FARMING FOR WILDLIFE PROJECT

Jordans Cereals Ltd

Annual report 2007/8

Richard Pywell & Marek Nowakowski

NERC Centre for Ecology and Hydrology, Monks Wood, Abbots Ripton, Huntingdon, Cambs, PE28 2LS
e-mail: rfp@ceh.ac.uk
Wildlife Farming Company, Chesterwood, Alchester Road, Chesterton, Oxon, OX26 1UN

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

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1. Executive summary

1) Post-war agricultural intensification has resulted in the loss of habitats and species from the countryside. Conservation Grade is an industry-led assured produce scheme which aims to reverse these declines through the creation of carefully targeted wildlife habitat on land removed from agricultural production.
2) The aim of this project was to scientifically evaluate a range of core Conservation Grade habitats for enhancing wildlife and determine their optimum location in a typical farming situation.
3) In autumn 2006 an experiment was established on four arable fields of 5-6 ha each growing Conservation Grade oats on the Upton Estate, Warwickshire.
4) One of four habitat types (crop, natural regeneration, wild bird seed mix and wildflower seed mix) was established in the corner of each field using a latin-square design with four replicates. Identical habitats were established on the north- and south-facing field margins separating each corner using the same design.
5) The effect of habitat type and location was recorded on plants, flower resources, pollinating insects, other insects and birds using standard methodologies.
6) There were a large number of differences in the value of difference Conservation Grade habitats for wildlife over the 2 years.
7) Few species were found in the intensively managed cereal crop.
8) Allowing vegetation to regenerate naturally resulted in tall, competitive vegetation dominated by undesirable grass weeds and thistles. However, these were attractive to bumblebees.
9) The most effective treatments (wildflower and wild bird seed mix) were those specifically targeted to the requirements of declining wildlife groups.
10) Sowing an annual mix of seed-bearing crops was a very effective means of providing food resources for farmland birds during the winter.
11) Sowing a mixture of perennial wildflowers proved to be a reliable and rapid means of creating a diverse and weed-free vegetation community which was most attractive to bees, butterflies and other invertebrates.
12) Habitat location (margin or corner) had relatively few effects on abundance and diversity of wildlife after 2 years. However, habitat location may become more important as vegetation communities become established and colonised by species with more exacting habitat requirements.

2. Introduction

Traditional farming practices have created some of the most diverse habitats in north western Europe. However, over the last century agricultural intensification to increase productivity has resulted in the loss of habitats and species, and damage to the environment. It is widely recognised that these impacts of modern agriculture on biodiversity and other natural resources can be mitigated through approaches which either protect areas from intensive farming practices or decrease the intensity of agricultural management on farmed land. In the UK both approaches are delivered through the voluntary agri-environment schemes, such as Entry Level Environmental Stewardship (ELS) (www.defra.gov.uk/erdp/schemes/es/). However, the recently published Environmental Stewardship Review of Progress (www.defra.gov.uk/erdp/schemes/es/es-report.pdf) confirmed that the majority of farmers are selecting a limited range of environmental enhancement options (e.g. hedge cutting and grass margins) and that options are not always situated in the most appropriate location to benefit wildlife. In contrast, Conservation Grade (www.conservationgrade.co.uk/) is an industry-led assured produce scheme which requires growers to establish a greater diversity of ES options on a higher proportion of farmed land (10%). It also requires provides land manager with a detailed protocol and training in the location and management of these habitats to maximise benefits for wildlife.

The aim of this project is to scientifically evaluate a range of core Conservation Grade habitats for wildlife and determine their optimum location in a typical farming situation. This will provide the critical scientific evidence base to underpin this innovative scheme and inform future revisions of the management protocol. In order to achieve this aim the project will answer the following research questions:

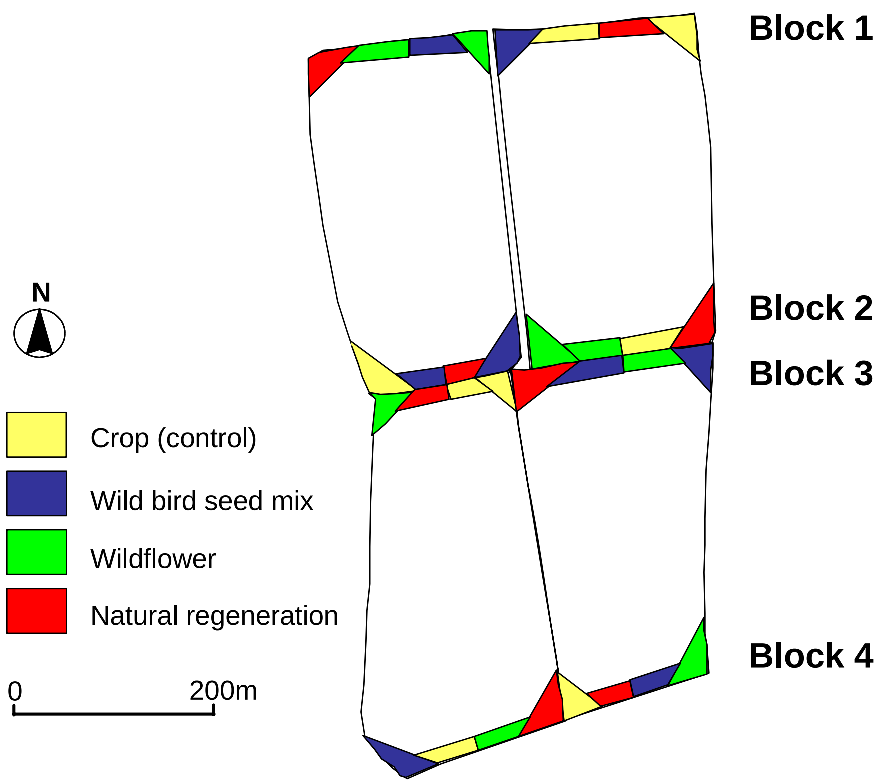
1) What is the best Conservation Grade wildlife habitat for plants, butterflies, bumblebees, other insects and birds?
2) What is the optimum location each habitat type (field corner or margin)?
3) Are there any positive or negative interactions between habitat type and location for biodiversity?
4) What is the most practical and cost-effective mix of habitat type and location from a farming perspective?

3. Methodology

3.1 *Experimental design*

The experiment was undertaken at the Upton Estate, Warwickshire (SP378434) on four arable fields of approximately equal size (5.6 ha) growing Conservation Grade oats in 2006 and winter wheat in 2007. One of four habitat types (crop, natural regeneration, wild bird seed mix and wildflower seed mix) was established in the corner of each field using a latin-square design with four replicates (Fig. 1). Identical habitats were established on the north- and south-facing field margins separating each corner using the same design.

Fig. 1. Experimental design



3.2 *Treatments*

3.2.1 Crop (control)
The crop treatment comprised Conservation Grade oats drilled in April 2006 and winter wheat in 2007 which were managed with conventional inputs of pesticide and fertiliser. The crop treatment was the experimental control, enabling us to quantify the environmental benefits resulting from the wildlife habitat creation treatments.

3.2.2 Natural regeneration (EF1, EE3)
The natural regeneration treatment involved allowing vegetation to colonise naturally from the seed bank and adjacent hedge base. This treatment aimed to replicate two of the most popular approaches to habitat creation under ELS, namely field corners (EF1) and 6 m field margins (EE3) both created by natural regeneration. Thistles were controlled by an application of Dow Shield (18.0% w/w Clopyralid applied as a foliar spray at 1 l ha^{-1}, Dow AgroSciences, Hitchin) in summer 2006. Otherwise this habitat was left unmanaged.

3.2.3 Wild bird seed mixture (EF2)
The wild bird seed mixture aimed to provide a continuous supply of seed for farmland birds during the winter months. The seed mix comprised five small-seeded species sown each spring at a rate of 14 kg ha^{-1} (£56 ha^{-1}; Table 1). Insect pest species (flea and pollen beetles) were controlled by typically two

applications of the pesticide Mavrik (EC 240 g l^{-1} tau-fluvalinate A.I. applied at 150 ml ha^{-1}, Makhteshim-Agan UK Ltd) during early summer of each year.

3.2.4 Wildflower margins and corners (EF4)

Sowing margins and corners with a wildflower seed mixture aimed to provide habitat for a wide diversity of insects, particularly those feeding on pollen and nectar, and also those providing an important food source for farmland birds. In order to minimise costs the seed mixture included 4 grass species comprising 90% of the mix and 25 broad-leaved species (dicots) comprising 10% of the mix sown at a rate of just 20 kg ha^{-1} (£311 ha^{-1}; Table 2). The seed mix was drilled on 20 August 2005 and emerging grass weeds were controlled by the application of Fluazifop-P-butyl (as Fusilade Max, Syngenta Crop Protection Ltd) at 0.5 litres in 200 litres of water ha^{-1}in November of that year. These plots were cut and the biomass removed in April, May and October of 2006. Cutting was carried out in April and October of 2007.

Table 1. Details of the wild bird seed mixture

English name	Latin name	Sowing rate (kg ha^{-1})	% of mix
Fodder radish	*Raphanus sativus*	1.4	10
White millet	*Echinochloa esculenta*	3.5	25
Camelina (Gold of Pleasure)	*Camelina sativa*	1.4	10
Buckwheat	*Fagopyrum esculentum*	4.2	30
Quinoa	*Chenopodium quinoa*	3.5	25
Total		**14.0**	**100**

Table 2. Details of the wildflower seed mixture

English name	Latin name	Sowing rate (kg ha^{-1})	% of mix
Crested dogstail	*Cynosurus cristatus*	18.0	3.6
Chewing's fescue	*Festuca rubra ssp commutata*	31.5	6.3
Slender red fescue	*Festuca rubra ssp juncea*	22.5	4.5
Smooth meadow grass	*Poa pratensis*	18.0	3.6
Yarrow	*Achillea millefolium*	0.25	0.05
Common Knapweed	*Centaurea nigra*	0.75	0.15
Wild Basil	*Clinopodium vulgare*	0.25	0.05
Wild Carrot	*Daucus carota*	0.25	0.05
Meadowsweet	*Filipendula ulmaria*	0.30	0.06
Hedge Bedstraw	*Galium mollugo*	0.20	0.04
Lady's Bedstraw	*Galium verum*	0.50	0.10
Field Scabious	*Knautia arvensis*	0.50	0.10
Rough Hawkbit	*Leontodon hispidus*	0.20	0.04
Oxeye Daisy	*Leucanthemum vulgare*	0.40	0.08
Birdsfoot Trefoil	*Lotus corniculatus*	0.40	0.08
Ragged Robin	*Lychnis flos-cuculi*	0.20	0.04
Musk Mallow	*Malva moschata*	0.50	0.10
Hoary Plantain	*Plantago media*	0.30	0.06
Cowslip	*Primula veris*	0.50	0.10
Selfheal	*Prunella vulgaris*	0.50	0.10
Meadow Buttercup	*Ranunculus acris*	1.00	0.20
Yellow Rattle	*Rhinanthus minor*	0.50	0.10
Common Sorrel	*Rumex acetosa*	0.50	0.10
Salad Burnet	*Sanguisorba minor ssp minor*	0.75	0.15
Red Campion	*Silene dioica*	0.50	0.10
Bladder Campion	*Silene vulgaris*	0.25	0.05
Betony	*Stachys officinalis*	0.25	0.05
Red clover	*Trifolium pratense*	0.05	0.01
Tufted Vetch	*Vicia cracca*	0.25	0.05
Total		**20.00**	**100.00**

3.3 *Monitoring*

3.3.1 Vegetation composition

In early July 2006 and late June 2007 the percentage cover of all vascular plant species was recorded from three 1 × 1 m quadrats placed at random in each plot.

3.3.2 Pollinator transects

The abundance and diversity of bumblebees and butterflies was recorded by walking a transect through the centre of the field margins plots and in a zig-zag pattern through the field corner plots. The aim in both instances was to record all butterflies and bees present in each plot. Transects were walked on five occasions between June and September in 2006 and on six occasions in 2007.

3.3.3 Flower resource

The abundance of flowers of all broad-leaved (dicotyledon) species was scored in each plot using a simple five point scale after each bee and butterfly transect count: 1. approximately 1 – 25 flowers per plot; 2. 26 – 200 flowers; 3. 201 - 1000 flowers; 4. 1001 - 5000 flowers; 5. >5001 flowers.

3.3.4 Vacuum sampling for invertebrate

The abundance and diversity of canopy active invertebrates were sampled in each plot in early July 2007. No sampling was undertaken in the establishment year of 2006 due to the necessity to cut the vegetation in early summer to control competitive weed species. Sampling was undertaken using a Vortis™ suction sampler (www.burkard.co.uk). Each sample comprised nine 10-s 'sucks' collected in a zig-zag pattern through each plot (avoiding a 1 m edge buffer), giving a total sample area of 0.174 m^2. Invertebrates were sorted into broad groups (orders and families) and counted.

3.3.5 Winter bird counts

Counts were made of all bird species utilising each plot on seven occasions between December 2006 and March 2007, and on four occasions between December 2007 and March 2008. This was achieved by firstly observing each plot from a distant vantage point, avoiding disturbance of the birds, for a 20-min period and then walking a transect through the middle of both plots to flush out any remaining birds. Counts were not made in adverse weather conditions (heavy rain, strong winds or poor visibility).

3.3 *Statistical analysis*

Mean abundance and species richness values for all groups were calculated for each plot. Logarithmic transformation was undertaken on count data to achieve normality of residuals as required. Species richness data were untransformed. Differences in abundance and richness were investigated using analysis of variance (ANOVA) with a factorial model comparing location (corner or margin), habitat type and location × habitat type interactions. The field corner plots were considerably larger (mean 707±32 m^2) than the equivalent field margin plots (348±18 m^2). For whole plot counts of flowers, bees, butterflies and birds covariates of plot area (m^2) and log plot area were applied to the ANOVA models for abundance and species richness respectively to take account of these differences. Bonferroni pairwise comparison tests were used to investigate overall differences between the four habitat types.

4. Results

4.1 *Vegetation composition*

In the establishment year (2006) a total of 17 grasses and 74 broad-leaved species were recorded from the quadrats. In 2007 17 grasses and 73 broad-leaved species were recorded. In both cases this comprised 4 grasses and 23 broad-leaved species sown in the seed mixtures. Similarly, in both years the grass weed Sterile Brome (*Anisantha sterilis*) was the most abundant species, followed by the sown grass Red fescue (*Festuca rubra*) and the sown broad-leaved species Fodder radish (*Raphanus sativus*).

In 2006 there were highly significant differences in the total number of plant species recorded between the four habitat types (ANOVA $F_{3,21}$=88.04; P<0.001; Fig. 2a). Species richness was significantly higher in the wildflower treatment (mean 16.9 species m^{-2}) compared with all others, followed by the wild bird seed mix (10.8 m^{-2}), natural regeneration (6.8 m^{-2}) and the cereal crop (2.0 m^{-2}). Similarly, the number of grasses ($F_{3,21}$=24.36; P<0.001), dicots ($F_{3,21}$=91.25; P<0.001) and perennials ($F_{3,21}$=186.24; P<0.001) were all significantly higher in the wildflower treatment compared with all other treatments. The number of annual species was significantly higher in the wild bird seed mix compared with the other treatments ($F_{3,21}$=33.78; P<0.001). Location of habitat also had a significant effect on total number of annuals ($F_{1,21}$=7.92; P<0.01; Fig. 2b) and grass species ($F_{1,21}$=6.20; P<0.05), with richness higher in the corners compared with the margins. However, there was no significant effect of location on the species richness of grasses, broad-leaved plants, annuals or perennials.

In 2007 total the number of plant species per m^2 declined as annual species were replaced by perennials in the vegetation. However, there remained highly significant differences in plant diversity between the four habitat types ($F_{3,21}$=26.02; P<0.001; Fig. 3a). Species richness was significantly higher in the wildflower treatment (mean 9.7 species m^{-2}) compared with all others except the wild bird seed mix (8.0 m^{-2}). Also, vegetation resulting from natural regeneration was significantly more diverse (5.5 m^{-2}) than the cereal crop (3.1 m^{-2}). Similarly, the number of broad-leaved species was significantly higher in these two treatments compared with the others ($F_{3,21}$=42.88; P<0.001). The number of grasses was significantly higher in the wild bird seed mix compared with all other treatments ($F_{3,21}$=19.89; P<0.001). The number of perennial plants was significantly higher in the wildflower treatment followed by natural regeneration ($F_{3,21}$=156.95; P<0.001). There was no difference in the number of perennials between the crop and wild bird seed mix. Finally, the number of annuals was significantly higher in the wild bird seed mix followed by the natural regeneration and crop, and lowest in the wildflower treatment ($F_{3,21}$=59.77; P<0.001). There were no significant differences in species richness between margin and corner plots (Fig. 3b).

Fig. 2. Effects of a) habitat type and b) habitat location on the species richness of plants in 2006

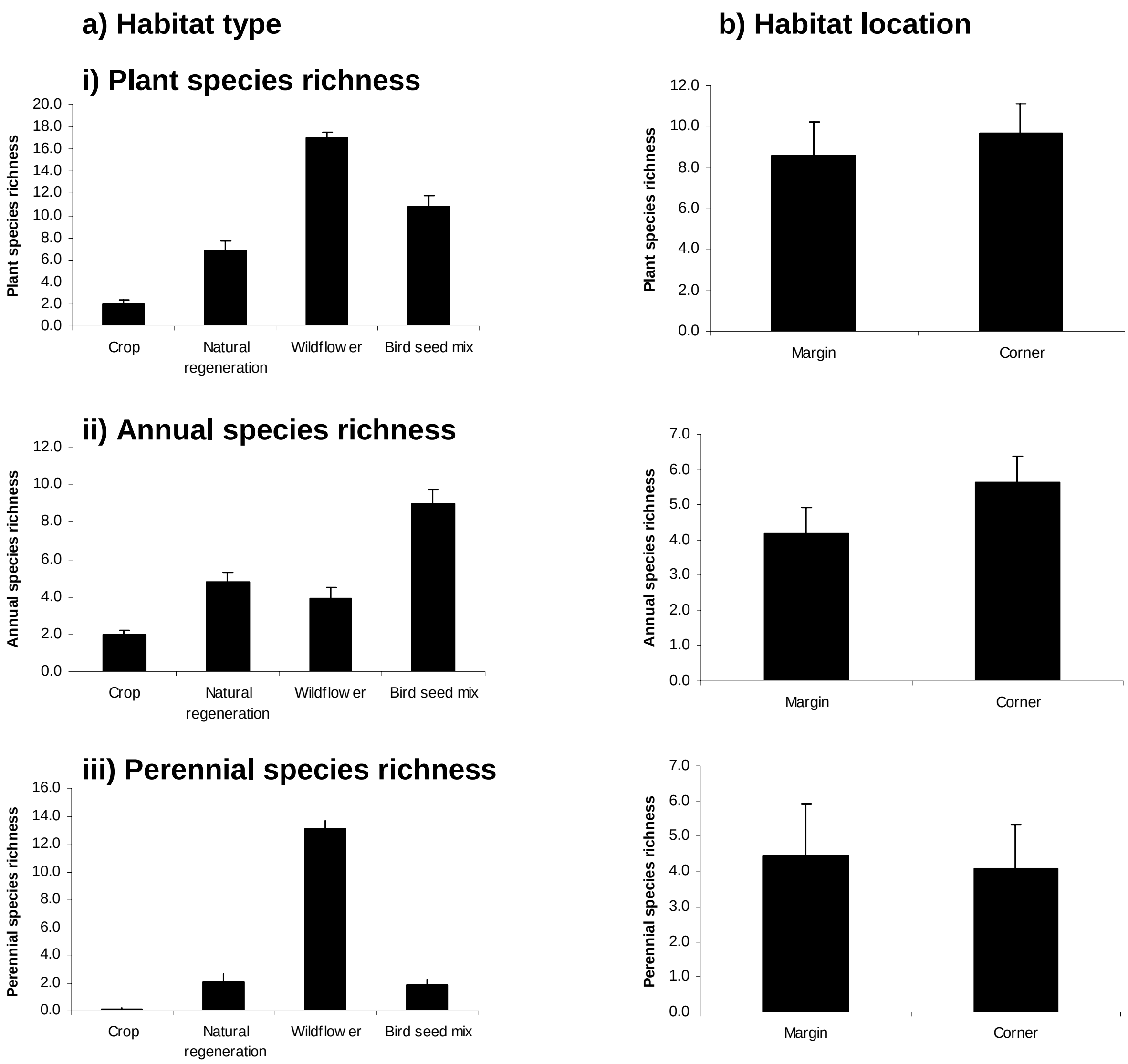
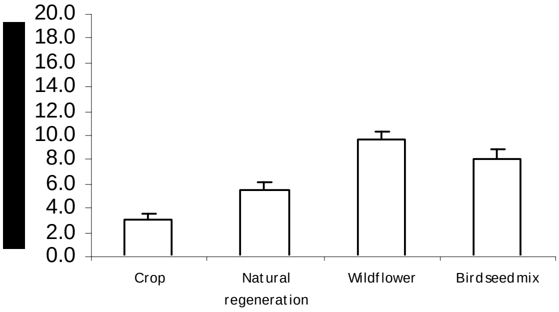


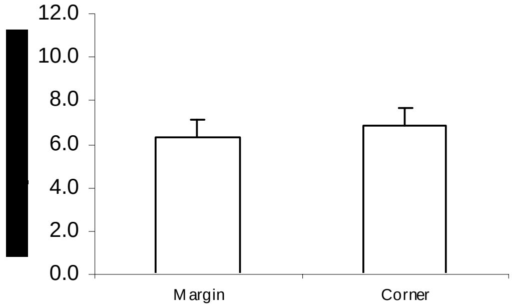
Fig. 3. Effects of a) habitat type and b) habitat location on the species richness of plants in 2007

a) Habitat type

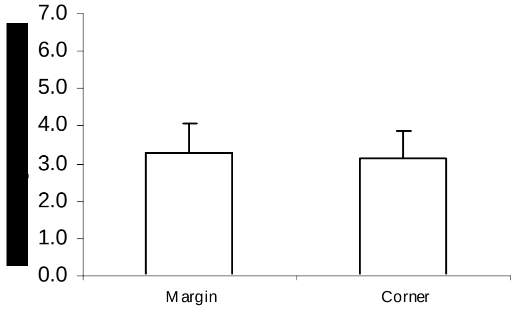
b) Habitat location

i) Plant species richness

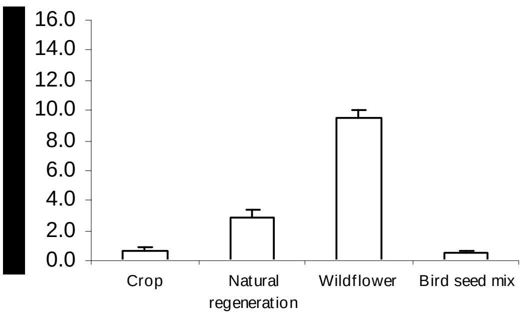


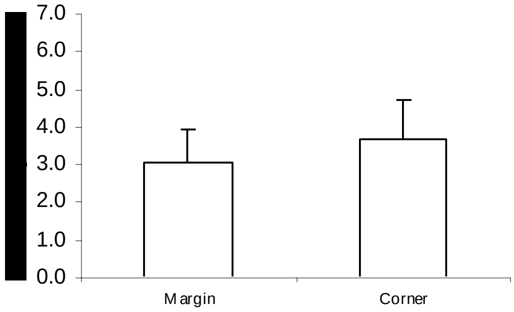


ii) Annual species richness



iii) Perennial species richness





4.2 *Flower resource*

In year 1 (2006) flowers of the sown broad-leaved (dicot) species Yarrow (*Achillea millefolium*) and Fodder radish (*Raphanus sativus*) were the most abundant in the experimental plots, followed by those of the unsown species Scentless mayweed (*Tripleurospermum inodorum*). The abundance of all flowers summed between June and September was significantly higher in the wildflower, wild bird seed mix and natural regeneration treatments compared with the crop ($F_{3,20}$=116.35; P<0.001; Fig. 4a). Species richness of the flower resource was significantly higher in the wildflower treatment compared with all others (mean = 29.4 species), followed by the wild bird seed mix (17.5 species), natural regeneration (12.0 species) and the crop (0.7 species) ($F_{3,20}$=84.05; P<0.001) (Fig. 5a). Location had no significant effect on the abundance of flowers ($F_{1,20}$=1.98; P>0.05) or species richness flowers ($F_{1,20}$=0.00; P>0.05) (Figs. 4b & 5b). However, there was a significant treatment × location interaction ($F_{3,20}$=4.18; P<0.05), reflecting higher numbers of flowers in the corner plots of the wild bird seed mix and natural regeneration treatments compared with the margins, and lower flower numbers in the wildflower corners.

In year 2 (2007) flowers of the sown species Fodder radish (*Raphanus sativus*), Yarrow (*Achillea millefolium*) and Red clover (*Trifolium pretense*) were the most abundant. Total abundance of flowers was significantly higher in both the wildflower and wild bird seed mixtures compared with all other treatments ($F_{3,20}$=32.02; P<0.001) (Fig. 6a). Flower abundance was also significantly higher in the natural regeneration compared with the crop. Species richness of flowers was significantly higher in the wildflower treatment compared with all others ($F_{3,20}$=31.62; P<0.001; Fig. 7a). Richness was also significantly higher in the wild bird seed mix and natural regeneration treatments compared with the crop. There was no significant effect of location on the abundance ($F_{1,20}$=0.04; P>0.05) or species richness ($F_{1,20}$=0.20; P>0.05) of the flower resource (Figs. 6b & 7b).

4.3. *Pollinator transects*

In year 1 (2006) the short-tongued bumblebees *Bombus terrestris / B. lucorum* and *B lapidarius* were the most common species recorded. Also, the rare (UKBAP) Large Garden Bumblebee (*Bombus ruderatus*) was recorded in the wild bird seed mix. The total abundance of bumblebees between July and September was significantly higher in the natural regeneration treatment (mean 55.1 per plot) compared with the crop (0.0) and wildflower (7.1) ($F_{3,20}$=26.86; P<0.001; Fig. 4a). Species richness of bumblebees was significantly higher in the natural regeneration treatment (4.6 species through the season) followed by the wild bird seed mix (3.7 species), wildflower (2.2 species), and lowest in the crop (0.0) ($F_{3,20}$=26.48; P<0.001; Fig. 5). Location of habitat had no significant effect on bee abundance ($F_{1,20}$=0.80; P>0.05) or species richness ($F_{1,20}$=0.06; P>0.05) (Figs. 4b & 5b).

Small White and Meadow Brown butterflies were the most abundant species recorded in the first year. The declining butterfly species Small Copper and Common Blue were also recorded exclusively in the wildflower treatment. The abundance of butterflies was significantly higher in the wild bird seed mix (mean 24.7 per plot) compared with the crop (1.0) ($F_{3,20}$=22.83; P<0.001; Fig. 4a). Butterfly species richness was significantly higher in the non-crop treatments (means 6.2 to 4.5 species) compared with the crop (mean 0.9 species) ($F_{3,20}$=10.06; P<0.001) (Fig. 5a). Location had no significant effect on the abundance ($F_{1,20}$=0.25; P>0.05) or species richness of butterflies ($F_{1,20}$=0.47; P>0.05) (Figs. 4b & 5b).

In year 2 (2007) the long-tongued bumblebee *B. pascuorum* was the most abundant species. The rare Large Garden Bumblebee (*B. ruderatus*) was recorded in wildflower and wild bird seed mixes. Total bee abundance was significantly higher ($F_{3,20}$=31.06; P<0.001; Fig. 6a) in the wildflower (mean 62.9 per plot) and wild bird seed mixtures (39.6) compared with natural regeneration (7.1). Bees were absent from the crop. Species richness of bees was significantly higher in the wildflower treatment (5.4 species through the season) compared with all other treatments except the wild bird seed mix (3.7) ($F_{3,20}$=14.73; P<0.001) (Fig. 7a). Bee richness was also significantly higher in the wild bird seed mix compared with the crop (0.0). Location had no significant effect on overall bee abundance ($F_{1,20}$=0.50; P>0.05) or species richness ($F_{1,20}$=0.53; P>0.05) (Figs. 6b & 7b). However, there were significant treatment × location interactions for the most abundant bumblebee (*B. pascuorum*; $F_{3,20}$=6.94; P<0.01) and Cuckoo bees ($F_{1,20}$=4.78; P<0.05). Both reflect higher than expected numbers of each species in the wildflower corners compared with the wildflower margins.

Meadow Brown and Green-veined White were the most abundant butterflies recorded in year 2. Butterfly abundance was significantly higher ($F_{3,20}$=21.81; P<0.001; Fig. 6a) in the wildflower (mean 18.0 per plot) and wild bird seed mix (18.4) compared with all other treatments. There was no difference in butterfly abundance between the crop (1.0) and natural regeneration (4.5) treatments. Species richness of butterflies was significantly higher ($F_{3,20}$=14.51; P<0.001; Fig. 7a) in the wildflower (5.5 species through the season) and wild bird seed mix (5.7) compared with all other treatments. There was no difference in butterfly abundance between the crop (0.9) and natural regeneration (2.2) treatments. Location had no significant effect on overall butterfly abundance ($F_{1,20}$=0.20; P>0.05) or species richness ($F_{1,20}$=0.31; P>0.05) (Figs. 6b & 7b). However, the commonly occurring Green-veined White was significantly more abundant in field corners compared with margins ($F_{1,20}$=4.59; P<0.05).

4.4 *Canopy-dwelling invertebrates*

After 2 years the abundance of canopy-dwelling invertebrates was significantly higher in all of the non-crop treatments (means of 840 to 1197 invertebrates m^{-2}) compared with the cereal crop (254 m^{-2}) ($F_{3,21}$=25.35; P<0.001; Fig. 6a). There were no significant differences in abundance between non-crop treatments. The number of invertebrate groups was also significantly higher in the non-crop treatments (means of 10.4 to 11.5 groups) compared with the cereal crop (8.4) ($F_{3,21}$=11.63; P<0.001; Fig. 7a). Location had no significant effect on invertebrate abundance ($F_{1,20}$=0.19; P>0.05) or richness ($F_{1,20}$=3.13; P>0.05) (Figs. 6b & 7b).

Fig. 4. Effects of a) habitat type and b) habitat location on abundance of flowers, bees and butterflies in 2006

a) Habitat type **b) Habitat location**

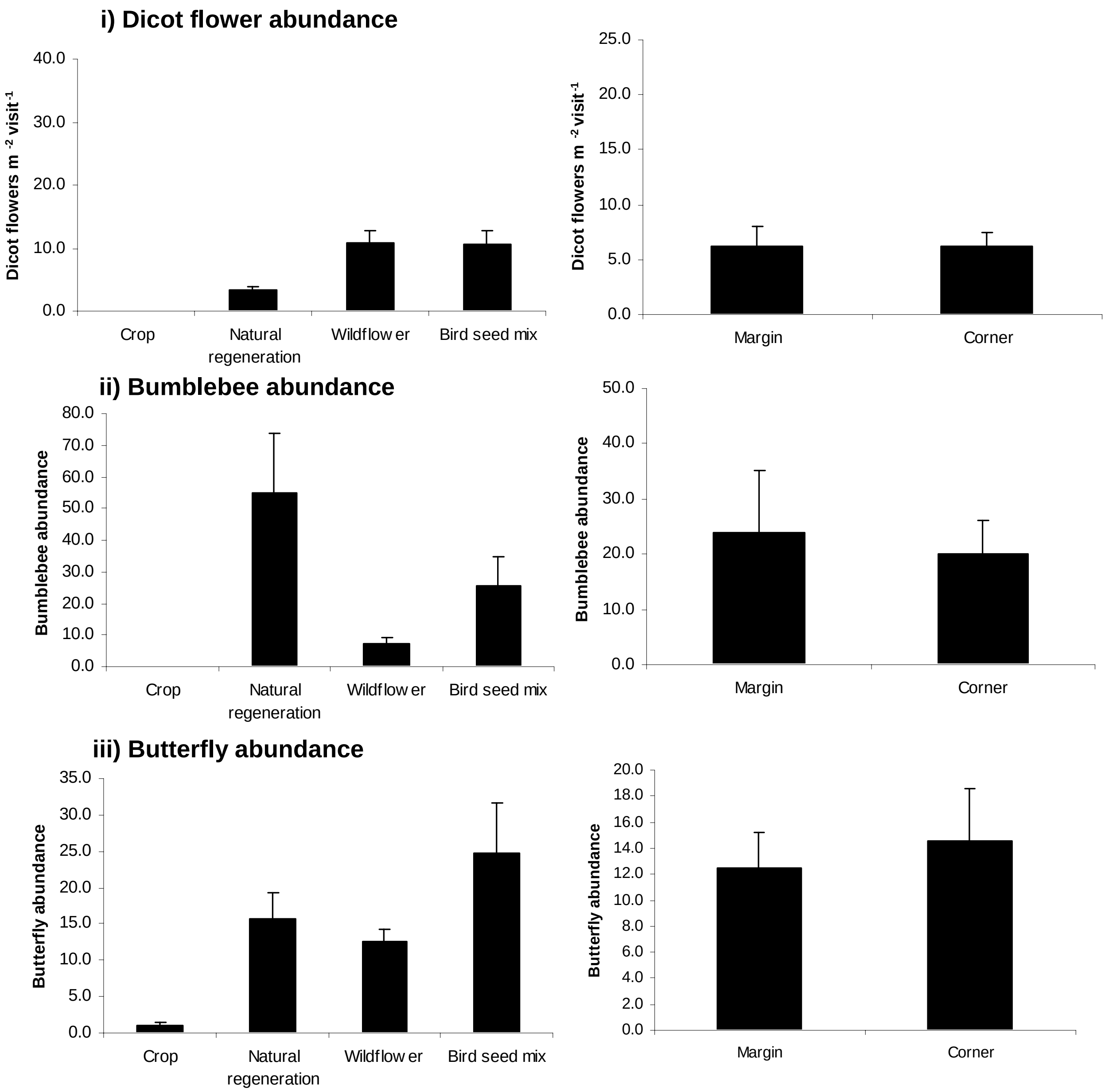


Fig. 5. Effects of a) habitat type and b) habitat location on species richness of flowers, bees and butterflies in 2006

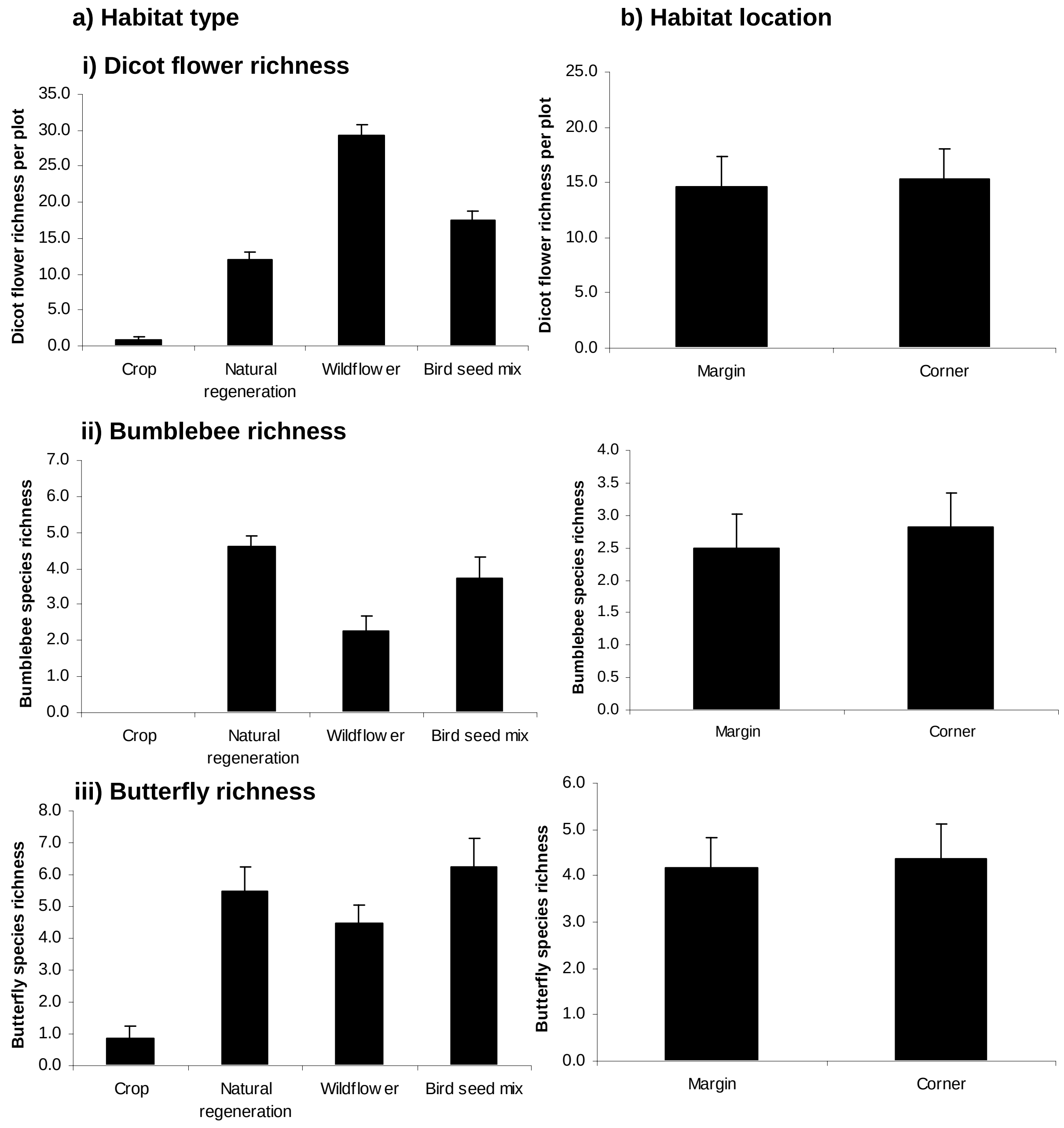


Fig. 6. Effects of a) habitat type and b) habitat location on abundance of flowers, bees and butterflies in 2007

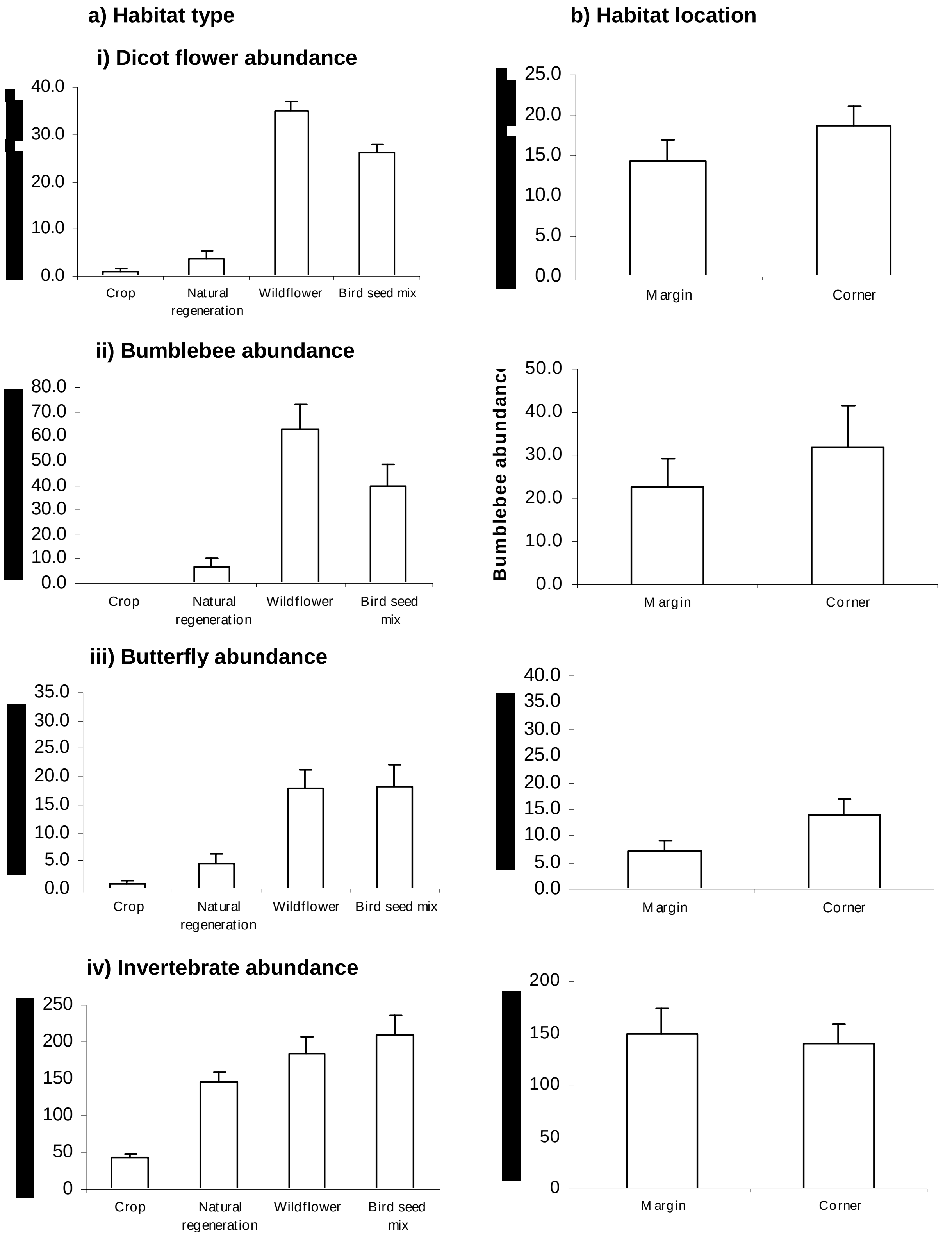
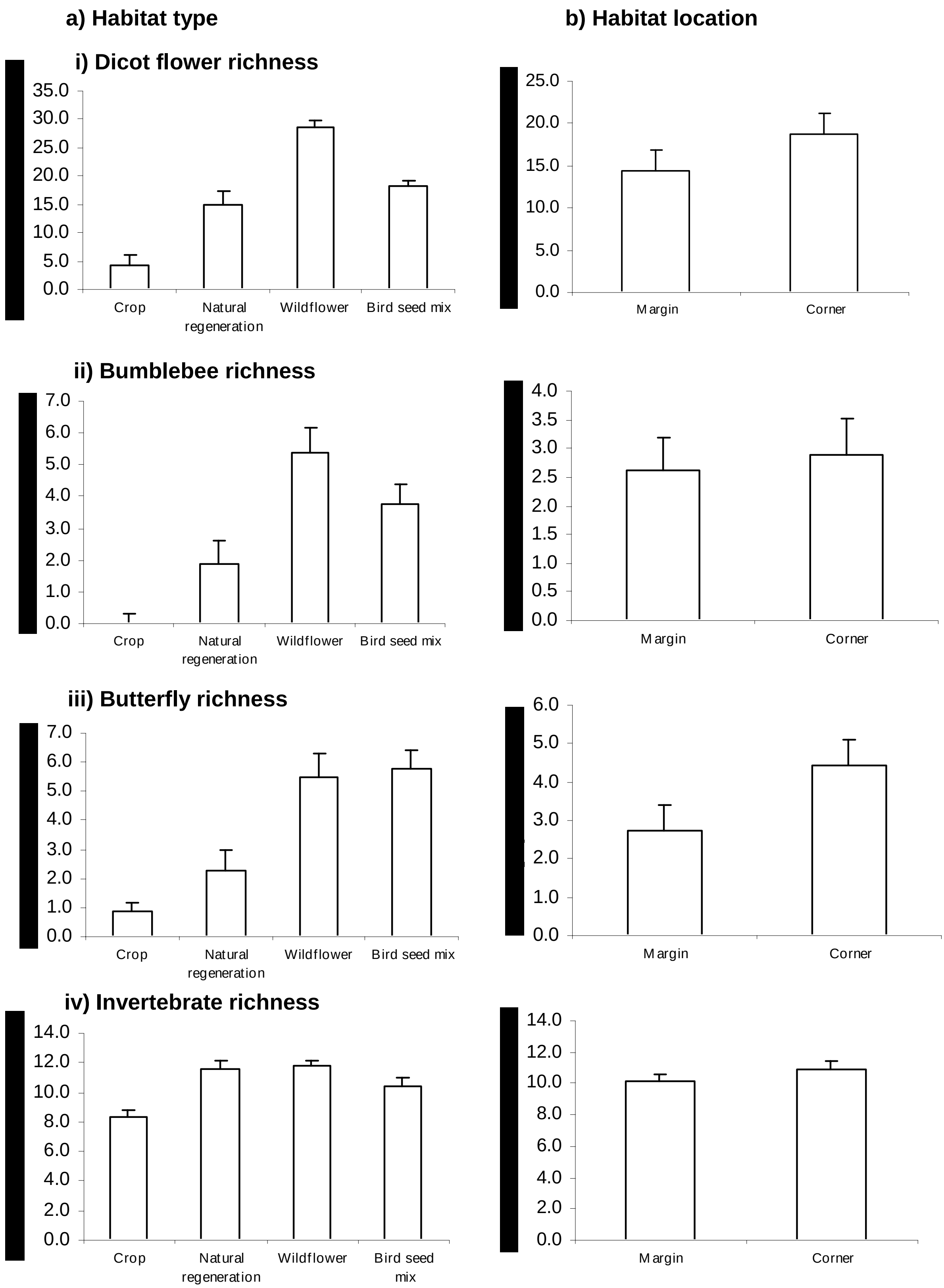


Fig. 7. Effects of a) habitat type and b) habitat location on species richness of flowers, bees and butterflies in 2007



4.5 *Farmland birds*
Linnets and Greenfinches were the most abundant bird species recorded in the winter of 2006/7. The total abundance of birds recorded between December and March was significantly higher on the wild bird seed mix (mean 54.7 per plot) compared with all other treatments (means 0.1 to 1.0 per plot) ($F_{3,20}$=37.22; P<0.001; Fig. 8a). Species richness of birds was significantly higher in the wild bird seed mix plots (mean 3.9 species) compared with all other treatments (means 0.1 to 0.7 species) ($F_{3,20}$=16.42; P<0.001) (Fig. 8a). However, location had no significant effect on the abundance ($F_{1,20}$=2.75; P>0.05) or species richness of birds ($F_{1,20}$=1.79; P>0.05) (Fig. 8b).

Linnets and Chaffinches were the most abundant bird species recorded in the winter of 2007/8. Total abundance of birds recorded between December and March was significantly higher on the wild bird seed mix (mean 86.0 per plot) compared with all other treatments (means 1.7 to 2.0 per plot) ($F_{3,20}$=35.30; P<0.001; Fig. 9a). Similarly, species richness of birds was significantly higher on this treatment (6.2) compared with all others (0.4 to 1.6) ($F_{3,20}$=36.06; P<0.001; Fig. 9a). Finally, location had no significant effect on the abundance ($F_{1,20}$=0.01; P>0.05) or species richness of birds ($F_{1,20}$=1.03; P>0.05) (Fig. 9b).

Fig. 8. Effects of a) habitat type and b) habitat location on abundance and species richness of birds in 2006

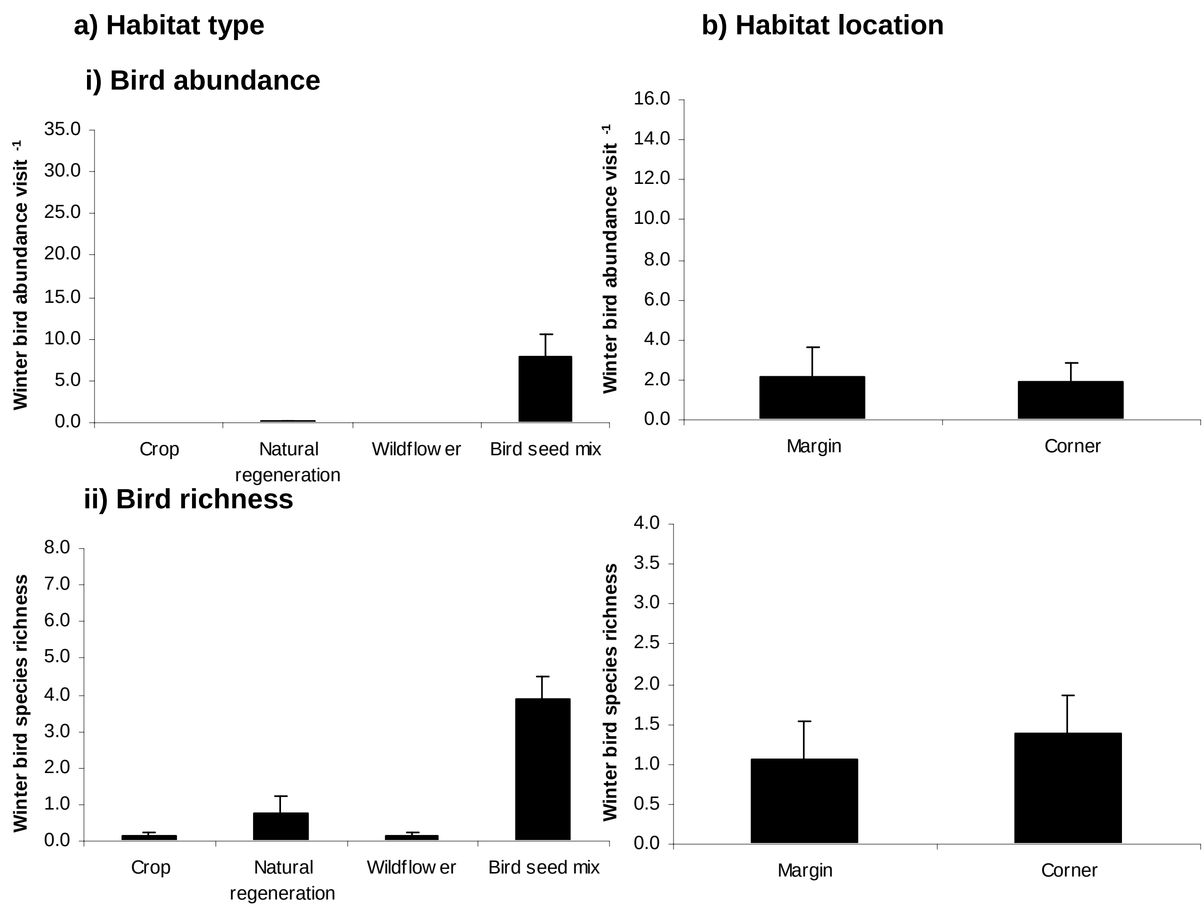
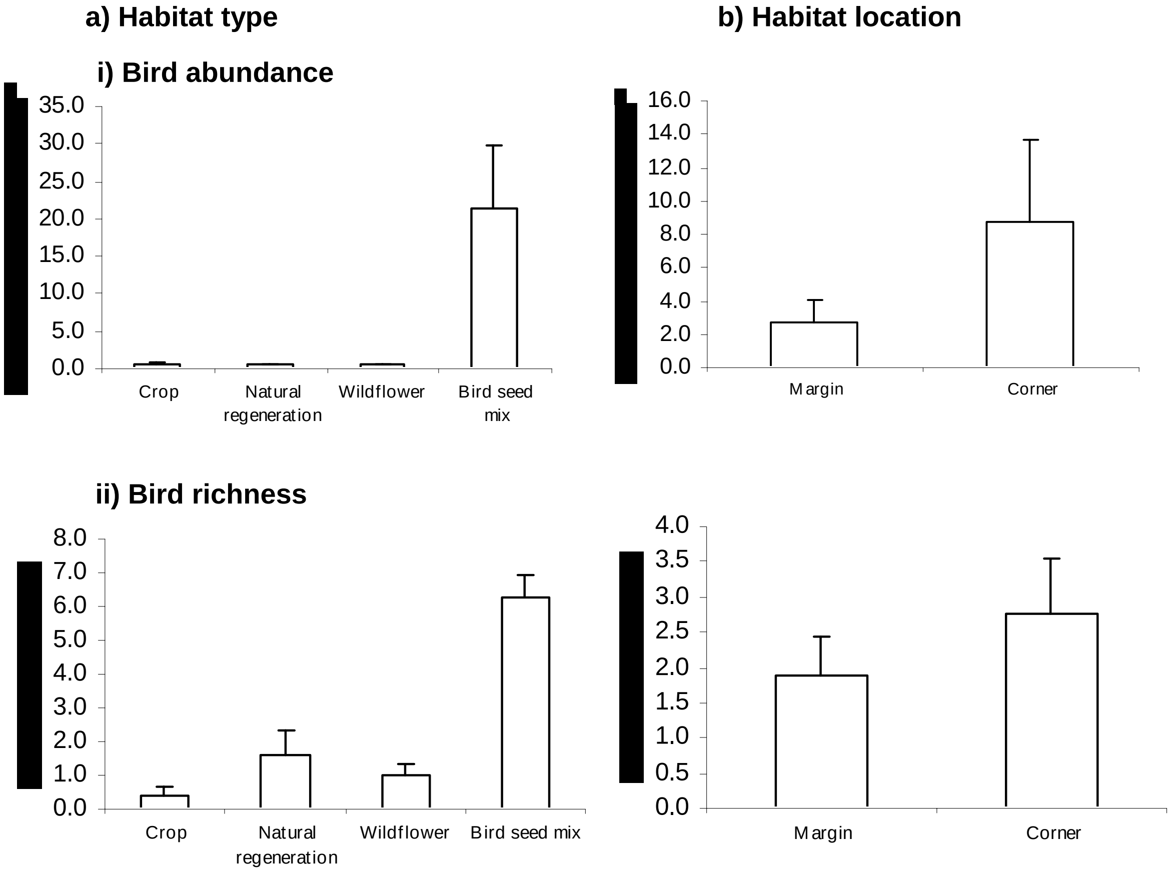


Fig. 9. Effects of a) habitat type and b) habitat location on abundance and species richness of birds in 2007



5. Discussion

5.1 *Effect of habitat type on biodiversity*

Habitat type had the primary effect on biodiversity enhancement in year 1 and this effect persisted strongly into year 2. The effects of each habitat type on different groups are summarised in Table 3. Intensive cereal crop management was highly detrimental to the abundance and diversity of plants, insects and bird in each year. The popular and cheap ELS option of allowing natural regeneration of vegetation from the crop stubble produced vegetation dominated by competitive and undesirable weed species, such as Sterile brome, (*Anisantha sterilis*), Spear thistle (*Cirsium vulgare*) and Musk thistle *Carduus nutans*. This confirms that wildlife habitat creation on farmland is severely limited by lack of seeds of desirable species in the seed bank and the surrounding landscape. This vegetation required management intervention (selective herbicide application) to prevent the spread of injurious weeds (*Cirsium* sp.) after just 1 year. However, thistles provided a valuable pollen and nectar source for bumblebees and other invertebrates in year 1.

This study demonstrates the most effective non-crop management prescriptions were those specifically targeted to the requirements of declining taxa. Sowing a mixture of perennial wildflowers and fine-leaved grasses, together with management by graminicide application and cutting, proved to be a reliable and rapid means of creating a diverse and weed-free vegetation community. This vegetation provided the most abundant and diverse resource of flowers despite the frequent cutting and removal of vegetation in year 1. Abundance of perennial flowers increased markedly in year 2 making this treatment the most attractive to butterflies and bees. Finally, sowing the annual mix of seed-bearing crops, together with appropriate management, proved to be a highly effective means of providing food resources for farmland birds during the winter months. Some of these species, such as Fodder radish (*Raphanus sativus*), were also popular forage plants for short-tongued bumblebees and other invertebrates.

Table 3. Ranked value of each habitat for the different wildlife groups

Taxa	**Measure**	**Crop**		**Natural Regeneration**		**Wild bird seed mix**		**Wildflower seed mix**	
		Yr 1	Yr 2	Yr 1	Yr 2	Yr 1	Yr 2	Yr 1	Yr 2
Plants	Richness	4	4	3	3	2	2	1	1
Flower resource	Abundance	4	4	3	3	2	2	1	1
	Richness	4	4	3	3	2	2	1	1
Bumblebees	Abundance	4	4	1	3	2	2	3	1
	Richness	4	4	1	3	2	2	3	1
Butterflies	Abundance	4	4	2	3	3	1	1	2
	Richness	4	4	2	3	3	1	1	2
Other invertebrates	Abundance	-	4	-	3	-	1	-	2
	Richness	-	4	-	2	-	3	-	1
Bird	Abundance	3=	3=	2	2	1	1	3=	3=
	Richness	3=	4	2	2	1	1	3=	3

5.2 *Effect of habitat location on biodiversity*

In both years habitat location proved to have a secondary effect on biodiversity enhancement. Indeed there were relatively few significant effects of location or treatment × location interactions for any group studied. However, field corners did support a higher diversity of plant species compared with field margins in year 1. This probably reflected less efficient weed control and fertiliser application in field corners compared with margins. However, this effect did not persist into year 2 and so there are likely to be few beneficial effects on associated insect in future years. In the early years of restoration, habitats are utilised by highly mobile species with few specific habitat requirements. Location may become a more important determent of habitat quality in future years when the plant communities in the wildflower and natural regeneration treatments becomes more stable and perennial, and they are colonised by insect species with more exacting habitat requirements. Indeed, at the individual species level there was evidence that some butterfly and bumblebee species were significantly more abundant in the field corners compared with the margins. This is likely to reflect greater sheltering in the field corners.