Field Studies 7 (1988), 153–158

PLANT SPECIES ENRICHMENT OF ECOLOGICALLY IMPOVERISHED GRASSLAND: A SMALL SCALE TRIAL

M. FENNER and IAN F. SPELLERBERG
Biology Department, The University, Southampton, SO9 5NH

ABSTRACT

Twelve selected native plant species were introduced into a species poor, moderately fertile, neutral grassland using two alternative methods: (1) Seeds were sown directly onto four plots which had been cleared of vegetation; (2) plants were raised from seed in pots and then transferred to the grass sward. The first method proved less satisfactory because of the labour involved in clearing the plots and the subsequent growth of ruderals. The second method resulted in greater overall success but some species had a high survival rate regardless of the method used. Undertaken on a small scale, these experiments could form the basis of valuable exercises in field ecology as well as being cost effective ways of increasing the plant species richness of small areas of grassland.

INTRODUCTION

THE LOSS of lowland, herb-rich grassland in Britain, due mainly to changes in agricultural practices, has been well documented (Duffey, 1974; N.C.C. 1985; Green, 1985). This loss has been particularly notable in fertile neutral grasslands, traditional examples of which are becoming increasingly scarce and are now often confined to small designated, protected areas. The major change in the ecology of these grasslands has been caused by agricultural improvement, a process of re-seeding and intensive application of fertilisers which results in diminished species richness of both flora and fauna.

Many field centres including those run by the Field Studies Council have, within their ownership or control, areas of grassland which have become ecologically impoverished owing to intensive agricultural practices. Such areas often support species-poor communities usually dominated by tall-growing grasses such as *Lolium perenne, Dactylis glomerata* and *Holcus lanatus**. These grasslands offer opportunities for practical conservation with the object of increasing floral diversity by the introduction of carefully selected species, and by appropriate management. For the diverse groups of people making use of field centres, projects on species enrichment offer experience in both applied ecology and conservation, as well as contributing to wildlife conservation in a wider sense.

On a national scale, large areas of agriculturally-improved grasslands are likely to revert to less highly productive management regimes in the near future because of decisions taken by the European Economic Community to discourage over-production of milk and beef. Some grassland, formerly devoted to intense grazing, may now be allocated to different forms of land use including amenity, recreation, education and conservation. In the case of such grasslands, the opportunity will exist for restoring the former plant species richness where this is appropriate.

Management methods which promote diversity in grassland communities are well known, particularly those methods involving mowing and grazing regimes (Green, 1979).

*See Table 1 for the English names of the plants indexed.

Only more recently has there been a rapid growth of interest in species enrichment of grasslands by direct sowing or planting of wild plant species.

This paper describes an experiment in which carefully selected native plant species were introduced to a previously grazed but unimproved, species-poor neutral grassland. The aim was to assess two treatments used in the introduction of wild species. In the long-term, the objective is to establish a species-rich sward for use not only in field studies but also for use as an amenity and conservation area, such as might be established within the grounds of a school. Since the purpose was to create a plant community typical of the area, no rare or exotic species were used. The project was undertaken on a small scale so as to be as cost-effective as possible.

There are many alternative methods used for establishing communities of wild plants. One is to plough the whole site and sow an appropriate seed mixture (Wells, 1987). This method is very expensive especially on a large scale and may be beyond the resources of most organisations concerned with field studies. There are many sites where it is more satisfactory to use the existing turf as a matrix, into which appropriate plants or seeds are introduced. This necessitates use of gaps in the vegetation which facilitate colonisation of the introduced material. In nature, self-sown seedlings establish in gaps resulting from the activities of moles, rabbits and livestock (Grubb, 1977). Artificial gaps can be created mechanically on a large scale by slot-seeding, in which strips are cleared of vegetation and the seeds sown into the strips (Wells, 1986).

In the trials described here, two small-scale and unmechanised methods were assessed. In the first, seeds were sown into cleared plots created in the turf. In the second method, container-grown plants were inserted into small gaps. Both methods proved to be simple and cost-effective and suitable for widespread use where financial resources are limited.

MATERIALS AND METHODS

Twelve common species of native British grassland plants were chosen to test the feasibility of introducing them into established turf. The choice of species was determined by the following considerations:
(1) Ecological suitability to well-drained meadow conditions on neutral soil; (2) absence or low frequency in the existing turf; (3) widespread distribution in Britain (no rare or exotic species used); (4) attractiveness (species of "popular" conservation interest used); (5) availability of seed.

The site of the experiment was part of a 3 ha meadow at the Southampton University Chilworth Research Centre, Hampshire. The soil is a black gravelly loam with a pH of 5.5 in the area used. Although the soil is slightly acid, the vegetation is "neutral grassland" as defined by Tansley (1939). The meadow was formerly used as unimproved grazing land for cattle. After the winter of 1983/84, grazing ceased and in the summer of 1984, large and vigorous stands of Ragwort (*Senecio jacobaea*) were removed by hand. The rank growth of Yorkshire fog (*Holcus lanatus*) and Cocksfoot (*Dactylis glomerata*), and the persistence of nettles (*Urtica dioica*) in some areas of the meadow indicated a high level of fertility.

Experiment One consisted of sowing seeds directly onto the soil surface in gaps cleared of vegetation. Four rectangular areas (8 m × 1.2 m) were sprayed with a systemic herbicide on 4 March 1986 and the plots were dug over three weeks later, removing all dead vegetation including roots. In order to see if seedling establishment could be enhanced by various simple methods, four treatments were used on these cleared plots: (1) bare soil as a control; (2) a 2·5 cm layer of John Innes No. 2 compost placed on the soil surface; (3) a

"Nordene" cloche (made of perforated polythene which expands with the growth of the plants) placed on the surface; (4) combined compost and cloche treatment.

The purpose of these treatments was to provide a favourable seed bed for germination and early growth. The J.I. compost is rich in organic matter and mineral nutrients and it was hoped its presence would suppress the germination of unwanted species from the soil seed bank by excluding light from the surface. The Nordene cloches create a favourable microclimate by retaining heat and moisture. All the plots were initially covered with a fine plastic netting to exclude rabbits.

Each 8 m strip was divided into three sections 2.6 m long, giving twelve such sections in all, i.e. four treatments each with three replicates. Within each section the seeds of the twelve species were sown onto patches 40 cm × 40 cm. A total of 0.5 g were sown in all cases except for four large-seeded species (*Centaurea nigra, Knautia arvensis, Ranunculus bulbosus* and *Rhinanthus minor*) for which 1.0 g was sown. A border of 20 cm of bare soil was left around each strip to allow for encroachment of the surrounding turf. The plots received no further attention except the occasional removal of the largest weeds. The site received its first cut in August, 1987.

Experiment Two consisted of raising small plants from seed in flowerpots and inserting these container grown specimens into holes in the sward. The aim was to see if well-rooted plants would have a better chance of survival in the turf than plants grown from seed sown *in situ*. Twenty-four pots of each species were prepared by sowing the seeds into J.I. No. 2 compost on 11 April 1986 in 7·5 cm plastic pots. These were kept in a polytunnel for the first six weeks, then transferred to a cold frame. Shade was provided by nylon netting, but a number of plants were killed by drought during one particularly warm dry period in June. In mid-July a square grid of pot-sized holes was created in the turf with holes at 1 m intervals. The plants were removed from their containers and inserted into the slots. The sward was 10–15 cm in height at this time, and was left uncut throughout the remainder of the season. It received its first annual cut in early August 1987. In both experiments, the emergence and subsequent growth of each species was noted at intervals for the first two seasons. The results presented here are from the end of the second growing season (in September 1987). The numbers of plants surviving in all treatments were counted and the diameters of six randomly chosen clumps of each species in both experiments were recorded. A preliminary report on the results at the end of the first season is given in the British Ecological Society Bulletin, August 1987.

RESULTS

Table 1 lists the species used, the per cent germination of the samples in the laboratory, the per cent survival in each of the two techniques, and the approximate sizes of the plants at the end of the second season. In Experiment 1 where seeds were sown onto the surface, no marked effect (beneficial or otherwise) was found in the compost or cloche treatments, so the results for all four treatments for each species have been combined, giving twelve replicates for each species. In Experiment 2 where the pot-grown plants were transplanted into the turf, the numbers of replicates of each species varied because of deaths in the pots before planting out. The numbers planted are given in brackets in the Table, but survival is expressed as a percentage to facilitate comparisons between the two methods.

The results show that some species had a high survival rate regardless of the method used. These were *Centaurea nigra, Hypericum perforatum* and *Malva moschata*. Three species had a much higher success rate in the cleared pots than as pot-grown specimens.

Table 1. *Germination, survival and plant size at the end of the second growing season for plants introduced into turf using two methods of establishment*

Species	Common name	% germination under lab. conditions in 30 days	% survival when seeds sown onto soil surface in cleared patches (n = 12)	Mean diameter of sown plants (cm)	% survival when pot grown plants inserted into turf	Mean diameter of transplantees after 18 months (cm)
Betonica officinalis	Betony	42	0	—	80 (n = 10)	13
Campanula rotundifolia	Harebell	49	8.3	3	0 (n = 3)	—
Centaurea nigra	Knapweed	43	100	58	100 (n = 10)	21
Galium verum	Lady's Bedstraw	47	58	11	25 (n = 12)	11
Hypericum perforatum	Perforate St. John's Wort	46	83	18	92 (n = 12)	16
Knautia arvensis	Field Scabious	1	0	—	—	—
Leucanthemum vulgare	Ox-eye Daisy	89	100	62	60 (n = 10)	14
Malva moschata	Musk Mallow	14	100	47	91 (n = 11)	22
Primula veris	Cowslip	2	17	19	88 (n = 8)	13
Prunella vulgaris	Self-heal	84	100	39	55 (n = 11)	15
Ranunculus bulbosus	Bulbous Buttercup	14	0	—	8.3 (n = 12)	6
Rhinanthus minor	Hayrattle	0	0	—	—	—

These were *Galium verum*, *Leucanthemum vulgare* and *Prunella vulgaris*. Two species established more successfully when transplanted from pots than when directly sown in cleared patches. These were *Primula veris* and *Betonica officinalis*. Others did poorly in both techniques, either because of low seed germinability (*Rhinanthus minor* and *Knautia arvensis*) or because of losses during establishment (*Campanula rotundifolia* and *Ranunculus bulbosus*). Eight species in the "plots" experiment and nine in the "pots" experiment had survived at the end of the second season. By this time the plants on the cleared plots were much larger than those transplanted from pots, in most cases.

DISCUSSION

This experiment is one of many carried out in recent years investigating ways of establishing species rich grasslands (Wells, 1983, 1986). Perhaps the most important finding is that no one method is suitable for all species. Those species which survived best in cleared plots are possibly more sensitive to competition for light than those which grew best as transplanted specimens. In nature, seedlings of *Leucanthemum vulgare* and *Prunella vulgaris* for example may require relatively large open gaps for establishment. *Primula veris* and *Betonica officinalis* in contrast seem to be relatively shade-tolerant but may be more sensitive to competition below ground and so require a well-established root system before they can successfully compete with surrounding vegetation. There is a marked contrast between the behaviour of the two groups.

In terms of logistics, both techniques have advantages and limitations. The clearing of plots is labour expensive and their subsequent invasion by unwanted ruderals (*Sonchus arvensis*, *Urtica dioica*, *Cirsium vulgare*) was, in this case, a distinct disadvantage. There is also a large natural wastage of seeds in this method. Many seedlings appeared to die from water loss in the early stages. An advantage however is the large size of the clumps which establish, at least in the case of the more vigorously growing species (e.g. *Leucanthemum vulgare*, *Centaurea nigra*).

In the transplanting technique there is a large initial demand on labour setting up pots, but the work is less onerous than plot clearing. A major problem was keeping the small pots adequately watered. Another disadvantage of the transplanting method was that the plants tend to remain much smaller than the plot-sown specimens because of competition from surrounding vegetation. Both the problem of desiccation before planting and the size problem after planting could be alleviated by the use of much larger containers, e.g. 12.5 cm pots.

Special problems are encountered on sites where fertility is as high as it is at this site. The only way to reduce the effects of the severe competition associated with fertile soils is to mow frequently, once the plants become established. A greater level of survival might have been expected in this experiment if the plots had been mown frequently in the first two seasons.

In addition to the technical problems encountered, a major practical aspect of species-enrichment of grassland is its economic feasibility. The experiments described here were all carried out within a planned limited budget (in this case £525). Most of the cost was spent on employment of a technician (appointed for this project) and travel. The cost of the seeds amounted to only 9% of the costs. Pots, labels, compost and cloches were also only a small part of the cost. Since the last two items proved unnecessary, a longer list of species could have been cultivated for the same outlay. The use of staff already in employment at a field centre or volunteers could obviously reduce costs.

Experiments of this kind could provide centres with interesting teaching resources. Investigating requirements for seed germination in the field (e.g. the effect of gap size, shape, surface texture and time of season) are but a few aspects which could usefully be incorporated in ecology and conservation projects. The survival of seedlings and causes of mortality could also be monitored. Since the subsequent management of the community in the first few years is probably crucial to success of the newly established plants, the effect of different cutting regimes could be investigated. Once the grassland has achieved a stable species composition with self-sustaining populations of all the constituent species, an ecologically valuable asset will have been created. A wide range of plant species could be used for such field studies. An emphasis on conservation value would seem to be important when so much plant species impoverished of grasslands has taken place.

Clearly the sites involved have limitations with regard to certain ecological studies within the first few years (e.g. detection of spatial distribution patterns within and between species), but with time the community will aquire a more "natural" structure. Even in the short-term it will be of considerable educational and aesthetic interest. The small scale experiments outlined here provide an example of simple techniques which can be used for introducing new species into existing grasslands vegetation, and illustrate some of the problems involved.

Acknowledgements

These experiments were funded by a Small Ecological Projects Grant from the British Ecological Society. The seeds were purchased (at 20% discount) from Emorsgate Seeds, Norfolk. We gratefully acknowledge the assistance of Michael Omasta.

References

Duffey, E. (1974). Lowland grassland and scrub: management for wildlife. In Warren, A. and Goldsmith, F. B. (eds), *Conservation in Practice*, pp. 167–198, John Wiley and Sons, London.

GREEN, B. H. (1979). *The management of extensive amenity grasslands by mowing*. In Rorison, I. H. and Hunt, R. (eds.), Amenity grassland. An ecological perspective, pp. 155–161, John Wiley, Chichester.

GREEN, B. (1985). *Countryside Conservation* (2nd ed.), Allen and Unwin, Boston.

GRUBB, P. J. (1977). The maintenance of species-richness in plant communities: the importance of the regeneration niche. *Biological Reviews*, **52**, 107–145.

N.C.C. (1985). *Nature Conservancy Council 11th Report*. N.C.C. Interpretive Branch.

TANSLEY, A. G. (1939). *The British Islands and Their Vegetation*. Cambridge.

WELLS, T. C. E. (1983). The creation of species-rich grasslands using native species. In Warren, A. and Goldsmith, F. B. (eds), *Conservation in Perspective*, pp. 215–232, Wiley, Chichester.

WELLS, T. C. E. (1986). Alternative approaches to creating attractive grasslands using native species—success and failures. *Report 26th Askham Bryan Horticultural Technical Course*, 1986.

WELLS, T. C. E. (1987). The establishment of floral grasslands. *Acta Horticulturae*, 195, 59–69.

WELLS, T., BELL, S. and FROST, A. (1981). *Creating attractive grasslands using native plant species*. N.C.C.