Question 6: What evidence is there, from the survey of birds in Module 5 and other sources, of the value of different types/patterns of hedges for birds and, by comparison with previous surveys, of changes in the condition of hedges (for birds)?

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DEFINITIONS

- 'Types/patterns' (of hedges) – the creation of a typology of sample squares according to hedge and landscape characteristics will form part of the research.
- 'Birds' – In this analysis, we looked at 28 bird species which were selected according to their habitat association and ranged from hedgerow specialists through to woodland specialists (Fuller *et al* 2001). A number of generalist and hedgerow specialist bird species are recognised as farmland birds.

POLICY CONTEXT STATEMENT

1 *The following policy context statement has been drafted and presented at the May 2002 workshop.*

2 The importance of birds as ecological indicators is now widely recognised. In particular, farmland birds (as a group) are the subject of concern as declining numbers in many species are observed and reported. One of the key habitats in many of the farmed landscapes is hedgerows and their associated features. Research shows that there is no single ideal shape or size of hedge for all bird species. It is suggested that on balance, birds prefer a hedge with high volume, few gaps and plentiful protection (e.g. thorns) from predators. However, some birds (e.g. yellowhammer) are known to like low trimmed hedges with occasional song perches, while other species prefer large, overgrown hedges for nesting.

3 The routine collection of physical and management data on hedgerows as part of CS2000, and the introduction of Module 5 whereby transects were walked in a large proportion of the 1 km sample squares, and birds recorded at different distances from the transect lines, allows an assessment of the association between different hedge types and bird frequency. This research is further enhanced by the potential to examine aspects of landscape pattern associated with hedgerows and to relate this to bird numbers and distribution.

4 This question will address, in general terms, which types of hedgerow, and which spatial characteristics, are best suited to particular bird species and to overall avian diversity. This is important in planning new landscapes, so that optimal conditions for a range of bird species can be achieved.

SCIENCE OUTPUTS

Part 1: What evidence is there, from the survey of birds in module 5 and other sources, of the value of different types/patterns of hedges for birds?

Approach

General approach

5 We selected/extracted a number of hedgerow and landscape characteristics for 336 CS2000 squares for which bird data are available.

6 Key hedgerow and landscape parameters were identified by regression analysis that were the best descriptors of the occurrence and abundance of hedgerow specialist bird species in the 336 CS squares. This subset of hedgerow and landscape variables were used to classify the CS sample squares into groups exhibiting similar hedgerow and landscape characteristics, called clusters.

7 The clusters of CS squares were described using the initial 19 hedgerow and landscape characteristics and their distribution in GB plotted.

8 Bird population density estimates were calculated for each cluster using distance sampling methods (Buckland *et al.* 1993). Results are presented for the three groups of bird species – generalists, hedgerow specialists and woodland specialists. In using the bird data collected under Module 5 to answer this question we would bear in mind that the methods we used were designed to give a 'whole square' appraisal of the bird community. Therefore it will be difficult to relate the bird counts to individual hedges and therefore many individual hedge characteristics.

9 The final stage in the analysis was to use Canonical Correspondence Analysis (CCA) to relate bird community composition to the environmental variables in each cluster.

Hedgerow and landscape characteristics

10 Attribute data associated with each hedge was assembled using ArcInfo GIS analysis and database querying. A subset of 19 variables thought to be relevant to birds *a priori* were used in this analysis (Table 6.1).

11 There were 12 variables related to hedgerows. They described their overall representation in the square as well as their structure and species characteristics. Hedgerow trees within 2 meters of hedges were identified from an existing spatial dataset and allocated to 3 age groups. Multiple numbers of hedgerow trees all with differing ages could be associated with a single hedge.

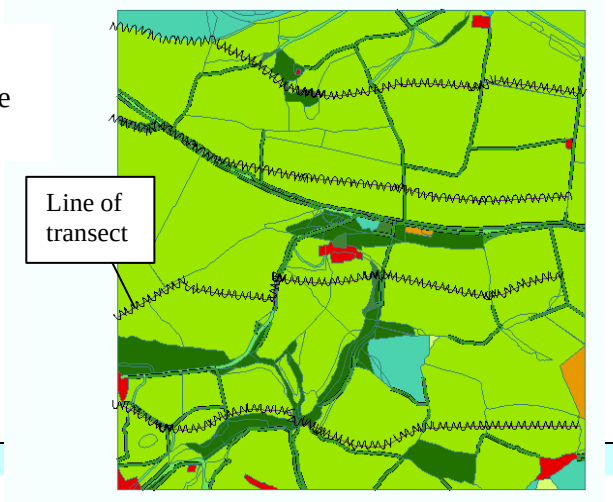
12 There were 7 variables describing the landscape context. Three variables described the location of the square (coordinates and altitude). Four variables described the amount of land use types that are important for birds as well as the overall diversity of the mosaic. The index of diversity combines the number of elements (in this case Broad Habitat) with the distribution of their respective area within the mosaic.

Table 6.1 The 19 hedgerow and landscape variables used in the regression analyses.

Variables (code)	Description
Hedge characteristics	
Hedge density	1998 total length of hedge in meters / non-sea area of 1km square
Hedges/all boundaries	hedge expressed as a proportion of total boundary features
Hedge species richness	Mean H plot species richness
Hawthorn	Length (metres) of hawthorn dominated (>50%) hedgerow (metres)
Other species dominant	Length(metres) of hedgerow dominated (>50%) by another tree/shrub
Mixed species dominant	Length (metres) of mixed hedgerow
Length of hedge >2m	Length (metres) of hedgerow >2m height
Length of hedge 1-2m	Length (metres) of hedgerow 1-2m height
Length of hedge <1m	Length (metres) of hedgerow <1m height
Hedgerow trees <20 years old	Total number of standard trees in hedgerows that are <20 years old
Hedgerow trees 20-100 years old	Total number of standard trees in hedgerows that are 20-100 years old
Hedgerow trees >100 years old	Total number of standard trees in hedgerows that are >100 years old
Landscape characteristics	
Easting	OS grid Ref – easting
Northing	OS grid Ref – northing
Altitude	mean altitude
Arable	Arable farmland as % of farmed land (grass +arable)
Coniferous	total area (ha) of conifer woodland
Broadleaved	total area (ha) of conifer woodland
Square diversity	Shannon-Wiener Index of Broad Habitat diversity in square

13 Although the outputs will not make an input to work within FOCUS, the digitising of transects mapped during Module 5 fieldwork was completed for all 336 squares as agreed. Existing GIS CS spatial datasets were edited to add linear transect data and additional adjacent land information. There are over 1300 transects covering 1,211km in the CS database. An example of the resultant spatial dataset can be seen in Figure 6.1

Figure 6.1. A 1km x 1km CS survey square with digitised BTO transect line location.



Bird Data

14 Bird data for CS2000 were collected using a line-transect method, with up to 4km of transects surveyed on two visits (between April and June 2000) to each of 336 CS2000 squares. More detailed information on field methods can be found in Wilson & Fuller, 2001.

15 In this exercise 28 common bird species were selected, which range from hedgerow specialists, through to woodland specialists according to an analysis of habitat preferences by Fuller *et al.*, 2001 (Table 6.2).

16 Bird population density estimates were calculated using distance sampling methods using two distance bands, 0-25 metres and 25-100 metres (Buckland *et al.* 1993).

Table 6.2 Species used in analysis, preference for hedgerows versus woodland, and population trends 1970 to 1999.

Habitat preference[1]		Species (two letter code) and *latin name*		Population trend 1970-1999 [2]
Strongest preference for hedges				
	Hedgerow specialists	Yellowhammer (Y.)	*Emberiza citrinella*	***-53***
		Linnet (LI)	*Carduelis cannabina*	-52
		Goldfinch (GO)	*Carduelis carduelis*	+23
		Whitethroat (WH)	*Sylvia communis*	-16
		Greenfinch (GR)	*Carduelis chloris*	+13
		Dunnock (D.)	*Prunella modularis*	-40
		Lesser Whitethroat (LW)	*Sylivia curruca*	+3
	Generalists	Chaffinch (CH)	*Fringilla coelebs*	+30
		Blackbird (B.)	*Turdus merula*	-24
		Mistle Thrush (M.)	*Turdus viscivorus*	-37
		Stock Dove (SD)	*Columba oenas*	+127
		Blue Tit (BT)	*Parus caereleus*	+21
		Robin (R.)	*Erithacus rebecula*	+36
		Great Tit (GT)	*Parus major*	+46
		Wren (WR)	*Troglodytes troglodytes*	+40
		Long-tailed Tit (LT)	*Caudatus caudatus*	+41
		Song Thrush (ST)	*Turdus philomelos*	-56
		Bullfinch (BF)	*Pyrrhula pyrrhula*	-53
		Willow Warbler (WW)	*Phylloscopus trochilus*	-38
		Garden Warbler (GW)	*Sylvia borin*	+26
	Woodland specialists	Blackcap (BC)	*Sylvia atricapilla*	+125
		Chiffchaff (CC)	*Pylloscopus collybita*	+20
		Great Spotted Wdpckr (GS)	*Dendrocopos major*	+125
		Nuthatch (NH)	*Sitta europaea*	+112
		Coal Tit (CT)	*Parus ater*	+19
		Treecreeper (TC)	*Certhia familiaris*	-16
Strongest preference for woodland		Spotted Flycatcher (SF)	*Muscicapa striata*	-77
		Goldcrest (GC)	*Regulus regulus*	-22

[1] Fuller et al., 2001
[2] Gregory et al., 2002

Results

Classification of squares into clusters

17 The identification of key hedgerow and landscape characteristics was carried out using regression analysis.

18 Seven of the independent variables were good predictors of presence/absence of at least one of the hedgerow specialist species (Table 6.3). Of these seven variables, only two were hedgerow characteristics: length of hawthorn dominated hedgerow and hedge species richness.

19 Nine variables were significantly related to the abundance of the hedgerow specialists within squares. Of these, four were hedgerow characteristics (Table 6.4).

20 In all, ten of the 19 independent variables were found to significantly influence the distribution or abundance of the hedgerow specialist bird species.

Table 6.3 Results of Logistic Regression (presence / absence of hedgerow specialist bird species)

Parameter	Estimate	Standard Error	Pr > χ2
Intercept	-2.13	1.266	0.0928
Hawthorn	0.00105	0.000524	0.0458
Coniferous	-0.0321	0.00833	0.0001
Square diversity	-1.29	0.3656	0.0004
Hedge species richness	-0.346	0.162	0.0324
Northing	0.00527	0.00114	<0.0001
Altitude	0.00526	0.00172	0.0022
Arable	-0.0524	0.0238	0.0275

Table 6.4 Results of Linear Regression (abundance of hedgerow specialist bird species)

Parameter	Estimate	Standard Error	Pr > F
Intercept	0.288	0.118	0.0156
Hawthorn	0.0000539	0.0000187	0.0042
Length of hedge <1m	-0.000156	0.0000646	0.0164
Broadleaved	-0.00466	0.00219	0.0344
Hedges/all boundaries	0.211	0.130	0.1043
Square diversity	0.116	0.0405	0.0047
Hedge species richness	0.0288	0.0153	0.0607
Northing	-0.000347	0.000110	0.0018
Altitude	-0.000496	0.000223	0.0269
Arable	0.00441	0.000744	<0.0001

21 These ten variables were then used to perform a cluster analysis to classify all squares into broad grouping based on hedgerow and landscape characteristics that most influence the hedgerow species community.

22 This revealed 6 clusters, according to a minimum criterion of separating at Semi-partial R-Square values of 0.02 or more. The distribution of squares attributed to these clusters can be found in Figure 6.2. The distribution by land classes can be found in Table 6.5

Figure 6.2. Distribution of 336 CS2000 squares allocated to the 6 clusters.

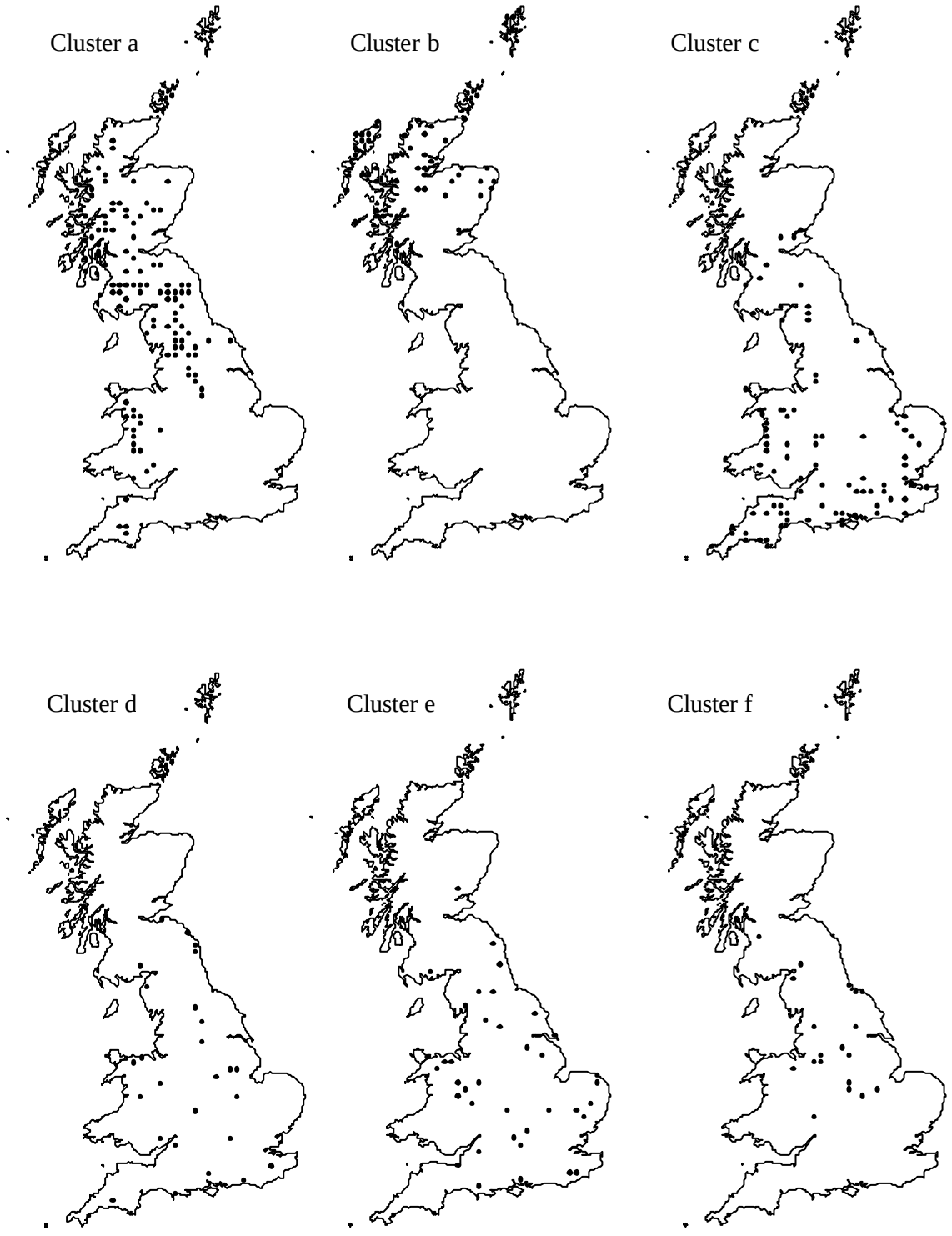


Table 6.5. Distribution of CS squares in the six clusters by Land Classes

	Clusters					
landclass	a	b	c	d	e	f
1			10	3	3	1
2			8	3	3	
3			8	1	5	
4			7	1	2	
5			3			
6	1		12	1		
7	2		6		2	
8			7		1	
9	1		2		2	2
10	2			4	3	5
11			1	2	1	2
12				2	2	
13	1	2	3	1		5
15	1		4	1	2	
16	1		2	2	2	1
17	18		5	2	4	
18	10		1			1
19	13	1	3		3	
21	8	6				
22	20	1				
23	11	1				
24	10					
25	4	4	2	1	1	1
26		2	2	2	1	1
27	2	2	3		1	
28	2	7	1			
29		8				
30		9				
31		5				
32		8				
Total	107	56	90	26	38	19

Description of the six clusters

23 The description of hedgerow and landscape variables for each cluster can be found in Appendix 1. From this information it is possible to generalise about the characteristics of each of the six clusters, as shown in Table 6.6.

24 Each cluster was assigned a rank for each of the 28 species from 1 (cluster with the lowest density) to 6 (cluster with the highest density). These ranks scores were then summed across all species in each of the three guilds to show give a total rank score for each cluster (Table 6.7). The species density estimates for individual bird species in each of the six clusters are presented in Appendix 2.

Table 6.6. Hedgerow and landscape characteristics of the six clusters

Cluster	Regions	Dominant hedge type	Landuse/landscape
A	Uplands of England, Wales and Scotland	Little or no hedgerow	High altitude, extensive conifer, little arable
B	Islands and marginal uplands of northern Scotland	Little or no hedgerow	Low altitude, little arable and broadleaved woodland
C	South and west, East Anglia and central lowland of Scotland	Hedge density low, predominantly mixed species	Broadleaved woodland extensive, mixed farming
D	Lowland England, Wales and southern Scotland	High hedge density, tall hedges	Arable farming dominant
E	Lowland England, Wales and southern Scotland	Hedge density low, predominantly mixed species. Low hedges	Arable farming dominant
F	Lowlands and marginal uplands of England	Very high density of tall hawthorn hedges	Mixed farming

Table 6.7. Total ranked species density scores for each cluster and species guild

	A	B	C	D	E	F
Total rank score -hedge specialists	8	13	27	36	26	37
Total rank score -generalists	30	18	58	44	56	67
Total rank score –wood specialists	24	12	44	27	29	32

25 Clusters A and B are located in the Uplands of England &Wales and Scottish islands and marginal uplands (Figure 6.2). Squares are characterised by the absence (or a very low density) of hedgerows, little arable land and extensive coniferous plantations (Table 6.6). In terms of bird occurrence and density, clusters A and B are the poorest for all three guilds (Table 6.7).

26 Clusters C and E are located in lowland areas and exhibit low to intermediate hedgerow densities. Cluster C is characterised by mixed farming and the highest land cover of woodland in all clusters while cluster E is characterised by 40% cover of arable land (Appendix 1). Both clusters exhibit average ranked species density scores hedge specialist species, relatively large scores for generalist species (Table 6.7). Unsurprisingly, cluster C has the highest score for woodland species.

27 Cluster D is also located in lowland areas with more than 40% arable cover but exhibits a high density of tall hedges with many standard trees (Appendix 1). It is characterised by a high score of hedgerow specialist bird species but average scores for generalist and woodland bird species (Table 6.7).

28 Cluster F is restricted to the lowlands and marginal uplands of Northern England and characterised by very high density of tall hawthorn dominant hedges with many mature standard trees, in a mixed landscape (Table 6.6). Squares belonging to cluster F have the highest bird densities (Table 6.7). Indeed, cluster F holds the highest average density of five of the seven hedgerow specialists: Dunnock, Lesser Whitethroat, Greenfinch, Goldfinch and Yellowhammer (Appendix 6.2). A similar pattern holds true for the 13 habitat generalists, seven are found in their highest densities in cluster F.

Relationship between bird communities and hedgerow and landscape characteristics in the clusters

29 The bird populations density estimates for each cluster of squares and the mean value of the environmental variables for each cluster (Appendix 6.1) were used in the CCA to produce an ordination plot, showing how the bird species are related to the environmental variables.

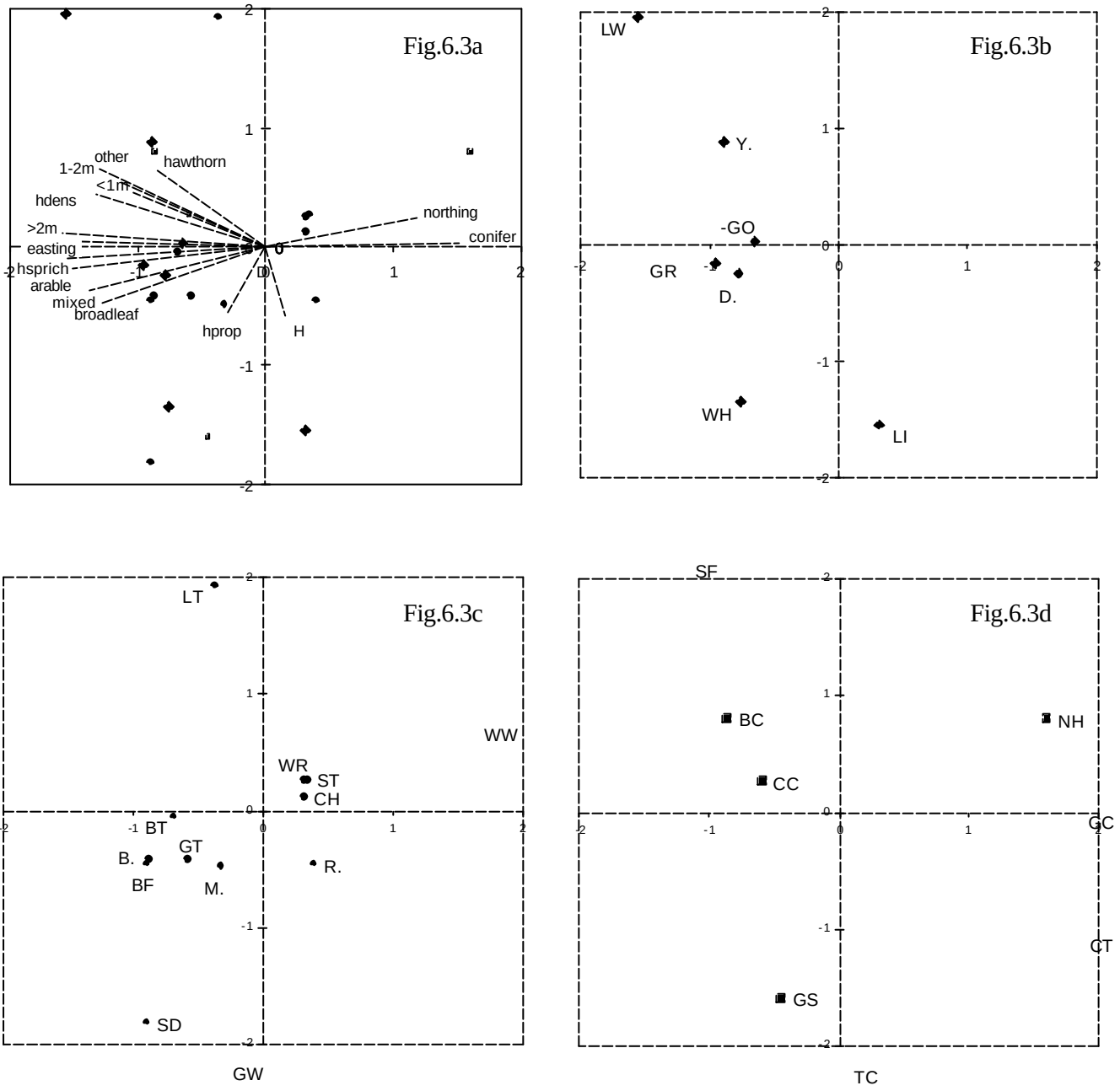
30 The first ordination plan of the CCA shows species and environmental gradients of hedgerow and landscape characteristics (Figure 6.3a). Axis 1 explains 65.4% of the species-hedgerow and landscape variables relationship. Axis 1 is very strongly associated with hedge attributes and it appears clearly that the vectors for hedgerow characteristics are highly inter-correlated. Because of this strong inter-correlations, we can only state that axis 1 is a measure of overall hedge richness, with the highest hedge density, hedge species richness and number of standard trees occurring towards the left of the ordination plots.

31 The location of the species in the ordination plots indicates with which of the environmental variables their densities are most closely associated (Figure 6.3b). The ordination plot for the hedgerow specialists shows that, as is to be expected, they are generally found to the left of the plot, in the locus where hedgerow characteristics indicate hedge rich areas. The location of Lesser Whitethroat and Yellowhammer towards the top may indicate affinities with hawthorn hedges. Linnet is quite different for the other 6 hedgerow specialists in being found to the right of the origin, suggesting that its numbers are less influenced by hedgerow richness.

32 Most of the generalist species are clustered fairly close to the origin (Fig 6.3c), as one would expect, indicating that their numbers are not so strongly influenced by any of the hedgerow or landscape characteristics. One exception is Long-tailed Tit, which may be influenced by the presence of mature standard trees, while another is Garden Warbler, which appears to prefer hedges with few standard trees.

33 The woodland specialists are scattered across the ordination plot (Fig 6.3d), possibly as a result of few woodland characteristics being taken into account in the analysis. The location of Nuthatch, Goldcrest and Treecreeper at the right of the plot does however indicate that these species are not associated with hedgerows and are genuine woodland specialists.

Figure 6.3. CCA biplots showing a) species and environmental gradients b) hedgerow specialist species c) generalist species d) woodland specialist species. Two letter species codes can be found in Table 6.



Part 2: What evidence is there, by comparison with previous surveys, of changes in the condition of hedges (for birds)?

Approach

34 The significance for birds of the changes that CS2000 has identified in hedge condition between 1990 and 1998 was reviewed. This was based on existing knowledge of the requirements of different bird species coupled with reference to other material that is available at the BTO (to whom a sub-contract was let to provide (a) joint method development (b) a literature review and (c) a report).

Changes in hedgerow characteristics between 1990 and 1998

35 Net change between 1990 and 1998 in 16 of the 19 hedgerow and landscape characteristics identified (easting, northing and altitude excluded) were calculated for the 336 squares. Net change per cluster are presented as percentage of the 1990 stock in Table 6.8. This table shows hedge density has been relatively stable overall but that there are important variations between clusters, i.e a decrease in cluster C and an increase in cluster E. Change in hedge condition were sometimes important with some general trends as well as more localised changes. There were net losses in medium height hedges (1-2m tall), especially in cluster F while the stock of tall hedges has increased everywhere. Net losses have generally been in hawthorn-dominated hedgerows with stocks of other or mixed hedgerows actually increasing between 1990 and 1998 in clusters. Hedge species richness also showed a general upward trend. The stock of standard trees in hedgerows also changed noticeably between 1990 and 1998, with a decrease in young trees and mature trees. Other changes include a net increase in the areas of both arable (except cluster E) and broadleaved woodland cover and a general small net increase in the diversity of the landscape mosaic.

Table 6.8. Net change in hedgerow characteristics between 1990 and 1998 expressed as a percentage of the 1990 stock figure.

	All squares	Cluster					
		A	B	C	D	E	F
Hedge density	-0.7	0.8	0.0	-3.2	1.2	2.6	-1.0
Hedges/all boundaries	-3.0	1.3	30.2	-4.6	-0.6	-1.8	-3.9
Hedge species richness	7.5	0.0	0.0	11.2	-3.5	2.8	24.2
Hawthorn dominated	-7.3	-50.3	0.0	-8.2	-13.1	-4.1	-3.6
Other species dominated	22.1	54.8	0.0	8.7	63.8	17.0	34.0
Mixed species dominated	2.7	-35.6	0.0	-2.9	15.1	8.7	11.3
Length of hedge>2m tall	13.5	-2.3	0.6	5.2	12.7	18.4	47.6
Length of hedge 1-2m tall	-2.1	-12.0	-0.5	-0.4	0.7	-0.8	-7.0
Length of hedge <1m tall	37.9	0.0	0.0	62.9	37.4	-47.3	32.8
Hedge trees <20 yrs	-7.7	50.0	0.0	-8.1	0.0	-25.7	-4.7
Hedge trees 20-100 yrs	1.4	-12.5	0.0	5.2	-6.4	-3.1	5.0
Hedge trees >100 yrs	-0.1	-50.0	0.0	14.9	-15.6	6.9	-8.6
Arable	1.2	2.8	8.9	0.2	5.4	-4.8	9.5
Broadleaved	5.7	9.4	0.9	4.3	5.7	8.1	2.3
Coniferous	0.9	2.4	-2.3	-5.1	3.7	10.0	7.4
Square diversity	1.2	2.3	-1.7	0.5	6.3	-0.2	6.1

Significance of hedgerow and landscape characteristic change for birds

36 The overall loss of hedgerow density in clusters C and more especially F will almost certainly have led to a loss of nest sites for a range of species in some areas. Lesser Whitethroat and Yellowhammer could be considered the two species most likely to have been affected by the recent changes in hedgerows shown by the CS as it is in cluster F that these hedgerow specialists are found in highest densities.

37 The loss of hawthorn hedges across all clusters could have affected several species and again, the Lesser Whitethroat, a species known to favour tall and thick hawthorn hedges (Green *et al.* 1994) could well have been affected by this change. The population of Lesser Whitethroats in Britain was remarkably stable throughout the 1960s, 70s and 80s, in contrast to that of the Whitethroat, which has shown periodic population crashes associated with conditions on the wintering grounds in sub-Saharan Africa (Marchant *et al.* 1990). Subsequently however, there was a significant reduction in Lesser Whitethroat numbers during the 1990s with a 20% decrease between 1994 and 2000 (Noble *et al.* 2001). While this recent decrease in numbers may be due to factors outside of the breeding grounds, the loss of hawthorn hedgerows between 1990 and 1998 as indicated by CS data could have contributed to the decline. The loss of hawthorn hedgerows between 1990 and 1998 coupled with the corresponding increase in the extent of hedges of other and mixed species may reflect both the loss of ancient hedges, which were predominantly hawthorn, and the increase in new hedge plantings, which may be of mixed species.

38 Yellowhammers also showed an accelerating decrease in numbers in Britain during the 1990s, thought to be due to reductions in food supply both in the winter (Moorcroft *et al.* 2002) and the breeding season (Kyrkos *et al.* 1998; Bradbury *et al.* 2000). Yellowhammers have been shown to make extensive use of non-cropped field margins for foraging and for nesting (Perkins *et al.* 2002; Stoate & Szczur 2001). A preference for low-medium height hedges has been shown for this species (Green *et al.* 1994; Stoate & Szczur 2001), which may therefore have been affected by the loss of hedges between 1m and 2m high in many areas.

39 The overall reduction in the number of tall standard trees may not have affected some of the hedgerow specialists, as most of them tend to be most abundant in hedgerows without trees (Green *et al.* 1994; Fuller *et al.* 2001). One exception is the Greenfinch, which has been shown to be associated with hedges containing mature trees (Green et al. 1994; Macdonald & Johnson 1995). The Greenfinch is one of the few hedgerow specialists to show a significant increase in numbers during the 1990s (Noble *et al.* 2001).

40 The effects of the changes in hedgerows on the other hedgerow specialists and the generalists are difficult to ascertain. Loss of hedgerows, the removal of standard trees and a reduction in hedgerow quality will all certainly have an impact on a local scale but there is no evidence of a causal link between these changes and farmland bird declines at a larger scale (Gillings & Fuller 1998).

41 The changes in stock of trees in the three age categories used in this analysis may be difficult to interpret as this gives no indication of whether the changes may be partly due to changes in tree species and whether there have been changes in the available of old dead wood, which is a crucial limiting factor for hole nesting species such as the tits, Stock Dove and Great Spotted Woodpecker.

42 Several of these considered in this analysis have undergone substantial population declines since the 1970s. The two species exhibiting the strongest preference for hedgerows, the Linnet and the Yellowhammer, have decreased in abundance by more than 50% between 1970 and 1999 Table 1). While both these species (and indeed many others included in this study) use hedgerows principally as a nesting and refuge habitat and the major causes of the declines have

largely been attributed to a loss of food within fields, there can be no doubt that a loss of hedge quantity and quality has aggravated the situation. Whether the changes in hedgerow stock or quality shown between 1990 and 1998 were substantial enough to have had had an impact on national bird populations of any of the 28 species considered here is difficult to ascertain. The recent declines of two hedgerow specialist species, the Lesser Whitethroat and Yellowhammer may be due to reasons other than hedgerow loss but the maintenance of suitable hedgerows for these two species in particular will be important in helping to arrest these declines.

SUMMARY

Part1: What evidence is there, from the survey of birds in Module 5 and other sources, of the value of different types/patterns of hedges for birds

43 Ten of the 19 hedgerow and landscape variables were found to significantly influence the distribution or abundance of the hedgerow specialist bird species Of those variables only four were hedgerow characteristics. Hawthorn and hedge species richness were predictors of both species occurrence and abundance.

44 The ten variables were used to identify six groups of squares exhibiting different hedgerow and landscape characteristics that are relevant for hedgerow, generalist and woodland birds. Two groups were characterised by absence or very low density of hedges and were the poorest for all three bird guilds. A further two groups exhibited low to intermediate hedgerow densities and had average densities of hedgerow bird species and relatively large densities of generalist and woodland bird species. The final two groups were characterised by high to very high hedge densities and exhibited the highest densities of all three guilds of birds.

45 Landscapes characterised by a very high density of tall hawthorn dominant hedges with many mature standard trees and a mixed land use are the most favourable for a diverse and abundant bird community.

46 Multivariate analysis suggest that hedgerow characteristics are strongly inter-correlated, such that areas with a high density of hedgerow also tend to hold the highest and most botanically species rich hedges. This implies that it is difficult to disentangle the effect of a particular hedgerow characteristics on bird communities.

Part 2: What evidence is there, by comparison with previous surveys, of changes in the condition of hedges (for birds)?

47 Changes in stock and quality of hedgerows between 1990 and 1998 were modest compared with the large changes in previous decades. However, loss of hedgerows in cluster C and more especially the species-rich cluster F will probably have been detrimental to a range of bird species.

48 The loss of traditional hawthorn hedges through the 1990s is identified as a change that may have had a detrimental effect on populations of some species, noticeably the Lesser Whitethroat and Yellowhammer.

49 The overall reduction in the number of mature hedgerow trees is unlikely to have affected hedgerow birds, as most of them tend to prefer hedgerows without trees.

50 There is insufficient evidence to suggest that generalist and woodland species have been adversely affected by changes in hedgerow stock and characteristics through the 1990s, although

undoubtedly deleterious effects will occur on a local scale when hedges are removed or managed inappropriately.

FURTHER WORK AND RECOMMENDED CHANGES TO CS METHODS

51 The digitising of bird transects in CS squares will allow us to explore the relationships between the occurrence and abundance of individual bird species to the characteristics of individual hedgerows. Such fine scale analysis would enable us to disentangle the effect of individual hedgerow characteristics on bird communities (which we could not achieve here). It should be added that the combination of a very fine scale approach (the individual hedge) applied to a large nationally stratified dataset (around 1600 transects) will give insight into the regional variations in species-habitat relationships, a key factor in predictive modelling of species occurrence/abundance.

52 As other questions in Topic 2, Question 6 calls for a number of recommendations as to the information to be recorded during the next Countryside Survey. The width of linear features would be a meaningful variable for birds, as in conjunction with height, it enables estimation of the volume of vegetation. Careful consideration needs to be given to extra categories for attributes, for example 'absence of' should be recorded rather than the assumption that no information indicates this. The advances in field survey technologies will ensure comprehensive recording through the use of mandatory data fields.

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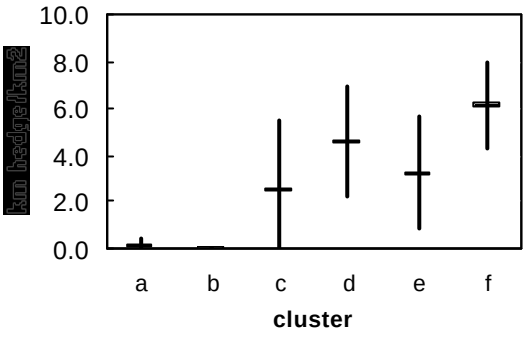
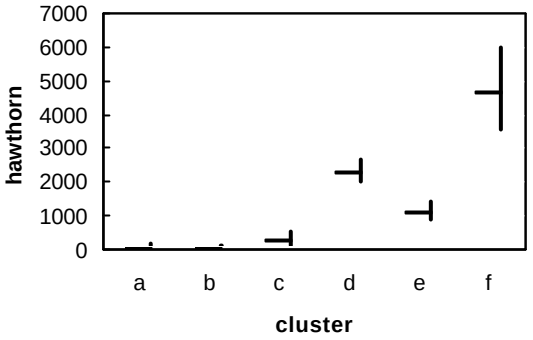
Appendix 6.1: Means and Standard deviations of Environmental variables for each cluster of squares

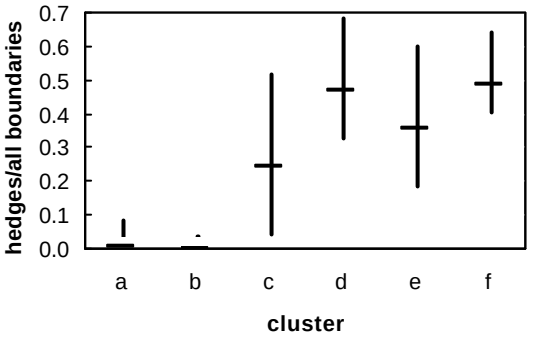
Hedge density



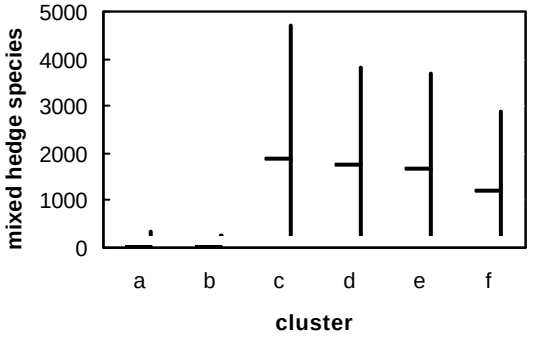
Length of hawthorn hedges (metres)



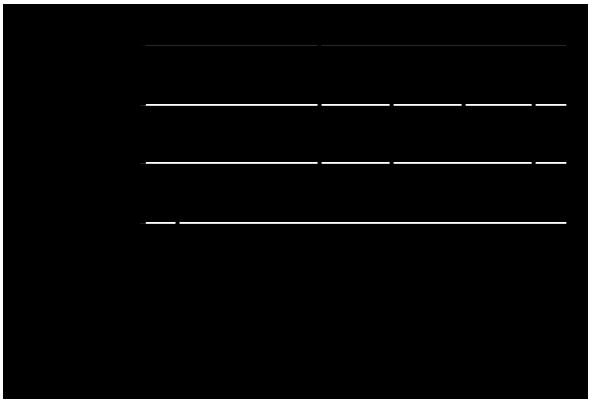
Hedges as proportion of all boundaries



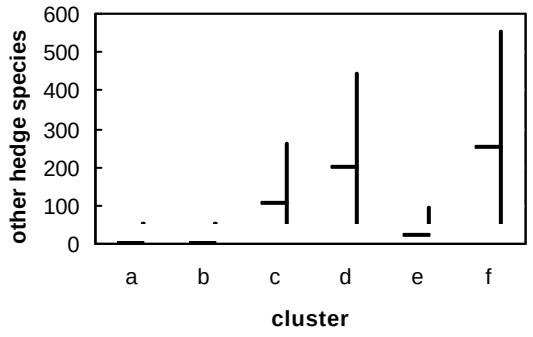
Length of mixed hedge (metres)



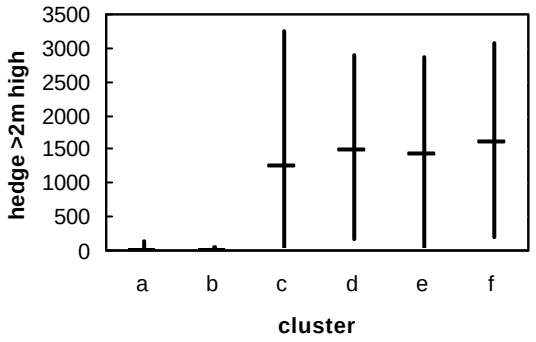
Hedge Species Richness



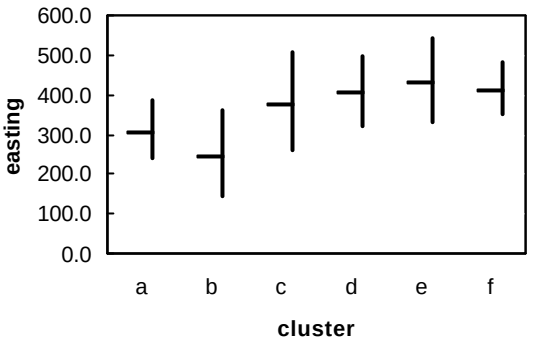
Length of other hedge (metres)



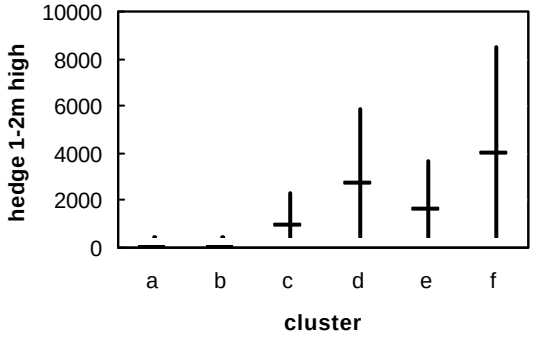
Length of hedge >2m high (metres)



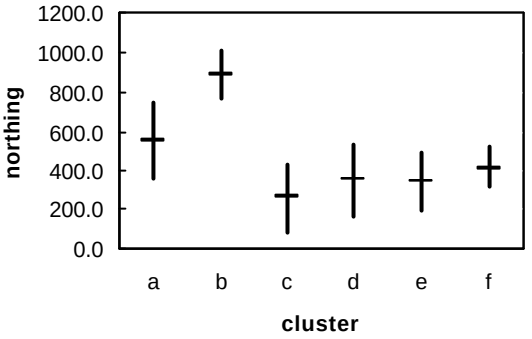
Easting



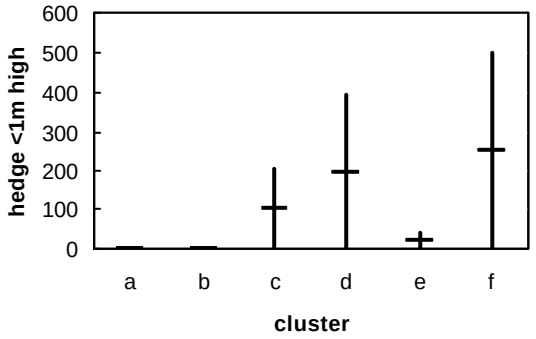
Length of hedges 1-2 m high (metres)



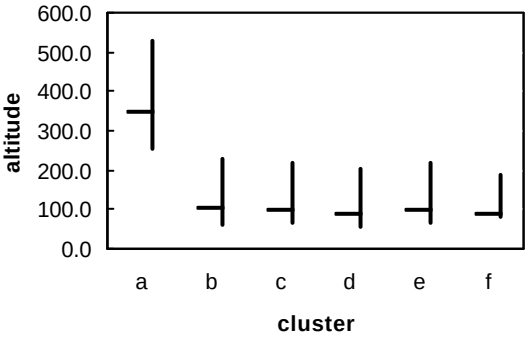
Northing



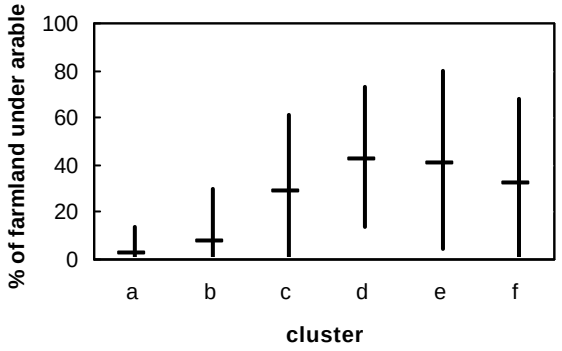
Length of hedges <1m high (metres)



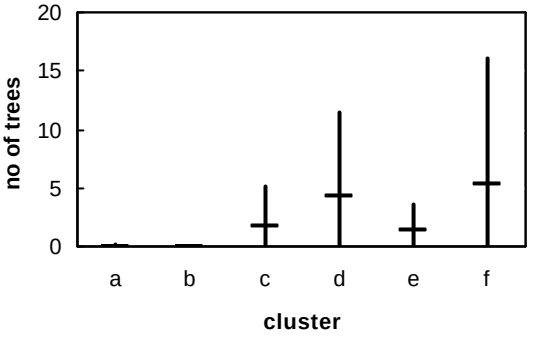
Altitude



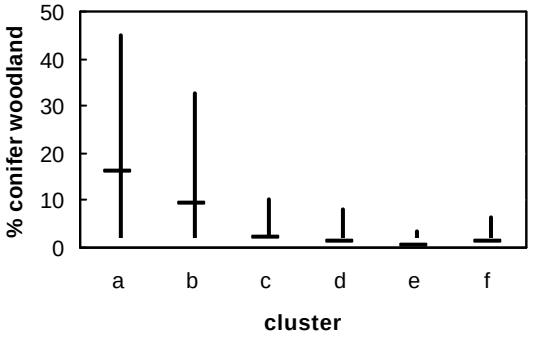
Percentage arable



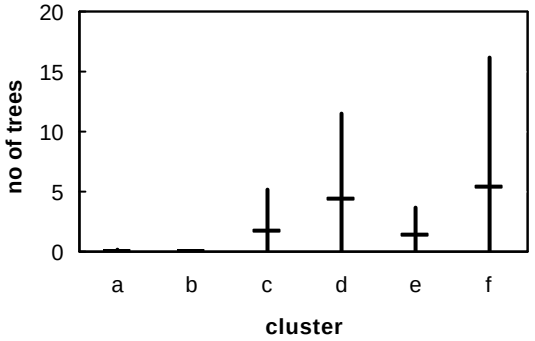
Number of hedgerow trees <20 yrs



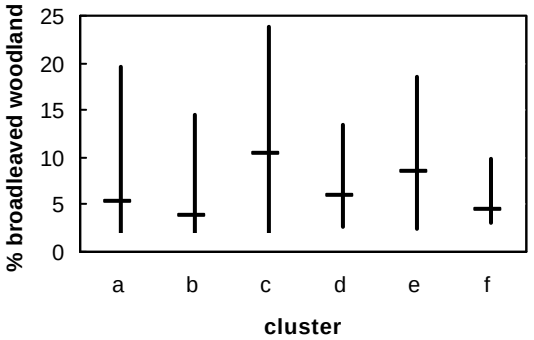
Percentage coniferous woodland



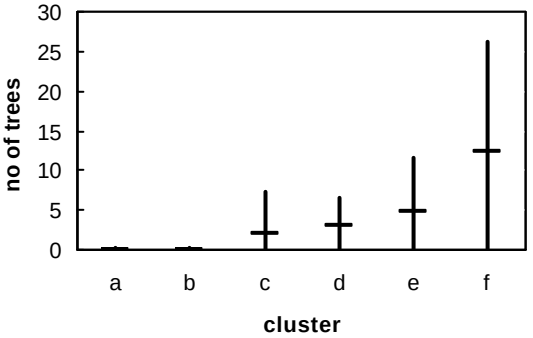
Number of hedgerow trees 20-100 yrs



Percentage broadleaved woodland



Number of hedgerow trees >100 yrs



Appendix 6.2: Population density estimates (bird/km^2) with lower and upper confidence limit for each cluster and across all squares

cluster	species	Birds/km^2	LCL	UCL
a	Stock Dove	0.2	0.1	0.4
b	Stock Dove	0.0	0.0	0.2
c	Stock Dove	2.8	1.6	5.0
d	Stock Dove	1.8	1.0	3.5
e	Stock Dove	7.9	4.1	15.1
f	Stock Dove	2.1	0.7	5.8
GB (all)	Stock Dove	2.2	1.5	3.3
a	Grt Spotted Woodpckr	0.8	0.3	2.7
b	Grt Spotted Woodpckr	0.1	0.0	0.2
c	Grt Spotted Woodpckr	2.4	1.4	4.1
d	Grt Spotted Woodpckr	2.9	1.3	6.6
e	Grt Spotted Woodpckr	2.1	1.0	4.3
f	Grt Spotted Woodpckr	1.6	0.4	5.9
GB (all)	Grt Spotted Woodpckr	1.5	1.0	2.1
a	Wren	34.5	25.9	46.0
b	Wren	24.5	15.7	38.3
c	Wren	75.5	61.5	92.6
d	Wren	55.1	37.3	81.3
e	Wren	61.6	44.3	85.6
f	Wren	89.8	59.2	136.2
GB (all)	Wren	52.0	45.7	59.3
a	Dunnock	2.5	1.5	4.3
b	Dunnock	3.2	1.4	7.4
c	Dunnock	26.6	20.7	34.3
d	Dunnock	25.3	15.8	40.3
e	Dunnock	18.6	12.2	28.4
f	Dunnock	29.2	18.2	46.9
GB (all)	Dunnock	14.2	11.8	17.1
a	Robin	27.2	19.5	38.0
b	Robin	17.1	9.0	32.6
c	Robin	69.2	55.2	86.7
d	Robin	42.2	28.3	62.9
e	Robin	44.6	31.6	63.0
f	Robin	53.3	34.1	83.2
GB (all)	Robin	41.5	35.8	48.2
a	Blackbird	8.4	5.2	13.9
b	Blackbird	5.7	3.0	11.1
c	Blackbird	73.5	58.7	92.0
d	Blackbird	78.3	54.2	113.1
e	Blackbird	64.5	42.5	98.0
f	Blackbird	83.1	54.6	126.4
GB (all)	Blackbird	41.1	34.8	48.5
a	Song Thrush	5.4	3.5	8.2
b	Song Thrush	6.8	3.4	13.3
c	Song Thrush	17.5	12.5	24.3
d	Song Thrush	9.9	5.6	17.5
e	Song Thrush	11.7	7.0	19.7
f	Song Thrush	18.6	9.9	35.1
GB (all)	Song Thrush	10.7	8.7	13.1

cluster	species	Birds/km^2	LCL	UCL
a	Mistle Thrush	2.1	1.2	3.7
b	Mistle Thrush	1.2	0.4	3.6
c	Mistle Thrush	6.2	4.1	9.6
d	Mistle Thrush	6.5	3.2	13.1
e	Mistle Thrush	8.3	4.8	14.5
f	Mistle Thrush	7.3	3.4	15.6
GB (all)	Mistle Thrush	4.4	3.4	5.7
a	Lesser Whitethroat	0.0	0.0	0.1
b	Lesser Whitethroat			
c	Lesser Whitethroat	0.3	0.1	1.0
d	Lesser Whitethroat	2.0	0.6	6.1
e	Lesser Whitethroat	1.0	0.4	2.8
f	Lesser Whitethroat	2.9	1.0	8.8
GB (all)	Lesser Whitethroat	0.5	0.3	0.9
a	Whitethroat	1.2	0.5	2.6
b	Whitethroat	2.3	0.8	6.9
c	Whitethroat	13.3	9.0	19.7
d	Whitethroat	16.4	9.3	29.2
e	Whitethroat	14.4	8.8	23.5
f	Whitethroat	11.6	5.0	26.8
GB (all)	Whitethroat	8.0	6.2	10.2
a	Garden Warbler	0.6	0.2	1.8
b	Garden Warbler	0.1	0.0	0.3
c	Garden Warbler	3.5	2.2	5.6
d	Garden Warbler	1.8	0.7	4.8
e	Garden Warbler	2.1	0.9	5.0
f	Garden Warbler	0.4	0.1	1.0
GB (all)	Garden Warbler	1.6	1.1	2.3
a	Blackcap	2.2	1.0	4.7
b	Blackcap	0.1	0.0	0.2
c	Blackcap	15.3	11.3	20.8
d	Blackcap	9.8	5.4	17.9
e	Blackcap	13.5	8.8	20.7
f	Blackcap	21.7	11.9	39.4
GB (all)	Blackcap	8.4	6.7	10.5
a	Chiffchaff	1.4	0.6	3.0
b	Chiffchaff	0.0	0.0	0.2
c	Chiffchaff	8.5	5.6	12.7
d	Chiffchaff	3.8	2.4	6.2
e	Chiffchaff	3.5	2.2	5.4
f	Chiffchaff	7.4	3.8	14.6
GB (all)	Chiffchaff	4.2	3.2	5.6
a	Willow Warbler	38.3	28.2	52.1
b	Willow Warbler	32.0	19.6	52.4
c	Willow Warbler	21.5	15.8	29.2
d	Willow Warbler	8.6	4.2	17.7
e	Willow Warbler	17.3	10.5	28.5
f	Willow Warbler	24.9	13.0	47.8
GB (all)	Willow Warbler	27.2	22.7	32.5

cluster	species	Birds/km^2	LCL	UCL
a	Goldcrest	11.7	7.5	18.2
b	Goldcrest	5.0	2.1	11.7
c	Goldcrest	12.6	8.4	18.8
d	Goldcrest	0.6	0.3	1.3
e	Goldcrest	6.1	3.0	12.2
f	Goldcrest	5.9	2.0	17.7
GB (all)	Goldcrest	9.1	7.0	11.8
a	Spotted Flycatcher	0.2	0.1	0.5
b	Spotted Flycatcher	1.0	0.2	4.0
c	Spotted Flycatcher	2.7	1.4	5.4
d	Spotted Flycatcher	2.4	0.4	15.0
e	Spotted Flycatcher	1.4	0.4	4.6
f	Spotted Flycatcher	2.9	0.0	8
GB (all)	Spotted Flycatcher	1.4	0.9	2.2
a	Long-tailed Tit	4.4	1.3	14.8
b	Long-tailed Tit	0.4	0.1	2.3
c	Long-tailed Tit	8.4	5.5	13.0
d	Long-tailed Tit	5.7	2.5	12.6
e	Long-tailed Tit	11.0	5.5	22.3
f	Long-tailed Tit	20.1	10.7	37.9
GB (all)	Long-tailed Tit	6.3	4.6	8.7
a	Coal Tit	5.6	3.3	9.7
b	Coal Tit	2.5	1.1	6.1
c	Coal Tit	6.0	3.7	9.6
d	Coal Tit	0.8	0.3	2.5
e	Coal Tit	3.8	1.8	7.8
f	Coal Tit	1.2	0.6	2.5
GB (all)	Coal Tit	4.6	3.4	6.2
a	Blue Tit	9.2	5.0	16.8
b	Blue Tit	6.2	2.9	13.1
c	Blue Tit	56.8	44.3	72.9
d	Blue Tit	53.7	35.8	80.6
e	Blue Tit	45.4	31.9	64.7
f	Blue Tit	68.0	42.8	108.2
GB (all)	Blue Tit	33.1	27.8	39.4
a	Great Tit	4.9	2.2	10.8
b	Great Tit	2.9	1.3	6.3
c	Great Tit	29.8	23.0	38.7
d	Great Tit	22.5	14.0	36.2
e	Great Tit	24.6	16.9	35.9
f	Great Tit	28.3	17.0	46.9
GB (all)	Great Tit	16.5	13.6	20.0
a	Nuthatch	2.5	0.6	10.2
b	Nuthatch			
c	Nuthatch	2.6	1.5	4.6
d	Nuthatch	0.5	0.1	1.9
e	Nuthatch	1.0	0.4	2.5
f	Nuthatch	2.1	0.6	6.6
GB (all)	Nuthatch	1.6	0.9	2.7

cluster	species	Birds/km^2	LCL	UCL
a	Treecreeper	0.6	0.2	1.5
b	Treecreeper	0.4	0.1	1.5
c	Treecreeper	1.8	1.0	3.3
d	Treecreeper	2.1	0.7	6.0
e	Treecreeper	1.4	0.6	3.5
f	Treecreeper	0.7	0.1	3.8
GB (all)	Treecreeper	1.1	0.8	1.7
a	Chaffinch	46.7	35.1	62.2
b	Chaffinch	38.7	23.2	64.7
c	Chaffinch	84.2	68.3	103.9
d	Chaffinch	88.4	60.7	128.6
e	Chaffinch	96.7	70.2	133.1
f	Chaffinch	120.6	79.0	184.2
GB (all)	Chaffinch	69.0	60.4	78.8
a	Greenfinch	2.1	1.0	4.6
b	Greenfinch	2.8	1.0	7.9
c	Greenfinch	25.5	18.2	35.7
d	Greenfinch	31.6	19.1	52.0
e	Greenfinch	26.3	16.0	43.1
f	Greenfinch	35.7	20.3	62.7
GB (all)	Greenfinch	15.7	12.5	19.7
a	Goldfinch	3.0	1.6	5.7
b	Goldfinch	3.2	1.0	10.7
c	Goldfinch	17.4	12.6	24.2
d	Goldfinch	20.5	11.6	36.1
e	Goldfinch	14.6	9.3	22.9
f	Goldfinch	24.1	12.9	44.9
GB (all)	Goldfinch	10.9	8.8	13.6
a	Linnet	6.3	3.4	11.7
b	Linnet	16.5	6.4	42.4
c	Linnet	25.4	17.3	37.3
d	Linnet	35.8	19.9	64.2
e	Linnet	17.2	9.2	31.9
f	Linnet	17.9	7.5	42.8
GB (all)	Linnet	17.2	13.3	22.1
a	Bullfinch	0.4	0.2	1.1
b	Bullfinch	0.1	0.0	0.3
c	Bullfinch	2.9	1.7	4.9
d	Bullfinch	3.0	1.2	7.5
e	Bullfinch	3.0	1.3	6.7
f	Bullfinch	3.3	1.2	9.3
GB (all)	Bullfinch	1.7	1.2	2.4
a	Yellowhammer	0.6	0.3	1.0
b	Yellowhammer	3.9	1.4	10.6
c	Yellowhammer	10.9	7.1	16.7
d	Yellowhammer	17.9	10.4	30.6
e	Yellowhammer	15.9	9.7	26.0
f	Yellowhammer	27.7	13.2	57.8
GB (all)	Yellowhammer	8.6	6.6	11.0