



USING PONDS AND PONDSCAPES AS NATURE-BASED SOLUTIONS

GUIDANCE FOR POLICY MAKERS ON THE USE OF PONDS
AND PONDSCAPES AS NATURE-BASED SOLUTIONS
FOR CLIMATE CHANGE MITIGATION AND ADAPTATION



Ponderful
PONDS FOR CLIMATE

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SUMMARY

Ponds are globally abundant and critically important habitats for freshwater species and provide multiple ecosystem services and Nature's Contributions to People.

Benefitting from ponds, and the ecosystem services they provide, requires legislative, policy and practical frameworks to be in place.

In this guide, created by the EU Horizon 2020 funded **PONDERFUL** project, which ran from December 2020 to 2024, we provide policy makers with the tools to design effective plans for ponds and pondscapes. The guide should be read in conjunction with the **PONDERFUL** technical handbook¹ ('Ponds and Pondscapes: A technical guide to the use of ponds and pondscapes as nature-based solutions for climate change mitigation and adaptation').

To protect and manage ponds effectively as nature-based solutions policy makers should create national and regional plans for ponds which:

- Understand the resource by making national pond inventories, mapping ponds and assessing their importance for biodiversity and the Nature's Contributions to People and other ecosystem services they provide

- Establish monitoring programmes on five or 10 year cycles to assess pond condition and delivery of key Nature's Contribution to People
- Set targets for pond and pondscape improvements and delivery of goals to meet policy aims (e.g. of the EU Nature Restoration Law)
- Introduce practical programmes, with numerical targets, for protecting, managing, restoring and creating ponds and pondscapes
- Identify or devise funding programmes for ponds and pondscapes.

We provide a specimen format for a national plan for ponds and pondscapes. Recognising the under-protection of ponds we also highlight recent proposals for a global convention on ponds. The value and importance of ponds is briefly summarised, along with approaches to their practical management, monitoring and financing. Throughout the document we signpost the more detailed guidance provided in the **PONDERFUL** technical handbook.

1. www.doi.org/10.5281/zenodo.13844497

A close-up photograph of a dragonfly perched on a green leaf. The dragonfly has a blue and black body with white spots on its abdomen and thorax. Its wings are transparent with a complex network of veins. The background is a soft-focus green and yellow, suggesting a natural outdoor setting. The text is overlaid on the right side of the image.

USING PONDS AND PONDSCAPES AS NATURE-BASED SOLUTIONS

1. ABOUT THIS DOCUMENT

This guide provides practical advice for policy makers and legislators on the contents of national and regional plans to support the use of ponds and pondscape as nature-based solutions for addressing societal challenges.

The protection, management, restoration and creation of ponds and pondsapes presents many opportunities to mitigate and adapt to the impacts of climate change and benefit from the ecosystem services and Nature's Contributions to People that are provided by ponds.

More detailed practical guidance on the use of ponds and pondsapes as nature-based solutions is provided in the **PONDERFUL** technical handbook 'Ponds and Pondsapes: A technical guide to the use of ponds and pondsapes as nature-based Solutions for climate change mitigation and adaptation' (hereafter, the **PONDERFUL** technical handbook).

2. WHAT ARE PONDS?

Ponds are critically important, globally abundant, freshwater habitats (or brackish water in some cases). They are a natural component of all terrestrial environments but are also widely created by people. Despite their small size they are often collectively the richest part of the water environment and are refuges for endangered and endemic species. They provide a wide range of ecosystem services. Because they are small, ponds have often been assumed to be unimportant, attracting less scientific attention than larger waters. Because they lack an extensive evidence base like that available for rivers and lakes, they have often been overlooked in freshwater policy making.

Surprisingly, ponds are numerically the most abundant kinds of freshwater habitat globally, found from the tops of mountains to the depths of forests, lining the floodplains of our biggest natural rivers and providing oases of water in the driest of lands. They probably make up 30% of global standing water in terms of area and enormously outnumber lakes. Because they are hard to see on satellite images (ponds are often seasonal or obscured by trees) estimates of total numbers are still uncertain but could be in the billions.

2. <https://link.springer.com/article/10.1007/s10750-016-3007-0>

3. www.nature.com/articles/s41598-022-14569-0

BOX 1. WHAT IS A POND?

Ponds are small standing waters with a surface area from 1 m² to 5 ha that may be permanent or temporary, man-made or naturally created (Kelly-Quinn et al, 2017²; Richardson et al, 2022³).

This definition includes both semi-permanent and temporary ponds. In Europe, temporary ponds are common throughout the continent, in wet and dry climates, but are best known in drier Mediterranean regions. Temporary ponds usually dry up in summer whereas semi-permanent ponds dry up every 5 to 10 years. Both support specialised pond communities, including many rare and threatened species. This definition also include ponds with brackish waters. Ponds are usually shallow (up to 5 m deep) but occasionally deeper examples occur.

Ponds are essentially a natural type of habitat which has existed on the surface of the Earth as long as there has been land and water. Ponds are created by a range of natural processes but in the modern human-dominated world they are often created by people and in some landscapes human-made ponds now dominate. Because ponds have not been as intensively studied as other freshwaters, we are still learning many new things about them. The **PONDERFUL** project added important new information about ponds and the ecosystem services they provide.

Ponds have a vital role in every landscape to ensure that we protect the variety of freshwater life, helping to reverse the freshwater biodiversity crisis, and to deliver a wide range of other ecosystem services and Nature's Contributions to People (Box 3 and Section 5).

Because ponds are individually small, they are easy to work with and have immense potential to function as nature-based solutions: habitats whose management, restoration and creation benefits both nature and people. From individual tiny ponds supporting rare amphibians or endangered invertebrates, bringing enjoyment to garden owners or supplying fish in rural villages, through to immense networks of ponds in some of the world's biggest wetlands, ponds are ubiquitous and vital. Together, the natural biological richness of ponds means that they have a disproportionately large role to play in maintaining humanity's options for the future.

The small size of individual ponds is both a blessing and a curse: it is much easier to completely destroy a pond than a river, or to reduce the ecosystem services it provides virtually zero, compared to other, larger, freshwater habitats.

This guide will help you to develop policies which overcome this problem and enable society to exploit the special advantages of ponds and pondsapes.

BOX 2. PONDS AND WETLANDS: WHAT IS THE DIFFERENCE?

Wetlands are defined by the Ramsar Convention on Wetlands as “areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters”.

The Convention on Wetlands includes 42 types of wetlands, grouped into inland wetlands, marine/coastal wetlands and human-made wetlands (UNESCO 1994). Ponds are part of the category of inland and human-made wetlands (which are principally fresh water). To conclude, ponds can be included in the family of wetland types.

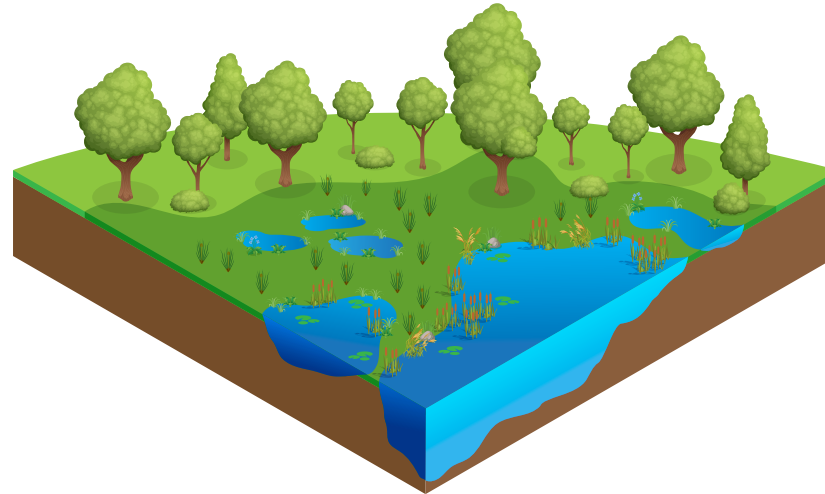
3. ABOUT PONDSCAPES: A SHORT OVERVIEW

A pondscape is a group of ponds, often of different sizes, shapes and depths, spread across the landscape to form a network, providing habitats for more species than a single waterbody of the same size and multiple ecosystem services for people. The pondscape may comprise anything from a handful to hundreds, or thousands, of ponds. Biologically, the ponds will form a habitat network, even if they are not physically connected, because freshwater plants and animals are adapted to dispersing between them.

Ponds and pondsapes do not exist in isolation but form a network of freshwater habitats with all other types of waterbody. Although many species are

unique to ponds, others are shared with rivers, lakes and wetlands, forming a vital part of this freshwater network.

Pondsapes include both the aquatic habitats that make up the ponds themselves and the terrestrial habitats where these waterbodies are located. These can include urban areas, farmland, grassland, peatlands, mountains, moorlands, salt marshes, woodlands and larger wetlands.



4. THREATS TO PONDS

It is important for policy makers and legislators to understand the threats facing ponds. Ponds share the same threats as other freshwaters and have some of their own, mostly because of their small size.

HABITAT LOSS: DESTRUCTION OF PONDS

In Europe, estimates suggest that we have lost between 50% and 90% of ponds in the last century, mainly due to habitat destruction through intensification of agriculture, water abstraction and urbanisation. Temporary ponds can also be destroyed simply by draining the land. Added to this, a large proportion of remaining ponds are affected by pollution, just like rivers and lakes. However, in contrast to rivers and lakes, there are larger numbers of ponds free from pollution because of their small catchments which make it much easier to find locations protected from pollution. Note that net pond loss has probably stopped in western Europe, although data to unequivocally support this assessment is only available in a few areas (e.g. UK).

POLLUTION

Pollution is one of the greatest threats to ponds, the biodiversity they support and to other ecosystem services they provide. Freshwater biodiversity needs clean water to survive and it only takes a tiny amount of pollution to damage habitats, harming the sensitive plants and animal communities they support. Although net pond loss has slowed or reversed, pollution remains pervasive and there is evidence of on-going whole-landscape losses of pond biodiversity even while pond numbers remain constant.

Water quality is affected by pollution from human activities, including agriculture, livestock farming, tourism, housing and construction of infrastructure (roads, railways, etc.). According to the European Environment Agency, 22% of Europe's rivers and larger lakes, and 28% of the groundwater area, are significantly affected by diffuse pollution from conventional agriculture, both by nutrients (nitrates and phosphates) and pesticides. Although there are no EU-wide statistics on pond pollution, the situation is probably at least as bad for ponds. Around 80% of sites surveyed by **PONDERFUL** had high nutrient concentrations suggesting pollution by nitrogen and phosphorus is widespread.

Poor water quality damages the whole freshwater environment, but ponds are particularly vulnerable. This is because their small size and volume means they are less able to dilute pollutants. To make the situation worse, much of their biodiversity is highly sensitive to water pollution (e.g. amphibians, dragonflies, mayflies, etc.). Ponds that are linked to streams and ditches are at even greater risk because these watercourses often bring in polluted water.

CLIMATE CHANGE

We are already seeing the impacts of climate change on the freshwater environment, including ponds. There are a range of threats to ponds from climate change. At the coast, rising sea levels are likely to damage coastal wetlands which commonly support networks of ponds (Horton et al., 2018)⁴. Inland, higher average temperatures and our shifting seasons are changing the hydrology and chemistry of ponds and altering the breeding behaviour and lifecycles of pond-associated species. Changes in the ranges of pond-associated species are already occurring widely.

4. <https://www.nature.com/articles/s41467-018-05080-0>

5. <https://www.sciencedirect.com/science/article/pii/S0048969723019484>

Extreme weather events, both wetter and drier, are also a threat to ponds and pondsapes. For example, high rainfall and flooding can increase pollution inputs to all kinds of ponds. Temporary ponds, both in southern Europe and at higher latitudes, which depend on regular drying out, are likely to be particularly affected and are already experiencing extended periods of drought caused by climate change and exacerbated by water abstraction. (Felipe et al., 2023)⁵. Severe droughts are expected to reduce the time that temporary ponds hold water, damaging the plant and animal communities they support, especially in Mediterranean regions where some pondsapes have dried up completely.

INVASIVE SPECIES

Invasive species threaten freshwater ecosystems worldwide, including individual ponds and whole pondsapes. Ponds are affected by both non-native plants and non-native animals which can outcompete indigenous species for space and resources.

Controlling established invasive species in ponds is often very difficult or impossible. This means that preventing the introduction of non-native species is crucial. Swift action to eliminate invasive species as soon as possible after they have colonised ponds can sometimes be successful in preventing establishment and spread but this activity should always be secondary to preventing non-native establishment in the first place.



BOX 3. WHAT ARE ECOSYSTEM SERVICES AND NATURE'S CONTRIBUTIONS TO PEOPLE?

Ecosystem services are the many benefits provided to people by the natural environment, and can be divided into provisioning, regulating, supporting and cultural services. Some are direct contributions, such as water, clean air, food and raw materials. Others provide indirect benefits to people, such as physical and mental health, tourism, knowledge and learning.

These benefits are likely to be increasingly referred to as 'Nature's Contributions to People', a term introduced by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). These include both the positive and negative impacts of nature on people's quality of life. The positive contributions are similar to those described as ecosystem services, while negative contributions can include disease transmission or predation that damages people or their assets. In this guide we have primarily used the IPBES terminology but have occasionally referred to 'ecosystem services' to help the reader understand the context.

Nature's Contributions to People are not generated from nature alone but through a series of social-ecological functions and interactions. Nature-based solutions are part of, or facilitate, many or all stages of this co-production process to secure the supply of Nature's Contributions to People.

5. POLICIES AFFECTING PONDS IN EUROPE

In Europe, three main pieces of legislation provide varying degrees of support for the protection and management of ponds and pondscape:

- Nature Restoration Law
- Water Framework Directive
- Habitats Directive

Individual EU member states, and countries outside Europe, also have national and regional laws to protect small waters. For planners and policy makers elsewhere in the world Stanković et al (2023)⁶ provide examples of current policies which can be used to support pond and pondscape work.

5.1 EU NATURE RESTORATION LAW

The EU Nature Restoration Law represents an important opportunity for freshwater habitat restoration, freshwater biodiversity protection and the use of ponds and pondscape as nature-based solutions.

Six Articles of the Nature Restoration Law are relevant to ponds and pondscales:

Article 2. Protection of Priority Habitats: EU Member States shall put in place the restoration measures that are necessary to improve to good condition areas of Annex I habitat types (see Section 5.3 below) which are not in good condition. Such measures shall be in place on at least 30% of the area of Annex I habitat types that are not in good condition, as quantified in the national restoration plans referred to in Article 12, by 2030, on at least 60% by 2040, and on at least 90% by 2050. Member States shall also put in place the restoration measures for the terrestrial and freshwater habitats of the species listed in Annexes II, IV and V of the Habitats Directive which has significant implications for ponds.

Article 5. Improving biodiversity in urban areas where ponds are part of urban green space.

Article 7. Restoration of the natural connectivity of rivers and natural functions of the related floodplains. Commonly, this should include measures to restore riverine pondscales and ponds.

Article 9. Improving farmland biodiversity: Member States shall achieve an increasing trend at national level of the share of agricultural land with high-diversity landscape features, including ponds, in agricultural ecosystems.

Articles 12 and 13. In summary, the preparation and review of national implementation plans will include quantification of pond habitats to be restored under Articles 4 to 9, a description of the restoration measures planned, or

6. <https://onlinelibrary.wiley.com/doi/10.1002/aqc.4008?af=R>

put in place, for achieving the targets and an indication of the measures to ensure Annex I and II ponds, and habitats of the species referred to in Articles 4 and 5, do not deteriorate.

An amendment to Article 7 to protect all small waters (running and standing) was narrowly voted down in the European Parliament despite widespread support. Although the measure was not adopted, the international recognition of small waters at the EU level was an important milestone in the development of freshwater management.

Policy makers and planners can use the guidance provided in this document to draft national plans which help to deliver the objectives of the Nature Restoration Law.

5.2 WATER FRAMEWORK DIRECTIVE

The Water Framework Directive (WFD) is intended to protect all freshwaters in Europe but has mostly focussed on large lakes and rivers. Most EU Member States, with the notable exception of Spain, choose to apply a clause in the WFD which excludes lakes and ponds of less than 50 hectares from protection. It is likely that a future review of the WFD will ensure that small waters are properly protected.

The United Kingdom is now including ponds in legislation to protect freshwaters in the Environment Act 2021.

5.3 HABITATS DIRECTIVE

Nine types of pond meet the criteria for EU Annex 1 Habitats Directive habitat types which, in the EU-27, Iceland, Norway, Switzerland and the Balkan countries, should be maintained at, or restored to, favourable conservation status. In the United Kingdom, ponds originally identified as needing protection under the Habitats Directive remain Priority Habitats under the Natural Environment and Rural Communities Act 2006.

Ponds are included in the following Habitats Directive categories:

- 3110 Oligotrophic waters containing very few minerals of sandy plains (*Littorelletalia uniflorae*)
- 3130 Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or Isoeto-Nanojuncetea
- 3140 Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp
- 3150 Natural eutrophic lakes with Magnopotamion or Hydrocharition–

type vegetation

- 3160 Natural dystrophic lakes and ponds
- 3170 Mediterranean temporary ponds
- 3180 Turloughs (mainly Ireland)
- 2190 Humid dune slacks
- 21A0 Machairs (in Scotland and Ireland).

6. USING PONDS AS NATURE-BASED SOLUTIONS

Ponds and pondsapes can be used as nature-based solutions that provide a range of benefits for people and wildlife, including climate change adaptation and mitigation.



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BOX 4. WHAT ARE NATURE-BASED SOLUTIONS?

Nature-based solutions are measures to address challenges facing society. They use the natural functions of healthy ecosystems to protect the environment and provide economic and social benefits. These range from environmental issues, such as climate change and biodiversity loss, to food and water security, human health and people's wellbeing. We link the definitions used by IUCN, the EU and the UN in treating nature-based solutions as measures which must provide benefits both for biodiversity and for human wellbeing. The definitions of nature-based solutions used by these organisations are:

- **United Nations:** 'Actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems, which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services and resilience and biodiversity benefits.'
- **European Commission:** 'Solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions.'
- **IUCN:** Actions that 'address societal challenges through actions to protect, sustainably manage, and restore natural and modified ecosystems, benefiting people and nature at the same time.'

6.1 PONDS AND PONDSCAPES AS NATURE-BASED SOLUTIONS ADDRESSING KEY SOCIETAL CHALLENGES

Why should ponds be considered as nature-based solutions?

The European Commission⁷ (2021) identifies 12 societal challenge areas that can be addressed by nature-based solutions.

The **PONDERFUL** project showed that ponds and pondscapes can address 11 of these societal challenges (Table 1). Success stories in the PONDERFUL technical handbook illustrate how pondscapes across Europe and in South America are providing these nature-based solutions.

Because ponds deliver many benefits and are relatively easy to implement, they provide good value for money when seeking to address these societal challenges through nature-based solutions.

In many situations, ponds and pondscape as nature-based solutions can effectively replace grey infrastructure, providing the same benefits, with a lower implementation cost. One example is using a pond rather than a closed reservoir as a source of water for public supply.



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7. <https://data.europa.eu/doi/10.2777/244577>

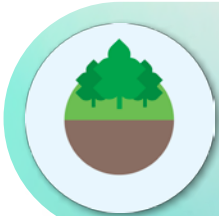
Table 1. How ponds can provide nature-based solutions to address societal challenges

	<p>1. REGULATION OF CLIMATE</p> <p>Ponds are major sources and sinks of greenhouse gases and carbon. Their abundance and high biogeochemical activity means that they have a significant role to play in the management of the carbon cycle.</p> <p>PONDERFUL and other data show that we can reduce greenhouse gas emissions to the lowest level from ponds and pondsapes by ensuring that they are as free from pollution as possible.</p>
	<p>2. REGULATION OF HAZARDS AND EXTREME EVENTS</p> <p>Ponds have a long history of helping to regulate hazards from flooding but also protect against heatwaves by storing water in the landscape, ensuring that water is present for longer during increasingly frequent hot and dry weather. In addition, they can provide water for fire-fighting. Ponds and pondsapes can also help to cool landscapes, especially in urban areas.</p>
	<p>3 AND 4. REGULATION OF FRESHWATER QUANTITY AND QUALITY</p> <p>Ponds are widely used to 'clean up' polluted water running into other freshwater habitats. By holding back and cleaning up water as it flows through catchments.</p> <p>In the PONDERFUL technical handbook we provide practical advice about the optimum way of ensuring that, as this clean up service is provided, it does not impair the underlying biological contribution that must be made by nature-based solutions.</p> <p>Creating new clean water ponds, protected from pollutant sources, in low intensity landscapes is a quick and easy way of bringing more clean water into the network of freshwater habitats.</p>
	<p>5. FOOD AND FEED</p> <p>Some ponds and pondsapes (both natural and man-made) support the production of food or feed, for example, providing drinking water for livestock or fish for people to eat.</p>
	<p>6. POLLINATION</p> <p>Ponds support populations of many groups of organisms that help pollinate crops. We are just starting to understand the magnitude of the contribution made by freshwaters, including ponds, to pollination. However, it is clear that managing or restoring overgrown and neglected ponds can cause substantial increases in numbers of pollinators.</p>



7, 8, 9. PHYSICAL AND PSYCHOLOGICAL EXPERIENCES, LEARNING AND INSPIRATION, SUPPORTING IDENTITIES

Ponds are well known for their ability to provide learning, inspiration, health and wellbeing. The techniques for pond management, restoration and creation that we summarise in the **PONDERFUL** technical handbook can all be used to maintain or create ponds and pondsapes which allow people to benefit from these Nature's Contributions to People. Climate change is likely to increase this demand, with swimming ponds providing an important refuge for people living with a hotter climate.



10. HABITAT CREATION AND MAINTENANCE

Central to the value of ponds is their importance as habitats and for maintaining freshwater biodiversity. We summarise the key practical measures needed to protect, manage, restore and create ponds and pondsapes to maximise the habitat creation and maintenance benefits they provide.



11. MAINTENANCE OF OPTIONS

Ponds play an important role in maintaining the capacity of freshwater ecosystems, habitats, species, or genotypes to keep options open to support a good quality of life. "Biodiversity," interpreted as living variation, is an important aspect of "maintenance of options."



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© Freshwater Habitats Trust

Dune pond. © Jael Palhas



Alpine pond. © Shogun



7. PROTECTING, MANAGING, RESTORING AND CREATING PONDS

Central to the delivery of Nature's Contribution to People from ponds and pondscape is their practical protection, management, restoration and creation. In the **PONDERFUL** technical handbook we provide detailed practical information for site managers on measures to do this including:

- guidance on how to plan and prioritise pondscape projects and how to risk assess the different options for managing, restoring or creating ponds
- advice on how to ensure that work with ponds fits into the 'mitigation hierarchy' so that damage to ecosystems in infrastructure and other building projects is, as far as possible, designed out of projects
- how to plan projects and avoid inadvertent impacts on existing high value ponds and pondscape when preparing pond or pondscape management plans.



The **PONDERFUL** technical handbook summarises the key concepts for effective pond and pondscape management including:

- understanding the pond catchment
- the importance of 'clean water'
- the role of different water sources in delivering Nature's Contributions to People
- the long-term management of ponds and pondscape.

Existing ponds need to be managed or restored to maintain their value as a nature-based solution or to reintroduce functions into the landscape. Providing protection for ponds, through national or international regulation, is often an important part of management.

Any intervention is likely to have both positive and negative impacts and we provide detailed practical guidance on risk assessing pond and pondscape work.

7.1 PRACTICAL MANAGEMENT MEASURES

Measures that can be applied to ponds and pondscape to enhance their role as nature-based solutions broadly fall into three categories:

1. Management of existing ponds as nature-based solutions:

Applying practical measures to existing ponds or pondscape to maintain their function as nature-based solutions. This can involve:

- regular aquatic vegetation, invasive species or shade management for a particular plant or animal species
- maintaining a good viewpoint for wildlife-watchers or nature-lovers.

Management can also slow or reverse successional change in ponds. Pollution by nutrients is expected to accelerate the process of pond succession, so more frequent management is often needed in polluted ponds.

Management at the landscape scale also includes protecting existing high-quality ponds.

Measures to protect ponds include:

- granting a pond protected status (e.g. nature reserve, regional or national park)
- addressing issues such as pollution in the broader pond catchment
- creating buffer zones around the ponds

- removing drains bringing in polluted road runoff.

2. Restoration and ‘resurrection’ of ponds as nature-based solutions

Where ponds have lost their function, or to recreate habitat for a particular species, more intense intervention may be required. This could include:

- clearing trees and scrub
- dredging long-accumulated sediment
- the ‘resurrection’ of ‘ghost’ ponds: re-establishing old ponds which have been deliberately filled in in the past.

There is considerable overlap between restoration and management and these terms are sometimes used interchangeably.

3. Creation of ponds as nature-based solutions

Digging or building a new pond in a location where there was no pond before brings this nature-based solution into the pondscape. Creating new ponds increases the amount of clean water in the landscape or pondscape, increases freshwater habitat connectivity and reverses the effects of pond loss.

All types of interventions – management, restoration and creation – are valid depending on the nature of the pondscape. A project may focus on managing or restoring existing ponds or on creating new waterbodies. In many pondscales, it will be necessary to use all three approaches.

Remember, it is the range of waterbodies within a landscape that delivers multiple benefits.

7.2 POND HYDROLOGY

Fundamental to managing, restoring and creating ponds is ensuring that they have the ‘right’ hydrology. In many cases this means ensuring that hydrology follows natural seasonal fluctuations with ‘permanent’ pond water levels falling in summer to provide rich drawdown zones, semi-permanent ponds drying occasionally (one year in 10) and temporary ponds drying annually. Draw-down zones, the marginal area between the winter high water level and the summer low water level, are an important and biodiverse part of permanent and semi-permanent ponds. In other situations, water levels must be managed to provide the ecosystem service or Nature’s Contribution to People for which the pond or pondscape is intended. For example, fish ponds and pollution interception ponds may need to be regularly fully drained to remove sediment.

8. MONITORING PONDS AND PONDSCAPES

To ensure that the use of ponds and pondscales as nature-based solutions benefits both people and nature, monitoring is important. Good monitoring methods have been developed for ponds and the ecosystem services they provide and the principles are summarised in the **PONDERFUL** technical handbook.

Monitoring is a vital part of effective delivery and is often inadequate in the management of nature-based solutions delivered by freshwater habitats. Policy makers often specify new approaches based on limited evidence which are not then monitored soon enough or well enough to ensure that practical actions are modified and adapted quickly. This wastes resources on practical measures which seem attractive but are often ineffective.



Monitoring of ponds is most commonly concerned with assessing ecological status. This is fundamental to ensure that they are playing their role fully as nature-based solutions. This usually includes a combination of physico-chemical methods and biological surveys. To assess the effectiveness of other Nature’s Contributions to People it is often necessary to adopt methods that are more widely applied to a variety of habitat types and are not specific to ponds (e.g. flow modelling and monitoring to assess the effectiveness of flood control and questionnaire surveys to assess the extent to which they deliver psychological or physical benefits for people). New methods for assessing Nature’s Contributions to People are still being developed so we recommend that site managers and practitioners engage with researchers to ensure that new methods meet their needs.

9. PLANNING FOR PONDS AND PONDSCAPES: THE KEY REQUIREMENTS

The key requirements for designing, planning and implementing programmes to maximise the benefits from ponds and pondscapes as nature-based solutions are:

- Creating effective legal frameworks and clarifying responsibilities
- Ensuring that sufficient water of high enough quality is available for ponds and pondscapes
- Developing locally relevant techniques and measures for ponds and implementing these practically
- Devising practical programme to protect ponds from pollution
- Creating programmes specific to urban and rural landscapes
- Ensuring the data collection and monitoring for ponds are properly designed and implemented.

Taken together these measures will ensure the biological value of ponds is maintained and they can effectively deliver Nature's Contributions to People. We provide specific recommendations for work likely to be needed by policy makers to support practical action. A standard format for a national plan for ponds and pondscapes is shown in Box 5.

9.1 DETAILED CONSIDERATION FOR PLANNING POND AND PONDSCAPE MANAGEMENT

I - Create an effective legal framework and clarify responsibilities

Ponds remain insufficiently represented in environmental legislation although some progress is being made. In Europe, for example, the Nature Restoration Law incorporates ponds in a number of its articles and the Ramsar Convention on Wetlands recently adopted a resolution on the conservation and management of small wetlands, including ponds.

However, as explained in section 5, in water policy and water management, ponds are not so well considered.

Nature conservation legislation has a better record of including ponds. For example, the EU Habitats Directive provides protection for certain types of ponds (see section 5.3). The protection of ponds is also helped by laws to protect threatened species that use ponds including amphibians, dragonflies, damselflies and large branchiopods. In the context of the recent Convention

on Biological Diversity resolution to conserve 30% of terrestrial and freshwater habitat, ponds and pondscapes should be an important target.

However, lack of clarity in the legal protection status of ponds, ultimately driven by the limited representation of ponds in freshwater science, leads to a lack of practical implementation of management and protection measures. As a result, local and national authorities are often unaware of the importance of small waterbodies which leads to a lack of resources for their management and protection.

Recommendation 1: In most states, an important way for policy makers to protect the freshwater environment is to put the protection and management of ponds on the same level as that applied to rivers, streams and lakes.

II - Clarify competences and define responsibilities

Due to often unclear or inconsistently interpreted legal frameworks, the official responsibilities for small waterbodies are often unclear and insufficient. This results in a lack of sustainable practical pond protection, management and maintenance.

Any national plan for ponds usually needs to properly identify bodies responsible for the protection and management of ponds. Responsibility can sometimes be transferred to civil society actors such as associations, societies, foundations and initiatives, e.g. through sponsorships, 'godparenthood' and similar models. However, even with voluntary commitment, sufficient resources and good professional practice in water management and maintenance must be ensured. This is most likely guaranteed if there is a proper legal framework.

Stakeholder involvement is essential to ensure that all relevant interests and needs are taken into account in areas where ponds or pondscapes are created, restored or managed.

Recommendation 2: Policy makers working at state or regional level will often need to designate responsible authorities concerned with the protection and management of ponds, and the management to provide ecosystem services and Nature's Contributions to People.

III - Ensure minimum environmental water needs

As climate change progresses, existing water scarcity will increase. It is therefore important to ensure minimum environmental water

needs for ponds. In both rural and urban areas, approaches need to be developed to ensure sufficient quantity and quality of water supply to maintain ponds as functioning ecosystems able to provide ecosystem services and Nature's Contributions to People.

The development of ponds as nature-based solutions can help to create suitable conditions for water quantity and quality. This requires consideration of the ecohydrological functioning of pond catchments, i.e. how and when water is stored and released in landscapes. Assessing how different land uses affect the partitioning of "green" (evaporation and transpiration) and "blue" (groundwater recharge and runoff) water provides a crucial basis for evaluating how water storage and water and pollutant flux dynamics can be mediated by land management strategies to build resilience and protect water resources against future climate change.

A prerequisite for ponds and ponds as nature-based solutions is that the minimum environmental water needs for ponds are met, even in the event of water shortages. Minimum environmental water requirements describe the quantity, timing and quality of freshwater flows and levels required to sustain aquatic ecosystems. Only water in sufficient quantity and quality can support biodiversity, which in turn is essential for resilient ecosystems. This is because diverse habitats and species communities provide a kind of "insurance" against external stresses, environmental changes and fluctuations, including human-induced changes such as climate change. Biodiversity increases the likelihood of survival of species and species communities and the functioning of the ecosystems on which we depend.

Recommendation 3: Planners concerned with protecting ponds should create plans which specify the amounts, quality and levels of water needed to maintain ponds and ponds as nature-based solutions in a favourable condition.

IV - Develop management guidelines for ponds

Depending on their type, region and location, ponds can have different characteristics and management needs. The PONDERFUL technical handbook and other guides (e.g. in English 'The Pond Book') provide an overview of approaches to managing ponds. However, specific local guidance is likely to be needed to reflect the approaches to ponds with differing hydrology (groundwater vs surface water), chemistry (high pH vs low pH), landscape types (woodland, heathland, moorland, peatland), levels of

exposure to pollution and ecosystem services provision (flow amelioration, pollution control, greenhouse gas minimisation etc).

For this reason, guidelines should be developed for the different types of small waterbodies, which can be used as a basis for operational water management. Guidelines should be supported by an appropriate catalogue of maintenance measures.

Recommendation 4: State and regional water and conservation management agencies should come together to create a region-specific guide to pond management. One approach, recently adopted by the Irish NGO An Taisce, was to remodel Freshwater Habitats Trust's manual 'The Pond Book' to the specifically Irish context.



V - Promote the management, restoration and creation of ponds

Management, restoration and protection of existing ponds is needed, especially those of high biological value or which provide important ecosystem services. Mapping existing ponds and assessing their value for people and biodiversity is therefore the first step.

The creation of new small standing waterbodies is also important. This increases regional freshwater biodiversity, contributes to the conservation of

rare species, strengthens freshwater networks by helping biota disperse and, perhaps most crucially, is an easy method for restoring clean water to the landscape.

To increase the ecological function, biodiversity and ecosystem services of ponds, it is necessary to improve their water quality and structure (e.g. presence of underwater and riparian vegetation). The success of the measures should be monitored, combined with continuous and qualified biotope management and maintenance. In addition, ponds and pondscape should be given a higher priority for development and support through public programmes. Overall, to be effective, conservation measures should focus more on maintaining a large number of different pond types in a pondscape, combining measures to protect individual sites with high species richness or diversity and those which are providing ecosystem services for people (e.g. cooling the landscape, providing educational or health benefits).

Recommendation 5: Follow the protection, management, restoration and creation guidance provided in the **PONDERFUL** technical handbook, with appropriate local adaptations (e.g. depending on types of ecosystem service required, specific uncommon species targets).

VI - Reduce emissions and create riparian strips and buffer zones

Policymakers should consider whether substance emissions should be more tightly regulated as water scarcity increases and pollutant and nutrient loads interact with the effects of warming and reduced dilution. Given the importance of water quality for biodiversity and ecosystem services, it is essential that nutrient, sediment and pollutant inputs to ponds are reduced as much as possible. This can be achieved most effectively by reducing landuse intensity throughout the catchment of the pond or, if this is not possible, in the vicinity of the pond. In practice, this often means establishing 50-100 m buffer zones, in which semi-natural vegetation is maintained or very extensive (low input) farming is practised without the use of fertilisers or pesticides. In both rural and urban areas, sufficiently large physical barrier zones or strips should be established to reduce hazardous inputs to waterbodies through retention or chemical transformation. These riparian strips should be frequently monitored by the authorities.

Recommendation 6: Planners and water managers should establish national, regional and local policies which deintensify pond catchments. If

whole-catchment deintensification is not possible, establish the largest possible barrier zones of natural vegetation, or low input farmland, around ponds. These should be 50-100 m or more.

VII - Give more consideration to ponds in urban and settlement planning

Ponds are common in urban environments. They provide a range of ecosystem services and Nature's Contributions to People in towns and cities including being valuable systems for freshwater biodiversity. Available evidence suggests that, although ponds are often as badly damaged by urban pollution as running waters, there are likely to be more high ecological quality ponds than running waters in urban areas.

Ponds may contribute to the concept of "sponge cities", where rainwater is not discharged directly into the sewerage system, but infiltrates into the urban soils and, in the best case, is purified by biogeochemical processes. Precipitation can thus contribute to the recharge of near-surface water systems and groundwater, which in turn supports ponds.

Management of urban water has traditionally involved using ponds to intercept and treat polluted water to protect 'more valuable' downstream running waters. Whilst this may be an effective use of ponds it is worth remembering that clean unpolluted ponds are likely to be the highest quality part of the water environment in urban areas so can be prioritised to maintain freshwater and other species in urban areas.

Recommendation 7: Planners should ensure that the full potential of ponds is exploited in urban areas to provide ecosystem services and Nature's Contributions to People. To maintain the landscape level quality of freshwater environments, ensure that at least 25% of new ponds created in sustainable urban drainage systems are not connected to polluted inputs. All new urban ponds should be designed to minimise greenhouse gas emissions (see **PONDERFUL** technical handbook).

VIII - Improve protection of small waterbodies in agricultural landscape

Many agricultural practices and products cause long-term damage to the water environment, including ponds, in the wake of ongoing climate change. Landscapes and soils need to be designed and managed to absorb and store water better and to release it more slowly. In particular, measures to



Grassland pond (NL). © Nils Bacher

reduce pollutant runoff into ponds should be introduced widely. It is often very difficult to reduce pollutant losses and the effectiveness of measures to do so are often exaggerated.

Increased water retention in the landscape can also benefit both agriculture and ponds in providing valuable water security Nature's Contributions to People. The creation and protection of ponds can contribute to this. The development of sufficiently large buffer zones around ponds will be essential to maintain their quality and functioning. The two main measures for protecting ponds in agricultural areas from pollution are:

- Identify the extent of pond catchments and deintensify those catchments as much as possible
- Where whole catchments cannot be de-intensified, make the largest buffer zone possible.

The **PONDERFUL** technical handbook provides more details of examples of effective measures.

Recommendation 8: Policies to encourage and support the creation of new clean water ponds on every farm should be adopted alongside effective management of existing high nature value ponds.

IX - Make information and data publicly available to experts

All existing ponds should be listed in an up-to-date and complete manner in accessible environmental databases and be easily identifiable and findable through stored geodata. Their respective subtypes, characteristics and, where appropriate, existing protection status and official responsibilities should also be recorded. This will also enable the organised civil society, such as NGOs, to contribute to the protection of ponds.

The economic, social and environmental benefits of ponds and pondsapes can only be assessed through long-term and systematic monitoring, which requires both resources and commitment.

Recommendation 9: Suitable survey and monitoring programmes (e.g. of the standard used in the Water Framework Directive) should be introduced at the state and regional level to ensure that use of ponds and pondsapes as nature-based solutions is effective.

BOX 5. CREATING A NATIONAL PLAN FOR PONDS

The key stages for creating national and regional plans for ponds are:

1. Create a national or regional legal mandate for protecting and creating ponds. Mandates exist already but may need to be enhanced.

For example, the Water Framework Directive is intended to protect all freshwater but EU states often have adopted the 50 hectare rule (see Section 5.2). This approach was originally driven by the lack of data on ponds when WFD was implemented, so their importance was underappreciated. Newer data show that ponds are such a crucial part of the freshwater network that there is a critical need to incorporate them in this legislation.

2. Identify the most important sites

Not every pond is equal and allocation of resources requires that funds are well spent. Ways of identifying important ponds have been developed in several EU states.

3. Create a monitoring programme to assess condition of ponds

4. Allocate resources to the creation and management to protect important ponds

5. Identify locations for pond creation

These should help to strengthen the network of habitats by being close to existing high-quality locations helping species spread. New ponds can also be made in any location that can provide clean and unpolluted water.

6. Set plausible targets. Most water management has set unrealistic targets which have proved very difficult to achieve.

Targets for ponds should focus on:

- Number
- Quality
- Amount of clean water in the landscape
- Services provided

10. FINANCING PONDS

Providing resources for protecting, managing, restoring and creating ponds can be challenging because their importance in the network of freshwater habitats and their role and value as nature-based solutions has been under-appreciated. However, with growing understanding of the importance of ponds and pondscape we expect that this 'resource squeeze' may be gradually relaxed as funders of practical work recognise the great benefits to be obtained with ponds and pondscape.

Indeed, ponds as nature-based solutions can often provide the same benefits as grey infrastructure at a lower cost.

Given the urgency of the freshwater and climate crises, an important benefit of ponds and pondscape is the quick results they provide compared to other kinds of water management. There are important drivers in local, national and international policy to correct the pattern of under-investment in ponds, particularly the recently adopted EU Nature Restoration Law which highlights the importance and value of ponds.

The **PONDERFUL** Sustainable Finance Inventory in the **PONDERFUL** technical handbook identifies 24 different "financing instruments" that pondscape managers can use to pay for ponds, including: revenue-generating measures for government or private landowners, public subsidies and grants, private donations, borrowing, investing, and contractual approaches.



Pinkhill Pondscape (UK). © Freshwater Habitats Trust

11. CREATING A CONVENTION FOR PONDS

Plans to effectively protect and manage ponds could be helped by the further development of international measures for the protection of ponds and pondscape. Recently, a proposal for a new convention on the protection of ponds titled 'Convention on the protection of ponds, especially as the habitats of protected species' has been made (Stanković et al, 2023)⁸. This has some valuable suggestions for the effective delivery of pond ecosystem services and Nature's Contributions to People and we reproduce this proposal below in Appendix 1.

The proposal for the convention notes that ponds, the most numerous freshwater habitats globally, are becoming increasingly recognised as being important for rare, endemic and endangered species, owing to the high levels of biodiversity they support and their role in ecosystem services.

However, they remain largely overlooked and widely excluded from policies that might protect them. Even though their size and permanence are highly important for their legal protection, these two characteristics are not precisely and universally defined in theory or international legal documents.

The existing international legislative frameworks do not seem to provide global, comprehensive, or detailed protection of ponds as significant and widespread habitats. On the contrary, they safeguard only fragmentary examples – either by protecting certain types or only those that are parts of larger protected areas. Also, pondscape are not specifically recognised as forms in need of legal protection.

The proposal for a 'Convention on the protection of ponds' provides some valuable suggestions for policy makers concerned with management of land and water.



La Pletera pondscape (Spain). © UdG

8. <https://doi.org/10.1002/aqc.4008>

APPENDIX 1. FRAMEWORK FOR AN INTERNATIONAL CONVENTION ON THE PROTECTION OF PONDS

(adapted from Stanković et al, 2023⁹)

The framework comprises the following Articles:

1. Definitions of relevant terms used in the Convention (most importantly, definition of ponds and pondscales).

2. Definition of the purpose of the Convention (explaining that it is necessary to provide adequate protection of ponds from various adverse environmental impacts even if these ponds are not located within other protected areas such as wetlands of international importance).

3. Explanation of the environmental importance of ponds (despite their small size) as the habitats of numerous unique species and provision of ecosystem services.

4. The obligations of the State Parties to the Convention.

4.1. The definition of ponds in their national laws, strategic documents, action plans and policies pertinent to environmental protection and emphasizing the fact that the ponds should be provided protection regardless of the location.

4.2. Adequate measures for the protection of ponds in national legislations. A multi-disciplinary and cross-sectoral approach is required in order to provide comprehensive protection of ponds from all potential sources of negative environmental impacts (pollution, urbanization, mining, tourism, agriculture etc.). At the same time, it is necessary to provide the environment that would allow sustainable and balanced use of natural resources without causing any harm to ponds. These measures could be classified as preventative and punitive. Preventative measures would include: mapping the areas with ponds, creating a database of these areas and inhabited species (having in mind that ponds might be permanent and that their size might vary throughout the year), setting visible marks in the pond areas, raising awareness on the importance of ponds for the survival of protected species and entire ecosystems, prohibiting agriculture, tourism, mining and other similar activities in the areas where ecologically highly important ponds are

located. Punitive measures would include prescribing some form of sanction. Other types of measures would include financial incentives, provided by the state, with the aim to motivate all relevant entities to contribute to the protection of ponds.

4.3. Provisions related to raising awareness about the importance of ponds through the presentation of scientific research and relevant publications, social media and other accessible resources.

5. The collaboration among the States Parties to the Convention.

5.1. Exchanging information about existing ponds and creating a comprehensive database about them.

5.2. Exchanging experiences and examples of good practice regarding the protection of ponds.

5.3. Conducting joint efforts aimed at the promotion and raising awareness about the global environmental importance of ponds.

6. Control of the application of the measures prescribed by the Convention.

6.1. Establishing state bodies that would be entitled to track and note the application of the Convention.

6.2. Submitting reports on the conditions of ponds and the effectiveness of their protection.

6.3. Organizing regular meetings and providing space for discussion about current issues and the best practices for the protection of ponds.

9. <https://onlinelibrary.wiley.com/doi/10.1002/aqc.4008?af=R>





