Guidance for the preparation of National Restoration Plans using the example of bogs, mires and fens

DECEMBER 2024

CEEweb for Biodiversity

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The abridged version of the Hungarian guide

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Release date: December 2024

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1. Introduction

The National Restoration Plans (NRPs) outline measures to achieve the nature restoration targets set in the European Union's Biodiversity Strategy for 2030. The quantified restoration targets for each ecosystem – both area-based and indicator-based – are established in the EU Regulation 2024/1991 on Nature Restoration (hereafter: the Regulation). Developing and implementing these plans presents both an opportunity and a challenge for Member States. It is an opportunity because well-planned and well-founded measures, if successfully implemented, can significantly improve the condition and extent of ecosystems. This is crucial for addressing the interconnected environmental crises of climate change, biodiversity loss, and pollution. However, it is also a major challenge, as multiple factors must be considered in both the design and implementation of the plans. Beyond strict technical criteria, the plans must align with other national strategies and policies while ensuring effective public participation – ideally from the earliest planning stages. A lack of public support or potential conflicts with national legislation could hinder the achievement of restoration objectives. Given these complexities, the preparation of the plans requires thorough groundwork, including data collection, engagement with scientific communities and experienced experts, and strategic planning based on a sound scientific framework (WWF 2024). Successful restoration efforts also depend on strong political commitment, as achieving ambitious targets requires substantial investment and intervention, often necessitating paradigm shifts.

The aim of this case study is to examine the considerations, approaches, and possible interventions for bogs, mires and fens – a specific habitat group – within the framework of legal requirements and the data content outlined in the National Restoration Plan (NRP) template. This analysis supports the development of the NRP. The study explores various options based on the Hungarian context, with specific proposals for action tailored to Hungary. However, the issues discussed and the potential solutions can be applied and adapted to a broader geographical area. The abridged English version of the study includes these key aspects.

2. Why the bogs, mires and fens?

As terrestrial wetlands directly dependent on groundwater, bogs, mires and fens have a significant role to play in mitigating climate change by absorbing greenhouse gases and are also important carbon sinks. At the same time, they are the most vulnerable and sensitive habitat types to climate change in terms of decreasing precipitation and extremes of rainfall distribution, and increasing average temperatures, and provide habitat for many protected, rare and endangered species. In addition to preserving and improving the condition of ecosystems, their structure and function, biodiversity and resilience, and achieving favourable spatial extent, the other main objectives of habitat restoration, as stated in the Regulation, are to mitigate climate change, achieve climate adaptation and achieve soil degradation neutrality. The extent of bogs, mires and fens, mainly due to drainage, has been drastically reduced in almost all of Europe over the last century, and their condition is also deteriorating, due to changes in their hydrology and the resulting degradation processes. They are therefore a priority habitat type for restoration, both in terms of favourable spatial extent and condition.

3. What ecosystems are bogs, mires and fens habitats part of?

Bogs, mires and fens are generally classified as terrestrial wetlands, but when looking at wetland habitat types of Community importance, they can also be linked to grasslands (6410) and rivers, lakes, floodplain and riparian habitats (3160, 6430, 91E0) from the larger habitat groups in the Regulation (Table 1). A general habitat typology has been prepared in the context of the NRP, including the classifications according to the Regulation and the Natura 2000 Priority Action Plan (PAF). There are differences in classification between the two systems. The first is the classification of 6430 habitat type, which according to the PAF categories belong to grasslands, whereas according to the Regulation they belong to Rivers, lakes, floodplain and riparian ecosystems. The other difference is the classification of 91E0 habitat type, which in the PAF classified as forests and in the Regulation as rivers, lakes, floodplain and riparian ecosystems. These discrepancies are not a problem for the NRP compilation, the targets for the habitat group should be met, just a reminder that the PAF has categorized these habitats differently.

Table 1 Classification of bogs, mires and fens habitat types of Community importance into habitat categories

General simplified habitat typology (for NRP)	PAF categories and associated wetland habitat types	Annex I of the Regulation and associated wetland habitats	Differences between the Regulation and the PAF classification of wetland habitats
Wetland ecosystems (coastal and inland)	Bogs, mires, fens and other wetlands	Wetlands (coastal and inland) 7110 7140 7210 7230	-
Grassland	Grasslands	Grasslands and other pastoral habitats 6410	6430 classified as grassland according to PAF
Rivers, lakes, alluvial, riparian	Freshwater habitats (rivers and lakes)	River, lake, alluvial and riparian habitats 3160 6430 91E0	91E0 is classified as forest according to the PAF

4. Which restoration objective do mire habitats contribute to?

The restoration of wetland habitats is or can be linked to a number of objectives of the Regulation, contributing to both area-based and indicator-based objectives. They add most value to the spatial objectives for habitats under Article 4 (terrestrial, coastal and freshwater habitats), to the objectives for pollinator community diversity and populations under Article 10 and to the objectives for restoration of agro-ecosystems under Article 11. To a lesser extent they are also linked to the urban ecosystem objectives of Article 8.

The targets for terrestrial, coastal and freshwater habitats under Article 4 are to restore 30% of the area of all degraded habitats by 2030 and 60% and 90% of the area of degraded habitats by 2040 and 2050 respectively, for each habitat group as defined in Annex 1 of the Regulation. It also includes the achievement of the coverage of the Favourable Reference Area (FRA) for habitats (Article 4(4)) and restoration to improve the quality and quantity of habitats for species listed in the Annexes to the Habitats Directive (Article 4(7)). To achieve the FRA, the necessary measures must be implemented on at least 30% of the additional area concerned by 2030, at least 60% by 2040 and 100% by 2050.

With regard to derogations, the stipulation in Article 4(5) that measures should not be taken until 2050 on 100% of the additional area needed to achieve a favourable distribution area may be relevant in several CEE member states. For wetland habitats, the favourable reference area would in almost all cases be larger than the current one, but it is questionable whether the habitat is actually developable or whether there are appropriate and enforceable measures in place for it.

The objective for Article 10 is to halt the decline and increase the diversity of pollinator community populations by 2030 and to achieve an increase in populations after 2030 to a satisfactory level, to be determined by the Member State. Moths are one of the most important groups of marsh invertebrates. Among the butterfly species of Community importance are the false ringlet (*Coenonympha oedippus*), the large copper (*Lycaena dispar*), the scarce large blue (*Phengaris* (*Maculinea*) *teleius*), the dusky large blue (*Phengaris* (*Maculinea*) *nausithous*) and the marsh fritillary (*Euphydryas aurinia*) are associated with fen ecotypes in or directly adjacent habitats. The maintenance and enhancement of the populations of the listed butterfly species of Community importance is of course closely linked to the habitat objectives of Article 4 for these species. For pollinator populations, in addition to traditional habitat improvement measures, pollution reduction, in particular the reduction of chemicals used in agriculture and forestry, has an important role to play.

In the context of Article 11, in addition to the measures related to agricultural ecosystems that the legislator intends to implement in protected areas and habitats of protected species covered by Article 4 – and which should already contribute to improving the indicators – additional measures are needed in other areas covered by Article 4. Furthermore, measures should be implemented in other areas that, in combination with those under Article 4, contribute to enhancing the diversity of agricultural ecosystems and priority indicators, including the grassland butterfly index, organic carbon stocks in mineral soils of arable land, high-biodiversity landscape elements, and the farmland bird index.

The index of grassland butterflies referred to in the Regulation includes 2 Natura 2000 species of relevance to marsh habitats, the dusky large blue (*Phengaris* (*Maculinea*) *nausithous*) and the marsh fritillary (*Euphydryas aurinia*) (Van Swaay 2020).

Landscape features with high biodiversity may include patches of wooded or shrubby mires and fens in undrained depressions.

In the context of maintaining the green cover of urban ecosystems under Article 8, wetlands on municipal land can also have added value.

The Article 9 objectives of restoring river connectivity and associated floodplains are worth mentioning here in the context of the repercussions that restoration of these has on the condition of wetland habitats. Wetland habitats – willow scrubs, swamp woodlands, tall-sedge meadows, fens – occur close to rivers, but they do not receive water from surface run-off, and in fact this is particularly bad for them. However, reversing the strong drainage effects as part of river restoration, for example, will also benefit wetlands and all water-dependent ecosystems through increased regional groundwater levels. On the other hand, it is noted that floodplain restoration measures, which may also affect marshy oxbow lakes, willow scrubs and fens, need to consider which habitats are desirable to maintain in the long term and which interventions are desirable in terms of contributing to other policies.

In the previous section, we covered all bog, mire, and fen habitats of Community importance, regardless of their classification in the habitat types. In the following section, we will focus on the specific approaches and issues related to the four types of wetlands.

5. Within a given ecosystem group, what criteria can be used to prioritise between habitats for planning restoration measures?

For the planning of restoration measures, it is also necessary to prioritise habitats within a given habitat group based on their current status, how it has changed over time, and the relationship between current and favourable reference area. In this respect, the status and prioritisation of the 4 bog, mire and fen habitat types classified as wetlands should not be an issue, even if climate change is strongly influencing their conservation status, and their gradual disappearance without intervention may be pronounced.

Although there is no clear precedence or direct correspondence between "good status" under the Regulation and "conservation status," the assessment of status is, in principle, based on the conservation status of habitat types of Community importance, as reported under Article 17 of the Habitats Directive. In this regard, an assessment of three reporting cycles is available, allowing for the deduction of some changes over time, with reservations regarding potential discrepancies due to increasing knowledge gaps or the use of different methods.

If we look at the situation of the four wetland habitats in a wider geographical context, the Pannonian biogeographical region and the four countries belonging to it, Slovakia, the Czech Republic and Romania, the picture is not favourable. It is important to underline here that in the other countries of the Pannonian region, the Pannonian region covers a smaller area, with other biogeographical regions, which are in many cases more important. In the other countries of the Pannonian region, only two wetland habitat types occur in the Pannonian region itself, namely transition mires (7140) and alkaline fens (7230). These habitats are not restricted to the Pannonian region either, while the other two habitat types (7110, 7210) are clearly associated with other regions (continental and/or alpine) (Table 2). 99% of the alkaline fens (7230) occur in Hungary within the Pannonian region, and 91% of the transition mires (7140).

Table 2 Conservation status of bog, mire and fen habitat types of Community importance classified as wetlands in the other countries of the Pannonian biogeographical region in each reporting cycle

Habitat code	Conservation status under Article 17 of the Habitats Directive per reporting period								
	2001-2006			2007-2012			2013-2018		
	CZ	SK	RO	CZ	SK	RO	CZ	SK	RO
7110	CONT	ALP	ALP	CONT	ALP	ALP	CONT	ALP	ALP
7140	FV	U1	CONT/ALP	U1	U1	CONT/ALP	U2	U1	CONT/ALP
7210	CONT	ALP	CONT	CONT	ALP	CONT	CONT	ALP	CONT
7230	U2	U1	CONT/ALP	CONT	U2	CONT/ALP	CONT	U2	CONT/ALP

For habitats that are considered priority habitats based on their current condition, their smaller extent than the favourable area, and their national importance, the question of restoration potential is an important issue. This includes not only whether there is an appropriate and effective method, whether there are realistically feasible measures, but also the regeneration potential of the habitat in question. International research confirms that improving hydrological conditions is a key and primary objective in restoring bogs, mires and fens, but that vegetation and soil condition management are also important factors. Restoration of hydrological conditions also has a positive effect on the soil microbial community and mesofauna, and plays a role in vegetation regeneration. In addition to the above, proper management of nutrient levels can also help regeneration. German studies have shown that rewetting drained fens may not fully restore the original condition, but can significantly reduce carbon loss and increase the potential for carbon sequestration during dry periods (Kreyling et al. 2021). The success of restoration is also greatly influenced by adaptive management strategies adapted to environmental conditions and site conditions, as well as knowledge and understanding of land use history.

6. Knowledge related to bogs, mires and fens as a foundation for measures

The restoration measures under Article 4 aim to achieve good habitat status and a favourable reference area (extent), as well as good habitat status and extent for species of Community importance, with percentages defined on an area basis. In other words, information must be available on how much of the current extent is in poor condition and precisely where it is located, how much is needed to reach the favourable reference area, and where additional habitat needs to be created. To determine whether good status has been achieved or maintained at a given site, it is essential to define what constitutes good status.

Regarding good status, each habitat type has descriptions outlining what is considered good in terms of structure and function. However, this is not always universally applicable – mire habitats are a particularly good example. It is not feasible to apply a single definition of good status to every patch of habitat in poor condition that requires restoration. Instead, it is important to adapt the definition of good status to the current conditions and opportunities and, based on that, define a target status that is already considered good.

The Regulation does not equate poor status with the conservation status of habitats of Community importance (Natura 2000). However, the fundamental assumption is that a site cannot be considered in good condition if its structural and functional status is not favourable. While there is no dispute that restoring degraded mire habitats is necessary, the specific restoration requirements can vary significantly between different habitats.

7. Measures that can be used for restoring mire habitats and their timing

The possible restoration measures for mire habitats can be well deduced from their threats. The Article 17 report and the assessment of the European Environment Agency (2020) can also be used for this purpose.

Changes in hydrological conditions are also a primary, highly significant threat. The water supply of mires, which typically or entirely originates from groundwater, has been severely deteriorating. This decline is driven by human impacts (water extraction), natural and artificial drainage effects, as well as reduced recharge due to climate change-induced decreases in precipitation and increasing aridity. The quantitative decline of groundwater has significantly accelerated over the past 5–10 years, becoming increasingly evident.

The hydrological changes and overall drying trend have led to the advanced succession. This would not necessarily be problematic if the goal were not to maintain open mire habitats. In mires, species such as birch, alder, downy oak, and reed are increasingly spreading. The drying process also alters species composition – for instance, in fens, steppe meadow characteristic species begin to appear, while in mires with Sphagnum moss, species with a broader ecological tolerance are becoming dominant.

A further consequence of the drought is that invasive species from surrounding areas can also establish and spread.

Damage caused by wild animals is mainly due to the fact that, especially during dry periods, mires remain wet the longest and often serve as the only water-rich habitat in a broader region. This attracts wildlife, which then damages the area through wallowing.

Pollution of surface and groundwater is a concern, mainly from fertilisers and chemicals from surrounding farmland, due to rising nutrient levels. This can lead to the initiation of eutrophication, which is not beneficial to mire species and in some habitats causes a significant spread of reeds.

In particular, degradation can occur in the case of fens due to the effects of inappropriate habitat management. Habitat conversion and changes in land cover (ploughing, construction) can also reduce the area of wetlands.

Table 3 summarises the spatial measures that could be implemented based on the threats (Haraszthy 2014, Kupilas et al. 2024, Nilsson 2016, Šefferova-Šeffer-Janak 2008), also identified in the NRP list of measures (January 2025 version).

We emphasize the creation of new mire habitats, as there is potential for the restoration of quarry lakes and material extraction sites, especially in the regions most affected by drought. This area is characterized by deep-water sand and gravel pit lakes that strongly drain groundwater. By filling in deep lakes with steep slopes, which have little ecological value, shallow-water wetland habitats can be created. This process may involve designing water bodies of varying depths and dry land (islands) while aiming for diverse surface formations. In terrestrial areas, fens can also be established. It is crucial to develop fens where water interacts with sand, as gravel surfaces are unsuitable for this purpose. Areas of a few hundred square meters with relatively uniform surfaces can be created so that the highest groundwater level is just below the surface or 5–10 cm deep. These areas should be designated in a way that avoids contact with reed beds and bulrushes, as these species can easily spread and outcompete fen meadow species. After abandonment, mud vegetation will naturally appear in these areas. However, unlike vegetation developing on typical mud surfaces, wet-sand species will dominate instead of ruderal elements. Management should begin when perennial species start to dominate, and with annual mowing, a species-rich fens can be maintained in the long term.

Table 3 Potential restoration measures for wetland community wetland habitat types in relation to the sources of threat

Threads	Possible measures	Measure under NRP list
Changes in hydrological conditions Climate change induced precipitation loss and drought	Water retention on drainage systems (installation of new ones, renovation, replacement of existing water retention structures) Increasing infiltration (e.g. vegetation clearance) Targeted groundwater recharge (NaBa MAR) Prohibition of drainage Species recovery - introduction of wetland species (adaptability to Mo is questionable) Top soil stripping (no example in Mo) Preservation/improvement of hydrological conditions by administrative means	MA13 Manage agricultural drainage and water abstraction (incl. the restoration of drained or hydrologically altered habitats) MK02 Reduce impact of multi-purpose hydrological changes MK03 Restoration of habitats impacted by multi-purpose hydrological changes MXX Restoring natural bogs, mires and fens MXX Rewetting of organic soils and/or drained bogs, mires and fens MXX Restoring natural wetlands MF08 Manage changes in hydrological and coastal systems and regimes for construction and development (incl. restoration of habitats). MF09 Adapt the management of water abstraction for public supply and for industrial and commercial use to reduce negative impacts on habitats and species (incl. restoration of habitats) MJ02 Implement climate change adaptation measures MS01 Reinforce populations of species from the directives MS02 Reintroduce species from the directives

		MS03 Restoration of habitat of species from the nature directives MS04 Restoring and managing native species as part of restoration of habitats MXX Adopting new policy and legislation MXX Compliance and enforcement MXX Economic and other incentives MXX Designation and effective management of protected areas MXX Designation and effective management of strictly protected areas
Sucession	Reduction of woody vegetation (e.g. ringing, cutting back of mud)	MXX Restoring natural wetlands MM01 Management of habitats (others than agriculture and forest) to slow, stop or reverse natural processes that occur without direct or indirect influence from human activities or climate change
Emergence and spread of invasive species	Targeted control of invasive species in buffer zones Mechanical eradication of invasive species in the target area	MXX Restoring natural wetlands MI03 Management, control or eradication of other invasive alien species MI05 Management of problematic native species
Damage to wildlife	Fencing of the area Removal of wildlife attracting facilities in the vicinity of the target area Deploitation of wildlife	MI05 Management of problematic native species
Pollution (surface and subsurface)	Establishment of a buffer zone Reinforcement of the buffer zone Reducing nutrient intake	MA09 Manage the use of natural and synthetic fertilisers as well as chemicals in agriculture for plant and animal MA10 Reduce/eliminate point or diffuse source pollution to surface or ground waters (including marine) from agricultural activities
Land management (mowing, grazing)	Develop/implement adaptive management practices (minimum intervention is the goal)	MA03 Maintain existing extensive agricultural practices and agricultural landscape

	Removal of accumulated organic matter (incineration)	MA05 Adapt mowing, grazing and other equivalent agricultural activities (e.g. burning) MA06 Stop mowing, grazing and other equivalent agricultural activities e.g., MXX Restoring natural wetlands
Habitat modification, surface cover change	Establishment of new stands by creating artificial wetlands (abandoned mines) Prevent habitat conversion through administrative measures	MA01 Prevent conversion of natural and semi-natural habitats, and habitats of species into agricultural land MXX Re-establishing bogs, mires and fens MXX Re-establishing wetlands MC02 Adapt/manage exploitation of energy resources MXX Adopting new policy and legislation MXX Compliance and enforcement MXX Economic and other incentives MXX Designation and effective management of protected areas MXX Designation and effective management of strictly protected areas

Criteria for defining the measures of the NRP for wetland habitats, taking into account the time objectives and realistic feasibility:

- By 2030, a 30% spatial target for restoration of degraded habitats should be met for all Annex I habitat types, in which mire habitats do not play a major role in some countries due to their small size, but if, in conjunction with marsh restoration, more complex water systems are restored or started, this will also make a positive difference for many other habitat types.
- Restoring hydrological conditions on a regional scale requires larger (strategic) interventions, the implementation of which may take a long time, especially if preliminary studies are needed. Until then, efforts should focus on smaller interventions that can yield short-term results. Major watercourses and their

associated floodplains fall into the former category, while riparian forests and fens along smaller streams can often be restored with minimal intervention, facilitating their natural regeneration. In other areas, it is also advisable to plan small-scale interventions before undertaking larger ones – for example, closing drainage channels or retaining water in ditches. These measures can help ensure the survival of species and habitats (by creating refuge areas) until larger-scale restoration projects are completed.

- In connection with the previous point, it is always worth considering whether local water conservation can be a result or whether landscape/regional intervention is required.
- According to the Regulation, interventions that are in progress and those that have been implemented but have not yet reached their target can also be taken into account. In the case of mire habitats, projects that have already been implemented and projects that are in progress or in the planning stage can also be taken into account. In addition to these, measures that are necessary and can be implemented in the short term should be counted as a first step.

The Regulation defines the concept of restoration as the active or passive facilitation of ecosystem regeneration. According to the literature, passive restoration refers to natural regeneration or succession following the removal of disturbing factors. This study, however, addresses both active interventions that lay the foundation for restoration and measures that facilitate passive regeneration, which are primarily administrative in nature and often require the creation or modification of legal regulations.

One element of this is the clear inclusion of mires in sectoral strategies as a manifestation of political commitment, with specific goals set for them. A study by CEEweb (2024a) analysed peatland policies in six Central and Eastern European member states. It is important that as many countries as possible in the CEE region have a strategy for peatlands/mires.

In the following, we will focus on the improvement of hydrological status as the cornerstone and key element of mire habitat restoration, including measures that are not specific spatial interventions, but administrative steps that are essential for the landscape-level, regional conservation and restoration of groundwater resources.

8. Restoring the hydrological status

8.1. Groundwater protection

Wetlands are terrestrial ecosystems that depend directly on groundwater. Their permanent or intermittent surface water cover is partly or entirely derived from below the surface. Where surface water cover does not occur intermittently, it is also dominated by the additional water influence of the near-surface groundwater table. The quantitative status of groundwater bodies can have an impact on the ecological quality of surface water and the terrestrial ecosystems associated with that groundwater body (Directive 2000/60/EC - hereafter referred to as the WFD - recital 20). The protection of groundwater is already an obligation for Member States under the Water Framework Directive to prevent, protect and enhance the status of terrestrial ecosystems and wetlands directly dependent on groundwater in order to prevent further deterioration. Climate change, increased abstraction and land use are the primary drivers of groundwater recharge and groundwater depletion across Europe, which has accelerated dramatically in recent years. It is important to note, however, that groundwater depletion is not a uniform phenomenon across regions, but shows significant regional variations, influenced by local hydrological conditions and anthropogenic impacts.

8.2. Landscape-level, regional restoration

The sustainable restoration of wetlands requires a comprehensive, regional approach focused on groundwater resources, and cannot be managed in isolation from surrounding wetlands. It requires sustainable groundwater management practices that take into account the complex interactions between hydrological processes and human activities. Complex, integrated management of groundwater-dependent habitat systems linked to directly connected water bodies and flow regimes will enable more effective organisation of restoration measures. This may, however, entail the potential for undesirable effects (swamping or inland flooding) in an area relatively distant from the habitat targeted by the restoration, which should also be taken into account in the design of measures.

8.3. Possible areas of intervention

Changing the practice of inland water management

The drainage of excess water from the surface, which results from the rising of groundwater in cultivated areas and settlements, is harmful, as targeted activities to lower the groundwater level could lead to landscape-scale desiccation in sensitive areas. This is particularly crucial for mires, as the excess water appearing on the surface (internal flooding) may indicate potential restoration areas where the creation of groundwater-dependent ecosystems—such as mires—could be sustainably implemented.

Review of water extractions

The main factor contributing to groundwater depletion is the imbalance between groundwater recharge and extraction. In many regions of Europe, particularly in Central and Eastern Europe, there are significant negative trends, reflected in the degradation of groundwater-dependent ecosystems, including mires. Numerous studies show that groundwater recharge in Eastern and Central European and Mediterranean countries is declining and out of balance with the increasing demand for water extraction. Prolonged periods of drought can be critical to maintaining freshwater supplies for drinking water and irrigation through the reduction of potential groundwater recharge. Regular collection of data on the amount of water abstracted would be important. Concrete data could also be used as a basis for raising public awareness, overcoming the common perception that groundwater resources are inexhaustible and infinite. Based on this data, a review of the general legislation governing extraction regimes and procedures could be a major step forward in the protection of groundwater resources.

Targeted water recharge based on hydrogeological studies

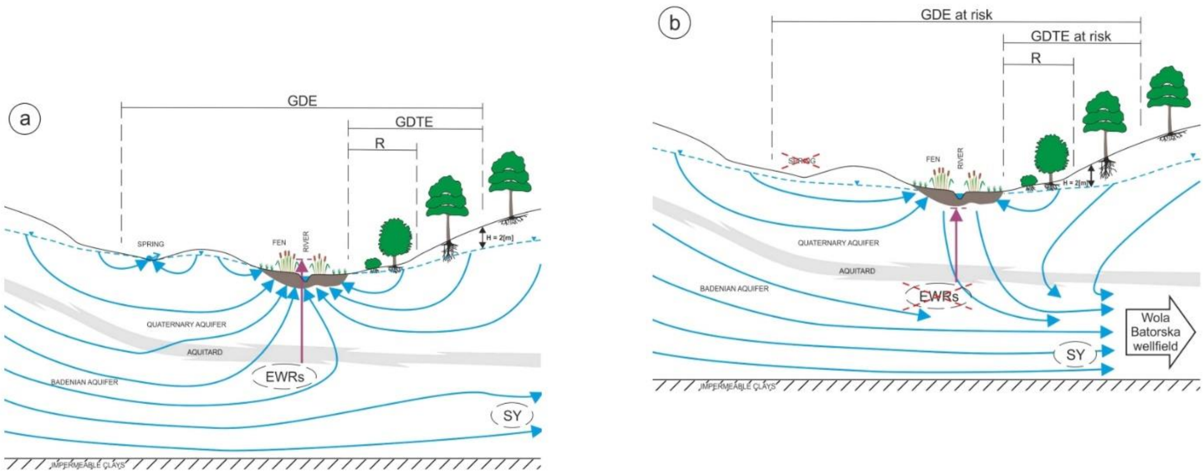
The problem for groundwater recharge is the changing hydrological cycle, mainly as a consequence of climate change. Hydrogeology is key to understanding this and to restoring freshwater ecosystems that are directly dependent on groundwater, including mires. Atmospheric, surface and groundwater are linked by the hydrological cycle, as groundwater is connected to surface water on the input side, through infiltration or precipitation, groundwater is renewed and recharged, and is affected by atmospheric processes through evapotranspiration. On the other hand, the expenditure side is even more important to consider for a restoration project, as it is in natural areas of recharge - i.e. where groundwater is present at the surface (springs, ponds, intermittent and permanent water cover, and through soil and vegetation) - that wetlands can be sustainably restored.

The use of groundwater in restoration measures can only be sustainable if we understand the flow processes in the groundwater and look at groundwater in a new paradigm based on a systems approach. Water can pass through rocks that are thought to be perfectly impermeable, simply by affecting their flow rate. Some water-retaining rocks (e.g. clay, marl) can significantly slow down the movement of water, while others, such as limestone, sandstone or gravel, are aquiferous or water-conducting rocks that store and help water to move. Groundwater is organised into coherent systems and is in a continuous, (mostly) slow-moving state, travelling considerable distances, possibly tens or hundreds of kilometres. Groundwater transport systems are interconnected (Mádlné et al. 2022).

Understanding the groundwater pathways - regional, local, intermediate flow regimes - can also help to understand why some mires, swamps, (saline) lakes are located where they are naturally formed (Simon et al., 2024). If groundwater flow regimes are altered by climatic factors, significant abstraction or drainage, the water supply of a whole range of wetlands in the area may be compromised. Systems thinking may require, among other things, baseline studies and hydrogeological modelling to restore mires. As a result, intervention sites can be identified where groundwater recharge can be targeted using NaBa-MAR® - Nature Based Managed Aquifer Recharge (a registered innovation of Eötvös Lóránd University of Sciences). However, it is also necessary to examine land use and water abstraction as a background to the often modified flow conditions revealed by hydrogeological models. Any intervention below the surface can significantly affect a distant surface wetland (Figure 1). Successful restoration of a degraded groundwater-dependent ecosystem is highly dependent on knowledge of groundwater flow regimes and their appropriate rehabilitation.

It is also important to highlight that if targeted water replenishment cannot be implemented, the knowledge of subsurface flow systems provides a good foundation for identifying where infiltration can be increased. This could be achieved, for example, through surface water retention or vegetation removal, in order to improve the water supply of a given area. Furthermore, it also provides information on what impacts modifying the flow systems need to be eliminated in order to at least partially mitigate the negative effects on a specific habitat or habitat complex.

Figure 1 Illustration of the groundwater flow regime in (a) unmodified and (b) modified condition (Zurek et al. 2015) (abbreviations: GDE – groundwater-dependent ecosystem; GDTE – groundwater-dependent terrestrial ecosystem; R – riparian forest; EWRs – environmental water requirements; SY – safe yield of the aquifer exploited by the Wola Batorska well field)



Cross-compliance of the Common Agricultural Policy

There is a strong link between agricultural practices and groundwater sustainability. Climate change will continue to increase agricultural water demands, which will generate additional surface and groundwater withdrawals, while the sudden surge in rainfall and associated flash flooding will also increase drainage demands. This predicts landscape-scale drying, making changes in agricultural practices essential. This is supported by the Common Agricultural Policy (CAP) cross-compliance system (Regulation (EU) No 2021/2115), under which the Good Agricultural and Environmental Condition (GAEC) has been extended to include a new GAEC 2 standard for the protection of wetlands and bogs, mires and fens (to be introduced in most Member States from 2025). The standard is linked to the objectives of the Regulation, as water retention is carried out to preserve soil organic carbon in addition to ecological considerations. The strategic planning of the new CAP should effectively take into account the peatland aspects of the Regulation. Furthermore, in relation to groundwater protection, it would be essential to introduce a strong and binding system of water protection standards, which would compensate for the damage caused by the obligations in the form of CCI compensation payments.

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The national restoration plans include measures to achieve the nature restoration targets set out in the EU's biodiversity strategy to 2030. The preparation and implementation of these plans is both a great opportunity and a major challenge for Member States.

The purpose of this study is to examine, using the example of wetland habitats, the considerations, approaches and possible interventions that can be taken along the lines of the legal requirements and the data content required in the national restoration plan template, in order to support the development of plans. The study is based on the Hungarian context, but the issues raised and possible solutions can be applied and adapted to a wider geographical area.

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