Appendix E – Lowland Heathlands

Alonso, I., Curson, J., Cox, J. and Drewitt, A.

E1. Habitat variation (adapted from Alonso *et al.* in prep and Rodwell 1991)

The term “heathland” encompasses a diverse mix of vegetation types which vary according to soils, climate and management. For practical purposes, as ecologically there is a continuum, it is usually divided in the UK into upland and lowland heathland. This document refers to lowland heathland only.

Lowland heathland is an open habitat on impoverished, acidic mineral and shallow peat soil, characterised by at least 25% cover of heathers and dwarf gorses. Lowland heathland is generally found below 250-300 m altitude in Great Britain, but in the north the altitudinal limit is often lower.

The hydrological conditions, in combination with the rainfall and drainage, determine a further division into dry and wet heathlands, with intermediate types called humid heaths. Dry heaths usually occur on freely drained sand or podzols across the warmer parts of Britain. They are characterised by combinations of heather *Calluna vulgaris*, bell heather *Erica cinerea* and gorse *Ulex* ssp. Where drainage is slowed down, rainfall is higher and there is periodical waterlogging, other species such as cross-leaved heath *Erica tetralix* and purple moor-grass *Molinia caerulea,* as well as bog mosses *Sphagnum* spp. acquire a more significant role. If drainage is impeded and the water table is consistently high then peat accumulates creating lowland raised mires and valley bogs.

Lowland heathland is a dynamic habitat which undergoes significant changes through successional change, from bare ground and grassy stages (e.g. after burning or tree clearing), to mature, dense ericaceous-dominated heath, and, potentially, scrub or acidic woodland. These different stages often co-occur on a site. Lowland heathland in favourable condition (JNCC 2009) should have an ericaceous dwarf shrub layer of varying height and structure, along with some or all of the following, depending on environmental and/or management conditions: areas of bare ground; an herbaceous component; lichens and bryophytes; gorse; bracken; and scattered and clumped trees and scrub. It is usually associated with other habitats, such as acid grassland, mire or woodland. The occurrence of habitat mosaics at all spatial scales is important to provide niches for different stages in the life cycle of all characteristic species. The presence and numbers of characteristic birds, reptiles, invertebrates, vascular plants, bryophytes and lichens are also important indicators of habitat quality.

Locally, in areas of chalk and limestone, there are interesting communities intermediate between lowland acidophilus heathland and calcicolous grassland. In the East Anglian Breckland, a patchy overlay of blown sand on chalky till gives a range of community types from calcicolous grassland to acidophilus dwarf shrub heath, sometimes in an intimate mixture. Similarly, limestone heathland is found where thin soils with acidified and decalcified upper horizons have developed over calcareous bedrock, for example in a few small areas of the South Downs. Some heathland types characteristically have lower dwarf shrub cover, such as certain heaths in inland dune habitats or some Breckland grass-heaths, where the percentage of acid grassland is high and dwarf shrubs are less frequent. On the Lizard Peninsula in south-west England, heathlands associated with ultrabasic serpentine rocks occur; these are the only locations where Cornish heath *Erica vagans* is found.

Many lowland heathlands occur in association with woodland of birch *Betula* ssp. and Scots pine *Pinus sylvestris*. The woodland and scrub components, including common gorse *Ulex europaeus*, can have value in their own right and as part of the succession but they usually pose a management problem.

E2. Factors affecting ecological position in the landscape

Based in pollen analyses, Webb (1986) pinpointed the appearance of heathland landscapes in various parts of England from the Neolithic to the Bronze Age, about 5,000-3,000 BP. However, heather *Calluna vulgaris* and grasses indicating a more open landscape began to increase much earlier, about 7,000 BP in parallel with a decrease of tree cover. Prior to that, heather and other heathland species are likely to have been restricted to woodland glades on poor soils, clearings and

forest edges where there was enough light. They would have been abundant above the tree line and on dune heaths, and on bogs when their surfaces were drier (Gimingham 1960).

As indicated in the previous section, most lowland heathlands are restricted by edaphic requirements to oligotrophic, podzolic or shallow peaty acidic soils (pH 3.5 – 5.5). Some of these soils originated as a result of centuries of exploitation in the form of vegetation removal (trees, shrubs, turves), by cutting and/or burning and grazing by livestock. Those interventions resulted in soil acidification and erosion, and nutrient losses.

On wet heathlands, human intervention mainly meant turf removal for fuel or animal bedding and drainage for agricultural intensification. Turf removal may have brought the water table closer to the surface, resulting on a loss of species which cannot survive root waterlogging, such as heather, which would have then been restricted to hummocks and drier areas above the water table (Gimingham 1960). Drainage, on the other hand, had the opposite effect, ie benefiting species more adapted to drier conditions.

The current lowland heathland distribution, which is only about 20% of that in the 19th C (HMCO 1994), is the result of losses and fragmentation due to urban development, afforestation, agricultural intensification and neglect. Much of the remaining resource lacks some of the structural niches it had in the past, when heathlands were part of a subsistence agriculture and were exploited much more intensively. Today's heathlands are, in general, less open, more homogeneous and in many cases lack bare ground or peat which was a by-product of use and disturbance.

On the other hand, management or current use involving drainage, burning and grazing may result in floristic convergence of various vegetation types (upland and lowland, dry and wet), even under diverse environmental conditions (Gimingham 1960, Rodwell 1991).

E3. Ecological function and relationships

The concept of ecological and spatial hierarchy is explained in the main report (Section 2), using an example of river habitats. As for the rivers, many of the characteristic heathlands organisms live at micro-habitat scale (from few cm to few m) but require larger scales to fulfil their life cycle (tens to hundreds of hectares) (Figure E1). As Webb *et al.* (2010) indicated, more than half the priority species associated with lowland heathland require bare ground and early stages of succession and only a few require ericaceous species. Thus being aware of the species needs and integrating conservation advice at all scales would be most helpful for the management and conservation of this habitat and its characteristic species.

10^3 m

Heathland SITE within the landscape: mosaic of wet and dry heathland, wooded and grassy areas, bracken, etc. Used by e.g. birds (nightjar, woodlark) which can move from site to site.

10^2 m

South facing SLOPE with a diverse vegetation structure. Used by e.g. reptiles constrained to each site.

10^1 m

AREA with diverse vegetation composition, including areas of bare ground, grass, flowering plants, shrubs (and trees and temporary water in some areas).

10^0 m

South-facing MICRO-CLIFF with loose sand. Used by nesting invertebrates, which will hunt at larger scale.

10^{-1} m

Areas of MICRO-DISTURBANCE (e.g. a cow print) in appropriate substrate, under the right vegetation structure (grazed *Molinia*) where species can germinate (in this case *Lycopodiella inundata*)

Linear Spatial space

Figure E1. Heathland habitat hierarchy.

E4. Current geographical distribution and status

Figure E2 shows the distribution of lowland heathland stands according to the most recent Priority Habitat Inventory data. Unfortunately, there are still many errors in the PHI: e.g. sites wrongly mapped as heathland; excessive fragmentation in the digitalisation (a heath stand with a path through it is usually mapped as two parcels, rather than one; this has resulted in over 42,000 heathland parcels, which is unrealistic and unhelpful); some upland heaths are mapped as lowland and (probably) *vice versa*; some heathlands in unfavourable condition due to excess tree cover have been mapped as "woodland".

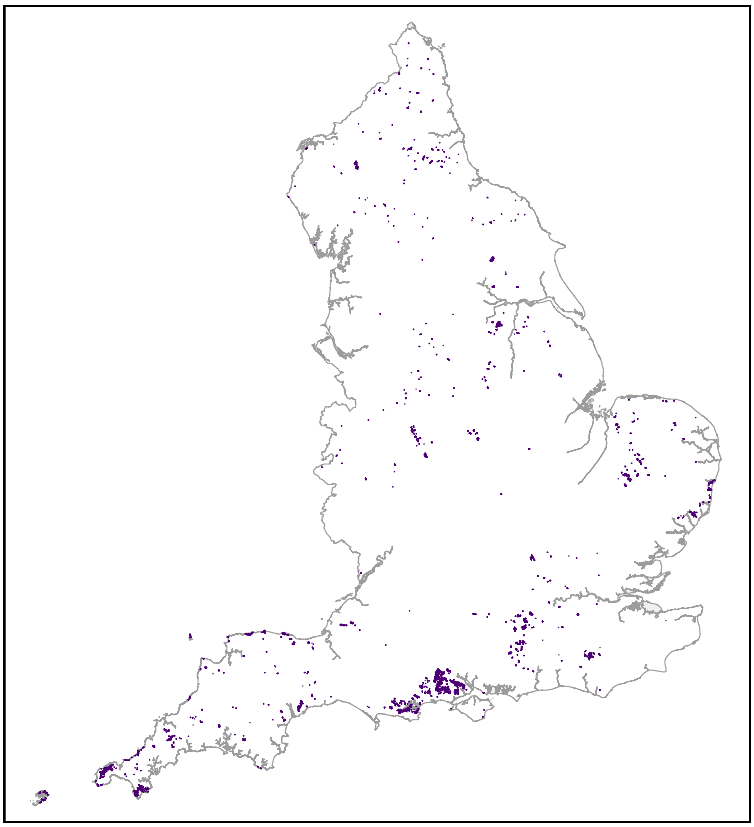

Figure E2. Lowland heathland distribution map in England (parcels ≥5 ha) according to the Priority Habitat Inventory.

Figure E3 shows the current reasons for unfavourable condition as recorded in Natural England's condition reporting system for designated sites. Although some categories are rather vague, it clearly indicates that there are significant problems with e.g. disturbance, invasive species and hydrology. However, this graph does not show the sites in "Unfavourable Recovering Condition", because advisors do not need to record the reasons for unfavourable condition for these sites.

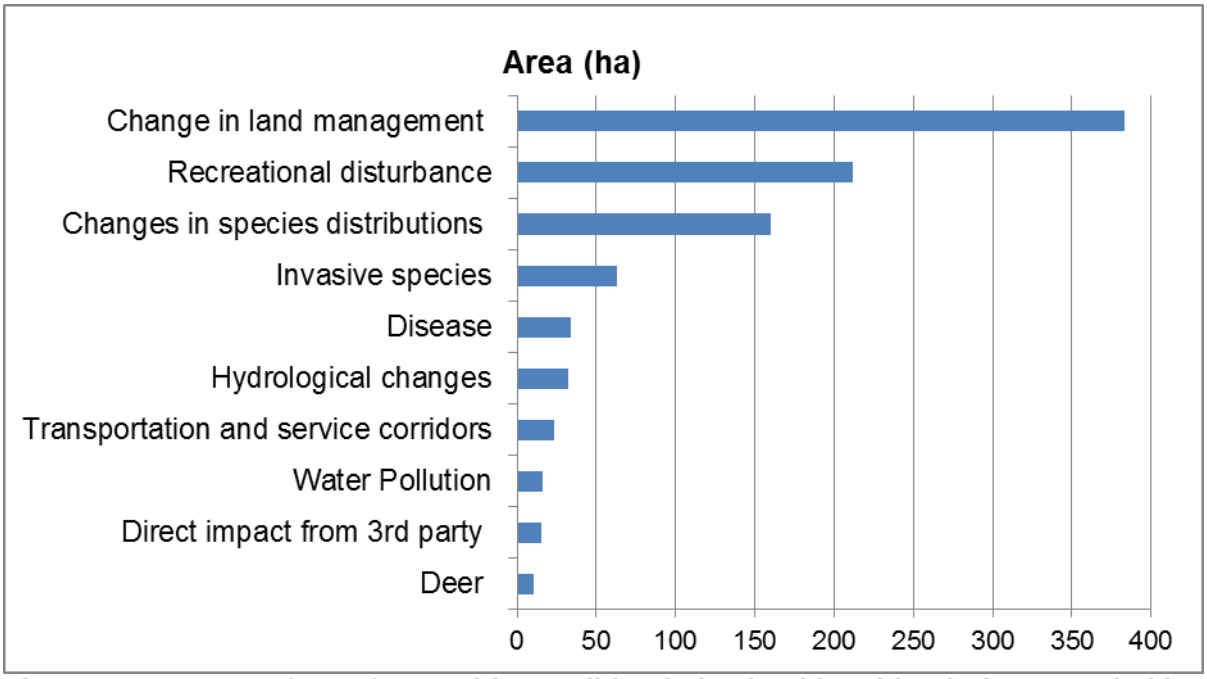

Figure E3. Reasons for unfavourable condition in lowland heathlands (as recorded in Natural England's condition reporting database, August 2016).

E5. Potential for restoration of natural function

Heathland is a classic plagioclimax habitat: human management activities prevent natural successional processes from proceeding through to the creation of woodland, which would result in the loss of many of its characteristic species and therefore an overall loss of biodiversity.

It is therefore not helpful to refer solely to "natural function or processes" when talking about an eminently cultural habitat such as lowland heathland. However, the following actions related to soils and hydrology would generally help to improve heathland condition (Tables E1-4):

- Maintaining or restoring the site hydrology by removing artificial drainage and/or addressing blockages to water movement in the catchment. The aim would be to have fully functional transitions from dry to wet heath and further into mire which allow the movement of species between niches. A practical example could be to install a culvert or raised boardwalks, rather than compacting the ground or importing material to facilitate public access.

- Reducing water pollution and atmospheric deposition of nutrients such as nitrogen, so less competitive and characteristic heathland species, including heather, won't be outcompeted. This would ensure that oligotrophic soils are not unduly influenced by nutrient enrichment.

- Introducing when possible livestock grazing, mimicking (up to a point) the impact of long-lost large herbivores. This would contribute to develop a fine-scale, heterogeneous structure and to the maintenance of species which require small scale disturbance and bare ground/peat.

Projects that have aimed to re-create lowland heathland on sites where there have been significant land use changes, e.g. to arable land, have required a long period of soil amelioration, usually to reduce nutrient loads and pH. The original soil structure is likely to have been destroyed but in freely draining soils that may not be an impediment to restoration.

In order to avoid physical damage to the soil (and other features), restoration and conservation management should follow the advice in Hawley *et al*. (2008). This report recommended:

- investigating the initial condition (land use, soil characteristics and potential archaeology) involving relevant experts;

- evaluating the potential impact of the intervention versus the value of the soils and the habitat to be restored; and
- applying the most appropriate techniques to reduce disturbance and increase efficacy.

However, as shown in Figure E3, the interventions which would make the largest difference in terms of heathland condition are those depending on maintaining or re-introducing appropriate management to maintain an open vegetation cover; and those aiming to reduce the impact of disturbance.

Table E1. Prevalence of state ('natural function') within the habitat resource: lowland wet heathland. (Judgements relate to the most prevalent state of naturalness out of the three categories used)

	Hydrology	**Nutrients**	**Soil/sediment**	**Vegetation control**	**(Non-native) Species composition**
State of naturalness: High/Moderate/Low	Moderate	Moderate	High	Low	High
Confidence	*High*	*High*	*Low*	*High*	*High*
Comments	*Hydrology is a key process but many sites show signs of artificial drainage from past activities (forestry, cultivation, access-related)*	*Point nutrient* pollution *and atmospheric N deposition. There is relatively good information on the impacts of nutrient inputs on lowland heathlands*	*Soil 'health' expected to be moderate for wet heathlands but unavailable evidence one way or the other.*	*Favourable condition on many wet heathlands is achieved by management: mainly cutting or livestock grazing*	*Some wet heaths may have populations of non-native species (e.g .pitcher plants) but the main threat is from natural succession and excessive cover of native scrub species*

Table E2. Restoration of 'natural function': lowland wet heathland.

	Hydrology	Nutrients	Soil/sediment	Vegetation control	(Non-native) Species composition
Desirability	Yes	Yes	Yes and No	No	Yes
Comments	Hydrology is a significant issue for this habitat	Reduce or eliminate excess nutrients (both from atmospheric and other sources) to below critical loads	Soil structure and biota are valuable attributes supporting favourable condition (although they are not regularly monitored)	Some level of "naturalness" may be achieved by grazing by livestock, but further interventions are likely to be needed (e.g. burning, cutting)	Management and control measures are needed to reduce the cover and impact of non-native species and facilitate the establishment of semi-natural species assemblages.
Conservation constraints	None	'Natural' nutrient levels are generally a shared conservation goal across all habitats and species	Some level of superficial disturbance is desirable to provide a supply of bare peat but lower soil horizons/peat should not be disturbed	Potential conflicts with objectives for scrub/woodland habitats occurring in a mosaic	None

Table E3. Prevalence of state ('natural function') within the habitat resource: lowland dry heathland. (Judgements relate to the most prevalent state of naturalness out of the three categories used)

	Hydrology	Nutrients	Soil/sediment	Vegetation control	(Non-native) Species composition
State of naturalness: High/Moderate/Low	High	Moderate	High	Low	Moderate
Confidence	*High*	*High*	*Low*	*High*	*High*
Comments	*Hydrology not a key process for a dry habitat over (generally) acid rocks/superficial deposits*	*Point nutrient* pollution *and atmospheric N deposition. There is relatively good information on the impacts of nutrient inputs on lowland heathlands*	*Soil 'health' expected to be moderate for dry heathlands but unavailable evidence one way or the other.*	*Favourable condition on dry heathlands is achieved by management: cutting, burning or livestock grazing*	*Non-native species such as Rhododendron or Gaultheria are still abundant in some heaths (mainly in the periphery of heath stands) although there has been a big control effort over recent decades*

Table E4. Restoration of 'natural function': lowland dry heathland.

	Hydrology	Nutrients	Soil/sediment	Vegetation control	(Non-native) Species composition
Desirability	No	Yes	Yes and No	No	Yes
Comments	Hydrology not generally a significant issue for this habitat but see constraints below	Reduce or eliminate excess nutrients (both from atmospheric and other sources) to below critical loads	Soil structure and biota are valuable attributes supporting favourable condition (although they are not regularly monitored)	Some level of "naturalness" may be achieved by grazing by livestock, but further interventions are likely to be needed (e.g. burning, cutting)	Management and control measures are needed to reduce the cover and impact of NNIS and facilitate the establishment of semi-natural species assemblages.
Conservation constraints	Certain associated habitats may be hydrologically 'dependent' such as wet heathland and mires	'Natural' nutrient levels are generally a shared conservation goal across all habitats and species	Some level of superficial disturbance is desirable to provide a supply of bare ground but lower soil horizons should not be disturbed	Potential conflicts with objectives for scrub/woodland habitats occurring in a mosaic	None, most NNIS produce a dense understory where little else can survive.

E6. Provision of habitat for particular species

E6.1 General

Webb *et al*. (2010) identified 133 priority species which were associated with lowland heathland (Figure E4), the highest number for any individual priority habitat. Contrary to what might be expected, only 9% of them were associated with heathers, whereas 53% required bare ground and early stages of succession.

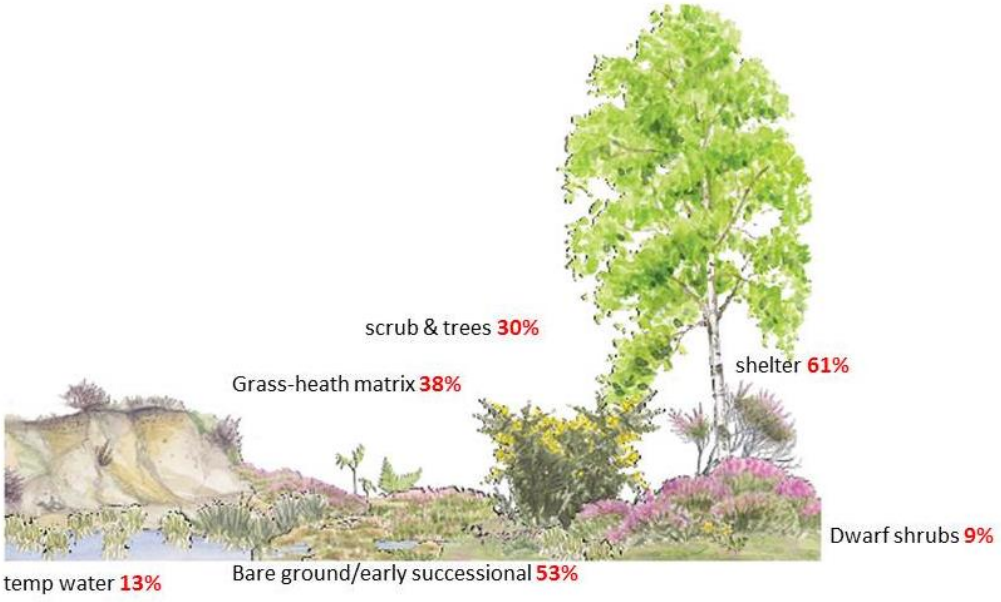

Figure E4. Niches requires by priority species associated with lowland heathland (data from Webb *et al*. 2010).

Table E5 indicates the number of species by taxonomic group, with invertebrates being the most numerous group. The report also indicates that many of these species are of a southern or south-western distribution.

Table E5. Species numbers across different taxonomic groups - lowland heathland (from Webb *et al*. 2010).

Taxonomic group	No. species
Fungi	1
Lichens	3
Bryophytes	10
Vascular plants	21
Invertebrates	82
Amphibians/reptiles	6
Birds	10

Therefore, ensuring that the warmer southern heaths have a good structural diversity through appropriate management will help to achieve favourable condition for both the habitat and the species.

E6.2 Invertebrates

As indicated above, lowland heaths are a very important habitat for invertebrates, which account for 62% of all species associated with this habitat. The niches shown in Figure E4 are very important components of heathland for invertebrates and it is especially important that several (or all) of these occur in small-scale habitat mosaics to give a good structural diversity and ensure that the full suite of invertebrates associated with this habitat is catered for. As mentioned in Section E6.1, a large number of the invertebrates associated with heathlands require bare ground and early successional areas, but many of these will also visit flowers growing in the grass-heath matrix and dwarf shrub niches to collect pollen and nectar (for example the heath bumblebee *Bombus jonellus* and other bumblebees, butterflies, moths). The silver-studded blue *Plebejus argus* uses flowers such as heathers as a nectar source and also as a larval foodplant, but it also requires taller vegetation for shelter and use bare ground/ very short vegetation for egg laying and basking. Thus it requires good areas of many of the niches shown in Figure E4. Many of the specialised heathland invertebrates that are primarily associated with one of these niches will also use others. However, the ground-dwelling invertebrates are the group that are more or less restricted to the bare ground/ early successional niches (e.g. Heath Tiger Beetle *Cicindela sylvatica* and Heath Grasshopper *Chorthippus vagans*.

Not all heathland specialist invertebrates are associated with bare ground. The dragonflies and damselflies associated with heathlands require permanent pools (e.g. Four-spotted Chaser *Libellula quadrimaculata)*, pools in streams (e.g. Golden-ringed Dragonfly *Cordulegaster boltonii*); shallow flowing water in runnels and small streams (e.g. Southern Damselfly *Coenagrion mercuriale*) or small pools in sphagnum bogs (e.g. small red damselfly *Ceriagrion tenellum*). All these species will use the grass-heath and dwarf shrub matrices for hunting other insects and the larger dragonflies will use shrubs for shelter.

Left alone, natural succession would quickly revert heathland to scrub and then woodland; therefore active intervention in the form of management is essential in order to maintain it. The ideal management is grazing with livestock, preferably cattle or Exmoor ponies rather than sheep. Cattle and Exmoors graze by tearing up clumps of grass, which leads to variation in the sward height, and being heavier their hooves cause localised poaching which maintains small and regular patches of bare ground. Sheep on the other hand nibble the grass and act a bit like lawnmowers, producing a rather short, uniform sward, reducing the structural diversity. It is also important not to overgraze, whatever stock are used. Some parts of the New Forest are heavily grazed with new Forest Ponies (which are less hardy than Exmoors and graze more like sheep) and in many areas they have reduced extensive areas to short grass swards which resemble lawns and, while being good for the bare ground and early succession specialists, will not support anything like the full community of invertebrates. Locally, rabbits may have the same effect.

E6.3 Bryophytes

Bryophytes in lowland heathland may occur at lower species diversity than some other habitats, but are often conspicuous, and robust pleurocarpous mosses such as *Hypnum jutlandicum, Pleurozium schreberi, Hylocomium splendens* and *Dicranum scoparium* may occur at high cover within the vegetation. In open heathy ground pioneer species such as *Polytrichum juniperinum* and *Ceratodon purpureus* can be abundant, as can the introduced carpeting moss *Campylopus introflexus*. In wetter areas the moss *Polytrichum commune* may grow to a height of nearly half a metre.

Maritime lowland heathland is influenced by salt spray, and provides a refuge for some rarer Section 41 species such as the liverworts *Cephaloziella dentata* and *Riccia bifurca* in damp unshaded hollows and tracks on the Lizard peninsula in Cornwall. Another Section 41 species, the moss *Dicranum spurium*, shows a preference for damp heath, often on sloping ground.

The restoration of natural processes on areas of lowland heathland is in many cases likely to be beneficial for bryophytes, for example extensive grazing by hardy cattle or ponies helps keep the vegetation structure open, creates suitable microhabitats, and prevents the bryophytes from being overwhelmed by taller vegetation and the build-up of litter. Stocking rates should be well controlled, and overgrazing should be avoided. Bare ground creation is likely to benefit the pioneer species of open ground, such as the smaller *Polytrichum* mosses, however soil stripping needs to be undertaken with caution to avoid existing locations of uncommon species. Burning of lowland heathland similarly needs to be undertaken with caution. A rapid burn over damp heathland soil may not be too harmful, however prolonged hot fires that burn into the upper soil layers are extremely damaging, and the bryophyte flora may take decades to recover after such events, with some species possibly never returning. The decline of the Section 41 moss *Dicranum spurium* in Britain is considered to have been at least in part caused by the burning of lowland heathland.

E6.4 Birds

A range of Section 41 bird species use lowland heathland habitats for at least part of their life cycle (Table E6).

Table E6. Section 41 bird species strongly associated with heathland habitats. (B = breeding, NB = non-breeding)

Species	Breeding status	Lowland heathland habitat
Hen Harrier	NB	Extensive tall heather
Stone-curlew	B & NB	Grass-heath mosaics (Breckland)
Curlew	B & NB	Grass-heath mosaics (Breckland and New Forest)
Cuckoo	B	Scrub and heath areas supporting host species
Nightjar	B	Bare ground and heath/woodland transitions, some bracken
Woodlark	B	Bare ground/short vegetation and tussocks
Skylark	B & NB	Grass-heath mosaics
Tree Pipit	B	Heath/woodland transitions
Grasshopper Warbler	B	Open scrub
Linnet	B & NB	Scrub/heath mosaics

Short-grazed acidic grass-heaths are important breeding habitats for the scarce and restricted stone-curlew, where bare areas and very short vegetation are important for nesting and foraging. Extensive open areas, free from disturbance, are necessary. Woodlarks have a similar requirement, though they also need some taller heather or grass tussocks for nesting. Curlews are very restricted, with small numbers breeding in the New Forest and the Brecks. They require extensive undisturbed areas with a mosaic of taller vegetation for nesting and short vegetation for foraging and chick-rearing.

Skylarks and meadow pipits, the latter a brood host species for cuckoos, require open areas of grass-heath mosaics. Other breeding species require some taller vegetation in the form of bracken, open scrub and scattered trees in a mosaic with open heathland. Nightjars in particular need bare ground amongst taller vegetation for nesting and woodland edge for foraging. Tree Pipits similarly require scattered bushes and trees and both Grasshopper Warblers and Linnets require some scrub habitat for nesting. Hen harriers, which roost on some heathlands during the non-breeding season, require extensive, undisturbed areas of tall cover provided by tall heather, grasses and rushes.

Extensive grazing by livestock is essential to create and maintain suitable conditions for those species requiring a mosaic of short vegetation and taller grass and/or heather. Also, some natural succession to allow the development of open scrub, scattered trees and small wooded areas, or patches of gorse, will benefit many heathland bird species and increase diversity.

Nutrient enrichment from atmospheric and diffuse pollution could be a significant problem in some areas if it encourages vegetation growth to the point where grassland conditions become unsuitable for these species. The restoration of natural process, such as the natural regeneration of open scrub and early tree growth where compatible with other objectives, and more extensive, traditional management would benefit many breeding bird species associated with lowland heathland.

E7. Key messages

1. Consideration of natural function as a biodiversity integration rationale needs to recognise that heathland vegetation has been created by traditional pastoral management over millennia plus activities such as turf and shrub cutting.

2. This said, heathland habitats have important abiotic relationships with natural function.

    - They can only occur on appropriate soil types, and habitat restoration and re-creation has to work within these constraints.
    - Generating an ecologically appropriate balance of wet and dry heathland is best pursued through restoration of natural hydrological function in sites.
    - Today's heathlands are likely to survive under higher nutrient loads than was the case historically, from atmospheric (traffic and industrial), agricultural and other land management sources (e.g. fertiliser runoff from golf courses); or even from nutrient cycling from advanced stages of succession (e.g. under secondary woodland, scrub or gorse). Restoration of more natural nutrient levels will help to restore characteristic vegetation.

3. Heathlands are cultural landscapes which exist because of regular management interventions to: a) provide a diverse vegetation structure and the specialised niches that many species require; and b) reset the natural successional processes. If left alone, natural vegetation succession would transform the heathland into woodland with the loss of the species which require open vegetation structure. Management approaches that mimic natural vegetation controls (through herbivory) help to generate the best heathland vegetation mosaics.

4. The main approach to achieve favourable condition of the habitat and its associated species is to ensure that there is structural diversity including small areas of bare ground in vegetation mosaics, scrub and different sward heights and openness; links with adjacent habitats, such as woodlands and wetlands; patches of nectar-rich flowers and uncut/ungrazed tall vegetation to provide important feeding and overwintering areas for invertebrates, reptiles and other species; and temporary pools. Restoration of natural hydrological function, through drain-blocking, is

needed in some cases to restore mosaics of wet and dry heath, in association with mire and freshwater habitats (pools runnels and streams).

5. Evidence of historical heathland vegetation cover is important to the success of heathland restoration and re-creation, and future projects should focus on sites with historical records of heathland vegetation.

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