Bogs are particular types of wetlands which are fed only by direct precipitation (in contrast with fens, fed by enriched groundwater or surface flows). The waterlogging in both bogs and fens prevents the complete decomposition of dead plant material so peat is usually built up over time. Precipitation water is poor in nutrients and somewhat acidic; in combination with the presence of peat and near-permanent waterlogging, these extreme conditions usually mean that bogs are species poor. Many bog species are, however, highly specialised and not found in other habitats.

Terrestrial wetland habitats are formed by the flow and retention of water in the landscape. Their nature is determined by landform and hydrological pathways, the characteristics of the water supply, and climatological and biological influences which generate a mosaic of wet grasslands, fens, bogs, and other habitats of various degrees of wetness and types of hydrochemistry.

The UK Biodiversity Action Plan (published in 1994), described the biological resources of the UK which were identified as being the most threatened and required conservation action – our priority species and habitats. Detailed plans set out actions to protect and restore our threatened wildlife, and work continues today, as a key part of the delivery within Biodiversity 2020 and the Water Framework Directive (WFD). Across catchments, action to enhance our many freshwater habitats is intrinsically linked; with works to rivers able to benefit wetland habitats, and vice versa. Delivery on a catchment scale can take account of these synergies, and can look to secure opportunities to achieve biodiversity benefits across the full range of habitats present within a catchment.

WFD AND B2020 SYNERGIES: SOME CROSSOVER

As terrestrial wetland habitats, bogs fall under the Water Framework Directive primarily as a feature of water-dependent Protected Areas, which must achieve their conservation objectives under the Directive. Delivery under WFD can also benefit a wide range of species that are the focus of B2020 Outcome 3 (protecting species). Under Biodiversity 2020, activity to enhance or create Priority Habitats (Outcome 1a or 1b) can benefit adjacent water bodies, for example via land management changes which reduce pollutant inputs and enhance water quality. The same is the case with the restoration of degraded ecosystems (outcome 1D) through activity such as reconnecting rivers and their floodplains.

Bogs form where active peat accumulation occurs above the surrounding water table generating acidic, low-nutrient conditions that support a species-poor plant community dominated by Sphagnum mosses.

BOGS IN A CATCHMENT CONTEXT

Peatlands (or mires) – formed when organic matter is produced faster than it is decomposed, causing partially-decomposed vegetation to accumulate as peat – are a key component of the wetland mosaic, and are abundant in areas where climatic and topographic conditions create the water saturation necessary for peat formation. Across the spectrum of peatlands, pH and nutrient availability combine to determine the vegetation and broader species communities. Bogs form where active peat accumulation occurs above the surrounding water table, (often in the upper parts of catchments), meaning that precipitation dominates the water supply and generates acidic, low-nutrient conditions that support a species-poor...
plant community dominated by *Sphagnum* mosses and cotton-grass. By contrast where peat is formed at lower points in the landscape, surface waters and groundwater bring nutrients and reduce acidity, giving rise to fens – these exhibit higher species richness and are more productive, supporting taller sedges and reeds.

In those catchments which contain bogs, their restoration and future function will be influenced by the management/restoration of the catchment’s peatland areas as a whole; restoration of these areas can deliver large improvements in the many ‘regulating’ ecosystem services that can be provided by bog habitat, such as water quality, water flow regulation and carbon storage. Bogs within catchments are an essential element of the overall hydrology of the system.

**NATURAL ECOSYSTEM FUNCTION IN BOGS**

Healthy bogs consist of two layers – a thin living surface layer of peat-forming vegetation (the acrotelm), generally between 10 cm and 40 cm deep, and the relatively inert, permanently-waterlogged peat store (the catotelm) which may be several metres deep. Often separated into two types, ‘active’ bogs are those which support a significant area of vegetation which is normally peat forming (in England these sites will usually be designated); whilst ‘degraded’ bogs possess a peat soil from which the peat-forming vegetation has been completely removed or replaced, most commonly by human action. In recognition of the global importance of the UK’s peatlands, even degraded bogs will often benefit from protected area designation. Understanding which areas of a catchment support active bog, and which degraded, will be important in planning the restoration of peatland habitats.

Peatlands encompass three main and broadly-distinct forms of habitat; blanket bog, lowland raised bog and fen (covered separately).

Lowland raised bogs are peatland ecosystems which develop primarily in lowland areas such as at the heads of estuaries, along river floodplains and in topographic depressions. In such locations drainage is impeded by a high groundwater table, or by low-permeability substrata such as estuarine or glacial clays. Continued accumulation of peat elevates the bog surface above regional groundwater levels to form a gently-curving dome from which the term ‘raised’ bog is derived, due to peat accumulating faster in the centre. The thickness of the peat mantle varies considerably but can exceed 12 m. Raised bogs feature distinct plant communities of hummock- and lawn-building *Sphagnum* mosses. The characteristics of this vegetation and the peat layer generated from it are important in regulating the flow of water within the bog as well as at a catchment scale, playing an important role, both at times of high rainfall and during drought. *Sphagnum* in particular contributes to the formation of peat habitats due to its growth habit; growing upwards from its tips and dying from the base, preserving its remains in the lower wet layers as peat.

The raised bog ecosystem is defined by the peat soil extent, within which a number of key areas can be identified, including the dome itself (active and non-active peat forming) and the edge area (once part of the dome). At the edge, a natural transition to fen can develop where nutrient runoff accumulates at the fringes or ‘lagg’ of the bog, but many edge areas are now degraded and under different land use.

In England, some of the best remaining examples of raised bogs are found in river valleys of the north-west, though there is evidence of their development across the country. In England, some of the best remaining examples of raised bogs are found in river valleys of the north-west, though there is evidence of their development across the country, even the south east (Sussex’s Arun valley, the East Anglian Fens).

Supporting a similar range of vegetation to raised bogs, valley bog systems occur in those depressions or valleys where any groundwater input comes from extremely base-poor sands and gravels (such as in the New Forest), maintaining the low nutrient status which prevents progression to fen. In the least damaged valley bogs, the very wet central zone can be very rich, supporting now extremely rare species such as the large marsh grasshopper, slender cotton grass and bog sedge. Over time, it is the centre of the bog where water and nutrients ultimately accumulate, causing shifts in vegetation communities and transition to other habitat types.

By contrast, the location of blanket bogs is determined more by climatic conditions than by landscape. They form in areas with an oceanic climate, high levels of

---

**AT A GLANCE GUIDE BOGS**

**Bogs** are rainwater-fed wetlands where waterlogging prevents the complete decomposition of dead plant material, allowing the formation of peat.

The ‘ACROTELM’ is a thin living surface layer of peat-forming vegetation.

The permanently-waterlogged peat store below (the ‘CATOTELM’) may be several metres deep.

In raised bogs, common in the lowlands, groundwater impedes drainage, causing a build-up of peat – the domed surface gives rise to the name Blanket bog.

Blanket bogs form mainly in the uplands – with peat forming due to the slow decomposition of organic material experienced in cold, wet climates.

Extreme conditions often make bogs species poor, but those species may be highly specialised.

---

**KEY PEAT-FORMING SPECIES LIKE COTTON GRASS CAN BE LOST THROUGH DRAINAGE, BURNING OR OVERGRAZING**

© Tom Marshall
rainfall and low rates of evapotranspiration; factors which promote the spread of Sphagnum and contribute to the very slow decomposition of plant material. This enables peat to form not only in waterlogged soils and wet hollows, but over large expanses of undulating ground, cloaking the whole landscape. In England, these blanket bogs occur extensively across the moors of the West Country, and from the Peak District to Northumberland in northern England.

PRESSURES ON OUR BOGS

Bogs have been subject to a massive range of anthropogenic impacts including pollution, drainage, burning and peat extraction; for example, over 90% of the UK’s lowland raised bog has been destroyed or damaged. Areas that have been designated for biodiversity (e.g. SSSI) represent only the remnants of the naturally-occurring habitat that have survived these impacts, and the degradation of surrounding areas is still having a huge impact upon bogs, and therefore upon the dynamics of catchments as a whole. To implement effective long-term restoration of bogs requires the wider peatland areas also to be managed differently, in a manner which restores the wider benefits to society. The vast majority of our peatlands have been degraded; most lowland peat soils are now intensively farmed as arable cropland or grass pasture, whilst other sites have had their surface vegetation removed to facilitate the extraction of peat for horticultural use. Extensive parts of the upland landscape are similarly peatlands which are no longer peat-forming, in this case because past atmospheric pollution, drainage, afforestation, burning and overgrazing have removed the key peat-forming species (Sphagnum and cotton-grasses) from the vegetation.

Many declines in wetland wildlife can be directly related to drainage schemes, as the integrity of bog systems and the features they support depends upon an intact hydrological regime across the whole system. Along with burning, moorland gripping – digging ditches – has resulted in the loss of active blanket peat, with its distinctive and diverse habitat mosaic of Sphagnum-dominated bog, drier areas with ericaceous vegetation and bog-stream transitions. Specialist communities of beak sedges found in depressions in the wettest parts of bog systems have suffered perhaps the greatest losses across any habitat in England, including national extinctions, e.g. Rannoch-rush.

Added to the major effects of drainage, abstraction and water level management further modify patterns and volumes of water supply. Nutrient pollution, either waterborne or through atmospheric deposition of nitrogen, can create major shifts in vegetation and associated fauna. Acid deposition adds a further pressure to wetland types with low buffering capacity such as bogs.

Extraction for gardening and horticulture continues only at a handful of sites, but has left a legacy of degraded, bare and eroding peat at numerous others.

Managed burning, wildfire and grazing pressure additionally impact the vegetation community and soil structure of bogs, altering characteristic communities and reducing resilience to further environmental degradation.

From a climate change perspective, hotter drier summers will cause increased drying out leading to changes in plant community composition, peat loss through increased oxidation, and increased susceptibility to damage from wildfires, grazing and visitor pressure promoted by drier conditions. Wetter winters and heavier rainfall will increase erosion, leading to loss of bog habitat and reducing downstream water quality. Furthermore, degraded bog habitats will release significant quantities of stored carbon, so their degradation is particularly damaging. This gives a high level of urgency to restoring these ecosystems, as in a fully-functional state they will be far more resilient to climate change impacts and better able to withstand future changes.

Restoring natural hydrological regimes and vegetation communities will not only prevent further habitat degradation and susceptibility to damage, but will aid in the restoration of ‘active’ bog habitats, securing the ecosystem services that these deliver.

KEY PRESSURES ON BOGS

- **POLLUTION:** Waterborne or atmospheric nutrient pollution and acid deposition create major shifts in vegetation and fauna in bogs
- **HABITAT LOSS:** The extraction of peat for gardening and horticulture continues in only a few places, but has left a legacy of degraded, bare and eroding peat bogs
- **DRAINAGE:** Drainage schemes across the whole hydrological system directly affect bog habitats and species as they depend on an intact water regime
- **MANAGEMENT:** Most peatlands have been degraded – lowland peat soils are intensively farmed as arable crops or pasture, and upland areas are afforested
- **CLIMATE CHANGE:** Predicted drier, warmer summers will cause increased drying out, leading to changes in plant communities, peat loss and wildfires
- **HABITAT LOSS:** Historic gripping and burning of moorland has resulted in the loss and degradation of bog soil structure, vegetation and characteristic wildlife
• **RESTORATION OF NATURAL PROCESSES**

Measures that seek to restore natural processes – hydrological, geomorphological and water quality regimes – are key to delivering wetland habitat objectives. These range from protection (e.g. tackling pollutant inputs) to direct intervention (e.g. infilling & blocking of drains). Understanding historical modifications and their impacts (perhaps via GIS/models) allows practitioners to consider how the site would function under natural conditions, taking this as a foundation for planning restoration, and factoring in implications for existing habitats in, and adjacent to, the site.

• **LARGE-SCALE PERSPECTIVE**

The condition of bogs depends on many factors including what is happening in the catchment and, (in terms of nutrient deposition), in the atmosphere above. Restoring hydrology and natural water quality and chemistry in the catchment is crucial – it is not only about addressing direct impacts on the bog itself.

• **TAKING ACTION IN THE RIGHT ORDER**

With bog function highly dependent upon an appropriate water level regime, other interventions will not deliver the greatest possible biodiversity benefits unless actions such as water-level raising and drain blocking are undertaken first.

• **TAKING THE LONG VIEW**

Whilst active intervention can be important in kick-starting restoration, taking a longer-term approach enables natural recovery to play the fullest role possible. For instance, long-term plans to tackle over-abstraction will support the return to a more natural bog hydrological regime. A long-term vision encourages management decisions which are more sustainable, particularly if the seemingly ‘immovable’ socioeconomic constraints of today may be resolved in the longer term.

• **SPECIES MANAGEMENT**

In some circumstances the preferred management regimes for key species and habitats may be incompatible. For example, manipulation of water levels or land form to meet the habitat needs of certain species will prevent the establishment of naturally functioning wetland habitats. In bogs, maintenance of a stable high water table which is critical for specialist bogland invertebrates can most sustainably be achieved by tackling existing drainage or excessive tree cover which cause drying, rather than by modifying land form. As with all priority habitats, the ideal, of course, is that bogs develop within landscape-scale initiatives, where natural hydrological processes will create a full range of self-sustaining habitats and dependent species populations. At a smaller scale, when restoring naturally functioning habitats the implications for priority species and other species of conservation concern need to be considered (see below).

• **RATIONALISING CHANGES IN SPECIES DISTRIBUTION AND ABUNDANCE**

The current distribution of many rare (and more common) peatland species is limited as a result of previous habitat loss or degradation. For example, the presence of certain rare ground beetles at the bare margins of peat diggings is likely a result of the loss of natural processes that create pools and hollows throughout the peat landscape, supporting the case for restoration of the processes which generate these features naturally. Plans for species conservation and ecosystem restoration should therefore take into account the (positive and negative) implications for species of the restoration of natural processes, and of climate change. Suitable habitat needs to be maintained or created to prevent local or regional extinctions and to aid species recovery. Direct management, including reintroduction, can also be considered to assist in the transition to restored environmental conditions.

• **SUCCESSION**

Peatlands have experienced a complex history of development and
modification over time, but whilst in other habitats it can be unclear as to which point along this succession is most desirable for conservation; succession in bogs largely occurs as a result of past damage; for example, with trees only able to survive on drained, degraded bog sites. As such, it is clearer for bogs than for some other habitats that the restoration of natural processes – intrinsic environmental characteristics and unimpacted water supply mechanisms – forms an appropriate basis for sustainable restoration.

• **BARRIERS TO CONNECTIVITY WITH WIDER ENVIRONMENT**

Reinstating connectivity is a key step in restoring a naturally functioning wetland environment. Non-natural features within and around wetlands, such as ‘catchwater’ drains which cut off upland areas from the wetlands below, should be addressed where possible; modification to minimise their impacts is the next best option. A long view will often need to be taken, particularly where external factors such as air quality have an impact; and wherever changes will be felt more widely, for example, if neighbouring land may become wetter as a result of the proposed restoration.

• **SEASONALITY**

Ephemeral pools and seasonally exposed peat support characteristic flora and fauna such as brown galingale, but can be destroyed by drainage, infilling or deepening. Natural seasonal water-level fluctuations are essential to maintain this type of habitat.

• **UNDERSTANDING THE LOCATION OF EXISTING FRESHWATER BIODIVERSITY**

To maximise the benefits of restoration work, and eliminate damage to priority or endangered species, it is important to obtain a clear picture of the distribution of local freshwater biodiversity, (indeed, this knowledge is legally necessary for some species). Practitioners should take account of standing water, running water and wetland biodiversity. Specialist advice can be valuable; for example, work being undertaken by the Freshwater Habitats Trust to identify ‘Important Freshwater Areas’ could inform local delivery.