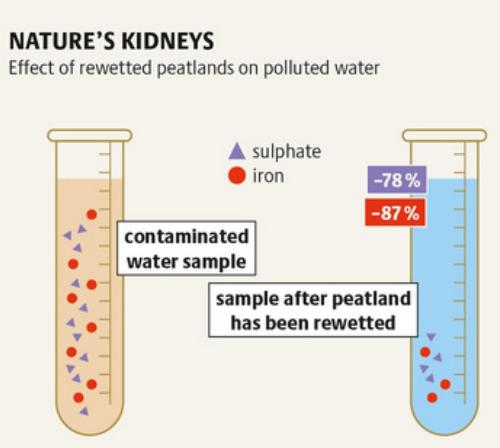
Bogs hover between land and water.

PEATLANDS AND WATER

Introduction

Intermediate between land and water, peatlands are the main subclass of wetlands in Ireland. **Water is the blood of all peatlands**. Undisturbed peatlands provide important ecosystem service benefits by providing a buffer against acidification and eutrophication, locking up nutrients and other elements (sulphur, nitrogen and heavy metals from atmospheric deposition) and therefore buffering downstream waters and their biota. Although the water in blanket bogs is acidic and low in mineral content, the streams that drain these areas host an unusual variety of organisms (280).

Blanket bog catchments are also important for **drinking water** supply (307). In Ireland and the United Kingdom, approximately 85% of the drinking water is sourced directly from peatlands, highlighting the crucial role that peatlands play in the water security of these nations (934). However, at the global scale, only 28% of water-supplying peatlands remain pristine or protected, emphasising the urgent need for responsible stewardship.



Source: Eimermacher/stockmarpluswalter, CC BY 4.0. Peatland Atlas 2023, Heinrich-Böll-Stiftung & others.

Drainage lowers the water table and leads to significant changes in hydrology (the way the water is stored and flows off the peat surface) and the water quality within the bog and downstream water bodies (704, 715). Land use management, such as afforestation and subsequent forestry operations as well as peat extraction, further lead to a **deterioration in the water quality that flows from these degraded peat soils** (304, 641).

Peatland drainage and extraction provide several **serious challenges to aquatic life**, including increased mortality, reduced species richness, behavioural changes, habitat alterations and changes in community structure (235).

Flume to monitor water quality at All Saints Bog.

The improvement of water quality associated with peatlands requires the development of (a) management tools at both the site level (water treatment) and landscape level (rewetting) to help meet regional water quality standards, and (b) the regular monitoring of water chemistry as an integral part of current and future peatland management practices (704).

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Key Research Findings

Water quality from peatland catchments

The current state of Irish peatlands and the consequences of widespread degradation in terms of loss of various ecosystem services related to water quality have been highlighted by many studies. The **Midlands region is facing a significant and widespread reduction in water quality** with high fluvial nitrogen and carbon concentrations present in all streams. This necessitates (a) the development of management tools at both the site level (water treatment) and landscape level (rewetting) to help meet regional water quality standards, and (b) the regular monitoring of water chemistry as an integral part of current and future peatland management practices (704).

- **Streams that drain upland catchments carry substantial amounts of carbon** from terrestrial sources to downstream freshwater and marine ecosystems. There, the carbon is either stored long-term in sediments or released to the atmosphere as gaseous carbon through various biotic and abiotic processes. However, there is increasing concern about the long-term stability of terrestrial carbon stores in blanket peatland catchments due to anthropogenic pressures and climate change (240). Carbon stored in peat is a key constituent of aquatic food webs in rivers and lakes of peaty catchments, and changes in the downstream transport of this exported carbon may have considerable implications for the production of Atlantic salmon and brown trout (208).

- **Upper peatland catchment dynamics** have also been shown to impact the sediment flux of water bodies downstream (280).

- The change in **dissolved organic carbon** (**DOC) concentrations** with storm events in streams that drain natural blanket bogs have shown two patterns: (1) in colder periods, the DOC concentration seems to be independent of changes in stream flow; (2) in warmer periods, the DOC concentration was found to rise with increases in stream flow on some occasions and to decrease with increasing stream flow on other occasions (461).

Effects of climate change

During the winter months, an increase in effective runoff is projected for the western half of country (peatlands), which could have implications for flood frequency, as well as the extent and duration of winter flooding (130). Greater winter precipitation could also increase the percentage of seasonally deposited reduced sulphur in the bogs in the winter and increase sulphur into surface waters in the summer, thus decreasing the role of landscape sequestration of sulphur, and leading to higher concentrations of pollutants in surface waters (515).

Robust mitigation measures are required to counteract the browning of surface waters, as seen here from an extracted peatland.

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Key Research Findings (continued)

- **Plantations on deep peat can negatively affect stream ecosystems**, potentially influencing the legal status of a water body. Differences in runoff patterns have been highlighted between open, relatively intact blanket bogs and areas affected by forestry. This gives rise to less stable, more stressful abiotic supporting conditions for aquatic ecosystems compared to natural conditions and may explain declines in water body status across Ireland in mature plantation forestry areas in blanket peat catchments (304).

- **Afforestation** results in a decrease in streamflow and an increase in evapotranspiration, particularly in summer (492). Biogeochemical impacts of clearfelling and reforestation on blanket peatland streams may head to a large increase in molybdate reactive phosphorus, and increased nitrate in some cases. Potassium and manganese concentrations may also increase. Concentrations of DOC and organic monomeric aluminium increase gradually (196, 197).

- **Forest operations**, such as fertilisation, can negatively impact water quality. Peat soils with a high organic matter content have low cation content and do not chemically adsorb phosphorus as mineral soils do and so phosphorus is more easily lost from peat soils (202, 450). However, the use of grass seeding and mini-buffer practices to immobilise nitrogen onsite could be an efficient and feasible method for reducing nitrogen export from harvested blanket peatland forests, thereby protecting sensitive watercourses (17).

- The degradation of **peatland lakes** is likely to become more prevalent as plantation forestry continues to expand worldwide (243).

- Peatland runoff contains a high concentration of natural organic matter, which poses challenges for the treatment of **drinking water**. It reduces the effectiveness of conventional methods and can lead to the formation of potentially **carcinogenic disinfection by-products**, necessitating the development of new, cost-effective technologies (524). In a national assessment of trihalomethanes (THM) exceedances in Irish drinking water, catchments with more-degraded peat soils and agricultural land use were identified as significant contributors to THM concentrations in treated water (649). Furthermore, disinfection by-products are an ever-increasing occurrence in water networks, particularly those that abstract water from peatland areas (344).

- There is a close connection between weather, catchment carbon cycling and their effects on **downstream aquatic systems**. The implications for carbon availability and water treatment are likely to be more pronounced in rivers than in lakes, as the effects in lakes or reservoirs will likely be dampened by their retention time (414).

- **Soil temperature, discharge and drought are significant drivers of DOC concentrations**, while soil temperature, discharge and rainfall are significant drivers of particulate organic carbon concentrations. The results illustrate the complexity of the interactions between climate and land management in driving stream water carbon export (763).

- During **prolonged dry periods**, runoff contains highly mineralised water, which reflects the flow of water beneath the bog before it emerges in the stream. The quality of this water varies with flows and is determined by the types of minerals present beneath the peat (280).

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Let's not forget the water bodies associated with peatlands

- **Peatlands are associated with a wide range of water bodies** including rivers, lakes, pools of various sizes and micro-habitats, such as *Sphagnum* hollows, all of which are biogeochemically distinct (15, 360).

- **Peatlands pools** have been found to be highly regionally variable, and proximity to the marine environment is an important factor (867). Soaks are special water bodies within raised bogs that exhibit different biogeochemistry (185).

- The areas of lower hydraulic conductivity (i.e. the ease that water can move through the peat) at the **margins of blanket bogs** play an important role in the overall health of peatlands as they maintain the **elevated water table levels** at the centre of the bog (410).

- **Alkaline fens** in Ireland have been studied to develop metrics for defining 'good' fen habitat. Results indicate that an **annual water level** always above the ground surface within a threshold depth of between 0.03 and 0.28 m is required for at least 60% of the year for healthy fen vegetation (45).

Management: Rewetting

- **Research on the impact of rewetting and restoration of peatlands on water quality** is limited but some studies are of note. The development of a *Sphagnum* layer can influence the timing and magnitude of lateral flow, creating a positive feedback loop for *Sphagnum* development. As the *Sphagnum* moss layer forms, its greater storage and hydraulic conductivity compared to the peat soil enable it to initially retain more water, which is then subsequently distributed throughout the system (814).

- In some cases, the lack of a basal sealing layer (galcial clay) means the raised bog is in hydraulic connection with the regional groundwater system requiring **a regional approach to hydrological management** for successful restoration. This analysis implies that careful placement of monitoring stations is essential for tracking long-term regional groundwater dynamics (715).

Restoration of degraded blanket bog in the Wicklow Mountains with coir roll dams in a project funded by the National Parks and Wildlife Service, and co-funded by Intel.

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Management: Rewetting (continued)

- During the 2020 winter flood event, rivers in the lower Shannon catchment with the greatest nitrate, sulfate and DOC concentrations were **'hotspots' of chemical export.** These rivers drained areas with industrial peat extraction operations, converted grassland, and a high density of surface drains. The results demonstrated the **impact of flood conditions** on chemical export in peatland grassland catchments and underscored the need for water reallocation across Ireland to address water resource concerns (787). Field trials that applied short-term flooding to sites that differed in soil pH, average soil moisture and history of fertiliser application, showed that there was no overall effect of flooding on phosphate, nitrate, ammonium, iron concentrations and pH of the pore water. Problematic phosphate release was only induced by long term flooding of fen meadows that had a history of fertilisation (35).

- Despite increased water table levels that can occur following removal of closed canopy cover of afforested bogs, the **continued functioning of furrow and drain networks** gives rise to hydrological and hydrogeological regimes that hinder re-establishment of hydrological supporting conditions necessary for peat-accumulating species (304).

- **Zooplankton** communities can provide a valuable component for **ecological assessment in restoration of blanket bogs** representing a gradient of alkalinity and anthropogenic impact, primarily owing to nutrients and/or acidity in peatland lakes (108).

- A lack of standardisation in **monitoring water in restoration projects** and lack of transparency and data sharing around publically funded projects severely constrains evidence-based analysis of peatland restoration outcomes.

How can we effectively address water quality issues through the sustainable management of Irish peatlands?

River catchments and their diverse uses exemplify social-ecological systems, where sustainability assessment necessitates integrated ecological, economic, and societal approaches that consider institutional change. **A call for sustainable peatland management is, therefore, in synergy with a call for sustainable water resource management in Ireland.**

Database

This factsheet is part of a series produced by Peat Hub Ireland (PHI). The reference numbers in brackets refer to individual publications in the PHI database which link to the original source of evidence. Use the QR codes to access the database or view research projects associated with the themes. All factsheets in the series are available on the PHI website.

Research Projects