Working towards the development of Ecohydrological Guidelines for Blanket Bog and Associated Habitat – A Scoping Study

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Non-technical summary

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Environment Agency,
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Non-technical summary

Background and methodology

Peatlands cover roughly 2.5% of the land surface area of England and Wales and around 10% of Scotland, the majority of which occur as part of an extensive blanket mire landscape. Upland mires are not covered by existing ecohydrological guidelines, and in recent years there has been a move away from target setting to an increased emphasis on restoration of natural hydrological functioning of mires in the landscape. The UK Country Agencies have perceived a need to provide more user-friendly guidelines for upland mire habitats to support work on reducing carbon emissions and natural flood management. This project has been undertaken as a scoping study aimed at reviewing information that could be used to characterise the water supply mechanisms of upland mires, and to understand how these relate to the different vegetation types of blanket mire landscapes. Sections 1–3 of this report identify the main drivers, aims and delivery of this project.

A broad aim of this study has been to determine the availability of ecological and hydro-geological data sources for individual upland mire sites that could be used for a 'bottom-up' analysis, providing the foundation for an upland mire classification. Such work would help to provide a holistic understanding of the requirements of upland mire vegetation types and provide a basis for assessing the likely outcomes of conservation actions. The process of gathering information has involved a search of the available literature, including published reports and journal articles, and unpublished work where this could be acquired. Where possible, gaps in the available information have been identified and recommendations for further work have been made.

Acquisition of data has not been straightforward because of the short timescale of the project, with most contacts very busy, some not responding at all to enquiry, and some indicating that funding would be required to pay for time spent on collating relevant data. There was also some potential sensitivity in releasing data to contractors. As a consequence the study is at the point where, although a range of data are held, other data are known to be available but their precise nature is not understood ('known unknowns'). There are also likely to be other information sources that have not yet come to light ('unknown unknowns').

Relevant information from the various literature sources has been synthesised, with particular attention paid to the basic data rather than their interpretation by authors. These data have been used to develop several discussion sections regarding the characterisation of blanket mire landscapes, mire vegetation, hydrology, and related habitat features. In addition, published and unpublished data sources have been used to develop case study accounts for a series of reference sites. These are presented in Annexe 1 and comprise the following sites or regions: South Wales; the South Pennines; North York Moors; the Border Mires of Cumbria and Northumberland; Silver Flowe (Galloway); 'Bog Woodland' sites of the Scottish Highlands; Loch Shiel Mosses; the Flow Country of northern Scotland; and a selected range of Scottish sites examined by the Scottish Peat Survey.

Section 4 of this report gives consideration to important wetland terms and the categories and concepts that underlie them, partly to clarify their meaning as used in this report, but also because they are relevant to understanding some of the ecohydrological processes that occur in mires. A brief overview is given of existing hydromorphological wetland classifications, and the rationale behind the 'Wetland Framework' approach to wetland classification (see Figure 1).

Features and characteristics of ombrogenous peatlands

Section 5 discusses the characteristics and hydrodynamics of ombrogenous ('rain-fed') peatlands.

Two main types of ombrogenous mires have generally been recognised in Britain, *raised bog* and *blanket bog*, but it is often not clear what features have led to these designations, and it appears that their classification can often be a source of uncertainty to surveyors. Some authors have categorised ombrogenous mires by their location or climate. Others have emphasised the extensiveness of blanket bog terrain compared with raised bogs or have classified sites by virtue of their proximity to other blanket bog sites. Often the presumed status of ombrogenous surfaces as raised bog or blanket bog may reflect the extent to which their sub-surface topography has been investigated, rather than any fundamental differences in the character of their ombrogenous surfaces. To initiate a more robust and useful categorisation of ombrogenous mires and related peat deposits, their most important characteristics have been collated in this report, focussing upon upland mires but with some reference to lowland examples for comparative purposes.

Two main sets of developmental processes have frequently been identified in mires: *terrestrialisation* of open water, and *paludification* (wetting up) of dry ground, both of which can lead to the development of ombrogenous mire. There is a third starting point, which may also be considered to be a form of paludification, in which mire initiation occurs in poorly drained hollows or on flat ground that is wet but not flooded. Some researchers have considered that blanket bogs have developed by paludification whereas raised bogs developed via terrestrialisation, though others have considered that the only requirement for raised bog formation was an almost level surface with impeded drainage.

In terms of composition and characteristics of ombrogenous peat, perhaps the most widespread type is peat dominated by the macrofossil remains of *Sphagnum* mosses and cotton-grasses, with varying amounts of heather. This occurs widely across sites that are referred to as raised bog and blanket bog, though remains of deergrass in the peat can become more prominent further north and west. Layers of peat dominated solely by *Sphagnum* mosses also occur widely in ombrogenous bogs, sometimes reaching several metres in thickness, and whilst these are particularly a feature of some raised bogs, they are also present in sites regarded as blanket bog.

Many workers have accepted the conceptualisation of ombrogenous peatlands as *diplotelmic* ('two-peat') systems, with a thin, relatively permeable upper *acrotelm* layer overlying a much thicker and less permeable *catotelm* layer, with the main runoff of excess precipitation occurring laterally through the acrotelm. More recently other workers have suggested that this approach is too simplistic, and that there is a need to consider horizontal variations in hydraulic properties as well as depth variations (see Figure 2).

Where ombrogenous mires have developed on flat ground, peat accumulation tends to be greatest at the least well-drained location (*i.e.* the centre of the site), where peat depths can reach 10 m or more. Consequently a raised dome of peat may develop independently of the underlying topography, its surface typically flattest at the centre and steepening towards the margins. The height and shape of the peat dome are partly determined by its area, but also depend upon age, rate of peat decomposition, and the effects of artificial drainage and peat digging.

In cooler, wetter, and often more upland contexts, the dominant form of ombrogenous peatland is often described as blanket bog. Ombrogenous peat has been reported on relatively steep slopes, and extensive, quite shallow deposits (≤ 2 m depth) can occur across hillslopes, constituting the typical 'hill peat' of many upland districts. Although on more steeply sloping ground there may be little evidence for any peat mounding other than as a reflection of the underlying topography, true domes of ombrogenous peat do appear to be quite widespread in blanket bog contexts, though they are often rather small. They are usually associated with shallow basins or poorly drained flattish ground, and whilst some examples are clearly defined, in others peat-covered adjacent slopes may obscure the margins of the dome. In areas of very irregular terrain, several small peat mounds may occur in separate basins, linked by shallower peat across ridges, and in some cases the peat can be 'punctured' by hillocks of mineral ground. Despite this, where a domed surface is drained by radial water flow it is likely to retain the hydrological features and often the vegetation characteristics of a lowland raised bog. However, where an ombrogenous peat dome has developed upon a gentle slope, there is a greater potential for drainage to be distributed asymmetrically down the main direction of slope and for the dome of peat to be located eccentrically.

An ecohydrological distinction can be made between different elements of upland ombrogenous slopes. The topmost, flatter areas, in a watershed location, are likely to be irrigated almost exclusively by precipitation, whilst downslope areas will also receive down-slope flow. In some situations, this may be augmented by runoff from adjacent non-peat slopes, sometimes giving rise to areas of more fen-like vegetation. Water movement in sloping peatlands is dominated by overland flow and near-surface seepage through the peat, and their hydraulic characteristics may resemble the sloping edge (rand) of raised bogs. In addition, there is a strong tendency for flow to become concentrated into flow-tracks and small streams. Sub-surface pipes and gullies can occur widely, and the collapse of peat pipes has been identified as the beginning of gully erosion at some sites. Recent studies of sloping bogs have demonstrated that most surface runoff is generated in the upper 5 cm of peat, and that macropores (>1 mm diameter) are important runoff pathways, connecting the surface layer with deeper peat pipe networks (Figure 2) and allowing the flux of sediment and nutrients from deeper peat layers. Runoff flow through pipes appears to be more important for smaller rainfall events, whereas flow through the surface peat and over the surface are more significant during heavier rainfall.

A distinctive feature of some ombrogenous peatlands is the occurrence of surface patterning, the two main types being hummock–hollow and ridge–pool surfaces. The various components of surface patterning have been categorised in terms of their vertical zonation and distinctive vegetation types by Lindsay *et al.* (1988) (see Figure 9). The amplitude of the hummock–hollow or ridge–pool patterning is strongly related to climate, and different patterns are broadly associated with different parts of Britain. Larger ridge–pool surfaces, often with crescent-shaped pools aligned across the slopes, are generally found only on bogs in northern and western Scotland, whilst in England and Wales surface patterning, when present, is mostly represented by the more subdued hummock–hollow microtopography. Steeper ombrogenous slopes typically support a more uniform vegetation, usually lacking a conspicuous hummock–hollow surface relief, and are generally associated with thinner peat deposits.

Although pools are a common feature of many peatlands, relatively little is known about their hydrological functioning, though there is evidence that pools can be important sources of methane, dissolved organic carbon (DOC) and particulate organic carbon (POC). Connectivity between pools and the surrounding peat appears to be greatest within a few centimetres of the peat surface, indicating that heavy rainfall events are important for flushing out the carbon and other nutrients that have been processed within the pools. Where studied, pool complexes have often been found to be situated over some form of hollow in the underlying mineral ground, and pool complexes appear to have gradually spread outwards from their initial focus.

Section 6 describes other types of mires and habitat that are often associated with ombrogenous peatlands, particularly minerotrophic mires and areas of marked water flow within ombrogenous mires. The potential ecohydrological significance of lateral water flow is that it can increase nutrient availability and oxidation status of the peat, and it is often marked by different types of vegetation. Such 'flow tracks' are quite widespread in ombrogenous mires, but they appear to be a more prominent feature in wetter parts of Britain. Minerotrophic mires often form a distinctive component of upland areas but are sometimes subsumed within dominant ombrogenous habitats and can thus be overlooked. Minerotrophic mires may be largely peripheral to ombrogenous mires, embedded within them, or they may occur as complex mixtures of ombrotrophic and minerotrophic surfaces.

Vegetation and habitat conditions of ombrogenous peatlands

Section 7 discusses the types of vegetation and habitat features often associated with blanket bog landscapes.

Blanket bog landscapes support mainly ombrotrophic and weakly minerotrophic vegetation types (Table 9). Many of these plant communities support a similar suite of species and can sometimes be difficult to separate floristically, especially when the vegetation is impoverished. Vegetation classifications such as the National Vegetation Classification (NVC), which are based on floristic composition rather than species dominance, are important because they are better able than some broader 'habitat'-based systems to differentiate between plant communities that appear structurally similar (because they are dominated by one or a few species) but that support a suite of different associated species (Figure 5). Since the NVC scheme was published, some additional communities have been proposed – modifications relevant to upland peatlands include bog-bean bog pools, *Molinia*-dominated vegetation, and common sedge–lesser spearwort mires.

The NVC plant community M18 is characteristic of wetter surfaces, and on steeper slopes can be replaced by communities such as M15b, M19 and, sometimes M17, although it can be difficult to distinguish between M17 and M18. In general, M18 can be separated from M21 by the presence of bog rosemary and hare's-tail cottongrass. M20 is a very species-poor community dominated by hare's-tail cottongrass that appears to be a degraded form of M19 (Figure 6).

Some plant species are associated with habitat conditions such as wetness, which can make them useful proxy indicators of environmental conditions. Where bog surfaces show patterning with pools, ridges, hollows and hummocks, this niche separation can lead to the formation of vegetation mosaics at various scales, and this structural diversity provides a range of habitat niches for other species in bog ecosystems, particularly invertebrates and birds. A detailed sampling protocol has been used by some workers to characterise variation of vegetation based upon the microtopographical characteristics of blanket mires, but this is best seen as an adjunct to a standard NVC sampling of mire surfaces, not as an alternative.

Blanket bogs supporting 'active' bog vegetation are recognised by the EC Habitats Directive as habitats of international importance, although the term 'active' is poorly defined and ambiguous. The EUNIS classification of European habitats includes a confusing mixture of units based on various criteria, and the lack of detail and poor characterisation of many of the units, and the top-down nature of the classification, limits the value of this scheme in the description of British mires, particularly in the development of any understanding of their ecohydrological processes and the tolerances of distinctive vegetation. Other broad schemes such as the UK Priority Habitats, or the recent UKHab system, can be similarly unhelpful. Despite its limitations, the National Vegetation Classification provides a better general tool.

Environmental data, particularly those that can be linked to vegetation types, are generally sparse for upland peatland habitats. As far as is known, there is no dataset for habitat conditions in upland mires, particularly ombrogenous examples, comparable to that which was available from lowland England and Wales for the former Wetland Framework project. In addition, although there are several published studies on various hydrological aspects of upland mires, the information they provide is often highly processed, and it is not possible to extract from them underlying baseline data. To extend the Wetland Framework approach to upland ombrogenous mires there is a need to obtain linked vegetation and unprocessed hydrological datasets.

Restoration potential of damaged blanket bogs

Section 8 briefly summarises the potential for, and value of, restoration of damaged blanket bogs. A large proportion of the blanket bog resource in Britain has been damaged in one way or another by activities such as drainage, burning, atmospheric pollution, over-grazing and afforestation, and as a consequence the cover of bog vegetation has in many places become degraded. Bogs are an important carbon sink and the prevention of carbon loss from peatlands is a major governmental priority, as is the reduction of runoff and peak flow rates, which are believed to have an impact upon downstream flood risk. Degradation of bog sites can have a profound effect, generally causing a decrease in botanical diversity, a reduction in the extent of *Sphagnum* bog-mosses (where they were formerly present), and an increase in cover of dwarf shrubs, cotton-grasses, and purple moor-grass. Removal of degradation pressures can increase the cover of species considered to be indicative of good quality bog habitat (e.g. *Sphagnum*), and a high cover of *Sphagnum* species has been correlated with a significant reduction in overland flow. Restoration of vegetation cover on bare peat has been shown to result in reductions of particulate organic carbon flux and runoff rates, probably because of increased surface roughness. Ditch blocking has been seen to increase water tables and cover of 'wet bog' indicator species such as *Sphagnum* bog-mosses. In recent years there have been attempts to transplant *Sphagnum* into damaged bogs, although establishment has not always been successful. In some cases this may be because inappropriate locations have been selected, including areas that have not naturally supported a significant *Sphagnum* cover. An important omission from many restoration initiatives has been a failure to collect before-and-after vegetation data, especially in a way that can be related to NVC plant communities.

Classification of ombrogenous peatlands

Section 9 provides an assessment and critique of the current understanding of different types of ombrogenous peatlands in Britain, with particular regard to types of 'blanket bog'. The term 'blanket bog' is an informal and variable unit that represents a broad range of upland ombrogenous peatlands. Variations in character include peat depth and peat type, surface topography and patterning, and position in the landscape. JNCC (1994) recognised several sub-types of blanket bog based primarily on the topographical location of the mires in the landscape, but these are generally ill-defined and poorly described units that appear to represent the more 'interesting' structurally and botanically diverse versions of blanket bog that are typically associated with deeper peat and distinctive surface features and patterning. The JNCC typology appears to exclude the thinner forms of blanket bog whose surfaces follow the underlying topography of mineral ground, even though these are very widespread and extensive. These 'less interesting' botanically and structurally uniform ('bog standard') surfaces can themselves be divided into a small number of sub-types, but these are not obviously part of the JNCC typology. Because the JNCC sub-types depend upon landscape location, similar examples of blanket bog may be classed as different blanket bog sub-types, thereby creating overlapping entities. There appears to be little consistent distinction between the JNCC categories of 'valleyside mire' and 'spur mire', whilst the category of 'watershed mire' has affinities with both 'valleyside mire', and with lowland raised mire. However, its field characteristics seem to have been very poorly investigated and characterised.

The two main ombrogenous peatland units that have been recognised in Britain – *raised bog* and *blanket bog* – may often be assumed to have similar status and parity both in concept and compass, but this is not the case. In general, 'raised bogs' show relatively little variation, and their gross-form and characteristics are largely predictable. By contrast, sites and surfaces that are generally called 'blanket bog' are much more variable in form and character and, overall, consist of a melange of units, some of which have greater affinities with 'raised bogs' than with some other versions of 'blanket bog'.

It would be desirable, both for ecohydrologists and conservation managers, to develop a more coherent and comprehensive characterisation of blanket bog surfaces, to identify their salient characteristics, and thereby help distinguish more rigorously and clearly the different types of blanket bog, and to clarify their relationships with more lowland examples of ombrogenous peatlands elsewhere in Britain. This would require examination of additional unpublished sources that have been unavailable to this project as well as acquisition of additional carefully targeted field data. Conservation managers would benefit from the development of an objective typology of ombrogenous upland peatland based on ecohydrological data, since different units are likely to vary in their hydrodynamics and vulnerabilities, and may require different conservation targets. SSSI Selection criteria and Common Standards Monitoring thresholds would probably need to be revised as part of this process.

Recommendations

Section 10 provides some recommendations for future work. It should be noted that many of the sources of information used in this scoping study were published journal articles and unpublished reports in which the original data have been interpreted by the research authors. For the purposes of this project it is important to be able to view, and potentially re-analyse, the raw data; whilst it is possible that the field data upon which these articles are based are in existence somewhere, it is not possible for us to verify this without direct communication with the research scientists.

Similarly, it seems likely that there are other potentially useful datasets in existence for a range of blanket bog studies that we were unable to locate or access as part of this scoping study. In some cases this is because the data-holders require funds to collate the datasets that they have gathered (e.g. Moors For the Future Partnership, Yorkshire Peat Partnership); for others there may be issues with releasing data prior to publication of research (e.g. peat depth and stratigraphic data for

Munsary, northern Scotland); for yet others the lack of response to a request for information makes it difficult to ascertain whether relevant data exist (e.g. Scottish Power Renewables, United Utilities).

It has become clear during the course of this work that in general there is a dearth of ecohydrological data available for blanket mires, including basic topographical and peat depth data, especially at a 'whole site' or 'hill slope' level. There is variable *NVC* coverage and there are a few detailed vegetation datasets for blanket bogs. The majority of studies of blanket bogs are hydrological or relate to restoration, and the vegetation of the studied areas is often not sampled, or if it is, it is often not sampled in a way that allows cross-referencing to NVC plant communities.

In order to progress this project so as to extend the Wetland Framework approach to blanket bogs and associated mire types and to develop ecohydrological guidelines for these areas, it is necessary to acquire more linked environmental and vegetation datasets for blanket bog sites. This will require continued communication with the data-holders identified during this scoping study, development of data-sharing relationships, with payment where necessary for data extraction and collation, and carefully targeted collection of new environmental and vegetation data from carefully targeted bog sites. Once such data are available, they can be analysed using multivariate classification and cluster analysis procedures, as used in the original Wetland Framework approach. In addition, it would be useful to undertake systematic hydrological modelling of selected bog sites using the DigiBog programme developed at the University of Leeds.

Consequently, it is suggested that the project should continue beyond this scoping stage, and that the extended project should have a longer timescale to allow for the anticipated slow progress in accessing datasets, and considerable budget provision for obtaining datasets, visiting agency offices, carrying out targeted fieldwork, processing data, and detailed report writing. It is anticipated that the final output, a Wetland Framework-style set of ecohydrological guidelines, would be an important tool for upland and wetland land managers.

SEPARATE AND ELECTRONIC DOCUMENTS

	Filename
Report summary	**SWE EcoHydro Report Summary Aug_2020.pdf**
Report main text	**SWE EcoHydro Report Main text Aug_2020.pdf**
Annexe 1: Reference Sites **Annexe 2: Classification of 'Upland' Peat Soils.**	**SWE EcoHydro Report Annexe 1+2_Aug 2020.pdf**
Annexe 3: Literature sources. Spreadsheet catalogue of literature sources	**SWE Ecohydro literature 09-03-2020.xlsx**
Annexe 4: Datasets. Spreadsheet catalogue of datasets	**SWE Ecohydro datasets 09-03-2020.xlsx**
Annexe 5: Scottish lowland peatland *NVC* types. Spreadsheet of Scottish peatland *NVC* plant communities, collected as part of a comparative survey of a wide range of habitat conditions related to specific plant community-types in lowland minerotrophic mires in Britain, by Wheeler and Shaw (unpublished)	**SWE Ecohydro ScotHabQ 09-03-2020.xls**

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Frequently-used terms

The following terms are used frequently in this report. A more detailed glossary is provided in Section 12.

Mire	Unconverted permanent telmatic* wetlands. Includes wet sites on both peat and mineral soils but excludes former wetlands that have been badly damaged or converted into another habitat.
Peatland	All areas with peat, including sites with natural or semi-natural vegetation and areas converted to agriculture or forestry or used for peat extraction.
Bog**	Acidic (pH < *c.* 5.5) mires (mainly on peat, but some mineral soils).
Fen**	Base-rich (pH > *c.* 5.5) mires (peat and normally wet mineral soils).
Topogenous	Wetness resulting from topography and poor drainage (such as hollows).
Soligenous	Wetness resulting from moving water supply (such as seepage slopes).
Ombrogenous	developed under the exclusive influence of precipitation
Ombrotrophic	Surface irrigated directly and exclusively by precipitation.
Minerotrophic	Surface irrigated both by precipitation and telluric water
Eutrophic	High fertility conditions, rich in nutrients.
Mesotrophic	Moderately fertile conditions.
Oligotrophic	Low fertility conditions, nutrient poor.
Meteoric water	Precipitation.
Telluric water	Water that has had some contact with the mineral ground
Water table	Below-ground free water surface
Water surface	Surface of standing water
Water level	Used generically to include water table and water surface
Stand	A relatively uniform patch of vegetation of distinctive species composition and appearance. Can vary in size from very small (in m^2) to very large (in ha).

* Wet, semi-terrestrial wetlands (not aquatic wetlands)

** These definitions of 'bog' and 'fen' differs from common usage. Many workers follow Du Rietz (1949) in equating 'bog' with ombrotrophic peatlands and 'fen' with minerotrophic sites. However, Du Rietz's distinction, based mainly on water source, does not relate well to hydrochemical or vegetational differences between the habitats. The definition suggested here is used in the Wetland Framework (Wheeler *et al.*, 2009) and follows the proposals of Damman (1995) and Wheeler and Proctor (2000), and comes very close to the original meaning of the terms as used by Tansley (1939).

The Framework of Wetland Habitats

Wetland Landscape Type	Hillslope	Valley-head	VH trough / basin	Basin	Lake-side	Trough	Flood-plain	Coastal Plain	Plateau-Plain

Base Richness	Highly acidic (<4.0)	Acidic (4.0 – 5.5)	Sub-neutral (5.5 – 6.5)	Base-rich (>6.5)

Fertility	Oligotrophic	Mesotrophic	Eutrophic	Hypertrophic

WETMEC	1	2	3	4	5	6	7	8	9	10
	11	12	13	14	15	16	17	18	19	20

Management	Un-managed	Winter Grazed	Winter Mown	Summer Grazed	Summer Mown	Burnt

List of WETMECs

1: Domed Ombrogenous Surfaces ('Raised Bogs')
2: Buoyant Ombrogenous Surfaces (quag bogs)
3: Buoyant Weakly Minerotrophic Surfaces ('Transition Bogs')
4: Drained Ombrotrophic Surfaces in Bogs and Fens
5: Summer 'Dry' Floodplains
6: Surface Water Percolation Floodplains
7: Groundwater Floodplains
8: Groundwater-fed Bottoms with Aquitard
9: Groundwater-fed Bottoms
10: Permanent Seepage Slopes

11: Intermittent & Part-Drained Seepages
12: Fluctuating Seepage Basins
13: Seepage Percolation Basins
14: Seepage Percolation Troughs
15: Seepage Flow Tracks
16: Groundwater-flushed Bottoms
17: Groundwater-flushed Slopes
18: Percolation Troughs
19: Flow Tracks
20: Percolation Basins

Figure 1. The layers of the Wetland Framework, originally developed for wetlands (fens and bogs) in lowland England and Wales (Wheeler *et al*., 2009).

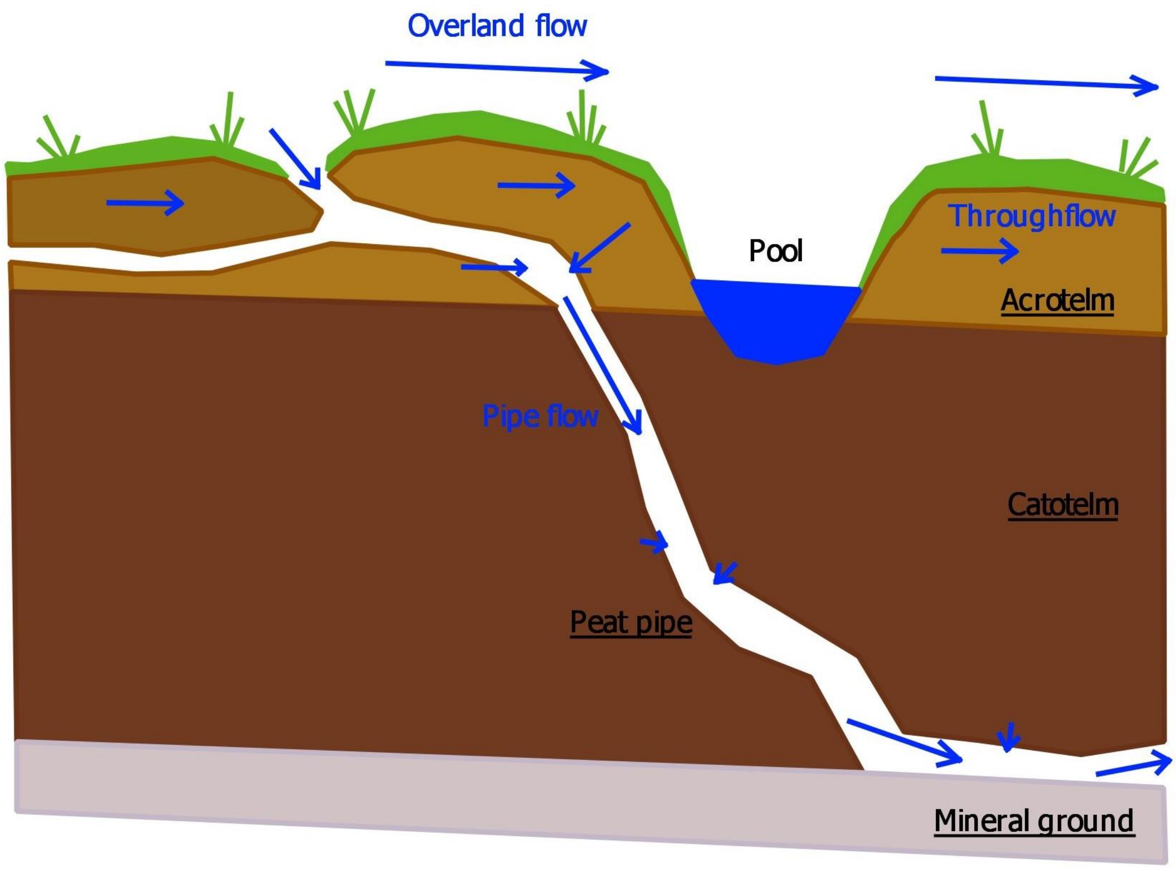

Figure 2. Conceptual diagram of possible water flow routes through peatland acrotelm, catotelm and peat pipes, at varying water table levels.

(Based on Holden & Burt, 2002).

Figure 5. Bog vegetation types

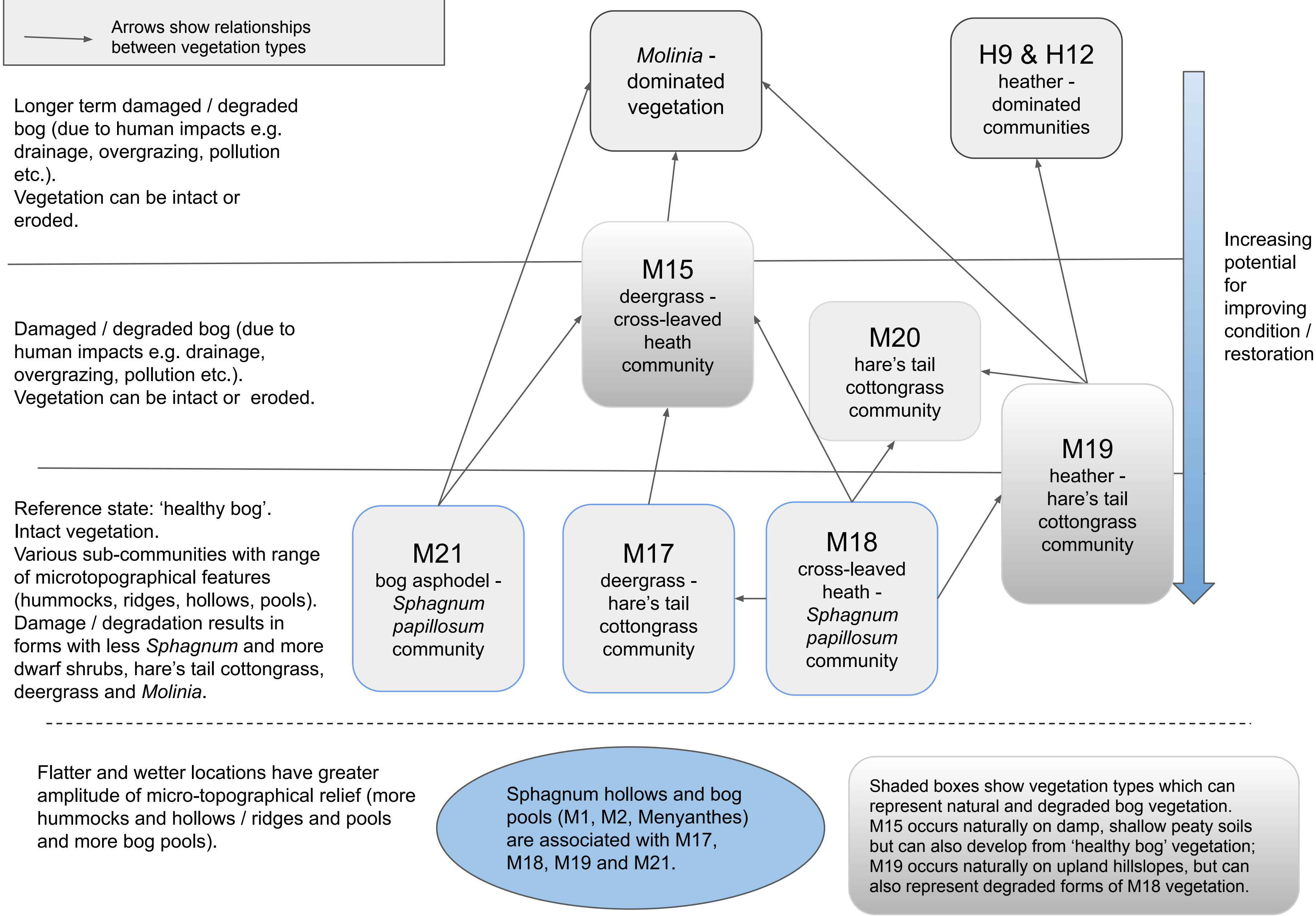

Fig. 6. Bog vegetation: sketch representations of *NVC* communities

[Based on descriptions in Rodwell (1991)].

Degraded variants of communities are shown on the left hand side; hummock-hollow complexes are shown on the right-hand side, but degraded vegetation can occur in all topographical situations, not just on slopes and at the bottom of slopes. Pools and wet hollows occur frequently in the wettest areas; when these features are large they are usually classified separately.

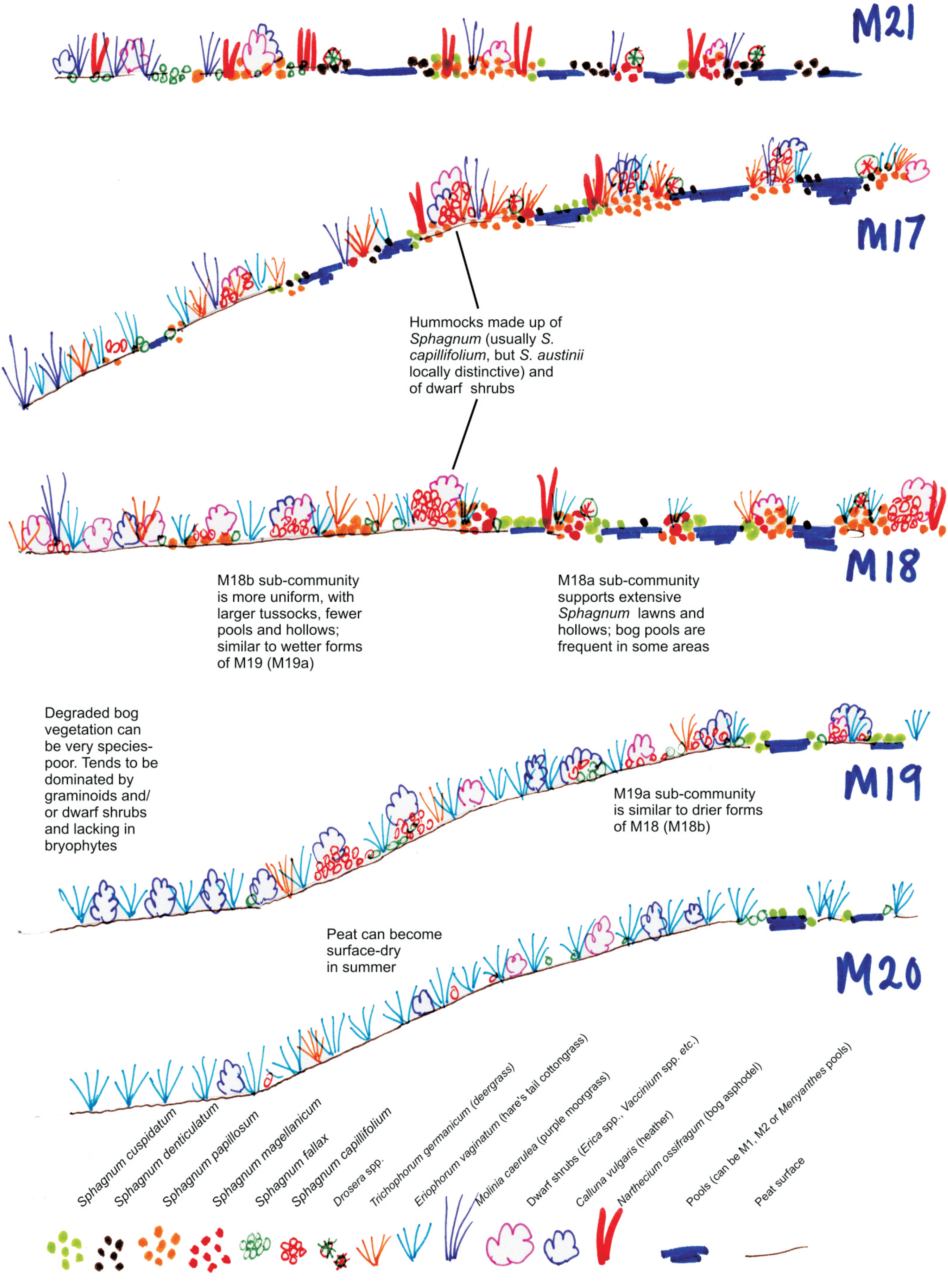

Table 9. NVC vegetation & blanket bog landscapes (based on Rodwell, 1991; Rodwell *et al.,* 2000; JNCC, 2011; see Annexe 1 case studies). Scientific names have been updated, see Table 8 for original community names.

NVC code	NVC revised name	Description	Situation / conditions	Key sites / case studies
Vegetation of stagnant, acid and dystrophic waters in the pools of Sphagnion bogs on deep peats				
M1	M1 *Sphagnum denticulatum* community	Mixtures of *Sphagnum denticulatum* and *S. cuspidatum* in pools with sparse *Menyanthes trifoliata* (bog bean), *Utricularia* spp. (bladderworts) and *Potamogeton polygonifolius* (bog pondweed) in open areas of water. *Rhynchospora alba* (white beak sedge) frequently forms a marginal fringe. With M17 and M21, in hummock–hollow / ridge–pool complexes.	Flat or very gentle slopes Very wet pools and wet hollows.	Highlands: Trichophoreto-Eriophoretum pool component
M2	M2 *Sphagnum cuspidatum / fallax* community	*Sphagnum cuspidatum* and/or *S. fallax* forming extensive carpets in hollows and pools. With M18, in hummock–hollow complexes.	Flat or very gentle slopes Very wet pools and wet hollows.	Border Mires: runnels & laggs; fen complexes.
M2a	*Rhynchospora alba* sub-community	*Rhynchospora alba* (white beak sedge) very frequent with *Andromeda polifolia* (bog rosemary) and *Drosera* spp. (sundews).	Flat or very gentle slopes Very wet	
M2b	*Sphagnum fallax* sub-community	*Sphagnum fallax* abundant with frequent *Vaccinium oxycoccos*.	Flat or very gentle slopes Very wet	
M3	M3 *Eriophorum angustifolium* community	Patchy *Eriophorum angustifolium* (common cottongrass). Bryophytes form sparse patches – mainly *Drepanocladus fluitans*, or tufts of *Sphagnum cuspidatum*.	Flat or very gentle slopes, erosion channels	With M19 and M20 in erosion complexes, particularly in the Pennines.
New swamp sub-community	*Menyanthes trifoliata* bog pool community	Peaty pools with sparsely vegetated open water. *Menyanthes trifoliata* (bog bean), *Potentilla palustris* (marsh cinquefoil) and *Utricularia* spp. (bladderwort) are present at low cover.	Peaty pools with water 30–100cm deep.	Only found in Scotland – particularly characteristic of the flow country.
M4	M4 Bottle sedge (*Carex rostrata)*–*Sphagnum fallax* community	Extensive patches of aquatic *Sphagnum* spp. with patchy and open cover of sedges most frequently *Carex rostrata* (bottle sedge), but *C. curta* (white sedge), *C. limosa* (bog sedge)*, C. lasiocarpa* (slender sedge) locally	Flat or very gentle slopes, pools and water flow tracks	Border Mires: fen complexes; laggs Moorhouse: Sphagneto-Juncetum effusi, Carex rostrata facies

NVC code	NVC revised name	Description	Situation / conditions	Key sites / case studies
Small-sedge poor-fen vegetation of acid, oligotrophic flushes and soligenous mires on peats or peaty mineral soils				
M6	M6 Star sedge (*Carex echinata)–Sphagnum fallax / denticulatum* mire	Sparse cover of mixed sedges and rushes over a wet layer of *Sphagnum fallax* and *S. denticulatum* with sometimes prominent *Polytrichum commune*.	Base-poor groundwater outflow; water flow tracks. Slopes mean 5° (0–28°); acidic, pH 3.3–6.0)	Border Mires: laggs
M6a	*Carex echinata* sub-community	Very variable flush vegetation. *Carex echinata* (star sedge) generally the most abundant sedge.		Highlands: Sphagneto-Cariecetum subalpinum Wales: Sphagnum–Carex nigra mire
M6b	Common sedge *(Carex nigra)*–mat grass *(Nardus stricta)* sub-community	Rather more grassy vegetation with frequent *Nardus stricta* (mat grass) and *Juncus squarrosus* (heath rush) and with more *Carex panicea* (carnation sedge) and *C. nigra* (common sedge) in the sward.		Highlands: Sphagneto-Cariecetum subalpinum
M6c/d	Sharp flowered rush / soft rush *(Juncus acutiflorus /effusus)* sub-communities	Rather species-poor vegetation dominated by rushes and often forming patchworks with rush pasture (M23 *Juncus acutiflorus/effusus–Galium palustre* community).		Berwyn: *Juncus actiflorus/J effusus* flush bog Highlands & Moorhouse: Sphagneto-Juncetum effusi
New community [M6/M10]	Common sedge (*Carex nigra)*–lesser spearwort *(Ranunculus flammula)* community	New community which includes vegetation transitional to more base-rich flushes. Sometimes referred to as neutral or sub-neutral flush.		Wales, other locations in moorland fringes
[OXYCOCCO-SPHAGNETEA Br.-Bl. et Tüxen ex Westhoff *et al*. 1946] Wet heath and bog vegetation of acid, oligotrophic peats, permanently or winter-waterlogged in raised, blanket or valley mires and their surrounds **Wet heath vegetation on drying deeper peats or winter-waterlogged peaty intergrades**				
M15	M15 *deer grass (Trichohorum germanicaum)–cross-leaved heath (Erica tetralix)* community	Very variable community. *Molinia caerulea* (purple moor grass), *Trichophorum germanicum* (deer grass), *Erica tetralix* (cross leaved heath) and *Calluna vulgaris* (heather) are frequent throughout but their proportions can be very variable as well as the range of associates. A wide range of bryophytes form a patchy layer.	Occurs at a range of altitudes in cool and wet northern and western areas mean slope 8º (0–42°); mean annual precipitation >1200mm; at least 180 wet days or on areas of impeded drainage. peat depth <2m Better drained than M17	

NVC code	NVC revised name	Description	Situation / conditions	Key sites / case studies
M15a	Carnation sedge *(Carex panicea)* sub-community	Flushed heath and water flow tracks within wet heath. Rather variable vegetation. Some samples may represent forms of M6/M10, M10a or M14 embedded within heath, classified here due to inclusion of surrounding wet heath vegetation in samples.	Areas of water flow / flushing embedded within wet heath vegetation. pH recorded here can be quite high (up to pH7.4), suggesting telluric influence.	Samples from Devon, Shropshire, Cumbria, North York Moors are associated with water flow tracks channelling more base-rich water and are referable to other communities (with affinities to M6, M10 and M14).
M15b	Typical sub-community	This type is transitional to M17 and M18 *Sphagnum capillifolium* can be patchy within this community.	Deeper peats Moderately high water table	
M15c	Bilberry *(Vaccinium myrtillus)* sub-community	Dominated by mixtures of *Calluna vulgaris* (heather) and *Molinia caerulea* (purple moor grass) with small tussocks of *Nardus stricta* (mat grass), *Deschampsia flexuosa* (wavy hair grass) and other grasses. Pleurocarpous mosses become more frequent, and Sphagnum spp. less.		
Molinia dominated, species-poor vegetation	Basal community (Rodwell 2000).	Very species poor *Molinia* dominated vegetation.		Border Mires: rand, often mixtures of tussocky Molinia and Eriophorum vaginatum. Scotland: Molinia Myrica mire of McVean and Ratcliffe.
M16	M16 cross-leaved heath (*Erica tetralix)*–*Sphagnum compactum* community	Very variable vegetation mainly occurring in east and south, generally on thinner peaty soils (wet heath vegetation).		
M16d	Heath rush (*Juncus squarrosus*) – *Dicranum scoparium* sub-community	Mainly in the north and east of Britain. *Erica tetralix* (cross-leaved heath), and *Trichophorum germanicum* (deer grass) are prominent in this sub-community. *Sphagnum compactum* and *S. tenellum* can be frequent together with a range of pleurocarpous mosses.		North & East; North York Moors – forms bulk of vegetation with H9, grades into M19 on Winter Hill peat soils

NVC code	NVC revised name	Description	Situation / conditions	Key sites / case studies
Bog vegetation on deeper, wetter peats in raised, blanket and valley mires				
M17	M17 deergrass–hare's tail cottongrass *(Eriophorum vaginatum)* community	Vegetation is dominated by mixtures of *Trichophorum germanicum* (deergrass), *Molinia caerulea* (purple moor grass) and dwarf shrubs over a *Sphagnum*-rich ground layer. Can form a ridge / hummock component to *Rhynchosporion* hollows (M1 / M2). *Sphagnum papillosum* is a major dominant at water level. *E vaginatum* (hare's tail cottongrass) is not a dominant component of this community despite being in the NVC name.	Flat or gentle slopes (mean 4°, range 0–25°). Below 500m altitude (mean 300m). Mean annual precipitation >2000 mm; >160 wet days (180–200) Peat depth 2–4m High, stagnant water table Oligotrophic, pH 4	Border Mires: some 'flow' sites show similarities Wales: Erica tetralix–Sphagnum papillosum mire Devon & Cornwall: Dartmoor and Bodmin
M17a	Sundew (*Drosera rotundifolia*) – *Sphagnum* spp. sub-community	Extensive carpets of *Sphagnum* spp. particularly *S. papillosum*, with *Drosera* spp. (sundews). Areas with soligenous influence can include butterwort and black bog rush. The distinctive liverwort *Pleurozia purpurea* is strongly preferential. Ridge–pool and hummock–hollow patterns are frequently found in this type of vegetation.		Highlands: Trichophoreto-Eriophoretum typicum
M17b	*Cladonia* sub-community	*Calluna vulgaris* (heather) and *Trichophorum germanicum* (deergrass) tend to co-dominate. *Erica cinerea* (bell heather) can be prominent. *Sphagnum* layer is rather patchy and there is little development of hummock–hollow transitions. *Racomitrium lanuginosum* (woolly hair moss) is often prominent with frequent *Hypnum jutlandicum* (plait moss) and conspicuous lichens (*Cladonia* spp.)	Tops of hummocks – drier locations	Highlands: Trichophoreto-Eriophoretum typicum – Racomitrium-rich type

NVC code	NVC revised name	Description	Situation / conditions	Key sites / case studies
M17c	Heath rush *(Juncus squarrosus)*–*Rhytidiadelphus* sub-community	Transition to M19 – *Calluna vulgaris* (heather) and *Trichophorum* (deergrass) are dominant accompanied by a range of other dwarf shrubs *Vaccinium myrtillus* (bilberry), *V. vitis-idea* (cowberry) and *Empetrum nigrum* (crowberry). *Eriophorum vaginatum* (hare's tail cottongrass), *Juncus squarrosus* (heath rush) are also more abundant and grasses can be prominent, particularly *Nardus stricta* (mat grass) and *Deschampsia flexuosa* (wavy hair grass). Pleurocarpous mosses are conspicuous in the ground layer. *Sphagnum papillosum*, *S. capillifolium* and *S. subnitens* are patchy.	Higher altitude than other sub-communities; drier	Further east in Scotland: Juncus squarrosus bog
M18	Cross-leaved heath (*Erica tetralix)*–*Sphagnum papillosum* community	*Sphagnum* spp. are dominant with vascular plants forming a less prominent component of the vegetation (*Calluna vulgaris (heather), Erica tetralix (cross-leaved heath), Eriophorum angustifolium (common cottongrass)* and *E. vaginatum* (hare's tail cottongrass) are most common). Pronounced hummock–hollow complexes can occur in this type of vegetation. More extensive pool features can be assigned to bog pool communities.	Generally flat or slightly domed 0–2° Deep peat up to 10m or more Altitude, generally below 550m Mean annual precipitation 800–1200mm; 140–180 wet days Waterlogged, high, stagnant water table, pH 4	Border Mires, Scotland and Wales: central and rand parts of domed bogs Present in Pennines blanket mire landscapes as localised features (e.g. Ringinglow Bog in Peak District and Shackleborough Moss on Cotherstone Moor.)
M18a	*Sphagnum magellanicum*–bog rosemary *(Andromeda polifolia)* sub-community	Most distinct sub-community. Extensive areas of *Sphagnum papillosum* and *Sphagnum magellanicum*. *Andromeda polifolia* (bog rosemary) and *Vaccinium oxycoccos* (cranberry) are distinctive where they occur.	Domed ombrogenous surfaces – wettest areas; vegetation rafts Wetter conditions	Border Mires: several types in central parts of domed bogs Silver Flowe: Flat communities
M18b	Crowberry (*Empetrum nigrum*)–*Cladonia* spp. sub-community	*Sphagnum capillifolium* dominant with *S. papillosum* still frequent but not forming extensive areas. Vascular species have higher cover. Lichens (*Cladonia* spp.) can be abundant. May be analogous to M19b.	Domed ombrogenous surfaces drier areas – hummocks, towards rand Drier conditions (edges and erosion features)	Silver Flowe: medium & tall hummocks Moorhouse: Trichophoreto-Eriophoretum: Typical facies

NVC code	NVC revised name	Description	Situation / conditions	Key sites / case studies
M19	M19 heather (*Calluna vulgaris)*–cottongrass *(Eriophorum vaginatum)* community	Vegetation dominated by mixtures of *Calluna vulgaris* (heather) and *Eriophorum vaginatum* (hare's tail cottongrass). Only rarely shows the development of hummock hollow structure, but does often support a well-developed bryophyte flora. *Sphagnum* element not so rich or luxuriant as in M17 and M18, but the M19a sub-community is transitional in composition. Large areas have typically managed by rotational burning and sheep grazing. Erosion of the peat is common.	Found on flat or gently sloping (mean slope 4°, range 0–10°) ground at altitudes above 300m (mean altitude 550m): "high level plateaux and broad watersheds"; "occurs on broadly convex summits and slopes which shed water quite readily" Mean annual precipitation 1200–2000 mm; 160–200 wet days. Well humified peat, depth usually >2 m Can be surface-dry or oxidised in the summer. Surface often not water-logged. Oligotrophic pH<4	Border Mires: Extensive on hill slopes, and in degraded domed bogs Pennines (north and south) – extensive Berwyns – extensive
M19a	Cross-leaved heath (*Erica tetralix)* sub-community	Transitional to wetter bogs (e.g. M18). *Erica tetralix* (cross-leaved heath) can be abundant. May support 'lawn' species e.g. *Narthecium ossifragum* (bog asphodel), *Drosera rotundifolia* (round-leaved sundew). *Sphagnum* spp. are abundant in the ground layer – *Sphagnum capillifolium* and *S. papillosum* are most characteristic.	More western distribution; extends over flat or concave areas of relief where a high water table can be maintained. Mean altitude 400m. High water table	Berwyns: *Erica tetralix–Vaccinium oxycoccos* series, *Plagiothecium–Hylocomium* and *Racomitrium–Cladonia* noda. Moorhouse: Trichophoro-Eriophoretum
M19b	Crowberry (*Empetrum nigrum)* sub-community	*Rubus chamaemorus* (cloudberry) is characteristic in this sub-community together with *Empetrum nigrum* (crowberry) and *Vaccinium myrtillus* (bilberry).	Extensive in Pennines Mean altitude 600m	Moorhouse: Calluneto-Eriophoretum
M19c	Cowberry (*Vaccinium vitis-idea)–Hylocomium splendens* sub-community	Montane bog with many variants	Montane areas in Scottish highlands with outliers in Pennines, Cheviot and parts of Wales. Mean altitude 700m	Berwyns: *Juncus–Deschampsia* series Moorhouse & Scottish Highlands: Empetro-Eriophoretum

NVC code	NVC revised name	Description	Situation / conditions	Key sites / case studies
M20	M20 hare's tail cottongrass (*Eriophorum vaginatum)* community	Species-poor, impoverished vegetation dominated by tussocks of *Eriophorum vaginatum* (hare's tail cottongrass). Result of management treatment – grazing, burning, aerial pollution, draining.	Degraded forms of bog vegetation? Gentle slopes 0–10° 500–700m 1200–1600mm 160–200 wet days	Border Mires: recognised a dry and wet form in rand and lagg areas.
M20a	Species-poor sub-community	Very species poor.		South Pennines: widespread – derived from M19
M20b	Heather *(Calluna vulgaris)–Cladonia* spp. sub-community	Transitional to M19 with scattered dwarf shrubs		South Pennines: widespread – derived from M19
M21	M21 bog asphodel (*Narthecium ossifragum)–Sphagnum papillosum* community	Vegetation is dominated by areas of *Sphagnum* spp with scattered herbs and dwarf shrubs. Low amplitude relief (microtopography) compared to M17 and M18 – ridge–pool patterning is not a feature, but there are hummocks and hollows. Similar to M17 but *Eriophorum vaginatum* (hare's tail cottongrass) and *Trichophorum germanicum* (deergrass) are more scarce; *Andromeda polifolia* (bog rosemary) not generally present in this community.	Valley mires; peat depth 20–150cm Mostly <200m altitude, but can occur on higher ground in Dartmoor & Exmoor Mean precipitation <1200mm <160 wet days; Saturated surface pH3.5–4.5	Important sites in New Forest, Dorset, Cumbria. Probably under-recorded in blanket bog complexes in Scotland (Averis & Averis 2004).
M21a	White beak sedge *(Rhynchospora alba)–Sphagnum denticulatum* sub-community	Very mixed mosaic of *Sphagnum* patches with *Rhynchospora alba* (white beak sedge) frequent. Liverworts are abundant.		
M21b	Cranberry *(Vaccinium oxycoccos) – Sphagnum fallax* sub-community	*Sphagnum papillosum* is more patchy in occurrence, with *S. fallax* more prominent. *Rhynchospora alba* (white beak sedge) is scarce and *Vaccinium oxycoccos* (cranberry) is more abundant in this sub-community.		
Dry heath				
H9	*Heather (Calluna vulgaris)–Wavy hair grass (Deschampsia flexuosa)* community	Dominated by *Calluna vulgaris*; usually managed by rotational burning and sheep grazing.	Low to moderate altitudes; acid and impoverished free-draining soils, including drained deep peat which has been subjected to drainage and grazing.	Pennines

NVC code	NVC revised name	Description	Situation / conditions	Key sites / case studies
H12	*Heather (Calluna vulgaris)–bilberry (Vaccinium myrtillus)* heath	Similar to H9, but more varied shrub layer including frequent *Vaccinium myrtillus* (bilberry).	Sub-montane zone 200–600m altitude. Moist, acidic free-draining soils.	Pennines

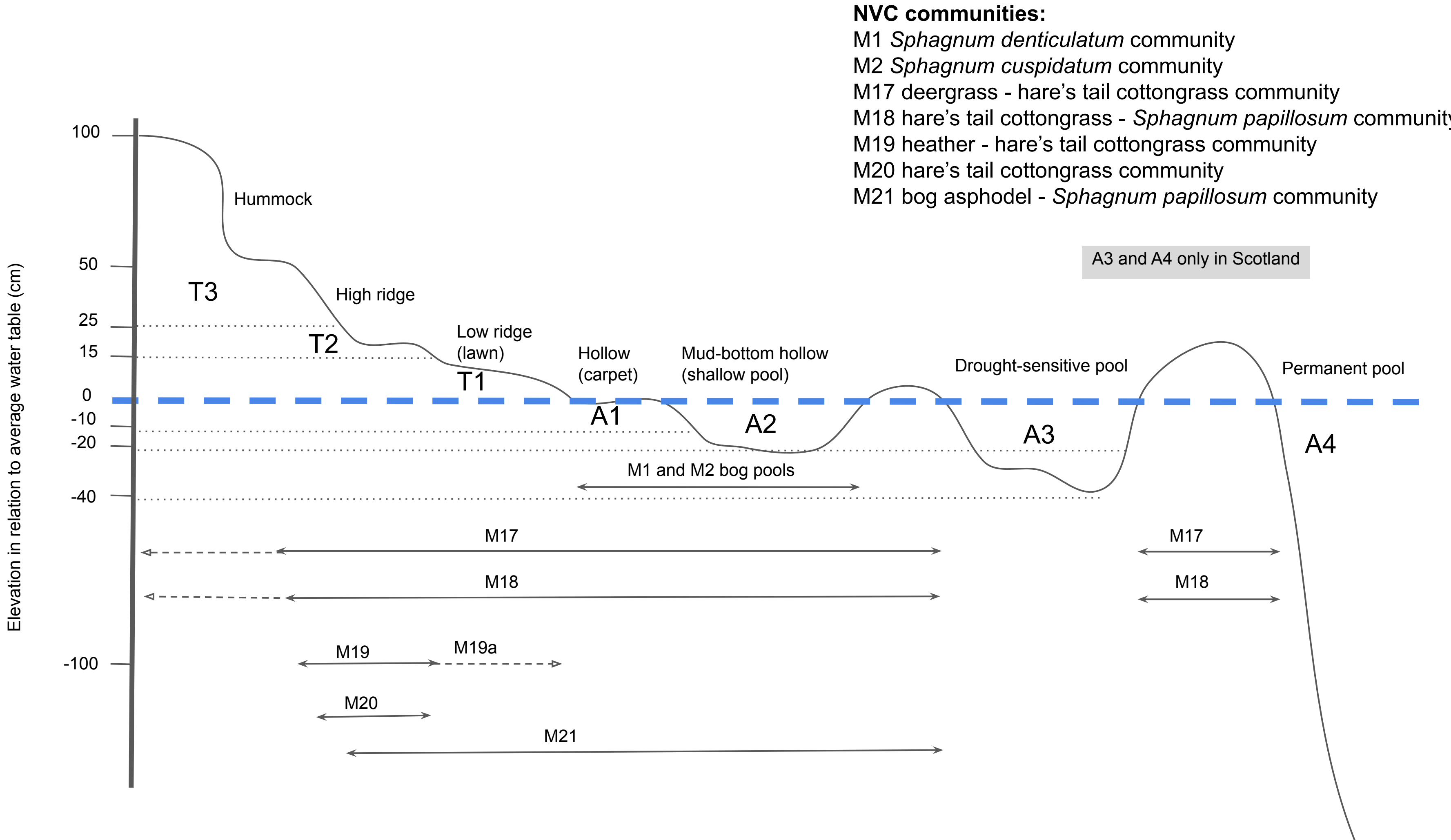

Figure 9. Bog habitat microforms and their relationship to NVC communities.
Microforms present on bog vegetation surfaces are shown as terrestrial (T) and aquatic (A) zones relative to the average water table (based on Lindsay 2010), and related to National Vegetation Classification (NVC) plant communities (based on descriptions in Rodwell 1991 and Averis *et al.* 2004). Solid lines show main zones present in different NVC communities; dashed lines show more extreme variants. The deeper pools (A3 and A4) are found only in Scotland, are often sparsely vegetated and were not represented in the published NVC accounts. A new NVC community (Menyanthes pool) has been suggested for the distinctive vegetation supported by these pools (Rodwell 2011).