11 *Grassland creation*

11.1 Introduction

This chapter covers the creation of grassland. Grassland restoration is covered in Chapter 10. Grasslands are perceived (often wrongly) to be 'easy' habitats to create offering quick results for a minimum of input. It can be relatively easy to create something that is aesthetically pleasing and moderately diverse in a fairly short space of time but grassland creation should never be put forward as a substitute for the *in situ* conservation of semi-natural grassland. Once ancient semi-natural grassland has been destroyed it can never be re-created, at least over short time-scales.

There are many opportunities for grassland creation. For example: landfill sites, other industrial waste sites, sites associated with development, such as roadside verges or landscaping around housing, set aside and reversion from arable.

Created wild flower grasslands have several important roles:

- Inherent value for biodiversity.
- Linking areas of semi-natural vegetation which are currently 'islands' in an intensively managed landscape.
- Buffering existing habitats from disturbance or pollution eg chemical spray drift.
- Sowing wild flower swards provides an alternative to restoring mineral sites to agricultural land.
- Providing accessible new grasslands serves as a local amenity and educational resource especially in urban and urban fringe areas.
- Assists in the management of existing sites ie through creating a larger area of grassland thus making hay/grazing management more practicable.
- Promotion of biodiversity targets.

11.2 Planning grassland creation

To avoid expensive failures it is important to plan at an early stage and consider the options for creating the grassland.

Some options are:

- allow natural recolonisation. The speed with which plants and animals colonise will depend on whether there is a semi-natural grassland nearby and on the availability of colonisation gaps in the new site. Because of previous losses of semi-natural grassland, most native species will simply be too far away for their seeds to reach the site. This option is best suited to sites adjacent to existing biologically-rich grasslands. Such projects have low establishment costs. If the objective is to create something visually attractive for amenity purposes in a relatively short space of time, natural recolonisation is probably not the most appropriate option. Allowing a grassland to recolonise naturally may take years for it to become visually attractive and of nature conservation value. However, where nutrient levels are low and/or there is adjacent ancient grassland, after 5-10 years a relatively diverse community may develop if a management regime of grazing and/or cutting is introduced;

- create attractive grassland communities on sites which detailed survey has shown to support little or no conservation interest eg ex-arable land, newly created road verges, derelict land or ex-mineral workings by the introduction of seed;

- enhancement/diversification - this is not strictly creation but building on what already exists eg introducing wild flower plugs and transplants into improved grasslands including rye-grass swards.

Consider the following:

- Why the grassland is being created in the first place (see section 11.1).

- It is important to consider the cost implications in terms of finance and other resources such as time and effort required, tools and machinery. This is important not only for the initial grassland creation but for essential long-term management (including monitoring). Costs for wild flower seed can range from £600 per ha for a general purpose grassland mix to more than £1,000 per ha for calcareous grassland mixes which contain more broad-leaved herbs. Costs of creating the grassland could be offset initially by the sale of turf and topsoil. Once the grassland has become established, it may be possible to sell hay and wildflower seed harvested from the site or gain revenue from letting out grazing.

- It is important to take account of land ownership and access as it will be necessary to get cutting equipment or stock onto the land to manage the grassland. It is very important to consider who will manage the land ultimately eg potential tenants and lessees.

- If stock are to be used to graze the site once it has become established, it is important to consider that they will need to be watered, fenced in and looked after properly (see Chapter 5).

11.3 Choosing the site

Targeting areas carefully will improve the chances of success. Before deciding on a site it is important to conduct a thorough survey to determine its suitability for a grassland creation project. Seek professional advice wherever possible. The following should be considered:

- A thorough biological survey of the proposed creation site is very important. A survey will locate any areas of existing wildlife value which might rule out habitat creation as an option. The survey should include the adjoining land. This will indicate whether there is a nearby source of species to colonise the newly created grassland. The survey will provide baseline information by which it will be possible to judge success and guide the management programme.

- The physical characteristics of the site. The most important physical factors determining the success of a grassland creation project are: soil pH, soil structure, soil-water relations and soil fertility. The presence of steep slopes, changes of level, drainage lines and seepage zones will influence the method of creation chosen.

- Knowledge of current and past management and plant and animal communities may provide information about important factors such as level of soil fertility and clues as to the sort of treatment that may need to be applied eg top soil stripping. It will also give an idea of the type of grassland that might successfully be created or conversely, whether the site is unsuitable and may be better suited to heathland, marsh or woodland.

- Position in the ecological landscape is important. Does the site enlarge, provide a buffer zone or link to an existing site(s).

11.4 Soil type

The objectives for grassland creation must be compatible with the soil type present at the habitat creation site. Soil fertility and pH are key factors influencing the success of grassland creation particularly where the intention is to establish grassland of wildlife interest from native seed mixtures. These will establish and thrive best where competition from competitive grasses and dicotyledonous weeds is low and, normally where soil nutrient status is low (see sub-section 11.4.1). Soil pH under arable cultivation will normally be >6.0 and on non-calcareous soils this will have been previously maintained by liming. It is important to have an idea of the likely soil pH range which is appropriate for the target grassland type and to know the pH of the site where creation is planned.

11.4.1 Creating grasslands on soils of high nutrient status

Soil fertility, particularly the presence of major plant nutrients, nitrogen, potassium and particularly phosphorus, is one of the most important factors determining the likely establishment and success of a newly created grassland. The level of soil fertility influences the options available regarding the method of grassland creation. In semi-natural grasslands, high species diversity only occurs within a narrow range of both extractable (plant available) phosphorus and potassium.

Creating a wild flower grassland without topsoil removal is likely to be difficult where the land has been receiving more than 200kg of nitrogen fertiliser per ha per year (ie on ex-agricultural land) or on former agricultural land where crops have included legumes which fix atmospheric nitrogen into the soil. If the soil is too fertile, it is likely that any wild flower mix sown will be swamped by fast growing perennial species such as docks, thistles and coarse grasses (depending on the existing seed bank and how it is managed).

Free draining sandy soils which are easily cultivated give a good sowing medium. Clay subsoils are more difficult to cultivate. These soils retain nutrients more readily and become waterlogged more easily and are likely to be better for species characteristic of damp conditions (see Table 11.4). It may be necessary to plough such areas in the autumn and leave them for frost action to break up the structure before rotovating in the spring.

The predominant soil type in agricultural use in the UK are neutral deep loamy soils with a neutral to slightly alkaline pH. These are the soil types that are most likely to be available for arable reversion to grassland. However, the high fertility of most of these soils is likely to be a problem and a programme of fertility reduction may be necessary at the start of a habitat creation project.

On ex-arable soils arable weeds such as black grass *Alopecurus myosuroides* and sterile brome *Bromus sterilis* may be a problem. These are encouraged by grazing or cutting in late autumn which opens up the sward when weed seeds are ready to germinate. They need a spring graze or cut at the appropriate time to stop them flowering and setting seed. In time, given management and establishment of perennials, they should not persist (see Chapter 7 for treatment of grassland weed species).

If practical, it is best to measure soil fertility at the proposed grassland creation site. The crucial nutrients are available phosphorus and potassium and total nitrogen. Phosphorus is particularly problematic as it is persistent. Soil fertility can be measured by chemical analysis or bio-assay technique (growing test plants in a sample from the site and comparing plant growth with a control sample eg typical plant growth in a semi-natural grassland).

To give meaningful results, a soil sample must be representative of the area and comprise a minimum of 25 cores per sample. These should be obtained using a cheese-corer auger to a depth of approximately 15cm. The standard sampling depth for established grassland is 7.5cm. ADAS are able to give professional advice on measuring and evaluating soil fertility. The type of vegetation growing at the proposed site will give an indication of the level of soil fertility eg an abundance of coarse competitive grasses such as false oat-grass *Arrhenatherum elatius* and cocksfoot *Dactylis glomerata*, nettles, *Urtica* spp. rosebay willowherb *Chamerion angustifolium* and cow parsley *Anthriscus sylvestris*, indicate high levels of nutrients. On ex-arable land, previous crop yield can give an idea of the nutrient status of the site. The lower the yield, the less fertile the site. It is possible that for anything less than 10ppm for phosphorus has the potential to develop into a diverse wild flower grassland (P. Anderson pers. comm.) Tallowin (1997) showed that the soil P and K content for semi-natural grasslands in the UK range from 0-2 mgP/100g dry soil and 5-40 mg K/100g respectively.

The soils below existing semi-natural grasslands have concentrations of P and K which equate to MAFF soil indices (see MAFF 1988 for details) of 0 (<10 mg/l) for P and between 0 and 1 for K.

Many ex-arable sites are likely to have soil indices of at least 2 for Phosphorus (16-25 mg/l) and Potassium (121-240 mg/l) as these are the minimum indices required to sustain productive grass growth (MAFF 1988). The soils below many existing semi-natural grasslands are thus below the minimum for productive grass growth (Tallowin 1997).

Some ecologists and practitioners have claimed that diverse grasslands can be established on more nutrient-rich soils (i.e. P & K indices of 2 or more). It is however, widely accepted that where P is index is 2 or more, and particularly where soil N is low, there is a higher risk of white clover *Trifolium repens*, or perhaps other legumes, becoming dominant. There may also be a higher risk of perennial weed ingress. Published evidence for the establishment of diverse grasslands on nutrient-rich soils is lacking. In addition, the definition of "diverse" is also often unclear. However, it would be wrong to completely discourage the creation of grassland on land with initial high fertility if there are other good reasons for grassland establishment (eg buffering or linking of existing semi-natural grasslands).

Should fertility reduction be unfeasible, then species which are able to thrive on more fertile soils should be selected. Reference to the NVC tables for semi-improved or reverted grassland types (MG1, MG6) (Rodwell 1992) may assist in species choice.

11.4.2 Measures to reduce fertility

Top soil stripping

One option for reducing soil fertility on ex-agricultural land is topsoil stripping. Stripping the topsoil to a depth of 20-25cm removes most of the soil nutrients and the seed bank which can contain some highly competitive species such as docks, thistles and arable weeds (Ash *et al* 1992). The topsoil can be sold or used for planting trees and shrubs. It is important to ensure that topsoil stripping will not cause problems to adjacent land by disturbing drainage patterns and that if it is to be removed from a site you will need planning permission (contact your local MAFF service centre - see Annex 5).

Cropping

Taking an arable or grass crop continuously without the addition of fertilisers can reduce nutrient levels (leguminous crops must not be used because they fix nitrogen from the atmosphere). However, there are few successful examples and it can be a long process.

Sowing of yellow rattle *Rhinanthus minor*

Yellow rattle is a hemiparasitic angiosperm that inhibits the growth of the surrounding grass species. This could be of use for grassland restoration projects where high soil fertility is a barrier to the establishment of a species-rich sward. Tests have been carried out (Davies *et al* 1997) to use yellow rattle to control sward productivity. In naturally occurring stands, areas containing hay rattle were consistently found to have lower productivity than adjacent unaffected areas. The impact on productivity was found to be accompanied by characteristic changes in sward composition with herbaceous species occurring at the expense of grasses. The results of this experiment suggest that sowing yellow rattle could be used as a tool to manipulate the balance between grass and flower species in established grassland or new sowings.

It is best to sow the seed of yellow rattle in the late summer or autumn onto short grass. This allows it to overwinter and vernalise (be subject to frost which encourages germination in the spring). The seed does not need to be worked into the soil surface. As a rough guide, 0.5kg should be sown per acre (*c*1.2 kg/ha). The best success will be achieved where grass is kept short from August through to early March either by cutting and removal or by grazing. This prevents grass out competing small seedlings in the spring. The grass should not be cut from early March through until the end of July to allow the seed to ripen and set. If allowed to flower and set seed and other conditions are favourable, yellow rattle will spread rapidly and it will suppress grass growth and help the establishment of other wild flowers from seed in following years.

In the long-term, it should be remembered that yellow rattle will reduce sward productivity which may be an issue in situations where the hay and aftermath grazing is being let to a farmer.

11.5 Preparing the seed bed

To help the seeds germinate and the seedlings establish it is important to prepare the seed-bed carefully:

- Preparation needs to be carried out when the soil is dry and manageable.

- Ensure there is a good weed-free tilth, 6-10cm is adequate. Except on the very lightest soils it will be necessary to raise a tilth, but unless there is serious soil compaction this should normally be as shallow as possible, using a chain disc or tine harrow as necessary. However, recent MAFF-sponsored work has shown that in terms of species establishment, there is no difference between surface cultivation and ploughing. Beware of over-cultivating the soil, this will release nutrients, encourage weed seed germination and moisture loss.

- It is possible to achieve good results on light soils without any cultivation using glyphosate to control weeds (I.Trueman pers. comm.).

11.6 Controlling weeds

Some weed seeds can remain viable in the soil for many years. Disturbing the soil while preparing the seed-bed can encourage their germination. Problem weeds such as thistles, docks and black grass can be spot treated with glyphosate or cut and pulled in June before flowering (for more detailed information on controlling grassland weeds see Chapter 7). In the second and subsequent years, the wild flowers will have become established and the sward should have become dense enough to suppress problem weeds such as black grass. Perennial weeds such as docks and thistles may need further treatment to keep them under control.

Weed control methods include the following:

11.6.1 Sowing nurse crop

This is only recommended on very infertile substrates, such as fine sand, where the wildflowers might take longer to get established or on steep slopes where erosion may be a problem. Sowing a crop of

cornfield annuals will help out-compete weeds and provide shelter for the slower-growing wild flowers. Nurse crops can be sown in either spring or autumn but are recommended for autumn sowing to provide cover over winter and to lessen the risk of soil erosion.

As weeds tend to germinate and grow quickly, they can be controlled without any adverse effects on the rest of the sward. The following techniques can be used to control a "flush" of weeds that emerge either before or after sowing.

11.6.2 Controlling weeds using herbicides (see also Chapter 7)

If there are no practical alternatives to herbicide use, careful use of chemicals can be an effective way to control weeds, particularly persistent perennial ones. Herbicides cannot be applied except by a certificated operator. Certificates can be obtained through the National Proficiency Tests Council (see Annex 5).

Once germinated the weed seedlings can be killed by spraying with an appropriate herbicide (for example glyphosate) before sowing the seed mixtures.

Once the flowers have germinated, spot application of an appropriate herbicide by a hand-held weedwiper or knapsack sprayer will have least effect on other wildlife.

11.7 Choosing the seed mixture

The species selected and source (eg hay/commercial mix/hand collection) will partly depend on the objectives for the site but also the ecology of the site. It is also important to know what habitats and species were there originally. One of the keys to success is to sow seeds of plants that are adapted to the local soils and climate. It is also important to consider wider policy plans eg Local Biodiversity Action Plans, Natural Area Profiles etc.

Key factors to consider include:

- soil fertility
- soil PH
- hydrology
- soil texture
- aspect
- proposed management regime
- biogeographical location
- future management

If possible, it is best to make up your own seed mixture because the mixture can be related to local conditions or a known vegetation type such as an NVC type. The NVC classification system (Rodwell 1992) can be used as a guideline for devising suitable wild flower seed mixes for different soils and regions. This will require more expertise and is more time-consuming than buying an 'off the shelf' seed formula but the results are generally better (I. Trueman pers. comm.).

It is important to use only native-origin species and, if available, seed that has been harvested locally as the introduction of non-native species can alter the plant composition of UK habitats and change the gene pool of native species (Akeroyd 1994). Flora Locale Ltd (see Annex 5 for address) are producing a series of technical guidance notes on the subject of the use of wild flower seed in habitat creation. These will include a code of practice on the collecting, supplying, growing and purchase of wild flower stock and what to plant and where to plant it. Certain species, particularly plants sown for animal fodder eg agricultural forms of grasses and clovers can grow very vigorously and out-compete native plants.

When choosing seed mixtures consider the following points:

- Seed should be ordered from recognised suppliers who should be asked to supply a list of the proportions and sources of species included in the mixtures.

- Avoid rare species which may have special habitat and management requirements or species which may have special germination requirements.

- If the aim of the project is to create an amenity grassland, choose some plants with attractive flowers that will flower in the first year such as oxeye daisy *Leucanthemum vulgare*. Aim for a seed mixture that will give flowers over the whole flowering period.

- On sites where phosphorus levels are high avoid legumes such as red and white clover or vetches which fix nitrogen.

- Choose some species which germinate easily over a wide range of conditions such as oxeye daisy, buttercup *Ranunculus acris*, yarrow *Achillea millefolium* and self-heal *Prunella vulgaris*.

11.8 Sowing wild flower seed

Grass seed is relatively cheap and is readily available commercially but it is difficult to obtain native-origin seeds. It is hoped that this situation will change in the near future. In the interim, the use of any variety of native grass species is acceptable but agricultural varieties are preferable to amenity ones. Seeds of broad-leaved plants are not available in such large quantities and are much more expensive.

Wild flower mixtures are normally sown with grasses. The relative mix usually recommended is 80 per cent grasses and 20 per cent wildflowers. However, on many grassland sites, grasses do not constitute 80% of the sward. On sites of lower nutrient levels it is possible to sow a lower seed quantity with more wild flowers and less grasses. On more nutrient rich sites grasses are likely to be very vigorous so it is worthwhile trying a higher quantity of broad-leaved plants as opposed to grasses. Grasses provide important cover especially during winter and help stabilise the soil before the wild flowers get established and are in themselves, an important component of semi-natural grasslands.

- Acquire seed from a supplier that will give a breakdown of the proportions of different species by seed numbers rather than by weight. Seeds of the different wild flower species vary considerably in size, shape and texture. For example, some species of St John's wort *Hypericum* spp. can have 10,000 seeds per gram, while tufted vetch has about 14. A breakdown by seed numbers rather than by weight will give a much better idea of the likely composition of the wild

flower grassland (although this will also depend on seed viability and the rate of establishment success too).

- Mix the wild flower and grass seed before and during sowing to make sure it is evenly distributed. Mixing the seed with sawdust, barleymeal or dry sand in the ratio of 1:3 will help sow more evenly. This also shows where the seeds have been sown.

11.8.1 Methods of seed sowing

Hand sowing

On small areas, the most effective method of seed sowing is to broadcast by hand. Divide the seed into smaller quantities, split the site into sections and sow the seed into these plots.

Machine sowing

Key points:

- On large areas, using tractor mounted machinery such as fertiliser spreaders, cereal seed drills and slot seeders saves time and effort. Equipment for seed sowing can be hired from local agricultural machinery merchants or provided by contractors (see Yellow Pages). Drilling the seed directly into the ground using agricultural equipment means that large areas can be sown in a relatively short space of time using small quantities of seed. Pedestrian drills are available for more precise and effective sowings on a smaller scale. Larger areas can be broadcast using a rotary fertiliser hopper provided the seed is sufficiently bulked up (3:1), with an appropriate carrier (eg barleymeal). This helps give an even distribution of seeds of differing size. It is important that the seed containers are shaken regularly to avoid the smaller seed dropping to the bottom of the seed hopper.

- It is better to drill seed directly **after** cultivation as sowing the seeds into a fine tilth gives the seed a better chance of germinating.

- As a general rule, drill at rates of a minimum of 1g/m. sq. for cornfield annuals and wild flower mixtures. This is the equivalent of 10kg/ha. (Or 4.5lbs /acre) up to about 30kg/ha. The seed should not be sown deeper than 0.5cm to encourage germination.

- Drills should generally be spaced at about 5cm.

- Roll to maximise seed contact with the soil.

11.8.2 Using hay and seed collected from existing meadows to sow wildflowers

This should be read in conjunction with the information in Chapter 6, section 6.14 on harvesting of wild flower seed.

Spreading hay or using seed collected from local flower-rich grasslands is another, cheaper, way of creating grasslands. Hay barn sweepings used to be spread to improve or create grasslands before commercial seed mixtures were available. A bale weighing 21kg contains about 450,000 seeds of which about 90 per cent are grasses and the remainder broad-leaved plants. However, the loss of flower-rich grassland over the last few decades means that local sources of such hay are often difficult to obtain.

There are two ways of using hay bales:

- Dried or freshly cut hay is spread thinly or chopped up and spread over the site. Freshly cut hay gives the best results (I.Trueman pers. comm.). Jones *et al* 1995 found that the latter was best in terms of the quantity and species composition of seed transferred. It is also important to strew cut hay quickly after cutting. It is then left for about three weeks for the seeds to fall. The hay should be turned once if possible. Afterwards, the hay should be lifted to prevent smothering the seedlings, and to help shake out the seeds. This is not so critical if the hay has been chopped up.

- Seed can be extracted from the hay by passing it through a combine harvester. The seed can then be sown onto a prepared seed bed in the normal way.

11.8.3 Sowing dates

Mixtures sown in spring can initially be faced with greater competition from weeds and grasses than autumn sown grasslands. Sowing in August or September generally gives the best results. In late summer, conditions are relatively warm and moist and young plants will get well established during the winter ready for vigorous growth the following spring. Some wild flowers such as cowslip need a spell of cold weather (vernalisation) to stimulate germination in the spring.

The following tables suggest plant species suitable for sowing in four different situations. This is general guidance. It is best to select seed mixes to suit the project objectives and individual site characteristics (see Sections 11.2 and 11.7). If the aim is to re-create a target semi-natural grassland type then the species mix could be drawn up with reference to the species composition of local semi-natural sites or the NVC grassland tables in Rodwell (1992).

Latin names have been used to avoid the confusion that can arise from the different common names given to plants. English names are given in the species glossary for Tables 11.1- 4 which follows the references at the end of the Chapter.

Many of the species listed do not occur naturally throughout Scotland. However, the tables have been annotated to show parts of Scotland eg SE,SW,NE where these species are most appropriate. Scottish Natural Heritage should be contacted for further advice (see Annex 5).

Table 11.1 Wildflowers suitable for sowing on neutral soils (neutral = ph 6-7)

Grasses	Herbs
Agrostis capillaris	*Achillea millefolium*
Alopecurus pratensis	*Centaurea nigra*
Anthoxanthum odoratum	*Hieracium pilosella*
Briza media	*Hypericum perforatum (SE,SW,NE)*
Cynosurus cristatus	*Hypochoeris radicata*
Festuca pratensis	*Knautia arvensis (SE,NE)*
Festuca rubra ssp rubra or commutata	*Lathyrus pratensis**
Poa pratensis	*Leontodon autumnalis*
P. trivialis	*Leucanthemum vulgare*
Trisetum flavescens (SE)	*Lotus corniculatus **
	Pimpinella saxifraga (SE,SW,NE)
	Plantago lanceolata
	Primula veris (SE,SW,NE)
	Prunella vulgaris
	Ranunculus acris
	R. bulbosus
	R. repens
	Rhinanthus minor
	Rumex acetosa
	Saxifraga granulata (SE,SW)
	Tragopogon pratensis (SE)
	*Vicia cracca *
	*V. sepium **

* = legume (use native strain only)

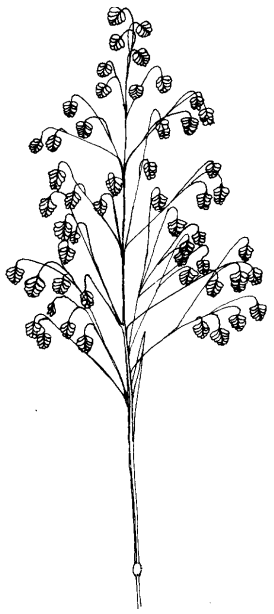


Table 11.2 Wildflowers suitable for sowing on calcareous soils (calcareous = pH >7.5)

Grasses	Herbs
Agrostis capillaris	*Agrimonia eupatoria (SE,SW,NE)*
Avenula pubescens	*Anthyllis vulneraria **
Briza media	*Campanula rotundifolia*
Cynosurus cristatus	*Carlina vulgaris (SE,SW)*
Festuca ovina	*Centaurea nigra*
F. rubra	*C. scabiosa*
Koeleria macrantha	*Daucus carota*
Trisetum flavescens	*Filipendula vulgaris ~*
	Galium verum
	Geranium pratense (SE,SW,NE)
	Helianthemum nummularium (SE,SW,NE)
	Hieracium pilosella
	Hypericum perforatum (SE,SW,NE)
	Knautia arvensis (SE,NE)
	Leontodon hispidus (SE,SW)
	Leucanthemum vulgare
	*Lotus corniculatus **
	Ononis spinosa ~
	Origanum vulgare
	Pimpinella saxifraga (SE,SW,NE)
	Plantago media
	Primula veris (SE,SW,NE)
	Ranunculus acris
	R. bulbosus
	Rhinanthus minor
	Sanguisorba minor(SE)
	Saxifraga granulata (SE,SW)
	Scabiosa columbaria
	Tragopogon pratensis (SE)
	Thymus praecox

* = legume (use native strain only)

~ = localised

Table 11.3 Grasses and wild flowers suitable for sowing on acid soils (acid = pH 4.5-5.5)

Grasses	Herbs
Agrostis capillaris	*Achillea millefolium*
Anthoxanthum odoratum	*Campanula rotundifolia*
Deschampsia flexuosa	*Centaurea nigra*
Festuca ovina	*Hieracium pilosella*
F. rubra	*Hypericum pulchrum*
Trisetum flavescens	*Hypochaeris radicata*
	Leontodon autumnalis
	Lotus corniculatus *
	Plantago lanceolata
	Potentilla erecta
	Potentilla sterilis
	Prunella vulgaris
	Ranunculus acris
	Rhinanthus minor
	Rumex acetosa
	R. acetosella
	Stachys officinalis
	Succisa pratensis
	Vicia cracca *
	Viola riviniana

* = legume (use native strain only)

Table 11.4 Grasses and wildflowers suitable for sowing on damp acid/neutral soils

Grasses	**Herbs**
Alopecurus geniculatus	*Achillea ptarmica*
Anthoxanthum odoratum	*Ajuga reptans* †
Deschampsia cespitosa	*Caltha palustris*
Festuca pratensis	*Cardamine pratensis*
F.rubra	*Filipendula ulmaria*
Poa trivialis	*Hypericum tetrapterum (SE,SW)*
	Iris pseudoacorus
Sedges	*Juncus spp.*
Carex flacca	*Leontodon autumnalis*
C. hirta (SE,SW)	*Lotus uliginosus* *
	Lychnis flos-cuculi
Rushes	*Lycopus europaeus*
Juncus spp	*Pulicaria dysenterica*
	Ranunculus flammula
	R. repens
	Sanguisorba officinalis
	Stachys palustris
	Succisa pratensis
	Thalictrum flavum ~

† = plant as transplant

* = legume (use native strain only)

~ = localised

11.9 Grassland aftercare

Many wild flower mixtures have been sown only to degenerate within a few years to unattractive, rough, species-poor grassland with few species. To maintain conservation interest the grassland must be managed either by mowing (see Chapter 6) or grazing (Chapter 5) or a combination of both. On extremely infertile soils it may not be necessary to cut at all in the first year (P. Anderson pers. comm.).

11.9.1 Cutting

Mowing dates and frequency of cutting will be influenced by the rates of grass and weed growth and the type of wild flower seed sown. Aim to introduce a hay cutting regime with one cut a year in mid-June to July (see Chapter 6). On more fertile soils it may be necessary to cut twice a year for a year or two with one cut earlier in the year to reduce the weeds and competitive grasses and a late cut in August or September.

Where annuals such as hay rattle have been sown, set the cutter bar high if carrying out an early cut and do not cut again until the annual plants have seeded, eg do not cut before the end of July.

Cutting equipment (see also Chapter 6)

The ideal equipment needs to be able to cut long grass on what may be uneven ground and collect the cuttings for removal from the site. The machinery should be manoeuvrable enough to cope with smaller sites while being stable on slopes. Equipment suitable for smaller sites includes strimmers and handscythes.

Equipment suitable for larger sites includes sickle bar; cutter bar; forage harvester; drum, disc or horizontal rotary mowers mounted on a tractor.

Key points

- Do not cut too low, ie below 4cm. This might "scalp" the turf and can create bare patches. Some bare ground is desirable as it creates places where wildflowers can get established. Too much bare ground can encourage weed infestation.

- Do not mow when the soil is damp, machinery can damage the soil. Heavy clay soils are prone to this.

- **Remove cuttings**. If cuttings are not removed they are likely to smother new growth and, as they decompose, nutrients are released which may encourage coarse competitive species. If it is not possible to remove them they should be chopped up finely and scattered.

11.9.2 Grazing the grassland

Conservation interest can be maintained by a grazing only regime where the aim of management is to have an extended period of summer flowering for amenity purposes (see Chapter 5). The duration, intensity and timing of grazing will vary according to site objectives and the practicalities of getting stock onto the site (see Chapter 5, Section 5.7). On dry sites, winter grazing (October-April) could be introduced as an alternative to cutting.

If the grassland is to be managed with a hay cutting regime, livestock should be put on to graze the aftermath (see Chapters 5 and 6). Light trampling by sheep and cattle helps to create gaps where wild flowers can get established. For other created grasslands, the aim may be to graze for longer periods. In the experiment reported in Christal *et al* 1997, botanical diversity in sown plots was highest in the treatments with an early cut, cuttings removed and aftermath grazing by cattle. This may be particularly beneficial on more fertile soils.

Grazing should not be introduced until the grassland has become reasonably established (this might take a couple of years depending on the site). Established grasslands have developed 'rootmats' which help withstand trampling by animals.

11.10 Diversifying existing turf

11.10.1 Slot seeding

Slot seeding is a technique that has been adapted from agricultural use as a method of introducing wildflowers into an existing grass sward. The machines are designed to sow large areas and usually require calibration to ensure precise drilling rates. Much of the original work was carried out by the Institute of Terrestrial Ecology (Wells *et al* 1989 a&b).

The Hunters seeder rotovates strips and introduces seeds into a freshly tilled slot. The Stanhay precision drill has a band sprayer attachment to spray herbicide along each 10cm slot. The Gibbs drill with band sprayer is similar to Hunters but sprays herbicide in a 5cm wide band along the slot. Slot seeding is best performed in less competitive swards dominated by fine- leaved grasses rather than competitive grasses.

Management techniques

- Before slot seeding commences ensure the grass areas to be seeded are grazed or mown as closely as possible to prevent grass getting tangled in the machinery and to give the wild flowers a head start.

- Soil conditions are important. If the ground is hard it will be difficult for the slotting operation.

- The slot seeder needs to be calibrated. Bulk up the seed with a carrier such as barley meal to enable seeding of a large area.

- Cut when grass height exceeds a height of 5cm to prevent swamping of the young plants. Remove cuttings.

- In following years employ a hay cutting/grazing regime as appropriate. Recent research indicates that seedling establishment is greatest where the initial management consists of two cuts followed by aftermath grazing (Jones and Hayes 1998)

- Chain harrow areas at the end of the year to maintain an open sward for new seedlings.

11.10.2 Introducing wildflower plugs and pot grown plants

Wild flower plugs can be planted either into bare ground or existing sward. Special care is needed during the establishment period as they are prone to drought due to their small root stock. When planted into the existing sward there is also the danger of them being swamped by quicker growing grasses. Plugs are best planted into bare ground in combination with seed mixes or where the turf has been removed at the point of planting.

Appearance in the first year can be improved by using pot grown wild flowers. These generally have well developed root systems and are more able to withstand drought conditions than plugs. As these plants are more mature they will usually flower within the first year - important if the site is primarily for amenity value. Introduced into bare areas, these plants will self seed and spread naturally without the addition of a seed mix.

Good species for plants and plugs are listed below:

Betony *Stachys officinalis* (neutral/acid)
Clustered bellflower *Campanula glomerata* (calcareous)
Cowslip *Primula veris* (neutral/calcareous)
Devil's bit scabious *Succissa pratensis* (acid/neutral/calcareous/wet grassland)
Field scabious *Knautia arvensis* (neutral/calcareous)
Greater knapweed *Centurea scabiosa* (calcareous)
Harebell *Campanula rotundifolia* (acid/neutral/calcareous)
Meadow cranes-bill *Geranium pratense* (neutral/calcareous)
Ragged robin *Lychnis flos-cuculi* (wet)
Bugle *Ajuga reptans* (neutral)
Sedges *Carex flacca* and *Carex hirta* (acid/damp/neutral)

Planting should be carried out in autumn (mid September-mid November) or early spring (mid February to early April depending on ground conditions). Plant at a density of around 2-9 plants per m sq. For aftercare see Section 11.9.

11.10.3 Rotovation

Another method of introducing broad-leaved plants into an existing grassy sward is to rotovate the whole sward and then to broadcast broad-leaved plant seeds in autumn. To help the wild flowers get established, spray with a monocotyledenous herbicide in spring to reduce the grass growth.

11.11 Creating grasslands on specialised substrates

11.11.1 Industrial wastes

Alkaline wastes (pH greater than 7.5) ie blast-furnace slag

Few experiments to reduce the pH of alkaline wastes have been carried out. Choose species which naturally grow in alkaline and calcareous habitats (see table 11.2). Seed should be sown without fertilizer but it may be necessary to add low dressings of fertilizer in the first spring after germination (always test the nutrient levels first).

Acid wastes (pH 4-5) eg colliery spoil

At around pH 4-5 it is possible to create an acid grassland or heathland community. If the substrate is too acid, liming may be an option (50t/ha of ground limestone is typical for standard reclamation schemes but should be adjusted according to individual circumstances).

Pulverised fuel ash (PFA)

When first tipped PFA contains enough salt and boron to be toxic to plants. It has a minimal nitrogen content and although phosphorus compounds are present, these tend to be immobilised by aluminium owing to the high pH (Shaw 1994). The high salinity of fresh PFA is tolerated by halophytic plants such as spear-leaved orache *Atriplex prostrata.* The soluble salts that make PFA toxic to non-halophytes are gradually removed by natural weathering (typically 3-5 years). The residual ash remains alkaline and has many of the features of an infertile calcareous silt readily colonised by ruderals such as coltsfoot *Tussilago farfara.* Legumes are boron tolerant and can fix their own nitrogen. Three species of orchid are also found, eg southern marsh-orchid *Dactylorhiza praetermissa*, common spotted-orchid *D. fuchsii* and early marsh-orchid *D. incarnata*.

The PFA succession can be seen to be analogous to sand-dune colonisation. Salt loving communities are replaced by species of dune slacks and calcicoles followed by woodland encroachment.

An experiment has been established at Tilbury power station's Energy and Environment Centre, examining the successional changes on PFA following various seeding and fertilizer treatments (Shaw 1991).

The following species are considered to be fairly tolerant of boron:

Kidney vetch *Anthyllis vulneraria*
Autumn hawkbit *Leontodon autumnalis*
Rough hawkbit *L. hispidus*
Oxeye daisy *Leucanthemum vulgare*
Common bird's-foot trefoil *Lotus corniculatus*
Selfheal *Prunella vulgaris*
Meadow buttercup *Ranunculus acris*
Creeping buttercup *Ranunculus repens*
Creeping bent *Agrostis stolonifera*
Sweet vernal-grass *Anthoxanthum odoratum*

Brick rubble

This is a reasonably fertile material pH 7 or over, however nitrogen may be deficient. As the soil is likely to be fertile omit legumes from the seed mixture. If there is some soil mixed in with the rubble a low dose of fertilizer may be needed after germination. Stone picking and rolling may be needed before cultivation to produce a seed-bed.

Crushed concrete

This is concrete waste from demolition rubble. Coarse grades are hard to rotovate evenly, but fine dust (0-10mm) are available and effective giving a good calcareous soil. The pH of this material is rather high. At a high pH nutrients become unavailable to plants. Mixing it in with subsoil at a 50:50 ratio should give a pH of about 8. Approximately 2 tonne of waste will be required for each 10m sq. Sow a calcareous/wild flower grass seed mix at a rate of up to 5g/m. sq. (see table 11.2 for appropriate species)

The supply of crushed concrete varies but is generally more common in urban areas where redevelopment is taking place. As it will be quite costly to transport, it makes sense to concentrate on using these materials in urban or urban fringe areas.

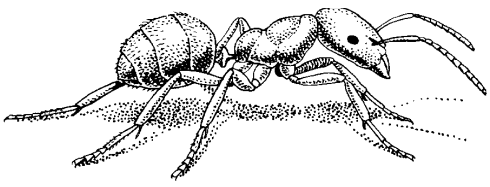
11.12 Creating grasslands for fauna

The structure, physical attributes and management of grassland (eg sward height and architecture, bare ground, hydrology, timing and density of grazing etc) are of paramount importance when undertaking the creation of new grasslands to benefit fauna (see Chapter 13, sections 13.1, 13.2, 13.3 & 13.6).

However, as a broad generalisation, where grassland creation involves the sowing of seed mixtures, the establishment of diverse swards consisting of a mix of grasses and forbs will be more beneficial for invertebrates and birds than mixes consisting of one or a few grass species. It is important though to be clear as to what the nature conservation objectives are at the outset as there may be situations where the establishment of grassland by natural colonisation may be perfectly appropriate. In fact natural colonisation may, in many cases, be a better option in terms of creating a habitat of value for invertebrates and the earlier stages of colonisation may be of greater interest than more established swards (Kirby 1992).

A diverse grassland sward will support a greater range of invertebrates due to the greater range of host plants for plant-feeding species and the greater range of niches resulting from the diversity of plant life-forms. Diverse swards may in turn support a greater richness of potential prey species for predatory invertebrates and insectivorous birds and a greater variety of seeds for birds.

As a general principle, whether swards are established by the use of seed mixes or natural colonisation, the development of nature conservation value will be enhanced where new grasslands are established adjacent to existing semi-natural swards.



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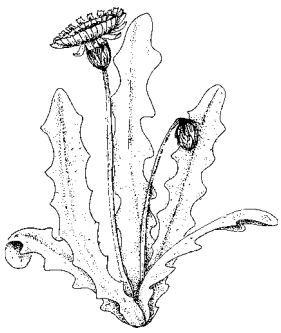

Species glossary

Grasses

Agrostis capillaris Common bent
Alopecurus pratensis Meadow foxtail
A. geniculatus Marsh foxtail
Anthoxanthum odoratum Sweet vernal grass
Avenula pubescens Downy oat-grass
Briza media Quaking-grass
Cynosurus cristatus Crested dog's tail
Deschampsia cespitosa Tufted hair-grass
D. flexuosa Wavy hair-grass
Festuca pratensis Meadow fescue
F. rubra ssp rubra or commutata Red fescue
F. ovina Sheep's-fescue
Koeleria macrantha Crested hair-grass
Poa pratensis Smooth meadow-grass
P. trivialis Rough meadow-grass
Trisetum flavescens Yellow oat-grass

Herbs

Achillea millefolium Yarrow
A. ptarmica Sneezewort
Agrimonia eupatoria Agrimony
Ajuga reptans Bugle
Anthyllis vulneraria Kidney vetch
Caltha palustris Marsh-marigold
Campanula rotundifolia Harebell
Cardamine pratensis Cuckoo-flower
Carlina vulgaris Carline thistle
Centaurea nigra Knapweed
C. scabiosa Greater knapweed
Daucus carota Wild carrot
Filipendula ulmaria Meadowsweet
F. vulgaris Dropwort
Galium verum Lady's bedstraw
Geranium pratense Meadow crane's-bill
Helianthemum nummularium Rock-rose
Hieracium pilosella Mouse-ear-hawkweed
Hypericum perforatum Perforate St. John's-wort
H. pulchrum Slender St John's-wort
H. tetrapterum Square-stalked St. John's-wort
Hypochoeris radicata Cat's-ear
Iris pseudoacorus Yellow flag
Knautia arvensis Field scabious
Lathyrus pratensis Meadow vetchling
Leontodon autumnalis Autumn hawkbit
L. hispidus Rough hawkbit
Leucanthemum vulgare Oxeye daisy
Lotus corniculatus Bird's-foot-trefoil
L. uliginosus Greater bird's-foot-trefoil
Lychnis flos-cuculi Ragged robin
Lycopus europaeus Gypsywort
Ononis spinosa Spiny restharrow
Origanum vulgare Wild marjoram
Pimpinella saxifraga Burnet-saxifrage
Plantago lanceolata Ribwort plantain
P. media Hoary plantain
Potentilla erecta Tormentil
P. sterilis Barren strawberry
Primula veris Cowslip
Pulicaria dysenterica Fleabane
Prunella vulgaris Selfheal
Ranunculus acris Meadow buttercup
R. bulbosus Bulbous buttercup
R. repens Creeping buttercup
R. flammula Lesser spearwort
Rhinanthus minor Yellow rattle
Rumex acetosa Common sorrel
R. acetosella Sheep's sorrel
Sanguisorba minor Salad burnet
S. officinalis Greater burnet
Saxifraga granulata Meadow saxifrage
Scabiosa columbaria Small scabious
Stachys officinalis Betony
S. palustris Marsh woundwort

Succisa pratensis Devil's-bit scabious

Thalictrum flavum Common meadow-rue

Tragopogon pratensis Goat's-beard

Thymus praecox Wild thyme

Vicia cracca Tufted vetch

V.sepium Bush-vetch

Viola riviniana Dog-violet

Sedges

Carex hirta Hairy sedge

C. flacca Glaucous sedge

Rushes

Juncus spp. Rushes