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Relationships between birds and habitats in Latvian farmland

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Abstract. This point-count based study (1995–99) provides information on the avifauna of different farmland habitats in Latvia. Ordinations identify the main gradients within the species composition pattern: from arable land to natural habitats and from woodland across open, dry areas to wet meadowlands with rivers and ponds. Regression models describing the relationship between species richness and habitat show that the best positive predictors of species richness are woodland, scrub, natural meadows, unfarmed patches such as piles of stones or brushwood, and ponds. Regression models of the habitat affinities of the 30 most frequently recorded bird species are used to describe the present-day situation and to predict the effects of possible changes in Latvian farmland. The current high bird diversity is largely upheld by a non-intensive agriculture and large set-aside areas. Both further abandonment and development towards western standards of agricultural production may have adverse effects on populations of several species of conservation concern. Environmental considerations should therefore become an integral part of the development of Latvian agriculture.

Key words: species–habitat relationships, farmland birds, species richness

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INTRODUCTION

Farmland in Latvia occupies approximately 40% of the territory. Of this, 71% is arable land, 27% — grassland and less than 1% — natural meadows. Small-scale farming is characteristic: 30% of all farms are less than 5 ha, and only 6% are more than 50 ha. Due to political and economical changes, Latvian farmland has changed dramatically since the early 1990s. The processes of land abandonment on large territories of former collective farms and re-privatisation to former owners have been going on simultaneously. This has resulted in a steep increase in the area of abandoned fields, while grasslands are converted to arable land by the new landowners. No more than 37 to 40% of the agricultural area was sown in 1995–1999, peaking in 1997. The number of cattle declined by 70% in the period from 1990 to 1997 and the process is still ongoing. The usage of fertilisers decreased from 217 kg/ha in 1990 to 23 kg/ha in 1995 followed by an increase to 34 kg/ha in 1997–1999. Pesticide usage was reduced by 88% from 1990 to 1995, but increased from 0.2 kg/ha in 1995 to 0.5 kg/ha in 1996, after which it has been stable.

The principal purpose of the present study was to provide information about the bird fauna in different farmland habitats and to establish a baseline for the monitoring of changes in farmland bird populations in Latvia. Models describing the relationship between the occurrence of farmland bird species and various landscape and habitat features were developed, with the aim of making a prediction of effects of the changes in Latvian farmland possible. Analysis of actual trends and fluctuations of bird numbers as well as regional comparisons are beyond the scope of this paper. The latter subject is partly covered in Priednieks et al. (1999).

MATERIAL AND METHODS

The field studies were conducted in 1995–1999 in four areas (Fig. 1). All study areas are located in mixed farmland, and each has a size of 100 km^2. They are located in different regions of Latvia and were selected to be representative for the dominating farming practice in each region. Together they create a gradient of farming intensity which is representative for Latvian farmland as a whole.

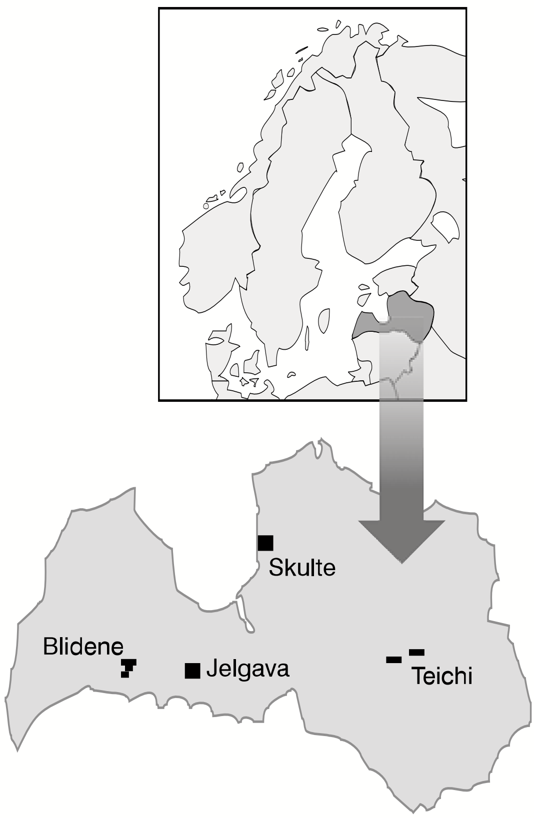


Fig. 1. The location of the four study areas in Latvia.

Landsat TM satellite images were used for obtaining general information about land cover within each study area. The Jelgava area is the most intensively farmed with less than 5% forest, and during the study years up to 68% of the farmland area was used for annual crops. In the Blidene and Teichi areas, forests make up about 25%, and up to 40% of the farmland area was used for annual crops. The least intensively farmed area is Skulte, where 30% is forest and a maximum of 30% of the farmland area was used for annual crops. During the study period, the percentage of farmland being cropped showed a tendency to increase in all study sites, most prominently in the Jelgava area. In terms of yields, the highest farming intensity was found in the Jelgava and Blidene areas (about 25 quintals of cereals per ha in 1999), while yields in the Teichi and Skulte areas were very low (about 10 quintals of cereals per ha in 1999). The mean yield for Latvia was 18.8 quintals per ha in 1999. This figure is typical for the Baltic region but considerably less than in Western European countries like Germany, Denmark, Netherlands, France and UK where cereal yields are above 60 quintals per ha.

In each of the four study areas, 60 bird count points were chosen randomly using a grid pattern layout with a minimum distance of 400m between points (see details in Priednieks et al. 1999). This procedure ensured that the census points constituted a representative sample of Latvian farmland and that the probability of recording an individual bird at more than one point was negligible. The points are not strictly independent, but we believe that no serious biases are introduced by treating them as such. After the 1995 season, the study had to be limited to 40 census points within each area; these points were selected at random from the total sample. Only the 160 points that were used in all five study years were included in the analyses.

At each census point, five-minute bird counts with unlimited distance were performed twice per season: around mid-May and mid-June, respectively. Migrating birds and other birds flying high above the site were excluded from further analysis. So were Swifts *Apus apus* and *Hirundidae* species as their occurrence is very dependent on meteorological conditions. All *Corvus* species were excluded as well, because they are mainly seen in foraging groups on fields, without any relation to their breeding habitat.

The total number of species recorded per point, with the above-mentioned exceptions, was used as a measure of species richness. For each point and species, the number of birds recorded was interpreted in pairs (e.g. two singing birds were considered as two pairs while one bird singing and one bird observed (if not an obvious male) were considered as one pair); the maximum of the two counts was used. The 30 most frequently recorded species were used for analysis of species-habitat affinities. Before analysis, all numbers except species richness and number of Skylarks *Alauda arvensis* were $\log_e(x+1)$ transformed in order to optimise the approximation to a normal distribution.

The area within a circle with radius 200m (area 12.56 ha) around each point was described by means of 26 habitat variables (Table 1).

Table 1. Habitat variables recorded and the transformations used prior to analysis. [1] Coded as 0.5% if present, but occupying less than 1% of area

Variable	Explanation	Transformation
WINTER	Winter cereals (% of area)	arcsin vx
SPRING	Spring cereals (% of area)	arcsin vx
ROOTS	Root (furrow) crops (% of area)	arcsin vx
FALLOW	1st year fallow (% of area)	arcsin vx
ABANDON	Abandoned fields (% of area)	arcsin vx
SOWNGR	Sown grass fields (% of area)	arcsin vx
CULTM	Cultivated meadows (% of area)	arcsin vx
DRYM	Dry meadows (% of area)	arcsin vx
WETM	Wet meadows (% of area)	arcsin vx
PONDVEG	Ponds or pools with water-fringe vegetation (% of area)[1]	arcsin vx
PONDCL	Ponds or pools without water-fringe vegetation (% of area)[1]	arcsin vx
WOOD	Forests (% of area)	arcsin vx
ORCHARD	Orchards (% of area)	arcsin vx
SHRUB	Scrub (% of area)[1]	arcsin vx
FARM	Farmsteads (% of area)[1]	arcsin vx
BUILD	Isolated farm buildings outside farmsteads (% of area)[1]	arcsin vx
RUDERAL	Waste (ruderal) areas (% of area)	arcsin vx
DITCH	Length (m) of ditches and regulated watercourses	not transformed
RIVER	Length (m) of natural rivers	ln (x+1)
ALLEY	Length (m) of tree lines	ln (x+1)
SHRUBLIN	Length (m) of shrub belts and hedges	not transformed
ROAD	Length (m) of roads	not transformed
ETL	Length (m) of electricity and telegraph lines	not transformed
FENCE	Length (m) of fences (including cattle enclosures)	ln (x+1)
TREE	Number of single trees	v (x+0.5)
HEAP	Number of stone or brushwood heaps (remains after amelioration works)	v (x+0.5)

For each year, a correlation matrix was made to check for possible strong correlations between habitat variables. Only 17 out of 1625 (2–5 out of 325 each year) correlations between the variables exceeded 0.30, and none of them exceeded 0.50. The following four pairs of variables were correlated with r exceeding 0.30 in two or more years (numbers of correlations and sign are given in parentheses): FARM and ETL (5+), WETM and RIVER (5+), FENCE and DRYM (2+), and SHRUBLIN and DITCH (2+). Thus, intercorrelation of habitat variables was not a serious problem. A model describing the relationship between bird species richness and the habitat features was derived for each year using stepwise multiple regression (Sokal & Rohlf 1995). SPSS 10.0 for Windows software was used with $p < 0.05$ as entry criterion. Species-habitat ordinations were performed for each year, using Canonical Correspondence Analysis (ter Braak 1986, 1994) with PC-ORD (Multivariate Analysis of Ecological Data) 4.0 for Windows software. To investigate species-habitat relationships in more detail, regression models for each species and year were constructed using the method described for species richness.

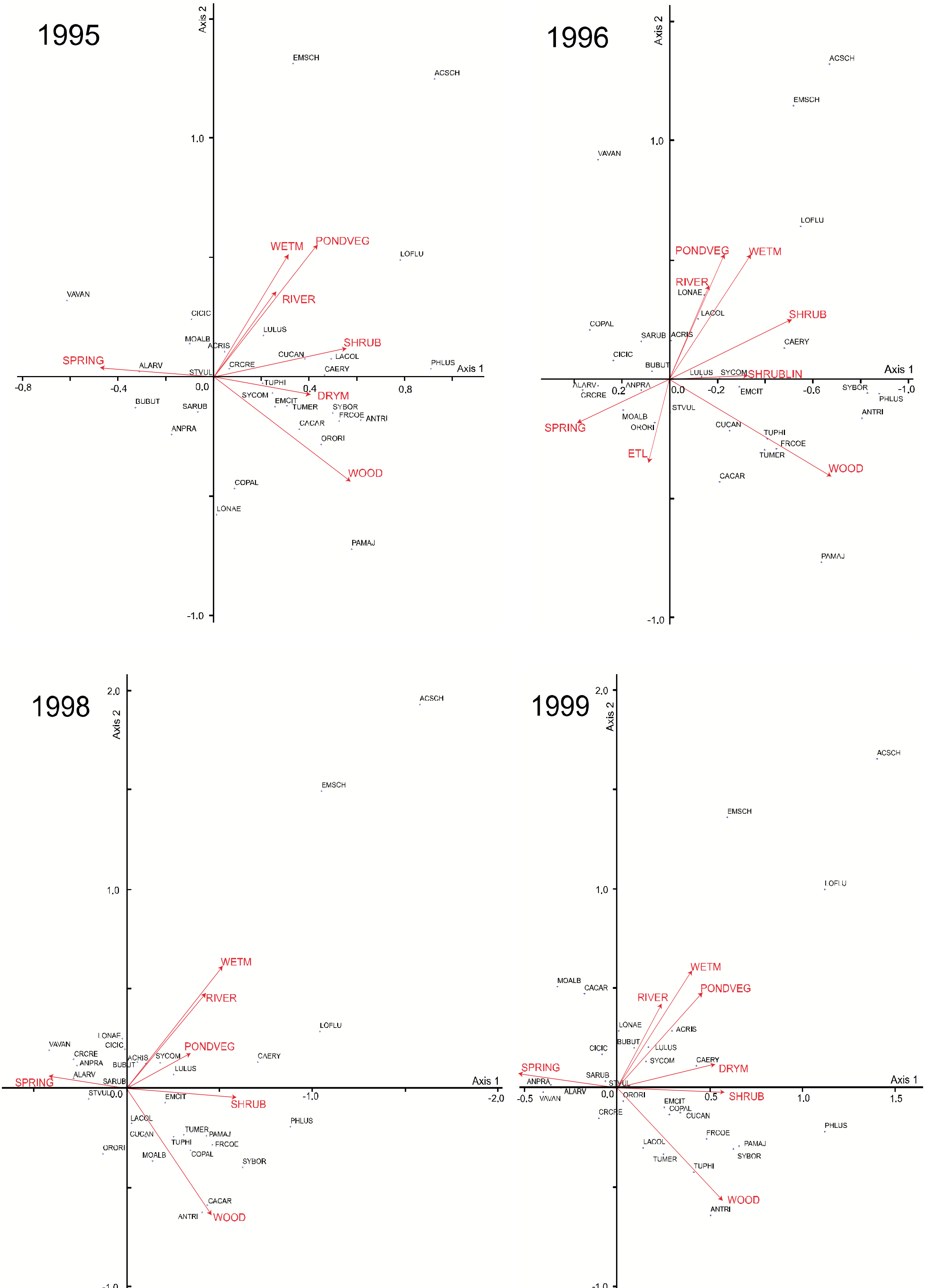
RESULTS

The average species richness (as defined above) was 12.5 (SD 4.27, range 2–25).

The models for species richness (Table 2) indicate that annual crops influence overall bird diver-

Table 2. Results of the stepwise regression analyses of species richness. For each year, the regression coefficients of predictor variables included in the final model are shown. P — years with the variable.

Variables	1995	1996	1997	1998	1999	Sign	P
WOOD	5.232	6.175	7.669	6.727	4.814	+	5
SHRUB	3.804	2.746		5.048	3.269	+	4
HEAP	3.160	2.431	3.254		2.554	+	4
DRYM	2.688	2.572	3.012		4.069	+	4
PONDVEG	3.242		3.677		2.978	+	3
SOWNGR		-2.378	2.458	2.361	2.437	+/-	3-1
FENCE			2.143	2.433		+	2
WETM	2.845		2.137			+	2
ALLEY	1.989	4.119				+	2
ROAD	2.508					+	1
RIVER			3.876			+	1
DITCH					2.107	+	1
WINTER	-1.985	-5.005				-	2
SPRING	-3.860	-3.111				-	2
ROOTS	-2.026		-2.633		-1.900	-	3
Adjusted R^2	0.520	0.475	0.504	0.345	0.412		


1995
Axis 2
Axis 1
1.0
0.0
-1.0
-0.8
-0.4
0.4
0.8
EMSCH
ACSCH
WETM
PONDVEG
LOFLU
VAVAN
RIVER
CICIC
LULUS
MOALB
ACRIS
SHRUB
CUCAN
LACOL
PHLUS
SPRING
ALARV
CRCRE
CAERY
STVUL
TUPHI
SYCOM
DRYM
EMCIT
BUBUT
TUMER
SYBOR
SARUB
FRCOE
ANTRI
CACAR
ANPRA
ORORI
WOOD
COPAL
LONAE
PAMAJ
1996
Axis 2
Axis 1
1.0
-1.0
0.2
0.0
-0.2
-0.6
-1.0
ACSCH
EMSCH
VAVAN
LOFLU
PONDVEG
WETM
RIVER
LONAE
LACOL
SHRUB
COPAL
SARUB
ACRIS
CAERY
CICIC
BUBUT
LULUS
SYCOM
SHRUBLIN
ALARV
CRCRE
ANPRA
EMCIT
SYBOR
PHLUS
ANTRI
STVUL
MOALB
ORORI
SPRING
CUCAN
TUPHI
FRCOE
TUMER
ETL
WOOD
CACAR
PAMAJ
1998
Axis 2
Axis 1
2.0
1.0
0.0
-1.0
-2.0
ACSCH
EMSCH
WETM
RIVER
LOFLU
LONAE
VAVAN
CICIC
CRCRE
ANPRA
ACRIS
SYCOM
PONDVEG
BUBUT
LULUS
CAERY
ALARV
SPRING
SARUB
STVUL
EMCIT
SHRUB
LACOL
PHLUS
CUCAN
TUMER
PAMAJ
TUPHI
FRCOE
ORORI
MOALB
COPAL
SYBOR
CACAR
ANTRI
WOOD
1999
Axis 2
Axis 1
2.0
1.0
-1.0
-0.5
0.0
0.5
1.0
1.5
ACSCH
EMSCH
LOFLU
WETM
MOALB
CACAR
PONDVEG
RIVER
LONAE
ACRIS
BUBUT
CICIC
LULUS
SYCOM
CAERY
DRYM
SPRING
SARUB
ANPRA
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ALARV
VAVAN
ORORI
EMCIT
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TUMER
TUPHI
WOOD
ANTRI

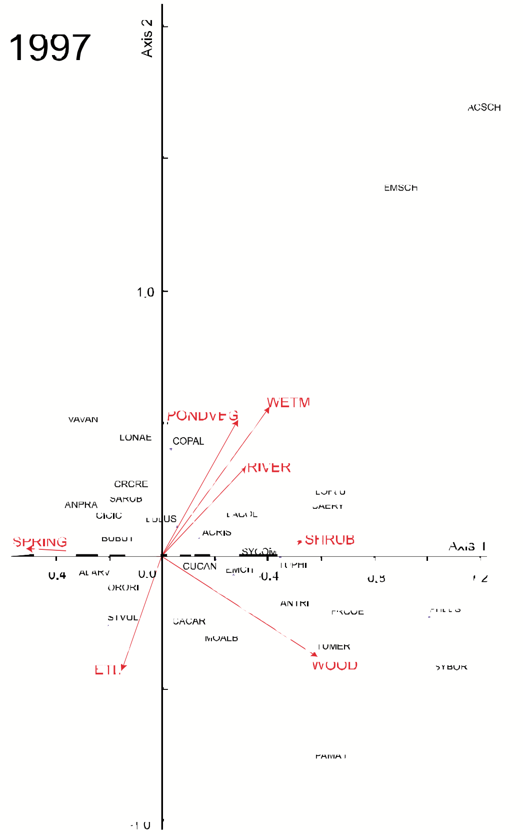

Fig. 2. Species-habitat relationships according to Canonical Correspondence Analysis. For each of the five study years, the first two canonical axes are shown. Only habitat variables with scores larger than 0.10 on one or both axes are plotted. To ease between-years comparisons, the first axis is shown reversed for 1996, 1997 and 1998 (negative values to the right).
Abbreviations of the bird variables: CICIC — *Ciconia ciconia*, BUBUT — *Buteo buteo*, CRCRE — *Crex crex*, VAVAN — *Vanellus vanellus*, COPAL — *Columba palumbus*, CUCAN — *Cuculus canorus*, ALARV — *Alauda arvensis*, MOALB — *Motacilla alba*, ANPRA — *Anthus pratensis*, ANTRI — *Anthus trivialis*, LACOL — *Lanius collurio*, SARUB — *Saxicola rubetra*, LULUS — *Luscinia luscinia*, TUMER — *Turdus merula*, TUPHI — *Turdus philomelos*, LONAE — *Locustella naevia*, LOFLU — *Locustella fluviatilis*, ACRIS — *Acrocephalus palustris*, ACSCH — *Acrocephalus schoenobaenus*, SYBOR — *Sylvia borin*, SYCOM — *Sylvia communis*, PHLUS — *Phylloscopus trochilus*, PAMAJ — *Parus major*, STVUL — *Sturnus vulgaris*, ORORI — *Oriolus oriolus*, FRCOE — *Fringilla coelebs*, CACAR — *Carduelis carduelis*, CAERY — *Carpodacus erythrinus*, EMCIT — *Emberiza citrinella*, EMSCH — *Emberiza schoeniclus*.

sity negatively while other types of landscape features increase it. All the final models were highly significant ($p < 0.001$). This general pattern was consistent between years though the importance of different habitat elements varied. The most persistent positive predictor of species richness was WOOD (significant all years), followed by SHRUB, HEAP and DRYM (significant 4 years).

In the species–habitat ordinations, the cumulative percentage of variance explained by the first two axes ranged from 11.8 (1995) to 15.7 (1999). A large part of the variation thus remains unexplained. The relationship between the habitat variables and the canonical axes was quite stable from year to year (Fig. 2). The eigenvalue of the first axis ranged from 0.118 (1996) to 0.139 (1997) and the percentage of variance explained from 8.3 (1995) to 10.6 (1999). This axis displays a gradient from arable land (especially spring cereals) to more natural habitats like woodland, scrubs and wetlands — i. e. a gradient of general farming intensity. The second axis (eigenvalues ranging from 0.051 (1995) to 0.071 (1997) and percentage of variance explained from 3.4 (1995) to 5.3 (1998)) may be interpreted as a gradient from woodland across arable land and other open, dry areas to wet meadowlands with rivers and ponds.

Although the exact correlations between the bird species vectors and the canonical axes varied between years, the overall pattern was fairly consistent. Several groups of species can be identified. The most clearly demarcated group is the wetland/pond species: Sedge Warbler *Acrocephalus schoenobaenus* and Reed Bunting *Emberiza schoeniclus*, in some years accompanied by River Warbler *Locustella fluviatilis*. Also a group of open area species consisting of, e.g., Skylark, Lapwing *Vanellus vanellus*, Corncrake *Crex crex*, Meadow Pipit *Anthus pratensis* and Whinchat *Saxicola rubetra* is quite well defined. Species that mostly feed on fields and sown grasslands but breed somewhere else, such as Buzzard *Buteo buteo*, Starling *Sturnus vulgaris* and White Stork *Ciconia ciconia* also fit into this group. The woodland and scrub species show a gradient from woodland species like Tree Pipit *Anthus trivialis* and thrushes *Turdus* to species associated with more open areas (e.g. Scarlet Rosefinch *Carpodacus erythrinus*), with most species fitting somewhere between the WOOD and SHRUB vectors.

The woodland/scrub species group is further divided when a third canonical axis is included (two examples are shown in Fig. 3). This axis (percentage of variance explained ranging from 2.7 (1995, 1996) to 4.2 (1997)) seems to represent a gradient from farms and habitats associated with them to more remote areas with woods, abandoned fields and stone and brushwood heaps. Among the arboreal species, Great Tit *Parus major* and Goldfinch *Carduelis carduelis* show an association with farmsteads and alleys, where they meet

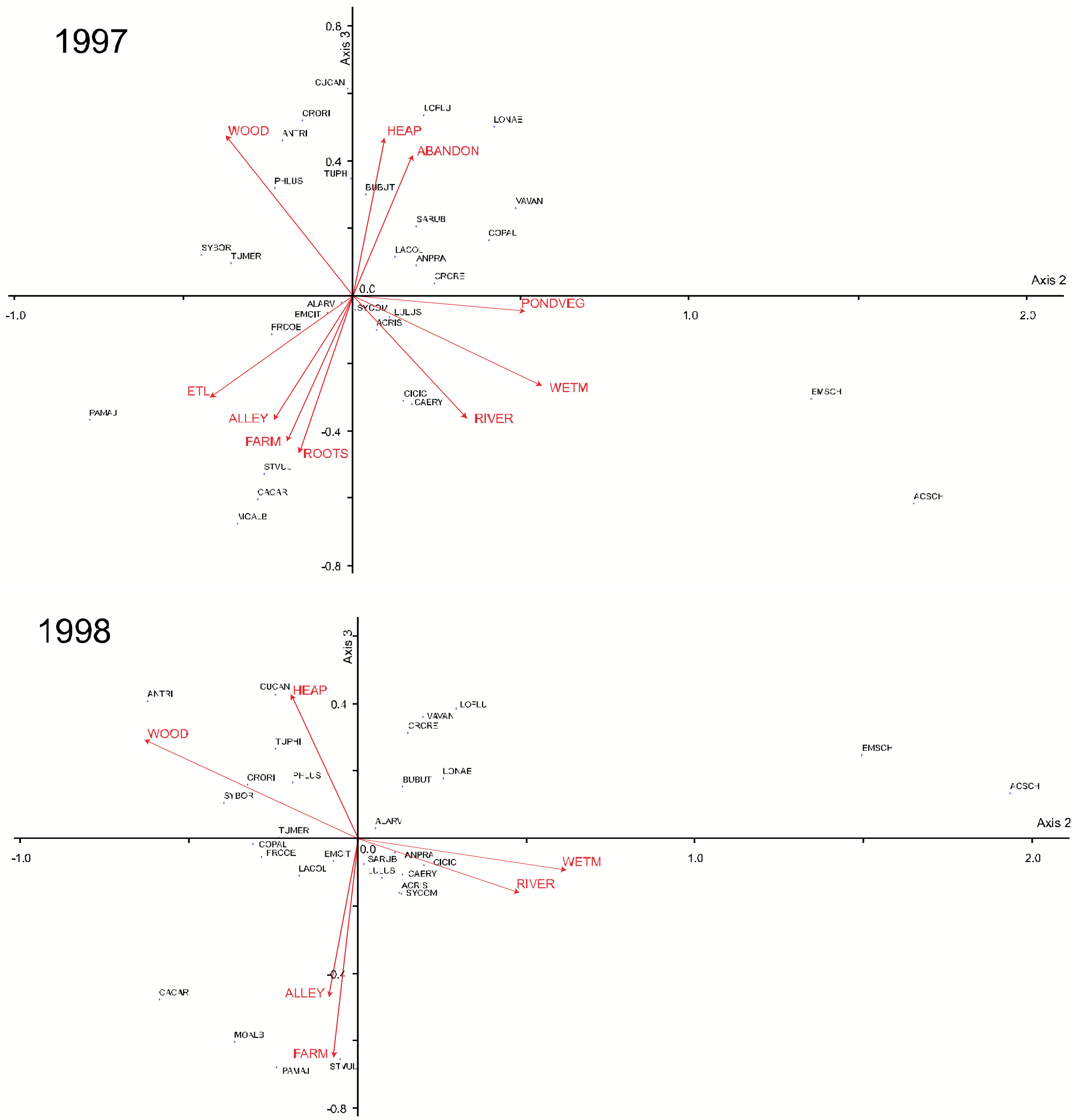

Fig. 3. Additional CCA biplots of species-habitat relationships, showing the second and third canonical axes. 1997 and 1998 are shown as examples. Only habitat variables with scores larger than 0.10 on at least one of these axes are plotted. Abbreviations of bird variables as in Fig. 2.

open land species such as White Wagtail *Motacilla alba* and Starling.

Regression analyses of species-habitat associations (Tables 3 and 4) indicate that there were more positive than negative correlations. All modelsw were statistically significant. Very few species (Skylark and Lapwing) benefit from the presence of arable fields. All other species dealt with here require the presence of one or more of the following habitat types: grassland, wetlands, shrubs or trees.

Persistency and predictive value of the models varied between species. Predictor variables included in 3 or more yearly models were considered as stable. The most stable models were those for species with small territories and specific habitat needs (e.g. Sedge Warbler and Reed Bunting) as well as those for woodland species and Skylark. The models of least predictive value were those for species with large territories, species feeding outside their breeding territories and species easily detectable beyond the 200m zone around the

Table 3. Percentage of variance explained by the yearly species-habitat models resulting from stepwise regression analysis. In brackets - the number of predictor variables in each model. Statistical significance of each model: * - p < 0.05, ** - p < 0.01, *** - p < 0.001.

	1995	1996	1997	1998	1999
Ciconia ciconia	7.8 (4)***	12.2 (3)***	10.9 (3)***	10.8 (4)***	6.5 (2)**
Buteo buteo	6.7 (2)**	2.5 (1)**	5.0 (1)**	2.5 (1)**	11.0 (3)***
Crex crex	2.7 (1)*	14.4 (4)***	4.2 (2)*	9.7 (4)***	2.6 (1)*
Vanellus vanellus	20.9 (4)***	17.3 (6)***	17.8 (4)***	11.7 (4)***	7.7 (2)**
Columba palumbus	9.4 (3)***	9.9 (3)***	6.5 (2)**	8.2 (2)***	16.3 (3)***
Cuculus canorus	19.3 (5)***	35.5 (7)***	12.8 (2)***	29.8 (6)***	30.5 (7)***
Alauda arvensis	33.4 (6)***	34.0 (5)***	42.7 (9)***	47.3 (10)***	47.6 (7)***
Motacilla alba	7.1 (3)**	16.0 (5)***	17.5 (4)***	10.6 (3)***	9.8 (2)***
Anthus pratensis	18.8 (6)***	14.0 (3)***	12.3 (3)***	10.6 (4)***	11.0 (3)***
Anthus trivialis	31.8 (5)***	27.5 (2)***	28.5 (3)***	30.4 (3)***	36.1 (4)***
Lanius collurio	3.3 (1)*	5.3 (2)**	3.7 (1)*	0	1.9 (1)*
Saxicola rubetra	21.2 (6)***	22.2 (7)***	21.8 (5)***	10.7 (3)***	18.8 (6)***
Luscinia luscinia	11.6 (2)***	7.3 (2)**	15.3 (5)***	14.5 (4)***	21.0 (5)***
Turdus merula	18.9 (4)***	21.0 (3)***	21.8 (3)***	14.9 (3)***	8.3 (2)***
T. philomelos	9.4 (3)***	7.0 (1)***	12.9 (2)***	12.7 (2)***	22.2 (5)***
Locustella naevia	4.5 (1)*	8.7 (2)***	21.5 (4)***	7.7 (2)**	16.2 (2)***
Locustella fluviatilis	14.3 (4)***	15.2 (2)***	17.6 (3)***	19.5 (3)***	26.9 (3)***
Acrocephalus palustris	7.5 (3)**	8.9 (3)**	1.8 (1)*	5.2 (1)**	26.8 (4)***
A. schoenobaenus	39.6 (3)***	32.0 (5)***	58.0 (3)***	46.8 (3)***	42.9 (3)***
Sylvia borin	11.2 (4)***	39.1 (7)***	29.0 (4)***	22.0 (3)***	32.0 (4)***
S. communis	11.5 (3)***	16.7 (5)***	16.8 (5)***	14.4 (2)***	12.4 (3)***
Phylloscopus trochilus	40.8 (4)***	30.5 (6)***	32.4 (5)***	18.9 (3)***	44.6 (6)***
Parus major	18.5 (3)***	36.9 (7)***	28.3 (6)***	11.1 (6)***	14.5 (3)***
Sturnus vulgaris	0	2.4 (1)*	14.0 (2)***	21.5 (2)***	13.4 (3)***
Oriolus oriolus	5.2. (2)**	11.6 (4)***	25.3 (5)***	25.2 (4)***	24.2 (5)***
Fringilla coelebs	37.3 (8)***	31.7 (4)***	40.0 (5)***	39.6 (6)***	43.3 (5)***
Carduelis carduelis	5.0 (2)**	10.3 (2)***	13.2 (3)***	11.8 (4)***	11.6 (3)***
Carpodacus erythrinus	21.1 (5)***	17.4 (4)***	15.8 (3)***	20.8 (3)***	21.5 (5)***
Emberiza citrinella	31.3 (7)***	9.2 (2)***	11.2 (4)***	11.2 (4)***	18.0 (5)***
E. schoeniclus	23.9 (4)***	23.3 (2)***	37.1 (6)***	30.2 (7)***	23.1 (3)***

census point (e.g. Buzzard, Corncrake, Woodpigeon *Columba palumbus*, Starling and Golden Oriole *Oriolus oriolus*). The models for species with prominent fluctuations in numbers between the study years (e.g. Marsh Warbler *Acrocephalus palustris* and Red-backed Shrike *Lanius collurio)* were also unstable.

DISCUSSION

The spatial distribution of birds and the structure of their communities may be affected by various factors, and although habitat structural factors are usually thought to be the most important, they leave a large part of the variation unexplained (e.g. Fuller et al. 1997, Petersen 1998, Schifferli et al. 1999). The numbers and distribution of birds are also affected by yearly fluctuations in food abundance, demographic parameters, mortality in different stages of the annual cycle, weather conditions etc. (Wiens 1989, Fuller 1994). These variables were not included in the present study, and together with variation in census conditions (observer differences, variation in date and time of day, meteorological conditions) they are surely responsible for a major part of the unexplained variation.

The species richness per point, as reported here, cannot be compared directly with other studies, due to the limitations in the range of species and individuals included. The general pattern of species-habitat associations is roughly similar to the results of a comparable study in Denmark (Petersen 1998), despite the differences in the structure of the landscape. In both studies, the main gradient of species diversity follows a gradient from uniform to structurally diverse landscapes, although more species were associated with the landscape belonging to the uniform part of the first canonical axis in Latvia (Fig. 2) than in Denmark. Among these are species of global or European conservation concern like Corncrake and White Stork which are rare in Western Europe but still common in the Baltic countries. The decline of these open-land species has been associated with the intensification of agriculture during the last decades in Western

Table 4. Summary of the yearly regression models of species-habitat associations. + — positive associations, - — negative, numbers — years (if > 1).

	WINTER	SPRING	ROOTS	FALLOW	ABANDON	SOWNGR	CULTM	DRYM	WETM	PONDVEG	PONDCL	WOOD	ORCHARD	SHRUB	FARM	BUILD	RUDERAL	DITCH	RIVER	ALLEY	SRUBLIN	ROAD	ETL	FENCE	TREE	HEAP	Stable predictors
Ciconia ciconia	4-				-	+	2+					4-	-		-		-			+							2
Buteo buteo			-		+		+			+					2-		+							-			0
Crex crex	2-	-			+	2+					2+	2-														2+	0
Vanellus vanellus		5+	+					-	+	+				-	2-	-		3+				-		-		2+	2
Columba palumbus		+	-		+	+		+			+	+			-			+		+						3+	1
Cuculus canorus	2-	2-	2-	+	+		-			+		4+								+	-	3+		4+		4+	4
Alauda arvensis	+	4+		+		+	2-	-	4-			5-		5-	2-	-		+		-	2-		+	3+		3+	6
Motacilla alba			+							-				+	3+	4+	2+		+		-		+	-		+	2
Anthus pratensis	-				2+	2+	+			-	+	2-		3-	-			+					+	2+		-	1
Anthus trivialis			2-					2+	-		+	5+		2+									-	+		2+	1
Lanius collurio	+							+							+								-		+		0
Saxicola rubetra	2-	2-	-		3+	+	-	+		-		2-	-	-	2-	2+		+	-	+	-		+	+		+	1
Luscinia luscinia	-						-	3+		2+	+			+	+				2+	+				2+	-	2+	1
Turdus merula						+	+		+			5+		+					2+	+				+-	+		1
T. philomelos						-						4+		+	-					-				+	+	3+	2
Locustella naevia					5+						+							3+			-					+	2
Locustella fluviatilis								+-	4+	+	+			3+							+				2+	+	2
Acrocephalus palustris	-			+				+		+				+		+		4+	+							+	1
A. schoenobaenus									5+	5+	+							+	4+	+							3
Sylvia borin				-	-		2+			-		4+	+	4+	+			+	+		+				+	2+	2
S. communis		2-	-	-	+			+				+-		4+		+		+	+			+	+			+	1
Phylloscopus trochilus					2+			2+		4+	2+	5+		4+							3+	+	+				4
Parus major			2+		2+		+					5+			2+		2+			4+	3+			2+			3
Sturnus vulgaris												+			2+		+		-	2+			+				0
Oriolus oriolus		+		+	2+	2+	-	+	-			2+		+						+				3+		4+	2
Fringilla coelebs		3-	-	+	-		-				-	5+		4+	4+		+	2-	+	+		+					4
Carduelis carduelis		2-							-			-				+	2+			5+				2+			1
Carpodacus erythrinus						+	+	3+	2+			2+		3+	-				2+		+	+		+-	+		2
Emberiza citrinella		-		+			2+	3+				2+		4+				+			3+	2+		+-		+	3
E. schoeniclus					-				5+	5+	2-	2-			-				+		2+		-		+	-	2
Total no. of -	13	13	9	2	4	1	7	3	7	4	3	19	2	10	14	2	1	2	2	2	6	1	3	6	1	2	
Total no. of +	2	11	4	6	21	12	11	20	18	21	11	46	1	34	14	9	9	18	16	19	14	9	7	24	8	34	

Europe (Tucker & Heath 1994). In Latvia, these species benefit from a less intensive agriculture with little use of chemicals, small field sizes ensuring a diverse landscape, extensively managed grasslands and an increased amount of abandoned fields. The habitat model for Corncrake (Table 4), although not highly significant, supports the findings of the Corncrake survey in Latvia in 1996 (Keišs 1997). In the Corncrake survey, abandoned fields appeared to hold the highest densities followed by various grasslands (chiefly sown grass), while the species avoided arable fields. Abandoned fields and grasslands contained almost 30% and more than 50% of the Latvian population, respectively.

The habitat models of most bird species in Latvian farmland are rather similar to those reported from comparable studies in other European countries (Fuller et al. 1997, Petersen 1998, Schifferli et al. 1999), although several differences exist, both in the models themselves and in the overall importance of specific habitat types. The most contradictory results, compared to results of recent studies in Britain (Fuller et al. 1997, Kyrkos et al. 1998, Gregory 1999) and Denmark (Petersen et al. 1995), were found in the Yellowhammer *Emberiza citrinella*. In Latvia, the Yellowhammer prefers meadows (CULTM and DRYM, Table 4) among the agricultural habitats, whereas it shows a strong preference for arable lands in Britain and Denmark. The habitat model for the species in Swiss farmland falls in between these two extremes, with both grasslands and arable lands being positive predictors (Schifferli et al. 1999). Probably the distribution of Yellowhammers in Latvian farmland is mainly governed by the availability of suitable breeding habitat, i.e. scrub (SHRUB and SHRUBLIN) and woodland edges, because hedges along field margins are less widespread than in Britain and Denmark. The association with meadows may reflect the current overgrowing of meadows with bushes.

Farmsteads and other buildings have a less prominent impact on species composition in this study than in the Danish study, where building/garden area was the main predictor of densities of 13 species (Petersen 1998). In large parts of Western European farmland, human dwellings with their surrounding vegetation are important habitat islands in a rather uniform agricultural landscape, whereas their importance is much smaller in Latvia, where the population density is lower and agricultural land occurs in a mosaic structure with forest and scrub.

As might be expected, woodland area appears as a significant predictor in more models than any other variable, showing the highest number of positive as well as negative associations. A large group of species with almost no relation to agricultural land is associated with forests, while most of the typical agricultural bird species are indifferent or avoid areas close to forest. Although woodlands thus reduce rather than increase the densities of typical farmland bird species, small woodland patches within agricultural land raise the biodiversity value of the area on a larger scale.

The variable showing the second highest number of positive correlations, scrub (SHRUB and SHRUBLIN), attracts more species that are connected with an agricultural landscape (e.g. Whitethroat *Sylvia communis* and Yellowhammer). This habitat type is very common as patches or linear structures along roads and ditches and is also a common feature of traditional farmsteads. Patches of scrub are often the result of an overgrowing of open areas - i.e. the habitats of the typical species of agricultural lands - due to abandonment. A further succession on these areas will eventually lead to woodland which would be undesirable from a biodiversity point of view, as 45% of Latvia is already covered with forest. However, a suitable amount of scrub, e.g. along ditches and roadsides, has a positive effect on farmland biodiversity.

Stone and brushwood heaps (HEAP) have an unexpectedly high, positive effect on the occurrence of many species. The same is true for wet depressions (especially PONDVEG), indicating the value of such habitat islands in agricultural areas. Within the otherwise uniform arable land, they provide suitable unfarmed patches which can be used as nesting sites, protecting the nests against losses due to mechanised farming and thus ensuring a higher nesting success for various farmland species.

The most important agricultural habitats, natural meadows (DRYM and WETM), are suffering a continuous decline in Latvian farmland, partly because they are turned into arable land, partly due to overgrowing with bushes after traditional use of the areas has ceased. Several scrub species (Thrush Nightingale *Luscinia luscinia*, Scarlet Rosefinch, Yellowhammer etc.) appear associated with dry meadows, indicating the current stage of the overgrowing of these areas. The natural meadows within the study areas are too scattered and do not have enough uninterrupted open areas to hold the typical meadow species with larger territories (e.g. Lapwing, Redshank *Tringa totanus* and Common Snipe *Gallinago gallinago*); even the habitat model for Corncrake does not include these habitats. A further reduction of the area with wet meadows will also severely affect the presence of species with small territories such as Sedge Warbler and Reed Bunting which are associated with this habitat and do not have any associations with scrublands. A reintroduction of extensive farming on these areas would be desirable. Unfortunately, current state policy is orientated towards afforestation of abandoned land.

Like the meadows, abandoned fields are an important landscape element, with a number of species (e.g. Whinchat *Saxicola rubetra* and Grasshopper Warbler *Locustella naevia*) being associated with them. However, as a temporary habitat they can rapidly lose their value due to overgrowing or ploughing. From a biodiversity point of view, the most advisable management of this habitat would be an introduction of extensive mowing and/or grazing, allowing these areas to maintain their actual high densities of the globally threatened Corncrake (cf. Keišs 1997).

CONCLUSIONS

Latvian farmland currently supports a high diversity of birds and high populations of farmland species nowadays rare in Western Europe. This situation is mainly upheld by a non-intensive agriculture and large set-aside areas. Both are subjects to change with the foreseeable increase of the area being cropped and a development towards intensive agricultural production. Therefore, it is of vital importance that environmental considerations become an integrated part of the development of Latvian agriculture.

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STRESZCZENIE

[Zależność występowania ptaków od środowisk terenów rolniczych Łotwy]

Tereny rolnicze zajmują ok. 40% terytorium Łotwy. Charakteryzują się one dużą różnorodnością gatunkową i dużą liczebnością ptaków polnołąkowych, które są już rzadkie w Europie Zachodniej. Celem badań było określenie składników środowiska, które sprzyjają bogactwu awifauny. Badania prowadzono w latach 1995–1999. Wybrano 4 tereny badań, różniące się intensywnością i charakterem użytkowania rolniczego (Fig. 1). Na każdym z nich wybrano losowo 40 punktów i przeprowadzano 5-minutowe liczenie, dwukrotnie w sezonie lęgowym. Co roku teren w promieniu 200m wokół punktu został opisany przy użyciu 26 zmiennych środowiskowych (Tab. 1). Najbardziej skorelowane z bogactwem gatunkowym były: obfitość zadrzewień, krzewów, suchych łąk oraz kęp zarośli i stosów kamieni (Tab. 2). Określono gradient zmian środowiska, związany ze składem gatunkowym ptaków — od pól uprawnych do terenów naturalnych i od lasów poprzez tereny suche i otwarte, do wilgotnych łąk z rzekami i stawami (Fig. 2), jak również od terenów rolniczych do terenów bardziej naturalnych (Fig. 3). Analizy zależności występowania ptaków od czynników środowiska przeprowadzono dla najczęstszych 30 gatunków (Tab. 3 i 4).

Obecna wysoka różnorodność ptaków w środowiskach rolniczych Łotwy jest głównie utrzymywana przez ekstensywne rolnictwo i dużą ilość ugorów. Intensyfikacja rolnictwa, podobna do zachodnio-europejskiej, może negatywnie wpływać na populacje wielu gatunków ptaków. Dlatego rozwój rolnictwa powinien uwzględniać jej wpływ na środowisko przyrodnicze.