Definition of Favourable Conservation Status for alkaline fens

Defining Favourable Conservation Status Project

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Executive summary

This document sets out Natural England's view on favourable conservation status for alkaline fens in England.

Favourable conservation status is the minimum threshold at which we can be confident that the habitat, and its associated species, are thriving in England and are expected to continue to thrive sustainably in the future.

This definition has been produced following the Natural England approach to defining favourable conservation status described in the guidance document Defining Favourable Conservation Status in England.

Section 1 of this document describes the habitat covered by this definition and its ecosystem context.

Section 2 specifies the units used to describe the three favourable conservation status parameters. These are:

- Natural range and distribution (where the habitat occurs).
- Extent (how much habitat there is).
- The structure and function attributes (habitat quality).

Section 3 outlines the evidence considered when developing the definition. This definition is based on the best available evidence on the ecology of alkaline fens. The evidence covers the current situation, historical changes and possible future changes.

Section 4 sets out the conclusions on the favourable values, that is the value for each of the three parameters when the habitat has achieved favourable conservation status.

This document does not include any action planning, or describe actions, to achieve or maintain favourable conservation status. These will be presented separately, for example within strategy documents.

Summary definition of favourable conservation status

Alkaline fen is a species-rich wetland type, fed by a permanent supply of base-rich, oligotrophic groundwater from springs and seepages. Once widely dispersed across England, in both upland and lowland areas, much alkaline fen has been lost or degraded, particularly in the lowlands. It now typically occurs in small patches, supporting many rare and declining plant and animal species.

The following are required for favourable conservation status:

- Maintenance of the habitat across its current range of 573 tetrads (2 km x 2 km grid squares), and restoration of the habitat within 79 tetrads from which it has been lost, or where degraded examples persist, giving a total of 652 tetrads.
- Increase from the current area of 2,385 ha to 3,663 ha by doubling the area and the number of stands in the lowlands (to approximately 330 ha) and, where potential remains, in areas of historic occurrence and by increasing the area in the uplands by at least 50% (from 2,221 ha to 3,333 ha).
- To ensure that 95% of the favourable habitat extent, on existing and restored sites, meets the structure and function requirements through removal of pressures and restoration of natural hydrological regimes in and around alkaline fen sites.

Table 1 Confidence levels for the favourable values

Favourable conservation status parameter	Favourable value	Confidence in the proposed favourable value
Range and distribution	652 tetrads. An increase of 79 tetrads from the current range of 573 tetrads.	**Moderate**
Extent	An increase from the current area of 2,385 ha to a total favourable area of 3,663 ha.	**Low**
Structure and function	95% of the favourable area of the habitat should meet the favourable structure and function requirements. All species associated with alkaline fen should be of IUCN Least Concern status at the GB scale.	**Moderate**

As of March 2024, and based on a comparison of the favourable values with the current values, alkaline fen is not in favourable conservation status. Note, this conclusion is based solely on the information within this document and not on a formal assessment of status nor on focussed and/or comprehensive monitoring of status.

Contents

About the Defining Favourable Conservation Status project

Natural England's Defining Favourable Conservation Status (DFCS) project is defining the minimum threshold at which habitats and species in England can be considered to be thriving. Our Favourable Conservation Status (FCS) definitions are based on ecological evidence and the expertise of specialists.

Through setting our ambition and aspiration for species and habitats, our definitions will inform decision making and actions to achieve and sustain thriving wildlife.

Our FCS definitions will be embedded into delivery of the 25 Year Environment Plan, through the Nature Recovery Network, biodiversity net gain and environmental land management schemes (ELMS).

Conservation bodies will use them to inform their work, including management planning for the land they own. Businesses will have a clear understanding of how their work impacts nature recovery and how they can help contribute to achieving thriving nature.

By considering the evidence for FCS, decisions will be more confident and strategic, with an understanding of their contribution to, or impact on, the national ambition.

1. Habitat definition and ecosystem context

1.1 Habitat definition

Alkaline fens are here defined as waterlogged wetlands mostly or largely occupied by peat or tufa-producing small sedge and brown moss communities developed where oligotrophic, base-rich, often calcareous, water is stable at, or near the substratum surface. Peat formation, when it occurs, is infra-aquatic. Calciphile small sedges and other *Cyperaceae* usually dominate the mire communities, characterised by a usually prominent "brown moss" carpet formed by *Campylium stellatum*, *Scorpidium cossonii* (*Drepanocladus intermedius*), *Scorpidium* (*Drepanocladus*) *revolvens*, *Palustriella commutata* (*Cratoneuron commutatum*), *Calliergonella cuspidata* (*Acrocladium cuspidatum*), *Ctenidium molluscum*, *Fissidens adianthoides*, *Bryum pseudotriquetrum* and others.

Additional species include a grass-like growth of black bog-rush *Schoenus nigricans*, brown bog-rush *S. ferrugineus*, broad-leaved cottongrass *Eriophorum latifolium*, long-stalked yellow sedge *Carex lepidocarpa*, tawny sedge *C. hostiana*, carnation sedge *C. panicea*, blunt-flowered rush *Juncus subnodulosus*, deergrass *Trichophorum* (*Scirpus cespitosus*) and few-flowered spike-rush *Eleocharis quinqueflora.* A very rich herbaceous flora including early marsh orchid *Dactylorhiza incarnata*, narrow-leaved marsh orchid *D. traunsteinerioides*, fen orchid *Liparis loeselii*, marsh helleborine *Epipactis palustris*, common butterwort *Pinguicula vulgaris*, and bird's-eye primrose *Primula farinosa* may also be present.

This definition covers those National Vegetation Classification (NVC) plant communities that are considered to qualify as alkaline fen in England as listed in Table 2.

Table 2 NVC communities considered as being Annex 1 'alkaline fen' habitat, and of national or international conservation importance.

NVC community	Main Region	National	International	Comment
M9* *Carex rostrata–Calliergon cuspidatum* mire *Carex diandra* sub-community	S & E (see comment)	Yes	Yes	Only M9 *Juncetosum* (M9/M22) and M9 *Schoenetosum* (M9/M13) are included here. All other M9 is considered as H7140 transition mires and quaking bogs.
M10 *Carex dioica–*	N & W	Yes	Yes	Occasional stands occur in South & East

NVC community	Main Region	National	International	Comment
Pinguicula vulgaris mire				
M11 *Carex demissa–Saxifraga aizoides* mire	NW	Yes	Yes	Found in the uplands, strongly linked to the distribution of *Saxifraga aizoides.* Stands in high altitude locations with arctic/alpine species should be considered as H7240 alpine pioneer formations of the *Caricion bicoloris-atrofuscae*.
M13 *Schoenus nigricans–Juncus subnodulosus* mire	S & E	Yes	Yes	All M13, including stands with *Cladium mariscus,* are included. Some M13 with *Cladium* has been previously classified as H7210 Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*
M37 *Cratoneuron commutatum–Festuca rubra* spring. M38 *Cratoneuron commutatum–Carex nigra* spring	Mainly upland, but under-recorded in lowlands			Spring communities often associated with more extensive wetland vegetation. Standalone examples, not found with M9, M10, M11 or M13, are *not* included within alkaline fen. Tufa-forming examples represent Annex 1 habitat H7220 Petrifying springs with tufa formation (*Cratoneurion*))
M22 *Juncus subnodulosus - Cirsium palustre* rush pasture. M24 *Molinia caerulea - Cirsium dissectum* fen meadow				Standalone examples, not found with M9, M10, M11 or M13, are *not* included within alkaline fen. Some examples are very species-rich. Can sometimes (but not always) represent degraded and impoverished former M13 stands, as identified by earlier plant or alkaline fen records.

*See Wheeler (1980b), and Wheeler, Shaw & Tanner (2009) for explanation of M9 sub-divisions.

Transitional vegetation types (M13/M22, M13/M24 and M9/M22) are often found in base-rich mires, sometimes in locations irrigated by weak or intermittent base-rich seepage, and sometimes at the margins of stands of M13. These are included within the definition of alkaline fen.

Relationship with Annex 1 habitats

NVC community M13 is also regarded as a core vegetation type of the Annex 1 habitat 7210 Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae.* However, as interpreted in Britain, this Annex 1 habitat also encompasses any vegetation with *Cladium mariscus* including rather species-poor swamps (for example, NVC community S2 *Cladium mariscus* swamp and sedge beds). Much of the mowing management on important M13 stands is aimed at reducing dominance of *Cladium mariscus* so, although M13 stands with *Cladium mariscus* do match the description of 7210 in the Interpretation Manual (Italian Ministry of Environment and Energy Security 2013), in England they generally have greater floristic and habitat similarities with alkaline fen than with the other *Cladium*-dominated vegetation types described in the JNCC habitat description of Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae.* If assigned to the calcareous fens habitat, management of M13 stands to reduce *Cladium* dominance could cause a reduction in the extent of habitat 7210, with a consequent increase in extent of alkaline fen. Because of this, all known M13 stands, with and without *Cladium mariscus*, are included within this FCS definition as alkaline fen. To avoid 'double accounting' such stands should not be considered as Habitat 7210.

A distinctive vegetation type transitional between M6, M10 and M14 *Schoenus nigricans-Narthecium ossifragum* mire has been widely recorded in surveys of seepages and flushes, particularly in Cumbria, Shropshire and Wales (Stevens and others 2010; Eades and others 2012; Tratt & Eades 2013). This type of vegetation has affinities to M10, but is usually rather less species-rich, and associated with more base-poor water. It has been called 'neutral' or 'sub-neutral' flush in survey reports (for example, Stevens and others 2010; Callaghan 2012). This type of vegetation is likely to be more widespread in the uplands but may not have been consistently recorded or described in surveys because of its transitional nature. These vegetation types are not included within alkaline fen and do not sit comfortably in any Annex 1 habitat, despite their relative rarity, species-richness and the scarce taxa they support. The bryophyte flora in this vegetation can be particularly rich, including the Annex II and Schedule 8 moss *Hamatocaulis vernicosus*, and the rapidly declining *Tomentypnum nitens*, both associated with alkaline fen in other contexts.

Some of the inconsistencies and ambiguities identified above relate not only to the lack of an independent characterisation of habitats but also to the nebulous character, and wide variation, of certain NVC communities. For example, stands of M9 which occur in conjunction with alkaline fen communities are often of a distinctive floristic character compared to those associated with transition mire and quaking bog (TMQB) communities. This provides an obvious basis for disambiguation, in that it is possible to allocate certain versions of M9 to alkaline fen and others to TMQB, but for such an approach to be of general utility it is necessary to be able to define which versions of M9 belong to which habitats. It is not possible to use the NVC sub-communities of M9 for this purpose, as they are themselves far too broad and ill-defined (see Wheeler, Shaw & Tanner 2009). However, an appropriate allocation can be made using the earlier, and more detailed, classification of Wheeler (1980). Wheeler recognised an *Acrocladio-Caricetum diandrae* community which corresponds closely with what has since come to be known as the *Carex* diandra–*Calliergon giganteum* sub-community of M9 (M9b). Two of the sub-associations that Wheeler allocated to this (*schoenetosum* and *juncetosum subnodulosi*) have strong floristic and ecohydrological links with M13 and M22 (respectively) and can reasonably be included within alkaline fen.

Other sources: Tratt and others 2013; Diack and others 2013.

1.2 Habitat status

Alkaline fen is listed under Annex I of the Habitats Directive. It is a component of both the Lowland Fens and Upland Flushes, Fens and Swamps habitats which are listed as Habitats of Principal Importance under Section 41 of the Natural Environment and Rural Communities (NERC) Act 2006.

The European Red List of Habitats (Janssen and others 2016) assessed D4.1a Small-sedge base-rich fen and calcareous spring mire as Endangered.

1.3 Ecosystem context

Alkaline fens in England are associated with wetlands irrigated by base-rich water (pH > 6) from springs and seepages(soligenous) and they are often found on hillslopes. Very often the water supply is not strictly alkaline (that is, pH > 7), nor even weakly so, but in other cases it is sufficiently ‘calcareous’ to permit the precipitation of calcite (calcium carbonate solids), and sometimes even large tufaceous spring mounds. This habitat may also occur in topogenous situations, where water is retained due to impeded drainage and fed by groundwater outflow (percolation).

Alkaline fens are often very small in extent - sometimes only a few square metres - but they are typically species-rich and can support many rare species. They occur in upland and lowland contexts wherever there is an upwelling of base-rich, oligotrophic water, typically in valley-head and hillslope situations. They are often found in association with other wetland habitats including wet grasslands, tall sedge beds, reedbeds and fen sedge beds. Communities related to transition mires and amphibious or aquatic vegetation or spring communities may develop in depressions within the fen.

Alkaline fens are also found within calcareous, neutral and acid grasslands, wet and dry heaths, on the margins of raised and blanket bogs and in clearings within woodland. They can occur in small patches in dune slacks, in transition mires, in wet grasslands, on tufa cones and in a few other situations. In many of these landscapes the springs and seepages supporting the habitat form the headwaters of streams and rivers, including chalk rivers such as the river Wensum in Norfolk, and around the margins of standing water bodies including such hard-water lakes as Haweswater in Lancashire.

Sources: Averis 2003; Diack 2015; Stubbs 2015; Tratt and others 2013.

2. Units and attributes

2.1 Natural range and distribution

Tetrad (2 km × 2 km grid square).

The appropriate unit given the relatively wide distribution of the habitat across England, local clustering around appropriate hydrogeological conditions and the small size of most stands.

2.2 Extent

Hectares & number of stands

While hectares may appear to be the most straightforward metric, most alkaline fens are very small so accurate mapping can be difficult, particularly in large upland landscapes. Despite their small size, however, individual stands can be very species-rich and support important populations of rare species (Wheeler and others 2009). For this reason, using the number of stands in combination with an area figure also provides useful information for understanding the state of the habitat resource. This approach is illustrated in Figure 1, in which the number of stands per tetrad highlights the core areas of distribution.

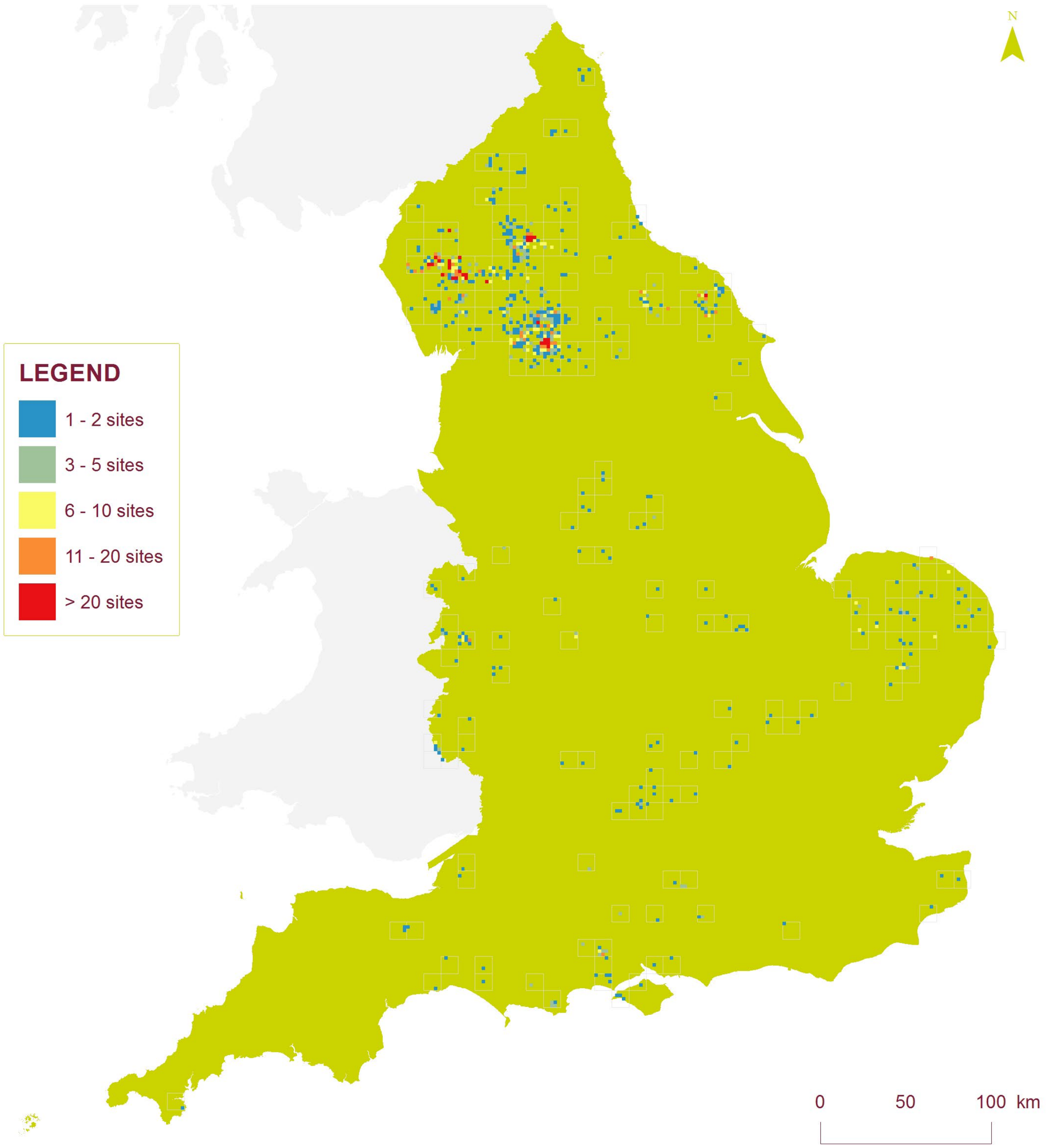

Figure 1 Map showing density of recorded stands of current Annex 1 habitat 'Alkaline Fen' in tetrads in England

2.3 Structure and function attributes

The following section describes the structure and function of the core vegetation communities of alkaline fens in England. The relationship between vegetation and environmental variables, including water supply, from alkaline fens throughout England and Wales has been investigated in the Wetland Framework (Wheeler, Shaw & Tanner 2009) and much of these accounts is derived from this report.

M9b/M22 *Carex rostrata - Calliergon cuspidatum/giganteum* 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. Occurs in more stagnant situations than M10 and M13. Also supports several rare species.

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, with 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, for example dioecious sedge *Carex dioica* and bird's-eye primrose.

Overlaps with M13, but generally more species-poor, are often more open and lower growing and tend 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.

Water Supply

Occurs on soligenous slopes, fed by groundwater from semi-confined 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.

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.

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. Further diversity is provided by raised hummocks within the fen which can support species of more acid conditions such as *Potentilla erecta* and *Erica tetralix*. M13 supports several rare species.

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).

Structure attributes

- Vegetation community composition.
- Absence of invasive, non-native and/or introduced species.
- Extent of scrub or tree cover.
- Extent of exposed substrate across the feature.
- Presence of microtopographic variation across stands such as open runnels and mossy hummocks.
- Signs of damage or disturbance to the vegetation in which tufa is visible.

Function attributes

- Hydrological regime.
- Quality of irrigating water (usually groundwater).
- Functional connectivity with wider landscape.
- Concentrations and deposition of air pollutants.
- Vegetation management.

3. Evidence

3.1 Current situation

Natural range and distribution

Figure 2 shows the current occurrence of alkaline fen in England. Alkaline fens are found within 573 tetrads.

While these data are much improved from the situation ten years ago, it should be noted that ongoing vegetation surveys in previously under-surveyed areas of the uplands, particularly in Northumberland and Cumbria, are uncovering a greater number of alkaline fens including some large and very rich stands. These will be added to the inventory in due course and status and implications for action updated.

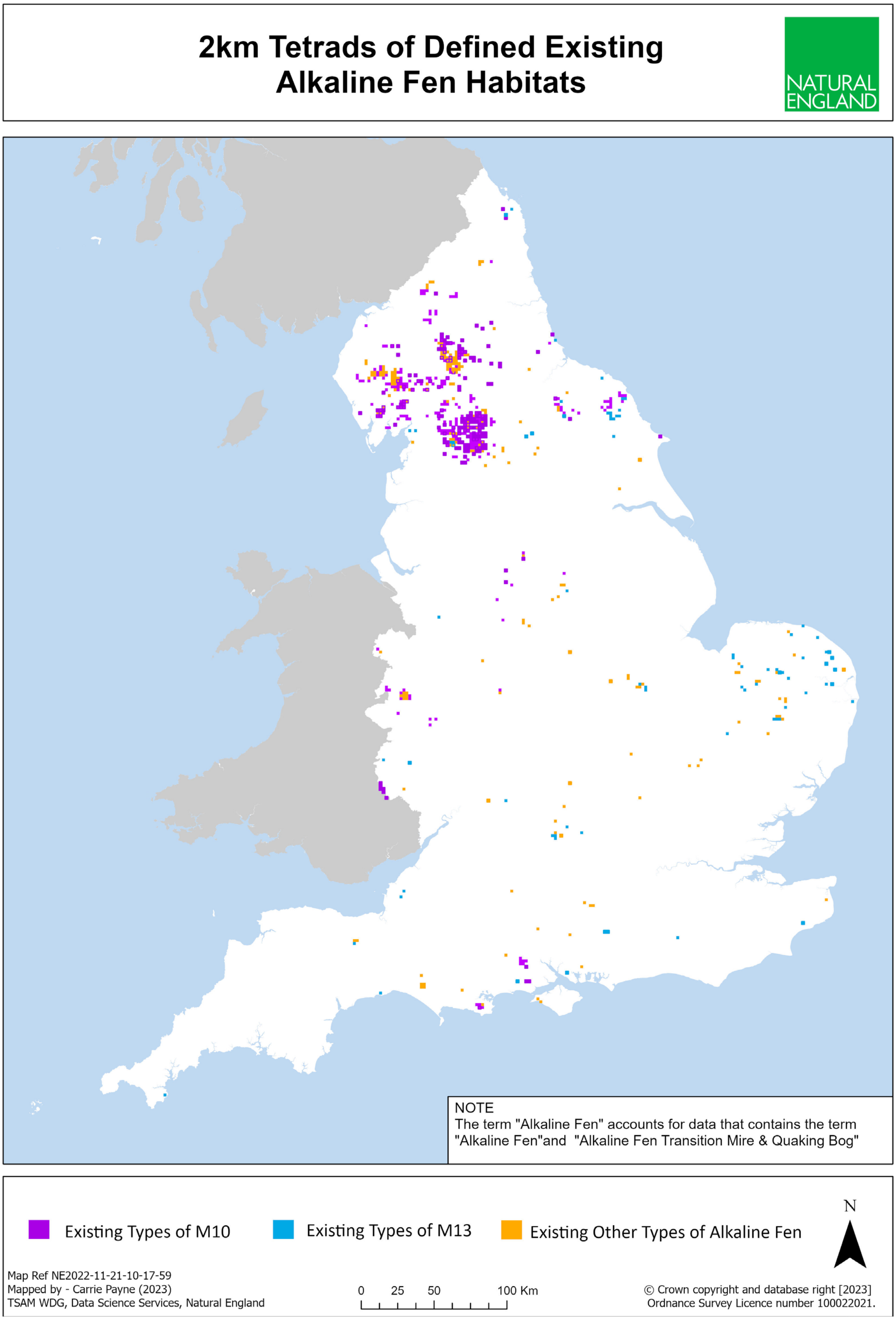

Figure 2 Map showing locations of stands of M10, M13 and other vegetation types representing Annex 1 habitat 'Alkaline Fen' in England.

Sources: Jerram 2013; Tratt and others 2013; Wheeler & Shaw 1992.

Confidence: Moderate-High

Extent

Table 3 lists the area of the different alkaline fen communities in England, derived from the Alkaline Fen inventory (Tratt and others 2013). It includes an upland/lowland split based on occurrence relative to the Moorland Line which distinguishes enclosed from unenclosed land. With few exceptions, sites within the Moorland Line are generally at higher altitude (typically > 300 m AOD). That which is included as 'Upland'. 'M10_mosaic' is almost certainly over-estimated as some mapped areas will include habitats other than alkaline fen. More detailed survey is required to obtain a more accurate figure.

The total area of alkaline fen within England is 2,385 ha (figure rounded).

The M13 and M13_affinity sites within the Moorland Line are all at altitudes below 300 m. The M13_affinity sites have some affinity with M13 but are not typical examples of M13 vegetation. Some require survey to verify whether they are M13.

The remaining area of M13 – the lowland expression of alkaline fen habitat - in England is only 37.9 ha, if all M13 and transitional vegetation is included. The area of vegetation unambiguously referable to M13 is only 20 ha (Tratt and others 2013).

Table 3 Area of alkaline fen communities, within and outside the moorland line.

Alkaline Fen	Stands (points and polygons) Outside Moorland Line	Area of polygons (ha) Outside Moorland Line	Stands (points and polygons) Within Moorland Line	Area of polygons (ha) Within Moorland Line
M10, M10_affinity & M10/11	113	32.22	2,683	409.12
M10_mosaic	8	32.96	576	1,802.87
M11 & M11_mosaic)	0	0.00	47	2.62
M13, M13_mosaic & intermediates	131	31.72	38	3.73
M13_affinity	24	6.18	19	1.64

Alkaline Fen	Stands (points and polygons) Outside Moorland Line	Area of polygons (ha) Outside Moorland Line	Stands (points and polygons) Within Moorland Line	Area of polygons (ha) Within Moorland Line
Other	50	61.36	14	0.54
Total	326	164.44	3,337	2,220.52

Source: Tratt and others 2013

Confidence: Moderate-High

Patch size and connectivity

The majority of stands are less than 0.1 ha or 1,000 m^2 in extent, with many only a few square metres in size (Tratt and others 2013).

Table 4 Median area of stands outside the Moorland Line and within the Moorland Line.

Alkaline fen	Median area outside the Moorland Line (ha)	Median area within the Moorland Line (ha)
M10	0.036	0.015
M10_mosaic	0.638	0.300
M11	0.004	0.005
M13 & intermediates	0.068	0.038
M13_affinity	0.017	0.157
Other	0.109	0.001

Confidence: Moderate

Quality of habitat patches

Aspects of function are less than ideal on most lowland alkaline fens, in common with those in much of the rest of Europe. Pressures include severe nutrient enrichment, lack of vegetation management, development pressure on aquifers and ongoing attempts to drain by landowners.

There is little specific data on the quality of alkaline fens. For example, most monitoring of the quality of SSSIs to date has been completed at the SSSI unit scale and as most alkaline fens are likely to be but a small fraction of any unit, unit condition may largely be determined by the condition of its more extensive components.

Confidence: Moderate

Threatened species

A number of obligate fen species occurring in England were recognised in Annex 2 of the Directive as having importance at European scale. These are listed below together with their red list assessment and the habitats where they are found. Habitats listed in brackets are also used but are less significant for the species than those listed first.

- Southern damselfly *Coenagrion mercurale* (Endangered) –Transition mire & quaking bog; Alkaline fen; Depressions on peat of the *Rhynchosporion*; Atlantic wet heath.
- Marsh fritillary *Euphydryas aurinia* (Vulnerable) – Molinia meadows; (Transition mire & quaking bog; Alkaline fen).
- Narrow-mouthed whorl snail *Vertigo angustior* (Vulnerable) – Alkaline fen/Calcareous fen with Cladium; Dune slacks.
- Geyer's whorl snail *Vertigo geyeri* (Near Threatened) – Alkaline fen; Petrifying springs.
- Desmoulin's whorl snail *Vertigo moulinsiana* (Vulnerable) – Calcareous fen with Cladium (Alkaline fen).
- Round-mouthed whorl snail *Vertigo genesii* (Near Threatened) – Alkaline fen; Alpine pioneer formations.
- Varnished hook-moss *Hamatocaulis vernicosus* – Transition mire and quaking bog; Alkaline fen.
- Marsh saxifrage *Saxifraga hirculus* (Least Concern in England but Vulnerable in GB) – Alkaline fen; Petrifying springs.
- Fen orchid *Liparis loeslii* (Endangered) – Calcareous fen with Cladium; (Alkaline fen; Transition mire & quaking bog).

Alkaline fens are also important for their fly (Diptera) fauna, with rare species including some soldier flies (for example, *Stratiomys chamaeleon* - Endangered) and crane flies. Many of these species require permanently wet, open, warm, mossy environments for larval and pupal stages. Over-shading and dehydration are the key risk-factors for the characteristic invertebrates.

In an upland context, the perennial supply of mineral-rich water to these features in landscapes dominated by acidic and mineral-poor soils means that they provide important feeding areas for various vertebrates, including wading birds such as snipe (Near Threatened), curlew (Endangered) dotterel (Endangered) and other upland birds including ring ouzel (Vulnerable). Larger expanses of the habitat in upland and lowland landscapes provide breeding habitat for ground-nesting wading birds and passerines.

Vascular plants

Wheeler, Shaw & Tanner (2009) recognised a number of species that are particularly characteristic of M13, and so help to distinguish it from other communities. Eight of the 22 vascular plants associated with M13 are recognised as being under threat as a result of decline in range and/or population.

Other species have declined over longer periods, such that almost three-quarters (73%) of the characteristic plants of M13 have experienced significant declines in range and/or population.

Similarly, some of the core and distinctive species of upland alkaline fens have declined over the period assessed by Stroh and others (2014) and two characteristic M10 species, bird's-eye primrose and flat-sedge *Blysmus compressus*, are classed as Near Threatened and Vulnerable, respectively. Grass-of-Parnassus *Parnassia palustris* is an example of a species that remains relatively widespread in the uplands, including in alkaline fens, but due to its catastrophic (and ongoing) loss from the lowlands it is classed as Vulnerable. Whereas this species occurs in a range of damp calcareous habitats in the north of Britain, it was probably restricted to alkaline fen sites in southern England, and as a result of their widespread loss, is now extinct in many southern counties.

Table 5 Red-list status of Wheeler and others' characteristic M13 species (based on Stroh and others 2014).

M13 Species	Red-list status (Stroh and others 2014)	Least Concern (1930-1999) % decline detected when assessing 1987+ data as a proportion of all records including pre-1930 data
Anagallis tenella	*LC*	*30*
Aneura pinguis		
Bryum pseudotriquetrum		
Campyliadelphus elodes		
Campylium stellatum		
Carex dioica	*LC*	*42*
Carex hostiana	*LC*	
Carex pulicaris	***NT***	
Carex viridula ssp brachyrrhyncha	*LC*	
Cladium mariscus	*LC*	*43*
Dactylorhiza incarnata	*LC*	*43*
Dactylorhiza praetermissa	*LC*	
Dactylorhiza traunsteineri	*LC*	

M13 Species	Red-list status (Stroh and others 2014)	Least Concern (1930-1999) % decline detected when assessing 1987+ data as a proportion of all records including pre-1930 data
Drosera anglica	***EN***	
Eleocharis quinqueflora	*LC*	*41*
Epipactis palustris	***NT***	
Eriophorum latifolium	*LC*	*53*
Euphrasia pseudokerneri	***VU***	
Fissidens adianthoides		
Gymnadenia conopsea	*LC (DD)*	
Hamatocaulis vernicosus		
Listera ovata	*LC*	
Moerckia hibernica		
Palustriella commutata		
Parnassia palustris	***VU***	
Pedicularis palustris	***VU***	
Pellia endiviifolia		
Philonotis calcarea		
Pinguicula vulgaris	***VU***	
Plagiomnium elatum		
Plagiomnium ellipticum		
Potamogeton coloratus	*LC*	*47*
Preissia quadrata		
Pseudocalliergon lycopodioides		
Riccardia chamedryfolia		
Riccardia multifida		
Sagina nodosa	***VU***	
Schoenus nigricans	*LC*	*44*
Scorpidium cossonnii/revolvens		
Scorpidium scorpioides		

**Lower plant status awaiting completion of England Red-list.

Sources: Hajek and others 2016; EU Red List of habitats 2017; Natural England 2008; Rodwell 1991 Stroh and others 2014; UK Wetland TAG 2013; UKTAG 2014; Wheeler and others 2009.’

Confidence: High

3.2 Historical variation in the above parameters

There has been a significant decline in the extent and quality of alkaline fens during the 20th century, particularly in the lowlands. Figure 3 shows the distribution of known former, degraded and current alkaline fens. It is highly likely that additional sites have been lost both from the core areas and potentially from areas without current records but where appropriate environmental conditions would have been found, for example in the home counties, where some of the core species (for example, common butterwort, dioecious sedge) still occur or previously occurred.

The limited evidence available suggests that a number (possibly a high number) of significant East Anglian fen sites were lost around the time of the Enclosure Act, but there is better evidence to suggest that a surprisingly large proportion of those that survived remained in relatively intact condition at least until the 2nd World War or shortly afterwards (Wheeler & Shaw 1992). Since the 1950s, however, many sites have been lost and many which remain have lost their characteristic species. Records from past surveys (Francis Rose 1950s; Wheeler 1970s) and records from county floras across the rest of the English lowlands suggests that this is a common experience, with records of alkaline fen plants from before and up until the mid-1800s that are never subsequently re-recorded, and a gradual loss of sites and species through the second half of the 20th century (for example, Sinker and others 1991; Killick and others1998).

The major reasons for these changes have been:

- Dehydration, largely through drainage and groundwater abstraction, leading in the most severe cases to complete loss of habitat, and in less severe cases to the loss of species associated with the wettest conditions. Dehydration has been widespread in the lowlands where groundwater abstraction and drainage, including that of whole river valleys, is prevalent and intensive. The drainage of alkaline fens has also been - and remains - a factor in the loss of fens in the uplands, and several perhaps once extensive alkaline wetlands in areas such as the Craven Limestone in North Yorkshire have been in a drained state for centuries. Spring-fed alkaline fens near upland habitations have often been used for domestic water supply and may have been adversely affected as a result.
- Nutrient enrichment from surface water, groundwater and atmospheric nitrogen deposition. Lowland sites are particularly vulnerable because surrounding land-use is more intensive than in the uplands. An increase in fertility is associated with a decrease in species-richness and the loss of specialist species.
- Dereliction, particularly an issue in East Anglia and other lowland sites following loss of livestock farming, or intensification of livestock production leading to the abandonment of agriculturally unproductive areas. Absence of vegetation management can lead to development of tall fen vegetation or scrub encroachment, with associated losses of bryophytes and other characteristic species. The combined effects of dereliction and/or dehydration and/or nutrient enrichment often

lead to irreversible change. Unfortunately, the three factors have acted in concert on many lowland sites.
- Afforestation has destroyed or damaged alkaline fens in a number of localities, including the North York Moors and the North Pennines.
- Urban development near to alkaline fens is likely to have prevented recharge of aquifers with impacts on flows and chemistry of groundwater feeding the wetland.

Overall, alkaline fens have fared much better in the uplands than in the lowlands, largely because drainage, arable cultivation or nutrient enrichment are so much more easily achieved in the lowlands. The impacts of overgrazing in the last 40 years are not fully understood – it is likely that there has been some loss of species, but as many of the species closely associated with alkaline fens require high light levels and low levels of competition, the impacts of heavy grazing may be less severe than the impacts of little or no grazing. Evidence suggests that the action of animals' hooves in areas of high rainfall, such as Upper Teesdale, actually prevents the development of closed turf, subsequent surface acidification through leaching and ultimate loss of alkaline fen, by keeping the surface in a relatively skeletal state thereby maintaining base-rich conditions at the surface (Wheeler & Shaw 2011).

Natural range and distribution

The current range, mapped at a very coarse scale, appears to be similar to that of approximately 100-150 years ago. However, alkaline fen has been lost entirely from parts of its historic range, and in many other lowland areas representation is down to as little as one somewhat degraded site. The inventory lists 79 tetrads with records of former or now-degraded alkaline fen showing that there has been a contraction in range and distribution.

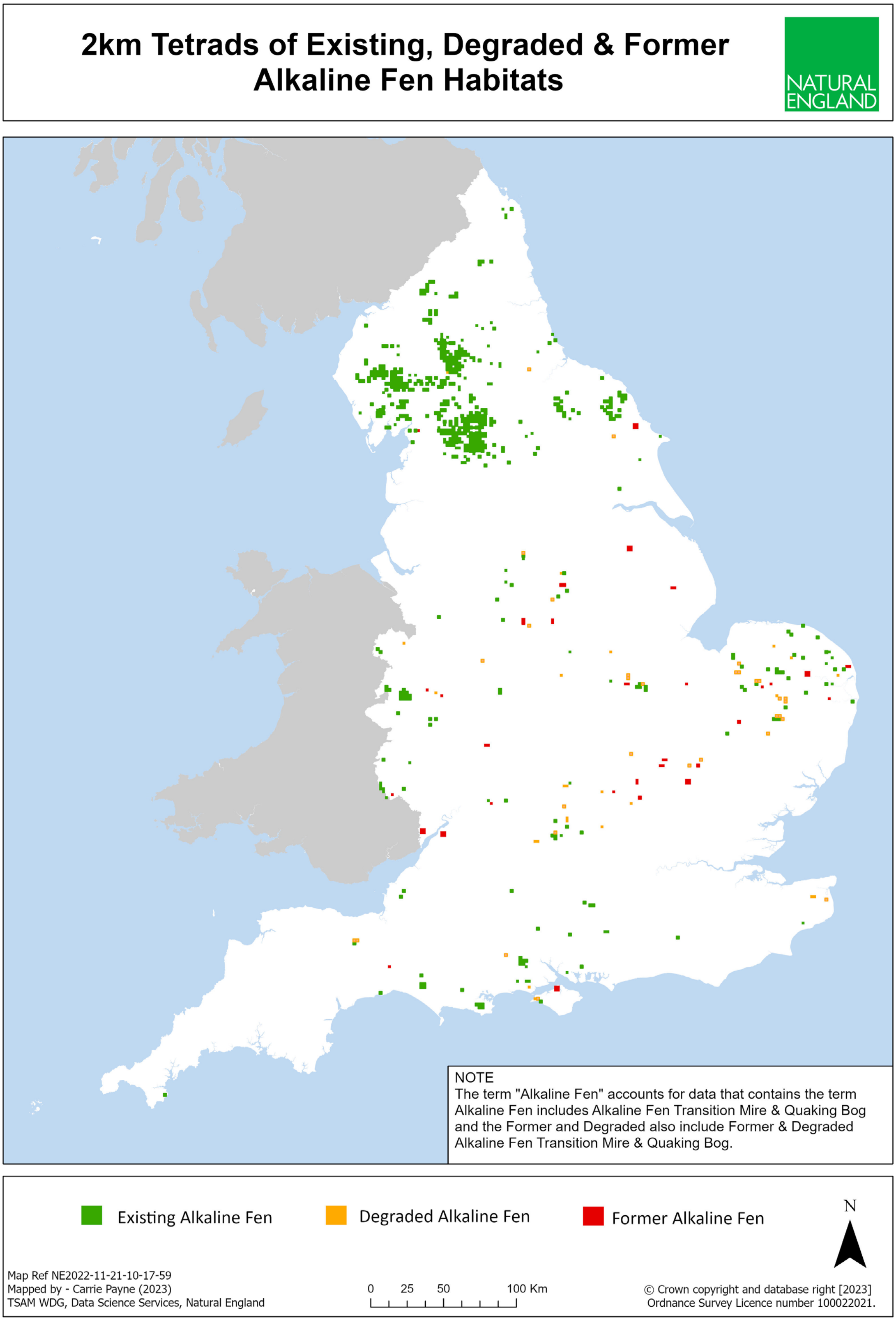

Figure 3 Map showing locations of existing, degraded and former Alkaline Fens

Confidence: Moderate

Extent

Both the area and the number of stands of alkaline fen have decreased, although it is not possible to give an accurate figure for the scale or pace of decline. The alkaline fen inventory lists 86 stands of former or degraded fen with a combined area of 174.91 ha. However, this is likely to be only a fraction of the total loss.

The losses have been particularly severe in the lowlands and although less information is available to assess the loss of alkaline fen in the uplands, it is believed that the extent and number of stands has not changed as significantly as in the lowlands, although there has undoubtedly been loss through drainage and general agricultural intensification.

Confidence: Low

Patch size and connectivity

With the decline in extent of alkaline fen it is possible that there has been a decline in patch size but there is no information available.

Quality of habitat patches

In their review of the status of fens in East Anglia - the most important English region for lowland alkaline fen - Wheeler & Shaw (1992) provided evidence suggesting that the vast majority of sites have shown deterioration in floristic composition, as determined by the loss of the less common fen species, and particularly by the loss of those that are typically associated with consistently wet conditions. A few sites did not appear to have experienced appreciable floristic change, but even here, it is likely that there has been some reduction in at least the abundance of species or of the diversity of the vegetation. It is highly likely that these losses have been mirrored in the loss of obligate fen fauna, although little hard evidence is available. This situation is common to the whole of the English lowlands.

The pressures known to have led to destruction and damage to alkaline fen - both historically and currently - suggest that before the losses of habitat and component species the lowland sites would have been wetter, the groundwater supplying the fens would have had lower macronutrient concentrations, the fens would have been part of extensive grazing systems, on some sites peat may have been cut on a small scale, and alkaline fen and related wetlands supporting the component species, as well as other semi-natural habitats, would have been far commoner and more extensive in the wider landscape.

Sources: Diack pers comm. 2016; Jerram 2013; McBride and others 2011; Shaw & Wheeler 1991; Tratt and others 2013; Webb, J., pers. comm.; Wheeler & Shaw 1992; Wheeler & Shaw 2011.

Confidence: Moderate-High

3.3 The future for the habitat and its conservation

A significant proportion of remaining alkaline fen occurs in 'upland fringe' situations, or in the enclosed uplands and appear to be at more risk of loss and damage than those above the line of enclosure. Losses continue as upland farming enterprises intensify land management through drainage, herbicide and fertiliser applications (for example, Tratt & Eades 2013). In several areas, for example, in Shropshire, Staffordshire and the North York Moors, the upland fringe contains the majority of the remaining sites, in most cases supporting the M10 element of the alkaline fen resource. These upland fringe alkaline fens are perhaps the most vulnerable sites, as most of the remaining lowland sites are protected as SSSIs, whereas many of the remainder are outside protected sites.

Climate change may affect hydrological regimes (including groundwater supply). Changing patterns of rainfall (overall, seasonal, daily) could lead to change, including the potential for degradation and loss. However, the precise effects are difficult to predict. Currently, the habitat faces greater threats from more immediate human impacts, such as drainage, groundwater abstraction and nutrient enrichment, particularly in lowland England**.** The habitat is likely to be far more resilient to all change if these pressures are reduced or removed, and a more natural hydrological regime is re-established (for example, Natural England & RSPB 2019; Natural England 2015; Mainstone and others 2016).

Natural range and distribution

The current range at a very broad scale, that is, across the whole of England, is required in order to maintain biological diversity and variation across the habitat. The range across the uplands of northern England is considered broadly adequate, but all parts of the lowland range (that is, largely those areas supporting M13) require a significant restoration and creation effort. At a minimum, FCS requires the establishment of alkaline fen in the 79 tetrads where there are records of former or degraded alkaline fen (the red and orange dots in Figure 3). Communities that are likely to develop following successful restoration of the range are shown in Figure 2.

Confidence: Low-moderate

Extent

The very small total extent of the habitat in the lowlands, and the very small size and relative isolation of individual stands, make the habitat and its component species extremely vulnerable to loss from change, whether anthropogenic or natural. An increase in habitat area and number of stands is required to increase both the likelihood of species survival and general resilience of the habitat to change. A crude estimate based on the number of degraded/former alkaline fen sites relative to existing sites (roughly equal) suggests that doubling the current 'lowland' area of alkaline fen (M10 and M13 combined - 165 ha – see Table 3) gives a favourable area of about 330 ha for lowland alkaline fen.

There is less evidence of loss of alkaline fen within the uplands. However, the habitat is poorly recorded in the uplands and figures for extent should be treated with caution. There is anecdotal evidence of ongoing damage and loss. Therefore, it is essential to maintain current alkaline fen sites in the uplands and to expand the area by at least 50% - from 2,221 ha to 3,333 ha - through restoration of damaged existing sites.

Confidence: Low

Patch size and connectivity

The extent of individual alkaline fens should be determined by re-establishment of the natural hydrological regime at site and landscape-scale.

Confidence: High

Quality of habitat patches

Given the current degraded state of many sites, restoration of structure and function attributes is required for favourable status.

It is considered that maintenance or restoration of natural hydrological regimes (including hydrology and hydrochemistry) within and beyond alkaline fens is the most likely to sustain/restore conditions of greatest structural and biological diversity and confer the greatest resilience to change in most situations. In a few situations, alkaline fen vegetation has developed following human modifications to natural hydrological systems, and in these sites significant ongoing intervention may be necessary to sustain the habitat in the long-term. Ideally, opportunities should be sought in and around these sites to restore the habitat in a more natural and sustainable context.

The restoration of semi-natural habitats on a wider scale around and particularly upslope of alkaline fen is also likely to be required in order to help achieve more natural (that is lower) nutrient levels and confer greater resilience to and reduce fragmentation of semi-natural habitats.

Atmospheric nitrogen deposition can cause dramatic shifts in fen bryophyte composition, triggering major changes within the fen vegetation and fen hydrochemistry (for example, Pauliessen and others 2011). Current nitrogen deposition levels exceed critical loads over many alkaline fen sites, and reductions in atmospheric nitrogen are required in order to maintain or restore favourable conditions.

Confidence: High

Sources: Hopkins and others 2007; Lawton and others 2010; Mainstone and others 2016; Natural England 2015; Tratt and others 2013.

3.4 Constraints to expansion or restoration

Habitat restoration depends on an ability to generate the supporting environmental conditions. Of these conditions, a constant supply of low nutrient, base-rich groundwater is the most significant. Figure 4 shows the current areas and the geological formations from which the groundwater supporting the habitat issues. These areas will provide the major opportunities for restoration and re-creation, as long as the water table/groundwater flow is still sufficiently high to sustain the hydrological and hydrochemical conditions year-round, and that groundwater nutrient levels are appropriately low. Threshold levels for nitrogen concentration in groundwater bodies for various wetland types have been developed, and these allow some level of assessment of the suitability of aquifers to support the restoration of alkaline fen (UKTAG 2012). However, reducing nitrogen levels in large aquifers may take many years. Nevertheless, alkaline fen is known to persist in conditions of high nitrogen groundwater where phosphate is immobilised by co-precipitation, so high nitrogen may not always be a constraint on restoration of alkaline fen.

Management and restoration work currently seeks to enhance and restore alkaline fen habitat at several sites. Worked-out quarries on appropriate geology offer some of the best or even only opportunities for creation (Meade & Humphries 2006). For example, fen creation has been successful at Dry Sandford Pit in Oxfordshire in a quarry abandoned in the 1960s, adjacent to existing high value alkaline fen. Limestone quarries in Cumbria and Shropshire have been reported as developing what appears to be alkaline fen and attempts are underway in other areas through addition of seed from nearby sites, for example, the limestone uplands of north-west Shropshire (Dan Wrench. pers comm.).

The potential for restoration is likely to be greatest on degraded alkaline fen sites that currently support partially-drained, low nutrient habitats or taller fen types that have not been enriched. In many cases, protected sites that previously supported the habitat will offer particularly good opportunities, as the habitat on SSSIs has at times been overlooked (Tratt & Eades 2013). Therefore, restoration may not have been seen as a priority, or indeed the loss of the key species may have gone unremarked due to lack of understanding of habitat requirements. Where the habitat had become overgrown or derelict, reinstatement of cutting and grazing regimes on protected sites has given mixed results, with wet, low nutrient sites recovering particularly well, although the full complement of character species has not yet been fully restored (for example, Shaw & Tratt 2015). Re-introduction of species may be required for those with short-lived seed banks, poor dispersal abilities and/or an absence of local seed sources. Restoration may involve sites currently supporting valued habitats such as *Molinia* meadow (M24) and M22. In these cases, it is highly unlikely that any of the current vegetation types or species would be lost, rather that small areas of wetter conditions are restored within the wider habitat.

While dry and nutrient-enriched peat on ex-alkaline fen may be a current constraint on restoration, stripping of the top layers has been employed with some success including at sites in Wales and in continental Europe (for example, Menichino and others 2013; Jones and others 2015).

Other situations that offer a reasonable probability of success include afforested areas with base-rich groundwater supplies. As described earlier, sites with enriched peat/soil that otherwise have high potential can be stripped of their top layers and lower nutrient peat exposed (for example, Menichino and others 2011). Successful re-colonisation is likely to be better if adjacent to existing alkaline fen.

In areas which previously supported alkaline fen, but which now have low water levels (perhaps as a result of groundwater abstraction or regional or even local drainage schemes), restoration may be more challenging as it may necessitate significant change to drainage infrastructure. Ensuring that alkaline fen restoration is identified as a priority in relevant river systems/catchments will be critical if suitable conditions are to be created through river restoration programmes or flood management activities. In some cases, the restoration of alkaline fen may be seen as contributing to flood attenuation downstream and should also be seen as restoration of river headwaters.

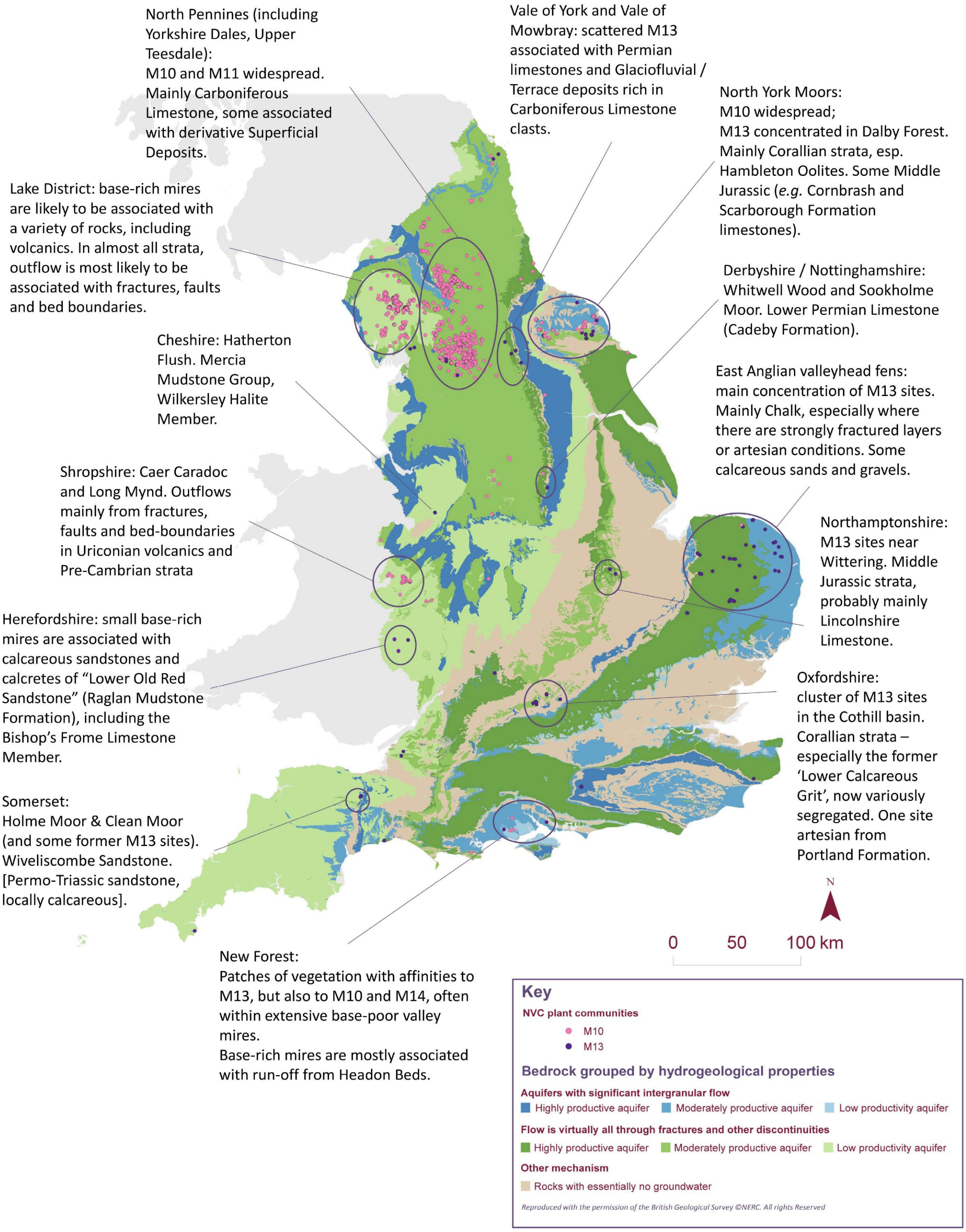

Figure 4 Distribution of stands of M10 and M13 in England in relation to bedrock and aquifer properties (Diack and others 2013), (British Geological Survey symposium 2023).

Sources: Boyer & Wheeler 1989; Diack and others 2013; Jones and others 2015; Meade & Humphries 2006; Menichino and others 2011; Natural England 2008; UKTAG 2014; Wheeler and others 2009; Tallowin and others 2014.

Confidence: Moderate-High

4 Conclusions

4.1 Favourable range and distribution

The favourable range is 652 tetrads. This includes the current range of 573 tetrads plus an additional 79 tetrads where, although fen may be present, habitat has been lost or partially lost (degraded).

4.2 Favourable extent

The favourable area is 3,663 ha consisting of the current area of the habitat, 2,385 ha plus stands in the lowlands, in areas of historic occurrence and by increasing the area in the uplands. In the lowlands, at least a doubling of the area (to 330 ha) and number of stands by restoration of degraded sites and re-creation from plantations, quarries and other situations in which a constant supply of low-nutrient base-rich groundwater can be restored and/or established.

In the uplands, an increase of 50% of the current extent in the Alkaline Fen inventory (to 3,333 ha). There is scope for the increasing extent wherever small-scale artificial drainage has brought about degradation and loss. This may result in modest increases in extent, while restoration of some larger drained wetland basins in limestone uplands (some of these in protected sites), and removal of forestry plantations in key areas, such as the North York Moors, offers greater opportunity for a more significant increase in extent.

4.3 Favourable structure and function attributes

Structure attributes

- Presence of appropriate vegetation community composition.
- Absence of invasive, non-native and/or introduced species.
- Less than 10% scrub/tree cover.
- Exposed substrate between 5% & 25% across feature.
- Presence of microtopographic variation across stands, for example, open runnels, mossy hummocks (largely driven by hydrology and vegetation management).
- No more than 1% of the vegetation in which tufa is visible is showing signs of damage or disturbance.

Function attributes

- Hydrological regime that provides the conditions necessary to sustain the feature within the site, including a high piezometric head (where relevant) and permanently high water table (allowing for natural seasonal fluctuations). While water level 'targets' can be identified for vegetation communities, restoration of a natural hydrological regime is likely to better provide the conditions that will support the greatest diversity of structure and function, in most cases.
- Low nutrient status of irrigating water (usually groundwater), rich in base ions, particularly calcium, reflecting naturally-determined hydrochemistry and macro-nutrient content.
- Functional connectivity with wider landscape, including uninterrupted transitions with other habitats and maintenance/restoration of natural hydrological regime (hydrology & hydrochemistry) in wider landscape, that is, unimpacted by groundwater abstraction, off-site nutrient enrichment, drainage etc.
- Concentrations and deposition of air pollutants at or below the site-relevant Critical Load or Level values given for this feature.
- Vegetation controls preventing dominance of competitive species and succession to scrub and woodland. This can be achieved through browsing and grazing by herbivores and/or cutting.

Quality of habitat patches

At least 95% of the favourable area of the habitat meets the structure and function requirements as described above. Species-re-introductions may be necessary on sites and landscapes where known losses of core, functionally important and/or nationally threatened species have occurred. Quality of the habitat patch is generally conditional on activities on neighbouring land and in the catchment, therefore central to improvement of quality is the removal of pressures in these places.

Threatened species

All species partially or wholly dependent on this habitat should be Least Concern, when assessed using IUCN criteria (or considered to be Least Concern if not formally assessed), as regards to this habitat.

Application of current CSM guidance for lowland alkaline fen vegetation (particularly M13), if not modified for site specific features, could result in failure to detect significant loss of species without a change in condition status being recorded. It is therefore recommended that CSM guidance for the relevant communities is amended to ensure adequate coverage of critical aspects of structure and function.

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