Supplementary material: Hardman et al. Delivery of floral resources and pollination services on farmland under three wildlife-friendly farming schemes

Appendix A: Farm characteristics.

Table A1: Farm characteristics used in site selection to match triplets of farms in three agri-environment schemes: ELS (Entry Level Stewardship), CG (Conservation Grade) and Org (organic). NCA = National Character Area, HLS = Higher Level Stewardship, Starting year = year farm entered focal scheme (ELS, organic or CG).

Scheme	NCA	Soil type	Crops	Livestock	HLS in 2013? (Y/N)	Farm size (ha)	Starting year
ELS	Low Weald	Slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils	Wheat, barley, oats	Beef cattle, sheep	N	183.8	2007
Org	Wealden Greensand	Slightly acid loamy and clayey soils with impeded drainage. Freely draining slightly acid loamy soils.	Barley-pea mix, turnips, lucerne, clover	Dairy cows	Y	344.5	1999
CG	Low Weald	Slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils. Freely draining slightly acid loamy soils.	Wheat, OSR, oats, maize	Beef cattle, sheep	Y	344.7	2006
ELS	Chilterns	Slightly acid loamy and clayey soils with impeded drainage. Freely draining slightly acid loamy soils.	Wheat, OSR, barley, maize, poppies	Beef cattle	N	295.4	2010
Org	Chilterns	Slightly acid loamy and clayey soils with impeded drainage.	Wheat (ancient varieties)	Beef cattle, pigs	Y	144.5	1997
CG	Chilterns	Slightly acid loamy and clayey soils with impeded drainage.	Wheat, OSR, barley, oats, linseed	Beef cattle	N	356.5	2004
ELS	Chilterns	Slightly acid loamy and clayey soils with impeded drainage.	Wheat, oats, barley, OSR	Beef cattle, horses	N	475.7	2007
Org	Chilterns	Slightly acid loamy and clayey soils with impeded drainage.	Wheat, oats, field beans, rye, spelt, clover	Beef cattle, horses	N	111.7	1998
CG	Chilterns	Slightly acid loamy and clayey soils with impeded drainage. Freely draining lime-rich loamy soils.	Wheat, oats, barley, peas, field beans	Beef cattle, horses, sheep	Y	182.7	2006
ELS	Hampshire Downs/Thames Basin Heaths	Shallow lime-rich soils over chalk or limestone. Slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils.	Wheat, barley, mustard, OSR	Sheep	N	672.1	2007
Org	Hampshire Downs	Shallow lime-rich soils over chalk or limestone	Wheat, barley, oats, spelt, einkorn, clover	Sheep, cows, turkeys	Y	118.8	1999
CG	Hampshire Downs	Shallow lime-rich soils over chalk or limestone. Freely draining slightly acid loamy soils	Wheat, barley, oats, OSR	Sheep	Y	266.8	2006

Table A.2: Farm intensity parameters collected through farmer interviews and using cropping maps.

Scheme	Region	Mean no. of crops per year (±SE)	No. of insecticide products in 2012	Mean nitrogen fertiliser (N kg/ha) (±SE)	Mean winter wheat yield (t/ha) (±SE)	Stocking density in 2013 (LU*/ha)	Mean field size (ha) (±SE)
ELS	LW	2.67±0.33	6	149.91±12.7	6.85±0.23	0.33	4.48±0.46
ELS	CS	3.33±0.33	6	197.75±34.7	6.81±0.23	1.3	12.53±1.89
ELS	CN	3.67±0.33	3	195±71.0	6.92±0.58	0.61	17.23±1.97
ELS	HD	2.00±0.58	3	180±20.8	7.48±0.40	0.37	11.93±1.34
Org	LW	2.67±0.33	0	0	NA	0.86	7.50±0.92
Org	CS	1.00±0.00	0	0	2.29±0.36	0.48	4.28±0.37
Org	CN	6.67±0.88	0	0	2.99±0.19	1.31	7.90±1.05
Org	HD	7.00±0.00	0	0	3.18±0.53	0.59	5.34±0.74
CG	LW	2.33±0.33	4	225±41.3	8.56±0.49	0.62	7.31±0.92
CG	CS	5.33±0.33	6	168.4±23.8	7.72±0.42	1.22	11.32±1.20
CG	CN	2.00±0.58	2	159.07±25.2	NA	0.5	10.51±1.67
CG	HD	3.33±0.33	6	142.5±27.5	7.61±0.00	0.25	9.54±1.24

*LU = livestock units

To check whether farms in different schemes varied in farm intensity, data on several intensity parameters was collected through farmer interviews (Table 2.4). Farmers were asked to provide data for the years 2011 – 2013, but the data farmers had available did not always cover all years. Differences between scheme types were tested using i) GLMMs with nested random effects for farm nested in region, for parameters data was available over several years or crop types, with scheme type differences tested using a likelihood ratio test (LRT), ii) Friedman Chi^2 for parameters where only one year of data was available and three scheme types were tested (n=12), iii) Welch's two-sample t-test for parameters where only one year of data was available and two scheme types were tested (n=8).

The mean number of crops per year did not differ significantly between scheme types (Years: 2012-2014, GLMM, LRT, Chi^2= 1.42, df=2, n=36, p=0.491). The number of insecticide products used did not vary between CG and ELS farms (Year: 2012, t=0.392, df=5.48, n=8, p=0.710). The amount of synthetic nitrogen applied (kg/ha) did not differ significantly between CG and ELS farms (Years 2012 and 2013, GLMM, LRT, Chi^2 =0.079, df=1, n=30, p=0.779). The most frequently grown crop across all farms was wheat, so yield comparisons were only tested for wheat. Spring wheat was grown by some organic farms and no non-organic farms. Overall, winter wheat yields differed significantly between schemes (Years: 2009-2013, GLMM, LRT, Chi^2= 87.48 df=2, n=46, p<0.001). Post-hoc tests revealed that winter wheat yields were significantly lower on organic farms compared to CG (p<0.001) or ELS (p<0.001). Stocking density did not differ significantly between scheme types (Year: 2013, Friedman Chi^2 = 2, df = 2, n=12, p-value = 0.3679). Mean field size was significantly smaller on organic farms (Year: 2013, GLMM, LRT, Chi^2=5.43, df=2, n=327, n=12, p=0.066, post-hoc test: Org<ELS, p=0.021). Farm size did not differ significantly between scheme types (Year: 2013, Friedman Chi^2= 3.5, df = 2, n=12, p-value = 0.1738, Table 2.1).

Table A.3: Habitat composition for farms in the three schemes in 2013 (proportion (%), mean ± SE over four farms per scheme type) and Friedman Chi² testing for differences between schemes

Habitat type	ELS	CG	Org	Friedman Chi² (2 df)	P value
ES grassland	6 ± 3.1	14.5 ± 5.2	20 ± 6.1	2.8	0.25
ES field margin	3.7 ± 1	7.6 ± 2.2	2 ± 1.3	3.5	0.17
Improved grassland	20.5 ± 10.2	8.7 ± 3.8	25.9 ± 9.8	1.5	0.47
MFC	10.4 ± 6	7.2 ± 4.5	13.2 ± 4.5	0.6	0.75
Other	11.1 ± 6.2	10.2 ± 3.2	8.8 ± 4.9	0.5	0.78
Non-MFC	48.4 ± 13.9	51.8 ± 5	30 ± 16.6	2	0.37

Table A.4: Definitions of habitat categories

Habitat category	Definition
ES grass	Grassland in Environmental Stewardship, includes low-input grassland, species-rich grassland, heathland restoration.
ES margin	Land at the edge of arable fields in Environmental Stewardship, includes field margins, grass buffer strips, flower plantings, wild bird crops, uncultivated arable blocks.
Improved grass	Grassland not in Environmental Stewardship, including grass ley and permanent pasture.
Mass-flowering crops	Crops which provide potential floral resources for pollinators: clover, sainfoin, lucerne, field bean, field pea, oilseed rape, poppy, linseed and kale.
Non-mass flowering crops	Crops which do not provide potential floral resources for pollinators: cereals and turnips.
Other	Woodland, tree planting areas, game cover crops and fallow.

Table A.5: Landscape composition for 1km buffer around study farms in 2013

Region	Landscape complexity category	Scheme	SNH (%)	MFC (%)
Chilterns North	Simple	CG	8.13	5.45
		ELS	11.45	3.65
		Org	9.35	4.67
Chilterns South	Complex	CG	27.52	3.38
		ELS	19.85	0.75
		Org	23.57	0
Hampshire Downs	Simple	CG	5.54	0
		ELS	19.84	0
		Org	7.84	1.8
Low Weald	Complex	CG	22.62	0.82
		ELS	31.95	0.33
		Org	38.6	1.6

*SNH = semi-natural habitat, MFC = mass flowering crop.

Appendix B: List of plants considered insect-rewarding that were recorded in this study

Achillea millefolium
Aethusa cynapium
Anacamptis pyramidalis
Anagallis arvensis
Anthriscus sylvestris
Arctium lappa
Arctium spp.
Bellis perennis
Brassica napus
Brassica oleracea acephala
Bryonia dioica
Capsella bursa-pastoris
Centaurea cyanus
Centaurea nigra
Centaurium erythraea
Cerastium fontanum
Chaerophyllum temulum
Chamerion angustifolium
Circaea lutetiana
Cirsium arvense
Cirsium vulgare
Clematis vitalba
Conopodium majus
Convolvulus arvensis
Cornus sanguinea
Crataegus monogyna
Crepis capillaris
Daucus carota
Digitalis purpurea
Epilobium ciliatum
Epilobium hirsutum
Erica cinerea
Fumaria officinalis
Galium aparine
Galium palustre
Geranium dissectum
Geranium pratense
Glebionis segetum
Hedera helix
Heracleum sphondylium
Hieracium spp.
Hypericum perforatum
Hypochaeris radicata
Knautia arvensis
Lactuca serriola
Lamium album
Lamium purpureum
Lathyrus pratensis
Leontodon hispidus
Leucanthemum vulgare
Ligustrum vulgare
Linum usitatissimum
Lonicera periclymenum
Lotus corniculatus
Malva sylvestris
Matricaria discoidea
Medicago lupulina
Medicago sativa
Mycelis muralis
Myosotis arvensis
Odontites vernus
Onobrychis viciifolia
Ophrys apifera
Papaver rhoeas
Papaver somniferum
Persicaria maculosa
Phacelia tanacetifolia
Pisum sativum
Plantago lanceolata
Polygonum aviculare
Potentilla reptans
Prunella vulgaris
Prunus spinosa
Ranunculus acris
Ranunculus ficaria
Ranunculus repens
Raphanus sativus
Rosa arvensis
Rosa canina
Rubus fruticosus agg.
Sambucus nigra
Scrophularia nodosa
Senecio jacobaea
Silene dioica
Silene latifolia
Sinapis arvensis
Sisymbrium officinale
Solanum dulcamara
Sonchus asper
Sonchus oleraceus
Stachys officinalis
Stellaria graminea
Stellaria holostea
Stellaria media
Taraxacum agg.
Torilis japonica
Trifolium dubium
Trifolium pratense
Trifolium repens
Tripleurospermum inodorum
Verbascum nigrum
Veronica arvensis
Veronica chamaedrys
Veronica persica
Vicia orobus
Vicia sativa
Vicia sepium
Viola arvensis

Appendix C: Additional results

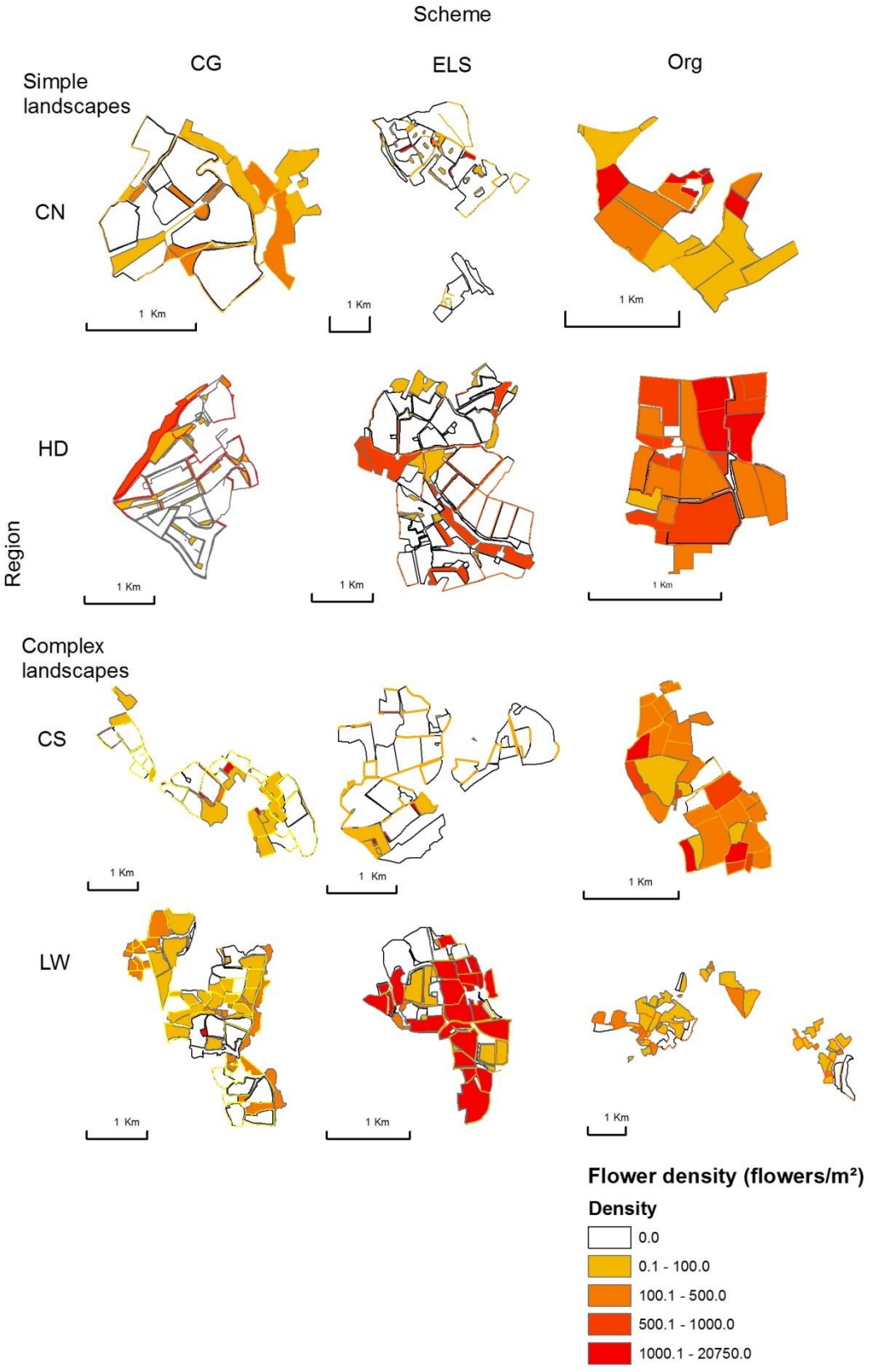

Figure C.1: Habitat maps (including hedgerows) coloured by flower density (flowers per m^2) in July from twelve farms in three different wildlife-friendly farming schemes across four regions. Farm triplets labelled by National Character Area: CN=Chilterns North, CS=Chilterns South, LW=Low Weald, HD=Hampshire Downs.

Table C.1: Model results for a zero-inflated negative binomial model on floral density.

Count model coefficients (negative binomial with log link):

	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	4.4442	0.7003	6.346	2.21E-10	***
Farmtype CG	1.1771	1.2836	0.917	0.35913	
Farmtype Org	3.223	0.8491	3.796	0.000147	***
Cropfactor: noncrop	4.1027	0.7513	5.461	4.75E-08	***
Farmtype CG:cropfactor noncrop	-1.6906	1.3328	-1.268	0.204662	
Farmtype Org:cropfactor noncrop	-3.161	0.9245	-3.419	0.000628	***
Log(theta)	-0.9501	0.1302	-7.296	2.97E-13	***

Zero-inflation model coefficients (binomial with logit link):

	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	1.1118	0.4655	2.388	0.0169	*
Farmtype CG	-0.2582	0.4569	-0.565	0.5721	
Farmtype Org	-1.9836	0.6873	-2.886	0.0039	**
Cropfactor noncrop	-2.4014	0.4847	-4.954	7.26E-07	***

* significant at p<0.05, ** significant at p<0.01, *** significant at p<0.001

List of reports used to calculate 5 year average yield difference between organic and conventional winter wheat for England and Wales, available at http://www.orgprints.org/

Moakes, Simon and Lampkin, Nicolas (2010) Organic farm incomes in England and Wales 2008/09 (OF 0373). Aberystwyth University and Organic Research Centre, Aberystwyth and Newbury.

Moakes, Simon and Lampkin, Nicolas (2011) Organic farm incomes in England and Wales 2009/10 (OF 0373). Aberystwyth University and Organic Research Centre, Aberystwyth and Newbury.

Moakes, Simon; Lampkin, Nicolas and Gerrard, Catherine L (2012) Organic farm incomes in England and Wales 2010/11 (OF 0373). Aberystwyth University and Organic Research Centre, Aberystwyth and Newbury.

Moakes, Simon; Lampkin, Nicolas and Gerrard, Catherine L (2013) Organic farm incomes in England and Wales 2011/12 (OF0373). Aberystwyth University and Organic Research Centre, Aberystwyth and Newbury

Moakes, Simon; Lampkin, Nicolas and Gerrard, Catherine L (2014) Organic farm incomes in England and Wales 2012/13. Aberystwyth University and Organic Research Centre, Aberystwyth and Newbury