Supplementary Electronic Material: Chapter 8

Spatial variation and habitat relationships in moorland bird assemblages: a British perspective

MURRAY C. GRANT
Royal Society for the Protection of Birds, Scotland, and RPS Planning & Development

and

JAMES W. PEARCE-HIGGINS
Royal Society for the Protection of Birds, Scotland, and British Trust for Ornithology

Appendix E8.1 Methods and data

Derivation of moorland bird list

The upland bird list used here is based largely on that produced by Thompson *et al.* (1995) for heather moorlands, with six species added. All of the six further species are identified in at least two, and five are identified in at least three, other British or UK upland bird lists (Fuller, 1982; Thompson *et al.*, 1988; Ratcliffe, 1990; Avery and Leslie, 1990; Stillman and Brown, 1998).

Details of moorland bird surveys that contribute to the analyses of regional variation

Most of the survey data come from an extensive study of changes in upland bird abundance in Britain, with 10 regions surveyed in either 2000 or 2002 (Sim *et al.*, 2005; Tables E8.1 and E8.2). These data were augmented by data from Dartmoor in 2006 (Stanbury *et al.*, 2006), The Forest of Bowland in 2005 (Stephen *et al.*, 2010), southern Scotland in 1999 and 2000 (Pearce-Higgins and Grant, 2006), Orkney Mainland in 1990–1992 (M. Grant and S. Lowther, unpubl.) and Fetlar, Shetland in 2007 (M. Grant, unpubl.). Therefore, with the exception of Orkney, data from the different regions came from within a 10 year period. Several of the surveyed regions

Table E8.1 *Details of the survey regions, timing, methods, species coverage and unit of bird abundance used.*

	Survey area (km^2)	Composition of survey area	Survey years	Survey method	No. of survey visits	Measure of abundance used	Bird species counted[a]
Dartmoor	107–187[b]	The North Moor area, plus two smaller areas	2006	250 m transects	2	Mean count of individuals within 100 m of transect	All
Exmoor	154	Several large contiguous blocks plus smaller fragments	2002	B and S[c]	2	Max. count of apparent pairs[d]	Restricted range of 'target' species
N Wales	97	17 plots of 1.8–9.1 km^2	2002	200 m transects	2	Max. count of individual registrations	All
S Pennines	208	68 plots of *c*.4 km^2	2000	B and S	2	Max. count of individual registrations	All
Bowland	35	42 plots of 0.5–1 km^2	2005	200 m transects	3	Max. count of individual registrations	All
N Yorkshire	63	11 plots of 3.9–7.3 km^2	2002	200 m transects	2	Max. count of individual registrations	All
N Pennines	72	12 plots of 6 km^2	2000	200 m transects	2	Max. count of individual registrations	All
Lake District	75	15 plots of 3.6–6.7 km^2	2002	200 m transects	2	Max. count of individual registrations	All
S Scotland	144	72 plots of 2 km^2	1999 and 2000	200 m transects	3	Max. count of individual registrations	Waders, grouse, selected raptors and passerines

NE Highlands	201	12 plots of 4.5–44.6 km^2	2000	200 m transects, B and S	2	Max. count of individual registrations	All
East Flows	197	34 plots of 2– 25 km^2	2000	500 m transects	2	Max. count of individual registrations	All
West Flows	325	16 plots of average 18.3 km^2	2000	250 m transects	2	Max. count of individual registrations	All
Lewis and Harris	110	19 plots of 3–7.4 km^2	2002	200 m transects	2	Max. count of individual registrations	All
Orkney Mainland	21	12 plots of 0.5–3 km^2	1990 – 92	200 m transects	2	Max. count of individual registrations	Waders, grouse and raptors
Fetlar	14	*c.* 60% of island's moorland area	2007	200 m transects	1	Count of individual registrations	Waders

[a] In some surveys where a subset of species were counted, the presence or absence of other species was recorded.

[b] Data on counts of individuals were not available for all spp. from the entire survey area, so some density indices are calculated from a subset of the area.

[c] B and S – counts made using the method of Brown and Shepherd (1993), which entails covering all ground to within a distance of 100 m or so, and is approximately equivalent to using 200 m transects.

[d] Estimates of pairs, rather than individuals, made in Exmoor, except for meadow pipit and skylark counts, which were of individuals.

Table E8.2 *Data used in the analyses of regional variation in the moorland bird community. Counts represent the count of individuals km^{-2}, except for Exmoor where apparent pairs km^{-2} are presented (see Table E8.1). X denotes species recorded during surveys, but for which counts are unavailable. – denotes that data on occurrence are unavailable from that survey. Bird species are listed in four groups according to their dependence upon moorland habitats (as defined in Table 8.1). Scientific names of species are in Table 8.1.*

		Survey region (with area surveyed in km^2)														
	Species	Dartmoor (187[a])	Exmoor (154)	N. Wales (97)	S. Pennines (208)	Bowland (35)	N. Yorkshire (63)	N. Pennines (72)	Lake District (75)	S. Scotland (144)	NE Highlands (201)	East Flows (197)	West Flows (325)	Lewis and Harris (110)	Orkney (21)	Fetlar (14)
A	Hen harrier	0.01	–	0.27	0.00	0.40	0.03	0.01	0.04	0.10	0.04	0.06	0.00	0.00	0.71	0.00
	Golden eagle	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.01	0.20	0.00	0.00
	Merlin	0.00	–	0.18	0.03	0.14	0.05	0.14	0.19	0.03	0.02	0.03	0.03	0.08	0.05	0.00
	Peregrine	0.09	–	0.10	0.08	0.29	0.00	0.06	0.04	X	0.04	0.02	0.01	0.00	0.00	0.00
	Red grouse	0.28	0.00	0.64	4.61	7.93	7.41	4.90	1.77	4.34	7.85	0.57	0.87	0.89	1.10	0.00
	Black grouse	0.00	0.00	0.26	0.00	0.00	0.13	0.38	0.00	0.17	0.14	0.01	0.00	0.00	0.00	0.00
	Golden plover	0.01	0.00	0.05	1.58	0.12	3.67	4.83	0.01	1.10	0.59	1.65	2.27	5.94	0.05	2.79
	Dunlin	0.07	0.00	0.01	0.11	0.00	0.25	0.61	0.00	0.02	0.12	0.47	1.04	5.49	0.00	5.14
	Common snipe	0.27	0.05	0.00	0.15	0.20	0.00	0.71	1.23	1.42	0.22	0.16	0.30	0.00	1.81	5.64
	Whimbrel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	3.21
	Curlew	0.01	0.03	0.32	2.10	5.82	3.51	5.25	1.49	4.38	1.33	0.34	0.12	0.34	31.43	3.79
	Greenshank	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.47	0.78	0.00	0.00
	Short-eared owl	0.01	–	0.02	0.05	0.26	0.22	0.04	0.07	0.12	0.04	0.02	0.01	0.02	0.52	0.00
	Skylark	57.70	16.71	2.36	3.87	X	3.43	9.85	15.70	X	1.28	3.30	5.08	11.26	X	X
	Meadow pipit	85.72	34.32	20.64	14.35	X	21.00	28.40	32.24	X	21.88	8.50	17.09	16.78	X	X
	Whinchat	0.49	X	1.96	0.13	0.55	0.03	0.01	0.55	0.50	0.24	0.02	0.09	0.01	0.00	0.00
	Stonechat	1.19	X	0.98	0.06	1.64	0.03	0.03	0.84	0.63	0.27	0.78	0.45	0.44	X	0.00
	Wheatear	5.28	X	0.33	0.26	1.27	0.46	1.45	1.61	1.11	1.11	0.35	0.28	0.83	X	X

	Ring ouzel	0.07	0.01	0.02	0.11	0.40	0.05	0.07	0.01	0.06	0.46	0.00	0.004	0.00	0.00	0.00
	Raven	0.21	X	0.64	0.10	0.20	0.06	0.12	0.51	0.55	0.41	0.12	0.09	0.55	X	X
	Twite	0.00	0.00	0.00	0.13	0.00	0.00	0.08	0.00	0.01	0.10	0.04	0.03	0.00	X	0.00
B	Buzzard	0.15	_	0.47	0.00	0.32	0.03	0.07	0.47	X	0.20	0.10	0.07	0.08	0.00	0.00
	Kestrel	0.32	X	0.18	0.17	0.61	0.13	0.11	0.55	X	0.10	0.01	0.00	0.00	0.00	0.00
	Oystercatcher	0.00	0.00	0.00	0.02	0.92	0.05	0.21	0.11	0.10	0.33	0.05	0.08	0.14	3.38	12.36
	Lapwing	0.01	0.00	0.00	0.33	0.75	1.27	1.31	0.39	1.07	0.37	0.07	0.03	0.18	1.95	2.86
	Redshank	0.00	0.00	0.00	0.06	0.06	0.00	0.36	0.01	0.02	0.04	0.03	0.03	0.19	0.29	2.36
	Cuckoo	0.24	X	0.05	0.04	0.26	0.02	0.01	0.08	X	0.01	0.01	0.02	0.12	–	0.00
	Wren	0.83	–	1.49	0.69	5.13	0.36	0.69	0.64	X	0.61	0.31	0.18	1.02	X	0.00
	Grasshopper warbler	X	X	0.10	0.00	0.00	0.00	0.00	0.00	–	0.00	0.01	0.01	0.00	0.00	0.00
	Whitethroat	0.01	X	0.23	0.01	0.00	0.00	0.00	0.17	–	0.00	0.00	0.00	0.00	0.00	0.00
	Willow warbler	0.28	X	0.78	0.19	1.24	0.02	0.06	0.16	–	0.25	0.18	0.34	0.00	–	0.00
	Carrion/ hooded crow	2.29	X	4.19	1.26	2.07	1.33	0.89	2.45	3.39	0.23	0.10	0.12	0.27	X	X
C	Greylag goose	0.00	0.00	0.00	0.01	0.00	0.00	0.24	0.15	–	0.00	0.19	0.21	0.95	0.00	X
	Wigeon	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.00	–	0.06	0.00	0.03	0.00	–	0.00
	Teal	0.02	–	0.00	0.00	0.03	0.09	0.37	0.00	–	0.08	0.09	0.27	0.17	–	0.00
	Arctic skua	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	1.13	X	X
	Great skua	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.16	X	X
	Black-headed gull	0.00	0.00	0.00	0.01	0.14	4.89	4.74	0.00	–	3.31	0.16	0.05	0.01	X	X
	Common gull	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	–	0.93	0.23	0.42	0.15	X	X
	Lesser black-backed gull	0.01	–	0.19	0.15	0.95	0.00	0.58	0.00	–	0.03	0.00	0.17	0.00	X	X
	Herring gull	0.85	–	0.00	0.00	0.00	0.00	0.10	0.00	–	0.01	0.06	0.01	4.76	X	X

Table E8.2 (*cont.*)

		Survey region (with area surveyed in km^2)													
	Species	Dartmoor (187[a])	Exmoor (154)	N. Wales (97)	S. Pennines (208)	Bowland (35)	N. Yorkshire (63)	N. Pennines (72)	Lake District (75)	S. Scotland (144)	NE Highlands (201)	East Flows (197)	West Flows (325)	Lewis and Harris (110)	Orkney (21)	Fetlar (14)
	Great black-backed gull	0.02	–	0.03	0.00	0.03	0.00	0.08	0.00	–	0.01	0.01	0.01	3.22	X	X
	Arctic tern	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	X
D	Greenland white-fronted goose	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Red kite	0.01	–	0.06	0.00	0.06	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	Goshawk	0.00	–	0.02	0.00	0.00	0.00	0.00	0.00	X	0.00	0.01	0.00	0.00	0.00	0.00

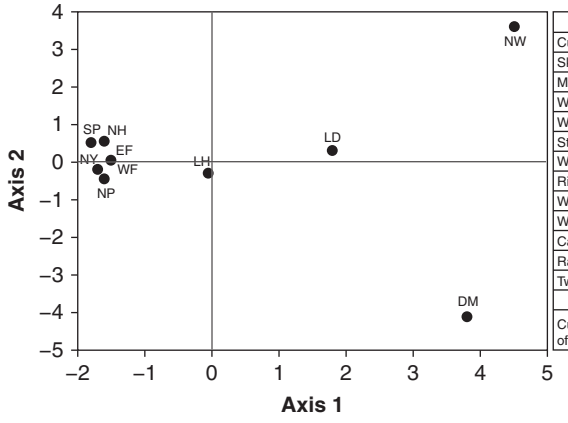
[a] total area of moorland surveyed but for some species density estimates are produced from subareas (always ≥107 km^2) due to availability of data in form comparable to other surveys.

included small amounts of enclosed upland farmland (largely grassland), and *c*. 30% of the northeast Highland region was classed as montane (arbitrarily defined as land above 600 m altitude in this case – Fuller *et al*., 2000). Orkney data came from a wider sample of wetland and moorland plots, using only those that derived from plots $\geq 0.5\ km^2$ in area, and with >50% cover of heather and/or hare's-tail cottongrass (to avoid inclusion of wetland-dominated plots). Survey plots were generally non-random and were not necessarily representative of the wider area in which they occurred, although those from south Scotland and Bowland were a stratified random selection.

All data were collected using standard upland bird survey methods; either line-transects 200 or 250 m apart (except in East Flows where they were 500 m apart), or the Brown and Shepherd (1993) method, which gives similar coverage to 200 m transects (Table E8.1). Two visits, covering the main period of breeding activity, were made to plots in most regions, but there were three visits in South Scotland and Bowland, and a single visit only on Fetlar. Most surveys were conducted during the day (0830–1730), although surveys in Dartmoor, South Scotland and Bowland included some visits close to dawn or dusk, when the activity of some species is greater. The maximum number of individuals (excluding flocks) counted on any one visit was used as the measure of abundance for our analyses, except in Dartmoor and Exmoor, where the mean count of individuals and maximum count of presumed pairs, respectively, were used for most species, potentially under-estimating abundance relative to other regions (Table E8.1). The greater transect spacing in the East Flows may also have caused relative underestimation of abundance, whilst differences in the number of survey visits is a further source of bias that should be borne in mind.

Appendix E8.2 Regional variation in passerine densities

Limited information could be extracted on variation in the passerine (and cuckoo) assemblage, because only 10 regions provided sufficient data for analysis, whilst biases from variation in survey methods are likely to have relatively large effects on some of these species (e.g. Buchanan *et al*., 2006). Principal components analysis (PCA) first separated North Wales (NW), Dartmoor (DM) and the Lake District (LD) with positive scores, from Lewis and Harris (LH) with a near-zero score, and the remaining sites with negative scores (Axis 1 of Fig. E8.1). Regions with positive scores contained high densities of a range of relatively common and widespread passerines, including carrion crow *Corvus corone* and raven *Corvus corax*. interpretation of the second axis was less clear, and separated only North Wales and Dartmoor at opposite extremes from the other regions (Fig. E8.1).



	Axis 1	Axis 2	Axis 3
Cuckoo	0.28	−0.34	0.01
Skylark	0.24	−0.42	0.05
Meadow pipit	0.25	−0.39	0.17
Wren	0.30	0.18	0.21
Whinchat	0.34	0.28	0.10
Stone chat	0.35	−0.07	−0.12
Wheatear	0.22	−0.42	0.19
Ring ouzel	−0.11	0.01	0.73
Whitethroat	0.30	0.32	−0.07
Willow warbler	0.26	0.27	0.16
Carrion/hooded crow	0.35	0.15	0.02
Raven	0.26	0.23	0.12
Twite	−0.25	0.05	0.53
Cumulative proportion of variation	0.44	0.72	0.84

Figure E8.1 Distribution of regions along the first two axes of a principal components analysis examining variation in moorland passerine densities across 10 regions. Coefficients are given for each species for the first three PCA axes. Locations and codes for regional samples are shown in Figure 8.2.

References for the supplementary material

Avery, M. and Leslie, R. (1990). *Birds and Forestry*. London: Poyser.

Brown, A. F. and Shepherd, K. B. (1993). A method for censusing upland breeding waders. *Bird Study*, **40**, 189–195.

Buchanan, G. M., Pearce-Higgins, J. W. and Grant, M. C. (2006). Observer variation in estimates of meadow pipit *Anthus pratensis* and skylark *Alauda arvensis* abundance on moorland. *Bird Study*, **53**, 92–95.

Fuller, R. J. (1982). *Bird Habitats in Britain*. Calton: Posyer.

Fuller, R. M., Smith, G. M., Sanderson, J. M. *et al*. (2000). *Countryside Survey 2000 Module 7. Land Cover Map 2000*. Final Report. Monks Wood: Centre for Ecology and Hydrology.

Pearce-Higgins, J. W. and Grant, M. C. (2006). Relationships between bird abundance and structure of moorland vegetation. *Bird Study*, **53**, 112–125.

Ratcliffe, D. (1990). *Bird Life of Mountain and Upland*. Cambridge: Cambridge University Press.

Sim, I. M. W., Gregory, R. D., Hancock, M. H. and Brown, A. F. (2005). Recent changes in the abundance of British upland breeding birds. *Bird Study*, **52**, 261–275.

Stanbury, A., Salter, A., Slader, P. and Tayton, J. (2006). *Breeding bird survey of Dartmoor training area*. Unpublished RSPB report.

Stephen, L., Grant, M. C., Munro, E. and Wilson, P. (2010). *United Utilities Sustainable Catchment Management Programme (SCaMP): Monitoring the response in bird abundance, 2005–2009*. Unpublished report to United Utilities.

Stillman, R. A. and Brown, A. F. (1998). Pattern in the distribution of Britain's upland breeding birds. *J. Biogeogr.*, **25**, 73–82.

Thompson, D. B. A., MacDonald, A. J., Marsden, H. and Galbraith, C. A. (1995). Upland heather moorland in Great Britain: A review of international importance, vegetation change and some objectives for nature conservation. *Biol. Conserv.*, **71**, 163–178.

Thompson, D. B. A., Stroud, D. A. and Pienkowski, M. W. (1988). Afforestation and upland birds: consequences for population ecology. In *Ecological Change in the Uplands*, ed. M. B. Usher and D. B. A. Thompson, pp 237–259. Oxford: Blackwell Scientific Publications.