**BD1228 Determining Environmentally Sustainable and Economically Viable Grazing Systems for the Restoration and Maintenance of Heather Moorland in England and Wales**

# Identification of Upland Habitats and Criteria by which to Judge Successful Restoration

***ADAS Wolverhampton***

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**Convened by**

**ADAS/IGER/RSPB/CEH/SAC/University of Newcastle Upon Tyne/Penny Anderson Associates Ltd.**

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## 1 INTRODUCTION

A workshop was held at ADAS Wolverhampton and focused on the identification of upland habitats and criteria by which successful restoration can be judged. This forms part of the delivery for DEFRA funded contract BD1228 (Determining Environmentally Sustainable and Economically Viable Grazing Systems for the Restoration of Maintenance of Heather Moorland in England and Wales).

The aim of the workshop was to consult (through invitation) with relevant conservation and agricultural bodies to:

- Identify the range of degraded habitats requiring restoration
- Establish the biodiversity requirements for degraded habitats
- Identify the economic issues, penalties and benefits of degraded habitats
- Identify some of the existing grazing operations that seek to restore and maintain heather moorland habitats
- Identify a range of criteria to define the endpoint(s) for successful moorland restoration against which habitats/sites can be evaluated

## 2 WORKSHOP STRUCTURE

The workshop consisted of:

- A presentation from Owen Davies, which introduced the workshop, aims and objectives and how it fitted into the overall objectives of the project (Section 3)
- Morning breakout session, introduced by Penny Anderson, on defining requirements (Section 4)
- Afternoon breakout session, introduced by Sarah Gardner, on defining criteria (Section 5)
- General discussions on the findings of the workshop, potential problems and concerns (Section 6)

## 3 PROJECT AND WORKSHOP INTRODUCTION

This workshop report on the 'Identification of Upland Habitats and Criteria by which to Judge Successful Restoration' is part of the delivery for the project 'Determining Environmentally Sustainable and Economically Viable Grazing Systems for the Restoration and Maintenance of Heather Moorland in England and Wales'. This new research project, funded by Conservation Management and Beef & Sheep Divisions in DEFRA, English Nature and the Countryside Council for Wales, has as its aim the development of environmentally sustainable and economically viable grazing systems for restoring and subsequently maintaining heather moorland habitats. This joint initiative, worth over £1M over 5 years, aims to integrate environmental and livestock production objectives into sustainable grazing regimes appropriate for the uplands of England and Wales.

The project consortium comprises of ADAS (consortium leaders), IGER, CEH, RSPB, SAC, University of Newcastle upon Tyne and Penny Anderson Associates Ltd. The consortium members combine considerable knowledge of hill systems, including farming, ecology and economics. Members of the collaborative organisations present at the workshop are listed in Appendix 1.

The project includes five main objectives:

- Scoping of the project including consultation with stakeholder representatives to identify the habitats and species of key concern and the criteria against which successful management of these habitats/species should be evaluated
- Evaluation of existing grazing operations and intervention techniques for maintaining and restoring heather moorland habitats, in order to determine the factors influencing their success, their impact upon biodiversity and their economic viability
- Development, through modelling of single (sheep or cattle) and mixed grazing practices and intervention techniques appropriate for restoring and maintaining heather moorland in areas of England and Wales
- Assessment of the impact of sheep only, cattle only and mixed grazing practices on vegetation recovery, livestock production, biodiversity and

economics together with impacts on birds and invertebrates, and an assessment of the selective grazing preferences of different breeds of sheep and cattle

- The results of the research project will provide the basis for guidelines that will be prepared for land managers and advisers on environmentally and economically sustainable grazing systems for the uplands

The project scoping study of which this workshop is part also includes a project initiation meeting with the funders, literature reviews and a wider stakeholder consultation to identify existing restoration and maintenance regimes. In addition to the results from the workshop, this report also includes information gathered from stakeholder questionnaires, which were returned by organisations unable to attend the workshop, but wanting their contributions to be included.

## 4 DEFINING HABITATS AND REQUIREMENTS

The factors leading to degradation in upland habitats, their interactions and their potential results were highlighted in a presentation by Penny Anderson, which is summarised in section 4.1. Following this presentation a breakout session commenced covering specific objectives of the workshop aims. During this session delegates (Appendix 2) selected one of four workshop groups, which covered the following topics:

1. Definition of and regional variation in degraded habitats
2. Biodiversity requirements for degraded and restored habitats
3. Economic requirements of degraded habitats
4. Identification of current restoration activities, their drawbacks and problems

Each group had very narrow and focused objectives, and these are summarised along with the discussions in sections 4.2-4.5.

## 4.1 Factors leading to degradation in upland habitats, their interactions and their potential results

Before discussing the factors leading to degradation it is important to define what is meant by degradation. A value judgement is made on the ideal vegetation type and, therefore, how the condition of the site differs from that ideal. The objectives for nature conservation, management, agricultural use and landscape may be different and, therefore, identification of degradation will vary from place to place, both in type and in intensity, and from person to person.

Degradation is not a single process but an interaction of factors putting vegetation under different stresses, which might be related to climate, season, grazing pressure, fire *etc*. The possible combination of factors covers a wide range. Degradation is not necessarily a simple process nor is it necessarily recent in origin.

It is very important when considering degradation not to use the same idealistic end-point or identification of condition everywhere. Every place has its own unique identity, and we must be very careful not to produce criteria that tend towards homogeneity. Variety is all-important on a local and geographical basis.

<u>The Degradation Process</u>

Basically, this concerns changes in plant and animal communities derived from, for example:

- the loss or decline of dwarf shrub species
- the increasing dominance of *Eriophorum* spp., *Nardus, Molinia* or *Pteridium*

Severe degradation may result in the total loss of vegetation which might be partial or complete on small or large scale. This can lead to erosion, both on small and large scale. When the peat is lost, the regolith is exposed and the materials are then dissected.

The Factors Leading to Degradation

The main factors to consider are:

- grazing
- fire
- air pollution
- trampling
- disease
- climate

These tend to interact but one may be more important than another.

***Grazing***

Care is needed in attributing degradation simply to overgrazing. There are many other factors associated with grazing which may be involved. For example, cattle have been widely replaced by large numbers of sheep in the uplands, although this pattern has not occurred everywhere - sheep have been on some upland areas in large numbers for many centuries dating back to the Cistercian monasteries. Sheep type and size have changed. Sheep breeds specialising in feeding on the vegetation on the moors have been replaced by those more productive for the market place, but not necessarily as well adapted to use of moorland plants. The seasonal use of the moorlands has changed, with much more all-year use now than in previous decades or centuries. Lamb is much more important now than mutton, so the age range of sheep is different. In addition, there is very little shepherding now and sheep are in higher numbers particularly building up since the 1930s.

There are few areas where grazing by itself has destroyed vegetation on a large scale. Examples were given from County Mayo on a large-scale blanket bog with degradation of the hill above to a *Nardus*/heath rush vegetation. For the most part sheep hagging along with concentration on more palatable species, has resulted in small areas of bare ground, for example on wavy hair-grass areas on the edge of some Peak District hills. Sheep may also reduce successful regeneration of vegetation at damaged sites, due to their habit of feeding in short vegetation or at the edges of bare ground.

***Fire***

Summer fires in dry conditions can have catastrophic effects on vegetation, destroying the rootmat and exposing the peat or subsoils to erosion. This is very extensive in some areas particularly the Peak District where recreational pressure has been blamed along with arson for many of the fires. Fire damage, however, goes back more than 100 years having occurred in particularly dry periods. Fire will differentially damage vegetation depending on how dry it is, how hot the fire is, whether it back burns, whether it burns fast or slow across an area etc. Fire within the legal burning season may also damage vegetation during dry periods (such as the six weeks of dry weather in March/April 2001) on dry ground. Such burning can lead to badly damaged *Molinia* and *Eriophorum* tussocks. Tussocks tend to degenerate over time and when combined with heavy sheep grazing and air pollution, such degeneration can prevent mosses such as *Sphagna* from patching up the ground, and enable erosion to commence.

Repeated fires on an annual or near annual basis have been blamed for reducing dwarf shrubs such as *Calluna* and *Ericas* which regenerate more slowly than grasses. Heavy grazing can compound this effect.

***Air Pollution***

In the areas of moorland affected most by sulphur dioxide pollution in the past (Peak District, South Pennines and South Wales) *Sphagna* and some lichens have disappeared from blanket bog vegetation, removing species which might otherwise help repair damaged ground. Air pollution is not blamed for destroying vegetation but there have been serious concerns about the condition of moorland vegetation as a result of sulphur dioxide pollution in the past.

Sulphur dioxide pollution is now reducing but NOx pollution is increasing. Its impact on the condition of moorland habitats is not yet clear but there is evidence that increasing nitrogen deposited on heather increases its sensitivity to heather beetle. This in turn can result in loss of heather in a moor where grazing levels might prevent regeneration after damage.

***Trampling***

There is a wide perception amongst landowners in particular that recreational trampling has major impacts on the moors. Although scars are evident, for example the trampling zone of the Pennine Way reached a width of 100m prior to its recent restoration, the total amount of ground damaged by recreational trampling is in fact quite small in relation to the quantity of moorland. However, trampling by livestock may also be an issue in places. Investigations in the Peak District are examining whether heavy trampling on shale, mineral and thin peaty soils by high numbers of stock on unimproved, enclosed land is resulting in a more impervious surface, more runoff, less infiltration, and resulting in the equivalent of the drought effect in summer and bad poaching and puddling in winter. This may be having an effect on soil invertebrates and, therefore, also on wader birds which are declining within areas otherwise managed for them, though there is also evidence that high rates of nest predation may be a cause of decline for breeding waders in this area. Trampling on some moorland areas such as Bodmin, where cattle are kept out in the winter is another example of livestock trampling problems.

***Disease/Pests***

The pest that has the most obvious effect on moorland vegetation is the heather beetle which can be responsible, as in 1998-99, for very extensive loss of heather. The loss may be permanent where heavy grazing pressure prevents regeneration. In normal circumstances on a well-managed grouse moor, the heather should recover during the normal management cycle. Although there are no other major diseases or pests responsible for degradation of moorland at the moment, with the changes predicted for climatic warming, further disease/pest factors might become important.

***Climate***

It is possible that climatic warming is already having effects on moorland conditions in combination with some other factors. For example, on shallow soils, particularly south facing slopes, in periods of drought as in 1995-96, a grazing pressure producing short vegetation could result in widespread loss of

heather. It has been suggested that tight grazing in drought conditions increases transpiration/evaporation losses to the extent that there are species changes in the vegetation (cf. the recommendation not to mow a lawn during hot weather). Drought in the burning season can produce higher intensity effects of fire as described above. Increased NOx pollution also makes heather more susceptible to winter browning in frosts. The result will be a variety of competitive advantages for some species over others and changes, therefore, in the inter-specific relationships between species in the vegetation.

Higher rainfall is also predicted as a consequence of climatic warming. With high grazing pressures and regular burning, vegetation is short which means that runoff is increased. There is a concern that flushes and streams may be drying out because of the compaction already described. These are areas of high biodiversity in the moorlands, particularly of floristic and possibly invertebrate assemblages. With higher winter rainfall and less penetration into the ground, the risk of greater runoff and floodings downstream is increased. This may lead to further degeneration in the condition of the moorland although the precise impacts are not fully recognised at the moment.

### 4.2 Definition and regional variation in degraded habitats

The aim of this breakout session was to:

- Define the range of degraded upland habitats in England and Wales requiring restoration
- Collate opinion on the regional variation in these degraded habitats and prioritise them

**Summary of results from workshop group and questionnaires**

The range of degraded upland habitats that should be targeted for restoration included those in which there has been:

- A loss of diversity and where monocultures of any species (except *Calluna*) dominate (*Nardus*, *Molinia*, *Ulex* and *Pteridium* dominated)
- A loss of species of conservation importance such as dwarf shrubs and *Sphagnum* (fragmented upland dry heaths, upland fringe habitats)

- A loss of vegetation structure associated with mismanagement such as missing age classes of heather (suppressed heather on dry heaths)
- A change in physical attributes such as erosion of substrates and hydrology (blanket bogs, valley mires, wet heath)

Several important points were raised and are noted below.

- It is important to define an end point for restoration for each site/landscape under consideration. Whilst these endpoints will be influenced by the Biodiversity Action Plans for the different habitats within the landscape, they should also consider the degree of local variation in the habitat types, that is or was present in the past and the extent to which the reinstatement of such variation is practical
- Habitats should nor be viewed in isolation. It is important to examine them in terms of overall upland ecosystem function
- Habitats should be targeted and prioritised in order of their ease of restoration, such as suppressed heather on dry heath, then *Molinia* and *Nardus* grasslands

### 4.3 Biodiversity requirements for degraded and restored habitats

The aim of this breakout session was to:

- Define the floral and faunal biodiversity requirements for restored degraded habitats

**Summary of results from workshop group and questionnaires**

There is difficulty in defining the historic biodiversity requirements of degraded and restored habitats. Therefore, they have to be reset by current conservation frameworks such as National Biodiversity Action Plans (BAPs), Local BAPs and other recognised criteria that may be specific to particular taxa (e.g. red, amber and green listed Birds of Conservation Concern).

At the generic level the use of existing conservation frameworks needs to be used to set the biodiversity objectives, giving priority to habitats and species of international and national importance. However, at the regional and local

level of individual moors these priorities need to be set within the context of what are typical moorland assemblages for that area. Thus, it is likely that the process of measuring the success of restoration on a particular moor will involve several tiers of assessment, along the following lines:

- Changes in the extent of priority BAP habitats
- Changes in the population sizes of individual BAP species (that are considered part of the moorland assemblage)
- Changes in the extent of LBAP habitats
- Changes in the population sizes of non BAP species that are identified as priorities for conservation under other criteria (e.g. red and amber listed bird species of conservation concern)
- For particular taxa, changes in their overall abundance and in the diversity and richness of the moorland species assemblage for that taxa (set in the context of what is typical for that particular area or region)

An important point to bear in mind with regard to moorland restoration is, that in order for this to be undertaken in a biologically sustainable way, the impact of the restoration programme on neighbouring areas and habitats must be considered. For example, reductions in livestock density on a degraded moor that allowed successful recovery of dwarf shrubs on that moor could result in a net biodiversity loss if the livestock were simply moved onto adjacent in-bye habitats, causing degradation there.

### 4.4 Economic requirements of degraded upland habitats

The aims of this breakout session were to identify:

- Economic issues associated with degraded moorland habitats
- Penalties and benefits of degraded moorland habitats
- Penalties and benefits of restoring degraded moorland habitats

This session was to include and cover farming, shooting and other economic activities.

**Summary of results from workshop group**

Many of the economic issues relating to degraded moorland habitats are associated with agricultural production based subsidies. At present environmental payments are based on income foregone rather than public good and habitat value. There are problems rewarding and giving recognition for biodiversity and landscape gains produced by individuals for wider benefits of tourism and the rural economy. The use of direct payments for management rather than agriculturally based payments such as on the basis of income forgone would benefit moorland restoration but the criteria for these payments are difficult to determine.

**Benefits of current degraded moorland habitats**

- Large-scale farming can potentially occur equally or better on degraded (grassy) habitats
- High subsidies and simple payment systems
- No cattle housing costs by heavy use of outdoor areas
- No slurry problems
- Higher farmer based rural employment
- Degraded moorland may provide a potential for better grazing

**Penalties of current degraded moorland habitats**

- Overgrazing can lead to loss of payments
- Vulnerable to changes in subsidies
- Vegetation may decrease in agricultural value
- Reduced animal performance may occur
- More degradation, therefore higher cost for future restoration
- Reduced shooting value
- Higher pollution costs
- Higher risk of flooding and its associated costs downstream

**Benefits of restoring degraded moorland habitats**

- Short-term economic benefit from selling stock and leasing quota out
- Increased sustainability
- In line with future European Union support
- Possibly more agri-environment payments
- More diverse products, of better quality which can have added value
- Animal health/welfare can be improved
- Potential to use more native breeds, which may have market and tourism benefits
- Economic benefit to the rural economy of restoration industry
- More tourists
- Less flooding and associated costs
- More potential for incomes from shooting

**Penalties of restoring degraded moorland habitats**

- Reduction in stocking rates and associated loss of direct subsidies
- Associated economic losses from extensification for agriculturally related businesses downstream
- Loss of traditional labour skill
- Depopulation
- Direct costs of restoration (fencing, burning, herbicides and seeding)
- Shortage of skilled people to carry out restoration work
- Potential for animal health and welfare issues, such as those from off-wintering, or of grazing animals as tools to manage vegetation where animal production is not a priority
- Agri-environment payments are insufficient for proactive management
- Difficulties in matching restoration with animal production systems
- Costs of changes in extension services, and need for more effort

## 4.5 Identification of current restoration activities, their drawbacks and problems

The aims of this breakout session were to identify:

- Current restoration techniques and grazing practices that are already being used to maintain and restore upland habitats
- The potential drawbacks of using these practices for the large-scale restoration of upland habitats
- Potential problems when implementing these techniques or practices

**Summary**

Techniques to restore heather moorland were summarised into five main categories these were grazing manipulations; re-vegetation of bare ground; re-vegetation following control species; drain blocking and burning.

Manipulation of grazing included:

- Exclusion with temporary fencing (small scale – mid term)
- Shepherding
- Large scale exclusion
- Hefting and associated large scale stock clearance (requires co-ordinating when several graziers are involved)
- Changes in season when grazing occurs
- Increasing carrying capacity of moors (by controlling unpalatable species such as *Molinia)*
- The introduction of different grazing animals such as cattle and ponies
- Reducing the ratio of sheep to cattle
- Supplementary feeding

The re-vegetation of bare ground may require several steps that should potentially be conducted in the following order. However, each additional step has higher associated costs, which need to be considered in terms of each individual site.

- Removal of grazing animals
- Introduction of desired vegetation
- Heather as a nurse crop for other moorland vegetation
- When there are problems establishing heather then a grass nurse crop may be required
- If difficulty in establishing grass nurse crop then the minimum use of fertiliser and lime may be necessary
- If the ground is still unstable the use of geotextiles may need to be considered to stabilise the ground

Combinations of cutting burning and spraying treatments can be used to control dominant species. The timing and sequence of these can have major effects on the control obtained. For example burning the dominant species will cause it to produce a flush of growth and therefore the spray will have a more effective kill. Habitats dominated by bracken may have more biodiversity potential if stock is removed and woodland/scrub or tall herb communities are considered the goal rather than dwarf shrub heath. In habitats where drains require blocking and there is an erosion problem with gullies, it is worth evaluating whether these are the result of mismanagement or natural erosional processes.

**Defining criteria**

The introduction to the afternoon breakout session highlighted (a) how the definition of criteria will help the project, (b) important characteristics in relation to the definition of criteria which need to be considered during the brainstorming sessions, and (c) how they will be used.

The definitions will be used for identifying when a site can be considered a success with respect to restoration of upland heath both in terms of its environment and economic value. They will be used to help define

endpoint(s) and milestones by which progress can be assessed.

The criteria can be divided into two sub-groups; economic criteria relating to farm, estate and visitor-based businesses, and environmental criteria relating to physical, biological, heritage and landscape.

It was suggested that the criteria identified need to be:

**Practical –** easy to identify and measure, typical and representative of the upland heath environments or of upland business interests.

**Specific –** objective (not relying on expert judgement), measurable and clearly linked to either environmental or economic status of the site.

**Progressive –** can be used to indicate progress at one or more stages of the restoration process for example Years 1-3 (preliminary criteria), Years 5-10 (secondary), 10+ years (tertiary).

The criteria identified from the workshop sessions are summarised in section 6 and are scored according to the following characteristics: objective, measurable, requiring expert judgement, practical. A score of 1 indicates a low value for a particular criterion and a score of 5 indicates a high value.

Delegates selected to attend one of four breakout groups that were to consider criteria in four different areas. These areas were:

- Criteria for defining restoration success in relation to flora and fauna
- Criteria for defining restoration success in terms of landscape and recreation
- Criteria for defining restoration success in terms of farm business and livestock performance
- Criteria for defining restoration success in terms of shooting and other non-farming activities

Each group were asked to brainstorm as many potential criteria as possible and then evaluate in terms of the following questions:

- Can they be specifically measured?
- Are they objective?
- Do they require expert judgement?
- Are they practical?
- Are they linked to one or more elements?
- Can they be used as progress markers through the restoration phases highlighted in the introduction (primary 1-3 yrs, secondary 3-10yrs, and tertiary 10yrs+)?

Although criteria in relation to fauna and flora were identified in the workshop, these are likely to be superseded by the forthcoming JNCC Common Standards Monitoring attributes and targets.

Deleted: superceded

## 5 SUMMARY OF FINDINGS AND DISCUSSION

Degraded upland habitats that should be targeted for restoration:

- Those suffering a loss of diversity and where monocultures of any species (except *Calluna*) dominate (e.g. *Nardus*, *Molinia*, *Ulex* and *Pteridium*)
- Those suffering a loss of species of conservation importance such as dwarf shrubs and *Sphagnum* (e.g. fragmented upland dry heaths, upland fringe habitats)
- Those suffering a loss of vegetation structure associated with mismanagement such as missing age classes of heather
- Those undergoing physical change such as erosion of substrates or altered hydrology (blanket bogs, valley mires, wet heath)

Concerns over the use of favourable condition for non-designated sites were expressed and the question raised about defining the starting point for restoration and in what direction environmental criteria should be heading. The problem was partly related to the determination of historical changes and partly to the level of information available for the habitats.

At the other end of the process the ability to define the end point(s) when a

restoration regime switches to maintenance were discussed. At present it comes down to professional judgement based on experience and who was making the decision.

The capability for objective measurement of landscape/recreational criteria was questioned. Landscape heterogeneity and linear features could be measured by remote sensing but concepts such as ‘wilderness’ are less easily assessed.

Limited discussion about the production of guidelines (the project output) included views on what they should contain such as:

- Required vegetation heights for different objectives
- Cost effective way of achieving this
- Livestock breeds
- Economic viability

**Criteria for defining restoration success in relation to flora and fauna**

| Criteria | Specifically measurable | Objective | Expert judgement | Practical | Progressive Primary (1), secondary (2), or tertiary (3) |
|---|---|---|---|---|---|
| Increase in dwarf shrubs | 5 | 4 | 2 | 4 | 3 |
| Reduction in grazing of dwarf shrub grazing at interfaces with more palatable vegetation types | 4 | 4 | 4 | 2 | 1-2 |
| Reduction in frequency of grazing induced growth forms | 4 | 2 | 5 | 3 | 3 |
| Decrease in the % of eroding peat | 4 | 3 | 3 | 3 | 1 |
| Decrease in the % of bare ground | 4 | 3 | 3 | 4 | 1 |
| Increase in flowering of grasses | 2 | 2 | 4 | 2 | 1-3 |
| Increase in structural variation in dwarf shrubs | 3 | 2 | 4 | 2 | 1-3 |
| Decrease in grazing of unpalatable grasses | 1 | 2 | 4 | 1 | 1 |
| Decrease in grazing of dwarf shrub | 4 | 4 | 4 | 2 | 1 |
| Decrease in Deschampsia | 4 | 4 | 2 | 4 | 1-2 |
| Decrease in Juncus | 4 | 4 | 2 | 4 | 1-2 |
| Decrease in monocultures | 4 | 2 | 4 | 2 | 3 |
| Reduction in Nardus | 4 | 4 | 2 | 4 | 1-3 |
| Increase in bryophytes/lichens | 4 | 4 | 3 | 2 | 3 |
| Increase in diversity of dwarf shrubs | 3 | 3 | 4 | 2 | 2-3 |
| Reduction in Molinia | 4 | 4 | 2 | 4 | 1-2 |
| Increase in the ratio of dwarf shrub to total moorland grass cover | 3 | 3 | 3 | 3 | 2-3 |

**Criteria for defining restoration success in relation to flora and fauna (contd)**

| Criteria | Specifically measurable | Objective | Expert judgement | Practical | Progressive Primary (1), secondary (2), or tertiary (3) |
|---|---|---|---|---|---|
| Increase in the heterogeneity of vegetation structure | 4 | 3 | 2 | 2 | 1 |
| Increase in relative abundance of plant species present | 3 | 3 | 2 | 3 | 2-32 |
| Increase in ratio of desirable to undesirable species | 4 | 3 | 2 | 2 | 1-3 |
| Reduction in Pteridium cover | 4 | 4 | 2 | 4 | 1-2 |
| Reduction in Ulex europaeus | 5 | 4 | 2 | 4 | 1-2 |
| Increase in local species indicative of particular habitats | 4 | 4 | 3 | 2 | 3 |
| Increase in Sphagnum spp. | 2 | 3 | 3 | 2 | 2-3 |
| Increase in spp richness/diversity of the moorland invertebrate assemblage | 3 | 2 | 5 | 1 | 3 |
| Increase in species richness/diversity of the moorland bird assemblage | 4 | 4 | 4 | 1 | 3 |
| Increase in bird populations, with particular emphasis on species of conservation concern (e.g. black grouse and skylarks) | 4 | 4 | 4 | 2 | 3 |
| Increase in invertebrates populations with particular emphasis on species of conservation concern (e.g. *Tipula serrulifera*) | 3 | 4 | 5 | 2 | 3 |

**Criteria for defining restoration success in relation to flora and fauna (contd)**

| Criteria | Specifically measurable | Objective | Expert judgement | Practical | Progressive Primary (1), secondary (2), or tertiary (3) |
|---|---|---|---|---|---|
| Increase in moth populations with particular emphasis on species of conservation concern (e.g. netted mountain moth, argent and sable moth, small lappet, northern dart and sword-grass moth) | 3 | 3 | 4 | 3 | 3 |
| Increase in non rock lichens with particular emphasis on species of conservation concern (e.g. *Cladonia botrytes* and *Cladonia peziziformis*) | 4 | 4 | 5 | 2 | 3 |

**Criteria for defining restoration success in terms of landscape and recreation**

| Criteria | Specifically measurable | Objective | Expert judgement | Practical | Progressive Primary (1), secondary (2), or tertiary (3) |
|---|---|---|---|---|---|
| Increased landscape heterogeneity[1] | 3 | 4 | 2 | 1 | 2-3 |
| Increased sense of wilderness[2] | 1 | 1 | 5 | 1 | 3 |
| Decrease in presence of sharp habitat boundaries and fence lines[3] | 2 | 2 | 3 | 3 | 2-3 |
| Increase in flowering heather | 4 | 5 | 2 | 5 | 1-2 |
| Increase in flowering cotton grass | 4 | 5 | 2 | 5 | 1-2 |
| Presence of moorland bird communities | 4 | 4 | 2 | 4 | 2-3 |
| Increase in shepherding | 4 | 4 | 1 | 5 | 2-3 |
| Maintenance of pathways styles and gates | 3 | 2 | 3 | 4 | 1-3 |
| Numbers of hill walkers | 4 | 4 | 2 | 3 | 2-3 |
| Decreased fire risk for wet communities | 1 | 1 | 5 | 1 | 2-3 |
| Increased fire risk for dry communities | 1 | 1 | 5 | 1 | 2-3 |
| Qualification for Open Access | 1 | 1 | 3 | 2 | 2-3 |
| Conservation of heritage sites | 2 | 2 | 4 | 2 | 3 |
| Enhancement of boundaries (walls and hedges) | 3 | 3 | 3 | 3 | 2-3 |

[1]Landscape heterogeneity – at landscape scale, the extent of visible variation in moorland habitats.

[2] Wilderness: - vast open spaces, imposing mountains, hills etc, lack of human presence.

[3] Linear features:- this is concerned with sharp habitat boundaries in relation to restoration, as opposed to habitats that are interspersed and merge into each other

**Criteria for defining restoration success in terms of farm business and livestock performance**

| Criteria | Specifically measurable | Objective | Expert judgement | Practical | Progressive Primary (1), secondary (2), or tertiary (3) |
|---|---|---|---|---|---|
| Optimise food carrying capacity of moorland plant species | 1 | 1 | 1 | 4 | 1-3 |
| Optimise gross margins (per head) | 4 | 4 | 3 | 4 | 1-3 |
| Optimise gross margins (per hectare) | 4 | 4 | 3 | 4 | 1-3 |
| Optimise gross margins (per moor) | 4 | 4 | 3 | 4 | 1-3 |
| Changes in net farm incomes associated with moorland restoration | 4 | 5 | 4 | 2 | 1-3 |
| Change in weaning weights | 5 | 5 | 3 | 4 | 1-3 |
| Decrease in % of barren ewes | 5 | 5 | 2 | 4 | 1-3 |
| Increase in carcass specification | 3 | 4 | 4 | 4 | 1-3 |
| Increase in livestock quality | 1 | 2 | 5 | 3 | 2-3 |
| Decrease in finishing age | 4 | 3 | 4 | 4 | 2-3 |
| Increase in lambing percentage | 5 | 4 | 2 | 5 | 1-3 |
| Reduction in income from subsidy payment | 4 | 3 | 4 | 3 | 2-3 |
| Greater or equal return of income from sale of produce | 3 | 3 | 4 | 3 | 2-3 |
| Increase in labour inputs for conservation maintenance | 4 | 3 | 3 | 2 | 1-3 |
| Bought in feed | 4 | 3 | 4 | 4 | 1-3 |

**Criteria for defining restoration success in terms of shooting and other non-farming activities**

| Criteria | Specifically measurable | Objective | Expert judgement | Practical | Progressive Primary (1), secondary (2), or tertiary (3) |
|---|---|---|---|---|---|
| Increase in quarry numbers (hare, deer, red grouse) | 4 | 3 | 4 | 5 | 2-3 |
| Increase in quarry breeding success | 3 | 3 | 5 | 3 | 2-3 |
| Increase in flowering vegetation | 2 | 3 | 4 | 3 | 1-2 |
| Decrease in predator numbers | 3 | 2 | 4 | 4 | 1-3 |
| Increase in shoot bag counts | 5 | 3 | 1 | 5 | 2-3 |
| Level of economic shooting activity | 3 | 3 | 3 | 5 | 1-3 |
| Increase employment | 2 | 2 | 4 | 2 | 2-3 |
| Presence of Muirburn cycle | 5 | 4 | 2 | 5 | 1-3 |
| Change in drainage water acidity | 3 | 2 | 3 | 1 | 2-3 |
| Level of nitrates in drainage water | 5 | 2 | 2 | 2 | 3 |
| Increased flood retention | 1 | 2 | 4 | 1 | 3 |
| Increased water supply in drought | 1 | 2 | 4 | 1 | 3 |
| Reduction in sediment load in reservoir traps | 4 | 2 | 2 | 2 | 2-3 |
| Decrease in humic acids in drainage water | 4 | 3 | 3 | 2 | 2-3 |
| Increased fishing in catchment | 4 | 2 | 3 | 1 | 3 |

**APPENDIX 1**

**Staff of the Project Team that Contributed to the Workshop**

| Name | Organisation |
|---|---|
| Mr Owen Davies | ADAS |
| Dr Sarah Hetherington | ADAS |
| Dr Sarah Gardner | ADAS |
| Dr Rob Rose | CEH |
| Dr Murray Grant | RSPB |
| Dr Graeme Buchanan | RSPB |
| Dr Tony Waterhouse | SAC |
| Dr Barbara McLean | ADAS |
| Dr Roy Sanderson | University of Newcastle |
| Dr James Pearce-Higgins | RSPB |
| Mr Arthur Davies* | IGER |

* Was invited as a participant.

**APPENDIX 2**

**Delegates of the Workshop on Upland Habitats and Criteria by which to Judge Successful Restoration**

| | | Group Membership for breakout sessions | |
|---|---|---|---|
| **Name** | **Organisation** | **Morning** | **Afternoon** |
| Ms Penny Anderson | Penny Anderson Associates | **4** | **4** |
| Mr Kevin Austin | NAWAD | **1** | **1** |
| Ms Judy Clavey | Lake District National Park | **1** | **2** |
| Mr Ian Condliffe | RDS | **3** | **2** |
| Mr Alistair Crowle | English Nature | **1** | **2** |
| Mr Arthur Davies | IGER | **3** | **3** |
| Mrs Joanna Drewitt | Scottish Executive | **2** | **1** |
| Mr Geoff Eyre | WM Eyre & Son | **2** | **3** |
| Dr David Garwes | DEFRA | **2** | **1** |
| Mr Bill Grayson | Grazing Animal Project | **3** | **3** |
| Mr Rob Gritten | Snowdonia National Park Authority | **4** | **2** |
| Mr Dafydd Jarrett | National Farmers Union | **3** | **3** |
| Dr Barbara Jones | Countryside Council for Wales | **1** | **2** |
| Ms Rosemary Mansbridge | Rare Breeds Survival Trust | **3** | **3** |
| Sir Anthony Milbank | Moorland Association | **4** | **4** |
| Mrs Kath Milnes | English Nature | **4** | **1** |
| Mr John Philips | The Heather Trust | **3** | **3** |
| Mr Mike Roper | DEFRA | **3** | **3** |
| Ms Jan Sherry | Countryside Council for Wales | **2** | **1** |
| Mr Eric Steer | English Nature | **2** | **1** |
| Mr Rhodri Thomas | Peak District National Park | **4** | **2** |
| Mr Philip Warren | Game Conservancy Trust | **2** | **4** |