Foundation for Common Land

Hill Sheep Husbandry in England:

Adaptive to change in diverse ecosystems

Evolving responses to changing economic and environmental conditions in hill farming with particular reference to cultural landscapes and stewardship of semi-natural resources

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Evolving responses to changing economic and environmental conditions in hill farming with particular reference to cultural landscapes and stewardship of semi-natural resources

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Preface

At first I had intended to write about hill sheep in terms of their nutritional requirements in a strictly agricultural context. For today and the future that is insufficient, since the range of interests in hill land is complex and characterised by the need to recognise, understand and respond to stakeholder interdependence through mutuality in practice. The focus is therefore on nutrition, but in the context of wider cultural, environmental and economic influences which modify, and are modified by sheep nutrition.

Whilst the principles of nutrition carry vital messages I have deliberately added elements and insights that may add value, interest and relevance to understanding hill sheep nutrition. Its evolution and diversity, is not an incidental process, but one that is central to the future of England's hills, facing unprecedented changes. The adaptation to changes, challenges and opportunities over long time periods has been deliberately included to emphasise the full contribution of hill farmers and their sheep to the life, landscape and natural history of England's diverse hills.

The primary aim is to provide insights for non-agricultural professionals for whom an understanding of hill farming, its evolution, and interactions with landscape, ecology and the application of improved production techniques is important. The document may also be of interest to farmers, students and others. The uplands are immensely diverse in respect of topography and climate.[1] The biological and economic environments are also dynamic. It follows therefore that the issue of hill sheep nutrition needs to be understood as a set of principles, but recognising that practice needs to be flexible according to the needs of particular sheep in particular places at particular times. Practice is necessarily a combination of art and science.

The English hills mean different things to different people, and only through shared understanding and respect can holistic improvement be a reality. Dr Johnson defined improvement as 'making things better'; seemingly a simple interpretation, but one that is full of complexity. Pastoral husbandry is a significant human activity that goes back to the genesis of agriculture, yet in the twenty-first century remains generally not well understood in a predominantly urban society. Understanding is concerned with having the knowledge and comprehension to inform reasoned decisions.

Heraclitus, a Greek philosopher, observed, 'you can't put your foot in the same river twice.' Even he might be surprised at the contemporary rate of change. Lester Brown, founder of the Earth Policy Institute, observed that, 'When the world is changing slowly you don't need much information. But when change is rapid there is a premium on information to guide the processes of change.' Accepting the tenor of Brown's observation we may add that perhaps we are faced with a potential excess of information at the expense of understanding and wisdom in its application. Sharing experience, learning together, and exploring issues and opportunities unconstrained by narrow agendas, will build respect for diverse opinions to the benefit of all stakeholders and society as a whole.

[1] Climate itself may be changing and bringing an added dynamic to bear.

Hill sheep nutrition reflects centuries of practical enquiry and observation by farmers, implemented through custom, shaped by local communities as appropriate to their needs. The application of appropriate technology and adaptation to external influences have characterised recent decades, presenting new challenges and opportunities. Evaluating the implications of rapid changes and adjusting to them is a genuine challenge to hill farmers. Making sense of the world around us is a complex of challenges which has the capacity to endorse or undermine pastoral agriculture on England's hills. Working hard to establish a common understanding and seeking a common language will take leadership and commitment at all levels with genuine and sustained mutuality at its core. Combining purposeful hill farming with the delivery of high value non-market public goods is an outcome worthy of our best efforts.

Sir George Stapledon (1882-1960), arguably the leading pioneer in grassland science of the twentieth century, reflected with regret in his later years that, 'nothing has been done to found a research station for experimental ecology.'[2] He had always seen his work in relation to society and human life in the widest sense. Now we face the challenge to make a difference, based on shared understanding and full participation, constrained by time and challenged by a constant emergence of new issues that complicate solutions. All stakeholders need to be conscious of the Chinese proverb:

> *If you don't change direction, you will end up where you are going.*

Hill farming presents cultural landscapes of national and international significance, yet resilient farmers and their sheep are increasingly vulnerable. Changing direction without the luxury of adequate time periods challenges them and their sheep to respond to the needs of a society which itself is facing an unpredictable future:

> *A considerable body of information exists; but it is scattered, unstandardized and diffuse, and has been collected by all manner of different persons for all manner of purposes. Much of the evidence collected has been published, and a great deal has not.*[3] (Sir George Stapledon, 1944)

The Natural England Evidence Review (NEER006, 2013)[4] includes a valuable report on the impact of moorland grazing and stocking rates. This concluded that there is a relative lack of good quality studies on which to base management decisions. Furthermore, issues relating to the impacts of vegetation change on sheep diets as relevant to ecosystem delivery are almost absent from the document. Stapledon's observations seem to remain relevant, posing needs and unprecedented opportunities for all stakeholder interests.[5]

Consideration of the past, present and future can inform wise decisions and demonstrate that change has characterised pastoral agriculture from the earliest days, albeit with greater autonomy for the farming response than is the case for present and future generations. All parties can bring valuable contributions to the table subject to reciprocity and respect.

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[2] Waller, R. (1962) *Prophet of the new age.* London, pp. 76-77.
[3] Stapledon, G. (1942) *The land: now and tomorrow*. London, p. 288.
[4] *Impact of moorland grazing stocking rates*.
[5] Martin, D., Fraser, M.D., Pakeman, R.J. and Moffat, A.M. (2013) 'Review of upland evidence 2012 - impact of moorland grazing and stocking rates', *Natural England Review*, NEER006.

In setting the context, an overview of the evolution of hill-sheep husbandry is an important process of social and cultural significance which has 'land-shaped' upland areas continuously since Neolithic times. Hill farmers and scientists together have the responsibility to address scientific, technical and economic challenges and opportunities to ensure that sheep nutrition plays its full role in sustaining a sense of purpose in farming practice as a pre-requisite to delivering a wide range of public goods.

Collaborative working is strongly influenced by policy formation and implementation and herein lies perhaps the major challenge. For policy makers as well as practitioners on the ground the speed of change and the complexity arising from the multiplicity of objectives makes genuine progress increasingly elusive. New approaches to the relationship between top-down and bottom-up implementation are needed:

> *The faster things change, the more problematic the policymaker's assumption of predictability becomes.*[6]

Europe's biodiversity policy to 2020 includes specific objectives for agriculture (target 3.1). Defra has published a strategic response that commits to improving the environmental outcomes from agricultural land management practices 'whilst increasing food production'.[7] This presents the essence and nature of the challenge.

The opportunity to work in the English uplands and with the farming community in particular, has been a privilege and an education for me, emphasising the diversity and the passion that is integral to contemporary English hill sheep husbandry. Careful management and wise husbandry are the essence of responsible hill farming. I have been fortunate in receiving life-long learning from numerous farmers, students, colleagues, friends, and other stakeholder professionals. I particularly remember David Ker of Craigdarroch, an inspirational friend who so generously shared his exceptional experience as a border shepherd, hill farmer and chair of the Hill Farming Research Organisation, linking science and practice. His grasp of hill farming and its pattern of life reflected a capacity to reflect, observe and contemplate; things that are not easily engaged in the modern world but which form the basis of wisdom. Some of the knowledge transfer structures and people that shaped hill farming in past decades are now a memory, leaving the initiative to a different circle of people. Bodies such as the Foundation for Common Land are evolving and contributing to leadership and offering fresh perspectives.[8]

Hill sheep grazing is an important factor in the shaping of the structure, diversity and functioning of terrestrial ecosystems. The benefits or services are a part of public goods and reflect the outcomes for the natural environment and people that arise from their functioning. Ecosystems services and public goods relevant to pastoralism

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[6] Taylor, M. (2013) 'The policy presumption', *RSA Journal*, Issue 4, pp. 11-15.

[7] Great Britain. Department for Environment, Food and Rural Affairs (August 2011) *A strategy for English wildlife and ecosystems services*.

[8] The Foundation for Common Land is a registered charity managed by a board of trustees. Its objectives include the conservation of pastoral commoning for public benefit through responsible and sustainable practices. It also conducts and commissions research and shares the results. Education of the wider public is integral to its work.

include food production, biodiversity, and provision of clean water, landscape and access. The range of agendas and complexities of interactions emphasise the need for understanding, trust and a commitment to mutuality. Participation seems at first sight to be a simple concept but to be effective it must be an active and inclusive process leading to informed decision making and behavioural change. This publication seeks to identify key aspects of hill sheep husbandry particularly related to grazing and nutrition which have perhaps been somewhat marginalised in recent years. The text may be read as a whole or by selecting particular sections for reference. Readers will bring different experiences and understanding. For these reasons there is some overlap in order to describe topic areas comprehensively.

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The Hadfield Trust has generously grant aided the printing as a contribution to fostering understanding of hill farming as a purposeful and worthwhile occupation. Caroline Roy skilfully brought order to my draft. I acknowledge the numerous individuals who have responded to my questions and contributed to the terminology glossary. The illustrations reflect something of the diversity in hill sheep production and Kath Birkinshaw made a particular contribution from her encyclopaedic collection from the Peak District. I am grateful to H&H Reed the printers for their guidance. Jane, my wife, as always has influenced and supported with forbearance and helpful criticism for which I am truly thankful.

Andrew Humphries, Wetheral Cumbria 2015.

England’s fells and moorlands: pastoral diversity

Ian Lawson

The Esk Gorge Cumbria

Dartmoor Commoners Council

Dartmoor

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The evolution of hill sheep husbandry and its interaction with the biological environment and cultural landscape

Changeless or changing?

Andrew Humphries

The only constant is change (Hieraclitus)

Hill farming systems have traditionally been founded on self-replenishing stocks of hardy sheep in regular ages. The farms are generally dominated by rough grazings which in many areas are maintained in 'heafs', 'hefts' or 'cuts' to which particular flocks or sub-flocks are bound and acclimatised, grazing within the confines of these particular areas. In a few areas the sheep have been 'trained' by shepherds to rake the hill. They graze the lower areas in the day moving to the hill tops in the late afternoon and evening and back down in the morning.[9] Each ewe confines itself to a narrow track between high and low ground which passes from generation to generation.

Hill grazings reflect a range of variables including soils, climate, topography and management, between and within farms, and within individual hillsides. In England a significant proportion of flocks have rights to graze communal or common grazings where management is dependent on collaboration and 'good neighbourhood'.

[9] The practice of raking was most strongly expressed in the Southern Uplands and Northumbria but demands a higher input of labour for daily shepherding. Each shepherd had the care of a hirsel comprising a number of hefts, typically five or six.

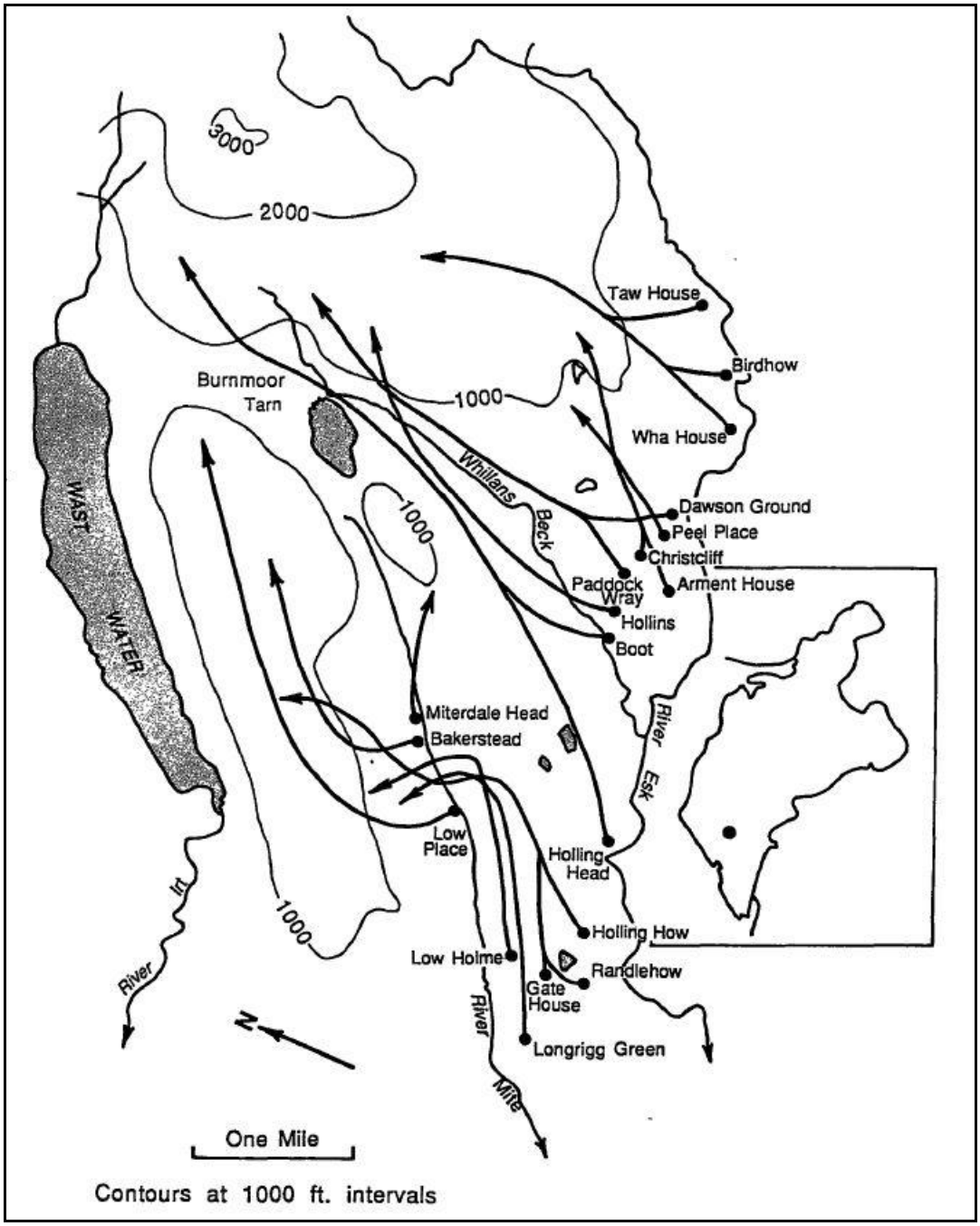

Figure 1. Sheep heafs on Eskdale commons, Cumbria (redrawn 16th century map)[10]

Hill farms with reasonable in-bye land resources may also have a draft flock of older ewes from the hill that produce cross-bred lambs, or alternatively they keep a different breed or cross-bred on the lower or marginal parts of the farm. These flocks became more significant from the early decades of the nineteenth century. Cattle play a varying role, but are generally subsidiary to the sheep and demand higher fixed costs. In recent decades hill farms have been regarded as synonymous with the European

[10] Dilley, R.S. (1991) *Agricultural change and common land in Cumberland, 1700-1850*. Open Access dissertation and theses, paper 8396, p. 168. The map is redrawn from a map in CRO/Sykes/II.

Union (EU) category of 'Less Favoured Areas'[11] which are constrained by permanent natural handicaps of climate, infertile soils and topography in particular. They generally comprise land suitable for extensive livestock farming, where depopulation is a danger and where the conservation of the countryside is important.

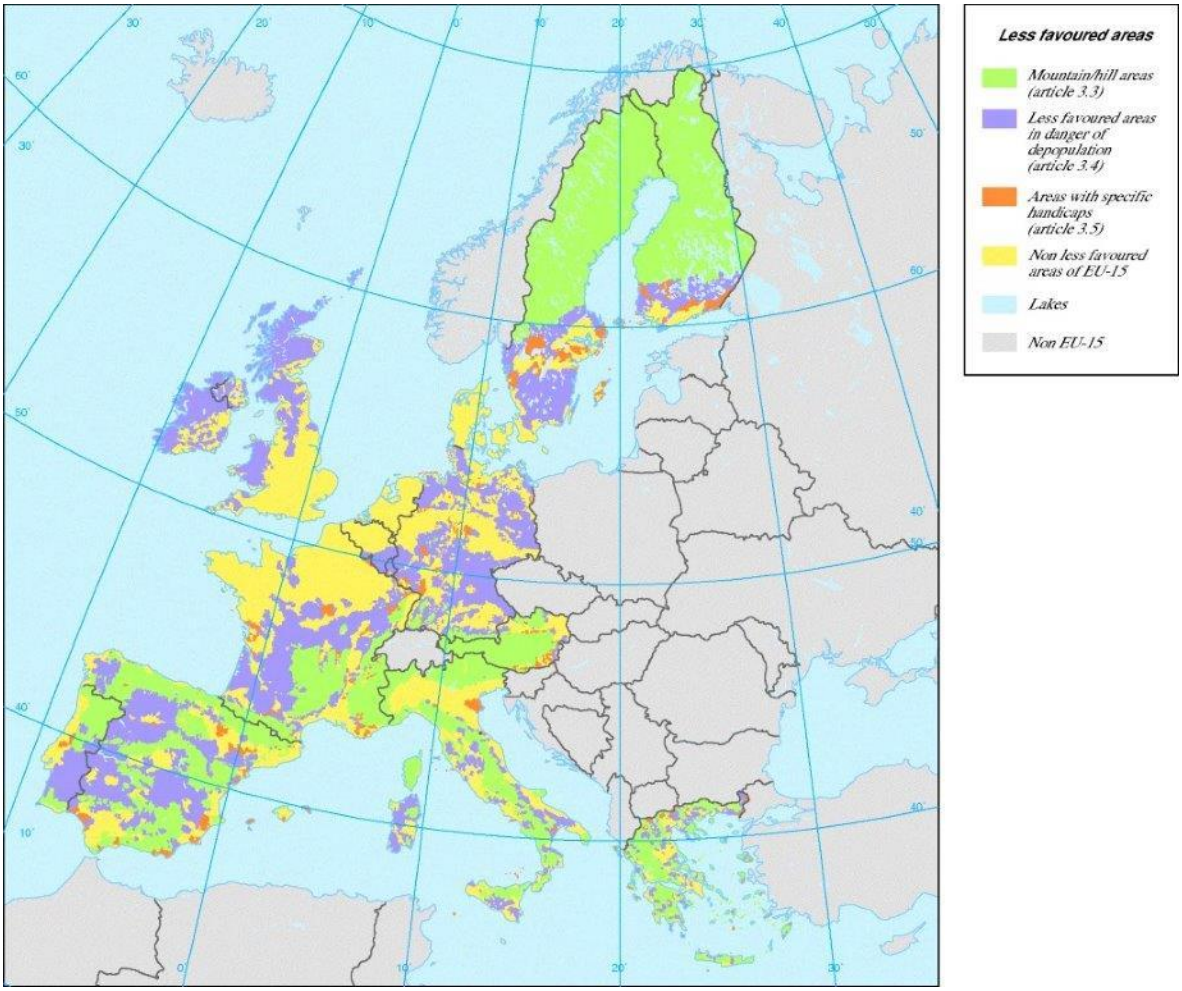

Figure 2. Less Favoured Areas in EU (15 states), 1992

By the late 1960s, sufficient progress in research, development and practice had secured an understanding to enable a synthesis of knowledge to be integrated more widely into practice, offering a systems approach to improve hill farming productivity, through positive input-output relationships. These now need to be increasingly sensitive to the needs of other public goods. The challenge to reconcile the common aims of stakeholders, expressed through different objectives, is at the heart of change management with direct implications for sheep nutrition.

Some biodiversity goals in Europe crucially depend on low-intensity farming over significant areas that favour natural processes and ecological networks. This is leading to a recognition of 'High Nature Value' (HNV) farming and is particularly relevant to hill areas. However, the level of translation of HNV into policy and

[11] There is no statutory definition of 'hills and uplands'. EEC Directive 268/75 Article 3.4 covers the English LFA which is distinct from the Mountain Areas under Article 3.3, and small areas of specific handicap under Article 3.5. These amount to 1.55m hectares.

practice remains uncertain. Crucially, nature conservation policies in Europe have focussed on protecting the biodiversity value of farmland rather than actively maintaining and developing beneficial farming systems.[12] A systems approach to the pastoral use of hill land needs to create a working association between stakeholder interests that is reflected in land management systems, which value the contribution of livestock and people as vital. Collaboration within and outwith agriculture is not an option; rather it is a necessity.

Natural England[13] has a statutory role to work alongside other stakeholders to secure sustainable management of the uplands, and recently published a review of evidence to support its advice and decisions. The impact of moorland grazing and stocking rates informed a major consideration 'to comprehensively review the effects of different grazing regimes and stocking rates on upland landscapes and biodiversity.' The review concluded that the quality of evidence was found to be variable, identifying 'a relative lack of reliable studies on which to base management decisions.' That in itself is an important and valuable conclusion and points to the need for a sounder scientific base for decisions and sensitivity to site specific diversity.[14] Further examination of this and other reports reflects concerns focussing on the impact of livestock grazing solely on biodiversity, rather than considering the interactions in a more holistic fashion as articulated by the European Forum on Nature Conservation and Pastoralism, in its review of experiences across 35 countries in Europe.

There is clearly a rationale that a sound understanding of the agricultural characteristics of grazing, and the experience and skills of farmers, should be included in developing systems that are genuinely focussed on sustainability. The vegetation of the uplands of England forms the primary diet of the grazing stock. Changes in vegetation have an impact on biodiversity and ipso facto animal diets and farming businesses. All are valid parts of understanding the complexities of hill land management. However, hill farming practices themselves, whilst diverse, are based on common principles which need to be considered on a site specific basis. Land management innovations may be adopted or rejected but experience has shown that on England's hills the response is more frequently through adaptation to diverse situations. Best practice is achieved by taking cognisance of local experience.

In 2007 the UK became a signatory of the European Landscape Convention (2000). This requires a recognition by signatories to establish measures that express the legal principle that landscape is a fundamental component of human populations' identity, and an essential factor in their quality of life. Management based on comprehensive consultation should be reflected in policies. The emergence of cultural landscapes as recognised public goods in contemporary policy considerations holds implications for English hill farming.[15]

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[12] Oppermann, R., Beaufoy G. and Jones, G. (eds) *High Nature Value farming in Europe*, pp. 13-14.
[13] Natural England is a non-departmental government agency with responsibilities to protect and enhance the natural environment.
[14] NEER006 *op.cit*. The report asserts that in only 21% of the individual conclusions is the evidence judged as strong.
[15] Created by the Council of Europe in 2000, the convention is committed to raising awareness of living landscapes and was signed by the UK in 2007.

Hill sheep in the evolution of pastoral agriculture and a bio-diverse environment

Whilst the nutrition and management of hill sheep is practised in relatively isolated settings with well recognised limitations to production, it is nevertheless part of, and an example of, dynamic agrarian development that has progressed since the Neolithic period. Between five and ten thousand years ago, hunter gatherer systems gradually gave way to the domestication of livestock, which on England's hills initially favoured cattle, and later, sheep. Fig. 3 summarises the pattern of succession in pastoral development. Changes are dynamic and key elements are reversible and central to some of the issues discussed in this publication.

Forest ⟶	**Open woodland, scrub and dwarf shrubs**	⟶ **Grassland**[16]
Deer Swine Wild cattle Predators many and widespread	Cattle Swine fewer Deer few Predators fewer	Sheep Cattle Predators few

Figure 3. Stylised development of pastoral systems on England's hills[17]

Fig. 3 is stylistic since the evidence on sheep breeds has yet to be more clearly determined. However what is clear is that domesticated breeds of sheep represent a range of changes from wild sheep for different purposes in different environments, over a period of perhaps four to five thousand years. Some breeds, such as the Soay retain stronger elements of primitiveness. Recent work on three northern hill breeds suggests that the Herdwick and Rough Fell breeds show genetic characteristics pointing to a common ancestry with sheep in Scandinavia, Orkney and Iceland. Further progress can be anticipated in evaluating the natural history of hill sheep, and a greater understanding of the range and values of their genomes.[18] The Natural England Evidence Review[19] recommends that a better understanding of the grazing and ranging behaviour of the common hill sheep breeds in England is needed, as the few studies that exist are based on Scottish Blackface sheep.

All branches of agriculture are dependent on the environment, especially soils and climate; which have in practice been less modified for agriculture on our hills than elsewhere. They shape and limit the range and intensity of farming practice, in which sheep grazing in semi-natural systems continues to be central. Agriculture's relationship with the environment in contemporary practice has nevertheless changed significantly in recent decades.

Traditionally the concept of conquering nature reflected a fight for survival against weather, pests and diseases in the absence of useful scientific understanding. Through human ingenuity, agricultural improvement provided the means of sustaining a growing population. Such processes are naturally reflected in the culture of agrarian

[16] Here the term 'grassland' should be interpreted as rough grazings.
[17] The ecological pattern suggested by Pearsall, W.H. (1950) *Mountains and moorlands*. London: Collins, p. 256.
[18] PLOS ONE, an open access peer reviewed journal. *The Natural England evidence review,* NEER006. Available at http://dx.plos.org/10.1371/journal.pone.0087823.
[19] *Op. cit*., p. ix.

communities. The nature of agriculture is now seen as embracing vulnerable flora and fauna, precious landscapes and access for the refreshment of urban populations. The complexity may be obvious but the balance must recognise the continuing importance of pastoralism as a productive expression of farming culture, as well as its role in providing non-market benefits. The term 'semi-natural' implies a dynamic challenge to balance 'livestock production' with due regard to other public goods, especially flora and fauna. In this context it is important to recognise that in continental Europe, farming in Less Favoured and Mountain areas has typically been smaller scale, and generally a part-time activity. In the UK therefore a greater emphasis on food production as a key income source on farms is a cultural norm. English hill farms by comparison to the wider EU are larger, and founded on significant year round grazing, reflecting distinctive differences in approach, objectives. These need to be reflected in policy formation and implementation:

> *High Nature value farmlands are the result of centuries of agricultural cultivation. In the past the farming systems that brought about these high nature values as a side-effect [that] followed their economic purpose.*[20]
>
> *... There is a powerful consensus that Europe must strive to maintain its HNV farming systems embracing NGO's … institutions such as DG Environment and the European Environment Agency. Indeed HNV farming has featured in EU policies … for several years … Nature conservation policies traditionally have focussed more on "protecting" farmland of biodiversity value, rather than on maintaining the beneficial farming system.*
>
> *HNV farming as a policy concept says that the first priority is to maintain farmland of environmental value in active low-intensity farming use, ie to maintain the farming system and prevent its abandonment or intensification. The approach takes full account of the socio-economic realities of farming systems and puts these at the heart of conservation strategies.*[21]

For those engaged in managing land and delivering policy objectives in the hill areas of Britain, understanding sheep grazing and nutrition are integral to effectively reconciling the complexities of multi-functional management. In particular the '*agri*-cultural' elements that characterise its past remain relevant to its future.

[20] Dacian Ciolos, Commissioner for Agriculture and Rural Development, Janez Potocnik, Commissioner for the Environment, European Commission (2012) in Oppermann, R., Beaufoy, G., Jones, G. (eds) *High Nature Value farming in Europe, 35 European Countries - experiences and perspectives*, verlag regionalkultur, p. 9.
[21] *Op. cit.*, pp. 13-14.

Evolution of cultural landscapes through changing hill sheep systems

The inspirational landscapes of the English hills reflect interactions between people and their environment in a continuum from Neolithic times. The past millennium has incrementally developed pastoral systems primarily based on sheep, in response to market and other external influences. These interactions are diverse and complex in temporal and spatial distribution. An overview of key influences on the establishment and adjustment of hill sheep production is necessary to understanding contemporary cultural landscapes. Regional and local variations in practice can be considerable even over small distances and require a site specific examination of evidence to optimise outcomes.

The Monumental Turf
Albrecht Durer, 1503[22]

Prior to the Norman Conquest, a more subsistence upland economy relied on sheep as a multi-purpose species, providing a wide range of products for domestic use and local markets. With the Normans came an opportunity to enjoin the European wool trade and the establishment of a market based economy driven by export demand. The granting of large upland areas to the Norman nobility as 'the spoils of conquest' was followed by the gift and grants of parts of these seemingly unpromising hills in England, Wales and parts of Scotland to monastic orders as a means of securing a safe passage to heaven for the soul of the donor. These endowments or chantries were essentially monetary trust funds to secure a stipulated number of masses to speed the donor's soul in an upward direction.

The monastic orders had come from Europe where they already engaged in land-based commercial activities on a large scale, with particular emphasis on wool, the key product in the medieval European economy. In the British uplands the monks found the solitude that they required and coincidentally recognised the commercial potential of their surroundings. Encouraged and assisted by Norman nobility through grants, exchanges of land and the definition of boundaries, agricultural estates were formed. Initially cattle herds or vaccaries were established in the valley heads. Sheep

[22] Durer's masterpiece painted in 1503 provides a representation of hill grassland (Bavaria) through a common meadow created as cultural landscape. The species include dandelion, creeping bent and meadow grass, embracing a sense of order which inspired the artist. Such turf remains widespread in the English uplands.

expansion across the fells and moors developed differentially.[23] Sheep walks on a large scale yielded wool for export to the continent, with the Italian and Flemish buyers prominent in the trade. Their example was followed by others, some large landowners, others typical small farmers. The Barons in 1297 stated clearly that wool in England amounted to half the value of the whole land.[24]

The Cistercians were of particular importance through the innovative creation of lay brothers, which facilitated the labour that sheep farming on a grand scale required. Income followed to finance the building of abbey and priory churches that are such valued elements in the cultural landscape of contemporary Britain.[25] Many monasteries had their own export houses, trading their own wool and that from other flock owners. Their reputation for well-presented wool enhanced demand and profitability.[26] The result was large flocks of sheep with the focus on wethers for wool production. Cheese production is recorded from the milking of breeding ewes as well as cattle.[27] Other monastic orders also engaged in hill sheep keeping but generally on a more modest scale.

Sheep continued to be important in a growing market economy in succeeding centuries, particularly where and when textile manufacture markets at home and abroad were expanding. Through the wool-based economy, a significant impact on the landscape followed, and its legacy remains recognisable through vernacular features expressing local identity. Monastic settlements, domestic farm buildings and stonewalls have moulded and shaped landscape patterns with structures and textures that are highly cherished. In practice the Cistercian influence varied in different areas, being particularly strong in the hills and moors of northern England. The dissolution of the monasteries 1536-41, accelerated an established trend transferring their estates the hands of larger farmers and landowners. Monasticism was already in decline. The response included an expansion of yeoman farmers who benefitted from rising prices, as the population of England rose from 2.5-3.0 million to over 5.0 million by 1660.

Until the late nineteenth century, wethers featured strongly in hill flocks as primary sources of wool and high quality mutton for a growing urban and industrialising society. These castrated males which were typically kept until three or four years of age were also valued for their ability to hold the heaf boundaries against other flocks and in utilising the hardest ground. Their relatively lower selectivity of diet and without the nutritional demands of pregnancy in late winter compared to ewes, made wethers genuinely ‘easy care’ sheep.

[23] Collingwood, W.G. (1925) *Lake District history*. Kendal: Titus Wilson.
[24] Power, E. *The wool trade*. The Ford Lectures.
[25] Butler, A. (2006) *Sheep*. Ropley: John Hunt Publishing. The lay brothers, being unwaged and not part of the formal monastic life, provided a cost effective work-force not available to other orders or lay estates. Other monastic orders engaged in wool production but generally on a more modest scale than the Cistercians.
[26] Holm Cultram and Furness Abbeys for example had export licences in the 1220s and records of Cumbrian wool export sales appear in the accounts of Pegalotti, an Italian wool merchant, in 1315.
[27] Bolton Abbey accounts in 1298 show 130 stones of sheep’s cheese and a small amount of sheep’s butter.

Andrew Humphries

Rievaulx Abbey, North Yorkshire

In the later nineteenth century the importation of cheap refrigerated Canterbury lamb from New Zealand dramatically challenged the domestic hill farming economy. The first shipment of frozen meat was sent in 1882, marking a turning point for New Zealand sheep farming, and a challenge for British hill farming. In 1895 New Zealand exported 2.3 million sheep carcasses, rising in 1900 to 3.3 million, and in 1910, 5.8 million.[28] Lamb in Britain had been the perquisite of the privileged as a seasonal delicacy dating from at least Elizabethan times. New Zealand Canterbury lamb rapidly pushed home-produced mutton aside. Wethers, the principal source of mutton from the hills were rapidly displaced, as public taste for younger, smaller and leaner joints changed the whole composition of hill flocks. They increasingly comprised a preponderance of breeding ewes with a different pattern of nutritional need.[29] Falling wool prices in response to imports from Australasia, and the replacement of tallow (mutton and beef fat) by imported vegetable and whale oils, hastened the demise of wether flocks. By 1914, only 32 years after the first frozen lamb imports, very few wether stocks remained.[30]

These changes necessitated significant adjustments to breeding strategies towards earlier maturing lamb.[31] This had the effect of making the care of ewe lambs to breed at an earlier age more critical.[32] Finishing wethers at three to four years of age from the hill gave way to flocks almost entirely devoted to breeding ewes, lambing at two to three years of age. In practice this meant growing replacements to 80% of mature

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[28] Stringleman, H. and Peden, R. 'Sheep farming - the refrigerated meat trade', *Te Ara encyclopedia of New Zealand*, p. 5.

[29] Fraser, A. (1954) *Sheep farming*. 6th edn. London, pp. 15-22. Also Robert Hudson MP (1942) *Second reading of the hill farming bill*, 3 June.

[30] Great Britain (1944) *Report of the committee on hill sheep farming in Scotland*. HMSO (Cmd. 6494, para.15).

[31] Early in this context is relative to what had gone before. Hill sheep remained, and still remain, slower maturing than lowland breeds.

[32] For most hill areas of England, female replacements lambed for the first time at two years old. In the most challenging areas a further year was, and remains, necessary to ensure a satisfactory size and condition in the mature breeding ewe.

weights by the first mating; a change precipitated by global trading.[33] The flood of produce from the 'New World' was followed by a period of economic depression that lasted until the end of World War Two. Hill sheep production continued necessarily as a low input-low output system, with little room for high risk initiatives.

After World War Two the strategic need for greater food security expanded the demand for a supply of breeding stock to lowland farms.[34] The hills provided the main reservoir of stock for the national flock which expanded with EU membership. The demand for breeding stock from the Less Favoured Areas influenced hill breed distribution and development within breeds. The links between hill and lowland established a stratified system of production that expressed mutual benefits.[35] Hill farmers, who had traditionally sold fat wethers directly from the hill grazings, lacked the nutritional resources to finish younger lambs for direct marketing. Generally these were sold to lowland farmers to finish on grass, fodder crops and by-products.[36] The inability to finish lambs and gain the direct advantages from price guarantees exposed hill farmers to fluctuating prices at the autumn sales and lengthened the food chain. A lack of capacity to retain and finish stock in systems that maximised numbers in summer and minimised them in winter created vulnerability in periods of low prices. Methods of finishing lambs have occupied hill farmers with varying degrees of success and still need further development to optimise the production of high quality meat from a semi-natural environment. High feed costs combined with the declining food conversion ratios that come with lamb maturity, challenge the opportunities to shorten the food chain.

Hill farmers in the present generation are facing challenges and opportunities linked to environmental and other public goods, bringing external influences and changes in quick succession. The issues relating to reductions in stock numbers, and questions about the sustaining of a sense of purpose, currently challenge all stakeholders as interdependent interests.

What is clear at a strategic level is that systems have for a thousand years been shaped in part by external markets and national policies in a challenging environment. Through the development of customary practices appropriate to the locality, market hill farmers have adapted to significant change. Keeping sheep over the millennium since the Norman Conquest has engaged farmers in the challenges of animal nutrition in a harsh environment which both shaped, and was shaped, by pastoralism. At its heart lay the challenge to use and provide for livestock specifically adapted to the hills. Each age used its brains and hands as pioneers in their own context, adding new insights and skills down the generations.

[33] Typically for a 50-55kg ewe today this means target weights of 40-44kg by 19 months of age.
[34] By the 1930s following sixty years of economic decline in favour of cheap imports, Britain was the world's largest importer of agricultural produce.
[35] Older hill ewes were crossed with other breeds on marginal land to supply high quality crossbreds with hybrid vigour, mothering ability and milk.
[36] The unfinished lambs were sold as 'store lambs'.

Andrew Humphries

Swaledale wether lambs finishing indoors

The quality of pasture, the core pastoral resource, revealed itself to the observant centuries ago. The monks of Kelso valued a change of pasture as early as 1165. The Liber de Calchou[37] mentions the shielings on the summer pastures in the hills to which the cattle were moved in June to increase the milk supply, to put a bloom on their coats and to conserve grass at home into hay for the winter.[38] Fodder in winter was always a consideration especially in years of severe weather. Shielings were in evidence in all upland areas from Dartmoor to the northern extremities of Britain. They were most important in the Highlands where commercial sheep production came only in the late eighteenth century.

In contrast, sheep moved into the hills at an earlier time on most of the English hills and moors displacing the shieling system. Areas varied in timing and emphasis. On Dartmoor and Exmoor for example the Norman Period was influenced by Forest Law leading to a high population of deer. Cattle have been significant since the thirteenth century on Dartmoor. Agistment entries in the court rolls for North Dartmoor 1571-1 give cattle numbers of 1,224 belonging to 54 owners and 830 sheep from 21 owners.[39] Sheep gained prominence from the later seventeenth century, whereas the Lake District was primarily sheep country at least a century earlier.[40]

[37] Probably 14th century.
[38] Franklin, T.B. (1953) *British grasslands.* London, p. 12. The 'Liber de Calchou' is the cartulary register of land and privileges.
[39] Cox, J.C. (1905) *The royal forests of England*. London, p. 345.
[40] Dartmoor was one of many royal forests subject to forest law to protect the hunting grounds of the crown. See Cox, J.C., *op. cit*., pp. 340-348.

Communal grazing has survived on a considerable scale in the south-west of England, Cumbria, Yorkshire and Durham. In Northumberland and the Welsh Marches a small area of commons remains whilst in the Peak District enclosure has been virtually complete in its extent.[41]

Customary practices relevant to year-round grazing systems distinguish upland pastoralism in Britain from practice in continental Europe. Sydney O. Addey in 1893 described sheep and cattle feeding in Derbyshire where holly leaves and branches provided the principal supplementary fodder. The practice, which dated back to the earliest period of hill farming, disappeared soon after Addy's observations.

Ash pollard, Borrowdale
Andrew Humphries

Abraham de la Pryme recorded in 1697 the use of holly, particularly on the grits and sandstones of the southern Pennines in Yorkshire and Derbyshire where:

> *…they feed all their sheep in winter with holly leaves and bark.*

Manorial courts exercised control over its sustainable use.[42] Thomas Pennant in the Lake District in 1772 noted a holly park preserved entirely for sheep. The farm lease and sheep bond for Glencoyne on Ullswater in 1785:

> *…assigns liberty and privilege of cropping holly wood in winter for feeding the sheep.*[43]

Lopping at 2-6 years produced leafy branches beyond the reach of sheep that could be harvested for winter fodder. Delaying lopping up to 20 years provided poles for farm use. Ash pollards in particular are still visible evidence of a 'wood pasture' system of winter fodder production. Their active management is included in some agri-environmental schemes,[44] regenerating the thumbprint of natural history after a century of neglect. The use of woodland areas for pasture and shelter historically extended into the uplands. Wildlife Trusts have reported upland ash-woods in the Mendips and Yorkshire Dales as historically significant, while others have provided

[41] For an overview of common grazings in the English Uplands see www.foundationforcommonland.org.uk. 'Trends in pastoral commoning' was produced for Natural England.
[42] Radley, J. (1961) 'Holly as a winter feed', *Agricultural History Review, 1x,* pp. 89-92.
[43] Humphries, A.B. (1998) *Report to the National Trust on the grazing rights appurtenant to Glencoyne farm.* Unpublished.
[44] Now entitled Stewardship Agreements.

evidence for the Howgill Fells and Lakeland.[45] Shedding light on the complexities of wood pastures which generally seem to have had more links with cattle than sheep may inform the possibilities for future upland wood-pasture and agro-forestry.

Whilst burning may be perceived as a relatively modern management tool associated with grouse moor management it has been a natural and deliberate phenomenon that probably emerged as a 'useful' technique in Neolithic times. Also known as 'swaling' or 'swiddening', it has been applied to dwarf shrub and grassland species, especially *Molinia*. On Exmoor in 1338:

> *Richard Gaune of Leucote burnt the moor of the Prior of Taunton near to the Lord King's land of the forest… from which burning the flame of fire leaping out… burnt a hundred acres of heath in the same.*[46]

It may be supposed that graziers considered burning as a useful technique to encourage more nutritious young heather and possibly as a means of controlling its dominance to encourage a mix of species, especially grasses. It was ordered at Millom in Cumberland in 1590 and again in 1595 that 'none shall burn any ling upon the fell but within his own heaf.' The risks associated with burning clearly implied the need for a code of conduct, and in 1607 a statute forbade:

> *…raysing of fires in the moorish grounds and mountainous Countries in the north of England between May and September on pain of a months imprisonment.*[47]

In the nineteenth century the value of the sporting asset associated with grouse would have been an imperative for owners of heather dominant grazings to take firm and direct control as the writer of this letter suggests:

> *I have been informed that a large extent of lingy ground within Skiddaw Forest has been set fire to and the ling burned and destroyed. Have you any knowledge of this or any means of ascertaining the offenders, as if they could be discovered I apprehend it will be Lord Egremont's determination to prosecute them.*[48]

The focus away from wether flocks towards earlier maturing sheep from the late nineteeth century emphasised the increased importance of improved in-bye land for winter fodder production. The seasonal needs of flocks comprising mainly breeding sheep increased its importance. These and many other thumbprints of history are embedded in upland landscapes across England, and have influenced changes in customary practice. Sheep breeds evolved through selection and adaptation to local

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[45] 'Virtual fauna of Lakeland', *Wood pasture and parkland*. Available at www.lakelandwildlife.co.uk/biodiversity/key_hb_woodpastureparkland.html (Accessed 26 March 2014). The Wildlife Trusts. *Upland mixed ashwood*. www.wildlifetrusts.org/wildlife/habitats/upland-mixed-ashwoods (Accessed 26 March 2014). The potential of active wood pasture or agro-forestry management as a relevant part of contemporary land management in particular circumstances may have merit.

[46] McDermot, E.C. (1911) *The history of the forest of Exmoor*.

[47] Darling, F.F. (1947) *Natural history in the highlands and islands.* London: Collins.

[48] CRO/D/Ben.

conditions and market opportunities. The establishment of breeds preceded that of breed societies:

> *People did not say to each other -"Let us establish a breed". Rather they said "here we have a useful and profitable breed. We should protect its purity and our own interests as possessors of this valuable breeding stock…."*[49]

Whiteface Dartmoor, Exmoor Horn, Lonk, Gritstone, Swaledale, Dalesbred, Herdwick and Rough Fell are examples of breeds created by communities. They command remarkable loyalty from breeders, though inevitably changes in distribution have, and will continue to reflect the economic environment. Several have disappeared due to enclosure and the disappearance of their 'habitat'. In other cases market influences, the impact of agri-environmental agreements and an adjustment to the relative importance of stratification have reduced numbers within particular breeds.[50] Change is constant. Matching sheep to hills of different types has been important in maintaining breed choice. In the case of breeds that cover large areas of the uplands such as Swaledale, sub-breeds have emerged with different emphases in breeding and selection to reflect their diverse grazings and systems.

Gritstones and Lonks for example are large sheep with a rumen capacity suited to the wet millstone grit areas and the coarse herbage of the mid and southern Pennines. Conversely, Cheviots have been favoured on the grassy hill areas of the Southern Uplands, whilst Swaledale and Blackface have traditional associations with heather fells and moors. The Whiteface Dartmoor is an example of an ancient breed, indigenous to Dartmoor. It has dwindled in numbers through the expansion of other breeds including Swaledale and Blackface, which have characteristics that better fit contemporary commercial hill sheep production with a propensity to produce crossbred females from draft ewes for lowland breeders. Others like the Limestone sheep of south Cumbria became extinct in the twentieth century. Conserving the genetic capital that the diverse range of breeds and sub-breeds contains is an important part of sustaining contemporary and future pastoral agriculture in the hills.

[49] Fraser, A. (1960) *Animal husbandry heresies*. London, p. 34.
[50] Pollot, G.E. and Stone, D.G. (2006) *The breeding structure of the British sheep industry*. Defra.

Derbyshire Gritstone

Cheviot

Whiteface Dartmoor

Source: RBST

Chapter 2

Key principles and approaches to hill sheep nutrition

Systematic studies

Until the 1960s there had been no systematic scientific study of hill sheep systems which had evolved according to custom and practice, linked to local circumstances. Over time, market demands changed emphasis in respect of wool, mutton, lamb and breeding stock, stimulating local responses of gradual adoption and adaptation. Trow-Smith in 1950 wrote that:

> *…a knowledgeable eye and experienced hand are sufficient "science" in themselves.*[51]

Whilst affirming the critical value of experience, the comment fell short of what was required to sustain continuing progress in hill sheep husbandry, embracing the opportunities that science could facilitate. Exceptionally, the work on hill land improvement led by Sir George Stapledon and the Welsh Plant Breeding Station from the 1930s had initiated a significant response of applied science that reflected his zeal and charismatic leadership, but which was necessarily limited in scope. Though based on the Welsh Plant Breeding Station and the Cahn Hill experiments, he and colleagues also evangelised their approach in England.

Broader systematic studies of hill sheep farming germinated in the 1950s and 1960s under the leadership of the Hill Farming Research Organisation.[52] A baseline of information and knowledge directed progress towards systems development and its diffusion into practice. Hill sheep nutrition formed an important element in the process, but in itself did not provide the range of solutions necessary to effect comprehensive change. Ecosystems comprise many components and therefore present complex interaction possibilities. Systems research is concerned with putting components together and evaluating the syntheses. From the 1960s this approach established a range of recognisable changes to hill sheep systems albeit based primarily though not exclusively on production. The aim was that changes should be consonant with maintaining or improving natural resources.[53] Contemporary stakeholder interests inform the critical components of emerging hill land management systems, seeking outcomes that are more complex. Grazing remains a central feature, but the nature of husbandry practice is again being shaped by external influences beyond the direct control of hill farming communities. Progress remains limited until practical approaches to participation remove a culture of consultation fatigue. Getting the process right is not about what you do as much as how you do it.

[51] Trow-Smith, R. (1950) *English husbandry*. London, p. 160.
[52] The organisation followed the Balfour and De La Warr committee reports on the future policy for hill farming in Scotland, England and Wales at the end of World War Two.
[53] Cunningham, Professor J.M.M. (1979) 'A perspective of twenty-five years of hill farming research', *Science and hill farming*, HFRO 1954-1979. Edinburgh, pp. 1-8.

Approaches to applying improved nutrition to support improved production

In the decades following the Second World War the approach to supplementary feeding hill ewes was the subject of robust debate, concerned with costs, benefits and the possible impact on grazing behaviour and hardiness. Now, in the twenty-first century, supplementary feeding is widely practised as a key element in the production of quality lambs of pure hill breeds in Britain. In earlier decades supplements were generally limited to storm feeding of hay. Those who were more generous frequently found themselves the subject of strong criticism from a significant number of their peers and advisers toward practices that were both expensive and perceived as potentially damaging to hardiness. The changes that came with imports of wool and lamb from the New World had necessitated changes from the late nineteenth century towards earlier maturing animals capable of producing lamb rather than mutton if domestic markets were to be secured. This in turn was reflected in nutrition appropriate to changed needs, though this aroused valid scepticism:

> *…if lowland sheep-farming practices are carried up the hill, hill sheep will soon have the characters of lowland sheep and lose the special virtues of being hardy, independent and easily kept…*[54]

In practice hardiness remained vital but increasingly in the context of relatively earlier maturing and more productive sheep stock. The needs of many though not all hill flocks had changed. Adjustments to nutrition gained validity through knowledge exchange, observation and individual adaptation. Some reduction in nutritional risk was achieved by leaving shearlings unbred until two shears,[55] delaying lamb production until growth had reached the desired level of maturity. Conversely, older ewes with twin pregnancies frequently suffered considerable nutritional shortfalls that were expressed in lamb mortality and poor milk yields. Winters like that of 1947 survive in communal memories. Lambs reared per hundred ewes varied but on harder farms were frequently well under 70 in years of harsh weather with added mortality rates for breeding ewes.

[54] Quotation from Alan Fraser M.D., lecturer in Animal Husbandry, lately Research and Advisory Officer on sheep, Rowett Institute, Aberdeen and director of the Institute farm at Aberdeen and its hill farm in Argyll.

[55] These would be put to the ram at 31 months of age to lamb at three years old.

Table 1. A Northumberland trial of feeding cake to hill ewes in winter[56]

	1954-5		1955-6		1956-7		1957-8	
Type of Winter	**Mild**		**Average**		**Very Mild**		**Severe**	
	No Cake	**Cake Fed**	**No Cake**	**Cake Fed**	**No Cake**	**Cake Fed**	**No Cake**	**Cake Fed**
Lambing % (reared)	94	01	94	102	104	110	91	102
Lamb weights at weaning (lbs)	59	66	61	67	78	76	61	67
Cost of concentrates per ewe		2s-6d		7s-0d		8s-9d		9s-0d
Additional return per ewe fed cake		17s-0d		17s-0d		8s-0d		21s-0d
Profit or loss from cake feeding		+14s-6d		+10s-0d		-9d		+12s-0d

From the 1950s, under the influence and leadership of the Hill Farming Research Organisation (1954), issues of ewe nutrition assumed a priority in research and development. The emphasis focussed on the 'hungry gap' between January and April when pregnant ewes had access to a sub-maintenance grazing diet and drew heavily on body reserves. A decade later a more systematic examination of the relationship between nutrition and a wider range of important factors had developed. Reproduction, lactation, lamb growth and other needs were examined, and nutrition from all sources became a year round consideration. The husbandry needs that had sufficed for stocks geared to breed only at the two shear stage, and with a market emphasis on wether stocks producing quality mutton and wool, had changed significantly. Adjustments and innovations in husbandry were necessary in most hill farm settings supported indirectly by policy to raise levels of self-sufficiency in temperate foods.[57] In practice the individual components of a pastoral system had been shown to interact dynamically with each other.

From the late 1950s development programmes incrementally focussed on regional testing across Britain through Experimental Husbandry Farms (EHF). Knowledge transfer by specialist and district advisers to local communities through discussion societies and demonstrations made the connections from research to farming practice and contributed to the expansion of applied science. The EHFs in England and Wales most relevant to hill sheep production comprised Great House in Rossendale (1955), Liscombe in Exmoor (1955/6), Redesdale in Northumberland (1967), and Pwllpeiran in Wales (1955).

[56] Clarke, H.G. (1958) 'Cake for the hill ewe', *Farmer and stockbreeder*: Vol. 72, 23 Sept.
[57] Leaving sheep unbred until two shear reduced lamb output by increasing the number of non-productive ewes.

Andrew Humphries

Pwllpeiran land improvement grazed by Welsh Black cattle at 1600ft a.s.l.[58]

In 1955 the Cumberland and Westmorland Farm Institute had prepared and articulated the case for an educational provision for those pursuing a career in hill farming. Low Beckside, a Lake District fell farm, was purchased in 1960 to demonstrate progressive practice, provide courses for young people from hill areas, outreach to farming communities and collaborate with the advisory services and experimental farms.[59]

The EHF publicly funded network no longer exists. More recent research has embraced mathematic modelling to provide guidance and a logical approach to decision making. Modelling is an aid to decision making but is not in itself capable of producing robust solutions, which need to reflect the diversity of practical situations and the value of well-grounded experience. Testing and demonstrating of 'near market' research radically declined under the repositioning of national policy, leaving the initiative to hill farmers, ancillary organisations and other stakeholder initiatives. The potential for, and cost of land improvement varies immensely and is further complicated by additional ecosystem aims.

In contrast the potential for land improvement in the high fells of Buttermere offers limited prospects, emphasising the nutritional value of those small green in-bye meadows and the diversity of nutritional environments.

[58] Pwllpeiran formed part of the Cahn Hill experimental area. In addition the HFRO farms in Scotland were a valuable source of 'practice with science'.

[59] Humphries, A.B. (1996) *Seeds of change*, Penrith, pp. 17-28. Hall, J.S. (1966) 'Hill farming in the four northern counties', *Journal of the RASE*: Vol. 127, pp. 17-28.

Roger Hiley

Sour Milk Gill, Buttermere

The national agenda has assumed greater complexity over the past half century with particular reference to stocking densities. Discussion frequently lacks a shared understanding of the objectives followed by a range of stakeholders, and in particular those with nature conservation outcomes as their primary aim. Of equal significance is the need for scientific evidence to underpin decisions. Policy implementation in general, and agri-environmental schemes[60] in particular, are frequently unsatisfactory to practising farmers, and in some measure to conservation focussed stakeholders. More robust science, applied science, shared scheme design, monitoring and evaluation matched with conversations that foster mutuality and innovative solutions, need to be the basis for progress in practice. Local customary practice continues to be relevant but has an insecure place in the process. The nutrition of hill sheep and the sustaining of systems that match resources should surely be a shared aim. The nature of diversity suggests the need for a more site specific than formulaic approach, which respects and embraces local custom born of experience and informed by robust and relevant science.

[60] Now referred to as Environmental Stewardship.

The art and science of hill sheep nutrition

Hill sheep nutrition does not lend itself to precise recommendations due to the greater influence of variables compared to other branches of livestock husbandry. Climate, soils, vegetation and geomorphology reflect a semi-natural environment that fundamentally compromises the rigid application of standards. These constraints have influenced stock selection for hardiness to cope with environmental challenges. Hardiness is an elusive characteristic which interacts with, and modifies nutritional needs. Factors which influence hardiness include dentition, fleece type, body shape, size, the capacity to mobilise body fat reserves in particular, and foraging behaviour. These are important considerations in breeding and selection. Science and practice must generally interact more flexibly than in lowland livestock production where environmental variables are of a lower order, and in some cases removed in part from a pastoral setting. Nevertheless the application of science in partnership with skilled husbandry has enabled hill flock performance to be enhanced, and the production of quality stock to be the key to economic success and a sense of a purposeful outcome.

The management of a hill flock of whatever size, and whether or not subject to Environmental Stewardship agreements, should respect the primary aim of farmers to produce the maximum number of good quality lambs from the flock to sell or to select for breeding. Such an objective is consistent with the concept of ecosystems services of which food production is part, and through which other services are delivered. Of all the farm livestock enterprises, hill livestock arguably offers the strongest potential to deliver outcomes of 'High Nature Value'.

The capacity to express the full potential of the ewe flock will substantially reflect the individual farm environment and the husbandry skills of farmers and shepherds. The increased productivity of hill flocks has been significant over the past two generations in particular, though pro-rata quantitatively less than in many other branches of agriculture. This reflects the enduring constraints of land and climate, but is complemented by the enhanced delivery of other public goods.

Maximum crops of vigorous and good quality lambs within the constraints of the environment are heavily dependent on ewe condition and health. Lambs born to ewes in good condition are likely to be heavier at birth and have a weight advantage that has the potential to be maintained through the grazing season. Ewe health influences loss levels and the number of replacement female lambs required to maintain the flock. Even with skilled husbandry the annual variations in climate and market prices will cause fluctuations in financial returns.

Optimising the production of quality weaned lambs

Following the Balfour and De la Warr committees' recommendations on the future role and needs of hill farming at the end of the Second World War, the Hill Farming Research Committee was established in 1945 to advise the Department of Agriculture for Scotland on steps that should be taken to stimulate the adoption into general practice of promising scientific research and experiments in new farming methods.[61] This led to the formation of the Hill Farming Research Organisation (HFRO) in 1954. By the end of the 1970s the output of weaned lamb from hill farms had demonstrated the capacity to raise production typically from 15-20 kg/ha to 30-65 kg/ha (Table 2). By the 1970s a systems based approach synthesising lactation, lamb growth and fertility on year round grazing with land improvement emerged to integrate a whole range of findings from research and experimental husbandry.

Table 2. Increased productivity through technology transfer 1960s-1980s[62]

Site	Initial Sheep Output kg/ha	Improved Sheep Output kg/ha
Redesdale EHF, Northumberland	16	55
HFRO Sourhope, Roxburghshire	28	66
Low Beckside, Newton Rigg College, Cumbria	26	37

Kath Birkinshaw

Swaledale sheep in the southern Pennines

[61] *Hill farm research, report of the Scottish Hill Farm Research Committee* (1951). HMSO. The committee included three members of the scientific and farming interests in the north of England and Wales.

[62] Humphries, A.B. (2000) 'The heafs of England', *Journal of the RASE:* Vol. 161, pp. 97-111.

The improvements in output reflect the application of relevant techniques in different environments. In the Borders, under easier conditions, the response was of a higher order than in the harder environment of the Lake District, compounded by the complexities of common grazings. Farmers responded in varying degrees, influenced by economics, the inherent potential of the land resource and risk strategies. As a rule of thumb, where the proportion of good quality improved land exceeds 10% of the total, the opportunity to express the productive potential of hill flocks increases on a rising plane.

Andrew Humphries

HFRO Sourhope Experimental Hill Farm in the Borders

Sources of hill ewe nutrition

1. Grazing

- For most of the year this will be on the open hill.[63]

- At key times such as lambing and tupping (the breeding period) the use of enclosed land is important, particularly the limited areas of improved in-bye. Improved areas are generally on the drier soils and nearer to the home steading but can include areas of allotments.[64] The removal of sheep from the hill in winter will increase the need for additional grazing and other nutritional resources. On the meadows and best grazings generally, if reseeding has taken place they will have a base of perennial ryegrass. White clover is also likely to be important, though often less in the meadows, where shading prior to cutting can limit its contribution. Over time, less improved 'native' species will come in. These will often include Yorkshire fog, sweet vernal, meadow grasses (*Poa spp.*) with *Juncus* on wetter sites. These areas may have been improved and sustained with drainage, subsoiling, fertiliser and farm-yard manure, to limit the extent of reversion.

- The grazing of sheep away from the farm on lowland areas has a place in some systems for breeding flock replacements (hoggs). Sometimes shearlings and other ewes may be away wintered on a limited scale but this will generally raise costs compared to traditional low cost systems. Lowland grazing is increasingly difficult to find, especially on the more intensive dairy farms, where the policy is frequently to remove all grazing stock by the end of February in the interests of milk production.

Andrew Humphries

Ewes on semi-improved in-bye for lambing in Cumbria

[63] In the past decade there has been a significant reduction in winter grazing under Environmental Stewardship programmes.

[64] Intakes/newtakes.

2. Conserved forage

- Sheep have changing nutritional requirements through the year. Since grass growth is seasonal, supply and demand do not necessarily coincide. During the peak summer growth period, grass is made into silage or hay on suitable meadow ground and used at times of low growth or high nutritional demand, to supplement the sheep's diet including those times when severe winter weather prevents adequate access to the vegetation. Conserving grass in this way emphasises the importance of the limited areas of improved land.

Andrew Humphries

Haymaking - winter feed conservation

3. Purchased supplements

- The use of concentrates based on cereals with added protein and minerals is generally focussed on late pregnancy and early lactation. These supplements are high cost but used carefully can have a significant impact on production. The condition of the ewe and weather conditions influence the approach from year to year.

- **Minerals for hill sheep**
  Whilst energy and protein are the key considerations in hill sheep nutrition, minerals are required for growth and production through a complex of functions. They influence bone development, enzyme activity, muscle function and hormone levels. Some are only required in 'trace' levels and are termed trace elements of which low levels of copper, cobalt and selenium are perhaps the most important. For example, copper deficiency can cause problems to the unborn lamb's nervous system. Determining the need for additional trace elements is complex especially since there may be interactions between them.

- Plants derive their trace elements from soils but do not appear to need iodine, selenium or cobalt themselves. Trace element levels vary with location especially in the case of copper and cobalt but other factors such as weather patterns and genetic characteristics can be significant. Some trace elements can be stored and compensate for periods of under-supply in the diet. Cobalt in contrast is not stored and is required continuously by rumen bacteria to supply vitamin B12 which is particularly important during ova production and early pregnancy. Trace elements may also interact with each other. The impact of cobalt deficiency is complex ranging from growth levels to poor vaccination immunity response. Cobalt deficiency is also linked to soil type.

The ewe's body reserves of fat deposited mainly in late summer and early autumn are used to balance shortfalls in feed sources especially at times of peak need. These reserves need to be replenished and are generally assessed prior to the breeding season. Sheep management is concerned with optimising the resources of the land with the addition of supplements where appropriate, so that the input-output relationship makes best use of pastoral resources.

Key episodes in the nutritional cycle of hill ewes

1. Tupping time (late autumn)

Management is generally geared to:

- Having sufficient time post weaning for ewes to recover body condition on the hill.

- Providing where possible improved grazing at tupping (typically up to 12 ewes per ha of improved land). Over the pre- and post-mating period ewes on improved in-bye, grazing swards declining from 6 cm to 2 cm, will respond to modest supplementary feeding through increased lambing rates.[65] From mating, the fertilisation of ova, migration and implantation of embryos takes just over a month. Maintaining body condition and avoiding stress where practicable are important at this stage. For hill ewes in hard conditions with snow or prolonged wind and heavy rain the use of blocks and hay may occasionally be worthwhile.

- **Body condition and condition scoring**
  The condition of a sheep can be measured on a scale from 1 (very thin) to 5 by placing the hand on the back over the last rib and feeling for the sharpness of the bones. For hill ewes the target condition ranges from 2.5 at tupping (mating) to 2 at lambing and weaning. For upland and lowland ewes higher scores are recommended. Formal condition scoring may not always be practised but the process of condition assessment is integrated into flock management whether formally or informally.

[65] Milne, J.A. and Mayes, R.W. (1986) 'Supplementary feeding and herbage intake', *The Hill Farming Research Organisation, biennial report 1984-85.* Edinburgh, p. 115. Sward is the herbage – generally grassland.

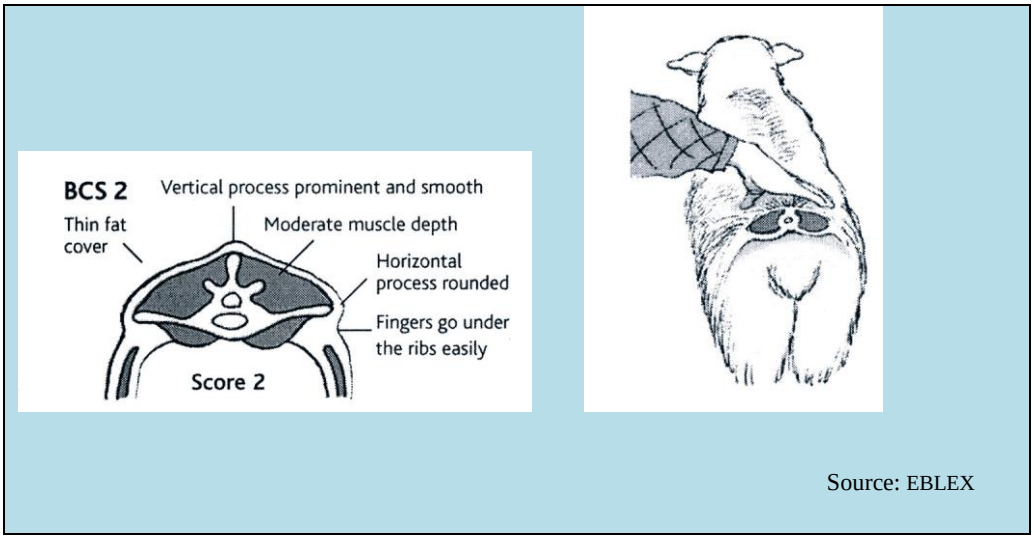


Figure 4. Condition scoring

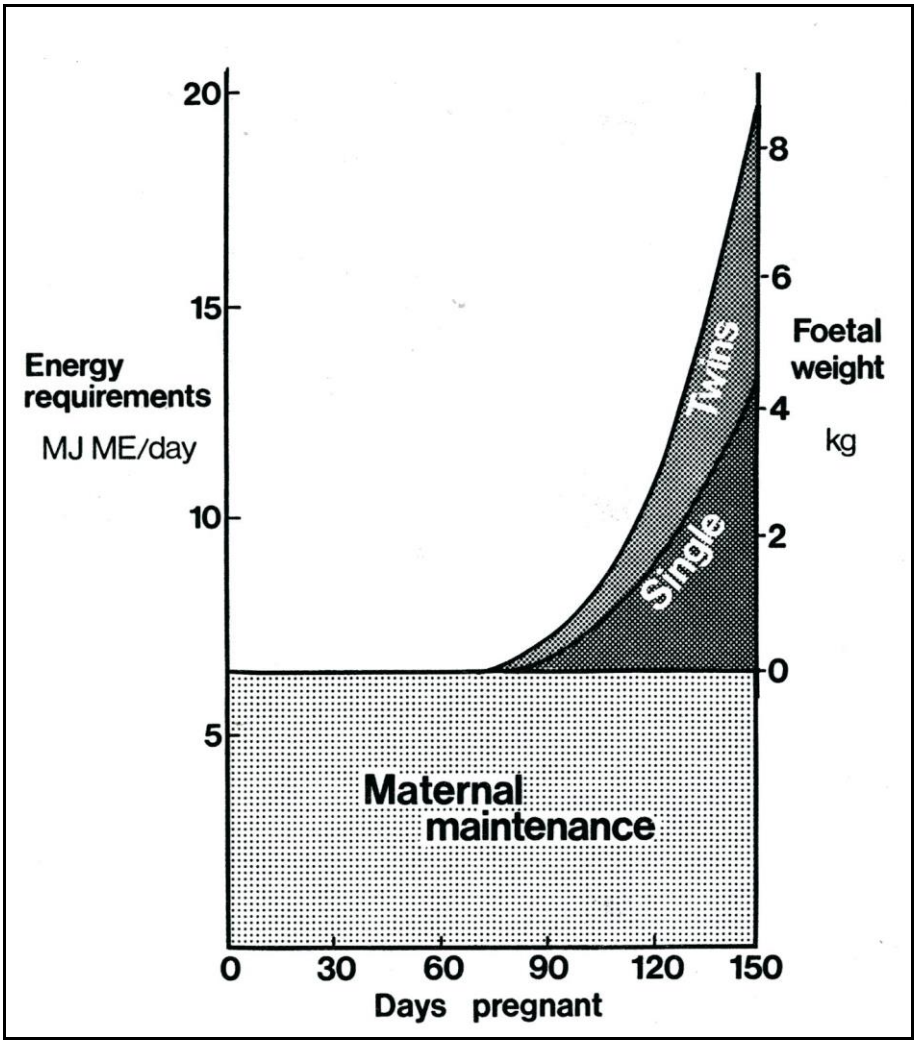
2. Late pregnancy

During early pregnancy (c.147 days[66]) lambs develop[67] but growth is limited. In the last six weeks of pregnancy lamb growth is very high and demanding of energy in particular and protein. Whilst the growth is rapid this reflects the benefit of a short period of high demand. Generally fertilised eggs are implanted in the uterus at around three weeks.

In late pregnancy a typical hill ewe with a single lamb will require twice the energy of a non-pregnant or geld ewe. A ewe with twins would require up to three times the energy of a geld ewe (Fig. 5). These levels are the theoretical ideals but in practice a 20% shortfall will have a 10% effect on lamb birth weights. The practicalities of managing the very different requirements relating to litter size can be resolved by ultrasound scanning the ewes at 80 days of pregnancy onwards to identify different litter sizes and those ewes that are geld.[68] This enables sheep to be fed and managed according to need and represents a major benefit from science and technology in matching diet to need. Lambing rates vary considerably from flock to flock according to weather patterns and the particular characteristics of the hill. A generation ago 80-90 lambs were typically reared per 100 ewes whereas now the figure would generally be higher. A 120% lambing would reflect around 25% of ewes producing twins, emphasising the value of feeding according to need. Failure to allow adequate pre-lambing nutrition especially in severe weather will bring consequences:

> *Hill ewes tend to be penalised by the "defect of their virtue" in developing foetal lambs at the expense of their bodily reserves.*[69]

[66] Pregnancy in total is about 147 days or 5 months less one week.
[67] Especially the central nervous system.
[68] Barren.
[69] Robinson, J.F., Currie, D.C. and Peart, J.N. (1961) 'Feeding hill ewes', *Transactions of the Highland and Agricultural Society of Scotland*. Reprint.



Source: HFRO

Figure 5. Theoretical energy requirements of hill ewes in pregnancy[70]

The result of over-exploitation of reserves can be a lack of strength to deliver, mother and feed the lamb. In the last two weeks or so of pregnancy the developing milk in the udder thickens forming colostrum with typically 20% protein.[71] The protein molecules carry antibodies that protect the lamb when consumed. By day two post lambing the protein levels will fall to 4-6%. For the first day or so the small intestine of the lamb has the ability to directly absorb the antibodies that are richly concentrated in the colostrum. The process is not yet fully understood but its importance is clearly well recorded.

[70] Energy is calculated as megajoules of metabolisable energy per day (MJ ME).
[71] Colostrum is a nutrient rich fluid produced by the ewe shortly prior to lambing. It contains nutrients and immunoglobulins or antibodies.

Kath Birkinshaw

Swaledale ewe mothering new-born twins

Colostrum is also a vital energy resource to allow the lamb to adjust to conditions that may be challenging in respect of temperature, wind speed and wetness, often in combination.[72] The laxative effect of colostrum in clearing the digestive tract is also important. New-born lambs are wet and have a high surface area to volume ratio making them vulnerable to the dramatic change in environmental temperature at birth. The capacity of the ewe to actively 'mother' the lamb, lick it dry and ensure that it takes an early drink depends on her condition and pre-lambing nutrition to optimise her genetic mothering characteristics.

Clearly the nutrition of the ewe in late pregnancy, the weather and the husbandry are all interdependent in establishing lamb potential for survival and growth.

[72] Heat loss following birth is countered significantly by homeostasis – the capacity of internal systems to keep the lamb stable.

Andrew Humphries

Andrew Humphries

Same place – different nutritional needs

3. Post lambing

- The first two weeks of lactation establish the potential lactation curve.

- Ewes grazing improved swards less than 4 cm will benefit lamb performance where supplementary feeding is practised.[73]

- For ewes with twins this critical period for better nutrition is much greater. Twin bearers will typically not go back to the hill at least until clipping time and often only with one lamb. For ewes with singles, the milk yield and therefore growth potential of the lamb will be modified by the vegetation on individual sites, and no generalisation should be made, except that with under-nutrition the milk yields will be below genetic capacity.

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- Whilst nutritional needs in early lactation are significantly greater than in pregnancy, the onset of spring growth and less challenge from inclement weather generally modify the scale and cost of supplementary feeding.

- For most of the year ewes will be at the hill and largely dependent on the quality and quantity of grazing available.[74]

[73] Milne and Mayes, *op. cit.* p. 115.

[74] In some instances the modification of the system under Environmental Stewardship may significantly reduce grazing on the hill, especially in winter.

Body composition of hill ewes

Research has shown that in many hill ewes, fat reserves even at the autumn peak were typically around 6 kg or 12-14% of live weight. More than half of this was used during pregnancy, leaving low reserves to stimulate lactation. Over 85% of subcutaneous fat was used prior to lambing as well as considerable skeletal fat. This is an indicator of an aspect of hardiness in typical hill breeds. Up to 20% of body protein and minerals were also utilised in pregnancy.

Fig. 6 shows stylised patterns of change in bodyweight, fat and protein during the year in ewes on open hill grazings.

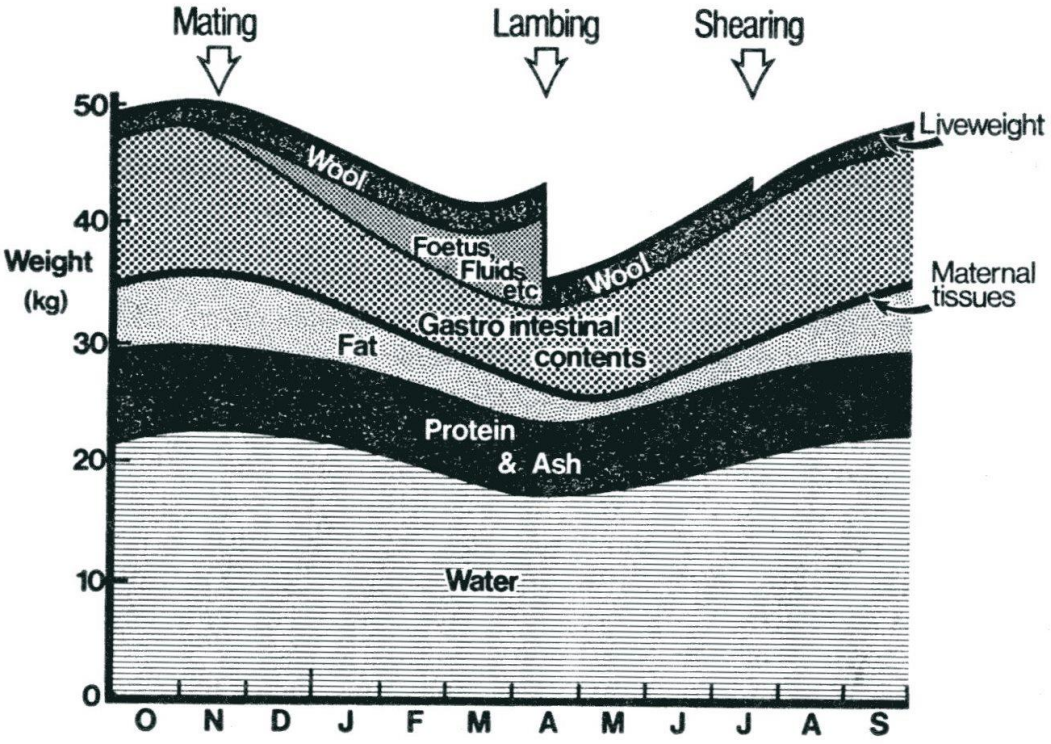

Figure 6. Patterns of change in bodyweight, fat and protein in ewes on open hill grazings[75]

Table 3 shows the general pattern of nutritional management to complement grazing, based on different land classes. Traditionally, speaned wether lambs were kept in-bye on improved ground for a variable period ranging from days to months dependent on whether they were to be finished or sold store. On hard Lake District farms in former times there was little provision of in-bye land for speaned female lambs. The solution was to smear Stockholm tar on the ewes' teats to bring suckling to a conclusion as a means of speaning without physical separation on the fell.

[75] Russel, Foot and McFarlane (1979) *Science and hill farming*. Unpublished. Lephinmore, Argyll: HFRO, p. 52. The diagram is based on an annual monthly cycle from October to September.

Table 3. Nutritional calendar for a typical pure-breeding hill flock[76]

Month	Fell Gathers	Location of Ewes[77]	Feeding Ewes	Feeding Shearlings[78]	Female replacement Lambs
November	Tupping	In-bye			Agisted to lowland till March[79]
December		In-bye/Fell			
January		Fell		Supplements	
February	Take thin ewes in-bye	Fell	Feed blocks or hand feed	Supplements	
March		Fell	Concentrates and forage	Supplements	
April	Lambing	In-bye	Concentrates and forage		
May		In-bye			
June		Fell			
July	Clipping	Fell (off for clipping)			
August		Fell			
September	Speaning (weaning)	Fell			Speaned lambs in-bye[80]
October	Drafting	Fell			

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Down for lambing in good condition, Peak District

[76] In practice the diversity of hill environments, breeds, local custom and practice and climatic variation determine the particular contribution of each source of nutrition in a particular year. Dates and details will vary but the principles apply across hill areas and are only indicative. See Appendix 1 for an illustration of supplementary feeding.

[77] Comments relate to single bearing ewes.

[78] The shearlings (gimmers in Scotland) will probably be off the fell, and the form of supplements may be blocks or concentrates.

[79] The replacements selected are gimmer hoggs and are generally wintered or agisted on a lowland farm if possible though this wintering is increasingly scarce. On return in March the hoggs are put to the fell.

[80] Generally on the meadow re-growths (also known as foggage or aftermaths).

Chapter 3

The relationship between soils, vegetation and grazing levels

Soils, vegetation and grazing are interdependent and influence the future development of soils, vegetation patterns and grazing characteristics. The complexities of hill grazing systems are not fully understood, yet science and practice are themselves interdependent and both capable of bringing more evidence and experience to mutual benefit. Hill farmers recognise that different vegetation types attract different grazing pressures and exhibit seasonal differences. Optimising the management of these characteristics demands matching experience and husbandry skills with evidence from scientific enquiry. Science and practice are not alternative but complementary tools in management:

> *New problems of a practical nature are seldom indeed to be solved with the aid of a single science; one of the first essentials of the agronomist therefore is to think beyond. New problems of a practical nature are seldom indeed to be solved with the aid of and the limitation of any particular science or sciences, and in particular, beyond the limits of those in which he may have been trained.* (Sir George Stapledon)

Low stocking rates encourage selective grazing, a greater proportion of shrub species and other plants unattractive to sheep and cattle. Conversely high grazing pressures reduce selectivity and encourage a predominance of prostrate species. Finding the balance and stabilising the nature and feed value of grazing should be a shared aim. How much is eaten and returned as excreta to the soil, and how much decays or is burned in situ influences future soils development and their future vegetation. Over time this establishes patterns and mosaics of vegetation forming elements of the food supply for sheep and other grazing animals. Thus vegetation is determined by soil conditions and modified by grazing and burning.[81]

[81] Hunter, R.F. 'Hill sheep and their pasture: a study of sheep-grazing in South-east Scotland'. *Journal of Ecology:* Vol. 50, pp. 651-680.

Langholm Project

Natural England has recently reviewed burning as a management tool on dwarf-shrub heaths, acid grasslands and some bogs.[82] The broad relationship between upland soils and vegetation is presented in Table 4. Research consideration of the merits of burning has largely focussed on its influence on vegetation, soil structure and hydrology, and particularly the link between burning and unfavourable SSSI conditions.[83] The opportunity to assess the dynamics of management on sheep diets and grazing habits merits more attention, especially where dominance of *Calluna* restricts species choice for grazing, and presents a sub-maintenance diet.

[82] Burning is a complex subject. Yallop, A., Thomas, G., Thacker, J., Brewer. T., Sannier, C. (2005) 'A history of burning as a management tool in the English uplands', *English Nature Report 667.*
[83] Tucker, Dr G., (2003) 'Review of the impacts of heather and grassland burning in the uplands on soils, hydrology and biodiversity', *English Nature Report 550*.

Table 4. Main soil and vegetation types of hill grazings in Britain[84]

Soil	pH	Vegetation Type	Principal Spp.
Brown earth free draining	**5.3-6.0**	*Agrostis-Fescue* grassland or spp. rich	*Agrostis tenuis* *Festuca rubra* *Festuca ovina* *Poa spp.* *Trifolium repens*
Gleys poorly drained	**5.3-6.0**	As above with wet land spp. *Carex, Juncus*	*Carex spp.* *Juncus spp.*
Brown earth free draining	**4.5-5.2**	*Festuca-Agrostis* grassland, low grade or spp. poor	*Agrostis spp.* *Festuca ovina* *Pteridium aquilinum (bracken)*
Gleys poorly drained	**4.5-5.2**	As above with *Nardus* and wet-land spp. *Carex, Juncus*	*Nardus stricta* *Carex spp.* *Juncus spp.* *Deschampsia cespitosa*
Podsols[85] Peaty podsols free draining	**4.0-4.5**	*Nardus or Deschampsia-Festuca* grass heath or *Calluna* shrub heath	*Nardus stricta* *Deschampsia flexuosa* *Festuca ovina*
Peaty gleys poorly drained	**4.0-4.5**	*Molinia* grass heath or *Calluna-Molinia* heath	*Calluna vulgaris* *Vaccinium spp.* *Erica spp.* *Molinia caerulea* *Festuca ovina* *Deschampsia flexuosa* *Calluna vulgaris*
Deep blanket peat poorly drained	**3.5-4.0**	*Trichophorum-Eriophorum-Calluna* bog	*Trichophorum cespitosum* *Eriophorum spp.* *Calluna vulgaris* *Sphagnum spp.*

[84] Newbould, P. (coordinator), Floate, M.J.S., Grant, S.A. and King, J. (1979) 'Soils and vegetation of the hills and their limitations', *Science and Hill Farming*. Edinburgh: HFRO, p. 11.

[85] Podsols are essentially leached soils, acid by nature and showing a grey light coloured horizon below the organic layer. Weathering and organic acids have removed iron and aluminium oxides which have been re-deposited in lower horizons.

Drainage and soil base status are key determinants for grazing vegetation. Where the soils are least acid[86] and white clover is present to fix nitrogen through bacterial activity, high grade and productive *Agrostis-Fescue* swards can be sustained. Greater acidity reduces grassland quality, species mix and the ability of clover to thrive. Grazing pressure even so may still be high, though if species such as bracken are dominant, the productivity of the sward is dramatically reduced. On gleys and other inherently wet soils, shrub and grass heath develops with increasing quantities of *Nardus* and *Molinia*.[87] Acidity and nutrient supply are important limiting factors on improvable soils. Acidity is the most critical single limiting factor on pasture production and is a major factor in soil nutrient cycling.

The grazing diet available to hill ewes is determined by climate, site, soil vegetation and land management. Some limiting factors are 'permanent'[88] and have been the reference points to designate areas for special recognition and support.[89] Other factors such as bracken removal may be technically feasible. Management practices such as supplementary feeding, breeding and selection, and health all offer potential for immediate application. Grazing control and improvement potential are theoretical possibilities that are site specific. In this context common or communal grazings are more limited than those in sole occupation.

Kath Birkinshaw

Mosaic of vegetation for a balanced diet, Peak District

[86] As indicated by the pH on a scale in which 7 is neutral. Below 7 are degrees of acidity and above 7 soils are alkaline.

[87] Gley soils are poorly drained and waterlogged either periodically or permanently.

[88] In some instances minor modifications can be made but in practice cost is often prohibitive. Traditional modification in the form of sheep stells and bields to provide respite shelter in storms on exposed sites are an example of a practical response.

[89] For many years the term 'Less Favoured' has been used to administer policy. Within the designation are subclasses of Disadvantaged (DA) and Severely Disadvantaged (SDA).

Indigenous or semi-natural grazings express a variety of characteristics, including seasonality of growth, accumulation of dead material and the quality of herbage available to graze. Acid grasslands have a relatively long growing season subject to temperature and light levels. Heath shrubs generally are more restricted but may remain winter green whilst other species, especially on wet sites, such as *Molinia* and *Eriophorum* (cotton grass) have restricted growth patterns but do not present winter grazing. Generally on acid grassland, with good management, quantity is more limiting than quality whereas for most other species the quality of herbage is the major limiting factor.[90]

Table 5. Dry matter production and seasonal quality of native hill pastures[91]

Vegetation Type	**Dry Matter Yields kg/ha**[92]	**Quality index - digestibility as % of dry matter**			
		May/June	**September**		**Jan/March**
			1st cut	**regrowth**	
Agrostis-Festuca, **acid grassland**	**2200-**[93] **3200**	**70-76**	**45-55**	**65-73**	**40-50**
Festuca-Deschampsia, **grass heath**	**2240**[94]	**65-75**	**50-55**	**(65-73)**	**-**
Nardus, **grass heath**	**1000-2240-**[95] **4000**[96]	**60-70**	**45-50**	**-**	**35-40**
Molinia, **grass heath**	**1110**[97] **1700**[98] **2000-4000**[99]	**60** **65-70** **-**	**-** **45-50** **-**	**-** **-** **-**	**-** **(38-litter)** **-**
Calluna, **shrub heath**	**1750-3400**[100]	**60**	**50**	**55**	**40**
Trichophorum/Eriophorum/ Calluna, **blanket bog**	**1450-1700**[101]	**60-68**	**40-55**	**-**	**-**

Source: Newbould, Floate, Grant and King (1979) *Soils and vegetation of the hills and their limitations.* HFRO

[90] Newbould et al, *op. cit*, pp. 18-19.
[91] Newbould et al, *op. cit.*
[92] For further references on the basis of the yields including cutting dates see Newbould et al, *op. cit*., p. 21. A fuller discussion is presented on pp. 9-21.
[93] Monthly cuts of green – total DM of green.
[94] Sum monthly cuts.
[95] Sum monthly cuts.
[96] Total green DM.
[97] Sum monthly cuts.
[98] Green DM April-Aug.
[99] Total standing crop.
[100] Current shoots heather cover 85%+.
[101] Current shoots, sheaths and green material, grasses and sedges.

Table 6 provides a useful indication of the link between particular plants and dietary contribution.

Table 6. The main grazed plants and their estimated contribution to the diet[102]

Species	Part of Plant	Main Contribution to Diet	Winter Contribution	% digestible organic matter (D)		% crude protein	
				March/ April	Highest summer value	March/ April	Highest summer value
Heather	Tips	Late summer	Good	42	46-May	9.7	10.9-May
Blaeberry	Leaves Green Stem	Spring Late summer Late winter	Poor Good	55 38	58-Aug 39-Aug	7.9 6.9	14.4-Aug 8.3-Aug
Molinia	Green parts	Early summer	Poor	30	58-June	6.1	12.0 June
Hard Rush	Green parts	Winter	Good	33	43-May	7.6	14.8-May
White Bent	Green parts	Late winter Spring	Moderate to Fair	43	60-May	10.0	15.8-May
Draw Moss	Young heads Leaf butt Green leaf	Late winter early spring Spring Spring	Very good Good Fair	70 54 52	70-Apr 59-May 56-Apr	13.8 9.7 13.2	13.8-Feb 11.5-May 13.2-Apr
Sheep's[103] Fescue	Green parts	All year	Good if available	57	63-May	21.2	15.4-May
Crowberry	Green needles	Autumn early winter	Moderate[104]	45	43-Aug	8.0	9.0- Aug
Deer Hair	Green parts	Spring	Poor	31	50-May	5.3	11.7-May

Note: *digestibility is expressed as the percentage of the dry matter of plants that can be utilised for energy or animal tissue such as muscle and fat.*

[102] Redesdale Experimental Farm, Northumberland in vitro data.
[103] *Agrostis tenuis* or brown top is a grass of comparatively high value found on the best brown earth hill sites and commonly grows in association with Sheeps Fescue.
[104] Crowberry is not commonly eaten by sheep. It is comparatively bitter but can make a contribution in late autumn.

Chapter 4

Grazing characteristics, behaviour and food intake

Grazing factors in practice

Stocking rate is critically important to the performance of the sheep, business viability and the well-being of the environment. In agricultural terms 'over-grazing' generally lowers individual animal performance and creates greater demands for expensive nutritional supplements.[105] Weaned weight of lambs per ewe and per hectare can provide a good basis for performance monitoring. Lower stocking rates may imply improved animal performance but this may not always be the case, if for example the vegetation changes provide more of species that are of low nutritional value, or if ungrazed dead material dilutes the quality of the diet.

In ecosystems terms the stocking rate needs to recognise risks such as erosion and invasion by inferior species. The ability of plants to recover from grazing and provide for soil maintenance is also a requirement of sustainable management. On hill land in sole occupation the stocking is an individual decision. On common grazings the situation is more complex and customarily was monitored and managed through manorial courts. These declined particularly in the eighteenth and nineteenth centuries as a formal means of governance. Perversely commons, whilst they are a major feature of England's hill areas and contribute disproportionately to biodiversity, are not adequately considered in policy formation and implementation.

Establishing stocking rates may theoretically be informed by calculating usable forage to estimate biomass, mapping and observation. Usable forage may be quite different where access and distance from water supplies are locally important, and where exposure and altitude make limitations. Estimating forage demand is theoretically influenced by the average weight of grazing animals and the number of days in the grazing calendar, with due regard to local factors such as horses. On common grazings, proper regard will need to be paid to the variation in vegetation on different heafs and the implications for nutrition and grazing capacity.

The relationships between soils, vegetation, nutritional values and grazing characteristics provide guidance in respect of 'High Nature Value' farming. However, the intricate diversity of sites, husbandry systems, weather patterns, unexpected environmental events and economic conditions emphasises significant obstacles to progress with this approach. The site specific experience of farmers and robust scientific evidence, shared monitoring and evaluation offer possibilities. Learning from change through shared monitoring and evaluation is self-evidently a prime consideration. Failure to give this the attention that it merits to promote good practice, mutuality, and to inform policy formation and implementation, justifies re-consideration.

[105] The terms 'over-grazing' and 'under-grazing' cannot be precisely defined. They are concepts that may be used in terms of livestock production, landscape and biodiversity for example. As value judgements the terms need to be considered carefully in relation to specific sites.

Grazing characteristics of hill sheep and cattle

Grazing is also influenced by physiological factors which are well recognised in grassland management. Sheep harvest grass by cutting it between incisor teeth in the lower jaw and the dental pad in the upper jaw in a biting action.[106] They are well known as selective grazers and can harvest material down to about 3 cm. Wethers, kept for several years as wool producers and mature mutton, were perceived as less selective than breeding ewes and lambs. Accurate information on breed differences may also be a factor for which empirical evidence is weak, but could be valuable.

Ewe with four permanent incisors and four temporary or milk teeth

Cattle are less selective than sheep, combining the grazing action of sheep with the capacity to use their tongues to pull material in a less selective fashion. For hardy suckler cows vegetation needs to be 6 cm or more. They are perceived as being particularly suited to mat-grass and purple moor grass. Dartmoor hill farmers generally use a greater proportion of cattle for purple moor grass areas which is less useful for sheep. The cattle's grazing allows other species beneficial to sheep to be sustained in the sward.

Dartmoor Commoners Council

Belted Galloways grazing Molinia on Dartmoor

[106] Adult sheep have four pairs of incisor or cutting teeth that form a long sharp edge. Dental characteristics are highly heritable. If the teeth drift forward grazing is impaired. They then lengthen (become 'long in the tooth') and are prematurely lost.

Work at the Hill Farming Research Organisation (HFRO) evaluated comparative studies of diet selection by hill sheep and cattle. Sheep diets were more variable than cattle and the two species varied significantly for most but not all dietary components.[107] On *Agrostis-Fescue* and *Nardus* sites sheep diets contained more live material. On *Molinia* sites cattle and sheep intakes of live and dead material were similar in early summer, but in autumn sheep grazed other grass species and cattle grazed *Juncus* (rushes). The observations suggest that on *Nardus* areas, both cattle and sheep showed preferences for *Festuca* and *Deschampsia* (wavy hair grass) from between tussocks of *Nardus*, but the decline in biomass and herbage height in later grazing periods was associated with an increase in the *Nardus* content of the diet by cattle but not sheep.

Grazing patterns also reflect the distribution of vegetation mosaics. The Lake District ridge below provides a modest crop of draw moss (cotton grass) for late winter and a small source of water on a fell otherwise distant from it, and could be significant in holding heaf boundaries. Shepherds observe these aspects of grazing behaviour; others may be unaware of such matters.

C. Sean McMahon

The principal indication of the work was that dietary differences reflected the different heights at which animals grazed, the greater capacity for sheep to select their preferences, and the readiness of cattle to graze taller, more fibrous material. Horses and ponies can graze even shorter material than sheep and have incisors in both upper and lower jaws but are more selective than cattle.

[107] Grant, S.A., Suckling, D.E., Smith, H.K., Torvell, L., Forbes, T.D.A. and Hodgson, J. 'Comparative studies of diet selection by sheep and cattle: the hill grasslands', *Journal of Ecology:* Vol. 73, pp. 987-1004.

Grazing behaviour will also be influenced by supplementary feeding practices with concentrates and conserved forage. For example studies comparing feed-blocks with concentrates suggest the use of scattered blocks results in less disruption to the distribution of sheep than the use of feed pellets. In some inaccessible situations blocks are taken to feeding points on the hill in early winter for shepherds to feed as required. Siting of block feeding points needs to be sensitive to avoid vegetation damage, for example in old mature heather stands. Intakes of block are often controlled by salt levels and the hardness of the block. This does lead to greater intake variation between individuals than is generally the case with concentrates. Blocks are generally more expensive per unit of feed value though benefits may outweigh costs. In a few situations blocks are taken to sites inaccessible to farm vehicles by helicopter.

Sheep fed on concentrates (pellets) gather at the feed point prior to feeding and remain nearby before migrating as a group to the main heaf.[108] However concentrated feeds and blocks can provide nutrients without satisfying appetite, encouraging further foraging. Feeding concentrates early in the day allows more daylight hours to continue active grazing. Some hill farmers also assert breed differences in grazing across the full range of the heft in winter.

On bare hills, or when snow interrupts grazing, a bulk forage may be provided. Good hay has traditionally fulfilled this role being easier to carry and spread. High quality hay is not necessarily as common as would be required and this may limit its use, especially if climate change makes quality hay more difficult to make.[109] Silage has generally increased in use at the expense of hay. Foddering needs careful consideration in relation to sheep congregating over long periods, thus reducing grazing activity. Big bales are popular as a means of fodder conservation but may not be suitable in some open hill conditions and under the terms of Stewardship where sheep may tend to congregate for longer periods and potentially damage local vegetation. Prolonged cover of grazing by hard snow may result in sheep being taken in-bye pro-tem.

[108] Waterhouse, A., 'Impact of husbandry methods on environmental issues related to British hill farming systems', *CIHEAM - Options Méditerranéennes.* Auchincruive, Ayr: Scottish Agricultural College.
[109] As selective feeders sheep will not readily eat poor hay.

Kath Birkinshaw

Block feeding

Andrew Humphries

Feeding concentrates, Bowscale Fell

Feed costs typically represent 30-40% of variable costs in hill flocks.[110] The advantages for the survival and growth of lambs need to be balanced against costs and is a key management consideration.[111]

Sheep generally seek the most digestible material available, leading to seasonal differences in diet. On open commons and other hills where heafs are significant, the movement of sheep over a limited range will also influence diet and emphasises the need for a vegetation mosaic or mix within the range of a particular flock or group. In May for example many hill flocks are turned back to the fell where the preference for *Agrostis-Fescue* grassland is strong whilst grazing heather of low digestibility is unattractive. Black hills dominated by heather will generally limit milk production and therefore lamb growth. Heather is more useful in the winter and in summer sheep select other plants by preference. This has implications for the utilisation of those grazings with significant proportions of heather if off wintering is practised or required by Stewardship.

Food intake

Where there is an adequate supply of grazing biomass the intake of hill sheep is heavily dependent on the digestibility of vegetation and animal size. The Macaulay Land Use Research Institute (MLURI) has calculated intakes for sheep (and estimates for other stock). Using the devised formula the following predicted intakes were calculated.

Table 7. Estimated intakes for grazing livestock on English hill grazings[112]

Grazing animal	Average liveweight Kg	Kg dry matter intake per day summer	Kg dry matter intake per day winter
Sheep			
Swaledale/Blackface	50	1.4	0.7
Herdwick	43	1.2	0.7
Cattle			
Galloway	455	7.2	3.9
Aberdeen Angus	485	7.5	4.1
Limousin x Friesian	550	8.3	4.5
Hill Pony	450	13.1	13.1

***Note**: summer digestibility is assumed to be 0.7 and winter digestibility 0.5, 40% is added to the lactating ewe intake at turnout in early summer rising to 66% in late summer prior to speaning.*

[110] Typically 20-25kg of concentrates per ewe for budgeting, and access to 30kg of hay (or equivalent) per ewe. Actual usage can vary widely.
[111] See Appendix 2 for an indicative example of supplementary feeding.
[112] The data are adapted from Armstrong, H., *The grazing behaviour of large herbivores in the uplands. (Note 47)*, Macaulay Land Use Research Institute (MLURI), now part of the James Hutton Institute, Aberdeen.

Chapter 5

Hill sheep nutrition and vegetation succession

Grazing animals have a profound effect on vegetation and that has been the focus of agri-environmental programmes with defined biodiversity aims. Self–evidently the converse is true, that changes in vegetation may have important effects on the diet of grazing livestock. The 'agri' element in agri-environmental programmes has received scant attention. The concept of 'vegetation improvement' must therefore be used with care as it has relevance to most ecosystems services but reflects different values. The national and international challenges of Environmental Stewardship and food supply require policy makers, administrators and land managers to understand the underlying principles and practices that need to be reconciled. Sectoral thinking and the pursuit of narrow agendas will fail to deliver the optimum range of benefits that can and should be pursued.

In Britain, in the absence of people and animals, most and perhaps all land would revert to the climax forest vegetation. Our hill grazings are predominantly semi-natural 'grasslands'. In the absence of grazing animals the 'natural' trend will typically be towards ferns, and heather followed by birch, scrub or woodland. The hills, clothed in 'grasslands', express the direct outcome of centuries of biotic influence in the establishment and development of pastoral systems of husbandry. The object of management has primarily though not exclusively been livestock nutrition and sustainable production, generally through prolonged experience and experimentation, customarily on a site specific basis.

The basis of vegetation on hill farms is therefore a complex of 'associations of plants' living together. Changes in composition of these associations usually develop gradually, and may not be particularly noticeable over short timescales, though the infiltration of new species and changes in the abundance of existing species may be taking place. Successions may be influenced by a number of factors including soils, climate variation, management and husbandry practices. On rough hill grazings reductions in stocking will result in succession from grassland to dwarf shrub, scrub and ultimately forest in most situations. The transition to more woody species has clear implications for grazing diets.

Improved and unimproved grassland

Typically hill farms comprise rough grazings which have never been improved by the use of fertiliser and seeds, and enclosed land where certain grasses and clovers have been deliberately sown. These areas should not be considered as discrete but rather as complementary elements in meeting nutritional needs. The hill cannot be considered in isolation. The less that the hill can deliver to the nutritional needs of hill ewes, the more critical the input from other sources.

Kath Birkinshaw

Improved in-bye, Peak District

Enclosed land is critical in its contribution both to grazing and conserving winter feed. Until the mid-twentieth century many hill farms expressed a degree of self-sufficiency to control costs by growing small areas of crops on the best enclosed soils. These included oats and roots for livestock, and potatoes for human consumption, through small-scale rotational cropping. Re-seeding of grassland was a limited but integral practice. Where enclosed land is of exceptional biodiversity value, generally as ancient meadows, there may be a clear case for sensitively managing the resource to sustain the diverse botanical value.

First grade improved pastures and meadows with more than 30% ryegrass in the sward complemented with white clover are uncommon, but represent potentially the most productive grasslands. Even on the better in-bye ground[113] the proportion of ryegrass will usually be at a lower level reflecting a transition that is often characterised by increasing proportions of *Agrostis* and other agriculturally inferior grasses, herbs and weeds. On better soils, meadow fescue, meadow foxtail and rough-stalked meadow grass make useful contributions. Yorkshire fog, creeping soft grass, crested dogstail, sweet vernal and fine leaved fescues frequently infiltrate.

Reducing the levels of productivity through agri-environmental schemes will generally encourage a succession from ryegrass to *Agrostis* and then to fescues and on wet land to rushes and sedges. Newly sown grass pastures and meadows will have different grassland associations to older established swards. Shorter-lived species and strains will provide more rapid growth initially and the more persistent strains will establish more slowly which is important in the design of seeds mixture. Mixtures have shown yield benefits over single varieties and increased reliability of

[113] In-bye is enclosed land, usually of higher productivity, and utilised for the production of winter feed and grazing at times of greatest nutritional need.

performance. Agricultural management has aimed to reverse the natural processes of succession to maintain enhanced grazing value. Grazing, mowing and manuring are the key management tools to help to maintain a grassy sward.

Grass is a crop, and as such needs soil conditions that are similar to a well-made compost. Soil analysis to produce grass economically and efficiently with low environmental risks should inform husbandry practice. Management techniques include the addition of animal dung and urine through adequate stocking, with grazing control. Adding lime as required is important especially to the utilisation of nitrogen (N) which is the foundation for yield and protein content. Phosphate is important to root development and of particular relevance to clover. Potassium (K) interacts with N and aids drought resistance, a potential limiting factor to yield. Sulphur is now an additional consideration since the reduction of industrial emissions to the atmosphere. Farmers and agency staff need to find common ground in sustaining appropriate levels of productivity rather than adjusting management without a clear understanding of the consequences.

Increasing attention is now given to reversing the effects of soil compaction by using subsoiling techniques, and in some situations investment in drainage systems.[114] When necessary, sward renovation and reseeding may be required, but the aim is to manage grassland as a permanent crop, to maintain a productive surface capable of resisting high rainfall without undue poaching, and to avoid costly sward renewal.[115] The enclosed land that is vital for grazing and conservation needs to be managed for 'optimum' production. As permanent grassland it is likely to produce around 25% less dry matter per ha than a short term ley, but in the uplands there are other factors to consider. Permanent pasture develops a denser sward which is important under wet winter grazing. Stapledon recognised in the 1930s that improving strains of pasture plants held considerable potential. Early 'hay' strains of ryegrass and other sown species were recognised as earlier to grow in spring and were easier to harvest for hay but lacked persistency.[116] Pasture types which tillered from the base formed a denser sward, were more persistent and leafier.[117]

Varieties improved and today offer considerable choice, although the fundamental principles that were recognised almost a century ago still broadly apply. Higher yields, earlier spring growth, improved digestibility, lower protein and higher water soluble carbohydrates reflect important developments. The difference in heading dates between early and late varieties can be around a month. Recommended lists provide comparative data on varieties of the key grass and clover types in respect of suitability for grazing, conservation and propensity for ground cover. Whilst perennial ryegrass will generally be the primary species, other types can be included with benefit. Timothy *(Phleum pratense)* grows at a lower temperature than ryegrass and that can be beneficial in a cold spring. Its winter hardiness is good and it covers the ground well. Some fescues are also worth consideration.

[114] The selection of low ground pressure machinery is also a practical consideration.
[115] Poaching occurs when sodden ground is trampled by animal hooves creating muddy holes.
[116] Varieties are now classified by heading dates when 50% of the ears in fertile tillers have emerged.
[117] Tillering is the capacity to produce multiple stems and stimulates a leafy form.

Soil nutrition, soil structure, the timing of seeding and recognising the importance of moisture and temperature in upland areas are all critical. Often over-seeding is preferred to a full re-seed.[118] Management to establish the newly sown sward is also vital to success. Generally the key species in sown swards will be perennial ryegrass and white clover.

Perennial ryegrass establishes well, has a high sugar content for silage-production and forms dense persistent swards. Diploids are better suited to wet upland conditions and are particularly good at establishing sward density.[119] Managing newly sown swards is important as they are initially relatively unstable.

Andrew Humphries

Unimproved species-rich neutral meadow (SSSI), Cumbria

White clover has a long reputation as the cornerstone of grassland improvement in the uplands. Particularly on the better in-bye soils it can make a significant contribution to animal nutrition quantitatively and qualitatively. Low input systems of sheep husbandry using white clover are productive and cost effective, though stocking rates are not as high as with high N based fertiliser systems.[120]

Fertiliser N has become a significant cost consideration, and its use at high levels also raises questions about environmental impact. In recent decades application rates have been determined on the basis of 'how little rather than how much'. White clover is a high quality farm produced protein source with the potential to enhance sheep diets, coincidental with improvements to soil fertility and structure. Soil density can also be decreased through the resultant improvements to porosity.

[118] Overseeding is the introduction of new seeds into an existing sward.
[119] Tetraploids have double the number of chromosomes of diploid varieties.
[120] Clovers 'fix' nitrogen through Rhizobia bacteria that colonise root nodules.

Andrew Humphries

Direct drilling grassland reseeding into a peaty gley

On good in-bye grassland N fixation is estimated as equivalent to 150-200 kg/ha of N. Ruminants may consume up to 25% more white clover than grass; the clover also containing a higher content of minerals and protein. The advantages only come with careful and positive management that is derived from a full understanding of both the potential and limitation of white clover. Much of the development work to improve sustainable grassland management is taking place at The Institute of Biological, Environmental and Rural Sciences (IBERS), Aberystwyth. For hill sheep systems the production value of limited in-bye areas is highly significant to the production of high quality crops of lambs.

Decision support tools

How a reasonable balance between financial and environmental objectives is achieved has proved to be a major challenge, since they are not separate but interdependent. In addition to the evidence and experience of different stakeholders, researchers have looked at the potential of decision support tools.

These tools consider the individual components of grazing systems including climate, soils, vegetation and grazing stock and the interactions between them generally focused on stocking densities. In upland settings the complexities involved in achieving desired outcomes are challenging. Methods of improving the predictability of the interactions between grazing livestock and hill vegetation offer positive benefits to Stewardship agreement negotiations and more broadly to stakeholder relationships. In the context of the English uplands the interaction between production and the non-market ecosystems services of landscape, flora and fauna pose an immediate challenge.

Decision making support tools are being developed in a number of extensive semi-natural grazing situations including Australia and the United States under range conditions. In the UK a decision making support tool called ‘HillPlan’ has been

developed by the MLURI building on earlier work by the Hill Farming Research Organisation. From 1 April 2011, MLURI became part of the James Hutton Institute:

> *There must be knowledge of the grazing preferences of different grazing species and the ability to predict what they will choose to eat and how much of it. There must be the ability to predict the consequences for the balance of plant species which will result from their different patterns of growth, senescence and selective removal by the grazers. The seasonality of plant growth and senescence and of animal requirements for energy and protein must be predicted. The knowledge… comes largely from research but also from the expert knowledge of people who manage and interact with hill resources.*[121]

The use of the term 'Decision Support Tools' rather than 'Decision Making Tools' is highly significant as they assist in making decisions, allowing comparison of options and the probable impact of different management strategies. The simulation works by modelling the management routine of a grazing area, the biomass production of the plant communities, the foraging behaviour of the animals and the responses of the plants and communities to the grazing and their environment. There is a need to test such tools over timescales of perhaps a decade or more to establish the level of confidence that can be ascribed to the predictions.

For farmers and other stakeholders it is important to recognise the value and current limitations of support tools. The potential to use them as a positive aid can easily be lost if the options are considered as answers rather than predictions using the data provided. A key additional development should be to forecast the productivity of grazing animals as a vital element. In addition the evaluation of sites over longer timescales will ensure that the quality of science in its application is optimised and capable of developing real confidence.

Dartmoor Commoners Council

Land of milk and honey

[121] Sibbald, A. *Decision making support tools to link ecology and land management: development of HillPlan.* Aberdeen: MLURI.

Chapter 6

The feeding value of hill plants commonly grazed by sheep on the English hills

The major useful species of grazed plants on hill grazings and associated in-bye land have different feed values at different times of the year. Generally a mixture of grazed species is advantageous since they are complementary in their contribution to sheep nutrition at different times of the year and the cycle of the breeding flock.

6.1 Grass family

Common Bent or **Brown Top** (*Agrostis tenuis*)
Frequently associated with sheep's fescue and red fescue on drier acid hill land. Birds-foot trefoil *(Lotus corniculatus)* is widespread in these swards and as a legume, fixes nitrogen for the associated grasses. Other associated grasses include sweet vernal *(Anthoxanthum odoratum).*

Sheep's Fescue (*Festuca ovina*)
A fine leaved grass with a low growing habit (75-100 mm) often forming 'cushions'. Sheep's fescue is evergreen and always has a useful feed value in the growing season. From May onwards if grazed regularly, it maintains that value. In winter, although remaining evergreen, the contribution to the sheep's diet is minimal as it is usually heavily grazed in summer, making its main input from May to August. Other fescues include Dog's fescue *(Festuca canina*).

White Bent *(Nardus stricta)*
Height c. 20-25 cm, a round-leaved grass and one of the least palatable, which grows quickly from mid-May onwards and runs to seed very soon afterwards. The foliage dies back in September leaving the white tufts that blanket many 'grassy' fells. These have a poor feed value and its low palatability leads to low utilisation by sheep. If eaten by cattle in early summer the plants retain a greater proportion of green and are grazed more readily by sheep into winter. *Nardus* is high in silica and stiff and rough to the touch. The energy value of the green leaves is high in early summer. Its main quantitative contribution to sheep grazing is October to May when other options are few. Early summer growth may be diluted by dead leaves from the previous year retained in the tussocks. *Nardus* has the capacity to spread on damp sites at the expense of other species. Tussocks are reduced if the area is grazed by cattle in summer. Associated species include heath rush (*Juncus squarrosus*), wavy hair-grass and, under wetter conditions, purple moor grass and bilberry.

Wavy Hair Grass
(Deschampsia flexuosa)
Wavy hair grass has round leaves and is grazed mainly from May to July. As it is evergreen there is some winter grazing. Wavy hair grass grows in clumps and is associated with acid heaths and moorlands often in association with heather and may be somewhat invasive. It is only moderately palatable and of low productivity.

Flying Bent or **Molinia** *(Molinia caerulea)*, also known as **Purple Moor Grass,** grows rapidly from the characteristic large coarse dead tufts in late May. A huge quantity of long flat leaves of comparatively good feed value up to 60 cm high affords quite good feeding value with digestibility sustained into July. It rapidly runs to seed forming a relatively slender flowering stem topped with a purple seed head. The green leaves have withered by late September with a proportion characteristically 'flying' or blowing away in the autumn winds.[122] Much withered material remains and makes the grazing of the underlying green material difficult to win.

Cattle eat the late spring and early summer growth with enthusiasm. If the dead material is burned at the start of the season sheep will gain grazing benefit. Winter feed value is low and unattractive to sheep. The value of *Molinia* is confined to June (cattle and sheep) and July and August (cattle only). The digestibility of new growth at 65% (D value) in May to July is a figure comparable to sown species, but falls to around 40% by September. However the feed value depends on the removal of dead material by burning or a sufficient grazing level in spring and early summer.[123] The making of *Molinia* hay was fairly widespread across Europe and is still practised in some areas. Research in Ireland has also identified sites of wet meadows which embrace cutting of *Molinia*.[124]

Sweet Vernal (*Anthoxanthum odoratum*)
Sweet vernal is a common grass of acid grassland where drainage is relatively good. It often associates with *Agrostis tenuis* and sheep's fescue on lower hill slopes and is very common on semi-improved in-bye. Readily grazed by sheep in spring, sweet vernal goes to head early and is then less productive. The grass is noted for the sweet taste arising from dicoumarol which has anti-coagulant properties that have caused haemorrhage in cattle in some parts of the world.

[122] Hence the name 'flying' bent.
[123] Molinia is still harvested in a few areas for hay on the continent, a practice which has been noted historically in Britain.
[124] O'Neill, F. and Martin, J. (2011) *High Nature Value meadows*. Teagasc Publications.

6.2 Sedge family

Deer Hair (*Trichophorum cespitosum* formerly *Scirpus cespitosus)*
Deer hair is abundant on wet acid moorland. In early May growth generally commences with fine tubular leaves bearing characteristic brown spikelets (c. 20-25 cm). At this stage sheep readily graze it. This early growth is relatively nutritious but by mid-June the leaf has turned orange and soon dies and disappears. The grazing contribution in May and early June is a useful contribution, filling a gap in the food supply of hill ewes. Its contribution is however limited to May and early June.

Draw Moss or **Cotton Grass** *(Eriophorum vaginatum*)
Draw moss is evergreen sedge found in very wet places, usually on peat. The Pennines and moors of south-west England provide better blanket bog habitats than the hard and steep Lake District fells. The tufts are typically c. 50 cm high. It commences growth usually in early February especially in mild winters. This onset of growth precedes most other vegetation and large numbers of palatable seed heads begin to appear. The phosphorus rich leaf bases also emerge from the dense dead tussocks. The seed heads have the appearance of the bristles of an artist's paintbrush and are eagerly sought by hill ewes and are 'drawn' out of the tufts. These seed heads are of high digestibility (D value 70%) and superior to the phosphorus rich leaves that follow and which can be grazed until July. Nevertheless even the leaves are valuable at this period of winter and early spring. In hard frost the 'mossing' is interrupted. After May/June sheep ignore the plants which have become unpalatable. In summer the familiar solitary 'cotton heads' appear on each flowering stem. In early winter the leaves cannot be drawn until growth commences in February.

Kath Birkinshaw

Sheep on draw moss, southern Pennines

6.3 Rush family

Heath Rush or **Stool Bent**
(Juncus squarrosus)
Low-growing (c.5cm), except when seeding, the glossy grass-like leaves grow in a rosette and these often form characteristic circles in the sward, generally in wet situations. Sheep graze heath rush mainly in autumn and early winter, readily consuming this 'fill belly' which seeds in late spring. Grouse are said to eat the seeds. Being low-growing, the plants are quickly covered in snowy conditions. Its main contribution is from September to May but its low form makes it of little use to cattle. Common rush *(Juncus conglomeratus)* is of no interest to sheep but if short will be browsed by cattle. Toad rush *(Juncus bufonis)*, though not widespread, and low growing, is useful to sheep where it occurs. All of the plants listed as grasses, sedges and rushes are adapted to acid soils and are generally poorly provided with calcium and other minerals.

6.4 Dwarf shrub

Crowberry family ***(Empetrum nigrum*****)**
Crowberry is a loosely formed shrub with a growth habit similar to pink bell heather, reaching a height of c. 30 cm. It is usually found in association with common heather but with bright green, soft, needle-like short leaves. It flowers early (May). The black edible berries are not found universally as many plants appear to be either male or female. The feeding value varies little seasonally, being similar to heather, but the palatability is not good, reflecting the bitter taste. It is only eaten on a 'needs 'basis and this appears to be September and October.

6.5 Heath family

Heather or Ling *(Calluna vulgaris)*
Heather is an evergreen shrub typically growing to a height of 30 cm. It produces shoots in the spring that remain green longer than most other hill vegetation in winter, providing valuable herbage for grazing. Although relatively unpalatable in summer, heather potentially has a high winter feed value including its contribution of minerals.[125]

Grazing effects on heather and other shrubs are sensitive since the meristems are at the tips of shoots and so are removed when shoots are eaten. Grasses have meristems at ground level and are less susceptible to grazing levels. Meristematic cells give rise to new cells for plant growth. Whilst grazing removes a proportion of shoots well above ground level, the practice of burning stimulates regeneration of the plant from the protected meristem at the base of the plant. However this is not always the case, especially in stands of moribund heather over fifteen years of age.

The withered heather seed heads stay on the plant through most of the winter concealing the green material below. Sheep graze the needle-like, soft green leaves and shoot tips.

[125] Copper and cobalt – Grant S.A. and Milne J.A. 'Heather Management', *Blackface Journal:* Vol. 33, pp. 13-17. The feed value is dependent on the quality of the heather.

Langholm Project

Intakes in winter may comprise 40% of rumen contents contrasting with much lower levels in summer when more palatable and digestible species are usually available. The feed value of the shoots is lower in winter and does not constitute a full maintenance diet. The shortfall is significant at tupping and during lactation.[126] Autumn grazing is potentially damaging to overwintering shoots, pointing to the value of tupping on improved in-bye as beneficial to sheep and heather.[127]

Local grazing of heather is influenced by the presence of other species. *Agrostis-Fescue*, often found on drier soils, will encourage more grazing than if the accompanying vegetation is *Molinia* or *Nardus* which are more typical of wetter sites.

[126] Typically in England sheep are removed for tupping and early lactation.
[127] *Ibid*.

Traditionally since sheep heafs are more extensive than those of grouse, hence burning for grazing has been in large patches. The intense patchwork of burning for grouse provides a mix of young nutritious heather adjacent to more mature stages that afford cover. In practice these intense mosaics encourage sheep to rake more effectively across their heaf, seeking the younger heather and potentially a more varied diet. Generally the territory of grouse is within the range 2-5 ha within which the birds have access to a range of heather ages for feed and cover. Typically a grouse will eat 70 g of heather dry matter per day and a 50 kg ewe will graze 1.4 kg per day.

The grazing density is influenced by the mix of vegetation and where grassland species are significant, summer grazing values are raised with lower levels of heather utilisation. This is further complicated when the age structure of heather is considered. Old heather is vulnerable if it is grazed which may happen if mixed ages have not been maintained. Extensive areas of old heather may well divert grazing pressure elsewhere.

Stocking rates on heather are usually calculated to levels of utilisation of annual growth that have 'no effect' on its capacity to maintain condition. This was a generation ago suggested as 40% though more recent commentary has suggested 25-40% as a range that should be considered depending on site specific factors.[128] The approach using levels of utilisation as the key to grazing levels is a technique worthy of wider application. This would be dependent on a more active approach to monitoring and shared evaluation by stakeholders than has been the cultural norm. A dynamic approach that allows adjustment of stocking rather than adherence to pre-determined levels is likely to be more site specific and valuable in its application, and provide a more robust basis for agreement by different stakeholders. The monitoring would also yield empirical information for a range of species, and potentially on different lengths of grazing season.

In England, of the estimated area of heather (466k ha), 60% is classified, comprising 25% managed with burning and 35% dominant but with little burning. The remainder of sub-dominant comprises 40% of the whole and itself has less than 50% heather and dwarf shrub cover. There are many sites identified by satellite in the uplands where grouse management is absent, and where burning on steep slopes and the higher rainfall would create a significant risk of erosion and where labour for burning is not readily found. This suggests that sheep may be a valuable tool for the sustaining of heather based on balanced grazing. Such considerations need to be effectively researched and understood so that the utilisation of such sites through grazing can be scientifically and practically informed.

[128] Pakeman, R.J. and Nolan, A.J. (2009) 'Setting sustainable grazing levels for heather moorland: a multi-site analysis', *Journal of Applied Ecology*, pp. 363-368.

Andrew Humphries

Heather on steep slopes, Bowscale Fell

On this site, burning may present increasing risk of soil erosion especially if reduced stocking levels accelerate the biomass and the need for burning. The site also encompasses a nationally important high level sessile oak-wood emphasising the case for a sensitive approach in which monitoring and grazing adjustments need to be carefully implemented site by site. In high rainfall western areas the limitations on suitable days for muirburn can be a practical constraint to acknowledge.

Bilberry *Vaccinium myrtillus* (Bleaberry, Blaeberry or Whortleberry)
Generally bilberry grows in association with heather, commencing growth in April and May, giving the fellside a deceptively verdant appearance in nutritional terms. The soft green stems have small ovate leaves (c. 18 mm).

The plant quickly produces waxy pink flowers that form the bluish-black berries which supplement human diets in various recipes and those of local grouse. The leaves fall by November. In non-grazing habitats ungrazed plants reach c. 40 cm, but often are of lower structure due to sheep feeding. Sheep often graze the green stems during winter if alternatives are scarce. Under these conditions the plants are almost evergreen. The feed value is greatest in winter and early spring, and when in leaf is similar to good heather and rich in minerals, but is limited by low palatability.

Andrew Humphries

Bowscale Fell, Cumbria in late spring showing an extensive area of bilberry with high level Atlantic oak-wood in the centre contiguous with Calluna beyond

The shrubs described above are lime-hating but are much more efficient at collecting minerals including calcium and trace elements than grasses, sedges and rushes.[129]

[129] Plants that are intolerant of lime are often described as 'calcifuge' – from the Latin to 'flee from chalk'.

Chapter 7

Postscript:
Hill sheep husbandry and future changes – responding or reshaping?

Heraclitus' assertion that 'the only constant is change' continues to be reflected in hill farming, despite widespread perceptions of an unchanging scene. The establishment of commercial flocks stimulated by the European wool trade, the demand for mutton in the late eighteenth and nineteenth centuries and the changes stimulated by imported lamb from the new world, have all influenced methods of production, breeding strategies and marketing. All of these external influences have borne directly on hill sheep nutrition and its interaction with the environment to shape the cultural landscape of the English hills.

The changes that are now reshaping hill farming are somewhat different in that non-farming stakeholder interests are complex, well-articulated and actively influential on agricultural policy and funding. New perspectives on climate change and carbon sequestration are examples of influences that present emerging challenges and opportunities for present and future hill farmers. The control of funding is now linked increasingly to non-farming agencies and organisations, making clear the need for wise decisions to be based on high levels of understanding and mutuality. The evidence to date suggests that hill sheep have not only adapted to change but have shaped it.

In the post-war period policies have not adequately facilitated the integration of different outputs and values from the hills to achieve the stated aims of government. For example, policies establishing guaranteed prices for agricultural production alongside conservation acts clearly needed to be considered as a whole.[130] The Commons Registration Act stands as a mark of the lack of understanding of customary practices. There has been an absence of approach leading to a single end, but rather a complex of ends and means of achieving them lacking 'wholeness'. There is now a new opportunity to build on recent experience, knowledge and collaboration but a short timescale to build on lessons learned for the common good.

Underlying life on the English hills has been hill sheep husbandry and the issues of pastoral practice. Grazing is concerned with the nutritive value of herbage to livestock and in particular the amount of herbage and sward composition. Voluntary intake and digestibility are at the core of the value of the diet and the two are generally linked. The proportion of green leaf, chemical composition and the age of the herbage are all important. Voluntary intake and digestibility are generally higher in sown grasses and clovers than in indigenous grasses, sedges and dwarf shrubs. The age, species and physiological state of the grazing animal is also variable. The interface between animals and vegetation is complex, dynamic and expressive of a high order of diversity. There is much understanding to share and much to acquire. Sir George Stapledon, arguably the leading agronomist of the twentieth century, was

[130] The 1947 Agriculture Act, strongly based on raising output through price support, was closely followed by, but not related in practice to, the 1949 National Parks and Access to the Countryside Act which brought into being the Nature Conservancy.

described by his biographer Robert Waller as the 'Prophet of the New Age' whose observations have resonance with contemporary discussion on the future of the hills:

- *Master decisions affecting too many people are made by too few.*
- *Standardisation assumes that our system is perfect.*
- *An adviser cannot serve three masters: science, the farmer and the government.*
- *Wisdom is wholeness. Wisdom can be heightened by a closer contact with the country and perhaps by taking greater heed of the lessons of the country and of nature.*

Sharing experience and understanding[131]

Sheep nutrition is at the heart of hill land management. Continuing to develop and integrate science and practice to improve the conversion of natural and improved pastures into animal products is vital to sustaining upland farming communities. Achieving these aims must be consonant with the maintenance and improvement of natural resources and other public goods and undertaken with the full participation of all interests. What needs to be done, and how, forms the challenge and opportunity to sustain hill sheep husbandry as a continuing contributor to life and improvement on England's hills. David Ker observed in 1979 that over a 25 year period, cattle and

[131] Joe Relph, Yew Tree Farm, Borrowdale, working with other land use professionals to foster mutuality.

sheep on our hills had improved in condition, health and production.[132] That process has now progressed through another generation during which hill sheep nutrition has emerged as one of several key aims which need to be reconciled into pastoral grazing systems to purposefully serve multi-functional aims.

The history of hill farming does not present a serene unchanging cultural landscape or 'a perfect republic of shepherds and agriculturalists' as espoused by Wordsworth. Fundamental changes have had their origins in a series of external economic and political influences. Policies for developing the uplands and hills have not been holistic in any real sense, but rather a complex of ends and the means of achieving them. The reconciliation of interests needs to be a participative process based on genuine understanding and mutuality with a commitment to link good practice and robust science:

> *... a constantly renewed effort of mind is necessary.* (Henri Bergson)

[132] Chairman of the Hill Farming Research Organisation, countryman and leading hill farmer.

Glossary of terminology relating to hill sheep in England

Hill sheep terminology is diverse and strongly regional. As an aide memoire for those who may not have sheep terms as a second language this document provides examples of traditional terminology for sheep by age, and a range of additional terms that are considered helpful to better understanding and communication. The terms are widely used but not precisely linked to strict geographical boundaries and they are indicative rather than fully comprehensive. Many thanks to those who provided the data. In due course adjustment will be made on information submitted. The tables comprise data from the individual noted. In addition Matt Bagley of NSA undertook to collect information from NSA members which has been collated into the regional sections. Please note that some variants in spelling occur (examples include: tup, tupp, tip; wether, whether, wedder; hoggett, hogget).

South-west England

Item	Period	Entire male	Castrated male	female	Brief comment
1	Birth to weaning	Ram lamb	Wether	Ewe lamb	
2	Weaning to shearing	Ram lamb	Wether	Ewe lamb/ hogg	Hogg December 31 to first shearing
3	First to second shearing	Ram hogg	Wether	Ewe hogg	2 tooth
4	Second to third shearing	Ram	4 tooth	4 tooth	4 tooth
5	Third to fourth shearing	Ram	6 tooth	Ewe 6 tooth	6 tooth
6	Thereafter				Full mouth

Word or term	Meaning
Lear	heft
Swaling	moor burning

Source: John Waldon, Exeter

The Peak District

Item	Period	Entire male	Castrated male	female	Brief comment
1	Birth to weaning	Tup lamb	Wether lamb	Ewe lamb or Gimmer lamb	
2	Weaning to shearing	Tup hogg	Wether hogg	Gimmer hogg	
3	First to second shearing	Shearling tup	Two shear wether	Theave or Two tooth	
4	Second to third shearing	Two shear tup		Double or Four tooth or Two shear	
5	Third to fourth shearing	Three shear tup		Six tooth ewe	
6	Thereafter	Aged ram		Full mouth ewe	

Source: Alastair Sneddon, Bakewell

Northern England

Item	Period	Entire male	Castrated male	female	Brief comment
1	Birth to weaning	Tup lamb Ram lamb	Wether lamb	Ewe lamb Gimmer lamb	Sometimes, in Cumbria, 'tups' are pronounced as 'tips'
2	Weaning to shearing	Tup hogg Yearling ram/tup (1yr + old)	Wether hogg Yearling wether (1yr+ old)	Ewe hogg Gimmer hogg	
3	First to second shearing	Shearling tup/ram	Shearling wether	Twinter (2 yr old Herdwick ewe) Shearling ewe Gimmer/shearling (lowland ewe)	
4	Second to third shearing	Two shear tup/ram Three year old tup/ram (3 yrs + old)	Two shear wether	Two shear ewe	Historically the term trinter was noted
5	Third to fourth shearing	Aged tup/ram	Three shear wether	Three shear ewe	
6	Thereafter	Aged tup/ram	Old wether	Four shear and older ewe	

Word or term	Meaning
Hoggett	A term normally used in the sheep-meat market for fat (finished) lambs from the start of the new year
Full mouthed	Full mouthed sheep have replaced all milk teeth with broad teeth
Broken mouthed	Broken mouthed sheep have lost some or all of their broad teeth
Geld ewes	Barren ewes
Lugs	Ears
Smit	Fleece mark
Crossing ewes	Mating ewes with a different breed of ram
Crossing tups	Rams used for mating ewes of a different breed
Crossed ewes	Ewes bred from two or more breeds
Half-bred ewes	Ewes bred from two breeds
Store lambs	Lambs sold or transferred to other resource for fattening
Draft ewes	Ewes transferred (or 'drafted') from the fell/moorland flock after 2–4 lambings to the kinder conditions of marginal and lowland farms (still having a breeding potential, best exploited on improved/semi-improved grassland); in Cumbria, sometimes referred to as 'drought' ewes
Clouting	Sewing cloth over the vulva of Herdwick shearling ewes to prevent them from mating (a traditional practice for Herdwick flocks in the Lake District but reportedly only now practised on two flocks)
Scanning	Pregnancy diagnosis
In-bye	Fields or enclosures of improved grassland, forage and arable crops adjacent to hill land.
Intakes and allotments	Relatively small enclosures of hill land
Fell	Hill and mountain pasture land

Source: Mervyn Edwards, Penrith

Borders (Langholm to Eskdalemuir and the Liddle valley, probably down the Ettrick and Yarrow Valleys and the upper reaches of Teviotdale)[133]

Item	Period	Entire male	Castrated male	female	Brief comment
1	Birth to weaning	Tup lamb	Wether lamb	Ewe lamb	
2	Weaning to shearing	Tup hogg		Ewe hogg	
3	First to second shearing	Dinmont		Gimmer	A gimmer would be expected to lamb for the first time
4	Second to third shearing	Tup		Young ewe	
5	Third to fourth shearing			Ewe	
6	Thereafter	Cast tup			A tup that is no longer fit for breeding from
	Six Years Old			Draft ewe	A ewe that will have had five crops of lambs and if 'correct' will go on to breed on a lowland farm for perhaps another 2 crops

Word or term	Meaning
Heft	A sheep that through regular shepherding will stay within the fenceless boundaries of a given territory
Cut	A group of sheep from a common heft
Single back, or, Single back bit	A sheep with a single notch taken from the back of the lug
Double fore, or Double fore bit	A sheep with two ear notches in the front of her ear
Correct ewe	A draft ewe with a full mouth and fully functional udder
Correct below	A ewe with teeth missing but with a functional udder
Correct above	A feeding ewe whose udder is not functional

Source: Hamish Waugh, Langholm

[133] The system in the Borders includes much of the Northumberland LFA.

Further reading

For current commentary on issues being debated across the hill sheep sector, a number of national organisation websites provide up to date information and useful reports.

At grassroots level The National Sheep Association (www.nationalsheep.org.uk) promotes and represents the views and interests of sheep farmers nationally. Regional perspectives in the South-west can be accessed through the Southwest Uplands Federation (www.swuf.org.uk) which works for hill farmers on Dartmoor, Exmoor and Bodmin, and the Dartmoor Commoners Council (www.dartmoorcommonerscouncil.org.uk). Cumbria Commoners Federation works as a representative organisation to maintain and improve the viability of hill farming (www.cumbriacommoners.org.uk). Nationally the Foundation for Common Land is a registered charity established to protect the public benefits from pastoral commoning; offering a gathering place for those in Great Britain and beyond with a stake in pastoral commons and their future (www.foundationforcommonland.org.uk).

EBLEX is an organisation funded by beef and lamb levy payers to promote an efficient supply chain and add value to the industry. It produces a range of technical publications on production and marketing including theoretical nutrient allowances for sheep in the hill ewe weight range (www.eblex.org.uk).

The European Forum on Nature Conservation and Pastoralism (EFNCP) is the only European organisation focusing on the maintenance of low intensity livestock farming using semi-natural pastures and meadows (www.efncp.org). The website reflects their role in 35 countries across Europe.

The James Hutton Institute is a major research provider of the Scottish Government and its work includes soils, land use including key issues relating to food, energy and environmental security, and the development of effective technological and management solutions to the key global issues that are related to them (www.hutton.ac.uk). The Institute of Biological, Environmental and Rural Sciences (IBERS) is an internationally recognised research and teaching centre within Aberystwyth University responding to global challenges. Its publications focus on knowledge-based innovations (www.aber.ac.uk/en/ibers). The Countryside and Community Research Institute (CCRI) is a partnership between the University of Gloucestershire, the Royal Agricultural University and Hartpury College undertaking research relevant to Britain and Europe emphasising sustainable development, economic regeneration, sustainable environments, local distinctiveness and inclusive processes (www.ccri.ac.uk).

Comparative analysis of hill farming businesses in England is undertaken by the Rural Business Research (RBR) unit as part of the Farm Business Survey. Data including comparative analysis is produced for Hill Farming in England (www.ncl.ac.uk/afrd/business/FarmBusinessSurvey.htm) (2011).

Defra (www.defra.gov.uk) and other government agencies including Natural England (www.naturalengland.org.uk) are major providers of information on policy formation and implementation in practice.

The evolution of hill farming practice was conditioned by market forces from the post-conquest period. Eileen Power provides well researched insights in her book *The Wool Trade in English Medieval History* (OUP, 1941). For an insight into the emergence of hill farming development, the gift of Lord Milford establishing the Welsh Plant Breeding Station, and the Cahn Hill experiments funded in 1933 by the businessman and philanthropist Sir Julian Cahn, mark a turning point in hill farming development. Under the leadership of Sir George Stapledon the possibilities to improve life in the hills was demonstrated. Stapledon's work is well described in his own apostolic style in *The Way of the Land*, (London, 1943). Allan Fraser, Research and Advisory Officer on Sheep at the Rowett Institute, provides very readable insights, informed by practical and research experience in *Sheep Farming* (6th edition. London, 1954). The public investment in scientific research for the hills that came after the Second World War through HFRO is the subject of *Science and Hill Farming 1954-1979* (HFRO, 1979). Twenty-five years of work from its inception are summarised, focussing on the emergence of a systems approach.

Terminology in hill farming is diverse in different areas, and a number of glossaries are available from the organisations listed.

Appendix 1. Supplements for hill ewes

Evaluation of 'value for money' feeding supplements to pregnant hill ewes on indigenous grazing is difficult, as nutritional deficits are hard to quantify, and will include minerals and trace elements. Specifically on heather-dominant hills, extra protein supply in mid-pregnancy from feeding blocks increases lamb birth weight. The cost of feeding the material in time and labour has also to be accounted for. Supplements may affect grazing behaviour and hence overall feed intake. Simple comparisons of cost per unit of ME and CP are less relevant than with other classes of stock – see Table 8 below.

Table 8. Supplements for hill ewes[134]

Supplement & typical daily intake	Cost per tonne (£)	Cost per day (p)	Labour cost	Packaging cost (£/t)	Approx % of energy requirement	% Minerals and vitamin requirement
0.45 kg compound (12.5 ME, 18% CP)[135]	180	8.1	Very high	Bags 25 Tote 5[136]	45	70
0.8 kg good hay	100	8.0	Moderate	Nil	55	Variable
0.45 kg beet pulp	210	9.4	Very high	Bags 25 Tote 5	45	20
80 g hard pour high energy bucket block	618	4.9	Very low	Plastic 80	10	90
0.15 kg standard block	400	6.0	Very low	Bags 8	15	100
0.25 kg super energy block	430	10.7	Low	Bags 8	25	100
0.2 L liquid feed containing urea[137]	285	7.4	Moderate	n.a.	15	10

[134] Table adapted from SAC Year round feeding the ewe for lifetime production, 2009 p. 21, last updated Nov 2009.
[135] ME – metabolisable energy; CP– crude protein.
[136] Tote – canvas dumpy bags holding bulk feed.
[137] Urea is a non-protein compound containing nitrogen (46.7%) which is broken down to form ammonia in the rumen. Micro-organisms combine the ammonia with the products of carbohydrate fermentation to form microbial protein and are taken down the digestive tract for digestion and absorption. One kg of pure urea contains as much nitrogen as 2.92kg of protein.

Appendix 2

Table 9. Example of feeding summary from a single year in a north of England hill flock[138]

Month	Hay	Feed blocks[139]	Concentrates[140]	Post-lambing Concentrates for Twin-bearers
January		**18th - 0.13 kg**		
February	**8th - 0.3 kg** **19th - 0.6 kg**			
March	**22nd- 0.4 kg**		**10th- 0.1 kg** **22nd- 0.22 kg**	
April	**20th hay feeding ceased**	**30th block feeding ceased**	**1st- 0.45 kg** **20th concentrates ceased for single bearers**	**20th - 0.45 kg**
May				**15th – concentrates ceased**
Total per ewe	**33.8 kg**	**13.65 kg**	**11.95 kg**	**11.25 kg (ie 23.2 kg in total)**

[138] Figures per ewe. The Newton Rigg College Hill Farm hill flock grazes on the Skiddaw Massif.
[139] Ewes began on standard blocks and changed to high energy nearer lambing.
[140] On this farm scanning of the fell flock was instituted after the above figures were recorded.

Appendix 3. List of illustrations in order

(credits in text where appropriate)

My thanks to those who have provided and given permission to use these images

The Foundation for Common Land

The Foundation for Common Land is a registered charity established to protect the public benefits from pastoral commoning. Our charitable objects are as follows:

- To conserve the agricultural systems and the cultural landscapes associated with commoning and the management of common land for the benefit of the public

- To promote the conservation of the physical and natural environment of common land by supporting the responsible and sustainable pastoral use of commons

- To conduct and commission research into commoning and common land issues and publish the results of such research to the public at large

- To educate the public, particularly policy makers and other interested parties in subjects pertaining to commoning and common land

www.foundationforcommonland.org.uk