

Calcareous, groundwater-fed fens in England: Distribution, Ecology and Conservation

Iain Diack¹, Phil Eades², Mark Parnell², Sue Shaw², Ros Tratt² & Bryan Wheeler³ ¹Natural England, ²Independent consultants, ³University of Sheffield



Introduction

Calcareous, groundwater-fed fens are some of the most botanically diverse habitats in England, supporting several rare and threatened species, often within a very small area (individual stands range from a few square metres up to a few hectares). These habitats are also important for other wildlife, particularly invertebrates (JNCC, 2007).

These wetlands typically occur in valleyhead and hillslope situations and are mainly irrigated by groundwater discharge from springs and seepages, with the water table close to the surface all year. The underlying bedrock is usually the source of the irrigating water, although some sites are irrigated by groundwater derived from calcareous superficial deposits.

Distinctive types of vegetation associated with calcareous groundwater outflow in England are represented by several National Vegetation Classification (NVC) plant communities (Rodwell, 1991).

The relationship between vegetation and environmental variables, including water supply, from sites throughout England and Wales has been investigated in the Wetland Framework (Wheeler,

Natural England National Habitat Inventories

• In 2012 Natural England commissioned a project to create a GIS Inventory capturing the location and extent of vegetation qualifying as Annex 1 habitat 'Alkaline Fen' in England.

- This was a desk-based project collating information from a wide variety of sources. • Approximately 3000 records (points and polygons) were captured from existing datasets. For many sites the most recent available survey data were pre-1990.
- Records will be added and updated as new survey datasets become available.
- The GIS Inventory will allow NE to plan survey, monitoring and management of these habitats. **Figure 1** shows the known general distribution of the NVC plant communities M10 and M13 in relation to bedrock grouped into hydrogeological types.



Left: 'Alkaline Fen' in Shropshire (L) & in the French Alps (R)

> **Right:** tufa formation in North York Moors (L



Shaw & Tanner 2009).

Key features of the main plant communities of calcareous, base-rich fens are summarised below. Several of these plant communities are recognised as habitats of International importance and are classified as EU Habitats Directive Annex 1 habitats.



Left to right:

'Brown mosses' including Scorpidium cossonii Gymnadenia conopsea with Drosera longifolia Dactylorhiza incarnata Liparis loselii Dactylorhiza traunsteinerioides Nomenclature follows Stace, 2010 and Smith, 2004.

Vegetation types and habitat characteristics

Based on Rodwell 1991; Wheeler, Shaw & Tanner 2009; Wheeler 1988

Main NVC plant communities

M10 Carex dioica - Pinguicula vulgaris mire*

Widespread in the uplands, particularly in North-Western England, where it often occurs in mosaics with unimproved grassland and heathland; a few isolated patches in lowland England. Low-growing vegetation with an open sward, typically dominated by small sedges, with *Schoenus nigricans* at some sites. Extensive bryophyte component and wide range of associated herbs including many with a particularly northern distribution eg. Carex dioica and Primula farinosa. Overlaps with M13, but generally more species-poor, often more open and lower growing. Tends to occur in locations of slightly lower fertility and base-status than M13. Some more acidic versions occur. Some examples occur within acidic peaty habitats, and soakways. M10 can be transitional to several different vegetation types.

Shaw & Wheeler (1991) found an increase in base-richness was associated with an increase in the number of rare species recorded, but there were fewer rare species in the most fertile stands.

	Left: Carex dioica	Plant diversity (121 stands)	Total species	Mean (range) species 4r
		All species	264	32 (10 – 55)
	Below: Primula farinosa	Principal mire species	136	23.5 (10 –37)
		Rare mire species	32	2.1 (0 – 8)

Figure 1. Distribution of stands of M10 and M13 in England in relation to bedrock

North Pennines (including Yorkshire Dales, Upper Teesdale): M10 and M11 widespread. Mainly Carboniferous Limestone, some associated with derivative Superficial Deposits.

Lake District: base-rich mires are likely to be associated with a variety of rocks, including volcanics. In almost all strata, outflow is most likely to be



Conservation issues

- Size often small, many stands are only a few square metres in extent
- Sites in the lowlands are often isolated, and vulnerable to changes in management
- Management mowing and grazing is important in maintaining low growing vegetation
- Groundwater abstraction can cause dehydration and loss of characteristic and rare species, particularly bryophytes
- Nutrient enrichment from surface water, groundwater and atmospheric pollution; lowland sites are particularly vulnerable because surrounding land use is generally more intensive; increase in fertility is usually associated with decrease in species-richness and loss of rare species (Shaw & Wheeler, 1991; Fen Management Handbook, 2010).

Vale of York and Vale of Mowbray: scattered M13 associated with Permian limestones and Glaciofluvial / Terrace deposits rich in **Carboniferous** Limestone clasts.

North York Moors: M10 widespread; M13 concentrated in Dalby Forest. Mainly Corallian strata, esp. Hambleton Oolites. Some Middle Jurassic (e.g. Cornbrash and Scarborough Formation limestones).

Derbyshire / Nottinghamshire: Whitwell Wood and Sookholme Moor. Lower Permian Limestone (Cadeby Formation).



Water Supply

•Occurs on soligenous slopes, fed by groundwater from semiconfined or un-confined bedrock or drift aquifers, either directly – as seepages; or by downslope flow of groundwater over an (often superficial) aquitard – as flushes. Some examples have marl or tufa precipitation. •Mean pH 6.7 ; range 4.9 – 7.7



with Dactylorhiza

traunsteinerioides

M13 Schoenus nigricans - Juncus subnodulosus mire*

Generally occurs in lowland England, mainly in East Anglia, with hotspots in Oxfordshire and North Yorkshire. Similar to M10, but usually structurally more complex. Schoenus nigricans and Juncus subnodulosus usually dominate, with a rich range of associated species. The *Schoenus - Juncus* sward is generally of moderate height, but in most sites there are low-growing surfaces amongst the dominants and there can be small runnels or pools. These lower-growing patches are typically the most botanically diverse areas and include an extensive bryophyte component. M13 supports several rare species.

Epipactis

palustris

Plant diversity (117 stands)	Total species	Mean (range) species 4m
All species	367	30.9 (7 – 65)
Principal mire species	154	22.2 (3 – 53)
Rare mire species	39	2.3 (0 – 13)

Water Supply

•Strongly soligenous, often with visible springs. Typically fed by lateral or vertical groundwater discharge from a semi-confined or unconfined aquifer. Calcite precipitation often visible.

• Irrigating waters are typically base-rich/high pH (mean pH 7.0; range 5.7 – 8.3).

Related NVC plant communities

M11 Carex demissa - Saxifraga aizoides mire*

Upland vegetation closely related to M10. Usually found in open, stony runnels beneath spring lines on mountain sides. Often occurs in association with M10.

M9/M22* Carex rostrata - Calliergon cuspidatum mire transitional to M22 Juncus subnodulosus - Cirsium *palustre* fen meadow.

Distinctive vegetation often with Carex diandra, C. lepidocarpa and C. rostrata as well as Juncus subnodulosus over extensive 'brown' moss lawns.

associated with fractures, faults and bed boundaries.

> Cheshire: Hatherton Flush. Mercia Mudstone Group, Wilkersley Halite Member.

Shropshire: Caer Caradoc and Long Mynd. Outflows mainly from fractures, faults and bed-boundaries in Uriconian volcanics and **Pre-Cambrian strata**

Herefordshire: small base-rich mires are associated with calcareous sandstones and calcretes of "Lower Old Red Sandstone" (Raglan Mudstone Formation), including the **Bishop's Frome Limestone** Member.

Somerset:

Holme Moor & Clean Moor (and some former M13 sites). Wiveliscombe Sandstone. [Permo-Triassic sandstone,

East Anglian valleyhead fens: main concentration of M13 sites. Mainly Chalk, especially where there are strongly fractured layers or artesian conditions. Some calcareous sands and gravels.

> Northamptonshire: M13 sites near Wittering. Middle Jurassic strata, probably mainly Lincolnshire Limestone.

Oxfordshire: cluster of M13 sites in the Cothill basin. Corallian strata – especially the former 'Lower Calcareous Grit', now variously segregated. One site artesian from Portland Formation.

Occurs in more stagnant situations than M10 and M13.

Fen Meadow:

M10 and M13 often inter-grade with fen meadow communities, M22 and M2 M22 Juncus subnodulosus - Cirsium palustre fen meadow (pictured left) M22 often occurs in base-rich fens and it is a very variable plant community: be strikingly species-rich or species-poor. It is the most widespread community rich fens in England, and generally occurs in more fertile conditions than M10

M24 Molinia caerulea - Cirsium dissectum fen meadow** (pictured left) M13 and M24 often occur together as complex mosaics of tussocks and hollow frequently develops from M13 as a consequence of drying (resulting from dra natural seral processes), or it replaces M13 spatially along a water table gradie M22 and M24 are associated with areas of permanent and intermittent grour seepage.



M37 Cratoneuron commutatum - Festuca rubra spring & M38 Cratoneuron *commutatum - Carex nigra* spring *** (pictured left) Low-growing spring-head vegetation dominated by the golden brown moss C commutatum (now split into Palustriella commutata and P. falcata - inset pict variable range of associated species. In the most calcareous locations occurs M11 and M13; but can also occur on its own. Often, but not always, associate precipitation of tufa, sometimes forming impressive mounds.

EC Habitats Directive Annex 1 habitats:

*H7230 Alkaline Fen

** Most examples of M24 are classed as H6410 Molinia Meadows, but are regarded as H7 Alkaline Fen where M24 overlaps into M13

*** H7220 Petrifying Springs

locally calcareous].

M24.		0 50 100 km
y: stands can nity of base- 10 and M13. llows. M24 drainage, or adient. oundwater	New Forest: Patches of vegetation with affinities to M13, but also to M10 and M14, often within extensive base-poor valley mires. Base-rich mires are mostly associated with run-off from Headon Beds.	U SU FUO KIII Key NVC plant communities • M10 M13 Bedrock grouped by hydrogeological properties
n 5 <i>Cratoneuron</i> icture). Very rs with M10, ated with	References & Further information: Joint Nature Conservation Committee (2007). Second Report by the UK under Article 17 on the implementation of the Habitats Directive from January 2001 to December 2006. Peterborough: JNCC. Available from: www.jncc.gov.uk/article17 Rodwell, J. (ed.) (1991). <i>British Plant Communities, Volume 2. Mires & Heaths</i> . Cambridge University Press, Cambridge. Shaw , S.C. & Wheeler, B.D. (1991). A review of habitat conditions and management characteristics of herbaceous fen vegetation types in lowland Britain. Report to Nature Conservancy Council, Peterborough. Department of Animal and Plant Sciences, University of Sheffield. Smith, A.J.E. (2004). The Moss Flora of Britain. Cambridge University Press, Cambridge. Stace, C.A. (2010). New Flora of the British Isles. Cambridge University Press, Cambridge. The Fen Management Handbook. (2011). Editors: McBride, A., Diack, I., Droy, N., Hamill, B., Jones, P., Schutten, J., Skinner, A. & Street, M. Scottish Natural Heritage, Perth.	Aquifers with significant intergranular flow Highly productive aquifer Moderately productive aquifer Low productivity aquifer Flow is virtually all through fractures and other discontinuities Highly productive aquifer Moderately productive aquifer Low productivity aquifer Other mechanism Rocks with essentially no groundwater Reproduced with the permission of the British Geological Survey @NERC. All rights Reserved
47230	 Wheeler , B.D. (1988). Species-richness, species rarity and conservation evaluation of rich-fen vegetation in lowland England and Wales. Journal of Applied Ecology, 25, 331-353. Wheeler B.D., Shaw S. & Tanner K. (2009). A Wetland Framework for Impact Assessment at Statutory Sites in England and Wales. Environment Agency, Bristol. www.jncc.gov.uk (Annex 1 habitats, Annex 2 species; BAP habitats and BAP species; NVC) www.naturalengland.org.uk and www.natureonthemap.naturalengland.org.uk (Habitat inventories; protected sites) Acknowledgements: Photos - P.A. Eades, J. O'Reilly, S.C. Shaw, R. Tratt, B.D. Wheeler; Providers of data for the GIS Inventory (including National Trust, ENTEC (AMEC), Natural England local teams, B.D. Wheeler). 	en:mapping Sheffvets Signal Services Sheffield Wetland Ecologists The University Of Sheffield.