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POLICY PERSPECTIVE

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New policy directions for global pond conservation

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Abstract

Despite the existence of well-established international environmental and nature conservation policies (e.g., the Ramsar Convention and Convention on Biological Diversity) ponds are largely missing from national and international legislation and policy frameworks. Ponds are among the most biodiverse and ecologically important freshwater habitats, and their value lies not only in individual ponds, but more importantly, in networks of ponds (pondscapes). Ponds make an important contribution to society through the ecosystem services they provide, with effective conservation of pondscapes essential to ensuring that these services are maintained. Implementation of current pond conservation through individual site designations does not function at the landscape scale, where ponds contribute most to biodiversity. Conservation and management of pondscapes should complement current national and international nature conservation and water policy/legislation, as pondscapes can provide species protection in landscapes where large-scale traditional conservation areas cannot be established (e.g., urban or agricultural landscapes). We propose practical steps for the effective incorporation or enhancement of ponds within five policy areas: through open water sustainable urban drainage systems in urban planning, increased incentives in agrienvironment schemes, curriculum inclusion in education, emphasis on ecological scale in mitigation measures following anthropogenic developments, and the inclusion of pondscapes in conservation policy.

KEYWORDS
biodiversity, ecosystem services, freshwater policy, international nature conservation, landscape-scale, pond networks, small waterbodies

1 | INTRODUCTION

Longstanding international environmental and nature conservation policies (such as the Ramsar Convention, the Convention on Biological Diversity, and the European Water Framework Directive [WFD]) are important for protecting species and habitats, in the face of growing anthropogenic pressures (Dudgeon et al., 2006). Despite this, the number of threatened species listed on the IUCN Red List continues to increase, human-dominated lands (urban, agricultural) continue to replace natural lands (Decker et al., 2016), and a number of key terrestrial and freshwater habitats continue to be overlooked by policy makers. Ponds, defined in the United Kingdom and most of Europe as lentic waterbodies <2 ha in area (Williams et al., 2010), and pondscapes, defined as a network of ponds and their surrounding terrestrial matrix (Figure 1), are one such historically neglected habitat. Recently, there has been a significant increase in recognition of the importance of ponds and pondscapes to biodiversity and ecosystem services by scientific and nonscientific communities. Yet these small waterbodies remain largely outside the remit of international, and in many cases national, conservation and environmental legislation.

2 | CURRENT CONSERVATION STATUS OF PONDS

Ponds are abundant across the globe (c. 500 million ponds and lakes are estimated to exist worldwide; Holgerson & Raymond, 2016) and are critically important for ecology and society. Recent evidence indicates that pondscapes support high biodiversity (The Pond Manifesto; EPCN, 2008), and contribute disproportionately more to catchment aquatic biodiversity than larger and more widely studied freshwater bodies such as lakes and rivers (Davies et al., 2008b). Furthermore, ponds provide essential habitat for many nationally and internationally rare and threatened species and are important refuges in urban and agricultural landscapes (Chester & Robson, 2013; Davies et al., 2008b). The significant contribution of pondscapes to local and regional aquatic biodiversity can be attributed to: (1) the small catchments of individual ponds, resulting in idiosyncratic environmental conditions and habitat complexity, leading to landscape scale habitat heterogeneity (Davies et al., 2008b), (2) the value of anthropogenic ponds (e.g., farm ponds) for increasing the area of freshwater habitat available for wildlife, and (3) the provision of refuge habitats for aquatic communities, especially where natural wetlands have been largely converted into farm ponds or paddy fields (Chester & Robson, 2013; Takamura, 2012). Ponds also play an important role in supporting semiaquatic and terrestrial flora and fauna, for example, agricultural areas that contain ponds support higher richness and abundance of terrestrial species than agricultural areas without ponds (syrphids and bees: Stewart et al., 2017; birds: Davies, Sayer, Greaves, Siriwardena, & Axmacher, 2016).

Ponds are increasingly recognized for the important ecosystem services they provide to society including flood alleviation, storage of urban storm water, the supply of irrigation water (Takamura, 2012), and nutrient or pesticides removal from water. Ponds have been estimated to sequester a similar amount of carbon to the world's oceans (Downing et al., 2008), and may help mitigate the effects of urban heat islands (Coutts, Tapper, Beringer, Loughnan, & Demuzere, 2012). These small waterbodies also provide considerable amenity, providing social and cultural benefits including improved physical and mental well-being and increased awareness of biodiversity and nature conservation (Lundy & Wade, 2011).

Despite these benefits, current national and international environmental legislation and management strategies are almost exclusively focused on large waterbodies, with ponds being harder to characterize, evaluate, monitor, and protect (Table S1). In Europe, the EU WFD was implemented to protect and improve the water quality of all freshwaters and shallow coastal water. Yet, in practice the WFD only covers rivers and standing waterbodies ≥50 ha, while excluding the vast majority of small wetlands and lentic waterbodies (Hassall, Hill, Gledhill, & Biggs, 2016). It has been suggested that the broad catchment-scale measures implemented under the WFD for larger waterbodies should also protect smaller waterbodies, but there is little evidence for this (Biggs, von Fumetti, & Kelly-Quinn, 2016). Nature conservation organizations have been quicker to identify the value of ponds for biodiversity, and as a result, nature conservation legislation at a European scale is currently the most important tool for protecting pond habitats and their biota (Hassall et al., 2016). The Habitats Directive provides protection as priority

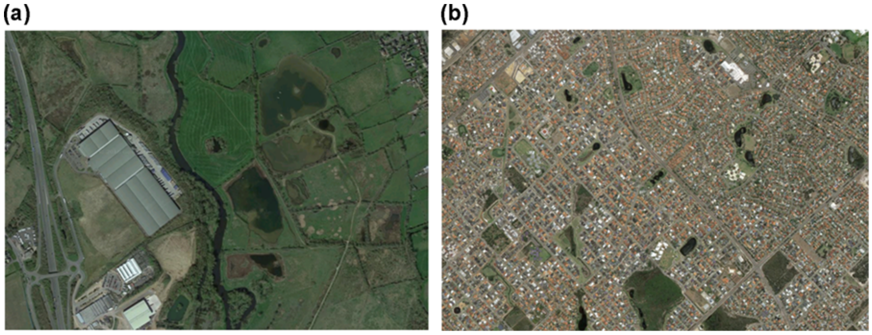

FIGURE 1 Groups of small ponds and surrounding habitats ("pondscapes") provide important ecosystem services in human-dominated landscapes. A pondscape in (a) an agricultural landscape in the United Kingdom (Leicestershire) and (b) an urban setting in Australia (Perth; providing important habitat for amphibian meta-communities). Map data credit: Google Earth (2016)

habitat to only a few pond types (e.g., Mediterranean temporary ponds, natural dystrophic lakes and ponds) and some pond-associated species (e.g., Great Crested Newt, *Triturus cristatus*; EC, 1992). However, the scale at which pond conservation is applied currently (i.e., individual site designation) is not the scale at which ponds contribute most to biodiversity (pondscape scale; Hill, Ryves, White, & Wood, 2016). Furthermore, as significant advances in knowledge of pondscapes occurred after the implementation of the Habitats Directive and WFD, there remain significant gaps in the protection that these directives provide to pondscapes and their biota (Biggs et al., 2016).

Similarly, in North America and Australia, pond habitats in general do not receive direct legislative protection despite the Clean Water Rule 2015 of the Clean Water Act in the United States (Department of Army, Corps of Engineers and US Environmental Protection Agency, 2015) and the national-scale Environment Protection and Biodiversity Conservation Act, 1999 in Australia (Act, 1999). The latter includes an inventory of >900 "nationally important" wetlands that are protected based on meeting ≥1 of 6 criteria. However, these criteria focus on attributes of single wetlands, ignoring their landscape contexts, and few small waterbodies are specifically designated.

In Asia, international legislation specifically targeted for conservation of pond habitats is largely lacking. A possible reason for this is a lack of holistic biodiversity or water quality surveys of ponds in international or national monitoring programs. In Japan, the Ministry of Land, Infrastructure, Transport, and Tourism (1990-) conducts nation-wide and long-term censuses of water quality and biodiversity in rivers and impounded reservoirs, local governments (1970-) monitor water quality of lakes, and the Ministry of the Environment (monitoring site 1,000 programme; 2009-) evaluates biodiversity of some 20 wetlands or lakes. Although action plans for wetland/pond conservation exist in conjunction with the National Biodiversity Strategy of Japan 2012-2020, comprehensive or long-term water quality and biodiversity monitoring data are lacking. In India, almost all ponds and pondscapes are excluded from environmental and nature conservation legislation. Some large wetlands in India receive legislative consideration from the Wetlands (Conservation and Management) Rules under the Environment Protection Act 1986 and the National Environment Policy 2006, which regulates the activities that can be undertaken within these wetlands (Sundar & Kittur, 2013). A few ponds within protected areas also receive some protection under the Wildlife Protection Act 1972. However, there have been heated debates between civil society and central governments because of restrictions on activities in these wetlands (although in September 2017, wetland conservation and management legislation in India was amended, potentially excluding certain categories of human-made waterbodies). Legislation for the sustainable management of ponds in India is difficult as irrigation departments, fisheries departments, and district councils often manage them jointly.

Ponds may receive indirect protection through other legislation. For example, South Africa's National Biodiversity Strategy and Action Plan (NBSAP, 2005) and Namibia's National Biodiversity Strategy and Action Plan (NNBSAP, 2013) aim to integrate terrestrial and aquatic management to minimize the impacts of processes that threaten biodiversity, to enhance ecosystem services and, to improve social and economic security. In such water-scarce countries, pond security is thereby embedded in policies aimed at water security, biodiversity conservation, and resilience without specifically referring to the thousands of water retention ponds throughout these nations. Importantly, both these southern African NBSAPs emphasize not only hydrology, resilience, and sustainability, but also the importance of conserving the rich heritage of endemic species.

At the international level, the Ramsar Convention, signed by 169 countries, ensures that key wetland (Ramsar) sites of international importance are protected (Ramsar, 2016), with many encompassing large numbers of ponds. Other international initiatives, particularly the Convention on Biological

Diversity, have stimulated development of the international partnership for "Satoyama Initiatives" to promote the sustainable management and use of natural resources that benefit society and biodiversity, partially incorporating pondscapes (Bélair, Ichikawa, Wong, and Mulongoy, 2010). In addition, there are a few national-scale policies that provide protection for ponds, such as the United Kingdom's recognition of "Priority Habitats" and "Priority Species" for site- and species-specific conservation and management (JNCC & Defra, 2012). However, most ponds and pondscapes fall outside of contemporary nature conservation policy. This has arisen largely from a lack of recognition and poor understanding of the importance of pondscapes for sustaining local and regional biodiversity at a policy/management level. In arid and semiarid countries like Namibia and South Africa, where ponds are included in regional plans, the focus is to protect water resources and promote hydrological cycles rather than pond biodiversity per se. The reality of global freshwater conservation is nuanced and complex, incorporating a range of political issues (e.g., definitions of different freshwater habitats, top-down vs. bottom-up management), social issues (property and societal rights), and economic issues (economic development vs. environmental conservation, and cost effectiveness of management; Calhoun, Jansujwicz, Bell, & Hunter, 2014). However, there remain significant opportunities for the inclusion of ponds and pondscapes in international and national conservation and policy frameworks.

3 | OPPORTUNITIES FOR POND CONSERVATION, SUPPORTED BY SCIENCE

3.1 | Patch-network conservation

Knowledge regarding the value of pondscapes, even in human-dominated environments (Hill et al., 2016), now provides clear empirical evidence and support for their inclusion in environment and nature policy frameworks. Conceptual advances in ecological research from "corridors" to "connectivity" have provided critical scientific evidence to underpin the development of practical conservation strategies across landscapes. Groups of small habitats generally provide as high (or higher) conservation value than a single large habitat of equal area (Fahrig, 2017). Several studies have shown that networks of smaller ponds support higher taxonomic richness and conservation value than one large pond (Martínez-Sanz, Canzano, Fernández-Aláez, & García-Criado, 2012; Oertli et al., 2002). In addition, higher pond density is associated with greater species richness in UK urban ponds (Gledhill, James, & Davies, 2008). This suggests that the current legislative focus on large, contiguous habitats at the exclusion of small habitats is potentially misguided (e.g., EU Natura 2000 network; European Commission, 2008). Furthermore, applying patch-network conservation exclusively at large spatial scales can be ecologically ineffective, missing local-scale biodiversity hotspots, particularly in human-dominated landscapes. One way to improve the effectiveness of landscape conservation is to incorporate networks of smaller freshwater habitats (≈pondscapes), alongside large-scale habitat networks. For example, in the context of widespread agroforestry in South Africa, large-scale ecological networks (ENs) of remnant land within agroforestry landscapes have been set aside to mitigate the effects of agroforestry. These ENs are rich in natural and artificial pondscapes and are similar in biodiversity value to those in neighboring protected areas (Pryke, Samways, & De Seadeleer, 2015). However, urban and agricultural landscapes often represent barriers (e.g., roads) for the dispersal and colonization of pond biota. Managing pondscapes would increase focus on management actions that increase connectivity between ponds, especially for native species migration between ponds (e.g., culverts beneath roads, restoring drains as streamlines with fringing vegetation). Consideration of pondscapes favors landscape complementation because they encompass a variety of habitat types (proximal terrestrial and aquatic habitat) for many species to complete their life histories (Pope, Fahrig, & Merriam, 2000). Furthermore, conservation of pondscapes facilitates connectivity and dispersal, particularly in agricultural landscapes, acting as stepping stones between larger protected freshwater habitats, thereby increasing the effectiveness of conservation measures at larger spatial scales (Kukkala et al., 2016; Pryke et al., 2015).

In human-dominated landscapes, many ponds and pondscapes are located on private land and if faced with the prospect of mandatory conservation initiatives, it may be financially and logistically easier for landowners to remove (i.e., drain or infill and build over) ponds given their small size (Calhoun et al., 2014). In some agricultural and urban landscapes where private ownership of ponds is high, environment and conservation legislation may need to be flexible and designed to allow environmentally friendly farming, forestry, fisheries, ecotourism, and/or urban development to ensure the persistence and protection of ponds, while not overly restricting local economic activities (Usio & Miyashita, 2014). For example, most pondscapes in Japan are used for irrigation for rice farming and form a part of Satoyama, a landscape mosaic of paddy fields, dry cropland, farm ponds, grassland, secondary forests, streams, and villages. Given that the biodiversity of Satoyama is maintained through traditional farming, forestry and fishing activities, moderate levels of human activities are encouraged to maintain indigenous biodiversity as well as to sustain the local economy (Takeuchi, 2010). Furthermore, to raise public awareness of the value of multifunctionality in agricultural areas, the Food and Agriculture Organization of the United Nations designates regions with traditional agriculture, indigenous culture, scenic landscape, and sustainable use of natural resources as Globally Important Agricultural Heritage Systems (GIAHS, 2017). Biodiversity conservation in urban areas presents a number of challenges associated with development. However, ponds are increasingly recognized for the ecosystem services they provide in cities. In some new urban developments, stormwater/groundwater recharge ponds have been created. These provide some "natural" habitat, offsetting pond loss and maintaining biodiversity in new developments (Hassall & Anderson, 2015).

3.2 | Monitoring ecological condition

Ponds and pondscapes are rarely monitored in a systematic manner because of the resource and logistical implications for protecting these abundant waterbodies. Other monitoring options are possible, such as the use of sentinel sites that can be monitored over long time periods, citizen-science-based monitoring projects, or environmental DNA techniques that may facilitate rapid and effective assessment of pond biodiversity and presence of protected species (Biggs et al., 2016). Monitoring approaches need to be further refined to provide rapid, low-cost assessments of the environmental and biological quality of ponds to guide conservation management (Rosset et al., 2013). This is currently being implemented in South Africa using a Dragonfly Biotic Index, which can be applied to small pond environments as well as other freshwater systems (Samways & Simaika, 2016). Monitoring a charismatic taxon like dragonflies, which may also act as an umbrella for many other taxa, makes data collection more feasible, especially as citizen scientists can be readily engaged. In India, the identification of ponds and wetlands through the development of the Wetland Atlas (Bassi, Kumar, Sharma, & Pardha-Saradhi, 2014) provides significant opportunities for the periodic monitoring of pondscapes using remotely sensed data and citizen scientists.

Ponds provide frequent opportunities for citizens to engage in conservation and habitat management activities, especially when linked to education or enjoyment of wildlife through dedicated trails (Willis & Samways, 2013). Given the inadequate funding levels for global biodiversity conservation (Waldron et al., 2013), there is increasing reliance on agencies such as environmental charities to act as intermediaries among government policy makers, stakeholders, and the public to realize the aspirations of conservation initiatives. The development of a forum which connects stakeholders such as scientists, landholders, citizens, environmental groups/agencies, and policy makers may facilitate pond conservation. Such a forum should provide digital and/or physical space for dialogue among groups, make scientific findings accessible to resource managers, stakeholders, and citizens, provide training in pond monitoring, and facilitate the development of conservation initiatives that are robust, innovative, and accessible for all groups (Calhoun et al., 2014).

4 | POLICY-BASED RECOMMENDATIONS

Sufficient research now exists to underpin policy recommendations for ponds. There is an ecological need for the Ramsar Convention, the Convention on Biological Diversity, and other international environmental legislation (e.g., the WFD in Europe) to now explicitly recognize pondscapes. Below, we provide recommendations on how ponds, pondscapes, and their ecosystem services should be incorporated into policy.

(1) Environmental context: Given that ponds often occur in networks linked by important terrestrial habitats, identifying groups of important sites as management units (recommended by the WFD; EC, 2003) will be logistically easier and more cost-effective than monitoring/protecting individual ponds. Defining pondscapes as management units increases opportunities to monitor ponds over wider areas and to identify objectives for each pondscape (Biggs et al., 2016). In addition, requiring permits for modifications (positive or negative) of ponds provides a policy tool that can consider the role of each pond within the pondscape, and would require applicants to maintain/enhance a pond's capacity to sustain native biodiversity within the pondscape. Local government or nongovernment environmental organizations would be well-placed to implement pond management units and permits.

(2) Urban planning: Planning regulations can be adapted to prioritize open water-sustainable urban drainage systems alongside other nature-based solutions (Dadson et al., 2017). Mitigation for pond loss during development should be based on pondscape-scale considerations rather than individual habitat creation. Also, during urban development, there should be a focus on zero ecological loss, as opposed to zero habitat loss, and ponds could form a key part of this strategy. Under some conditions, stormwater ponds can support significant biodiversity (Hassall & Anderson, 2015), especially where a treatment train of clean water ponds (e.g., receiving roof water) is initially separated from ponds receiving contaminated water (e.g., from roads or vehicle parks). Diverting runoff water that would otherwise flow directly to lakes or rivers, into such ponds, could increase pond density and biodiversity in urban areas as well as help mitigate flooding and retain pollutants.

(3) Flood management: The current trend toward natural flood management provides an opportunity for policies to incorporate pondscapes. Ponds can be easily integrated into open water flood storage strategies because small waterbodies may pose fewer logistical issues than larger ones, yet hold an equivalent volume of water. It may be also relatively easy to integrate numerous small ponds into urban or rural land management schemes, such as the "sponge city" concept currently being adopted in China (Liu, Jia, & Niu, 2017).

(4) Agriculture: Financial incentives are sometimes provided (e.g., under the EU agrienvironment schemes) for the maintenance of individual farmland ponds of significant biodiversity value (Attwood et al., 2009; Davies, Biggs, Williams, Lee, & Thompson, 2008a). These incentives could be modified to ensure that the protection and creation/restoration of pond networks is rewarded at a rate greater than the sum of the individual ponds, provided collaborative agreements could be made between multiple landowners.

(5) Education: Opportunities may exist for "pond schools" which parallel "forest schools" in their focus on nature as a core of education (Austin et al., 2016). Many schools in urban or rural landscapes could make greater use of nearby ponds to provide enhanced pedagogical and health benefits. In addition, as part of the increased focus on nature play and kitchen gardens in schools, "frog ponds" could be constructed to provide these benefits to students and their communities. In human-dominated landscapes, public awareness of pondscapes can be increased by designating globally or nationally important pondscapes (through frameworks such as GIAHS, 2017).

5 | CONCLUSION

Current conservation policy is failing to preserve much of the aquatic biodiversity and ecosystem services supported by pondscapes. For policy to be consistent with current scientific understanding, pondscapes should be better integrated into national and international policy frameworks to maximize opportunities for conserving and protecting biodiversity and ecosystem services. Although the economic implications of new environmental policies will be contested in certain quarters, because of their small size pondscapes may be easier to conserve and maintain than larger waterbodies. Moving away from site-specific conservation to a strategy that conserves resilient landscapes, puts people at the heart of the environment, and grows natural capital will promote biodiversity conservation (Natural England, 2016). An evidence-based conservation strategy that incorporates pondscapes into policy frameworks will significantly improve existing legislation by protecting a valuable, multifunctional habitat type that provides a solution to multiple complex societal challenges while supporting and enhancing biological diversity.

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SUPPORTING INFORMATION

Additional Supporting Information may be found online in the supporting information tab for this article.

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