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Sustainable grazing practices on the South West moors of England

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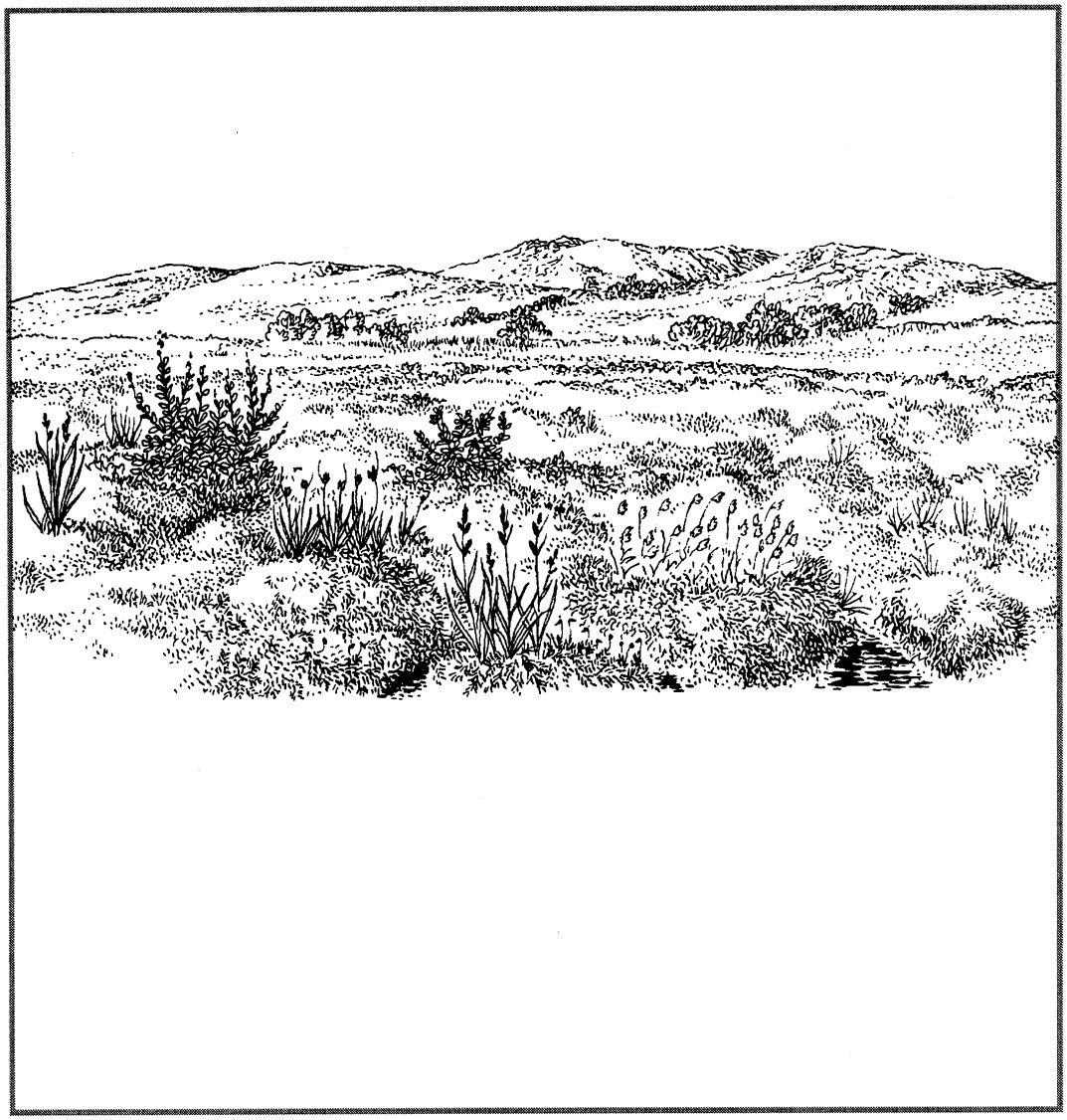

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SUSTAINABLE GRAZING PRACTICES ON THE SOUTH WEST MOORS OF ENGLAND

A REPORT TO ENGLISH NATURE

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SUMMARY

This report aims to provide English Nature and its partners with an enhanced understanding of how to achieve sustainable grazing levels and associated management in the South West Moors of England, in terms of both nature conservation and agriculture. Examples of best practice in environmentally sustainable management regimes are documented, principally in the Dartmoor and Exmoor Natural Areas, with some additional information from Bodmin Moor and West Penwith. Key findings and common themes are sought, to produce a report that can be shared, and used, by farmers, conservationists and statutory and advisory bodies.

Twenty examples of what are considered to be moorland in good ecological condition are described in detail in a separate Annex and summarised and analysed in this report, in order to determine whether a "model" of sustainable moorland management can be defined. Ten sites on Exmoor, seven on Dartmoor, one on Bodmin Moor and two in West Penwith were selected for investigation, although not all parts of all sites were necessarily in high quality condition. The principal factors investigated were habitat quality, stocking regimes and levels, livestock types and breeds, supplementary feeding, burning practices and other aspects of farm enterprise relevant to moorland management.

The data collected show considerable variation, which probably reflects differences in the intrinsic qualities of moorland units and the types of management regime imposed upon them. A particular problem in drawing common themes was variation in the amount and quality of grassland contained within the grazing units.

High quality sites have avoided the extremes of intensive and under-management. It was rare for entire sites to be in high quality condition, so the management factors identified may not necessarily represent optimal conditions. Livestock subsidies have encouraged the keeping of greater numbers of stock, but this has been tempered by the advent of environmental land management scheme incentives and by actions taken by MAFF to control undesirable practices. The resultant reductions in stocking have led occasionally to under-utilisation of purple moor-grass (*Molinia caerulea*) and poor scrub control, although these may be inevitable consequences of attempts to improve the condition of dwarf shrubs.

The moors of the South West are grazed by cattle, sheep and ponies (and red deer on Exmoor). Livestock systems contained elements of both upland and lowland regimes, with mixes of hardy (especially Galloway cattle and Scotch Blackface sheep) and non-hardy breeds combined with movements of stock between moor and inbye for calving/lambing, bulling/tupping, dipping, shearing and drying-off. In addition, ponies were typical of many sites in Bodmin Moor, Dartmoor and Exmoor. Stocking levels (including ponies) at 18 dwarf shrub dominant sites averaged 0.29 LU/ha (range 0.12–0.54) over the year as a whole (0.34 in summer, 0.24 in winter), which is higher than the rates (0.075–0.225 LU/ha) associated nationally with upland heather in good condition and slightly higher than the prescribed stocking levels for Darmoor and Exmoor ESAs. Grazing units with greater than 50% heather cover were associated most closely with stocking levels of less than 0.3 LU/ha overall and less than 0.13 LU/ha of winter cattle.

Where available, estimates of heather utilisation suggested that heathland containing western gorse was less suppressed than pure heather stands. Such communities may be unable to support the same livestock densities as heather-based communities. Maintaining heathland with a diverse structure may require novel solutions to achieve even grazing over a unit and adequate scrub control.

Winter supplementary feeding, especially on Dartmoor and Bodmin Moor, has been practised regularly to maintain the condition and calving rate of both hardy and non-hardy cattle. There is some evidence to suggest that daily rations of around 0.7 kg of concentrate and 3–4 kg of hay per cow are necessary for this, although dwarf shrub damage must be expected, unless feeding is restricted to extensive, dry, heather-free areas. Although most feed is put out essentially for cattle, sheep and ponies also make use of it, but mainly in residual quantities. Supplementary feeding can be used to achieve more even grazing pressure over a grazing unit, although conversely feeding in restricted sacrificial areas may support stocking levels above those normally regarded as sustainable, by diverting livestock from more sensitive vegetation.

The scant detail available on burning suggests that there are difficulties in adhering to the Heather and Grass Burning Code, principally due to a scarcity of manpower. However, there is some lack of awareness in both the farming community and the general public about the ecological and agricultural benefits of properly planned and executed burning programmes. Most burning at the sites studied was carried out to improve grazing. There is a need to establish a pragmatic approach for burning in the South West which will satisfy the concerns of both the public and those seeking environmental and agricultural benefit.

It proved impossible to produce a comprehensive model for sustainable grazing, because of the lack of robust data on which to base it. However, simple relationships are given, which can be used predictively, if with some caution. The sites investigated represent largely the products of ecologically benign practices, which may be sustainable in the long term only if viable farm units are maintained. Such viability is currently enabled by livestock subsidies and environmental land management scheme payments. Tentative conclusions suggest that ESA prescriptions are broadly similar to the sites examined, although the results of monitoring must be awaited before the effects of applying these prescriptions on degraded sites can be assessed. The variations noted in the data, the habitats and agricultural quality of the sites suggest that site-specific management guidelines, rather than blanket prescriptions, should be adopted.

This study has drawn together information from a variety of sources and has identified the factors most likely to be needed for the attainment and maintenance of high quality moorland. These include suitably low stocking levels, preferably by leared, hardy animals; limited and carefully-placed supplementary feed; and planned, controlled, small-scale burns of dwarf shrubs. The financial incentives for moorland grazing encourage firmly the adoption of practices which are close to those identified at the sites studied, although it remains to be seen how degraded sites will respond. However, the findings generally bode well for the future health of the important moorlands of South West England.

1. INTRODUCTION

BACKGROUND AND JUSTIFICATION

Area and vegetation characteristics

The South West Moors of England comprise Exmoor and the Quantocks, Dartmoor and Bodmin Moor Natural Areas[1] (NAs), with West Penwith NA (Cornwall) also having a moorland character. Agriculture, particularly grazing and its associated management, is arguably the primary determinant of the nature conservation interest of these open moorland areas and their associated habitats. These NAs between them contain a large proportion of the nature conservation interest of the South West peninsula and are essential to the range of variation and interest of the English, UK and international uplands. In recognition of this, most of Dartmoor's open moorland is a candidate Special Area of Conservation, whilst Dartmoor, Exmoor and West Penwith are Environmentally Sensitive Areas (ESAs), designated principally to address threats to the quality and extent of their heathland.

Moorlands in the South West comprise a range of dwarf shrub, mire and acid grassland communities, some of which are absent from northern Britain, where much of the research on sustainable grazing practices has been carried out; very little such research has been done in the South West. The principle National Vegetation Classification (NVC) communities found in the region comprise:

H4 *Ulex gallii – Agrostis curtisii* "south-western" heath.
H8 *Calluna vulgaris – Ulex gallii* heath.
H12 *Calluna vulgaris – Vaccinium myrtillus* heath.
M6 *Carex echinata – Sphagnum recurvum/auriculatum* mire.
M15 *Scirpus cespitosus – Erica tetralix* wet heath.
M17 *Scirpus cespitosus – Eriophorum vaginatum* blanket mire.
M21 *Narthecium ossifragum – Sphagnum papillosum* mire.
M23 *Juncus effusus/acutiflorus – Galium palustre* rush-pasture.
M25 *Molinia caerulea – Potentilla erecta* mire.
U3 *Agrostis curtisii* grassland.
U4 *Festuca ovina – Agrostis capillaris – Galium saxatile* grassland.
U20 *Pteridium aquilinum – Galium saxatile* bracken.
W25 *Pteridium aquilinum – Rubus fruticosus* underscrub.

Notable differences in the plant components, compared with the upland moors of northern England, for example, include the presence of the relatively unpalatable bristle bent (*Agrostis curtisii*) and western gorse (*Ulex gallii*). The latter occurs principally below 400 m AOD and can be an effective governor of grazing, by deterring livestock, especially sheep, from penetrating stands of dwarf shrubs during the building phase of dwarf shrub regrowth, which occurs some 5–15 years following a burn (ADAS 1996). A further distinction of South West moorland is the more rapid (but unquantified) growth rate of heather (*Calluna vulgaris*) and

[1] Natural Areas have unique combinations of physical attributes, wildlife, land use and culture, which give a "sense of place" and a distinctive nature conservation character; they provide a framework for securing public support for wildlife and geological conservation.

its also unquantified ability to grow more rapidly and to "layer", by rooting adventitiously. In heather-dominant stands, the layering exposes ground for regeneration from rootstock or seed, thereby reducing, perhaps even removing, the need for burning.

Animal systems

Compounding the differences in dwarf shrub species is the presence of different species of livestock, notably cattle and ponies, but also red deer on Exmoor. The foraging preferences differ between the various species, and to some extent the breeds, of livestock, and again the low palatability of the bristle bent and western gorse are local issues which govern the carrying capacity of stock at different periods of the heathland growth cycle.

In many ways, therefore, the plant and animal communities and farming systems are more allied to lowland heathland than the uplands. However, upland financial incentives, such as Hill Livestock Compensatory Allowances (HLCA), have resulted in the use of the relatively mild moors of the South West for rearing non-hardy cattle and sheep, often at levels which have not been able to sustain valuable habitats. For example, the beef herd on Dartmoor increased ten fold to 20,000 animals between 1952 and 1994, whilst ewe numbers increased threefold to 132,000; on Exmoor there were increases of 9% in both beef (to 14,000) and sheep (to 233,000), respectively, between 1983 and 1994, although this followed a period of major increase in livestock numbers in the 1970s.

Agricultural advances in the 1960s and 1970s allowed an increase in the production and conservation of forage on inbye land, which in turn facilitated increased stocking densities, both on inbye and moorland. Non-hardy, but more productive, breeds of cattle and sheep have come to greatly outnumber the traditional breeds which are able to utilise coarse moorland vegetation. However, non-hardy stock appear to require more supplementary feeding than non-hardy stock during winter (here defined as November to April). Unlike moorland in the north of Britain, supplementary feeding is a standard feature of winter husbandry in the South West, irrespective of weather conditions. It is held by graziers to be necessary for all stock to avoid animal welfare problems; to attain calving/lambing rates in order to meet HLCA requirements; and to provide an economic return. This practice and the consequential impact of the large numbers of stock it can maintain are among the key determinants of moorland condition. Not only have more stock, particularly cattle, been outwintered, but a further damaging influence has been the turning out of large flocks of lowland sheep in late summer, when heather is particularly susceptible to grazing pressure.

High quality habitats

"Sustainable grazing levels" are defined for the purpose of this report as those which maintain high quality habitats in the long term, or restore lower quality habitats in the medium term. This report is concerned primarily with the former. High quality habitats include the following:

- Upland and lowland heathland with more than 50% ground cover of dwarf shrubs, viz. heather (*Calluna vulgaris*), bell heather (*Erica cinerea*), cross-leaved heath (*E. tetralix*), bilberry (*Vaccinium myrtillus*) and western gorse. Such areas of dwarf shrubs will have a varied age structure, generally achieved by planned, small-scale burns; will have growth largely unsuppressed by livestock grazing or trampling; and will not have been damaged as a result of supplementary feeding, either directly, through poaching or wheel damage,

or indirectly, through soil enrichment and the introduction of plants not typical of heathland.

- Blanket bog and valley mire with high ground cover of bog-mosses (*Sphagnum* species) and lower cover of heathers and purple moor-grass (*Molinia caerulea*). Such areas will not have been burned or poached, but will have been grazed so as to produce an open sward and to prevent suppression by purple moor-grass.

AIM

The aim of the project is to provide English Nature (EN) and its partners in the Moors with an enhanced understanding of how to achieve sustainable grazing levels and associated management in the South West Moors, in terms of both nature conservation and agriculture.

OBJECTIVES

- To document current examples of best practice in environmentally sustainable management regimes, principally in the Dartmoor and Exmoor NAs; relevant material from the Bodmin Moor and West Penwith NAs to be added where already available.
- To identify any key findings and common themes, including reference to current and previous related studies.
- To produce a report that can be shared, and used, by farmers, conservationists and statutory and advisory bodies.

2. METHODOLOGY AND INFORMATION SOURCES

SITE SELECTION

In the absence of evidence from research programmes, this project used examples of "best practice" to indicate themes for a "model" of sustainable moorland management. Therefore, examples of what was considered to be moorland in good ecological condition were identified during discussions with EN Conservation Officers and National Park Ecologists. Some additional sites were suggested by ADAS, based on experience from assessments for MAFF's ESA and HLCA monitoring work. Ten sites on Exmoor and seven on Dartmoor were selected for investigation, although it has to be stressed that not all parts of all sites are necessarily in high quality condition. The details gathered for these sites are given in a separate Annex, together with additional, less comprehensive, details from sites in Bodmin Moor and West Penwith. The key findings and common themes are summarised and explored in section 3 of this document.

The farm enterprise and moorland management details for most sites have been gathered on the understanding that individual sites will not be identified in any published reports. For this reason, references to sites are coded, with the prefix denoting the Natural Area, "D" representing sites on Dartmoor, "E" Exmoor, "B" Bodmin Moor and "W" West Penwith. Brief sites details are given in Appendix 1

ASSESSMENT OF VEGETATION QUALITY

For most of the sites selected, evidence of habitat quality was somewhat subjective and often based upon the fragmentation and growth form of heather, although, as stated above, rarely were all aspects of a grazing unit in perfect ecological condition. In addition, however, a limited number of sites have been surveyed recently using the English Nature Grazing Index (ENGI) method for assessing recent and older damage to heathland (English Nature, 1995). In addition, objective assessments of the previous season's heather utilisation by sheep have formed the basis of ESA monitoring in Dartmoor and Exmoor: these provided a more objective measure of quality for some sites, notably on Exmoor (ADAS, 1995).

SITE DESCRIPTIONS

Habitat

Descriptive statistics were derived from the following sources:

- EN vegetation maps for 1991–92 for sites within Exmoor SSSIs.
- Vegetation maps from 1995 ground survey of Dartmoor Newtakes drawn up as part of the Duchy of Cornwall's Dartmoor Newtake Project (courtesy of the Duchy of Cornwall and its tenants).

- MAFF/ADAS ESA Land Cover maps from air photo interpretation for Dartmoor (1993/4) and Exmoor (1993).

As the level of detail varied between these sources, the areas covered by broad habitat categories were used to calculate comparative data. The categories used depend on the source(s) available, those from ground survey generally being more precise. In each site report, the percentages of the common or grazing unit in each category, where known, are tabulated; further detail, where available, is given in descriptive text. The proportions of certain categories can be used to indicate habitat quality, to some degree. For example, a high ratio of dwarf shrub heathland to grassland is advantageous in nature conservation terms. It should be noted that in the first few years following a lowland heathland burn, the ground is typically dominated by grasses; in the South West the most common species is bristle bent, a speciality of the region, although other, more palatable, grasses sometimes prevail.

Indications of heathland quality from ENGI survey or ESA monitoring data are given where available and relevant. These describe the condition of heather and the extent to which it has been "suppressed". The graduated scale for ENGI scores is as follows:

Score												
0	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
Vegetation condition												
GOOD				*INTERMEDIATE*				*POOR*				
Grazing pressure												
LIGHT				*INTERMEDIATE*				*HEAVY*				

The thresholds beyond which heather is said to be suppressed have not yet been fully tested in the South West. However, in principle, any dwarf shrub which is prevented from progressing through its natural cycles of growth (pioneer, building, mature and degenerate), can be said to be suppressed (although the "layering" habitat of heather in the South West may prevent stands from attaining the last growth phase). In the absence of a tested alternative, the suppressive thresholds for heather which have been applied to ESA monitoring data are as follows:

Heather type	**Age (years)**	**Heather utilisation**
Young (pioneer stage)	0–5	40%
Intermediate (building)	5–15	10%
Old (mature/senescent)	>15	5%
Blanket bog	–	15%

Agricultural management

Information on farm enterprises and moorland management have come from a variety of sources:

- EN/farmer interviews for Exmoor SSSIs
- Interviews with tenants undertaken as part of the Duchy of Cornwall Dartmoor Newtake Project ("newtakes" are large blocks of enclosed moorland)
- ADAS/farmer questionnaires and interviews

In addition to details of the moorland management practices at the time of the vegetation assessment (i.e. during 1991–96), attempts were made to gather similar information for recent decades. It was desirable to collect the latter, in case the beneficial practices which had produced the high quality moorland had changed since 1990. Where significant changes in management were established, the data for periods of approximately stable conditions are summarised together. Unfortunately, historic data or details were frequently found to be lacking; in these cases subjective comments on recent changes were sought. Definitions of livestock units (LU) and summer/winter are given in Appendix 2.

Although the emphasis for this project was on the details of moorland grazing units, problems arose with the availability of comprehensive stocking and management information for commons. In order to give informed comment in these circumstances, particularly on the relationship of common land to inbye and the contribution which the common makes to farm business, example commoners were interviewed; these were selected on the basis of being considered sensitive practitioners, who sought to maintain their moorland in good environmental condition.

Although livestock belonging to different commoners may move freely within (and, on Dartmoor, between) commons, the practice of supplementary winter feeding has caused stock, particularly cattle, to concentrate. Thus, in a few cases it was possible to obtain and use data for discrete parts of commons, where stock were considered to be leared (or hefted) to the moor and to reside in fairly restricted areas. Supplementary feeding was taken to exclude occasional feeding during abnormal weather conditions.

Very locally, natural concentrations of stock activity, such as around a drinking point or along a track, may provide small areas of bare ground which may be exploited by certain rare plants or invertebrates. However, these desirable patches should not be confused with the sometimes large, poached areas which may become ecologically degraded very quickly as a result of insensitive supplementary feeding.

Some information on the scale of burning has been gathered by reference to maps compiled from a combination of ground survey and air-photo interpretation. The concept of rotational burning of small blocks of heather has evolved principally to optimise production of red grouse (*Lagopus lagopus*) for shooting (but not in the South West), though it has advantages for other objectives too. In addition to increasing the palatability of heather for livestock, a carefully planned heathland burning programme should facilitate more even

grazing across a unit, reduce the risk of accidental, large-scale burns and provide ecological diversity through a range of heathland plant communities and structures.

It should be noted that the data collected were those of an ecological or agricultural nature. The effects of other activities, such as military use or leisure pursuits, did not form part of the study.

DATA ANALYSIS

The project brief required consideration to be given to the production of a model for sustainable agricultural systems in the South West moors. Unfortunately, the variation in quality and extent of the data available precluded sophisticated statistical analysis, such as Principal Component Analysis. Instead, regressions have been carried for those parameters with the most robust data, principally examining the relationships between stocking levels and the proportion of the site with dwarf shrub cover (as a rough measure of its habitat quality).

3. RESULTS

This section summarises the key findings and any common themes emanating from the information gathered at the study sites. Inevitably, the sites examined exhibited a range of habitat types and qualities and an equally diverse range of farm practices. Particular problems included:

- the scarcity of comprehensive stocking, supplementary feeding and burning information for commons;
- changes in grazing regimes, particularly as a result of entering land management schemes;
- variation in the grazing quality and area of the sites;
- the scarcity of comprehensive, objective data on moorland quality; and
- the lack of objective data on the effects of cattle, ponies and red deer on South West moorland vegetation communities.

VEGETATION QUALITY

Table 1 summarises the proportions of the units dominated by heath, mire and grassland.

Table 1: Proportion (%) of grazing unit covered by heathland and mire (including mosaics) and grassland.

Site	Heather	South-western heath	Blanket and valley mire	Grassland
Dartmoor				
D1	79	0	2	19
D2	90	0	2	1
D3	60	7	29	4
D4	<— 44 —>		45	7
D5	57	0	28	7
D6	36	62	2	0
D7	0	67	0	5
Exmoor				
E1	31	0	11	9
E2	82	0	0	14
E3	69	0	0	20
E4	(most)	0	?	?
E5	<— 86 —>		1	2
E6	0	(most)	0	?
E7	0	61	1	33
E8	0	67	0	?
E9	4	0	11	85
E10	0	0	56	44
Bodmin Moor				
B1	0	45	21	41
West Penwith				
W1	0	>90	1	0
W2	0	>95	>1	0

Note to table 1. D1: area fenced since 1992.

Eighteen of the sites comprised 31% – 98% cover of dwarf shrubs (mean 70%), either with heather as the dominant species (eight sites with 31% – 90%), as mixed dwarf shrub south-western heath (eight sites with 45% – >95%), or as mixtures of the two (two sites with 44% and 86%). In addition, blanket or valley mire at seven sites covered 11% – 56%. Dry or wet acidic grassland comprised a relatively small proportion of most sites, often in a mosaic with heather and other dwarf shrubs. Of 15 sites (excluding the blanket mire sites E9 and E10) for which data were available, grassland covered an average of about 11% (range 0%–41%). The two blanket mire grazing units on Exmoor contained substantial areas of dry grassland, which supported relatively high grazing levels.

FARM ENTERPRISE

Post-war incentive schemes aimed at supporting agriculture in less-favoured areas, together with technological advances allowing greater fodder production on inbye land, have resulted generally in the greater use of moorland. In the relative mildness of the South West, the outwintering of hardy cattle, originating from the north of Britain, has been possible during the present century. Drier, more accessible areas have seen the brunt of habitat degradation, resulting from the concentration of livestock around winter feeding areas. An increasing scarcity of labour has led to the burning of large blocks of heathland and purple moor-grass, the high frequency of burning potentially militating against dwarf shrubs. Blanket and valley mires have suffered some degradation as a result of damaging burns, though not at the two selected mire sites (E9, E10).

MAFF environmental policy, through ESAs and action taken under HLCA regulations against graziers who practised unsuitable winter feeding, has promoted regimes more sympathetic to habitat conservation. Some of these changes are reported upon here, together with sites which, exceptionally, have retained higher quality heathland and mire.

All farms investigated were essentially stock-rearing enterprises, the principal moorland livestock systems including:

- All year round stocking (sheep: 4 sites; cattle: 7 sites).
- All year round stocking, but with some or all stock brought onto inbye for a few weeks, principally for calving/lambing and bulling/tupping (sheep: 8 sites; cattle: 2 sites).
- Additional ewes, principally lowland breeds, for drying off in late summer, typically during July–October (10 sites).
- Summer grazing only (sheep 2 sites, cattle 4 sites).
- Outwintered cattle (10 sites).

These differing systems affect moorland quality in different ways. For example, cattle which calve and are put to the bull on inbye (or, as at D4, another newtake) during early summer miss the first flush of purple moor-grass, which becomes less palatable as summer progresses unless grazed throughout; the surge in the numbers of lowland breed sheep in late summer and autumn risks damage to heather at the time when it most vulnerable; and outwintered cattle, especially of non-hardy breeds, require supplementary feeding to maintain condition and acceptable calving rates, with the consequent risk of damage as described earlier.

Nevertheless, the examples studied are considered to be generally benign because of their combinations of stocking level and grazing system.

Livestock types and breeds

Table 2 summarises the types and hardiness of livestock reported to have been grazed on sites during the decade or so prior to the habitat quality "assessments". Cattle were grazed at 16 sites, sheep at 18 and ponies at seven (four on Dartmoor). A total of at least eight sites held hardy breeds of cattle[1] and at least 16 sites were grazed by hardy sheep[2]; the respective totals for non-hardy breeds were 10 and 11.

Table 2: Use of livestock types and hardy breeds.

Site	Cattle		Sheep		Ponies
	Hardy?	Non-hardy?	Hardy?	Non-hardy?	
Dartmoor					
D1	N	Y	N	Y	N
D2	Y	N	Y	Y	Y
D3	Y	N	Y	N	N
D4	Y	Y	Y	Y	Y
D5	Y	Y	Y	Y	Y
D6	Y	Y	N	N	N
D7	N	Y	Y	y	Y
Exmoor					
E1	N	N	Y	Y	N
E2	N	N	Y	N	N
E3	N	Y	Y	N	N
E4	?	?	?	?	Y
E5	N	N	Y	Y	N
E6	N	N	Y	Y	N
E7	Y	N	Y	N	Y
E8	N	Y	Y	N	N
E9	N	Y	Y	y	N
E10	N	Y	Y	N	N
Bodmin Moor					
B1	Y	y	Y	y	Y
West Penwith					
W1	Y	N	Y	y	N
W2	N?	Y?	N	N	N

Lower case indicates a minor proportion of the livestock type.

Cattle were dominated by hardy Galloway (at 4 sites), Galloway crosses (4) and Highland (1) and non-hardy South Devons (4) and various other cross-breeds (6 sites), plus single instances of North Devon, Hereford, Friesian and Charolais. Sheep were dominated by hardy Scotch Blackface (11 sites), with hardy Dartmoor, Exmoor, Herdwick, Swaledale, Welsh, Cheviot, Cheviot x Scotch Blackface and Exmoor x North Country Cheviot at up to three sites each; non-hardy Bluefaced Leicester x Scotch Blackface, Beulah and Texel x Suffolk were at one or two sites each, with various mixed breeds at three sites.

[1] Hardy breeds of cattle in the South West include Galloways, Luing, Welsh Black and Highland.

[2] Hardy breeds of sheep in the South West include Welsh Mountain, White-faced Dartmoor, Swaledale, Scotch Blackface, Exmoor Horn, Cheviot and (rarely) Herdwick and Soay.

Changes in breeds

Precise data on the changes in favoured breeds were generally unavailable, but anecdotal evidence strongly suggests a large reduction in the proportion of hardy breeds of cattle (but not sheep) kept on moorland. The keeping of non-hardy breeds in areas with rough vegetation which they are unable to utilise has been encouraged inadvertently by livestock support schemes. Traditionally, Dartmoor was stocked in summer only with South Devons and Ruby Reds, which tended to be brought off the moor at night. In West Penwith, the traditional Guernsey dairy herds were hit badly by Bovine Tuberculosis in the 1950s, after which many heathland areas were not re-stocked and tended to become rank and neglected, apart from large-scale burns.

Stock ratios

Ratios were calculated from average livestock densities (LU/ha) over the year as a whole and are presented in table 3 as percentages. Where these have varied over the decade prior to habitat quality "assessment", a weighted average has been calculated. There were tendencies (but not statistically significant) for high cattle ratios to be associated with low percentage of dwarf shrub cover, and for high sheep ratios to be associated with high percentage cover. Grazing at eight sites was dominated by cattle, at 11 by sheep and at one by ponies; these are summarised by moor in table 4. The pony-dominated site is an atypical, low-altitude common of high environmental quality. The two Exmoor sites grazed predominantly by cattle comprise the two selected blanket bog sites, each of which includes extensive areas of acid grassland and little by way of dwarf shrubs.

Table 3: Ratios of different livestock types (LUs expressed as %).

Site	Cattle	Sheep	Ponies
Dartmoor			
D1	62	31	7
D2	3	91	6
D3	62	38	–
D4	68	7	25
D5	39	51	10
D6	100	–	–
D7	7	20	73
Exmoor			
E1	–	100	–
E2	–	100	–
E3	23	77	–
E4	<34	<66	(>0)
E5	–	100	–
E6	–	100	–
E7	21	79	–
E8	8	92	–
E9	66	34	–
E10	100	–	–
Bodmin Moor			
B1	48	28	24
West Penwith			
W1	23	77	–
W2	100	–	–

Note to table 3. B1: based on 1991–95 data.

Table 4: Numbers of sites dominated by each livestock type, by moor.

Moor	Cattle	Sheep	Ponies
Dartmoor	4	2	1
Exmoor	2	8	–
Bodmin Moor	1	–	–
West Penwith	1	1	–

Stocking levels through the year

Stocking levels for the year as a whole, together with the means and ranges for summer (May–October) and winter (November–April) are summarised in table 5, and summer and winter means are illustrated in figure 1. The levels have been calculated for the whole areas within current grazing unit boundaries. Where necessary (and where data exist), levels have been averaged over the decade prior to the habitat quality "assessment".

Table 5: Stocking levels (LU/ha).

Site	Overall Mean	Summer		Winter	
		Mean	Range	Mean	Range
Dartmoor					
D1	0.20	0.39	–	0	–
D2	0.16	0.16	0.06–0.19	0.16	0.11–0.19
D3	0.17	0.26	0.08–0.44	0.08	–
D4	0.29	0.28	0.22–0.37	0.31	0.23–0.36
D5	0.28	0.30	0.25–0.34	0.26	0.15–0.30
D6	0.50	0.56	0.02–0.84	0.45	0.02–0.59
D7	0.54	0.55	0.52–0.56	0.53	0.52–0.56
Exmoor					
E1	0.46	0.54	0.10–0.96	0.38	0–0.56
E2	0.19	0.25	0–0.44	0.13	0–0.26
E3	0.37	0.37	0.20–0.61	0.37	0.17–0.45
E4	>0.12	>0.19	0.05–0.62	>0.05	–
E5	0.14	0.20	0–0.24	0.09	0–0.13
E6	0.25	0.33	0–0.40	0.17	0–0.40
E7	0.39	0.42	0.31–0.46	0.36	0.24–0.40
E8	<0.35	<0.43	–	<0.27	0–<0.51
E9	0.46	0.58	0.23–1.16	0.34	0–0.72
E10	0.78	1.44	–	0.11	0–0.67
Bodmin Moor					
B1	0.32	0.35	0.19–0.50	0.29	0.16–0.48
West Penwith					
W1	>0.35	0.4	0.30–0.50	>0.3	0.15–1.9
W2	0.14	0.14	–	0.14	–

Notes
E1: an average of ESA and pre-ESA data; possibly now "undergrazed".
E4: excluding ponies and based on pre-ESA figures.
E7: based on pre-ESA data
E8: based on pre-ESA licensed stock, rather than actual stock numbers.
B1: based on 1991–95 data.
W1: levels were higher on occasions prior to 1994.

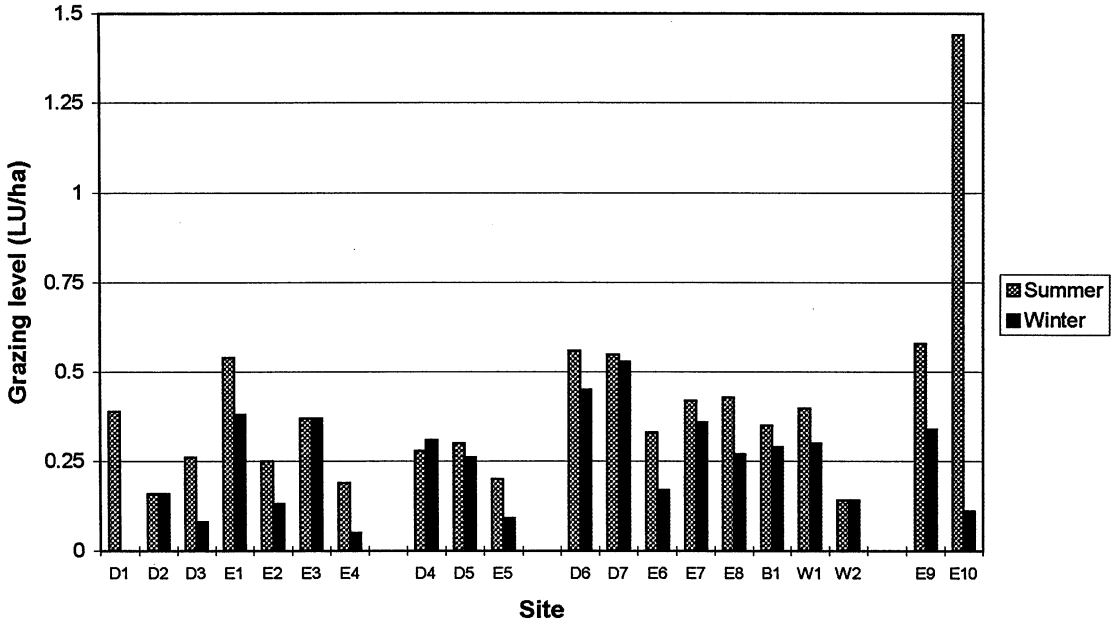

Figure 1: Mean seasonal stocking levels, with sites grouped by heather (7 sites), heather + south-western heath (3), south-western heath (8) and blanket bog (2).

Stocking levels (including ponies) at the 18 dwarf shrub dominant sites averaged 0.29 LU/ha (range 0.12–0.54) over the year as a whole (0.34 in summer, 0.24 in winter).

The relationships between mean monthly stocking levels (overall, summer and winter, and summer sheep and winter cattle) have been investigated for nine "heather" sites for which estimates of dwarf shrub cover were available (excluding the anomalous site D6). Overall, summer and winter stocking levels were significantly related to dwarf shrub cover. The regression equations (where y = dwarf shrub cover and x = stocking level) are:

Overall mean stocking level:	$y = -153x + 106$	($p = 0.004$, $R^2 = 71\%$) (figure 2a)
Summer mean stocking level:	$y = -126x + 107$	($p = 0.032$, $R^2 = 51\%$)
Winter mean stocking level:	$y = -105x + 88$	($p = 0.029$, $R^2 = 52\%$)

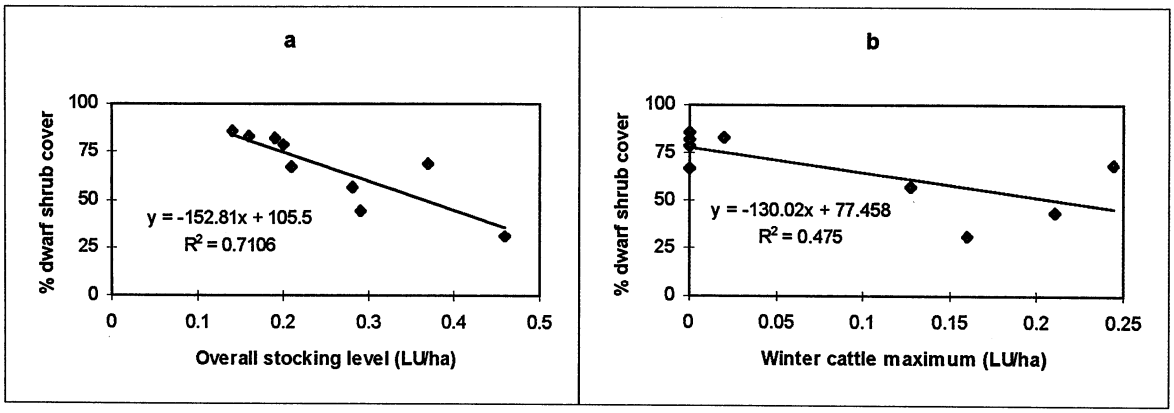

Figure 2: Relationships between dwarf shrub cover and (a) overall stocking levels and (b) winter cattle maximum (data for sites D1–D5, E1–E3 and E5 only).

The mean and maximum monthly stocking levels for summer sheep and winter cattle were also investigated, as these have been regarded as critical factors in determining moorland quality. Relationships were not significant for mean monthly summer sheep or winter cattle stocking levels, nor for summer sheep maximum, but they were significant for winter cattle maximum ($y = -130x + 77$; $p = 0.041$, $R^2 = 47\%$) (figure 2b).

Similar relationships were investigated for seven sites (D6, D7, E7, E8, B1, W1 and W2) dominated by south-western heath and 15 sites for which grassland area was known (see Table 1). However, neither overall, summer or winter stocking levels were significantly related to dwarf shrub cover or grassland area.

Changes in stock numbers

Eleven sites have seen the recent removal or reduction in numbers of cattle in summer (D3, D6, E4), in winter (D1, D2, E3, W1), or over the year as whole (D1, D5, E1, B1), although two (D6, E8) saw more in winter. Six sites have seen the removal or reduction in numbers of sheep in summer (D6, E4, E6), in winter (E8), or over the year as a whole (D1, E1, E7), although one site (E5) has held more sheep all year round. Therefore, overall change has been one of reductions in the numbers of sheep and especially of cattle. The reduction in summering cattle has implications for purple moor-grass, which may become dominant if it not well utilised. Pony numbers have been reduced at D7 for welfare reasons, but despite continued high densities, scrub has become an increasing problem.

Supplementary feeding

Table 6 summarises supplementary winter feeding practices. Eight sites have no history of feeding, while a further three have ceased to feed (either hay or silage) on the moorland unit. Hay is still fed on at least five sites (on Dartmoor) and silage on at least two. At least two sites still feed hay or silage on linked inbye fields.

Daily rations for cattle at three Dartmoor sites (D4, D5, D6) for which feed has been quantified comprised 3–4 kg hay and 0.7 kg of cobs, fed between mid-December and mid-May; sheep and ponies had access to some of this. Such rations were considered to give sufficient roughage, permit outwintering without welfare problems and avoid vegetation damage, provided that feeding is on dry ground and the sites are moved around (keeping away from heather) and provided that stock are kept in small groups (e.g. 30 cattle rather than 80). It should be noted that suitable areas of dry grassland once may have been heathland, but degraded as a result of supplementary feeding and the associated concentration of livestock. On Exmoor, cattle at E8 received concentrate only, during November–January, while at the blanket bog site E9 cattle were fed 14.3 kg of silage daily, avoiding the wettest areas , also during November–January.

Changes in supplementary feeding

Feeding, apart from in severe weather, had ceased at five sites (D1, E1, E4, E6, W1), while silage was no longer fed at another five (D2, D5, D6, D7, E3).

Table 6: Supplementary winter feeding.

Site	On-site		On linked inbye	
	Hay	Silage	Hay	Silage
Dartmoor				
D1	(✓)	–	–	–
D2	✓	–	–	–
D3	–	–	–	–
D4	✓	–	<— ✓ —>	
D5	✓	(✓)	–	–
D6	✓	(✓)	–	–
D7	✓	(✓)	–	–
Exmoor				
E1	✓	–	–	–
E2	–	–	–	–
E3	–	(✓)	–	–
E4	–	–	<— (✓) —>	
E5	–	–	✓	✓
E6	–	✓	–	–
E7	–	–	–	–
E8	–	–	–	–
E9	–	✓	–	–
E10	–	–	–	–
Bodmin Moor				
B1	?	?	–	–
West Penwith				
W1	(✓)	(✓)	–	–
W2	–	–	–	–

(✓) - former practice

Burning

Data for the size and minimum numbers of burns are summarised in table 7. Details are more comprehensive for Dartmoor and West Penwith than for other sites. The advent of payments for environmental management has led to more programmed, small-scale burns at some sites, though these efforts can be nullified by the actions of determined graziers and arsonists, as well as by genuine accidents). ESA monitoring in West Penwith has suggested encouraging trends to smaller, planned burns as a result of agreed rough land management plans (ADAS, 1996).

Changes in burning practices

The frequency and extent of burning decreased over at least eight sites (D1, D2, D3, D4, D5, D7, E1, W1), while B1, where vegetation was too short to burn previously, suffered an extensive burn in 1996 after several years of unsuppressed growth. About one-third of the sites have been brought into planned burning regimes, generally involving small areas. There is some evidence that the reduction in the numbers of hardy cattle, particularly in early summer (because of calving on inbye) has led to inadequate utilisation of purple moor-grass: in turn, this has led to an increase in burning for litter control. On the wettest areas, notably blanket and valley mire, this has degraded the habitat, damaging bog-mosses and (if burning was too frequent) dwarf shrubs.

Table 7: Burns of known area since 1965.

Site	1–5 ha	6–49 ha	50+ ha
Dartmoor			
D1	2	2	–
D2	4	8	2
D3	3	5	–
D4	–	3	3
D5	1	2	2
D6	–	2	1
D7	>2	>1	–
Exmoor			
E1	–	–	–
E2	–	approx. 15	–
E3	11	4	2
E4	?	?	>1
E5	–	>1	–
E6	?	?	>1
E7	?	?	?
E8	?	?	?
E9	–	–	–
E10	–	–	–
Bodmin Moor			
B1	–	–	1?
West Penwith			
W1	2	2	–
W2	>4	1	?

Notes to table 7:
E1: no burns since 1979.
E2: 25–40 ha burned in most years, on an approximate 10 year rotation.
E5: areas of about 20 ha burned regularly on a 5–6 year cycle.
E7: large burns in the 1970s and 1980s, with smaller areas since.
E8: unquantified area(s) burnt in 1996.

4. DISCUSSION

This section discusses the results in the light of the circumstances prevailing in the South West, in particular its nationally and internationally important moorland and heathland plant communities and its characteristic livestock enterprises.

VEGETATION TYPES

The main vegetation types present at the sites comprised a range of moorland plant communities, many of which are restricted to, or are particularly well-represented in, South West England. These have evolved over several millennia as a result of human activity, notably extensive agriculture, into valued dwarf shrub dominated heathland and deep peat based blanket and valley mire. Although arable cultivation was often practised during milder periods in the distant past, the principal agricultural activity until recent decades has been extensive livestock grazing at a level restricted by the inherent infertility of the moorland. However, with the advent of improved grassland production systems on inbye and financial support mechanisms which encouraged the keeping of greater numbers of livestock, the impact of livestock on moorland vegetation has been the widespread degradation of valued habitats.

The recent detrimental changes to moorland have included, most importantly, the conversion of communities dominated by dwarf shrubs and bog-mosses to dry and wet acid grassland, respectively. This has occurred as a result of overgrazing, trampling and vehicle damage, soil enrichment and large scale and frequent burning. This increase in the presence of grassland, which is often more palatable than the vegetation which it replaced, together with supplementary winter feeding, has caused stock to concentrate, typically on the lower, more sheltered, fringes of moorland where supplementary feeding tends to occur. In turn, this has drawn livestock from areas which have, as a consequence of reduced grazing and trampling, seen increases in purple moor-grass, scrub, bracken and bramble cover. Thus there has been increasingly uneven grazing of moorland units in recent decades, exacerbated by a lack of shepherding. In grazing units with a high grass to heather ratio, there is a greater risk of livestock concentrating on heather in autumn/winter when grass growth slows or ceases.

In addition to problems associated with excessive utilisation, some areas such as isolated peripheral commons in Dartmoor and Bodmin Moor and some coastal and inland heaths in Exmoor and West Penwith (and much of the heathland in the Quantock Hills), have been degraded by inadequate levels of agricultural utilisation, principally by undergrazing. This has resulted in the loss of structural diversity to heathland and mires and successional change to scrub. The concentration of livestock to limited parts of large grazing units has also resulted in undergrazing in blanket bog on Dartmoor and more widespread increases in bracken.

The sites studied have targetted some of the best examples of habitats which have avoided the worst of the aforementioned problems. However, they exhibited a range in the proportions of these valued vegetation communities. Generally, dwarf shrubs covered the

majority of the area of sites selected for their heathland quality. Objective evidence of the health of the dwarf shrubs was often lacking, and where it was available, it often suggested that suppression to varying degrees either had occurred in recent decades or was still happening. Sites with low levels of heather suppression tended to be associated with south-western heath, where the western gorse component deters stock, especially sheep, from entering dense stands. It is notable that many graziers view western gorse as a considerable nuisance to agriculture because of this deterrent effect.

"Heather" sites with the highest cover of heather were associated with the lowest overall stocking levels, probably due more to the levels of winter cattle than summer sheep, both of which have been implicated in heather damage in the South West and elsewhere. Four of the six "heather" sites with more than 50% dwarf shrub cover had overall, summer and winter stocking levels of less than 0.3 LU/ha (except D3, at 0.33 in summer, and E3, at 0.37 in summer and winter). These levels include ponies, rated at one livestock unit each, which practical experience in the South West suggests is correct in spite of their body weight being lower than that of cattle. The same sites all had peak winter cattle levels of no more than 0.13 LU/ha, except E3, where some past cattle damage is acknowledged to have occurred as a result of winter feeding (although this has now ceased under ESA agreement). However, there was no tendency for greater dwarf shrub cover to occur with higher ratios of cattle to sheep, over the year as a whole.

The data for south-western heath sites suggested that dwarf shrub cover may be more strongly related to summer stocking levels, which are governed principally by sheep numbers. This is unexpected, in view of the difficulty which sheep have in penetrating dense western gorse, although the relationship for the small number of sites studied was not statistically significant.

The two Exmoor blanket bog sites contain high proportions of acid grassland, presumably converted from heathland at some point in the past, which can now support relatively high densities of cattle, winter fed at one site. Despite this, or perhaps because winter feeding attracted livestock away from sensitive areas, the bog plant communities have not been damaged. However, traditional grazing of much of Darmoor and Exmoor Forest was summer only and winter grazing is generally undesirable on blanket bog. On Dartmoor, the areas of blanket bog within the units reported upon are not in pristine condition and have suffered to some degree by burning, poaching or undergrazing. An important element of vegetation control in both blanket and valley mires is the removal of purple moor-grass growth by cattle from early summer onwards, to prevent dominance and to maintain a relatively open sward for various animals and other plants. The alternative of burning to clear litter has the detrimental effect of damaging bog-mosses, reptiles and invertebrates, and is not always followed up by appropriately timed cattle grazing as it needs to be, otherwise purple moor-grass benefits.

FARM ENTERPRISE

All farms studied were essentially stock-rearing enterprises. Non-hardy, and the majority of hardy, moorland stock calve and lamb on inbye in April, though some farms calve in autumn. Some farms had a shortage of inbye, necessitating the purchase of hay or silage.

The effects of improved in-bye management, leading to greater stock capacity on individual holdings, and the incentives provided by HLCA and other subsidies, has led to increase usage of moorland in Dartmoor, Exmoor and Bodmin Moor. The relatively easy access to moorland edge and the mildness of the South West has allowed graziers to use moorland as an extension to their farm unit for holding stock all year.

Conversely, the sites studied have been subjected to less intensive use than other areas, for several reasons. Most importantly, they have been under the control of single, or a very small number of, active graziers, especially on commons. In some cases, the stocking levels permitted by landlords have been limited by licence and these have not always been used to the full. Some owners, landlords and tenants have entered ESA and National Park agreements, where the reduction in stocking levels has been beneficial. The payments received for such agreements can play a major part in sustaining farms and traditional agricultural systems, although the role of ESAs has yet to be quantified fully. While West Penwith ESA commenced in 1987, the schemes for Exmoor and Dartmoor are much more recent (1993 and 1994, respectively).

Factors which have prevented sympathetic grazing in parts of West Penwith, the Quantock Hills and locally elsewhere, include stock control because of defective (or even non-existent) boundaries and the incidence of rustling, road traffic accidents and sheep worrying by dogs.

STOCKING REGIMES

South West moorland has been used frequently as a convenient holding ground for increased numbers of livestock, thereby enabling greater agricultural production or avoiding sward damage on inbye. Lowland sheep and cattle systems have been applied widely to moorland in the South West. This has led to a scarcity of cattle in early summer (when purple moor-grass is at its most palatable and grazing control is most feasible) and an abundance of sheep in late summer and autumn (when heather is at its most vulnerable to grazing damage). Hardy breeds of livestock have been replaced by cross-breeds less capable of utilising moorland vegetation throughout the year. Non-hardy stock are frequently part of a lowland regime, notably for calving/lambing, bulling (bulls being prohibited on open commons) and tupping and for drying-off sheep (on moorland in late summer/early autumn) to rest inbye. The very high densities of "lowland" sheep in late summer which appear to be a major factor in determining the extent and quality of heather areas, at least in the South West, were an uncommon feature of this study and peak numbers were not related to the extent of dwarf shrubs.

Overall stocking levels averaged 0.32 LU/ha over all 20 sites (0.40 in summer, 0.24 in winter), including ponies. However, excluding two blanket bog sites, the figures were 0.29

overall, 0.34 summer and 0.24 winter. Correlations between these data and the proportions of each grazing unit covered by dwarf shrubs gave some simple relationships, although the scarcity of standardised, objective data prevented more sophisticated analysis. Using 50% dwarf shrub cover as a threshold to basic habitat quality for sites with substantial heather or south-western heath cover, the data suggested that overall levels generally were below 0.3 LU/ha and winter cattle no more than 0.13 LU/ha; surprisingly, no clear relationship was established between sheep levels and dwarf shrub cover.

Edwards and Marsden (1991) reported that, nationally, 64% of upland heather (mostly dominant and in good condition) was associated with stocking rates of 0.5–1.5 ewes/ha (0.075–0.225 LU/ha). For Dartmoor, Seal (1991) concluded that a stocking rate of 0.3 LU/ha (but exceptionally up to 0.45 LU/ha) was the lowest associated with good quality vegetation that could be achieved without additional support payments. The ESA scheme Tier 1 prescription for Exmoor heather moorland requires stocking levels of no greater than 0.225 LU/ha in summer and 0.15 LU/ha in winter, while the levels for Dartmoor moorland are 0.225 LU/ha in summer and 0.17 LU/ha in winter (excluding up to 0.04 LU/ha for ponies); revisions in the Darmoor scheme in 1996 allowed 0.36 LU/ha in summer and 0.235 LU/ha in winter for dry grass areas and also higher pony ratios in exceptional cases.

Thus, the grazing levels found on the heathland sites in this study were higher than those associated nationally with upland heather in good condition and slightly higher than the prescribed stocking levels for Darmoor and Exmoor ESAs. The impact of reducing to ESA prescribed levels on heathland which is not in good condition will be revealed by the future monitoring of heather utilisation and dwarf shrub condition.

There is a risk that, in trying to meet ESA prescriptions, some sites may suffer inappropriate reductions in stock numbers. For example, cattle may be withdrawn in favour of sheep, leading to the under-utilisation of purple moor-grass. The diversity of habitats created and maintained by grazing hardy sheep, cattle and ponies may be reduced by the loss of the last two stock types. In the Exmoor ESA, agreement-holders are not permitted to graze cattle in winter on heather moorland: this has had the effect of promoting winter housing off the moor, while others have paid to have stock away-wintered. In West Penwith ESA, agreement-holders are required to graze (without undergrazing, overgrazing or poaching) "rough" land which previously had often fallen into neglect; where the reintroduction of grazing has not been possible for practical reasons, a programme of burn management has been agreed. Some Exmoor coastal heaths have been grazed at low densities which meet the requirements for ESA Tier 2, which was designed to reduce stocking rates on overgrazed moorland. However, these sites had been managed at such densities for some time and it is reasonable to assume that south-western heath generally can support fewer livestock than heather-dominant moorland, because of its lower palatability and the deterrent effect of western gorse. This brings with it the risk of scrub invasion, as has occurred at D7and several other lower Dartmoor commons, as well as a number of coastal Exmoor sites.

More sites (16) were grazed by hardy sheep (notably Scotch Blackface) than hardy cattle (eight sites, principally with Galloways and Galloway crosses). Sheep kept on moorland after November are generally hardy breeds. Hardy breeds of all stock types, including ponies, are able to utilise coarse moorland vegetation, especially in late winter/early spring before

spring growth recommences. Ponies, especially Exmoor, are acknowledged to be good browsers of scrub, including gorse (Oates, 1994) and may be of considerable benefit in controlling woody growth on lower, more sheltered slopes.

SUPPLEMENTARY FEEDING

Stock, especially non-hardy cattle, concentrate at the moor edge where feeding occurs or has occurred. Such areas degrade to acid grassland and this compounds the problems of uneven grazing pressure: a lack of control of purple moor-grass (to the detriment of heathers); undergrazing in remote blanket bog areas (to the detriment of breeding golden plover); spread of bracken (to the detriment of heathers and grazing potential); and increased density of bracken and its litter (to the detriment locally of woodland-type plants and butterflies such as the high brown fritillary). The drier, lower and milder parts of moors are often those which would, in the absence of dwarf shrub suppression, carry valuable lowland heath communities of plants and animals.

Hardy cattle, and young sheep with a good set of teeth, should maintain their body condition on moorland. Galloway cattle, for example, can utilise the roughest of roughage, but there are doubts that calving rates as high as those required for HLCAs (80% on moorland) can be attained without supplementary feeding.

Evidence from this study suggests that daily rations of about 0.7 kg of concentrate and 3–4 kg hay per cow should give sufficient additional nutrition, permit outwintering without welfare problems and avoid vegetation damage, provided that feeding is on dry ground and the sites are moved around (keeping away from heather) and provided that stock are kept in small groups. Rations at this level provide about one half of the daily energy requirements of cattle. In late springs, feeding has been required until mid-May. Feeding on the heather fringe is potentially damaging, as these margins are particularly susceptible to feeding and trampling damage. Winter housing has encouraged the keeping of more-productive, cross-bred cattle, which, in the absence of supplementary feed, can only survive on the moor in summer.

Mineral and feed blocks are not used widely on the higher quality moorlands in the South-West, although they have the potential to locally degrade moorland habitats by causing stock to concentrate and by altering soil chemistry, unless they are moved frequently. Feed blocks may be a convenient, if relatively expensive, method of achieving more even grazing over a unit, by encouring livestock to remain longer in specific areas. Supplementary feeding of hay and cobs also can be used to encourage more even grazing pressure, although this may be limited by the availability of suitable feeding sites. Livestock may be encouraged to avoid sensitive areas (for example, the blanket bog at E9) by feeding at sites well away. Similarly, it is conceivable that levels above those normally regarded as sustainable may be supported by feeding at very restricted "sacrificial" sites.

MOORLAND BURNING

It was apparent from the study sites that burning practices have been far from ideal, assuming that the basic principles of burning moorland and lowland heath apply to the dwarf shrub based communities in the South West. As noted earlier, however, heather layering, at least in heather-dominant stands, may reduce or even remove the need for burning.

The tradition, if anything, has been of extensive, poorly-controlled burning, for the control of western gorse or purple moor-grass and with the objective of improving grazing conditions. Although moves have been made to bring burning under greater control, for example through ESA management plans, there are still fundamental difficulties preventing good burning practice, in addition to the frequent problem of burning under appropriate weather conditions.

General problems include some lack of awareness in both the farming community and the general public about the ecological and agricultural benefits of properly planned and executed burning programmes; a scarcity of manpower to burn according the Heather and Grass Burning Code (MAFF, 1992); and a tradition of burning extensive tracts with essentially agricultural gain in mind. These have led to public resentment of burning and a desire by farmers to continue with what are perceived to be agriculturally beneficial practices, which it is possible to carry out (though should not be) with minimal staffing. Extensive "accidental" burns, which may be expected in areas which attract large numbers of tourists in summer, also hinder burning programmes, which accordingly require a degree of flexibility.

Problems specific to the South West revolve principally around the lack of expertise and desire for small burns which comes with heather management for red grouse; the flammable nature of western gorse; and too frequent burning of bristle bent and especially purple moor-grass. In the region's rugged and/or upland terrain, cutting firebreaks in advance of burning specific blocks of heathland may be hampered by rocks and other uneven ground. At best, therefore, natural firebreaks, such as tracks, tend to be used opportunistically and may result in the burning of larger than ideal blocks. ESA monitoring in West Penwith (ADAS, 1996) has raised the potential problem of encouraging western gorse dominance by burning at long intervals, which releases greater amounts of nutrient that gorse may exploit to the detriment of heathers. Conversely, frequent burning of south-western heath may kill off dwarf shrubs and promote purple moor-grass or bristle bent, while in mires and wet moorland the former may come to dominate, especially if decoupled from the controlling effect of summer cattle grazing.

In all areas where burning occurs, there are difficulties in adhering to all the conditions of the Burning Code, especially in meeting the labour requirements, and public opinion is largely against burning. There is a need to convey to both graziers and the public in the South West that there are good environmental reasons for aspiring to well-planned and well-executed moorland burning programmes, whilst acknowledging the difficulties in doing so and seeking to alleviate these.

5. CONCLUSIONS

This report has drawn together information from a small number of South West moorland sites which are considered to be in good ecological condition. These sites largely represent the products of ecologically benign practices, which may be sustainable in the long term only if viable farm units are maintained. Such viability is currently enabled by livestock subsidies and environmental land management scheme payments.

The data collected show considerable variation, which in some cases is a result of the inadequate quality of retrospective information. However, in many cases it is thought to reflect real differences between the intrinsic qualities of moorland units and the types of management regime imposed upon them. It has proved difficult to draw common themes, but the knowledge of factors which have been shown elsewhere to degrade moorland generally in the South West has assisted in pinpointing some factors. Those which appear to be important include the following:

- High quality sites have avoided the extremes of both intensive management and under-management; however, the increased structural complexity associated with sites tending towards the latter may be of at least temporary benefit. It should also be recognised that areas of short, open (even muddy) vegetation on heathland, mire and grassland may enhance biodiversity, but such areas will generally cover only a small proportion of any site.
- It is rare for entire sites to be in high quality condition, so the management factors listed below, which have been associated with better quality sites, may not necessarily represent the ideal state. The quality assessments which have led to the selection of sites for this report can not be considered fully objective, but have relied on various concepts of quality.
- Estimates of heather utilisation by sheep suggest that heathland communities which contain the potentially obstructive western gorse suffer less suppression by grazing than pure heather stands. For the same reason, such communities may be inherently unable to support the same livestock densities as heather-based communities over their respective growth cycles. However, no significant relationship was apparent between the proportion of south-western heath dwarf shrubs in a site and the stocking level, nor were these levels significantly different to those on heather-dominant sites.
- Heather proportions of greater than 50% of the site were associated with stocking levels mostly of less than 0.3 LU/ha overall and mostly less than 0.13 LU/ha of winter cattle. However, there was no clear relationship between cattle to sheep ratios and the proportions of dwarf shrub cover.
- Stocking levels (including ponies) at 18 dwarf shrub dominant sites averaged 0.29 LU/ha overall (0.34 in summer, 0.24 in winter), which are higher than those associated nationally with upland heather in good condition and slightly higher than the prescribed stocking levels for Darmoor and Exmoor ESAs. These may be higher than optimal levels where heathland has previous been converted to grassland.

- Livestock systems contained elements of both upland and lowland regimes, with mixes of hardy and non-hardy breeds (although frequently dominance by hardy Galloway cattle and Scotch Blackface sheep) and movements of stock between moor and inbye for calving/lambing, bulling/tupping, dipping, shearing and drying-off.
- Livestock subsidies have encouraged the keeping of greater numbers of stock, but this has been tempered in recent years by the advent environmental land management scheme incentives to adopt lower stocking levels and by actions taken by MAFF to control undesirable practices. There is a risk that reduced numbers of ponies and summer cattle may lead to some under-utilisation of purple moor-grass and locally to poor scrub control, although these may be inevitable consequences of attempts to improve the condition of dwarf shrubs.
- The problem of maintaining heathland with a diverse structure may not be resolved simply by modern agricultural means: for example, there is no current equivalent to cutting scrub or gorse for firewood (site D7 illustrates the difficulty of achieving scrub control even with ponies), nor is there an easy alternative to shepherding for ensuring even grazing over a unit.
- Winter supplementary feeding has been practised mainly on Dartmoor and Bodmin Moor in order to maintain the condition and calving rate of both hardy and non-hardy cattle. There is some evidence to suggest that daily rations of around 0.7 kg cobs and 3–4 kg of hay per cow are necessary for this. However, such feeding will cause dwarf shrub damage if it is not restricted to extensive, dry grass areas well away from the heather interface.
- Detailed information on burning is scant, but there is evidence of difficulties in adhering to the Burning Code and little to suggest that most graziers have burned for reasons other than to improve grazing. With requirements of burning which cross the boundaries of upland and lowland heathland, there is a need to establish a pragmatic approach for the South West which will satisfy the concerns of both the public and those seeking environmental and agricultural benefit.

Although more research is required to fully establish sustainable grazing practices, simple regressions have suggested some relationships which may be used predictively, if with caution. Encouragingly, the somewhat tentative conclusions from this study suggest that the stocking levels and other moorland management practices required by ESA prescriptions are broadly similar to those which have been identified as typical of the high quality sites examined. However, it is possible that poorer quality sites will not respond as favourably to the same management. The variations both in the data, the habitats and agricultural quality of the sites favour the adoption of site-specific management guidelines, rather than blanket prescriptions.

This study has drawn together for the first time information from a variety of sources and has identified the factors most likely to be needed for the attainment and maintenance of high quality moorland. The environmental conditions applied to livestock subsidies, together with the availability of agri-environment incentives, provide firm encouragement for the adoption of grazing practices which are close to those identified at the high quality sites studied. This bodes well for the future health of the important moorlands of South West England.

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APPENDIX 1: SUMMARY OF STUDY SITES

DARTMOOR

D1	Heather newtake
D2	Heather common
D3	Heather newtake
D4	Heather + south-western heath common
D5	Heather + south-western heath common
D6	South-western heath newtake
D7	South-western heath common (part)

EXMOOR

E1	Heather
E2	Heather
E3	Heather
E4	Heather
E5	Heather + south-western heath
E6	South-western heath common
E7	South-western heath
E8	South-western heath
E9	Blanket bog
E10	Blanket bog

BODMIN MOOR

B1	South-western heath

WEST PENWITH

W1	South-western heath
W2	South-western heath

APPENDIX 2: DEFINITION OF LIVESTOCK UNITS

The following are standard MAFF definitions of livestock units (LUs).

Cattle (>2 years)	1.0	
Cattle (0.5–1 year)	0.4	
Cattle (0.5–2 years)	0.6	(the ESA definition, used only where data were available only on this basis)
Sheep (>1 year)	0.15	
Ponies	1.0	

For the purposes of producing mean stocking levels, summer is taken to be May–October inclusive, winter as November–April.