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The lowland heathland management handbook

C H Gimingham

English Nature Science

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THE LOWLAND HEATHLAND MANAGEMENT HANDBOOK

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1 INTRODUCTION

Aims

The aim of this handbook is to provide practical guidelines for the management of lowland heathlands where the primary objective is conservation. It draws together information and advice from a variety of sources, some of them published and some consisting of the accumulated wisdom of experienced practitioners. It should therefore lay a foundation on which new generations of managers can build instead of having to start from scratch and learn everything the hard way.

My main aims are these:

- to show that, with very few exceptions, the conservation of heathlands requires active management
- to set out the various options available to the manager
- to assist in the choice between these options
- to provide basic practical information about procedures, methods, equipment and the ways to achieve good management
- to list the most useful sources from which more detailed guidance can be obtained on specific matters
- to provide, by means of brief case studies, examples of various current approaches to management in different parts of the country.

In recent years the conservation of heathlands, both in Britain and elsewhere, has become a top priority. Why should these systems, which in the main are semi-natural and of human origin, have such importance?

The answer to this question has three components.

1 Heathlands have been a major feature of the vegetation and landscape of the Atlantic and sub-Atlantic parts of western Europe for a very long period of time, in fact ever since man started his inroads into the forests of the area.

2 It follows from this that distinctive assemblages of plants and animals have had time to develop in the tree-less habitats created by forest clearance, and these habitats have in a number of instances been adopted by species which are now rare or otherwise of special interest.

3 For a variety of reasons there has been a devastating loss of heathlands throughout western Europe over the past 100 years, a loss which continues today at an alarming rate.

These three aspects, which together establish the 'conservation value' of heathlands, will be developed in Chapter 2 of this handbook. There are, of course, other reasons why heathland

conservation is widely regarded as important. Chief among these is the beauty of heathland landscapes, especially in late summer when heather *Calluna vulgaris* and other ericaceous plants are in bloom. The purple heaths and moors are much admired by the general public and correspondingly lamented when they disappear. They are appreciated not only for their scenic quality, but also for the purposes of out-door recreation, their popularity often being the cause of considerable and sometimes damaging pressure.

No sensible management strategy can be developed without a clear understanding of the objectives to be achieved and the ecological characteristics of the systems requiring conservation. For this reason, a fair amount of space in the first part of this handbook (Chapters 3 and 4) has been devoted to presenting the ecological background, defining the problems and explaining why management is essential if conservation aims are to be met. Only then is it appropriate to set out the available methods, but at that stage (Chapters 5-10) as much practical information as possible is included. These Chapters are followed by a discussion (in Chapter 11) designed to assist in management planning, by analysing objectives and setting out guidelines for making management decisions.

Next, an outline is given (Chapter 12) of methods for monitoring the results of management regimes. Finally, although the handbook deals mainly with methods of maintaining and enhancing surviving heathlands, the opportunity has been taken to incorporate a short section on the reconstruction of heaths that have been damaged or destroyed and the creation of communities resembling heaths in artificial habitats. This chapter (Chapter 13) may contribute some ideas to those attempting restoration where permitted developments have degraded existing heaths.

Readership

The handbook is directed at all who are concerned with the practical problems of heathland management for the purposes of conservation. These will include regional officers of English Nature and other conservation agencies, wardens and other managers of nature reserves, rangers, estate managers and others involved in conservation or land management whose task it may be to formulate or implement management plans. It should also be of value to policy-makers in the fields of nature conservation, landscape conservation and provision for recreation, where these activities impinge on heathlands. Among these will be officers of voluntary bodies concerned with nature conservation as well as staff of government organisations (including civil servants in appropriate Departments) and planners employed by local government and industry. Land managers involved in land uses that affect nature conservation, such as agriculture and forestry, may also find these pages of interest. While much is known about methods of managing heathlands and many experiments have been carried out or are in progress, the information was scattered in a variety of reports and papers. I hope that, by bringing it together in a single handbook, I may help managers of nature reserves and other heathland conservation areas to avoid the risk of setting up trials which merely 'reinvent the wheel'.

Note: English names of plants and animals have been used throughout to make the text easier to read for the non-specialist. Scientific names are given as well at the first mention of any organism but not thereafter, except where the context requires them for the sake of clarity.

Heathland

It is not easy to impose a precise definition on the word 'heathland', which relates more to a characteristic type of landscape than to its vegetation and fauna. Throughout much of the book, attention will be concentrated on communities largely dominated by heather or one of its close allies (partly because this type is fast disappearing from the lowlands). The chief plants are low, woody shrubs, while tall shrubs and trees are either completely absent or sparse and scattered. This description would include not only the 'lowland heaths' generally developed on freely drained, acidic, sandy or gravelly soils, usually below about 250 m, but also the 'upland heaths' and 'moorlands', which, fortunately, are still quite widespread in upland Britain and tend to occur on wetter, peaty soils (or pure peat). This handbook will be concerned mainly with lowland heaths, where conservation is most urgent, but reference will be made as appropriate to upland heaths occurring below the potential tree limit. The many interesting montane and alpine heath communities that are to be found above the tree limit and are natural rather than anthropogenic, will not be considered. The term 'heath' as commonly used also extends to other community types, such as grass heaths on acidic soils, wet heaths, lichen heaths and moss heaths; these will also be discussed. They are all important types, in terms of nature conservation, and in lowland Britain some are now confined to very restricted areas.

Because most heathlands owe their origin and continued existence to traditional forms of land use and management, they are potentially unstable and liable to quite rapid successional change to other vegetation when, as is now all too often the case, that management is abandoned or changed. If representative examples of heathland ecosystems are to be conserved it is essential to devise appropriate forms of management, without which they will be lost.

Bibliographies and suggestions for further reading

In planning the present handbook priority was given to setting out guidelines rather than presenting extremely detailed practical prescriptions. In many cases the latter can be found in the relevant references in the Bibliography at the end of each chapter, to which the reader is directed for additional information and further details on specific aspects. Rather than cluttering the text with numerous references to original works, the main sources used in the preparation of this handbook are also contained in the Bibliographies.

In addition, at the end of this chapter there is a list of suggestions for further reading, which contains a number of important sources relevant to all the topics covered in this handbook, rather than to specific chapters.

Acknowledgements

I have drawn freely on the wisdom, experience and published writings of so many friends, colleagues and authors that it is impossible to thank them all individually, but I am most grateful to each of them. Authors who recognise in the text information derived from their publications are asked to regard this as grateful acknowledgement. However, my particular thanks go to Lynne Farrell for her support and encouragement throughout the preparation of this handbook, and to Terry Rowell who gave invaluable help by visiting and gathering

information from numerous heathland sites and managers. In addition he wrote three of the Case Studies, which also include contributions by Paul Dolman, Ceri Evans and Peter Gotham, Caroline Fitzgerald and Stephen Evans, to whom I am most grateful. Nigel Webb and Norman Moore nobly read the whole handbook in draft, and their comments and suggestions have enormously improved the final product, as have those of others who kindly read particular chapters or provided information on various matters: Penny Anderson, Martin Auld, Arnie Cooke, Paul Dolman, Nick Hodgetts, Marcus Humphrey, Rob McGibbon, Robert Marrs, Richard Ninnes, Jim Parkin, Bryan Pickess, Pat Rae, John Rodwell and Roy Watling. I am also grateful to Richard Ninnes for the Heath and Moorland Recording Form (Appendix 3) and Martin Auld for the data on costs of various management operations (Appendix 8). Most of the information in Appendices 4 - 6 was supplied by Terry Rowell. Dr Nick Michael, lowland heathland specialist at English Nature headquarters and Stefa Kaznowska in Publicity and Marketing Branch gave invaluable help in the later stages of preparation for publication. To all of these and many others who accompanied me in the field and helped in numerous ways I extend my thanks.

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2 WHAT IS THE PROBLEM?

The management of heathlands for wildlife must be based on a clear idea of the reasons for devoting effort and money to their conservation and an appreciation of exactly why management is necessary. This chapter deals with the first of these points; the second is covered in Chapter 4.

General distribution of heaths in Britain and Europe

Heathlands are found in various parts of the world under suitable conditions of climate and soil and in the absence of forest or scrub. However, for historical reasons (see Chapter 4), lowland heaths were especially well developed and widespread in western Europe, at least until about 100 years ago. They occur chiefly on the western fringe of the continent, where the climate is temperate and 'oceanic', with mild winters and relatively high rainfall, well distributed throughout the year. Within this 'heath region' acidic soils, if not covered by woodland, may support heaths, including 'dry heaths' on freely drained soils and 'humid heaths' and 'wet heaths' on soils of impeded drainage. (Upland and montane heaths are not confined to the area shown, but extend much more widely.)

British heaths form an integral part of this complex of west European heath communities, relating closely to their counterparts on the other side of the North Sea and the English Channel. While the similarities are obvious, there are also differences caused partly by the British climate, which is more strongly oceanic than that of mainland Europe, partly by soil factors, and partly by our separation from the continent, probably some 7,500 years ago, which prevented some plant species from reaching these islands.

Within Britain, suitable habitats for lowland heath are rather restricted, both because of the extent of arable agriculture and because of the patchy distribution of suitable soil parent materials. (These include sands and gravels, in some cases glacially deposited but elsewhere the products of weathering of ancient acidic rocks, which give rise to soils of low fertility that are poor in plant nutrients, notably calcium and phosphorus.) The main areas of lowland Britain where these conditions apply and have given rise to heathlands are the south-western peninsula, the counties along the south coast of England, southeastern England, East Anglia and parts of the Midlands. In addition there are scattered areas in Bedfordshire, Leicestershire, Worcestershire, Staffordshire, Nottinghamshire, Lincolnshire and Yorkshire, as well as in the coastal and lowland parts of South Wales and eastern Scotland. In some instances little is now left of formerly much more extensive tracts of heath.

Heath communities also occur on suitable substrata in places around the extensive coastline of the British Isles. These include dune heaths, which develop in the course of primary succession on siliceous sands, and maritime heaths on cliff tops, where tree growth is inhibited by wind exposure.

Much more extensive heathland vegetation, however, still survives in upland Britain (including for example Dartmoor, Wales, parts of Yorkshire, the Pennines and much of Scotland). The greater part of this lies at moderate altitudes below the potential forest limit, with the true montane heaths above this level. While some of the upland heaths occupy fairly freely drained soils, large areas lie on peaty ground and are commonly referred to as 'moorland' rather than heath. There is no precise definition of 'moors' and no sharp distinction between lowland heath, upland heath and moor. Transitions from a flora and fauna typical of the

gentler climate of the lowlands to the more exacting and often wetter conditions of the uplands are gradual.

The conservation value of heathlands

As Chapter 4 will show in more detail, heathland landscapes below the potential tree limit are semi-natural, resulting from human activity. If 'naturalness' were singled out as all-important in evaluating sites for nature conservation, it could be argued that heathlands would rank lower than some other more 'natural' types. However, very few British ecosystems are truly natural, and heaths, like most native woodlands and permanent grasslands, are semi-natural communities of naturally occurring species, as distinct from crops or exotics. Furthermore, while some heaths are relatively recent in origin, many are ancient, dating back to Bronze or Iron Age times, or earlier. Since then, communities of plants and animals have been assembled in these heathland habitats where heather or one of its relatives became dominant. As would be expected, some of the flora and fauna of heaths are shared with the communities which belonged to the former woodland, whether pine-birch forest in the north or broadleaved wood further south. Others, however, are species which require more open situations but are able to compete effectively in acid, nutrient poor conditions. Yet others need the very open habitats created by various forms of disturbance. The result has been the development of unique communities of plants and animals which are of great interest to naturalists, ecologists and all who appreciate the countryside and its history.

This alone would justify assigning high conservation value to well-developed heathland ecosystems, but there are additional powerful considerations. As would be expected, in view of the ways in which heathlands have originated, few species belong solely to heath communities. However, heaths have provided suitable niches for some whose other habitats have now all but disappeared and which are therefore, in effect, confined to heathlands. Examples include the petty whin *Genista anglica,* the Dorset heath *Erica ciliaris* (a species very local in Britain where it is at the margin of its geographical range), the marsh gentian *Gentiana pneumonanthe,* the Dartford warbler *Sylvia undata,* the smooth snake *Coronella austriaca* and a number of invertebrates. Over the years these organisms have found that heathland environments met their physiological and life-history requirements. Some are quite common, but others are rare and confer 'scarcity value' on the localities containing them. In addition to this small group of species, various others can be regarded as particularly characteristic of heaths, although also occurring elsewhere. The two dwarf species of gorse, *Ulex minor* and *U. gallii,* the bristle-leaved bent *Agrostis curtisii,* the sand lizard *Lacerta agilis* and the nightjar *Caprimulgus europaeus* may be cited as examples of these.

Furthermore, many heathlands are very varied, both in terms of range of habitats, for example from wet to dry and from true heath to acid grassland or scrub, and of species richness. Many people, while prepared to admire heath landscapes, think of the plant cover as little more than a pure stand of heather and regard heaths as dull and monotonous as far as natural history interest is concerned. This idea probably springs from the fact that many of the more extensive heaths and moors (especially those of the uplands) have long been managed by grazing and burning, with the specific objective of creating something approaching a monoculture of heather. However, where more variety has been allowed under different management regimes, much greater species richness often results and many attractive and interesting plants and animals may be found. It remains true that communities on acid soils

are seldom as diverse as those of chalk or limestone, but they are none the less important ecologically and are equally deserving of conservation.

Another popular misconception about heath communities is that they are much the same wherever they occur. In fact, as Chapter 3 shows, there is a great deal of variation in different parts of the country, which amounts to a continuum of variation of great importance to plant and animal ecologists and geographers. Some of the communities are very similar to those of other countries in the European heath region, but because conditions are never the same the communities are never identical. Others have features which are unique to Britain. It is therefore of the utmost importance to ensure that conservation measures are adequate to secure representation of this important range of variation. In addition, loss of heathland ecosystems on the continent of Europe has in many cases been even more disastrous than in Britain, and if certain types are to be conserved it is now only in Britain that this can be achieved, even though the British versions may not be exact replicas of those of other countries.

Finally, it is now widely recognised that a deeper understanding of the ecological effects of human impacts upon natural and semi-natural systems is urgently required. Heathland ecosystems, which owe their origin and continued existence to use and management by man, are particularly suitable for research of this kind. Already a substantial amount has been and is being done, and there is scope for much more, but only if sufficient examples of viable size are conserved.

Current trends of loss to other sorts of vegetation

In the past, heathlands afforded valuable grazing for domestic animals, despite the fact that their productivity is low compared to that of good quality grasslands. In fact, the total area of heathland in western Europe was still expanding, relative to that of woodland, until well into the 19th century. However, with the great improvement of agricultural productivity which accompanied the introduction of chemical fertilizers and mechanisation at about that time, the traditional use of heathlands for sheep and cattle rapidly declined over much of the region. Lack of management allowed some areas to revert to woodland, but the innovations which were leading to intensification of agriculture on more fertile land also introduced the possibility of 'reclamation' of heathland and its replacement by arable farmland, improved grassland or tree plantations. During the past 100 years these changes, augmented by urban and industrial developments and the construction of motorways, airports and other artefacts, have caused the loss of heathland at an accelerating rate. Today lowland heaths are correctly described as an "internationally endangered habitat type".

A well-documented example is provided by the province of Halland in south-west Sweden. Heathlands there accounted in 1850 for about 75% of the total area of the province; today they cover less than 5% and survive only where protected, while afforestation or agriculture have replaced most of the rest. In Denmark the Danish Heath Society was formed in 1866 to encourage the conversion of extensive tracts of heath to more profitable farmland and, in some areas, forest. It is a measure of its success that the Society is now more concerned to protect the remaining examples of heathland, which amount to only about 2% of the total land area of Jutland. The Netherlands (where the area of heathland today is only about 5% of that in 1835), Belgium, northern Germany and northern France (Normandy, Brittany) all tell the same tale. Currently, data from these countries are being collated in order to document the trend

and establish the urgency of ensuring conservation of the remaining fragments of the various types of heath ecosystem represented.

The lowland heaths of England have suffered the same fate. The Nature Conservancy Council (1984) estimated losses varying between 50 and 90% of the peak heathland area attained in the late 18th or early 19th centuries in various counties. These losses amount overall to a decrease of about 75%. Further losses have occurred since these figures were compiled. Careful comparisons of maps and other records have shown that among the worst affected areas are the counties of Dorset, where only about 14% of the area known to be heathland in 1750 survives, Surrey, where the figure is about 15% of the area in 1762, and Suffolk, where only about 10% of the area known as the 'Suffolk Sandlings' remains as heathland.

Not only has there been this massive decline in total area, but the remaining heathland is now broken up into separate fragments, many of them isolated by quite considerable distances from their nearest neighbours. An additional problem is that even where there has been no deliberate reclamation or conversion to new uses, traditional management has often been abandoned and successional change is taking place, with the invasion of either bracken or shrubs and trees. In certain areas there is also a tendency, not yet fully explained, for the dominant heather to give place to grasses such as wavy hair-grass *Deschampsia flexuosa* or purple moor-grass *Molinia caerulea*. In some cases overgrazing may cause changes of this kind, but there is evidence from research in The Netherlands that they may result from increases in soil nutrient levels (especially nitrogen) due either to the abandonment of traditional management or to inputs from atmospheric pollution (or both). Air pollution, together sometimes with fertilizer drift, may well be having an effect on some English heaths, as for example in East Anglia.

In conclusion, we are presented with the problem of arresting a decline in a valuable ecosystem which has been proceeding at an increasing rate over a period of 150 - 200 years. It is clearly an urgent necessity to ensure that sufficient examples to represent the full range of variation in community composition are protected in reserves. However, protection alone is not adequate because of the fact that we are dealing with a potentially dynamic semi-natural system which depends on management for its survival. In this instance, to rely solely on protection is a recipe for certain loss of the object of protection.

Summary

1 This chapter concerns the reasons for placing high priority on heathland conservation.

2 Lowland heaths were, until recently, widespread in the more oceanic parts of Europe, i.e. western Europe, especially in the countries bordering the North Sea and English Channel.

3 In Britain, lowland heaths are confined to areas of acidic soils, low in plant nutrients.

4 Some heathlands date back to Bronze Age times (or earlier); hence there has been a considerable time for characteristic communities to develop. These are of great interest in terms of both their flora and fauna and their aesthetic appeal.

5 Heathlands have provided virtually the only remaining habitats for the survival of certain species, some of which are rare.

6 Far from being uniform, heathland communities are varied, ranging from dry through humid to wet, from coastal to inland, from grass or lichen heath to heather dominated vegetation.

7 Heaths offer excellent opportunities for research into human impacts on semi-natural vegetation.

8 There have been disastrous losses of lowland heath in Britain (as elsewhere in western Europe) during the past 100 years. Remaining areas have been fragmented.

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3 TYPES OF HEATHLAND VEGETATION

As indicated in Chapter 2, heathland ecosystems are by no means all alike: they represent a continuum of variation. It is, however, always possible to break up a continuum into a number of types (although the distinctions between them will not be sharp and transitional examples will be frequent). This is what has usefully been done by the National Vegetation Classification (NVC) (Rodwell 1992) to which the reader is referred for detailed information. If conservation of heathland is to be effective, all the recognised types must be represented in a comprehensive strategy. Merely to ensure survival of good examples of heathland treated as a single category is not enough. Therefore it is necessary to be aware of the 'directions of variation' of heathland communities, in relation to the several ecological factors which affect them, and of the diagnostic features of composition and structure of the different types. Only with this information can site selection and management achieve their objectives.

Gradients in composition of heath communities

Where pronounced environmental gradients occur over short distances, the consequent vegetational trends may be very obvious. This is the case with the change from dry heath with heather and bell heather *Erica cinerea,* on very freely drained soils, through increasingly humid heath, where soil drainage is impeded and cross-leaved heath *Erica tetralix is* present, to wet heath, where in addition to these species *Sphagnum* and other indicators of peaty soils are prominent and heather cover is reduced. Such sequences, induced by undulating topography, may be represented in their entirety and repeated many times over in a single area of heathland, giving rise to a habitat and vegetational mosaic which is both attractive and of high conservation value, because of the variety of communities and species represented.

Other environmental gradients are more evident on a geographical rather than a local scale. Examples are gradients in climatic factors such as temperature, rainfall, incidence of frost, snow etc. Their effects on community composition are not generally seen on the small scale of transitions within any one area but can be picked up or reconstructed by comparing examples of heath ecosystems from different geographical locations along gradients, e.g. from south to north or from east to west. Each example will represent a different point on a series of such gradients, and, although each will be distinct, when all are considered together they represent points on a continuum of variation. Despite the complexity of this continuum, a number of fairly well-marked heath types are recognisable and their differences are attributable to climatic and soil variation across the country.

Dry heaths

Among the drier types, there is a marked gradient in the floristic composition of the southern British heaths, which form a series strung out across the broad southern 'base' of England from East Anglia to the south-west peninsula and South Wales. At the eastern end of this gradient, where climatic conditions approach the sub-continental, sheep's fescue *Festuca ovina* is the chief associate of heather. In places (as for example in parts of the Breckland heaths), heather may be insignificant or lacking, and grass heath vegetation (usually with abundant wavy hair-grass *Deschampsia flexuosa*) is then characteristic where the surface soil is leached and acidic.

From the New Forest westwards (with an outlier at Chobham Common, Surrey), bristle bent *Agrostis curtisii* soon becomes prominent, and dodder *Cuscuta epithymum* is a frequent

component in these southern heaths. In the sector from Surrey and the High Weald in the east, through the New Forest to Poole Harbour, dwarf gorse *Ulex minor* is a major contributor to the vegetation, but passing further west it gives place rather abruptly to western gorse *Ulex gallii*. Communities with this species extend to the extreme south-west and South Wales, while in the Lizard peninsula, Cornwall, there is a local type containing Cornish heath *Erica vagans*, along with common gorse, western gorse and bell-heather, on moderately base-rich brown-earth soils.

This sequence of southern heaths displays the effects of the east-west climatic gradient from sub-continental to strongly oceanic conditions. There are also two other predominantly western or oceanic heath types, one a heather-western gorse type found mainly in south-west England, Wales, the Isle of Man and Northern Ireland; and the other, a heather-bell heather type, with a somewhat more northerly distribution in Scotland, north-west England and Wales.

The south-north gradient, on the other hand, is expressed in differences between the predominantly southern types just described and those of central and northern Britain. In the centre, wavy hair-grass is a prominent associate of heather, while further north (Wales, northern England and Scotland) species of more northerly geographical affinities are associated with heather, including bilberry (blaeberry) *Vaccinium myrtillus*, cowberry *V. vitis-idaea*, crowberry *Empetrum nigrum* and bearberry *Arctostaphylos uva-ursi*.

Where maritime influences are strong, coastal heaths show distinctive features. Two types are recognised: one in which sand sedge *Carex arenaria* is prominent in coastal dune heaths, and the other a low-growing heath type containing spring squill *Scilla verna*, found on cliffs all round the coasts of Britain except in parts of the east and south.

Wet heaths

Where soil drainage is impeded and peaty humus accumulates at the surface, humid and wet heaths are common, often forming transitional communities between drier heath and true peat-bog. Although there is a fair amount of variation in the composition of wet heaths, they do not fall into types so obviously associated with north-south or east-west climatic gradients as do the dry heaths. Two broad groups, however, can be recognised: the cross-leaved heath-*Sphagnum* (*Erica tetralix-Sphagnum compactum*) group, which is widespread throughout Britain, and the deer-grass-cross-leaved heath (*Scirpus cespitosus-Erica tetralix*) group, which is predominantly western in distribution. Another local type, in which Cornish heath is associated with black bog-rush *Schoenus nigricans*, occurs only on the Lizard peninsula and may also be regarded as a wet heath.

National Vegetation Classification types

For the purposes of this handbook, which concerns heaths of low and medium altitudes only (the potential forest zone), the 12 most relevant dry and three wet heath types have been extracted from the NVC, and brief descriptions of each follow, in the order in which they appear there.

H1 *Calluna vulgaris-Festuca ovina* (heather-sheep's fescue) heath

On acidic sandy soils in the more continental conditions of eastern England, including Breckland and elsewhere in Norfolk, Suffolk, Lincolnshire and Sussex.

Sheep's fescue is the only major and regular associate of heather (bell-heather and the two dwarf species of gorse, dwarf gorse and western gorse, are absent). Often rich in lichens; may be moderately rich in mosses.

H2 *Calluna vulgaris-Ulex minor* (heather-dwarf gorse) heath

On freely drained, nutrient-poor acid soils in eastern and central parts of southern England from Kent, Surrey and Sussex to Hampshire and the eastern parts of Dorset.

Bell heather and dwarf gorse are intimately mixed with heather; wavy hair-grass is prominent in the more easterly examples of the community.

H3 *Ulex minor-Agrostis curtisii* (dwarf gorse-bristle bent) heath

Soils sometimes less well drained than is normal for H1 and H2; climate more oceanic; more or less confined to Hampshire and Dorset.

Bristle bent is a regular component along with heather and dwarf gorse. Cross-leaved heath and purple moor-grass are frequently present.

H4 *Ulex gallii-Agrostis curtisii* (western gorse-bristle bent) heath

On moist acid soils in the warm, markedly oceanic parts of south-west England, replacing H3 in west Dorset, extending into Devon, Somerset and Cornwall.

Similar to H3, except that western gorse replaces dwarf gorse, the boundary between the two types being remarkably sharp.

H5 *Erica vagans-Schoenus nigricans* (Cornish heath-black bog rush) heath

Wet mineral or peaty soils, relatively base-rich (though poor in calcium). Only on the Lizard peninsula, Cornwall.

Besides Cornish heath and bog-rush, purple moor-grass, cross-leaved heath and western gorse are frequent.

H6 *Erica vagans-Ulex europaeus* (Cornish heath-common gorse) heath

On freely draining, moderately base-rich brown earth soils; only on the Lizard peninsula, Cornwall.

Cornish heath and common gorse co-dominant. Bell-heather and western gorse constant; heather frequent.

H7 *Calluna vulgaris-Scilla verna* (heather-spring squill) heath

Low heath community on maritime cliff-tops with moderately base-poor soils much influenced by sea-spray, all round the coasts of Britain except the east and south-east coast from Durham to Dorset.

Heather is generally accompanied by bell heather, in the north often by crowberry or cross-leaved heath, and in the south by western gorse. Several maritime species are present, and spring squill is a constant.

H8 *Calluna vulgaris-Ulex gallii* (heather-western gorse) heath

On freely drained, generally acid soils in the warm oceanic, mainly western parts of Britain, often maritime but also inland, from the Isle of Man and Wales to south-west England, with a few examples in central England and even East Anglia.

Intimate mixture of heather, western gorse and bell-heather (but generally lacking cross-leaved heath, purple moor-grass and bristle bent).

H9 *Calluna vulgaris-Deschampsia flexuosa* (heather-wavy hair-grass) heath

Acid and impoverished soils in the relatively cool and wet climate of the Midlands and northern England.

Heather generally dominant, often in almost pure stands. Wavy hair-grass the only constant associate, bilberry fairly frequent.

H10 *Calluna vulgaris-Erica cinerea* (heather-bell heather) heath

Freely drained acid soils of the cool oceanic lowlands of north and west Britain.

Bell-heather is a regular and often abundant associate of heather, and the community may contain species typical of the more oceanic heaths, such as green-ribbed sedge *Carex binervis*.

H11 *Calluna vulgaris-Carex arenaria* (heather-sand sedge) heath

On stabilised non-calcareous coastal sand dunes.

Sand sedge is constant along with heather; also marram grass *Ammophila arenaria*. Bell heather or crowberry may be associates, and mosses may be prominent.

H12 *Calluna vulgaris-Vaccinium myrtillus* (heather-bilberry) heath

The most widespread type in the climates of the north of England and Scotland, and at moderate altitudes in upland areas, on acidic podsols and peaty podsols.

Together with heather and bilberry, bell heather, cowberry and crowberry are common, and wavy hair-grass is frequent. Mosses are often luxuriant.

H16 *Calluna vulgaris-Arctostaphylos uva-ursi* (heather-bearberry) heath *(Pyrola media-Lathyrus montanus* (intermediate wintergreen-bitter vetch) sub-community)

On generally freely-drained mineral soils with shallow organic horizon, at moderate altitudes in the cold, more continental climate of the east-central uplands of Scotland.

Heather with bearberry, bell heather and often both bilberry and cowberry. Although this is predominantly an upland type, examples occur at medium altitudes in the foothills of the Scottish Highlands. In particular, a herb-rich sub-community, with species such as slender St.John's-wort *Hypericum pulchrum,* intermediate wintergreen *Pyrola media,* petty whin, bitter vetch *Lathyrus montanus* etc., is a readily recognisable community-type occurring at altitudes of between 100 and 500m, mainly on the eastern and northern sides of the Grampian-Cairngorm massif.

M15 *Scirpus cespitosus-Erica tetralix* (deer-grass-cross-leaved heath) wet heath

Widespread in the north and west of Britain on acidic peaty mineral soils with impeded drainage, and peat.

Composition variable, but usually including deer-grass and cross-leaved heath, heather and purple moor-grass. Bell heather, bilberry and bog myrtle *Myrica gale,* frequent. Some Sphagna, but not usually forming extensive ground cover.

M16 *Erica tetralix-Sphagnum compactum* (cross-leaved heath-*Sphagnum*) wet heath

On acid, oligotrophic mineral soils with impeded drainage or peat, usually in habitats transitional between those of drier heath types and those of *Sphagnum* bogs. Widespread throughout Britain, though rare in central England.

Sphagnum compactum, S. tenellum and some other *Sphagnum* species are usually prominent; cross-leaved heath, heather and purple moor-grass are often the dominant vascular plants. Deer-grass, the two common species of cotton-grass, *Eriophorum vaginatum* and *E. angustifolium,* bog asphodel *Narthecium ossifragum* and common sundew *Drosera rotundifolia* often present. It is in this type of heath that, in suitable localities in southern England, marsh gentian occurs, and (within its localised area) Dorset heath.

The above summary of community types of lowland heaths includes only those given in the NVC under 'Heaths' and 'Mires' (Rodwell 1992). In addition, lowland heaths include acidic grass heath (e.g. NVC U1), lichen heath and bryophyte heath communities. Generally, it will not be too difficult to determine which of these types are represented in any particular heathland site. In view of their distinctive characteristics and the wide range of floristic and faunal composition, it is important that examples of all types are included in safeguarded areas.

While climatic and soil factors play the major parts in determining the distribution of the species, and hence the composition of the various types, use and management have also had a profound influence that has been ignored in the above brief descriptions. Past use and management, however, must be taken into account in deciding on appropriate management to secure the conservation of examples of each and all of these types.

Summary

1 British heathland vegetation constitutes a continuum of variation, with recognisable east-west and south-north gradients in composition, corresponding to environmental gradients from sub-continental to oceanic, and from warm southern to cool northern conditions respectively.

2 Any one heathland may display a mosaic of sequences, from dry heath on freely drained sites, through humid heaths where drainage is impeded, to wet heath on peaty soils.

3 These ranges can usefully be divided up into types, as in the National Vegetation Classification. Brief descriptions are given of the 12 dry and three wet heath NVC types most relevant to lowland heaths.

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4 WHY IS MANAGEMENT NECESSARY?

Management is needed when the conservation of a particular type of ecosystem depends on the prevention of unwanted changes. This applies to most heathlands, but a few types are apparently stable and require little or no management. Brief reference will first be made to these, before examining the reasons why management is essential for the effective conservation of the rest.

Stable heaths

On exposed coastal cliffs and above the tree limit on mountains, as in sub-arctic areas, conditions are such as to exclude trees and tall shrubs. Here the heather or other dominant ericoid species is forced by 'wind pruning' to adopt a low, often creeping habit, and the individual plants may persist in this form for long periods of time. In the absence of disturbance or other damage such communities show few signs of change.

There are also certain other habitats in which individuals or clones of heather may be very long-lived, for example moist peat, where trailing branches root adventitiously in the organic matter and give rise to 'daughter' bushes by a process akin to 'layering'. In such situations, if trees are scarce or absent because of the wetness of the substratum, the overall composition of the wet heath vegetation may be stable over long periods of time, despite considerable flux in the occupancy of any particular patch of ground.

For these reasons, some maritime heaths and wet heaths will persist as heath, undergoing little or no change, in the absence of management. There may also be a few localities where the soils, although otherwise suitable, are so poor in nutrients (especially phosphorus) as to reduce the capability of trees, grasses or bracken to invade heather stands. These may also need very little management, as heather will tend to re-establish on bare patches before its place can be taken by any other species.

Heaths as dynamic systems

Most European heaths, however, belong to places in the lowlands or middle altitudes of the uplands where both climate and soils are suitable for trees, and woodland is the natural 'climax' vegetation. Indeed, it has been shown conclusively, mainly by pollen analysis, that the overwhelming majority of these heathlands were formerly forest covered. Replacement of forest by heath was not a sudden event but took place progressively over a long period, starting probably as far back as the Neolithic period (*ca.* 3000 BC) and continuing right up to the 18th or even 19th century.

It was the demands of the expanding human settlements that were responsible for the depletion of the forest. This was, at first, a gradual process, in time becoming increasingly rapid. The people required land for cultivation, forage for their domestic animals and wood for fuel and building purposes. The result of progressive forest clearance was the expansion of grassland (on the better soils) and heaths (on the poorer, acid soils). Both offered valuable grazing for the growing flocks of sheep and cattle. Hence from earliest times the heaths had important uses, and the use made of them generally prevented reversion to woodland.

Like the grasslands, our heathlands are therefore semi-natural landscapes. They occupy habitats capable of supporting woodland and, in the absence of continued use and

management, prove to be unstable and liable to change - usually towards a return of woodland. If this change seems in places to be almost imperceptibly slow, this may be due to a lack of tree seed in the neighbourhood or to conditions of soil or vegetation which for the time being may not encourage tree seedling establishment, but the fact remains that heath communities are intrinsically dynamic, and given time will tend towards scrub or woodland. Hence, if they are to be conserved, management is essential.

Why heather fails to persist in the absence of management

It is only in the special habitats mentioned above, where continued wind-pruning or layering in moist humus prolongs the life-span of individuals, that heather plants have a natural tendency to survive indefinitely. By contrast, in the more moderate conditions where heather has become dominant following forest destruction, each individual bush normally passes through a series of growth phases and typically dies at an age of about 30 to 40 years (Figure 4.1). These phases, recognition of which is very important when it comes to principles of management, may be summarised as follows:

a **Pioneer phase** This is the period of establishment, either of seedlings or of sprouts from stem bases surviving after fire. In both cases the young plants are neatly pyramid shaped, but seedlings are scattered whereas stem-base sprouts are clustered. Flowering usually begins in the second growing season after establishment, and from about this time growth is no longer concentrated in a leading shoot but takes place in a number of radiating branches.

b **Building phase** Radiating growth gives rise to a dome-shaped bush in isolated individuals, or to a closed canopy in dense stands. This is the most vigorous growth-phase, with abundant production of light green, short shoots near the periphery of the branches, and of flowers and seed. Very little light penetrates the canopy.

c **Mature phase** In time, extension growth becomes rather less vigorous while the woody parts of the branches continue to increase in girth. The short shoots are now rather darker in colour and more clustered, while the canopy becomes more irregular and inclined to open up. In isolated plants a central gap may form in the canopy.

d **Degenerate phase** Gaps in the canopy increase as the older central frame-branches become moribund and die. Branches tend to collapse sideways, increasing the gaps, but any lateral branches that have rooted in the moist humus may remain alive for long periods. Eventually the whole plant may die.

These phases merge gradually one into another without sharp transitions. The rate at which the whole process takes place varies considerably according to habitat and geographical location, but to give a general indication the pioneer phase may last until plants are from two to six years of age, the building phase up to about 10 to 15 years of age and the mature phase up to 20 to 25 years of age, when the plants pass gradually into the degenerate phase and die back progressively from the central branches outwards. Note however that in Breckland in East Anglia some heather has been found to be entering the degenerate phase after only about 13 years. Heather in Breckland may therefore require management on a relatively short (6-10) year rotation.

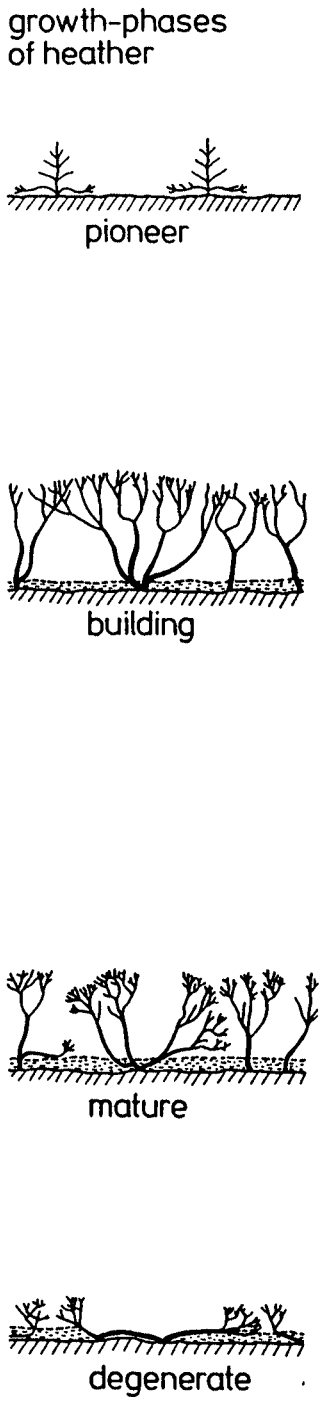

Figure 4.1 Diagram illustrating the four growth phases of heather (from Gimingham 1975)

It is because of this characteristic behaviour in its more typical habitats that heather, left to itself, is a successional plant. Within a period not usually much exceeding 20 years, gaps appear in the canopy of a heather stand and gradually enlarge until, on reaching an age of 30 to 40 years (or less when subject to some environmental stress), whole individual bushes die. The spaces left are seldom filled immediately by a new generation of heather plants, except in the moister habitats, where layering may occur. Instead, this is an opportunity for other species to establish. Sometimes these may be other plants of the heath community like bilberry, crowberry, bracken *Pteridium aquilinum* or grasses such as wavy hair-grass or common bent *Agrostis capillaris,* but (depending on seed sources) the gaps may provide a niche for the entry of shrubs such as gorse or trees such as birch, pine or oak.

Thus heather has all the features of a successional dominant. It is a relatively fast colonist of suitable habitats such as cleared woodland, but in the normal course of events it is inclined to give place to other species after a period of some 30 years or more. Heathland vegetation is inevitably potentially unstable and liable to change.

Traditional land uses and management

The continued existence of heathlands, sometimes over periods of hundreds or even thousands of years, can therefore be explained only in terms of their use and management by man.

Grazing The main reason why heaths have survived is because they provided useful grazing on relatively infertile acid soils. Being evergreen, heather offers useful forage throughout the year, especially in winter when other food is scarce. In much of western Europe winters are relatively mild, and in the course of time hardy breeds of sheep and cattle were developed that could be wintered outside on the heaths. Even when this was impossible, heather could be cut and brought in to feed the animals, as for example in parts of northern Scotland.

In Britain, a system common in the past was to graze dry heath by day and fold the sheep on fallow arable 'in-bye' fields at night. This had the effect of transferring nutrients from the heath to the arable land (cf. the 'plaggen' system, see below).

Cutting In the past, heather was often cut, when old and tall enough, for a variety of purposes. These included the provision of fodder and bedding for animals in sheds or byres, thatch for roofs or roof ridges and, when gathered into bales, foundation material for tracks or roads. Infusions of heather were also used for dyeing wool.

Both grazing and cutting helped to prevent the invasion of heaths by trees and to maintain relatively pure stands of heather.

Burning Normally, however, although grazing may prolong the building phase and delay the onset of maturity and degeneration, it cannot indefinitely prevent the heather from passing into the later stages of its series of growth phases. Where there was a demand for cut heather, stands were periodically rejuvenated by this cutting. Elsewhere, particularly in the moister and cooler north of England and Scotland, burning proved to be a practice well suited to the management of heather, so long as stands were burnt before they became too old. Well-controlled fires removed most of the above-ground parts of the bushes without becoming too hot, so leaving most of the moss and litter layers intact on the soil surface, protecting the

stem bases and permitting vegetative regeneration. Thus stands were rejuvenated and vigorous growth of new, edible shoots resulted.

Burning has probably been employed occasionally for this purpose for a long time over much of the western European heath region. In some places, especially northern Britain, it became an accepted and routine way of managing heaths for the benefit of sheep, cattle and, more recently, red grouse *Lagopus l. scoticus*. Shepherds and gamekeepers came to adopt a regular regime of burning strips or patches of heather on a rotation, of about once in every 10-12 years. In the warmer and drier habitats of the southern English heaths, burning was less appropriate for management, and there is little evidence that it was adopted as a regular practice on the lowland heaths. They have always, however, been subject to accidental fires.

Both grazing and burning may intervene in the life history of heather before the end of the building phase. They normally encourage rapid vegetative regeneration, thus virtually by-passing the pioneer phase and leading to reconstitution of a building-phase canopy within two to three years. On the other hand cut heather, to be useful, must be taken from older, taller stands; regeneration may then be limited to the slower process of seedling establishment. All three practices, however, have one feature in common: a proportion of the plant nutrients contained in the above-ground parts of the vegetation are removed from the system. This prevents nutrient accumulation, a trend which has recently been shown to lead to a decline in heather and its replacement by grasses or other plants.

Turf-cutting The practice of 'turbary', turf- or sod-cutting to provide domestic fuel, had a similar result, for it removed not only the above-ground plant parts but also the surface (organic) layer of the soil as well. It was for long periods a traditional form of land use in southern heathlands, for example in the New Forest (Hampshire), Dorset, the Lizard peninsula (Cornwall), Surrey and East Anglia. A special tool was used to lift the turves, and normally for every length of turf removed two were left in place, to allow the heath to recolonise the bare patches quickly and to resume the accumulation of organic material.

Turf-cutting was also practised in southern Scandinavia, where the material taken from the heath was used as a source of organic matter on arable fields. In the Netherlands and northern Germany a related type of land-use known as 'plaggen' evolved, probably during the 9th century AD, and survived until less than 100 years ago. Here, sheep were grazed on the heath during daytime, but were returned to a barn every night. The barn floor was lined with turves cut from an area of heath, complete with the heather which had been growing on them. These, after being well trampled down and mixed with urine and faeces, were used as fertiliser on the sandy fields around the village. Over the years this created raised, fertile, organic-rich soils (plaggen soils), and a steady flow of nutrients was maintained from the heath to the arable land. Heath plants gradually recolonised the exposed leached mineral surfaces from which sods had been removed. The process could be repeated on the same spot after a lapse of anything between about 25 and 100 years.

Cropping In some countries, for example Denmark, France and northern Spain, heathland was used on a temporary basis for agricultural crops such as buckwheat or rye. Again, this had the effect of depleting the system of nutrients. After two to four crops the fields were abandoned and allowed to revert to heath. This system was also followed in Breckland.

Effects of traditional management on the fauna

Whichever form of management was traditionally employed, it tended to maintain the dominance of heather. The effect on the fauna, both invertebrate and vertebrate, has inevitably been strongly selective. However, it has promoted the populations of those animals which either use heather as a food plant or find suitable niches in heathland ecosystems. Heather itself supports large populations of only relatively few phytophagous species. Heathland faunas also include characteristic predators, especially reptiles and birds (Chapter 2).

Management, whether by grazing, cutting, burning or turf-cutting, involves periodic 'perturbations' of the habitat. Although these may at the time have destructive local consequences for some components of the fauna, if properly controlled and over small areas the effects are only temporary. Cutting, burning and turf-cutting are normally applied to small patches on a fairly long rotation. Some animals are sufficiently mobile to escape from a small area, and each affected patch may be recolonised from surrounding intact stands. Management, especially burning, is normally limited to late autumn or early spring when animals are least active and some species are protected below the soil surface.

As far as the fauna is concerned, the most important feature of traditional management is that it maintained a mosaic of stands over the heathland, each at a different stage of recovery after treatment. Not only did this avoid any large-scale destruction of species populations, but it also created a diversity of habitats, ranging from bare ground and the relatively open conditions of early stages after treatment to the shade and shelter afforded by dense heather. In this way, both floristic and faunal diversity were maintained.

The need for management for conservation

All these traditional forms of land use interrupted the natural successional processes, which otherwise would have led to the replacement of heather by species ranging from grasses to shrubs and trees. As semi-natural communities, heathlands are inherently unstable and will inevitably tend towards some other type of vegetation if action is not taken to prevent this. Where conservation of heathlands is the objective it is therefore essential to manage. Management may take the form of continuing or reinstating traditional practices, or something like them, or making use of certain other options. The following chapters explore these possibilities.

Summary

1 In Britain only a few heath types are stable and 'natural': e.g. those on exposed coastal cliffs or above the tree limit on mountains.

2 Lowland (or mid-altitude) heaths were, generally, formerly forest covered: forest clearance has taken place over a long period from Neolithic times onwards.

3 Heaths, replacing forests on acidic soils, had important uses, mainly for grazing domestic animals. Use and management prevented reversion to woodland.

4 Heathlands are therefore semi-natural landscapes and are intrinsically dynamic. In the absence of management most heaths tend to scrub or woodland, or in some cases to acid grassland or bracken.

5 In typical habitats, in the absence of management, heather plants progress through a series of growth phases: pioneer, building, mature and degenerate.

6 Where gaps develop in a heather canopy these may be colonised by other species. Heather, left to itself, is a successional, not a 'climax', dominant.

7 Heaths have survived because they have been managed. Grazing can delay the onset of the mature and degenerate phases, but it is normally necessary to rejuvenate the stand periodically by cutting, burning or turf-cutting.

8 For the conservation of heathlands, management is therefore essential; otherwise the object of conservation will be lost in succession to other types. Conservation management may involve the reinstatement of traditional practices, or certain other options.

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5 OBJECTIVES AND METHODS OF HEATHLAND MANAGEMENT

The management of heathlands has never been a simple matter. A variety of management practices associated with different land uses have been employed in the past. The purpose of this chapter is to show how different objectives demand different approaches to management, and how a given management practice, which may be suitable under one set of objectives, may be inappropriate under another.

Attention will be directed first to the management of the drier heather-dominated heathlands, since a large proportion of the lowland heaths fall into this category. Wet heaths, grass heaths, lichen heaths etc. are, however, also important and will be considered at the end of the chapter. In heather dominated areas, the main objective of traditional management was generally to maintain as vigorous and dominant a stand of heather as possible, since it either represented a 'crop', or, by contributing its litter of dead foliage, short shoots, twigs and flowers, was responsible for the accumulation of useful organic matter. Management, especially in grazed systems, was thus often directed towards maximising the production of heather. Production and biomass in heather are at their peak in the building and mature phases, while the annual production of edible green shoots reaches its maximum in the building phase.

The aim of conservation management for lowland heathland is different. It is to conserve the heathland ecosystem as a whole incorporating the requirements of characteristic and rare species. This necessitates a diversity of heathland vegetation structures such as all four growth phases of heather and features such as firm (not churned up) bare ground.

Modern management options

Grazing, cutting and burning all remain as management options today. They will, if properly used, maintain heathland vegetation and its characteristic fauna in a relatively satisfactory condition. In addition, turf-cutting or rotovating may have a role in certain circumstances, while other management tools such as the use of herbicides may be necessary to solve particular problems.

1 **Cutting** can now be carried out quickly and effectively using one of the several different types of machine listed in Chapter 6, depending on the terrain and the nature of the stand. Where stands are in the building or early mature growth phases, heather plants will resprout from the stem bases after cutting, so long as they are not checked by a thick layer of cut material remaining *in situ*.

2 **Controlled burning** can be a useful tool for heathland management. Guidelines for good burning practice are set out in Chapter 7, and if these are strictly adhered to there may be little damage either to the habitat or to wildlife (though note that burning may damage the bryophyte component of wet heath). Its effects on heather plants are similar to those of cutting: if the stand is no more than about 15 years of age (or 6-10 years old in Breckland where heather is relatively short-lived), vigorous, uniform vegetative regeneration follows the fire. Older stands may also be rejuvenated by burning, though dependence on seedling establishment results in a longer pioneer phase in which the community is liable to invasion by competitor species. Care must therefore be taken if aggressive competitors such as bracken are present in the area. Burning is permitted only from late autumn to late winter, and it is important to make

adequate provision for fire control. Sufficient manpower is an essential requirement, but new machinery is also available for this purpose.

3 **Grazing** Sheep grazing is still widespread on upland heathland. This contrasts with the current situation on most lowland heaths where, although a common practice in the past, it has now largely been discontinued. To a lesser extent cattle and ponies are also grazed on heathlands. Grazing, if carefully controlled, is an important option for conservation managers. Grazing has the effect of removing a proportion of the current year's growth of young green shoots, at canopy level. So long as the proportion removed is not excessive, the heather plant responds by producing new growth from shoot apices and buds remaining below the level of grazing, and in this way the stand may be maintained in a relatively juvenile 'building' condition for at least some years. This can be achieved when grazing (or cutting) removes about 30%, or perhaps slightly more, of the annual growth increment, but at levels at or in excess of 40% the plants suffer and may eventually be killed. This indicates that where grazing is to be used for purposes of conservation management a moderate, on-off grazing management approach is required (further details are given in Chapter 8). Cattle may also be used in heathland management under some circumstances (notably the regeneration of heath that has been neglected and is tending towards grassland), but care is necessary because of the susceptibility of heather to heavy trampling. Similarly, where ponies or horses have traditionally been pastured on heathland, as was widespread on the southern heaths where each area had its own breed, careful continuation of this practice at a suitably low stocking rate to prevent the wholesale replacement of heathland by grassland may be appropriate for conservation purposes. In the New Forest, in particular, pony grazing is still important, and grass 'lawns' have been developed in the heath to improve the grazing. Work at Southampton University has shown how the social behaviour of the animals creates a characteristic vegetation pattern.

4 **Herbicides** Tests have been carried out on the use of herbicides in heather management, to kill off the aerial parts of the bushes and permit regeneration of the stand. While this can be successful, it is relatively expensive and may be subject to other objections, so it is likely to be useful only in very special circumstances when other methods are inappropriate. Herbicides, however, may offer the most appropriate solution to the problem of controlling unwanted, aggressive plant species, including bracken and some woody species (Chapter 9).

5 **Turf-cutting** Methods of management by turf-cutting (or 'turf-stripping') are also available, simulating to some extent the effects of turbary or 'plaggen'. These may be considered if it appears that an area of heath is giving place to another community, such as grassland, because of nutrient accumulation in the soil. Ploughing or rotovating may, however, lead to the re-establishment of heath vegetation in similar circumstances, but care has to be taken where a consequent release of nutrients may encourage competitor species.

6 **Management for particular species** Specialised management is sometimes necessary when high priority is to be given to the needs of species of special conservation interest or value. This is considered in Chapter 10.

Promoting heathland diversity

All these methods of heathland management have a similar outcome: the maintenance of a relatively uniform, even-aged stand of dominant heather in its most competitive and exclusive building phase. While this conserves the heathland as a system and a landscape, it does little or nothing to promote heterogeneity in stand structure or species diversity in the community. In sites being managed for nature conservation the latter is the prime objective. What is wanted is an uneven-aged stand with an interrupted canopy containing many gaps. This poses a management dilemma: on the one hand it is desirable to allow the heather, or at least some of it, to become mature and degenerate, permitting other species to co-exist; on the other this may reduce the capacity of heather to regenerate and may allow other species to take over. In small areas it may be sufficient to restrict management to the removal by hand of invaders such as trees and shrubs and to refrain altogether from managing the heather, which will then gradually become uneven-aged. Under these conditions, further changes in the community may be cyclical in nature, with the creation of a mosaic of different species, including heather at all stages of its growth sequence. It is likely that this will satisfy most conservation objectives, but although a tempting solution it may be difficult to achieve.

In most instances, especially on larger areas, management by one of the methods mentioned above will be essential if the heathland resource is to be conserved: without it heather may be lost as a result of successional processes.

Other types of heath

Grass heaths Certain types of grass heath, notably those of the Breckland in East Anglia, are of high conservation value. Management of these is also essential for their conservation, because where it is lacking they are subject to invasion by trees, bracken, or aggressive grasses such as tor-grass *Brachypodium pinnatum.* From the viewpoint of flora and fauna, an important feature of the grass-heath communities is the relatively high proportion of bare ground, offering regeneration niches for annuals and opportunities for the establishment of often rare species (both plant and animal) which may have special environmental requirements.

Of the management practices listed above, grazing is particularly appropriate for these grass heaths. In some instances they have been preserved over many years by rabbit grazing, and where possible the continuation of this is appropriate for conservation purposes. The problem here lies in coping with fluctuations in the rabbit populations, which may lead to periods of under- or over-grazing, each in different ways damaging to conservation interests. Unless rabbit grazing is effectively checking the growth of dominant grass species, it may be necessary to use controlled sheep grazing (Chapter 8), keeping a careful eye on its effect on the sward.

Wet Heaths Some wet heaths require relatively little management. In these instances, usually neither heather nor grasses become unacceptably dominant, while bracken is absent from soils of impeded drainage. However, many wet heaths need management to maintain a varied structure and species diversity, the vigorous growth of purple moor-grass, which outcompetes other plants of wet heath, being a common problem. Light grazing, preferably by cattle and/or horses, is probably the most efficient method of maintaining these heaths in the long term. Burning may be useful as a one-off treatment to clear rank growth prior to reintroducing

grazing, though damage to bryophytes can occur. There is also the danger that peat may burn, leading to its loss and the production of sterile areas. Where rushes (*Juncus* spp.) are a problem, goat grazing could be considered.

In wet heaths the open, muddy patches and the margins between these and the closed vegetation areas often provide a niche for more diverse communities. On some sites, particularly in the north, small-scale turf-cutting was a traditional practice that created open and wet conditions. In most areas this has ceased, but it remains a useful management option that adds to the diversity. It is of particular benefit for such species as marsh club-moss *Lycopodiella inundata* and sundews *Drosera* spp. *Sphagnum* lawns also colonise these wet depressions.

Except as mentioned above, fire should seldom be permitted on wet heaths. Rapid surface burns may not permanently damage *Sphagnum,* but short, hot burns will kill it and also damage the peat substrate. However, occasional fires may promote reproduction in the marsh gentian (see Chapter 10), so it is important to use the appropriate management for the particular interest of the site.

Lichen Heaths Lichen heaths occupy small areas on dry, sandy soils. Because of their scarcity and the relative richness of their lichen flora (including some rarities), combined with the annual flowering plants and other plants and insects of open sandy habitats, they should be protected wherever possible. Most forms of management discussed in this chapter should be avoided including all except very light sheep grazing, as lichens are particularly susceptible to trampling. It may be necessary to prevent tree invasion by hand pulling or cutting, while in some circumstances, if there is a tendency for the community to become closed, discing or shallow rotovating of small areas to disturb the surface and open it up for regeneration may be desirable.

Summary

1 Management of the drier heather-dominated heathlands is considered separately from that of grass heaths, wet heaths and lichen heaths.

2 The objectives of traditional heathland management are:

   a to maintain dominant stands of heather, preventing invasion by other plants, and

   b to keep most of the heather in a vigorous, productive condition, i.e. in the building phase.

3 Modern management options include the traditional practices of grazing, cutting and burning as well as others.

4 Cutting, now carried out mechanically, is an effective means of heather management. Vegetative regeneration takes place in much the same way as after burning.

5 Burning, if effectively controlled, may be a valuable management tool. Heather regenerates vegetatively after burning if the plants do not exceed about 15 years of age.

6 Grazing by sheep was in the past a common practice on lowland heaths, though now largely discontinued. It remains an important option for conservation management. Cattle and pony grazing are also appropriate in certain areas.

7 In special circumstances, the use of herbicides to kill the above-ground parts of a heather stand may be justified. It may also offer the best means of controlling certain undesirable plants like bracken, rhododendron etc.

8 Turf-cutting may have a role, especially where it is necessary rapidly to deplete an area of accumulated nutrients.

9 While traditional management was directed towards creating uniform, even-aged heather stands, uneven-aged stands with canopy gaps and greater diversity are desirable for conservation purposes. Modifications of traditional practices are therefore necessary.

10 Grass heaths, such as those of the Breckland, require management by grazing. Rabbit grazing may be adequate, but otherwise sheep grazing may be necessary.

11 Some wet heaths are relatively stable and require little or no management. In other cases light grazing (especially by cattle and/or horses) is often appropriate to maintain variety in community structure and species diversity. Burning should be employed only for special purposes and then sparingly. Local turf-stripping may be useful to open up habitats for species of the early stages of succession.

12 Lichen heaths require protection and freedom from all except very light sheep grazing.

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6 CUTTING AND MOWING

Heather and several of its associated species can be managed by cutting and mowing. In addition, control of scrub (including gorse) and bracken may involve cutting; the use of cutting and mowing machinery for these purposes is considered in Chapter 9. This chapter is concerned mainly with cutting as a method of managing heather-dominated heathlands.

Objectives

Provided the heather is not too old, vegetative regeneration will take place from undamaged buds below the level of the cut. Cutting is usually carried out with machinery which cannot operate on very rough, steep or bouldery ground or where tree stumps may create a problem.

Since cutting produces quantities of debris, managers are confronted with the problem of whether to remove this or leave it lying. Undoubtedly regeneration is inhibited by dense deposits of coarse material. Leaving heather debris in swathes (bands of dense brash alternating with cleared areas) is therefore undesirable, but lifting and removing it may be costly, unless a market for baled heather can be found. On the other hand, finely chopped material (such as that produced by a double-chop forage harvester) may be incorporated into the soil relatively quickly and have little adverse effect. However, in view of the need to reduce nutrient accumulation in heathlands, the debris is not usually left lying but is blown directly into a silage trailer for use elsewhere or removal.

Cutting is particularly useful for maintaining small areas of heather where a mosaic of patches of differing age is desired. It may also be the best way of trying to restore very old stands of heather, where burning could be unacceptably risky (in this case reliance is placed on regeneration from seed, as very old heather does not sprout from stem bases). Cutting or mowing is also a way of creating and maintaining protective firebreaks.

Effects on flora and fauna

Compared with burning, cutting causes less damage to animals and lower plants and permits the maintenance of greater overall species diversity. The taller shrubs and trees, together with any other perennials with renewal buds more than a few cm above ground, are adversely affected, though some (such as young birch and rhododendron) can sprout from the base after cutting. Effects on these plants depend upon the frequency of cutting. Plants with buds protected in or below the soil surface are capable of regeneration in the following growing season, while heather, if cut in February or early March, may grow again quickly and flower in the following August.

Cutting is not restricted by law to any particular time of year, and it is not as constrained by weather as burning. However, to minimise effects on the fauna, as well as the flora, it should normally be confined to the same period as burning, and the nesting season should always be avoided. The nesting season may begin in March if woodlarks are present (see Case Study no. 8) and extend until late August in the case of nightjars. The early part of the year (from January to March) is sometimes preferred to the autumn, particularly on sandy soils, because rapid regeneration during spring reduces the risk of surface erosion. It has been shown that heath plants damaged during spring and early summer generally recover during the growing season sufficiently to survive the following winter, whereas after damage in late summer or

autumn, winter survival is poorer. On the other hand, some managers have found autumn the better time for cutting because the ground is usually drier and less boggy, so tractor-drawn machines cause less damage than in spring. Cutting in October or November enables the collection of seed for use in the reconstruction of heath vegetation in nearby areas. Frosty periods are generally best avoided, except where humid heath is to be cut and the frost creates a firm ground surface for machinery, reducing damage.

Some types of machinery, notably the chain swipe, tend to tear the heather stems rather than cut them cleanly. In very dry weather this may cause loss of water from the damaged stems. It has been suggested that vegetative regeneration may be adversely affected, but it is not known to what extent. In general it is best not to use a swipe; a forage harvester is preferable.

Machinery

1 Cutting

There are several types of machine available for cutting, all of which are currently in use in heathland management. (Some details of makes, prices and, where possible, operating costs are given in Appendix 4.) In view of the cost it is important to choose the type most suited to the purpose it has to serve. The distinctive features of each are mentioned below to assist with this choice.

a **Pedestrian operated sickle bar (reciprocating) mowers** These are the smallest, least expensive machines, appropriate for cutting small strips or patches on relatively smooth terrain. The Allen scythe has been used successfully on a small scale and gives a clean cut, but does not deal effectively with old prostrate heather. Other reciprocating mowers (Appendix 4) mounted on two-wheel tractor units (preferably with double tyres) have also proved efficient. Although the cut swathe is narrow (bar widths are commonly just over 1 m but range from 0.6 - 2 m), these machines are easily manoeuvrable and in restricted areas may be as quick to use as tractor-mounted cutters. It is possible in some cases to fit a buck rake and small dozer blade.

b **Tractor-mounted machinery** The size of tractor depends on the type of cutter to be used, but if the ground is at all boggy a four-wheel drive tractor with double wheels is best.

i) **Tractor-mounted reciprocating cutter arms** are available, and may be useful in relatively uniform stands on easy terrain. However, although the cut is wider than in the pedestrian-operated version, manoeuvrability is sacrificed. For most purposes they may not be sufficiently robust and for general heather management the following types of machine, which are drawn behind the tractor, are usually preferred.

ii) **Forage harvesters** may be good for routine management, if a crop of cut heather is not required. A double-chop forage harvester

produces fine debris, which is usually delivered into a trailer and removed (though it can be spread over the cleared area or blown onto the surrounding heather, where it may be incorporated into the litter and humus, but this is open to the objections mentioned above). Forage harvesters can give a good clean cut, but reports suggest that heath vegetation is hard on this type of machine and that they are suitable only if the terrain is relatively smooth and free from rocks and other obstacles. If used with a trailer, tractors must be greater than 65 horsepower and manoeuvering may be difficult on uneven or sloping ground. Single-chop forage harvesters are also used and are preferable on stony ground, but unless the brash is removed it tends to fall in thick clumps which may suppress regeneration.

The double-chop forage harvester is the appropriate machine when finely-chopped material is required for a particular purpose, such as a supply of heather seed for heather land restoration. Cutting is then done in late October or November, with the cutting level set at 10-15 cm (4-6 in) so as to remove only the upper part of the heather canopy where the seed capsules are located. (However, it is often useful to have a proportion of stem and foliage in the mulch when spread, as this improves the micro-climate for seedling establishment.) This constitutes a relatively mild defoliation not dissimilar to the effects of grazing, and in addition to harvesting the seed this may be a useful way of managing a fairly young heather stand (Chapter 13).

Where more robust machinery is required for reliable heather management on rougher types of terrain, and in older, tougher, stands, the choice lies between swipes and flails.

iii) **Swipes** operate by the rapid horizontal rotation of (usually) two chains or blades, under a protective hood. These sever or tear the vegetation at a variable height above ground, and are suitable for cutting bracken or grass but are not ideal for heather or gorse. In most cases, a tractor of at least 60 hp is required, but the Huard mini-swipe, suitable for the lighter work (e.g. maintaining firebreaks), can be drawn by an 18 hp mini-tractor. Some managers prefer blades to chains, having had problems of breakage of the latter at the link with the rotor. Swipes are designed to ride up over irregularities in the ground surface but cannot cope with large stones, boulders or tree-stumps, and blades or chains may be damaged if there are many smaller stones. The width of swathe is up to about 1.5 - 1.8 m.

Wear and tear on these machines may be considerable, and annual repair bills have been quoted in the region of £250. However, blades are tough and break only if severely worn, but they are readily blunted on stony ground or by old, tough heather stems. Two passes may be necessary in old stands.

iv) **Flails** consist of a number of chains or blades attached in the vertical plane to a rotating drum. These tend to produce a cleaner cut than swipes. When the flail is used at fast tractor speeds the cut material may be suitable for gathering or baling, while slower speeds (essential in older heather), if coupled with high revs of the flail drum, result in a mulch of finer debris. While the heavy-duty flails require powerful tractors (60 hp or more), some flail cutters may be operated with, for example, 27 - 37 hp 2-wheel drive tractors and may be fitted with a vacuum device to suck up the brash. Again, some operators prefer blades to chains: blades seem to give a cleaner cut whereas chains have a tendency to rip and tear. The flail is mounted on skids or wheels, and on encountering an obstacle such as a tree trunk the blades (in some models) can be deflected through 360°, so avoiding damage. Flails can cut a swathe of about 2.2 m in width.

There are not yet sufficient data on which to evaluate these different types of equipment fully. Further testing under a range of conditions is necessary. A number of trials are currently in progress, but the response of the vegetation to cutting in different ways, and to different means of disposal of the brash, needs to be monitored over a number of years following treatment. Some managers have rejected the use of swipes because of the damage caused to the heather stems and consequent risk of desiccation. However, there may also be objections to cutting by flail because of the displeasing appearance of the debris left on the ground. Probably none of the methods is ideal in all respects. The choice of which to use must depend on the exact objectives of management, the nature of the terrain, the age of the heather stands and the plant and animal species present.

2 Coping with the debris

When cutting is done on a small scale, for example using an Allen scythe or other pedestrian-operated mower, the brash can often be raked up by hand. It is then not difficult to remove and can be disposed of off-site. However, on the larger scale an important decision concerns whether the debris is to remain on site or is to be removed. If it is to remain, account must be taken of the fact that coarse material (larger fragments of stems and branches) may settle into a 10 cm deep mat persisting for three or four years, which may inhibit regeneration. 'Rowing-up' of the cut material (e.g. using a Vicon 'Acrobat') at least restricts this to the rows. However, it is clearly preferable for the material to be finely chopped and spread widely.

If, on the other hand, the brash is to be removed, it can either be taken off in the form of finely-divided material blown into a trailer or as coarser material, which can lifted from the ground and baled. Rowing-up prior to lifting has been advocated but may not always be an advantage. A loader wagon (such as the Reco-Mengele LW 330) can be used to lift and compact the cut heather. (Some types are equipped with a capacity to re-chop the material to aid compaction.) This machinery works well on rough ground, but on gentler terrain and in dry conditions a hay/straw baler (e.g. International Harvester B47) can be used, though this will not cope with wet heather. Vacuum devices are also available for attachment to flails, to suck up the debris.

In deciding whether to leave or remove the debris after cutting, a further factor to be considered is the effect on the nutrient status of the system. Leaving the material *in situ* may lead to a gradual accumulation of plant nutrients in the soil, whereas removal represents a periodic depletion. Heathland vegetation, being adapted to soils of low nutrient status, may be sensitive to nutrient accumulation (Chapter 2). If there is evidence that this might lead to a shift in species balance, for example towards an increase of wavy hair-grass, purple moor grass, bracken or birch, there may be good reason to opt for removal, thereby imitating and continuing the effects of traditional management practices such as burning or grazing or the removal of cut heather.

Removal, however, involves expense, and the decision may rest not only on management considerations but also on whether there is a market for cut heather or somewhere where it can be stored.

Size and shape of patch

Cutting is a very flexible method of managing, and there is scope for much variation in the size of the patch, according to local conditions. As with burning (Chapter 7), there are compelling reasons for preferring small patches to large ones, but the exact size can be adjusted within quite wide limits. Whether blocks or strips are chosen depends on local conditions: blocks may be the best way of creating a mosaic, but strips (say 10-12 m wide) may offer the best opportunities for recolonisation by plants and animals dispersing in from the margins. Irregular outlines are often preferable to straight margins from a visual standpoint, as well as having biological and micro-climatological advantages, and it is generally best to cut with the contours and, if possible, at 90° to the normal line of view. On a small scale, very narrow meandering strips, no more than the width of a reciprocating cutter bar (about 1.2 m), may be less visually intrusive than linear ones. On a larger scale, however, this would be too laborious and difficult to fit into a regular rotation, so strips or blocks made up of several widths of a flail or swipe may be suggested (e.g. up to 15 or 20 m).

Uses of cut heather

In certain areas there are limited markets for cut heather, some of which seem to have potential for development. Brief mention is made below of known commercial uses of heather which might be worth exploring.

1 Roof thatching

This was a a major use of cut heather in heathland areas in the past but has largely died out. Recently, however, some cut heather has been exported from the New Forest to the continent for this purpose, and it is possible that there may be some continuing demand in the future.

2 Bio-filtration

Recently, cut heather has been sold in England or exported to the Netherlands and Germany for use in bio-filtration systems, which remove smells from the air emerging

from factory ventilation plants. Old, woody heather is required, because its role is to support a mass of damp, fibrous peat and keep it sufficiently open for the contaminated air to circulate through. Quite large quantities of heather are needed, but once installed a filter bed may last for up to five years. Generally the heather is baled for export or delivery, but in some cases loose material is accepted.

One drawback is the fact that the particular type of peat required for the filter beds (a waste product of the peat industry) seems to be unobtainable in Britain and is currently imported. In any case, conservation considerations would tend to discourage additional peat extraction.

3 Mulches

A mulching material can be produced from cut heather, using a brash chipper or double chop forage harvested material. Some interest in this has been shown, mainly by the horticultural industry, which is at present exploring available alternatives to peat. Limited quantities have been bought from the North York Moors for this purpose, but it is unclear as to whether it could become an economic possibility. Furthermore, a saleable mulch must be free of viable seed. Unless the material were heat-treated, cutting would have to avoid the months from September to January.

4 Foundations for roads and tracks

At least until recently, baled heather was sometimes used to provide a resilient foundation for roads and tracks, for example in Hampshire.

5 A seed source for heathland restoration

The uses of cut heather for this purpose are discussed in Chapter 13.

Creation of firebreaks by cutting

As explained in Chapter 7, firebreaks are of two main kinds: temporary and maintained.

1 Temporary firebreaks made to provide a stop-line for management fires

Because these will be manned when burning is in progress, the width need not be greater than 3-4 m so long as the vegetation is cut as close to the ground as possible. This can be done effectively using a swipe, flail cutter, brush cutter or other form of mower as appropriate. The debris must be lifted but can be spread within the area to be burnt and disposed of in the course of normal burning.

2 Maintained firebreaks

These are designed to protect the margins of heathland where it abuts on to forest or other vulnerable property, or to divide up an area of heath to prevent accidental fires from devastating the whole. These firebreaks also serve to provide a means of access for fire-fighting vehicles and equipment. Some managers prefer a semi-permanent

system in which the firebreak is cut first in one place and then, on subsequent occasions, on a slightly different line. Some protection is given by a strip of bare ground of 10-20 m in width. Such firebreaks, however, may be unsightly and costly to maintain; also on some soils they offer a poor surface for the vehicles that may need to use them for fire-fighting purposes. Many managers prefer a low vegetation cover. A degree of protection may be obtained by first cutting or clearing the above-ground heath vegetation and then, as the ground cover of heath plants regenerates, keeping it closely mown.

The initial clearance is sometimes done by back-burning (see Chapter 7), producing a slow-moving intense fire that completely consumes the above-ground vegetation and slows regeneration. Alternatively, a forage harvester may be used to create the firebreak, with off-site disposal of the debris. It must then be maintained by periodic mowing close to the surface (e.g. using a gang mower) at intervals sufficient to ensure that the regenerating plants adopt a low spreading habit, not exceeding 2-3 cm in height. This may mean mowing at least twice a year.

A two-stage method of creating firebreaks has been tried: this consists of first cutting two parallel narrow strips separated by about 5 m, so that the intervening heather can then be safely burnt. This is an efficient and economical way of setting up firebreaks of sufficient total width. It may also be useful to reduce the height of the heather along the edges of a firebreak, creating a 'stepped' effect, which makes control easier in the event of an accidental fire. One of the systems currently practised in Dorset uses 5-10 m wide firebreaks which have, in places, a rotovated sand strip down one edge (usually the northern one to provide south-facing habitats for invertebrates and reptiles), thereby increasing the efficiency of the firebreak.

Visual and other considerations may set limits on the width of firebreaks, but certainly no reliance should be placed on firebreaks of less than 5 m in width; at least double this should be the norm and even these may be readily crossed by fires. Where firebreaks meet roads it may be necessary to prevent the public driving cars onto them. This can be done by discing the margin or end of the firebreak.

There can never be total reliance on firebreaks. Firebreaks should be seen as an aid to firefighting and only one element in a fire control plan which has been agreed with the local fire brigade.

Summary

1 Heather stands can be effectively managed by periodic cutting. (Scrub control and bracken control may also involve cutting - see Chapter 9.)

2 Cutting is a useful alternative to burning where the latter is unacceptable; similar rules apply but there is more flexibility in respect of time of year and weather conditions.

3 Since cutting depends on machinery (in some cases heavy), it is not likely to be a viable option on very rough, stony or steep ground. Very old, tough heather may cause problems.

4 It is especially useful for maintaining small areas of heather where a mosaic of patches of different ages is desired.

5 The chief types of machinery available are:

a pedestrian-operated sickle bar (reciprocating) mowers

b tractor drawn machines:

i) tractor mounted reciprocating cutters
ii) forage harvesters
iii) swipes (chains or blades)
iv) flails (chains or blades).

6 Pedestrian-operated machines are the most manoeuvrable and suitable for small-scale work. Forage harvesters give a clean cut on smooth ground and on stands that are not too old; they are especially useful for obtaining a supply of floral debris containing seed, when the cutting level is held high. Flails and swipes cope with rougher ground and older heather. Swipes cause more damage to the heather stems than flails.

7 Coarse debris should not normally be left lying: it is slow to disappear and may inhibit regeneration. Finely-chopped material may be spread over the mown area or adjacent heather; it usually becomes incorporated into the surface litter and humus quite quickly.

8 If the debris is to be removed, it may be in the form of finely-divided material that can be blown on to a trailer, or coarser brash which can be lifted and baled.

9 There are limited markets for cut heather:

i) for thatch
ii) for use in bio-filtration plants
iii) for mulching material
iv) as a foundation for roads and tracks
v) as a seed source for heathland restoration.

10 Cutting may be employed to prepare temporary firebreaks, or (by frequent mowing at a low level) to maintain permanent firebreaks.

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7 CONTROLLED BURNING

In some parts of Britain, especially the north and the uplands, controlled burning has been the traditional way of managing heathlands, and in these areas it is still widely used to maintain heather stands. It has probably never been so widely used for management on the southern and lowland heaths, though many of these have been subject to quite frequent accidental fires.

Controlled burning is used successfully in a number of lowland heath reserves. If carefully controlled according to well-known principles of good practice, it will often prove to be a reliable and effective means of heathland management.

The main reasons for using fire to maintain heather stands are:

a heather usually regenerates rapidly after a well-controlled fire, so long as the stand was not too old before burning;

b burning is relatively cheap compared with other means of management (although the manpower requirements may be somewhat expensive);

c burning is easy to carry out whatever the nature of the terrain, for example in areas inaccessible to machinery.

Where the main objective is the maintenance of stands of heather, burning is a suitable tool for conservation purposes, so long as its effects on the composition of the flora and fauna are understood and accepted, and so long as the rules of good practice are strictly observed. It can therefore occupy an important place in the manager's 'armoury' of methods. The considerations that govern the choice as to which of these are to be used, and the circumstances in which burning is appropriate, are set out in Chapter 11: here the main purpose is to describe good burning practice and to warn against the bad. Fire is a tool that must be carefully handled and kept under control; otherwise it is capable of causing great damage not only to wildlife and its habitats but also to neighbouring property. Properly conducted, however, burning can be a very effective form of management which, despite the fears and objections sometimes expressed, can be used in a variety of situations.

Objectives

Burning should only be used where it fulfils certain clearly defined objectives. These may include:

a creating a mosaic of heathland vegetation structures of different ages by burning heather stands at varying intervals;

b preventing invasion of the heath by unwanted species such as trees and shrubs;

c securing rapid and uniform vegetative regeneration of the stand;

d removing old or diseased heather bushes to permit renewal of the vegetation primarily by means of seedling establishment. (In the dry climate of the south of England, however, seedling establishment is often slow and erratic.)

e creating firebreaks or a line which can be defended against accidental fires.

Burning management should not be used to create vast, uniform and monotonous expanses of even aged heather stands. Instead, by burning in small patches according to a well-prepared plan, varying the rotation in different areas and leaving some unburnt, a mosaic of patches of different age and stage in the growth sequence can be developed.

Effects on the flora and fauna

By strictly adhering to the legal period (see below) and restricting burning to late autumn or early spring, when plant growth is minimal and most animals are dormant either underground or in spots sheltered from the heat of a fire, adverse effects on the flora and fauna are reduced. However, it has to be recognised that regular 'perturbation' by fire has a strongly selective effect, depending on its frequency and intensity. Trees and tall shrubs are excluded by most regular burning regimes, which destroy their seedlings or saplings. This prevents succession in the direction of woodland, but also eliminates certain attractive species, including mosses and lichens and other plants such as juniper *Juniperus communis,* which might otherwise be represented in some of our more northern heathlands.

Burning restricts the heathland flora to plants that have renewal buds in positions that escape the full effects of fire. These include species with underground structures such as rhizomes or tubers, for example bilberry, bitter vetch or tormentil (and also bracken); those that are capable of resprouting from a stem base which may be partially protected by the surface humus, for example heather, bell heather and the three species of gorse; and those with renewal buds located at ground level and surrounded by layers of old leaf bases, such as grasses, sedges and certain rosette species like devil's-bit scabious *Succisa pratensis.*

Burning may also affect the fauna. However, many of the larger animals are mobile and, if burning is restricted to small patches, can readily escape. Danger to ground-nesting birds is avoided if burning is confined to late autumn or winter, as required by law. Some other vertebrates, if hibernating in burrows at the time of burning, may escape the effects of fire. The moss, litter and upper soil layers provide excellent insulation and the rise in temperature only a few centimetres below the surface during a well-managed fire is minimal. Controlled burning should also be exercised with caution where reptiles are present.

On the southern lowland heaths, burning (where practised) tends to be restricted to mature or degenerate stands, and because this results in the death of most of the stools, regeneration relies on seedling establishment and may be slow. This leaves open spaces which may encourage diversity both in flora and invertebrate fauna. Inevitably, however, burning management limits species diversity to some extent, but this is at least partially offset in the following ways.

a Management fires are limited in any one year to relatively small patches, representing only a small proportion of the total area.

b The interval between fires on any one patch may be between 12 and 15 years in upland heaths, or on southern lowland heaths often longer (e.g. 20-30 years), with the

exception of Breckland (e.g. 6-10 years), giving a reasonable period for the redevelopment of flora and fauna.

c There should always be parts of any heathland that escape burning, through being set aside to provide areas of old heather, and these will help in the maintenance of diversity.

It almost goes without saying that bad burning practice, which includes excessive frequency or intensity of fires, burning outside the legal period and burning unnecessarily large areas, may have very damaging consequences for wildlife.

Effects on the habitat

Controlled burning may serve the purpose of preventing or limiting nutrient accumulation in the system, which in the case of nitrogen and phosphorus may be a cause of successional change away from heath vegetation. In well managed fires, temperatures in the heather canopy should not normally exceed 600° C, and the maximum duration of temperatures over 400° C at any spot should be less than one minute.

Burning of wet heaths and bogs may result in significant drying out of the habitat. This depends on the frequency and intensity of fires, but is one reason why wet heaths should not be burnt unless there are good reasons for doing so (Chapter 5). (Where active management of wet heaths is necessary it may usually be achieved by grazing (Chapters 5 and 11) or by turf-cutting.)

Legal periods for burning

In England (apart from the uplands), heather burning is permitted only between 1 November and 31 March, while in Scotland the legal period runs from 1 October to 15 April, and this applies to some upland areas in England. When adverse weather has restricted burning programmes, Scottish legislation allows proprietors to give written consent to tenants for extension of this period to 30 April or, on land above 457 m (1,500 ft) above sea level, to 15 May. In certain years the Secretary of State for Scotland may give general consent for such extension.

Other legal provisions include requirements for tenants to give notice to proprietors of intention to burn, and for neighbouring proprietors of lands or woodlands to be informed in writing not less than 24 hours in advance of burning. It is an offence to start a heath fire between one hour after sunset and one hour before sunrise, and to neglect to take due care or provide sufficient staff and equipment to control the fire so as to avoid damage to woodlands, adjoining land, fences etc. Appendix 1 lists the statutory provisions that control heather burning.

Guidelines for good heather burning practice

A clear burning policy and a well constructed plan of operations are essential, and every effort must be made to adhere to them consistently. Naturally, they must be sufficiently flexible to allow some modification on account of special conditions (abnormal weather, for example),

but it is not good enough simply to put off the choice of areas to be burnt until the day on which it is to be done.

The development of a policy and plan depend upon a thorough knowledge of the area and the details of terrain, local climate, soil (including drainage patterns), vegetation, fauna, grazing animals and use by the public.

The burning policy This must be determined in the light of the over-all management objectives for the area. It should give clear guidance on the following.

a The precise area or parts of the reserve to be managed by burning.

b Those parts from which fire must be excluded (sensitive habitats, locations of species susceptible to damage by fire, areas set aside as 'controls' or for the purpose of allowing natural successional change to take place).

c The burning rotation (i.e. the frequency of fires on any one patch). This depends on the growth rate of heather in the locality and the usual rate of re-establishment of cover following fire.

Too frequent burning may be damaging to both the heather and its associated plant and animal species; on the other hand if the interval between fires on a stand exceeds about 15 years, the fuel load may have become too great, generating too hot a fire. The heather may then fail to regenerate effectively from the stem bases. Recovery then depends on seedling establishment, which is a slower process and may open up the area to invasion by unwanted species.

On the southern lowland heaths, burning is often on a long rotation (e.g. once in 20-30 years) to achieve occasional rejuvenation of the heather.

The burning rotation determines the proportion of the total area that should be burnt each year. For example, if the heather stands are to be burnt about 20 years after the last fire, then one twentieth of the planned area should be burnt each year, leaving areas of unburnt heathland to ensure habitat diversity.

d The preferred season for burning. The most popular period, if weather conditions permit, is February - March. However, it is very often the case that there are too few days of suitable weather in those months to complete the programme, and it is well worth being ready to do some burning in late autumn. Well managed fires in autumn result in at least as good, if not better, heather regeneration as in early spring, and do not seem to have any particular disadvantages.

e The optimal size of burnt patches. This is bound to be influenced by the nature of the terrain and the number staff and kind of equipment likely to be available to control the fires. However, there are many reasons for keeping them relatively small (say between 0.5 and 2 ha, or even as small as 0.25 ha on some southern heaths), including minimising damage to fauna and reducing loss of material from the surface during the post-fire bare phase. Small patches help to maintain diversity and are visually less

intrusive, which may be important in amenity areas. Also, recolonisation by species which depend on dispersal into the area from neighbouring populations is more effective if the patch is not too large.

f The preferred shape of burnt patches. So long as the patches are small this does not matter greatly and can be be varied to suit the terrain and the proximity of other vegetation such as scrub and woodland. In nature reserves some managers feel that scattered blocks are less obtrusive and disruptive than narrower strips, though the latter may be easier to control and may allow more rapid recolonisation from the margins (by invertebrates, small vertebrates and seed-dispersed plants), since distances from margins to the centre are less than in square blocks. Scattered patches also reduce erosion losses on slopes. Where visual amenity is particularly important, sinuous margins may be better than straight ones, and these are also better in conservation terms.

g Whether to burn with the wind or against it. Generally, in the moister heaths of central and northern Britain, burning with the wind, which should be no more than a light breeze, is recommended. The fire should move through the canopy at a speed that ensures that high temperatures last for little more than one minute, after which there is rapid cooling as the fire moves forward. On the drier southern heaths, backburning (i.e. burning against the wind) may be preferred. It is regarded as easier to control, as it produces a slower-moving, though hotter, fire. It is useful where rapid vegetative regeneration of heather is not a prime requirement, and regeneration can take place from seed germination. Backburning is also useful in the preparation of fire-breaks or where a very old heather stand is being burnt-off in preparation for regeneration by seedling establishment (but this should only be considered where invasion by unwanted species such as bracken is not a threat). Backburning may also sometimes be appropriate where the vegetation is difficult to burn in the normal way. Using this method, the heather litter on the soil surface is largely consumed, and this may be desirable in some instances where nutrient accumulation might be a problem.

The plan of operations The decisions on these aspects of burning policy should be set out in the form of a plan of operations. This will be part of the overall management plan for the area and should be accompanied by a map showing the areas to be managed by burning and the planned rotation. In addition the map should show the position of firebreaks and details of their maintenance. The plan should cover the following points:

a the planned number and locations of patches to be burnt in successive years, say for a four or five year period (this will require annual up-dating);

b the names and addresses of persons to be given notice of burning (e.g. adjacent proprietors, the local fire brigade), and the period of notice required;

c the sources of manpower and numbers needed to carry out and control the burning (the number varies according to the nature of the ground, the surrounding vegetation or other property and the availability of firebreaks, but to achieve an adequate safety margin no individual should be expected to control more than about 5 m of fire front or edge;

d the need to identify suitable roads, tracks or wet flushes to act as fire stops, or to prepare, in advance of the burning season, temporary firebreaks to set limits to each burnt patch;

e the equipment, which must be available and ready for use when required.

Equipment

1 To start the fires, paraffin burners (or similar) mounted on long handles or Calorgas blow torches may be used. With one or two of these the fire is started along one edge of the patch, at close-set points.

2 To control the fire (i.e. to control the margins as it advances and to extinguish it when the patch is covered), the traditional method has been to equip a number of people with beaters. These usually consist of a head of wire netting or a piece of rubber conveyor belting (or car tyre) attached to a 2 m pole, but an even more traditional tool is a birch broom made by wiring a cluster of birch branches to the end of the pole. Scrapers are also useful for smothering flames: their heads consist of a rectangle of two or more layers of wire netting or a perforated tin sheet on a frame welded at right angles to the end of the handle, which may be made from a piece of aluminium alloy tubing. Whichever type is preferred, there must be sufficient for all personnel in attendance at the fire to be equipped with one.

3 Further control, which can to some extent compensate for fewer people, can be achieved by provision of additional equipment. This ranges from knapsack sprayers and a supply of water or a fire-retarding chemical such as mono-ammonium sulphate or sodium alginate, to tractor-drawn water tanks equipped with motor-driven sprayers, such as that used at Arne Peninsula (RSPB), which consists of a wagon with water tank, pump and hoses (see Case Study no. 1 for details). Using this equipment, burning can be carried out safely with 2 - 4 men who operate the 'fire-engine' and act as beaters. Improved control may be obtained by mixing sodium alginate with the water, but then the equipment must be specially modified to cope with the 'sticky' water. This coats the vegetation with a layer of liquid which is slow to evaporate and hence inhibits the fire. Agitators are needed in the tank, and this adds to the expense.

A recent development in use on several reserves is the foam spreader, which has great potential for increasing the possibilities of using fire, even in small heath areas. With this equipment mounted on the back of a pick-up truck or on a trailer (see Appendix 2 for details), the patch to be burnt is surrounded in advance with a foam barrier, which creates an effective firebreak. Small patches can be burnt safely by a team of three or four people.

Tractor-drawn water sprayers and foam spreaders, although adding to the expense (Appendix 2), can increase the safety margin of burning and the ability to control or extinguish a fire if an emergency should arise. But they do not in any way change the guidelines for good burning practice or the need to judge weather conditions carefully. Their usefulness is also confined to areas accessible to the transport, whereas fires controlled by beaters are possible on much rougher terrain.

Annual revision of the burning plan

Each year's programme should be prepared well in advance by undertaking an annual revision of the burning plan, preferably in the autumn. This is important because in most years the number of days of suitable weather within the burning period are all too few (often less than 20) and it is essential to be ready to take advantage whenever conditions are right, otherwise the programme is liable to fall behind schedule. The year's programme should identify on the map the locations for each fire, using natural firebreaks where available and showing where temporary firebreaks must be prepared in advance. Requirements for personnel and equipment should be set out so that arrangements can be made in advance to ensure that they are ready for quick mobilisation during the burning period.

Choosing the day

a Condition of the vegetation

This is very important and depends on the weather over a period of days. The vegetation, especially the heather, must be neither too wet nor too dry. After periods of heavy rain, or shortly after snow-melt, the stand will be too wet to burn properly and the fire will fail to remove the bulk of the above-ground vegetation. On the other hand, a period of very fine weather will dry out the heather to the extent that to start a fire would be highly dangerous. There would be a risk of it getting out of control and igniting the surface humus, which could then continue to burn or smoulder long after the fire has passed, with considerable damage to the habitat. However, on the southern heaths where the humus layer is shallow, there is little risk of deep burning and conditions when the surface is dry may be chosen with the deliberate intention of consuming both the vegetation and the surface litter by means of backburning.

The correct moisture content of the heather for controlled burning is a matter of judgement and experience. The aim is to achieve a fire in which temperatures in the heather canopy do not much exceed 500° C. This will effectively consume most of the above-ground plant parts, leaving a few centimetres of stem sticking up from the surface. Under these conditions temperatures at the ground surface seldom reach more than 100-200° C, these values lasting for short periods only. The surface humus is unaffected and provides insulation for the buds at the base of the heather stems, which are capable of regeneration. An effective fire can be achieved after a few days of fine weather when the heather has a moderate water content while the moss and humus at ground level is quite moist.

b Weather on the day

For normal management purposes the fire should be hot enough to give a good clean burn, but not so hot as to prevent rapid vegetative regeneration. This requires a fine day with a steady light breeze, not exceeding Force 3 on the Beaufort scale (sufficient to move leaves and small twigs on trees, but not large branches - see Appendix 3). As far as possible changeable conditions should be avoided, and if the direction or speed of the wind does change during burning it is wise to stop and reassess the position.

After the fire: maintaining records

After the fire the burnt area should be recorded, with the date, on the map. However, to maintain an annual up-date of the burning plan, more detailed records may be indispensable. To assist with this a 'Heath Fire Recording Form' has been proposed by R Ninnes and is reproduced in Appendix 3, together with notes to assist in completing it. Its purpose is to record information about individual fires that will be useful on future occasions and in revising the burning plan, as well as serving as a basis for monitoring the results of management. (It is not intended to substitute for the 'Fire Report Form' (PPG 1/81, NCC Fires Handbook 1981), which is required following accidental or maliciously started fires on NNRs or SSSIs or involving NCC staff.)

Firebreaks

No fire should be started without a clear knowledge of where and how it is to be brought to a stop. Unless adequate 'natural' fire breaks (such as streams, wet hollows, a rock face or area of recently burnt or cleared vegetation) are present, fire breaks must be prepared in advance of the period selected for burning. They can be created in various ways, differing in the degree to which they contain fires. None can be completely effective in stopping an intense fire that has run out of control on a windy day, but the following types of firebreak have a vital role in keeping normal management fires safely within bounds.

a The most reliable firebreaks are strips of bare ground from which all vegetation has been removed, either mechanically (e.g. by rotovating or discing) or by means of backburning. These may give some protection against the spread of accidental, uncontrolled fires, but a considerable width is necessary (e.g. 10 to 12 m). However, where the firebreaks are part of the provision for controlled burning and will be manned by a sufficient number of beaters, the width can be reduced (5 m may be adequate, but 3 m is likely to be insufficient unless a fire tender is always present). To prevent redevelopment of vegetation within the firebreaks, annual cultivation may be necessary. However, such regular cultivation may be undesirable for invertebrates, some of which require firm bare ground rather than churned up sand. Sand lizards' eggs are also at risk from periodic cultivation. If sand lizards are present on a site least damage will be done if cultivation is restricted to a period from about 7 May to the end of the month (Chapter 10) although this period may vary with the weather in different years and so specialist advice should be sought.

   Strategically sited areas of recently burnt or young heather may be useful on big sites. They can play an important role in reducing the risks of a single very large fire.

b A common practice is to maintain semi-permanent firebreaks by periodic mowing of the vegetation to within a few centimetres above ground. While these may provide a useful stop line for adequately manned fires, they are inclined to give a false sense of security, for in dry weather an unsupervised fire may burn through close-cut vegetation and start up again on the far side. They do however provide micro-habitats for species of young heather such as the silver-studded blue butterfly.

c Temporary firebreaks can be created cheaply by swiping a swathe of about 3 - 4 m width around the area to be burnt and placing the heather debris inside the area. Provided weather conditions are carefully judged and there are sufficient beaters, a normal fire can easily be extinguished at such a boundary. These firebreaks are best prepared in January, if burning is to be carried out in February or March.

Dealing with old heather

Whilst a significant amount of old, woody heather is desirable for conservation, very large areas may present a problem because of their susceptibility to accidental wildfire and the difficulty of getting good regeneration. However, the burning of old heather should be carried out with care since the increased proportion of wood adds to the available fuel and hence to the likelihood of very intense fire, while at the same time the plants themselves may have lost most of their capacity to regenerate vegetatively. Recovery then depends on seedlings and may be slow.

Where possible the area should be divided-up with long narrow fires, very carefully controlled, and then the rest burnt in very small strips between these firebreaks. Wherever possible and particularly if there is a very severe fire hazard, it may help to remove some of the vegetation first with a forage harvester and then burn. However, where there is a special risk, either because of the proximity of woodland or buildings or because of the presence of 'weed' species such as bracken which might invade, burning should be forgone and management by cutting substituted (Chapter 6).

Should some heaths not be burnt?

In the drier parts of the extreme south of England (where many of our surviving lowland heaths are located) the view has been expressed that on some sites burning introduces unacceptable hazards, either because they are too small or because they are close to forests or buildings. This is a genuine concern, and in these areas other forms of management (especially grazing or cutting - see Chapters 6 and 8) are to be preferred. However, even here burning should not be entirely ruled out as a possible management tool, because as indicated above there are ways of ensuring safe burning even on small sites in dry climates. The important point is to achieve adequate management to maintain the heath, by whichever method is best suited to the local conditions. Special care should be taken in the habitats of smooth snake and sand lizard (Chapter 10) and in those of the Dartford warbler, and attention should be paid in these areas to the need to maintain a good proportion of old heather stands.

Wet heaths, lichen heaths and species-rich grass heaths are vulnerable to severe damage from poorly controlled or accidental fires. In some of these types, as indicated above, properly managed burning may be acceptable in exceptional circumstances as a one-off treatment, but in general other forms of management, especially grazing by sheep, horses or cattle, are to be preferred.

A view has been expressed that in some of the drier heathland areas of southern England accidental fires are frequent and additional heather management is therefore unnecessary. This, however, is an extremely dangerous policy, because accidental fires strike in a random and unplanned manner, leaving parts unaffected and free to become old and woody, creating

an ever-increasing risk of further fire. To the extent that fire protection measures are effective, they will also promote this trend. Accidental fires, being uncontrolled and most frequent in the summer months, burn fiercely and cause much damage to fauna, flora and the habitat. Hence, it is a much better policy to make every effort to prevent accidental fires, while at the same time managing the heather, perhaps by means of cutting or controlled burning at the proper time of year, so as to avoid an undue proportion of fire-prone older stands.

Dangers of the misuse of fire

Failure to judge the weather correctly or the condition of the heather may lead to an inefficient or dangerous fire. Badly executed burning may allow the entry of plants such as birch, bracken, wavy hair-grass, or purple moor-grass, any of which may become dominant and replace more desirable heathland vegetation types. If fire escapes from control it may threaten areas which should never be burnt, such as woodlands, scrub, rock faces, screes, ravines, wetlands and high-altitude habitats, with disastrous consequences for wildlife.

Summary

What to do and what not to do

Burning can be a valuable and effective means of managing a wide variety of heathlands, so long as the following principles are observed.

What to do

1 **Make sure you are thoroughly familiar with your area**: local climate, vegetation, soils, grazing use etc.

2 **Be clear about your burning policy**:

- a the precise areas to be managed by burning
- b the burning rotation (frequency of fires on each patch)
- c preferred size and shape of patches to be burnt
- d proportion of area and number of patches to be burnt each year, calculated from b and c
- e places needing special care, and parts from which fire must be excluded.

3 **Plan your programme each year**

- a Decide exact locations of patches to be burnt in the current year.

b Identify natural firebreaks and, where necessary, arrange for fire breaks to be prepared in advance.

c List and arrange for essential resources of manpower and equipment.

d Prepare list of persons to be notified before burning takes place, and length of notice required.

e Decide if all burning is to be in the period February - March, or if opportunities for burning in autumn are to be taken.

f Locate burning with an eye to future management.

g Identify areas requiring special attention, e.g. patches of old or neglected heather.

h During the burning season, be ready to use any opportunity of favourable weather.

i Decide if burning is to be with the wind, or if any areas are to be 'back-burnt'.

4 On the day

a Decide if weather conditions are suitable and stable - use weather forecasts.

b Start burning as early as possible.

c Make sure condition of vegetation is suitable - not too dry and not too wet.

d Restrict width of fire front to that which personnel can handle.

e If conditions change, stop and reassess.

What not to do

NEVER burn outside the legal period (England: 1 November - 31 March; Scotland: 1 October - 15 April, with extensions by special permission).

DO NOT

a burn any patch more often than necessary

b burn excessively large blocks

c burn indiscriminately

d burn late into the evening

e burn on too wide a front for available control

f leave preparations to the last moment

g allow the fire to escape out of control

h burn in high wind, or when vegetation is too dry.

NEVER burn without enough people to control the fires.

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8 GRAZING

In the past, the majority of British heathlands, both upland and lowland, were used for grazing. The grazing animal, supplemented as necessary by burning, played a large part in maintaining the heather in a dominant and productive condition. This still holds good over parts of the uplands, but in the lowlands, where much of the heathland has been converted to more productive farmland, grazing has generally been discontinued on the surviving areas. Where small patches of heath remain on farms they may still be used to graze sheep or cattle for part of the year, and on those that are 'commons' the commoners sometimes still exert their grazing rights. Many areas of heathland in southern England were subject in the past to grazing by ponies ('heath-croppers') or horses, and in some, such as those in the New Forest, at the Lizard and in South Wales, this practice still continues. Most grass heaths owe their continued existence to grazing.

Most lowland heath nature reserves, therefore, do not have a recent history of grazing. Whereas much is known about sheep (and cattle) farming on heather land in the uplands on a commercial scale, reliable guidelines for the use of grazing as a means of heather management on a small scale in the lowlands are generally lacking. The idea is attractive, since it represents a relatively 'natural' and traditional way of maintaining heathland, avoiding the dangers inherent in burning on small areas and the sense of artificiality associated with cutting. Hence there is currently considerable interest in extending the use of grazing, especially by sheep, for heathland reserve management, and several trials have taken place recently or are in progress or planned. Controlled grazing offers a feasible and sustainable means of heathland management, applicable in all parts of the country. It is also applicable to many grass heaths, in some of which the significant component of the more nutritious grasses makes it possible to sustain grazing for longer periods than on heather. In some grass heaths rabbit grazing is an important factor.

'Overgrazing' and 'undergrazing'

Before considering practical details, it is important to understand that heather responds favourably only within a relatively narrow range of grazing intensities. The balance between an acceptable level of grazing and 'undergrazing' on the one hand or 'overgrazing' on the other is very delicate and depends on such factors as local climate and soil, as well as on the species and breed of animal. Use of grazing as a management tool depends on getting this balance right.

For present purposes, the words 'undergrazing' and 'overgrazing' are used purely in relation to the maintenance of a vigorous heather stand. In this context, undergrazing fails to meet the objective of 'holding' the heather in the building phase and retarding its passage through to the mature and degenerate phases. The heather becomes increasingly woody and 'leggy', its value for grazing declines and the gaps that form in its canopy may lead to its replacement by other species. Unless supplemented by burning or cutting, such low-intensity grazing is unlikely to succeed as a means of heathland reserve management.

On the other hand, overgrazing causes damage to heather plants, leading ultimately to die-back. It is known to have been responsible for the conversion of heather stands to acid grasslands, dominated for example by wavy hair-grass, mat-grass or purple moor-grass, though this depends to a considerable extent on the season of grazing, its duration and whether it is continuous or intermittent. Even at levels insufficient to kill the heather directly, overgrazing

weakens its competitive ability, allowing a gradual increase in the grass species. It has certainly been responsible for loss of heather in the uplands, and the same may be true in some of the lowland heath areas.

Grazing for conservation management

To make use of grazing animals in heathland management for conservation and to achieve the appropriate grazing intensity, avoiding both under and overgrazing, it is necessary to decide first which herbivore is to be used.

For most purposes sheep are the more manageable grazers, and their effect on the heather is easier to judge and adjust than that of cattle, or of ponies or horses if these are pastured on heathland. All three of these animals require access to grassland as well as heather, unless they can be put onto grass or provided with supplementary feed at critical times of the year. Some breeds of sheep, however, are less demanding in this respect than cattle. Furthermore, the very much heavier cattle can cause damage to old heather by trampling, to which it is very susceptible, in addition to the direct effects of grazing. Hence in general sheep may be best suited to grazing dry heath. However, it has been found that cattle and ponies are extremely useful in controlling the growth of vigorous purple moor-grass on wet heath. Cattle can also be useful in bringing areas of old heather under control, as they are less selective than sheep and will browse the old heather as well as the grass growing amongst it. Depending on its age, some of the heather may regenerate vegetatively, but even if it is killed off the trampling will open up a grass turf and create sites for seedling establishment.

Both cattle and horses create a characteristic pattern in the vegetation due to their social behaviour, and this may be advantageous in maintaining species diversity; it does not apply to the same extent with sheep. In certain areas it may be appropriate to graze heathland with horses or ponies, especially where this has long been a traditional practice, as in the New Forest. Trials have also been conducted with goats on heathland, and it has long been recognised that rabbit grazing is an important factor on certain heather and grass heaths. Each of these grazers will be considered later in the chapter.

Sheep grazing on heathlands

Which breed of sheep?

It is essential to use a breed of sheep which is not too demanding in terms of nutrition and which can thrive with a high proportion of heather in its diet. In general the upland breeds, which have become adapted to these conditions, are best. For heathland management, the most frequently used are: Scottish blackface, Swaledale and Welsh mountain, but a number of other breeds are also suitable (for example Beulah Speckle Faced ewes are used in the Sandlings project, Suffolk). As an alternative, some of the rarer breeds have been tried with success, such as Hebridean, St. Kilda and Icelandic, all of which (like the upland breeds) are very hardy. Some advantages of using the latter breeds are that they arouse public interest, and assistance and advice on acquisition of stock and management can be obtained from the Rare Breeds Survival Trust. Primitive breeds such as Hebrideans are particularly valuable since they have fewer requirements in terms of foot treatments, licks, supplementary feeding and shearing.

What is an appropriate stocking rate?

This depends very much on local conditions and on whether grazing is to be continuous throughout the year, or confined to certain seasons or periods. It also depends on whether the sheep are to be given free access to the whole area, or whether grazing will be controlled by shepherding or fencing (e.g. movable electric fencing).

Local conditions which affect stocking rates include the productivity of heather and the proportion of grassland available to the sheep, if they graze a heath area throughout the year. If there is little grassland within the heath the sheep need to be taken off onto pasture at intervals, or provided with supplementary feed. (The latter tends to concentrate the sheep in the feeding area, which should therefore not be sited on important or sensitive parts of the heath.)

The effects of sheep grazing on heather differ according to time of year. In general, heather is rather more resistant to winter grazing than to grazing during the growing season and is especially liable to damage from heavy grazing in the autumn (September, October). Where there is a reasonable proportion of grassland in the area, it will provide most of the sheep's needs in summer, and the heather will be grazed mainly in winter. This allows a higher stocking rate than can be sustained where the availability of grass in summer is limited and the sheep are forced to take heather then as well as in winter. Usually, however, lowland heaths are grazed only from April to August rather than all the year round.

However, what is most important is the overall offtake of heather by the sheep. A level of offtake equivalent to about 40% of the annual green shoot production is usually damaging to heather, so in most cases it should not exceed about 30%. The following stocking rates for predominantly heather areas have been suggested as very general guidelines for levels that would satisfy this requirement, on the basis of grazing throughout the year, though, as pointed out above, this is seldom the case on lowland heaths.

	ewes per ha per year
Eastern Scotland	1.5 - 2
Western Scotland (wet heath)	1
North-west England	1
North-east England	1.5
West Wales	1
Welsh Borders, the Midlands and south Pennines	1.5
South Wales and south-west England	2

These figures (some of which relate to predominantly upland rather than exclusively lowland areas) take account of differences in the productivity of heather in different parts of the country, but they must be treated as only a very broad indication. Appropriate levels at a particular site also vary according to the nature and proportion of grass and other species in the heathland area and their relative palatability and digestibility, and to the recent management of the heather. Sheep tend to concentrate on young heather, and, if management

has failed to ensure a sufficient proportion of this, such patches as are available will be overgrazed. As a very general rule, it may be taken that where stocking rates are in excess of 2 ewes per ha per year the amount of heather will decline progressively. In Suffolk, for example, a stocking rate of about 2.5 ewes per ha for a period such as April to August, has been adopted, while tests in Dorset are comparing similar regimes with 1.5 and 3.5 sheep per ha.

If alternative reserve grazings are available, these can be used at times of the year when the nutritional requirements of the sheep are greatest (pregnancy, lactation) and when the heathland shows signs of overgrazing or the animals need additional forage.

If grazing is to be used effectively in heather management, a careful watch must be kept on the offtake of shoots by the animals, and as soon as this seems likely to exceed the 30-40% level they should be removed. Methods of assessing offtake are referred to in Chapter 12 (Monitoring). Monitoring should also consider other species of conservation interest (especially on SSSIs), as well as the effects of grazing on nutrient availability, especially phosphorus. Utilisation varies from stand to stand, according to the age of the heather and other factors, so each stand should be separately assessed. In time it becomes possible to make visual estimates of the proportion of shoots grazed with sufficient accuracy to differentiate between these categories: less than 1/3 grazed, 1/3 - 2/3 grazed, and over 2/3 grazed. This may be sufficient to alert the manager to any danger of exceeding an acceptable level of grazing and in this way to determine when sheep should be removed from an area of heath. However, more thorough monitoring (Chapter 12) should be carried out in the autumn each year, after growth has stopped, to keep a check on the management regime.

What arrangements have to be made?

1 **Watering** This can be provided by a tractor-drawn mobile bowser unless water is available on site. The bowser or trough should not be positioned in an area of value for conservation because of the damaging effects of poaching.

2 **Feed, veterinary treatment, inoculations and insurance** All must be provided for. In England it is a requirement to inform ADAS and the animal section of the local authority of the presence of a sheep flock, and a stock movement book must be kept. Stock treated with IVERMECTIN should not be grazed on conservation sites.

3 **Fencing** This can either be permanent, or temporary electric fencing. The latter is more flexible and, on reserves open to the public, may be more acceptable. (Permanent exclusion from large areas is often unpopular.) Estimated costs of various types of fencing are given in Appendix 5.

4 **Staff** Adequate staff must be available to look after the stock and see to shearing, dipping, foot treatment etc. (Some of these operations, e.g. shearing, can often be 'bought in'.) Daily inspection is essential and the health of the animals must be maintained. No conservation organisation can afford the bad publicity of unhealthy animals.

Conservation authorities may sometimes feel that they do not have the capacity, or funding, to make their own arrangements for the use of sheep as a means of managing heathland. For these reasons, the solution may be to arrange for grazing by licence or agreement with a neighbouring farmer, but such arrangements are often difficult to operate to mutual satisfaction. They do have the advantage that when a suitable offtake from the heather has been achieved, the sheep can be removed to the farm before the heather is overgrazed. It is important, however, to enter into a written agreement as there have been cases of loose, verbal agreements breaking down or proving unworkable.

Undoubtedly, ownership of a sheep flock gives the best control and, where practicable, is the best (and most cost-effective - see below) arrangement. It is essential that there should be someone with experience of sheep flock management either on the reserve management staff or employed by the conservation authority. He or she should have the assistance of additional staff, some of whom may be volunteers. (In the Suffolk Sandlings project, the sheep flock is successfully run by the project staff and volunteers.)

The financial aspects of running a sheep flock must be fully explored in advance. (A breakdown of some of the costs is given below.) Grants are available for conservation management of heathlands, and these help to cover costs, and sponsorship of all animals can sometimes be organised on a yearly basis. There is considerable public appeal and valuable publicity attached to the ownership of a sheep flock for purposes of heathland management.

Costs

Costs include the capital outlay for the flock, staff expenses, fencing, feed, veterinary expenses, provision of water, shearing expenses etc. Against these may be set the income from sales of sheep and wool. Because there are as yet few examples of the use of sheep grazing for heathland conservation (as distinct from sheep farming), there is little information on which to base comparisons with other methods of management. A cost-benefit analysis in Germany, reported in 1985, concluded that despite higher initial investments, after the first two years the management of an area of heath by keeping sheep proved to be less expensive than management by mechanical cutting. Over a five-year period there was a considerable saving.

The Suffolk Sandlings Project employs sheep grazing as its chief strategy for the management of a series of heathland reserves. The cost of a flock of 150 Beulah Speckle Faced ewes was £5,760 in 1989, and four rams (three Blue Faced Leicester, one Beulah) cost £1,081. The flock is run by the project staff and volunteers, who cover lambing, shearing, dipping, foot treatment and daily checking. Shearing and travelling expenses have to be met.

The heathlands are grazed at a low stocking rate (2.5 ewes and followers per ha, or one ewe per acre) between May and September, while alternative grazing (meadows and marshland) on Suffolk Wildlife Trust reserves is available from September. The flock is in-wintered from Christmas for lambing in February. A further cost is for fencing: 100 ha (250 acres) of heath are fenced in summer with three-strand electric fencing, which can be removed and reassembled elsewhere for winter grazing. The cost of this was £3,000, but a 50% grant was available.

The enterprise is cost-effective, as shown by the following summary:

Income	**£**
All animals sponsored on a yearly basis (£30 per ewe; £100 per ram)	5,600
Lamb sales	6,720
Wool sales	312
Ewe premium	900
Total	**13,432**
Expenditure	**£**
Feed, transport, veterinary and medical, insurance etc.	**4,985**
Budget surplus towards capital cost and salaries	**8,447**

(**Note**: Labour costs are omitted from the above budget because in this project they were covered by the Manpower Services Scheme. Their inclusion might make the outcome less attractive.)

General

The use of sheep in heathland reserve management has much to commend it, provided it has the enthusiastic support of the conservation body and its local staff. It is likely to be most acceptable in areas that are known to have been used for grazing in the not too distant past. Clearly, however, there are many aspects which need to be carefully considered before embarking on it. In addition to those mentioned above, the reaction of the public may be a significant factor. On the one hand, there is an opportunity to stimulate their interest in this type of management (especially, for example, where rare breeds of sheep are used), but on the other they may find the necessary fencing and possible exclusion from parts of the area objectionable. It would obviously be unwise to attempt grazing management on heaths that are much used for recreation and in particular where people are accustomed to walking dogs.

Cattle grazing on heathlands

There are examples of successful maintenance of heather-dominated heathlands by cattle grazing, but it is not easy to determine the right level of usage. Breeds such as Galloway or Highland are often favoured in heathland areas. In very general terms, the effects of one 'cattle beast' are regarded as equivalent to four or five ewes, but the much heavier cattle can damage old heather by trampling. For these reasons, cattle may be more useful over short periods, as a means of coping with old heather stands, than as a long-term method of heathland management for conservation. Fairly heavy cattle grazing for a year or two, followed by complete protection from grazing for three or four years, may be an effective way

of restoring an old heather stand. Experiments along these lines have been conducted in the Netherlands with considerable success.

It has also been shown in Denmark that where patchy heather occurs in a matrix of grass heath (e.g. bent-fescue), grazing by Galloway cattle may prove to be a satisfactory means of maintaining the existing balance of heather and grasses. (The uptake of heather in these trials was highly seasonal, being confined mainly to July and August.)

Cattle grazing has also proved beneficial where management of wet heath is found to be necessary, as for example at Presceli in South Wales. Cattle grazing is very effective in controlling competitive grasses such as purple moor-grass. While it is not always necessary to manage wet heath (Chapter 5), there are many instances where very vigorous purple moor-grass threatens to suppress scarce members of the flora of high conservation value. Cattle, or in some instances ponies or horses, grazing at a rate of about 0.5 - 1 cow (or pony) per ha per year, may be a suitable form of management, especially if the periods of actual grazing are variable in length and pressure is greater in winter than summer. However, all-year-round grazing by ponies, with in addition some cattle in summer, has also been shown to be sustainable. In Ashdown Forest, grazing throughout the year with Welsh black cows, accompanied in summer by sheep, has been effective in controlling invasive pine and birch, as well as checking the vigour of purple moor grass.

Ponies and horses

In the past on many lowland heaths pony grazing was a traditional use, leading to the development of local breeds ('heath-croppers'). In addition to pony grazing on wet heath, mentioned above, the practice survives in several areas such as Exmoor, the New Forest, and the Lizard peninsula where the heaths have long been managed in this way. In the New Forest, the commoners have exercised rights for rearing ponies, cattle and, to some extent, sheep and pigs (the latter only in the autumn for 'pannage', i.e. to eat acorns and mast) for up to a thousand years, under the control of the Verderers. This system has preserved the lowland heaths and damp valleys, preventing them from becoming colonised by trees and maintaining the nutrient-poor status of the soils. The social behaviour of the ponies has led to the development of a mosaic of lawns and grass patches in the heath.

Where pony grazing has helped to maintain the character of the heathland, it is clearly appropriate to continue this form of management, if possible. However, unless there is strict control of numbers of animals there is always a danger of overgrazing, which may leave only scattered old heather bushes, destined to die out, in a matrix of grass. This is the case in some places on the Lizard peninsula. On the other hand, grazing by horses helps to control rushes.

Goats

Goats can be grazed on vegetation that includes heather, and they will graze earlier in the season and more heavily than sheep. Hence they would have to be very carefully managed if used on heathland in conservation areas, but they have been proved useful in two particular situations: first, where invasion by trees and shrubs is a major problem, and second, where the growth of rushes is vigorous in wet heath or grassland. The dune heath and dune slacks at Tentsmuir, Fife, are an example of the former, where goat grazing has kept tree and bush

invasion in check, while experiments in the Southern Uplands of Scotland have shown that goats can effectively check the growth of rushes in a damp pasture.

Rabbits

Although rabbits hardly lend themselves to being used for heathland management, rabbit grazing is often a factor to be reckoned with. In some areas where they are very numerous, they may concentrate on young heather and keep it nibbled down to a low, dense sward. The choice of methods of managing heather in such cases may be constrained, and burning (which creates young, even stands particularly attractive to rabbits) may be best avoided. Very dense populations of rabbits may be responsible for killing off patches of heather. Conservation management then involves rabbit control.

However, in certain species-rich grass heaths (as in the Breckland), floristic diversity depends on a level of grazing sufficient to prevent aggressive grass species from spreading and to maintain a sward structure with small bare patches for the regeneration of ephemerals, annuals and other short-lived plants. In such cases rabbits may be a vital component of a conservation regime (see Case Study no. 10). If their populations decline, as they did following the initial outbreaks of myxomatosis, some substitute has to be found (possibly mowing, or introducing sheep grazing). The optimum level of rabbit grazing is difficult to determine and the balance between undergrazing and overgrazing (when bare areas expand and valuable species are damaged) is a delicate one. On occasions rabbits have been imported to sites where their population has fallen too low, or shot or gassed where it has risen too steeply.

Summary

1 Grazing is often an attractive option for heathland reserve management.

2 While grazing has been discontinued on most lowland heaths, many were grazed in former times by sheep, cattle or ponies. As a means of management, grazing is likely to be most acceptable in areas known to have been used for this purpose in the past.

3 Grazing intensity must be restricted to an offtake not exceeding 30-40% of the current growth increment of heather; otherwise the heather will progressively decline. The effects vary with season of grazing, being most severe in autumn and least in winter.

4 Which animal?

   a Sheep are the most manageable, and usually best for maintaining good quality heather stands. Primitive breeds such as Hebrideans are particularly recommended as they are very hardy and relatively undemanding.

   b Cattle can also be used, but are inclined to damage heather by trampling. They have been proved effective for restoring old stands, by grazing fairly intensively for short periods. Cattle may be very useful in controlling purple moor-grass on wet heath.

c Pony grazing is a traditional use of heathland in some areas. Where it has survived it is appropriate to continue the practice at levels compatible with maintenance of the vegetation.

5 All these herbivores, if grazing throughout the year on a heath area, need either access to grass (in addition to heather) or supplementary feed.

6 Where sheep are to be introduced for conservation management, decisions are required on: (i) breed, (ii) stocking rate, (iii) watering, (iv) feed, (v) fencing, (vi) veterinary provision, (vii) insurance, (viii) staff for lambing, shearing, dipping etc. and (ix) funding.

7 Two alternative approaches are available:

a grazing by licence (agreement with a neighbouring farmer), or

b ownership of the flock.

Where practicable (i.e. if supervisory staff, funding and pasture additional to heather are available), the latter may be the more controllable option. Where grants or sponsorship are available, it may also be cost-effective.

8 Rabbit grazing may be a factor to be reckoned with. It can be damaging where high populations are present in heather areas, but in species-rich grass heaths it (or some equivalent) may be essential to retain floristic diversity.

9 Stock treated with IVERMECTIN should not be grazed on conservation sites.

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9 CONTROL OF UNWANTED PLANTS AND ANIMALS

In previous chapters we have been concerned with methods of managing heathland vegetation on a relatively broad scale. Their purpose is to maintain a vegetation in which there is a substantial proportion of heather and other characteristic heath species. To the extent that they encourage the dominance of heather, they also reduce the opportunity for unwanted plant species to establish and spread. Hence the best way to control unwanted plants is to follow the guidelines for good heathland management.

However, as indicated in Chapter 2, there is almost always a tendency for successional changes to occur on heathland and, in the absence of continuing management, species characteristic of the later stages of succession (shrubs and trees) will invade. Alternatively, bracken may be the invader, or grasses such as wavy hair-grass or purple moor-grass, either of which may be unwanted if it becomes exclusively dominant. It is quite a common experience for a manager of a newly-acquired site to be confronted with a heathland that has been neglected for a number of years and has undergone successional changes.

In such situations species which are unwanted from the viewpoint of heathland conservation may already have established and may be spreading at the expense of the heath plants. Control of these plants may present problems, but unless they are tackled vigorously the conservation value of the site as an example of heathland may steadily decline. At the same time it should be borne in mind that scattered trees and shrubs or small copses are often an asset on heathland reserves and in some instances should be encouraged by positive management, as in the case of the conservation of certain rare animal species (e.g. gorse for the Dartford warbler - see Chapter 10 - or the rare moth *Pempelia genistella;* Scots pine for the pine hawk moth *Hyloicus pinastri).* However, apart from heaths on soils of very low nutrient status (in particular, low phosphorus adsorption maxima), the problem is generally that of controlling potential invasion by one or more species of trees or shrubs (notably pine *Pinus sylvestris,* birch *Betula* spp., gorse *Ulex europaeus* and rhododendron *Rhododendron ponticum),* or of preventing the spread of bracken or certain grasses.

Methods of reversing succession: control of tree and scrub invasion

Mechanical removal Invasion of heathland by scrub composed of mixed deciduous species or by trees such as birch or pine may create a problem for conservation management. In the short term, cutting (with hand implements or by machine - for details see Appendix 6) may clear the scrub, but this is labour-intensive and, where resprouting from stem bases takes place, may be a temporary solution only. Pulling by hand or grubbing-out with a tractor give better control but are expensive and cause soil disturbance. Where these options have to be rejected, the use of herbicides or a combination of mechanical and herbicide methods must be considered.

Application of herbicide to cut stumps The scrub is cut close to ground level and herbicide immediately applied to the stumps, usually with a paint brush. Notching or grooving the stump may aid retention of the herbicide. In comparative trials at Thursley Common National Nature Reserve, glyphosate applied in April-May was far more effective than ammonium sulphamate, triclopyr and fosamine ammonium as a birch stump treatment. Correctly applied glyphosate can achieve virtually a 100% rate of kill (see Case Study no. 8). The method can be used in winter and has the additional advantage of avoiding problems of spray drift.

Regrowth of birch stumps, if treated early in the growing season, is best done with a weedwiper using glyphosate.

Foliar spraying Approved herbicides for foliar spraying are glyphosate, fosamine ammonium applied in late summer (from August until just before leaf fall), or triclopyr. Glyphosate is systemic and only a small amount of chemical need be applied to a part of each plant to be effective. It is also considerably cheaper than fosamine ammonium per application and can be applied more quickly because it is systemic. Its drawback is that it is a broad spectrum herbicide so care is required when applying and the only method that can be recommended is a placed spray using either a selectokil drench gun or CP15 type knapsack with suitable nozzle, on plants between 0.5m and 2.5-3m high. On smaller plants 0-1m high use of a rope-wick applicator is recommended. The use of these methods has achieved high rates of kill of invasive broadleaved scrub species at Thursley Common National Nature Reserve (Case Study no. 8). In addition, with glyphosate there is a differential between the rate that kills birch and that which kills heather. Therefore, by applying early in the season (May-June) with the weakest possible application of glyphosate, one can achieve a high rate of kill with little damage to non-target species. Fosamine ammonium is very effective against certain species, e.g birch, though ineffective against others, e.g. willows *Salix* spp. However it is non-systemic, requiring application to all leaf parts of the plant to be effective, relatively expensive and causes damage to non-target species. Foliar spraying leaves dead plants, which may be unsightly, but it may open-up dense patches of scrub which can then be cleared more easily and permanently with a scrub cutter.

Cutting followed by foliar spraying of regrowth Sprouting is allowed to take place following cutting, and the young shoots are then sprayed (as above). For this to be practical, spraying must be done within two years of cutting.

Other methods These include basal bark herbicide applications (applying the herbicides ammonium sulphamate or triclopyr to the stem bases without cutting), frill girdling (applying glyphosate, triclopyr or ammonium sulphamate to notches cut in the bark), and 'weed wiping' using glyphosate applied by means of a rope-wick applicator. These have not yet been fully tested but may prove effective for particular purposes, e.g. the latter for control of scattered low shrubs.

(Details, including costs, of examples of spraying equipment are given in Appendix 6.)

Currently available products containing the herbicides mentioned above and in subsequent paragraphs include the following: Krenite (fosamine ammonium), Garlon (triclopyr), Amcide (ammonium sulphamate), Roundup (glyphosate) and Asulox (asulam). A further product, Broadshot (a mixture of dicamba, triclopyr and 2,4-D), is now available and may have applications in conservation areas. It is active against many scrub species but does not kill grasses and is approved for weed-wiper use.

There may be some reluctance to countenance the use of herbicides in nature reserves. However, all those mentioned usually have very low persistence in the environment and will in any case be used only in relatively small areas and on few occasions. Where they make possible the achievement of conservation aims and help to bring areas which would otherwise be lost to heathland into a management programme, the possibility of their use should not be

dismissed. If the proper choice of method and substance is made and care taken to avoid spray drifting, they can be used to achieve a specific objective with minimum damage to other components of the ecosystem. Reference should be made to publications listed in the Bibliography for further details.

Control methods applicable to particular tree and scrub species

Pine The best method of controlling pine is hand pulling of young trees. Where these are numerous, this is labour-intensive, but in many cases volunteers have given effective help. Older trees have to be cut. The logs can be sold for pulp, firewood, the rustic timber market or even commercial timber; the brash can be dealt with by chipping (see Appendix 6) and the chips sold for horticultural use. Where there is a continual supply of seed from mature pine trees in or close to a heathland, as for example where heath borders onto a pine plantation, the appearance of seedlings and saplings amongst the heather will pose an on-going problem. This will be most apparent in older heather stands where gaps in the canopy offer regeneration niches to the pine. It may therefore desirable in these conditions to manage the heather to keep it in its most vigorous and competitive phase (i.e. the building phase), though this may be difficult at the edge of a heath next to forestry. However, it must be added that for purposes of nature conservation areas of old heather are always needed (Chapter 11), and in such locations cutting or pulling will inevitably be part of normal management.

Birch Where soil nutrient levels are adequate and phosphorus adsorption maxima relatively high, birch presents more of a problem because of its high seed production and light, wind-blown seed, and because young trees sprout vigorously from the base after cutting (or burning). Cutting, without further treatment, achieves no more than a breathing space of up to six years before further management is required. To avoid this, stumps can be treated with a herbicide applied with a paintbrush. Glyphosate or triclopyr are recommended for this purpose. The safest foliar spray is fosamine ammonium.

Common gorse Small amounts of gorse in a heathland are acceptable - even valuable (see below and Chapter 10) - but it becomes an 'unwanted species' when it dominates large tracts or blocks. It then rapidly invades adjacent areas, particularly where disturbance has occurred (e.g. construction of tracks or paths, fires, trampling or overgrazing). Patches of gorse are readily cut or burnt, and if they have reached the degenerate phase (15 or more years of age) they may be killed. Cutting followed by stump treatment as for birch is probably the best means of control. Isolated bushes or small patches can be cut with a bow saw or chainsaw to ground level, preferably in winter; larger blocks may be cleared with a tractor-mounted swipe or scrub cutter (e.g. Junglebuster - see Appendix 6). Burning is a feasible alternative in situations where the fire can be properly contained.

Clearing blocks of gorse, however, leaves the problem of how to deal with the site they occupied, which is usually covered with a thick layer of gorse litter and enriched with nitrogen as a result of root nodule activity. A large number of gorse seeds remain in the soil and germinate over many years, making the plant very difficult to eradicate. While new gorse seedlings can establish, heather and most other heath species are inhibited and a common invader is bracken, which may rapidly become extensively dominant. If the objective is to return the site to heathland, the soil surface should be scarified or rotovated and the litter preferably lifted and removed by a bulldozer or turf stripper. Unless the topsoil contains a

substantial seed bank of heath species it may then be necessary to spread seed on the ground (Chapter 13). Whatever course of action is followed, the aim must be to bring the area into the heathland management system as quickly as possible; otherwise gorse will return.

Rhododendron This is not such a widespread problem on heaths as in woodlands, but in some areas (for example in Dorset, Staffordshire and parts of Wales), where rhododendron is abundant in neighbouring woodland, it can become a serious pest on adjacent heath into which it spreads its seeds. If it has gained a strong foothold, eradication is very labour-intensive and must therefore be tackled at an early stage. The bushes should be cut at about 10 cm above ground level. Small stumps can be winched out or dug up and subsequently burnt, but others must be poisoned. This involves drilling holes 1 cm in diameter in the cut stumps (generally using an electric drill run off a portable generator) to a depth of about 8-10 cm and filling these with a supersaturated solution of ammonium sulphamate (about 25 kg to 45 litres water). Even this gives only about 90% kill and must be followed up by weed-wiping or spraying any resprouts with glyphosate, preferably with the additive 'mixture B' to assist penetration of the waxy leaves. (Recent trials with triclopyr suggest even better results than with glyphosate. Stump treatment may also be effective.) Unfortunately rhododendron litter and leachates have a sterilising effect, and it may be a considerable time before a cleared area can be recolonised by heath species.

Control of bracken Bracken control presents a major problem on many lowland heaths. It seems to be less invasive on the Dorset heaths but is potentially a serious pest in most other parts of the country. If heather is dense and uniform, bracken has little opportunity to invade, but whenever the competitive vigour of the heather stand declines, bracken (if present) can extend into it, exploiting gaps in the canopy. In time the bracken may become dominant, completely shading out the heather. In areas where this is a danger, heather management must be planned with an eye on bracken control. One approach is to manage areas of heather that are prone to invasion to keep them in the building phase and prevent development through to the mature or degenerate phases, but on the other hand care must be taken to avoid disrupting the cover for any length of time. Burning, for example, may be inappropriate unless it is possible to be sure of very rapid vegetative regeneration. Where practicable, grazing may provide a means of keeping the heather in a juvenile state without creating gaps in the canopy or bare areas. The same effect can sometimes be achieved by mowing at fairly frequent intervals at a level a little below that of the canopy, so removing only a portion of the current year's growth. In these ways the heather stand may be kept sufficiently vigorous to exclude the bracken.

Prevention of bracken invasion by careful heather management is clearly the best (and cheapest) strategy, but where bracken has a foothold in a heather stand, or has become dominant in an important part of the heath, it may be necessary to eliminate or at least reduce it.

The traditional method is by cutting. This is still an option, although labour-intensive and inclined to be unsatisfactory except on a small scale. It may be done by hand with a scythe, or by using a strimmer, pedestrian-operated cutter bar or flail mower, or with a tractor-mounted swipe or forage harvester. Cutting once a year, in late July, gradually reduces the density of fronds to quite low levels over a 6-8 year period, but the treatment has to be maintained on a regular basis, otherwise the bracken recovers quickly. Cutting twice a year,

preferably in mid-June and late July (or even better three times a year, in June, July and August), achieves a more rapid and effective control. However, in one study 10 years of regular cutting twice a year did not completely eradicate it, and recovery took place when cutting stopped. Where bracken and heather are mixed, cutting at a height of 30-50 cm may be effective because it releases the heather from the shade of the bracken and gives it a chance to expand. Otherwise the fronds should be cut at just above ground level.

The most commonly used alternative to cutting is spraying with asulam (with an adjuvant such as 'Agral'). Although the degree of control is variable, this can be very effective if used at the right stage of development of the fronds (i.e. when the fronds are well developed but are not too lignified, often but not always in July). At this stage there has been maximum withdrawal of food reserve from the rhizome. Relatively small areas can be treated with a knapsack sprayer or Herbi. On larger areas that are accessible to heavy machinery, tractor spraying with a boom up to 6 m may be tried, taking in a few hectares at a time. The use of ultra low volume applicators such as the Micron Ulva is no longer recommended because of potential problems with spray drift affecting sensitive species. Aerial spraying should only be considered in exceptional circumstances where ground spraying is not possible and control is essential.

Again, control is never complete and the bracken will recover unless the treatment is followed up by respraying, usually two years later. Alternatively, spraying can be followed up with annual cutting of surviving fronds, but spot spraying may be more effective. Where the bracken infestation is very dense, or other constraints (including cost) operate, good control may be achieved by cutting twice a year for two years, followed by spraying the remaining regrowth in the third year. If bracken is inclined to invade after heather burning, it can be eliminated by annual spraying with asulam for up to three years without damaging the regenerating heather.

It is important to note that spraying asulam will damage ferns besides bracken. Where other ferns are present asulam should not be used. Instead bracken should be cut or pulled by hand.

Complete eradication of bracken is seldom, if ever, a practicable objective. Reasonable control can be achieved if treatment is accepted either as a continuing necessity or as an infrequent 'blitz' allowing for substantial recovery between treatments. Bracken control should be accompanied by positive measures to re-establish or improve the heath vegetation.

An alternative method of reclaiming bracken-infested heathland on ground that is relatively smooth and free from obstacles has been tried with success, for example on the Suffolk heaths. After cutting the standing bracken, or else in early winter when it has died back, first the area is disced and then the bracken mulch is skimmed from the surface to a depth of about 10 cm, using a specially adapted double-chop forage harvester. The material is blown into trucks alongside and sold for use as garden compost by the horticulture industry. Bracken rhizomes remaining on the site are either exposed or lie close to the new surface and may be killed by frost. The ground is then disced again and finally rolled with a Cambridge (ribbed) roller to produce a ridge and furrow micro-relief. If the intention is to re-establish heather, the area is then ready to receive a mulch of heather material harvested during the previous October, November or December (Chapter 13), containing abundant seed. This collects in the hollows and germinates there during the following spring and summer. At this time there will be some

new growth of bracken fronds from surviving rhizomes, which must be controlled by cutting or spraying. If the latter, care must be taken to use only sufficient spray to achieve control while avoiding damage to the young heather. It is also essential that health and safety rules and regulations are known and observed.

At Thursley Common National Nature Reserve (Case Study no. 8) bracken has been very effectively controlled by chisel ploughing using 18 inch tines. This is preceded by two cuts to pre-stress bracken rhizomes.

The heather beetle *Lochmaea suturalis* and other insect herbivores

In the context of heathland management for conservation, large scale attacks by the heather beetle can be a problem. The heather beetle feeds exclusively on heathers (predominantly *Calluna* but very occasionally *Erica* spp.), in both the larval and adult stages. In England outbreaks are generally patchy and localised, varying from year to year and spasmodic and unpredictable in occurrence. They are generally rarer in the lowlands than in the uplands, and in the south the larval populations appear to be controlled by an insect parasitoid. Outbreaks seem to follow a succession of moist springs and early summers, but there is no sure way to control or prevent them. They normally begin in mature or old stands in moist or wet areas, spreading to younger stands. Burning infested areas is often recommended, but this does nothing to prevent outbreaks and may have the effect of encouraging the dispersion of the beetles. The only way to reduce the risk of severe outbreaks is to follow the guidelines of good management, which minimise the extent of mature and degenerate stands of heather. There is some evidence from the Netherlands that outbreaks are more frequent and damaging where the nitrogen content of the heather foliage is higher than normal. Any management practices that bring about nutrient depletion of the ecosystem may therefore be advantageous in reducing the incidence of outbreaks.

In recent years large patches of heather defoliated by caterpillars of the winter moth *Operophtera brumata* have been noted, chiefly in northern localities, including Orkney. The conditions leading to these outbreaks are not understood, nor is it known whether the heather plants are completely killed or remain capable of resprouting in a subsequent year.

Grasses

Various grass species are normal components of heath communities. Where heather is vigorous and a stable balance exists between the ericoid shrubs and grasses, there is no problem. However, heathland managers are sometimes confronted with evidence that heather is in decline and its place is being taken by grass; or they may be faced with the task of restoring heathland on an area where it has been largely replaced by a dominant grass. The main species which may present this type of problem on acid soils are wavy hair-grass *Deschampsia flexuosa* on the drier land and purple moor-grass *Molinia caerulea* on peats and other wet soils.

As with bracken, prevention is better than cure, and where any of these species are present it is especially necessary to manage the heath as described in previous chapters, to keep the heather in a vigorous condition and to ensure rapid regeneration after treatment. Where one

or other has become completely dominant, the resulting acid grassland may prove to be stable over quite long periods, eliminating any possibility of natural reinvasion by heath species.

If a trend towards the replacement of heather by grass is identified before it has gone too far, it is important to determine the cause and take action to counter its effects. For example, on dry lowland heaths in central and eastern Britain, wavy hair-grass may become too abundant after poorly managed burning, or where heather has been allowed to get too old before burning or cutting, resulting in slow and patchy regeneration. There is also mounting evidence that aerial enrichment with nitrogen favours the spread of wavy hair-grass at the expense of heather, notably in localities such as the Breckland heaths. So long as some heather is present, however, any action to reduce the vigour and spread of the grass, such as sheep grazing in summer or mowing the grass patches, may give it the necessary opportunity to expand.

While the expansion of grasses at the expense of heather may often be due to a decline of grazing pressure, there are also instances in which heather has been replaced by grasses such as purple moor-grass because of overgrazing by sheep. In such cases, a reduction in grazing pressure may be sufficient to alter the balance in favour of heather. Over-burning of wet heaths is also sometimes a cause of increased dominance of purple moor-grass.

Even where one of the grasses has established a dominant sward, there are means of tackling the problem. In some cases there may be small amounts of suppressed heather surviving in the sward that can be encouraged by repeated mowing of the grass at a level which leaves the heather largely untouched. On the other hand, where heather has been completely eliminated by competition, there may still be a substantial soil seed bank of heather, bell-heather and some other heath species, whereas the prevalent grass species do not lay down a lasting seed bank. Hence, if tests show the presence of such a seed bank, any means of disrupting the grass turf and creating bare patches may be sufficient to allow the establishment of heather seedlings and create centres from which it may spread later. This may be done manually on small areas, by machinery, or by introducing very heavy grazing for short periods, preferably by cattle, whose weight and trampling are effective in breaking the turf.

As an extension of this approach, the whole turf and surface humus may be stripped mechanically and removed from the site. This may sometimes be the only sure way of rapidly curtailing grass dominance and opening up an area to re-establishment of heath species. Again it depends on the presence of a soil seed bank for heather and other heath species, unless seed is to be introduced from elsewhere (Chapter 13). While a proportion of this seed bank may be removed with the surface humus, it has been shown that seed is generally present in sufficient quantity down to about 10 cm (although about 90% of the viable heather seed is usually contained in the top 5 cm of the soil). Good germination can usually be obtained so long as the depth of stripping is kept to a minimum. This treatment is similar to the system of 'plaggen' formerly practised in The Netherlands and northern Germany (Chapter 4). Where accumulation of plant nutrients may have contributed to the increased grass competition, it has the added advantage of depleting the system of some of its nutrients. Were it not for the cost, this could be a reliable method of restoring heath vegetation where it has given place to wavy hair-grass, purple moor-grass or mat-grass. However, it should not be used where there are important populations of reptiles or soil-inhabiting invertebrates.

Heather seed germination may take place in the autumn, and this may give seedlings a greater chance to develop a root system and thus survive summer stress than germination in the spring. Reappearance from a seed bank or after spreading seed may take a year or more because seedlings are susceptible to both drought and waterlogging. Once the seedlings are established, protection from grazing may be necessary (since herbivores are attracted to young heather seedlings), but later on measures to reduce grass competition, as described above, may be needed and may include grazing.

Herbicides have also been used in an attempt to eliminate a dominant grass and open-up an area to germination of heather seed. It has been shown, for example, that Dalapon kills purple moor-grass efficiently, though its rate of recovery has not yet been documented. Mat-grass, on the other hand, recovers fully from the effects of Dalapon within one season.

General

This chapter shows that methods are available to control most of the 'unwanted species' that are likely to cause problems on heathland, though at a cost in terms of money and labour. Where late successional developments are to be reversed, it is essential to follow control measures with effective restoration of heath vegetation. Some of the appropriate techniques have been mentioned above in connection with the follow-up to control of particular invasive species, but the subject is dealt with more fully in Chapter 13. As a general principle, prevention is better than cure, and the aim should always be to prevent the spread of invasive species by following the guidelines given in this handbook for good heathland management. Any action to achieve restoration of heathland following the removal of competitor species should lead as quickly as possible to the resumption of regular management of the heather.

Summary

1 **Trees and shrubs** Where pine, birch or mixed scrub have invaded heathland and caused problems for conservation, the following control methods are available:

- i) hand pulling
- ii) winching-out by tractor
- iii) grubbing-out by tractor
- iv) cutting by hand
- v) cutting by machine
- vi) use of herbicides:
  - a foliar spraying (may be followed by cutting and removing dead plants)
  - b cutting followed by spraying of regrowth
  - c application of herbicide to cut stumps
  - d basal bark herbicide application, frill girdling, 'weed wiping'.

The choice of method depends on circumstances, cost, availability of labour etc. (Table 9.1; Figure 9.1).

2 **Gorse *Ulex europaeus*** Older gorse (over *ca.* 15 years) may be killed by burning. For younger stands the above methods are applicable. If the objective is a return of

heathland vegetation, it may be necessary to remove accumulated gorse litter and apply seed of heath plants.

3 **Rhododendron** Older rhododendron bushes must be cut near ground level and 1 cm diameter holes drilled in the stumps to a depth of about 10 cm for application of ammonium sulphamate solution. Regrowth may be controlled by painting the stumps or spraying resprouts with glyphosate or triclopyr.

4 **Bracken** Cutting twice or three times in the year, or application of the herbicide asulam (in July), may effectively reduce frond density but must be followed up in subsequent years. A combination of cutting, e.g. twice a year for two years, with spraying regrowth in the third year may be effective. Re-establishment of heath vegetation after cutting bracken may require lifting the bracken litter, rolling, and applying heather seed.

5 **Heather beetle** Good heather management, especially where accompanied by depletion of the nutrient fund in the ecosystem, seems to be the only way of reducing the severity of heather beetle attack.

6 **Grasses** Dominant stands of species such as wavy hair-grass, purple moor-grass and mat-grass may be tackled in one of the following ways:

i) if some heather is present in the sward, repeate mowing may allow it to spread;
ii) if there is a heather seed bank in the soil, disruption of the turf either mechanically or by a period of heavy grazing may permit germination;
iii) use of herbicides (e.g. Dalapon on purple moor-grass);
iv) turf stripping. (Unless there is a seed bank of heather, this may have to be followed by application of seed.)

7 **General** Where control measures are employed to reverse late successional changes on former heathland, appropriate action must be taken to restore the heath and bring it back into regular management.

Table 9.1 Potential problems associated with different scrub control techniques (from Marrs & Lowday 1982)

	High cost	Demand on labour	Regeneration of target species	Spray drift	Effect on non-target species	Unsightly dead plants
Grubbing out	✓				?	
Cutting	✓	✓	✓			
Foliar spraying of suitable herbicide	?			?	?	✓
Foliar spraying followed by cutting in the following year	?	✓		?	?	
Cutting followed by stump treatment		✓				
Cutting followed by foliar spraying of regenerating stump	?	✓		?	?	
Basal bark	?	?		?	?	✓
Frill girdling	?	?				✓

Key
✓ - probable problem
? - possible problem under certain circumstances

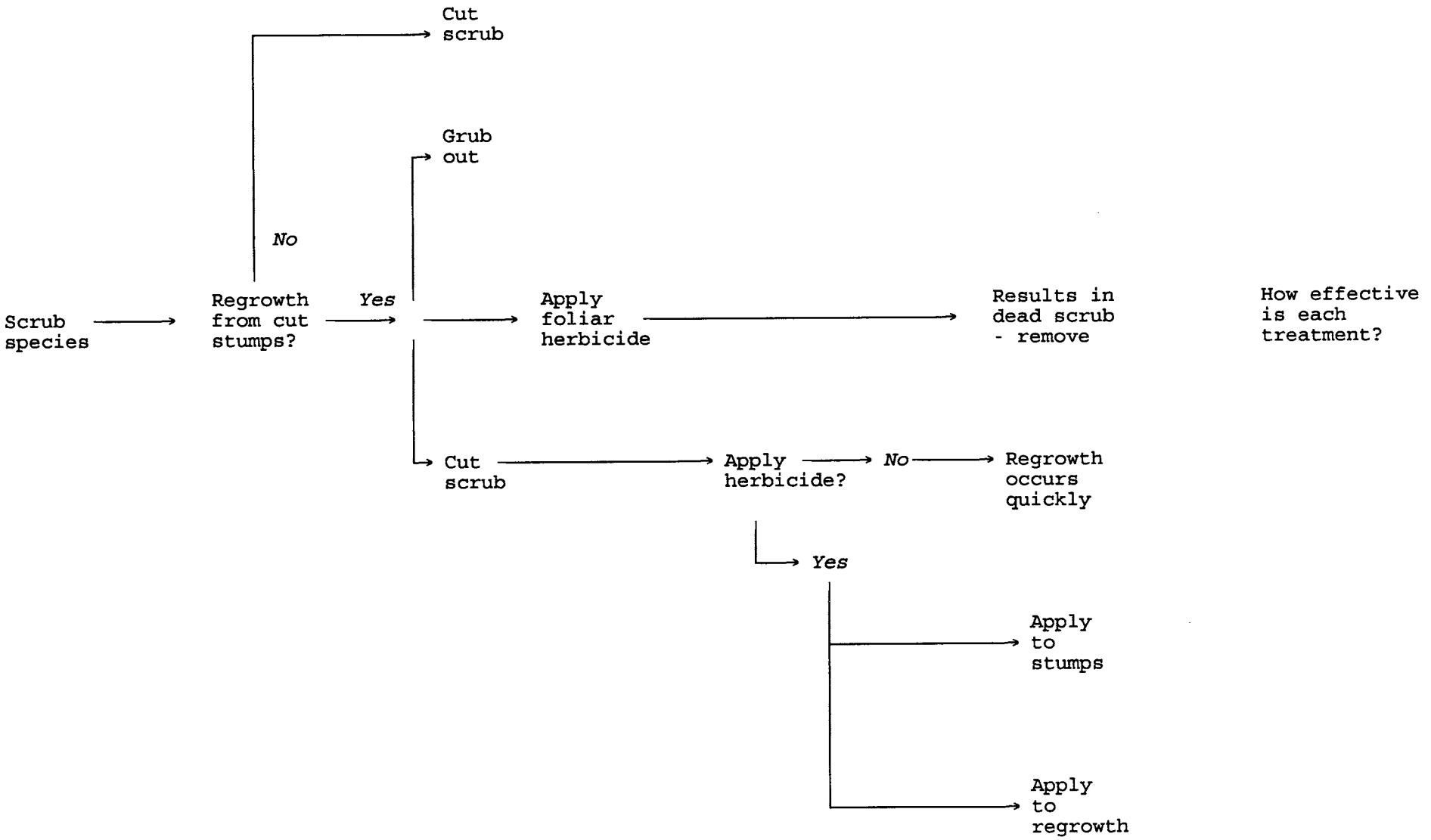

Figure 9.1 Management options for scrub control (from Marrs 1982)

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10 REQUIREMENTS FOR PARTICULAR ANIMALS AND PLANTS

Because much of the rest of the handbook concerns vegetation management, this chapter emphasises management for selected animal species but concludes with a short section devoted to particular plants.

The aims of management of lowland heaths for wildlife are largely met by managing the system as a unified whole. This allows as much diversity as is compatible with maintaining its general character as heathland and providing habitats for a wide range of species of plants and animals typical of the heath types represented. This may be sufficient for the survival of populations of some of the heathland specialities or rarities. On the other hand, in view of the fragmentation and overall loss of habitats, there may be good reason for taking special measures to secure the future or promote the increase of species which may be under threat of local extinction or are of special interest for other reasons. Such measures may require adjustment of the general management prescriptions for the area: they may for instance require forgoing burning or some other forms of management, or creating open patches devoid of vegetation.

Where the chief reason for acquiring or designating a small reserve was the protection of certain special plants or animals, there should be no problem in directing management towards their particular requirements, but where they represent a part of a larger complex of wildlife interests careful consideration must be given to the extent to which their special needs are to be accommodated. It may be decided that normal management will offer them sufficient scope, or that a part of the area can be devoted to special management. What is essential is a clear understanding of the habitat requirements of such species and how to provide them. It is unfortunately not possible in a handbook of this kind to cover the management requirements for all the different animals and plants that may be of special interest in lowland heath reserves. Instead, this chapter outlines the management appropriate for a selection of species that may be of special importance in various types of heath: in each case other publications can be consulted for further details.

Reptiles

Smooth snake (*Coronella austriaca*) and sand lizard (*Lacerta agilis*) There are six species of reptile native in Britain. Although occupying a variety of different habitat types, all six occur to a greater or lesser extent on lowland heaths. The conservation of heathland is therefore of great importance for British reptiles in general. Here, attention will be concentrated on the two rarer species, the smooth snake *Coronella austriaca* and the sand lizard *Lacerta agilis* (both Schedule 5 species in the Wildlife and Countryside Act 1981). These are of special concern in some of the lowland heaths of southern England because of their rarity (there may be less than 2,000 smooth snakes and about 5,000 sand lizards) and because they are largely confined to heathland. Their requirements are broadly similar: both species are particularly associated with mature, dry heath. They need fairly dense vegetation cover, but heterogeneity is essential. Open patches of bare ground or low vegetation are favoured for basking, and, in the case of the sand lizard, bare sandy soil is required for egg laying. Topographical variation, including features such as hillocks, track sides and tumuli, is preferred by reptiles, as it creates south facing slopes. Sand lizards may establish quite large colonies in such sites. A good ground vegetation (e.g. of lichen) or heather litter also seems important. The home ranges of these reptiles are not generally large (typically between a few hundred to 2,000 m^2 for sand lizards and about 1 ha for smooth snakes); these ranges

tend to be smaller in optimal habitats. Smooth snakes and juvenile sand lizards may range the most.

Management Large-scale management of heathland that aims to promote the regeneration of heather before it reaches the older, mature, phase is not well suited to the reptile species. In particular, careless burning can be damaging in that it removes both heather and ground vegetation. Accidental or malicious fires in summer are a severe threat to animals. Although individuals may survive in pockets little affected by the fire or on the margins of a burnt area, they are slow to recolonise unless regeneration of the vegetation cover is very rapid (as is sometimes the case where gorse is abundant). The best populations are found in areas that have been unburnt for at least 20 years. Similarly, grazing and cutting of heather both tend to reduce the amount of old heather. Grazing, if used, should be only at low intensity and should generally avoid areas with high reptile densities; this will help to reduce the impact of trampling.

For these species, management should maximise the amount of mature heather; this may mean taking special measures to control invading species such as trees. However, since mature heather is often more fragile than younger stands, trampling needs to be kept to a minimum, and access to the heathland for purposes of tree clearance must be strictly controlled. Annual 'pine pulls' should not be permitted; intervals of at least three years (and preferably five years) should be left between such management events.

If suitable bare sandy patches are few or lacking, it may be necessary to create some. It has been suggested that, for sand lizard conservation, they should occupy 2-5% of the total area. Scattered cleared patches of 1-2 m have been tried, with wider patches being provided on level ground than on slopes, to avoid shading by heather. However, these patches will become covered in vegetation and will need managing every three to five years to keep them open. Another approach advocated by some is to create long, sandy strips, 2-3 m wide. These are associated with fire control measures (see below) and are made using a Hi-mac, either with bucket (removing the material or dumping it to one side) or with an angled blade, which turns the spoil to one (the northern) side. These tracks will offer an expanse of open sand for egg-laying, and their banked-up sides, once they have developed vegetation, provide ideal features for basking and tunnelling. However, there are objections to this procedure, which creates unsightly scars (especially in the short term), is damaging to the heath vegetation locally, may assist invasion by non-heathland species and, unless sensitively positioned, could allow access by horse riders and motor cyclists.

Fire protection, especially of key features, is important, and the creation and maintenance of fire-breaks (Chapters 6 and 7) is one solution. On smaller sites, or those that are inaccessible, 'passive' breaks may be useful for containing fire, particularly side- and back-burns. These firebreaks may consist of bare sand or have bare sand at their edges and consequently may also serve as sand lizard breeding areas. Creating a fire-break wide enough to contain a fire front is likely to be impracticable, but bare ground of 1-2 m width, especially if next to a mown fire-break, may prevent side- or back-burns creeping to adjacent heather. However, bare sand or banked-up sides can cause access problems for fire control vehicles. The relative merits of 'passive' breaks and the question of access for fire-fighting need to be addressed on a site-by-site basis. Where fire-breaks are maintained by rotovations or bull-dozing, these activities should be confined to late April - May, to avoid excavating either hibernating

animals (prior to April) or sand lizard eggs (June - September); mown fire-breaks may be improved by providing a rotovated strip 1-1.5 m wide alongside, to serve both for fire control and to provide an open, sandy habitat.

Although such management is usually targeted at only small areas of heathland, there may be conflict between management aimed at improving the habitat for certain species of special concern and management directed towards conserving the system as a whole. Decisions must be based on a knowledge of the reptile populations in the area to be managed and the extent to which their habitat requirements are met without special management. It is then necessary to establish clear priorities for management, which will determine whether or not management for the benefit of the reptiles takes precedence in all or part of the area (see Chapter 11).

Amphibians

Natterjack toad *Bufo calamita* There are now very few heathland populations of the natterjack toad, a rare species formerly associated with wet heath habitats in southern England as well as with certain coastal dune systems. Unlike the common toad, the natterjack burrows and so needs a sandy habitat. The reasons for its decline on heathland are not fully understood, but contributory factors may include habitat loss and fragmentation, together with acidification of breeding ponds. Recent studies have clarified many aspects of the habitat requirements of natterjack toads, and, despite the fact that it has almost disappeared as a heathland species, brief mention of them is made here so that any opportunity for its conservation in the heathland part of its range may be taken.

For breeding purposes, shallow (maximum winter depth 1 m) unshaded pools are required, and their pH must be in the region of 6-7, certainly never less than 5. (If the pH falls below 6, liming may be necessary if continued use is to be secured.) Occasional drying-out in the late summer or autumn, to keep the pools clear of predatory fish, beetles and dragonfly larvae, may be advantageous, and the removal of common toads may be necessary as the natterjack tadpoles are poor competitors. With regard to the terrestrial habitat, open areas are especially important (i.e. 75% bare substrate with vegetation on the remaining area less than 5 cm high). Natterjacks require open ground on which to forage. Where ground vegetation becomes too dense or overgrown, the ability of natterjacks to find food is decreased and the habitat becomes more suitable for common toads. Mossy ground with low vegetation tends to be preferred, and for this reason any invading trees should be removed from areas frequented by natterjack toads, and areas of heather may need managing, by cutting or burning in winter.

Birds

Dartford warbler *Sylvia undata* In Britain this species is entirely confined to the lowland heaths of southern England, mainly those in Dorset and the Hampshire and Thames basins. Its numbers have fluctuated considerably since 1960, ranging from over 600 pairs down to as few as 11 after a severe winter. The preferred habitat is gorse in association with (touching) mature heather. The birds generally nest in old heather (or dense gorse), while the gorse provides abundant invertebrate food and shelter (especially important during periods of snowfall).

Management In the interests of conserving the Dartford warbler, management should seek to maintain a fair proportion of gorse in the heathland. Again, this may be contrary to management objectives in other heath areas, where gorse may be an invasive species which needs to be controlled. Gorse of between six and 12 years of age (about 1-1.5 m tall) is best, since beyond this age the canopy opens out and the bushes become straggly, providing less food and shelter. A suitable aim is to 'recycle' gorse patches at about 15 year intervals, generally by cutting. Resprouting soon produces a good bushy canopy, preferred by the birds. A similar result can be obtained by a mosaic of small fires, but burning in dense gorse can be hazardous. However, where gorse is present in areas scheduled for burning, this will serve to rejuvenate it, provided that it is less than about 15 years old.

In some areas it may be desirable to increase the amount of gorse by planting. If rabbits or hares are plentiful their nibbling may kill the young plants and they should be excluded with rabbit netting for about three years until seedlings or resprouts are well developed (see Case Study no. 1).

Young pines which have regenerated naturally amidst the heather may be allowed to grow until their branches break through the heather canopy, after which they are cut back.

Nightjar *Caprimulgus europaeus* The breeding population of nightjars in Britain has been steadily declining over a period of 50 years and is now largely restricted to heathy areas in Dorset, the New Forest, Surrey, Sussex and East Anglia. This species is also characteristic of woodland edge habitats, especially young plantations and replants or restocks less than about 10 years old, nesting on the ground, often near the base of small trees.

Management While nightjars use both heathland and young plantations (less than 10 years old) for feeding, fairly large areas containing some bare ground are required for nesting.

Populations have been successfully increased in Suffolk by creating glades in heathy woodlands and increasing the length of woodland/heath boundaries ('resculpturing'). Trees at these margins may be thinned and coppiced to create a scattering of small bushy trees. Clearing of heather from small patches of about 1 m^2, some of them near the base of these small trees, helps to provide suitable nest sites. Creating a habitat in this way costs about £2-6,000 per breeding pair (100-300 worker days, 1989 prices).

Since the reduction in nightjar populations may have been partly due to loss of habitat to conifer plantation, progressive felling and restocking may lead to some improvement, because young conifer restocks offer suitable habitat. However, as with the red-backed shrike the decline may also be due to climatic factors.

Woodlark *Lullula arborea* The woodlark is found on lowland heaths and has declined in the last 30 years both in numbers and distribution. At present it is largely confined to lowland heaths in Devon, Cornwall, Dorset, Hampshire, Surrey, Breckland and the Suffolk Sandlings. Numbers fluctuate considerably from year to year, for reasons that are not well understood. The population fluctuations sometimes seem to relate to the occurrence of cold winters, but this is not always the case. What is certain, however, is that the future of the species is now dependent on the maintenance of a good range of heathland habitats in the south of England. Like the nightjar, transitions between woodland and heath are favoured.

Woodlarks forage by walking on bare or sparsely vegetated ground, picking arthropods from the surface of the soil or low vegetation. Feeding areas typically consist of short (<5 cm) grass, moss or lichen with bare ground. In ideal habitats, 1.5-2 ha are sufficient for a territory, but in more heterogeneous areas at least 3 ha are needed. In addition, patches of taller vegetation (e.g. grass tussocks, heather bushes) are required for sheltered nest sites and isolated young trees for perches.

Management In the past, grazing may have helped to maintain suitable feeding habitats in heathland, but now that this has often been discontinued its place may be taken by mowing, forage harvesting or burning to produce areas of low vegetation. Soil disturbance techniques may be useful, and where appropriate the encouragement of large rabbit populations may benefit woodlarks (e.g. in the Breckland heaths).

Stone curlew *Burhinus oedicnemus* Although primarily a species of dry grassland and arable fields in some areas, the stone curlew breeds on some of the Breckland heaths where dry, open conditions with short vegetation provide suitable sites. Management may be directed to creating or maintaining this type of habitat (see Case Study no. 10).

Hobby *Falco subbuteo* Although characteristic of farmland, the hobby is traditionally associated with England's lowland heath. The key management requirement is to maintain traditional nest sites in mature pines.

Wintering raptors and short-eared owl *Asio flammeus* England's lowland heaths provide important winter roosts for raptors such as the hen harrier *Circus cyaneus*, merlin *Falco columbarius* and short-eared owl. It is therefore vital to maintain areas of mature heather where roosts are known to occur.

Invertebrates

Heathlands, especially where there is a good variety of habitat types including a mosaic of age-classes of heather, scrub and firm (not churned up) bare ground, generally support large numbers of invertebrates belonging to many different species, despite the low diversity directly associated with Ericaceae. Heaths therefore constitute a very important invertebrate habitat in Britain. Southern heathlands are particularly rich in species, of which a number are rare or at the edge of their European ranges. While a large proportion are not heathland specialists, many are regularly associated with the heathland vegetation and environment.

As an indication of the extensive invertebrate fauna characteristic of heathland and the niches occupied, a few examples are selected for mention. **Spiders** (Araneae) are well represented, with 47% of the British species found on the southern heaths. These include pioneer species appearing soon after a fire, others whose populations peak about 5-10 years after burning, and a further set belonging mainly to the mature and later stages of heather cover. These include both ground dwelling species and web spinners (the nursery webs of *Pisaura mirabilis* are common in July and August). Among the **ants** (Formicidae), several species are common on heathland, for example *Lasius niger, Myrmica scabrinodis* and *M. ruginodis* on the wetter heaths, *Formica fusca* on drier areas with a well developed litter layer, and *Tetramorium caespitum* and *Lasius alienus* on the dry heaths. Their habitat requirements are bare ground or short heather and 'hot spots' such as flat stones or pieces of wood for cover and nesting.

Several species of **grasshopper** (Orthoptera) occur regularly on heathlands. The three most common are all grass feeders. A rare species confined to heathland is the heath grasshopper *Chorthippus vagans*, which occurs only on heaths in the New Forest and Dorset. The large marsh grasshopper *Stethophyma grossum* is nowadays virtually restricted to quaking bogs in heathland. There are also several **bush crickets**, of which the bog bush cricket *Metrioptera brachyptera* is common in both wet and dry *Calluna* heath, while the rare long-winged cone-head *Conocephalus discolor* is found in Dorset and the New Forest. **Bugs** (Hemiptera) are very abundant on heathlands, some feeding only on heather but many on other plants. They include various Heteroptera, froghoppers (Cicadellidae) and jumping plant-lice (Psyllidae), of which *Strophingia ericae* is very common on heather while *S. cinerea* is restricted to bell-heather in south-west Britain.

Of the **butterflies and moths** (Lepidoptera), three butterflies are typical of heathland: the grayling *Hipparchia semele*, the green hairstreak *Callophrys rubi* and the silver-studded blue *Plebejus argus*. There are numerous heathland moths, of which several species feed on heather. These include the true-lovers' knot *Lycophotia porphyrea*, the emperor moth *Saturnia pavonia*, the fox moth *Macrothylacia rubi* and the northern eggar *Lasiocampa callunae quercus*, the latter belonging mainly to the more northern and upland heaths and moors. These are all conspicuous species, but Microlepidoptera are also abundant. **Beetles** (Coleoptera) are well represented. Many are ground dwellers, such as the green tiger beetle *Cicindela campestris*, which along with other species is widespread on hot, dry, sandy heaths. Several weevils are associated with heather and *Erica* species, such as the heather weevil *Micrelus ericae*. Among other beetles that use heath plants for food (mainly Chrysomelidae), the most important is the heather beetle *Lochmaea suturalis*, both the larvae and adults of which feed on heather shoots (Chapter 9).

Bees and wasps (Hymenoptera) are often abundant on heaths. Those of warm, dry, sandy locations provide suitable habitats for the digger wasps (Spheciidae) and some of the bees that also make burrows. Bees in the genera *Andrena* and *Lasioglossum* are frequent visitors to heather flowers, as are bumble bees, such as the heath bumble bee *Bombus jonellus*. These are important pollinating agents, as are **thrips** (Thysanoptera), which are often present in the flowers of heather in very large numbers, belonging mainly to three species, *Ceratothrips ericae, Aelothrips ericae* and *Frankinella intonsa*.

Various microhabitats that are usually present in heathland are very important for invertebrates. Bare sandy ground has already been mentioned and attracts, for example, tiger beetles, ground beetles (Carabidae), digger wasps (Sphecidae), wolf spiders (Lycosidae) and butterflies such as the grayling, while many **flies** (Diptera) use hot, sandy areas for sunbathing. Patches of scrub and bracken and the communities of the margins of heath all add to the diversity of invertebrate species, though on the smaller sites the invasion of scrub and bracken may pose a threat to the true heathland species.

Other important habitats for insects include grass tussocks, wet heath and pools. Many species of **dragonflies** and **damselflies** (Odonata) breed in acid pools on lowland heaths. Eight species are almost confined to heathland; of these, several (such as the white faced darter *Leucorrhinia dubia* and the small red damsel fly *Ceriagrion tenellum*) belong to pools containing *Sphagnum*, while the southern damselfly *Ceriagrion mercuriale* breeds in flushes

where water tends to be richer than in the surrounding bog areas. The keeled skimmer *Orthetrum coerulescens* is also confined to boggy pools and seepages.

The soil fauna of heathlands is limited, owing to the generally high acidity. However, **mites** (Acari) and **springtails** (Collembola) are abundant, though less so than in many richer soils. Only one species of **earthworm,** *Bimastos eiseni,* is common. **Pot-worms** (Enchytraeidae) may be abundant in the wetter heathland soils.

Management The management guidelines for lowland heaths (Chapter 11), especially in so far as they emphasise the maintenance of habitat diversity, are appropriate for many invertebrate species. The provision of firm (not churned up) bare ground and the heath/scrub ecotone are also important for invertebrates.

Those for which heather is the chief or only food plant will benefit from good heather management. Some favour pioneer or early building heather, such as the silver-studded blue butterfly, which is now virtually confined to North Wales and southern England. Surviving populations occur on heathland, where the presence of exposed soils create particularly warm microclimates and where one or both of the ant species *Lasius niger* and *L. alienus* is present. The larvae will feed on a variety of plants, but only on the young growing tips of their shoots. Because of the abundance of bare ground pioneer heather is especially favoured, particularly on south-facing slopes in North Wales. In the warmer south of England the species will breed in both pioneer and building-phase heather, and on slopes of all aspects, and even in fairly open humid heath. The presence of the ants, which also require warm habitats, is essential for the survival of the silver-studded blue. They tend both the larvae and the pupae of the butterfly and have been seen to escort the young adults to the surface.

Management demands continual availability of young stands of heather. Burning, cutting or grazing of small patches on a short rotation is essential, and each patch should be adjacent to previously managed areas. Where the proportion of young heather is high in a site, large populations of the butterfly can develop.

The grayling butterfly and the mottled grasshopper *Myrmeleotellix maculatus* are also examples of species characteristic of heather stands in the very early phases of the growth sequence. On the other hand, two of the large moth species that are typical of heaths throughout the country, the emperor moth and the fox moth, require older heather. Therefore, except where one particular species demands priority treatment (such as, in places, the silver-studded blue), the standard practice of managing to produce a mixture of heather stands of different phases will normally promote the greatest diversity of insects. Any of the accepted methods, including grazing, cutting and burning, can be used. Burning, however, should be carried out with care and in limited patches only as it may cause the extinction of localised invertebrate populations. Grazing, so long as stocking rates are kept low, is however probably the best option for managing heathland for the benefit of invertebrates. In general what is needed is variety in both composition and structure of the vegetation, including areas of bare and sparsely vegetated ground where species of the early stages of succession are present. Plants such as ragwort and thistles on disturbed areas of ground are valuable nectar sources for invertebrates, although ragwort should be controlled on areas that are cattle grazed.