13 Grassland management for species

13.1 The management of lowland wet grassland for birds

This section only provides an introduction to the subject.
For further detailed information the reader is referred to Treweek *et al* (1997).

13.1.1 Introduction

Lowland wet grassland is managed grassland situated below 200m in altitude which may be subject to periodic flooding (Buisson & Williams 1991). It includes flood plain grasslands, man-made washlands, coastal grazing marsh as well as isolated areas of poorly drained grassland (O'Brien & Smith 1992). However, it does not include salt-marsh.

Sympathetically managed lowland wet grassland is now a scarce and precious resource. There are estimated to be about 1.2 million ha of potential lowland wet grassland in England, Wales and Scotland (Newson 1991) but according to a survey (Smith 1983) only 7 per cent of the proportion of this potential area falling within England and Wales supports any breeding waders at all.

It has been estimated that 80 per cent of lowland wet grassland in Essex has been lost since 1930 and 50 per cent of the North Kent Marshes (Ekins 1990). The primary threats to lowland wet grassland are: agricultural intensification, land drainage and inappropriate management of existing drainage or flood defence infrastructure.

Threats of lesser importance to lowland wet grassland but which can have significant effects upon those few and smaller sites where they occur are: groundwater abstraction, pollution of groundwater and surface water from acid deposition and neglect in the form of a decline in traditional management.

A number of bird species of conservation concern are dependent or partly dependent on lowland wet grasslands in the UK (see Chapter 2, Table 2.5). Using a wider definition, Treweek *et al* (1997) list more than 40 species of conservation concern which use wet grassland.

13.1.2 Habitat requirements of birds on lowland wet grasslands

Lapwing, snipe and redshank are the most numerous waders breeding on lowland wet grasslands in the UK. Black-tailed godwit and ruff breed more sporadically and less data is available about these two species. Table 13.1 illustrates factors influencing breeding of lapwing, snipe and redshank on peat-based sites such as West Sedgemoor (Somerset) and clay such as the North Kent Marshes.

The preferences of each species differ, but all three favour at least some of the conditions associated with high water levels in ditches, such as soft, damp soil with higher invertebrate densities, a number of shallow surface flashes or 'pools', low intensity grazing and late cutting operations, ie post 1 July. Figure 13.1 indicates the inter-relationships between the factors associated with the presence of breeding waders.

Figure 13.1 Factors affecting site suitability for breeding waders

TABLE 13.1 Habitat variables associated with breeding wader presence, showing differences between peat and clay sites

	Lapwing		Snipe		Redshank	
	clay	**peat**	**clay**	**peat**	**clay**	**peat**
soil-water						
high ditch water level	+	+	+	+	+	+
soft soil	0	-	+	+	0	+
early-season flooding	+	+	+	0	+	0
surface water	+	0	+	+	+	+
Vegetation and land use						
tall vegetation	-	-	+	+	-	0
species-rich vegetation	0	-	0	+	0	-
tussocks	0	+	0	+	0	+
rushes	+	0	+	+	-	0
no hedges/bushes	0	+	0	+	0	0
grazing/mowing	0	+	-	-	-	-
large field	+	+	0	+	+	+

+ = positive association
- = negative association
0 = no association (usually due to lack of data)

Source: Green (1986, 1988a); Herbert *et al* (1990); Chown (1992); O'Brien & Smith (1992) and Vickery *et al* (1997).

Requirements of breeding waders

" **Lapwing** are the least dependent on wet or damp conditions - unlike snipe and redshank - they breed on a wide range of farmland types. They appear only to require short vegetation during the breeding season so they can detect predators early and respond by mobbing. A height of up to 15cm has been suggested (Green 1986). Shallow surface pools are often the only open areas in otherwise tall swards and serve as 'nursery areas'. Abundant invertebrates can be picked from the muddy edges.

" **Snipe** probe for soil invertebrates in soft, damp soil and need taller vegetation (probably more than 25cm) for concealment. Feeding adults and adults with broods move only short distances and depend on ideal field conditions. The edges of pools and ditches are only used when conditions in the field are unsuitable (Green 1986).

Clay sites with widely spaced ditches in drier parts of the UK (especially coastal grazing marshes in the south-east) tend to have dry, hard field surfaces in spring and a closely cropped sward and support few snipe.

" **Redshank** appear to require shallow surface water where invertebrate prey is located. Adults move up to 1.5km or so to feed at pools and at the edges of fleets and creeks at coastal sites.

Newly hatched broods are escorted some distance to suitable feeding areas. A preference is shown for short swards (probably less than 15cm) but they must have tussocky taller areas in which to nest. This allows the birds to detect predators and conceals the incubating adult.

" **Black-tailed godwits** appear to favour areas with short, tussocky, easily probed turf and surface water within 300m or so for breeding (Green 1986). The chicks actively glean vegetation for invertebrate prey and have a preference for taller vegetation. However, little research has been undertaken on the habitat preferences of black-tailed godwits.

" **Ruff** require raised areas with short turf for 'lekking' (Beintema 1982) probably with some shallow surface water nearby (Cramp & Simmons 1983). Leks are situated on raised areas or on other sites, often close to water, where birds have an unobstructed view in several or all directions (Rhijn 1991).

" **Curlew** appear to prefer damp, disturbance free, extensively managed areas (Chown 1992, Baines 1988).

" **Breeding wildfowl** require ditches and, ideally, pools, since nests are almost always within 20m of open water. Garganey are particularly important breeding species on a number of lowland wet grasslands. Provision of surface pools with a range of depths (up to 2m for diving ducks) can considerably improve wet grassland for wildfowl. However, summer flooding is not a traditional management practice on lowland grasslands - it damages or kills grass, restricts the use of grazing animals and machinery, and favours the growth of unpalatable rushes *Juncus* species. Flooding can also delay or even prevent breeding by waders and deplete the soil of invertebrates (Chown 1992, Edwards & Lofty 1972).

A decision to flood even small areas of grassland in the summer should be carefully evaluated. Any area selected should have limited botanical or invertebrate interest (Beintema 1982).

The traditional practice of winter flooding is preferable. Flooded areas can provide feeding and roosting areas for wildfowl and waders - a mean depth of 0.3m is considered optimal for dabbling ducks (Owen & Thomas 1979).

Requirements of wintering wildfowl and waders

In general, these species require suitable disturbance-free roosts and/or feeding areas. Most species have a requirement for winter surface flooding or high water tables. Most species do not necessarily require semi-natural grassland swards.

" Grazing species such as **swans, geese and wigeon** require short (5cm-15cm), even grass swards which contain finer/less coarse grasses. White clover is an important food source for geese and wigeon. **NB**: bean geese prefer taller, cattle-grazed grassland. These species also require large areas of open water as safe disturbance and predator-free roost sites.

" **Surface-feeding or dabbling ducks** (eg teal, shoveler, pintail) require shallow, open water in pools and ditches and as a result of flooding (generally <25cm). They feed mainly on plant material, especially seeds. Thus, presence of seed sources is beneficial.

“ **Diving ducks** (eg tufted duck, pochard) feed by diving underwater for plant material and invertebrates. They require deep water (>2m) with high densities of invertebrates in the sediment.

“ **Waders** (eg lapwing, golden plover, snipe) feed on soil-dwelling invertebrates especially earthworms and require high water tables which provides soft, damp soil together with areas of shallow, open water where species such as redshank forage at the water's edge. Islands of non-flooded grassland are used as secure roosting sites. Sward heights of <10cm are generally preferred although snipe will forage in taller vegetation for concealment. Larger fields lacking tall boundary features and away from human disturbance are preferred (Milsom *et al* 1998).

13.1.3 Management objectives

Management of lowland wet grassland should seek to halt the decline of this habitat and its associated bird communities and, where possible, play a role in the recovery in the numbers of key breeding and wintering species.

The following objectives for the management of lowland wet grassland for birds can be identified:

“ Maintain the present numbers, distribution and productivity of birds breeding on lowland wet grasslands.

“ Increase the populations of key wet grassland bird species by enhancing the management of existing areas of suitable habitat, while ensuring there is minimal conflict with the wider nature conservation objectives of the sites.

“ Increase the populations and extend the range of wet grassland bird assemblages by increasing the area of lowland wet grassland by habitat restoration and recreation in appropriate areas. Such action should be targeted on land at low existing nature conservation value that will link and/or extend core areas of semi natural lowland wet grassland habitats.

It is important to decide which priority species or groups are to be targeted. This will allow specific management options to be chosen.

It is also important to consider the potential for creating suitable conditions given the particular constraints of a site. These include:

“ available resources;

“ site topography and soils;

“ the water budget of the site;

“ the existing water control infrastructure;

“ the ability to maintain/introduce appropriate grazing and cutting regimes.

13.1.4 Achieving objectives

Water control

The water budget is calculated by offsetting inputs (springs, groundwater precipitation, streams) against outputs (groundwater, seepage, evaporation, streams, extraction and soil moisture deficit). The water available to change levels by the desired amount is that which remains when all the outputs have been considered.

Complete control of site hydrology is not possible because of variations in rainfall and evaporation. Water management can be best planned for a 'typical year' using data from a local meteorological office or MAFF technical bulletins.

A wide range of water control structures can be used to get water onto sites or parts of sites, to retain it, and to manipulate levels:

" Ditches, drains and pipes.

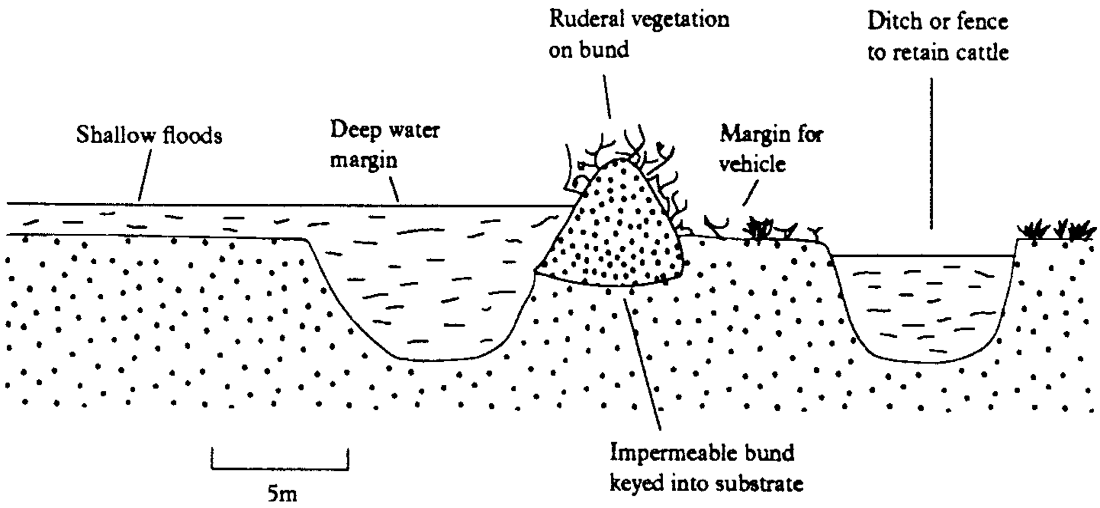
" Structures normally used for field drainage can be operated in reverse to supply water. Pumps may be operated to provide additional water.

" Dams, bunds and sluices.

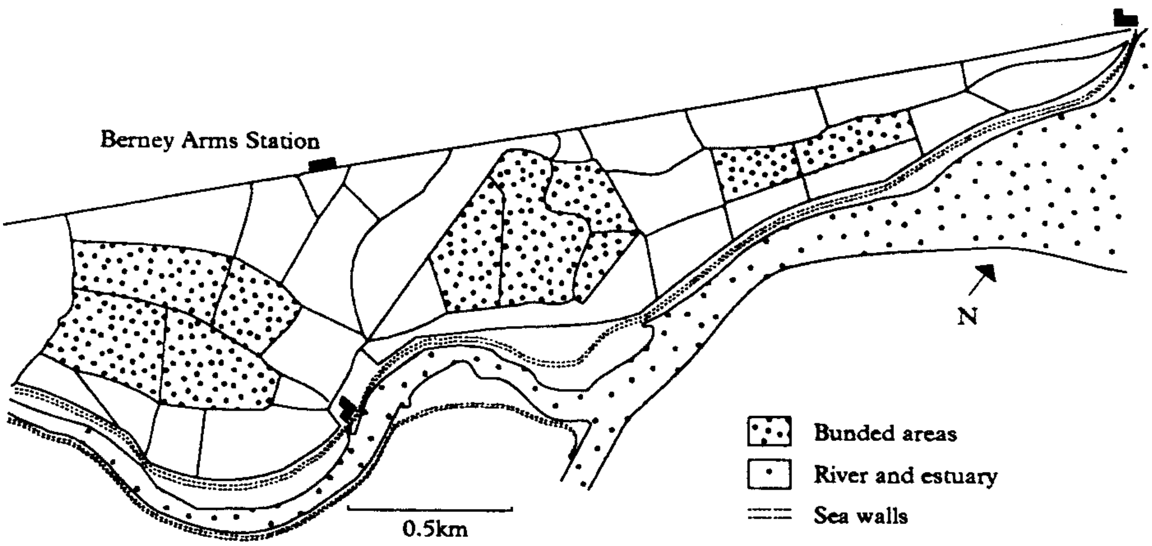
These enable water to be retained either over a whole site or in discrete hydrological units. Figure 13.2 shows a typical bund used on a RSPB reserve.

There are three main types of sluice incorporating either rigid pipes, flexible pipes or drop-boards (Figure 13.3).

a) A typical bund in use on a RSPB reserve



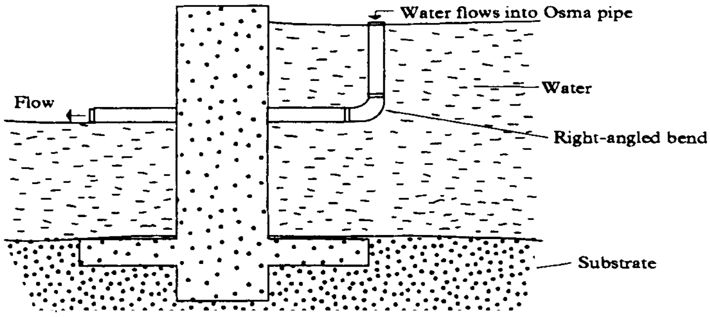
b. Bunded areas at the RSPB reserve at Berney Marshes, Norfolk



From Burgess & Hirons (1990)

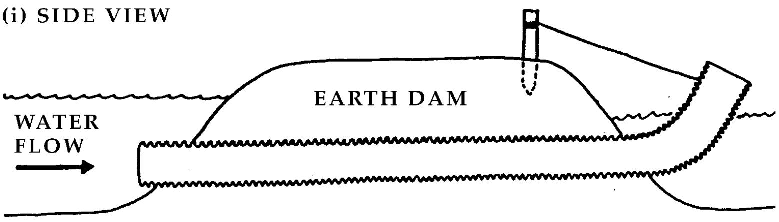
Figure 13.2 Bunds

1.

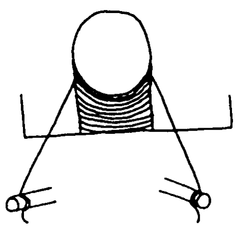


2. A: SINGLE WALL FLEXIBLE (CORRUGATED) PIPE

(i) SIDE VIEW

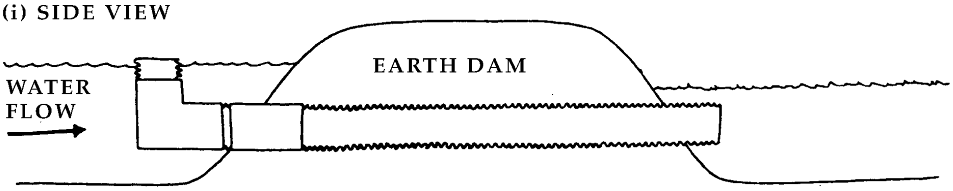


(ii) TOP VIEW

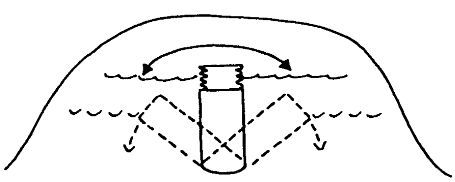


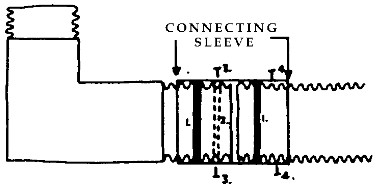
B: TWIN WALL RIGID (CORRUGATED PIPE WITH
ADJUSTABLE RIGHT ANGLE CONNECTOR

(i) SIDE VIEW



(ii) FRONT VIEW



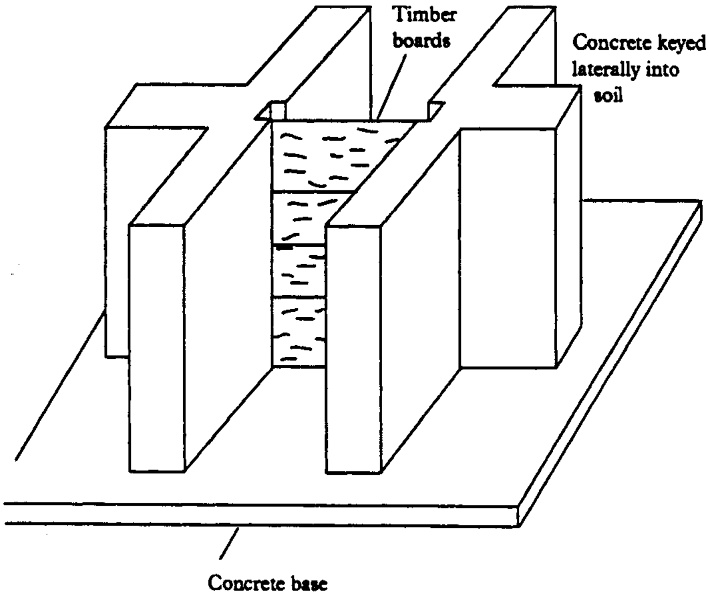


1: SOLID RUBBER RETAINING RING FITTED INTO GROOVE
2: HOLLOW RETAINING RING FITTED INTO GROOVE
3: SELF TAPPING SCREWS INTO 2- ALLOWS RIGHT ANGLE TO MOVE
4: SELF TAPPING SCREWS- DIRECTLY INTO PIPE

Figure 13.3 Types of sluice used on RSPB reserves

NB: Higher water levels can be gained by adding on a connecting sleeve to the entrance to the right angle

3.



1. Rigid rotatable plastic pipe.
2. Flexible and rigid plastic pipes.
3. Dropboard

Figure 13.3 Types of sluice used on RSPB reserves

Monitoring

The effectiveness of hydrological management on a site should be monitored as this enables management operations to be modified and refined where necessary. Gauge boards can be installed in each hydrological unit to measure ditch water level changes, and dipwells (lengths of perforated pipe) placed in representative fields to monitor water table heights and profiles. Piezometers enable upwelling groundwater to be detected and monitored.

The suitability of lowland wet grassland for breeding waders and wildfowl is dependent on both hydrological management and management of vegetation. Neither should be considered in isolation.

Vegetation management

Extensive farming systems are most suited to the conservation of lowland wet grassland and their bird populations. Conventional silage cropping involves land drainage, extensive reseeding, early and repeated cutting and fertilisation practices that are bad for both waders and botanical interest.

With respect to mowing management, only one cut is recommended, as late as possible, preferably using a traditional method. A hand scythe is best (Beintema, 1982) but, unfortunately, not practicable on most sites. The choice is usually between a cutting bar and rotary mower, the former being more acceptable. Potential breeding wader nest losses must also be considered since snipe and yellow wagtail may continue breeding into August.

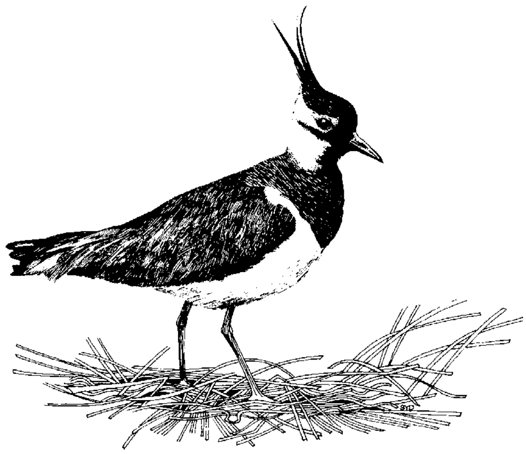
Avoid mowing entire fields in a spiral from the outer edge inwards - this drives the chicks towards a central 'island' where they may be killed during the final few cuts. Cut in stripes from side to side, or from the inside outwards to allow mobile broods and the adults to escape the cutter (see also Chapter 6).

Grazing is an essential part of sward management on most lowland wet grasslands. Cut fields are usually aftermath grazed in the autumn. Cattle tend to produce a structural mosaic with closely grazed patches and longer tussocky growth, especially at lower densities. Cattle grazed pastures may support high densities of invertebrates largely due to the tussocky sward and large quantities of dung. A certain amount of poaching is acceptable as these can provide valuable wader feeding areas.

A short uniform sward (which can be produced by either cattle or sheep grazing) can be of particular value to lapwing, redshank and black-tailed godwits. However, the lack of structural diversity can result in little invertebrate interest.

Grazing pressure is a crucial determinant of both vegetation structure and the risk of damage to breeding wader eggs and young. Wader productivity is reduced when animals are grazed during the breeding season and at high densities. Figure 13.4 indicates the probability of nests being trampled when subjected to differing densities and types of grazing stock, based on work by Green (1986).

In relation to creating suitable conditions for wintering birds, particularly geese and waders, where late summer/autumn grazing is not possible, it is suggested that the sward is cut once or, preferably, twice.



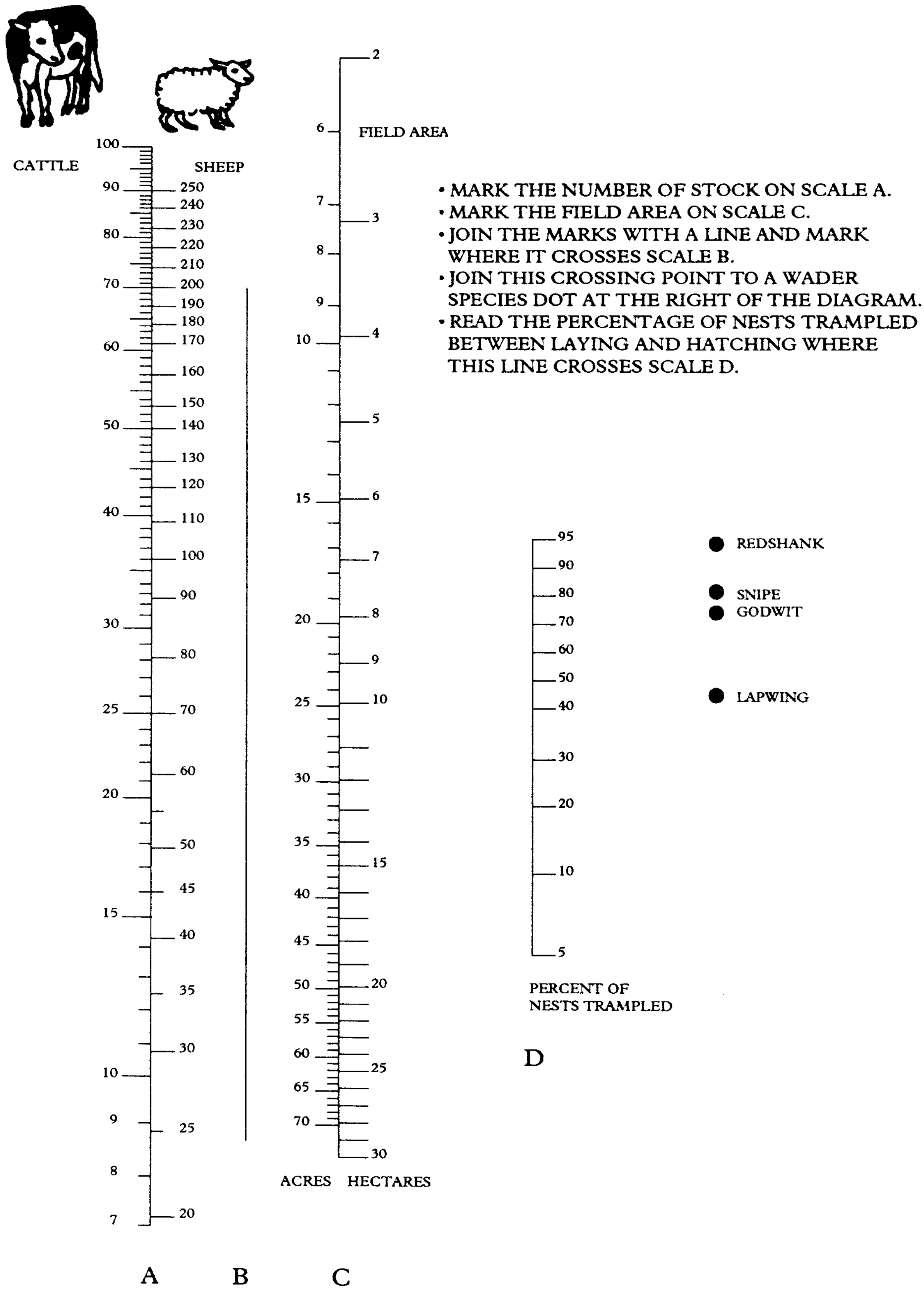


Figure 13.4 A chart for calculating the risk of wader nest trampling by grazing stock during the whole incubation period
From Green 1986

Summary of management techniques

Bird, plant and invertebrate species dependent on lowland wet grasslands benefit from a water management regime that provides damp grassland, surface water and full ditches at appropriate times of the year.

Low intensity sward management is essential for breeding and wintering bird populations. Management should aim for minimal trampling during the breeding season and maximum sward structural variety.

Figure 13.5 illustrates the generalised hydrological management regimes which can be used for the benefit of breeding/wintering birds. A, B and C represent three typical compartments on a wet grassland reserve.

Spring

Ditch water dropped to field-surface level, retaining scattered shallow pools in lower parts of fields. A flooded area may be retained.

Damp, soft ground and the margins of shallow pools have higher invertebrate densities and are easier to probe. The margins of floods and gently shelving ditch edges are especially important on clay sites which dry rapidly when surface water is removed.

Summer

Ditch water levels and any shallow pools allowed to drop progressively on part of the site (ideally the parts with least biological interest), the remainder kept wet for as long as practicable. Livestock grazed on drier parts, or a first hay/silage cut no earlier than late June.

Wet areas allowed to progressively dry into July and then grazed at low intensity or cut as late as possible. Ditch water levels to 50cm below field surface by end-July. Some areas kept partly flooded for breeding wildfowl.

All waders benefit from reduced intensity farming operations during the breeding season, although sward management is necessary for a number of species. The need to retain areas with a tall sward into July depends on the presence of snipe. All species benefit from scattered pools and the wet margins of full ditches on clay sites in particular. Breeding wildfowl benefit from areas kept flooded into Autumn.

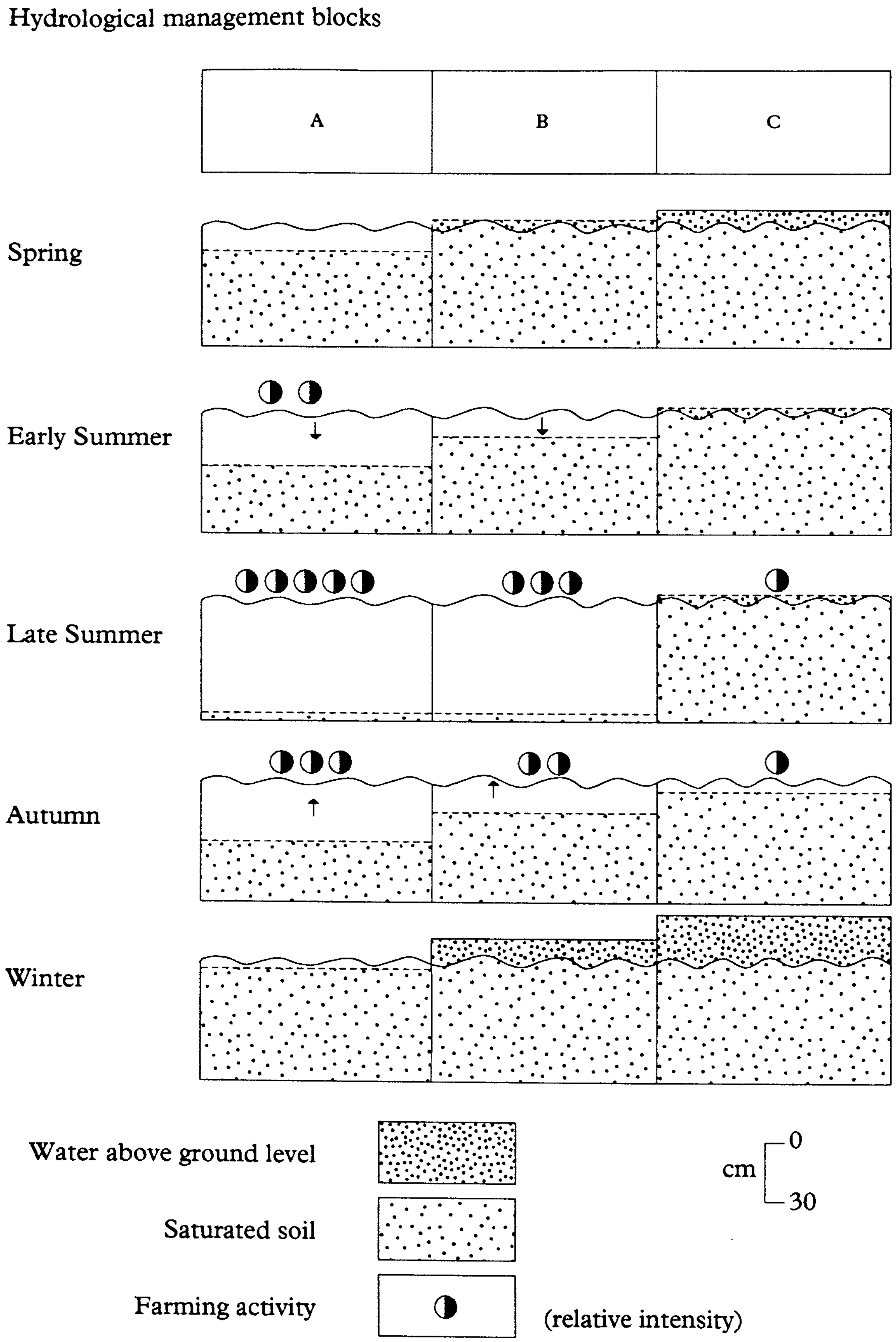


Figure 13.5 Generalised lowland wet grassland management regimes
Modified from Burgess & Hirons 1990

Autumn

Any remaining inundated areas are allowed to partly dry. Later in the autumn, ditch water levels reinstated to field surface level - rainfall begins to exceed evaporation by this time of year to assist the process. Livestock removed.

The muddy remains of previously flooded areas are attractive to passage waders.

Winter

Ditches allowed to overtop and flood lowest lying fields, or only those in selected compartments on very flat sites. A mosaic of floods and grass is ideal. Water at a range of depths to 30cm.

Winter floods providing feeding and roosting areas, and safety for grazing wildfowl. Seeds are floated out of longer vegetation and made available.

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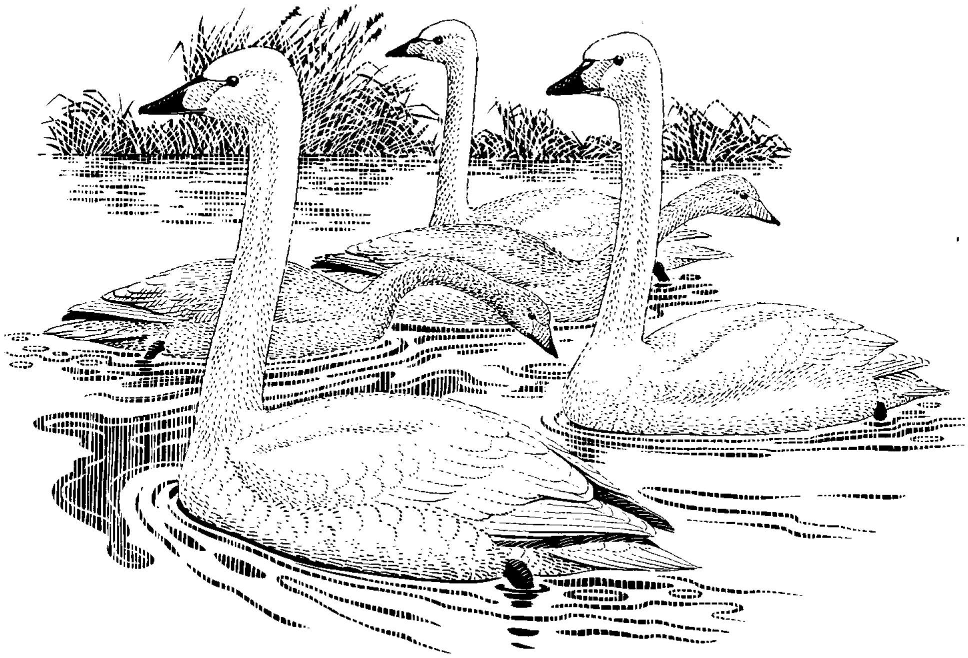

13.2 Management of lowland dry grassland for birds

13.2.1 The birds of lowland dry grasslands

The breeding birds of lowland dry grassland (see Chapter 2 for definition) include several widespread and abundant species, such as skylark *Alauda arvensis*, meadow pipit *Anthus pratensis*, grey partridge *Perdix perdix*, kestrel *Falco tinnunculus*, green woodpecker *Picus viridis* and rook *Corvus frugilegus*, together with a range of less common and dispersed species which occur more locally. These include stone curlew *Burhinus oedicnemus*, lapwing *Vanellus vanellus*, barn owl *Tyto alba*, wheatear *Oenanthe oenanthe* and corn bunting *Emberiza calandra*, with buzzard *Buteo buteo*, quail *Coturnix coturnix*, curlew *Numenius arquata*, woodlark *Lullula arborea* and whinchat *Saxicola rubetra* breeding at a fewer number of sites. Nightjar *Caprimulgus europaeus* and Montagu's harrier *Circus pygargus* also breed at very few localities.

Many of the above-mentioned species are recognised as birds of conservation concern in the UK by virtue of their rarity, declining breeding populations or European conservation status, as listed in Chapter 2, Table 2.6. In addition, stone curlew, grey partridge, skylark, woodlark, nightjar and corn bunting are recognised as priority species under BAP and have jointly agreed species action plans already published.

All the above species are more common in other open habitats, with the exception of stone curlew; its population is balanced between lowland dry grassland, the Breckland grass heaths and arable farmland (the highest densities occurring in semi-natural habitats). Many birds characteristic of lowland dry grasslands on the continent, such as bustards, pratincoles and some larks (‘steppic’ species), are absent from Britain, apart from species such as stone curlew and woodlark. However, Britain’s lowland dry grasslands also support important non-breeding bird populations. In winter, raptors which breed in the British uplands or in northern continental Europe, such as hen harrier *Circus cyaneus* and merlin *Falco columbarius*, hunt and roost over downland in southern England, together with short-eared owls *Asio flammeus*. Post-breeding gatherings of lapwings occur at a number of dry grassland sites, which have traditionally provided staging areas for certain migrants, such as dotterel *Eudromias morinellus* and ring ouzel *Turdus torquatus*.

While the UK has an internationally important quantity of calcareous lowland dry grassland (Dijk 1991), the bird populations they support constitute a negligible proportion of European populations (Hagemeijer & Blair 1997). Dry grassland birds have therefore been traditionally regarded as a low conservation priority in Britain (Porter *et al* 1991). In recent years, however, interest in the UK's lowland dry grassland birds has risen as we have become aware of; firstly great losses in both habitats and species populations on the continent, and secondly, the significance of Britain's bird populations in maintaining the geographical range of several bird species. This prompted English Nature to commission the first major review of the status, ecological requirements and conservation priorities for dry grassland birds in Britain (Dolman 1992).

13.2.2 Habitat requirements of dry grassland birds

Several bird species that occur on lowland dry grasslands have been subject to intensive study. However, there has been little research on the ecological requirements of most species and so we are often unsure of their precise management needs. This section outlines the habitat requirements of key bird species found on dry grassland habitats (as recently reviewed by Dolman 1992). These are drawn together in the following section to provide guidelines for the management of lowland dry grasslands for birds.

“ **Stone curlews** nest on bare or sparsely vegetated, stony or sandy ground (Green 1988b). Such conditions can be provided by chalk grassland that has been tightly grazed by sheep or rabbits, and on Breckland grass heaths with its mixture of short grass, bare ground and ericaceous shrubs. Birds will readily take to specially prepared nesting plots where suitable nesting conditions are not available. Stone curlews nesting in semi-natural habitats suffer from high predation losses, but will lay replacement clutches up to the end of July if suitable nesting conditions remain. Preferred feeding habitats consist of close-cropped semi-natural and improved grassland, manured arable fields, arable headlands and even manure heaps (Batten *et al* 1990). During incubation, birds may fly 2km-3km to feeding areas. A variety of prey is hunted on the soil surface, mainly at night. This includes invertebrates (earthworms, woodlice, millipedes and beetles, particularly those associated with livestock dung) and occasional mice and small birds (Green 1988b). For specific information on the management requirements of the stone curlew, contact the specialists at RSPB.

“ **Lapwings** breed in a variety of habitats, all of which have short vegetation or bare ground for feeding. Such conditions were once widespread on close-cropped chalk grassland and grass heath within Breckland but are now provided only locally. Lapwings feed mainly on a wide range of small invertebrates which are located by sound and vision, both on and within the ground. These include a diverse range of insects (beetles, flies, crickets, grasshoppers, moths and ants, both adults and larvae), spiders, earthworms and molluscs, as well as the seeds of grasses and certain herbs. Arable-nesting birds regularly move their chicks to adjacent grassland soon after hatching.

“ **Wheatears** usually nest in rabbit burrows on lowland dry grasslands, although few sites now support breeding pairs. Nests must be adjacent to areas of seasonally insect-rich short turf or bare patches. Wheatears feed mostly on insects (including grasshoppers, crickets, beetles, earwigs, bugs and moths, both adult and larvae) and also spiders, molluscs and other small invertebrates (Condor 1989).

“ **Woodlarks** require extensive areas of sparsely vegetated ground (including bare areas) for feeding, with patches of taller vegetation (long grass, heather or bracken) for nesting, and isolated trees or bushes for perching. They feed on a range of medium-sized invertebrates during the breeding season, but their winter diet mainly consists of seeds. Woodlarks now rarely occur on lowland dry grassland due to the lack of short turf areas, preferring clear-felled and restocked conifer plantations.

- **Skylarks** are much less exacting in their habitat requirements; they feed and nest in short vegetation yet reach their highest densities in lightly-grazed grassland. However, a mosaic of sward heights with a sward height of greater than 15cm in the summer (Wakeham-Dawson & Aebischer 1997) ranging from bare ground to longer grass up to 25cm is ideal to meet both nesting and feeding requirements. Skylarks also prefer open fields which do not have scrub around the boundary (Wakeham-Dawson *et al* 1998).

- **Barn owls** nest in buildings and cavities in isolated trees. In contrast to the above species, they prefer ungrazed or lightly grazed, rough grassland for feeding; closely grazed grasslands do not support the abundant small mammal populations that they require, in particular, short-tailed voles.

- **Curlews and quails** nest locally in tall, tussocky, ungrazed, or lightly grazed areas on lowland dry grassland.

- **Whinchats** also require taller vegetation. They nest in or beneath tussocky grass and require suitable song posts, such as bushes, tall weeds or fences. They will tolerate a certain amount of scrub within their breeding habitat.

- **Meadow pipits** also tolerate light scrub within their nesting territories and avoid areas with short grass or mostly bare soil.

- **Corn buntings**, although largely associated with arable and mixed farmland, also breed on lowland dry grassland. They are usually found along edge habitats, often nesting in hedgerows, and feed on weed seeds, grasses, leaves, cereal grain, fruits and invertebrates (the chicks are largely fed on invertebrates). An abundant source of cereal grain and seeds is particularly important in winter, and a recent study has shown that feeding stations for out-wintered cattle are an important source of food for corn buntings.

An abundant food supply is a key requirement for raptors that winter on lowland dry grassland. All these raptors require large, open areas for hunting with suitable taller vegetation for roost sites.

- **Hen harriers** feed mainly on small mammals, particularly voles, and small birds, but also take young rabbits. They often hunt for long periods, using terrain and vegetation to mask their approach as they fly at low level.

- **Buzzards** take a wider variety of prey which, in addition to mammals (particularly rabbits) and birds, extends to reptiles, amphibians, larger insects, earthworms and occasionally carrion.

- **Merlins**, by contrast, feed almost exclusively on small birds taken on the wing.

- **Short-eared owls**, which winter on dry grasslands, require areas of long grass for hunting small mammals.

13.2.3 Management of dry grassland for birds

Almost without exception, the breeding birds of lowland dry grasslands are suffering from long-term population declines in all areas (Dolman 1992). These declines are associated with the loss and fragmentation of their dry grassland habitats resulting from both direct destruction, such as agricultural improvement, and indirect factors, such as lack of management due to agricultural abandonment and myxomatosis. Management of lowland dry grasslands for birds should therefore seek to halt these population declines and, where possible, play a role in the recovery in the numbers of key breeding species, such as stone curlew.

13.2.4 Management objectives

The following objectives for the management of lowland dry grasslands for birds can be identified:

“ Maintain the present numbers, distribution and productivity of birds breeding on lowland dry grasslands.

“ Increase the populations of key dry grassland bird species by enhancing the management of existing areas of suitable habitat, while ensuring there is minimal conflict with the wider nature conservation objectives of the sites.

“ Increase the populations and extend the range of dry grassland bird assemblages by increasing the area of lowland dry grassland habitats by habitat restoration and re-creation in appropriate areas. Such action should be targeted on land of low existing nature conservation value that will link and/or extend core areas of semi-natural lowland dry grassland habitats. This objective is beyond the scope of this handbook and will be addressed by other conservation initiatives.

13.2.5 Achieving objectives

Apart from the specialist nesting or feeding requirements of certain species, there is a pronounced split in the habitat preferences of key lowland dry grassland species; those which require a close-cropped grassland sward, often with areas of bare ground, and those which prefer longer vegetation for nesting and/or feeding, often in association with shorter vegetation. Management of dry grasslands should aim to meet the varying requirements of both groups of bird species by achieving the appropriate balance between the areas of short and long grass, set in the context of the wider conservation objectives of the site or larger habitat unit. In practice, due to a lack of management on many sites, management should concentrate on restoring and/or maintaining the short grassland sward needed by certain key bird species and other rare plants and animals.

Bird species which require short vegetation (around 2cm) with areas of bare ground for nesting sites and/or feeding areas include stone curlew, lapwing, woodlark and wheatear. A close-cropped sward can be provided by intense grazing by rabbits and/or livestock, with the areas around rabbit burrows providing important patches of bare ground. The management of grassland by livestock grazing is discussed in detail in Chapter 5. A possible alternative on some sites, resources permitting, is to enclose existing or potential areas with rabbit-proof fencing to intensify grazing pressure from rabbits. This has already been used with success at Weeting Heath NNR following pressure from adjacent landowners to control rabbits (see case study Chapter 13, Section 13.2, sub-section 13.2.6). At other sites, where grazing pressure is not sufficient to maintain a short vegetation cover, periodic cutting/mowing at an appropriate time of year may be necessary.

Bare areas on lowland dry grassland are created by the rabbits but also, historically, by human activities such as short-term arable cultivation, turf stripping and quarrying. While these activities have traditionally been more common in certain areas, such as Breckland, active disturbance by rotovation has been successfully reinstated on some sites (see case study) and could be applied more widely within Breckland and elsewhere as a management tool. Such management may allow losses of accumulated nitrogen from the soil and has been shown to benefit certain rare plants within Breckland (Dolman & Sutherland 1992). The disturbance of the grassland surface, or cutting of the sward, should obviously not take place during the nesting season for grassland birds, ie between April and August inclusive.

With the exception of wheatear, which usually nests in rabbit burrows, all these species nest on the grassland surface and can suffer from high predation losses. Suitable nesting conditions should therefore be maintained for as long as possible through the breeding season to allow for replacement clutches to be hatched and reared. Stone curlews can nest as late as August and so it may be necessary to delay the introduction of high densities of livestock to prevent trampling losses, though grazing is vital for this species to provide the necessary habitat structure and dung-dwelling invertebrates. Nest protection for the control of certain mammalian and avian predators could also be considered at some sites, though this should be viewed as a last resort or a stop-gap measure to protect or restore an especially vulnerable population while addressing more fundamental problems (eg concerning habitat management or fragmentation).

A number of key lowland dry grassland bird species require longer grassland swards for nesting and/or feeding. These include skylarks and meadow pipits, which favour lightly-grazed swards, and whinchats, curlew and quail which breed in long, tussocky or rank grassland. Although they feed in areas of short grass and bare ground, woodlarks require longer vegetation for nesting and isolated trees or bushes for perching.

Lightly grazed or ungrazed grassland supports abundant vole populations which sustain breeding and wintering owls and raptors. The structure of the longer vegetation may also be important as grassland containing tall herbs, such as species of the families Umbelliferae (carrot family) and Onagraceae (willow herbs) and brambles *Rubus* spp. may limit the availability of voles to aerial predators.

Long grass requires periodic cutting or mowing to prevent succession to scrub and woodland. Appropriate techniques are discussed in detail in Chapters 5 and 8, although it is important to stress that cutting should be avoided in the nesting season. Birds nesting on lowland dry grassland are particularly prone to disturbance by humans and dogs. Appropriate visitor management is essential to minimise disturbance at sites with public access.

13.2.6 Case study - Weeting Heath NNR

Weeting Heath NNR contains one of the finest remaining grass-heaths in Breckland, comprising dry acid and calcareous grassland and lichen heath. Covering 137 hectares, the heath supports a number of rare plants and invertebrates, as well as being important for ground-nesting birds, including stone curlew, woodlark and formerly wheatear and ringed plover *Charadrius hiaticula*. Past land use has consisted of periods of sheep grazing and rabbit warrening interspersed by arable cultivation. Other forms of physical disturbance have included trackways, gravel and marl diggings, and the construction of glider defences. Such a management history is typical of many Breckland heaths and is responsible for the creation and maintenance of the sparsely vegetated, oligotrophic plant communities, rich in lichens, bryophytes and annual vascular plants. The site is owned and managed by Norfolk Wildlife Trust (in partnership with the Nature Conservancy Council/English Nature from 1954 to 1997). Since 1974 a summer warden has been employed each year to undertake species protection and visitor reception duties. Two pairs of hides provide good views of nesting stone curlew for around 7,000 visitors a year.

Since the later 1950s, a combination of active management techniques have been employed in order to restore and/or maintain the mosaic of short calcareous and acid grass-heath communities in the face of fluctuating rabbit numbers. Following myxomatosis, a small area of the heath was annually swiped until rabbit numbers increased in the mid-1960s. From 1960 annual rotovation was carried out on six plots totalling 2ha, principally to provide nesting habitat for stone curlews. Stone curlews nested on these plots between 1961 and 1964 before increasing rabbit numbers restored the structure of the surrounding grass heath. Rotovation was stopped in 1975 as rabbit populations reached a high level, although some plots were re-rotovated in some years. Subsequently the old rotovated plots have revegetated and now show the desirable features typical of heavily rabbit grazed sites. By contrast adjacent unrotovated areas, having suffered years of undergrazing, were more fertile and have developed tussocky, species-poor vegetation (Dolman and Sutherland 1992).

In 1959 a 27 ha compartment was fully enclosed with rabbit netting following pressure from adjacent landowners to control rabbits. Rabbit fencing of the remainder of the heath was completed in 1995, both preventing adverse impacts on adjacent land uses (arable and forestry) and intensifying grazing pressure by rabbits on the heath. Further mechanical treatments were not required, until a crash in the rabbit population in the late 1980s dramatically reduced the grazing pressure on much of the reserve.

In 1989 forage harvesting was carried out over parts of the heath which had become tussocky following the reduction in rabbits, including about 16 ha of the principal area for stone curlew breeding. 90 rabbits were introduced to the same area in 1990 to replenish the population. Rotovation was re-introduced in 1989, with plots rotovated on a 2-3 year cycle, providing a range of disturbed and re-vegetating conditions. Stone curlews have used some of these plots for nesting in subsequent years, and continue to use a 3 ha plot ploughed in 1989 (and subsequently rotovated and rolled), demonstrating a preference for a higher proportion of surface stones and flints. Rabbit activity in these new plots was, as had been observed on the older plots, demonstrably higher than in untreated areas. Studies conducted by the University of East Anglia during this period (Dolman and Sutherland 1994) demonstrated the value of intermittent rotovation (ie every 2-3 years) in maintaining declining components of the grass heath (lichens, bare ground, cushion-forming mosses and annual plants). Annually repeated rotovation and, to a greater extent, ploughing provided fewer of these benefits. The usefulness of rotovation for invertebrates requiring open ground is less clear (Foster and Proctor 1992), since the treatment is initially severe, invertebrates are slow to re-colonise, and by the third year recorded species are similar to those in untreated areas.

Through the early 1990s, as the rabbit population recovered and dry summers reduced summer grass growth, rotovation as a method for providing stone curlew 'nest boxes' has become less important. Equally, suitable habitat for the characteristic plants and invertebrates of open, disturbed grass heath is well distributed across the reserve. As a result since 1997 rotovation has been undertaken annually on selected plots principally as a heathland restoration technique, to accelerate nutrient leaching. Repeat rotovation will subsequently be maintained on each plot for 10 years, and then suspended. Should rabbit numbers crash again the existing plots will provide suitable stone curlew nesting habitat, while intermittent rotovation could also be re-introduced to maintain plant and invertebrate benefits. Autumn and winter sheep grazing was introduced in 1995 with hardy breeds (Shetlands, Hebrideans and black Welsh mountains) to smooth the peaks and troughs of fluctuating rabbit numbers, with positive effects on formerly rank areas of grass heath.

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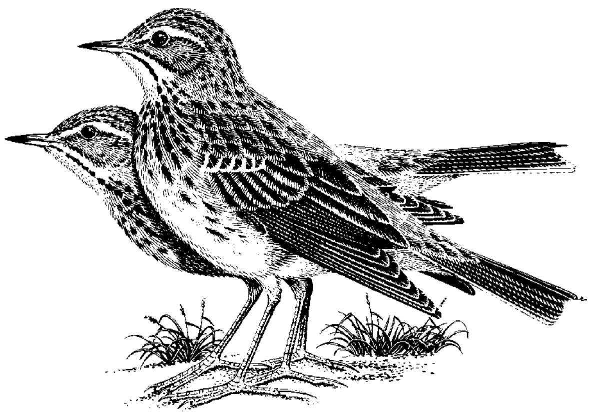

13.3 Grassland management for invertebrates

13.3.1 Introduction

There is no such thing as an ideal condition or structure for any grassland site which will always maximise the invertebrate interest. The main point to emphasise is that any grassland site should be managed to maintain its existing invertebrate interest rather than aim to maximise its invertebrate richness. For more detailed accounts or alternative views on the management of grassland for invertebrates, see the selected bibliography and Chapter 13.

The following gives some idea of the features of importance for invertebrates.

13.3.2 Plant species composition

In a sense, this is the least important factor for invertebrates. Although some invertebrates are restricted to a single plant species for food, it is more usual for the association to be broader than this. More important factors may be the plant family, flower colour, the time of nectar flow, plant structure or position with respect to heat, sunlight, shade, water or nutrients. Whatever the association, there must be enough host plants, in the correct conditions and in the right place.

Not all plant species in a grassland sward are equally used by invertebrates. Some, such as cowslip *Primula veris*, speedwells *Veronica* spp. and goat's-beard *Tragopogon pratensis*, seem to be very poorly exploited. Others such as knapweeds *Centaurea* spp., thistles *Cirsium* spp. and common bird's-foot trefoil *Lotus corniculatus*, have more than 50 invertebrate species associated with them and possibly almost double that number if generalist herbivores are taken into account. However, even this number is small compared with those associated with shrubs such as cherries *Prunus* spp., roses *Rosa* spp. or willows *Salix* spp., which all support more than 150 invertebrate species.

It is important for flowers to be present on a site from March to October. Even if the developmental stages of invertebrates have very specialised needs, the nectar-feeding adults often have more generalist tastes. Flowers must be widespread so as to be close to the various egg-laying habitats of the adults visiting them. As a general rule, the more simple or open-structured the flower, the more attractive it is.

It is not enough for a plant species to be present. Those animals exploiting that particular plant species have still to find it; by sight (silhouette), smell or, at close quarters, by taste. Having found its host plant, the adult female must be satisfied that it is, and will grow to be, suitable for the development of her offspring, and she must find appropriate egg-laying sites on the plant. If anything is wrong, that plant will be abandoned. If too much effort is spent in finding suitable host plants, there is a greater chance that the female will lay no eggs, lay eggs out of desperation in the wrong place, or be eaten herself.

The associations between invertebrates and plants operate in both directions. Just as invertebrates have precise requirements of plants, so plants have specific requirements of their invertebrate herbivores, pollinators and seed dispersers. Inappropriate management of either may have deleterious effects on the habitat.

13.3.3 Vegetation succession

Grassland sites which have a complex mosaic of structures including a range of sward heights, bare ground and some scrub are likely to support a large number and variety of invertebrate animals. Another important feature of managed grasslands is the variation in the small scale pattern of different structures which occur over different timescales. For example, bare ground created by the action of grazing animals will not always occur in the same place on a site from one year to the next. A structurally simple site is less likely to support the variety of habitats, and consequently the richness of fauna, which would occur on a more dynamically managed and varied one. This does not mean that every area should be as varied as possible to fully benefit invertebrates. Enough of each habitat must be present to support viable populations. On some sites the grassland habitats may be so important that management for structural simplicity, rather than a more varied structure, may be best.

On most sites, creating structural diversity will be beneficial but it is not advisable to make drastic changes over the whole site at the same time. This would be disastrous for the invertebrate fauna. Small scale management, even involving drastic treatment, is perfectly acceptable so long as the area can recover. Where there is some doubt about the outcome of drastic habitat change, eg scrub removal, it is better overall, and beneficial for the invertebrate fauna, if only small areas are treated. Even better would be management to improve remaining earlier stages of succession, eg scrub thinning around grassland remnants.

Sites managed as small scale mosaics, although more varied in structure, may be as stable as sites with a more uniform sward. Scrub may be allowed to develop in different areas. Soil exposures are extremely important but they need not always be present at the same spot. These could be encouraged to develop in different areas on a slope by adjusting grazing management over a period of time. Good grassland management for invertebrates exploits the natural dynamic changes within grassland and encourages these to take place continuously and erratically over the whole of a site.

13.3.4 Vegetation structure

Although the individual species of plant are important, it is often the structure of the vegetation which determines their suitability for egg-laying or as food.

Invertebrates recognise their host plants by a variety of cues and stimuli, for example a plant's silhouette is important in some cases. A plant hidden by other tall vegetation, or cropped down level with the rest of the sward, is not easily found.

Some invertebrates require several of their host plants growing together and do not select isolated plants. The females of other species will only lay their eggs on host plants occurring in specific situations, for example in sun or in shade. This behaviour maximises the survival of their offspring by ensuring that the food plant will be of sufficient quality to allow development.

Four types of vegetation structure are considered here. There are intermediates which support some invertebrates from either type but are less suitable for those species with most specialised needs.

Bare substrate

This is an extreme and, at first glance, structureless phase of colonisation or succession. However, a great variety of structure is present. The invertebrates of bare substrates are hunters or scavengers or use the area for nesting, provisioning their nests and obtaining their own food from elsewhere.

Those species associated with well-drained soils (eg chalk, limestone or sand) usually need high temperatures, so cannot tolerate shade or damp, for example ground-nesting species or solitary bees which gather pollen from surrounding vegetation, or solitary wasps which hunt for prey within a hundred metres or so of their nests. Several spiders, predatory beetles and ants hunt or scavenge in these areas. Soil exposures with a southerly aspect are favoured.

Species associated with moister clay soils need warmth and moisture but suffer high mortality during prolonged periods of drought. Saturated soils, or even those with periodic shallow standing water, are populated by specially adapted hunters and scavengers. These hunt animals which have strayed onto this generally inhospitable habitat, or feed on the remains of those that have become trapped or have died. Many flying insects may be seen around soil exposures. Some are mobile predatory species awaiting other visitors which they will kill for food, while others are waiting for a potential mate to pass by. The offspring of these species may develop in an entirely different habitat. Other species seek out soil exposures because they are warmer, and warm up more rapidly than vegetation. They bask in the sunshine to raise their body temperatures.

A different array of invertebrate species are found on vertical faces of soil exposures compared with horizontal plains. Many solitary bees and wasps prefer to nest in these exposures but scavengers and predators cannot easily climb and are largely restricted to their bases.

Sub-vertical faces are patrolled by carnivorous invertebrates and scavengers which prey on invertebrates which have strayed into the area and are struggling to climb up the sides or have died in the attempt. Some species of solitary bees and wasps build tunnels if the substrate is not too fragile. Horizontal surfaces are often very active with predators, scavengers and ground nesting species.

In general, very friable areas are not used for nesting because nest tunnels collapse too easily. Hard or compacted surfaces and areas of soft sand with many pebbles or rocks are also similarly avoided by ground nesting species because of the difficulties of burrowing. These areas are, though, important features for hunting and basking.

Large areas of exposures are valuable but small patches of bare ground are preferred by some species. Partially vegetated areas with less than 50 per cent exposed soil are still important, especially if they face south and the vegetation is short, or of a short to medium tussocky structure.

Short turf

Short grazed turf (ie less than 4cm) is extremely important for invertebrates which need high temperatures for development. Short turf on south-facing chalk grassland in the south of England supports a range of invertebrates which survive on the very northern edge of their ranges. Further south in Europe they survive in much taller swards but in the north such vegetation is too cool. The adonis blue *Lysandra bellargus* and the silver-spotted skipper *Hesperia comma* are examples of butterflies dependent on short turf.

Short turf is inevitably associated with small areas of bare soil caused by poaching during winter grazing. 'Walks' and hoof-prints create depressions which become very hot in summer and are ideal for heat-demanding southern fauna.

The fauna of short turf is so specialised that it cannot survive for long in a taller sward. Whenever short turf is present on a slope with a southerly aspect, management should be designed to retain this habitat. It should not be allowed to develop, even for a single summer. Allowing a normally short sward to grow tall will result in the extinction of the short sward invertebrate fauna and its replacement by a less interesting tall sward fauna.

Longer turf

Uniform long grass dominated by only a few plant species supports few invertebrates but a well managed medium height sward (10cm-20cm) with a mosaic of bare soil, short turf, medium turf with taller and shorter tussocks can be of great value for invertebrates.

Tall swards should be encouraged only on eastern or western facing slopes, rather than south facing ones which are generally more important for short turf communities.

Tussocks

Tussocks are natural features and can be very valuable for invertebrates providing an extra structural dimension and different niches. They tend to be richer in invertebrates than surrounding uniform land. Some plants are able to flower, or to flower more freely, in a tussock than in a uniform sward, and the support provided by a tussock allows taller plants to remain upright producing a visible silhouette. Silhouettes provided by tussock growth are attractive to species which would not recognise the same plants in a uniform sward.

Tussocks also provide shelter for invertebrates which need to hide from predators, eg birds, or to retreat from unfavourable weather, eg heavy rain or excessive heat.

Tussocks are important in mosaic with other structural forms. For example, the most abundant grasshoppers need bare or sparsely vegetated ground in which to lay their eggs, and medium or tall vegetation in which to develop and to find mates. Areas of tussocky grassland provide over-wintering sites for many invertebrates.

In wet grassland, tussocks provide drier refugia needed by many invertebrates, and even those which live in wetter areas during the summer may retreat to the shelter of the tussocks during the winter.

Very old tussocks seem to be of lesser value for invertebrates. Management should thus aim to continually create new tussocks while limiting the number of very old ones which are beginning to coalesce or have stopped enlarging.

Scrub

Scrub provides a further vertical dimension to grassland structure and is a vital component for invertebrates of a well-managed grassland habitat (see Chapter 12, section 12.3).

13.3.5 Substrate

In general, warm, well-drained substrates support faunas which are richer and different to those found on cool, wet ones.

A substrate, such as chalk, limestone or sandstone, cannot retain much moisture and so is warmer. The highest temperatures are found on these substrates on south-facing slopes.

The friable nature of these substrates make them easy to dig and burrow into, but still firm enough not to collapse. Burrows and cavities are not so hot and dry as the surface and suitable temperatures and humidity can be created by the positioning of entrances and orientation of passages. If the substrate is disturbed, eg by excessive trampling, grinding it into a loose sand or limestone powder, it is no longer suitable for tunnelling.

Where there is a well-drained substrate, the invertebrate fauna is likely to benefit from maintenance of a short or partially vegetated grassland sward.

There is a strong difference between the invertebrates on dry acidic sandstones and those on dry calcareous substrates. Those of calcareous systems are usually richer than those of acidic systems; but the fauna of acid grassland should not be considered impoverished unless there are fewer species than could be expected of such a habitat.

The temperature and humidity in the shallow litter layer above a well-drained soil is also very different to that over soil which retains moisture. The litter fauna tends to be richer in drier, short turf than in a tall sward over a wet soil.

Sand

Sandy soils are usually well-drained, at least during the spring and summer, and so are quite hot. The heat and low moisture allow some invertebrates to occur further north than would otherwise be the case for species which are ill-adapted to our cold and wet climate. Management should maintain a sparse, open turf with bare patches. Tall grass which shades the ground and so lowers temperature and raises humidity should be removed, or restricted to areas where an important shade-demanding community is present.

Small areas of sand exposures, eg rabbit scrapes and hoofprints, are important for providing very high temperatures, especially on south-facing slopes. Such areas are needed for rapid maturation and growth as well as for nesting and basking.

Larger areas of exposed sand are also of value but these are, by nature, temporary habitats. A number of such exposures, at various stages of re-vegetation, is desirable. Very large exposures, eg quarry faces and sandpits, can support large colonies of sand-dwelling invertebrates. Such areas, especially if facing south, should be managed as permanent exposures.

Chalk and limestone

Well drained, hot and dry calcareous substrates allow certain invertebrates to survive at the northern edge of the range, but high temperatures are only sustainable in bare or sparsely vegetated areas or where the turf is extremely short. The priority for management of south-facing areas of calcareous grassland should be to retain such a short turf with sparsely vegetated areas and patches of exposed soils in various stages of re-colonisation.

Soil exposures need not be large: hoof prints or rabbit scrapes become small sheltered hot-spots throughout the summer. Such areas are sought out by species which need high temperatures for development or maturation.

Large areas of exposed chalk or limestone are of value, especially if the substrate is not too hard and contains few flints or concretions. Chalk -pits and quarries are particularly important especially if plants are colonising exposures and spoil heaps nearby. Exposures need not be very large.

Clay

Clay soils are characteristically cold and water retentive. As such they are unsuitable for many grassland invertebrates. However, marshy grassland has an interest of its own because of the different plant species and physical factors. Lighter sandy clays and chalky clays, or those with a strong calcareous influence are also of importance.

During the summer, the clay surface may be dry and cracked. Several species are adapted to hunt in these conditions. During the winter, clay soil is so cold and wet that little is able to survive and here the litter layer and grass tussocks are important. These raised platforms support habitats which are drier, warmer and support many specialised niches. Predators, herbivores and decomposers live together and disperse into the wider sward during spring and summer.

13.3.6 Aspect

Northerly facing grasslands receive little direct sunlight and are cooler and moister than equivalent south-facing slopes. The invertebrate fauna may be rich and varied, perhaps even more so than on a parched, uniform southern slope, but lack specialist heat-demanding species.

There is scope on these slopes for more varied management but care should be taken to capitalise on any available sunlight and to provide shelter from prevailing winds.

Southerly, especially directly south-facing, slopes are extremely important for their invertebrate faunas. These slopes have the potential to support very specialised, heat-demanding species which can survive nowhere else. Wherever grassland is present on south-facing, well-drained slopes, and most importantly when the underlying substrate is chalk, it is essential that most of this area is managed as a short turf sward with an abundance of small scale soil exposures. This slope will heat up rapidly in the summer sun and provide ideal conditions for the specialist fauna.

There is scope for some variety in the sward, especially on lower parts of the slopes or in areas where the soil is deeper and less well drained. Gulleys with easterly or westerly aspects could be managed for longer turf, tussocks or sparse scrub as could the bottoms of valleys and coombes.

Although the most valuable grasslands for invertebrates are on southern chalk, northern limestone or sandstone slopes should be managed along similar lines to maintain the greatest potential area for colonisation by heat demanding species.

13.3.7 Management options

Grazing, mowing, burning affect invertebrates in different ways. Grazing is the preferred option for management for invertebrates. Other techniques should only be considered as temporary management for small or inaccessible areas, or as part of a grassland restoration programme. Even then, the areas treated should be small and the management should be spread over several years.

The objectives of grassland management should be to provide variety in structure and composition both on a macro and micro scale.

Grazing

Depending on the stocking density, grazing produces varied structure and composition. Heavy grazing in summer removes flowers and reduces structural variety which can be damaging to invertebrates. Grazing in the winter can be beneficial for invertebrates as poaching will produce exposed soil of value during the summer.

Grazing also has other benefits. It provides dung, which is a very valuable invertebrate habitat. The grazing animals themselves are habitats, although veterinary treatments eliminate many species, and they are a food source for blood or sweat feeding invertebrates. Grazing stock can transport some of the less mobile species to new areas or even to new sites. Finally, if only temporarily, there is the occasional piece of carrion. For further information on grazing as a management practice see Chapter 4.

Mowing

A mown grassland has little structural variety and so is of less value for invertebrates than a well-grazed area.

The cuttings, if left, form a dense mat which covers, and so destroys, the habitat of some species while providing an overwhelming abundance of cut grass at the wrong time of year for invertebrate decomposers.

Decomposer fauna is adapted to there being relatively small quantities of material throughout the summer and an increased abundance during winter. It is not adapted to, nor can it cope with, such a sudden over-abundance of material. The cut material, or much of it, is usually still green. The process of decay of this type of material different to that of vegetation which has died gradually. Cuttings should therefore be removed.

For further information on mowing as a management technique, see Chapter 6.

Burning

Burning is a catastrophic form of management for invertebrates.

A slow, deep burn will kill or fatally injure much of the invertebrate community. Only those in the deepest, moistest tussocks would have a chance of survival. A more rapid and superficial burn is less damaging but may not fulfil management objectives for the site.

The burning of a small portion of a site is more acceptable but it is likely that whole populations of some species would be eliminated.

Unless there has been a long history of burning management, or the management is part of a restoration programme, the use of burning as a management tool should be avoided. For further information on the use of burning as a management technique, see Chapter 9.

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13.4 Grassland management for rare and scarce vascular plants

13.4.1 Introduction

Lowland semi-natural grasslands provide a habitat for a number of nationally rare and scarce vascular plant species (Chapter 2, Table 2.4 lists 113 species). In the absence of management lowland semi-natural grasslands will change through the process of succession, initially to tall, often species-poor grassland and ultimately to scrub and woodland. Maintenance of the nature conservation value of semi-natural grassland communities is thus dependent on a continuation of management by grazing, mowing and more occasionally by burning and/or sporadic low intensity cultivation (see Chapter 2, Table 2.2).

The rare and scarce vascular plants associated with these grassland communities are similarly dependent for survival on a continuation of management. However, within this broad requirement, maintenance or expansion of existing populations of some species may be dependent on the type, timing and intensity of management, especially grazing.

In this section, it is intended, firstly to provide advice on the sorts of information land managers and conservation advisers should have access to prior to making decisions about management on sites supporting rare species and secondly to provide general advice on implementation of management. Further information on taking decisions about grassland management are covered in Chapter 3.

It is not intended here to provide detailed information on the autecology and management requirements of all rare and scarce grassland species but rather to cover general principles, include a few examples and provide further sources of information. It should be stressed that for many rare and scarce lowland grassland species there will be no special management requirements beyond the maintenance of the regime which ensures the grassland community retains favourable conservation status.

In many cases rare or scarce plant species may only be one of several priority nature conservation interest features on a site and it is important to take a holistic view and not be too overly focused on specific rare species at the expense of the grassland community, if this is also a key feature.

Optimum management for many rare and scarce species will often coincide with management for the community but not always. It is thus important to understand which species fall into this latter category and those where a change in grassland community management may compromise survival. Depending on relative priorities, it may be legitimate to maintain management prescriptions that may not be optimal for species if this is necessary to sustain other interest features.

13.4.2 Information/data requirements

Prior to taking decisions about the management of sites supporting rare and scarce species, information should be collated from the literature and from contacts with relevant experts and land managers. Many land managers, for example, have practical experience of how individual species perform under particular management regimes. Rich (1997) provides summary management recommendations for 15 selected rare and scarce grassland species. The Biological Flora accounts published in the *Journal of Ecology* are useful sources of published information on species autecology which can be used to help inform management prescriptions. Table 13.2 lists the rare and scarce species for which accounts have been published to date.

Table 13.2: Rare and scarce grassland plant species covered by published Biological Flora accounts *
(as at 31/10/1998)

Arabis scabra	Bristol rock-cress	*Orchis militaris*	Military orchid
Corynephorus canescens	Grey hair-grass	*Peucedanum palustre*	Milk-parsley
Draba aizoides	Yellow whitlowgrass	*Polemonium caeruleum*[1]	Jacob's ladder
Gentiana pneumonanthe	Marsh gentian	*Potentilla rupestris*	Rock cinquefoil
Helianthemum apenninum	White rock-rose	*Pulsatilla vulgaris*[1]	Pasque-flower
H. canum	Hoary rock-rose	*Sesleria albicans*	Blue moor-grass
Hornungia petraea	Hutchinsia	*Silene nutans*	Nottingham catchfly
Hypochaeris maculata	Spotted cat's-ear	*Tephroseris integrifolia*	Field fleawort
Linum perenne[1]	Perennial flax	*Thymus serpyllum*	Breckland thyme
Lobelia urens	Heath lobelia	*Viola lactea*	Pale dog-violet
Lychnis viscaria	Sticky catchfly	*Vulpia ciliata* ssp *ambigua*	Bearded fescue

[1] Species accounts produced in Rich (1997)
* For full references, see Chapter 17, section 17.2.

13.4.3 Life history characteristics

Understanding the life cycle is critical. Plants may be annuals, biennials or short- or long-lived perennials and may flower once only (monocarpic) or many times (polycarpic). Some short-lived plants may be a little plastic in these respects and may behave differently in cultivation to the wild (eg *Teucrium botrys*). The times at which each species produces leaves, flowers and fruits should be taken into account when deciding the timing of management operations such as grazing. Figure 13.6 (from Rich 1997) shows the sort of information that can be useful.

Some species reproduce by seed alone, some by both seed and vegetative growth and a few can spread vegetatively without producing seed. In the former two cases, allowing the populations to produce both flowers and ripe seed is clearly essential. Some species will have the ability to form a persistent soil seed bank which may be particularly important for restoration management.

Many orchid species spend periods underground as seedlings and tubers prior to producing leaves and time of first flowering may not necessarily coincide with the production of leaves and some adults may remain dormant for short periods depending on environmental conditions (Wells 1981). Thus management decisions, particularly changes, should not be made hastily but should be informed by long-term monitoring. With orchid species, merely censusing flowering plants may seriously underestimate population size and it is thus important to census vegetative plants and to ensure census is undertaken at other periods during the year as some individuals may produce leaves which are ephemeral and die back with the tuber surviving underground (Sanger & Waite 1998).

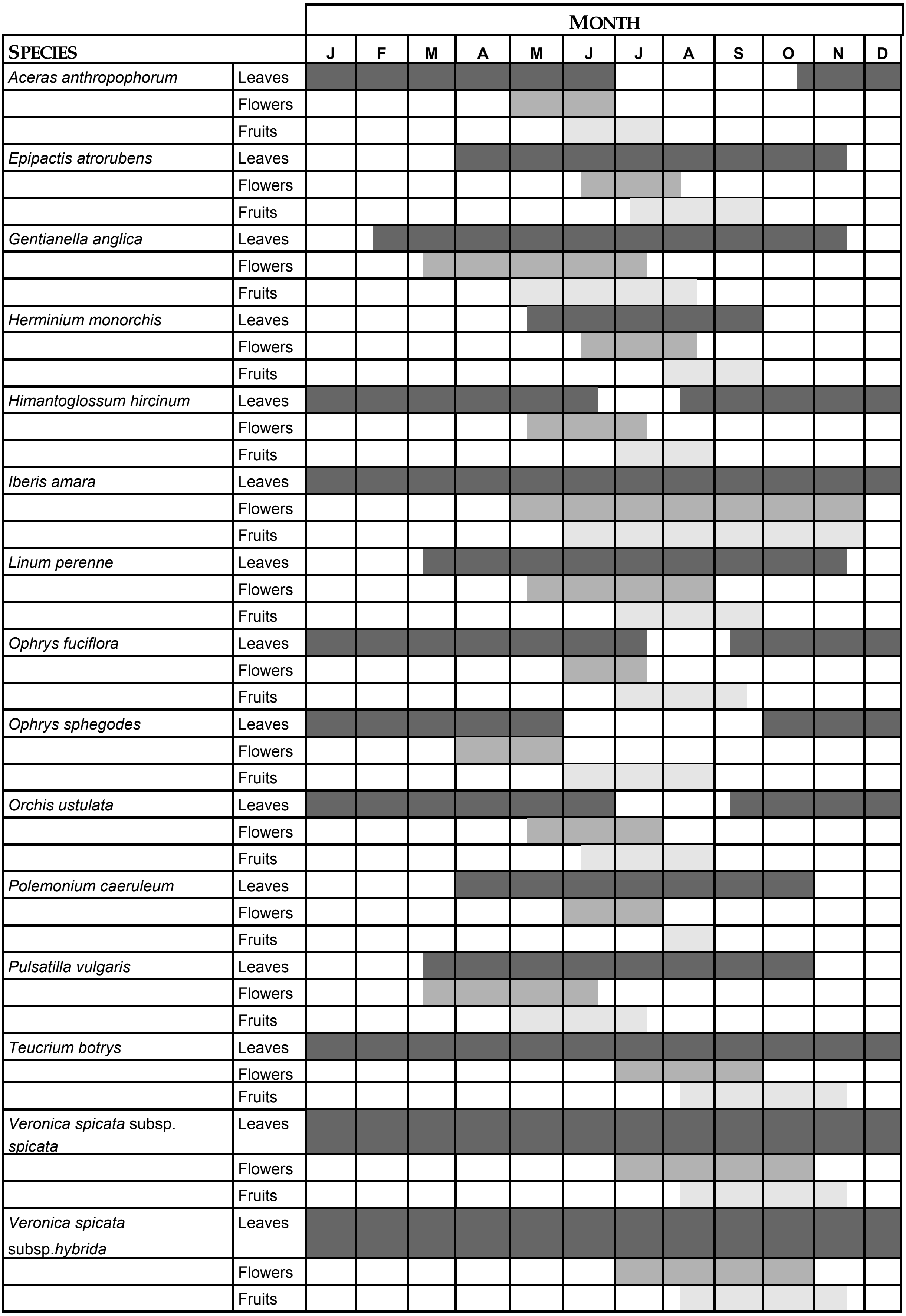

Figure 13.6 Summary of life cycles of selected rare and scarce lowland semi-natural grassland plant species (Rich 1997). See Table 13.3 for English names of species.

For many species, research and careful observation is required to determine which factors limit reproduction. It is notable, for example, that many rare orchids produce very few ripe seed pods due to limited pollination. An understanding of natural population cycles, which may vary according to the life cycle and climate in addition to management, is also valuable and may require observation over a period of five years or more.

13.4.4 Habitat requirements

A knowledge of the optimum environmental conditions for particular species is also critical for taking decisions about management, some of the former can be controlled by management regimes and some are dependent on the prevailing physical, chemical and biological environment. These include parameters such as soil type and nutrient status, microclimate, hydrology, sward structure and composition including amount of bare ground and associated flora and fauna (eg pollinators required, mycorrhizal associations etc). The impact of different management operations on the growth and behaviour on different stages of a species life history may also be useful. Waite & Hutchings (1991), for example, recommended that winter sheep grazing was the best management option for *Ophrys sphegodes* as cattle grazing increased the mortality of the tubers.

Knowledge of palatability of the species, including its various parts, to herbivores and its variation through the year can also be useful in reaching decisions about management.

The above information can be gained from the existing literature, research studies including monitoring, practical observation and experimentation, and discussion with land managers.

13.4.5 Management

Ideally the management regime should aim to maximise reproductive output and the amount of suitable habitat for germination and the survival of different cohorts (seedling, juvenile, adult) within the constraints imposed by the need to sustain other important habitats and species. In some circumstances management which is optimal, for example, for seedling germination, may be sub-optimal for adult plants. This constraint could be overcome by ensuring environmental heterogeneity is maintained within a site by adjusting the management regime or varying the management from year to year.

There is no substitute for practical experience of management, especially when this is coupled with detailed population studies and knowledge of appropriate habitat requirements. Although there is often much published about the autecology of individual species, suitable management regimes are rarely documented in the literature. As indicated earlier, the management regime often represents a compromise between different requirements of the different plant and animal species and communities on sites and it is important to be clear on the priorities.

The main forms of management relevant to rare plant conservation are livestock grazing, mowing, burning and disturbance. An outline of these techniques is provided in Chapters 5, 6 and 8. For grazing, the critical aspects in determining appropriate regimes for specific rare species are likely to be timing and intensity and possibly type of stock. For mowing the timing and height of cutting and whether cuttings should be removed should be considered. For controlled burning, the time of year and weather conditions and frequency are likely to be important. Finally, as far as mechanical disturbance is concerned (eg rotovation, chain harrowing) timing, intensity, depth and location are key parameters. Examples of management recommendations are provided in Table 13.3. These have been extracted from Rich (1997).

Table 13.3. Summary management recommendation for selected rare and scarce species

Man orchid *Aceras anthropophorum*	A polycarpic, short-lived* perennial herb which reproduces by seed. It occurs in lightly-grazed and rank grassland and scrub, and possibly also as a pioneer of open calcareous ground. Surprisingly little is known about what management favours it; scrub clearance and light late summer-winter grazing by cattle or sheep (less than 2/ha) are currently thought to maintain populations, while heavy grazing or dense scrub and woodland development are probably undesirable. It may tolerate mowing.
Dark-red helleborine *Epipactis atrorubens*	A perennial herb, reproducing by seed and forming small spreading clumps by rhizomes. It is susceptible to summer grazing (especially the inflorescences) and prefers ungrazed or lightly-grazed sites. Some ungrazed sites may require scrub clearance or no management at all. Some sites with populations in inaccessible places such as on ledges or limestone pavements can be grazed by stock at any density or timing. Other sites may be grazed by sheep at up to 5-6 animals/ha between September and April, preferable leaving a sward of about 10cm tall and up to 10 per cent bare ground.
Early gentian *Gentianella anglica*	A monocarpic, biennial herb of open chalk and limestone turf which reproduces solely by seed and varies markedly in abundance from year to year. Management is flexible but should aim to keep the turf less than 5cm tall and with 2-10 per cent bare ground, preferably by natural rabbit grazing or autumn-winter sheep or cattle (0.5-2 animals/ha) grazing from August to March.
Musk orchid *Herminium monorchis*	A perennial herb which reproduces both from seed and vegetatively. Populations vary in size depending on management and climate. The grazing regimes can be quite variable but if reproduction from seed is required it should not be grazed from June to September. It should be aimed to get a short open sward up to 5cm tall and 30 per cent bare ground, probably with intensive sheep grazing.
Lizard orchid *Himantoglossum hircinum*	A polycarpic, winter-green, long-lived* perennial plant which reproduces by seed and is often sporadic in appearance and in small quantities. The ideal habitat is tall, open, calcareous grassland with a sward height of 5-30cm and up to 50 per cent bare soil, which should be maintained by management in August by mowing with raking of leaf litter and moss, burning or scrub clearance. Grazing is not recommended.
Candytuft *Iberis amara*	An annual with a long-persistent seed bank. It requires open, chalky ground which can be created manually in spring or autumn, or naturally by rabbits or light stock grazing. It is tolerant of a range of grazing practices provided open ground is available, though it does not appear to tolerate intensive stock grazing.
Perennial flax *Linum perenne* subsp. *anglicum*	A polycarpic perennial which reproduces by seed. It can be managed by mowing late in the year to 10-15cm height, or by light cattle or sheep all year or preferably during the winter only leaving a reasonably long sward. It can persist for a number of years without management, or for short periods of moderate grazing all year.
Late spider-orchid *Ophrys fuciflora*	A polycarpic, long-lived* winter-green perennial which reproduces mainly by seed and locally vegetatively; seed set is very poor. It occurs in chalk grassland up to 15cm tall at flowering with up to *c* 2 per cent bare ground. Grazing by cattle (*c* 2/ha) and/or sheep (5-10 ewes/ha) from September to May to obtain the above sward is recommended. Mowing in August may assist with control of rank swards.
Early spider-orchid *Ophrys sphegodes*	A winter-green, short-lived* perennial herb which reproduces mainly by seed. Short-term fluctuations in grazing pattern can have marked effects on the population dynamics, and population should not be grazed in the flowering and fruiting seasons. Grazing should be by sheep from September to March (two animals/ha) or by cattle (0.5-1 animals/ha), aiming to get a short CG2 sward to *c* 2.5cm with *c* 1-5 per cent bare ground. Some coastal sites may need no management.

Burnt orchid *Orchis ustulata*	A polycarpic perennial herb which reproduces mainly by seed, though seed production may be very low. Grazing should be light and preferably by sheep or sheep and cattle, from early spring until April, and then with a further spell from July (from late August for var. *aestivalis*) into the winter. Hay meadows can be managed by traditional patterns with no grazing between May and the end of July, followed by light cattle and/or sheep grazing through the autumn and winter.
Jacob's ladder *Polemonium caeruleum*	A grassland/woodland edge perennial which reproduces by seed. It is sensitive to grazing, and sites should be ungrazed or grazed by cattle in the autumn at most once every three years. Occasional mowing or strimming with finely fragmented cuttings left in place may be a substitute for grazing if needed to control scrub or break up litter layers.
Pasque flower *Pulsatilla vulgaris*	A polycarpic, long-lived perennial herb which mainly reproduces vegetatively, and also rarely from seed. Management should aim to produce turf to *c* 5(-10)cm tall with up to 30 per cent bare ground, and there is much flexibility in how this is achieved. An ideal grazing regime is by sheep (up to 5/ha) from August to April. Plants also survive in burnt or mown swards.
Cut-leaved germander *Teucrium botrys*	A predominantly monocarpic, biennial of open disturbed ground which reproduces by seed. Management should aim to create open conditions in the autumn by rotovation, raking turf cutting or light grazing as appropriate taking care to protect established seedlings. Scrub invasion should be limited by cutting scrub or by light grazing.
Breckland spiked speedwell *Veronica spicata* subsp. spicata	A long-lived, evergreen, perennial which colonises open ground vegetatively but also reproduces by seed if the inflorescences are not grazed off. It requires short open turf, *c*1cm tall and with up to 30 per cent bare ground, and will be eliminated by closed, long turf. It is tolerant of heavy grazing by rabbits or sheep to high stocking rates. Sites can also be mown to maintain the short grass, but bare ground may also need to be created.
Western spiked speedwell *Veronica spicata* subsp. *hybrida*	A long-lived perennial which reproduces vegetatively and by seed. It typically occurs on cliffs and rocky slopes which require little or no management except control of scrub and non-native species. It will tolerate heavy grazing by sheep or mixed stock but does not flower; stock should therefore be excluded from June to September to optimise seed production.

* For orchids, short-lived = <8-10 years; long-lived = >8-10+ years

13.4.6 Summary recommendations

" Assess priority of specific species in context of other interest features (ie determine conservation objectives and establish appropriate targets).

" Collate data on species autecology and performance under various environmental conditions and management regimes from the literature and from practical experience.

" using collated information, assess management options which are likely to maintain/increase the population depending on objectives/targets.

" choose a management regime which will fulfill the conservation objectives and targets and which can be practically implemented given the specific constraints/opportunities pertaining to a particular site.

" monitor populations (remember - deciding which part of a species life history to monitor should be informed by information on life history characteristics) or monitor appropriate habitat condition. Evaluation of monitoring data should be undertaken in the context of the prescribed conservation objectives and targets which may or may not be determined by baseline population data.

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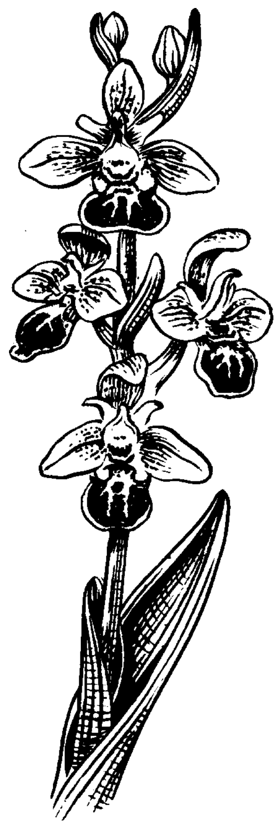

13.5 Management of lowland semi-natural grasslands for bryophytes and lichens

13.5.1 Introduction

The conservation of bryophytes and lichens (often referred to as cryptogams, plants with apparently hidden reproductive structures) in lowland grassland has for many years been largely incidental to the management of the habitat for other taxonomic groups. Lowland grassland is however important for these two groups, although the cryptogamic component is seldom present in such quantities as it is in various types of bog or woodland. The presence and range of microhabitats in grassland is often the key factor determining the richness of the cryptogamic flora.

A common problem for the non-specialist is to recognise when the cryptogamic component of a grassland is of interest or indeed present. As a guide, the conditions for cryptogam interest are likely to be favourable if the following features are present:

“ The grassland is tightly grazed, perhaps by rabbits and sheep, on calcareous soils but not exclusively so, with bare open ground, perhaps stony, interspersed with tussocks of fine grasses and herbs, particularly annuals and creeping herbs such as *Thymus praecox*, *Helianthemum nummularium* and *Hieracium pilosella*, but also some rosette-forming hemicryptophytes such as *Leontodon hispidus*, *Anthyllis vulneraria* and *Rumex acetosella*. Bare peaty surfaces in fen-meadows and rush pastures provide ground for a wide range of bryophytes including *Sphagnum* spp.

“ There are rock exposures, with crevices, scree, and partially embedded stones or rock fragments in the turf. Thin skeletal soils overlying rocks, perhaps remaining damp, are often very good for cryptogams. The presence of scrapes, ranging from small scale caused by grazing animals to large areas, perhaps caused by machinery, and spoil banks, adds further opportunities for establishment. Chalk-pits, sandpits and quarries within the grassland habitat are often very good for cryptogams.

“ Topography is varied with anthills, banks or ancient earthworks, or coombs, providing a range of aspects and angles of slope. Thin soils with low vascular plant cover on exposed south-facing sunny slopes are ideal for certain species of bryophyte while sheltered north facing slopes with more closed vegetation support a quite different assemblage of cryptogams. Tussocky structure in some fen-meadow types also encourages diversity, particularly of bryophytes.

“ Mosses, liverworts and lichens may be conspicuous, as in some Breckland grasslands and coastal cliff-top grasslands and fen-meadows, but often they are inconspicuous, particularly in the case of diminutive ephemerals.

Of the 32 lowland grassland NVC types (see Table 13.4) in British Plant Communities Vols. 2&3 (Rodwell 1991b, 1992) 116 bryophyte and lichen taxa are listed in the floristic tables. In the NVC, species with frequencies less than 5 per cent were not included in the floristic tables and bryophytes and lichens were not consistently recorded (furthermore the best time for recording bryophytes is in late autumn through to spring when surveyors are generally not in the field). At least 57 bryophytes typically found in mesotrophic, calcicolous or acidic lowland grasslands are not mentioned in British Plant Communities, and some 40 of these are either nationally scarce or rare (Porley, 1997a). To illustrate the problem, a more accurate assessment of bryophytes associated with mesotrophic, calcicolous and acidic lowland grasslands is at least 79 per cent greater than an analysis of the NVC floristic tables suggests. To give an idea of the relative importance of lowland grasslands for cryptogams, the number of bryophyte and lichen taxa listed in the floristic tables of each NVC type are shown in Table 13.4.

Table 13.4 Number of bryophyte and lichen taxa in each NVC type

NVC	Description	Nº of taxa
CG7	*Festuca ovina - Hieracium pilosella - Thymus praecox*	33
CG9	*Sesleria albicans - Galium sterneri*	30
CG10	*Festuca ovina - Agrostis capillaris - Thymus praecox*	29
U1	*Festuca ovina - Agrostis capillaris - Rumex acetosella*	26
MG2	*Filipendula ulmaria - Arrhenatherum elatius*	26
CG2	*Festuca ovina - Avenula pratense*	22
SD8	*Festuca rubra-Galium verum* dune grassland (includes machair grassland).	22
M25	*Molinia caerulea - Potentilla erecta*	20
CG1	*Festuca ovina - Carlina vulgaris*	13
OV37	*Festuca ovina - Minuartia verna*	13
CG8	*Sesleria albicans - Scabiosa columbaria*	12
U2	*Deschampsia flexuosa*	12
U4	*Festuca ovina - Agrostis capillaris - Galium saxatile*	11
M23	*Juncus effusus/acutiflorus - Cirsium palustre*	11
M27	*Filipendula ulmaria - Angelica sylvestris*	11
CG3	*Bromus erectus*	10
M22	*Juncus subnodulosus - Cirsium palustre*	10
M24	*Molinia caerulea - Cirsium dissectum*	10
M26b	*Molinia caerulea - Crepis paludosa - Festuca rubra* sub community	9
CG4	*Brachypodium pinnatum*	8
CG6	*Avenula pubescens*	8
U3	*Agrostis curtisii*	7
MG5	*Cynosurus cristatus - Centaurea nigra*	6
MG3	*Anthoxanthum odoratum - Geranium sylvaticum*	6
CG5	*Bromus erectus - Brachypodium pinnatum*	4
MG1*	*Arrhenatherum elatius*	4
MG4	*Alopecurus pratensis - Sanguisorba officinalis*	4
MG8	*Cynosurus cristatus - Caltha palustris*	4
MG9*	*Holcus lanatus - Deschampsia cespitosa*	4
MG6*	*Lolium perenne - Cynosurus cristatus*	3
MG10*	*Holcus lanatus - Juncus effusus*	2
MG7*	*Lolium perenne*	2
MG13	*Agrostis stolonifera - Alopecurus geniculatus*	2
MG11	*Festuca rubra - Agrostis stolonifera - Potentilla anserina*	1

* Communities considered to be of lower botanical interest (see Chapter 2)

Even making allowance for the under representation of cryptogams in the NVC there is clearly wide variation in the significance of the various lowland grassland types for bryophytes and lichens. Although there are relatively few Red List bryophytes and lichens (see Palmer & Hodgetts, 1996) associated with lowland grasslands, the highest incidence of such plants occurs in CG1, CG2, CG7 and U1 (Table 13.4). There are no Red List species associated with lowland examples of fen-meadows or rush pasture.

Bryophytes have some capacity to persist in a closed turf through the ability to retain and protect captured resources. Stronger competitors suffer greater loses through higher rates of tissue turnover and ineffective defences against herbivory (Grime, Rincorn & Wickerson, 1990). However, lichens are generally extreme stress-tolerators, and bryophytes are stress-tolerant strategists (Grime, 1979), or behave as ruderals. They are therefore most indicative of unproductive grasslands where competition from vascular plants is low. Bryophytes also show regenerative flexibility and have the ability to grow at low temperatures. This last feature is particularly important in explaining the ability of bryophytes to co-exist in grassland communities (Furness & Grime, 1982).

In terms of diversity, mesotrophic grasslands are generally of low interest because productivity is too high and vascular plants dominate. Only the common mosses *Eurhynchium praelongum* and *Brachythecium rutabulum* are normally found in mesotrophic grasslands, the last moss having a higher relative growth rate than many vascular plants (Furness & Grime, 1982). In some mesotrophic flood-plain grasslands the interest can be greater, with such species as *Amblystegium humile* occurring. A notable exception in mesotrophic grasslands is MG2, a tall-herb community that is typically ungrazed, found primarily in the uplands but also in the lowlands where cool, damp conditions prevail. Bryophytes here adopt a temporal strategy and exploit periods when vascular plants die back. The bryophytes and lichens occurring in MG2 are robust, relatively common plants.

The classic bryophyte/lichen-rich grassland types in Britain are CG7 and U1, particularly the *Cladonia* and *Cornicularia aculeata* - *Cladonia arbuscula* sub-communities respectively, both more or less restricted to the Breckland. The extreme continental climate, the oligotrophic soils and a long history of rabbit grazing are largely responsible for the rich cryptogamic flora typical of this area. Several Red-List lichens are found here including *Cladonia convoluta*, *Buellia asterella* and *Squamarina lentigera*. *Cladonia* spp. and *Cornicularia aculeata* form a prominent component of the open turf, together with the mosses *Hypnum cupressiforme*, *Dicranum scoparium*, *Rhytidium rugosum*, *Brachythecium albicans* and *Pseudoscleropodium purum* and the liverwort *Ptilidium ciliare*. The bryophyte flora of CG2 grasslands can also be very rich (Porley, 1997b). In Britain some species are more or less confined to semi-natural grasslands over chalk, such as *Seligeria paucifolia, Thuidium abietinum* ssp *hystricosum* and *Pottia caespitosa*. Other notable CG2 grassland bryophytes include *Entodon concinnus, Thuidium philibertii, Barbula acuta* and *Pterygoneurum ovatum*, all dependent on an open, tightly-grazed turf. Indeed, bryophyte and lichen communities of chalk downland are important in an international context (Palmer & Hodgetts, 1996).

Table 13.5 Red List and near threatened bryophytes and lichens that may occur in lowland semi-natural grasslands

Scientific name	NVC Community	Status
Acaulon triquetrum	CG1, CG7	RL
Cheilothela chloropus	CG1, CG7, CG2	NT
Eurhynchium meridionale	CG1	RL
Funaria pulchella	CG1, CG2, CG7, CG9, CG10	NT
Leptodontium gemmascens	U1, U2	RL
Weissia levieri	CG1, CG2, CG7	RL
Weissia condensa	CG1, CG2, CG7	RL
Weissia sterilis	CG2	NT
Cephaloziella baumgartneri	CG1, CG2, CG7	RL
Cephaloziella calyculata	CG1, CG2, CG7	NT
Cephaloziella integerrima	U1	RL
Lophozia perssonii	CG1, CG2, CG7, CG8	NT
Southbya nigrella	CG1	RL
Buellia asterella	CG7	RL
Cladonia convoluta	CG1, CG2, CG7	RL
Collema bachmanianum	U1, CG7	NT
Fulgensia fulgens	CG1, CG7	NT
Squamarina lentigera	CG1, U1	RL

RL = Red List
NT = Near Threatened (after IUCN criteria, 1994)

It is very difficult to unequivocally ascribe specific cryptogams to a particular grassland, or indeed to grassland. The microhabitat is the key determinant. Most can occur in a number of habitats, eg cliff tops, sand-dunes, mine waste, woodland rides, on walls and even on thatch. It is assemblages or communities of cryptogams rather than species *per se* that are of importance in lowland grassland.

13.5.2 Micro-habitats

Open bare ground is probably the most crucial requisite for cryptogams, and this is usually well represented in CG1, CG2, CG7, U1 and OV37. The cryptogamic flora of bare ground in dry calcifugous grasslands tends to be less diverse than those in calcicolous grasslands, although no less distinctive.

" Relatively large areas of bare ground, for example a spoil heap of weathered chalk, at least in the early successional stages, can support many local and notable plants, such as the Red List liverworts *Lophozia perssonii* and *Cephaloziella baumgartneri*. Bare ground is particularly important for the many ephemerals and often diminutive mosses such as *Phascum* spp., *Pottia* spp., *Ephemerum* spp., species that have a short lived gametophyte stage and persist through periods of stress (such as summer drought) by buried spores, or in the case of *Bryum* spp. and *Dicranella* spp., by underground tubers. Diaspore banks in grasslands are therefore important, but there has been little investigation into their viability over time or under different conditions. Indications are that in chalk grassland bryophyte vegetative diaspores can remain viable for 10 years or more (During & Horst, 1983). Depressions in calcicolous grassland, caused for example by cattle hooves, are also available for colonisation by bryophytes, such as the liverwort *Leiocolea turbinata*.

“ Anthills are typically characterised by a suite of bryophytes including *Ceratodon purpureus*, *Bryum* spp., *Polytrichum* spp., *Pleuridium* spp. and, in some calcicolous grasslands, *Rhodobryum roseum*, a distinctive and relatively robust moss capable of co-existing with vascular plants. Anthills that have been disturbed by woodpeckers or badgers frequently provide a niche for mosses such as *Pottia recta* and *Phascum curvicolle*, particularly on sheltered northern aspects of the mound.

“ Stony ground with a thin mantle of soil, which is relatively free of vascular plants, support such mosses as *Didymodon* spp., (*Barbula*), *Weissia* spp., *Pottia* spp., *Aloina* spp., *Tortella* spp., *Trichostomum* spp., *Seligeria* spp. and the liverworts *Riccia* spp., *Lophozia* spp. and *Cephaloziella* spp. Among the lichens of this microhabitat are *Fulgensia fulgens*, *Diploschistes scruposis*, *Toninia caeruleonigricans*, *Psora decipiens*, *Collema* spp. and *Peltigera* spp. These often occur near the coast where soils are droughted and under maritime influence. The Near Threatened moss *Cheilothela chloropus* is also typically found in open rocky calcicolous turf on the southern coast of England.

“ Small, partially imbedded chalk and limestone stones in grasslands are important in providing niches for the mosses *Seligeria paucifolia* and *S. calcarea*. Rock outcrops and crevices support species that would not otherwise find a niche, such as *Grimmia orbicularis*, *Tortella nitida*, and *Scorpiurium circinatum* in southern calcicolous grasslands. The diverse cryptogamic flora of the CG9, in part due to its more northern locus and hence wetter climate, is also to a large extent due to exposures of bedrock, ledges and talus.

“ In some fen-meadow types bare peaty ground can support a range of tiny hepatics together with more robust mosses such as *Aulacomnium palustre* and *Sphagnum* spp. In the west of Britain, *Hookeria luscens*, *Funaria obtusa* and *Archidium alternifolium* can be found on the bare bases of *Molinia* tussocks in Culm grassland (M24/25) and runnels in fen-meadows and rush pastures (M22-27) support such species as *Sphagnum auriculatum* and *Riccardia multifida*.

13.5.3 Aspect

“ A widespread calcicolous grassland typically on north-facing slopes is the *Pseudoscleropodium - Prunella* variant of a CG2a. It is marked by an abundance of the mosses *Pseudoscleropodium purum*, *Hypnum cupressiforme*, *Hylocomium splendens* and *Dicranum scoparium*, and more locally, *Neckera crispa*. The turf is characteristically ‘springy’ and is essentially dominated by bryophytes able to persist partly due to their relative unpalatability.

“ A distinctive and possibly British-endemic bryophyte community, termed by Francis Rose the *Scapanietum asperae* (unpub.), occurs on some north-facing slopes of chalk and limestone grasslands. It is characterised by the hepatics *Scapania aspera*, *Frullania tamarisci*, *Porella arboris-vitae* and *Jungermannia atrovirens*, and the mosses *Tortella tortuosa* and *Ditrichum flexicaule s.l .* Although predominately upland, this hepatic community extends into southern England. It has, however, markedly declined in the southern part of its range, thought not only to be due to loss of grassland, but also to a general trend away from sheep grazing to cattle grazing. On the southern downlands the *Scapanietum asperae* is characteristic of sheep terracettes; cattle eliminate these terracettes with a consequent loss of the specialised niche.

“ On southern aspects or on flat ground where unproductive soils periodically experience drought and are exposed to high levels of insolation a quite different cryptogamic flora develops. Such conditions typically occur in CG1, CG2, CG7, U1, OV37 but also frequently in CG3 and CG5 grasslands. Ephemerals are common in late winter, such as *Pottia* spp. and *Phascum* spp. but there are also characteristic perennials including the mosses *Homalothecium lutescens*, *Campylium chrysophyllum*, *Ctenidium molluscum* and more locally *Entodon concinnus* and *Thuidium abietinum* in calcicolous grasslands, and in calcifugous grassland, or on leached soils, *Racomitrium ericoides*, *R. elongatum* and *Polytrichum* spp.

“ Ancient earthworks and banks, with thin soils and open, species-rich turf, are invariably good for bryophytes. The variation in topography, aspect and position on slope provides numerous niches. Indeed, ancient earthworks are often the richest areas for cryptogams in grasslands, especially in calcicolous communities. *Entodon concinnus* and *Thuidium abietinum* are typically found here, and in more sheltered conditions *Thuidium philibertii* and *Tortella tortuosa*.

“ The scrub-grassland ecotone is also important for bryophytes, particularly in calcicolous grasslands. Typical species are *Rhytidiadelphus triquetrus*, *Eurhynchium striatum* and more locally *Mnium stellare*. *Fissidens pusillus* and *Rhynchostegiella tenella* occur on stones and detached fragments of rock under light shade, and more locally, *Seligeria paucifolia* and *Tortella inflexa* on chalk and soft oolitic limestone pebbles. Scrub itself is also often rich in epiphytes, particularly elder scrub.

13.5.4 Management of grasslands for bryophytes and lichens

Grazing is the most important factor in maintaining the cryptogamic interest of most lowland grasslands. Bryophytes and lichens are generally unpalatable to herbivores and most species are intolerant of shading. There has been a marked decline in lichens and bryophytes as a result of scrub and coarse grass encroachment as fewer grasslands are grazed. Many of the species have poor dispersal abilities and only slowly return, if at all, following resumption of grazing. Rabbits have been critical in maintaining open turf conditions in many parts of Britain, providing a refugia for bryophytes and lichens. Rabbit activity, unless leading to excessive disturbance, is therefore of benefit to cryptogams. The downward trend in rabbit numbers since the 1950s has had serious repercussions for the cryptogamic flora of grasslands, but locally at least, numbers are increasing, albeit not to the pre-myxomatosis levels

Best practice

“ Sheep are the ideal gazers in most situations on calcicolous and calcifugous grasslands. Timing is not critical, but is generally better in summer, particularly on the least productive soils. Sheep produce a fine turf and cause minimal damage through trampling. This is particularly important with respect to foliose lichens, which, under dry conditions, can be damaged by cattle. Rabbits are also desirable, and will produce a more open turf by selective grazing. Targeting and controlling rabbit grazing can, however, be a problem. Cattle are better than no grazers, and mixed grazing often achieves the objectives of maintaining a short open turf. However, sheep are the preferred grazers of the *Scapanietum asperae* community where it occurs on the southern edge of its range on the chalk. Where this community occurs on the limestones of the Mendips and further north, cattle grazing is acceptable. Moderate grazing by cattle of fen-meadows and rush pastures is ideal where trampling and minimal poaching will create favourable conditions for bryophytes. Dolman & Sutherland (1992) suggest that a combination of rabbit grazing and sporadic disturbance represent the optimal management for Breckland lichen-rich grass-heaths. Sheep grazing was considered to be sub-optimal but this may be due more to lower stocking densities than previously practised coupled with fewer rabbits rather than sheep being bad *per se*. However, the use of sheep grazing should clearly be carefully considered in the management of lichen-rich communities.

" In dry calcicolous and calcifugous grasslands grazing should aim to produce a turf of around 2cm in height, although on north-facing and sheltered slopes the turf can be up to 5cm. The aim should also be to graze some areas harder, most easily achieved by rabbits but difficult to control. Clearly it will be necessary to ensure that this level of grazing does not conflict with the wider conservation objectives of the grassland. On mesotrophic grasslands, such as pasture and aftermath grazing of hay meadows, where the bryophyte and lichen interest is inherently low, management should be directed towards maintaining the particular vegetation community. In fen-meadows and rush pastures structural diversity is important, and grazing should aim to produce short sedge-rich areas in among the taller herbaceous vegetation.

" An objective of managing dry grasslands should be to provide a patchwork of bare ground. This will often occur naturally as a result of thin droughted soils reducing competition from vascular plants, slippage on steep slopes, grazing activities and disturbance. Consider creating areas of bare ground if natural occurrences are limited, or to provide suitable conditions for specific plants. The optimal proportion of bare ground will depend on the particular interest and may vary considerably between sites.

Bad practice

Some of the management practises discussed in Chapters 8 and 9 are generally harmful to the cryptogam interest, either directly or indirectly.

" Fertiliser application raises the productivity of the soil and gives competitive advantage to vascular plants. In this situation only those bryophytes with high relative growth rates will survive or establish, leading to a rapid loss in the more interesting grassland specialists. The effect of herbicides on cryptogams applied to control vascular plants is complex; some bryophytes may benefit, and a flora resembling that initially developing after fire damage, comprising bryophyte weed species, has been reported (Brown, 1992). This has been attributed in part to reduced competition from vascular plants.

" Burning is generally harmful to cryptogams. Although it is often considered a useful method to eliminate litter accumulation, the consequent nutrient input, particularly in dry grasslands, will raise the productivity of the soil to the detriment of bryophytes and lichens. Although not usually used as a management tool on grasslands that are typically rich in cryptogams, burning is normally a practice carried out in the winter months when bryophytes in particular are actively growing.

" Scrub removal and control may be an important facet of management on a grassland. Care should be taken not to eliminate scrub that supports notable epiphytes.

" Air pollution is also thought to be damaging to the cryptogamic flora, despite the large buffering capacity of calcareous soils. There is evidence from Dutch chalk grasslands that nitrogen deposition has led to an impoverishment of the bryophyte and lichen floras (During & Willems, 1986). This is partly due to indirect effects such as increase in the productivity of the soil, but also probably has a direct effect since many grassland cryptogams are known to be sensitive to pollutants. In addition, air pollution also causes a reduction in fertility of some cryptogams which clearly has implications for dispersal.

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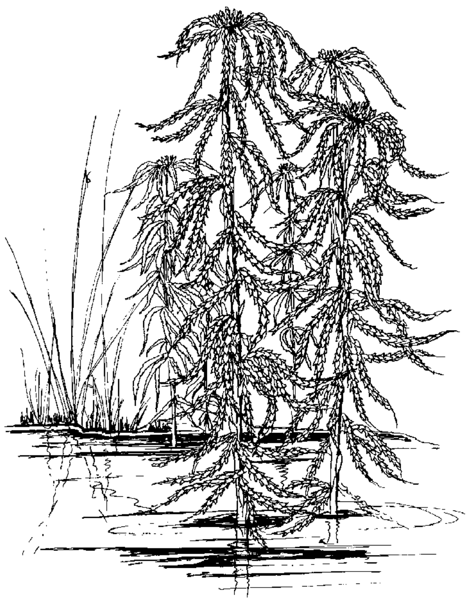

13.6 Management of grassland for reptiles and amphibians

13.6.1 Introduction

Most of the native (non-marine) British reptiles and amphibians (herpetofauna) rely to some extent on lowland grassland habitats in parts of their range. Common frogs *Rana temporaria*, common toads *Bufo bufo*, smooth newts *Triturus vulgaris*, palmate newts *T. helveticus* and great crested newts *T. cristatus* will all use grasslands for foraging and shelter where they occur in proximity to breeding ponds. It is often overlooked that most frogs, toads and newts spend a much greater proportion of their lives on land than in water.

Natterjack toads *Bufo calamita* have very different habitat requirements compared to the more widespread species of amphibians. They do occur in grassy habitats but usually where the sward is short and open and forms part of a mosaic with heathland, grazing marsh or dune habitats (see Beebee & Denton 1996).

Lowland grassland of various types is of vital importance to our widespread reptiles. Adders *Vipera berus* and common lizards *Lacerta vivipara* are frequently associated with grassland, especially where it borders heathland. The interface between grassland and another habitat type, such as scrub or broad-leaved woodland, will often be of particular importance. In some areas, such as Kent, adders are found almost exclusively in a small range of habitats of which chalk grasslands are of prime importance. Slow-worms *Anguis fragilis* have been recorded from grassland more frequently than any other habitat type in the most recent national survey (Swan & Oldham, 1993b). Grass snakes *Natrix natrix* are similarly often found on grassland, particularly in wetter areas. Although the "rare" reptiles (sand lizard *Lacerta agilis* and smooth snake *Coronella austriaca*) are much more restricted in their requirements, most commonly being associated with lowland dry heath, they may also take advantage of adjoining semi- or unimproved grassland, particularly short dry acid grassland (NVC types U1 and U3 - see Chapter 2).

Loss of and changes to habitats are reported to be the predominant causes for declines in reptile and amphibian populations. Within this broad category, unsympathetic management is a frequently overlooked factor, yet one which needs to be addressed seriously and rapidly. Whether it is in the form of "improvements" (eg Hilton-Brown & Oldham 1991) or inappropriate cutting or mowing regimes (see, for example, Corbett, 1989 p. 86), habitat management can have drastic effects on resident herpetofauna. In fact, it is true to say that, in some cases, insensitive management can have virtually the same effect as outright site loss through development.

13.6.2 Management objectives for reptiles and amphibians

Favourable habitat management can help to counter the declines outlined above by:

“ Enhancing existing herpetofauna populations on sites which were previously neglected or inappropriately managed (eg birch scrub clearance on a neglected acid grassland site).

“ Expanding the area of available high quality habitat on existing herpetofauna sites (eg converting abandoned arable land bordering a chalk downland site into a suitable amphibian foraging area).

" Forming links between sites, in order to (a) facilitate exchange of animals between sites, or (b) allow currently unoccupied sites to be colonised (eg the provision of a corridor of rough grassland between otherwise isolated amphibian ponds).

" Allowing currently unoccupied sites to be prepared as a receptor site for translocations (eg adopting an appropriate grazing regime to accommodate newts, on a site which has been previously been over-grazed)

Several features of the biology and ecology of reptiles and amphibians mean that management techniques must take particular regard of their presence. Being ectothermic (ie their body temperatures are maintained by external heat sources), the temperature relations of the habitat, chiefly governed by vegetation structure, substrate type and aspect, is of great importance. This is especially true for the reptiles, whose thermoregulatory behaviour (ie active control of temperature by behavioural means) involves periods of basking in order to achieve preferred body temperatures before activities such as foraging and courtship can occur. The species differ in their requirements for basking areas; for example common lizards often bask in exposed locations while slow-worms and smooth snakes prefer to sun themselves under partial cover. Conversely, areas of fairly dense vegetation are needed for cover when the heat of the sun is too intense or to provide cover when temperatures are too cool to allow activity. Management practices should therefore reflect the need for the provision of appropriate areas for basking and cover. In addition, a variation in topography is desirable as this aids thermoregulatory behaviour. Thus, the provision or enhancement of banks, gullies, tumuli, cuttings and slopes is of value.

The habitat must also supply sufficient prey to support the species in question. For juvenile and adult amphibians, this will mean a good supply of invertebrates, particularly insects, crustaceans, molluscs and annelids. Areas immediately surrounding breeding ponds should be managed so as to maximise their value for such invertebrates (comprehensive practical guidelines are given in Kirby, 1992). Lizards also prey upon a wide range of invertebrates. As a generalisation, grass snakes take largely amphibian prey while adders and smooth snakes prefer small mammals and lizards.

A key aim for management on amphibian sites will be to ensure there is a sufficient area of good quality terrestrial habitat near and immediately adjacent to the breeding pond. Adult amphibians may use this area for foraging throughout the active season, and emerging metamorphs (froglets, toadlets and efts) will require shelter and access to food from around June onwards. In practice, this requires rough or tussocky grassland and ideally some areas of scrub and woodland. These areas ideally need to be linked together by suitable habitats to allow movement between them.

Most native reptiles and amphibians hibernate for at least 3 months, and up to 6 months, during which time, being torpid, they are particularly vulnerable to invasive operations which disturb the ground. Many species will hibernate communally in large numbers.

Summarising these considerations, the needs of herpetofauna on grassland include:

For reptiles

- a varied vegetation structure to allow both open areas for basking and more densely vegetated areas for refuge (interfaces between habitats, such as grassland and scrub, providing "edge effects," can be beneficial);
- variation in topography and aspect, with some south-facing areas, to facilitate basking;
- night-time refuges such as log piles, dry stone walls or ground crevices;
- frost-free, well-drained hibernation sites such as south-facing banks.

For amphibians

- (for the widespread species) rank vegetation which affords shelter from desiccation, extremes of temperature, and predators, particularly around breeding ponds;
- hibernation structures such as wood piles, old tree stumps and crevices in roots, as found in woodland, rubble piles etc;
- breeding ponds;

For natterjacks

- extensive areas of short, well grazed habitats or bare ground to allow active foraging;
- soft, eg sandy ground for burrowing;
- shallow breeding pools;

For both groups

- suitable habitat to allow free movement between foraging, breeding and hibernating areas;
- lack of disturbance during the active season, particularly during the early period after hibernation and the breeding season (March - June for reptiles and February - May for amphibians);

13.6.3 Achieving management objectives

Planning

It is important to conduct a survey of the herpetofauna interest on a reserve or site before management is planned. This will allow the manager to identify where the animals occur on the site, how they use the site and which areas might be particularly important. From this information, it will be possible to determine the management needs of the site. As reptiles and amphibians have quite specific requirements, and relatively small sections of a site can be of disproportionate importance to their populations (eg a hibernation site on a boundary bank), the value of a prior survey cannot be understated. In addition, it will assist with planning monitoring exercises.

Techniques for managing amphibian and reptile habitats

The reader is referred to Chapters 5, 6, 8 & 9 for specific advice on techniques. The following notes should be read in conjunction with these when planning management on herpetofauna sites.

Grazing

Grazing is a technique to be viewed with caution when considering management options on sites supporting herpetofauna. Whilst grazing may be of increasing popularity as a means of effectively controlling the successional stage of grasslands, it has been shown to have seriously deleterious effects on some species, particularly reptiles. This appears most commonly to have been due to uncontrolled or over-intensive grazing regimes. Ironically the deleterious effects of grazing on many amphibian and reptile species may benefit natterjacks. Grazed areas favour the active foraging techniques of this species and also reduce competition from other amphibians and predators such as grass snakes.

When drawing up the management plan, it should be clearly decided what type - and what extent - of vegetation control is required to benefit the herpetofauna on site. From this, it will be possible to decide whether grazing is the best option. To check the growth of grass swards and some scrub species, grazing can be of considerable use as it overcomes some disadvantages of cutting or mowing. There is less chance of killing animals (although trampling may be a problem at high densities), and grazing can be selective (ie certain types of livestock will preferentially remove particular species). In a large site with a general need for control of sward height, grazing may be the best option. However, grazing animals may be difficult to control, may home in on sensitive areas and cause damage to favoured microhabitats and disturb reptiles and amphibians.

Livestock can be restricted via fencing to certain parts of the site so that particular problems with scrub can be targeted. Guidance on the best type of livestock is given in Chapter 5. Care should be exercised on important sites during the active season for reptiles (March-September), and in particular at the start of this period, when they are just emerging from hibernation (reptiles are especially vulnerable at this time).

On sites containing amphibian breeding ponds, cattle may need to be excluded from some ponds to avoid excessive poaching. However, in some circumstances - particularly in ponds choked with aquatic and marginal vegetation, some degree of trampling around part of the pond edge may be beneficial.

Muck heaps can provide high quality egg-laying sites for grass snakes if regularly maintained and located in sunny areas (see below and references).

Mowing, cutting and flailing

Removal of vegetation and checking of grass swards and scrub can be achieved quickly and easily by mowing and cutting. For control of grasses, scrub or shrubby species, the operation is best carried out from September to February, thus avoiding the active season. Care should be taken in years with an unseasonally warm autumn, when reptiles can still be found above ground in significant numbers into November. With careful planning, it is possible to create easily some very beneficial habitat features, such as a mosaic of rough and short sward areas. Areas to be maintained close-cropped should be mown regularly through the spring and summer (reptiles and amphibians generally avoid these areas - but checks should be made before any mowing takes place; in particular, emerging amphibians may be present after rain from June to October). Areas around amphibian breeding ponds should include some rank grass areas.

Scrubbed up areas within grassland sites can be targeted by a range of methods depending on the resources available and the size of the site (see Chapter 12). For reptile sites, it is often beneficial to retain some scrub and to create scalloped, south-facing bays, which can facilitate basking. Likewise, amphibians benefit from retention of some scrub as it provides cover and encourages prey species. Creating clearings or rides within scrubbed up patches or woodland linked to adjacent grassland sites, will assist with species migrations and will increase the value of these more densely vegetated areas for herpetofauna. Rides which run west-east should have the tree line on the southern edge set back to allow longer exposure to the sun.

Attention should be given when retaining a range of vegetation heights to including a range of species groups such as tussock-forming species (eg *Molinia,* some *Carex* spp), as well as tall grasses and herbs.

Grass cuttings, brash, coppice and other products of vegetation cutting may be retained on site to assist with herpetofauna requirements, rather than being chipped, burned or exported to other sites. Grass snakes require piles of decomposing vegetation for egg-laying (see references). These should be placed in sunny areas, close to cover, and should contain a mixture of "soft" material, such as a grass or hay cut, and more rigid material to provide crevices for females to enter the heap. Grass snake egg-laying sites should be as large as practical and may need to be replenished every year or two depending on the degree of decomposition. These need to be located in the same area each year as individual females tend to return to the same egg-laying site. Cut branches can be stacked in sunny areas to create plies which aid basking and provide refuge. Alternatively they can be cut into small sections and buried with topsoil to create hibernation sites.

Burning

Burning is not an appropriate technique on most herpetofauna sites, especially those supporting important reptile populations. Where it is identified as essential, it should only be carried out from November to February (to avoid killing active herpetofauna) and should be kept to as small an area as possible and care should be exercised to avoid burning important reptile "hotspots." Prior survey should be carried out to identify these areas, and likely parts of the site to avoid include around hibernation sites, summer feeding areas and favoured basking spots. Wherever possible, however, burning should be avoided. As well as threat to animals, the total removal of vegetation through burning may result in little or no cover being available when animals emerge from hibernation in Spring.

13.6.4 Damaging management operations, and conflicts with other objectives

Controlling or mitigating for damaging operations

On many sites, grazing will need to be controlled so that particular features are not overgrazed or trampled. Foraging and sheltering areas provided by rank and tussocky grassland areas are easily damaged by over grazing. Fencing can help, as can excluding livestock at sensitive times of the year.

Gassing of rabbits during winter is potentially disastrous for hibernating reptiles and amphibians. Snakes and lizards, and also sometimes amphibians, will hibernate communally in rabbit burrows (and those of other mammals). Gassing can thus eradicate a significant proportion of the population and should be avoided. Other below ground disturbance, such as rotovation, should be avoided in likely hibernation areas between October and March, so as not to damage hibernating animals. Even shallow disturbance can be very damaging, because both reptiles and amphibians sometimes overwinter just below the ground surface when substrate conditions are suitable.

As with other species groups, the importance of a prior survey to identify how these animals use the site cannot be stressed too strongly. The designation of non-intervention areas, to exclude key site features from damaging activities, can be useful. Ongoing monitoring of herpetofauna populations can help to assess the impact (positive or negative) of management operations, and is to be encouraged where appropriate expertise and effort is available.

Conflicts with other objectives

Sometimes, the desired habitat management for other species groups may compromise the interests of that for herpetofauna. Examples include heavy grazing on chalk downland, or grazing to reduce *Molinia* tussocks on acid grassland, in order to encourage certain flora. Where such management techniques are deemed as essential yet are likely to have a negative impact on the herpetofauna, it may be possible to divide the site into partitions and manage certain areas for reptiles and amphibians. Again, the key areas to be chosen would include hibernation, feeding and basking sites. It is also important to include links between these areas, as well as links to nearby sites. This is especially important when grazing on reptile sites is concerned, as a hard-grazed site will inhibit dispersal.

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