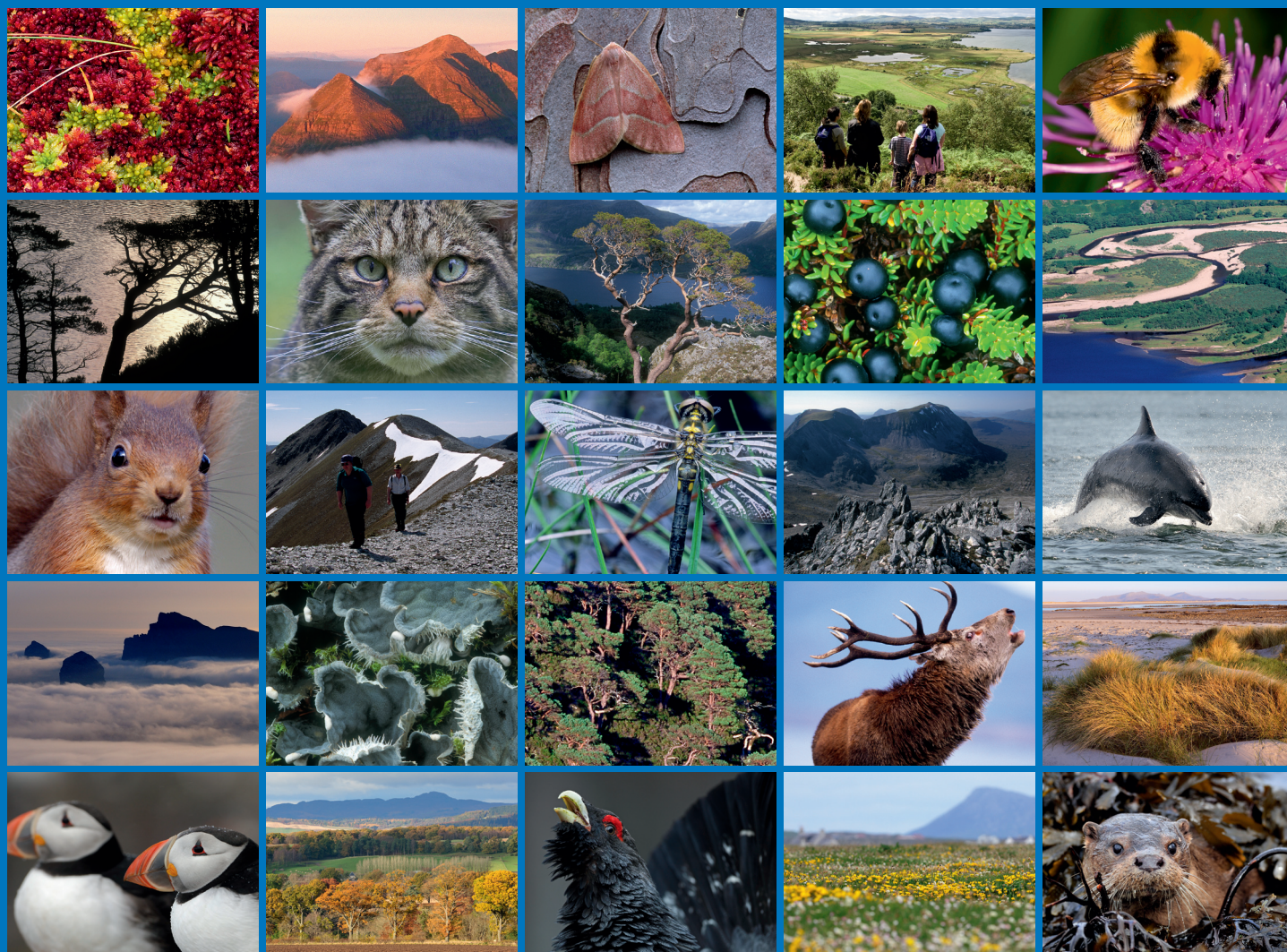


Developing guidance for managing extensive upland grazing where habitats have differing requirements



COMMISSIONED REPORT

Commissioned Report No. 402

Developing guidance for managing extensive upland grazing where habitats have differing requirements

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COMMISSIONED REPORT

Summary

Developing guidance for managing extensive upland grazing where habitats have differing requirements

Commissioned Report No. 402 (iBids No. 1206)

Contractor: John P. Holland, Meg Pollock, Tony Waterhouse, Claire Morgan-Davies, Helen Bibby, Sandra Stewart and Helen M. Armstrong

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Background

The vegetation of the Scottish uplands consists of a complex mosaic of habitats with differing grazing requirements. Each vegetation type has a range of grazing pressures that will maintain its species composition and structure. Grazing pressures outside that range are likely to lead to changes and potentially a decline in nature conservation value or conversion to another vegetation type. Some habitat types are very sensitive to grazing and require very low levels or no grazing at all, whereas others require moderate levels of grazing. Many upland designated sites have a range of habitats with varying grazing requirements often occurring within a relatively small area. This leads to potential conflicts between habitats in relation to their grazing requirements, which can lead to problems of how to manage the habitats on an extensive scale, maintaining or achieving favourable condition for the habitats and delivering specific nature conservation outcomes.

The aims of this project were: to explore existing site condition monitoring (SCM) and herbivore impact assessment (HIA) data from upland designated sites to review the evidence for conflicts between the grazing requirements of nearby habitats; to develop principles as decision support tools that can be used to help manage these conflicts or help to identify management priorities; and to produce a practical user guide for land managers.

Main Findings

- An expert opinion survey indicated that the most likely conflicts are between upland calcareous grassland and habitats such as tall herb vegetation and montane willow scrub which require very low levels of grazing or no grazing at all but are attractive to herbivores.
- Potential conflicts seen within the SCM data were not as expected. Issues of accessibility to herbivores, geographical location, the proximity of the different vegetation types and the large number of occasions where both vegetation types were at risk of herbivory are probably responsible for there being limited evidence of apparently realized habitat grazing conflicts.
- There were few observations of 'under-grazing' in the SCM data.
- Analysis of the HIA data from five designated sites has shown reasonable evidence that the level of herbivore impact on a particular feature type is affected by its proximity to other preferred feature types, and to the proportion of preferred habitats in the

surrounding area. The data provided evidence of potential conflicts between a number of different pairs of vegetation types. Most potential conflicts exist between grasslands and other feature types. There was evidence of probable under-grazing of grassland feature types at a number of sites.

- The methods that could be used to resolve conflicts are likely to differ between sites even where the grazing conflict is between the same vegetation types. It may therefore be hard to devise a management regime that will maintain all the habitats in a favourable condition. In these situations some compromise may be required with priority given to one or more features. The decisions on habitat priorities will have to be done on a site by site basis and take account of relative habitat priority with respect to designated interests, the extent of the feature types, and their local and national importance. The project references measured changes in habitat structure and composition following the reduction or cessation of grazing. Experimental trials have tended to focus on comparing grazed with ungrazed situations rather than with low impact grazing regimes which are likely to be preferable to no grazing. Site specific factors are likely to make it difficult to be able to predict how long habitats can be maintained under sub-optimal grazing regimes. Site monitoring is likely to be required to better establish the temporal dynamic of grazing regimes for habitats with competing requirements.
- The main findings from the project were used to develop a management guide. This guide provides practical information for land managers who are undertaking upland habitat management particularly on designated sites where habitats have different management requirements.

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1 INTRODUCTION

The vegetation of the Scottish uplands is complex and variable, consisting of a mosaic of habitats including grasslands, flushes, blanket bog, heaths and scrub. This mosaic of vegetation patches has developed through the interaction of a range of biological, environmental and anthropogenic factors including bio-climate, geology, pedology, hydrology, topography and grazing (Dickinson, 1998). The vegetation of the Scottish hills is largely semi-natural, having been affected by human activities for many centuries. The anthropogenic activity that has had the greatest impact on the vegetation over the last 250 years has been the grazing of domestic herbivores, in particular sheep (Fenton, 1937). In addition to domestic herbivores, red deer browsing and trampling has also had a major impact on the vegetation of the Scottish hills (Milne *et al.*, 1998).

The different upland habitats found in the Scottish hills have different grazing management requirements to achieve the nature conservation objectives that have been set. Each vegetation type has a range of grazing pressures that will maintain the species composition and structure of the vegetation (MacDonald *et al.*, 1998). Grazing pressures outside that range are likely to lead to changes in the structure and composition of the vegetation and potentially a decline in its nature conservation value or its loss. Some habitat types are very sensitive to grazing and trampling and require very low levels of grazing or no grazing at all to maintain their structure and species composition and can be destroyed by high levels of grazing, whereas others require moderate levels of grazing in order to maintain their structure, composition and nature conservation value. Many upland designated sites have a range of habitats with varying grazing requirements often occurring within a relatively small geographic area; leading to perceived conflicts between the habitats in relation to their grazing requirements. This can lead to problems of how to manage the habitats on an extensive scale with the aim of maintaining or achieving favourable condition for the habitats and delivering specific nature conservation outcomes.

Management of the uplands is not easy. There are significant economic, cultural and political issues involved. Any management of a site will have to take into account these issues as well as that of nature conservation, leading to a management approach which may often be a compromise.

The principles discussed in this report apply equally to designated sites and non-designated semi-natural habitats. However, there is more information available on habitat condition and impacts on designated sites, hence the findings are informed by analysis of this data. The expected condition of habitats, the methods used to assess habitat condition¹ and the hierarchy of statutory obligations which might be used to inform the extensive management, are more clearly set out with respect to designated than non-designated sites. Nevertheless, the principles can be followed using some simplified habitat survey methods.

2 AIMS AND OUTCOMES

The aims and outcomes of this project were:

- 1) To explore existing Site Condition Monitoring (SCM) and Herbivore Impact Assessment (HIA) data from upland designated sites to review the evidence for conflicts between the grazing requirements of nearby habitats.

¹ Information on assessing the condition of designated habitats can be found at:

http://www.jncc.gov.uk/pdf/CSM_upland.pdf
http://www.jncc.gov.uk/pdf/CSM_woodland.pdf

- 2) To develop principles as decision support tools, that can be used to help manage these conflicts or help to identify management priorities.
- 3) To produce a practical user guide to help inform objectives and practical management options.

3 METHODS

3.1 Expert opinion survey

At the start of the project a questionnaire was sent out to a range of upland vegetation experts to get their informed opinion on the grazing requirements of 28 upland feature types. This was used to help inform the project team as to why conflicts are likely to happen and which feature types were most likely to be in conflict.

A questionnaire approach was used to obtain informed anecdotal information on 28 upland features. Thirty six upland vegetation experts, mainly people who have carried out SCM or HIAs, were asked to contribute. The experts were asked to assign each of the features with a value of 1 to 5 (very low to very high) for three variables: (a) the grazing level required by the feature type in order for it to attain favourable condition; (b) the attractiveness of the feature type to herbivores; and (c) the accessibility of the feature type to herbivores (Figure 3.1). Sixteen questionnaires were returned.

Figure 3.1 - Questionnaire sent to experts.

Feature name (Official list name)	Guidance Section	Grazing impact required for favourable condition	Attractiveness to herbivores	Accessibility to herbivores
Alkaline fen (upland, excluding alpine flush)	Upland			
Alpine dwarf-shrub heath	Upland			
Alpine flush	Upland			
Alpine summit communities of moss, sedge and three-leaved rush	Upland			
Blanket bog and valley bog (upland)	Upland			
Calaminarian grassland and serpentine heath (upland)	Upland			
Calcareous grassland (upland)	Upland			
Calcareous rocky slopes	Upland			
Calcareous scree	Upland			
Juniper heath and scrub (upland)	Upland			
Limestone pavement	Upland			
Montane willow scrub	Upland			
Moss, dwarf-herb, and grass-dominated snow-bed	Upland			
Siliceous scree	Upland			
Spring-head, rill and flush (upland)	Upland			
Subalpine dry dwarf-shrub heath	Upland			
Tall herbs (upland)	Upland			
Transition mire, ladder fen and quaking bog (upland)	Upland			
Wet heath (upland)	Upland			
Wetland Springs (including flushes)	Wetland			
Bog woodland	Woodland			
Caledonian forest/Native pinewood	Woodland			
Scrub	Woodland			
Upland Birch Woodland	Woodland			
Upland Mixed Ashwood	Woodland			
Upland oak woodland	Woodland			
Wet woodland	Woodland			
Maritime cliff	Maritime			

Category: Means:

5 Very High	}	Impact required / Attractiveness / Accessibility
4 High		
3 Moderate		
2 Low		
1 Very Low		

Median values of the three variables were calculated across all the experts for each feature type. The feature types were first sorted by the grazing level required by the feature type

(from highest to lowest). This created six groups of feature types. The feature types within each of these groups were then sorted according to their attractiveness to herbivores (from lowest to highest), and then by their accessibility to herbivores (from highest to lowest).

3.2 Site condition monitoring data

3.2.1 Initial filtering process

A database summarising SCM data collected from terrestrial sites (Sites of Special Scientific Interest (SSSIs), Special Areas of Conservation (SACs), Special Protection Areas (SPAs) and Ramsar Sites) between 1999 and 2005 was provided by SNH. This comprised a subset of all designated features referred to as an 'audit' of potential herbivore impacts. This included an assessment of whether or not there is evidence from SCM data that a feature is 'at risk' or 'not at risk' of negative herbivore impacts. Features were regarded as potentially 'at risk' if any targets for SCM attributes relating to grazing or trampling impacts had not been met. This database was filtered to remove sites without any upland features and those with only one upland feature. Non-upland features at sites with two or more upland features were retained. The following features were removed as they were not considered relevant to the project: Dotterel (*Charadrius morinellus*); Golden eagle (*Aquila chrysaetos*); machair; montane assemblage; plants in crevices in base-rich rocks; plants in crevices on acid rocks; saltmarsh; sand dune; upland assemblage; vascular assemblage. This left a dataset containing 71 sites and a total of 357 features.

3.2.2 Standardisation of feature names

The remaining dataset contained information from sites designated as SSSIs and SACs. Since different names are used under the different designations for essentially the same vegetation type, the names were standardised following the Common Standards Monitoring (CSM) guidance (JNCC, 2006) with input from SNH (Table 3.1), leaving a total of 28 different feature names from the 46 initial names.

This process meant that features that had been monitored as two separate items at one site were occasionally combined into one feature. In almost all cases, both initial features had the same condition assessment, and the same category in the 'at risk from deer / other herbivores' column. In two cases, standardising the feature names meant that there was conflict within the new feature name (i.e. one row with favourable condition and one with unfavourable condition within the same site and feature name). These two cases were blanket bog (previously 'depressions on peat substrates' and 'blanket bog') on Rannoch Moor, and calcareous grassland (upland) (previously 'alpine and sub-alpine calcareous grasslands' and 'species-rich grassland with mat-grass in upland areas') at Glencoe. In both cases the habitats being combined are not an exact match, however a pragmatic decision was taken to regard both as unfavourable.

At seven sites standardisation of names meant conflict within the feature in terms of whether it was 'at risk from deer / other herbivores'. In these cases, the 'Yes' category was always applied. These cases were: calcareous grassland (upland) at Ardmeanach, Beinn a'Ghlo, Ben Lawers, Ben Lui and Ben Nevis, and blanket bog on Rannoch Moor and Rum.

Table 3.1 - Initial and standardised feature names.

Initial SSSI/SAC/Ramsar feature name	Standardised CSM feature name	Code No
Alkaline fen	Alkaline fen (upland, excluding alpine flush)	1
Base-rich fens	Alkaline fen (upland, excluding alpine flush)	1
Alpine heath	Alpine dwarf-shrub heath	2
Alpine and sub-alpine heaths	Alpine dwarf-shrub heath	2
Alpine flush	Alpine flush	3
High-altitude plant communities associated with areas of water seepage	Alpine flush	3
Alpine moss heath and associated vegetation	Alpine summit communities of moss, sedge and three-leaved rush	4
Montane acid grasslands	Alpine summit communities of moss, sedge and three-leaved rush	4
Blanket bog	Blanket bog and valley bog (upland)	5
Depressions on peat substrates	Blanket bog and valley bog (upland)	5
Bog woodland	Bog woodland	6
Grasslands on soils rich in heavy metals	Calaminarian grassland and serpentine heath (upland)	7
Alpine and sub-alpine calcareous grasslands	Calcareous grassland (upland)	8
Alpine calcareous grassland	Calcareous grassland (upland)	8
Dry grasslands and scrublands on chalk or limestone	Calcareous grassland (upland)	8
Species-rich grassland with mat-grass in upland areas	Calcareous grassland (upland)	8
Sub-alpine calcareous grassland	Calcareous grassland (upland)	8
Rocky slopes	Calcareous rocky slopes	9
Base-rich scree	Calcareous scree	10
Caledonian forest	Caledonian forest/Native pinewood	11
Native pinewood	Caledonian forest/Native pinewood	11
Moorland juniper	Juniper heath and scrub (upland)	12
Juniper on heaths or calcareous grasslands	Juniper heath and scrub (upland)	12
Limestone pavements	Limestone pavement	13
Maritime cliff	Maritime cliff	14
Mountain willow scrub	Montane willow scrub	15
Snowbed	Moss, dwarf-herb, and grass- dominated snow-bed	16
Scrub	Scrub	17
Acidic scree	Siliceous scree	18
Siliceous scree (includes boulder fields)	Siliceous scree	18
Hard-water springs depositing lime	Spring-head, rill and flush (upland)	19
Spring-head, rill and flush	Spring-head, rill and flush (upland)	19
Dry heaths	Sub-alpine dry dwarf-shrub heath	20
Sub-alpine dry heath	Sub-alpine dry dwarf-shrub heath	20
Tall herb communities	Tall herbs (upland)	21
Tall herb ledge	Tall herbs (upland)	21

Table 3.1 (continued) - Initial and standardised feature names.

Initial SSSI/SAC/Ramsar feature name	Standardised CSM feature name	Code No
Very wet mires often identified by an unstable 'quaking' surface	Transition mire, ladder fen and quaking bog (upland)	22
Upland Birch Woodland	Upland birch woodland	23
Mixed woodland on base-rich soils associated with rocky slopes	Upland mixed ash woodland	24
Upland oak woodland	Upland oak woodland	25
Western acidic oak woodland	Upland oak woodland	25
Sub-alpine wet heath	Wet heath (upland)	26
Wet heathland with cross-leaved heath	Wet heath (upland)	26
Alder woodland on floodplains	Wet woodland	27
Wet woodland	Wet woodland	27
Springs (including flushes)	Wetland Springs (including flushes)	28

3.2.3 Sites and features at risk from deer or deer and other herbivores, and where under-grazing occurs

Using the standardised SCM data, filtered to include all features at sites with more than one upland feature, information from the column 'outcome of audit - feature at risk from deer or deer and other herbivores? Y/N' was summarised to show the proportion of sites where the different features were at risk. A new column was also created where 'under-grazing' was mentioned in the comments. These observations do not constitute a systematic assessment, but indicate where under-grazing has been highlighted as a potential issue.

3.2.4 Pair-wise analysis of the SCM data

Using Genstat (11th edition) code written by S. Brocklehurst (BIOSS), the data were arranged so that every pair of features occurring within sites was listed, with information on the condition of each feature within the pair (i.e. favourable or unfavourable condition). Only sites with more than one upland feature were included.

There are many reasons for a feature being classed as unfavourable; not all of them are related to herbivory. All features with favourable condition were recorded as not at risk from herbivory, while features with unfavourable condition were recorded as either not at risk from herbivory (No), at risk from herbivory (Yes), or unknown (TBC). The 'at risk' assessment focused on features affected by a combination of wild herbivores and/ or domestic livestock² and excluded sites with purely domestic livestock, and focused on attributes related to over-grazing rather than under-grazing (J. Bryce, *pers. comm.*), however sites with only domestic livestock are rare in the uplands and therefore it was thought appropriate to use this data.

Vegetation pairs were generated as above. Pairs where the 'at risk' category was recorded as unknown were removed. Pairs containing 'siliceous scree' or 'calcareous scree' were removed, as the scree communities are generally not easily accessible to herbivores.

² The audit was carried out in support of Joint Agency Working on the impacts of deer either on their own or in combination with livestock.

3.3 Herbivore Impact Assessment data

3.3.1 HIA pre-analysis data preparation

Although the HIA and SCM methodologies have common roots they are designed to do different things. HIAs indicate the current herbivore impact level on the particular feature type. This can be used to assess potential conflicts between feature types where one feature is experiencing higher impacts than is desirable and is in close proximity to features with impacts in the desirable range, or lower than is desirable for that habitat type. Both the SCM and HIA assessments are based on a random sample of points within particular habitat types. Hence they do not provide a systematic picture of impacts across the habitat's distribution and hence may not indicate potential conflicts where they occur, or conversely may highlight conflicts that are not widespread.

Impact classes for the different feature types are not equivalent and do not carry the same prognosis and therefore cannot be compared directly between types. It is necessary to compare impacts within and outside the 'desirable ranges' for the given types. Using information from MacDonald *et al.* (1998), the expert opinion survey and the surveyors' workshop (Workshop 1), a table of the 'desirable' impact ranges for the different feature types was produced (Table 3.2).

Table 3.2 - Postulated 'desirable impact ranges' for the different feature types.

	Grazing Impact						
	Low (L)	Low to Moderate (LM)	Moderate (M)	Moderate to High (MH)	High (H)	High to Very High (HVH)	Very High (VH)
Smooth Grassland	X	✓	✓	✓	X	X	X
Flush	✓*	✓	✓	X	X	X	X
Tall Herb	✓**	✓	X	X	X	X	X
Scrub	✓**	✓	X	X	X	X	X
Blanket Bog	✓	✓	X	X	X	X	X
Dry Heath	✓**	✓	✓	X	X	X	X
Wind-clipped Heath	✓	✓	X	X	X	X	X
Species-rich <i>Nardus</i> grassland	X	✓	✓	✓	X	X	X
Alpine moss-heath	✓	✓	X	X	X	X	X
Montane grass-heath	✓	✓	X	X	X	X	X

*Flushes with a low impact are generally stable at high altitude and where they are very wet, but at lower altitudes there is likely to be a loss of structural diversity and the possible succession to scrub.

**At lower altitudes likely to be invaded by trees if a seed source is available (over two to three decades).

The herbivore impact assessment data from five designated sites were analysed to look at the spatial patterns of grazing impacts and any conflicts between feature types that may be occurring. The five designated sites were:

- 1) Beinn Heasgarnich (Dayton, 2007)
- 2) Meall na Samhna (Dayton, 2007)
- 3) Beinn Dearg (Macaulay Land Use Research Institute, 2007)
- 4) Fannich Hills (Wells, 2008)
- 5) East Cairngorms (Invercauld, and Inchroary and Glenavon Estates³) (Maier *et al.*, 2008)

Data from two other sites (Drumochter Hills (Dayton, 2008) and Inverpolly (Morris, 2008)) were looked at, however the data were not fully analysed as they were in a different format.

The HIA spreadsheet data from each site was checked and formatted. Each point was given a unique ID and where clusters of points had been surveyed (where sampling was per ¼ km square) a cluster ID was also created. The spreadsheets contained columns with the grazing and trampling impact scores and classes for each of the points⁴, and where appropriate, the cluster mean scores and classes. The spreadsheet files were then converted into .dbf (database) files for transfer to Arc GIS (ESRI). The point locations were mapped. The grid references of any outliers were checked and either corrected where possible or the data was removed. For each feature type the points were classified by their impact class.

It was considered that conflicts might occur between feature types where the impact on one feature type was within the desirable range and the impact on another feature type was outside the desirable range. The data was examined to look at where potential conflicts might occur. The analyses were carried out using data on grazing rather than trampling impacts, except on Beinn Dearg where the overall impact class (a combination of grazing and trampling) was used. One kilometre radius buffers were mapped around the feature type points where they were outside their 'desirable impact ranges'. The estate boundaries and recent deer count numbers were also mapped using data provided by the Deer Commission for Scotland. Where clusters of points had been surveyed, the geographic centre of the cluster was mapped using the GIS and the mean impact score for the cluster was calculated.

The vegetation at the five sites was mapped using data supplied by SNH. Some of the vegetation types were coded according to the Birks and Ratcliffe (1980) classification system and these were converted into the most appropriate National Vegetation Classification (NVC) type (Rodwell, 1992; 1991). A column with the main NVC type for each polygon was created and this was then used to create a column classifying the vegetation into the most appropriate feature type. For Beinn Heasgarnich, Meall na Samhna and Beinn Dearg, buffers with a radius of 500m were created around each point and the area of the different vegetation types within these buffers was calculated. This data was examined to see whether feature types which were outside their 'desirable impact ranges' were more likely to be in close proximity to vegetation that could be in conflict with them. This analysis does not take into account other confounding factors such as the influence of altitude, aspect, slope, exposure, accessibility or grazing behaviour.

For Beinn Heasgarnich and Meall na Samhna the NVC data was also converted into the broad vegetation types required in order to run the Hill Grazing Management Model (Armstrong *et al.*, 1997a, 1997b).

³ This is part of a much larger survey within the Cairngorms SAC. The area was selected because of the range of habitats (including calcareous grassland) and impact levels within close proximity.

⁴ The Beinn Dearg HIA data was in the form of an overall impact score rather than as separate grazing and trampling impact scores.

3.4 Workshops

As part of the project, two workshops were organised, the first in Tyndrum on 20th May 2009 and the second in Crianlarich on 9th December 2009. The main purpose of the first workshop was to report on the results of the SCM analysis to an invited group of SCM and HIA surveyors and other upland experts, to seek their opinions on the work and on the broader subject area and to find out where conflicts were being seen on the ground by the surveyors. The second workshop was targeted at land managers and practical conservation advisers from the West Perthshire, Argyll and Loch Lomond areas. The purpose of the workshop was to get the views of the delegates on how they thought upland designated sites could be managed in order to meet both the conservation needs of the site as identified by SNH and the economic needs of those who manage the land. Particular emphasis was placed on managing habitats which have different management requirements but occur close together on the same site. The workshop provided an opportunity to discuss some of the practical and economic issues of managing upland designated sites. Information derived from the workshop was used to help formulate the principles and develop the management guidance notes.

4 RESULTS

4.1 What conflicts do experts expect?

Table 4.1 shows the median expert opinions (and ranges), together with the authors' knowledge-based views on the likely implications of these in terms of the vulnerability of the features to too much, or too little grazing. The feature types were separated into six groups as shown in Table 4.1. For some of the features a wide range of values was assigned by the different experts and some of the experts declined to give a response for some of the feature types (Appendix A) indicating that there was a wide range of opinion and /or different levels of knowledge about the grazing requirements and attractiveness of the features. With respect to attractiveness to herbivores, the experts may also have made different assumptions about the underlying conditions by assuming, for example, a particular time of year. Since attractiveness to herbivores can vary with time of year, this would affect this assessment.

The feature highlighted in light green, calcareous grassland, is unique in that it requires a moderate grazing impact to be in favourable condition, but is also attractive and accessible to herbivores. It therefore needs high levels of grazing to be 'over-grazed' and low levels of grazing to be 'under-grazed'. The features highlighted in cyan require a low impact to be in favourable condition, and have a range of attractiveness and accessibility scores. Those that are most attractive (towards the bottom of the list) are most at risk of 'over-grazing' if they are accessible. The features in the bottom three groups require low to very low grazing levels in order to maintain favourable condition, and have a range of attractiveness scores. With the exception of the alpine summit communities, these features have low accessibility scores; they tend to be remnant communities clinging on to spots that are inaccessible to herbivores, or areas of scree, which are not accessible to grazing. Those that are most attractive to herbivores (at the bottom of the list) are at the highest risk of being 'over-grazed' if they are accessible. These features require such low grazing pressures to maintain their structures and species compositions that they are unlikely to suffer from 'under-grazing'.

We might expect that conflicts are most likely between calcareous grassland in favourable condition and the features in the lower three groups which are most susceptible to grazing

impacts, where they are accessible to herbivores. Conflicts are potentially possible between calcareous grassland and any of the features in the other groups as they all require lower levels of grazing. Features in groups two (dark green) and three (cyan) may also be in conflict with those features in the lower three groups. There are potential conflicts even within group three (cyan), between features at the top of the group, which are least attractive to herbivores, and those at the bottom of the group that are most attractive. However such conflicts are likely to be rare since they will require particular sets of conditions, and while they are possible, they are unlikely to be as extreme, or as common, as conflicts between calcareous grassland and the most attractive features in the other groups. Although there is a tendency to think that most conflicts relate to grazing levels being too high for one of the particular pair of features, conflicts can exist between features as a result of too little grazing. However, it should be noted that trampling impacts are of greater consequence for some habitats than grazing, notably the wetter communities; blanket bog, wet heath and flushes.

Calcareous grassland is most at risk from too little grazing, particularly in areas where herbivore numbers have reduced allowing habitats such as montane willow scrub to reach favourable condition. There are however few examples in the Scottish uplands of open habitats being grazed at such low levels that tree or scrub regeneration has made their condition unfavourable. This is because of generally high stocking rates of sheep and /or deer in the past and a lack of seed source. This situation may change as sheep stocking rates continue to decline in the uplands; depending on what happens with deer populations and other land management practices, for example muirburn.

Table 4.1 - Averaged (median) “expert opinion” on (a) the grazing level required by the feature in order to attain favourable condition; (b) the attractiveness of the feature to herbivores; and (c) the accessibility of the feature to herbivores.

Feature name	Favourable grazing level		Attractiveness to herbivores		Accessibility to herbivores		Vulnerability to too much or too little grazing ⁵
	Median	Range	Median	Range	Median	Range	
Calcareous grassland (upland)	3	(2 - 3.5)	5	(3 - 5)	5	(3 - 5)	Low vulnerability to too much grazing, but vulnerable to too little grazing
Subalpine dry dwarf-shrub heath	2.5	(1 - 4)	3	(2 - 4)	5	(2 - 5)	Low to medium vulnerability to too much grazing. Low to medium vulnerability to too little grazing
Calaminarian grassland and serpentine heath	2.5	(1 - 3)	3	(2 - 5)	4	(2 - 5)	
Blanket bog and valley bog	2	(0.5 - 4)	2	(1 - 3)	3.75	(2 - 5)	
Calcareous scree	2	(0.5 - 2.5)	2	(1 - 4)	2	(1 - 3)	Medium vulnerability to too much grazing. Low vulnerability to too little grazing (*woodlands highly vulnerable to no grazing in the long term)
Transition mire, ladder fen and quaking bog (upland)	2	(1 - 3)	2	(1 - 3.5)	2	(1 - 3)	
Alpine dwarf-shrub heath	2	(0.5 - 4)	2.25	(1.5 - 3)	4	(2 - 5)	
Wet heath	2	(1 - 3)	2.5	(2 - 3)	4.5	(2 - 5)	
Bog woodland	2	(1 - 3)	2.5	(2 - 5)	3	(2 - 4)	
Juniper heath and scrub (upland)	2	(1 - 4)	3	(2 - 5)	4	(3 - 5)	
Wet woodland	2	(1 - 3)	3	(2 - 5)	4	(3 - 5)	
Moss, dwarf-herb, and grass-dominated snow-bed	2	(1 - 3)	3	(2 - 4)	3	(2 - 4)	
Calcareous rocky slopes	2	(0.5 - 3)	3	(2 - 5)	2	(1 - 4)	
Scrub	2	(0.5 - 3)	3.25	(2 - 5)	4	(3 - 5)	
Maritime cliff	2	(1.5 - 3)	3.5	(3 - 4.5)	2	(1 - 2)	
*Upland birch woodland	2	(1 - 3)	3.75	(2 - 5)	5	(3 - 5)	
*Upland oak woodland	2	(1 - 3)	3.75	(2 - 5)	5	(3 - 5)	
Caledonian forest/Native pinewood	2	(1 - 3)	4	(2 - 5)	4.5	(3 - 5)	
Alkaline fen (upland, excluding alpine flush)	2	(1 - 3.5)	4	(2 - 4.5)	4	(2 - 5)	
Spring-head, rill and flush	2	(1 - 3.5)	4	(2 - 4.5)	4	(2 - 5)	
Wetland Springs (including flushes)	2	(1 - 3)	4	(2 - 5)	4	(2 - 5)	
Alpine flush	2	(0.5 - 3)	4	(1 - 5)	4	(2 - 4)	
Limestone pavement	2	(2 - 3)	4	(2 - 5)	2.5	(2 - 3)	
*Upland mixed ash woodland	2	(1 - 3)	4.5	(3 - 5)	5	(3 - 5)	
Alpine summit communities of moss, sedge and three-leaved rush	1.75	(0.5 - 3)	2.25	(2 - 4)	4	(1 - 4.5)	Medium to high vulnerability to too much grazing. Low vulnerability to too little grazing.
Siliceous scree	1.5	(0.5 - 4)	2	(1 - 3)	2	(1 - 3)	High vulnerability to too much grazing. Too little grazing is unlikely to be an issue for these vegetation types
Tall herbs (upland)	1.5	(0.5 - 3)	4.75	(3 - 5)	2	(1.5 - 5)	
Montane willow scrub	1	(0.5 - 2)	4	(2 - 5)	2.5	(1.5 - 5)	Very high vulnerability to too much grazing. Too little grazing is not an issue for this vegetation type

Key to numbers: 1 =Very Low, 2 = Low, 3 = Moderate, 4 = High, 5 = Very High

⁵ The vulnerability to too much or too little grazing has been derived from the three variables and reflects the desirable impact level, attractiveness and accessibility of the feature.

4.2 Which upland features are usually in unfavourable condition?

Only five, fairly uncommon, features were recorded as being in favourable condition at all of the sites where they occurred (calcareous rocky slopes, calcareous scree, maritime cliff, transition mire and wetland springs) (Table 4.2). Two, more common, upland feature types (tall herbs and siliceous scree) were in unfavourable condition at less than one third of the sites where they occurred (Table 4.2). Ten upland feature types, all common except juniper scrub and limestone pavement, were in unfavourable condition at two thirds or more of the sites where they occurred (Table 4.2).

Table 4.2 - Number of sites where the condition of the feature type was known and the proportion of sites where the feature was recorded as being in unfavourable condition.

Standardised Feature Name	Guidance Section	Favourable / Unfavourable condition	
		Number of sites where condition known	Proportion unfavourable
Montane willow scrub	Upland	15	1.00
Calcareous grassland	Upland	25	0.85
Alpine summit communities	Upland	24	0.83
Blanket & valley bog	Upland	33	0.82
Wet heath	Upland	25	0.81
Limestone pavement	Upland	4	0.75
Sub-alpine dry heath	Upland	34	0.74
Alpine dwarf-shrub heath	Upland	28	0.72
Juniper heath & scrub	Upland	3	0.67
Alkaline fen	Upland	12	0.67
Moss, dwarf-herb & snow-bed	Upland	5	0.60
Calaminarian grassland and serpentine heath	Upland	2	0.50
Alpine flush	Upland	12	0.46
Spring-head, rill & flush	Upland	9	0.44
Tall herbs	Upland	23	0.32
Siliceous scree	Upland	19	0.30
Calcareous rocky slopes	Upland	6	0
Calcareous scree	Upland	5	0
Transition mire, ladder fen and quaking bog	Upland	5	0
Caledonian forest	Woodland	11	1.00
Scrub	Woodland	1	1.00
Wet woodland	Woodland	2	1.00
Upland mixed ash-wood	Woodland	4	1.00
Upland birch wood	Woodland	8	0.88
Upland oak woodland	Woodland	9	0.78
Bog woodland	Woodland	4	0.25
Wetland springs	Wetland	1	0
Maritime cliff	Maritime	3	0
Total		332	0.67

4.3 Which sites and features are at risk from deer or deer and other herbivores?

Not all features in unfavourable condition are listed as 'at risk from deer or deer and other herbivores' as features sometimes fail SCM for reasons unrelated to herbivory⁶. Only one site (Caithness and Sutherland Peatlands SAC and SPA) had unfavourable features, but none that were assessed as being at risk from deer or deer and other herbivores in the first cycle of SCM. All other sites had at least one feature at risk. Only six of the feature types were never listed as being at risk from herbivory (Table 4.3). Another two feature types were recorded as 'at risk' at less than 20% of sites (Table 4.3). Many of these features tend to be inaccessible to herbivores either because of their nature i.e. screes, rocky slopes and cliffs, or because of historic heavy grazing restricting them to inaccessible places i.e. tall herbs. The other features seldom at risk were very wet, making access by herbivores both difficult and dangerous. Of the upland features, calcareous grassland, montane willow scrub, wet heath and blanket bog were most at risk from herbivory, with these features classed as 'at risk from deer or deer and other herbivores' in more than 70% of cases (Table 4.3). Of the woodland features, Caledonian pine forest, scrub, upland birch woodland and upland oak woodland all had high proportions (>77%) of sites where the feature was recorded as at risk from herbivory (Table 4.3).

Table 4.3 - Number of sites where the 'at risk' status was known, and the proportion of sites where features were recorded as 'at risk from deer or deer and other herbivores'.

Abbreviated Standardised Feature Name	Guidance Section	At risk from deer or deer and other herbivores	
		Number of sites where the 'at risk' status was recorded	Proportion of sites recorded as 'at risk'
Calcareous grassland	Upland	26	0.77
Montane willow scrub	Upland	15	0.73
Wet heath	Upland	24	0.71
Blanket & valley bog	Upland	34	0.71
Alpine summit communities	Upland	24	0.67
Juniper heath & scrub	Upland	3	0.67
Moss, dwarf-herb & snow-bed	Upland	5	0.60
Sub-alpine dry heath	Upland	33	0.58
Alpine dwarf-shrub heath	Upland	29	0.55
Calaminarian grassland and serpentine heath	Upland	2	0.50
Spring-head, rill & flush	Upland	9	0.44
Alkaline fen	Upland	12	0.42
Alpine flush	Upland	13	0.31
Limestone pavement	Upland	4	0.25
Tall herbs	Upland	24	0.17
Siliceous scree	Upland	20	0.10
Calcareous rocky slopes	Upland	6	0
Calcareous scree	Upland	5	0
Transition mire, ladder fen & quaking bog	Upland	5	0
Caledonian forest	Woodland	11	1.00
Scrub	Woodland	1	1.00
Upland birch woodland	Woodland	8	0.88
Upland oak woodland	Woodland	9	0.78
Wet woodland	Woodland	2	0.50
Upland mixed ash woodland	Woodland	4	0.25
Bog woodland	Woodland	4	0
Wetland springs	Wetland	1	0
Maritime cliff	Maritime	3	0
Total		336	0.521

⁶ The 'at risk' assessment incorporated SCM target failures relating to grazing and trampling impacts. The term herbivory is used in the text as short-hand for both types of impact.

4.4 Which features were recorded as ‘under-grazed’?

Using the original names from the SCM database (filtered to include all features from sites with more than one upland feature), cases where ‘under-grazing’ was listed in the comments were highlighted (Table 4.4). There appeared to be relatively few instances of ‘under-grazing’ occurring. Apart from the ‘vascular plant assemblage’ the other features highlighted all belong to the ‘calcareous grassland (upland)’ standardised feature type. Some features are listed as both ‘under-grazed’ and ‘over-grazed’. Examining the SCM reports for the calcareous features in question showed that at two sites (Cairngorms and Torridon Forest), the under-grazing had come about because of management to promote tree regeneration. On Ben Nevis, the under-grazing was reported only because bracken expansion had been observed, and this was thought to be as a result of reduced sheep grazing. Other factors may have caused the bracken to increase. On Ben Lui, ‘under-grazing’ was reported for species-rich grassland with mat-grass in upland areas, a result of too little disturbed ground, too much thatch, and tall vegetation. The alpine and sub-alpine calcareous grasslands on Ben Lui were reported to be simultaneously both ‘under-grazed’ and ‘over-grazed’, with some waypoints failing because vegetation was too short and one failing because it was too tall.

Table 4.4 - Cases where ‘under-grazing’ is listed under ‘comments’.

Site name	Feature name	Standardised feature name	Under-grazed	Under-grazed with some Disturbance	Under-grazed & Over-grazed
Ben Lui	Species-rich grassland with mat-grass in upland areas	Calcareous grassland (upland)	✓		
Ben Nevis	Species-rich grassland with mat-grass in upland areas	Calcareous grassland (upland)	✓		
Caenlochan	Species-rich grassland with mat-grass in upland areas	Calcareous grassland (upland)	✓		
Torridon Forrest	Sub-alpine calcareous grassland	Calcareous grassland (upland)			✓
Ben Lui	Alpine and sub-alpine calcareous grasslands	Calcareous grassland (upland)			✓
Cairngorms	Species-rich grassland with mat-grass in upland areas	Calcareous grassland (upland)		✓	
Morone Birkwoods	Vascular plant assemblage	Vascular plant assemblage			✓

4.5 Pairs analysis

An analysis of the condition of pairs of habitat features was carried out to analyse the multiple habitat combinations that can occur on sites. As there are numerous reasons, unrelated to grazing, why a feature can fail SCM (e.g. due to a landslide, rock fall, human trampling or vehicle damage), the analysis of pairs at risk and not at risk from grazing is perhaps more interesting and useful than the analysis of pairs in favourable or unfavourable condition. While both are included in Tables 4.5 and 4.6 and as appendices (Appendix B and C), the focus of the analysis was on the pairs at risk from herbivory. In Table 4.5 the data have been sorted so that pairs of features with the most occurrences where one feature type is in favourable condition and the other is in unfavourable condition are at the top of the table. In Table 4.6 the data have been sorted so that pairs of features with the most occurrences where one feature type has been noted as at risk from herbivory while the other feature is not at risk are at the top of the table. Only potential conflicts that occur four or more times are included in the tables. The feature types have been colour coded according to Table 4.1. It should be remembered that some sites are many kilometres across and the habitat pairs being compared may not be in close proximity and might in fact experience completely different herbivory levels. We would have expected feature types that are at the top of Table 4.1 (light green and dark green) paired with feature types at the bottom of Table 4.1 (orange and yellow) to occupy the top of Table 4.6. This was not the case. The issues of accessibility to herbivores, the geographical location and proximity of the feature types and the large number of occasions where both feature types were at risk of herbivory are probably responsible for the patterns seen in the data. If both feature types are at risk from herbivory then any potential conflicts that exist between the feature types will be masked.

Table 4.5 - Possible conflicts between paired vegetation types determined from Site Condition Monitoring data. The data have been arranged as pairs of features, noting whether each pair is in potential conflict (i.e. one feature in favourable condition, one unfavourable condition) or not (n.b. in these cases unfavourable condition does not necessarily relate to herbivory). Only potential conflicts that occur four or more times are included (for full table see Appendix B).

Feature Type 1	Feature Type 2	Number of occurrences where one feature type in favourable condition and the other in unfavourable condition	Type 1 in favourable condition Type 2 in unfavourable condition	Type 2 in favourable condition Type 1 in unfavourable condition	Total number of occurrences of the pair
Siliceous scree	Alpine dwarf-shrub heath	12	11	1	17
Siliceous scree	Subalpine dry dwarf-shrub heath	12	11	1	18
Siliceous scree	Alpine summit communities	10	9	1	18
Tall herbs (upland)	Alpine dwarf-shrub heath	9	9	0	16
Tall herbs (upland)	Alpine summit communities	9	8	1	17
Siliceous scree	Blanket bog and valley bog (upland)	9	9	0	15
Tall herbs (upland)	Blanket bog and valley bog (upland)	9	9	0	13
Siliceous scree	Calcareous grassland (upland)	8	8	0	10
Tall herbs (upland)	Calcareous grassland (upland)	8	8	0	14
Siliceous scree	Montane willow scrub	8	8	0	9
Siliceous scree	Wet heath (upland)	8	7	1	14
Tall herbs (upland)	Montane willow scrub	7	7	0	13
Tall herbs (upland)	Subalpine dry dwarf-shrub heath	7	7	0	14
Subalpine dry dwarf-shrub heath	Blanket bog and valley bog (upland)	6	5	1	21
Tall herbs (upland)	Wet heath (upland)	6	6	0	12
Alpine dwarf-shrub heath	Blanket bog and valley bog (upland)	5	4	1	18
Alpine summit communities	Blanket bog and valley bog (upland)	5	4	1	15
Siliceous scree	Alkaline fen (upland)	4	4	0	5
Alpine dwarf-shrub heath	Wet heath (upland)	4	3	1	15
Alpine flush	Calcareous grassland (upland)	4	4	0	10
Alpine flush	Montane willow scrub	4	4	0	8
Alpine flush	Subalpine dry dwarf-shrub heath	4	3	1	7
Subalpine dry dwarf-shrub heath	Alpine summit communities	4	2	2	20
Alpine summit communities	Wet heath (upland)	4	3	1	14
Calcareous rocky slopes	Calcareous grassland (upland)	4	4	0	4
Calcareous scree	Calcareous grassland (upland)	4	4	0	5
Calcareous scree	Subalpine dry dwarf-shrub heath	4	4	0	4
Siliceous scree	Caledonian forest/Native pinewood	4	4	0	5
Tall herbs (upland)	Caledonian forest/Native pinewood	4	4	0	4

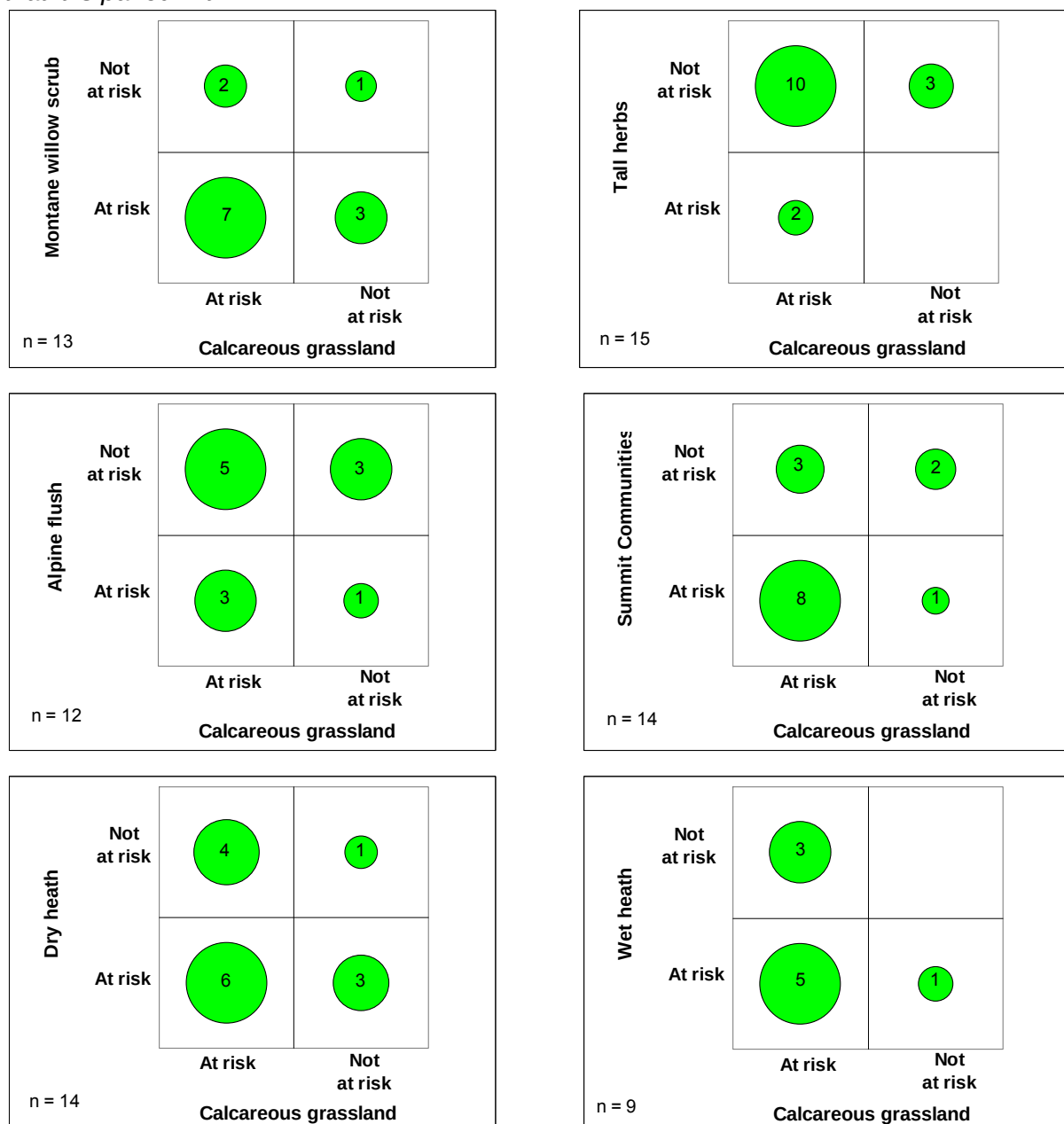
Table 4.6 - Possible conflicts between paired vegetation types determined from Site Condition Monitoring data (only includes features which were noted as at risk from herbivory). Only potential conflicts that occur four or more times are included (for full table see Appendix C)

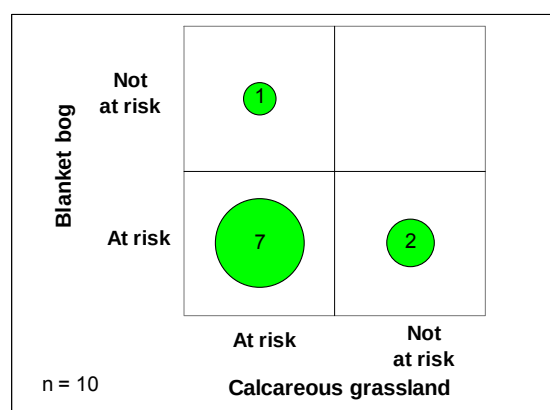
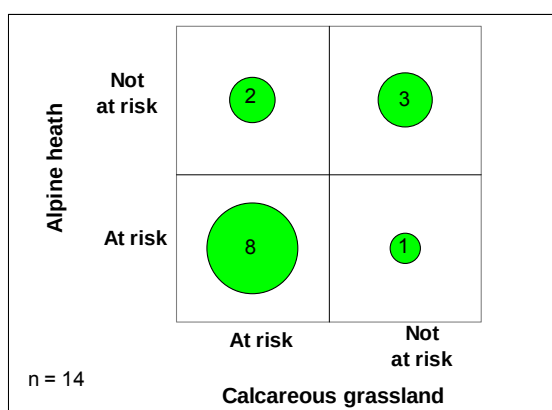
Feature Type 1	Feature Type 2	Count of Occurrences of Pair where:			
		Conflict occurring, Feature Type 2 at risk, Feature Type 1 not at risk from herbivory	Conflict occurring, Feature Type 2 not at risk, Feature Type 1 at risk from herbivory	Both Feature Types in the pair are at risk from herbivory	Neither Feature Type in the pair is at risk from herbivory
Tall herbs (upland)	Blanket bog and valley bog (upland)	12	1	0	1
Tall herbs (upland)	Calcareous grassland (upland)	10	0	2	3
Tall herbs (upland)	Alpine dwarf-shrub heath	10	0	1	5
Tall herbs (upland)	Alpine summit communities	10	0	1	6
Tall herbs (upland)	Wet heath (upland)	9	0	1	2
Tall herbs (upland)	Montane willow scrub	9	1	0	3
Tall herbs (upland)	Subalpine dry dwarf-shrub heath	9	1	0	4
Subalpine dry dwarf-shrub heath	Caledonian forest/Native pinewood	6	0	3	0
Alpine dwarf-shrub heath	Blanket bog and valley bog (upland)	6	3	9	2
Alpine flush	Calcareous grassland (upland)	5	1	3	3
Subalpine dry dwarf-shrub heath	Blanket bog and valley bog (upland)	5	2	11	4
Alpine summit communities	Blanket bog and valley bog (upland)	5	3	8	0
Calcareous rocky slopes	Calcareous grassland (upland)	4	0	0	0
Tall herbs (upland)	Caledonian forest/Native pinewood	4	0	0	0
Bog woodland	Caledonian forest/Native pinewood	4	0	0	0
Bog woodland	Wet heath (upland)	4	0	0	0
Alpine flush	Montane willow scrub	4	1	2	2
Alpine flush	Wet heath (upland)	4	1	0	0
Alpine summit communities	Subalpine dry dwarf-shrub heath	4	2	10	4
Alpine summit communities	Wet heath (upland)	4	2	7	1
Alpine dwarf-shrub heath	Wet heath (upland)	4	2	7	3
Subalpine dry dwarf-shrub heath	Calcareous grassland (upland)	4	3	6	1

4.5.1 Calcareous grassland and their paired vegetation types

Although from the expert survey we had expected calcareous grassland to be only infrequently at risk from herbivory, the SCM data showed that in fact calcareous grassland was frequently classified as at risk from herbivory, while the vegetation types it was paired with were sometimes at risk and sometimes not. Situations where calcareous grassland was not at risk from herbivory but its paired feature type was at risk were actually quite uncommon. We would expect that if calcareous grassland was at risk from herbivory, all other accessible vegetation types would also be at risk. It may be that in cases where calcareous grassland is at risk from herbivory and other vegetation types are not, they are geographically separate or the other vegetation type is inaccessible to herbivores. Figure 4.1 illustrates the pattern of relationships between calcareous grassland and some of the habitats it is paired with.

Figure 4.1 - The relationship between calcareous grassland and some of the other habitats that it is paired with.





4.5.2 Ledge habitats: tall herbs, montane scrub and their paired vegetation types

The most common state for pairs containing tall herb vegetation was with tall herbs 'not at risk from herbivory' and the other vegetation type 'at risk'. These were the most frequently recorded pairs and occupy the top of Table 4.6. This suggests that most of the monitored tall herb vegetation is restricted to cliff ledges that are inaccessible to grazing animals. For montane scrub, the reverse was a common situation, where the montane scrub was 'at risk from herbivory' and its partner vegetation was not, indicating that some of the montane willow sites are more accessible to herbivores or that populations were judged to be more limited by browsing impacts. Sites where both montane scrub and its partner vegetation type were at risk from grazing were very common (see Appendix C).

4.5.3 Sub-alpine dry dwarf-shrub heath habitats and their paired vegetation types

There were many instances where both sub-alpine dry dwarf-shrub heath and its partner vegetation type were at risk from herbivory, but there were also considerable numbers of sites in the other three categories (see Appendix C). Sub-alpine dry dwarf shrub heath returned a different assessment from Caledonian pine forest in six sites, and from blanket bog in seven sites.

4.5.4 Woodland habitats and their paired vegetation types

Caledonian forest was always at risk from herbivory, while the vegetation types it is paired with were sometimes at risk, sometimes not. Tall herbs paired with Caledonian forest were never at risk from herbivory, whereas montane scrub paired with Caledonian forest was always at risk. The commonest combination for upland oak woodlands was an 'at risk' assessment, with the other vegetation type in the pair 'not at risk'. In all cases where upland birch woodland was paired with blanket bog both features were 'at risk from herbivory'. Bog woodland, however, was always classed as 'not at risk from herbivory' while the vegetation types it was paired with frequently were 'at risk'.

4.6 Herbivore Impact Assessment Analysis

4.6.1 Ben Heasgarnich SAC, SSSI

Grazing impacts were generally low or low to moderate for all feature types (Tables 4.7 and 4.8). Willow scrub was assigned only low (L) and low-moderate (LM) impacts (which are within the desirable range). This suggests that the willow scrub locations were either inaccessible to large herbivores or had limited access. Moderate-high (MH) impacts were recorded at 1.7% of the flush locations, and moderate (M) impacts were recorded at 16.7% of the tall herb locations (outside the desirable ranges). Low impacts were recorded at 14.8% of the smooth grassland locations which is outside the desirable range. Grazing impacts tended to be higher at locations within Estate B even though sheep and deer densities were recorded as being lower compared with Estate A. Trampling impacts tended to be higher than those of grazing and browsing (Tables 4.9 and 4.10).

Table 4.7 - Grazing impacts on the assessed features on Ben Heasgarnich (counts). Impacts highlighted in green are within the 'desirable range' those outside the 'desirable range' are highlighted in red.

Feature	Estate	Count				Total
		L	LM	M	MH	
Flush	A	2	22	0	1	25
	B	17	63	6	1	87
	C	1	3	1	0	5
	All	20	88	7	2	117
Smooth Grassland	A	5	37	2	0	44
	B	6	24	8	3	41
	D	2	1	0	0	3
	All	13	62	10	3	88
Tall Herb	A	4	1	0	0	5
	B	11	4	4	0	19
	All	15	5	4	0	24
Willow Scrub	B	2	2	0	0	4

Table 4.8 - Grazing impacts on the assessed features on Ben Heasgarnich (percentages). Impacts highlighted in green are within the 'desirable range' those outside the 'desirable range' are highlighted in red.

Feature	Estate	Percentage			
		L	LM	M	MH
Flush	A	8.0	88.0	0.0	4.0
	B	19.5	72.4	6.9	1.1
	C	20.0	60.0	20.0	0.0
	All	17.1	75.2	6.0	1.7
Smooth Grassland	A	11.4	84.1	4.5	0.0
	B	14.6	58.5	19.5	7.3
	D	66.7	33.3	0.0	0.0
	All	14.8	70.5	11.4	3.4
Tall Herb	A	80.0	20.0	0.0	0.0
	B	57.9	21.1	21.1	0.0
	All	62.5	20.8	16.7	0.0
Willow Scrub	B	50.0	50.0	0.0	0.0

Table 4.9 - Trampling impacts on the assessed features on Ben Heasgarnich (counts).

Feature	Estate	Count					Total
		L	LM	M	MH	H	
Flush	A	2	15	3	5		25
	B	15	41	17	13	1	87
	C	1	4				5
	All	18	60	20	18	1	117
Smooth Grassland	A		17	19	8		44
	B		15	19	6	1	41
	D		2	1			3
	All		34	39	14	1	88
Willow Scrub	B		4				4

Table 4.10 - Trampling impacts on the assessed features on Ben Heasgarnich (percentages).

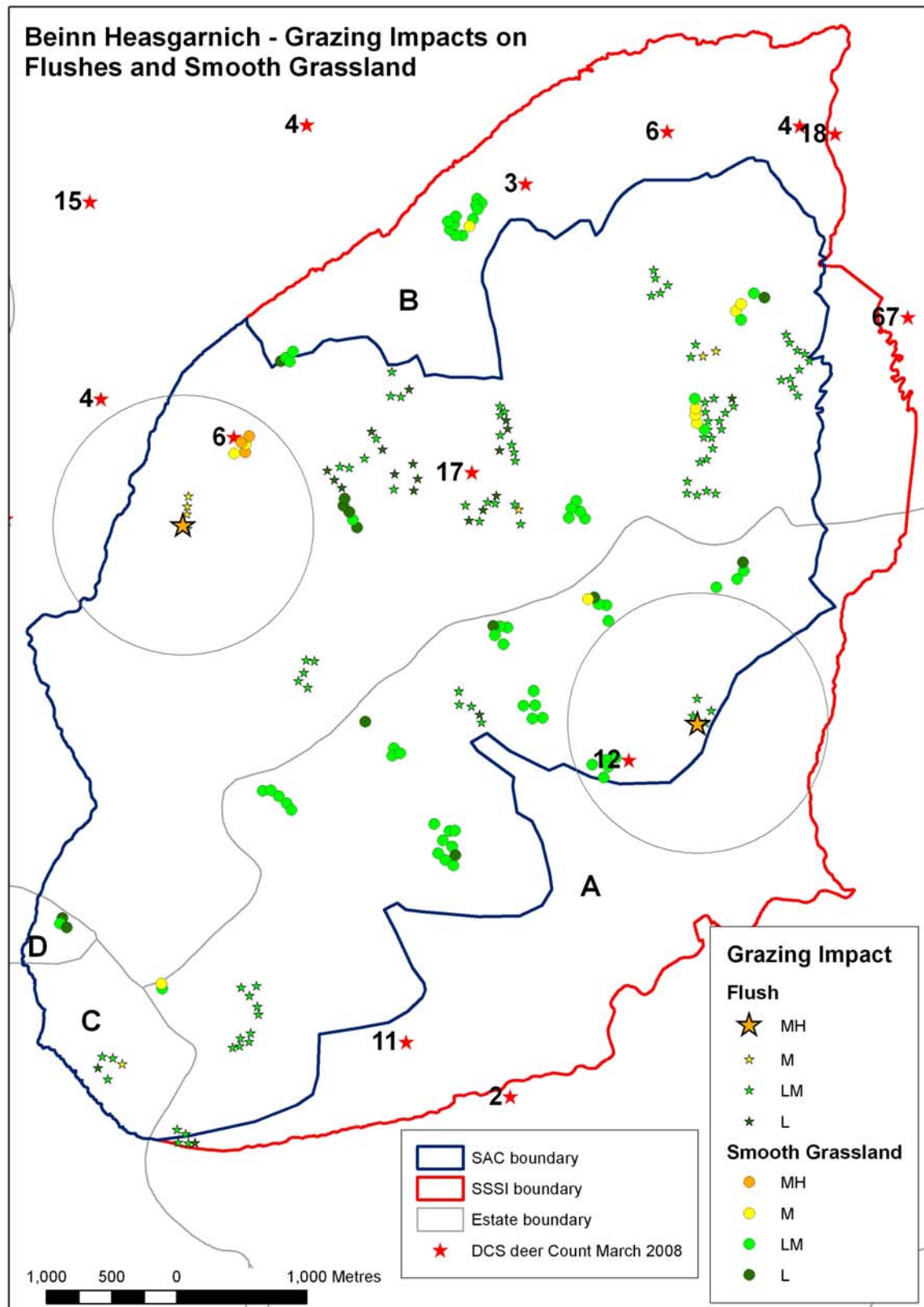
Feature	Estate	Percentage					
		L	LM	M	MH	H	
Flush	A	8.0	60.0	12.0	20.0	0.0	
	B	17.2	47.1	19.5	14.9	1.1	
	C	20.0	80.0	0.0	0.0	0.0	
	All	15.4	51.3	17.1	15.4	0.9	
Smooth Grassland	A	0.0	38.6	43.2	18.2	0.0	
	B	0.0	36.6	46.3	14.6	2.4	
	D	0.0	66.7	33.3	0.0	0.0	
	All	0.0	38.6	44.3	15.9	1.1	
Willow Scrub	B	0.0	100.0	0.0	0.0	0.0	

There is potential conflict between flushes and smooth grassland, and tall herb vegetation and smooth grassland if these features are in close proximity. Flushes and tall herb vegetation require lower levels of grazing than smooth grassland, and therefore grazing levels where the impact on smooth grassland is still within the desirable range may lead to higher impacts on nearby flushes or areas of tall herb vegetation, which are outside their desirable ranges. There may also be conflict between smooth grassland and all the other feature types, where the grazing impact has been assessed as low on the smooth grassland (which is below its desirable range) and is within the desirable ranges of the other vegetation types.

Figure 4.2 indicates that grazing impact levels of MH on flushes are rare (only two points in two distinct geographical areas). The point in the west of the SSSI is within 1km of some smooth grassland points which are within the desirable range (M and MH). The other location where a flush was recorded with an MH grazing impact assessment was in the east of the SSSI. This flush was in a cluster with other flush points with L grazing impact assessments, suggesting a very localised grazing impact. Smooth grassland locations with LM grazing impact assessments occurred within 1km of this site.

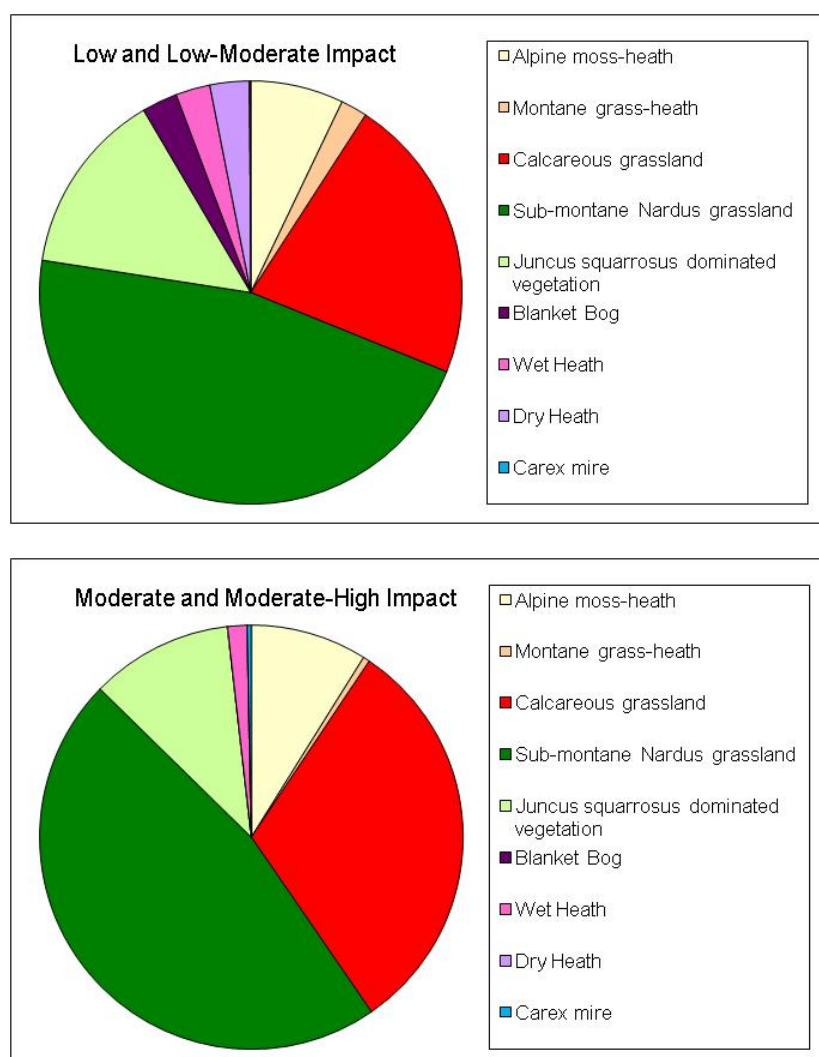
Figure 4.3 shows the mean percentage cover of the different vegetation types surrounding the flush locations in two groups of grazing impact classes. This suggests that flush points with M and MH grazing impact classes tend to occur in areas with a higher cover of grassland, which may encourage herbivores and lead to a higher level of grazing in the area, resulting in a higher grazing impact on the flushes.

Figure 4.2 - Map showing the grazing impacts on the flush and smooth grassland feature types on Beinn Heasgarnich. Buffer circles (1km radius) have been drawn around the flush locations where the impact was outside the desirable range. Estates are labelled A to D.



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Figure 4.3 - Mean percentage cover of the vegetation surrounding the flush locations in two groups of grazing impact classes. The areas of the different vegetation types within 500m radius buffer circles of each location were used to calculate the mean percentage cover of the different vegetation types within the different impact classes.



There were no tall herb points with grazing impact assessments of moderate-high or above. Figure 4.4 shows that there were three distinct areas where grazing impacts on tall herb vegetation was assessed as moderate. Smooth grassland locations with LM or M grazing impact assessments occurred within 1km of all three areas. There may be some localised conflict in these areas where the grazing levels are appropriate for the smooth grassland but are too high for the tall herb vegetation where it is accessible to herbivores.

Figure 4.5 shows the mean percentage cover of the different vegetation types surrounding the tall herb locations in two groups of grazing impact classes. This indicates that the moderate impact locations tend to occur in areas with a higher cover of more preferred vegetation types (i.e. calcareous grassland, alpine moss-heath and montane grass-heath). This may lead to increased grazing levels in these areas resulting in higher impacts on the tall herb vegetation. Alternatively the differences in surrounding vegetation types could reflect other behavioural preferences such as for higher altitudes in summer.

Figure 4.4 - Map showing the grazing impacts on the tall herb and smooth grassland feature types on Beinn Heasgarnich. Buffer circles (1km radius) have been drawn around the tall herb locations where the impact was outside the desirable range. Estates are labelled A to D.

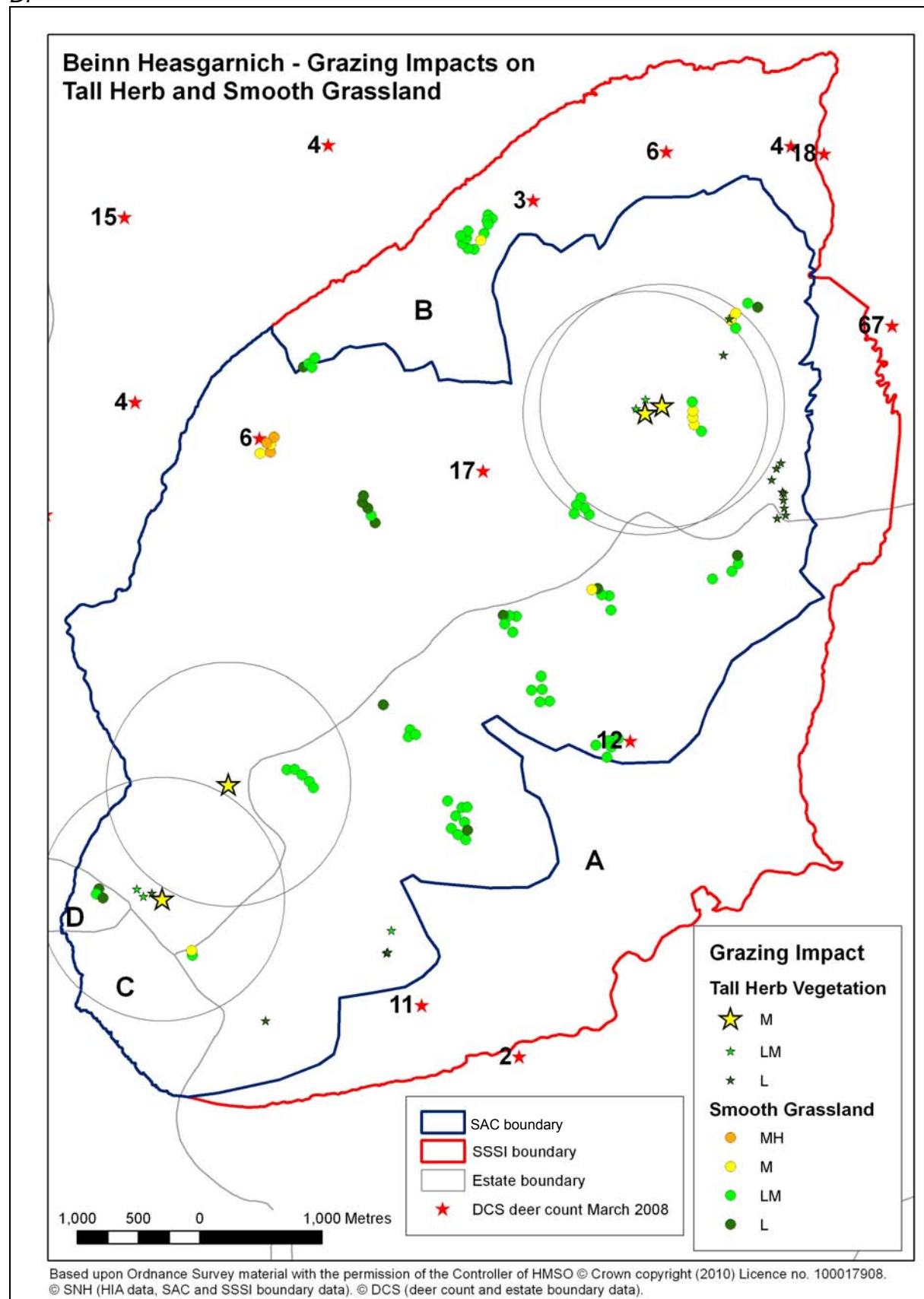
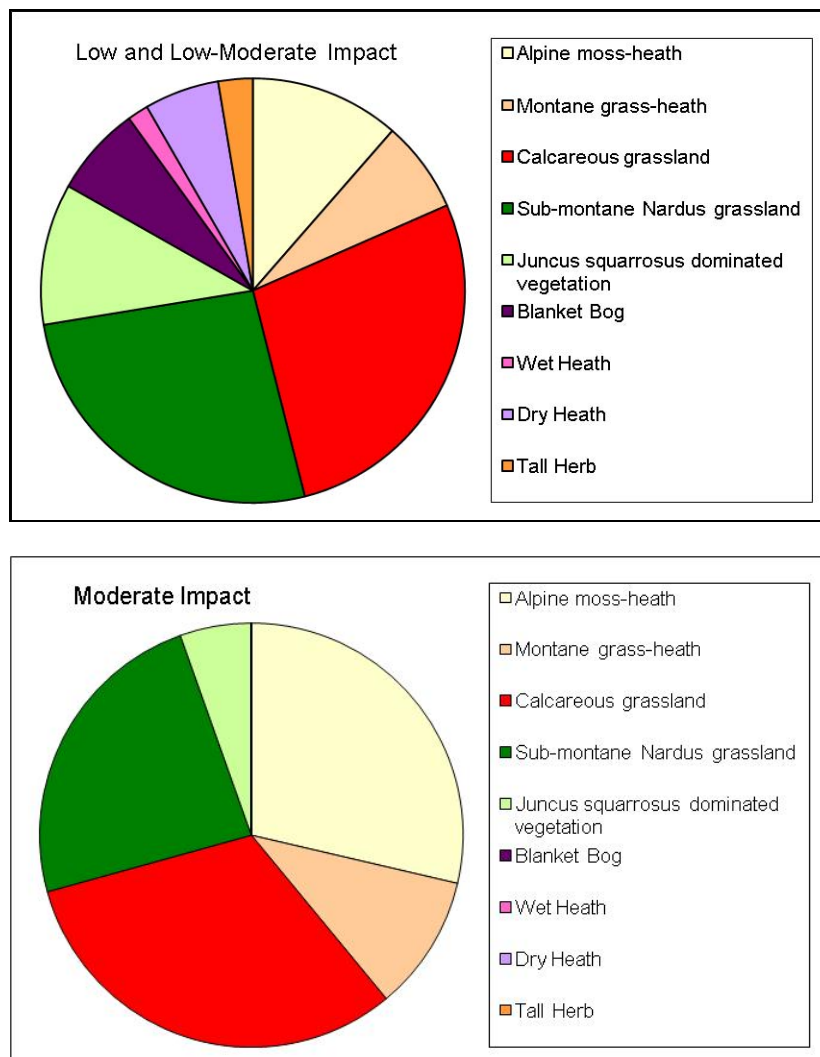
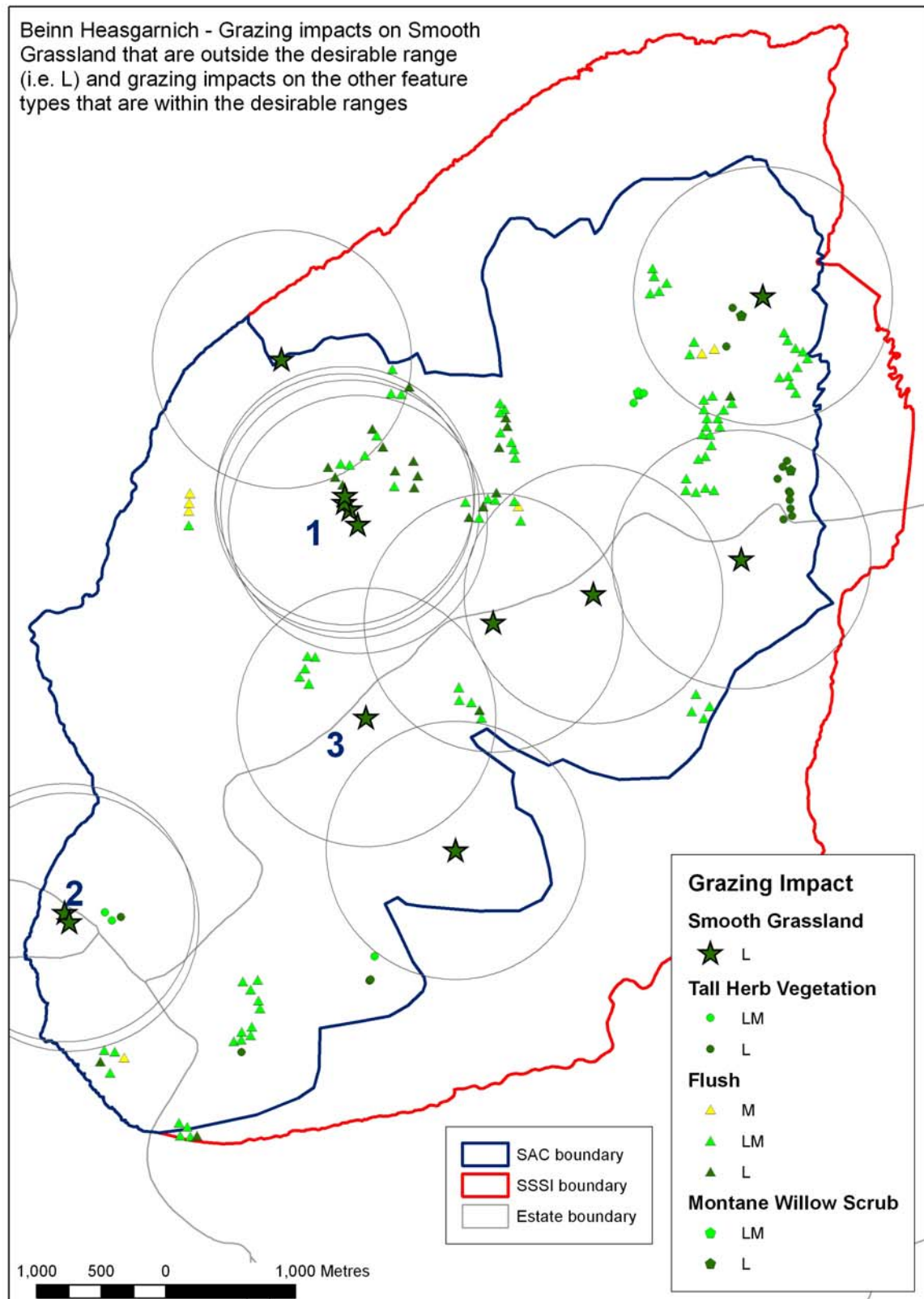


Figure 4.5 - Mean percentage cover of the vegetation surrounding the tall herb locations on Beinn Heasgarnich in two groups of grazing impact classes. The areas of the different vegetation types within 500m radius buffer circles of each location were used to calculate the mean percentage cover of the different vegetation types within the different impact classes.



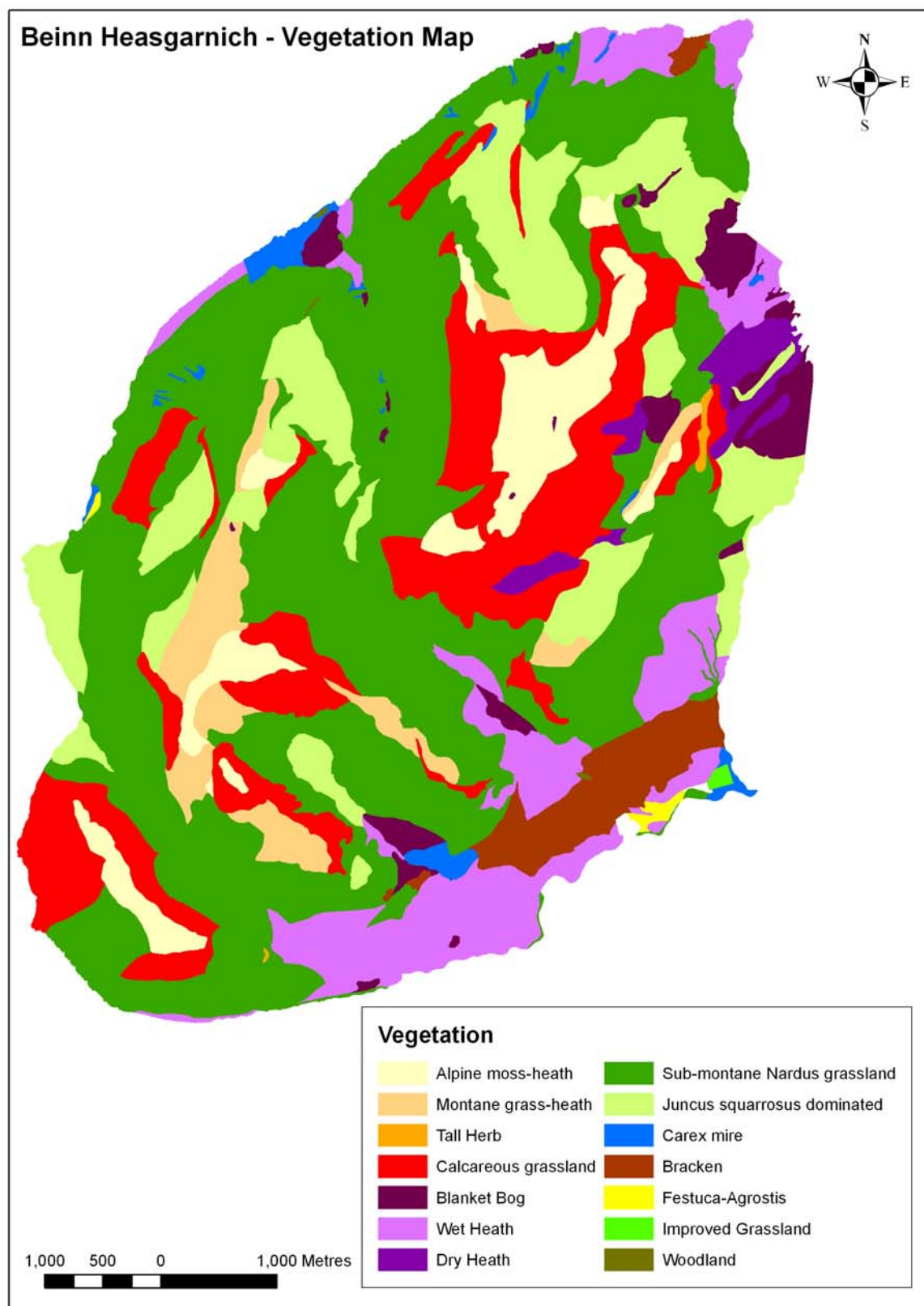
Smooth grassland locations with a low grazing impact assessment were found throughout the SSSI (Figure 4.6). This indicates that throughout the site there were areas where the smooth grassland is probably under-grazed, but most of the locations were within clusters that had an average grazing impact assessment within the desirable range. Three clusters (marked 1, 2 and 3 on Figure 4.6) had average grazing impact assessments of low. Flushes with grazing impact assessments within the desirable range occurred within 1km of clusters 1 and 3, and tall herb locations with grazing impact assessments within the desirable range occurred within 1km of cluster 2. There is potential conflict in these areas with the smooth grassland being under-grazed while the flushes and tall herb vegetation are within their desirable grazing impact ranges.

Figure 4.6 - Map showing the smooth grassland locations where the grazing impact was assessed as low (outside the desirable range) and the tall herb, flush and willow scrub locations where the grazing impact was within the desirable ranges of the particular feature type. Buffer circles (1km radius) have been drawn around the smooth grassland locations where the impact was outside the desirable range.



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Figure 4.7 - Vegetation map of Beinn Heasgarnich.



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4.6.1.1 Hill Grazing Management Model (HGMM)

The HGMM (Armstrong *et al.*, 1997a, 1997b) was run for Beinn Heasgarnich using the data in Tables 4.11 and 4.12, to look at the predicted utilisation rates (percentage of the annual production predicted to be removed by herbivores) on the different vegetation types, and to see how halving or doubling the stock numbers affected the utilisation rates.

Table 4.11 - Data and assumptions used to run the HGMM for Beinn Heasgarnich.

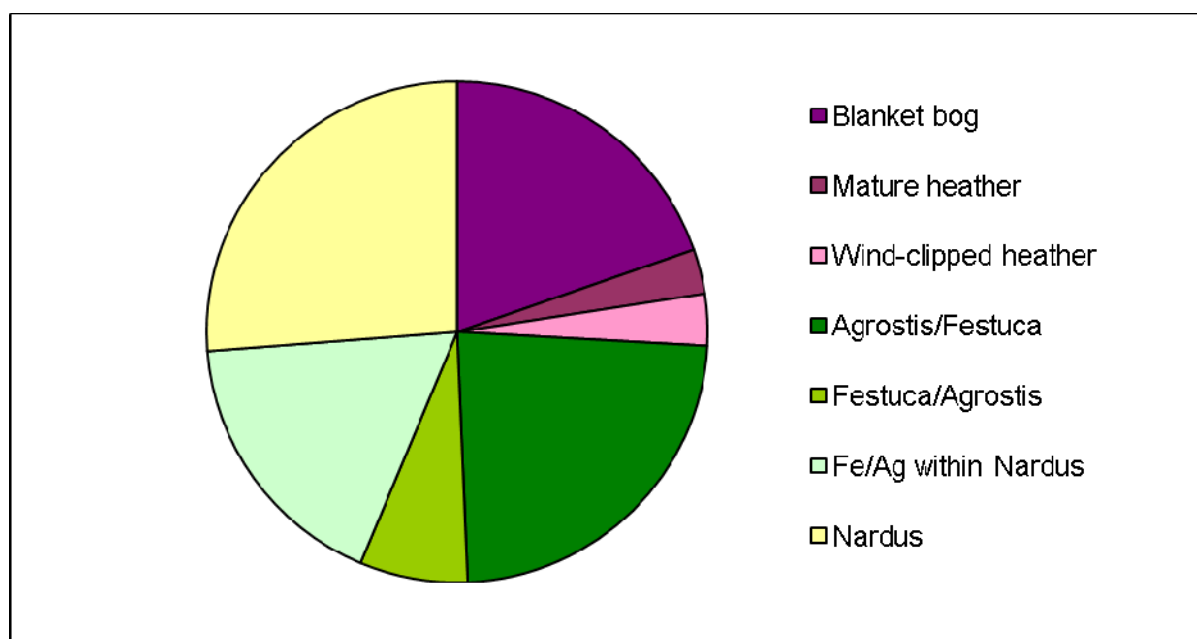
Information Required by the HGMM	Input Data
Zone	5
Location	Upland
Side	West
Mean altitude of heather communities	500m
Blanket Bog - Area	656.3 ha
Blanket Bog - Cover of <i>Calluna vulgaris</i>	65.00%
Blanket Bog - Cover of <i>Festuca/Agrostis</i>	1.00%
Mature Heather - Area	96.1 ha
Mature Heather - Cover of <i>Calluna vulgaris</i>	65.00%
Mature Heather - Cover of <i>Festuca/Agrostis</i>	1.00%
Wind clipped Heather - Area	110.8 ha
Wind clipped Heather - Cover of <i>Calluna vulgaris</i>	10.00%
Mean altitude of indigenous grassland communities	675 m
<i>Agrostis/Festuca</i> - Area	782.2 ha
<i>Agrostis/Festuca</i> - Cover	100% (fixed)
<i>Festuca/Agrostis</i> - Area	232.9 ha
<i>Festuca/Agrostis</i> - Cover	100 % (fixed)
<i>Nardus stricta</i> community - Area	2081.3 ha
<i>Nardus stricta</i> community - Cover of <i>Nardus stricta</i>	42.00%
<i>Nardus stricta</i> community - Cover of <i>Festuca/Agrostis</i>	28.00%
Average ewe weight	46 kg
Red deer equivalent of a ewe.	1.78
Area of Estate A (within SSSI)	1615 ha
Area of Estate B (within SSSI)	2309 ha
Area of Estate C (within SSSI)	125 ha
*Sheep stocking rate on Estate A	0.6 (summer), 0.4 (winter) ewes/ha
*Sheep stocking rate on Estate B	0.3 ewes/ha
*Sheep stocking rate on Estate C	1.0 (summer), 0.0 (winter) ewes/ha
**Deer on Estate A (March 2008 count)	6.2 deer/km ²
**Deer on Estate B (March 2008 count)	3.5 deer/km ²
**Deer on Estate C (March 2008 count)	2.1 deer/km ²

* Sheep data from Dayton (2007); **Deer data from DCS deer count report March 2008. It should be noted this data is a snapshot and may not reflect year round densities or patterns of habitat use.

Table 4.12 - Beinn Heasgarnich herbivore data for input into the HGMM.

		J	F	M	A	M	J	J	A	S	O	N	D
A	Ewes	646	646	646	969	969	969	969	969	969	969	646	646
B	Ewes	692	692	692	692	692	692	692	692	692	692	692	692
C	Ewes				125	125	125	125	125	125	125		
Total	Ewes	1338	1338	1338	1786	1786	1786	1786	1786	1786	1786	1338	1338
A	Red Deer	100	100	100	100	100	100	100	100	100	100	100	100
B	Red Deer	81	81	81	81	81	81	81	81	81	81	81	81
C	Red Deer	3	3	3	3	3	3	3	3	3	3	3	3
Total	Red Deer	184	184	184	184	184	184	184	184	184	184	184	184
Ewe equivalents		1645	1645	1645	2093	2093	2093	2093	2093	2093	2093	1645	1645
	Double	3291	3291	3291	4187	4187	4187	4187	4187	4187	4187	3291	3291
	Half	823	823	823	1047	1047	1047	1047	1047	1047	1047	823	823

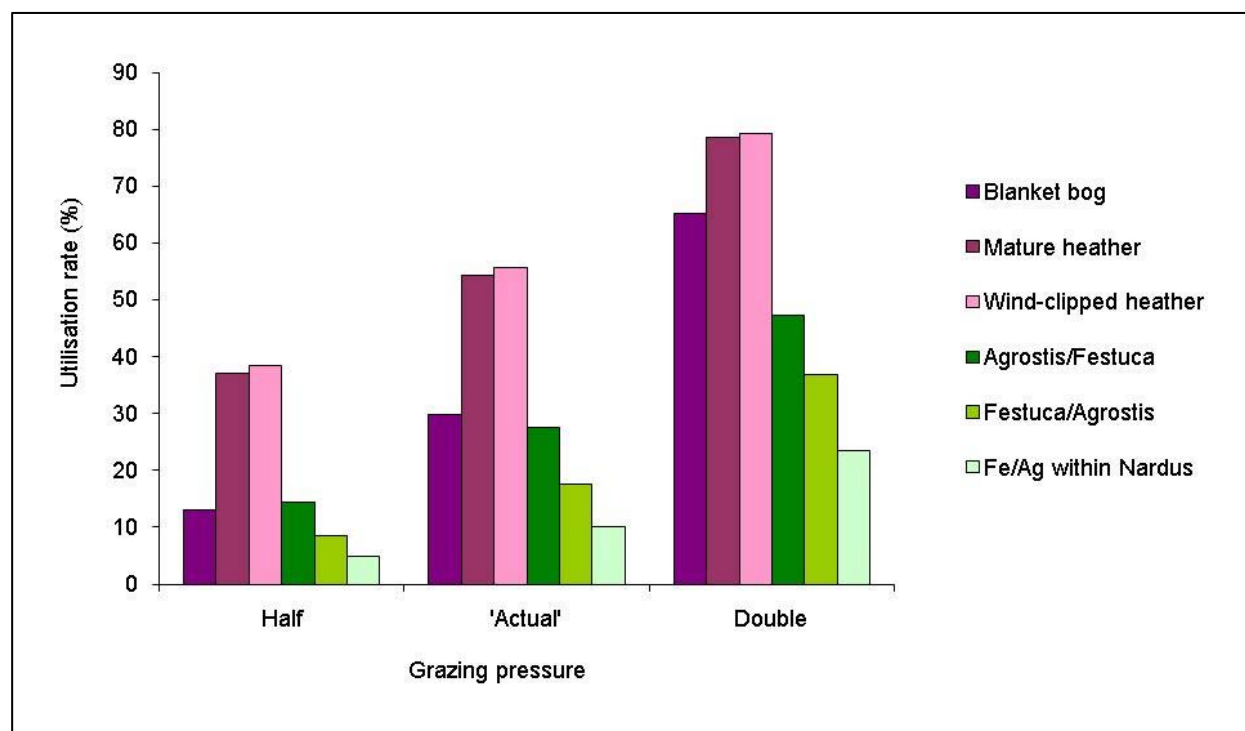
Figure 4.8 - Proportions of the different HGMM vegetation types on Beinn Heasgarnich.



The predicted utilisation rates for the different vegetation types are shown in Figure 4.9. These show that currently there are very high utilisation rates on the blanket bog and heather communities, but low utilisation rates on the grassland habitats. This is because the area of the heather communities is small compared to that of the grass communities. Since heather is more nutritious for sheep in the winter than is dead grass, the sheep will focus their grazing on the relatively small area of the heather communities in the winter, leading to high grazing pressure and high utilisation rates. At the same time, the utilisation rates of the grass communities are quite low and may even lead to them being in unfavourable condition. The HIA data indicates that this is happening with grazing impacts on the smooth grassland below the desirable range in almost 15% of the surveyed locations. If the stocking rate is halved to reduce the use of the heather communities, utilisation rates on the heather are still high whereas those on the grass communities are even lower (Figure 4.9). If the stocking rate is increased so that the grass communities are more heavily grazed, the heather communities become even more heavily grazed and are likely to decline. This example

illustrates the importance of the relative area of different vegetation communities in influencing the likelihood of grazing conflicts occurring. Where communities vulnerable to over-grazing are preferred by herbivores (as many are in winter when there is a high proportion of dead material in the grass communities) and when they cover only a small area relative to those vegetation communities that are less preferred and less vulnerable, conflicts are likely to arise. This principle applies to other preferred, and vulnerable, features such as woodland and montane willow scrub. This illustrates the importance of taking account of the relative area of available vegetation communities, and herbivore preferences, in predicting whether conflicts are likely to occur or not.

Figure 4.9 - Utilisation rates on Beinn Heasgarnich predicted by the HGMM.



From the analyses of the Beinn Heasgarnich HIA data there is only limited evidence for conflicts between the feature types examined. This is partly due to accessibility (i.e. most of the montane willow scrub and tall herb vegetation occurs on inaccessible cliff ledges removing any grazing conflict with the surrounding vegetation) and partly due to the extensive area of grassland on the site which requires higher grazing levels and is attractive to herbivores, reducing the potential impact on the other feature types. There is reasonable evidence that the area of preferred habitats (in particular grasslands) affects the level of impacts on more sensitive adjacent habitats. Although not surveyed as part of the HIA (as not part of the notified interests), the HGMM predicts that the utilisation of the blanket bog and other heath communities are likely to be high which would lead to high grazing impacts.

4.6.2 Meall na Samhna SAC/ SSSI

Grazing impacts were generally low or low to moderate for all the feature types on Meall na Samhna (Tables 4.13 and 4.14). Flush locations were assigned only L, LM or M impacts, all within the desirable range. Only two tall herb locations were recorded with grazing impacts of moderate or higher. Wind-clipped heath had the most locations in the moderate, moderate-high or high impact classes. The southern half of the SSSI had the most locations

with impacts of moderate or higher for all the feature types. Thirty nine percent of the smooth grassland locations had a low grazing impact assessment, which is outside the desirable range.

Table 4.13 - Grazing impacts on the assessed features on Meall na Samhna (counts). Impacts highlighted in green are within the 'desirable range' those outside the 'desirable range' are highlighted in red.

Feature	Estate	Count					Total
		L	LM	M	MH	H	
Flush	A	12	58	3	0	0	73
	B	2	24	2	0	0	28
	All	14	82	5	0	0	101
Smooth Grassland	A	11	12	2	0	0	25
	B	1	4	1	0	0	6
	All	12	16	3	0	0	31
Tall Herb	A	4	5	1	1	0	11
	B	1	2	0	0	0	3
	All	5	7	1	1	0	14
Wind-clipped Heath	A		3	7	3	4	17
	B	1	4	4	4	0	13
	All	1	7	11	7	4	30

Table 4.14 - Grazing impacts on the assessed features on Meall na Samhna (percentages). Impacts highlighted in green are within the 'desirable range' those outside the 'desirable range' are highlighted in red.

Feature	Estate	Percentage					
		L	LM	M	MH	H	
Flush	A	16.4	79.5	4.1	0.0	0.0	
	B	7.1	85.7	7.1	0.0	0.0	
	All	13.9	81.2	5.0	0.0	0.0	
Smooth Grassland	A	44.0	48.0	8.0	0.0	0.0	
	B	16.7	66.7	16.7	0.0	0.0	
	All	38.7	51.6	9.7	0.0	0.0	
Tall Herb	A	36.4	45.5	9.1	9.1	0.0	
	B	33.3	66.7	0.0	0.0	0.0	
	All	35.7	50.0	7.1	7.1	0.0	
Wind-clipped Heath	A	0.0	17.6	41.2	17.6	23.5	
	B	7.7	30.8	30.8	30.8	0.0	
	All	3.3	23.3	36.7	23.3	13.3	

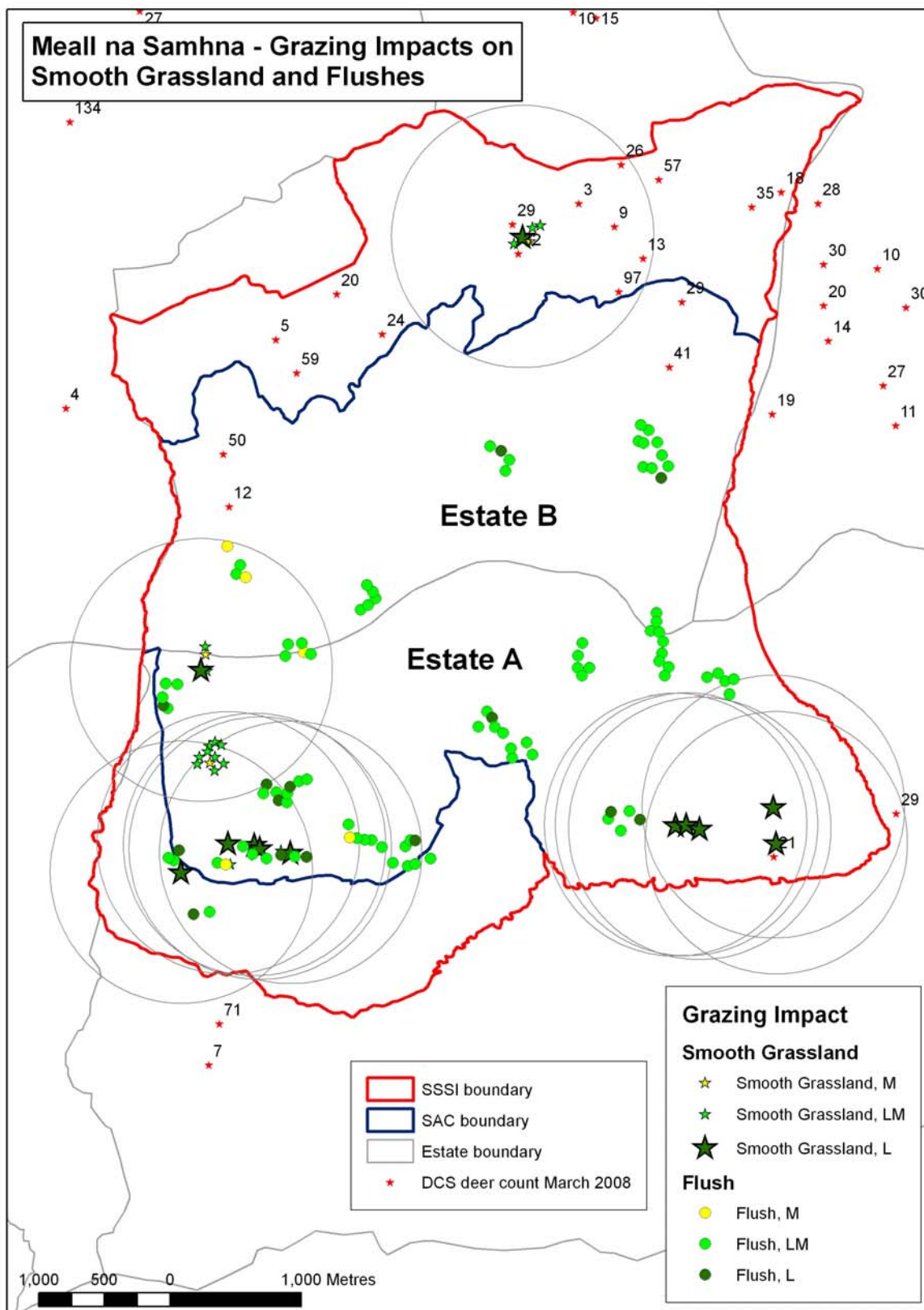
The locations where the grazing impact on the smooth grassland were assessed as low were mainly in the south-east and southwest of the SSSI (Figure 4.10). Nine locations where low grazing impacts were recorded on the smooth grassland were within 1km of flush features with grazing impact assessments of low, low-moderate or moderate (which are all within the desirable range). In these areas the grazing level is probably too low for the smooth grassland which may lead to changes in structure and species composition, however the grazing level appears to be appropriate for the flushes in these areas, suggesting that there may be a conflict. A small increase in the grazing pressure in these areas may allow

the grazing impact on both feature types to be within their desirable ranges. This may however be detrimental to other feature types in the area such as wind-clipped heath.

There were no surveyed smooth grassland locations within 1km of the tall herb locations that were recorded as having moderate or moderately high grazing impact levels (Figure 4.11). The tall herb locations with moderate or moderate high impacts occurred in clusters with other tall herb points that had low or low to moderate grazing impacts.

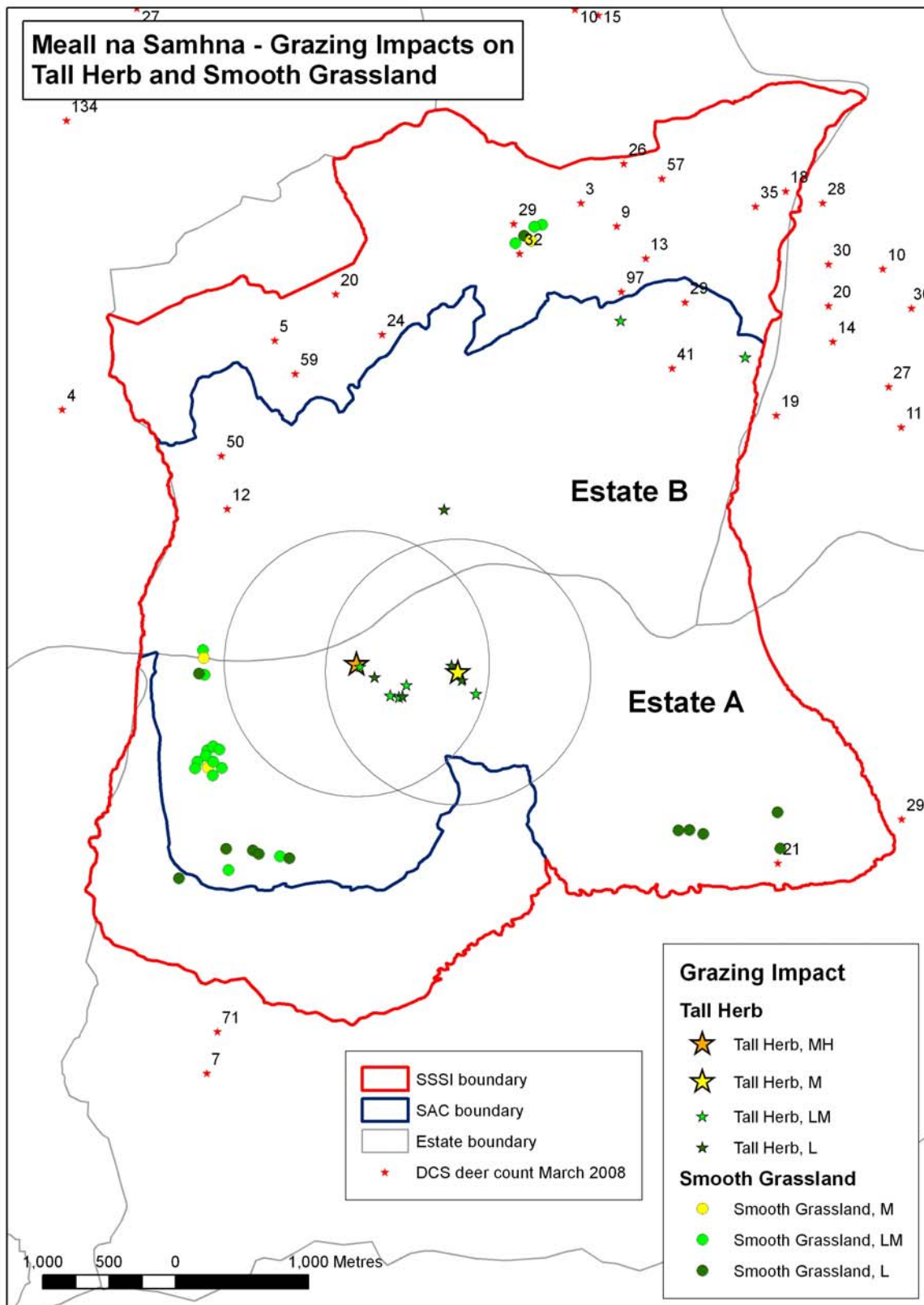
The wind-clipped heath locations with moderate, moderate to high and high grazing impact levels formed four clusters, one in the centre of the SSSI (which had no smooth grassland survey locations within 1km), and three to the south-west of the central cluster (Figure 4.12). The smooth grassland impact levels close to these three clusters suggest that conflict between the wind-clipped heath and smooth grassland was probably occurring in this part of the SSSI. Figure 4.13 shows the mean percentage cover of the different vegetation types surrounding the wind-clipped heath locations in three groups of grazing impact classes. The three pie charts are similar apart from the cover of alpine moss-heath which is higher surrounding the moderate-high and high impact level locations, replacing the montane grass-heath.

Figure 4.10 - Map showing the grazing impacts on the flush and smooth grassland feature types on Meall na Samhna. Buffer circles (1km radius) have been drawn around the smooth grassland locations where the impact was outside the desirable range.



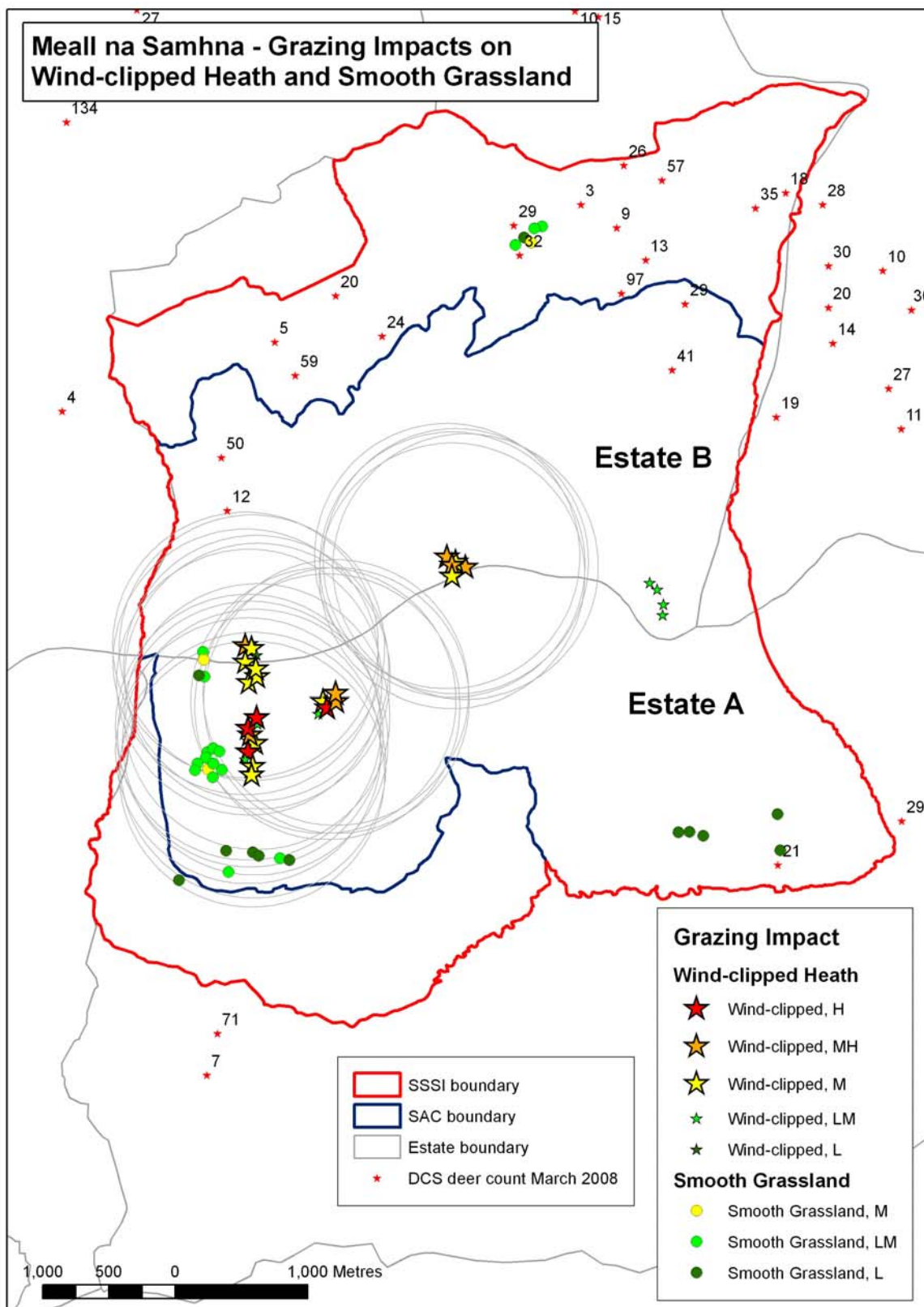
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Figure 4.11 - Map showing the grazing impacts on the tall herb and smooth grassland feature types on Meall na Samhna. Buffer circles (1km radius) have been drawn around the tall herb locations where the impact was outside the desirable range.



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Figure 4.12 - Map showing the grazing impacts on the wind-clipped heath and smooth grassland feature types on Meall na Samhna. Buffer circles (1km radius) have been drawn around the wind-clipped heath locations where the impact was outside the desirable range.



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Figure 4.13 - Mean percentage cover of the vegetation surrounding the wind-clipped heath locations on Meall na Samhna in three groups of grazing impact classes. The areas of the different vegetation types within 500m radius buffer circles of each location were used to calculate the mean percentage cover of the different vegetation types within the different impact classes.

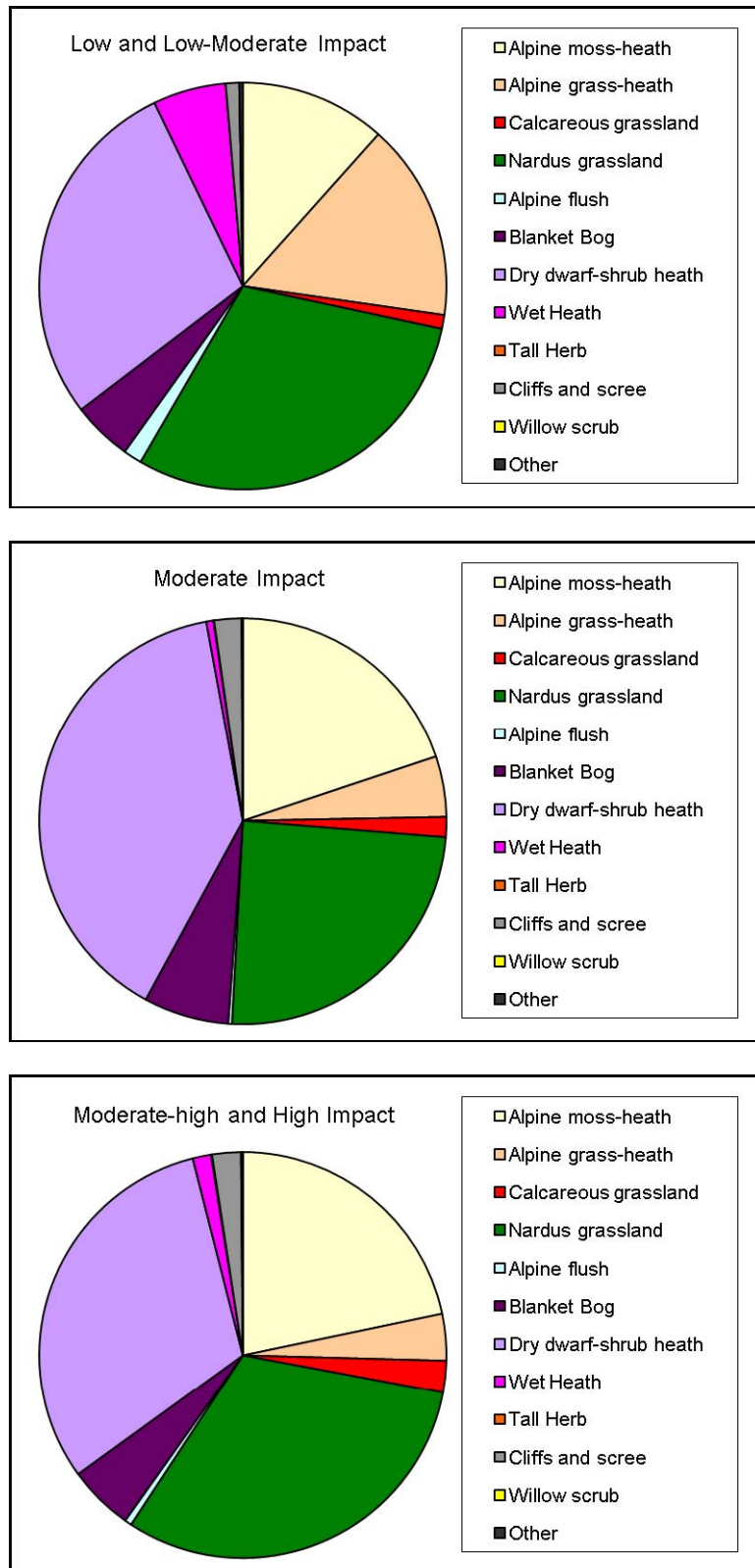
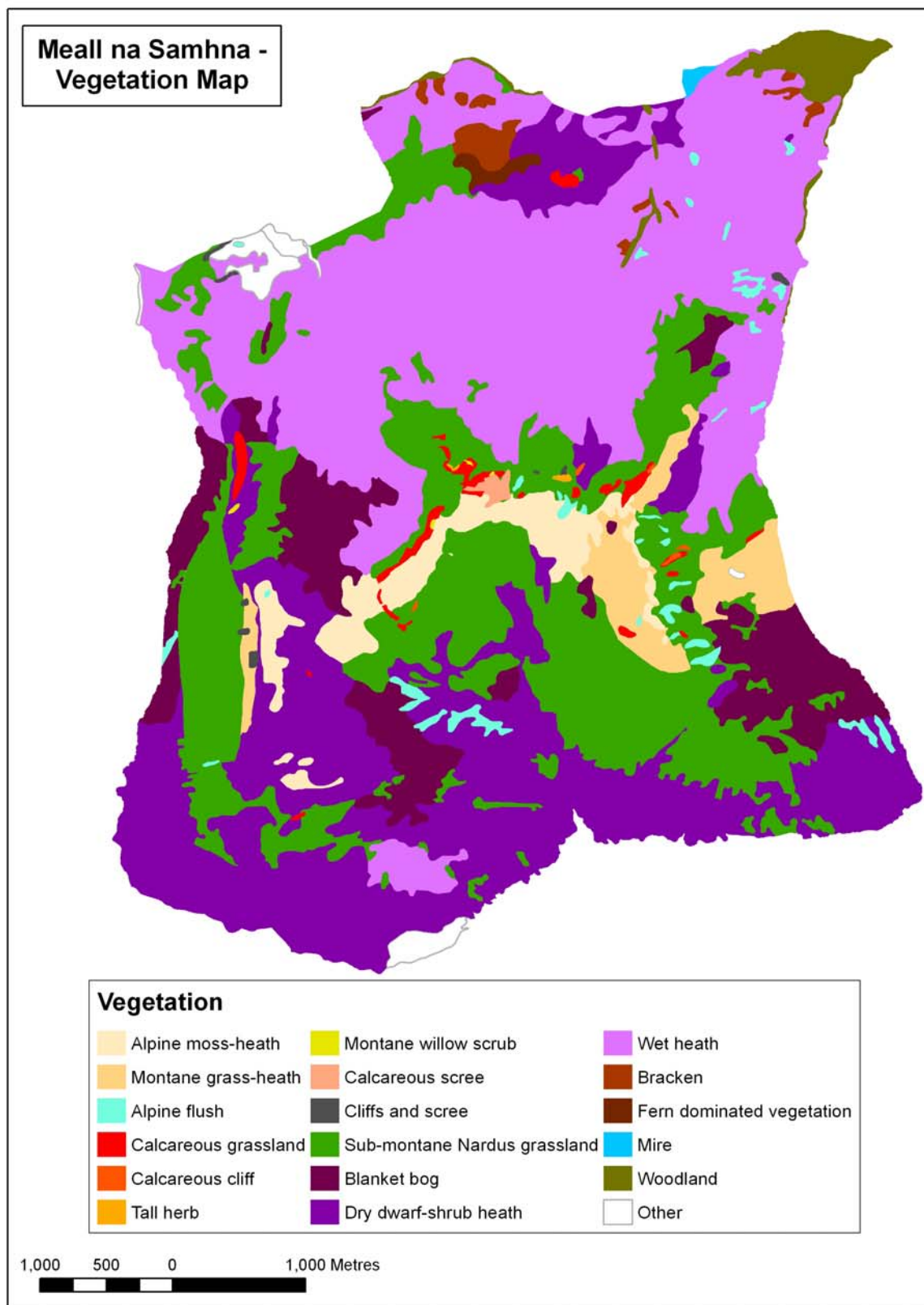


Figure 4.14 - Vegetation map of Meall na Samhna.



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4.6.2.1 Hill Grazing Management Model (HGMM)

The HGMM (Armstrong *et al.*, 1997a, 1997b) was run for Meall na Samhna using the data in Tables 4.15 and 4.16, to look at the predicted utilisation rates (percentage of the annual production predicted to be removed by herbivores) on the different vegetation types.

Table 4.15 - Data and assumptions used to run the HGMM for Meall na Samhna.

Information Required by the HGMM	Input Data
Zone	5
Location	Upland
Side	West
Mean altitude of heather communities	550m
Blanket Bog - Area ⁷	1168 ha
Blanket Bog - Cover of <i>Calluna vulgaris</i>	65.00%
Blanket Bog - Cover of <i>Festuca/Agrostis</i>	1.00%
Mature Heather - Area	713 ha
Mature Heather - Cover of <i>Calluna vulgaris</i>	65.00%
Mature Heather - Cover of <i>Festuca/Agrostis</i>	1.00%
Wind clipped Heather - Area	97 ha
Wind clipped Heather - Cover of <i>Calluna vulgaris</i>	10.00%
Mean altitude of indigenous grassland communities	650 m
<i>Agrostis/Festuca</i> - Area	22 ha
<i>Agrostis/Festuca</i> - Cover	100% (fixed)
<i>Festuca/Agrostis</i> - Area	1 ha
<i>Festuca/Agrostis</i> - Cover	100 % (fixed)
<i>Nardus stricta</i> community - Area	746 ha
<i>Nardus stricta</i> community - Cover of <i>Nardus stricta</i>	42.00%
<i>Nardus stricta</i> community - Cover of <i>Festuca/Agrostis</i>	28.00%
Average ewe weight	46 kg
Red deer equivalent of a ewe.	1.78
Area of management block 1 in Estate A (within SSSI)	500 ha
Area of management block 2 in Estate A (within SSSI)	700 ha
Area of management block 3 in Estate A (within SSSI)	117 ha
Area of Estate B (within SSSI)	1548 ha
*Sheep stocking rate on block 1 - Estate A	0.7 ewes/ha
*Sheep stocking rate on block 2 - Estate A	0.9 ewes/ha
*Sheep stocking rate on block 3 - Estate A	2.5 ewes/ha
*Sheep stocking rate on Estate B	0.5 ewes/ha
**Deer on Estate A (March 2008 count)	7.8 deer/km ²
**Deer on Estate B (March 2008 count)	33.2 deer/km ²

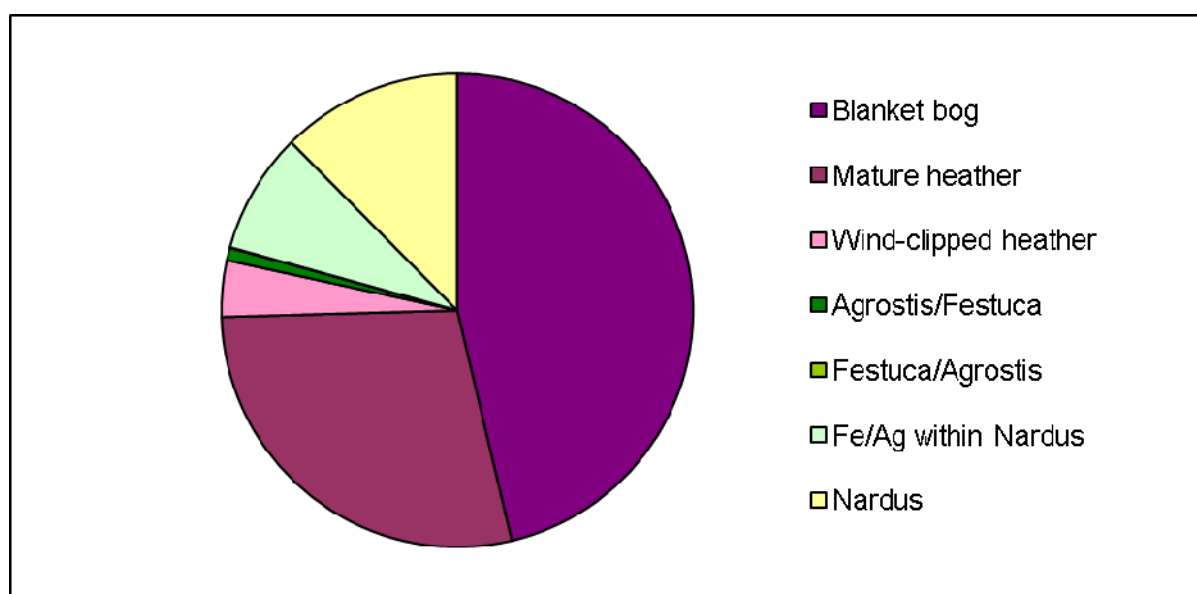
⁷ Includes wet heath.

* Sheep data from Dayton (2007); **Deer data from DCS deer count report March 2008. It should be noted this data is a snapshot and may not reflect year round densities or patterns of habitat use.

Table 4.16 - Meall na Samhna herbivore data for input into the HGMM.

		J	F	M	A	M	J	J	A	S	O	N	D
A	Ewes	1272	1272	1272	1272	1272	1272	1272	1272	1272	1272	1272	1272
B	Ewes	774	774	774	774	774	774	774	774	774	774	774	774
Total	Ewes	2046	2046	2046	2046	2046	2046	2046	2046	2046	2046	2046	2046
A	Red Deer	103	103	103	103	103	103	103	103	103	103	103	103
B	Red Deer	514	514	514	514	514	514	514	514	514	514	514	514
Total	Red Deer	617	617	617	617	617	617	617	617	617	617	617	617
Ewe equivalents ⁸		3076	3076	3076	3076	3076	3076	3076	3076	3076	3076	3076	3076

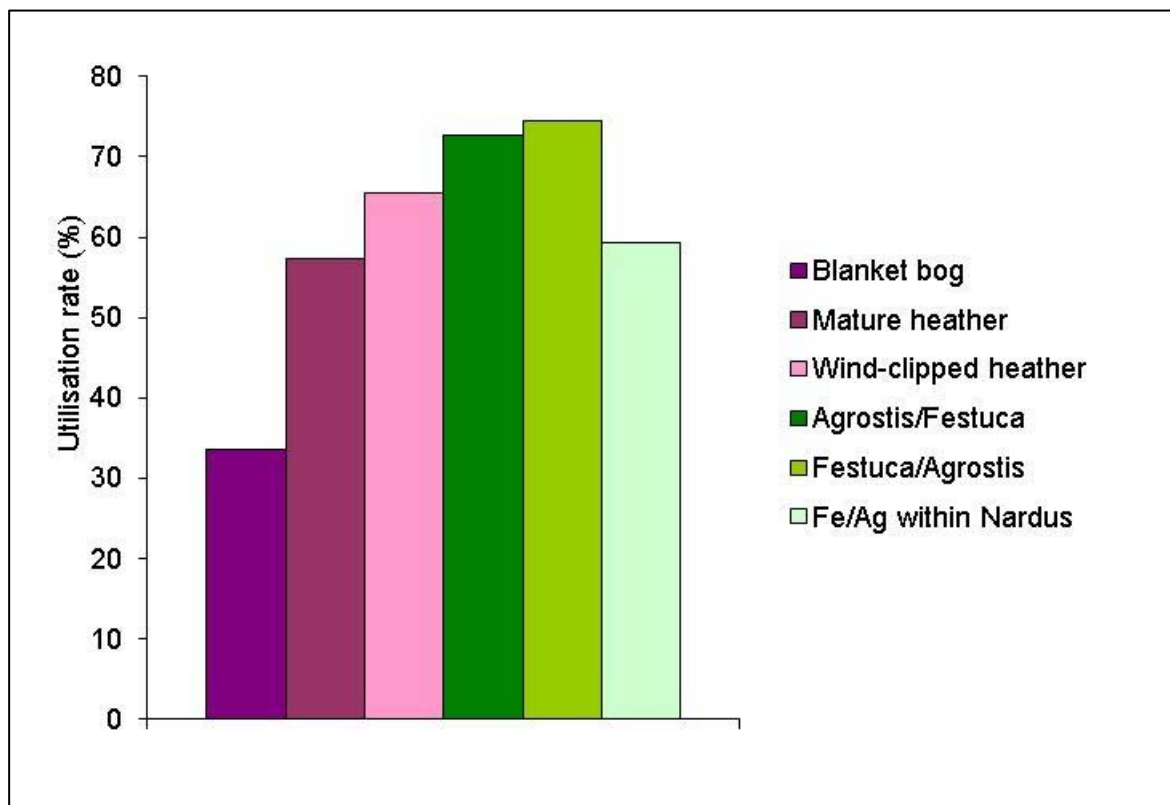
Figure 4.15 - Proportions of the different HGMM vegetation types on Meall na Samhna.



The predicted utilisation rates for the different vegetation types are shown in Figure 4.16. Unlike Beinn Heasgarnich the area of heather communities on Meall na Samhna is large compared to that of the grass communities (Figure 4.15). The model predicts that the relatively high number of sheep and deer are leading to very high utilisation rates on the blanket bog and heather communities, in particular the wind-clipped heath, and also high utilisation rates on the grassland habitats. The high utilisation rates on the wind-clipped heath are evident in the HIA data however the predicted high utilisation of the grassland is not evident. This may be due in part to an over-estimate of the number of deer present on the site throughout the year as the March deer count figure was used, which may not be representative of numbers at other times of the year.

⁸ Where 1 red deer = 1.67 ewe equivalents.

Figure 4.16 - Utilisation rates predicted by the HGMM on Meall na Samhna.



The HIA data suggests that the current level and patterns of grazing on Meall na Samhna appear to be appropriate for the flushes on the site but may be too low for the smooth grassland and too high for the wind-clipped heath. The data provides some evidence of real conflicts in achieving the nature conservation objectives for these different features.

4.6.3 Beinn Dearg SAC/ SSSI

Herbivore impacts above the 'desirable range' were recorded for all feature types within the Beinn Dearg SSSI (Table 4.17, Table 4.18 and Figure 4.17). Most of the high impact scores were recorded in the two northern estates of the SSSI in areas where high deer numbers were recorded (Figure 4.17). High deer numbers were also associated with a group of high impact sites in the west of the SSSI. However, again there is a caveat that deer counts are a snapshot of locations and numbers within the wider deer range.

The locations where impact scores above the 'desirable range' were recorded on the alpine moss-heath occurred in the eastern half of the SSSI (Figure 4.18). One location in the north of the SSSI was within 1km of an area of species-rich *Nardus* grassland which was recorded as having low to low-moderate impact levels. There is a likelihood that conflict between the two feature types exists in this area, with the grazing level too high for the alpine moss-heath and too low for the grassland. There was more *Nardus* grassland and montane grass-heath and less rock and scree surrounding the alpine summit community locations in the high impact class compared to the locations in the low and low-moderate impact classes (Figure 4.23). This suggests that the high impact sites may have been more accessible to herbivores (less rock and scree) and had more preferred vegetation in the area potentially attracting herbivores.

Over 31% of the montane grass-heath locations were assessed as having herbivore impact levels above the 'desirable range' (Table 4.18 and Figure 4.19). Five of these locations were within 1km of species-rich *Nardus* grassland locations which were recorded as having low impact levels.

Over 30% of the blanket bog locations were assessed as having herbivore impact levels above the 'desirable range' (Table 4.18 and Figure 4.20). The areas where high impact levels were recorded on the blanket bog were concentrated in the north east of the SSSI. None of the sites were close (i.e. within 1km) to areas of smooth grassland that had been surveyed, however they were all associated with areas that had high deer numbers recorded in March 2008 (Figure 4.17). The proportion of montane grass-heath in the areas around the blanket bog points with moderate-high and high impact scores was much higher than around the points with low and low-moderate impact scores and the area of alpine dwarf-shrub heath was much lower (Figure 4.24).

The montane willow scrub was restricted to a relatively small area in the west of the SSSI (Figure 4.21), and although it was not close to any areas of species-rich *Nardus* grassland that had been surveyed it was close to areas of alpine moss-heath that had been assessed as having low impact scores. There may be conflict here in that the willow scrub is more attractive to herbivores than the alpine moss-heath and although the grazing levels appear to be appropriate for the alpine moss-heath in this area they are too high for the willow scrub where it is accessible to herbivores. A reduction in grazing levels to reduce the impact on the willow scrub would be unlikely to cause the alpine moss-heath to become unfavourable. There was little variation in the mean percentage cover of the different vegetation types surrounding the montane willow scrub locations in three groups of grazing impact classes (Figure 4.25).

The species-rich *Nardus* grassland on Beinn Dearg has a restricted distribution (Figures 4.18 and 4.22). A large proportion (63%) of the species-rich *Nardus* grassland locations were assessed as having a low herbivore impact score, which is outside the 'desirable range', indicating that the level of grazing over much of this feature type is too low and likely to lead to changes in structure and species composition.

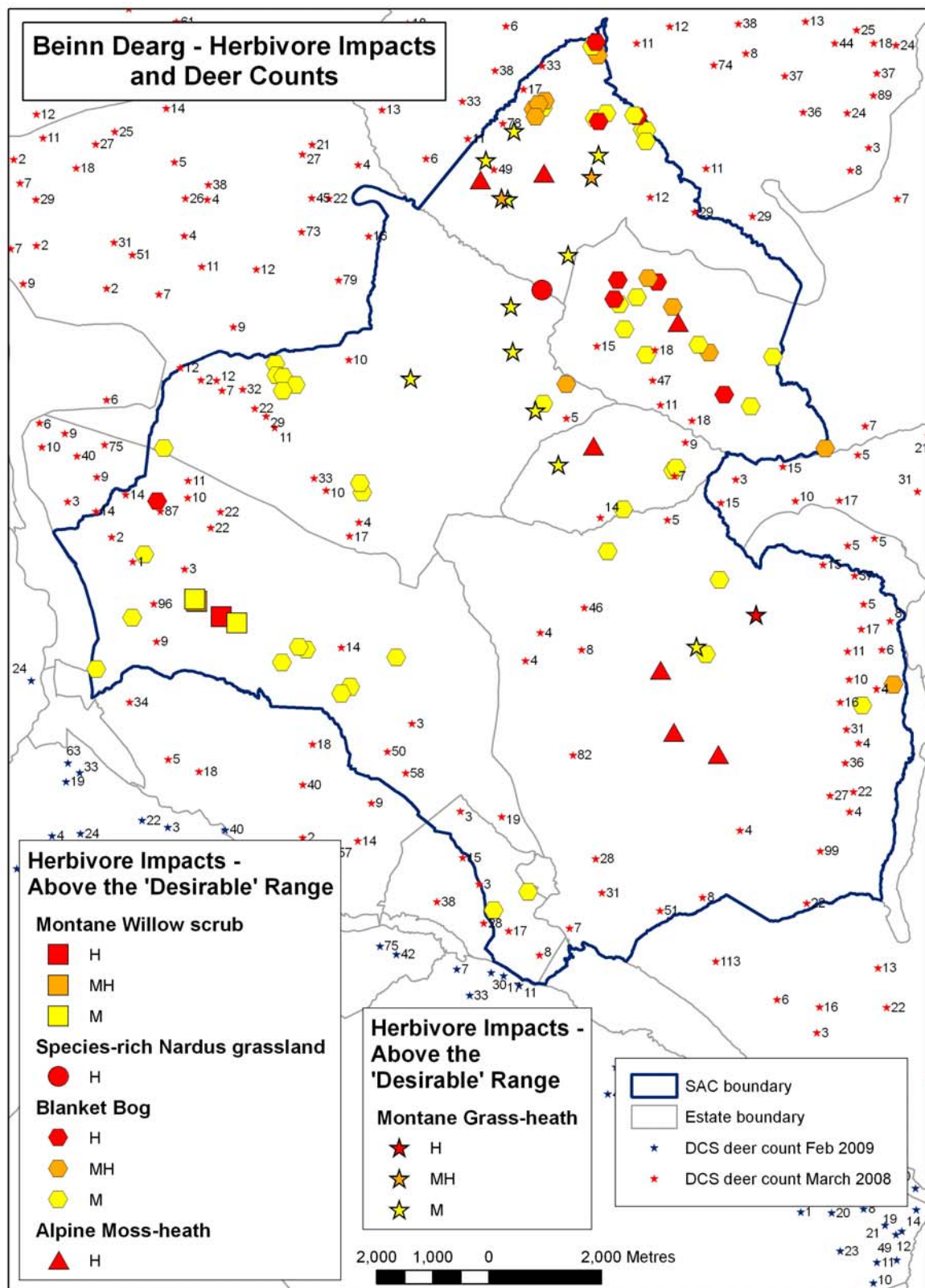
Table 4.17 - Herbivore impacts on the assessed features on Beinn Dearg (counts). Impacts highlighted in green are within the 'desirable range' those outside the 'desirable range' are highlighted in red.

Feature	Estate	Count					Total
		L	LM	M	MH	H	
Alpine moss-heath	A	8	0	0	0	1	9
	B	15	0	0	0	0	15
	C	1	0	0	0	2	3
	D	8	1	0	0	1	10
	E	7	0	0	0	3	10
	All	39	1	0	0	7	47
Blanket Bog	A	10	3	7	4	4	28
	B	21	1	9	0	1	32
	C	6	10	8	5	3	32
	D	16	4	12	1	0	33
	E	24	3	4	1	0	32
	F	32	2	2	0	0	36
Montane grass-heath	All	109	23	42	11	8	193
	A	2	1	1	0	0	4
	B	2	0	0	0	0	2
	C	5	3	4	2	0	14
	D	8	0	5	0	0	13
	E	8	1	1	0	1	11
Species-rich <i>Nardus</i> grassland	All	25	5	11	2	1	44
	A	22	5	5	0	0	32
	D	4	4	0	0	1	9
	E	20	7	4	1	0	32
Montane willow scrub	All	46	16	9	1	1	73
	B	1	2	2	1	2	8

Table 4.18 - Herbivore impacts on the assessed features on Beinn Dearg (percentages). Impacts highlighted in green are within the 'desirable range' those outside the 'desirable range' are highlighted in red.

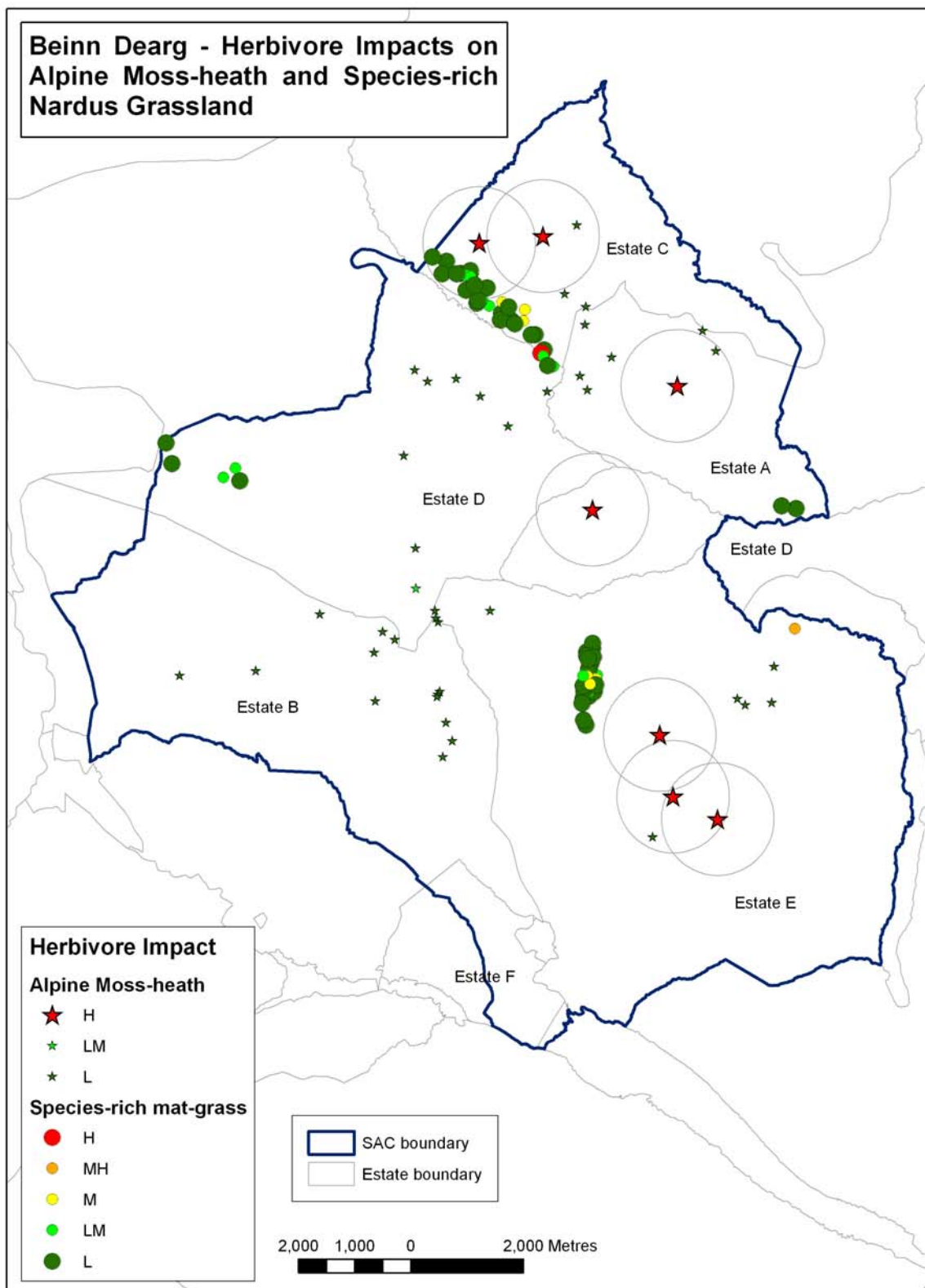
Feature	Estate	Percentage				
		L	LM	M	MH	H
Alpine moss-heath	A	88.9	0.0	0.0	0.0	11.1
	B	100.0	0.0	0.0	0.0	0.0
	C	33.3	0.0	0.0	0.0	66.7
	D	80.0	10.0	0.0	0.0	10.0
	E	70.0	0.0	0.0	0.0	30.0
	All	83.0	2.1	0.0	0.0	14.9
Blanket Bog	A	35.7	10.7	25.0	14.3	14.3
	B	65.6	3.1	28.1	0.0	3.1
	C	18.8	31.3	25.0	15.6	9.4
	D	48.5	12.1	36.4	3.0	0.0
	E	75.0	9.4	12.5	3.1	0.0
	F	88.9	5.6	5.6	0.0	0.0
Montane grass-heath	All	56.5	11.9	21.8	5.7	4.1
	A	50.0	25.0	25.0	0.0	0.0
	B	100.0	0.0	0.0	0.0	0.0
	C	35.7	21.4	28.6	14.3	0.0
	D	61.5	0.0	38.5	0.0	0.0
	E	72.7	9.1	9.1	0.0	9.1
Species-rich <i>Nardus</i> grassland	All	56.8	11.4	25.0	4.5	2.3
	A	68.8	15.6	15.6	0.0	0.0
	D	44.4	44.4	0.0	0.0	11.1
	E	62.5	21.9	12.5	3.1	0.0
Montane willow scrub	All	63.0	21.9	12.3	1.4	1.4
	B	12.5	25.0	25.0	12.5	25.0

Figure 4.17 - Map showing the herbivore impacts above the 'desirable ranges' of the feature types and the deer count numbers from March 2008/Feb 2009 on Beinn Dearg.



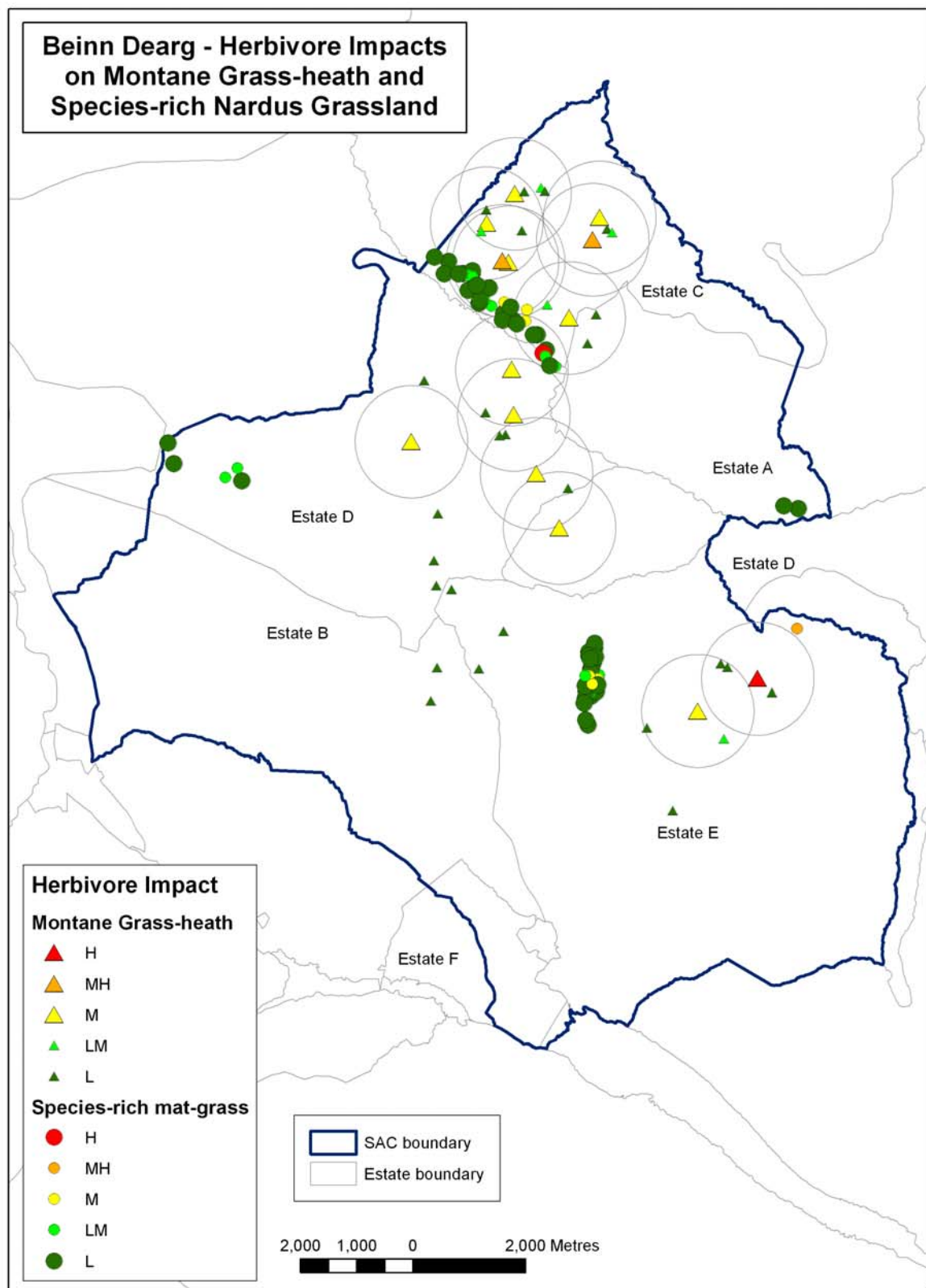
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Figure 4.18 - Map showing the herbivore impacts on the alpine moss-heath and species-rich Nardus grassland feature types on Beinn Dearg. Buffer circles (1km radius) have been drawn around the alpine moss-heath locations where the impact was outside the desirable range.



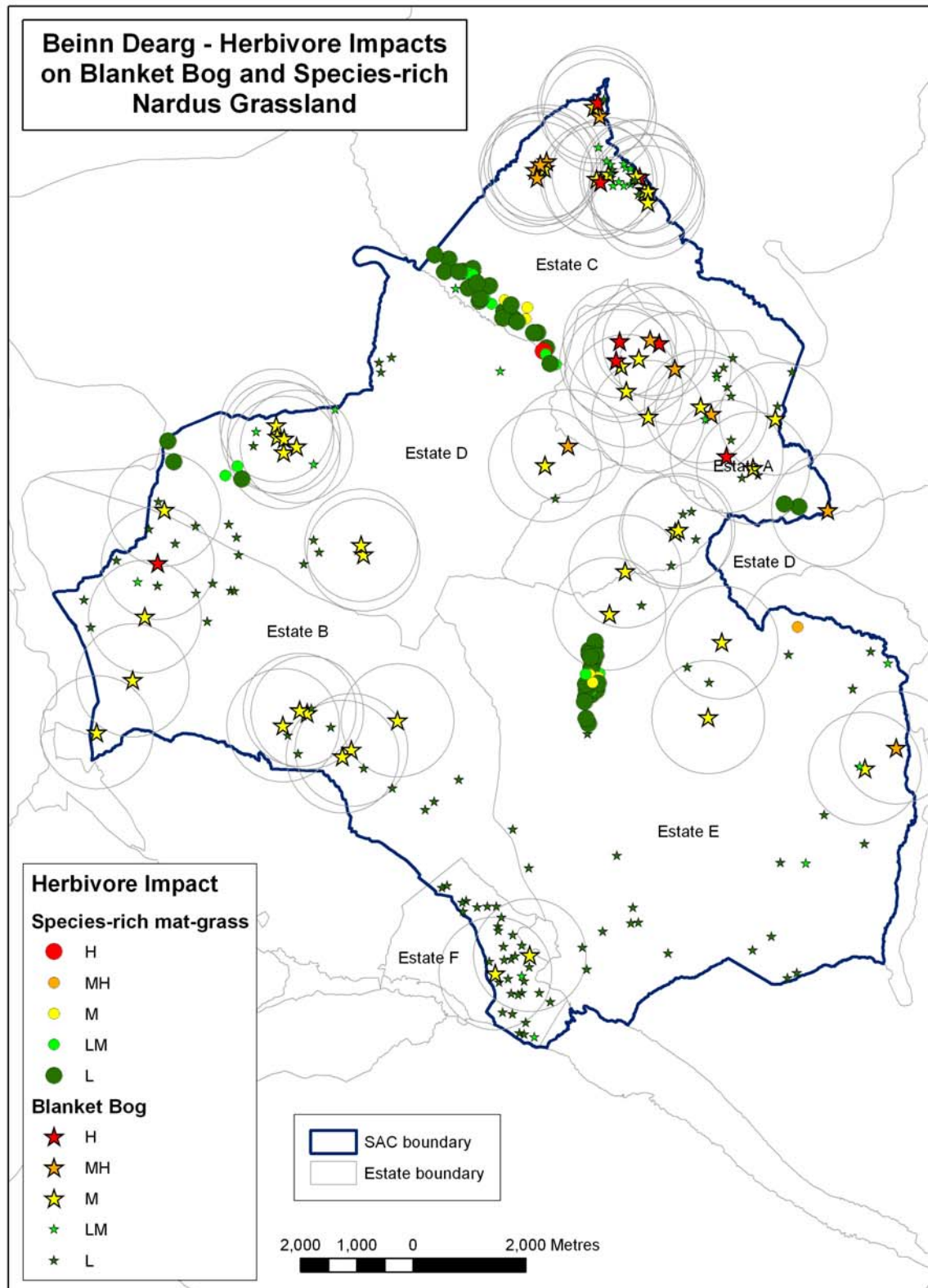
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Figure 4.19 - Map showing the herbivore impacts on the montane grass-heath and species-rich *Nardus* grassland feature types on Beinn Dearg. Buffer circles (1km radius) have been drawn around the montane grass-heath locations where the impact was outside the desirable range.



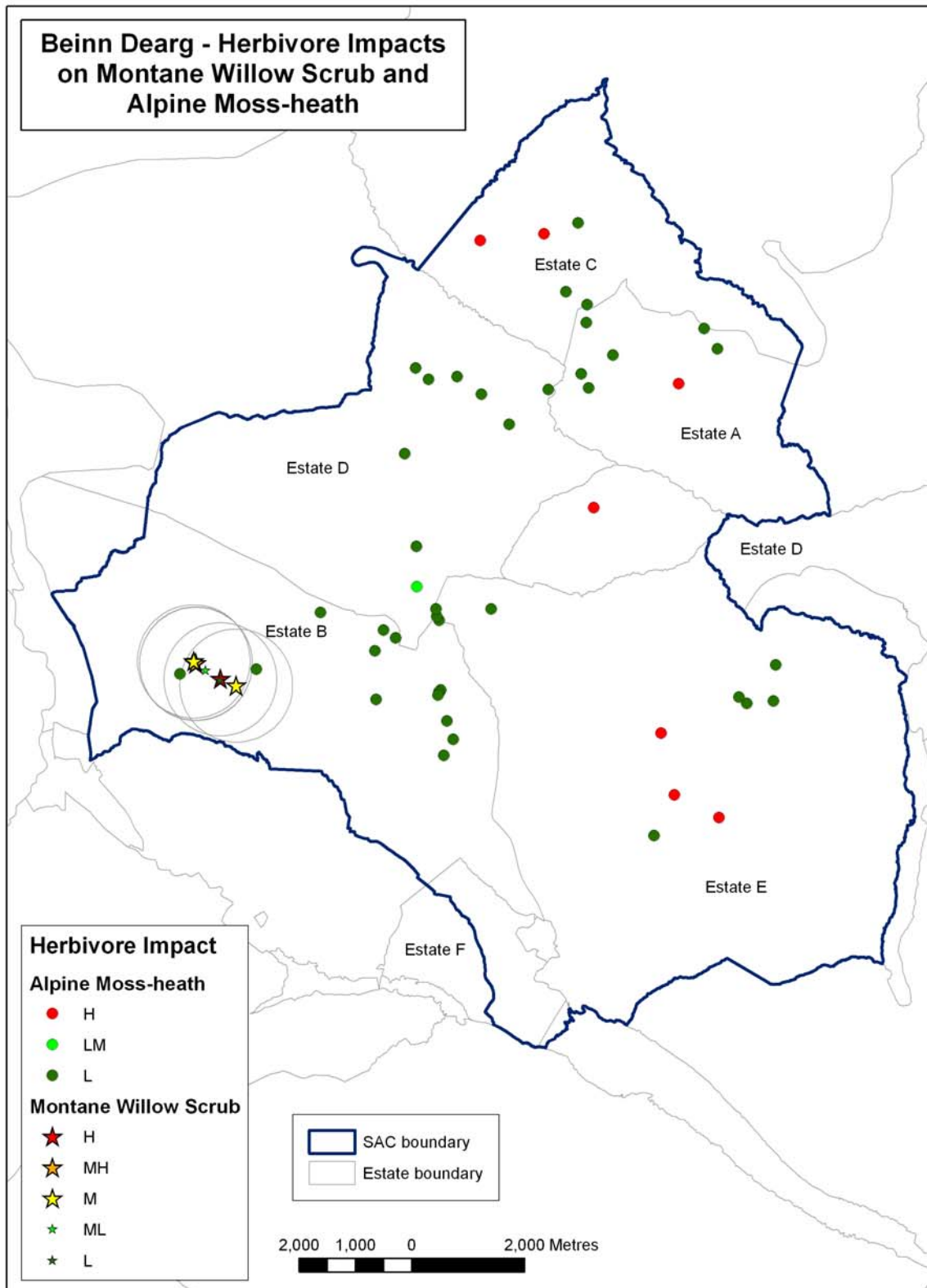
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Figure 4.20 - Map showing the herbivore impacts on the blanket bog and species-rich *Nardus* grassland feature types on Beinn Dearg. Buffer circles (1km radius) have been drawn around the blanket bog locations where the impact was outside the desirable range.



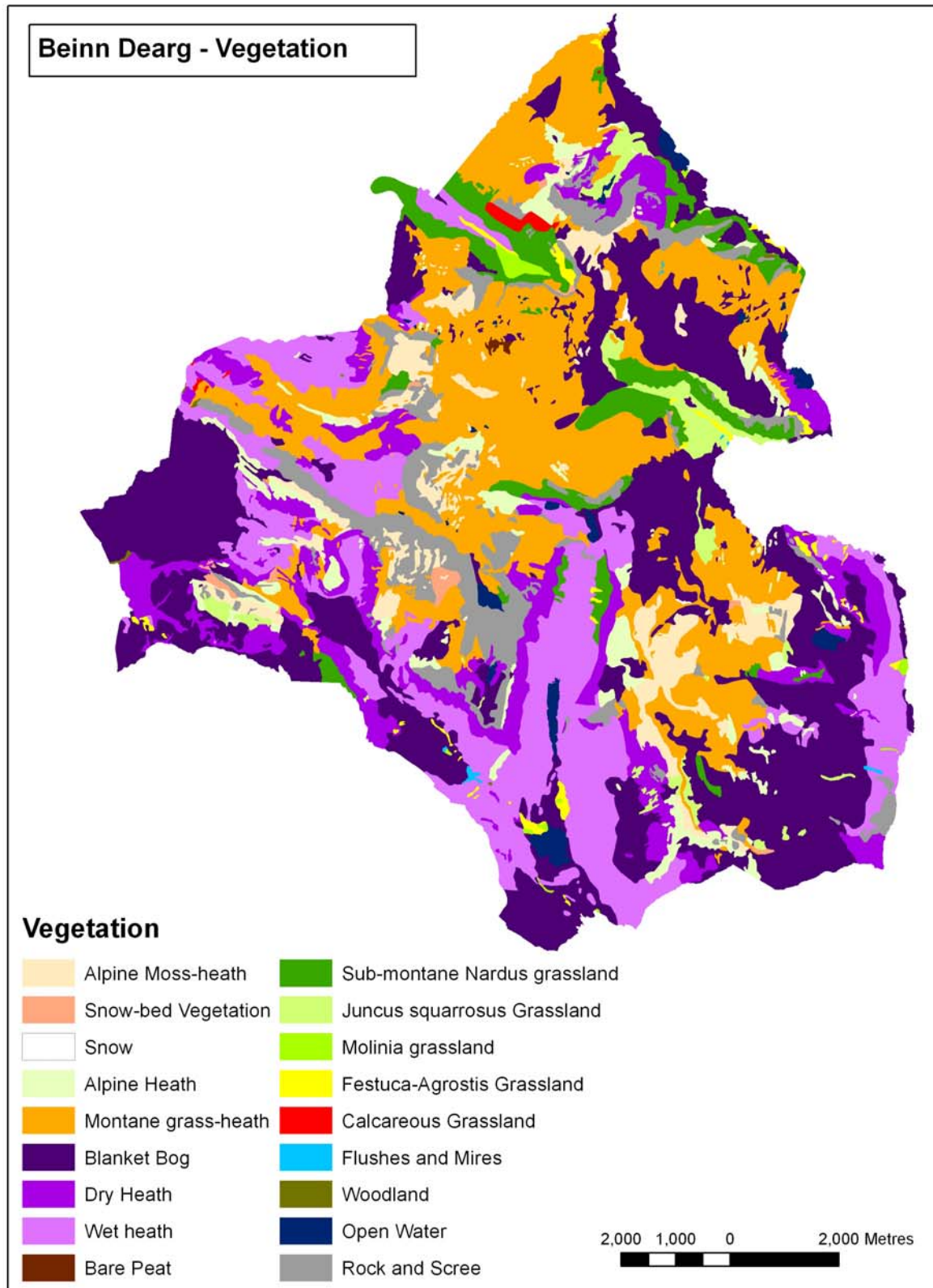
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Figure 4.21 - Map showing the herbivore impacts on the montane willow scrub and alpine moss-heath feature types on Beinn Dearg. Buffer circles (1km radius) have been drawn around the montane willow scrub locations where the impact was outside the desirable range.



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Figure 4.22 - Vegetation map of Beinn Dearg.



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Figure 4.23 - Mean percentage cover of the vegetation surrounding the alpine moss-heath locations on Beinn Dearg in two groups of grazing impact classes. The areas of the different vegetation types within 500m radius buffer circles of each location were used to calculate the mean percentage cover of the different vegetation types within the different impact classes.

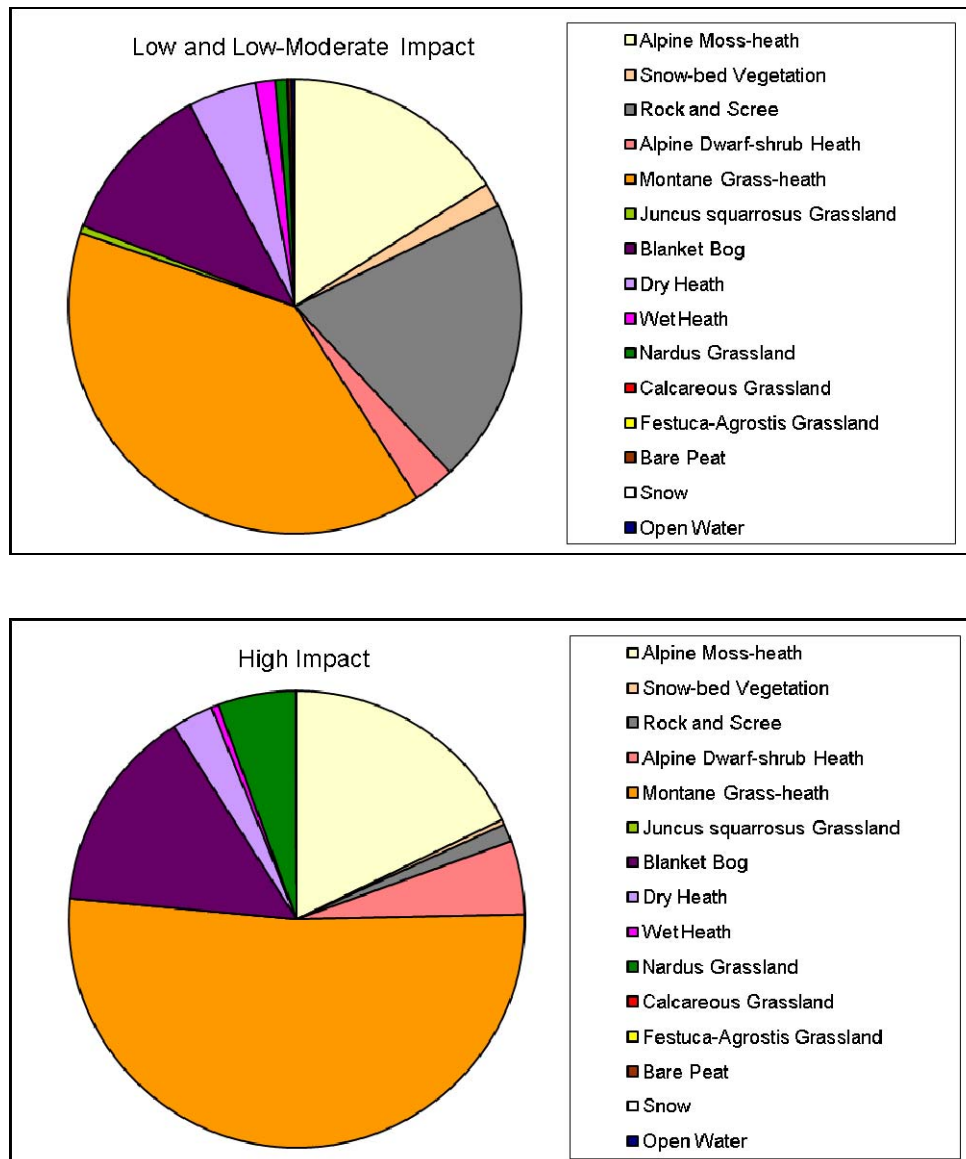


Figure 4.24 - Mean percentage cover of the vegetation surrounding the blanket bog locations on Beinn Dearg in three groups of grazing impact classes. The areas of the different vegetation types within 500m radius buffer circles of each location were used to calculate the mean percentage cover of the different vegetation types within the different impact classes.

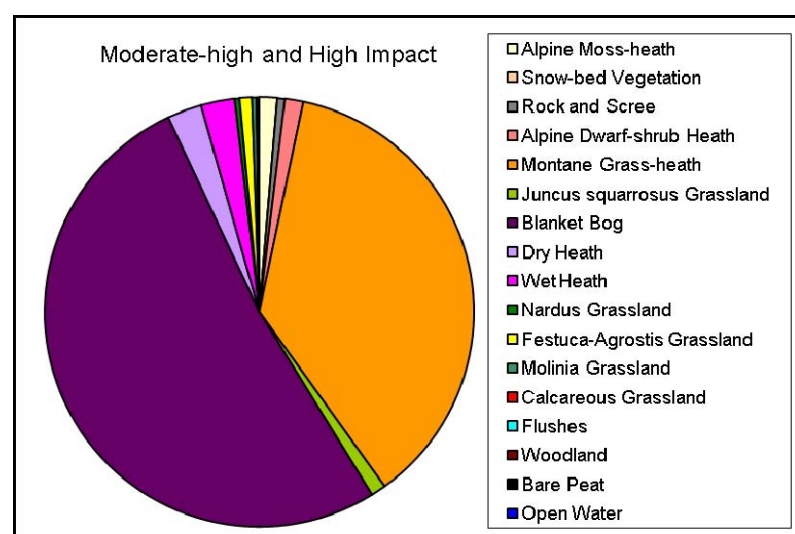
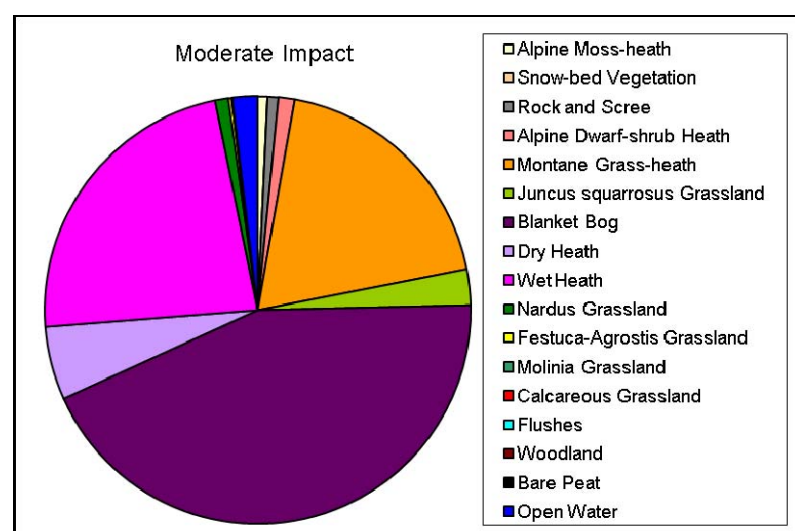
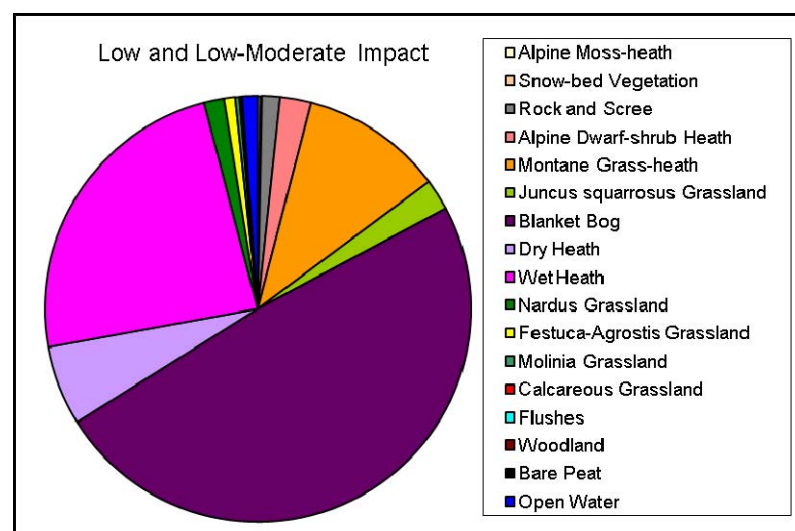
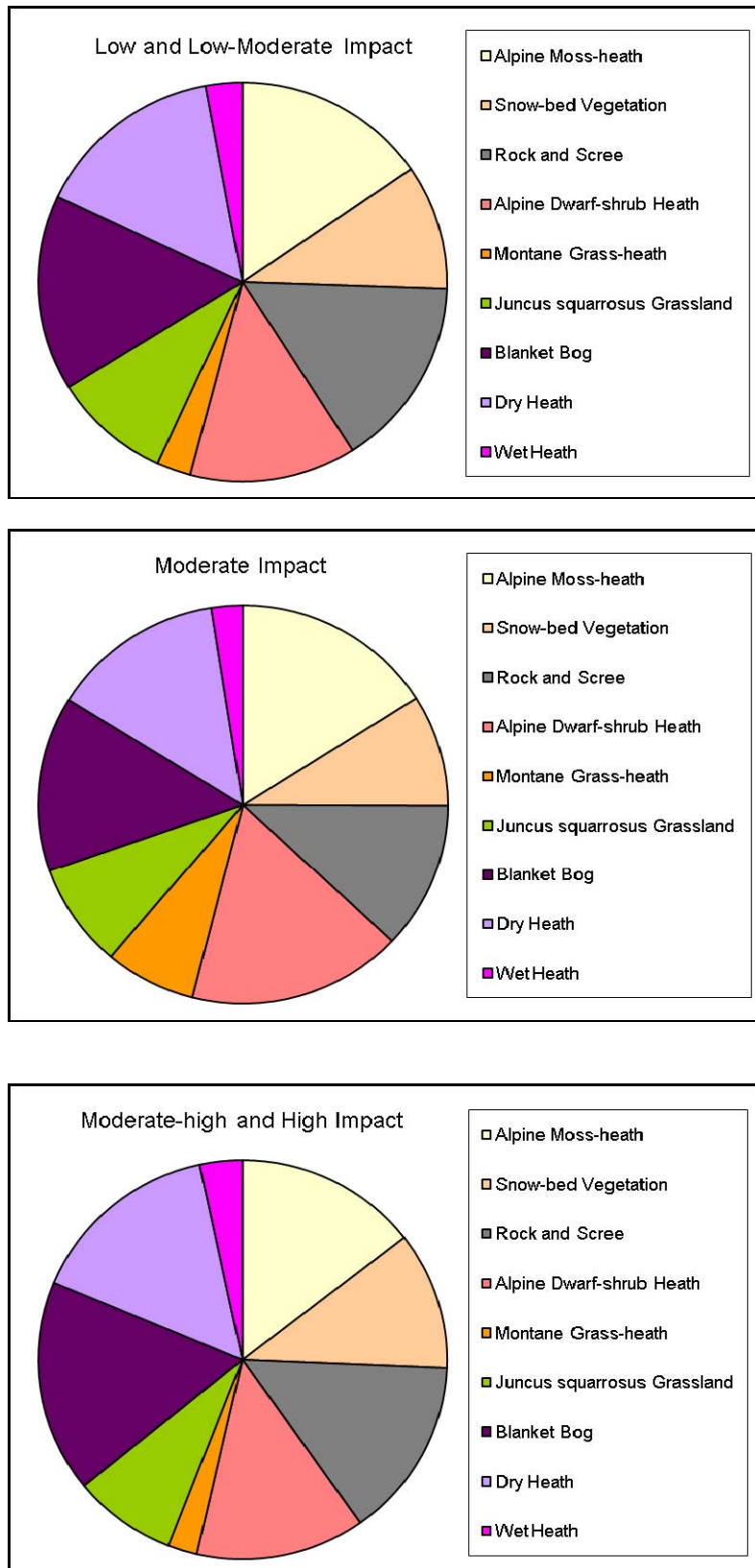


Figure 4.25 - Mean percentage cover of the vegetation surrounding the montane willow scrub locations on Beinn Dearg in three groups of grazing impact classes. The areas of the different vegetation types within 500m radius buffer circles of each location were used to calculate the mean percentage cover of the different vegetation types within the different impact classes.



Beinn Dearg is a large site with large areas of alpine moss-heath, montane grass-heath and blanket bog which in some places are experiencing higher impacts than is desirable for those habitats. The species-rich grassland occupies a much smaller area but unlike the other feature types is experiencing lower impacts than is desirable over much of its area. This is creating a potential conflict, with the grazing level in some areas too high to achieve favourable condition for the alpine moss-heath, montane grass-heath and blanket bog and yet too low for the grassland.

4.6.4 Fannich Hills SAC/ SSSI

Grazing impacts of MH, H and HVH were recorded at almost 15% of the feature type locations. Over 23% of the dry heath locations were assessed as MH, H or HVH (Table 4.19 and Table 4.20). The grazing impact assessment was outside the 'desirable range' of the particular feature type at 41% of the blanket bog locations, 46% of the montane grass heath locations and 29% of the alpine moss-heath locations (Table 4.20).

Table 4.19 - Grazing impacts on the assessed features on Fannich Hills (counts). Impacts highlighted in green are within the 'desirable range' those outside the 'desirable range' are highlighted in red.

Feature	Estate	Count						Total
		L	ML	M	MH	H	HVH	
Blanket Bog	A	19	13	23	13	1	0	69
	B	25	13	7	1	0	0	46
	C	6	14	17	1	1	0	39
	All	50	40	47	15	2	0	154
Dry Heath	A	5	8	7	4	4	4	32
	B	22	1	8	6	6	2	45
	C	25	8	0	0	0	0	33
	All	52	17	15	10	10	6	110
Montane Grass-heath	A	1	3	2	1	0	0	7
	B	20	3	8	0	0	0	31
	C	1	13	21	3	0	0	38
	All	22	19	31	4	0	0	76
Alpine Moss-heath	A	14	10	2	2	0	0	28
	B	8	1	1	5	4	0	19
	C	6	6	3	0	2	0	17
	All	28	17	6	7	6	0	64

Table 4.20 - Grazing impacts on the assessed features on Fannich Hills (percentage). Impacts highlighted in green are within the 'desirable range' those outside the 'desirable range' are highlighted in red.

Feature	Estate	Percentage					
		L	ML	M	MH	H	HVH
Blanket Bog	A	27.5	18.8	33.3	18.8	1.5	0.0
	B	54.4	28.3	15.2	2.2	0.0	0.0
	C	15.4	35.9	43.6	2.6	2.6	0.0
	All	32.5	26.0	30.5	9.7	1.3	0.0
Dry Heath	A	15.6	25.0	21.9	12.5	12.5	12.5
	B	48.9	2.2	17.8	13.3	13.3	4.4
	C	75.8	24.2	0.0	0.0	0.0	0.0
	All	47.3	15.5	13.6	9.1	9.1	5.5
Montane Grass-heath	A	14.3	42.9	28.6	14.3	0.0	0.0
	B	64.5	9.7	25.8	0.0	0.0	0.0
	C	2.6	34.2	55.3	7.9	0.0	0.0
	All	29.0	25.0	40.8	5.3	0.0	0.0
Alpine Moss-heath	A	50.0	35.7	7.1	7.1	0.0	0.0
	B	42.1	5.3	5.3	26.3	21.1	0.0
	C	35.3	35.3	17.7	0.0	11.8	0.0
	All	43.8	26.6	9.4	10.9	9.4	0.0

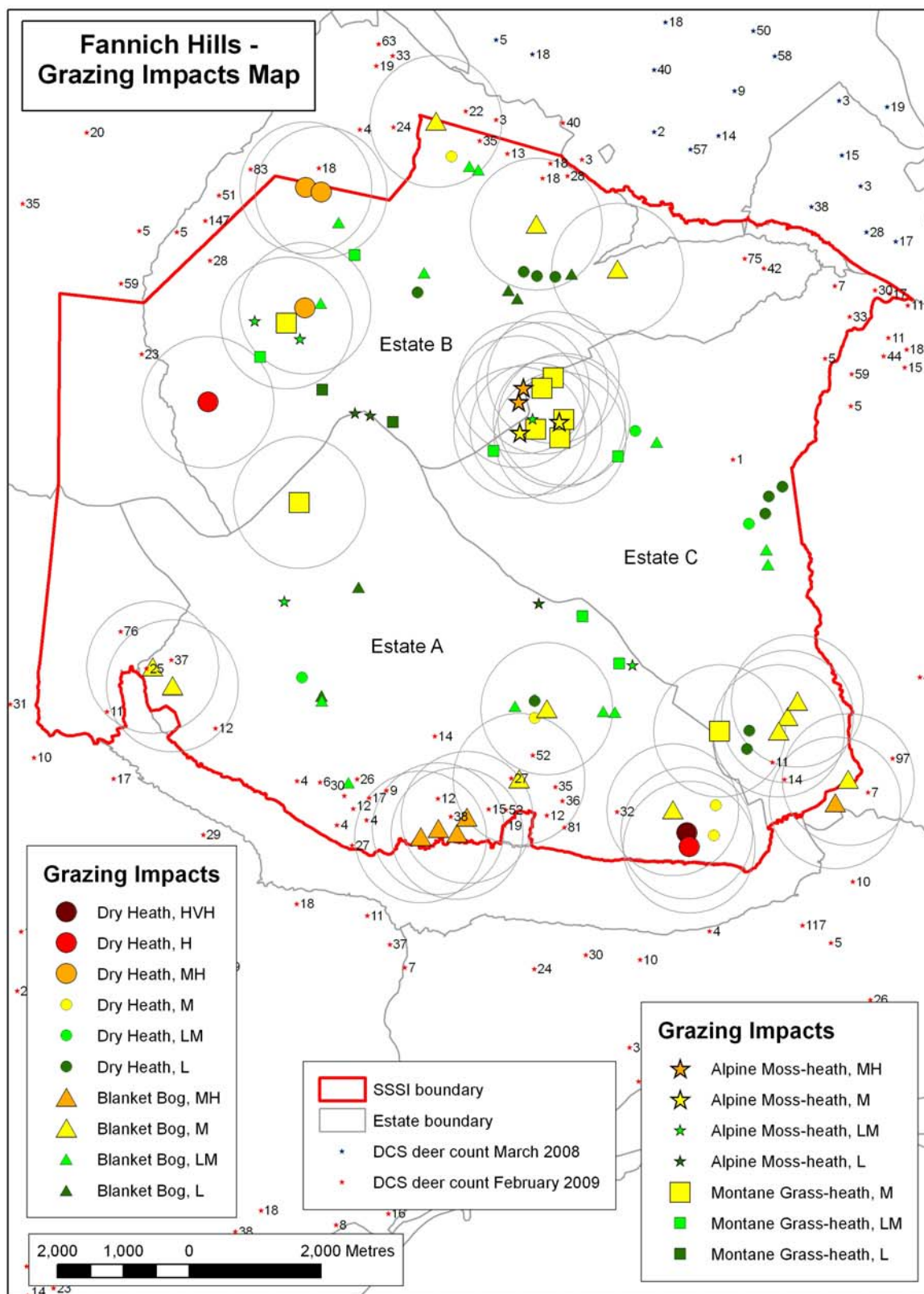
The herbivore impact assessment on the Fannich Hills was carried out as close clusters of survey points (within $\frac{1}{4}$ km squares) and therefore rather than mapping all the points, the centre of the cluster and the mean grazing impact level of the points within the cluster have been mapped (Figure 4.26).

Grazing impacts above the 'desirable range' of the different feature types were most frequent at the southern edge of the SSSI and in the northern half of the SSSI.

The blanket bog clusters with moderate or moderate-high grazing impact levels tended to be associated with areas where deer had been recorded during the February 2009 deer count (Figure 4.26). Sixteen of the 17 clusters with moderate or moderate-high grazing impact levels were within 1km of a deer count point, whereas none of the clusters with a low impact assessment were within 1km of a deer count point, and only 5 out of the 13 clusters with a low-moderate impact assessment were within 1km of a deer count point (Figure 4.26). However, the February 2009 deer count took place during snow cover and the location of deer will have been influenced by the weather conditions and will not represent a year round picture of utilisation.

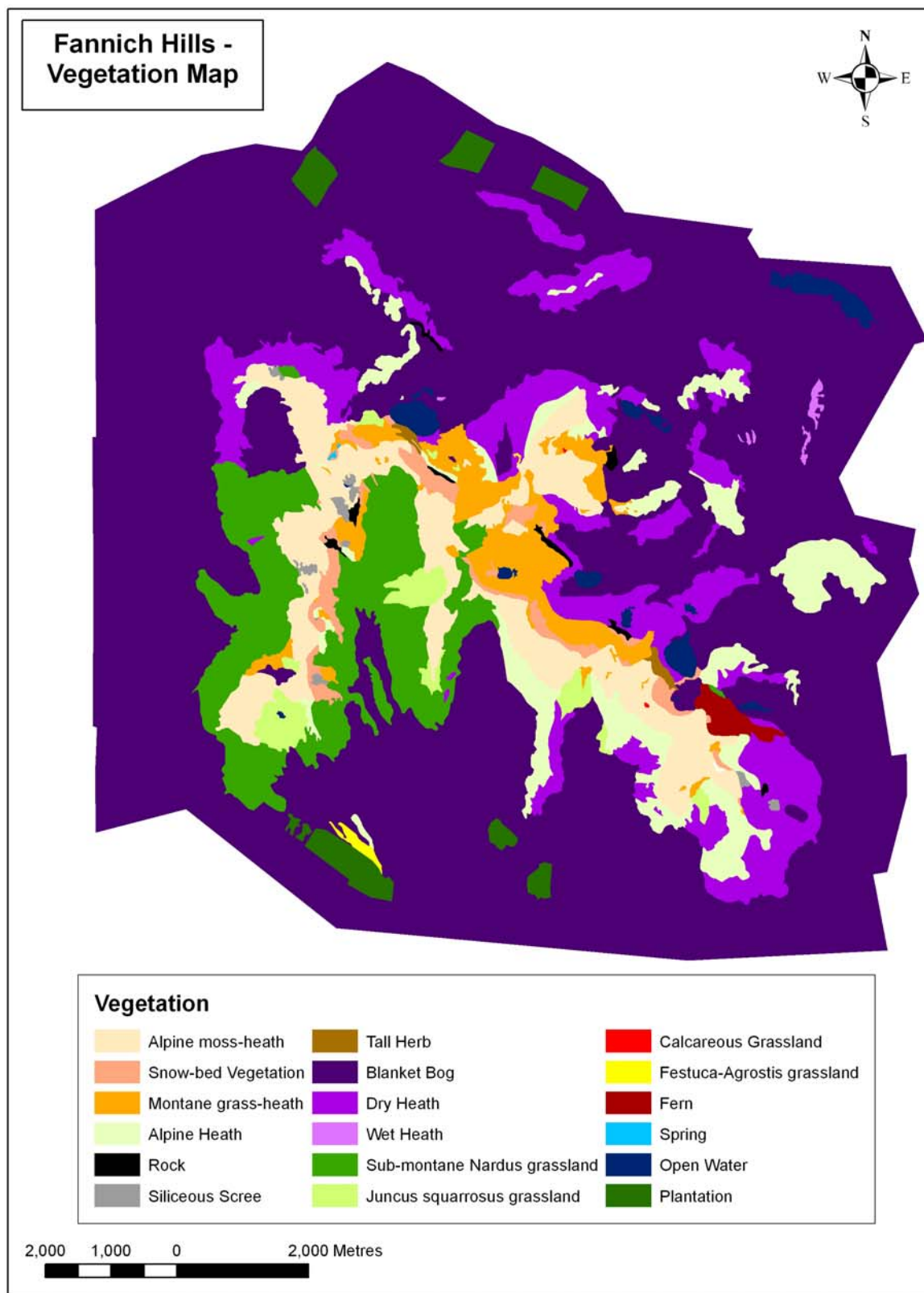
There is limited evidence of conflicts between vegetation types on Fannich Hills, however there are a few locations in the north and south west of the SSSI where potential conflicts between the dry heath and blanket bog, and the dry heath and montane grass-heath may exist (Figure 4.26). In these locations the dry heath has been assessed as having impacts within the desirable range, while the other two habitats have been assessed as having impacts outside their 'desirable ranges'. The dry heath is able to tolerate higher levels of grazing than the other two vegetation types. There is also possible conflict occurring in the area at the border between Estates B and C where the montane grass-heath and alpine moss-heath have grazing impacts above their 'desirable ranges' but the dry heath and blanket bog surrounding this area have grazing impact levels within their 'desirable ranges'.

Figure 4.26 - Map showing the grazing impacts on the feature types on Fannich Hills (the points shown on the map are the cluster means). Buffer circles (1km radius) have been drawn around the feature type where the impact was outside the 'desirable range'.



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Figure 4.27 - Fannich Hills vegetation map



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4.6.5 Cairngorms (East)

Most of the feature locations in the two estates on the eastern side of the Cairngorms SAC (Eastern Cairngorms SSSI) were assessed as having low or low-moderate grazing impacts (Tables 4.21 and 4.22). Only four blanket bog locations and 10 flush locations had a grazing impact assessment above the 'desirable range' of the habitat type (Table 4.21). None of the dry calcareous grassland or species rich *Nardus* grassland locations had grazing impacts above the desirable range, however there were some locations where the impact was lower than the desirable range (Table 4.21). The locations where deer were recorded during the February 2005 deer count tend to be associated with the areas of preferred grassland habitat in the east of the SAC (Figure 4.28).

The high and moderate-high grazing impact scores recorded on the flushes at the eastern side of Estate A were in close proximity to areas of dry calcareous grassland and species-rich *Nardus* grassland with low-moderate grazing impact scores (Figure 4.28). Within the buffer circles surrounding these flushes 223 deer were recorded at the deer count in February 2005, this represents almost a quarter of the deer recorded within the part of the SAC analysed. Blanket bog with moderate impact scores also occurred in the east of the SAC close to the area of grassland (Figure 4.29). There is possible conflict in these areas between the grassland communities and the flushes and blanket bog. Some of the grassland points in these areas were already recorded as having low impact scores and therefore any reduction in grazing levels may result in a lower impact over this area which may lead to the grassland becoming unfavourable. Achieving a grazing level that lowers the impact on the flushes and blanket bog but maintains sufficient grazing pressure on the grassland to prevent a change in structure or species composition would be the ideal situation. It may be possible to achieve this with slightly reduced herbivore utilisation, with the preferred grassland habitats continuing to attract the most use.

The flushes with high and moderate-high impact scores in the west of the area are not associated with grassland, however they are close to areas of blanket bog with low impact scores (Figure 4.30), suggesting that the flushes are the most attractive forage in these areas, leading to a concentration of grazing and resultant high impacts.

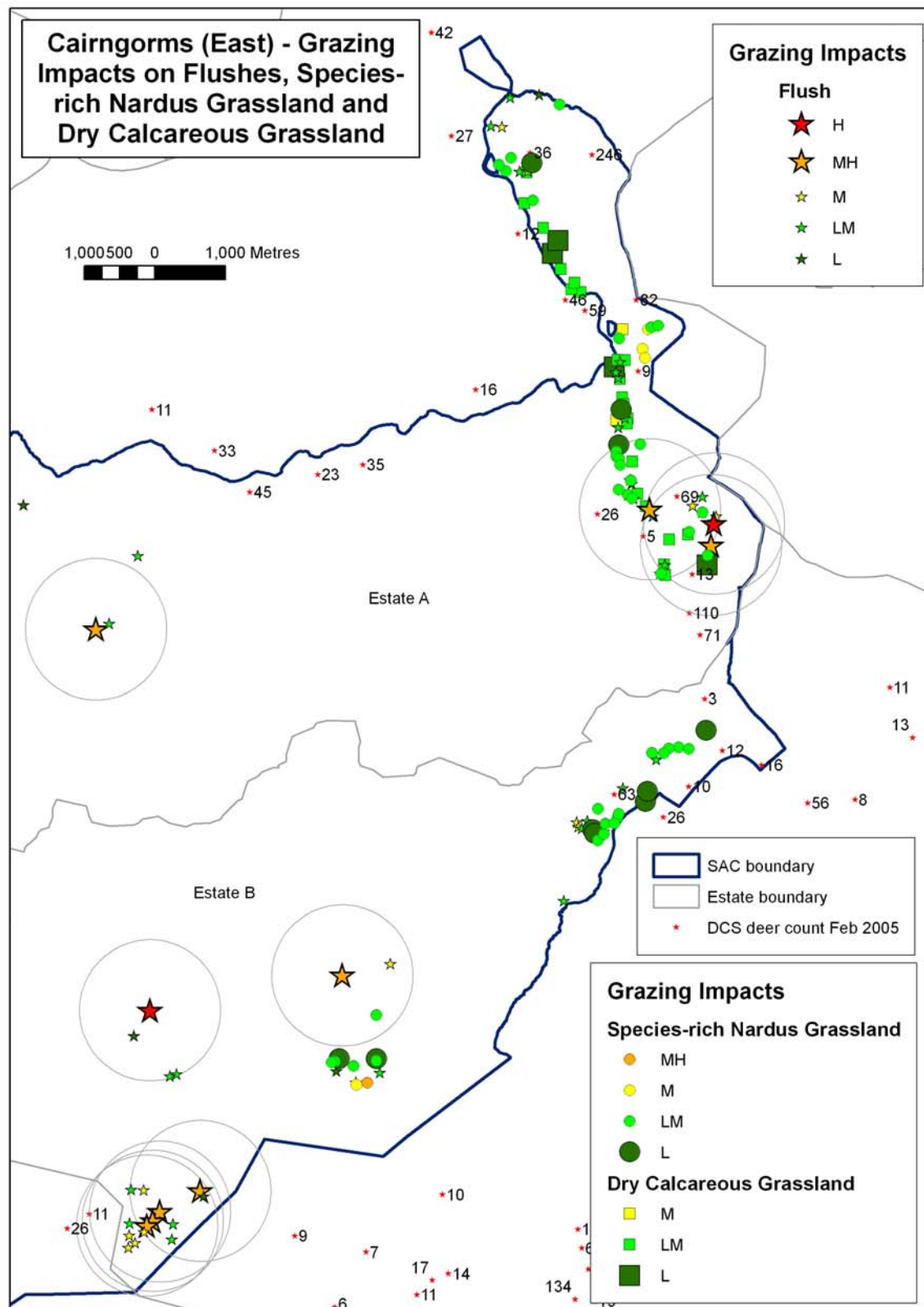
Table 4.21 - Grazing impacts on the assessed features on Cairngorms (East)(counts). Impacts highlighted in green are within the 'desirable range' those outside the 'desirable range' are highlighted in red.

Feature	Estate	Count				
		L	LM	M	MH	H
Blanket Bog	A	24	2	2	0	0
	B	19	9	2	0	0
Dry Calcareous Grassland	A	4	23	2	0	0
Flush	A	4	17	4	3	1
	B	3	14	8	5	1
Species-rich <i>Nardus</i> grassland	A	3	22	3	0	0
	B	7	17	1	1	0

Table 4.22 - Grazing impacts on the assessed features on Cairngorms (East) (percentage). Impacts highlighted in green are within the 'desirable range' those outside the 'desirable range' are highlighted in red.

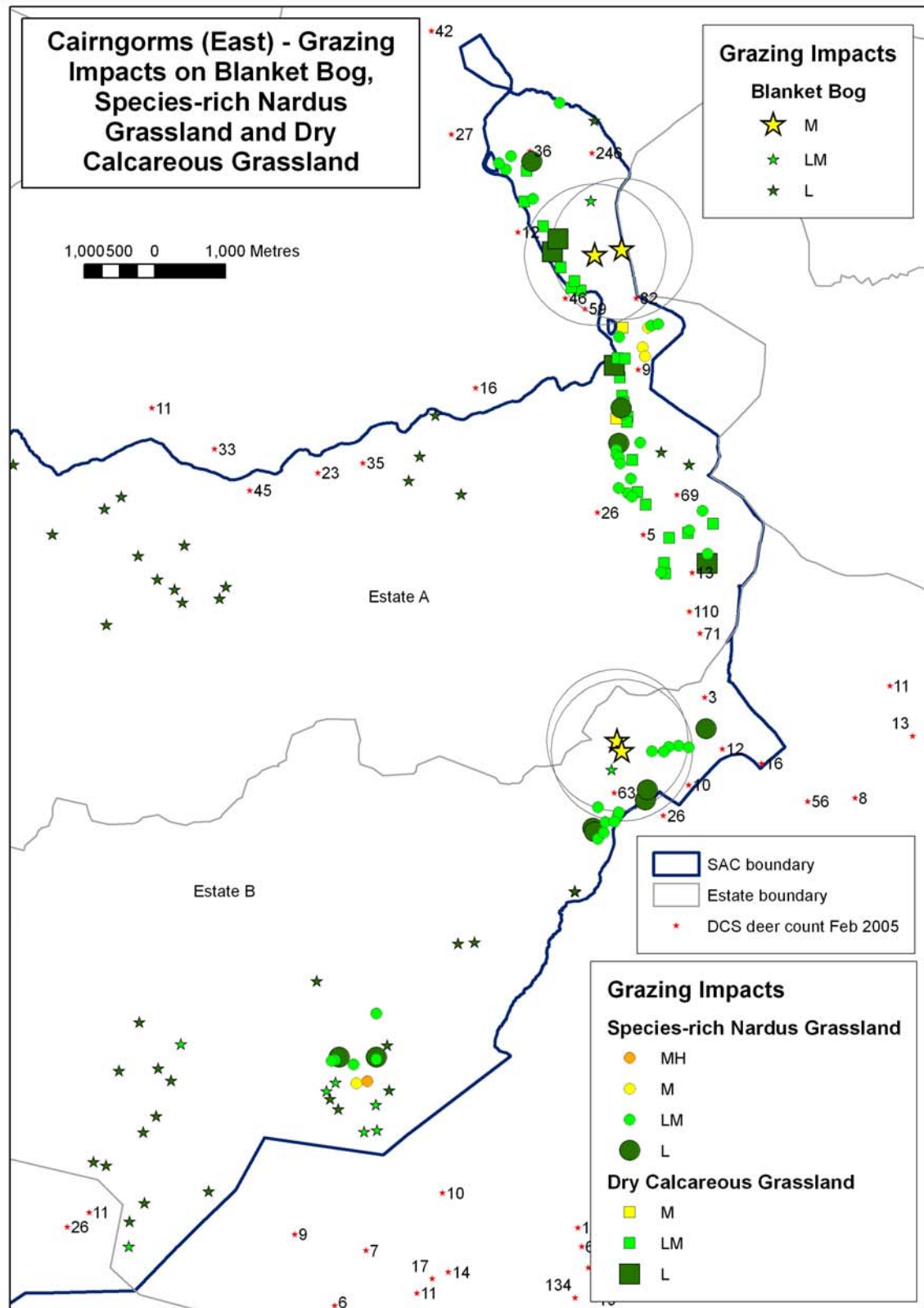
Feature	Estate	Percentage				
		L	LM	M	MH	H
Blanket Bog	A	85.7	7.1	7.1	0.0	0.0
	B	63.3	30.0	6.7	0.0	0.0
Dry Calcareous Grassland	A	13.8	79.3	6.9	0.0	0.0
	A	13.8	58.6	13.8	10.3	3.5
Flush	B	9.7	45.2	25.8	16.1	3.2
	A	10.7	78.6	10.7	0.0	0.0
Species-rich <i>Nardus</i> grassland	B	26.9	65.4	3.9	3.9	0.0

Figure 4.28 - Map showing the grazing impacts on the flushes, species-rich *Nardus* grassland and dry calcareous grassland feature types on part of the Cairngorms SAC. Buffer circles (1km radius) have been drawn around the flush locations where the impact was outside the desirable range.



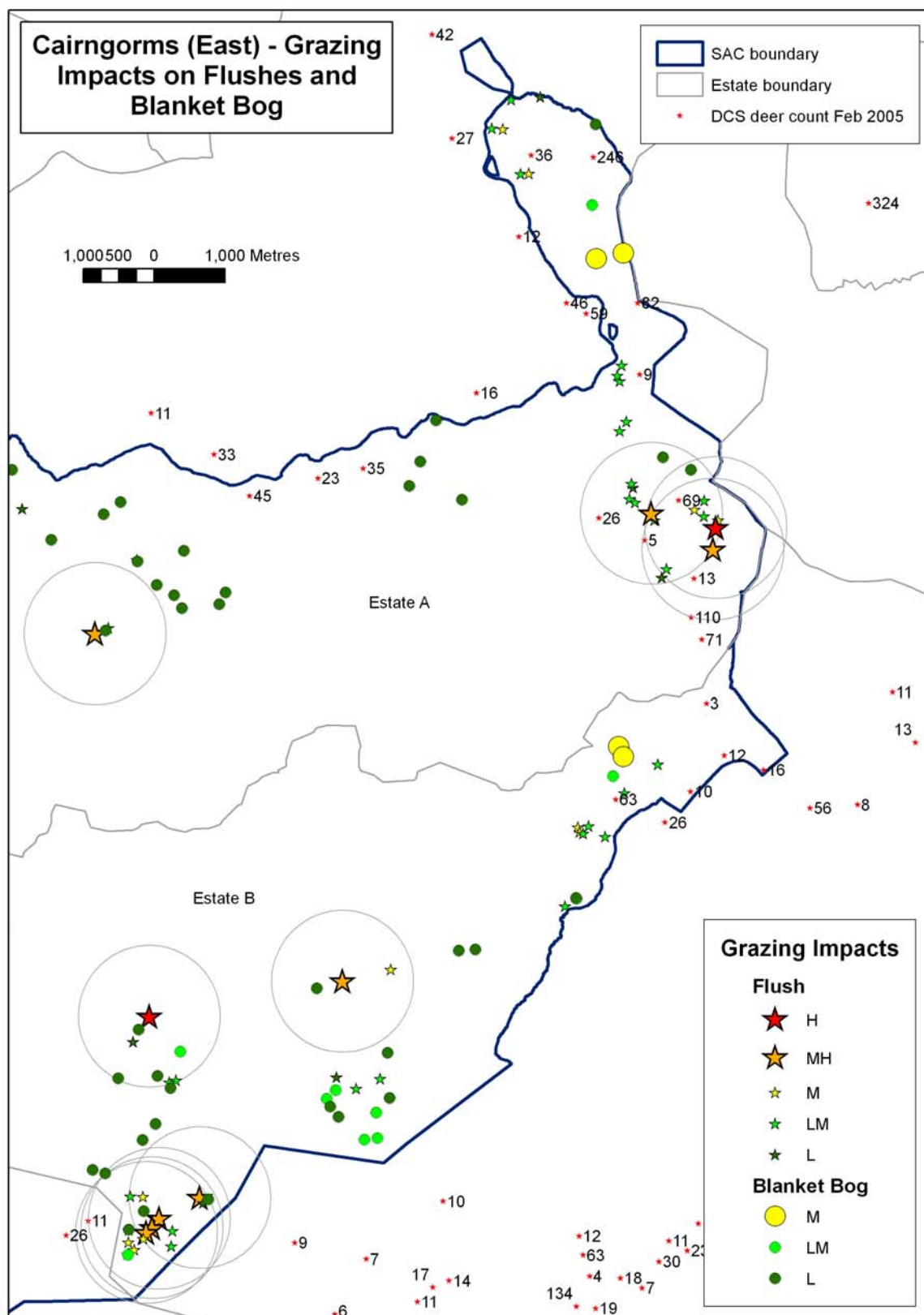
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Figure 4.29 - Map showing the grazing impacts on the blanket bog, species-rich *Nardus* grassland and dry calcareous grassland feature types on part of the Cairngorms SAC. Buffer circles (1km radius) have been drawn around the blanket bog locations where the impact was outside the desirable range.



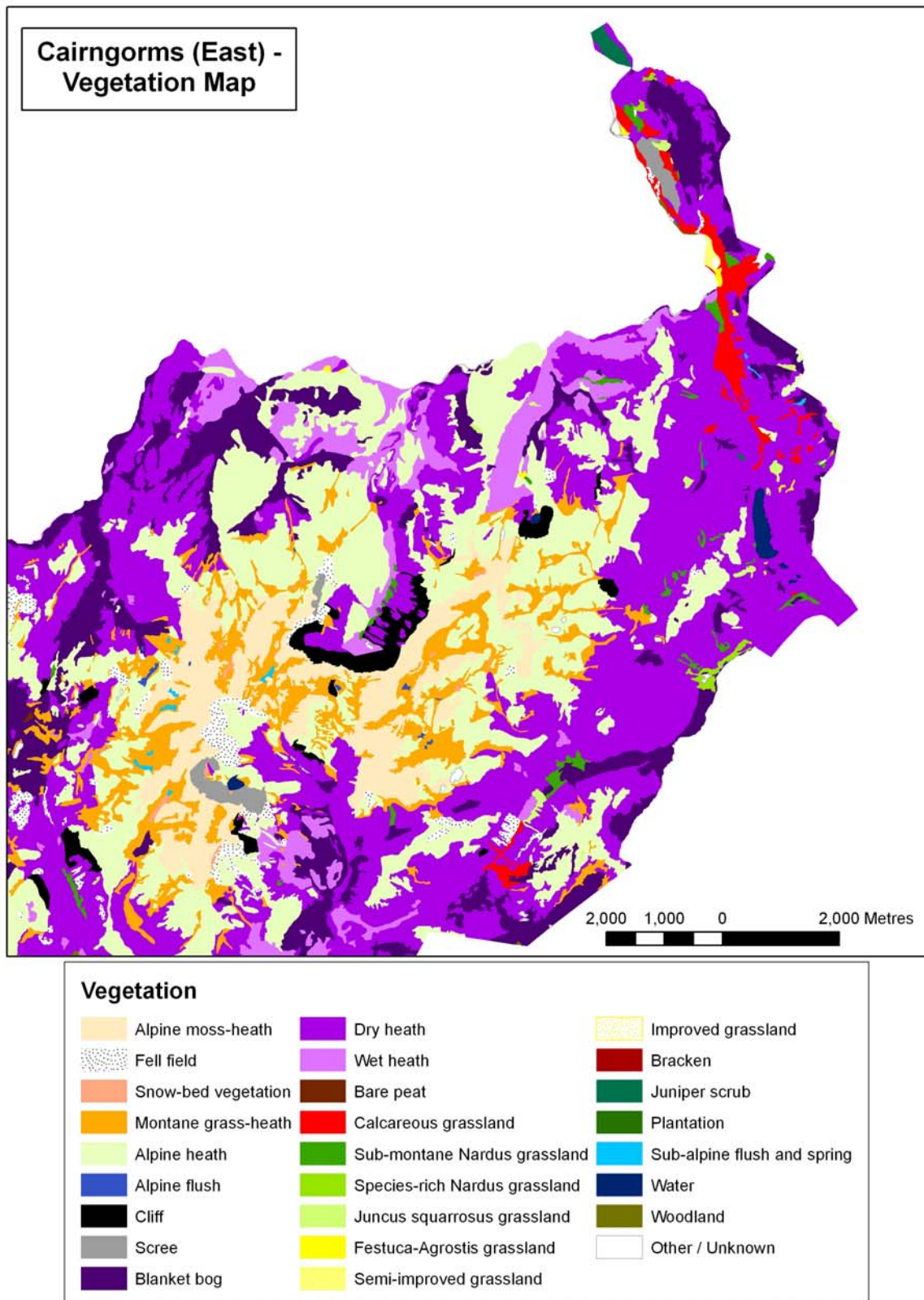
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Figure 4.30 - Map showing the grazing impacts on the flushes and blanket bog feature types on part of the Cairngorms SAC. Buffer circles (1km radius) have been drawn around the flush locations where the impact was outside the desirable range.



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Figure 4.31 - Cairngorms (East) vegetation map.



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4.6.6 HIA summary

The analyses of the HIA data from the five sites has provided evidence of potential conflict between a number of different pairs of vegetation types, which are summarised in Table 4.23. Analysis of the HIA data from the five designated sites has shown reasonable evidence that the level of herbivore impacts on particular feature types is affected by their proximity to other preferred feature types, and to the proportion of preferred habitats in the surrounding area. Most tensions exist between grasslands and other feature types. There was evidence of probable under-grazing of grassland feature types at a number of sites.

Table 4.23 - Potential conflicts between vegetation types from the HIA data

Vegetation Type 1 (herbivore impact level higher than the 'desirable range')	Vegetation Type 2 (herbivore impact level within the 'desirable range')
Wind-clipped heath	Smooth grassland
Alpine moss-heath	Species-rich <i>Nardus</i> grassland
Montane grass-heath	Species-rich <i>Nardus</i> grassland
Montane willow scrub	Alpine moss-heath
Blanket bog	Dry heath
Montane grass-heath	Dry heath
Alpine moss-heath	Dry heath
Flushes	Calcareous grassland
Flushes	Species-rich <i>Nardus</i> grassland
Blanket bog	Species-rich <i>Nardus</i> grassland
Blanket bog	Calcareous grassland
Flushes	Blanket bog
Vegetation Type 1 (herbivore impact level lower than the 'desirable range')	Vegetation Type 2 (herbivore impact level within the 'desirable range')
Smooth grassland	Flushes

4.7 Workshop 1 - 'Grazing conflicts between upland habitats: evidence and opinion'

4.7.1 Attendees

Twenty four people attended the workshop. Ten of the attendees had direct involvement in Site Condition Monitoring and Herbivore Impact Assessment of upland designated sites.

4.7.2 Workshop content and results

The workshop was led by Dr. John Holland, with support from Dr. Tony Waterhouse, Dr Helen Armstrong and Mrs. Claire Morgan-Davies. An introduction was given outlining the aims and objectives of the project and the aims of the workshop which were to present some of the results of the analyses of the Site Condition Monitoring and Herbivore Impact Assessment data; to get the views of the participants on the conflicts that exist between the grazing requirements of different habitats and how these conflicts might be resolved; to discuss the SCM and HIA methodologies. This was followed by a presentation of the results from the expert opinion survey, and the analyses of the SCM and HIA data. Between each section of the presentation there was an opportunity to discuss the results and issues raised. The participants were asked to write down any conflicts between vegetation types that have different grazing management requirements that they had observed on the ground. The results from this exercise are given in Table 4.24 and Appendix D. The observations from the workshop delegates as would be expected from what is 'known' about required grazing levels and attractiveness to herbivores of the vegetation types as outlined in the survey of experts Table 4.1; indeed many of the participants had completed the expert's questionnaire. The most frequently cited observed conflicts were between calcareous grassland (which is at the top of Table 4.1) and vegetation types at the bottom of Table 4.1 (Tall herb vegetation and montane willow scrub).

Table 4.24 - Summary table of conflicts observed on the ground by participants at the workshop. (see Table 4.1 - "Expert Opinion Table" for explanation of colour scheme).

Vegetation Type 1	Vegetation Type 2	Number of occurrences of conflict as reported by the workshop delegates
Calcareous grassland	Tall herb vegetation	10
Calcareous grassland	Montane willow scrub	9
Calcareous grassland	Woodland	8
Calcareous grassland	Blanket bog	7
Calcareous grassland	Dry heath	6
Calcareous grassland	Flushes & springs	9
Dry heath	Woodland	6
Wet heath	Woodland	4
Blanket bog	Flushes & springs	3
Calcareous grassland	Alkaline fen	2
Calcareous grassland	Alpine heath	2
Calcareous grassland	Juniper heath & scrub	2
Calcareous grassland	Scrub	2
Flushes	Woodland	2
Open habitat	Woodland	2
Alkaline fen	Woodland	2
Limestone pavement	Woodland	2
Calcareous grassland	Wet heath	1
Dry heath	Limestone pavement	1
Dry heath	Flushes	1
Bog	Limestone pavement	1
Siliceous alpine & boreal grassland	Alpine flush	1
Flushes	Montane willow scrub	1
Dry heath	Alkaline fen	1

Key points and comments from the workshop:

- There is considerable variation between upland surveyors as to the level of grazing required by different features.
- The conflicts cited by surveyors are much closer to the predicted conflicts than were those that emerged from the SCM data analyses.
- Sites often have multiple objectives and this leads to conflicts arising. There is a need for overall objectives that are set at appropriate scales.
- Conflicts between feature types depend on the proximity and extent of the feature types.
- There are also conflicts within habitats. For example, woodland managers may require very low levels of grazing to allow tree regeneration, but this could lead to loss of species-rich flushes, certain vascular plants, lower plant diversity and woodland structure.
- Habitats need to be dynamic and it is unnatural to maintain artificial boundaries (in terms of both change and spread).
- Grazing impact should not be interpreted as herbivore impact as trampling is often as important as grazing particularly on feature types such as blanket bog and flushes.
- The mismatch between the conflicts predicted from expert opinion to be most common and those that emerged from the SCM analyses may be due to issues such as the accessibility of the feature types to herbivores, the spatial distribution, area and proximity of the feature types, altitudinal differences and differences in scale.

Hence, as would no doubt be acknowledged by them, the expert opinion (Table 4.1) represents a simplification of a highly complex reality.

4.8 Workshop 2 - 'Managing hill land for different purposes'

4.8.1 Invitees and attendees

Thirty seven land-owners, farmers and land-managers from the West Perthshire, Argyll and Loch Lomond areas were invited to the workshop, together with a number of conservation advisers with an interest in upland management. Nine experienced land-managers and seven conservation advisers accepted the invitation, however only five of the land-managers actually attended the workshop.

4.8.2 Workshop content and results

The workshop was led by Dr. John Holland, with help from Dr. Tony Waterhouse and Mrs. Claire Morgan-Davies. A presentation was given at the start outlining the project and the main aims of the workshop. This was followed by a short slide show highlighting some of the upland habitats and species which have different management requirements. The participants were then asked to individually write down any issues relating to conflicts in land management that they had on their farms or that they had encountered in their work.

The participants were then split into two groups (Group 1 - Farmers; Group 2 - Conservation advisers). A farm scenario was presented to the groups and they were asked to produce a list of management options that could be used to manage the site (i.e. they were asked to produce a management 'toolbox'). Each participant was then asked to write down the advantages and disadvantages (or strengths and weaknesses) of the key 'tools' that had been suggested by the two groups.

After lunch the groups were asked to look at a series of relatively simple scenarios where management conflicts were occurring and to develop management plans for each of the scenarios to try and resolve the conflicts. A member of each group then presented the plans to the whole gathering.

The workshop produced some interesting ideas and suggestions and provoked some good discussion and debate.

Key points and comments from the workshop:

- There was considerable agreement between the land managers and conservation advisers in terms of the management options and tools required for the scenario management plans.
- The information gathered from the workshop was used to help develop a 'toolbox' of management options (see Section 7, Table 7.1), together with a list of constraints and considerations (see Section 7, Table 7.2).
- The 'toolbox' and management constraints tables were then used to develop the guidance notes for land managers.

5 PLANT-HERBIVORE INTERACTIONS

5.1 Diet selection

The diet that a herbivore selects is determined by a range of plant and animal factors, but is largely dependent upon what is available and the requirements of the animal (Gordon and Illius, 1989). Plant factors that affect diet selection include, the species composition and structure (e.g. height and density) of the sward, and the spatial distribution of the different species and plant parts within the sward, in particular the distribution and availability of more preferred species (Milne *et al.*, 1982; Grant *et al.*, 1985; Milne, 1991; Gordon and Illius, 1992). An array of grazing related plant attributes also influence diet selection, including the digestibility, nutritional value, fibre content and silica content of the plant material, and the levels of plant secondary metabolites within the plant material (Arnold, 1964; Hughes *et al.*, 1964; Grant *et al.*, 1985; Reichardt *et al.*, 1987; Hodgson *et al.*, 1991). There are also a number of animal functional attributes that affect diet selection and foraging behaviour, including body size; the morphology, size and function of the digestive tract; the size, shape and structure of the mouthparts; and the method of biting (Grant *et al.*, 1985; Gordon and Illius, 1988; 1992; Illius and Gordon, 1993). Small animals have relatively higher metabolic energy requirements per unit body weight than do larger animals, and require higher quality (lower fibre content) diets in order to survive (Bell, 1970; Jarman, 1974). Larger herbivores tend to have bigger mouthparts and are therefore less able to select individual species, live material, or the more nutritious plant parts, than are smaller herbivores (Grant *et al.*, 1985; Gordon and Illius, 1988; 1992). Sheep mouthparts differ from those of cattle, in that sheep have narrow jaws, with thin mobile lips, whilst cattle have wide jaws, with thick, relatively immobile lips and protractile tongues (used for grasping herbage) (Grant *et al.*, 1985). These differences allow sheep to be more selective and allow them to utilise proportionally more live material than cattle (Grant *et al.*, 1985; 1987). Large ruminants also have larger rumens and longer food retention times within the gut, than small ruminants, which allows them to utilise a more fibrous diet (Demment and van Soest, 1985; Gordon and Illius, 1988). Large animals also have higher foraging costs than small animals, and may therefore need to be less selective in order to contain these costs (Murray, 1991). The dietary preferences of domestic ruminants are strongly influenced by learning (Provenza and Balph, 1987). Between-breed differences in the diet selection of sheep have been observed by Osoro *et al.* (1999). The herbage intake rates of sheep and cattle are also dependent upon a range of factors, including the digestibility of the vegetation (Allison, 1985; Armstrong *et al.*, 1986; Hodgson *et al.*, 1991); the time of year (Hodgson *et al.*, 1991; Wallis de Vries and Daleboudt, 1994); the sward height and structure (Hodgson, 1981; Forbes and Hodgson, 1985; Penning, 1986; Illius *et al.*, 1987; Burlison *et al.*, 1991; Wallis de Vries and Daleboudt, 1994); the physiological state and body condition of the animal (Arnold and Birrell, 1977; Doney *et al.*, 1981); and the time spent foraging (Rook, 2000).

5.2 Foraging behaviour

The grazing distribution patterns of free-ranging ruminants are affected by abiotic factors such as slope, distance to water and exposure, and by biotic factors such as the distribution and proportion of different vegetation types, and the quantity and quality of forage within these different vegetation types (Hunter, 1962; Gordon and Illius, 1992; Bailey *et al.*, 1996; Armstrong, 1996; Hester *et al.*, 1999). In heterogeneous environments grazing ruminants have been shown to use a range of available food resources, rather than just the single source that provides the highest daily intake rate (Illius *et al.*, 1987; Wallis de Vries and Daleboudt, 1994). Observations on the distribution of South Country Cheviot sheep on a hillside in South-East Scotland (Hunter, 1962) indicated that although there was strong selection for the vegetation types with the highest nutritional value, the flock as a whole used

all the vegetation types. Work carried out by SAC on the grazing behaviour of hill sheep has shown that they do not graze randomly over hill vegetation. Vegetation type, time of year, topography and altitude all affected the foraging of the animals. Although there was some preferential grazing of vegetation with a higher digestibility and palatability, a range of vegetation types with varying degrees of digestibility were utilised as the sheep sampled the vegetation across the hillside. The next point at which an animal forages is partly dependent on their current position (i.e. it is not independent). Work by Hesse *et al* (2008) has shown that breed and season affect the foraging behaviour of cattle on semi-natural grasslands and that cattle avoided foraging in wet areas. Current work by SAC on the grazing behaviour of cattle on hill vegetation has also shown that there are differences in the foraging behaviour of different breeds and that cattle avoid steep slopes. Social interactions between individuals and home-range behaviour have also been shown to influence the grazing location of sheep (Hunter and Milner, 1963; Hewson and Wilson, 1979; Lawrence and Wood-gush, 1988). The hill sheep breeds tend to forage in a dispersed manner with individual animals retaining a home-range within the larger home-range of the management flock, a behaviour known as hefting (Hunter and Milner, 1963). In contrast, deer and cattle tend to graze as herds or small groups. Herbivores also show seasonal patterns in the grazing utilisation of different vegetation types, and these seasonal patterns of use differ between species (Osborne, 1984; Gordon, 1989). Deer populations can also have distinct summer and winter ranges.

5.3 Response of vegetation to grazing

How a particular patch of vegetation responds to grazing is dependent upon a complex set of direct and indirect interactions between the grazing animal and the individual plants within the grazed vegetation. The way in which an individual plant responds to grazing damage depends upon the functional attributes of the species, together with the time of year in which the damage occurred, the environmental conditions (e.g. climate, soil, altitude and topography), and the competitive interactions with other plants within the vegetation that are themselves responding to the effects of the grazing (Noble and Slatyer, 1980; Grime *et al.*, 1988; Milne *et al.*, 1998). Functional attributes include physical attributes (such as life form, longevity and maximum height), attributes related to growth and reproduction (such as regeneration mechanism, position of the meristem, and the optimum and range of soil and climate conditions under which the species can compete effectively), and attributes related to grazing (such as digestibility and the presence of anti-herbivore mechanisms) (Grime *et al.*, 1988; Armstrong and Milne, 1995). Field studies have shown that the response of upland vegetation to changes in grazing management is not always predictable. This unpredictability in vegetation response may be a consequence of the fact that no two vegetation patches have identical species compositions, structures, environments or management histories. Hence the starting point will differ, even between patches of similar vegetation type on the same hillside, and therefore the response of the vegetation to the same grazing regime will not always be the same (Hulme *et al.*, 1999). This varying response at the species level, and its associated unpredictability, is likely to be magnified on open hillsides containing a range of vegetation types. Vegetation always responds to management change, but this response may be gradual or rapid, subtle or clear (Miles, 1987). Any temporal stability within vegetation patches is only relative, as vegetation is constantly changing through time as individual plants die and are replaced (although the rate at which this change occurs can vary greatly) (Miles, 1987).

5.4 The impact of trampling

Trampling and poaching by herbivores can be more damaging to some vegetation types than grazing. This is particularly relevant to wet habitats such as blanket bog and flushes

which can be seriously damaged by poaching. Trampling can cause physical damage to individual plants and cause soil compaction, which reduces the air content within the soil and impedes water flow and root penetration (Brown and Evans, 1973; Frame, 1976).

5.5 Grazing requirements of different vegetation types

Each vegetation type has a range of grazing pressures that will maintain it in favourable condition. Grazing pressures outside that range are likely to lead to the habitat being in unfavourable condition. Some habitat types require very low levels of grazing (e.g. montane willow scrub), or little or no grazing at all (e.g. tall herbs), to be in favourable condition whereas others require moderate to high levels of grazing (e.g. calcareous grassland). The requirements of the other feature types lie somewhere between these extremes.

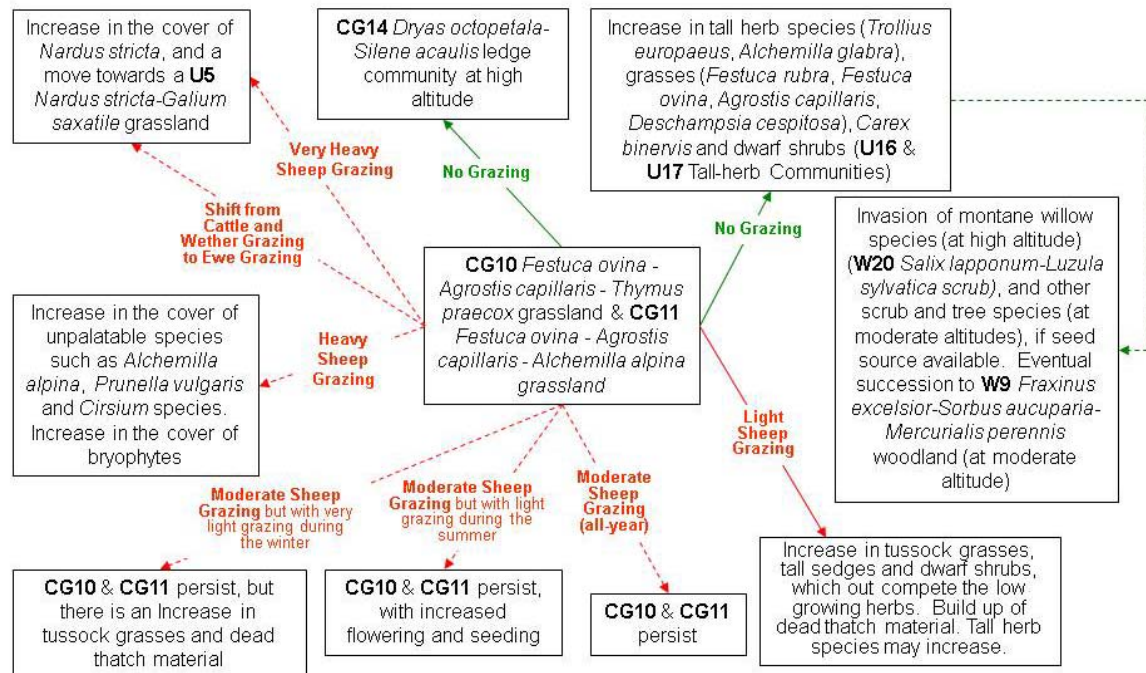
Many upland sites have a range of habitats and a mosaic of vegetation patches with varying grazing requirements often occurring within a relatively small geographic area. This complex pattern of vegetation has developed over time through the interaction of biological, environmental and anthropogenic factors, in particular grazing. Spatial and temporal changes in grazing have allowed the development of habitats with different grazing requirements in close proximity.

5.6 Succession

Several habitat types are linked by succession depending on the grazing management, for example upland calcareous grassland, tall herb vegetation and montane willow scrub (Figure 5.1). Calcareous grassland subject to low herbivore impact levels may over time develop into tall herb vegetation or montane willow scrub, however this will depend on factors such as soil conditions, the availability of a local seed source and some level of disturbance to allow seedling establishment within the closed grassland sward.

Another SAC report for SNH has recently reviewed evidence of habitat changes where grazing pressure has been reduced or excluded (Appendix E). Changes in structure and composition are reported over timescales of between 2.5 and 25 years depending on the communities involved. These studies have tended to focus on comparing grazed with ungrazed situations rather than with low impact grazing regimes. Vegetation changes under increased or heavy grazing pressures have been reviewed (appendix Table 3 in Milne *et al.* 1998); with changes having taken place over a similar range of timescales to those where grazing has been excluded. How long plants can survive under continued heavy browsing will depend on their palatability, tolerance, longevity and their method of reproduction. However, responses to herbivory are not always predictable (Pakeman 2004, del-Val & Crawley 2005) and hence the rate of vegetation change on a given site is likely to be difficult to predict. Hence when deciding on an extensive grazing regime it is likely to be difficult to accurately predict how long particular communities for which the regime is sub-optimal, may be maintained. However, site monitoring should enable changes to be detected before the conservation value is lost.

Figure 5.1 - Possible responses of species-rich calcareous grassland to changes in grazing management



Rodwell, 1992; Rawes & Welch, 1969; Stewart & Eno, 1998

6 CONFLICTS

A single upland management unit will often contain habitat types that require very different grazing levels. If there are habitats in the same land management unit that require very different grazing pressures and are accessible to grazing animals then a conflict might arise. This is more likely to occur when the feature types are in close proximity.

There are many variables that will affect whether conflicts occur or not, including:

- 1) The extent of the feature types.
- 2) The relative areas of the feature types. A small area of a preferred feature type will be more heavily grazed than will a large area at a given overall stocking rate. For example, if the management unit includes a small area of upland woodland, the grazing pressure is likely to be too high to maintain favourable condition even at quite low stocking rates since all the animals will shelter in the woodland in bad weather. If there is a large area of upland woodland then the impact of the same number of animals will be much lower.
- 3) The relative attractiveness (digestibility and palatability) of the feature types at different times of the year.
- 4) The accessibility of the feature types to grazing animals.
- 5) The location of the feature types with respect to each other (proximity).
- 6) The location of the feature types with respect to other vegetation types.
- 7) The geographical location of the feature types (altitude, topography etc.).
- 8) Shepherding and other management practices (fences, supplementary feeding etc.).
- 9) Different responses of the same vegetation type to the same grazing level due to soil, or climatic differences.
- 10) Factors affecting foraging behaviour such as:
 - The species, breed, age and sex of the herbivore or herbivores present.

- The time of year.
- The availability and location of watering points.
- Weather (temperature, wind speed/exposure/availability of shelter, snow lie).
- Presence of biting insects and flies.
- The density and location of other animals (family members, herd members, neighbouring hefted flocks, other species).
- Disturbance.

Although some of the factors will normally be less important than others, they may be important at a particular site in explaining the patterns of conflict that exist. This highlights the importance of checking any predicted conflicts on the ground.

Of the upland designated feature types, calcareous grasslands require the highest level of grazing to maintain their favourable condition and therefore their requirements can potentially be in conflict with any of the other feature types. Potentially the greatest problems are likely to occur where calcareous grassland, which requires moderate levels of grazing in order to maintain favourable condition, is in close proximity to vegetation types such as tall herb vegetation or montane willow scrub that are attractive to herbivores and yet require very low levels of grazing or no grazing at all to maintain favourable condition. In these situations there is a high chance that the tall herb and montane willow scrub will be too heavily grazed. As a result of long-term deer and sheep grazing much of the tall herb vegetation and montane willow scrub is now restricted to inaccessible cliff ledges and therefore this conflict may actually be rare. The SCM data indicates that this may be the case however the upland surveyors suggested that these conflicts are still a major issue. Conflict will arise if there is a desire or requirement to extend tall herb and montane willow scrub onto areas which are more accessible. Analysis of the HIA data indicates that potential conflicts are more frequent between habitats that are easily accessible to herbivores, are in close proximity and have different grazing requirements and levels of attractiveness to herbivores.

It is likely that as a result of the continued decline in hill livestock numbers (Renwick *et al.*, 2008) some areas of species-rich calcareous grassland may have too little grazing, resulting in a decline in annual and low growing perennial herbs and a rise in sward height leading to unfavourable condition. There is as yet little evidence of this from site condition monitoring, however the HIA data does appear to show that grazing impact levels on species-rich calcareous grasslands are below the 'desirable range' on some of the designated sites analysed. Many of the scarce alpine species found in these grasslands, which are of greatest conservation value, are likely to decline, while tall perennial grasses, sedges and dwarf shrubs will increase. Tall herb vegetation and montane willow scrub may replace the calcareous grassland, but this is dependent on a local seed source and some disturbance to open up the sward. Some plant species respond very rapidly to the removal of grazing and small isolated populations of these species are at risk of local extinction from particular sites. On areas where sheep have been removed red deer numbers are likely to increase as a result of the increase in available herbage, reduced competition from grazing livestock and lower levels of disturbance. These increases in red deer may in part compensate for the loss of livestock however there are differences in the foraging behaviour of sheep and deer and their numbers and geographical distribution are likely to be much more variable both seasonally and annually. Changes in the numbers of deer will also depend on how the rest of the vegetation responds, as grasslands may rapidly become tall and rank, reducing their attractiveness to foraging deer. Grazing animals will tend to graze upland calcareous grassland in preference to most of the other feature types, and therefore even at relatively low overall stocking rates it might still be adequately grazed and in favourable condition, but this will depend on the area of the grassland and the proximity to less preferred vegetation types. For example small patches of calcareous grassland surrounded by less preferred

habitats such as blanket bog may continue to be grazed at adequate levels, however very large patches of calcareous grassland surrounded by other preferred vegetation types may be at risk of 'under-grazing'. Conversely, a vegetation type such as blanket bog, which can suffer from too heavy grazing but is less attractive to grazing animals may not be damaged even at quite high overall stocking rates if other more preferred vegetation types are available.

7 MANAGEMENT TOOLBOX

There are many tools that can be used to manipulate herbivore numbers and distribution (Table 7.1). Determining which combinations of options are the most appropriate will have to be done on a site by site basis taking into account a range of constraints and factors that influence the management decisions (Table 7.2). Generic management prescriptions relating to livestock numbers and/or densities are rarely if ever appropriate.

Using information derived from the workshops and literature, a list of management requirements and the possible tools that could be used to achieve the management, for a number of upland feature types are shown in Table 7.3 (situations where habitats have too much grazing) and Table 7.4 (situations where habitats have too little grazing). Although the management tools have been presented at a habitat level, to avoid micro-management of a site they should be considered and prioritised at a site level.

Table 7.1 - 'Toolbox' - Tools or management options that are available for manipulating the number and distribution of herbivores.

General Management Tools	Options available
Grazing	Sheep Only Cattle Only Deer Only Combination of sheep/cattle/deer - Number of animals - Density of animals - Age - Breed (genetics) - Sex (e.g. wethers, breeding ewes, cows and calves, heifers, bullocks) No livestock grazing No large herbivore grazing Variations of above
Seasonal (temporal) grazing	Winter grazing Summer grazing Avoiding flowering/seeding season Short term grazing
Control of grazing distribution	Shepherding Supplementary feeding ⁹ Diversionary feeding Hefting Fencing (conventional stock fence, deer fence, electric fence, 'virtual' fence) Shooting/managing deer
Heather management	Burning Swiping (machine)
Grass burning	
Bracken management	Chemical (spraying) Mechanical (cutting, crushing)
Access management to reduce disturbance	Information Advisory routes Way-marked footpaths
Infra-structure changes	Buildings (sheds etc.) Tracks (4x4 tracks, quad bike tracks)
Drainage	More - improving drainage may encourage grazing animals onto an area and away from another area Less - Blocking drains and re-wetting an area may discourage grazing on that area
Inbye improvement	Fertiliser/Lime Reseeding Clover Forage crops
Woodland/Forestry	Plantations Shelter belts Native woodland
Collaboration with neighbours	Deer control Sheep management (hefts) Whole catchment management plans

⁹Supplementary feeding of red deer is rarely favoured on designated sites as a long-term solution, and is likely to be effective only as a short term diversion.

Table 7.2 - Constraints and factors influencing management.

Constraint	Relevant Issues
Overall economic viability	All the options incur some cost (money and/or time) Commercial agriculture/ private income <i>versus</i> conservation/ ecosystem services/ public benefit
Availability of grants	SRDP - Rural Priority Options - Land Management Options Other - e.g. LLTNP Natural Heritage Grant Scheme
The practicality of the management option within the farming business	Do the options fit in with the overall management of the farm? (e.g. if off wintering is required is there somewhere for the sheep to be off-wintered)
Cross compliance (GAEC)	Stock removal, reseedling, drainage and other management options may be restricted due to GAEC or other cross compliance
Availability of skilled labour	Shepherds (with “old style” shepherding skills) Fencers Deer controllers
Requirement for long-term management	Shepherding Deer Control
Requirement for long-term maintenance	Fencing Infrastructure
Availability of improved grassland or non-priority semi-natural grasslands	In order to reduce stock numbers on priority habitats but retain an economically viable flock some areas of improved grassland or non-priority semi-natural grassland are often required.
Other commercial interests	Grouse shooting Deer shooting Forestry Tourism Renewable energy Other diversification options
Health and Safety	Lone working Heather burning
Management/lack of management on neighbouring farms	Are neighbouring hefts still present? Are the deer managed in the neighbouring estates?
Availability of management expertise/knowledge/guidance	
Impact on the landscape	Fencing Burning Woodland Tracks for deer extraction
Impact on other wildlife and habitats (priority and non-priority)	Fencing (e.g. bird strike) Inbye improvement Burning Woodland Disturbance

Table 7.2 (continued) - Constraints and factors influencing management.

Constraint	Relevant Issues
Impact on the local community	The need to maintain farming jobs and contribute to the development of the local rural economy
Weather and climate	The effectiveness of the management option (particularly shepherding and fencing) can be influenced by the weather
Altitude and topography	The effectiveness of the management option (particularly fencing and shepherding) can be influenced by the altitude and topography of the site
Carbon footprint	Positive (decreased emissions and mitigation) - Livestock removal? - Peatland/peaty soil restoration - Woodland regeneration Negative (increased emissions) - Fencing - Infrastructure (buildings, tracks) - Away wintering (transport)
Possible future impact of climate change on the habitats and on the management system	Building in resilience
Risk assessment	Risk of reduction in biodiversity through too little grazing (habitats requiring grazing often occupy a much higher percentage of the total area of a site compared with habitats that are vulnerable to grazing) Risk of habitat loss and deterioration due to too much grazing and trampling Risk of public investment with little overall net benefit Risk of serious damage to open habitats and woodland through out-of control burning
Temporal dynamic	Long-term management over many years may be required in order to achieve favourable condition. In other situations short-term, seasonal or periodic grazing may be required for example to graze-off rank grassland or scrub, or to create niches for regeneration. Short-term removal of grazing may be required to promote flowering and seeding.
Communication and liaison between land managers and government agencies	Land managers need to know why they are being asked to manage their land and livestock in a particular way, and need to be kept informed.

Table 7.3 - Management options for different priority habitats - situations where habitats have too much grazing.

	Management required to shift from unfavourable condition (due to too much grazing) to favourable condition	Potential tools / options that could be used*
Calcareous grassland (upland)	1) Reduction in summer grazing pressure (particularly during the flowering and seeding periods) to moderately low levels 2) Reduction in all-year-round grazing pressure to moderate levels 3) Introduction of controlled cattle grazing coupled with a reduction in sheep grazing	a) <i>Shepherding</i> b) <i>Fencing</i> c) <i>Stock reduction</i> d) <i>Improvement of inbye ground (by fertilizer, lime and/or grazing management) to reduce pressure on semi-natural vegetation</i> e) <i>Cattle grazing</i> f) <i>Deer management</i>
Sub-alpine dry dwarf-shrub heath	1) Reduction in winter grazing pressure to low levels 2) Reduction in all-year-round grazing pressure to low or moderately low levels 3) Muirburn	a) <i>Away wintering</i> b) <i>Off wintering</i> c) <i>Stock reduction</i> d) <i>Shepherding</i> e) <i>Fencing</i> f) <i>Improvement of inbye ground to reduce pressure on semi-natural vegetation</i> h) <i>Burning/swiping</i> i) <i>Deer management</i>
Blanket bog and valley bog (upland)	1) Reduction/removal of winter grazing pressure to very low levels 2) Reduction in all-year-round grazing pressure to low levels	a) <i>Stock reduction</i> b) <i>Away wintering</i> c) <i>Off wintering</i> d) <i>Shepherding</i> e) <i>Fencing</i> f) <i>Improvement of inbye ground to reduce pressure on vegetation</i> g) <i>Deer management</i>
Alpine dwarf-shrub heath	1) Reduction in summer grazing pressure to very low levels 2) Reduction in all-year-round grazing pressure to very low levels	a) <i>Shepherding</i> b) <i>Fencing</i> c) <i>Stock reduction</i> d) <i>Improvement of inbye ground to reduce pressure on semi-natural vegetation</i> e) <i>Deer management</i>
Moss, dwarf-herb, and grass-dominated snow-bed	1) Reduction in summer grazing pressure to low or very low levels 2) Reduction in all-year-round grazing pressure to low or very low levels	a) <i>Shepherding</i> b) <i>Fencing</i> c) <i>Stock reduction</i> d) <i>Improvement of inbye ground to reduce pressure on semi-natural vegetation</i> e) <i>Deer management</i>

* Although the management tools have been presented at a habitat level, in order to prevent micro-management of a site they should be considered and prioritised at a site level. Options may be employed singly or in appropriate combinations.

Table 7.3 (continued) - Management options for different priority habitats - situations where habitats have too much grazing.

	Management required to shift from unfavourable condition (due to too much grazing) to favourable condition	Potential tools / options that could be used*
Wet heath (upland)	1) Reduction in winter grazing pressure to low levels 2) Reduction in all-year-round grazing pressure to low levels	a) Away wintering b) Off wintering c) Stock reduction d) Shepherding e) Fencing f) Improvement of inbye ground to reduce pressure on semi-natural heath g) Burning/swiping h) Deer management
Alpine flush	1) Reduction in summer grazing pressure to low levels 2) Reduction in all-year-round grazing pressure to low levels	a) Shepherding b) Fencing c) Stock reduction d) Improvement of inbye ground to reduce pressure on semi-natural vegetation e) Deer management
Alpine summit communities of moss, sedge and three-leaved rush	1) Reduction in summer grazing pressure to very low levels 2) Reduction in all-year-round grazing pressure to very low levels	a) Shepherding b) Fencing c) Stock reduction d) Improvement of inbye ground to reduce pressure on semi-natural vegetation e) Deer management
Tall herbs (upland)	1) Removal of grazing animals 2) Reduction in all-year round grazing pressure to very low levels	a) Fencing (may not be practical in some situations) b) Stock removal/reduction c) Deer management
Montane willow scrub	1) Removal of grazing animals 2) Reduction in all-year round grazing pressure to very low levels	a) Fencing (may not be practical in some situations) b) Stock removal/reduction c) Deer management
Woodland (e.g. Upland Mixed Ashwood)	1) Reduction in summer grazing pressure and removal of winter grazing pressure. 2) Introduction of controlled cattle grazing coupled with reduction in sheep grazing	a) Fencing b) Away wintering c) Off wintering d) Stock reduction e) Improvement of inbye ground to reduce pressure on woodland f) Deer management

* Although the management tools have been presented at a habitat level, in order to prevent micro-management of a site they should be considered and prioritised at a site level. Options may be employed singly or in appropriate combinations.

Table 7.4 - Management options for different priority habitats - situations where habitats have too little grazing.

	Management required to shift from unfavourable condition (due to too little grazing) to favourable condition	Potential tools / options that could be used*
Calcareous grassland (upland)	1) Increase in all-year-round grazing pressure to moderate levels 2) Increase in winter grazing pressure to moderate levels 2) Introduction of controlled cattle grazing	a) <i>Shepherding</i> b) <i>Fencing</i> c) <i>Stock increase</i> d) <i>Cattle grazing</i> e) <i>Deer management</i>
Subalpine dry dwarf-shrub heath	1) Muirburn 2) Increase in summer grazing pressure to low to moderate levels	a) <i>Stock increase</i> b) <i>Shepherding</i> c) <i>Fencing</i> d) <i>Burning/swiping</i> e) <i>Deer management</i>
Blanket bog and valley bog (upland)	Unlikely to be a major issue	a) <i>Deer management</i>
Alpine dwarf-shrub heath	Unlikely to be a major issue	a) <i>Deer management</i>
Wet heath (upland)	1) Muirburn 2) Increase in summer grazing pressure to low levels	a) <i>Stock increase</i> b) <i>Shepherding</i> c) <i>Fencing</i> d) <i>Burning/swiping</i> e) <i>Deer management</i>
Moss, dwarf-herb, and grass-dominated snow-bed	Unlikely to be a major issue	a) <i>Deer management</i>
Alpine flush	1) Increase in all-year-round grazing pressure to low to moderate levels	a) <i>Shepherding</i> b) <i>Fencing</i> c) <i>Stock increase</i> d) <i>Cattle grazing</i> e) <i>Deer management</i>
Alpine summit communities of moss, sedge and three-leaved rush	Unlikely to be a major issue	a) <i>Deer management</i>
Tall herbs (upland)	Unlikely to be a major issue	a) <i>Deer management</i>
Montane willow scrub	Unlikely to be a major issue	a) <i>Deer management</i>
Upland Mixed Ashwood	1) Introduction of controlled seasonal cattle grazing – depending on objectives (regeneration or wood pasture management)	a) <i>Cattle grazing</i> b) <i>Fencing</i> c) <i>Deer management</i>

* Although the management tools have been presented at a habitat level, in order to prevent micro-management of a site they should be considered and prioritised at a site level. Options may be employed singly or in appropriate combinations.

Note: the terms low, moderately low and moderate are relative and will depend on the site and the existing management.

8 MANAGING CONFLICTS

All sites are unique and therefore management plans have to be tailored to fit the particular site. Each land management unit has its own set of environmental and management conditions. The methods used to resolve each conflict are therefore likely to differ between sites even where the grazing conflict is between the same vegetation types.

When developing management plans the most important thing is the setting of clear objectives for the site. It may be hard to devise a management regime that will maintain all the habitats in favourable condition. In these situations some compromise may be required with priority given to one or more features. This will have to be done on a site by site basis. A number of principles can be used to help determine what the priorities are on a site. On Natura designated sites, Annex 1 qualifying habitats would take priority over non-qualifying habitat types; on Sites of Special Scientific Interest notified habitats would take precedence over non-notified habitat types (Table 8.1). The grading or priority attached to the interest and the extent of the feature would also have to be considered. Some notified habitat types may develop into other priority habitat types if the grazing management is changed, whereas others may lose their conservation value, and this also needs to be taken into consideration when setting the objectives. On non-designated sites, prioritising features may be more difficult. This will have to take into account the management objectives of the land-owner, the extent of the feature types, their local and national importance (e.g. UK and Local Habitat Action Plan priority habitats, Scottish biodiversity list habitats etc.) and the presence of nationally rare (Red Data Book), scarce or BAP species. In setting any objectives for a site, consideration needs to be given to economic, cultural and political issues as well as nature conservation. This may lead to a management approach which is a compromise.

Table 8.1 - Key factors affecting the conservation priority of habitats on a given site

Site types	Factors affecting priorities	Obligations
Natura Sites – SACs and SPAs	Habitats Directive Annex I qualifying habitats	EC and UK statutory requirement to avoid adverse effects on Natura site integrity (unless exceptional circumstances apply)
	Habitats Directive Annex II qualifying species	
	Birds Directive Annex 1 species	EC statutory obligation to avoid the deterioration of qualifying habitats and the habitats of qualifying species; also the significant disturbance of qualifying species.
	Is there a risk that a change in management could adversely affect the integrity of the site for any of its qualifying habitat/species – relating to their extent, population size, distribution and quality as an example of the type?	
	Is the habitat an EC Priority habitat?	
	Are the habitats or species one of the primary reasons for site selection?	
SSSIs	Notified interests	UK government objective to maintain all notified features in favourable condition.
Non-designated sites	Management affecting the habitats of European Protected Species (EPS)	Statutory protection for EPS, their resting and breeding sites – wherever they occur.
	Annex I habitats outwith SACs	EC objective to improve the ecological coherence of the network of Natura sites by maintaining and improving landscape features which are of major importance for wild flora and fauna - not site specific.
	UK BAP Priority Habitat	Objectives for habitat conservation described in Habitat Action Plans – not site specific.
	Management affecting the habitats of UK BAP Priority Species	Objectives for the species recovery described in Species Action Plans – not site specific.
	Scottish Biodiversity List habitat or species	Biodiversity duty on public bodies in exercising their duties – not site specific.
	Local Biodiversity Action Plan habitat or species	Objectives for conservation described in the LBAP HAPs or SAPs – not site specific.
	Management affecting the habitats of nationally or locally rare species.	

9 GUIDANCE NOTES

The main findings from the data analyses and project workshops were used to develop a set of guidance notes for land managers entitled 'Managing Upland Habitats with Differing Grazing Requirements - A Practical Guide' (Appendix F). This guide provides practical information for land managers who are undertaking upland habitat management particularly on designated sites. It aims to give guidance on management where important upland habitats have different management requirements in order to maintain their nature conservation value or to meet statutory requirements.

10 CONCLUSION

It would seem that, despite the huge range of factors affecting herbivore foraging and the response of vegetation, we can still come up with some general predictions about when and where grazing conflicts are most likely to occur. Nevertheless, variations will occur and each site needs to be assessed individually and solutions tailored to individual conditions and needs.

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13 MAP DATA

SNH – Designated site NVC shape files

SNH – Designated site boundary shape files

Deer Commission for Scotland – Estate boundary shape files

Deer Commission for Scotland – Deer count shape files

APPENDICES - A TO E

Appendix A - The number of responses from the experts to the questionnaire for each of the feature types. The feature types which had the fewest number of "expert" responses are marked (there is probably a low level of knowledge about these habitats within the group of "experts" who responded).

Feature name	Count of responses from "experts"			Feature Types with the fewest responses
	Favourable grazing level	Attractiveness to herbivores	Accessibility to herbivores	
Calcareous grassland (upland)	13	13	10	
Subalpine dry dwarf-shrub heath	12	12	11	
Calaminarian grassland and serpentine heath	10	10	8	✓
Blanket bog and valley bog (upland)	14	13	14	
Calcareous scree	11	11	11	
Transition mire, ladder fen and quaking bog (upland)	11	11	10	
Alpine dwarf-shrub heath	12	12	11	
Wet heath (upland)	13	13	13	
Bog woodland	11	11	11	
Juniper heath and scrub (upland)	14	14	14	
Wet woodland	12	12	12	
Moss, dwarf-herb, and grass-dominated snow-bed	12	12	11	
Calcareous rocky slopes	11	11	11	
Scrub	11	12	11	
Maritime cliff	9	9	9	✓
Upland Birch Woodland	12	12	11	
Upland oak woodland	12	12	11	
Caledonian forest/Native pinewood	11	11	10	
Alkaline fen (upland, excluding alpine flush)	11	11	11	
Spring-head, rill and flush (upland)	11	11	11	
Wetland Springs (including flushes)	10	10	10	✓
Alpine flush	10	10	9	✓
Limestone pavement	9	9	8	✓
Upland Mixed Ashwood	12	12	10	
Alpine summit communities of moss, sedge and three-leaved rush	12	12	12	
Siliceous scree	11	11	11	
Tall herbs (upland)	12	12	11	
Montane willow scrub	15	15	14	

Appendix B - Possible conflicts between paired vegetation types determined from Site Condition Monitoring data. The data have been arranged as pairs of features, noting whether each pair is in conflict (i.e. one feature in favourable condition, one un-favourable condition) or not (this does not necessarily relate to herbivory). Only sites with more than one upland feature have been used and only pairs that occur three or more times are included.

Feature Type 1	Feature Type 2	Number of occurrences where one feature type in favourable condition and the other in unfavourable condition	Type 1 in favourable condition Type 2 in unfavourable condition	Type 2 in favourable condition Type 1 in unfavourable condition	Total number of occurrences of the pair
Siliceous scree	Alpine dwarf-shrub heath	12	11	1	17
Siliceous scree	Subalpine dry dwarf-shrub heath	12	11	1	18
Siliceous scree	Alpine summit communities	10	9	1	18
Tall herbs (upland)	Alpine dwarf-shrub heath	9	9	0	16
Tall herbs (upland)	Alpine summit communities	9	8	1	17
Siliceous scree	Blanket bog and valley bog (upland)	9	9	0	15
Tall herbs (upland)	Blanket bog and valley bog (upland)	9	9	0	13
Siliceous scree	Calcareous grassland (upland)	8	8	0	10
Tall herbs (upland)	Calcareous grassland (upland)	8	8	0	14
Siliceous scree	Montane willow scrub	8	8	0	9
Siliceous scree	Wet heath (upland)	8	7	1	14
Tall herbs (upland)	Montane willow scrub	7	7	0	13
Tall herbs (upland)	Subalpine dry dwarf-shrub heath	7	7	0	14
Subalpine dry dwarf-shrub heath	Blanket bog and valley bog (upland)	6	5	1	21
Tall herbs (upland)	Wet heath (upland)	6	6	0	12
Alpine dwarf-shrub heath	Blanket bog and valley bog (upland)	5	4	1	18
Alpine summit communities	Blanket bog and valley bog (upland)	5	4	1	15
Siliceous scree	Alkaline fen (upland)	4	4	0	5

Appendix B (continued)

Feature Type 1	Feature Type 2	Number of occurrences where one feature type in favourable condition and the other in unfavourable condition	Type 1 in favourable condition Type 2 in unfavourable condition	Type 2 in favourable condition Type 1 in unfavourable condition	Total number of occurrences of the pair
Alpine dwarf-shrub heath	Wet heath (upland)	4	3	1	15
Alpine flush	Calcareous grassland (upland)	4	4	0	10
Alpine flush	Montane willow scrub	4	4	0	8
Alpine flush	Subalpine dry dwarf-shrub heath	4	3	1	7
Subalpine dry dwarf-shrub heath	Alpine summit communities	4	2	2	20
Alpine summit communities	Wet heath (upland)	4	3	1	14
Calcareous rocky slopes	Calcareous grassland (upland)	4	4	0	4
Calcareous scree	Calcareous grassland (upland)	4	4	0	5
Calcareous scree	Subalpine dry dwarf-shrub heath	4	4	0	4
Siliceous scree	Caledonian forest/Native pinewood	4	4	0	5
Tall herbs (upland)	Caledonian forest/Native pinewood	4	4	0	4
Alpine flush	Alkaline fen (upland)	3	2	1	8
Alkaline fen (upland)	Calcareous grassland (upland)	3	2	1	11
Calcareous scree	Alkaline fen (upland)	3	3	0	3
Alpine summit communities	Alpine dwarf-shrub heath	3	2	1	20
Bog woodland	Alpine dwarf-shrub heath	3	3	0	3
Calcareous scree	Alpine dwarf-shrub heath	3	3	0	3
Alpine dwarf-shrub heath	Juniper heath and scrub (upland)	3	2	1	3
Subalpine dry dwarf-shrub heath	Alpine dwarf-shrub heath	3	2	1	25
Alpine dwarf-shrub heath	Upland oak woodland	3	2	1	5
Alpine flush	Alpine summit communities	3	3	0	9

Appendix B (continued)

Feature Type 1	Feature Type 2	Number of occurrences where one feature type in favourable condition and the other in unfavourable condition	Type 1 in favourable condition Type 2 in unfavourable condition	Type 2 in favourable condition Type 1 in unfavourable condition	Total number of occurrences of the pair
Siliceous scree	Alpine flush	3	3	0	7
Alpine flush	Wet heath (upland)	3	2	1	4
Alpine summit communities	Montane willow scrub	3	3	0	13
Bog woodland	Blanket bog and valley bog (upland)	3	3	0	4
Calcareous scree	Blanket bog and valley bog (upland)	3	3	0	3
Wet heath (upland)	Blanket bog and valley bog (upland)	3	2	1	18
Bog woodland	Caledonian forest/Native pinewood	3	3	0	4
Bog woodland	Subalpine dry dwarf-shrub heath	3	3	0	4
Bog woodland	Wet heath (upland)	3	3	0	4
Spring-head, rill and flush (upland)	Calcareous grassland (upland)	3	3	0	7
Subalpine dry dwarf-shrub heath	Calcareous grassland (upland)	3	2	1	13
Wet heath (upland)	Calcareous grassland (upland)	3	3	0	8
Calcareous rocky slopes	Snow-bed	3	3	0	3
Calcareous scree	Montane willow scrub	3	3	0	3
Subalpine dry dwarf-shrub heath	Caledonian forest/Native pinewood	3	3	0	9
Spring-head, rill and flush (upland)	Montane willow scrub	3	3	0	3
Siliceous scree	Tall herbs (upland)	3	2	1	13
Subalpine dry dwarf-shrub heath	Upland oak woodland	3	2	1	6
Subalpine dry dwarf-shrub heath	Wet heath (upland)	3	3	0	19
Transition mire	Wet heath (upland)	3	3	0	4
Spring-head, rill and flush (upland)	Alkaline fen (upland)	2	1	1	6

Appendix B (continued)

Feature Type 1	Feature Type 2	Number of occurrences where one feature type in favourable condition and the other in unfavourable condition	Type 1 in favourable condition Type 2 in unfavourable condition	Type 2 in favourable condition Type 1 in unfavourable condition	Total number of occurrences of the pair
Tall herbs (upland)	Alkaline fen (upland)	2	2	0	6
Alpine flush	Alpine dwarf-shrub heath	2	2	0	8
Alpine dwarf-shrub heath	Calcareous grassland (upland)	2	2	0	13
Alpine dwarf-shrub heath	Montane willow scrub	2	2	0	10
Snow-bed	Alpine dwarf-shrub heath	2	2	0	3
Alpine flush	Blanket bog and valley bog (upland)	2	2	0	5
Tall herbs (upland)	Alpine flush	2	1	1	9
Bog woodland	Alpine summit communities	2	2	0	3
Transition mire	Blanket bog and valley bog (upland)	2	2	0	5
Limestone pavement	Calcareous grassland (upland)	2	1	1	4
Upland oak woodland	Caledonian forest/Native pinewood	2	2	0	3
Wet heath (upland)	Caledonian forest/Native pinewood	2	2	0	7
Spring-head, rill and flush (upland)	Limestone pavement	2	2	0	4
Subalpine dry dwarf-shrub heath	Montane willow scrub	2	2	0	11
Spring-head, rill and flush (upland)	Subalpine dry dwarf-shrub heath	2	2	0	3
Transition mire	Subalpine dry dwarf-shrub heath	2	2	0	3
Alpine dwarf-shrub heath	Alkaline fen (upland)	1	1	0	6
Alkaline fen (upland)	Limestone pavement	1	1	0	3
Alkaline fen (upland)	Montane willow scrub	1	1	0	7
Spring-head, rill and flush (upland)	Alpine dwarf-shrub heath	1	1	0	3
Calcareous scree	Alpine flush	1	1	0	3

Appendix B (continued)

Feature Type 1	Feature Type 2	Number of occurrences where one feature type in favourable condition and the other in unfavourable condition	Type 1 in favourable condition Type 2 in unfavourable condition	Type 2 in favourable condition Type 1 in unfavourable condition	Total number of occurrences of the pair
Alpine summit communities	Calcareous grassland (upland)	1	1	0	13
Alpine summit communities	Caledonian forest/Native pinewood	1	1	0	6
Upland oak woodland	Alpine summit communities	1	1	0	3
Upland oak woodland	Blanket bog and valley bog (upland)	1	1	0	5
Bog woodland	Siliceous scree	1	1	0	3
Calcareous grassland (upland)	Montane willow scrub	1	1	0	12
Calcareous scree	Tall herbs (upland)	1	1	0	4
Wet heath (upland)	Montane willow scrub	1	1	0	8
Snow-bed	Subalpine dry dwarf-shrub heath	1	1	0	4
Spring-head, rill and flush (upland)	Wet heath (upland)	1	1	0	3
Wet heath (upland)	Upland Mixed Ashwood	1	1	0	3
Upland oak woodland	Wet heath (upland)	1	1	0	6
Alpine summit communities	Alkaline fen (upland)	0	0	0	6
Blanket bog and valley bog (upland)	Alkaline fen (upland)	0	0	0	3
Subalpine dry dwarf-shrub heath	Alkaline fen (upland)	0	0	0	6
Wet heath (upland)	Alkaline fen (upland)	0	0	0	3
Caledonian forest/Native pinewood	Alpine dwarf-shrub heath	0	0	0	7
Spring-head, rill and flush (upland)	Alpine flush	0	0	0	3
Calcareous grassland (upland)	Blanket bog and valley bog (upland)	0	0	0	8
Caledonian forest/Native pinewood	Blanket bog and valley bog (upland)	0	0	0	6
Montane willow scrub	Blanket bog and valley bog (upland)	0	0	0	8

Appendix B (continued)

Feature Type 1	Feature Type 2	Number of occurrences where one feature type in favourable condition and the other in unfavourable condition	Type 1 in favourable condition Type 2 in unfavourable condition	Type 2 in favourable condition Type 1 in unfavourable condition	Total number of occurrences of the pair
Upland Birch Woodland	Blanket bog and valley bog (upland)	0	0	0	4
Caledonian forest/Native pinewood	Calcareous grassland (upland)	0	0	0	3
Siliceous scree	Calcareous scree	0	0	0	3
Montane willow scrub	Caledonian forest/Native pinewood	0	0	0	4
Upland oak woodland	Siliceous scree	0	0	0	3

Appendix C - Possible conflicts between paired vegetation types determined from Site Condition Monitoring data (only includes features which were noted as at risk from herbivory by deer or deer and other herbivores) - Count of occurrences.

Feature Type 1	Feature Type 2	Count of Occurrences of Pair where:			
		Conflict occurring, Feature Type 2 at risk, Feature Type 1 not at risk from herbivory	Conflict occurring, Feature Type 2 not at risk, Feature Type 1 at risk from herbivory	Both Feature Types in the pair are at risk from herbivory	Neither Feature Type in the pair is at risk from herbivory
Tall herbs (upland)	Blanket bog and valley bog (upland)	12	1	0	1
Tall herbs (upland)	Calcareous grassland (upland)	10	0	2	3
Tall herbs (upland)	Alpine dwarf-shrub heath	10	0	1	5
Tall herbs (upland)	Alpine summit communities	10	0	1	6
Tall herbs (upland)	Wet heath (upland)	9	0	1	2
Tall herbs (upland)	Montane willow scrub	9	1	0	3
Tall herbs (upland)	Subalpine dry dwarf-shrub heath	9	1	0	4
Subalpine dry dwarf-shrub heath	Caledonian forest/Native pinewood	6	0	3	0
Alpine dwarf-shrub heath	Blanket bog and valley bog (upland)	6	3	9	2
Alpine flush	Calcareous grassland (upland)	5	1	3	3
Subalpine dry dwarf-shrub heath	Blanket bog and valley bog (upland)	5	2	11	4
Alpine summit communities	Blanket bog and valley bog (upland)	5	3	8	0
Calcareous rocky slopes	Calcareous grassland (upland)	4	0	0	0
Tall herbs (upland)	Caledonian forest/Native pinewood	4	0	0	0
Bog woodland	Caledonian forest/Native pinewood	4	0	0	0
Bog woodland	Wet heath (upland)	4	0	0	0
Alpine flush	Montane willow scrub	4	1	2	2

Appendix C (continued)

Feature Type 1	Feature Type 2	Count of Occurrences of Pair where:			
		Conflict occurring, Feature Type 2 at risk, Feature Type 1 not at risk from herbivory	Conflict occurring, Feature Type 2 not at risk, Feature Type 1 at risk from herbivory	Both Feature Types in the pair are at risk from herbivory	Neither Feature Type in the pair is at risk from herbivory
Alpine flush	Wet heath (upland)	4	1	0	0
Alpine summit communities	Subalpine dry dwarf-shrub heath	4	2	10	4
Alpine summit communities	Wet heath (upland)	4	2	7	1
Alpine dwarf-shrub heath	Wet heath (upland)	4	2	7	3
Subalpine dry dwarf-shrub heath	Calcareous grassland (upland)	4	3	6	1
Alpine dwarf-shrub heath	Caledonian forest/Native pinewood	3	0	4	0
Alpine flush	Alpine summit communities	3	0	4	3
Alpine summit communities	Caledonian forest/Native pinewood	3	0	3	0
Alpine flush	Blanket bog and valley bog (upland)	3	0	3	1
Spring-head, rill and flush (upland)	Calcareous grassland (upland)	3	0	2	2
Transition mire	Wet heath (upland)	3	0	0	1
Transition mire	Blanket bog and valley bog (upland)	3	0	0	2
Subalpine dry dwarf-shrub heath	Wet heath (upland)	3	1	10	4
Alpine summit communities	Calcareous grassland (upland)	3	1	8	2
Wet heath (upland)	Calcareous grassland (upland)	3	1	5	0
Alkaline fen (upland)	Calcareous grassland (upland)	3	1	4	3
Alkaline fen (upland)	Subalpine dry dwarf-shrub heath	3	1	2	0

Appendix C (continued)

Feature Type 1	Feature Type 2	Count of Occurrences of Pair where:			
		Conflict occurring, Feature Type 2 at risk, Feature Type 1 not at risk from herbivory	Conflict occurring, Feature Type 2 not at risk, Feature Type 1 at risk from herbivory	Both Feature Types in the pair are at risk from herbivory	Neither Feature Type in the pair is at risk from herbivory
Wet heath (upland)	Upland oak woodland	3	1	1	0
Blanket bog and valley bog (upland)	Upland oak woodland	3	1	1	0
Tall herbs (upland)	Alpine flush	3	1	0	6
Alpine dwarf-shrub heath	Subalpine dry dwarf-shrub heath	3	2	13	8
Alpine summit communities	Alpine dwarf-shrub heath	3	2	11	5
Calcareous grassland (upland)	Montane willow scrub	3	2	7	1
Alpine summit communities	Montane willow scrub	3	2	6	2
Subalpine dry dwarf-shrub heath	Montane willow scrub	3	2	5	1
Wet heath (upland)	Blanket bog and valley bog (upland)	3	3	10	2
Wet heath (upland)	Caledonian forest/Native pinewood	2	0	5	0
Blanket bog and valley bog (upland)	Caledonian forest/Native pinewood	2	0	4	0
Alpine flush	Alpine dwarf-shrub heath	2	0	3	4
Alkaline fen (upland)	Alpine dwarf-shrub heath	2	0	2	2
Limestone pavement	Calcareous grassland (upland)	2	0	1	1
Tall herbs (upland)	Alkaline fen (upland)	2	0	1	3
Bog woodland	Blanket bog and valley bog (upland)	2	0	0	2
Bog woodland	Subalpine dry dwarf-shrub heath	2	0	0	2

Appendix C (continued)

Feature Type 1	Feature Type 2	Count of Occurrences of Pair where:			
		Conflict occurring, Feature Type 2 at risk, Feature Type 1 not at risk from herbivory	Conflict occurring, Feature Type 2 not at risk, Feature Type 1 at risk from herbivory	Both Feature Types in the pair are at risk from herbivory	Neither Feature Type in the pair is at risk from herbivory
Alpine dwarf-shrub heath	Calcareous grassland (upland)	2	1	8	3
Calcareous grassland (upland)	Blanket bog and valley bog (upland)	2	1	7	0
Alpine dwarf-shrub heath	Upland oak woodland	2	1	2	0
Subalpine dry dwarf-shrub heath	Upland oak woodland	2	1	2	0
Alpine flush	Alkaline fen (upland)	2	1	2	3
Alpine flush	Subalpine dry dwarf-shrub heath	2	1	2	3
Alkaline fen (upland)	Blanket bog and valley bog (upland)	2	1	1	0
Montane willow scrub	Alpine dwarf-shrub heath	2	2	5	1
Montane willow scrub	Alkaline fen (upland)	2	2	2	1
Montane willow scrub	Blanket bog and valley bog (upland)	1	0	7	1
Alkaline fen (upland)	Alpine summit communities	1	0	4	1
Alpine flush	Spring-head, rill and flush (upland)	1	0	1	2
Wet heath (upland)	Montane willow scrub	1	1	6	0
Spring-head, rill and flush (upland)	Alkaline fen (upland)	1	1	1	3
Spring-head, rill and flush (upland)	Limestone pavement	1	1	0	2
Alpine flush	Tall herbs (upland)	1	3	0	6
Montane willow scrub	Caledonian forest/Native pinewood	0	0	4	0

Appendix C (continued)

Feature Type 1	Feature Type 2	Count of Occurrences of Pair where:			
		Conflict occurring, Feature Type 2 at risk, Feature Type 1 not at risk from herbivory	Conflict occurring, Feature Type 2 not at risk, Feature Type 1 at risk from herbivory	Both Feature Types in the pair are at risk from herbivory	Neither Feature Type in the pair is at risk from herbivory
Blanket bog and valley bog (upland)	Upland birch woodland	0	0	4	0
Caledonian forest/Native pinewood	Montane willow scrub	0	0	4	0
Subalpine dry dwarf-shrub heath	Snow-bed	0	0	2	2
Snow-bed	Subalpine dry dwarf-shrub heath	0	0	2	2

Appendix D - Conflicts observed on the ground by participants at the workshop (see Table 4.1 - "Expert Opinion Table" for explanation of colour scheme).

Vegetation Type 1	Vegetation Type 2	Count
Calcareous grassland	Tall herbs	10
Calcareous grassland	Montane willow scrub	7
Calcareous grassland	Blanket bog	6
Dry heath	Woodland	6
Calcareous grassland	Dry heath	5
Calcareous grassland	Woodland	4
Wet heath	Woodland	4
Calcareous grassland	Alpine flush	3
Calcareous grassland	Alkaline fen	2
Calcareous grassland	Alpine heath	2
Calcareous grassland	Flushes	2
Calcareous grassland	Juniper heath & scrub	2
Calcareous grassland	Scrub	2
Calcareous grassland	Upland mixed ash-wood	2
Flushes	Woodland	2
Limestone pavement	Woodland	2
Open habitat	Woodland	2
Alkaline fen	Upland mixed ash-wood	1
Alkaline fen	Woodland	1
Calcareous grassland	Species rich Calluna heath	1
Calcareous grassland	Springhead	1
Calcareous grassland	Springs	1
Calcareous grassland	Wet heath	1
Calcareous grassland	Herb-rich birch woodland	1
Dry heath	Alkaline fen	1
Blanket bog	Flushes	1
Dry heath	Flushes	1
Palatable habitat	Flushes	1
Unpalatable habitat (Blanket bog)	Flushes	1
Bog	Limestone pavement	1
Dry heath	Limestone pavement	1
Alpine flush	Montane willow scrub	1
Species-rich Nardus grassland	Montane willow scrub	1
Palatable grassland	Blanket bog	1
Palatable grassland	Montane willow scrub	1
Siliceous alpine & boreal grassland	Alpine flush	1
Species-rich Nardus grassland	Herb-rich birch-wood	1
Palatable habitat	Springs	1
Unpalatable habitat (Blanket bog)	Springs	1

Appendix E – Tables 2.3 to 2.9 from *An Analysis of the Impact on the Natural Heritage of the Decline in Hill Farming in Scotland - Literature Review* (Holland *et al. in prep*).

Table 2.3 - Observed vegetation changes within upland grassland communities following a decrease or cessation of grazing.

Community	Grazing Change	Impact on Vegetation	Reference
Species poor <i>Agrostis-Festuca</i> sub-montane grassland (Rhum)	Exclusion of grazing domestic stock (No Grazing)	Impact after 12 years: Increase in <i>Poa pratensis</i> and <i>Festuca rubra</i> . Decrease in <i>Anthoxanthum odoratum</i> , <i>Cynosurus cristatus</i> , <i>Trifolium repens</i> , <i>Galium saxatile</i> , <i>Plantago lanceolata</i> , <i>Polygala serpyllifolia</i> , <i>Achillea millefolium</i> , <i>Luzula multiflora</i> , <i>Thymus polytrichus</i> , <i>Cerastium fontanum</i> , <i>Euphrasia officinalis</i> and <i>Veronica officinalis</i>	Ball, 1974
Species poor <i>Agrostis-Festuca</i> sub-montane grassland (Rhum)	Reduced grazing (removal of cattle and sheep, continued grazing by red deer, feral goats and highland ponies)	Impact after 12 years: Decrease in <i>Thymus polytrichus</i> , <i>Plantago lanceolata</i> , <i>Cerastium fontanum</i> , <i>Linum catharticum</i> , <i>Luzula multiflora</i> , <i>Prunella vulgaris</i> and <i>Carex pulicaris</i>	Ball, 1974
<i>Festuca-Agrostis</i> grassland (Eastern Jutland, Denmark)	Exclusion of grazing domestic stock (No Grazing)	Impact after 6 years: Increase in <i>Festuca rubra</i> and <i>Poa pratensis</i> . Decrease in <i>Luzula campestris</i> , <i>Agrostis canina</i> , <i>Agrostis stolonifera</i> and <i>Aira praecox</i> .	Buttenschön & Buttenschön, 1982 a, b.
<i>Agrostis-Festuca</i> grassland (Cleish Hills (240m), Fife)	Exclusion of grazing domestic stock (No Grazing)	Impact after 6 years: Increase in tall species and grazing sensitive species such as <i>Deschampsia flexuosa</i> and <i>Poa</i> spp. Decline in low growing species and species tolerant of high grazing intensities including <i>Festuca rubra</i> , <i>Luzula multiflora</i> and total moss cover.	Hulme <i>et al.</i> , 1999
<i>Festuca-Agrostis</i> grassland (with a substantial presence of moorland species) (Kirkton Farm (410m), Crianlarich, Perthshire)	Exclusion of grazing domestic stock (No Grazing)	Impact after 6 years: Increase in <i>Molinia caerulea</i> and dwarf shrub species Decline in species associated with short turf and heavy grazing including <i>Agrostis capillaris</i> , <i>Anthoxanthum odoratum</i> , <i>Carex pilulifera</i> and <i>Nardus stricta</i> .	Hulme <i>et al.</i> , 1999

Table 2.3 (continued) - Observed vegetation changes within upland grassland communities following a decrease or cessation of grazing.

Community	Grazing Change	Impact on Vegetation	Reference
<i>Festuca ovina</i> - <i>Nardus stricta</i> grassland (Cwm Idwall (365m), Snowdonia, North Wales)	Exclusion of grazing domestic stock (No Grazing)	Impact after 24 years: Decline in the cover of <i>Nardus stricta</i> and <i>Festuca ovina</i> . Increase in the cover of tussocky <i>Molinia caerulea</i> and <i>Agrostis vinealis</i> .	Hill <i>et al.</i> , 1992
<i>Agrostis capillaris</i> - <i>Festuca ovina</i> grassland, with <i>Galium saxatile</i> and <i>Polytrichum commune</i> (Cwm Idwall (365m), Snowdonia, North Wales)	Exclusion of grazing domestic stock (No Grazing)	Impact after 24 years: Decline in the cover of <i>Polytrichum commune</i> . Increase in the cover of pleurocarpous mosses. Replacement of <i>Agrostis capillaris</i> by <i>Agrostis vinealis</i> .	Hill <i>et al.</i> , 1992
<i>Agrostis capillaris</i> - <i>Festuca ovina</i> grassland, with <i>Galium saxatile</i> and <i>Holcus lanatus</i> (Moel Eilio (380m), Snowdonia, North Wales)	Exclusion of grazing domestic stock (No Grazing)	Impact after 13 years: Little change in species composition.	Hill <i>et al.</i> , 1992
<i>Agrostis capillaris</i> grassland with <i>Anthoxanthum odoratum</i> , <i>Cirsium palustre</i> , <i>Festuca</i> <i>ovina</i> , <i>Festuca rubra</i> and <i>Rhytidiadelphus</i> <i>squarrosus</i> (Llyn Llydaw (426m), Snowdonia, North Wales)	Exclusion of grazing domestic stock (No Grazing)	Impact after 23 years: Increase in the cover of <i>Achillea millefolium</i> and <i>Festuca rubra</i> . Almost complete disappearance of <i>Cirsium palustre</i> .	Hill <i>et al.</i> , 1992

Table 2.3 (continued) - Observed vegetation changes within upland grassland communities following a decrease or cessation of grazing.

Community	Grazing Change	Impact on Vegetation	Reference
<i>Agrostis</i> - <i>Festuca</i> grassland with patches of <i>Juncus squarrosus</i> (Knock Fell (747m), Moor House NNR, North Pennines)	Removal of free ranging sheep (previously at a stocking rate of up to 5.5 sheep/ha during the summer) (No Grazing)	Impact after 23 years: Overall increase in the cover of <i>Deschampsia flexuosa</i> , <i>Deschampsia cespitosa</i> , <i>Agrostis capillaris</i> , <i>Carex bigelowii</i> , <i>Festuca rubra</i> and <i>Galium saxatile</i> (the last two species reached a peak after 12 years and then declined). Decrease in the cover of <i>Juncus squarrosus</i> and <i>Vaccinium myrtillus</i> to near elimination. Decrease in all other forb species apart from <i>Rumex acetosa</i> and <i>Achillea millefolium</i> which increased. Decrease in bryophyte and lichen cover.	Rawes, 1981
Species-poor grass heath with dominant <i>Festuca ovina</i> (Moor House NNR (830m), North Pennines)	Removal of free ranging sheep (previously at a stocking rate of up to 5.5 sheep/ha during the summer) (No Grazing)	Impact after 23 years: Increase in the cover of <i>Carex bigelowii</i> and <i>Deschampsia flexuosa</i> . Decrease in the cover of <i>Festuca ovina</i> . Decrease in the cover of bryophytes and lichens.	Rawes, 1981
Grass heath with dominant <i>Festuca ovina</i> and abundant <i>Nardus stricta</i> , <i>Juncus squarrosus</i> , <i>Empetrum nigrum</i> and <i>Sphagnum</i> (Moor House NNR (830m))	Removal of free ranging sheep (previously at a stocking rate of up to 5.5 sheep/ha during the summer) (No Grazing)	Impact after 23 years: Increase in the cover of <i>Deschampsia flexuosa</i> . Decrease in the cover of <i>Festuca ovina</i> and <i>Juncus squarrosus</i> .	Rawes, 1981
<i>Nardus stricta</i> grassland (Moor House NNR (545m), North Pennines)	Removal of free ranging sheep (previously at a stocking rate of up to 5.5 sheep/ha during the summer) (No Grazing)	Impact after 23 years: Increase in the cover of <i>Nardus stricta</i> , <i>Galium saxatile</i> and bryophytes. Decrease in the cover of <i>Agrostis capillaris</i> .	Rawes, 1981

Table 2.3 (continued). Observed vegetation changes within upland grassland communities following a decrease or cessation of grazing.

Community	Grazing Change	Impact on Vegetation	Reference
<i>Juncus squarrosus</i> grassland (Moor House NNR, North Pennines, England)	Exclusion of grazing domestic stock (No Grazing)	Impact after 18 years: <u>Species change:</u> Decline in the cover of <i>Juncus squarrosus</i> , <i>Festuca ovina</i> , <i>Eriophorum angustifolium</i> , <i>Carex nigra</i> , <i>Luzula multiflora</i> and <i>Polytrichum commune</i> . Increase in <i>Calluna vulgaris</i> and <i>Eriophorum vaginatum</i> . <u>Structural change:</u> Decrease in the amount of live vegetation in the 0-10cm stratum. Increase in the amount of live vegetation in the 10-20cm and 20-30cm strata. Increase in the amount of dead material in the 10-20cm stratum.	Marrs <i>et al.</i> , 1988
<i>Molinia caerulea</i> grassland (75% <i>M. caerulea</i> , 9% <i>N. stricta</i> , 3% <i>Festuca ovina</i> and 11% other species) (Mid-Wales)	Exclusion of grazing domestic stock (No Grazing)	Impact after 5 years: Increase in <i>Calluna vulgaris</i> and <i>Erica tetralix</i> (20%) Impact after 18 years: Increase in <i>Molinia caerulea</i> to 90%, shading out most other species.	Davies, 1987
<i>Molinia caerulea</i> grassland (>90% <i>M. caerulea</i> cover) (Cleish Hills, Fife, Scotland)	Exclusion of grazing domestic stock (No Grazing)	Impact after 6 years: Number of species remained the same or showed a slight decline. Decrease in the cover of <i>Festuca ovina</i> .	Grant <i>et al.</i> , 1996
<i>Nardus stricta</i> , <i>Danthonia decumbens</i> , <i>Narthecium ossifragum</i> and <i>Festuca ovina</i> grassland/wet heath (Penypass (396m), Snowdonia, North Wales)	Exclusion of grazing domestic stock (No Grazing)	Impact after 23 years: Increase in the cover of ericoid shrubs (<i>Calluna vulgaris</i> , <i>Erica cinerea</i> and <i>Erica tetralix</i>), which became dominant. Increase in <i>Molinia caerulea</i> and <i>Trichophorum cespitosum</i> . Decrease in <i>Danthonia decumbens</i> , <i>Festuca ovina</i> and <i>Carex</i> species. <i>Nardus stricta</i> remained prominent over part of the site.	Hill <i>et al.</i> , 1992

Table 2.3 (continued) - Observed vegetation changes within upland grassland communities following a decrease or cessation of grazing.

Community	Grazing Change	Impact on Vegetation	Reference
U5 <i>Nardus stricta</i> - <i>Galium saxatile</i> grassland (Ben Challum (500m), Tyndrum, Perthshire)	Exclusion of livestock from an area that had previously been open to grazing at a stocking level of between 1.0 and 1.5 ewes/ha	Impact over 4 years: Mean July surface herbage heights were significantly higher ($P < 0.001$) in the un-grazed area compared with the continuously grazed area in all years. The herbage height increased significantly ($P < 0.001$) in the un-grazed area between year 1 and year 4. A frequency histogram of the herbage surface heights in July of year 4 showed that in the un-grazed area there were no patches of short grassland.	Holland <i>et al.</i> , 2008
CG11 <i>Festuca ovina</i> - <i>Agrostis capillaris</i> - <i>Alchemilla alpina</i> grass-heath (Cam Chreag (700m), Tyndrum, Perthshire)	Exclusion of livestock from an area that had previously been open to grazing at a stocking level of approximately 1.0 ewe/ha	Impact after 5 years: A number of annual, and low growing perennial, herbs including <i>Euphrasia</i> agg., <i>Bellis perennis</i> , <i>Cerastium fontanum</i> , <i>Linum catharticum</i> , <i>Persicaria vivipara</i> , <i>Alchemilla alpina</i> and <i>Thymus polytrichus</i> declined, while most of the tall perennial sedges, grasses and dwarf shrubs increased. The scarce montane species; <i>Sibbaldia procumbens</i> , <i>Silene acaulis</i> and <i>Carex capillaris</i> , all declined. Some tall-herb species increased in frequency, including <i>Trollius europeaus</i> and <i>Geum rivale</i> , but few of the tall-herbs flowered. Over the five year period the mean surface height of the vegetation measured in August increased significantly from less than 10cm to over 22cm.	Holland, 2006
U5 <i>Nardus stricta</i> - <i>Galium saxatile</i> grassland (Gleann a'Chlachain (450m), Tyndrum, Perthshire)	Exclusion of livestock from an area that had previously been open to grazing at ~1.0 ewe/ha	Impact after 2.5 years: The profile of the grassland altered, with significantly less vegetation in the lower strata, and more in the upper strata. Although there was little change in the amount of litter, the amount of dead standing material increased throughout the profile, and there was a shift in the distribution of bryophytes up the profile.	Pollock <i>et al.</i> , 2005

Table 2.3 (continued) - Observed vegetation changes within upland grassland communities following a decrease or cessation of grazing.

Community	Grazing Change	Impact on Vegetation	Reference
MG7 <i>Lolium perenne</i> ley grassland (50% <i>Lolium perenne</i> , 13% <i>Trifolium repens</i> , 37% other species - <i>Holcus lanatus</i> , <i>Carex</i> spp., <i>Juncus effusus</i> , <i>Phleum pratense</i> , <i>Poa pratensis</i> , <i>Ranunculus repens</i> , <i>Agrostis gigantea</i> , <i>Agrostis capillaris</i> , <i>Poa trivialis</i> , <i>Poa annua</i>) (Hartwood (245m), North Lanarkshire)	Reduced grazing and un-fertilised (extensification) (previously grazed, cut for silage and fertilised)	Impact over 15 years: Slow but continual change in species composition. Species that benefited from extensification: <i>Holcus lanatus</i> , <i>Agrostis capillaris</i> , <i>Poa trivialis</i> , <i>Bellis perennis</i> , <i>Trifolium repens</i> . Species that declined: <i>Agrostis gigantea</i> , <i>Lolium perenne</i> , <i>Poa annua</i> .	Marriott <i>et al.</i> , 2009
MG7 <i>Lolium perenne</i> ley grassland (64% <i>Lolium perenne</i> , 8% <i>Trifolium repens</i> , 28% other species - <i>Festuca rubra</i> , <i>Elymus repens</i> , <i>Arrhenatherum elatius</i> , <i>Poa pratensis</i> , <i>Dactylis glomerata</i> , <i>Holcus lanatus</i> , <i>Holcus mollis</i> , <i>Phleum pratense</i> , <i>Poa annua</i> , <i>Poa trivialis</i> , <i>Ranunculus repens</i> , <i>Deschampsia cespitosa</i> , <i>Urtica dioica</i> , <i>Agrostis capillaris</i> , <i>Anthoxanthum odoratum</i> , <i>Cerastium fontanum</i>) (Sourhope (367m), Borders)	Reduced grazing and un-fertilised (extensification) (previously grazed, and fertilised)	Impact over 15 years: Rapid changes in species composition followed by stabilisation. There were no late-successional species to invade and lead to further changes. Species that benefited from extensification: <i>Festuca rubra</i> , <i>Anthoxanthum odoratum</i> , <i>Agrostis capillaris</i> , <i>Poa trivialis</i> , <i>Trifolium repens</i> . Species that declined: <i>Deschampsia cespitosa</i> , <i>Urtica dioica</i> , <i>Poa annua</i> .	Marriott <i>et al.</i> , 2009

Table 2.4 - Observed vegetation changes within blanket bog and wet heath communities following a decrease or cessation of grazing.

Community	Grazing Change	Impact on Vegetation	Reference
<i>Eriophorum vaginatum</i> dominated blanket bog (Troutbeck head (685m) and Silverband (685m), Moor House NNR, North Pennines)	Removal of free ranging sheep (previously at a summer stocking rate of 0.25 sheep/ha (Silverband) and 0.5 sheep/ha (Troutbeck Head)) (No Grazing)	Impact after 14 years: Silverband - Significant increase in the cover of <i>Empetrum nigrum</i> , <i>Narthecium ossifragum</i> and <i>Rubus chamaemorus</i> . Vegetation density increased by 40%. Troutbeck Head - Significant increase in the cover of <i>Calluna vulgaris</i> and <i>Deschampsia flexuosa</i> . Significant decline in the cover of <i>Eriophorum vaginatum</i> and the leafy liverwort <i>Diplophyllum albicans</i> . Vegetation density increased by 20%	Rawes, 1983
Degraded <i>Calluna vulgaris</i> dominated wet-heath (Redesdale (300m), Northumberland)	Areas previously grazed at 2.1 sheep per hectare were subject to a range of grazing treatments 1) Summer only 0.7 sheep/ha 2) Winter only 0.7 sheep/ha 3) Year-round 0.7 sheep/ha 4) Year-round 1.4 sheep/ha 5) U-ngrazed 6) Year-round 2.1 sheep/ha (unfenced control)	Impact over 5 years: Increase in frequency of <i>Calluna vulgaris</i> in all reduced grazing treatments, no change in unfenced control, greatest increase in un-grazed treatment, least increase in year-round 1.4 sheep/ha treatment. Increase in frequency of <i>Carex nigra</i> , <i>Deschampsia flexuosa</i> , <i>Galium saxatile</i> and <i>Erica tetralix</i> under reduced grazing treatments. A range of moss species, including <i>Hypnum jutlandicum</i> and <i>Rhytidiadelphus loreus</i> were more frequent at higher grazing levels. Substantial increase in the cover of <i>Molinia caerulea</i> under the winter only grazing treatment, compared to relatively little change in the cover of <i>Molinia caerulea</i> under the summer only grazing treatment.	Hulme <i>et al.</i> , 2002

Table 2.5 - Observed vegetation changes within dry heath communities following a cessation of grazing.

Community	Grazing Change	Impact on Vegetation	Reference
<i>Vaccinium myrtillus</i> dominated heath (cover 53% <i>Vaccinium myrtillus</i> , 2% <i>Calluna vulgaris</i>), (Ashop Valley (310m), Derbyshire Peak District)	Exclusion of grazing livestock (exclosure plot was previously part of a 1600ha tract of unenclosed moorland carrying a thousand ewes and followers) (No Grazing)	Impact after 6 years: Significant increases in the cover of grasses (excluding <i>Nardus stricta</i>) and <i>Empetrum nigrum</i> . Significant decline in the cover of <i>Nardus stricta</i> . Abundant flowering of <i>Deschampsia flexuosa</i> . Significant increase in the height of <i>Vaccinium myrtillus</i> and <i>Calluna vulgaris</i> .	Welch, 1998
<i>Vaccinium myrtillus</i> dominated heath (cover 69% <i>Vaccinium myrtillus</i> , 28% <i>Calluna vulgaris</i>), (Ashop Valley (310m), Derbyshire Peak District)	Exclusion of grazing livestock (exclosure plot was previously part of a 1600ha tract of unenclosed moorland carrying a thousand ewes and followers) (No Grazing)	Impact after 6 years: Significant decline in the cover of <i>Vaccinium myrtillus</i> . Significant increases in the cover of <i>Calluna vulgaris</i> , grasses (excluding <i>Nardus stricta</i>) and <i>Empetrum nigrum</i> . Significant decline in the cover of <i>Nardus stricta</i> . Significant increase in the height of <i>Vaccinium myrtillus</i> and <i>Calluna vulgaris</i> .	Welch, 1998
Discontinuous <i>Deschampsia flexuosa</i> turf intermingled with patches of <i>Nardus stricta</i> , <i>Vaccinium myrtillus</i> and bare ground. (Western slopes below the Kinder plateau (~500m), Peak District)	Sheep stocking levels reduced from around 2.5 ewes/ha to 0.18-0.43 ewes/ha	Impact after 7 years: Significant increase in the frequency of <i>Deschampsia flexuosa</i> , <i>Calluna vulgaris</i> , <i>Vaccinium myrtillus</i> and bryophytes, creating a <i>D. flexuosa</i> dominated sward. Significant decrease in the frequency of bare ground.	Anderson and Radford, 1994

Table 2.6 - Observed vegetation changes within a range of upland communities following a decrease or cessation of grazing.

Community	Grazing Change	Impact on Vegetation	Reference
Eleven sites across the Highlands of Scotland, with a range of grassland and heath communities.	Comparison between areas where sheep had been removed for up to 25 years and areas where stocking rates had remained unchanged	Removal of sheep from five sites was associated with taller vegetation and more signs of vole activity. Relatively few changes in floristic composition (patches of dwarf-shrub vegetation tended to be larger and patches of grassland smaller). Removal of sheep from six sites appeared to have had little or no effect on the vegetation or on vole activity. This was thought to be due to an increase in grazing by red deer and continued heather burning.	Hope <i>et al.</i> , 1996
Twelve study sites across the Highlands of Scotland, with a range of grassland and heath communities.	Each study site had an area of reduced sheep grazing and an area of continued sheep grazing.	The study found that increased heather abundance, decreased abundance of rough grasses, taller vegetation, and a non-significant trend towards a reduction in heterogeneity were all related to a reduction in the level of sheep grazing.	Pollock <i>et al.</i> 2009

Table 2.7 - Observed vegetation changes within Norwegian alpine grass- heath communities following a cessation of grazing.

Community	Grazing Change	Impact on Vegetation	Reference
<i>Alpine grass-heath dominated by Vaccinium myrtillus, Deschampsia flexuosa, Nardus stricta, Empetrum sp. and Vaccinium uliginosum. (Setesdal Vesthei (900-1000m), Southern Norway).</i>	Exclusion of sheep from an area with a long history of heavy sheep grazing.	Impact over 5 years: Increase in vascular plant height. Increase in <i>Deschampsia flexuosa</i> (the only vascular plant species to show a significant increase). The bryophytes <i>Straminergon stramineum</i> , <i>Pohlia nutans</i> and <i>Cephalozia bicuspidate</i> increased, while <i>Brachythecium</i> coll., <i>Plagiothecium</i> coll. decreased.	Austrheim <i>et al.</i> , 2007

Table 2.8 - Observed vegetation changes within alpine flush communities following a decrease or cessation of grazing.

Community	Grazing Change	Impact on Vegetation	Reference
Alpine flush communities, (Cross Fell and neighbouring hills, North Pennines)	Removal of sheep from the hill ground as a result of the foot-and-mouth outbreak in the winter of 2001	Impact in the following growing season: Extensive flowering of <i>Alopecurus ovatus</i> in flushes above 670m (previously a very shy flowerer). Discovery of <i>Carex vaginata</i> . This species was not previously recorded in England, but has now been recorded in 13 separate locations within the North Pennines. Increased flowering of other rare alpine species: <i>Saxifraga hirculus</i> , <i>Epilobium alsinifolium</i> , <i>Sedum villosum</i> and <i>Myosotis alpestris</i> .	Roberts, 2010
Alpine flush communities (Cam Chreag (750m), Tyndrum, Perthshire)	Removal of hefted sheep flock from the hill ground (area still grazed by sheep from neighbouring hirsels and by deer)	Impact in the following growing season: Flowering of <i>Kobresia simpliciuscula</i> in four separate locations. Intensive botanising of the area by the recorder had failed to locate this species in the 12 years before the sheep numbers were reduced.	J. Holland (pers.com.)

Table 2.9 - Observed changes within particular plant populations following the cessation of grazing.

Community	Grazing Change	Impact on Vegetation	Reference
<i>Gentiana nivalis</i> population within a CG12 <i>Festuca ovina-Alchemilla alpine-Silene acaulis</i> dwarf herb community (Ben Lawers (950-1020m), Perthshire)	Protection from sheep grazing	Impact after 9 years: <i>Gentiana nivalis</i> plants in un-grazed plots grew taller than did plants in adjacent grazed plots. After 3 years the density of plants within the un-grazed plots began to decline and by year 9 it was only 20% of the density on grazed plots. Perennial vegetation within the un-grazed plots became taller and denser than it was in the grazed plots. The amount of bare soil declined in the un-grazed plots. The loss of potential gaps for seedling establishment was thought to be the main cause for the decline in <i>Gentiana nivalis</i> density in the un-grazed plots.	Miller <i>et al.</i> , 1999
<i>Pseudorchis albida</i> population within a H10 <i>Calluna vulgaris-Erica cinerea</i> heath (Tyndrum Community Woodland (190m), Perthshire)	Exclusion of livestock and deer from an area that had previously been subject to a low level of sporadic grazing by sheep and deer.	Impact after 6 years: The removal of grazing animals was accompanied by an initial increase in the number of flowering spikes of <i>Pseudorchis albida</i> (60 spikes were recorded two years after enclosure), followed by a dramatic decline. No flowering spikes were recorded after six years of enclosure.	Holland <i>et al.</i> , 2008

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