6 *Mowing and cutting*

6.1 Introduction

This chapter considers mowing and cutting as a method of managing grasslands. The emphasis is on the management of grassland for hay (hay meadows) but mention is made of mowing as an alternative to grazing where use of livestock is not a practicable option.

Semi-natural hay meadows are now some of the scarcest grassland types remaining in Great Britain and probably occupy less than 15,000 ha in total. Maintenance of their nature conservation value is dependent on a continuation of hay cutting and grazing together with periodic dressings of well-rotted farmyard manure and occasional applications of lime. As with other semi-natural grasslands, hay meadows have undergone a substantial decline over the last 50 years (see Chapter 2) with agricultural intensification being the principal cause of losses and degradation. This has involved ploughing, drainage and reseeding with high yielding rye-grass and improvement by use of inorganic fertilisers and herbicides. The effects of agricultural intensification on lowland semi-natural grasslands including meadows are documented in more detail in Fuller 1987, Green 1990, Hopkins & Hopkins 1994, Mountford, *et al* 1993, Mountford *et al* 1994, Smith 1994.

Many hay meadows remain within farm businesses and are managed by farmers and landowners for winter forage (hay) and spring/autumn livestock grazing. Sections 6.3-6.7 consider the production of conserved forage (hay and silage) from an agricultural perspective. This is then followed by management guidelines for achieving nature conservation objectives on grasslands managed by mowing and cutting. As the management of grassland for winter feed normally involves the application of various fertilisers and lime, the reader should ensure familiarity with Chapter 8, especially sections 8.1-8.5.

6.2 An introduction to the agricultural perspective

Livestock farming systems require conserved forage in order to compensate for a lack of grass growth in winter. Consequently, livestock are fed conserved[1] grass produced during the growing season in the form of hay or silage. Stock are frequently housed over winter and fed conserved forage as a means of avoiding poaching on wet ground. Horses are also fed conserved grass (principally hay) and may represent an important market for the sale of hay in some areas.

The main agricultural objective in conserving[1] grass is to make a product which closely resembles the original herbage in feeding value, has suffered minimal nutrient losses and is palatable to the animal. It is felt important that conservation managers and advisers should have a basic understanding of the agricultural objectives in hay and silage production as many grasslands of nature conservation value are managed by farmers for a forage crop.

[1] Conservation in this context means the preservation of grass as hay and silage and of fodder crops for winter feed.

6.3 Hay and silage

6.3.1 Silage

Silage-making preserves green forage crops, including grass, under acid conditions in a succulent state. When grass is ensiled it respires until all the oxygen is exhausted. During this time carbohydrates are oxidized to carbon dioxide and heat is released. Further oxygen supply would lead to more oxidation and decomposition. In silage-making the crop is kept in an airtight environment in clamps or in big bales, where the crop is shrink-wrapped in polythene sheeting or enclosed in bags.

In this anaerobic environment, bacteria control the fermentation process. The desirable bacteria are those that can convert soluble carbohydrate into lactic acid. They include *Lactobacillus* and *Streptococcus* species. Their activity is encouraged by mechanically chopping the grass, rapid compaction and the exclusion of air. Lactic acid production within the ensiled grass leads to acid conditions which inhibit further bacterial activity and further decomposition is prevented. If the pH does not fall quickly and respiration does not cease, other undesirable bacteria may flourish, leading to a spoiling of the crop and a reduction in its feed value. The pH at which this "pickling" occurs depends on the moisture content of the grass; the wetter the grass the lower the pH needed and the greater the quantity of lactic acid that has to be produced. Good quality silage is light brown in colour, has a characteristic sharp smell and is very stable, provided it is kept in an oxygen-free environment.

For the best fermentation the crop should have a high soluble carbohydrate content to provide a fermentation substrate and a low moisture content to reduce the volume requiring acidification. The carbohydrate content of grass generally increases during the growing season until just after the grass flower heads emerge, after which it declines. Thus the content is higher in the May to June period than later in the year (see section 6.5). The best grass crops can be produced when the carbohydrate content is high and when the crop can be wilted quickly.

Grass should normally be wilted from its normal moisture content of about 80 per cent down to between 70-75 per cent. Wilting is essential for all types of silage making because of the need to minimise production of effluent. With reduced moisture content, little or no silage effluent will be produced. This is important as effluent is highly polluting and results in nutrient losses from the crop. MAFF (1991) provides guidance on good practice to minimise water pollution caused by silage effluent. Wilting can be achieved *in situ* in the field. Additives are sometimes used to reinforce the natural fermentation process. There are a large number of additives, now mainly bacterial inoculants; where a forage harvester is used they are fed directly into the cutting mechanism. These additives contribute to rapid reduction in pH and encourage the development of a lactic acid fermentation.

The nutritive value of silage depends on the quality of the grass used and the efficiency of the preservation process, particularly with regard to the prevention of nutrient losses. This is why silage fields are usually intensively managed to promote maximum productivity of highest quality forage normally for use in intensive livestock systems.

6.3.2 Hay

In 1970, *c*10 per cent of all preserved forage was silage but by 1985 this had risen to 70 per cent with the most marked shift from hay occurring on dairy farms (Raymond *et al* 1986).

Although haymaking has declined over the last 20 years as more farms have moved into silage production, it nonetheless remains a widely used method of grass conservation in the UK and is of particular significance in the management of semi-natural grasslands of nature conservation importance (see sections 6.7-6.10 and 6.12).

The objective in making hay is to reduce the moisture content from fresh grass at 80 per cent to about 20-25 per cent. In this condition, fungal and bacterial growth is prevented and the product can be stored and used as a winter feed.

Weather at the time hay is being made is of paramount importance. Under dry conditions with low humidity, haymaking presents few problems. However, in the UK the number and length of periods without rain is restricted, particularly in the north and west. This can cause problems for haymaking as at least three days are normally required to reduce the moisture content from the cut herbage. Field drying rate is maximised if the cutting machine leaves the largest possible leaf area exposed to the sun and wind. This may be achieved by conditioning flails/brushes which bruise the crop and speed the drying process.

There are a number of ways in which drying of the swath (a band of grass or other crop cut by a mower and lying on the ground surface) can be assisted following cutting. Turning is widely used to invert the swath, increase aeration and transfer the hay to relatively dry ground. This is often undertaken in conjunction with other methods of hay conditioning, including tedding, which is the spreading, fluffing up or scattering of hay. Tedding assists in allowing air circulation and helps to speed drying. Frequent tedding is more effective than a single operation for dense grass crops but it increases production costs and results in greater losses of leaf material and hence nutrients. Tedding is normally undertaken mechanically, using a tractor mounted tedder which uses spring steel tines to lift and move the crop.

Another hay conditioning technique that is sometimes used in the early stages of the drying process is bruising or laceration. The stems of herbage dry more slowly than the leaves. Bruising the grass stems increases the drying rate. This can be achieved by the use of a flail mower, crimper, roller-crusher or combined mower-conditioner, the latter of which combines cutting with conditioning equipment in a composite unit.

6.3.3 Haylage

Haylage is a grass crop cut and harvested by a forage harvester for ensilement in a silo tower and has a dry matter content between 45-55 per cent (ie it has been wilted to achieve a moisture content between 45 per cent and 55 per cent). This term is also used for a would-be haycrop which is eventually made into big-bale silage due to adverse weather conditions.

6.4 Cutting methods

A high proportion of preserved forage is now cut with drum, disc or horizontal rotary mowers mounted on a tractor. Reciprocating-blade or cutter bar or finger bar mowers, which were formerly more widely used had a lower power requirement and were cheap. However, they were difficult to maintain in good working order. These types of mowers are now virtually obsolete on lowland farms in the UK (but see section 6.10). All these types of mowers are driven by the tractor PTO[2] and are usually mounted on the three point linkage at the rear of the tractor, although larger ones are now too heavy and are towed behind on their own wheels.

Drum mowers have small replaceable flat, free-swinging blades mounted at the base of two large vertical drums. The drums are driven to counter-rotate and allow the blade to swing out by centrifugal force. As the machine moves forward, the grass is cut by impact and pulled through between the drums to form a swath for drying. Maintenance is minimal and their efficient operation with fast forward speeds has made them popular.

Disc mowers are similar to drum mowers, except that the drums are replaced by a number (usually six) of low mounted discs each with two replaceable blades. The discs are rotated at high speed, allowing the blades to swing out by centrifugal force to cut the grass by impact. The crop passes over the row of discs to form a swath.

6.5 Timing of cutting

6.5.1 Silage

Grasslands managed for silage will normally consist of high yielding varieties of perennial rye-grass *Lolium perenne* and will receive moderate to heavy dressings of nitrogen, phosphorus and potassium fertilisers (see Chapter 8, section 8.2).

When making silage, farmers aim to achieve the best possible compromise between crop yield (dry matter production) and crop quality (digestibility).

Yield increases as the growing season progresses, while digestibility of the grass crop falls. When crops are cut at intervals of more than six weeks, dry matter yield is optimised but digestibility is reduced as the cutting interval increases. Generally speaking, an early first cut (from late April/to mid-May depending on regional differences in climate) followed by cutting intervals of *c* six weeks will produce silage of high digestibility and without a marked reduction in the herbage yield. The number of cuts in any particular year will depend on factors such as soil fertility, the prevailing weather conditions and the type of farming system although in practice most farms adhere to the same silaging regime every year unless the farm system changes. More than three cuts per season is rare. When the crop is to be partially or wholly dried in the field, a cutting height of about 5cm will assist the drying or wilting process, allowing freer circulation of air through the swath. Lower cutting heights do not produce increases in

[2] PTO = Power take-off. The PTO shaft at the rear of a tractor, which is connected to the engine by its own clutch, provides power for trailed and mounted machinery.

yield and can retard sward recovery, can result in soil contamination of silage and will produce bare soil which could encourage the invasion of agriculturally undesirable plant species.

High crop yields are normally required to justify the machinery, labour and fuel costs associated with silage making. Successive crops can only be obtained at viable levels of yield with the use of artificial fertilisers.

6.5.2 Hay

Most hay is made from improved grassland swards in lowland areas of the UK in June or early July. This is because the yield/digestibility relationship (see sub-section 6.5.1) is equally applicable to improved grassland managed for hay. Digestibility falls once the grass seed heads have formed, with a consequence that mature hay has usually lower feed value and reduced intake characteristics. However, moisture content continues to fall with increasing crop maturation which is an advantage in the making of hay and the need for dry, sunny conditions is another factor which clearly influences the timing of cutting. As for silage, it is a matter of attempting to take these factors into account and attempting to maximise crop yield and crop digestibility.

Cutting dates for hay made from semi-natural swards without the use of artificial fertilisers are likely to be later in order to ensure reasonable crop yields and to maintain their nature conservation value. Little is known about the seasonal changes in digestibility of the "grass" crop taken from semi-natural grassland swards, although the limited data available suggests a decline in digestibility as the season progresses (Tallowin 1997).

6.6 Baling and harvesting: silage and hay

6.6.1 Silage

Grass for silage is now normally cut first with a mower (see section 6.4) to allow wilting and is then collected chopped and loaded by chute onto a towed or adjacent high-sided trailer. Most silage crops are tedded/windrowed at least once prior to collection.

There are three main types of forage harvester all of which are PTO driven. The flail, double chop; which combines flail cutting with a flywheel chopping mechanism and a blower, and the precision chop harvester. All harvesters chop the grass to some extent. A self-loading forage wagon can collect and transport a crop in a one-person operation.

Cutting and immediate collection of the crop for silage is seldom undertaken as the lack of wilting will increase the amount of silage effluent produced which is highly polluting.

Where the grass crop is allowed to wilt in the field, the crop is either collected and chopped by a forage harvester and placed in a clamp, or is baled with a big-baler. A baler is a machine that picks up the grass crop, compresses it and ties it into bales. Bales may be square, rectangular or round depending on the type of baler used. Roll-bales 1.2m x 1.2m diameter weighing 300-500kg are the most common type today. Big-bales are stored in sealed plastic bags or in stretch film (big-bale silage). The loss of nutrients is usually higher in big-bale silage than in conventional silage-making systems because there is less

compaction than in a clamp or tower and secondly there is a greater surface area. This results in greater aerobic fermentation compared to the equivalent volume of material in the clamp or silo. However, unlike for clamp or silo silage there are no special storage requirements, although care must be taken to protect the bales from rodents and birds. They may eat holes in the bags causing spoilage by the admission of air.

6.6.2 Hay

In haymaking, the hay is baled into either a standard rectangular bale (36 x 46 x 90cm weighing 15-40kg) originally designed to be convenient for man-handling or into big-bales weighing from 150kg to 1 tonne and which may be rectangular or cylindrical. The latter are handled by machine and are increasingly becoming the norm in many areas.

Small-bale handling is now mostly mechanised and involves collector sledges pulled behind a baler, which collect and stack bales which are then periodically released to form groups. Groups of bales are then picked up by specialised lifting attachments to the front loader arms of a tractor or other handling machines and may be built up into larger stacks or loaded directly onto trailers for delivery to the storage area. The small bales have a greater labour requirement than big-bales as they still require stacking by hand in a barn.

6.7 Hay *v* silage

Both methods of preserving forage have their advantages and disadvantages. These are summarised below.

6.7.1 Weather

Hay-making is very reliant on weather and a minimum three-day period of dry, sunny conditions with some wind is normally required. Cold,wet weather can prevent or delay haymaking or can result in spoilt hay. Silage making is less susceptible to poor weather conditions, although wet weather leads to increased effluent production.

6.7.2 Feed value

Generally, the feed value of silage is higher than that of field dried hay due to earlier cutting, which is in part related to the application of fertiliser and is more suitable for intensive livestock rearing enterprises, especially dairying. Due in part to fertiliser application, silage can be cut earlier than hay. Because it is cut earlier in the leafy stage when the sap is rising and before the flower head has set seed the carbohydrate levels and palatability are high. Higher lignin and cellulose levels in the older crop mean reduced palatability and lower consumption. Despite this, hay made in June or July can still be a good feed for sustaining growth.

6.7.3 Yields

High grass yields can be achieved for silage making by using high rates of nitrogen application (typically 300kg per hectare per year). Very heavily fertilised grass fields produce heavy crops which are difficult to make into hay because it is difficult to get a very leafy, very soft crop dry enough.

6.7.4 Costs

The costs of producing silage and hay are not dissimilar but higher initial investment in facilities is required for silage making. Such facilities include the silage making equipment, storage and feeding facilities and effluent handling.

6.7.5 Technical considerations

Silage making requires greater technical expertise than haymaking in order to achieve a controlled fermentation and a high quality end product. Farming systems are designed around the type of forage being conserved. Weather, machinery costs and labour are important considerations. The choice of hay or silage is made by the farmer, through experience of weather and available labour. Farmers like using hay as a feedstuff as it is easier to handle and the dung produced by the animals is firm. With silage there is a high moisture content going into the animal so that a lot of urine and soft dung are excreted (slurry), producing general pollution problems. Making and feeding hay in small bales in general requires a greater farm labour input than silage making/feeding.

6.8 Nature conservation management: general principles

The preceding sections have considered the management of grassland where the maximisation of agricultural production is the primary objective. Where high production is the primary aim there are naturally strong pressures on landowners and farmers to establish grass swards which consist of high yielding grasses (for example varieties of perennial rye-grass) which respond well to applications of inorganic fertiliser, especially nitrogen (see Chapter 8). Production of high quality grass for forage (usually silage) with high digestibility for livestock normally involves early cutting prior to flowering and subsequent cutting intervals of six weeks.

Existing semi-natural unimproved grassland can also be made more productive and of better agricultural quality by the use of inorganic fertilisers and organic slurry (see Chapter 8).

It is clear that the above objectives and associated management conflicts with the objective of maintaining the nature conservation interest of lowland semi-natural grassland. These grasslands require soils of relatively low fertility and low intensity or extensive management to maintain their nature conservation value. Management of meadows for nature conservation normally involves a single late cut for hay in July, no use of inorganic fertiliser but occasional applications of farmyard manure and annual aftermath grazing (see Annex 1 for definition) with sheep or cattle.

A range of lowland semi-natural grasslands are managed for hay production (see Chapter 2) and this is usually combined with livestock grazing at various times during the season. Hay cutting is often the traditional management practice on lowland neutral grasslands on level terrain and where a reasonable

crop yield can be achieved. Haymaking is particularly a feature of meadow foxtail *Alopecurus pratensis* - great burnet *Sanguisorba officinalis* river valley flood meadows (NVC community MG4); the common knapweed *Centaurea nigra* - crested dog's tail *Cynosurus cristatus* old meadow communities (MG5) and sweet vernal grass *Anthoxanthum odoratum* - wood crane's bill *Geranium sylvaticum* northern meadows (NVC community MG3). Other unimproved neutral grasslands and fen meadow communities are occasionally mown for hay including MG8, MG13, and M22, M23, M24, M25, M26 and M27 (see Table 2.2, Chapter 2). Productivity and herbage quality of hay from unfertilised semi-natural neutral grasslands and fen meadows are lower than from improved swards (Tallowin 1997). Where still integrated with farming systems, meadows are now mostly associated with extensive livestock rearing enterprises.

It has been suggested, however, that hay from herb-rich meadows may contain a greater variety of essential minerals for animal production than hay from improved or semi-improved swards. It is still not really known if some herb species in grassland do have a positively beneficial effect on livestock (Foster 1988). Further research on this subject could be instructive.

Management of calcareous and acidic grasslands for hay is rare in Britain due largely to the nature of the terrain and the inherent low levels of fertility, and hence potential dry matter yield. On nature reserves cutting is sometimes undertaken purely for nature conservation purposes, particularly where grazing is impractical. Cut material is generally removed to avoid nutrient enrichment of the sward (see sub-section 6.10.1).

Mowing (whether for hay production or otherwise) differs from grazing and Table 6.1 summarises the differences.

Like grazing, regular mowing prevents the dominance of robust competitive grasses, herbs and the establishment of shrubs and trees, maintaining a grassland community in perpetuity.

6.9 Nature conservation management objectives

The management objectives for lowland semi-natural grasslands are as follows:

a. To maintain the nature conservation interest of grassland communities valued for nature conservation with their component species of flora and fauna.

b. To limit the establishment of undesirable robust competitive grasses and herbs.

c. To prevent the establishment of shrubs and trees.

Table 6.1. A provisional comparison between cutting and grazing

Attribute	Cutting	Grazing
Removal of bulk and biomass	Yes	Yes
Maintenance of low nutrient status of the soil	Yes, if all cuttings are removed	Yes, but there will be some nutrient return through dunging/urination
Creation of open ground and gaps to provide regeneration niches, habitat for invertebrates etc. (Gaps are necessary to recruit new individuals into the sward and to maintain/enhance species richness)	No	Yes, if by hoof action of cattle, ponies and sheep
Selection and removal of particular species (see also below)	No selection takes place	Yes, selection takes place with important effects: selective control of palatable species, favouring of unpalatable species and favouring of low-growing, less accessible species
Creation of patchiness in vegetation	No	Yes, unless stocking is very heavy. This results from the selectivity outlined above
Selection of flower and seed heads	No, all may be removed, or allowed to remain, depending on the timing of cutting	Yes, selectivity depends on type of stock and timing of grazing
Gradual patchy removal of the biomass over time	No, sudden and uniform	Yes
Creation of structurally varied sward (patchy, tussocks, lawns, bare areas, etc)	No	Yes, unless stocking is very heavy and continuous
Creation of dense and mattressy sward	Can occur with regular close cutting	Can occur with heavy and continuous grazing, particularly by sheep

6.10 Management guidelines: achieving objectives

6.10.1 Cutting/mowing methods

In situations where grasslands are being managed for a hay crop and where there is a history of mowing management, mowing is now normally undertaken mechanically by drum or disc mowers driven by the tractor PTO (see sections 6.3 and 6.5). All of this equipment is normally suitable for the management of semi-natural grasslands. However, the following are important considerations:

- Avoid very low cutting heights as there is a likelihood of excessive "scalping" resulting in the creation of bare patches in the sward. These provide favourable areas for the invasion of undesirable species, including creeping thistle *Cirsium arvense* (see Chapter 7). Conversely, some small-scale disturbance may be necessary for seed germination and may be beneficial for invertebrates.

- Consider using a centre-out mowing method where grasslands support important breeding bird species such as corncrake *Crex crex*. This allows adult birds and their broods of chicks to escape (see also sub-section 6.11.3). Use of this mowing technique is particularly helpful where it has not proved possible to delay cutting. Similarly, in appropriate circumstances, it is advisable to check sites for the presence of roe deer fawns prior to cutting.

- Discourage machinery access to grassland when ground conditions are damp, otherwise rutting will result which will damage the sward and create areas which could be invaded by undesirable species. In practice it is unlikely that haymaking would be attempted in these circumstances.

- Ensure hay bales are removed from the field within three-four weeks to avoid sward damage. Smaller bales coupled with older, lighter machinery are also preferable in this respect.

- Where a grass crop is cut but there is no intention to use it for winter feed, due to spoiling caused by adverse weather or infestation with, for example, a poisonous species, the crop should ideally be removed from the site. If this does not happen, changes in the botanical composition of the grassland may ensue, although the reasons for this may not be necessarily due to the return of nutrients to the system. Parr & Way (1988) suggested that the maintenance of higher species-richness in neutral grassland on roadside verges where cuttings were removed was more likely to be the result of the creation of small areas of bare ground by the action of raking. These provided sites for the establishment of broad-leaved herbs. They also considered that smothering by unremoved cuttings will depress species-richness.

  Schaffer *et al* (1998) studied roadside verge grasslands in the Netherlands. They concluded that cuttings should be removed within 1 or 2 weeks when the objective is to impoverish the soil.

- Failing to cut, bale and remove a hay crop for one year is unlikely to have any long-term consequences for the maintenance of botanical richness. However, it may hinder management the following year due to the presence of senescent plant material ("thatch") which may make cutting difficult and could lead to sward damage and the creation of excessive bare ground. Should mowing and harvesting for hay not be possible then there are three possible alternatives:

  a. Grazing with sheep and/or cattle followed by topping with a flail mower or chain harrowing in the autumn.

  b. Double chop forage harvest and blow the finely chopped crop back onto the site.

  c. Forage harvest and remove the crop for disposal.

  Current thinking suggests that the first and last options are preferable.

- On ridge and furrow fields, modern cutters do not perform very well as they tend to "scalp" the ridges and "undercut" the furrows. In these situations, finger bar cutters (see section 6.3) are better. Side mounted cutters are best used at right angles to the ridge crests whereas back-mounted cutters are better running along the line of the ridges and furrows.

- On small, isolated or steeply sloping sites which may be unsuitable for access by conventional tractor-operated machinery the crop can be cut with a pedestrian-operated cutter and baled with a "walk-behind" mini-baler. The latter produces mini round bales weighing 15-25kg (see Bacon, *et al* (1997).

6.11 Timing of mowing/cutting

Where grassland is being managed for a hay crop, it is important to retain an element of flexibility in prescribing dates for cutting where possible, as haymaking is very weather dependent (see sub-section 6.3.2).

Timing of cutting from an agricultural point of view is also influenced by yield and quality considerations and these are likely to vary geographically according to factors such as soil type, location including altitude, aspect and local climate. For example, in the Pennine Dales (200-300m), hay is normally cut mid-to late July, whereas in lowland central England hay is normally cut in mid-June to early July. Shutting-up date will also influence the timing of cutting.

6.11.1 Haymaking *v* silage/haylage

Making silage occasionally at hay-time from herbage from fields normally managed in a traditional manner for hay (haylage) is unlikely to change plant species composition provided the haymaking process is mimicked by ensuring that the swath is well tedded prior to baling to allow seeds to be shed. Incorporation of the latter practice emanates from concerns that silage making is normally a quicker operation and may reduce the quantity of seed that is returned to the soil, which in turn may result in population decrease for species reliant on regeneration from seed (Smith, Pullan & Shiel 1996).

From a nature conservation viewpoint, there are two main considerations relating to the cutting of meadows with a long history of such management; namely the effects on the botanical interest and, where applicable, on the breeding bird community.

6.11.2 Botanical interest

Hay cutting dates, nature conservation objectives apart, are principally dictated by the growth stage of the grass crop (which in turn is influenced by climate, altitude, aspect, timing duration and intensity of spring/autumn grazing, timing and amount of any nutrient additions) the prevailing summer weather conditions and, on farms with a number of meadows, the sequence of cutting.

Maintenance of the botanical richness of semi-natural meadows is best achieved by mimicking the historical management which was responsible for creating and maintaining them in the first place. In most years the hay should be cut at a suitable stage in terms of its biomass and quality . But this should not take place before breeding birds have hatched or populations of characteristic annual, biennial or short-lived perennial species which depend on seed production have set seed (for example yellow rattle *Rhinanthus minor*). Sustained early hay cutting is known to reduce species richness in meadows (Smith 1994). The dates will vary according to location and the nature of the wildlife interest but in practice will range from late June to late July in most years. Where there is reliable historical data on the sequence and

timing of cutting of fields such as in some areas of the Pennine Dales then this could be used as a guide (Smith & Jones 1991).

Examination of data on the phenology of species characteristic of neutral meadows from the botanical literature (Grime, *et al* 1988 and the various Biological Flora accounts in the *Journal of Ecology*), suggests that even with the above traditional cutting times, a number of vascular plant species will still be cut before they have set seed (Figure 6.1). Most of these species are perennials and in the absence of long-term life-history data it is unclear what the impact of repeated cutting before seed maturation might be over a long period. Maintenance of populations of these species may only require intermittent seed production, particularly if vegetative regeneration is an important means of reproduction.

However, there is some evidence that selection in response to hay meadow management over a long period has led to populations of plant species in meadows having earlier flowering and seed maturation dates than their counterparts in other habitats (Lack 1982). In addition, some species such as devil's-bit scabious *Succisa pratensis* may flower and set seed after the hay is cut, provided the flowering shoots are not removed during aftermath grazing. In some cases uncut field margins will be a source of seeds. In the absence of data, the best strategy is to ensure an occasional late cut in August or September. Occasional late hay cuts would have occurred in the past in years with cold, wet weather in spring and summer.

The following represents current advice:

- Maintain a flexible approach to hay cutting dates on semi-natural meadows (cut when the crop is at the right growth stage and when weather is suitable) **but** ensure cutting does not take place before breeding birds have hatched or populations of "desirable" plant species which depend on seed production for regeneration have set seed (eg yellow rattle *Rhinanthus minor*). The dates will vary according to the locality but will range from late June to late July.

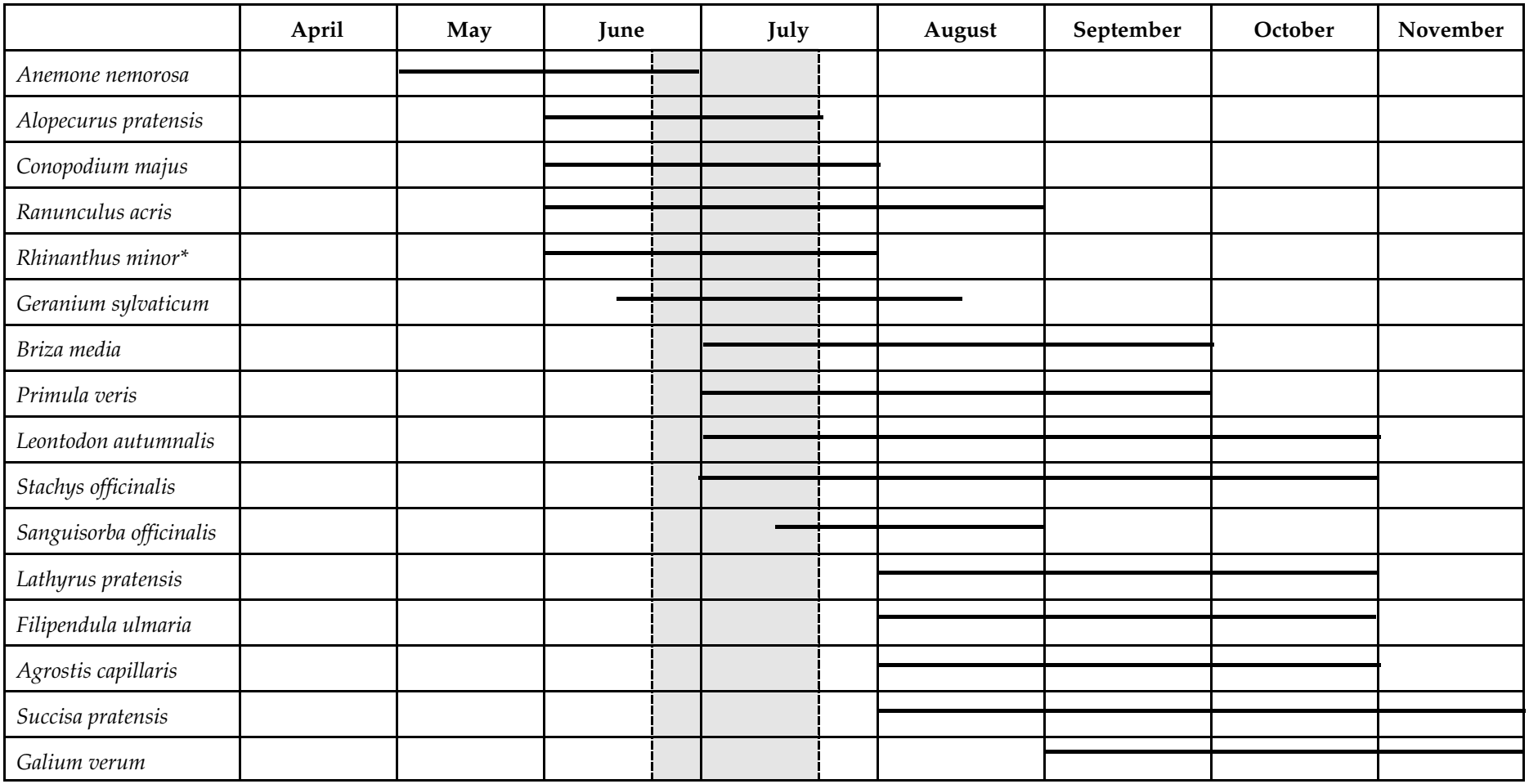
- Ensure an occasional late hay cut (late August/September) (e.g. 1 year in 5), where practical, especially on sites which support late-flowering species.

6.11.3 Ornithological considerations

Lowland flood meadows

These hay meadow communities can support important concentrations of breeding waders and wildfowl (see Chapter 2). Further detail on this subject is given in Chapter 13, section 13.1 and Treweek *et al* (1997). Where sites support breeding species of waders and wildfowl:

- Cutting should not be undertaken until the majority of chicks have hatched. This will vary according to the season and whether second broods are reared. Cutting on or after 1 July in the lowlands is normally acceptable. If an earlier cut is proposed, the situation should be checked on the ground.



* Annual

NB: rest of species are perennial.

Hay cutting period

Figure 6.1 Generalised seed maturation phenology of selected plant species of hay meadows

Northern hay meadows (NVC community MG3)

These are sometimes used by breeding yellow wagtails *Motacilla flava*. Occasionally nesting waders such as redshank *Tringa totanus* and curlew *Numenius arquata* may select nest sites vulnerable to hay cutting operations. Cutting should not be undertaken until chicks have hatched. Hay cutting on or after 15 July is normally appropriate.

Corncrake *Crex crex*

Changes in agricultural practice, particularly earlier cutting dates, associated with change from hay to silage, have contributed to the decline of the corncrake. Nearly all the corncrakes occurring in the UK breed in the Hebridean islands where they use hay meadows and other tall vegetation communities (such as iris/reed -beds) the latter earlier in the season. However, it is conceivable that corncrakes could attempt to breed in suitable habitats elsewhere in Britain from time to time.

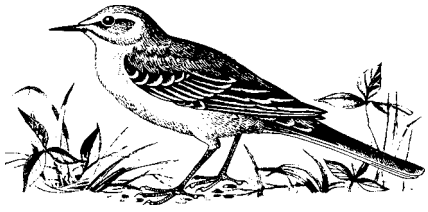
In relation to fields managed for hay or silage, the following recommendations for assisting corncrake survival are based on advice provided by RSPB (see Andrews & Rebane 1994 for a summary).

- Delay hay cutting until after 31 July if corncrakes are present.

- Do not mow entire fields in a spiral from the outer edge inwards - this drives chicks towards a central "island" where they may be killed by the mower.

- Consider alternative mowing regimes, for example, cut the field in strips from side to side or from the middle outwards after having first cut a strip at the top and bottom of the field. (See Figure 6.2).

Of the recommended mowing methods illustrated in Figure 6.2, 1a is not appropriate for offset mowers as the tractor wheels overrun the grass crop on the downward pass and 1b is very inefficient in terms of time and fuel (Bill Grayson, pers. comm.) In method 3, it is not necessary to leave the middle uncut.



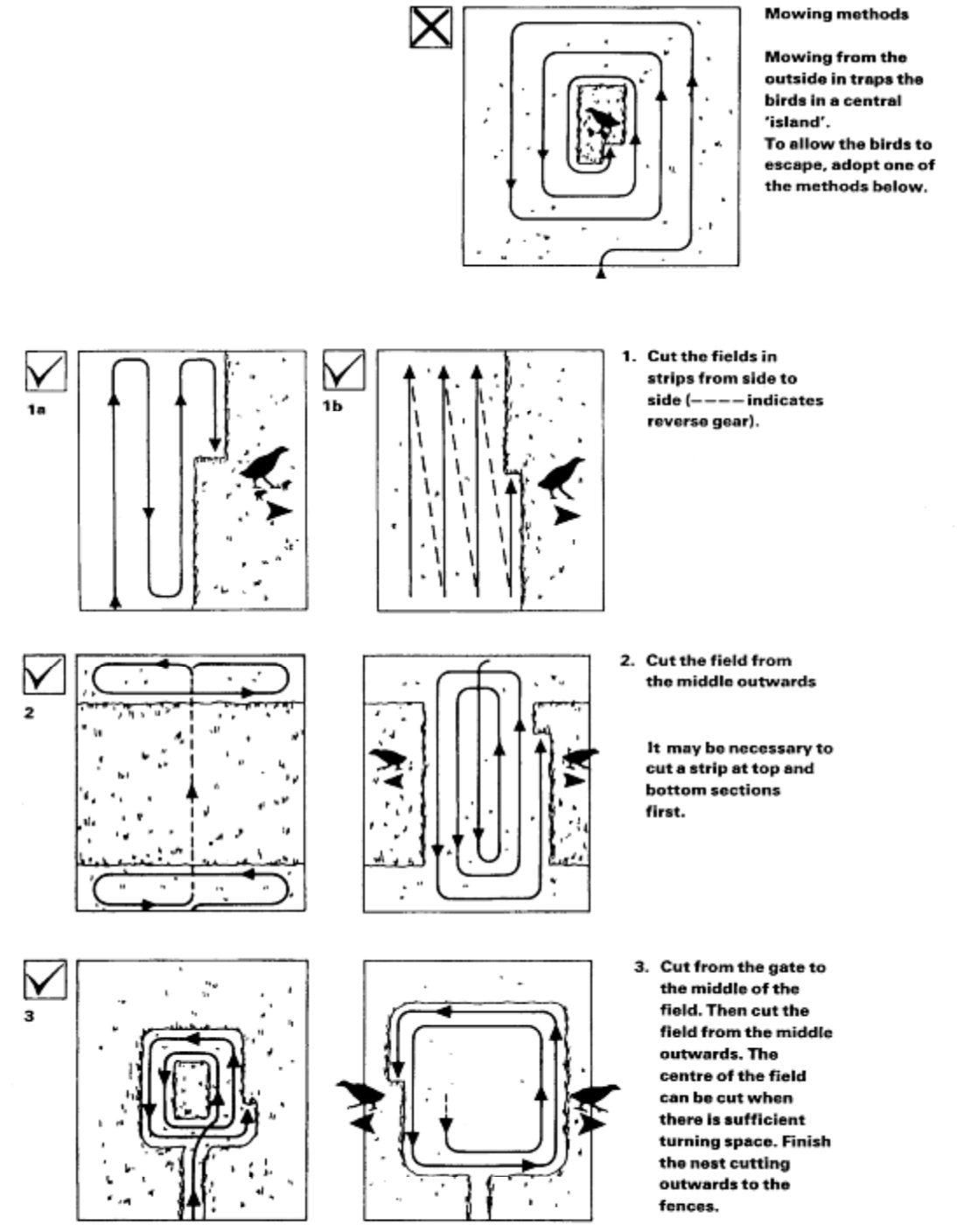


Figure 6.2 Mowing methods for fields supporting corncrakes

Reproduced from Andrews & Rebane (1994) p. 181 with permission of the Royal Society for the Protection of Birds.

6.11.4 Invertebrate considerations

Grasslands which have a long history of management as hay meadow are generally not considered to be of great importance for invertebrates. Typically, meadows may support large numbers of invertebrates but these comprise relatively few common species (Kirby 1992). The species present will be those whose life cycles fit with the existing long-established management regime. They often include species associated with other habitats which use meadows as a source of nectar and/or prey.

Although the invertebrate faunas of meadows could probably be diversified by a change in management in whole or in part, this is not recommended as this may prejudice the conservation of the botanical community which is normally the priority objective for semi-natural meadows.

6.12 Cutting as a substitute for grazing on pastures

6.12.1 Introduction

In situations where grazing, while being the preferred option, is not a practical proposition, the use of mowing can be considered as an alternative.

Most research into using cutting as an alternative management technique to grazing has focused on calcareous grassland (Wells 1971; Wells & Cox 1993) as this is often marginal land in a farming context.

At Knocking Hoe NNR in Bedfordshire, Wells & Cox (1993) demonstrated that cutting more than once a year maximised the species diversity of chalk grassland. In contrast, a single cut, while maintaining species-richness, produced a coarser sward where upright brome *Bromopsis erectus* was abundant and calcareous grassland herbs were at reduced frequencies.

It is stressed that the above study concentrated on the botanical interest of chalk grassland. Mowing does not create the same mosaic of habitat conditions as grazing and the maintenance of greater structural diversity in grassland may be necessary for conserving particular assemblages or rare species of invertebrate (Kirby 1992). Table 1 summarises the differences between cutting and grazing.

6.12.2 Achieving objectives

Where it is not feasible to use tractor mounted cutting equipment (see sections 6.3 and 6.5), as where grassland areas are small and/or on steep slopes, pedestrian operated or petrol driven mowing machines can be used, although this method is very labour intensive and may not be sustainable in the long-term.

Allen scythes or equivalents which have reciprocating blades producing a 0.6-2 m wide cut swathe can be used on level or uneven terrain, but are not suitable for use on steep slopes.

Petrol driven rotary mowers (eg Flymo), hand-held strimmers or power scythes can also be used on steep slopes for small scale management operations. Roworth (1998) provides details of a large pedestrian mower for small-scale mowing management. This equipment is apparently very easy to use. Cuttings

should be removed, although if this is not practical then they should be spread thinly across the sward. A mini-baler is now also available (see sub-section 6.10.1).

The following points should be taken into account prior to undertaking mowing management as a substitute for grazing:

- What has been the past management of the site?
- Where there has been no previous history of mowing, then the likely effects on the nature conservation interest of a change from grazing to mowing needs to be evaluated. This may be particularly critical for invertebrates.
- Will mowing achieve the management objectives for the site?
- More than one cut in a year may be necessary to simulate the former grazing management where this is no longer possible.
- Timing of cutting should seek to avoid the bird breeding season (April-June) where this is a relevant factor.

6.13 Grazing and meadow systems

Hay meadows which remain integrated into a farm system are often used for livestock grazing. The timing of grazing and the stocking density will vary according to geographical location, type of farming system and the hydrology.

In the upland valleys, hay meadows which form part of the "in bye" (see Annex 1) are grazed by sheep or cattle at various times of the year. One example of an upland sheep system is as follows. In mid-April through to May the ewes lamb on the meadows and following this the meadows are shut up for hay and the sheep (ewes and lambs) return to the hill. Hay is normally cut in mid-July. During the late summer and autumn, grass regrowth on the "in bye", which is sometimes known as the "aftermath", may be used for the finishing[3] of wether lambs (castrated males) or surplus ewe lambs. In mid-October/early November ewes for drafting[4] are kept on the "in bye" for mating with a long wool ram, or for sale. In October/November the hill ewes will be brought on to the "in bye" to raise their level of nutrition in readiness for mating (tupping). In January they will return to the hill. In April they will be brought back onto the in-bye to lamb and complete the cycle.

In the lowlands, the timing of grazing of hay meadows will vary according to the factors mentioned above but late summer/autumn or aftermath grazing is often practised following removal of the hay crop. Spring grazing of semi-natural meadows in the lowlands is not a common practice, as it reduces harvestable yield and delays maturation of the crop. It may also be undesirable on sites which support

[3] A 'finished' animal is one which has been carefully fattened and ready for sale.

[4] A 'draft' animal is one removed from the hill breeding flock while still able to produce lambs (ie normally after three crops of lambs) but is no longer suited to the harsher upland environment hence is 'drafted' to less harsh lowland farms.

early-flowering plant species which need to set seed (eg *Fritillaria meleagris*) or on damp river valley meadows which are vulnerable to poaching. The exception to this is the valley grasslands of Northern England (northern hay meadows NVC community MG3).

While grazing is dealt with in more detail in Chapter 5, the following points should be borne in mind in relation to the grazing of meadows managed for hay:

- Any proposed changes to a long-established traditional meadow management regime should be carefully evaluated using available knowledge of species and community ecology. If there is any doubt, the precautionary approach of avoiding changes in long-established management should be adopted where this is fulfilling nature conservation objectives.

  Conversion from meadow to permanent pasture is likely to result in changes in plant species composition (Baker 1937, Rodwell 1992). Early flowering species which rely on seed production for maintenance of populations will be reduced or eliminated by such change. Examples of vulnerable species include yellow rattle *Rhinanthus minor*, which occurs in a variety of neutral meadow types, and snakeshead fritillary *Fritillaria meleagris*, which is largely confined to MG4 flood meadows.

- If the nature conservation value of lowland semi-natural neutral grasslands managed for hay is to be sustained, aftermath or spring grazing is necessary. The cessation of aftermath grazing results in changes in species composition and a decline in species richness. (Kirkham *et al* 1996). The reasons for such changes are unclear but it may be that the hooves of livestock produce gaps providing sites for regeneration including seedling establishment. In addition grazing probably has an important role in controlling potentially competitive grasses, such as false-oat *Arrhenatherum elatius*.

- Cattle and sheep are both suitable for aftermath grazing. Horses can be used in conjunction with other livestock, or alone, but if the latter, care needs to be taken to ensure sites are not overgrazed (see Chapter 5).

- Feeding livestock with hay/concentrates can cause adverse changes to the botanical composition of the grassland sward through nutrient enrichment, trampling and smothering. The provision of supplementary feed blocks is acceptable in late summer/autumn. These should be carefully sited to avoid poaching around the blocks of feeding livestock. Feed blocks are most useful during autumn/winter grazing because of their ability to supplement low quality forage and provide essential minerals.

  Historically, the practice of winter feeding of hay on meadows was not damaging and may even have been a factor in maintaining the botanical value of unimproved semi-natural meadows by the introduction of seeds. However, compared to modern agricultural practice, historical management involved feeding hay from unimproved botanically-rich grassland. Hay was not fed repeatedly in the same spot and was often spread in a new area every day. Hoof action by sheep and/or cattle would have provided germination sites. This practice appears to have been especially prevalent in meadows in upland dales in England.

- Avoid overgrazing or poaching which creates bare ground and provides sites for the invasion of problem species such as creeping thistle *Cirsium arvense*, common ragwort *Senecio jacobaea* and docks *Rumex* spp. (see Chapter 7).

- The sward height at the end of the autumn/winter grazing period should be no higher than 3cms if the site supports wintering wildfowl or spring-nesting waders. Where there is no bird interest the height is less critical, although sward height of greater than 10 cm should probably be avoided.

6.14 Wild flower seed harvesting

With the increase in projects designed to re-create herb rich grasslands there has been an increasing demand for native wild flower seed. This has led to the exploitation of semi-natural hay meadows for seed and the development of two types of machines to harvest it. Suction harvesters, which are usually tractor mounted, normally consist of a series of suction heads resting on wheels pulled over the grassland sward. The heads can be set at different heights and the seeds are picked up by suction and collected into a large collecting vessel. In order to maximise the variety of seed collected, it is normal for the process to be repeated on a number of occasions during June, July and early August.

A brush harvester utilises a large brush to sweep seed out of the crop. This machine was developed by Emorsgate Seeds of Kings Lynn and normally operates on two harvests in the season. This machine is probably less damaging to invertebrate populations as it removes fewer individuals.

Following use of the seed harvester the crop may still be cut for hay. Harvesting of seed could have an impact on the populations of vascular plants and invertebrates.

6.14.1 Effects on the botanical composition

The points relating to the timing of cutting in section 6.10 are also relevant in this context.

The impact of seed harvesting on the botanical composition of the sward depends on the proportion of seeds removed from the range of species, the timing of seed set of individual species and the extent to which individual plant species rely on seed production as a regenerative strategy. Harvesting machines do not collect all seed but lighter ones are more efficiently collected by the suction harvester.

Initial advice (which may require modification in the light of further research) is as follows:

- Where grasslands are characterised by populations of annual species, such as yellow rattle *Rhinanthus minor*, which do not form persistent soil seed banks and which normally set seed prior to hay cutting, it is advisable to either not harvest every year or only harvest a proportion of the site or area in any one year.

- Where there are no significant populations of annual species, it may still be advisable to avoid harvesting every year or to harvest only a proportion of the site in any one year. This then allows early maturing perennial species to set and shed seed in some years. English Nature has

stipulated, for example, on one site that one fifth of the meadow may be harvested on a five year rotation.

6.14.2 Effects on invertebrate populations

Large numbers of invertebrates occur in hay meadows, but often there are relatively few species and those that do occur have life cycles which fit in with regular hay management (Kirby 1992).

Large numbers of invertebrates can be collected during wild flower seed harvesting (Waring 1990). Some species are likely to be more vulnerable than others to extinction or to reduction in their populations as a result of seed harvesting and this will depend largely on the initial size of population present and the nature of specific species life histories, including mobility.

- It may be inadvisable to change grassland management from extensive grazing to hay and aftermath grazing in order to harvest a seed crop. Invertebrates associated with seed heads are particularly vulnerable.

- If a meadow is known to support rare or local invertebrate species which may be vulnerable to seed harvesting (advice may be needed from an entomologist), it is advisable to prohibit its use for this purpose. If it is decided to go ahead, then the following measures may reduce the impact of seed harvesting on invertebrates:

    a. Cordon off areas if a species occurs on only part of a site.

    b. Only harvest a proportion of the site in any one year. For example, a site could be harvested in strips with one strip in every five being harvested for seed.

    c. Do not harvest every year. This is based on the assumption that invertebrate populations reduced by harvesting may recover if left for a year or two.

    d. Populations of rare and vulnerable species should be regularly monitored.

    e. Spreading seed onto sheets after collection allows a high proportion of invertebrates to escape thus mitigating the impact of harvesting.

6.14.3 Effects on bird populations

On sites supporting breeding bird populations, no seed harvesting should take place prior to 1 July.

6.15 Management of boundary features

6.15.1 Introduction

Many semi-natural grasslands have associated boundary features such as hedges, banks and ditches. The management of these can sometimes have an impact on the flora and fauna of the adjacent grassland and they may have their own intrinsic wildlife value.

6.15.2 Ditches

These are often associated with river flood-plain meadows and fen meadows and rush pastures. The maintenance and management of ditches is dealt with in Chapter 8, section 8.11.

6.15.3 Hedges/hedgerow trees

There are a number of publications which describe the nature conservation value of hedges and hedgerow trees and their management (see for example Pollard *et al* 1974, Kirby 1992, Andrews & Rebane 1994, papers in Watt & Buckley eds 1994). The retention and positive management of hedgerows bordering semi-natural grassland is normally a desirable goal.

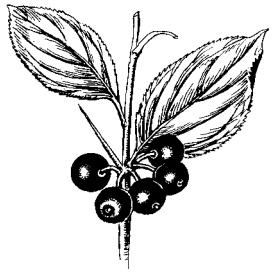
However, hedgerow/hedgerow tree management, enhancement and planting proposals should be evaluated with consideration of the following issues:

- Shading and the deposition of leaf litter may lead to vegetation change in the vicinity of a hedgerow leading to the establishment of less species-rich coarse grassland communities.

- Breeding success of grassland birds can be reduced where trees and bushes harbour avian and mammal predators.

- Anecdotal evidence suggests that breeding waders favour sites which have uninterrupted 'sitelines' which may be obscured by hedges.

- Tall hedges and trees can create difficulties for drying hay crops through shading and reducing wind.



6.16 Legal and financial considerations

6.16.1 Legal

Health and safety

The 1974 Health & Safety at Work Act is the main piece of legislation which aims to secure the health, safety and welfare of people at work and as such applies to anyone (employers, employees, contractors and volunteers) undertaking active conservation management or agricultural operations. There are also a number of Statutory Instruments which are specifically relevant to this section. These mostly relate to the use of machinery, especially tractors and their attachments. Space does not permit a detailed consideration of health and safety but further information should be available from employers or by contacting the local Health & Safety Executive office, listed in the telephone directory.

SSSIs/ASSIs

Where land is notified as a Site of Special Scientific Interest (SSSI) or Area of Special Scientific Interest (ASSI) under Section 28 of the 1981 Wildlife & Countryside Act or under Part VI of the Nature Conservation and amenity Lands (Northern Ireland) Order 1985, it is necessary to consult with English Nature/SNH/CCW/DOENI when intending to undertake mowing, cutting or other notifiable operations, on grassland SSSI/ASSI. Contact should normally be made with the local English Nature/SNH/CCW/DOENI office.

Birds

The primary legislation affecting wild birds in Britain is the 1981 Wildlife & Countryside Act (Part 1). All birds, their nests and eggs are protected by law and among other prohibitions it is an offence to (a) kill, injure or take any wild bird, (b) take, damage or destroy the nest of any wild bird while it is in use or being built, or (c) take or destroy the egg of any wild bird. These prohibitions have most relevance to this section, as harrowing and mowing management may lead to conflict with (a)-(c) above. However, (a)-(c) above are not illegal if it can be shown that such an action was the incidental result of a lawful operation and could not reasonably have been avoided.

Disturbance to wild birds during the breeding season is not illegal unless (a) a species is listed on Schedule 1 of the 1981 Act or (b) the land lies within a Statutory Bird Sanctuary (notified under the various Protection of Birds Acts) or an Area of Special Protection notified under Section 3 of the 1981 Act or (c) the land lies within a nature reserve (eg National Nature Reserve, Local Nature Reserve) where the operating authority (English Nature/ CCW/SNH/DOENI or a local authority) has created bye-laws which relate to disturbance.

Schedule 1 birds which breed in lowland grasslands and could be affected by mowing or cutting operations include corncrake, stone curlew *Burhinus oedicnemus*, garganey *Anas querquedula*, black-tailed godwit *Limosa limosa*, common quail *Coturnix coturnix* and ruff *Philomachus pugnax*.

Further information relating to wild birds and the law can be found in RSPB (1998).

Weeds Act 1959

This Act empowers Ministers, by notice, to require occupiers of land to prevent the spread of five species of pernicious weeds, namely: creeping thistle (*Cirsium arvense*), spear thistle *C. vulgare*, broad-leaved dock *Rumex obtusifolius*, curled dock *R. crispus* and ragwort *Senecio jacobaea*. The Act provides default powers and entitles Ministers to recover reasonable costs. For information on the control of grassland weed species see Chapter 7.

6.16.2 Financial considerations

The costs of agricultural machinery for hay making and contractors' charges are detailed in the annual edition of the `Farm Management Pocket Book' produced by the Department of Agricultural Economics, Wye College, Wye, Ashford, Kent TN25 5AH (Nix 1998) or the *Farm Management Handbook* produced by the Scottish Agricultural College, West Mains Road, Edinburgh (Chadwick (ed) 1999) 19th edition. As far as obtaining new agricultural equipment is concerned, the Institute of Agricultural Engineers Members' Handbook includes a buyers guide which lists the companies that supply equipment. Depreciation of new agricultural machinery is substantial. In many cases it should be possible to obtain serviceable second-hand hay-making equipment.

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