the explicit objectives of terrestrial restoration are not mutually exclusive to freshwater ecosystems (e.g., there are co-benefits of crossrealm planning; Adams et al., 2014; the motivation for some terrestrial restoration has been to improve water quality; Clewell & Aronson, 2006), they are most directly focused on benefiting terrestrial species and processes. While a holistic perspective may identify threats to watersheds that also concern freshwater ecosystems (i.e., soil erosion, nutrient loading, land-cover change), the various tools and techniques used to mitigate these threats are often terrestrial in focus. Freshwater ecosystem threats, such as the modification of flow regimes, the dewatering of wetlands, the spread of invasive aquatic species, or the loss of migratory pathways, cannot be addressed solely by terrestrial protection or restoration. Indeed, while many terrestrial threats can be mitigated through quantifiable and observable actions (i.e., fencing to reduce ungulate grazing, reforestation), restoration of the structure and function of freshwater ecosystems is often more complex (i.e., modification of flood pulses, improvements to fish passage). While there are clear benefits to integrating freshwater ecosystems in terrestrial protection and restoration planning (Adams et al., 2014), including a freshwater perspective throughout the process is likely to increase the co-benefits and reduce undesirable or unanticipated consequences.

2.2 **Emulate nature**

Several efforts to restore freshwater systems adopt more engineered designs that use artificial materials (Dalwani & Gopal, 2020). However, emulating nature has a number of advantages, including greater levels of long-term success (e.g., Mitsch & Wilson, 1996). Such nature-based approaches (Nesshöver et al., 2017) that rely on nature for inspiration in freshwater restoration include natural channel design (Rosgen, 2011) or environmental flows (Richter & Thomas, 2007). However, focusing solely on restoring physical attributes of freshwaters (e.g., hydrology and morphology; see Brookes & Shields, 1996) may be insufficient for ecological recovery, at least to a desired state that resembled pre-disturbance conditions (Ormerod, 2004). As such, restoration may also require biological interventions such as translocations to reintroduce extirpated organisms (George et al., 2009). Whether physical or biologically focused restoration, efforts should emulate nature and natural conditions to the greatest extent possible to restore both ecosystem structure and function (Cortina et al., 2006).

2.3 Think and act on a watershed scale

Watersheds (also known as basins and catchments) are often regarded as logical planning units given that there are downstream consequences of upstream actions. As such, restoration efforts often are approached from a watershed (or sub watershed) perspective (Palmer, 2009). Typically, restoration efforts begin in the upstream reaches and work downstream given that there is a hierarchy of physical and biological processes whereby downstream impairments cannot be addressed if upstream impairments continue (Palmer, 2009; Roni & Beechie, 2012). This is evident with issues such as thermal stress or sediment in upstream reaches (Wohl et al., 2015). In some instances there can also be upstream consequences of downstream actions. For example, dams that restrict movement of upstream migrating fish can alter the movement of energy and nutrients which impairs food webs and energy pathways. Recent dam removal projects have revealed how energy subsidies can be rapidly renewed when connectivity is restored (Tonra et al., 2015). Identifying priority sites for restoration and considering the ways in which physical and biological processes intersect is essential for making meaningful progress in watershed restoration given that piecemeal projects have been demonstrated to fail (Palmer, 2009; Wohl et al., 2015). There are a growing number of examples of large-scale restoration efforts that have been effective at achieving targets at watershed scales (e.g., Ogston et al., 2015).

2.4 | Design for environmental heterogeneity

Freshwater ecosystems are inherently dynamic given seasonal and climatic drivers that generate immense environmental heterogeneity. It is necessary to consider the extent of environmental heterogeneity that is "normal" or that could be anticipated (given climate change) and design restoration projects accordingly (Wohl et al., 2015). For example, depending on geography and seasons, a river may experience extreme floods, lengthy drought, and/or dynamic winter ice conditions-with such conditions being annual events (e.g., tropical rivers, billabongs). Failure to incorporate such environmental heterogeneity into restoration planning could lead to river restoration features being destroyed or not providing necessary function throughout different seasons (especially winter given that most freshwater restoration occurs during the summer). The same can be said for designing restoration to be resilient to climate change and anticipated increases in environmental heterogeneity (Battin et al., 2007). Ensuring restoration does not create overly homogeneous habitat (e.g., as occurred during re-wetting project at a degraded bog; Verberk et al., 2010) is also important to ensure diversity of environmental conditions for aquatic biota. Relatedly, when assessing freshwater restoration projects it is important to consider indicators that embrace environmental heterogeneity (e.g., geomorphology, hydrology, ecology; Yu, 2021).

2.5 | Mitigate threats alongside restoration

To ensure the success of restoration programs, threats that contributed to the initial problem should be controlled and new threats need to be monitored and mitigated. Reintroduction of key lost species could be hampered if diseases, parasites, predators, or overexploitation that caused their disappearance were not controlled (Jourdan et al., 2019). Also, other indirect pressures such as the loss of host fishes for the freshwater mussels or pollinators in aquatic plants ought to be attended to. Water pollution and eutrophication (and its consequences) produce lethal or sublethal effects on freshwater species. Restoration programs need to reduce the water pollution at the outset, taking account that this type of process has large inertia. On the other hand, it should be considered that the restoration processes themselves will promote improved water quality, turning restoration programs into virtuous cycles (Tickner et al., 2020). Finally, restored ecosystems can be a good environment for the colonization of alien species (Strayer et al., 2005). An analysis of invasion risk and a

monitoring program for early detection of alien species is essential. Although protecting what we have (e.g., functional riparian zones; Cooke et al., 2022) is preferable to restoration in most cases, we are at a point where freshwater ecosystems are degraded and where we need to focus efforts on threat mitigation and restoration.

2.6 | Identify bright spots

Bright spots represent examples of environmental successes that range in scope and scale (Bennett et al., 2016). The bright spot movement can help to build a sense of optimism among those engaging in environmental actions, as well as observers (e.g., publics; Cvitanovic & Hobday, 2018). Restoration bright spots can also serve as a means to identify, celebrate, share, and learn from what works so that the ideas can be scaled up and/or embraced or adapted by others (Cooke et al., 2018). A recent study explored bright spots in marine coastal restoration (i.e., Saunders et al., 2020) and in doing so revealed a set of characteristics that can be used to inform future restoration initiatives. Identifying bright spots related to freshwater restoration spanning systems (e.g., wetlands, tropical streams) and scales (from a site such as an embayment to the basinscale) would help to create optimism and showcase success stories that could inspire others. Restoration successes (and failures-so called dark spots) in freshwater are rarely shared (but see Twardek et al., 2022) which makes it difficult to learn from the experience of others and avoid repeating the same mistakes.

2.7 | Think long term—a decade is not long enough

Identifying threats responsible for deterioration, degradation, water pollution, and shrinkage of freshwater ecosystems puts the success of the restoration of freshwater ecosystems in doubt within the targeted decade of UN DER. It is doubtful whether a decade will be enough for the restoration of a freshwater ecosystem. Indeed, more continuous or periodical restoration may be needed to achieve long-term goals as has been noted by Suding et al. (2015). Because monitoring of restoration is often non-existent or short-term, little is known about the longevity and effectiveness of different freshwater restoration actions (Bash & Ryan, 2002). For example, Roni et al. (2002) considered the longevity of different watershed restoration practices, ranging from riparian tree planting to the placement of instream structures or fertilization, and concluded that some of these actions are short lived. Beyond that, response time following

different interventions is highly variable and may take decades before the outcome is known, particularly when restoration efforts focus on riparian zones or aspects of system function that are slow to respond and preface changes in ecosystem structure (Roni et al., 2002). Also relevant is determining the (historic) state that one is trying to achieve with restoration (Jackson & Hobbs, 2009). Often the concept of "drinkable, fishable, and swimmable" (see Carson & Mitchell, 1993) is used which fails to consider historical environmental conditions or focus on biodiversity and ecosystem integrity. Nonetheless, "drinkable, fishable, and swimmable" is understood by decision makers (including politicians), often entrenched in law, and has led to some successful restoration endeavors that have benefitted biodiversity. What is clear is that the restoration of freshwater ecosystems is a long game that needs to extend well beyond a 10-year period if we are to set goals that extend beyond small, partial restoration initiatives with goals and targets that are to focused on freshwater biodiversity.

2.8 | Embrace social-ecological systems thinking

Early restoration efforts focused largely on biotic and abiotic objectives and properties of ecosystems rather than thinking about how people and social processes interacted with ecosystems and restoration (Martin, 2017). Recently, there has been a major pivot whereby socialecological thinking is embraced, even in the context of restoration and the UN DER (Fischer et al., 2021). Freshwater ecosystems and watersheds are inherently conceptualized as (complex) social-ecological systems given interdependence and feedback (Dunham et al., 2018), thus necessitating that management interventions (such as restoration) embrace social-ecological systems thinking (Nguyen et al., 2016). Fischer et al. (2021) emphasize the role of humans as stewards, which is salient to freshwater restoration given the major role of individual volunteers and community organizations in watershed restoration (France, 2005). Engaging community members and other actors (e.g., rightsholders, stakeholders, champions) can help to shape freshwater restoration goals and ensure relevance to freshwater restoration efforts. Moreover, centering restoration around people and communities ensures that approaches are respectful, and even if restoration efforts fail to achieve ecological outcomes, societal outcomes can still be realized (Egan et al., 2011). Not least among the possible long-term outcomes of social-ecological thinking are ecocentric worldviews, that converge in many ways with Indigenous and local cosmologies (Taylor et al., 2020).

3 | IMPLEMENTATION PATHWAYS FOR THE RESTORATION OF FRESHWATER ECOSYSTEMS

The UN DER has identified three implementation pathways. Here we briefly reflect on those pathways from a freshwater lens (Figure 1).

3.1 | Pathway I: Building a global movement

Building a global movement for freshwater restoration is sorely needed but it also must be grounded at a regional and local scale. Most restoration work occurs in a very local manner by on-the-ground practitioners (Bernhardt et al., 2007) working with partners such as community groups and youth (e.g., through schools; Metcalfe et al., 2022). Connecting individuals to a broader community of like-minded individuals and organizations around the globe could help to inspire and elevate freshwater restoration efforts. Moreover, engaging community members



FIGURE 1 Overview of UN DER implementation pathways for ecological restoration tailored to freshwater ecosystems

supports how individuals engage with freshwater ecosystems and vote (relevant to political will below; Cooke et al., 2013). Such efforts need to be inclusive and need to ensure that the benefits arising from restoration are shared with all in an equitable manner (Wells et al., 2021). At present, much restoration effort occurs in a vacuum with success stories (and failures) not adequately shared, thereby hindering knowledge transfer and vicarious learning. Creating a network to share experiences (these could be in the form of bright spots as introduced above) and other forms of knowledge could be useful rather than relying on peer-reviewed literature as the sole method for disseminating knowledge (much of which is held by practitioners who are unlikely to publish peer-reviewed articles). The UN DER website and regional champions have begun to aggregate examples of success stories, but there is also opportunity for professional organizations such as the SCB and the Society for Ecological Restoration (see their international guidelines; Gann et al., 2019) to facilitate interactions (albeit both have traditionally had little focus on freshwater; Vance-Borland et al., 2008). Because freshwater ecosystems are often not at the fore when thinking about restoration, having freshwaterspecific opportunities for engagement will be key so practitioners will feel at home, valued, and represented. The Freshwater Working Group of the SCB has selected restoration as a focal area of effort for the coming years so there are opportunities to serve as a point of connection and leadership in building a global movement for freshwater restoration. We also recognize that the motivations (individual, institutional) for ecological restoration are diverse which emphasizes the importance of making connections among diverse stewards and embracing a unified approach that extents to responsibility for action (Clewell & Aronson, 2006).

3.2 | Pathway II: Generating political support

The UN DER has rightfully identified the necessity of generating political support (and will) necessary to institutionalize ecosystem protection and restoration. Yet, for restoration efforts focused on freshwater, the challenges are immense; freshwater biodiversity is often forgotten when it comes to policy discussions and political decisions (Abell, 2002). In many ways, freshwater itself is taken for granted and commoditized (Feitelson, 2012) for drinking water, irrigation, industrial uses, and hydropower generation. Despite the many and diverse ecosystem services provided by freshwater ecosystems (Postel & Carpenter, 1997) and their constituent biota (e.g., Lynch et al., 2016), when it comes to

trade off activities like energy and food production, freshwater biodiversity often loses (Garcia-Moreno et al., 2014). Despite efforts to raise the profile of freshwater ecosystems (Albert et al., 2021) and sectors such as inland fisheries (Cooke et al., 2016), freshwater biodiversity is frequently forgotten. Even in the UN Sustainable Development Goals (SDG), freshwater biodiversity is excluded from SDG 14 titled "Life below water - Conserve and sustainably use the oceans, seas and marine resources for sustainable development" which is symptomatic of the invisibility of freshwater biodiversity (Lynch et al., 2017). Although freshwater is the foundation for SDG 6 (i.e., Ensure availability and sustainable management of water and sanitation for all), there is little about ecosystem restoration of protection or restoration of freshwater from a biodiversity perspective (see https://www.unwater.org/full-picture-holistic-watergoal/). Freshwater ecosystems should be explicitly recognized as important habitats and ecosystems in their own right by policy makers and funding organizations, as well as management and restoration programs (Maasri et al., 2022). Aligning freshwater ecosystem restoration efforts conducted under the auspices of the UN DER with relevant SDGs will help to demonstrate connections between freshwater, freshwater biodiversity, and people. Generating political support will take a variety of efforts including demonstrating the value (economic, social and otherwise) of intact freshwater ecosystems and biodiversity (e.g., Wilson & Carpenter, 1999) and raising the profile of freshwater biodiversity among diverse publics (Cooke et al., 2013; He et al., 2021). When political support for freshwater restoration is achieved it will presumably be met with the necessary investments in effective restoration efforts. However, if there are weak governance structures in place for the management of freshwater ecosystems, political will may be impossible to achieve or may be irrelevant. Freshwater governance encompasses components such as accountability, clarity of roles, transparency, policy coherence (especially as related to restoration goals), stakeholder and rightsholder engagement and participation, and capacity (Berg, 2016). Sapkota et al. (2018) argue that restoration governance frameworks are essential for ensuring that restoration efforts succeed and we submit that this is particularly salient for freshwater systems given the complexity of governance (e.g., cross-jurisdictional-think watersheds). Even if political will for freshwater ecosystems is achieved, without good governance it could be quickly lost, and along with it, funding for restoration (Barwick et al., 2014). There are also many opportunities to engage in cross-sectoral dialogues with diverse water users given that freshwater restoration needs to be conducted within the context of integrated water resources management (Rahaman & Varis, 2005)-working with other users rather than working at odds (Golet et al., 2009).

3.3 | Pathway III: Building technical capacity

Restoring freshwater ecosystems is not easy, yet has been identified as a critical aspect of the emergency recovery plan for freshwater biodiversity (Tickner et al., 2020). The fact that the UN DER recognizes the need to build technical capacity related to restoration is a candid recognition that the current restoration toolbox is incomplete and often ineffective. Underpinning knowledge deficiencies regarding restoration effectiveness is a long-standing deficiency in post restoration monitoring (Suding, 2011) which represents lost learning opportunities. Evidence synthesis is a valuable approach for determining what works and in which contexts. In the last decade there have been a number of freshwater restoration-oriented syntheses that have revealed surprises and knowledge gaps. For example, several studies (i.e., Stewart et al., 2009; Taylor et al., 2019) have revealed that common approaches for restoring fish habitat are not overly effective. Most restoration studies take place in developed countries in the north (mostly Europe and North America) focused on specific economically valuable taxa or species (e.g., salmonids). The freshwater biodiversity crisis is global so such biases in the evidence base severely constrain the ability to engage in evidence-based (and effective) restoration. In freshwater systems there is a need for empirical research that is of high quality (e.g., replication with relevant and multiple controls and before and after restoration using diverse biotic and abiotic endpoints) to build a robust evidence base. Additionally, reliance on Western (colonial) science has largely ignored local or traditional knowledge systems, which has a long history of effective resource management (Berkes et al., 2000). When thinking about technical capacity and evidence, it is prudent to consider Indigenous knowledge using a two-eyed seeing approach (Reid et al., 2021) which has been embraced in terrestrial restoration but less so in freshwater restoration (Uprety et al., 2012). One area where technical capacity is needed relates to the fact that freshwater restoration actions tend to be largely ad hoc and site-specific. Ensuring that such efforts are nested within and guided by broader freshwater planning initiatives requires new frameworks (e.g., Higgins et al., 2021) that have been tested at relevant scales.

4 | CONCLUSION

Freshwater ecosystems are often forgotten when it comes to conservation which is partly to blame for the freshwater biodiversity crisis (Arthington, 2021). The same can be said for restoration where science-based freshwater ecological restoration is lagging. Early signals about the UN DER suggest that much of the thinking has been about terrestrial systems (Stanturf, 2021) and associated restoration actions (e.g., mass tree planting; Temperton et al., 2019; Duguma et al., 2020). Clearly freshwater systems can benefit from restoration of terrestrial systems (and tree planting; Brancalion & Holl, 2020) but they also demand and deserve targeted restoration efforts that incorporate diverse strategies that benefit biodiversity (Veldman et al., 2015) and help to create the conditions that enable long-term sustainability rather than focusing solely on short-term gains (Fleischman et al., 2020; Higgins et al., 2021). There is urgent need for integrated terrestrial-freshwater planning which has the potential to benefit biodiversity in both realms (Leal et al., 2020). Doing so requires crafting policy that recognizes the connections between terrestrial and freshwater systems and that treats those systems as equal in importance (Abell & Harrison, 2020). To date that is the exception rather than the norm with such guidance largely absent from the UN DER documents and initiatives. Aspects of governance are also critical to achieving restoration success in freshwater (Barwick et al., 2014; Sapkota et al., 2018) yet are understated in the UN DER.

Here we have provided considerations for achieving meaningful progression toward the restoration of freshwater ecosystems during the UN DER. Considerations include working across relevant spatial and temporal scales, thinking across boundaries, identifying bright spots, and designing restoration for a dynamic future (e.g., environmental change). These considerations can all be achieved with commitment of practitioners, decision makers, scientists, stewards, and other partners. The three implementation pathways identified by the UN provide clear direction on how to move from aspirational goals to action. Implementation of the UN DER is essential to deliver on its promise (Cooke et al., 2019; Young & Schwartz, 2019) and has the potential to help bend the curve for freshwater biodiversity (Tickner et al., 2020). The imperiled state of freshwater systems and the desperate need for effective restoration is both a challenge and opportunity. This paper provides candid guidance for those interested in embracing the UN DER and ensuring it benefits freshwater ecosystems and biodiversity. There are opportunity and need for knowledge generators, restoration practitioners and stewards, policy makers and organizational leaders, and civil society more broadly, to embrace the UN DER and to work collaboratively toward the restoration of freshwater ecosystems and biodiversity writ large. This unique opportunity may be squandered for the detriment of freshwater biodiversity and humanity if some of the actions outlined here are not fully embraced.

AUTHOR CONTRIBUTIONS

All authors were involved with idea generation, writing, and editing.

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This paper is a product of the Freshwater Working Group of the Society for Conservation Biology and we are publishing this paper in a Society for Conservation Biology journal (i.e., Conservation Science & Practice). Editorial decisions were completely independent of that relationship.

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