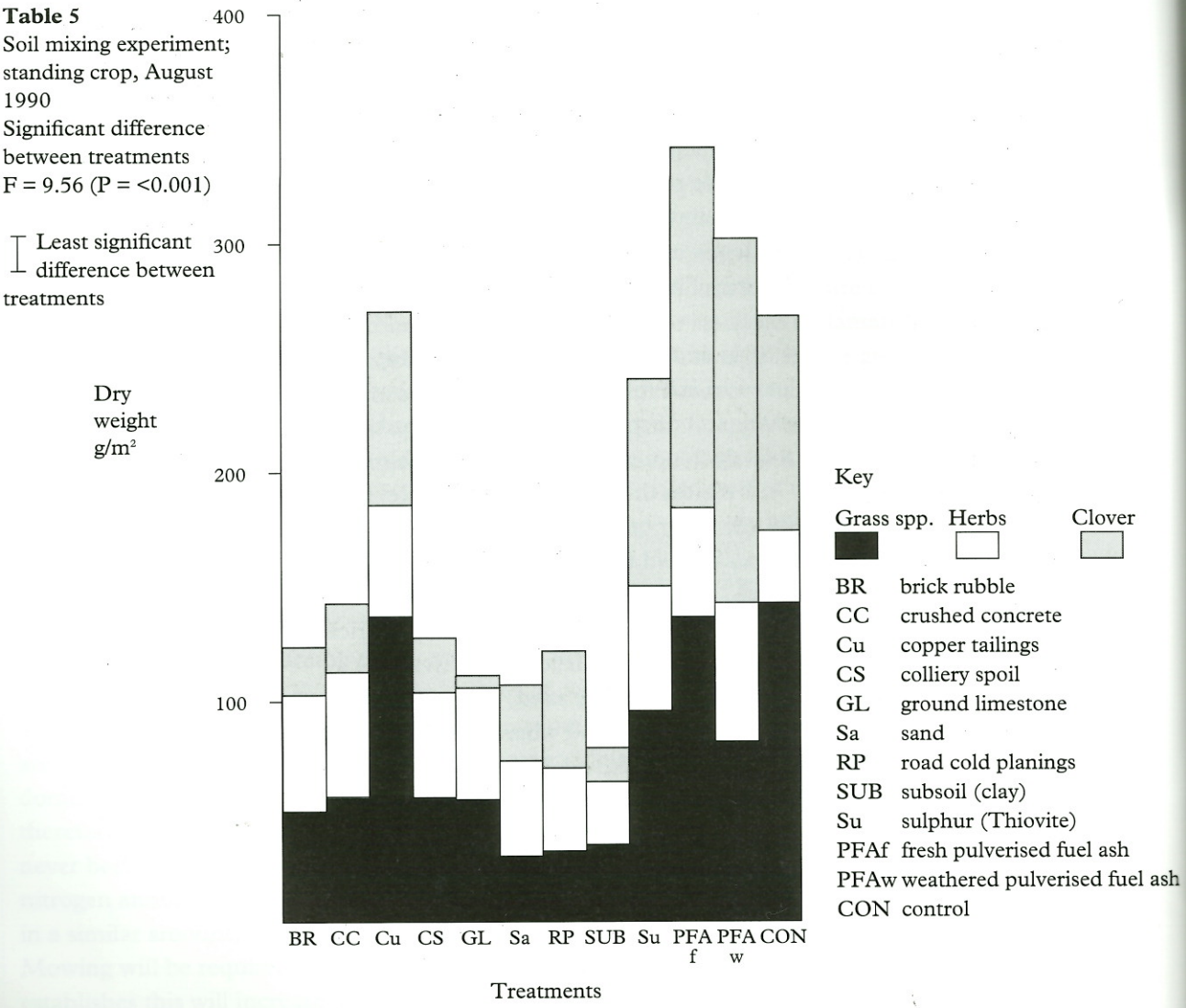
A related idea sometimes advocated is 'reversing the profile' - stripping top and subsoils separately and replacing in reverse order. Apart from wasting a valuable resource (topsoil), there is a danger that deep-rooting species will eventually penetrate to the fertile topsoil layer and grow to dominate the habitat.

- On many urban sites such drastic changes in land level will be problematical, especially where topsoils are deep or only small areas of wild flowers required. The alternative is to strip (and sell) the turf and the top 10 cm or so of topsoil. This removes much of the nutrient supply. Then apply 10 cm of a suitable waste material and rotovate to 20 cm depth, to give a 50:50 mixture (the precise depth can be adjusted to suit the rotovator available, but at least 20 cm is advisable).

After rotovation, the new soil can be harrowed, sown and rolled. No fertiliser is to be applied!

Table 5
Soil mixing experiment; standing crop, August 1990
Significant difference between treatments
F = 9.56 (P = <0.001)



From our trials (Figure 5) the best materials were:

Crushed concrete coarse grades are hard to rotovate evenly, but fine grades (dust) are available and effective, giving a good calcareous soil.

Colliery shale fresh shale is neutral/alkaline, but will steadily acidify to give a somewhat acid soil.

Ground limestone gives a good calcareous soil, but its extraction is destroying areas of scenic beauty and wildlife value, so its use is not recommended.

Subsoil can give good results, but pH and fertility will depend on the subsoil used. Infertile types are likely to be best, either sandy or such clays as can be suitably cultivated.

As a guide to costs, we treated 580 m^2 with dust-grade crushed concrete (from local tower-blocks). The cost for stripping, adding the material, rotovation and seeding was approximately £1.7/m^2 (plus cost of seed - £0.30/m^2). This would probably fall to about £1.4/m^2 on greater areas, with the use of bigger machinery and sale of topsoil.

- If materials of moderate fertility (subsoil, brick rubble) are available as wastes, it is possible to remove more topsoil (<20 cm depth) and replace with the waste material, without rotovation. These could then be treated as in Chapter 2. This might be more successful than mixing into a fertile topsoil. In mixing experiments, both brick rubble and PFA gave poor results, because the soil fertility was not sufficiently reduced.

- Another possible way of reducing fertility is cropping, either of grass or arable crops. This has been tried, with mixed results. On some soils, perhaps ones with low organic matter content or poor phosphate supply, fertility does seem to drop within a few years. However on most soils the evidence is that cropping, even where possible in urban situations, would take many decades to be effective, owing to reserves of plant nutrients in the soil and the inputs from rain. A typical hay-crop removes only about as much nitrogen as some urban rainfall puts in – around 30 kg/ha a year!

Stripping and soil mixing inevitably leave the area unattractive for a period. Seeking less visually damaging alternatives, we tried a) slitting various materials into the soil with a sand-slitter, and b) top-dressing. (We used sand, PFA and ground limestone, at 3 m^3/100 m^2. Slits were 20 cm deep, 3/m). Neither technique reduced soil fertility sufficiently over the 3-year time-scale of the experiments. It is possible that top-dressing might be effective if applied annually for some years before wild flowers were introduced. Ground limestone did have some effect on one site: crushed concrete would behave similarly and is environmentally preferable.

Sand less good results than those above, but could be used on group C soils. Soil pH will depend on sand and soil used.

The following are not advised: sulphur, metal tailings, road cold planings (= broken tarmac). The sub-base from main roads, removed during repair, contains much limestone; recent sowings on this material look promising.

5·2 Infertile soils (groups E,F,G in key)

On these soils there is a choice. Firstly, the area can be stripped of turf, harrowed and reseeded with a suitable wild flower mixture (without fertiliser!). This uses established technology but does carry the penalty of at least a year during establishment when the sward is not particularly attractive.

Secondly, the sward may be rotovated and wild flower seed (without a grass mix) sown on top. Many of the original grasses will regrow to form the grass matrix. This technique should be carried out in autumn (about September) and can give good results.

Thirdly, wild flower seed may be introduced using a 'slot-seeder'. This method has the advantages of using less seed, and keeping the area more or less green throughout (if somewhat stripy!). However this is a relatively new technique as applied to wild flowers, and there have been at least as many failures as successes. Possible reasons for failures include—

- Using on fertile soils - young seedlings are swamped by grass regrowth into slots
- Using on ill-drained soils where slugs/damping off kill many seedlings, especially in the first winter. Geoff Taylor (Johnsons Seeds) describes slots as 'a motorway for slugs'. Slug pellets can be sown with the seed, but they soon lose effectiveness, and are probably harmful to other wildlife. Liquid slug-killers may be more effective, but are untried.

Cost: about £450/ha, but up to £1800/ha depending on how closely the slots are spaced. Availability of machines can be a problem, and transport is a large portion of the cost. A suitable seeding rate, for wild flower seed without grasses, is 2 kg/ha. The seed has to be bulked up with sand, sawdust or the like to suit the machine used, and close supervision is needed.

Results to date have established that the Contraseeder is not suitable for this work. Of the Stanhay and Hunters machines, used on

We laid down trials using 4 machines:

1 Contraseeder: used for over-seeding sports pitches. Makes narrow slits and much seed falls on surface.

2 Hunters rotary strip-seeder: small rotovators cut slots 5 cm wide, 2-3 cm deep.

3 Stanhay precision drill, with band-sprayer attachment to spray herbicide along each slot. Slots 10 cm wide, 1-2 cm deep.

4 Gibbs drill, with bandsprayer: similar to Hunters but sprays herbicide in 5 cm-wide band along slot.

the same site, the Hunters showed better initial establishment, but losses of seedlings were high. Plants from the Stanhay sowings are bigger and performing well. Sowings with the Gibbs and Hunters machines on a different site both did poorly. The latter site is on a north-west facing slope and partly shaded by a church, so damp and cold could be responsible. Application of a growth retardant in spring might help establishment of seedlings in the slots by restricting grass regrowth. To date the Stanhay machine appears to have been most successful in these trials, but possibly a Hunters with a bandspray attachment would be equally successful. Further trials of these machines are needed, on different soils, to investigate the causes of success and failure. The Stanhay is a precision drill adapted by Dr T C E Wells; the adapted version is not available commercially. We have a suspicion that this technique may be better in dry areas, on well drained soil or on south-facing slopes. For those who wish to avoid the use of all chemicals, slot-seeding does not look promising at present, and it must be stressed that the whole method is still experimental.

Fourthly, the existing turf may be retained and transplants used. These are expensive both to buy and to plant, and many are needed if rapid effect is desired. Costs vary with species, but typical figures are 50-60p/plant. If facilities are available, wild flowers are no more difficult to rear from seed to transplants than horticultural species. Some have dormancy mechanisms but most of these can be broken artificially (see Emery in bibliography). Transplants are the only way of introducing some species which do not establish easily from seed in mixtures, for example harebell, and those which produce little seed in cultivation but easily reproduce vegetatively, for example bugle (see Appendix 1). This method is best used on small sites with many interested helpers, where being part of the process and getting results quickly are important, or to enrich an already attractive grassland (under professional ecological guidance!). Success rates from transplants are often high - over 60% for

most species during our experiments in rough grassland, despite a dry summer. If plants can be watered, this will increase the success rate.

5·3 Damp soils (D in key)

All poorly-drained habitats have declined greatly in recent decades, therefore there are good conservation reasons for trying to make new ones. However, there is little knowledge as yet on how to create, or manage, new damp grasslands. Waterlogging restricts plant growth, but is not usually sufficient management on its own. Comparison with traditional damp meadows suggests that a summer hay-cut (with the hay taken off) may be enough to maintain such communities.

There are many attractive plant species which grow in damp grasslands (Appendix 1). Transplants establish well in damp areas, and are a good option for small damp patches. On a large scale, stripping the existing vegetation and topsoil, and sowing with an appropriate seed mix may be the most practical method. All operations involving machinery risk soil damage, especially on clays, and need to be carried out when the soil is reasonably dry.

A major management problem may be invasion by Yorkshire-fog, against which few wild flowers can compete. Its control may be possible by lowering soil fertility, but experience is lacking.

5·4 Making a small site

The sections above may seem daunting to those who just want a small area of wild flowers, perhaps for a school nature garden. A good approach in such circumstances may be to make a mound. To do this, the topsoil (with or without turf) is sealed off by a layer of material hostile to plant roots, such as rubble. On top of this can be built a mound (at least 1m high) of some infertile substrate. Good successes have been achieved with chalk, but a sandy subsoil should be suitable, or a soil/waste mixture as suggested in the soil mixing technique (Chapter 5.1). Make sure the shape can be mown. The mound can then be sown or planted with suitable species,

whose attractiveness will be well displayed by the slopes. There is a slight risk that deep-rooted plants will eventually penetrate to the underlying topsoil, but on this small scale any over-vigorous individuals can be weeded out. A former school in Hertfordshire had examples on chalk which were 20 years old and still in good condition.

Natural colonisation

5·5

In the past, many attractive and species-rich habitats have developed because places have been left alone. Old industrial areas have many examples from quarries to waste heaps. Unfortunately such a strategy is rarely applicable in the modern landscape. Three things appear to have been necessary for interesting communities to develop; low fertility in the substrate, a supply of suitable species, and time. Owing to the decline in many native species, an area of infertile habitat exposed today is less likely develop into an attractive wildlife habitat. The plant colonists will probably be such few plants common in the surrounding landscape as can survive the conditions, and a small selection of wind-dispersed species tolerant of low fertility, such as the marsh orchids (*Dactylorhiza* spp.). Most native species will simply be too far away for their seeds to reach the site. Plant cover on an infertile site may take some decades to develop to an attractive condition. Allowing natural colonisation to proceed is therefore most likely to be useful as a means of extending an existing rich habitat, at the expense of adjacent less interesting ones, and ecological advice will be needed.

Chapter six

Species and mixtures

6.1 Suppliers

Not all wild flower seed suppliers sell seed of equal quality. Poor seed will give poor results! It is highly desirable that a seed certification scheme is set up, but in the current absence of adequate quality controls on wild flower seed, choose a reputable seed merchant who:-

- Supplies only British stocks - these will be best suited to our conditions and will not pose a genetic threat to wild populations, as foreign stocks do.

- Supplies native strains, not agricultural cultivars, of species such as bird's-foot-trefoil and kidney vetch. Agricultural varieties are visually and ecologically unsuitable for wild flower plantings.

- Supplies seed produced under closely controlled conditions, so that harvesting is carried out at the best time, and seed dried and stored carefully to preserve its viability. Ideally, to prevent stocks becoming adapted to nursery conditions, no seed should be more than 2 generations from the wild.

Some companies try to meet these criteria. At present these include the major producers of wild flower seed such as Emorsgate, Heritage Seeds, Johnsons, Naturescape and Suffolk Herbs.

For transplants, many small nurseries exist: you are advised to visit local ones, inspect the stock and ask about their seed source.

6.2 Mixtures

Seed merchants offer various ready-made mixtures, but also the facility to buy individual species or have one's own mixture prepared. They will also offer advice.

Seed mixtures are marketed for various soil types, for example moist loamy soils or calcareous soils. To give the species in a mixture a good chance of succeeding, it is essential to match the soil conditions on site as closely as possible to those for which a mixture is designed, considering pH, soil texture, water regime and aspect. The geographical location of the site to be treated is also important: some species used in mixtures are naturally confined to certain parts of the British Isles, for example meadow barley occurs mostly in south and east England. Such species stand less chance of success outside their natural areas and are best omitted. Table 6 gives a checklist of factors to be considered before approaching a supplier, to help in selecting suitable material.

Table 6 Factors affecting the choice of wild flowers

County
Substrate - for example sandy subsoil, topsoil mixed with crushed concrete
Soil fertility - see Appendix 3
Soil pH
Soil moisture regime - for example dry all year, standing water in winter
Aspect - for example slope facing south-west
Shade
Previous land use
Height above sea level
Is the site coastal?

At present it is not always straightforward to compare mixtures from different suppliers, as the composition of mixtures is usually quoted as % by weight (if at all!). Since wild flower

species vary manyfold in their seed weights, from 10,000 per gram for St John's wort to 40 per gram for tufted vetch, it would be better if compositions were quoted by % seed numbers. (Some catalogues do list seed numbers/gram so the arithmetic is possible, if tedious.) It would then be possible to check if a mixture was dominated by just one or two species, or contained such small amounts of some of the species listed that their success would be doubtful. A simple mix of species well-adapted to the conditions available will be equally, if not more, successful than a complicated one, some of whose species are not suitable, or present as only a few seeds. Scientific names should be quoted, as vernacular ones vary.

If you feel capable, there is much to be said for choosing your own mixture to fit each particular site, perhaps using a simple standard mix and adding appropriate species. Appendix 1 provides suggestions. This is especially useful on unusual soils such as industrial wastes, but on any site allows the inclusion of particular, local or well-adapted species, and may increase the variety of grasslands developing in different places.

Whether evaluating standard mixtures or designing ones own, a few guiding principles apply—

i Avoid rare species such as fritillary; they are likely to be particular in their habitat requirements.

ii Do not use species outside their natural range. For example clustered bellflower is restricted to calcareous habitats in southern England. Consult the BSBI Atlas of the British Flora (see bibliography), county floras or local experts such as the Wildlife Trusts as necessary. This can be extended to different ecotypes: northern forms of knapweed *Centaurea nigra* lack ray-florets and look quite different to southern types.

iii Do not use species known to fail in seed mixtures (see Appendix 1), no matter how nice this may make the mixture look on paper! Such species are best added as transplants once the sward is established.

iv A long species list is unnecessary and expensive; a handsome grassland can be had with a relatively few, attractive species, chosen to suit the site conditions available. Given time, and low fertility so that gaps remain in the sward, most species in a well-chosen mixture should appear. Ox-eye daisy will be there in the first year, St John's wort well-established by three, but in experimental plots pepper saxifrage took 8 years to germinate!

v If a wide choice of species is available, try to choose a range of colours and flowering times, but remember the latter have to be compatible with the management regime. Also consider attractiveness to insects, birds, etc., and cost. Think who will use the site; many children, seeing the grassland at close quarters, appreciate low-growing flowers, but folk with poor sight may prefer bright flowers and scented plants.

vi If wild-collected seed is a possibility, remember to use only plants which regularly grow in grasslands, are perennials, able to spread vegetatively, and not invasive species which form single-species stands in the wild. See Wells *et al.* (1981) for advice on collecting wild seed.

vii Some researchers feel that hay-rattle should be included in most mixtures, as a check to grass growth (it is hemi-parasitic on grasses). The same would apply to eyebright and red bartsia, but their seed is not commercially available. Hay-rattle can be unreliable in mixtures; vernalisation, using fresh seed and the presence of established grass roots all seem to aid germination. On bare sites it is therefore best sown a year after the main mixture, especially as mowing during the growing season will remove it (it is a strict annual).

6.3 Methods

The usual practice is to sow 20% wild flowers:80% grass seed at a rate of about 30 kg/ha. The grasses are a mixture of slow-growing, fine-leaved cultivars or native strains, exact species depending on the soil type. Avoid fast-growing agricultural or amenity cultivars. Highland bent *Agrostis castellana* is

used in agriculture rather than common bent *A. capillaris*: the former is unsuitable for wild flower areas because it is very vigorous, though it can be used successfully in very stressed sites such as upland peaty soils. There is evidence that red fescue can form a dense mat which inhibits other species. It should probably be kept to <50% of the grass mixture and the less vigorous forms used - chewings fescue *Festuca rubra* ssp. *commutata* and slender red fescue *F.r.*ssp. *litoralis*. Suitable varieties are those which do not form good turf (i.e. those found in the bottom half of the STRI merit table) - these are also cheaper. They include, for chewings fescue, 'Agram', 'Banner', 'Koket' and 'Wintergreen', and for slender red fescue, 'Dawson', 'Logro', 'Merlin' and 'Oriflame'. Strong red fescue is less suitable for use with wild flowers: if necessary a dwarf type such as 'Boreal' should be selected.

wild flower: grass	typical price/kg(1990)
20:80	£20
10:90	£12
5:95	£ 8

(for a simple mixture of 8 wild flowers plus a grass mix)

Some people recommend sowing a 'nurse' species with the seed mixture, when making spring sowings. Usually the annual Westerwolds rye-grass is used, which if cut before seeding should not persist into the second year. The advantages are said to be that the nurse germinates quickly, providing a better microclimate for the emerging perennial species, and its death leaves gaps in the sward for slower-germinating species. Sowing rate 20 kg/ha. Other people are much against the practice, arguing that if the nurse grass is not cut at the right time to prevent seeding, or does not die out in a mild winter, it can be difficult to eradicate once the meadow mowing regime is in operation. On moderately fertile soils the microclimate effect may be unnecessary, and the space needed for wild flowers, while under very stressed conditions (for example a drought following sowing) the Westerwolds may grow too sparsely to be useful. Further research is needed on this question.

The proportion of wild flower seed can be lowered to 10% or even 5% if a quick effect is unnecessary, with consequent savings (see box), providing the soil is suitable and management can be rigorously applied.

Wild flower seed can be sown in spring (March - May) or autumn (September - October), although if the recent dry summers continue, germination will be much better from autumn sowings. Species requiring cold treatment will appear more quickly from an autumn sowing, but provided the fertility is low enough the end result will be much the same from either. Soil treatment (stripping, mixing, etc.) should be done over winter for a spring sowing, or in late summer (August - September) for an autumn one. A long gap between treatment and sowing, if it occurs in the growing season, gives local plants time to colonise, not all of which may be welcome. Transplants can be set out at the same times.

6.4 Hay

An unusual source of seed, rarely available, is hay from existing species-rich grasslands. Inevitably the hay only contains a selection of the species present in the original habitat - those with ripe seed when the hay was cut. Therefore the timing of the hay-cut is important, and its seed composition will vary from year to year with the weather and the vagaries of seed set. However, Dr T C E Wells (1986) created an attractive grassland by spreading hay on bare soil. It included 18 species derived from bales which contained the seed of about 26 grass and wild flower species each. This technique is most likely to succeed where soil fertility is low. The ground is cleared of existing vegetation, by cultivation and/or herbicide, and the hay spread on the surface. Dried or green hay may be used: work at Wolverhampton has shown promising results with the latter. The hay should be lifted after some days to avoid smothering the seedlings. Labour requirements for this technique are quite high, and there is a risk of

the hay being set on fire if it is spread on public open space. Similar results may be obtained using seed collected by combine harvester from species-rich grasslands, as marketed by some seed companies

Similarly, once a new wild flower grassland is established, it can be used as a seed source for further plantings, either by using hay, or, if machinery is available, by harvesting seed. This reduces seed costs, but does need organisation to have receptor sites prepared at the right time. Penny Anderson reports that using such hay cut in September/October and spread on subsoil worked "well but slowly".

Existing habitats can sometimes be used as sources for very specific seed mixtures, given early planning to allow harvesting. When part of a habitat is to be disturbed, for example by a pipeline, seed can be collected from the pipeline track in advance and stored for sowing after the pipe has been laid. This technique has been used successfully for some years on heathland (Environmental Advisory Unit), and promising attempts are now being made to extend it to other habitats (David Russell pers. comm.) It is critical to the success of such schemes that the soil layers are replaced accurately before seeding is carried out, so that the fertility and water relations of the disturbed soil are as close to their original state as possible. The jigsaw has to be put together correctly if the picture is to fit.

6.5 Turf

Some purpose-grown, wild flower turf can now be obtained commercially, but is expensive. Very occasionally, it may be necessary to move an area of traditional species-rich turf. This should only be done if all attempts to conserve the site *in situ* have failed (Chapter 1). The techniques are still experimental; some examples have achieved reasonable, though never complete, success, others utter failure. The key points appear to be i) that the soil conditions (fertility, drainage, pH, topography) are matched closely between the donor and receptor sites and ii) similar management can be applied.

Before any work is carried out, several soil profiles should be dug on the donor site to see how deep the bulk of the roots go: this is the depth to which turf will need to be stripped. It is likely to be at least 20 cm, and could be up to 40 cm if it is necessary to move some subsoil as well. Turf is stripped from the receptor site and any necessary preparation done. Turf is then taken from the donor site, in as large a pieces and with as little damage as the available machinery can achieve. It should be relaid as soon as possible. Usually the turves are relaid as a carpet in their original positions with regard to one another, but they can be spread out and a simple seed mix sown in between. It is unlikely that all plant species will survive the move, but a reasonable proportion should do if the conditions above are met, and some animals will also have been transferred.

6.6 Cornfield annuals

Cornfield weeds have declined at least as severely as meadow plants. Many have attractive flowers and are good candidates for new urban habitats. However, cornfields are an entirely different habitat to meadows. Cornfield flowers (Appendix 1) are annuals, requiring yearly soil disturbance, open ground and reasonably fertile soil. On infertile soils, growth is stunted (or in the extreme, non-existent). Meadow species are mostly perennials, adapted to low fertility, continuity of management and little soil disturbance. It is sometimes suggested that cornfield annuals can be sown with a meadow seed mix to give interest in the first year. Opinions vary; one worker has had considerable success using a very low density of cornfield annuals (about 2 kg/ha) with a meadow mixture, giving some colour in the first year but still allowing space for the perennials to establish. However many people are entirely against the idea; so as to allow the perennials to establish, the annuals should be mown when in full flower - which is either not done, or if carried out leads to a public outcry.

Cornfield species are usually better treated as a separate display. An area of cornfield flowers can be maintained by annual rotovation, but this allows local annual weeds to accumulate and tends to favour a few species depending on the timing of rotovation (for example, autumn treatment favours autumn germinators like corn-cockle rather than poppies).

The best landscape uses for cornfield species appear to be

- A rotation of plots, one area cleared and sown with annuals and grass each year, then mown for a few years to reduce annual weeds.

- a one-off treatment for new grass areas. Hertfordshire County Council sows all new amenity grasslands with cornfield annuals and grasses, giving one year's colourful display before normal maintenance starts. This can also be done on new roadsides.

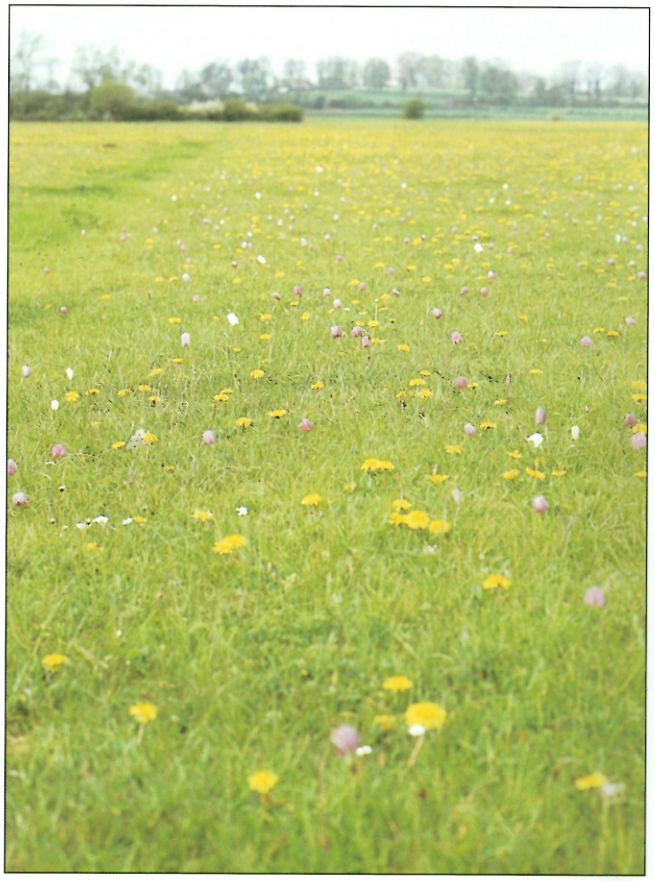
- A cosmetic treatment for temporarily unused sites.

Structurally monotonous and ecologically poor, the urban green desert offers little for people or wildlife.
(Photo: Groundwork Trust)

Flower-rich tall grasslands help create attractive and varied landscapes.
(Photo: Rainer Kretz)

Cornfield annuals can be attractive but need separate treatment. They should not be planted together with the grassland species.
(Photo: Richard Scott)

It is not possible to recreate long-established meadows like the fritillary meadows at Cricklade. The kinds of attractive grasslands we are creating are something quite different.
(Photo: Roy Harris)



One of the most pleasing and successful patterns is to edge woodland planting with tall grass and herbs.
(Photo: Rainer Kretz)

Even simple combinations can give spectacular results. Here knapweed, ox-eye daisy and perforate St John's-wort make an attractive show.
(Photo: George Barker)

Michaelmas daisy in rough grassland; part of the prairie transplants experiment.
(Photo: Groundwork Trust)

Young volunteers transplanting pot-grown wild flowers. Local people can often give valuable help with this kind of work.
(Photo: Groundwork Trust)

Lupins in rough grassland; part of the prairie transplants experiment.
(Photo: Groundwork Trust)

The often spectacular plants which colonise the stressed habitats of industrial waste tips point to the value of modifying the soils in order to establish viable attractive grasslands.
(Photo: George Barker)

Hunters slot-seeding machine in operation. Seedling establishment was good but later losses were high.
(Photo: Groundwork Trust)

Stanhay precision slot-seeder with a bandspray attachment. Seedlings were more vigorous and survived better in the longer term.
(Photo: Groundwork Trust)

Soil mixing plot two years after establishment showing a good range of species - including naturally-seeded white clover! (Photo: Groundwork Trust)

Soils mixing plots being prepared. The introduced materials being placed on site after topsoil stripping but before being rotovated in.
(Photo: Groundwork Trust)

The acid test. The soil mixing plots being assessed for attractiveness by local schoolchildren.
(Photo: Richard Scott)

40 years ago the topsoil was stripped from this site and the site was then left to nature. An attractive damp meadow has developed naturally.
(Photo: Tom Eccles)

A mound of chalk seeded with wildflowers has provided an attractive herb-rich grassland which has proved viable in the long term.
(Photo: John Doyle)

Chapter seven

Making unmanaged grasslands more attractive

Most rough grasslands exist because money is not available to manage them. This section looks at what can be done to make them more attractive without bringing them into regular management. If finance allows, rough grasslands can obviously be stripped, the soil treated if necessary, and flowery grasslands established and managed as in Chapter 5. Careful biological survey work is doubly important before such drastic measures are applied - remember the bee orchids (Chapter 2)? Even low levels of management will have an effect. Annual mowing each autumn (with cuttings removed) will allow a greater range of species to flourish. Alternatively, a hay-cut (and removal) in July may give a better floral display in late summer than no management, and should remove the worst of the summer fire danger.

As with mown grasslands, what can be achieved and the appropriate techniques depend on the soil fertility (see key in Appendix 3).

7·1 Fertile soils (A, B, C in key)

If no management can be applied, it is very difficult to diversify rough grasslands on fertile soils. The tussocks of the dominant grasses and the sheer mass of vegetation swamp less competitive species, and only a small range of species will survive. An annual cut and removal of material in autumn will increase the floral display, but in the absence of management, limited results will have to be accepted, or other habitats such as woodland attempted.

The best method of introduction is by transplants, grown in soil-based media, not peat. Apart from conservation of peatlands, plant roots spread more easily from soil-based media into the surrounding soil, especially in dry spells. A single grass cut (and removal) makes planting easier and may aid establishment. However do not be tempted to rotovate the area; this merely allows undesirable species such as docks and thistles to take hold. Planting can be done in autumn or spring. Unfortunately the plants are unlikely to be able to increase themselves in the sward, and the method is expensive. Plants cost 50-60p each, and labour costs will be considerable unless voluntary groups are able to help.

Ecologically, two approaches are possible; to plant natives, or to use some of the species from other countries which have become naturalised in many urban areas. Natives (Table 7a) are more appropriate in locations such as country parks and urban fringes. However in enclosed urban situations the naturalised species (Table 7b) may be more successful and appropriate. This has been dubbed the 'prairie' approach, since many of the typical species (Michaelmas

daisy, goldenrod, lupin, etc.) come from the North American prairies. However, each urban area has its characteristic species which can be exploited - wormwood in Leeds, yellow-cress in Manchester, tansy and soapwort in Sheffield (Gilbert 1989). To date, the prairie species have proved more successful than any others at surviving on coarse grassland on fertile soils.

A number of nurseries now supply native species, or seed from appropriate seedsmen can be grown up by normal horticultural methods (see Chapter 6, Appendix 1 and Emery 1986). It may be difficult to obtain suitable plants for the prairie approach. The latest garden varieties are often less suitable than strains closer to the wild types. Collecting seed from existing populations (if they produce seed in this country) or even dividing mature plants could occasionally be possible. However we achieved good results using stock from commercial nurseries (some of whom were dumbfounded by our plans!).

7·2 Infertile soils (E,F,G in key)

Most species growing on infertile soils are poor competitors, which makes introduction of wild flowers much easier. However, red fescue can sometimes form dense mats which deter establishment by other species. Never apply any fertiliser - a small amount of cock's-foot in the sward can rapidly become dominant if given nutrients. Technically, three options are possible to enrich swards on infertile soils; transplants (as in Chapter 6.1), rotovation followed by wild flower seeding, or slot-seeding (Chapter 5.2). If using the latter, it will be best to mow the sward about 4 times in the season after seeding, and/or to use a growth retardant, to aid establishment. In the present state of knowledge, transplants or rotovation are safer. However, infertile grasslands are more likely than fertile ones to allow introduced species to spread by seed, so that the impact of a relatively small number of transplants may gradually increase. A list of suggested species can be found in Appendix 1. Prairie species mostly thrive on fertile soils and are not recommended for infertile habitats.

7·3 Damp soils (D in key)

Really wet areas are better treated as marshes (see Emery 1986). Damp grasslands vary in soil fertility, but water-logging does restrict the growth of coarse grasses such as false-oat. Very little experience is available on how to tackle these soils, but transplants are probably the best option (see Appendix 1 for suggested species). If machinery can be used, clearing and re-sowing would be feasible. However, on all but the most infertile soils, this could lead to invasion by Yorkshire-fog, which is one of the few grasses to have a seed bank in most soils, and is difficult to control once established.

Table 7 Species suitable for enriching rough grassland D = best on damp sites

a Natives

Yarrow
Achillea millefolium

Wild angelica
Angelica sylvestris D

Wormwood
Artemisia absinthium

Mugwort
Artemisia vulgaris

Knapweed, hardheads
Centaurea nigra

Teasel
Dipsacus fullonem

Hemp-agrimony
Eupatorium cannabinum D

Perforate St John's-wort
Hypericum perforatum

Field scabious
Knautia arvensis

Oxeye daisy
Leucanthemum vulgare

Common toadflax
Linaria vulgaris

Ragged-robin
Lychnis flos-cuculi D

Musk mallow
Malva moschata

Common sorrel
Rumex acetosa

White campion
Silene alba

Marsh woundwort
Stachys palustris D

Hedge woundwort
S. sylvatica

Goat's-beard
Tragopogon pratensis

Tufted vetch
Vicia cracca

Bush vetch
V. sepium

b Naturalised species

Michaelmas daisy
Aster novi-belgii
A. novi-angliae, etc.

Canadian fleabane
Conyza canadensis

Elecampane
Inula helenium

Broad-leaved everlasting-pea
Lathyrus latifolius

Garden lupin
Lupinus polyphyllus

Yellow loosestrife
Lysimachia punctata

Peppermint
Mentha piperita

Spear mint
M. spicata and hybrids

Sweet cicely
*Myrrhis odorata**

Sainfoin
Onobrychis viciifolia

Soapwort
Saponaria officinalis

Canadian goldenrod
Solidago canadensis

Tansy
Tanacetum vulgare

or whatever grows on neglected land in your area!

*not found in southern England

#naturalised species are those from other countries which have recently established themselves here and spread without further help from man. The distinction between a) and b) is not always clear. Tansy, wormwood and soapwort were all formerly cultivated, but are now thought probably native in some parts of Britain.

Monitoring

Many people over the last 10 years have tried to create flowery grasslands, with varying success. We have endeavoured to tap a range of expertise, and some general principles have emerged, but many questions remain. Therefore it is to everyone's advantage if newly-created grasslands are monitored and lessons learnt. A pool of experience needs to be accumulated on the effects of soil, weather, rabbits, mowing, species used, etc. As with children, each one is different, but the same problems and patterns occur, in different combinations. Does dampness of climate affect the success of slot-seeding? Does aspect have a serious effect on germination? What about species not currently in commercial production, especially ones which grow near the area being treated? Even a country as small as Britain has considerable variation between areas, so local experience is always most relevant. Monitoring will also give early warning of changes in the sward, which may suggest alterations to the management regime.

It would be appreciated by scientists if information from the initial scheme and monitoring records were lodged in a safe place like the regional Biological Data Bank, so that the origin of the habitat can be traced in future years. This is particularly important if using species which are naturally indicators of old habitat, for example pignut, yellow-rattle.

Monitoring need not be arduous or complicated. The basic scheme could be a record of the management carried out, and when, coupled with an annual list of the plant species present and their abundance (Table 8). We need information on how things change from year to year. A more thorough botanical survey might be worthwhile every 5 years or so - the local Wildlife Trust can probably help. Traditional meadows support a large number and variety of insects and other animals. Very little is known about animals colonising new flowery grasslands, how effective such areas are at attracting wildlife, or the effects of the animals on the plants. A number of species seem to arrive of their own accord, but is there a case for introducing animals, perhaps on sites in closely-built areas? What about sedentary groups such as earthworms? At present, all such schemes are best discussed with the local Wildlife Trust or English Nature. Both fauna and flora monitoring schemes could form part of educational work such as GCSE projects and Ranger training schemes.

Table 8
Wild flower grassland at Tower Hill Park, Kirkby, Merseyside.

Scheme designed by Rainer Kretz of Knowsley Borough Council. Sown on a mixture of crushed tower blocks and subsoil, covered by 50-100 mm topsoil, June 1985. Area 16,000 m² in several sections. Mown 2x in 1985, 3x in 1986, once per year since in October (cuttings removed).
Mixture chosen by Mr Kretz to suit the calcareous substrate, and to try out some unusual species. % by weight and by seed no. in original mixture.

DAFOR: D = dominant, A = abundant, F = frequent, O = occasional, R = rare
agricultural cultivars were used, as native ones were not then available

	Seed mix (main mix 35% wild flowers, 65% grasses)	% by weight	abundance July 1990 (DAFOR)
Nurse crop	Westerwolds rye-grass 30 kg/ha		-
Grass mix	*Agrostis capillaris*	6%	-
	Festuca rubra ssp. rubra	47%)	
	F. rubra ssp. *commutata*	47%)	A

Wild flowers	(total approx. 10 kg/ha)	% by weight	% by seed nos.	abundance July 1990
Yarrow	*Achillea millefolium* #	2	9.5	F
Kidney vetch	*Anthyllis vulneraria* #	22	5.6	F
Knapweed	*Centaurea nigra*	8	2.9	A
Chicory	*Cichorium intybus*	3	1.4	F
Wild carrot	*Daucus carota*	5	4.4	F
Viper's-bugloss	*Echium vulgare*	2	0.2	-
Lady's bedstraw	*Galium verum*	3	3.2	F
Meadow crane's-bill	*Geranium pratense*	2	0.1	O
Rough hawkbit	*Leontodon hispidus*	4	2.9	O
Oxeye daisy	*Leucanthemum vulgare*	4	9.5	R
Common toadflax	*Linaria vulgaris*	2	6.5	-
Bird's-foot-trefoil	*Lotus corniculatus* #	8	3.4	O
Musk mallow	*Malva moschata*	1	0.4	R
Evening primrose	*Oenothera erythrosepala*	2	2.9	-
Spiny restharrow	*Ononis spinosa*	1	0.1	O
Common poppy	*Papaver rhoeas*	4	32.8	-
Hoary plantain	*Plantago media*	2	2.4	O
Selfheal	*Prunella vulgaris*	2	1.6	O
Yellow-rattle	*Rhinanthus minor*	5	1.1	O
White campion	*Silene alba*	2	0.8	-
Red campion	*S. dioica*	5	4.4	-
Lesser trefoil	*Trifolium dubium* #	4	3.6	F
Tufted vetch	*Vicia cracca*	2	0.1	O
Common vetch	*V. sativa*	3	0.1	-

also present;

Agrostis stolonifera	R	*Onobrychis viciifolia*	R
Artemisia vulgaris	R	*Plantago lanceolata*	F
Cirsium arvense	O	*Potentilla anserina*	R
Dactylis glomerata	O	*Ranunculus repens*	O
Holcus lanatus	R	*Rumex crispus*	R
Lathyrus pratensis	R	*R. obtusifolius*	O
Lolium perenne	R	*Senecio jacobaea*	R
Melilotus altissima	O	*Trifolium pratense*	O
		T. repens	A