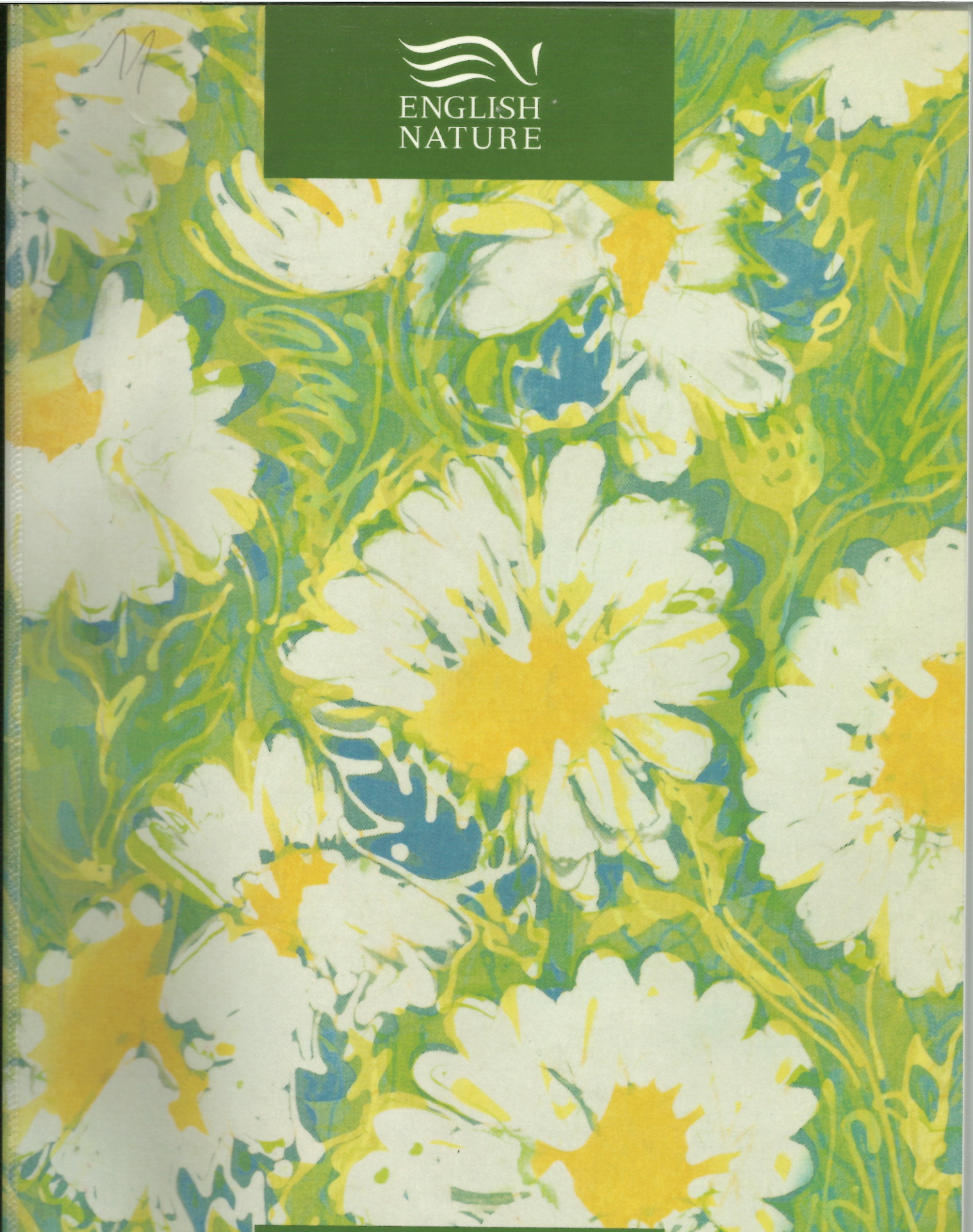
ENGLISH NATURE



Flowers in the grass

Flowers in the grass

Creating and managing grasslands with wild flowers

by
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Report of a research project carried out for the Nature Conservancy Council by the Groundwork Trust (St Helens, Knowsley & Sefton) in association with Knowsley Metropolitan Borough Council.

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Foreword

In the late 1970s/early 1980s the Nature Conservancy Council encouraged work being carried out by the Institute for Terrestrial Ecology under the direction of Dr T C E Wells in the creation of attractive grasslands using native plant species. The three publications deriving from this work which the Nature Conservancy Council produced proved popular and were widely used as practical guides. However, some problems arose, not least with fertile grasslands such as those found in some urban parks, when people tried to sow them with wild flowers and meadow grasses. As part of its urban programme the Nature Conservancy Council commissioned the St Helens Groundwork Trust to investigate practical ways of developing attractive grasslands in urban areas. They and Knowsley Borough Council, on whose land the experimental work was carried out, did an excellent job under the guidance of an expert steering group. As successor to the Nature Conservancy Council in England English Nature commends the results of this study as a practical guide to the difficult job of creating interesting, viable and visually attractive grasslands.

Chapter one

Introduction

Flower-studded meadows and pastures were once commonplace features of the British landscape and culture. Such traditional grasslands have suffered more than any other habitat from the changes of recent decades. Since 1947, 97% have been destroyed. Other habitats have experienced similar, if less drastic, decline. Many people are now concerned to halt, and if possible alleviate, such losses. Attitudes to the green landscape in general are also changing, with greater value put on the 'natural' and less on the formal.

Grassland occupies about a third of the area in most of our towns and cities. Of this, two thirds is close-mown amenity grassland, the remainder unmanaged 'rough' grassland communities. Several unsatisfactory features result. The green areas of urban landscape are often monotonous, show no local variation, are under-used by people and of low value to wildlife. The mown grasslands are expensive to maintain because of the large areas involved; a considerable workforce, which is underemployed at other times of the year, is needed to cope with the peaks of grass growth. Unmanaged areas are seen as signs of neglect, prone to fire and vandalism.

Most land managers are faced with financial stringency, and are seeking alternative, cheaper ways of managing land.

These factors have encouraged interest in 'naturalistic' habitats: the creation of landscapes similar in appearance to natural ones. Because working with natural processes is easier than changing them, lower management costs are expected in the long term. However, short-term costs, including re-training and new machinery, may be higher.

One such approach is the creation of flowery grasslands, attractive to people and other animals. These can bring variety to urban landscapes, reflecting the natural vegetation of the area, and varying subtly from year to year with age and weather. Their different management requirements shift work away from the mowing peaks. The new grasslands are not faithful mimics of traditional plant communities (which anyway show great variation), but they can provide new homes for some of the plants and animals characteristic of such areas. Such new grasslands can be valuable educational assets, close to home and school; attractive ambassadors for the natural world to urban people, without the access problems of our few remaining traditional grasslands. Attractive communities may also be achieved by relaxing mowing on existing swards (Chapter 3).

This booklet describes how such flowery grasslands may be produced, but we do not pretend that it is easy. Grasslands are one of the most difficult naturalistic habitats to create and maintain successfully. They entail moving from the simplest form of management (regular mowing) to one of the most difficult, whose methods are only partly known. This requires innovative, ecological and practical skills which are in short supply. All too often the story of a wild flower grassland is one of a showy second year, but diminishing interest thereafter as coarse grasses, docks and thistles replace the finer

wild flowers, creating disappointment, not beauty.

There are limits to what we can achieve. It is not possible to re-create old, species-rich grassland. The few remaining traditional meadows are irreplaceable and priceless, and the techniques described in this booklet must never be used as an excuse for their destruction. To quote D J Russell (Heritage Seeds), "Even if we have the facilities to copy an oil painting, it does not mean we should cut up the original!".

If new wild flower areas are to succeed, the emerging expertise needs to be shared. This book draws on a 3-year research programme carried out by the Groundwork Trust (St Helens, Knowsley & Sefton) and commissioned by the Nature Conservancy Council, a review of published literature, and the expertise of other practitioners, to all of whom we are grateful. Special thanks are due to Knowsley Metropolitan Borough Council, for encouraging us to experiment on their land, and for the active support of their staff. We are also grateful to the members of our Steering Committee, and colleagues at Knowsley Community College, the Joint Countryside Advisory Service and Landlife, for their help with this project.

How to use this manual

With any naturalistic approach it is essential to start from the existing characteristics of the site. For meadows, the most important factors are soil fertility and management, therefore this manual is structured around these. First decide the soil and management you have or can provide (Chapters 2 and 3), then consult the relevant portions of Chapters 4-6. For subsequent easy reference, an index to techniques is provided on the contents page. A glossary of technical terms is provided in Appendix 4. Scientific names of plants follow Clapham, Tutin & Moore (1987).

Chapter two

All mown grasslands look much alike at a casual glance, but on closer examination there is variety even in urban grasslands. Soils vary in fertility, drainage and aspect as well as past management. All these affect their present plant communities, their suitability as wild flower habitat and the type of grassland possible.

Many amenity grasslands are on fertile, well-drained soil, and the regular mowing with cuttings left on gradually adds to the nutrient supply. The combination of high fertility and frequent disturbance by mowing restricts the plants present to a few competitive species, such as rye-grass, meadow-grass, cat's-ear and clover. If unmanaged, such fertile soils are dominated by a small number of coarse grasses (for example cock's-foot, false-oat, twitch), to the exclusion of less vigorous species. Since much of Knowsley was built on good farmland, the majority of our study area was on fertile soil!

However, areas of lower fertility also exist. Where sandstone is near the surface, soils are naturally acidic (pH<5), exacerbated by a century of acid rain. They support fine-leaved, species-poor grassland of bents and fescues, with patches of Yorkshire-fog marking areas which have poor drainage and/or slightly more phosphate available. Large amounts of Liverpool's Victorian parks are in this state.

Most meadow species, such as quaking-grass, ox-eye, betony, are adapted to moderate levels of stress (low fertility, sometimes poor drainage) and occasional disturbance (haymaking and light grazing). To allow such species, including the popular wild flowers, to flourish, it is necessary to change the conditions to suit them. On fertile soils this will entail creating a degree of stress (usually by reducing soil fertility), and managing the area to give the correct amount of disturbance (Chapter 3). Already stressed soils obviously need less alteration.

Five main factors need consideration.

There is one precaution needed before setting out to choose sites: a simple biological survey to find any areas which already support good wildlife habitat. If a habitat survey of the district has already been carried out, most such areas should be known, but it is still worth checking for small patches which can be incorporated in a landscape scheme. Any area with appreciable wildlife value should be retained (and possibly enhanced) rather than starting again. If in doubt of the value of the existing habitat, consult your local Wildlife Trust or English Nature. Similarly, take expert advice before treating areas close to valuable wildlife sites. During this project, an experiment was laid down on some rough grassland growing on an old PFA dump. Only then did it emerge that the spot had a bee orchid colony: the few local people who knew had kept quiet, afraid that publicity might lead to the plants being dug up (the experiment was abandoned and the orchids are thriving).

a) Soil fertility

The less fertile the soil, the easier it will be to create and sustain a flower-rich community (with the exception of exceedingly infertile materials such as some industrial wastes, which have their own problems – see Chapter 4). Indeed it is not usually worth attempting such a habitat on fertile soils without taking action to reduce fertility (see Chapters 4.1 and 5). There are plenty of examples, dominated by docks, thistles and coarse grasses, to show that it is very difficult to sustain a grassland rich in wild flowers on fertile soil. The easiest way to determine soil fertility is by what is growing on it - a key is provided in Appendix 3. For bare ground, see Chapter 4. Working with nature is almost always easier (and cheaper) than changing it, but some modifications are possible. Soil pH, water regime and fertility can be changed, at a cost, and providing the necessary machinery can be used. One set of experiments was hurriedly moved when the machine proved just too wide for the gateway!

b) Landscape design

In urban areas any habitat needs to be part of a co-ordinated landscape covering the whole of a given open space. Small areas of flowery grassland seem to work best co-ordinated with hedges, shrubs or trees. Larger areas can stand alone, but both need clear edges and paths, and interpretation (see (d) below). Safety also has to be considered. All long grass poses some fire risk, and will not be welcome close to the neighbour's diesel storage tank! Meadows are not necessarily spectacular from a distance - one needs to approach closely to appreciate the detailed tapestry of colour and form.

c) Landscape management

If you can't mow it, don't sow it! Flower-rich grasslands must be managed, usually by mowing - see Chapter 3. The only exceptions are communities on some extremely infertile industrial wastes. One of the commonest reasons for the failure of wild flower schemes is lack of proper management, not just in the early stages but every year. As Chapter 3 shows, management of grasslands with wild flowers is more complex than standard amenity programmes, requiring different machinery and skills and a more flexible approach. If such management is not feasible, some form of enriched rough grassland may be possible (Chapter 7), or other habitats may be more appropriate, such as shrubs, coppice or high woodland.

d) Community involvement

Few people like change unless they can see the reason for it. This is a new approach: one cannot just impose it on an area and expect it to be welcomed. Any landscape design is more likely to succeed if local people understand it and are involved in it, but especially one which creates a habitat with which most people are unfamiliar. Only a tiny proportion of townsfolk have ever seen a wild flower meadow! Therefore it is sensible to involve the local community as fully as possible, from the planning stage onwards, including residents, users, children, schools and local expertise in the shape of Urban Wildlife Groups, County Wildlife Trusts, etc. Common complaints where wild flowers have been tried are litter, 'long grass', hay fever and 'look at the mess down the road' (the last being a past failure). Of these, only the problem of hay fever is really difficult to alleviate, although mixed flowery meadows seem to cause less problems than unmown grasslands on fertile soil (the grass species involved are different). Most problems can be overcome by involving local people. Local libraries, schools and community centres are usually only too willing to house exhibitions, public meetings and educational activities. A range of publicity material is required, suitably presented for different groups in the population. This needs to be well thought out, designed and written, but need not be expensive. In Texas, USA, there are 'wild flower trails' with a range of interpretive materials from notice boards to bumper stickers to spread the message. Having a known person who is easily contacted, possibly a Ranger, puts a friendly face on the scheme and allows a quick response when problems do arise. Continuity is important; how would you feel if you put tremendous effort into a garden, then the firm moved you on and it was all neglected and allowed to decay? Community groups can themselves decline, so there must be back-up available if necessary. Such involvement needs effort and some resources, but each success makes the next site easier, and does much to improve the image of the land managers, reduce vandalism, encourage community life and generally educate. The provision of Rangers, interpretive signs and other materials will increase the acceptability of the new area and reduce abuse.

e) Planning constraints

Traditional species-rich grasslands are now so rare that all examples should be protected in Local Government Plans to help avoid destruction. The creation of new flowery grassland is not easy, cheap or quick, so it is sensible to choose sites that are not planned for other uses, and to write such areas into new plans to minimise loss. Underground hazards such as services should also be avoided to prevent future disturbance.

Chapter three

Management

3.1 Principles

On most soils in Britain, grassland would soon turn into woodland without the action of man or other animals. To keep an area as grassland, it must be managed. In the European agricultural system, grasslands have been traditionally managed either as pastures or as meadows. Pastures were grazed for most of the growing season. Meadows were shut up in spring to allow the grass to grow long, harvested for hay after midsummer, and the aftermath grazed through late summer and autumn (sometimes also in early spring). These two types of management favoured different species. Meadows often had greater numbers of species, and, because many plants flowered while the meadows were shut up, were more attractive to people than pastures.

Agricultural grassland management has changed greatly in recent decades. Modern grasslands contain few plant species and support little wildlife, while traditional grasslands have all but disappeared. One aim of management of non-agricultural grasslands must therefore be to retain and maintain any surviving examples of species-rich or unusual grasslands, whether relics of former agriculture or those that occasionally develop on, for example, derelict industrial land (see Chapters 2 and 4). However, most areas have few such sites, so that attention must centre on newly-created habitats.

In an urban context, management should aim to encourage the wildlife value of grasslands, and to increase their attractiveness to people. These can run concurrently, as grasslands good for wildlife (plant and animal) usually appeal to the human animal also. Management also needs to keep the grassland habitat intact by controlling unwanted species, preventing ecological succession to scrub and woodland, and minimising damage by people.

Many wild flower mixtures have been sown, only to degenerate within a few years to unattractive rough grassland with few species. For a flower-rich habitat to survive long-term, it is best to create stressed conditions before sowing (see Chapters 5 and 7). This will deter problem weeds such as docks, thistles, nettles and charlock. Such small invasions which survive stress and mowing can be hand-weeded or spot-treated with glyphosate. Grasses are essential to a meadow, to form a matrix and to provide winter cover. However, vigorous grasses will suppress wild flowers. If stressed conditions have been created, these grasses can be controlled by mowing: prevention is much better than cure. Stress will also reduce the quantity of herbage produced, lessening the amount of cuttings to be composted (see below).

In some new wild flower grasslands large amounts of clover have invaded. Legumes are attractive species and essential to some insects (for example, common blue butterflies depend on bird's-foot-trefoil).

However they have the ability to fix atmospheric nitrogen, so that a large invasion of vigorous agricultural species such as white clover is likely to raise the fertility of the soil, which in the long term could reduce the sustainability of the flowery grassland habitat. Legumes need moderate levels of phosphate to thrive, and should not be a problem if phosphate levels are sufficiently low. On areas where clover has been abundant soon after sowing, there is some evidence that amounts decline naturally after 5-7 years: long-term monitoring is needed to confirm this. It is difficult, but not impossible, to control clovers by herbicides, therefore the best control is to choose sites or substrates with low levels of phosphate. To avoid problems of rising soil fertility, native legumes should be sown, not agricultural cultivars bred for high growth rates.

Succession to woodland can theoretically be prevented by grazing, regular burning or mowing. Only the latter is practical in most urban areas, and is essential to maintain a diverse grassland. Controlled burning, if feasible, can sometimes be useful, for example in reducing accumulated leaf litter to allow new seed to germinate.

Damage from people takes two main forms. Firstly, inappropriate maintenance; to avoid this a well-trained, sympathetic workforce is necessary, with suitable machinery and flexible work-programmes to cope with seasonal variation. Where contract maintenance is envisaged, contract documents should set out the requirements very clearly (Chapter 3.3).

Secondly, damage, whether intentional or not, caused by the general public. The more the local community can be involved in their landscape, and the more they understand it, the less damage there is likely to be. Communicating with local people, and enlisting their help from the design stage onwards, is therefore vital (Chapter 2.4). Good design will obviously help: careful path layout to allow access without trampling, avoidance of areas where long grass could be a nuisance (for example where there is an existing litter problem) and choosing the best season of display for the use the area will get (a summer meadow display in July/August is of little use to a school!). You can't please all of the people all of the time, and there are bound to be some who would prefer a formal landscape. Ideally, both formal and naturalistic should be available to everyone, but at present the formal predominates.

3.2 Practice

Managing existing interesting areas

This section is not for those fortunate few charged with managing a traditional grassland - the best sources of advice for those are English Nature and an old local farmer who remembers the usage of fifty years ago.

On any grassland, it is possible to mow different areas in different ways to get a pattern of varying grass lengths. This 'differential mowing' can be quite attractive, but in the vast majority of cases do not expect a

diverse show of wild flowers - the attraction will be mainly sculptural. However, carefully-timed mowing can make the most of whatever flowers are there. A simple botanical survey will show if any wild flower species are present in quantity in the sward. An eye-catching effect can be achieved with just one species. On many grasslands, stopping mowing for a few weeks in June will produce what Chris Baines calls a 'flowery hiccup' of buttercups and daises, without making it difficult to resume mowing using existing machinery. The 'hiccup' needs to be timed to match whichever flowery species are already abundant in the sward - May for dandelions, July or August for cat's-ear and hawkbits. Such management would reduce a typical amenity mowing regime of 12 cuts a year to about 5-7 cuts, spread unevenly through the season.

A related concept, of particular value when wildlife is a prime consideration, is 'rotational mowing': using a different pattern of mowing in successive years so that some part of the site is left long each year. The long area provides a refuge for invertebrates and small mammals, while the shifting pattern prevents any one part of the site developing into coarse grassland or scrub.

Existing efforts at differential mowing often experience problems of public acceptability, and amenity grass in flower seems to be a problem to hay-fever sufferers. This approach therefore has to be used carefully, with management chosen to make the best of the sward, and good publicity and interpretation. It needs to be clearly distinguished, both on the ground and in the minds of the community, from wild flower meadows, traditional or newly-created.

Damp areas with cuckoo-flower or creeping buttercup (flower April-May); do not mow in spring, mow and remove cuttings June/July, thereafter mow as usual.

Even in amenity or un-managed grasslands, it is quite common to find small areas of grassland different from the typical rye-grass or false-oat swards. Such areas may not be species-rich, but this is not necessary to give an attractive effect; they do relieve the monotony and may contain some unusual species. Thus Kirkby Old Rough, an amenity area since the 1960s, has patches of acidic grassland on sandy soil. These support sheep's fescue and common bent, with attractive colonies of bird's-foot *Ornithopus perpusillus*, and bird's-foot-trefoil *Lotus corniculatus*. Such patches could be enriched by more species (Chapter 5 and 6), or just managed to make the best of what is there. This type of management is popular in many German cities, such as Augsburg, Cologne, Karlsruhe and Munich.

Acidic grassland with bird's-foot-trefoil (flowers mainly June); mow April, leave May-June, mow and remove cuttings July/August, thereafter mow as usual.

On such areas, the mowing can be relaxed to allow flowering, but otherwise cut as usual - the species present have survived mowing for some years, so it is likely they will continue to do so. On most soils, the vegetation will have grown reasonably long during flowering and will need to be cut and removed. If the cut can be delayed until after seeding of the attractive species, this will help to ensure their survival. For examples, see boxes.

If the interesting areas are on rough grassland, mowing paths and neatening edges will show them off and help lessen abuse.

New and old grasslands

Urban areas have so much close-mown grassland because it is easy to maintain. Grasslands rich in wild flowers require less mowing, but in consequence the foliage is longer, which makes problems for current machinery and makes it impossible to leave cuttings on site. Timing and frequency of cuts cannot be so closely fixed, and are best determined by someone with ecological knowledge, as the weather and the age of the habitat influence the mowing needed. However, some guidelines can be given to help landscape managers.

Mowing frequency

This needs to be related to soil fertility and the water supply, as these control the vigour of grass growth. More nutrients and more water entail more cuts to prevent the grasses smothering the herbs. In the first year after sowing, the herbage needs to be kept low to allow smaller and slower-growing species to establish. This may need up to 4 cuts between April and October on moderately fertile sites in the west, but drought stresses grasses more than broad-leaved species, so less mowing is needed in the drier east of Britain. In dry years, especially after spring sowing, only 1 or 2 cuts may be needed on any site.

Thereafter, mowing regimes have to be devised to fit the flowering period desired and the amount of grass growth. In the wetter west, 2-3 cuts each year may be needed, in the drier east, only 1-2. If rabbits are present, this will reduce the mowing required. Only dry, very infertile or grazed sites will thrive on just one (September) mowing each year.

When to mow

Mowing needs to match the flowering period of the species chosen. Most wild flowers have only one main flowering season, the timing of which varies by 2-3 weeks from year to year. Artificial meadows are usually classed as 'spring' (cut after June) or 'summer' (cut in April/May and September). However, with a well-chosen seed mix flowers can be available from May to September, and a long-lasting meadow is better for invertebrates. (Any mowing between April and September will do some damage to invertebrate populations). If the grassland is cut in April/early May (exact timing depending on whether the spring is early or late and when ground conditions are suitable for machinery) this will depress grass growth for the next 2-3 months. Our well-watered study area in Knowsley needed 2 cuts, in April and May, in a normal spring. All sites need an end-of-season cut in September/October, before soils get too wet for machinery (especially on sticky clays!). These cuttings can be re-used as a seed source if sites are available. If a real spring meadow is required - cowslips and cuckoo-flowers in May - this cannot be mown in spring, but should be first cut in July after the desired species have seeded. Precisely when the mowing is best done will vary with the season. Cuts may be delayed in a late year, or brought forward to prevent weeds seeding. During dry summers it may be possible to miss a cut, but a wet spring may entail an extra one.

Varying the mowing regime within a site will produce somewhat

different displays. Cutting a summer meadow species mix in April will probably produce peak floral interest in early July. A slightly later cut in May will delay the peak of flowering by a few weeks. A portion of a site left completely uncut will protect over-wintering insects, but the portion left must be rotated each year to preserve the habitat.

Height of cut

This must stress the grasses but minimise damage to wild flowers. A guide would be 30-70 mm during establishment, falling to 20-70 mm after 2-3 years. On rough ground, the cut has to be set high enough to avoid scalping. Areas to be mown need to be clearly marked out, especially before the first cut of the year. It will help the man on the mower to do the correct areas if the specified height for wild flower areas is different from that for amenity grassland. Alternatively, outline areas with a sports pitch lining machine.

Machinery

Machinery is still being developed: some is available in Continental Europe but is expensive. The requirement is for machines capable of:

- cutting long grass, on somewhat rough sites;
- being manoeuvrable for small sites and on slopes such as road verges;
- picking up the cuttings, preferably mechanically as vacuum methods remove the insects as well, especially if the job is done in one operation with no gap between cutting and lifting.

Reasonable success has been achieved by ourselves and others with flail machines fitted with a brush to lift cuttings (for example Turf Maid, Lawn Genie) and a rotary mower with collecting box (Westwood). However all these can only collect small amounts of material at a time, which means frequent trips to the collecting point. Second-hand agricultural machinery may be obtainable for under £1000, for example side-mounted drum mowers (powered by tractor) and silage harvesters which chop the cuttings and blow them into a trailer (ideal for composting to replace peat). A friendly mechanic could be a great advantage in maintaining a meadow!

Costs

Costs vary with size of meadow and machinery available. Table 3 compares some very approximate costs for amenity and wild flower areas. Appropriate machinery could cut the estimated costs for wild flower areas by half.

Growth retardants

These can be used in conjunction with mowing. Mefluidide, applied in April/May before the main growing spell, tends to inhibit grasses more than other plants. However more research is needed into the effects of retardants on wild flowers and meadow fauna.

Cuttings

Cuttings should be removed on all except the most infertile sites, to avoid a gradual increase in fertility and to prevent long cuttings smothering the sward. Ideally the cuttings should be left on the ground for 3-5 days to allow insects to move back into the sward. However this may not be practical, and does increase costs by splitting the work into two operations. This can be up to 2-3 times more expensive than collecting the cuttings immediately in a forage harvester.

At present cuttings are normally regarded as a liability, but as peat becomes practically and ethically less acceptable, there will be a growing market for cuttings to be recycled as a mulch or compost material. Some firms are already developing this in a small way (see your local council or trade directories), and it is practised widely in some Continental cities such as Berlin (see *Urban wildlife news* August 1990). When the sward is cut after flowering, the mowings can be a valuable source of seed for more wild flower grasslands (Chapter 6). If hay-making is possible, it could be done as a community event, as now organised on some traditional hay-meadows. The hay can be sold for horses, guinea pigs, etc.

	Cuts/yr	Machinery	Estimated costs £/ha/ cut	£/ha/ yr
Small areas (<0.2 ha)				
Amenity med. quality	16	Ped. rotary	187.5	3000
Amenity low quality	8	Ped. flail	350.0	2800
Wild flower grassland	3	Ped. flail + Hand rake	666.7	2000
Medium areas (0.2-0.8 ha)				
Amenity med. quality	16	Triple	39.4	630
Amenity low quality	8	Compact flail	100.0	800
Wild flower grassland	3	Compact flail + sweeper	400.0	1200
Wild flower grassland	3	Amenity forage harvester	200.0	600
Large areas (>0.8 ha)				
Amenity med. quality	16	5-unit gang	21.9	350
Amenity low quality	8	Tractor flail	55.0	440
Wild flower grassland	3	Tractor flail + sweeper	116.7	350
Wild flower grassland	3	Forage harvester	100.0	300

Table 3
Estimated costs for managing amenity and wild flower grasslands.

NB Wild flower areas needing less than three cuts a year will work out cheaper. Appropriate machinery would considerably lower the estimated costs for wild flower grasslands.

Litter control

Unfortunately this is essential in all urban areas, and is likely to be more expensive in wild flower areas as long grass can trap litter. Good community involvement and interpretation will help to lessen the problem.

Weed control

As mentioned above (3.1), the best weed control is stressed growing conditions. However, some undesirable species may occur, particularly in the early stages, such as creeping thistle or ragwort (both of which are notifiable weeds and must be controlled in farming areas). These can be removed by hand or by spot-weeding with glyphosate, but a reasonably skilled person is needed to identify the plants correctly; for example, some thistles are desirable to encourage butterflies, but creeping thistle is very invasive. If major infestations should occur, it is possible to allow the weeds to grow taller than the general sward, then apply herbicide with a tractor-mounted weed-wiper.

Fertilisers

Fertilisers should *not* be applied! On very infertile sites, negligible growth and yellow leaves may indicate that a small application of nitrogen is needed (Chapter 4). If in doubt, do not apply fertiliser - seek expert help.

Harrowing

In traditional meadows animals created gaps in the sward by trampling. Meadow species are mostly perennials, but some replacement from seed is needed. Usually, cutting a tall sward in autumn will leave plenty of gaps. However, if a sward becomes too thick (perhaps as a result of rabbit-grazing), it may be opened by harrowing. This could be necessary at 3-5 year intervals, and is best done in October/November, when the ground is dry.

3.3 Contract maintenance

With local authority grounds maintenance being put to competitive tender, many landscape managers, whether client or contractor, need to be able to write contracts for meadow maintenance. Currently, specifications tend to be based either on frequency ('cut grass to 25 mm 16 times a year at 7-10 day intervals April-October') or performance ('keep grass height at 25-75 mm'). The latter are easier to manage, but do depend on the contractor knowing how best to achieve them. We do not know what standards are appropriate to specify for a wild flower grassland: 'keep a minimum of 20 cowslips/10 sq.m.' would baffle most people, and may bear no relation to the state of the habitat. Any specification tends to formalise maintenance and reduce the flexibility necessary in managing a naturalistic habitat.

In practice the simplest solution is to exclude urban wild flower areas from programmed contracts, and rely on dayworks. A contractor can still be given an estimate of the amount, type and timing of the work so resources can be available. Organisations with more competent staff may be able to programme routine operations; for example 'cut grass 3 times a year in April, May, September. Do not implement last cut until the following have shed seed; *Centaurea nigra*, *Hypericum perforatum*.' If mowing is specified by height, it is important that the cut is made as soon as any of the area reaches the set height, not waiting until the last area is long enough, by which time other parts are too long.

Farmers and foresters decide the exact dates for their harvests by a 'feel' which is a combination of knowledge and experience. Managers of naturalistic habitats need to develop the same feel for the habitats in their care, and should seek help where necessary to do so, both from local expertise such as Wildlife Trusts and from the small number of people with successful experience.

Starting from bare ground

This section considers creating grasslands rich in wild flowers on various substrates where there is little or no existing vegetation. People have been sowing grasslands for years, but the requirements for wild flowers are somewhat different to modern agricultural or amenity practice. The substrate available is a prime consideration. Its character may be obvious (for example industrial wastes) or deducible from the history of the site (for example reclamation scheme, recent farmland). If not, it may be necessary to resort to bioassay or chemical analysis. The most important chemical factors are nitrogen (N), phosphate (P) and pH, for which Table 4 gives some approximate guidelines. These figures are provisional - there are few data available on just how infertile various soil types need to be for wild flower meadows.

pH	
<5.5	acid
5.5-7.5	neutral
>7.5	alkaline
Mineralisable N	
µg/g	
<2	infertile
2-20	intermediate
>20	fertile
Extractable P	
µg/g	
<20	infertile
20-80	intermediate
>80	fertile

After Allen *et al.* (1974), Dutton & Bradshaw (1982), Marrs (1989) (methods in Allen *et al.*, other methods may give different readings)

Table 4
Soil fertility guidelines for chemical analysis

Soil fertility is affected by pH, especially at the extremes. In both acid and alkaline soils, phosphate is rendered unavailable to plants. If acid soils are limed, this may increase the amount of phosphate available. Ratings for N and P may well be different. A high P, low N substrate may eventually become a fertile soil through the action of legumes. High N, low P could be a candidate for reducing nitrogen by cropping, but this takes some years and may not be effective in areas with high inputs of N in rainfall, so such soils are best treated as fertile.

Organic matter is an essential part of the soil system, and will be lacking in many substrates considered in this section, for example raw industrial wastes. Such substrates can be vegetated successfully using small annual applications of artificial fertiliser, but if it is important to get a good sward quickly, it may be worth adding organic matter before sowing. This can be done by ploughing in a material such as farmyard manure, which will not release a flush of nutrients to encourage coarse species. Alternatively it may be possible to green manure, although the species usually used (for example mustard) may not flourish in infertile conditions. Such measures are not usually needed on subsoils. Most soil microfauna seem to arrive swiftly at new sites; worms take much longer but can be artificially introduced.

Fertile soils

4·1 An example might be newly-abandoned arable land - but no fertile soil stays bare for long, so unless action can be taken immediately, the first task will be to remove the colonising vegetation, probably including perennial weeds such as docks and thistles. Flowery grasslands are very difficult to sustain on fertile soils, needing careful selection of species and management, and should only be attempted by experienced practitioners. A particular problem can be a seed-bank of perennial weeds such as docks, nettles and creeping thistle. This is often absent on agricultural land but only too plentiful on urban sites. In most cases, it is better to reduce the fertility. One effective way to achieve this is to strip all or part of the topsoil, which also removes the seed-bank - see Chapter 5.1 for details. Additional stress may be provided by poor drainage or drought, but these are unlikely to be effective on their own. Suitable species to sow will depend on the conditions then created (see Chapter 6). If this approach is not possible, then some other form of naturalistic habitat may be attempted (shrubs, trees). Left unmanaged, such an area will soon become rough grassland, and one will be limited to the approaches described in Chapter 7.

Subsoils

4·2 Subsoil areas, such as those created during many reclamation schemes, are usually ideal for wild flowers, provided they can be cultivated to produce a reasonable seed-bed. If the subsoil is compacted, ripping or ploughing may be required, or even green manuring. Usually fertilisers are not required! If, after germination, the sward is poor with a yellow tinge, a small dose of nitrogen may be needed (no more than 30 kg/ha N), or some other element may be deficient. If in doubt, seek expert advice. Subsoils will support a range of meadow species, depending on the pH: see Chapter 6 on species choice.

Brick rubble

4·3 This is a reasonably fertile material: phosphate levels are adequate, pH 7 or over and only nitrogen is deficient. In fact, the biggest problem long-term may be keeping the fertility down. In most industrial areas the rain provides at least 30 kg N/ha each year. Legumes grow very well on brick rubble, as a look round your local area will confirm, and are probably best omitted from the seed mixture. Clovers will arrive of their own accord anyway! If legumes are used, make sure to obtain wild types, not agricultural (see Appendix 1). Too much nitrogen going in will only increase fertility, increase management costs and eventually turn the habitat into species-poor rough grassland. If there is little soil mixed in with the rubble, a low dose of N after germination may be needed. Stone-picking and rolling will be necessary before cultivation to produce a seed-bed.

Brick rubble is fairly calcareous, but may not be suitable for species restricted to chalk or limestone grasslands. However a wide range of attractive species will grow - see Chapter 6. Because of the fertility problems, it is worth considering the establishment of woody habitats (shrubs, coppice, woodland) on brick rubble sites: if left alone they would naturally turn into woodland in about 30 years anyway (Gilbert 1989).

Industrial wastes

4·4

Very infertile, physically and chemically hostile, ugly, sometimes dangerous - the usual reaction to industrial wastes has been the sledgehammer: regrade, drain, cover with soil, turn into rye-grass. This in itself has been an achievement, but refinements are now possible. These materials can be a gift in creating naturalistic habitats, in two ways:

- Mixing into fertile soils to reduce soil fertility - see Chapter 5.
- Using *in situ* as a substrate for flowery grasslands.

Some older waste sites have developed interesting and attractive vegetation by natural colonisation alone. These could provide ideas for treating nearby sites. It may be possible to treat modern wastes to mimic the soil conditions of such older examples, but the experiment has rarely been tried.

On all wastes: if an old site is being treated where some plants have colonised naturally, it is usually worth retaining as much of the existing vegetation as possible. The vegetation will have stabilised the surface, started accumulating organic matter, and may include unusual species. Problem elements may have been leached from the surface layers, therefore disturbance can create new difficulties by exposing toxic substances. Many old sites are important to industrial and local history: this interest should be conserved during reclamation schemes, which may include retaining the waste heaps! The open plant communities found on industrial wastes are very easy to enrich, either by overseeding followed by light harrowing, or using transplants. They will need little fertiliser and minimal management (Ash 1983).

The physical and design aspects of reclamation are outside the scope of this book; sufficient literature and expertise already exist. The following are suggestions for creating grasslands rich in wild flowers on such substrates, for which purpose industrial wastes are grouped by pH. It is possible to raise the pH of acidic wastes by liming, but not readily feasible to reduce the pH of alkaline materials. One waste can be used to ameliorate another, for example lime waste and colliery spoil, but owing to the variability of waste materials there are few successful examples (Costigan, Bradshaw & Gemmell 1981).

Alkaline wastes (pH>7.5), usually calcareous, for example blast furnace slag

If the waste is very stony, be prepared for patchy establishment (the plants will spread). Variability is a good thing in ecological terms, as it allows more species a chance to co-exist. It can also add landscape interest, but if too much bare ground in the early stages is unacceptable, try to find finer material elsewhere on site to make a seed-bed. Choose species which naturally grow in alkaline and calcareous habitats (see Chapter 6 and Appendix 1), including native calcicole forms of legumes if possible. Sow seed without fertiliser, but nitrogen and phosphate will both be deficient, so apply small dressings of these annually in spring, starting immediately after germination. Rates of 30-50 kg/ha N, 10-20 kg/ha P are appropriate, for perhaps five years - long-term treatment is still experimental. Stop when the sward looks good and before coarse grasses invade! Mowing will be minimal: one cut per year in autumn with cuttings removed - or none if there are rabbits in residence. A team from Manchester Polytechnic, advised by the Groundwork Trust, is currently using such techniques on limestone quarry reclamation in the Peak District, so more details on long-term development should emerge in due course.

Acid wastes, for example colliery spoil

The choice of plant community on these substrates will depend on the degree of acidity. At around pH 5-6, it is possible to create an acidic grassland community (Appendix 1). Between pH 4 and 5, heathland is an option, but caution has to be exercised on colliery shale: heathland is fire-prone, and if the shale has a high coal content, a surface fire can ignite the whole heap. Revegetation techniques involving the spreading of moorland litter on pipeline tracks have been successfully developed, and can be adapted for wastes. Below pH 4, relatively few species will grow. Wavy hair-grass looks lovely in flower but boring the rest of the year. Liming is possible, though pyritic spoils, as in the South Lancashire coalfield, may need high amounts (50 t/ha of ground limestone is typical for standard reclamation schemes), and on some shales liming may release phosphates, which encourage legume growth and thus boost fertility. More research is needed on establishing herbaceous plants on acid wastes, but probably similar levels of fertiliser application and management apply as for alkaline materials. A better option may be to plant trees, for which the techniques are well known!

Pulverised Fuel Ash (PFA)

This waste, from coal-burning power stations, is unusual among wastes in that it typically has adequate levels of P and K. When first tipped, it contains enough boron to be toxic to plants. This leaches out rapidly, but even after 10 years may restrict what species will grow. Legumes are boron-tolerant and can fix their own nitrogen. This double advantage means they will dominate a site if given the chance, rapidly increasing its fertility. A wild flower grassland, therefore, will require species tolerant of boron (some are given in Appendix 1, but many have never been tried), avoiding all legumes. Sow without fertiliser, but apply a low level of nitrogen annually in spring for a few years (about 30 kg/ha - remember the rain is likely to put in a similar amount). This will boost the sward and hopefully restrict invasion by legumes. Mowing will be required once a year in autumn, but eventually as the nitrogen cycle establishes this will increase to the 2-3 cuts per year required by grasslands on normal soils.

Chapter five

Turning mown grasslands into flowery swards

Any project to create flower-rich grasslands has to start with the soil. Mown grasslands may all look similar, but on closer examination the plants growing there can give an adequate guide to soil fertility - a key to soil types is provided in Appendix 3. The treatment needed is determined by the soil fertility.

5·1 Fertile soils (groups ABC in the key)

This is the difficult end, so first be sure a naturalistic habitat is really the best option; would a productive habitat such as coppice be better? If you do want wild flowers, it is best to reduce the soil fertility (Chapter 4.1) There are several possible approaches: all need some information on the depth of topsoil and type of subsoil on the site. This can be provided by a soil scientist swiftly and reasonably cheaply. Most of the options involve removing the turf and some or all of the topsoil. Such drastic measures remove nutrients and also the perennial weed seed bank: invasion by docks, nettles or creeping thistle is a major cause of failure. The options are:

- Strip and sell the turf and all the topsoil to leave an infertile subsoil. This removes most of the soil nutrients and the seed bank, which is likely to contain mainly undesirable species. On flat sites this may take the land level below winter water table, in which case you will get a marsh instead of a meadow. This technique is simple and relatively cheap (especially if the topsoil can be sold). However it is restricted to sites with an infertile and cultivatable subsoil, for example sand, at an accessible depth (<30 cm), and where stripping will not cause problems to adjacent land by disturbing drainage patterns. It is likely to produce a damp site in most situations, which will influence the species suitable for planting (see Appendix 1). After stripping, the subsoil can be cultivated and a wild flower mixture sown. Fertiliser should not be applied.