ESTABLISHING VEGETATION STRIPS IN CONTRASTED EUROPEAN FARM SITUATIONS

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ABSTRACT

Replicated field experiments are being made in the UK, The Netherlands and France to assess the impact of introduced field margin strips and to investigate the dynamics of field edge ecotones. Comparisons are being made between cropping to the boundary and sown strips of *Lolium perenne*, unsown natural regeneration and sown grass and wildflower mixtures. This paper describes the results of initial studies on fauna and flora and the sampling protocols employed. Initial studies on the development of the vegetation show differences between crop and other plots, while the influence of the field weed seed bank is apparent in the first year.

INTRODUCTION

Field margin habitats form a network of semi-natural ecosystems in farm landscapes which interact with adjacent agriculture (Marshall, 1988; Joenje & Kleijn, 1994). Such semi-natural areas have important functions within landscapes (Burel & Baudry, 1990), including acting as corridors for certain species (Burel, 1989). There are also a number of roles for field boundaries for crop and environmental protection within more sustainable farming systems (Marshall, 1993). Maintenance or expansion of a diverse perennial ground flora at arable field edges has been suggested as an ecological approach (Marshall & Smith, 1987) for increasing on-farm biodiversity, for controlling annual weed species of hedgerows that may colonise adjacent crops (Marshall, 1989) and for enhancing populations of beneficial insects (Thomas *et al.*, 1992). Previous work on the introduction of sown grass and wildflower strips has demonstrated that in fertile arable soils, control of weed species in the first year may be required (Marshall & Nowakowski, 1991). However, with the exceptions of work by Smith & Macdonald (1989) and Marshall & Nowakowski (1991;1992), there has been little work published on the impact of introduced vegetation strips. Classical work on secondary succession (Bard, 1952; Falinska, 1991) would indicate that a perennial flora should develop on regenerating plots, borne out by studies by Smith *et al.* (1994). However, the effects of soil fertility, weed seed burden and management may influence the direction of the new communities. The approach of creating vegetation strips forms part of a European Commission-funded programme on the ecology of field boundary habitats (reference: AIR3-

CT 920476). This paper describes the establishment of replicate experiments on contrasted margin strips in the UK, The Netherlands and France.

METHODS

A protocol for designed experiments on margin strips was agreed, setting the minimum for valid comparisons between sites, but allowing each group to expand their assessments and treatments. Either two fields with three replicate blocks each or a single field with six replicates have been established (Table 1). The sites have been selected with the same exposition, roughly perpendicular to the prevailing winds (South West). The side with the North East aspect has the plots, each 3 or 4m wide and a minimum of 8m long, arranged along it. The three basic treatments are: 1) a control with the arable crop planted up to the existing boundary, 2) a planted strip of *Lolium perenne* and 3) a plot for natural regeneration. The adjacent crop is typical of the local crop rotation. After crop harvest, non-arable crop plots are mown. The arable plots are treated in the same way as the rest of crop, receiving fertiliser and pesticide applications. Records of farm operations, including machinery and fertiliser used, are kept.

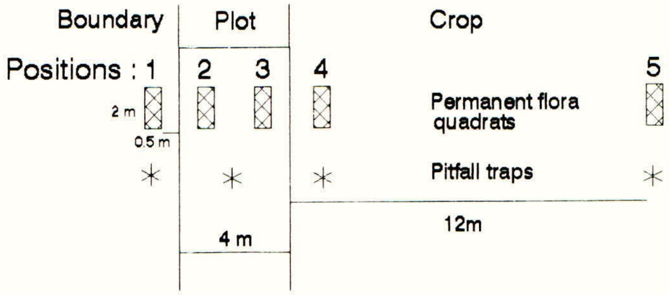
TABLE 1. Field edge plot treatments established in spring 1993 in three European areas.

Site	Aspect	Boundary Type	Soil	Replication	Crop	Treatments
UK						
A	NE	Tall hedge	Clay	3	Spring barley	Crop; Ryegrass; Regeneration; Grass+Wildflowers
B	SW	Tall hedge	Clay	3	Spring barley	Crop; Ryegrass; Regeneration; Grass+Wildflowers
C	NE	Hedge	Sandy loam	3	Winter wheat	Crop; Ryegrass; Regeneration; Grass+Wildflowers
The Netherlands						
D	NE	Ditch	Sand	3	Spring wheat	Crop; Ryegrass; Regeneration; Wildflowers; Crop with no inputs
E	NE	Ditch	Sand	3	Winter wheat	Crop; Ryegrass; Regeneration; Wildflowers; Crop with no inputs
F	S	Unpaved road	Sand	3	Triticale	Crop; Ryegrass; Regeneration; Wildflowers; Crop with no inputs
G	N	Unpaved road	Sand	3	Spring barley	Crop; Ryegrass; Regeneration; Wildflowers; Crop with no inputs
France						
H/I	NE	Tall hedge	Clay + silt	3+3	Buckwheat	Crop; Ryegrass; Regeneration

The occurrence of the flora is recorded in 0.5m by 2.0m permanent quadrats, using a modified Braun-Blanquet score (0-9) for each species present in early and mid-season. The permanent quadrats are arranged in five positions across the boundary, plots and adjacent crop

(Figure 1). Position 1 is located within the pre-existing boundary; Position 2 and 3 are within the sown plot, 0.5m from the inner and outer edges. Position 4 is 0.5m into the crop from the plot, while Position 5 is 12m from the plot. Maximum standing crop is assessed in July/August depending on site, by cutting above-ground vegetation in 0.5m x 0.5m quadrats in the boundary, the plot and the crop. Grasses, dicotyledons, crop and grain are separated for fresh and dry weight (24h at 80°C) determination. Soil seed banks are being estimated in the arable and regeneration plots from 20 core samples (diameter 2.5cm) per plot taken from two depth profiles, 0-5cm and 5-20cm. Samples are bulked, mixed and 0.5kg soil subsamples washed over 0.25mm sieves before flotation in saturated calcium chloride and seed identification under the binocular microscope. Soil samples are taken at the same time, in order to characterise soil chemistry at the different sites. Fauna, particularly Carabidae and Staphylinidae, are being examined in pitfall trap catches from Position 1 in the boundary, mid-plot between 2 and 3, and Positions 4 and 5 in the crop. Traps are open for three days every three weeks during the summer.

Figure 1. Layout for a single plot with adjacent boundary and crop, showing the position of permanent quadrats and pitfall traps.



The data are analysed using analysis of variance and differences between means assessed using LSDs. Data are transformed using squareroot or logarithms, where the data are not normally distributed. Simple classification of species data from quadrats into similar groups was also made using the TWINSPAN program (Hill, 1979).

RESULTS

Flora

The botanical composition of the three UK sites was assessed in June 1993 and the data subjected to TWINSPAN analysis. The resulting classification gave five end-groups, the first of which indicated the pre-existing boundaries of the three UK sites were similar, with *Galium aparine* as the indicator species. Sites A and B were located within the same field, while site C had a different crop and weed flora. Thus the crop areas and crop plots were classified into the same group in sites A and B, but different to site C. The sown and natural regeneration plots were dominated by weed species in sites A and B, notably *Sinapis arvensis*. Other indicator species were *Anagallis arvensis*, *Polygonum aviculare*, *Ranunculus repens* and *Sonchus asper*. In site C, the indicator species for sown and natural regeneration plots were *Poa annua* and *Plantago major*, weeds of pastures, where there was also little differentiation between sown and natural regeneration plots.

A summary of percentage bare ground on UK and Dutch sites is given in Table 2. In the UK, after logarithm transformation of the data and analysis of variance, there were significant differences (P=0.05) between the three sites, with poorest establishment and most bare ground in site A. Within the UK sown and unsown plots, natural regeneration plots had the greatest area of bare ground, significantly so at position 3. In the Netherlands, the crop plots had the greatest area of bare ground, with ryegrass providing greatest ground cover and regeneration plots having intermediate values.

TABLE 2. Percentage bare ground in July on field edge strips established in spring 1993.

Country	Position: Sowing	1 Hedge	2 Plot	3 Plot	4 Crop edge	5 Crop
UK	Crop	4.3	20.9	5.9	4.4	11.6
	Ryegrass	4.6	15.4	1.7	23.2	4.7
	Regeneration	9.3	27.8	41.7	22.4	3.1
	Grass+flowers	11.1	8.1	8.6	19.9	4.3
Netherlands	Crop	1.3	35.8	37.1	34.2	29.2
	Ryegrass	1.3	11.3	7.5	43.8	30.8
	Regeneration	2.9	20.0	19.6	44.2	30.4
	Wildflowers	0.8	18.8	14.2	46.7	32.5
	Crop, no input	5.4	43.8	50.8	40.4	31.3

Estimates of total standing crop as dry weight (g m^{-2}) from the three centres are shown in Table 3.

TABLE 3. Mean total dry weights (g m^{-2}) of above-ground harvests from samples taken at positions 1, 2, 3 and 5.

Country	Position: Sowing	1 Hedge	2 Plot	3 Plot	5 Crop
UK	Crop	505	798	925	987
	Ryegrass	387	472	611	1030
	Regeneration	510	367	507	931
	Grass+flowers	396	461	429	888
Netherlands	Crop	388	822	886	851
	Ryegrass	438	336	397	821
	Regeneration	416	393	484	884
	Wild flowers	386	406	483	880
	Crop, no inputs	356	633	603	877
France	Crop	198	342	548	792
	Ryegrass	295	228	226	810
	Regeneration	362	259	214	793

Examination of the total dry weights of vegetation in the UK after squareroot transformation, showed that mean values at position 1 in the boundary and position 5 in the crop, were not significantly different between sowing treatments. At positions 2 and 3 (plot), the crop had significantly greater biomass than any other sowing. Ryegrass plots tended to have greater biomass than the remaining treatments. There was evidence of differences between fields in the UK, with lowest biomass in site A, where soils were particularly heavy and establishment poor. Similar effects were found in the Dutch sites (Table 3), with crop plots having higher biomass than the sown grass, wildflowers or natural regeneration. The crop plots with no inputs had lower biomass than those receiving agrochemicals. In France (Table 3), where the crop was buckwheat, the buckwheat plots adjacent to the hedgerow had considerably lower dry weights than 15 m into the field, possibly because of shading.

Fauna

Initial examination of pitfall catches has been limited to grouping animals into Coleoptera, Araneae and others. Data on the catches of Coleoptera over five trapping periods in the UK are given in Table 4. There was evidence that there was some differentiation between arable crop plots and other sown plots as the summer progressed, though the patterns were not clear.

TABLE 4. Mean total individual beetles, expressed as the logarithm of beetle number [log(n+1)] from two traps per trap site, on four different vegetation strips in the UK from five trapping periods. SE = standard error of treatment means.

Treatment	10/5/93	27/5/93	17/6/93	8/7/93	15/8/93
Crop	0.88	1.20	1.59	0.69	0.70
Ryegrass	0.93	0.82	1.23	0.57	0.74
Regeneration	0.80	1.30	1.55	0.63	0.71
Grass+flowers	0.94	1.15	1.40	0.92	0.93
S.E.	0.083	0.095	0.087	0.123	0.098

DISCUSSION

Early establishment varied between sites and within countries. These effects were probably a reflection of soil conditions at sowing, soil type, climate and seed banks. The developing flora in regeneration plots were often a dominant component of sown plots within the same field. In the Netherlands, the crop areas had least ground cover, probably because of the sandy soils. The data showed that the arable crops were able to achieve greater standing biomass, compared with the spring sowing of ryegrass and grass + wildflower mixtures in the first year. Competition from weed species can affect the establishment of sown field margin strips (Marshall & Nowakowski, 1991). The effects of dicotyledonous weeds, notably *Sinapis arvensis*, on early establishment of sown swards in the UK have yet to be analysed. However, there was little evidence of lasting effects, as evidenced by the floral composition or visual examination of the plots. Plots sown with *Lolium perenne*, in particular, developed high levels of ground cover over the first year. Natural regeneration plots were more open, and ground beetle numbers in traps were highest on these plots in May and June, reflecting greater activity. Further studies are in progress to follow successional development of the flora, vegetation structures and their associated fauna.

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REFERENCES

Bard, G.E. (1952) Secondary succession on the Piedmont of New Jersey. *Ecological Monographs*, **22**, 195-215.

Burel, F. (1989) Landscape structure effects on carabid beetles spatial patterns in western France. *Landscape Ecology*, **2**, 215-226.

Burel, F.; & Baudry, J. (1990) Structural dynamics of hedgerow network landscapes in Brittany, France. *Landscape Ecology*, **4**, 197-210.

Falinska, K. (1991) *Plant demography in vegetation succession*. Tasks in Vegetation Science 26. Kluwer Academic Publishers, Dordrecht. 210 pp.

Hill, M.O. (1979) TWINSPAN - a FORTRAN program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. New York: Section of Ecology and Systematics, Cornell University, Ithaca.

Joenje, W. & Kleijn, D. (1994) Plant distribution across arable field ecotones in the Netherlands. In: *Field Margins - Integrating Agriculture and Conservation. BCPC Monograph No. 58*, Thornton Heath: BCPC Publications, this volume.

Marshall, E.J.P. (1988) The ecology and management of field margin floras in England. *Outlook on Agriculture*, **17**, 178-182.

Marshall, E.J.P (1989) Distribution patterns of plants associated with arable field edges. *Journal of Applied Ecology*, **26**, 247-257.

Marshall, E.J.P. (1993) Exploiting semi-natural habitats as part of good agricultural practice. In: *Scientific basis for codes of good agricultural practice*. (ed. Jordan V.W.L.) *EUR 14957*. Commission of the European Communities, Luxembourg. pp. 95-100

Marshall, E.J.P. ; Nowakowski, M. (1991) The use of herbicides in the creation of a herb-rich field margin. *Brighton Crop Protection Conference - Weeds 1991*, **2**, 655-660.

Marshall, E.J.P.; Nowakowski, M. (1992) Herbicide and cutting treatments for establishment and management of diverse field margin strips. *Aspects of Applied Biology* ***29***, *Vegetation management in forestry, amenity and conservation areas*. pp. 425-430.

Marshall, E.J.P.; Smith, B.D. (1987) Field margin fauna and flora; interaction with agriculture. In: *Field Margins* (eds) Way, J.M. & Greig-Smith, P. W. *BCPC Monograph No.35* , Thornton Heath: BCPC Publications, pp. 23-33.

Smith, H.; Macdonald, D.W. (1992) The impacts of mowing and sowing on weed populations and species richness in field margin set-aside. In: *Set-Aside, BCPC Monograph No. 50*, Thornton Heath: BCPC Publications, pp. 117-122.

Smith, H.; Feber, R.E.; Macdonald, D.W. (1994) The role of seed mixtures in field margin restoration. In: *Field Margins - Integrating Agriculture and Conservation. BCPC Monograph No. 58*, Thornton Heath: BCPC Publications, this volume.

Thomas, M.B.; Wratten, S.D.; Sotherton, N.W. (1992) Creation of 'island' habitats in farmland to manipulate populations of beneficial arthropods: predator densities and emigration. *Journal of Applied Ecology*, **28**, 906-917.

THE EFFECTS OF RESTORATION STRATEGIES ON THE FLORA AND FAUNA OF OVERGROWN HAWTHORN HEDGES AND METHODS OF REPAIRING GAPS IN OVERMANAGED HAWTHORN HEDGES

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ABSTRACT

The effects of different restoration strategies on the wildlife value of overgrown hawthorn hedges revealed that plant species richness was higher for all treatments compared to the control, though only the coppiced treatment was significantly higher. Similarly, all treatments increased the number of invertebrate groups trapped, though only the lay treatment was significantly higher. Comparison of methods of repairing gaps in overmanaged hawthorn hedges indicated no requirement to replace the soil with fresh topsoil, though watering, if required, and good weed control were very important for successful plant establishment.

INTRODUCTION

Family farms and field sizes in N. Ireland are small (mean areas 25.4 ha and 1.8 ha respectively), livestock production being the predominant agricultural enterprise. This has resulted in a landscape characterised by 150,000 km of hedgerows (Department of Agriculture for Northern Ireland (DANI), 1992a). However, many hedges have been poorly managed over the years and have become gappy (Hegarty, 1992). Such hedges fail to provide stockproof barriers and are of limited conservation value.

Poorly managed hedges can be categorised as those suffering from neglect and which have grown out of control, and those which have been overmanaged by frequent cutting and are becoming exhausted (Osborn, 1987).

Provided the gaps are not too large, overgrown hedges can be restored by laying if the stems are not thicker than 50-100 mm at the base (Hellewell, 1991). Where the stem bases are thicker than 100 mm, coppicing is recommended. Cutting an overgrown gappy hedge to a standard 1.0 - 1.5 m height is not encouraged since the base will remain thin and not stockproof (Hellewell, 1991).

Routine annual cutting of hedges reduces their vigour and also causes gappiness. DANI (1992b) suggests that the gaps in such hedges may be difficult to repair because of 'thorn sickness' in the soil. It is suggested that, if planting with hawthorn, the soil in the gaps should be replaced with fresh topsoil or, alternatively, different species such as blackthorn or holly should be planted (Brooks, 1988). To date, no research has been conducted into methods of establishing shrubs in existing hedges (Osborn, 1987).

The objectives of this study were (1) to assess the effects of different restoration techniques on the flora and fauna of overgrown hawthorn hedges, and (2) to determine the best method of planting up gaps in overmanaged hawthorn hedges. This paper presents early results from a long-term experiment.

METHODS

The effects of restoration strategies on the flora and fauna of overgrown hawthorn hedges

In 1990 and 1991 a randomised block experiment was set up in 14 overgrown, gappy, predominantly hawthorn hedges at 10 sites throughout N. Ireland (Figure 1). Both sides of all hedges bordered permanent pasture. In each hedge (= block), 25 m lengths of the following treatments were imposed:
1. Unchanged control - **Control**
2. Laid - **Lay**
3. Cut to 1.5 m high with stem bases nicked to encourage sprouting - **Pollard**
4. Coppiced with gaps interplanted with the same species (hawthorn) - **Coppice-ISS**
5. Coppiced with gaps interplanted with different species (blackthorn, hawthorn, hazel, beech and holly) - **Coppice-IDS**

Hedges were fenced on both sides to exclude stock and mechanical trimming planned for every third year. Those sites established in 1990 were trimmed in February 1993.

A list of all plant species occurring within each treatment plot (extending 1 m out on both sides of the hedge) was made during the summer of 1991 and 1992. Plots represented 20 m lengths of hedge, i.e. terminal 2.5 m sections were omitted. Fauna were monitored using five shelter traps (20 cm long x 5 cm diameter open-ended plastic cylinders filled with rolled corrugated cardboard) in each treatment plot, placed in the hedgerow canopy for 28 days in May 1992 and May 1993. Sample catches were identified to the main invertebrate groups, namely Arachnida, Crustacea, Insecta (Coleoptera, Collembola, Dermaptera, Diptera, Hemiptera, Hymenoptera, and Lepidoptera) and Myriapoda.

Repairing gaps in an overmanaged hawthorn hedge

An overmanaged hawthorn hedge was removed by coppicing and this revealed that many of the stumps were rotten and would not have resprouted. A randomised block experiment involving four treatments x two replicates (8 plots each 8 m in length) was imposed on the hedge in February/March 1992. Where feasible, two apparently healthy coppiced stumps were left untouched within each plot.

Hawthorn quicks (3 yr old nursery plants) were planted in all treatments which were:
1. Quicks planted in the existing soil - **Control**
2. Quicks planted in the existing soil and watered during the 1992 growing season - **Watered**
3. 500 g of organic composted farmyard manure (Dungstead, Abbey Organics, Portglenone) incorporated into the existing soil around the roots of each quick - **Fertilised**
4. Existing soil removed and quicks planted into fresh topsoil obtained from an adjacent field (trench 600 mm wide and 450 mm deep) - **Replace soil**.

A double staggered row method of planting was used, with 250 mm between plants and 300 mm between rows. Weed control was achieved using glyphosate (Roundup), propyzamide (Kerb granules), and hand weeding. Chemicals were used in accordance with the manufacturers' recommendations.

Stem diameter (mm) at 250 mm above ground and height (cm) were recorded for all quicks in May 1992 and July 1993. Stem diameter was measured using digital calipers and calculated as the mean of two measurements taken at right angles to each other. Survival of quicks was assessed in July 1993.

Data analysis

Data from both experiments were analysed using randomised blocks ANOVA. Where differences among means were significant, these were compared using Least Significant Range (LSR = $Q_{0.05}$ x SE mean) (Parker, 1979). Plant species composition data for the hedges in the restoration experiment were analysed using TWINSPAN (Hill, 1979a) and DECORANA (Hill, 1979b).

RESULTS

The effects of restoration strategies on the flora and fauna of overgrown hawthorn hedges

Ordination of floristic data by DECORANA with TWINSPAN groups superimposed, generally discriminated among sites, but not among treatments (Figure 1). However, in both 1991 and 1992, all restoration treatments resulted in an increase in the mean number of plant species, though only the coppiced/interplanted with hawthorn treatment had significantly ($P<0.01$, $F_{4,52} = 3.82$) more species than the control (Figure 2, 1992 data). There were significantly ($P<0.05$, $F_{4,52} = 2.97$) more invertebrate groups associated with the lay treatment than with pollard in 1993 (Figure 3). The lay and two coppice treatments had greater numbers of invertebrate groups than the control, though the differences were not significant.

Figure 1. TWINSPAN groupings superimposed on a DECORANA plot of hedgerow flora

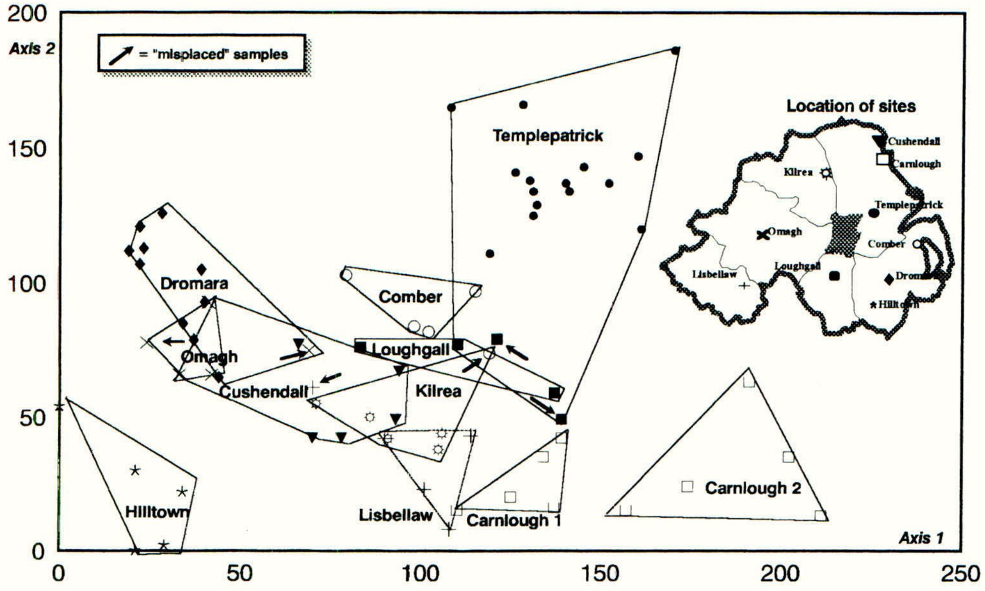


Figure 2. Plant species richness, 1992 *(Least significant ranges shown, P<0.05)*

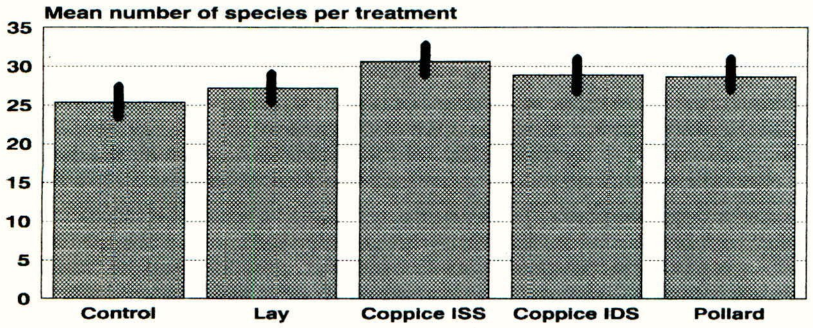
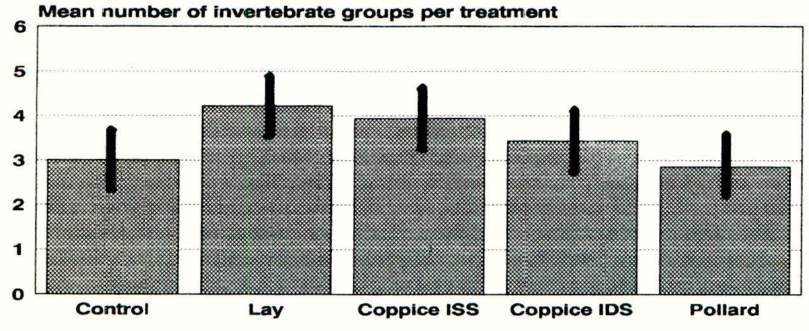


Figure 3. Invertebrate groups, 1993 *(Least significant ranges shown, P<0.05)*



Repairing an overmanaged hawthorn hedge

There were no significant differences in the increases in either height or stem diameter at 250 mm among the four gapping up treatments (Table 1).

TABLE 1. Mean increase in height (cm) and stem diameter at 250 mm (mm) between May 1992 and July 1993 for four treatments (40 - 60 hawthorn quicks per block, N=2)

Treatment	Control	Watered	Fertilised	Replace soil	SE mean
Height (cm)	24.05	23.60	29.50	29.15	3.02
Stem diam. (mm)	3.34	3.38	3.68	3.87	0.36

However, the watered treatment displayed significantly higher ($P<0.05$) quick survival than the control. The three months immediately post planting were much drier than the previous ten year mean rainfall. Fertilised and replace soil treatments showed higher quick survival than the control, but the difference was not significant.

DISCUSSION

Positive management is urgently required to restore the quality of Northern Ireland's hedges, most of which were planted between 1700 and 1850. DANI offers 80% grants to farmers for hedge restoration in the Environmentally Sensitive Areas (ESAs). Grant aid under the 'Hedgerow Incentive Scheme' (Countryside Commission, 1992) is available to English farmers for laying and coppicing hedges. However, to date, no information has been available on the effect of different restoration techniques on the wildlife value of hedges or on methods of repairing gaps.

This study has shown that the highest plant species richness occurred in the coppiced treatments, probably as a result of increased light penetration encouraging new species establishment. At some lowland sites, this has resulted in excessive weed growth which may be detrimental to hedge development and maintenance of forbs in the long term. All restoration treatments increased numbers of plant species compared to the control. The highest number of invertebrate groups was found in the lay treatment, presumably due to the greater density of the hedgerow canopy. One limitation of a sampling method such as shelter trapping is that it will inevitably be selective for particular groups. There may be occasional occurrences of groups not readily taken by this method, but the degree of replication in this experiment would mitigate against this source of error.

These differences among treatments were interesting at this early stage of a long term trial. It is likely that as the canopy develops in the coppiced treatments, these will become a better habitat for invertebrates.

Osborn (1987) requested a reliable method for establishing shrubs in gaps in overmanaged hedges. Despite advice to replace the soil with fresh topsoil (Brooks, 1988; DANI, 1992b), our results reveal no benefit in terms of hawthorn growth from replacing or fertilising the soil. The most important factor affecting survival was soil moisture. Watered quicks displayed significantly higher survival compared to the control. However, these results should be interpreted with caution as they were recorded over a 16 month period from a newly-planted hedge.

The results of this study indicate the dynamic nature of hedgerow ecology and suggest that a combination of coppicing and laying, combined with interplanting where appropriate, are the most beneficial strategies in achieving conservation objectives.

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REFERENCES

Brooks, A. (1988) *Hedging: a practical conservation handbook.* Wallingford: British Trust for Conservation Volunteers, p. 52.

Countryside Commission (1992) *Handbook for the Hedgerow Incentive Scheme.* Cheltenham: Countryside Commission, 8 pp.

DANI (1992a) *Field boundaries in the landscape.* Belfast: HMSO, 11 pp.

DANI (1992b) *Managing gappy and overgrown hedges.* Belfast: HMSO, 10 pp.

Hegarty, C.A. (1992) *The ecology and management of hedges in Northern Ireland.* Unpublished PhD thesis, University of Ulster, Coleraine, 260 pp.

Hellewell, M. (1991) Managing farm hedges. In: *Farm Woodland Management*, J. Blyth, J. Evans, W.E.S. Mutch and C. Sidwell, (Eds) Ipswich: Farming Press Books, pp. 45-47.

Hill, M.O. (1979a) *TWINSPAN: a FORTRAN programme for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes.* New York: Cornell University, 80 pp.

Hill, M.O. (1979b) *DECORANA: a FORTRAN programme for detrended correspondence analysis and reciprocal averaging.* New York: Cornell University, 52 pp.

Osborn, A. (1987) Management for conservation of wildlife - FWAG experiences. In *Field Margins*, J.M. Way and P.W.Greig-Smith (Eds), BCPC Monograph No. **35**, Thornton Heath: BCPC Publications, pp. 105-108.

Parker, R. E. (1979) *Introductory statistics for biology.* Studies in Biology, No 43, 2nd edition, London: Edward Arnold, p. 72.