

No. 11
**The lowland heathland
management booklet
version 2.0**

N. Michael

English Nature Science

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obtained from

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ISBN 1 85716 266 8

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Preface

This is version 2.0 of English Nature's lowland heathland management booklet. This booklet is intended as a concise guide to the objectives and techniques of managing lowland heath for nature conservation. It is aimed at those who are not heathland specialists. For fuller information the reader is referred to English Nature's lowland heathland management handbook (Gimingham 1992).

It is intended that this booklet will be revised in due course. I would like to thank all those whose comments on an earlier draft substantially improved the text. Comments on the booklet are welcome and should be sent to:

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English Nature, which is England's statutory nature conservation service can provide advice on heathland management free of charge.

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1. Introduction

Lowland heathland is characterised by dwarf shrubs such as heather (ling), bell heather and cross-leaved heath, as well as gorse and a number of grasses. It typically comprises a whole range of habitats including heather and heath species, gorse, grassland, scrub, woodland, bare ground, wet heath, valley mires (bogs) and open water.

Lowland heath tends to be associated with nutrient poor acid to neutral mineral soils such as sands and gravels. In England lowland heath is generally found below altitudes of about 250 metres.

Heathland supports a range of characteristic plants and animals some of which are rare and many of which are in decline. Rare species associated with heathland include the marsh gentian, marsh clubmoss, Cornish heath, the sand lizard, smooth snake, silver-studded blue butterfly, small red damselfly, Dartford warbler, woodlark, stone curlew and nightjar (Nature Conservancy Council 1986; Webb 1986).

Only one sixth of the area of lowland heathland in 1800 now remains, representing less than 0.3% of England's land surface. Lowland heathland is therefore a rare habitat of high nature conservation importance. The areas of heathland that remain are now highly fragmented and tend to be much smaller than in the past.

The international importance of England's lowland heath has been recognised in European legislation. This includes the Berne Convention and Habitats and Species Directive.

The purpose of this guide is to provide practical guidelines for the management and restoration of lowland heaths. The aim of management is to ensure the long term survival of the heathland habitat and its associated species. The management of heathland is necessary for the following reasons:

- 1.1 Heather must be actively managed to ensure that its full range of growth stages are present on a site and to encourage it to regenerate successfully.
- 1.2 Management is necessary to maintain the range of heathland habitats required to support its characteristic flora and fauna. These include areas of bare ground and heathland grasses, gorse and scrub, wet heath, valley mire and open water.
- 1.3 In the absence of management, lowland heath tends to be invaded by bracken, scrub and trees and is eventually replaced by woodland.
- 1.4 Management is needed to maintain or restore the low soil nutrient levels which are characteristic of lowland heathland and so reduce the rate of invasion of undesirable plant species such as bracken.

Management is needed to maintain or restore the low soil nutrient levels which are characteristic of lowland heathland and so reduce the rate of invasion of undesirable plant species such as bracken.

Heathland restoration is undertaken where heathland has been lost through the invasion of bracken, grasses, scrub or woodland.

2. Types of heath

Different types of lowland heath may require different management (see Section 10). The main types of heathland vegetation on a site will be identified by a vegetation survey (Section 3.1), with the most usual types being:

2.1 Dry heath

This is the most familiar type of lowland heathland found on well drained soils in which heather (ling) is typically the dominant plant species. Bell heather, a range of grasses and gorses are also characteristic of dry heath.

2.2 Maritime and coastal heaths

Maritime heathland is often associated with cliff tops and can have a 'waved' appearance caused by the effects of salt-laden sea winds. It may contain some plants which reflect maritime conditions such as thrift and spring squill. Coastal dune heath is often characterised by plants such as heather and sand sedge. Coastal heath beyond the maritime influence can be very similar to lowland heath found inland.

2.3 Lichen heath

Lichen heaths, where several species of lichen predominate, occupy generally small areas on dry sandy soils. They require careful management to maintain their conservation interest.

2.4 Grass heath

True grass heaths, as opposed to the many heaths that include areas of acid grassland, are particularly characteristic of areas such as Breckland in East Anglia and parts of Humberside. Heather may only be present in restricted areas with much of a site dominated by acidic or calcareous grassland. Sheep's fescue is a typical grass species.

2.5 Humid heath

Humid heath occurs where drainage is somewhat impeded and is an important type in its own right. Humid heath is particularly characteristic of the New Forest in Hampshire where it is dominated by heather, purple moor-grass and cross-leaved heath.

2.6 Wet heath

Wet heath occurs where soil drainage is markedly impeded. Characteristic species of wet heath are cross-leaved heath, deer grass, purple moor-grass, sundews and some bog mosses (*Sphagnum* species).

2.7 Valley mire

Valley mires (bogs) may be found in low-lying valleys which intersect heathland. They typically consist of basins which are lined with peat and contain carpets of bog mosses and plants such as bog asphodel and cotton grass.

3. Site survey

Before undertaking the management of a heathland site for nature conservation, a **management plan must be drawn up** so that the objectives of management are identified. The Nature Conservancy Council (1988) gives detailed guidance on drawing up site management plans and setting management objectives. Management plans are normally drawn up for five year periods. It is usual to divide sites up into a number of compartments consisting of areas of relatively similar vegetation for management purposes. The first stage is to survey the site so that a management plan can be drawn up.

3.1 Survey method

Sites should be surveyed to at least what is termed 'Phase 1' level. Ideally the National Vegetation Classification system (Rodwell 1991) should be used in a more detailed 'Phase 2' vegetation survey but it is recognised that this may not be practical on all sites.

The Phase 1 survey should identify and map the habitats that are found on a site. Typically these might include:

- Dry dwarf shrub heath (D1)
- Wet dwarf shrub heath (D2)
- Lichen/bryophyte heath (D3)
- Dry heath/acidic grassland mosaic (D5)
- Wet heath/acidic grassland mosaic (D6)
- Woodland (A1)
- Scrub (A2)
- Bracken (C1)
- Grassland (B1)
- Dune heath (H6.6)
- Coastal heathland (H8.5)

For further details of methods, habitat types and codes see Nature Conservancy Council (1990). Maps at 1:2,500 scale subdivided into management compartments of relatively similar areas (eg dry heath, woodland or bracken) should be produced. Management operations for each compartment should be identified in the management plan.

3.2 Rare or notable species

The management plan should also take into account the presence of rare or notable species. The locations of notable plants, invertebrates, amphibians and reptiles and favoured nesting and feeding areas for birds should be recorded on the map (see Nature Conservancy Council 1988 for details). Information may already be available from a number of sources.

3.3 Heather growth stages

On those parts of sites that are dominated by heather, for the purposes of management it is useful to map the major areas of heather in each growth stage. A number of growth stages (phases) can be identified which may occur in combination (Figure 1). The rate at which heather enters the different stages varies locally and regionally according to factors such as drought, soil nutrient levels, atmospheric nutrient deposition levels, and the frequency of frosts and heather beetle attacks.

3.3.1 Pioneer heather

This is the establishment stage in which heather develops from seed into small pyramid shaped plants accounting for about 10% of vegetation cover.

3.3.2 Building heather

In this stage the heather forms a closed canopy accounting for some 90% of vegetation cover.

3.3.3 Mature heather

In this stage heather plants become woody, with thick stems and fewer green shoots. The heather canopy begins to open up, contributing about 75% of vegetation cover, as other plant species, especially mosses, begin to increase in cover.

3.3.4 Degenerate heather

In the degenerate stage the central branches of heather plants tend to die off, creating gaps in the centre of the bush in which heather seedlings may sometimes establish. Heather contributes only about 40% of vegetation cover. Eventually plants may die, although on sites where it is moist collapsed branches can root to create new plants. This is known as layering. Regeneration in degenerate heather from seedlings or by layering should be noted in surveys as it may influence management decisions.

3.3.5 Dead heather

Areas of dead heather are commonly encountered on lowland heath. Large areas of dead heather are not generally particularly valuable for nature conservation.

growth-phases
of heather

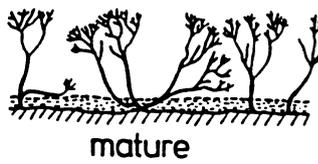
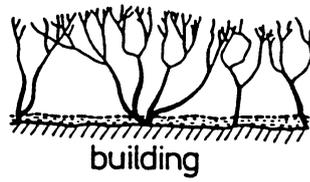


Figure 1. The four growth stages of heather

4. Heather management

The following section deals specifically with the management of heather on dry heath. This is of course only one element of heathland management on dry heath but an important one because heather commonly dominates large tracts of dry heath. The management of maritime, coastal, lichen, grass and wet heath is considered in Section 10.

The aims of heather management are to ensure that:

- all four growth stages of heather (see Section 3.3) are represented on a site;
- older heather can regenerate successfully;
- the accumulation of nutrients is prevented or reduced, thereby reducing the rate of invasion of undesirable plant species such as bracken.

Representation of the full range of heather growth phases is an objective of conservation management because it increases habitat diversity. Different heathland plant and animal species may be associated with particular growth stages of heather. The aim should be to have about 25% of heather in each of the four growth stages. However, some areas (eg 5% of the total area) of heather should not receive heather management to provide a deep litter layer for certain invertebrate species.

An advantage of having heather at the pioneer and building stages is that it tends to regenerate best from stems after cutting or rootstocks after burning before it reaches the end of the mature stage (see Figure 1). Once heather passes the early mature phase most heather regeneration is likely to be from seed in the litter or soil rather than cut stems or rootstocks. Regeneration from seed tends to be slower than from cut stems or rootstocks and may be less successful because competing species such as bracken have a greater opportunity to establish. Nevertheless it is important to ensure that mature and degenerate heather is well represented on lowland heathland sites.

Where large areas of heather are in the mature and degenerate stages heather management is usually necessary to ensure its regeneration. In some circumstances heather may regenerate vegetatively via trailing branches, but this does not occur on all sites and may not occur on all parts of a site even when it does happen. Therefore active management is almost always required to encourage heather regeneration. **Where heather regenerates vegetatively via trailing branches, a process known as layering, these areas will not necessarily require heather management, although scrub or bracken control may be needed.**

Extensive areas of dead heather will also require active management. Controlled burning, rotovation or turf cutting are to be preferred to cutting (see below).

Where large areas of heather are all at the same growth stage, management can be used to produce the desired mixture of pioneer, building, mature and degenerate growth stages. This can be done once the heather has passed the pioneer stage. Achieving the desired mixture of growth stages is likely to take a number of years on sites that do not already exhibit it.

Management is typically undertaken on a rotational basis. For example, on a 20 year rotation, one twentieth of the planned area would be burnt or cut each year. The precise length of rotation will vary according to geographical location and site specific considerations. Expert advice can be sought free of charge from English Nature.

Rotational management should provide areas of mature and degenerate stage heather. These areas should cover a reasonable proportion, eg 50%, of a heath. Management should be designed to ensure that areas of old heather are spaced out from each other to reduce the risk of large scale accidental fire. The size of patches to be managed should not generally exceed two hectares. Ideally patches should be long, narrow (eg as little as 10 m wide) and meandering strips with sinuous margins rather than square blocks to encourage recolonisation by animals and plants from nearby heathland, although it is recognised that blocks may have to be used for reasons of time and cost. Where possible it is desirable that each management plot shares boundaries with plots managed immediately before and after it in the rotation to encourage recolonisation.

There are four main methods of rotational heather management: cutting, controlled burning, rotovation and turf cutting. The following guidelines indicate how and when they should be used.

4.1 Cutting

Cutting is a useful rotational management technique which can often be used where grazing and burning cannot be employed. However, it has the disadvantage that it may not be very effective in removing the surface litter layer and so may encourage nutrient accumulation and the invasion of undesirable plant species such as bracken. Unlike burning, cutting has the advantage of not being weather dependent. Small scale variations in the height of heather can be created by cutting small strips in successive years which cross earlier ones in meandering swathes to encourage recolonisation. However, controlled burning is generally to be preferred to the cutting of areas of dead heather since burning removes more of the surface litter layer which encourages heather to regenerate from seedlings.

Cutting operations should be timed to prevent adverse impacts on heathland species such as reptiles and avoid the nesting season for birds which may typically extend between March and late August (see Section 8.2) and avoid the period when reptiles are active between March and October. Where heather shoots and capsules are required for heathland restoration, heather should be cut at a height of about 2.5 cm between mid October and the end of November when the capsules have a high seed content.

Cutting can also be used to regenerate old (mature and degenerate growth stage) stands of heather. Where regeneration from cut stems is poor because of the age of the heather it is beneficial to cut as low as possible and to rake or scrape off the bulk of the heather litter layer to encourage seedling regeneration. Cutting to a height of about 2.5 cm can also be used to create firebreaks. This will produce areas of short heather which can provide useful habitat for invertebrates. Cutting below about 2.5 cm reduces regeneration from heather rootstocks by removing the lowest dormant buds.

Heather may be cut using reciprocating mowers for small scale work, tractor-mounted swipes, flails or double-chop forage harvesters. Large machinery can only be used on relatively flat sites. Mayfield cutters, Allen scythes or scrub-clearing saws may be used on sites that are inaccessible to machinery, but their use is labour intensive and they only cut small areas. **Cuttings should be removed to avoid smothering vegetation, prevent the build up of heather litter and maintain low nutrient levels which may discourage the invasion of undesirable plants such as bracken and grasses.** They can also provide a seed source for heathland restoration. Removal of cut heather can be done by forage harvesting with a silage trailer or using a swipe or flail and collecting the cuttings with a baling machine or loader wagon or by raking cuttings up, although the latter is labour intensive. Cutting machinery should not be used on rocky or stump-ridden ground where it is likely to be damaged.

4.2 Controlled burning

Controlled burning is a method of promoting heather regeneration and diversifying the age range of heather. It has considerable advantages in terms of time and cost and the additional benefit that it removes nutrients which may discourage the replacement of heather by invasive plants such as grasses. It also provides areas of bare ground which are valuable for certain plant and invertebrate species.

Controlled burning must be carried out with great care on sites which adjoin forestry plantations or houses. **The burning of excessively large areas of heathland is incompatible with the conservation of many heathland plant and animal species. Burning should not normally be carried out where juniper is present.**

Controlled burning is particularly useful on slopes that are inaccessible to machinery and rocky or stump-ridden. Wet heath should only be burnt after careful consideration (Section 10.5).

4.3 Practical guidelines for controlled burning

Heather which is in the building or early mature stage will tend to regenerate best from rootstocks after burning. Older heather is likely to regenerate predominantly via seedlings rather than rootstocks giving more opportunities for invasive plant species to establish. Where there are likely to be very hot burns which destroy the heather roots and soil seed bank of heathland species, areas of old heather can be mown and the cuttings removed before burning. After the fire it may be necessary to rake up the litter layer to encourage seedling regeneration. Moribund heather which fails to ignite can be burnt with a flame gun.

The size of plots to be burnt should not exceed 1-2 hectares and should generally be smaller than this, eg 0.1 ha (for example a strip 100 m by 10 m). Where possible plots should be located away from major sources of invasive weed species such as pine, birch and bracken.

Controlled burning is confined by law to between **1 November and 31 March in England and Wales**. The regulations governing heather burning are given in the Heather and Grass Burning Code (Ministry of Agriculture, Fisheries and Food and Welsh Office Agriculture Department 1992). These must be followed. For instance, the owners of adjacent land must be informed of the intention to burn. In a dry autumn it may be possible to burn in November but the best period is often from mid-February until the end of March when the heather is relatively dry. **However it should be noted that controlled burning in March is best avoided on sites which support reptiles.**

Heather should only be burned in dry weather after several days of drying wind when the wind is light (no more than force 2-3). Fires are usually started with paraffin burners or blow torches. Burning should ideally be carried out in long strips as little as 10 m wide with sinuous margins to aid recolonisation although large blocks may have to be used for reasons of time, practicality and cost. Prior to burning, a meandering swathe about 4 metres wide should be mown as low as possible around the plot to act as a fire break. A greater width of fire break is advisable when gorse, pine or tall heather is adjacent to the patch to be burnt. The cut material should be raked onto the area to be burnt.

During burning, a fine jet of water from a fire tender can be used to control the spread and intensity of the fire. Alternatively the fire should be controlled using staff with fire-beaters. Knapsack sprayers, tractor-drawn diffuse mist water sprayers or bowsers can also be employed to control fires. At least three people should be present at all times with sufficient water and

equipment to extinguish the fire if it begins to get out of control. **No individual should be expected to control more than 5 m of fire front or edge using only fire beaters.**

A recent development is the foam spreader which allows controlled burning of small areas of heathland. Using equipment mounted on the back of a pick-up truck or trailer the patch to be burnt can be surrounded in advance with a foam barrier, which can be used to create an effective firebreak. Small patches can be burnt safely by a team of three to four people, although care needs to be taken that fires do not spread under the foam.

The aim of controlled heather burning is to remove all the above-ground vegetation cleanly so that regeneration can occur from rootstocks. In general on southern lowland heathlands heather should be 'back-burnt' (burnt against the wind rather than with it). Back-burning tends to produce a relatively intense, slow-moving fire which is easier to control and produces a clean burn which removes most of the litter layer, encouraging the regeneration of heather from seedlings. If seedling germination and establishment following burning is poor because the litter layer has not burned well it may help to disturb or remove the litter layer.

4.4 Turf cutting

Traditionally, turves were cut from many lowland heaths for fuel. This practice, known as turbarry, has now effectively ceased. The removal of heather turves can be an effective method of ensuring heather regeneration from seedlings and also has the advantages that it removes nutrients and provides areas of bare ground which are valuable for a range of heathland plant and animal species. Turf cutting can be used to break up even aged stands of heather and create small scale variations in vegetation growth stages. It is best undertaken on scattered plots so that heather litter and seed capsules can be washed or blown into the plots to supplement regeneration from the soil seed bank.

Turf cutting should be used with caution on sites that support important populations of reptiles or soil inhabiting invertebrates.

The removal of heather turves, which comprise the surface vegetation, litter layer and upper soil organic horizon by hand is only practicable on a small scale. Machines such as small long-arm excavators may be employed to cut turves on a larger scale.

Turf cutting can also be used on grass dominated areas to combat the invasion of undesirable grass species such as wavy hair-grass. This is further described in Section 6.5.

4.5 Rotovation

Rotovation is commonly employed to create major firebreaks of about 8-10 m width. It is also used to regenerate old heather in Breckland, and can be used elsewhere. Rotovation breaks up the litter layer, exposes bare soil and allows heather to regenerate from seedlings. It may not, however, remove as many nutrients as methods such as burning or turf cutting and so may not be a preferred option for heather management. Heather regeneration from seedlings may take a number of years.

4.6 Archaeological considerations

Archaeological remains occur both as above-ground monuments and as buried features. **In all heathland management and restoration operations care must be taken that such features are not disturbed in any way.** County Archaeologists maintain Sites and Monument Records, which contain extensive records of the archaeology within each County and they should be contacted

to establish whether there is any archaeological interest on the land and how it might best be managed. The County Archaeologist should be contacted as early as possible before undertaking any works. If the site is a Scheduled Ancient Monument the owner or occupier of the land should discuss the management of the site directly with English Heritage.

5. Fire control

Heathland is prone to accidental fire or arson, particularly in summer. **Such uncontrolled fires can do great damage to wildlife, destroying animals and plants.** A fire control plan to combat uncontrolled fires is therefore essential. This will involve the provision of fire fighting tools such as fire beaters or water tankers, close liaison with the local fire brigade, including the preparation of site maps showing fire access routes and tracks and training exercises on sites, firebreaks, and in some cases the provision of areas of open water. The fire service should be made aware of the importance of heathland and the need to put out accidental fires rather than leave them to burn out. Consultation with District Fire Officers is likely to be invaluable in developing a fire control plan.

Major firebreaks may need to be installed to protect heathland. These may stop or check fires and should act as access routes for fire-fighting teams. Scrub should be kept clear of the edges of firebreaks to increase their effectiveness. Major firebreaks are typically about 8-10 m wide. They should not normally have dead ends for safety reasons. Firebreaks are often created by cutting vegetation to about 2.5 cm above ground level or by rotovation or a combination of both. Heavy fire fighting equipment cannot travel on bare sand and so mown strips should be wide enough to take a 20 tonne fire truck, and wet areas should be avoided for the same reason. The provision of bare ground is essential for invertebrates, and sand lizards on sites on which they occur (Section 8.3), and so mown strips may include rotovated strips especially on south-facing sides. For the purposes of invertebrate conservation these should not be rotovated annually and should consist of firm rather than churned up sand. For invertebrates, rotovation should be carried out on only limited lengths of bare ground at a time at infrequent intervals of a number of years. Bare ground that is churned up by horses or motorbike scrambling is not useful for invertebrate conservation. Horse riding needs to be excluded from heathland or if unavoidable limited to restricted routes. Motorbike access should be prevented.

Controlled burning or cutting can be used to create strategically sited areas of short heather. By checking the speed of approaching fire fronts these may substantially reduce the risks of very large uncontrolled fires.

In addition to major firebreaks, a series of sandy paths about two metres wide may have some value in slowing down the progress of uncontrolled fires. A network of such paths is commonly to be already found on many heathland sites.

6. Control of invasive plant species

In the absence of management lowland heath tends to be invaded by bracken, scrub and trees. Grasses may also take over from heather, especially where nutrients accumulate. Management is therefore usually necessary to combat the invasion of undesirable species. However, it should be noted that, with the exception of rhododendron and *Gaultheria shallon*, which have negligible value for nature conservation and should be eradicated, all these invasive species are important components of lowland heath of considerable importance for heathland wildlife. Therefore only where invasive species are spreading or already occupy a substantial area of a site do they necessarily need to be controlled. Only rhododendron and *Gaultheria shallon* should be eradicated from all parts of a heathland site.

The main problem species are:

- Birch
- Pine
- Rhododendron and *Gaultheria shallon*
- Bracken
- Grasses, particularly wavy hair-grass and purple moor-grass.
- Gorse (although it may also need to be encouraged in some situations).

If herbicides are used then the health and safety regulations governing their use must be followed.

6.1 Birch

Silver and downy birch support a rich invertebrate fauna and can be managed by cutting on a rotational basis (eg one fifth every five years) to provide an age range of bushes. Invasive birch, however, needs to be controlled if the wildlife of open heathland is not to be eventually shaded out and lost.

Light grazing by sheep or cattle can be used to suppress, control and ultimately kill small birch (eg less than 1 metre high) (Section 7), but not larger established trees. On heathland that is grazed trees can be cut down and browsing by animals used to suppress the regrowth. On ungrazed sites herbicides must be used because birch is not killed by cutting alone. Controlled burning can also check the growth of birch and other scrub species although it may provide opportunities for invasion by birch and pine from seed (Section 4.2).

6.1.1 Small birch less than 1.5 m tall can be controlled by foliar spraying. Triclopyr and fosamine ammonium can be used but may cause damage to heather. If fosamine ammonium is used it should be sprayed in late August or September before the leaves fall. Glyphosate can be sprayed between May and August but **great care must be exercised** since it is a broad spectrum herbicide and can damage non-target plants. Alternatively glyphosate can be 'weed-wiped' on to target plants directly. An approved dye should be used to prevent multiple applications.

- 6.1.2 Larger trees should be cut down as close to the ground as possible with a saw to avoid future damage to machinery and the stumps treated in dry weather with triclopyr or glyphosate applied by paint brush unless the site is grazed (see above). Notching or grooving the stump may aid retention of the herbicide. **Application is most appropriate in autumn or winter because it avoids disturbance to nesting birds although late winter stump treatment can be much less effective because of sap flow.** The herbicide should be mixed with an approved dye so that stumps are not missed. The herbicide should be painted onto the stumps at the time of cutting or its effectiveness will be reduced.

Since some standing dead trees are valuable as song perches and for invertebrates, trees can be notched with a chain saw or drilled, and glyphosate applied to the cut. Birch and other scrub species should generally be cut back so as to maximise the length of the sheltered scrub edge with south-facing bays. A gradation from mature woodland to scattered birch and other scrub on heathland is desirable to maintain a range of habitats on the woodland edge. Too much scrub edge should not be removed in any one management operation to reduce the effects on invertebrate populations (Section 8.1.3).

On sites which are accessible to the public, signs should be erected for safety and information. Where trees are to be removed a felling licence is usually required from the Forest Authority. The regulations governing tree felling are available from the Forestry Commission (1991). Ancient woodland should not be cleared. If in doubt about whether a piece of woodland is ancient consult first edition 1:25,000 Ordnance Survey maps and the Ancient Woodland Inventory held by English Nature. A survey of the wildlife interest of the site may also be necessary.

Where large amounts of scrub are cleared the wood may be put through a chipper and sold or composted to make a mulch. Wood chips should not however be used as surfacing for footpaths on heathland because these are valuable invertebrate habitats. Wood chips can instead be sold for use on non heathland sites. Small trees can also be sold for horse jumps, broom making and other uses. Scrub that has been cut should always be removed or carefully burnt, preferably off site on an area of low conservation value to prevent the build-up of nutrients. Methods of control given above are generally applicable to other deciduous species such as oak and sweet chestnut.

6.2 Pine

Scots and sometimes Maritime and Corsican pine invasion can be a major problem on heathland. It should be noted however that Scots pine is important for invertebrates. Fortunately pine is easy to control because it does not regenerate after cutting provided all the lower branches are removed. Pine removal is best carried out in the winter months to avoid disturbance to nesting birds. Small pines or seedlings are readily controlled by burning management (Section 4.2).

Small pines less than 1 m high can be removed with loppers or by hand pulling although this is labour intensive. However, whilst regular pulling of very small pine is laborious it saves time in the long run as it avoids the problem of removing large quantities of cut material. Larger pines should be cut parallel and as close to the ground as possible to allow subsequent access for machinery with bow saws, scrub cutters (trees up to 5 cm in diameter) or clearing saws. Trees with a girth over 30 cm require felling with chainsaws. **The removal of trees usually requires a felling licence from the Forest Authority (see Forestry Commission 1991).** If sufficient timber is present it may be possible to generate some income from the sale of wood. Brash can be put through a wood chipper and sold or composted to make a mulch. Small Scots pine can also be sold as Christmas trees.

Once management of a heathland is in hand it may be desirable to retain small amounts of Scots pine. Scots pine can support a number of invertebrate species. Scattered trees may also be useful song posts for birds such as the woodlark and nightjar. Since pines may be a continued source of invasive self-sown saplings it may be best to retain most trees on areas of heathland which are located to the lee of the prevailing wind.

6.3 Rhododendron and *Gaultheria shallon*

Rhododendron ponticum can spread rapidly and has negligible nature conservation value. Dense rhododendron casts deep shade which excludes other vegetation. It should therefore be eradicated from heathland wherever possible.

This can be done by cutting bushes to ground level. Smaller stumps are mostly easily treated with triclopyr mixed with diesel using a paint brush or spray can. The use of diesel as a dilutant is recommended because it provides protection in the event of rain following application and assists penetration. Where there is grazing stock diesel is also likely to put them off going near the stumps. Very large stumps can be treated with ammonium sulphamate solution inserted into 3-5 8-10 cm deep and 1 cm wide holes made with an electric drill run off a portable generator. This typically gives about 95% kill provided that no stumps are missed. Regrowth can be weed-wiped or sprayed with glyphosate, preferably with the additive 'mixture B' to assist penetration of the waxy leaves. Triclopyr may be more effective than glyphosate in treating regrowth and can also be applied to larger cut stumps. If resources are available and the terrain permits it, total eradication may be best achieved by digging or winching out stumps and roots.

The introduced shrub *Gaultheria shallon* can also be a problem on heathland. It can be controlled using glyphosate or triclopyr.

6.4 Bracken

The spread of bracken is a problem on many lowland heaths. Bracken control should be targeted initially at locations where it is in the early stages of invasion. The control of bracken which is not spreading may not be justified on economic grounds, and may be undesirable from a nature conservation point of view.

Bracken can be controlled by cutting, rolling and crushing, herbicides or a combination of techniques. Cutting is most appropriate on relatively level, stump-free ground where bracken forms dense, pure, established stands. Bracken should be cut when the reserves of food in the rhizome are lowest. This is achieved by cutting as low as possible typically in mid June and again in late July with a tractor-mounted rotary swipe, forage harvester or brush cutter on rough ground. If only one cut is possible this should be in July. A third cut may also be made in August. Hand-held trimmers can also be used to treat small areas. If high-speed cutters are used, masks need to be worn to prevent the inhalation of bracken tissue or spores which may be carcinogenic. Care should also be taken if sheep ticks are present as these may be vectors of Lyme disease which is also associated with deer. The cut material should be removed wherever possible. **Cutting and rolling operations should avoid disturbance to ground nesting birds (Section 8.2). Note that nightjars may nest in bracken up until around late August. A survey should therefore be undertaken to check whether birds are nesting in the area where bracken is to be controlled.** Forage harvesting can be used to clear dead bracken fronds and remove accumulated bracken litter which inhibits the establishment of other vegetation. Bracken litter may be sold as a mulch or compost and it may be possible to get it collected on site and removed by horticultural contractors. It can also be raked off manually or using a forage harvester, long arm excavator or tractor-mounted blade. If an area is a monoculture of bracken, accumulated

bracken litter may be disposed of by controlled burning following the Heather and Grass Burning Code between November and March.

Cutting may need to be repeated on a regular basis as it is almost impossible to eradicate bracken completely.

Where bracken has become completely dominant and formed a deep litter layer an initial winter burn may help to remove some of the accumulated litter. Dense bracken monocultures can also be rotovated. Alternatively the ground may be disced or chisel-ploughed in winter and bracken litter skimmed off to just above the mineral soil layer using a specially adjusted double-chop forage harvester or a JCB and grader blade. Exposed bracken rhizomes may be killed by frost. The ground can then be disced in two directions to create small ridges and furrows. These can then be seeded with harvested heather cuttings and Cambridge rolled (see Section 9). Continued cutting or spraying (see below) is likely to be necessary to control surviving bracken.

The herbicide asulam, marketed as 'Asulox', can also be used to control bracken. Asulam works by translocation to the rhizome, inhibiting the following year's growth. Asulam is ideally suited to use where the terrain is sloping or uneven and cutting machinery cannot be used. It is best applied just as frond tips have unfurled. This is typically in July. Asulam requires a rain free period of 12 hours to ensure good results and should not be applied if bracken is drought affected as this will severely reduce its effectiveness. Asulam should be applied when fronds are dry and winds are light (force 1-3). Spraying is best carried out in cool conditions to avoid spray evaporation which may be a problem in still, hot conditions (Andrews 1990). A wetting agent (adjuvant), such as Agral, should always be used to improve take-up of the herbicide.

Knapsack sprayers or controlled droplet applicators such as the Herbi may be used to treat relatively small areas or for spot treatments. If controlled droplet applicators are to be used where ferns and other sensitive species are present a buffer zone of about 50 metres will be needed to prevent spray drift affecting them. Larger areas are best treated with tractor-mounted boom sprayers. **The use of ultra low volume applicators is now no longer recommended because of potential problems with spray drift affecting sensitive species.** If such applicators are used buffer zones of about 100 m will be needed to protect sensitive species. **Aerial spraying of asulam is not recommended because of problems of spray drift affecting sensitive species.** It should only be considered in exceptional circumstances where ground spraying is not possible and bracken control is essential.

Spraying asulam will damage ferns besides bracken and other plants. Where other ferns are present Asulam **should not** be used. Instead bracken should be cut by hand.

Initial spraying can be followed in the next summer but one by the spot spraying of surviving fronds. Cutting can also be used. Further spraying or spot treatments may be necessary in subsequent years.

On sites where heather has been much reduced, one approach is to cut bracken twice a summer for two years and spray asulam in the third. This will allow the gradual recovery of heathland vegetation whilst reducing the risk of creating large bare areas prone to invasion by birch, pine and other undesirable species.

6.5 Grasses

Certain grass species, notably wavy hair-grass and purple moor-grass, are prone to invade heathland. Whilst the presence of some grassy areas within heathland is desirable because it increases habitat diversity, large scale grass invasion of heather dominated areas is undesirable.

Research in the Netherlands suggests that atmospheric deposition of nitrogen may be implicated in the spread of wavy hair-grass and purple moor-grass on heathland. Mechanical methods of turf stripping to counter the accumulation of nutrients have been developed in the Netherlands using tractor mounted machinery to strip off the turf and top of the soil organic layer and these have been used to successfully re-establish heather on sites that have been invaded by grasses. **Large scale turf stripping should not be used, however, on sites that support important populations of reptiles or soil-inhabiting invertebrates.**

Light grazing, especially by cattle, and herbicides can be used to open up grassy areas to encourage the germination of heather. They may not, however, give such rapid results as turf stripping. On turf stripped land where negligible viable heather seed remains in the soil a seed source such as heather cuttings can be added as part of heathland restoration operations (see Section 9).

6.6 Gorse

Common gorse supports a rich invertebrate fauna and can be managed by cutting, or burning where it is safe to do so, on a 10-12 year rotation to provide an age range of bushes. Whilst gorse should be encouraged as a valuable habitat and is especially important where the rare Dartford Warbler occurs (see Section 8.2 for details of gorse management for this species), it may have to be controlled on sites where it becomes invasive, often as a result of soil disturbance. Gorse fixes atmospheric nitrogen and so may lead to local nutrient accumulation which may ultimately encourage bracken invasion, although rotational gorse management by cutting or burning should help to discourage this.

If necessary gorse can be controlled by cutting in winter by hand or with a chainsaw, tractor-mounted swipe or scrub cutter followed by stump treatment or foliar spraying of the subsequent regrowth. Glyphosate or triclopyr are recommended as stump treatments. Triclopyr is also very effective when applied as a foliar spray to entire bushes. It may be necessary to strip off gorse litter or burn it to prevent the invasion of bracken. Young gorse is eaten by most grazing animals whilst established gorse may be browsed into compact bushes by ponies.

7. Light grazing

Light grazing was one of the main traditional uses of lowland heathland. It has a number of benefits and is an important technique for managing heathland in association with techniques of rotational heather management such as controlled burning. Light browsing, especially by sheep and cattle can be used to suppress scrub such as birch, but the clearance of established woodland requires other methods (Section 6). Cattle, sheep and ponies check the growth of vigorous competitive grasses such as purple moor-grass and thus encourage a greater diversity of heathland vegetation. Small scale trampling is also beneficial for plants, including rare species, especially on wet heath, and a range of invertebrates. Trampling by cattle may also reduce the spread of bracken. In addition, grazing produces a range of vegetation heights and structures which is beneficial because it increases habitat diversity. Grazing also prolongs the life cycle of heather and therefore increases the length of rotational heather management (Section 4).

The overgrazing of heathland must be avoided. Overgrazing of lowland heath will lead to the death and loss of heather and its replacement by grasses which is not desirable.

Light grazing is particularly suited to large heathland sites because of the savings in terms of the continued scrub control that would otherwise be needed. However, the introduction of grazing involves initial expenditure and a number of practical considerations. Stock need to be provided with a water trough which will require a tractor-drawn mobile bowser unless water is available on site. This should not be located on an area of high conservation value because of the problem of poaching of the ground. Veterinary treatment, inoculations and insurance are also necessary. In England the animal health section of the local authority must be informed of the presence of a sheep flock and a stock movement book kept. The Ministry of Agriculture, Fisheries and Food must also be informed and appropriate records kept. If supplementary feeding is necessary, this should be carried out off-site. If it cannot be avoided on a site, supplementary feeding should be undertaken on non-heathland areas of low wildlife conservation interest because of the problems of nutrient build-up, the invasion of undesirable species such as nettles and perennial ryegrass, and poaching of the ground. Supplementary feeding may also mean that stock are less inclined to tackle the coarser and less palatable heathland vegetation and may mean that the site is overstocked and/or the wrong type of stock is being used. The provision of mineral licks may also be necessary.

Fencing is another requirement. Permanent fencing on Common land requires the permission of the landowner, the Department of the Environment and all commoners. Temporary electric fencing may be a useful alternative.

Adequate staff time must also be available to look after the stock and in the case of sheep see to tasks such as shearing, dipping and foot treatments. Stock must also be inspected regularly.

Note that stock treated with Ivermectin, a broad spectrum antiparasitic drug, should not be grazed on conservation sites. This is because it can reduce the number and variety of insects in dung. Alternative chemicals are available.

Grazing can be arranged through licences or informal agreements with local farmers or by ownership of stock. The ownership of stock by conservation organisations gives more control of timing and stocking rates but may require land for off-heath holding as well as a long term commitment of time spent looking after stock. Ownership of stock by conservation bodies is also likely to be more expensive. The main types of grazing that are suitable for lowland heaths are:

7.1 Sheep grazing

Where grazing cannot be arranged through local farmers, sheep are a practical option for heathland conservation organisations because they are relatively cheap to purchase, easy to transport and provide income in the form of lamb and wool sales. Subsidies are also available. However, sheep grazing is not a straightforward option because of the need for fencing, supervision of stock and associated staff time. The worrying of sheep by dogs can also be a problem, although it is illegal.

Sheep should be grazed on heathland in the summer period, typically over the period March to September so as to suppress birch and other scrub. Sheep can be wintered on grassland to ensure that their nutritional requirements are met. Specialist advice should be taken to ensure animal welfare such as the need for mineral blocks. The best breeds to use are hardy rather than commercial ones because heathland vegetation tends to have a relatively low nutritional value. Hebrideans are particularly recommended as they do not generally require foot treatments, licks or supplementary feeding. They tend to browse invasive species such as pine, birch and purple moor-grass in preference to heather, which is highly desirable for nature conservation purposes because it suppresses undesirable species and makes the overgrazing of heather less likely. Beulahs have been used to graze lowland heathland and suppress birch growth in the Suffolk Sandlings.

On sites where there is a high density of bracken this may need to be controlled prior to putting sheep on. Bracken is fatal to sheep, cattle, and ponies if ingested in large quantities.

The stocking rate to be used will depend on site factors such as the breed used, the condition of heather, the weather and the amount of scrub and grass on the site. As a rough guideline, however, the stocking rates on heathland should be no more than 2.5 ewes per hectare for a period such as March to September (including lambs in summer, assuming 100% lambing). The stocking rate used should be as low as possible consistent with the need to control small invasive birch (eg less than 1 m high) and other scrub and to produce and maintain a range of heathland vegetation heights and structures. A higher initial rate may be useful on previously ungrazed sites to get the vegetation under control. Where sheep or other stock are introduced, simple monitoring should be carried out to check that heather is not being overgrazed. Signs that heather is being overgrazed may include areas of dead heather and very low mature heather, shoots grazed to the previous season's growth, up-rooted or broken shoots, and the reduction of heather cover to almost invisible miniature shoots (Mitchley and Malloch 1991). Monitoring is also essential to check that overgrazing is not causing heather to be replaced by grassland. This can be accomplished by monitoring the percentage cover of heather over a number of years at a broad scale. **If there is evidence of overgrazing then stocking rates must be reduced.**

Where conservation organisations own their own stock this is a useful publicity tool. Animals can be sponsored by the public offsetting their costs of purchase.

It is likely to be difficult to introduce sheep on sites which are heavily used by the public for dog walking because of the problem of sheep worrying. To some extent this can be tackled by putting up signs explaining the reasons for grazing and the need to keep dogs on a lead.

Where grazing is used as a management tool some areas of established trees should always be retained to provide shelter for animals.

7.2 Cattle grazing

Cattle, like sheep, were traditionally grazed on lowland heath. Whilst being more expensive to purchase and harder to transport they have a number of advantages. Cattle are very effective at controlling the growth of vigorous grasses such as purple moor grass. The grazing of large grass tussocks can allow heathland plants which would otherwise be suppressed by competition to germinate and establish. Cattle grazing can thus be particularly beneficial on wet heath where the effects of trampling also produce ground disturbance which is useful both in providing patches in which plants can establish and valuable invertebrate habitats. In general cattle grazing is more suited to sites which have wet heath and mire than purely dry heath which is relatively unpalatable.

Cattle browsing also suppresses scrub such as birch. Pine will not be browsed by cattle unless they have little alternative to eating it. Cattle trampling damages bracken similar to a light cutting regime but bracken is fatal to cattle if large amounts are ingested. Therefore, large stands of bracken may need to be cut and/or sprayed before the introduction of stock. The stocking rate might be about one cow for two to five hectares. Low intensity beef rather than dairy cattle should be grazed on heathland because dairy cattle have high nutritional requirements. Galloways and Highland cattle have been grazed on lowland heaths. If cattle are grazed all year round high protein mineral blocks may be needed. Alternatively cattle may be grazed in the summer only, for example between March and September.

A disadvantage of cattle is that their trampling may damage stands of old heather but this depends on stocking rate and the geography of the site because old heather is not preferred grazing. On the other hand, trials have indicated that cattle grazing of grass-dominated heathland may be a good way of encouraging heather seedling establishment.

7.3 Ponies and horses

Pony grazing was a traditional use of many lowland heaths and is still practised on the Lizard Peninsula in Cornwall and, in conjunction with cattle grazing, the New Forest in Hampshire. Like sheep, they are relatively inexpensive to purchase. Ponies tend to graze grasses in preference to heather which is desirable because it checks the growth of vigorous competitive grass species such as purple moor-grass. The browsing of ponies tends to produce compact gorse bushes. However, ponies are less good at controlling birch and will not usually browse pine. They can be used, however, to control rushes. They also tend to penetrate further into mires (bogs) than cattle. Bracken is fatal to ponies and horses if large quantities are ingested and so bracken stands may need to be controlled prior to the introduction of stock.

It should be noted, however, that ponies have a habit of dunging in the same places. This may be undesirable because it leads to the replacement of heathland by species such as ryegrass, nettles and thistles.

Ponies used for heathland grazing should be hardy breeds such as New Forest ponies which are adapted to eat a wide variety of plants. The best horse breeds to use on heathlands may be those that are closest to native pony breeds. Studies in the New Forest have shown that some blood lines of ponies do better than others and so these 'true' ponies should be used as they are hardier and better adapted to heathland vegetation.

A typical stocking rate is one pony per 5-12 hectares. This is likely to require adjustment according to the vegetation on the site.

7.4 Mixed grazing regimes

A mixed grazing regime such as a combination of sheep and cattle may be the ideal for many heathland sites. Sheep may be particularly suited to dry heath and cattle to wet heath. As a guide the stocking rate might be one ewe per hectare plus one cow per 4-10 hectares per year.

7.5 Goats

Goats are not commonly grazed on heathland and so there is relatively little experience of their use. They are not particularly easy to manage as they are prone to escape but may be useful in two situations, where it is necessary to 'blitz' unwanted scrub and to control the excessive growth of rushes. Where domestic as opposed to feral goats are used they will usually require shelters.

7.6 Rabbits

Prior to the introduction of myxomatosis in the 1950s rabbit grazing was very important on lowland heaths in checking scrub invasion and creating areas of bare ground which are ideal for invertebrates and plants such as lichens. Rabbit populations have gradually recovered on many sites but tend to fluctuate as a result of continued outbreaks of myxomatosis.

Whilst a moderate level of rabbit grazing should be encouraged on heathland, particularly on grass heath sites, it has to be recognised that there is a legal requirement to control rabbit populations if they cause damage to agricultural land. One approach is therefore to erect permanent rabbit-proof fencing around the entire perimeter of a site, although this may be very expensive. Alternatively, rabbit-proof fencing can be used along a sensitive border or to confine rabbits within part of a site. Brushwood piles may be useful to provide cover. Whilst rabbits can be re-introduced where needed, areas supporting scarce species or young regenerating plants, such as heather or gorse, may have to be protected by suitable fences if the grazing pressure is too high. Rabbits will not, however, tackle taller vegetation. Rabbit control will be necessary if overgrazing by rabbits threatens to convert heathland vegetation into grassland or rabbits cause damage on adjacent agricultural land. In the latter case it may be most cost effective to carry out a regular programme of rabbit control on sensitive parts of a site boundary. Rabbit control by gassing should always be avoided on sites that support important populations of reptiles because they use rabbit burrows.

8. Managing for heathland fauna

Lowland heath should be managed to incorporate the needs of heathland fauna. Specialist advice can be sought from English Nature and other relevant experts.

Lowland heaths often include interesting invertebrates, birds, reptiles and amphibians.

8.1 Invertebrates

Heathland is a very important invertebrate habitat. The following general principles of management apply (Kirby 1992):

- 8.1.1 A range of habitats is required. Heather should be managed to produce a range of growth stages ranging from pioneer to degenerate. In addition, it is essential to provide areas of bare ground, scrub, patches of mosses and lichens, and to retain areas with herbs growing on disturbed ground and grassy areas with vegetation of a range of heights. Bare ground can be provided by clearing patches as small as one metre across by hand or rotovation. Moderately trampled paths provide valuable hard-packed sand but horse riding churns this up and destroys it. Horse riding should therefore be limited to restricted routes. Valuable nectar sources for invertebrates may be located outside sites, for example on roadside verges - these will require appropriate management such as cutting late in the year.
- 8.1.2 Slopes, particularly those that are south-facing, steep and have bare areas are important for certain invertebrates and should be retained. It may be necessary to create patches of south-facing firm (not churned up) horizontal, sloping and vertical bare ground if these are in short supply.
- 8.1.3 Scrub is valuable for invertebrate conservation. All the growth stages of broom, gorse and birch scrub, including mature and dead trees and stumps should be represented on a heath at all times since they support different invertebrate communities. Broom might be cut on a 15 year cycle (eg one fifth every three years), birch on a 25 year rotation (Section 6.1) and gorse on a 10-12 year cycle (Section 8.2) with some areas of dead scrub being left unmanaged. Small amounts of Scots pine are also valuable although *Rhododendron ponticum* should be eradicated from heathland. Bracken has some value for invertebrates and so small non-invasive patches can be retained.

Where dense scrub is cut back the aim should be to maximise the length of the sheltered scrub edge. Too much scrub edge should not be removed in any one management operation; a maximum of one-third is a useful rule of thumb. Trees can be kept as narrow shelter-belts, preferably around south-facing bays of heathland vegetation. Shelter-belts will be more effective if there is a shrub layer beneath trees.

- 8.1.4 Ideally, on dry heath each management plot should share boundaries with plots managed immediately before and after it in the rotation. This should make colonisation easier.
- 8.1.5 On wet heath, grazing and/or turf cutting are ideal management regimes. Light cattle grazing is particularly valuable. It controls the excessive growth of plants which may otherwise out-compete other species and reduce the invertebrate interest. In addition it produces ground disturbance which produces features such as small runnels which are useful habitats for invertebrates.

As on dry heath a diverse range of heathland habitats is desired on wet heath. Sallow carr has significant invertebrate interest and so should not be completely eradicated. A small amount of birch scrub should also be retained unless the area of wet heath is very small because there are invertebrates that are associated with it.

- 8.1.6 Weed-choked pools with peaty margins and bog moss dominated fringes may be very valuable invertebrate habitats even if there is no visible open water. Care should be taken not to deepen existing pools unnecessarily. **Since heathland is a rare habitat the creation of new ponds should only be contemplated after careful deliberation. If soil iron pans are punctured the hydrology of an area of wet heath may be adversely affected. In particular, if there is little wet heath on a site this should be retained in preference to digging new ponds.** New ponds should only be created where the hydrology is suitable and may be best located adjacent to existing wet areas to encourage colonisation. It may be necessary to remove the excavated spoil. New ponds should be no less than 20 m in circumference with a depth in the centre of about 1.5 m. They can be dug by hand or machinery and created with explosives in areas which are inaccessible to machines.

Heathland ponds are particularly valuable for dragonflies and damselflies. Management should aim to maintain areas of permanent open water and remove all encroaching trees (particularly on the southern face, to prevent shading). The introduction of fish should be prevented and if present their numbers controlled if excessive. Abundant submerged and floating vegetation and a fringe of emergent vegetation are also desirable. Trees and bushes about 20 m away from the edge of a pond provide valuable feeding habitat.

8.2 Heathland birds

A number of birds are associated with lowland heathland, including several rare, threatened or vulnerable species. It is therefore very important to avoid operations such as heather cutting, scrub and tree clearance during the nesting season. Nesting birds also tend to be sensitive to disturbance. **Depending on what birds are present the nesting season could extend from March (woodlark) to late August (nightjar).** In common with other heathland fauna, heathland bird communities also benefit from a range of vegetation types and structures.

Management can be used to encourage particular heathland birds. The **Dartford warbler**, a bird of certain southern heaths, prefers dense bushes of common gorse amongst mature heather which are in contact with it for shelter, especially for winter survival and invertebrate food. As much as 5% of a heathland area can be gorse. Once gorse becomes older than about 12 years old it becomes leggy with a hollow interior and less suitable for Dartford warblers. Older gorse should therefore be managed by cutting with a saw or swipe (or by carefully controlled burning in late winter because old gorse may burn very fiercely). Gorse can be managed on a 10-12 year rotation (so that a tenth or twelfth is cut each year). If the bushes are less than about 12 years old they may regrow from the base after controlled burning or cutting. The gorse litter should also be raked up and burnt to encourage gorse seedlings to establish and reduce the likelihood of bracken invasion. Where rabbits or other forms of grazing are present, fencing may be necessary to protect re-sprouts and seedlings. Very old stands of gorse can be cut or burnt but will not re-sprout and re-establishment will have to be from seed.

In situations where gorse was previously present and where it will not damage the existing conservation value of a site, if there is insufficient gorse it can be planted. Plots of about 0.5 m² can be prepared with a spade or rotovator and planted with 2-3 year old seedlings taken from places where they are abundant. Care should be taken during transplanting to avoid damage to roots and their drying-out. Ash from burnt areas can be added to provide potassium and the seedlings may need weekly watering for about six weeks after planting. Fencing against rabbit,

deer or other grazing may be needed for about three years. Gorse should not be encouraged adjacent to roads as Dartford warblers may suffer from high mortality near to them.

A limited number of bushy young pines encroaching onto open heathland which have branches still in contact with the heather canopy can also be valuable for Dartford warblers. The trees should be removed once their height exceeds about two metres.

Nightjars nest on patches of bare ground on heathland. Positive management can be used to increase populations of nightjars by creating potential nesting areas, roosts, songposts and foraging areas. This often requires labour intensive work. Nightjar populations can be boosted by creating glades of about 2 ha in woodland on heathland, leaving woodland shelter belts, resculpturing the margins of woodland to increase the length of the heathland/woodland edge, and by thinning and coppicing trees on woodland margins to produce a scattering of small and preferably bushy trees. The nightjar feeds on large invertebrates, particularly moths, which may be caught some distance away from nesting areas. This means that feeding areas, which may be outside heathland areas themselves, need to be available which support populations of large invertebrates. It is also worth remembering that nightjars may breed until late August and may nest in bracken. If nightjars are present on a site it is worth surveying areas to avoid nest sites if bracken control is being undertaken in the summer. Since nightjars are fairly easy to census they provide a useful index of the effectiveness of heathland management.

The **woodlark** is a bird that requires a diversity of vegetation types and heights, and favours heathland with a scattering of trees. Woodlarks need areas of bare or sparsely vegetated ground such as short (less than 5 cm tall) areas of grasses, mosses or lichens for feeding. Patches of taller vegetation such as grass tussocks and heather bushes are also required for sheltered nest sites and isolated trees are used as perches. Grazing, including the encouragement of rabbits, is an ideal way of providing suitable woodlark habitat. If grazing is not possible small scale mowing, forage harvesting, rotovation or burning may be acceptable alternatives. It should be noted that the woodlark is a very early breeder (March onwards). Both the woodlark and the nightjar are ground nesting birds and so are vulnerable to disturbance from dogs and other sources.

The **stonechat** is another heathland bird. As with the Dartford warbler, the provision of gorse bushes for nesting is important.

A number of birds of prey may use heathland. The **hobby** nests in mature trees on farmland and heathland. The main management requirement is to safeguard nest sites. The **hen harrier** roosts on heathland in winter and requires tracts of mature heather for shelter.

The **stone curlew** is associated with short, open grass heath vegetation such as that found in the Breckland of East Anglia. Sheep grazing between late summer and mid March to avoid the potential trampling of eggs and the encouragement of rabbit grazing are valuable to maintain suitable habitat. Nesting areas can also be created by rotovating plots of about 0.3 ha every three years or so. These should be located away from roads or paths as the stone curlew is very prone to disturbance, and should also avoid the locations of scarce plants. Specialist species management projects are in place to conserve stone curlews, and any measures to help this vulnerable species should involve consultation with RSPB and English Nature specialist staff.

8.3 Reptiles and amphibians

All six species of native British reptile occur on lowland heathland. The rare sand lizard and smooth snake are found on some heaths in southern England.

Reptiles are particularly associated with mature dry heath on south-facing slopes and generally these features should be given special consideration for conservation of these species. A mixture of dense vegetation for cover and short or bare areas for basking is needed. Sand lizards tend to be relatively immobile as adults and stick to 'foci', whilst snakes are more mobile and move widely on heathland. In addition, the sand lizard requires bare sand for egg laying. This can be provided by creating sand patches, which are typically 2-5 m long by 1-2 m wide lying east-west on slopes with a southerly or south westerly aspect. Sand patches should be targeted at reptile 'foci' and be located next to areas of tall heather on the northern side which provide cover for reptiles. A minimum target of 1-5% of the heathland area comprising bare sand has been suggested. A minimum of five sand patches per hectare has also been suggested with over 20 per hectare as an ideal. Wider patches are necessary on the northern side on level ground to prevent shading by heather. These patches will need managing every 3-5 years to keep them open. The spoil can be removed or stacked on the northern bank to provide south-facing basking areas.

Alternatively, particularly where reptile populations are vulnerable to fire and relatively immobile, there may be justification for installing a limited number of sandy traces provided these do not affect the conservation of any other groups such as invertebrates or scarce plants. These should be about 2-3 m wide and can be made using a blade. These sandy traces can be re-cultivated in subsequent years to keep them open on a rotational basis to minimise possible effects on invertebrate populations. Sandy traces may also help contain slow moving lateral and back-burning fires. Alternatively sandy traces could be used as moveable features created by turf cutting to allow the regeneration of pioneer stage heather and plants which require bare ground. On sites which support sand lizards, scraping, rotovation and turf cutting should be confined to the period around mid April to mid May when the animals are out of hibernation, but prior to egg laying. This period overlaps with the nesting season for birds and may vary with the weather in different years and so expert advice may need to be sought. Bare sand can also be provided by rotovating firebreaks (Section 5).

Since reptiles are associated with mature heather, care needs to be taken in managing sites that support reptiles. Since uncontrolled fires are a major threat firebreaks are needed and a fire control plan should be prepared (Section 5). Whilst small scale rotational management, for example controlled burning or cutting in winter, is likely to be necessary to ensure the long term survival of heathland vegetation, this should be carried out with care on sites that support important populations of reptiles. Scrub control is also needed to prevent succession to woodland.

All the native British amphibian species may be found on heathland and in the breeding season are particularly associated with ponds. The natterjack toad is now extremely rare as a heathland species, although re-introductions are taking place. For breeding purposes, shallow unshaded pools with a maximum winter depth of 1 m are required with a pH of 6-7. The occasional drying out of pools in the later summer or autumn is desirable to reduce predation as is the removal of common toads whose tadpoles appear to have an inhibitory effect on natterjack tadpoles.

On land natterjacks require as much as 75% bare ground or very short vegetation (less than 5 cm high) in which to forage. Once vegetation becomes more dense and trees invade natterjacks find it harder to feed and tend to be out-competed by common toads. Scrub invasion therefore needs to be controlled, bare ground provided and heather cut or burnt in winter to maintain suitable habitat. Light grazing is likely to be very desirable.

9. The restoration and re-creation of dry heath

Where heathland vegetation has been invaded by bracken, grasses, scrub or woodland it may be possible to restore dry heath by appropriate management. A seed bank of heathland plant species may remain from which heathers, gorse and other species may be encouraged to re-establish. Heather seed is concentrated in the top 5 cm or so of the soil profile and may remain viable for over 40 years. However, it should be noted that restored vegetation is unlikely to support a full suite of heathland plant and animal species. Table 1 proposes definitions for the range of situations that may be encountered, ranging from heathland management to creation.

Table 1 Definition of terms for lowland heathland

Definition	Heathland vegetation present (native ericaceous dwarf shrubs)	Heathland seed bank present (native ericaceous dwarf shrubs)	Was originally heathland
1. Management	✓	✓	✓
2. Restoration	X	✓	✓
3. Re-creation	X	X	✓
4. Creation	X	X	X

Heathland restoration, re-creation and creation should be carefully targeted. The greatest benefits to nature conservation are likely to be where:

1. Areas of existing lowland heathland are extended and/or linked up.
2. The integrity of complete hydrological units (eg from dry heath to valley mires) is maintained.
3. Populations of rare heathland species can be maintained and enhanced.
4. Areas are known to have been capable of supporting lowland heathland in the past.

The first priority is to tackle open heath that is in the process of being invaded by bracken or trees. Only once this has been secured should areas that have been taken over by bracken and trees be dealt with.

On areas that have become completely dominated by bracken the bracken litter should be scraped off to expose the mineral soil layer, reduce soil fertility and remove some bracken rhizomes. It may be possible to sell bracken litter on or off site to horticultural outlets as a compost or mulch. Bracken can subsequently be controlled by cutting and/or with asulam. If there is no appreciable germination from the seed bank, heather seeds must be added. One method is to use heather which has flowered profusely cut with a forage harvester, swipec or flail and baler between mid October and the end of November when the capsules have a high seed content. Tractor mounted leaf sweepers can also be used. Cuttings should be applied to a depth of about 2 cm at a rate of about 6,000-10,000 kg/ha of fresh material by hand or using a manure spreader. Ideally heather cuttings should be spread immediately but they can be stored over winter in shallow heaps less than 1 metre high to reduce the risk of rotting. The ground should be disced in two directions, heather cuttings added and then Cambridge rolled or run over with

a tractor to promote germination and establishment. Alternatively, heather litter may be collected from beneath heather plants by hand or using an industrial vacuum cleaner or 'Billy Goat' suction device. Heather litter should not be collected close to birch or other tree seed sources. A recommended application rate is 1,000-1,500 kg/ha. On large areas it may be possible to apply litter with a tractor-mounted fertiliser spreader, hydroseeder or mulch blower. Heather establishment may take a number of years and is influenced by weather conditions.

Heathland vegetation can be restored on areas which have been cleared of pine and birch scrub using similar methods. Ancient woodland should not be cleared (see Section 6.1). It is important to remove all cut material to prevent nutrient accumulation. If heathland vegetation has been completely lost the site should be scraped to the mineral soil layer and the surface pine or birch litter swept up and removed. This may be done mechanically using a bulldozer or road sweeping equipment to loosen the litter which is then brushed into piles and blown into a silage trailer with a grain blower. If there is little establishment from the seed bank heather cuttings can be added.

Wherever possible plant material from a local source should be used in heathland restoration. This is because the genetic make-up of local material is likely to be better adapted to local conditions and the mix of species will match the regional character of the vegetation community.

Where heathland vegetation has been replaced by acidic grassland this can be stripped off using machinery (see Section 6.5). Heather cuttings can then be added if necessary.

Areas of establishing heathland vegetation may require fencing protection from grazing for up to 4-5 years until plants become established. Rabbit grazing can be a considerable problem although it may help control scrub. Signs may also be needed to deter visitors from trampling the area. Where heather cuttings are added a ridge and furrow effect can be created using a Cambridge roller or tractor wheelings to promote plant establishment. The sowing of companion grass species may also aid heather establishment by improving the microclimate. The grass species selected should be present in the native vegetation (see Rodwell 1991) and not invasive or non native. Ripe grass seed can be collected from sites before it is dispersed using a forage harvester. Wavy hair-grass should not generally be used as it is an invasive species. Companion grasses should be sown at a rate of about 15 kg/ha on stable areas or 25 kg/ha on areas prone to erosion.

In addition to heather cuttings and litter, it may be possible to restore heathland using heathland turves, topsoil or propagated heather plants. The transfer of heather turves is most likely to succeed if it is carried out in early spring or autumn rather than in summer when drought is a common problem. Turves should be as large as possible (eg 1x2 m) and at least 20 cm deep and may be cut with a turving machine or crawler mounted bucket with a smooth cutting edge. Mowing or cutting mature heathland makes it easier to strip and replace. When carrying out turving, the heathland vegetation that is removed should be matched to the characteristics of the recipient site. For example, it would be inappropriate to place material taken from wet heath and place it on a dry heath site. The more care that is taken in moving and placing turves the more likely a scheme is to be successful. Turving of large areas such as 40 m² is necessary to ensure reasonable survival rates. Turves should be tightly packed into prepared pits to reduce water loss. Turving is usually carried out when sites are being destroyed and is very expensive on a large scale. Watering may be needed in a drought.

The placement of heathland topsoil on a site is also normally carried out where heathland is to be destroyed. It is not, however, necessarily a destructive technique as sites with building or mature stage heather may be mown and lightly rotovated to a depth of some 5 cm. This layer can be stripped off and spread to a depth of about 2.5 cm on the area to be restored using a

manure spreader, or by depositing material from a trailer and grading it. The donor site may regenerate satisfactorily.

It should be noted that the translocation of heathland may not be successful. It is very unlikely that a full set of heathland plants and animals will be reintroduced. Translocation should never be seen as a substitute for the conservation of existing lowland heathland.

Since heathland restoration operations disturb the soil, the germination of undesirable species such as rosebay willowherb may be encouraged. This may mean that long term management such as hand weeding, spot treatment with herbicide or mechanical cutting are necessary.

Where there are problems with erosion forestry brushings can be used to stabilise areas. A light cover should be used to ensure that there is sufficient light for heather to germinate and establish.

Heather plants grown in pots or tubs may also be planted out in restoration schemes. The use of cultivated varieties is not appropriate and plants should come from a local source wherever possible. This approach is, however, prohibitively expensive on all but very small areas.

Heathland restoration is most likely to be successful on infertile acidic sandy or gravelly soils which supported heathland in the recent past. If a seed bank of heathland species remains and land has not been managed too intensively heathland vegetation may gradually re-establish with time. However, the re-creation of heathland from scratch on relatively fertile land such as abandoned farmland using methods such as nutrient stripping by growing crops such as cereals or by stripping off the topsoil on areas of no archaeological value is still largely an experimental technique.

The restoration of fauna, via reintroductions, can be considered, but should wait until survey has established that the species no longer appears to be present, the habitat requirements of the species are fully known and the habitat is suitable. It may be valuable for a range of heathland species to produce topographical variation such as banks and gullies as part of the restoration process.

10. The management of specific types of heath

The previous sections have dealt mainly with the management of dry heath. Other types of heath which may require slightly different management will be dealt with here.

10.1 Maritime and coastal heaths

The management of maritime heaths is described in detail by Mitchley and Malloch (1991). In areas which are very exposed to maritime influence relatively little management may be necessary. Elsewhere, coastal heath management is very much as for lowland heath, except that in some cases growth, and thus heather recovery, is markedly slower on the coast. Light grazing with ponies, cattle or sheep and rotational cutting and burning are the main management options. Scrub and bracken control, the provision of firebreaks and the maintenance of disturbed ground or trackways for certain plant species may also be necessary.

Coastal dune heath consisting of heather-sand sedge communities is very localised in Britain and mostly found in Scotland (Rodwell 1991). Light grazing may be necessary to prevent succession to scrub and woodland.

10.2 Lichen heath

Lichen heaths are scarce and occupy small areas on dry, sandy soils. Since lichens are particularly susceptible to trampling all but very light sheep grazing is to be avoided. Burning is not appropriate on lichen-rich heath and the use of machinery should be avoided to prevent damage.

If the heather canopy becomes too dense it can be reduced by cutting with hand held machinery. Rabbits may play an extremely important role in keeping the vegetation low, suppressing scrub and creating bare patches for lichen colonisation. Rabbit grazing is associated with lichen heath because rabbits do not tend to graze lichens. In their absence it may be necessary to create bare ground artificially, for example by the discing or shallow rotovation of small areas.

10.3 Grass heath

Grass heaths such as those found in Breckland and parts of Humberside are best managed by grazing and not by cutting or burning, although heather stands within them may be treated in these ways. Rabbit grazing is very valuable in controlling the growth of vigorous grasses and producing bare ground although high levels of rabbit grazing may lead to the replacement of heather by grasses. Since rabbit populations tend to fluctuate, sheep grazing is often also necessary. Particularly valuable plant species may require fencing protection from rabbit grazing for part of the year to allow them to flower and set seed. Rotovation may also be a valuable management tool for plants and invertebrates which require bare ground and for ground nesting birds such as stone curlews.

10.4 Humid heath

Humid heath occurs where drainage is impeded but less so than in wet heath (see below). Cross-leaved heath is a typical plant. This and the much more localised Dorset heath both regenerate well after cutting. Frosty periods may be ideal for cutting on humid heath since the firm ground surface reduces damage by machinery.

10.5 Wet heath

Wet heath is commonly found on sites that have areas with impeded drainage. Wet heath is best managed by light grazing, especially with cattle, which checks the growth of vigorous grasses, especially purple moor-grass which might otherwise swamp out other plant species and produces ground disturbance (see Section 7.2). Small scale turf cutting and the creation of a limited number of deep ruts along vehicle access routes may also be very valuable in providing places for plant species to colonise. Wet heath should only be burnt after careful consideration because controlled burning can damage mosses, encourage purple moor-grass and remove the peat layer leading to the drying out of the habitat. If controlled burning is carried out it should be on small areas of less than say 0.1 ha and undertaken when the ground layer is damp. Controlled burning can be used as a one-off treatment to remove dead vegetation prior to the re-introduction of light grazing.

The marsh gentian is, however, a species that appears to benefit from occasional fires which reduce competition. Very small scale 'micro-management' using controlled winter burning with a blow torch on perhaps a ten year rotation may be appropriate for this species. Alternatively small scale turf cutting adjacent to marsh gentian colonies or light trampling by cattle might be tried.

Since drainage is impeded on wet heath, the invasion of bracken, shrubs and trees can to be less of a problem than on dry heath. However, the area of scrub such as willow carr may need to be reduced, although not eliminated as it is valuable for invertebrates. Birch, too, can be a serious problem. Scrub and woodland removal on dry heath may also be necessary to prevent wet heath from drying out. There is a need to prevent the nutrient enrichment of wet heath, for example from run-off from agricultural land. Off site effects such as water abstraction may also have adverse effects.

On wet peaty soils heather may regenerate vegetatively by layering. In such circumstances it may not require active management.

10.6 Valley mire

Valley mires (bogs) require management to maximise their nature conservation value. The grazing of valley mires is extremely desirable because it checks the growth of the more competitive species such as purple moor-grass. On sites which have been neglected for many years purple moor-grass tends to form tussocks which shade out bog mosses (*Sphagnum* species) and other interesting plants. In such situations controlled burning followed by light grazing to suppress the regrowth of purple moor-grass may be the best approach. On mires that are rich in bog mosses controlled burning may not be appropriate because mosses will be damaged unless the water table is very high.

11. Monitoring

A management plan should be drawn up before site management operations begin. It is also essential to record all the management activities that take place on site using a detailed system such as English Nature's project recording system. For details of how to prepare management plans and project recording see Nature Conservancy Council 1988. Note that English Nature must be consulted before any management is undertaken on a Site of Special Scientific Interest (SSSI) in England and the Countryside Council for Wales or Scottish Natural Heritage for SSSIs in Wales and Scotland.

Simply recording management activities is not enough in itself. This is because monitoring is necessary to determine whether management is achieving the desired objectives. If it is not remedial action will be necessary.

Since detailed monitoring is time consuming, monitoring should be carefully thought out. For broad scale monitoring designed to detect major changes, fixed-point photography backed up with aerial photographs is often used. This can be done at five and ten year intervals for fixed-point and aerial photography respectively.

The detailed monitoring of vegetation can be carried out using random or permanently located quadrats. Randomly located quadrats ensure more representative sampling which is easier to analyse and reduce the problem of damage caused by monitoring itself. However, a large number of say 1 m² quadrats subdivided into 20 cm squares might be needed to reduce sampling errors. Permanent quadrats may be more time-consuming to locate and monitor and present greater difficulties of analysis since they may not reflect change in the wider vegetation. On the other hand, the use of permanent quadrats may show more subtle changes. The problem of relocating permanent quadrats may be overcome by using metal markers and a metal detector. For more detailed guidance on monitoring see Rowell (1988).

Scarce or notable plants and animals should also be monitored to ensure that management is meeting their requirements. For example the numbers of pairs of key breeding bird species can be counted each year (see Bibby, Burgess & Hill 1992) and butterflies using the ITE butterfly transect approach (Hall 1981). The transect method can also be adapted for some other invertebrate groups such as grasshoppers and crickets. Pitfall and water trapping can also be carried out in invertebrate monitoring. Pitfall trapping should not be carried out on sites which have sand lizards.

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Appendix 1

Lowland heathland consists of a range of habitats. These may include:

Heather, Bell heather, Cross-leaved heath, Dorset heath, Cornish heath

Grasses

Gorses

Broom

Bracken

Birches and other deciduous species, eg oaks

Bare ground including lichens, liverworts and mosses

Humid heath

Wet heath

Sallow carr

Valley mire (bogs)

Open water

(Pines and rhododendron are also commonly found on lowland heath although they are alien species)

Appendix 2

A summary of management considerations for lowland heaths

- Main 1
 - Undertake survey of site (vegetation communities, heather growth stages, rare and notable plant and animal species).
- Main 2
 - Draw up management plan.
- Main 3
 - If there is a successional (eg birch, pine, rhododendron, bracken, grasses) problem implement control.
- Main 4
 - Implement heather rotation (eg by cutting, controlled burning, turf-cutting, rotovation).
- Main 5
 - Devise integrated management to maintain heathland including:
 - Minor 1 Grazing wherever appropriate
 - Minor 2 Control of invasive species as necessary (eg birch, pine, rhododendron, bracken, grasses)
 - Minor 3 Continued rotational heather management
 - Minor 4 Draw up a fire control plan and install firebreaks as needed
 - Minor 5 Undertake small scale management for heathland fauna and flora (eg creation of bare ground).
- Main 6
 - Carry out heathland restoration where appropriate.
- Main 7
 - Monitor the effectiveness of all management and any changes to the site.
- Main 8
 - Revise management plan accordingly.

Appendix 3

Guideline management objectives for lowland heathland

1. Provide all growth stages of heather (pioneer, building, mature and degenerate) by rotational management (controlled burning, cutting, turf cutting or rotovation). Aim for about 25% of heather in each growth stage. Some areas (eg 5% of the total area) of heather should escape the rotation to provide a deep litter layer for certain invertebrate species. The length of the heather rotation will vary in different geographical regions.
2. Rejuvenate areas of older (mature, degenerate and dead) heather by controlled burning, cutting, turf cutting or rotovation.
3. Ensure the provision of firm (not churned up) horizontal, sloping and vertical bare ground. Aim for a minimum of 2% on a site and if necessary provide it by controlled burning, turf cutting, rotovation or scraping.
4. Undertake any species-specific management that is necessary (for example cut or burn gorse bushes on a 10-12 year rotation where Dartford warblers are present, encourage rabbits on grass and lichen heath etc.).
5. Control species that are invading heathland, eg:

Birch, oak etc	(by light grazing/cutting/herbicides)
Pine	(by pulling/cutting)
Bracken	(by cutting/herbicide)
Rhododendron	(by cutting/herbicides)
Common gorse	(by cutting/burning/herbicides although note that on some sites it may be desirable to encourage gorse)
Grasses	(by turf cutting/light grazing)
6. Draw up a fire control plan and install firebreaks as necessary.
7. Consider light grazing management (sheep, cattle, ponies) of dry heath.
8. Consider light grazing management (cattle, ponies, sheep) of wet heath. Also undertake small scale turf cutting on wet heath in scattered plots for plants and invertebrates.
9. Once management of existing heathland is in hand, consider the restoration of areas of secondary birch woodland, pine woodland, bracken or invasive grasses to heathland.
10. Undertake monitoring to ensure that the management objectives are being met.

Appendix 4

Major lowland heathland management techniques

Rotational heather management (use to ensure the provision of all four growth stages of heather and rejuvenate older/dead stands of heather)		Control of undesirable plant species that are invading heathland				
Controlled burning (Sections 4.2 and 4.3)	Heather cutting (Section 4.1)	Turf cutting (Section 4.4)	Rotovation (Section 4.5)	Scrub Cutting (Section 6)	Herbicide application (Section 6)	Light grazing (Section 7)
<p>1 Nov-31 March only.</p> <p>Can be used to create firebreaks.</p> <p>Useful for dealing with dead heather.</p> <p>Always follow the heather and grass burning code.</p> <p>Exercise great caution next to forestry plantations.</p> <p>Ensure safety of all personnel.</p>	<p>Avoid nesting season for birds (March-late August) and avoid the period when reptiles are active (March-October).</p> <p>Can be used to create firebreaks.</p> <p>Cannot be used on steep slopes.</p> <p>Cut heather in autumn, ideally between mid October and late November to collect seeds for restoration.</p>	<p>Avoid nesting season for birds.</p> <p>Can also be used to tackle grass invasion and provide bare ground.</p> <p>Large scale turf cutting should not be carried out on sites that support important populations of reptiles or soil inhabiting invertebrates.</p>	<p>Avoid nesting season for birds.</p> <p>Can be used to create firebreaks.</p> <p>Can be used on bracken monocultures.</p> <p>Provides bare ground.</p>	<p>Avoid nesting season for birds, eg birch, oak etc, pine, rhododendron, possible gorse.</p> <p>If all the lower branches are removed pine will not regenerate after cutting.</p> <p>Other scrub species will require herbicide application.</p> <p>Cutting can also be used for bracken control.</p>	<p>Necessary to control birch, oak etc, rhododendron and gorse, if this is unwanted.</p> <p>Can also be used to control bracken.</p> <p>Health and safety regulations must be followed.</p>	<p>Spring-summer grazing is best for scrub suppression.</p> <p>Use low stocking rates and avoid the overgrazing of heather.</p> <p>Sheep, cattle and ponies can be used.</p>

Appendix 5

Recommended herbicides and application methods for control of invasive species on lowland heathland (see also Section 6)

1. **Birch**

Foliar spraying - small birch (less than 1.5 m tall) - triclopyr, fosamine ammonium (late August or September) or glyphosate (care needed as this is a broad spectrum herbicide).

Stump treatment - triclopyr or glyphosate.

2. **Bracken**

Asulam (in July) by knapsack sprayer, herbicide or tractor-mounted boom sprayer for larger areas. Buffer zones are needed where ferns or other sensitive species are present (see Section 6.4 for further details). Use an adjuvant (wetting agent) such as Agral. Avoid the use of ultra low volume applicators and aerial spraying because of the problem of sensitive species such as ferns being affected by spray drift.

3. **Rhododendron**

Stump treatment - triclopyr mixed with diesel or ammonium sulphamate for very large stumps.

Regrowth - triclopyr or glyphosate with the additive "mixture B".

4. **Gorse (only on sites where the control of invasive gorse as opposed to its encouragement is appropriate)**

Stump treatment - glyphosate or triclopyr.

Foliar spraying - triclopyr.

Appendix 6

Summary of lowland heathland restoration techniques (see Section 9)

1. Secondary birch woodland

1. Fell and remove birch (felling licence necessary) and treat stumps with herbicide and/or excavate stumps.
2. Scrape off and remove leaf litter layer to expose the mineral soil layer.
3. Cultivate surface by discing in two directions.
4. If there is no appreciable buried seed bank of heathland plant species (this can be determined by waiting for a year or so) add a seed source, eg heather cuttings.
5. If heather cuttings are added, Cambridge roll to encourage plant germination and establishment. Use cuttings from a local source wherever possible.
6. Institute ongoing heathland management, eg control of invasive and undesirable plant species.

2. Pine woodland

1. Fell and remove pine (felling licence necessary).
2. Scrape off and remove pine litter layer to expose the mineral soil layer.
3. Cultivate surface by discing in two directions.
4. If there is no appreciable buried seed bank of heathland plant species (this can be determined by waiting for a year or so) add a seed source, eg heather cuttings.
5. If heather cuttings are added, Cambridge roll to encourage plant germination and establishment.
6. Institute ongoing heathland management, eg control of invasive and undesirable plant species.

3. Bracken monocultures

1. Scrape off and remove bracken litter (or dispose of by controlled burning) to expose the mineral soil layer, reduce soil fertility and remove some bracken rhizomes. Alternatively use chisel ploughing or rotovation (see Section 6.4 for details).
2. Control bracken subsequently by cutting and/or herbicides (see Section 6.4 for details) over a number of years.
3. Cultivate surface by discing in two directions.

4. If there is no appreciable buried seed bank of heathland plant species (this can be determined by waiting for a year or so) add a seed source, eg heather cuttings.
5. If heather cuttings are added, Cambridge roll to encourage germination and establishment of heather.
6. Institute ongoing heathland management, eg further bracken control as necessary and control of other invasive and undesirable plant species.

4. Invading grasses

1. Strip off the turf and top of the soil organic layer (turf stripping). Remove turves.
2. If there is no appreciable buried seed bank of heathland plant species (this can be determined by waiting a year or so) add a seed source, eg heather cuttings.
3. Institute ongoing heathland management, eg control of invasive and undesirable plant species.

Note: Large scale stripping should not be used on sites that support important populations of reptiles or soil inhabiting invertebrates.

Appendix 7

English Nature's lowland heathland National Nature Reserves

Cornwall

Goss Moor
Lizard

Dorset

Hartland Moor
Holt Heath
Holton Heath
Morden Bog
Stoborough Heath
Studland and Godlingston Heaths

Hampshire

Kingston Great Common

Norfolk

Brettenham Heath
Roydon Common
Winterton Dunes (dune heath)

Shropshire

Stiperstones (intermediate between lowland and upland heath)

Suffolk

Cavenham Heath
Thetford Heath
Walberswick
Westleton Heath

Surrey

Thursley

Sussex

Lullington Heath (chalk heath)