3.2.2.4. Trees and scrub

The principals applied to dry heath in relation to the presence of trees and large shrubs also apply to wet heath.

3.2.2.5. Grades of unfavourable vegetation condition

Table 6 Wet Heath
Vegetation condition grading system

Criteria	Favourable (0 points)	Unfavourable (1 point)	Unfavourable (2 points)	Unfavourable (4 points)
Dwarf-shrub cover	51 - 75%	>75% or 26 - 50%	5 - 25%	<5%
Range of dwarf-shrubs	2 or more spp widespread & frequent	no more than 1 spp widespread & frequent		
Bryophyte abundance	frequent patches		occasional patches	rare
Age structure	> 50% excluded from burning	< 50% excluded from burning		
Graminoid cover	< 50%	50 - 75%	> 75%	
Alien trees & scrub	< 5 per 25ha	> 5 per 25ha		
Grazing impact	light	moderate	heavy	

3.3. Blanket and raised mires

3.3.1. Definition:

Any vegetation on blanket or raised peat bodies deeper than 0.5m should be assessed using these criteria. This will include not only typical ombrotrophic mire vegetation composed of a mix of *Eriophorum vaginatum, Scirpus cespitosus, Molinia caerulea, Sphagnum* spp. and ericoid dwarf-shrubs (*Calluna vulgaris, Erica* spp, *Vaccinium* spp. and *Empetrum nigrum*), but also vegetation superficially resembling dry heath on deep peat and other degraded forms where Sphagna and/or dwarf-shrubs may be absent. In addition to this, any vegetation in which *Eriophorum vaginatum* is more than occasional should be assessed as blanket and raised mire.

The following discussion deals mainly with blanket mires as these are the most widespread of the two mire types included here. However, much of what is said should also be applicable to upland raised mires.

The majority of English blanket mire on the Pennines belongs to the drier *Calluna vulgaris - Eriophorum vaginatum* type (Rodwell 1991) and its degraded derivatives. The wetter *Scirpus cespitosus - Eriophorum vaginatum* type is largely confined to the extreme west. As a result, the criteria tend to be biased towards favourable Pennine blanket mires. However, trials have shown that the criteria will also identify the better areas of western blanket mires and should also apply to upland raised mires.

3.3.2. Rationale

3.3.2.1. Sward composition

Blanket mire in good condition will have a fairly equal mix of bryophytes, including *Sphagnum* spp., dwarf-shrubs and graminoids, though exact proportions will vary according to local conditions. The criteria are designed to exclude stands where this balance has been unfavourably shifted by anthropogenic factors.

Although we have referred to a balance between these three groups, in practice there is no upper limit to the abundance of *Sphagnum* in a mire. Generally speaking, the higher the cover of *Sphagnum*, especially of species such as *S. magellanicum, S. capillifolium* and *S. papillosum*, the better a mire is likely to be. The majority of the blanket mire in England is found in the Pennines. The type of blanket mire found here appears to have a naturally lower *Sphagnum* content than may be expected, and pleurocarpous mosses frequently make up a significant proportion of the bryophyte layer. The wetter western type of blanket mire does occur in the extreme west of England on Dartmoor and Exmoor and in isolated but extensive stands in the Lake District. A long history of inappropriate management has, however, led to remnants of recognisable blanket mire vegetation being limited in extent in the two former areas, although blanket peat is extensive. Consequently, the abundance requirement for Sphagna is not as high as might be expected by those familiar with the wetter blanket mires of north-west Scotland. Even at the level set by our criteria, the majority of Pennine blanket mires are liable to be recorded as unfavourable. However, to lower this limit further would be to accept too high a level of degradation.

As with bryophyte cover, there is no upper limit to dwarf-shrub cover. Blanket and raised mires in good condition can have very high cover of dwarf-shrubs provided they still retain a good cover of *Sphagnum* and other bryophytes below the dwarf-shrubs. It is only where conditions are such that mires fail on the bryophyte criterion that mires with high dwarf-shrub cover are likely to be in unfavourable condition. As with dry heath, it is considered that the dwarf-shrub element in these mires should consist of several species and not have one species, most likely *Calluna*, as overwhelmingly dominant. It should be noted that in the wetter parts of mires dwarf-shrub growth, especially that of *Calluna*, can be inhibited by the high water levels, such that plants are stunted and are only a minor component of the vegetation. These conditions are common in good quality western blanket mires, mires on the Scottish border, central parts of raised mires and wetter areas in Pennine blanket mires. Stands exhibiting these features will be in favourable condition where they are accompanied by high *Sphagnum* cover.

Several graminoid species may become abundant or dominant in blanket mires under unsympathetic management regimes; consequently any predominance of these species is considered to be undesirable. An exception to this is found in some of the "border mires" in Northumberland and Cumbria where *Molinia caerulea* can attain very high abundance but the mire still has a very high cover of *Sphagnum* species and appears to be in good condition. It is not clear here whether this high cover of *Molinia* is the result of past management or whether it is the consequence of the mires being very wet, so reducing the cover of dwarf-shrubs.

3.3.2.2. Sward structure

As in wet heaths, dwarf-shrub cover, at least of *Calluna*, is maintained by layering. This will tend to produce a relatively even looking sward with no obvious patches of different age classes. Indeed, it may be difficult to distinguish the different growth phases, with most plants tending to look as if they are in the late building phase or the mature phase. Additional

Table 7 Blanket and raised mires
Criteria for favourable vegetation condition

(for vegetation to be favourable all criteria must be met)

- Bryophytes should be abundant and must include *Sphagnum* spp.
  Sphagnum spp. must be both frequent and widespread in the stand and not restricted to hollows, forming at least occasional lawns or hummocks.
- Cover of dwarf-shrubs must be greater than 33%, except in wetter areas where *Sphagnum* spp. are abundant and forming lawns.
- A range of dwarf-shrub species should be present, no one dwarf-shrub species should be dominant to the exclusion of all others and at least one species other than the dominant species, should be frequent and widespread in the sward.
- *Molinia caerulea, Eriophorum vaginatum, Scirpus cespitosus, Deschampsia flexuosa, Juncus squarrosus* or other graminoids should not dominate over dwarf-shrubs.
  The cover of graminoids should not exceed 50%, unless *Sphagnum* spp. are abundant/co-dominant and forming lawns below *Molinia*.
- Little or no bare ground, or bare ground carpeted by *Racomitrium lanuginosum, Polytrichum* spp, *Campylopus* spp, crust forming lichens or algal mats (found only after widespread and intensive searching). $_{SNH}$
- No erosion associated with human impacts (e.g. drainage, fires, peat extraction, recreational activities or military training).
- No trees or scrub on the peat body.
- Peat extraction absent (areas of cut peat which have revegetated with good mire vegetation which meets the other criteria for favourable vegetation condition may be acceptable).
- Grazing impacts should be light
  (An absolute maximum of 5% of the grazing unit may show signs of current heavy grazing).

Indicators of light grazing:	Widespread and abundant flowering of *Eriophorum* spp. $_{SNH}$
	No evidence of encroachment by graminoid species such as *Juncus squarrosus, Deschampsia flexuosa* or *Nardus stricta*. $_{SNH}$
	Sphagnum carpets extensive, not patchy or localised. $_{SNH}$
	No obvious grazing of *Calluna vulgaris* or *Vaccinium myrtillus*. Grazed shoots difficult to find without both intensive and extensive searching. $_{SNH}$
	Upright growth of *Calluna vulgaris* and *Vaccinium myrtillus* with regular but infrequent branching. Bush canopy open, not a tightly packed mass of contorted shoots. Very few or no instances of "drumstick", "topiary" or "carpet" growth forms. $_{SNH}$
	Little or no evidence of trampling of *Sphagnum* hummocks or carpets. $_{SNH}$
	At most only very localised occurrence of trampled bare ground, including animal paths and enhanced hagging. $_{SNH}$

SNH denotes field indicators taken from MacDonald *et al.* (in press)

structural diversity may be present in blanket mires due to the presence of pools, *Sphagnum* lawns and soakways, amongst other features.

3.3.2.3. Drainage

While moorland drainage produces no significant benefit for livestock grazing or game rearing, it can have a damaging effect on the nature conservation interest of blanket mires by reducing the cover of *Sphagnum* up to several metres from a drain, often to the point of elimination (Stewart and Lance 1991). The effects of drains appear to vary according to a number of factors including the distance between drains (the closer together the drains the more effective they are), rainfall (areas with higher rainfall may be less affected by drains), the hydraulic conductivity of the sub-surface peat (the greater this is the more effective drains are likely to be) and land management. It is, however, over-simplistic to make generalisations to cover all mire types (Stewart and Lance 1991).

In terms of vegetation condition the most significant effect of drainage will be its potential to reduce the cover of *Sphagnum*, though Stewart and Lance (1991) found that it could take over twenty years for this effect to become apparent on blanket mire at Moor House. It is interesting to note that Stewart and Lance (1991) found that drainage had no measurable effects on the cover of *Calluna*, but *Eriophorum* spp. showed decreases in cover downslope of drains. Additionally, Thompson *et al.* (1995) and Thompson and Miles (1995) suggest that drainage can result in the conversion of blanket mire vegetation into both wet and dry heath vegetation on deep blanket peat.

3.3.2.4. Burning

Burning is not required to maintain blanket mire or raised mire vegetation; neither is it required to maintain the cover of *Calluna*. On blanket mire, *Calluna* is maintained in a "steady state" by vegetative layering and the continual burial of above-ground stems by Sphagna and other bryophytes. This process keeps the age of above-ground stems low, with an unevenly aged structure, and prevents *Calluna* plants entering the degenerate growth phase (Hobbs 1984).

Burning can have a major effect on blanket mire vegetation and, when combined with high grazing levels, can convert blanket mire to dry heath vegetation on deep blanket peat (Thompson *et al.* 1995 and Thompson and Miles 1995).

Frequent burning, even in the absence of high grazing impacts, will tend to favour graminoids over *Calluna* and can lead to the replacement of the latter by species such as *Eriophorum vaginatum* and *Molinia caerulea* (Hobbs 1984). This may well account for the dominance of *Molinia* over large areas of blanket peat in Dartmoor. *Scirpus cespitosus* is also favoured by frequent burning.

Severe fires often lead to erosion as they can result in the removal of the acrotelm (the permeable surface layer of peat) and its replacement with a surface layer of algae which is far less permeable. This results in an increased flow of water over the surface and erosion (Coulson *et al.* 1992; see Section 3.3.2.7).

There appear to have been no specific studies on the effects of controlled burning on either Sphagna or invertebrate communities on blanket mires (Shaw *et al.* 1996). However there is a general presumption that as far as Sphagna are concerned any effects are likely to be detrimental.

There is some disagreement as to the suitability of burning as a management tool on blanket mire (Shaw *et al.* 1996), but many authors (Hobbs 1984, Hobbs and Gimingham 1987, Coulson and Fielding 1992 and MacDonald 1996 to name a few) have questioned the appropriateness of rotational burning on blanket mire where nature conservation is the principal objective. Further more, Hobbs (1984) states that the beneficial effects for red grouse and sheep produced by controlled burning of dry heath do not occur on blanket mires. This brings into doubt the need to burn blanket mire at all.

It is doubtful that rotational burning is compatible with maintaining blanket mire in favourable nature conservation condition as defined here and we have concluded that fire should not be used as a management tool where nature conservation is the primary management objective. Where other objectives take priority, it is suggested that burning should not be carried out at frequencies greater than every 25-35 years and then only under carefully controlled conditions and never at altitudes greater than 500m.

3.3.2.5. Grazing

Grazing by sheep can have significant effects on blanket mire vegetation and can lead to a reduction in cover of *Calluna* and an increase in cover of bare ground at stocking levels greater than one ewe per hectare (Grant *et al.* 1985). Grazing, in combination with burning, is widely regarded as being responsible for the preponderance of *Eriophorum vaginatum*-dominated blanket mire over the southern Pennines (Birks 1988). Thompson *et al.* (1995) and Thompson and Miles (1995) suggest that as well as being able to convert blanket mire to either wet or dry heath in combination with burning, grazing alone may convert blanket mire to *Juncus squarrosus* grassland.

Sheep will, however, tend to graze other vegetation types in preference to blanket mire (Rawes and Heal 1978) so that, where there is unrestricted access to a variety of habitat types, grazing impacts may only be noticeable on the interfaces of areas of blanket mire and more preferred vegetation types such as grasslands and flushes. This selectivity in grazing will, however, decline as stocking rates increase.

3.3.2.6. Atmospheric pollution

Deposition of pollutants such as sulphur dioxide and nitrogen oxides produced following the onset of the industrial revolution is generally regarded to be the main cause for the general absence of Sphagna in the blanket mires of the southern Pennines and locally elsewhere. While levels of sulphur deposition may be declining, deposition of nitrogen oxides is currently increasing and is likely to be having a continued effect on the vegetation of blanket mires and other upland vegetation in the southern Pennines and further afield (Lee *et al.* 1988).

3.3.2.7. Erosion

Some erosion on blanket bog is almost certainly natural, such as marginal fretting on breaks of slope. However, much of the erosion seen on the blanket mires in England appears to be associated with severe moorland fires. Exposed and burnt peat can take many decades to revegetate during which time the peat may be washed away by rain water. Tallis (1987) has shown that erosion on one blanket mire in the southern Pennines dates back to major fires in the eighteenth century and a subsequent rain storm, indicating that the erosion seen today can have originated several centuries ago. High grazing levels can also exacerbate erosion as they can prevent, or at least slow down, the revegetation process (Anderson and Radford 1994). Erosion can also be caused by moorland drainage channelling surface runoff or through trampling caused either by vehicles or people as, for example, on the military training ranges on Dartmoor or along sections of the Pennine Way.

Large scale erosion on blanket mires must be considered to constitute poor habitat condition, especially where it has been initiated by human activity. Natural erosion features can, however, be a feature of a blanket mire in good vegetation condition provided that other factors, such as heavy grazing, are not exacerbating the process.

3.3.2.8. Peat extraction

Active peat extraction is probably rare on blanket mires in England, though it may be present on raised mires in the uplands. Old peat cuttings, however, are quite frequently encountered on English moors. Shallow peat cuttings frequently revegetate with good mire vegetation (i.e. a high cover of Sphagna) and, where this is so, evidence of past peat extraction need not constitute poor habitat condition. Where extraction has led to the conversion of areas of blanket mire to other vegetation types, bare peat or has resulted in significant erosion, this will constitute poor vegetation condition.

3.3.2.9. Woodland

The planting of trees, especially alien conifers, clearly constitutes poor vegetation condition, particularly as it is likely to be accompanied by drainage operations. Blanket peat developed following tree clearance (Birks 1988). Provided water levels are sufficient to support *Sphagnum* growth, trees and shrubs are unlikely to have been a natural component of blanket mire in good condition, particularly as native broadleaved trees do not appear to be able to invade mires in these conditions (Burgess *et al.* 1995). The presence of any trees on a blanket bog are indicative of low water levels and hence poor vegetation condition.

3.3.2.10. Grades of unfavourable vegetation condition

Table 8 Blanket mire
Vegetation condition grading system

Criteria	**Favourable** (0 points)	**Unfavourable** (1 point)	**Unfavourable** (2 points)	**Unfavourable** (4 points)
Bryophyte abundance	abundant, including frequent & widespread *Sphagnum* spp	frequent to abundant but *Sphagnum* spp occasional - rare	occasional, *Sphagnum* spp more-or-less absent	rare
Dwarf-shrub cover	> 33% except in wetter areas	< 33% except in wetter areas	< 5%	
Range of dwarf-shrubs	2 or more spp widespread & frequent	no more than 1 spp widespread & frequent		
Graminoid cover	< 50%	51 - 75%	> 75%	
Extent of bare ground or ground covered by algal mats *etc.*	none	present	extensive	ubiquitous
Erosion features associated with human impacts	none	present	extensive	ubiquitous
Trees & scrub	none	present		
Active peat extraction (excluding areas revegetated with mire spp)	none	present	extensive	ubiquitous
Grazing impact	light	moderate	heavy	

3.4. Montane moss and lichen heaths

3.4.1. Definition:

Montane vegetation occurs above the natural tree line. This limit varies regionally according to climatic conditions but is generally taken to be around 600m (Pearsall 1950). However, local climatic conditions may lead to considerable variation between individual hills.

There is inevitably a gradation between sub-montane and montane heath. As a general guide, the two habitats can be distinguished floristically by the replacement of the hypnaceous mosses, such as *Hypnum jutlandicum* and *Pleurozium schreberi*, by species such as *Racomitrium lanuginosum* and *Polytrichum alpinum*. *Carex bigelowii*, *Racomitrium* or "bushy" lichens, notably *Cladonia arbuscula* and *C. impexa*, form a significant part of the vegetation in montane heath. Dwarf-shrubs are represented by *Vaccinium* spp. and *Empetrum nigrum* but *Calluna* and *Erica* spp. tend to be absent (note that the general absence of *Calluna* from this type of vegetation in England is probably grazing induced rather than climatic, see Section 3.4.2.1).

Grassland with *Deschampsia flexuosa, Festuca ovina* or *Agrostis capillaris* over the altitudinal limits above should be assessed as montane heath unless there are strong indications that sub-montane criteria should apply.

Montane heath has been identified on Lake District peaks, the North Pennines and Cheviots and may be present elsewhere, particularly in the Yorkshire Dales. Although most of the land above 600m is likely to be blanket mire over the southern Pennines and Dartmoor, some summits may support grasslands on mineral soils and, where such stands are encountered, they should be assessed as montane heath.

Exclusions:
Areas of peat deeper than 0.5m above these altitudinal limits should be assessed as blanket mire (see also definition of sub-montane dry dwarf-shrub heath).

3.4.2. Rationale

3.4.2.1. Sward composition, structure and grazing

A key feature of the vegetation of the *Carex bigelowii - Racomitrium lanuginosum* heath of windswept mountain summits appears to be the abundance of *Racomitrium*. In the Lake District *Racomitrium* tends to be scarce (Jerram 1992), but it is abundant on the summit of Cross Fell in the Pennines. In Scotland, however, the same vegetation tends to have a high cover of this moss (Rodwell 1993). Grazing appears to be the main factor which has led to this loss of *Racomitrium*, though it should be noted that Lee *et al.* (1988) suggest that a general decline in abundance of *Racomitrium* in England may be due to atmospheric pollution.

Equally, the abundance of the bushy *Cladonia* species is a key feature of the *Vaccinium myrtillus - Cladonia arbuscula* community of the slopes just below the summits. The minimum levels set for the cover of *Racomitrium* and lichens in these two communities are high but are considered to be reasonable expectations for this vegetation under significantly reduced grazing levels, as both can be present locally even under the high stocking rates that currently prevail (Jerram 1992).

Grazing can have a profound effect on montane vegetation. High grazing pressure can shift the character of montane heath towards that of sub-montane grassland (Rodwell 1993). MacDonald *et al.* (in press) use increased incidence of grassland species (*Festuca* spp, *Agrostis* spp, *Deschampsia flexuosa, Anthoxanthum odoratum, Poa* spp, *Galium saxatile* and *Potentilla erecta*) as indicators of increasingly heavy grazing impacts in montane heaths. Montane vegetation with a moderately high frequency of these species will be in poor nature conservation condition. High frequencies and extent of bare ground is also indicative of high grazing pressures (MacDonald *et al.* (in press).

Increased sward height allows for more structural complexity in the sward and may lead to increased invertebrate diversity. Again, sward height is highly dependent on grazing intensity. The minimum heights of 5 and 7cm are the mean vegetation heights for *Carex - Racomitrium* and *Vaccinium - Cladonia* heaths recorded by Rodwell (1991 and 1993) and lie in the upper range of the vegetation heights measured by Jerram (1992), suggesting that they are not unrealistic expectations given appropriate grazing levels.

Table 9 Montane moss and lichen heaths
Criteria for favourable vegetation condition
(for vegetation to be favourable all criteria must be met)

- In *Carex bigelowii - Racomitrium lanuginosum* moss-heath the cover of *Racomitrium* should exceed 66% over the whole stand.
- Mean depth of moss/lichen/dwarf-shrub mat, should exceed 5cm in *Carex bigelowii - Racomitrium lanuginosum* moss-heath.
- In *Vaccinium myrtillus - Cladonia arbuscula* lichen-heath "bushy" *Cladonia* lichens (e.g. *C. impexa, C. arbuscula, C. uncialis* and *C. rangiferina*) should contribute >50% of the vegetation cover over the whole stand.
- Mean depth of moss/lichen/dwarf-shrub mat, should exceed 7cm in *Vaccinium myrtillus - Cladonia arbuscula* lichen-heath.
- Grazing impacts should be light.

Indicators of light grazing:	No signs of grazing of any dwarf-shrubs present.$_{SNH}$
	Very little or no signs of grazing of plant parts, except on leaves of *Carex bigelowii* or fine-leaved grasses such as *Deschampsia flexuosa, Festuca ovina* and *F. vivipera* and then less than 10% of green leaves grazed (grazed leaves hard to find after intensive and extensive searching).$_{SNH}$
	Very little or no signs of grazing on leaves of broad-leaved grasses such as *Agrostis capillaris, A. vinealis, Anthoxanthum odoratum* or *Poa* spp.$_{SNH}$
	Fine-leaved grasses such as *Deschampsia flexuosa, Festuca ovina* and *F. vivipera* contribute less than 10% of the vegetation cover in total.$_{SNH}$
	Negligible collective cover of broad-leaved grasses such as *Agrostis capillaris, A. vinealis, Anthoxanthum odoratum* or *Poa* spp.$_{SNH}$
	No more than sporadic occurrence of either *Galium saxatile* or *Potentilla erecta*. (Where grazing intensity has been heavy in past but has now been reduced to favourable levels these two species may be present at more than negligible ground cover but other indicators will suggest light grazing).$_{SNH}$
	Juncus squarrosus absent or very scarce.
	No uprooting of plants.$_{SNH}$
	Dung of grazing animals sparse or absent - less than 5 groups of sheep pellets per 100m^2.$_{SNH}$
	Bare ground (not gravel) largely confined to the parts of the hill most exposed to the prevailing winds. Very little bare ground elsewhere.$_{SNH}$

SNH denotes field indicators taken from MacDonald *et al.* (in press)

Calluna is virtually absent from the montane zone in England except for small areas on Skiddaw and on The Cheviot. Rodwell (1991) suggests that high grazing pressures may have eliminated *Calluna* from English montane heaths. *Calluna* is approaching the altitudinal/climatic limits of its range in the low-montane zone so plants would already be under stress from climatic factors at these altitudes. Moderately high to high grazing impacts would increase stress levels further and greatly reduce *Calluna's* ability to survive in this vegetation.

3.4.2.2. Trampling

Trampling by people and livestock may have a significant effect on montane vegetation, particularly on broad ridges such as those of the Helvellyn range where walkers are likely to fan out over a wider area than on narrower or more rocky ridges. The most significant effect of trampling is likely to be the replacement of characteristic montane species with grassland species more tolerant of trampling. Bare ground is also likely to increase via trampling and, on moderately steep to steep slopes erosion may be initiated as a result of a loss of vegetation cover and destabilisation of the skeletal soils of the montane zone.

3.4.2.3. Burning

Burning is not usually a feature of management in the montane zone and is not justified as *Calluna*, where present, is generally kept short by climatic conditions and will regenerate through layering.

3.4.2.4. Grades of unfavourable vegetation condition

Table 10 ***Carex bigelowii* – *Racomitrium lanuginosum* Montane Heath**
Vegetation condition grading system

Criteria	**Favourable** (0 points)	**Unfavourable** (1 point)	**Unfavourable** (2 points)	**Unfavourable** (4 points)
Cover of *Racomitrium*	>66%	33 - 66%	5 - 33%	<5%
Mean depth of moss/ lichen/dwarf-shrub mat	>5cm	2.5 - 5cm	<2.5cm	
Grazing impact	light		heavy	

Table 11 ***Vaccinium myrtillus* – *Cladonia arbuscula* Montane Heath**
Vegetation condition grading system

Criteria	**Favourable** (0 points)	**Unfavourable** (1 point)	**Unfavourable** (2 points)	**Unfavourable** (4 points)
Cover of *Cladonia* spp	>50%	25 – 50%	5 - 25%	<5%
Mean depth of moss/ lichen/dwarf-shrub mat	>7cm	2.5 - 7cm	<2.5cm	
Grazing impact	light		heavy	

4. Field survey techniques

These vegetation condition assessment criteria have several potential applications. The two main applications will be to provide assistance with, and a degree of standardisation to, the filling out of English Nature's Site Unit Recording Forms (SURFs); and to provide a new survey methodology by which vegetation condition can be mapped and monitored over either whole sites or whole management units. These criteria can then be used as an aid to effective site management.

4.1. Field survey for completing EN Site Unit Recording Forms

To assess the condition of vegetation for a Site Unit Recording Form using these criteria, a minimum of 20% of both the SURF unit and the habitat within that unit must be covered on foot by doing a "W-walk" over the site. It is important that both the core area of the unit/habitat and the margins of the unit/habitat are covered during the assessment walk as impacts are likely to differ across the site. To take this into account, the assessor must cover both 20% of the unit margin and 20% of the core area of the unit.

Prior to making an assessment of a habitat, it is necessary to define the extent of the habitat in the unit as shown in Box 3.

4.2. Site/Management unit surveys

Both nature conservation bodies and land managers often wish to assess how the impacts of various land management practices vary across a management unit prior to formulating management prescriptions. On moorland sites, this frequently involves undertaking a Heather Condition Survey, which maps burning patterns and grazing impacts. The criteria presented here for assessing vegetation condition can be used in a similar manner, particularly if the criteria on which stands, or parts of stands, classified as unfavourable are mapped as well, rather than simply mapping which areas meet the criteria for favourable vegetation condition. Maps of vegetation condition will not only help to target management action but will also aid the zoning of moors where there are potential conflicts between nature conservation objectives. For example, golden plover require short vegetation to breed, but maintaining high

Box 3 - Defining the extent of the habitat (interest feature)	
The following definitions of extent are broad so that they will incorporate the marginal areas of the habitats. It is in these marginal areas where change in condition is most likely to occur so it is essential that these areas are included in any assessments.	
Dry and wet heaths:	For both these habitats the heath to be assessed will include all heath and acid grassland where the abundance of dwarf-shrubs is more than occasional. Areas of acid grassland where dwarf-shrub abundance is less than frequent can disregarded for the purposes of assessing heath for a SURF but for whole site/unit surveys they should be mapped as the appropriate heath in unfavourable condition.
Blanket and raised mires:	The area to be assessed includes the whole of the main peat body plus any satellite areas of deep peat. Any grassland or heath between the main peat body and these satellites should be included in the assessment area.
Montane heath:	The assessment area should include all the heath and grassland above the tree line for that region in the unit.

proportions of short vegetation usually involves burning at a frequency that is too high to maintain a botanically diverse sward. If areas that meet, or come close to meeting, the criteria for favourable vegetation condition are mapped, then these areas can be managed for their botanical interest whilst those areas which are unfavourable in terms of vegetation condition can be managed for breeding waders.

4.2.1. Modifications to vegetation condition criteria required to facilitate site/management unit surveys

Several of the criteria as defined above require assessments to be made taking into account whole management units. These are inappropriate for surveys designed to map variation in vegetation condition across a management unit and modifications are required:

All habitats:

- Criteria should refer to the stand, square or facet being assessed not the management unit.
- Grazing impacts must be assessed for each stand (or parts of larger stands), square or facet and the allowance for 5% of the assessment area to be either moderately heavily or heavily grazed is dropped.

Dry and wet heaths:

- The percentage cover of each age class in the stand, square or facet should be recorded so that the age class criteria can be assessed for the site as a whole once the survey is completed.

4.2.2. Methodology

Three potential methods for mapping vegetation condition are considered here.

4.2.1.1. Mapping individual stands

This is the most detailed method. All individual stands of each habitat present are mapped (the minimum size of stands to be mapped will vary according to the scale of the maps used; 1ha for 1:10,000 and 4ha for 1:25,000 are recommended). Each stand will be classified as either favourable or unfavourable and, where the latter is the case, the favourable vegetation condition criteria on which the stand failed will also be recorded. Where large stands contain areas of vegetation in both favourable and unfavourable condition, or where the failed criteria differ from one part of a stand to another, this variation should be mapped as separate stands. Ideally mapping will be carried out with the aid of recent aerial photographs. For this method to be accurate, each stand mapped must be walked over; consequently, survey coverage rates are likely to be slow. Box 3 gives guidance on how habitat stands are defined. Data can be recorded on record cards for each stand in the same way as the two methods described below if desired. However, this may result in the generation of a large number of records and may be unwieldy.

4.2.1.2. Raster mapping

To avoid the need to record every small vegetation stand, the area to be surveyed is divided into a series of squares based on the National Grid. 25ha (¼km^2) squares have been used by Scottish Natural Heritage for surveys using MacDonald *et al.*'s (in press) field indicators (D Horsfield pers. comm.) as this allows for increased coverage rates in comparison to recording every stand, while still retaining a sufficient level of detail to pick out local variation of impacts. Imposing a fixed grid for recording acts as a filter and helps to reduce the amount of between observer variability that all field survey is prone to.

A "W-walk" is made through each square and an overall assessment of the vegetation condition (favourable or unfavourable) is made for each habitat within the square. A minimum of 20% of both the square and each habitat present in the square must be walked through, including both core areas and the margins of stands of habitats present. When making this overall assessment, it is important not to give undue weight to small, local patches of an impact. The assessment should be based on the proportion of the habitat over which that condition occurs, not the proportion of the square with the condition. Habitats should only be recorded where they constitute more than 10% of the total area of a sample square. Likewise, where a sample square extends beyond the site boundary, it should only be recorded if more than 10% of the square lies within the site. Again, the criteria on which any unfavourable squares fail are also recorded. Recording can be done simply on to a map, but a considerable amount of additional information on the vegetation in each square can be collected if a standardised record card is completed for each habitat present in each square surveyed. Record cards devised during the field trials of this survey methodology are shown in Appendix 2.

Results can be presented as a habitat map with overlays of vegetation condition for each habitat present. The use of record cards is strongly recommended as it allows comparisons to be made if further surveys are carried out in subsequent years and facilitates input of survey data into a Geographical Information System (GIS) computer mapping/database programme. If data is entered into a GIS then further data analysis can be carried out as it is a relatively simple task to produce maps showing the distribution of particular impacts, light, moderate and heavy grazing for example, or the distribution of other features recorded, such as bryophyte abundance, or the distribution of active drains on a blanket mire.

This sampling technique was used in field trials of this vegetation condition assessment method on four sites in England by the authors (see Appendix 5) and also by Scottish Natural Heritage.

4.2.1.3. Facet mapping

The Northern Ireland Environment and Heritage Service have used a modified version of the raster technique for a monitoring exercise in a large upland site in 1997 (P Corbett pers. comm.). The main modifications to the raster technique are:

1. The survey area is subdivided into "facets" (physical units that have been identified from aerial photographs) usually on the basis of physical features such as rivers or breaks in slope which are readily identified in the field. Facet size can vary from 40 to 100ha.
2. The variability of the vegetation in a facet is assessed prior to the field visit using aerial photographs. The route the surveyor is to walk through each facet is drawn onto the map or aerial photograph so that it takes the surveyor through the full range of vegetation types and conditions present in the facet.
3. A minimum of 20% of both the facet and each habitat present in the facet must be walked through including core areas of the facet/habitat and the margins of the facet/habitat.
4. Periodic stops are made throughout the walk through the facet to assess the criteria on the relevant recording card in a 10 x 10m quadrat. At least 20 such stops should be made for the dominant habitat in the facet and between 5 to 10 stops for other habitats present.
5. The area of each facet must be measured before calculations can be made to assess whether the age structure criteria for dry and wet heaths are met.

The record cards used here to record vegetation condition in each habitat are the same as for the raster sampling technique. However an additional record card for each habitat is required to record the quadrat data and EHS surveyors also completed a summary card for each facet which recorded estimates of the area of the facet covered by each habitat and general comments on its management and vegetation condition. Again, the information recorded can be entered into a GIS database and presented as a map or series of maps.

4.2.1.4. The pros and cons of each sampling technique

All three sampling techniques can provide maps showing the range of vegetation condition by habitat across a site. The stand and facet mapping techniques will provide assessments related to recognisable geographical/vegetation units while the raster method provides an overview of the site as a whole which cannot be directly related to individual stands of vegetation.

The facet method probably has the edge in terms of repeatability as it has the most easily identifiable sample unit boundaries in the field. Determining where the edge of a sample square is can be difficult on featureless terrain. While this will not be particularly crucial most of the time, where this method is used as a serious monitoring technique an error of one or two hundred metres could change the grading of a criterion simply by including or excluding a stand which had been critical to a previous assessment. This problem could, however, be alleviated by the use of a Global Positioning System (GPS) in the field; though these are currently prone to errors of ± 100m unless a ground base correcting system is used. Similarly, vegetation stands recognised by one surveyor may not be apparent to a different surveyor on a subsequent visit.

In terms of data input to GIS databases, the production of maps and subsequent analysis, the raster method may have the advantage over the other two methods as the use of a grid system and uniform sample sizes allows maps to be generated quickly and simply as data can be displayed using symbols generated from a grid reference. The stand and facet sampling methods will require the drawing of polygons on the map, linked to a grid reference to represent the habitat stands or facets in order to produce a meaningful map.

4.2.3. Data handling

The discussion here is biased towards the use of MapInfo GIS software as this is the system used by English Nature. However, other GIS or database software can be used to produce similar results. Data collected in the form of record cards can be entered into a spreadsheet which can then be used as a database file by MapInfo. Data can be input directly into MapInfo but it is better to use one of the spreadsheet packages that MapInfo supports as they are easier to use and allow more complex data manipulation than is available in MapInfo. MapInfo Professional v.4 allows one to work directly with files created in other programmes if they conform to the following formats: Microsoft Excel (XLS files up to Excel v.5.0/95, but not v.97), Lotus 1-2-3 (WKS, WK1, WK3 and WK4 files), dBase (DBF database files) and delimited ASCII files. The maps in Appendix 5 were produced using MS Excel files and MapInfo Professional v.4. Base maps were scanned into MapInfo. Appendix 3 runs through data input into MS Excel and opening an Excel file in MapInfo and producing a map of vegetation condition from the data.

English Nature Uplands Team can provide MS Excel data input files which are compatible with the record cards in Appendix 2. These files will calculate vegetation condition grades for sample squares ready for input into MapInfo. These files, however, can only be used for surveys carried out using the raster mapping technique. If other mapping methods are used then area measurements for all stands/facets are required and these, together with additional calculations, need to be incorporated into the calculations for the age structure criteria for dry and wet heaths.

4.2.4. Training

To ensure a standardised application of the vegetation condition assessment criteria throughout English Nature, the technique should be incorporated into the staff training programme. Consideration should also be given to the need to run courses for staff from other organisations and for potential contractors. This would both promote the use of a standardised assessment methodology and ensure that surveys carried out by organisations other than English Nature or on contract to English Nature are comparable to those conducted by English Nature staff. One problem with the Heather Condition Survey is that different surveys have used slightly different methodologies leading to a lack of comparability.

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