Ornis Hungarica 12-13: 41-50. 2003

Bird population changes in Latvian farmland, 1995-2000: responses to different scenarios of rural development

A. Aunins and J. Priednieks

Aunins, A. and Priednieks, J. 2003. Bird population changes in Latvian farmland, 1995-2000: responses to different scenarios of rural development. – Ornis Hung. 12-13: 41-50.

After the collapse of the collective farm-based agricultural production system in Latvia during the early 90s, the agricultural sector reached its lowest point in the mid-90s. After 1995, some regions were showing various signs of agricultural recovery while others were experiencing further abandonment. A point count-based system for monitoring bird populations in an agricultural landscape was established in 4 geographically, structurally and economically different regions of Latvia in 1995, as was a scheme for mapping land use changes. Each of the 4 study areas has followed a different scenario of rural development during the study period. Our study analyses the changes of the species' populations and land use during the last 6 years revealing patterns common to all areas as well as prominent differences between them. Populations of several bird species changed considerably during the study period, as did the composition and area of most habitats. There was a general tendency for arable lands to increase whereas grasslands (especially meadows) and cattle enclosures decreased. The increase in abandoned land area peaked in 1997 but stabilised or started to decrease afterwards. However, the initial habitat distribution and the degree of the above changes varied between the areas, thus differently affecting bird populations within the study plots. The diverse patterns and sources of development and of bush clearance made these differences even more prominent.

A. Aunins, Latvian Fund for Nature, Kronvalda bulv. 4, Riga, LV-1010, Latvia. E-mail: dubults@lanet.lv. J. Priednieks, Dept. of Zoology and Animal Ecology, University of Latvia, Kronvalda bulv. 4, Riga, LV-1586, Latvia. E-mail: jpriedn@lanet.lv

1. Introduction

Populations of many farmland birds have declined dramatically in Western Europe (Flade & Steiof 1990, Saris *et al.* 1994, Fuller *et al.* 1995). Numerous papers have analysed these processes and have found that most of the factors are related to intensification of agriculture (*e.g.* Chamberlain *et al.* 2000, Donald *et al.* 2001). It has been acknowledged that cereal yields alone explained over 30% of variation in bird population trends (Donald *et al.* 2001) and thus can be used as a measure of agricultural intensity in arable lands.

The processes in the agricultural sector developed differently in Eastern Europe. The intensity of Latvian agriculture has never been as great as in many EU countries, where cereal yields exceeded 60 quintals per hectare (q/ha) (FAOSTAT Database). After the collapse of the moderately intensive collective farm-based system in the beginning of the 1990s, agricultural production in Latvia reached its lowest point in 1995 (Anon 1996a).

Cereal yields decreased from 23.3 to 16.6 q/ha, cattle numbers decreased by 70% and usage of mineral fertilisers and pesticides decreased by almost 90% at that time (Anon 1996a, 1999a). A more detailed overview of agriculture in Latvia is given in Aunins *et al.* (2001).

Unfortunately monitoring data on bird populations in agricultural lands are scarce for the period 1990-1995 (Priednieks, unpublished data) when these dramatic changes occurred. Thus the recovery and rapid increase of many bird species like Grey Partridge *Perdix perdix*, Kestrel *Falco tinnunculus* and others associated with farmland remain undocumented.

The principal purpose of the present study was to analyse changes of bird populations in Latvian farmland and the possible factors causing these changes. The species-habitats relationships and the importance of different habitats or landscape features have been reported earlier (Priednieks *et al.* 1999, Aunins *et al.* 2001).

2. Study Area and Methods

Field studies

The field studies were conducted in 1995-2000 in four areas (Fig. 1). All study areas are located in mixed farmland, each having a size of 100 km^2. They are located in different regions of Latvia, have different landscape structure and were selected to be representative of the dominant farming practice in each region. Together they create a gradient of farming intensity that is representative of Latvian farmland as a whole. The two westernmost study areas are located in regions of intensive farming but each has different landscape structure. Jelgava has very low percentage of forests and shrubland, most of its territory being used for agriculture. Blidene has a very mosaic landscape structure that is comprised of a large percentage of forests and shrubland, the presence of wetlands being characteristic. The other two areas are in areas of low intensity agriculture. The northern area (Skulte) has large percentage of woodlands and shrubland. Most former arable land is abandoned. The eastern area (Teichi) has lower percentage of forests and shrubland, and has still maintained a large percentage of natural (including floodplain) meadows. A more detailed comparison of the study areas has been given in Priednieks *et al.* (1999).

Fig. 1. Location of the study areas.

In each of the four study areas, bird count points were chosen randomly using a grid pattern layout as described in Priednieks *et al.* (1999) & Aunins *et al.* (2001). Only the 160 points (40 in each area) that were counted all six study years were included in the analyses.

At each census point, five-minute bird

Tab. 1. Relative occurrence of habitats and landscape features within the described 200 m zones around bird count points of the study areas (mean measurements over the six years taken).

	Blidene	Jelgava	Skulte	Teichi
Habitats measured and displayed as % of area				
Winter cereals	15.4	21.6	3.6	9.0
Summer cereals	5.5	23.7	13.0	17.2
Root crops	3.5	9.6	4.3	3.2
1st year fallow	2.5	3.8	2.6	3.8
Abandoned lands	19.9	7.6	21.4	13.4
Sown grasslands	10.3	15.9	22.8	22.6
Improved meadows and pastures	12.6	3.8	9.3	1.9
Dry and moderately moist natural meadows	11.6	1.1	2.8	11.7
Wet natural meadows	3.2	3.1	1.8	1.1
Ponds and pools with emergent vegetation.	2.4	0.1	0.2	1.1
Ponds and pools w/o emergent vegetation	0.2	0.1	0.0	0.5
Forests	4.6	2.9	9.8	6.7
Orchards	0.7	1.0	0.3	0.0
Shrubs	6.3	0.1	2.8	1.8
Farmsteads	1.1	2.9	4.3	3.4
Isolated farm buildings	0.0	1.7	0.4	1.0
Ruderal areas	0.1	0.9	0.8	1.4
Habitats measured as length (m), displayed as density (m/ha)				
Clean ditches	7.8	11.5	6.7	17.7
Ditches with bushes	8.5	14.8	10.5	8.7
Natural rivers	1.1	3.2	1.5	0.3
Alleys	0.5	2.3	5.1	0.3
Linear shrub belts	3.5	0.9	6.6	4.7
Roads	25.9	28.3	28.6	32.6
Electric and telephone lines	12.3	23.9	41.1	33.7
Enclosures and fences	0.0	1.4	1.7	19.2
Features counted as absolute numbers, displayed as number per 100 ha				
Small ponds and pools with emergent vegtn	0.8	0.3	0.2	2.9
Small ponds and pools w/o emergent vegtn	0.4	0.2	0.3	0.7
Separate trees	25.2	6.7	9.8	18.1
Separate bushes	17.6	16.3	15.0	34.1
Stone and brushwood heaps	1.3	0.2	1.3	8.3

counts (no limitation was placed on the horizontal distance at which birds were reported) were performed twice per season, at around mid-May and mid-June, respectively. Migrants and other birds flying high above the site were excluded from further analysis.

The total number of species recorded per point 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, whereas one bird singing and one bird observed (if not an obvious male) were considered as one pair). The higher of the two counts obtained was used.

The area within a circle of radius 200 m (area 12.56 ha) around each point was described by means of 30 habitat variables. The variables, their units of measurement, and their relative abundance within the described zones are shown in Tab. 1. Because the count points were distributed only in agricultural land, the proportions of habitats within the described 200 m zones differ from general landscape characteristics given above.

Tab. 2. Changes in land use and occurrence of landscape features in the four study areas (1995-2000).

	Blidene	Jelgava	Skulte	Teichi
Habitats measured as % of area				
Winter cereals	++	+++	+++	+++
Summer cereals	---(F)	+	0(F)	--
Root crops	0	++	++(F)	--
1st year fallow	F	F	F	F
Abandoned lands	+(F)	+++(F)	++(F)	+++
Sown grasslands	+(F)	---	-	++
Improved meadows and pastures	---	---	---	++
Dry and moderately moist natural meadows	0	--	--	---
Wet natural meadows	-	0	++	-
Ponds and pools with emergent vegetation	-	0	0	-
Ponds and pools without emergent vegetation	++	0	0	++
Forest	0	0	0	-
Shrubberies	--	0	+	++
Linear habitats				
Clean ditches	0	---	---	-
Ditches with bushes	-	+++	++	++
Natural rivers	---	0	0	0
Linear shrub belts	-	0	0	--
Alleys	0	---	0	+++
Roads	0	0	0	0
Enclosures and fences	0	---	-	-
Electric and telephone lines	+	-	0	--
Point objects				
Separate trees	--	0	+	0
Separate bushes	---	+	0	+
Stone and brushwood heaps	+++	0	-	-
Habitat groups				
Active arable	++	++	+++	-
Active arable incl. sown grass	++	0	++	0
Meadows	--	---	---	--
Meadows and abandoned	-	-	--	0

0 = change does not exceed 5%
+ or - = change between 5 and 20%
++ or -- = change between 20 and 50%
+++ or --- = change exceed 50%
F = fluctuating

We used the periodicals of the Central Statistical Bureau of Latvia (Anon 1996b, 1997, 1998, 1999b, 2000) as an information source on annual yields in the relevant districts (1995-1999), but these figures should be treated with care because they are not representative of all types of farming, being biased towards state farms and statutory companies. Nevertheless, they represent the regional differences quite well.

Statistics

TRIM version 3 software (Pannekoek & van Strien 2001) was used for analysis of bird count data. The following models were tested for each species (with 1995 as the reference year): no time effect (N), linear trend without covariates (L), linear trend including the study area as covariate (LC), linear trend without covariates and with stepwise selection of changepoints

(LT), and linear trend including the study area as covariate and stepwise selection of changepoints (LTC). Level $P \leq 0.05$ was used as significance criterion in Wald tests to enter or remove the changepoints in the stepwise procedures. Models that included the study area as a covariate were rejected if the value of the Wald test for significance of covariate exceeded $P=0.20$. The remaining models were compared and the model that gave the best fit according to Likelihood Ratio was chosen. In the few cases when several models gave maximum fit according to this test ($P=1.000$), the model with the smallest Akaike's Information Criterion was chosen. The modelled indices were used for estimating population status.

An attempt to use the TRIM software for analysing habitat changes was made, but almost all models were rejected, significance being $P<0.001$.

3. Results

Changes in habitats and farming intensity

All the study areas experienced significant changes in land use and the abundance of several landscape features during the six study years (Tab. 2). A steep decrease in meadows was common to all areas, being caused both by abandonment and conversion to arable land. However, there were different patterns of change in the 3 categories of meadows. Blidene did not experience significant decreases of dry and moderately moist natural meadows. Although conversion to arable land persisted, it was balanced by the introduction of mowing, grazing in previously abandoned lands, or both. The main meadow losses in this area were experienced in the category of improved meadows and pastures. Conversion of meadows to arable land was most severe in Jelgava & Skulte, but was less so in Teichi where the decrease in dry and moderately moist natural meadows was caused mainly by their natural improvement and encroachment by bushes after abandonment. An increase of abandoned land was common to all areas to various extents. However, note that the main increase occurred between 1995 and 1997, after which period the rate of abandonment stabilized or started to decrease, except in Teichi where it increased.

An increase in winter cereals was observed in all areas. Only Jelgava experienced increases of other crop types that fluctuated or decreased in the other areas. However, the area of active arable lands increased in all three western study areas.

An important source of differences between the study areas was reflected by changes in distribution of various shrub-dominated habitats (shrubland, ditches with bushes, linear shrub belts and isolated bushes). All these habitats decreased in Blidene and either remained stable or increased in Jelgava or Skulte. The main source of increase was ditches becoming overgrown. In Teichi bush encroachment took place in meadows, abandoned lands and ditches. At the same time, roadside shrub belts decreased. Jelgava experienced cutting down of roadside tree lines (alleys) whereas in Teichi new alleys appeared after removing the roadside bushes and not removing the trees. All study areas experienced reductions in cattle enclosures and other fences as a result of the continuous decrease in livestock keeping.

Tab. 3. Mean number of bird species registered per point and total number of species registered in the study areas.

Study area	1995	1996	1997	1998	1999	2000	Mean
Mean number of bird species registered per point							
Blidene	15.20	13.45	13.78	13.68	14.55	15.55	14.37
Jelgava	11.25	12.60	11.58	12.28	11.35	11.45	11.75
Skulte	14.78	16.25	14.78	16.70	14.25	15.93	15.45
Teichi	14.41	16.61	17.71	17.29	20.46	21.15	17.94
Total	13.91	14.74	14.48	15.00	15.19	16.05	14.90
Mean number of bird species registered per study area							Total
Blidene	77	65	69	67	70	71	104
Jelgava	63	62	65	59	57	57	85
Skulte	68	60	62	62	61	65	97
Teichi	73	76	69	72	70	72	101
Total	105	96	95	96	94	102	134

The intensity of farming (measured by yields) varied between the study areas as well as changing during the study period. The highest winter cereal yields were found in Blidene & Jelgava (31.5 and 30.5 q/ha on average), the values reflecting increasing yields (by 1.6 and 2.8 q/ha respectively). Winter cereal yields in Skulte & Teichi were much lower (19.3 and 15.7 q/ha respectively), the yield in Teichi decreasing significantly by 5.1 q/ha). A rapid growth of yields in Skulte was recorded between 1995 and 1997, followed by a decline, after which the 1999 yields approximated the 1995 levels (an increase of 0.2 q/ha). Summer cereal yields fluctuated synchronously in all study areas without any pronounced tendency, but they were higher in Blidene & Jelgava (23.0 and 23.3 q/ha on average) compared to Skulte & Teichi (13.9 and 12.1 q/ha). Yields of grass production also were higher in Blidene & Jelgava (45.0 and 39.8 q/ha) than in Skulte & Teichi (32.6 and 30.6 q/ha). Although the year-by-year numbers fluctuated, there was a tendency for the grass production yields to grow in Blidene & Skulte and to decline in Jelgava & Teichi.

Changes in bird populations

The mean number of species registered per point was stable in all study areas except Teichi (Tab. 3) where it increased from 14.4 in 1995 to 21.2 in 2000. At the same time the total number of species registered per study area did not increase in any of the study areas (but slightly decreased in Jelgava).

The analysis of the bird population changes is summarized in Tab. 4. Some species (*e.g.* Quail *Coturnix coturnix*, White Wagtail *Motacilla alba*, Sedge Warbler *Acrocephalus schoenobaenus*, Thrush Nightingale *Luscinia luscinia*) show a common change pattern in all study areas suggesting that populations of these species currently are more affected by large-scale factors than by area-specific factors. However, population change patterns for most of the species differ between the study areas suggesting that area-specific factors play important roles there.

In general, increases of shrub and forest generalist species are obvious and differences between the study areas are not as pronounced as for other groups. These

Tab. 4. Trends of bird populations in study areas (1995-2000).

Species	Registr ations	Blidene	Jelgava	Skulte	Teichi	Total	Best model
Open agricultural land (arable, grasslands, abandoned lands)							
White Stork *Ciconia ciconia*	494	--	--	++	+++	+	LC***
Quail *Coturnix coturnix*[1]	36	+++	+++	+++	+++	+++(F)	LT(1)***
Corncrake *Crex crex*	310	--	+	++(F)	+++	++(F)	LCT(4)[ns]
Lapwing *Vanellus vanellus*	505	F	F	+++	F	+?	N/A
Skylark *Alauda arvensis*	5245	--	+	++	++	+	LC***
Meadow Pipit *Anthus pratensis*	681	++	-	--	--	--	LC**
Whinchat *Saxicola rubetra*	877	++	+	++	0	+	LCT(1)*
Shrubby edge of agricultural land							
Grasshopper Warbler *Locustella naevia*	149	F	F	F	F	+++(F)	LT(2)**
Red-backed Shrike *Lanius collurio*	124	+	+	+(F)	+	+(F)	LT(3)***
Scarlet Rosefinch *Carpodacus erythrinus*	485	--	--	--	+++	-	LCT(1)*
Yellowhammer *Emberiza citrinella*	983	-	--	---	+++	-	LCT(2)***
Species feeding on agricultural lands							
Buzzard *Buteo buteo*	239	-	---	---	+++(F)	0(F)	LCT(2)**
Woodpigeon *Columba palumbus*	259	0	0(F)	0(F)	+++	++	LCT(1)[ns]
Fieldfare *Turdus pilaris*	155	0	0	0	0	0	LT(2)[ns]
Farmsteads							
White Wagtail *Motacilla alba*	222	---	---	---	---	---	LT(2)***
Icterine Warbler *Hippolais icterina*	115	+++(F)	--(F)	---(F)	+++(F)	+(F)	LCT(1)***
Starling *Sturnus vulgaris*	777	--	++(F)	+++(F)	--(F)	+	N/A
Goldfinch *Carduelis carduelis*	143	0	0	0	0	0	N*
Linnet *Accanthis cannabina*	112	+++	--	---	---	--	LC*
Wetlands							
Marsh Harrier *Circus aeruginosus*	66	0	0	0	0	0	N**
River Warbler *Locustella fluviatilis*	143	0	0	0	0	0	N**
Sedge Warbler *Acrocephalus schoeniclus*	168	--	--	--	--	--	L*
Reed Bunting *Emberiza schoeniclus*	146	0	0	0	0	0	N**
Shrubberies							
Thrush Nightingale *Luscinia luscinia*	979	+++	+++	+++	+++	+++	LT(2)**
Marsh Warbler *Acrocephalus palustris*	747	+++	--(F)	+++(F)	+++(F)	++(F)	LCT(5)***
Whitethroat *Sylvia communis*	1162	+++	++	++	+++	+++	LC***
Garden Warbler *Sylvia borin*	367	+++	+++	+++	+	+++	LTC(3)***
Forest							
Cuckoo *Cuculus canorus*	505	+++	+++	+++	+++	+++	LT(3)***
Tree Pipit *Anthus trivialis*	502	--	+++	+++	+++	+++	LC***
Blackcap *Sylvia atricapilla*	97	++(F)	++(F)	++(F)	++(F)	++(F)	L**
Willow Warbler *Phylloscopus trochilus*	304	--	--	--	--	--	LT(3)***
Chiffchaff *Phylloscopus collybita*	127	+++(F)	+++	+++	+++	+++	LT(1)***
Blackbird *Turdus merula*	463	-	++(F)	---	+(F)	-(F)	LCT(4)***
Song Thrush *Turdus philomelos*	371	--	-	+++	+++	+++	LCT(3)***
Redwing *Turdus iliacus*	103	+++	+++	+++	+++	+++	LT(1)*
Golden Oriole *Oriolus oriolus*	499	++	+++(F)	+++	+++	+++	LCT(3)***
Great Tit *Parus major*	144	+++	++	0	+++	+++	LCT(3)***
Chaffinch *Fringilla coelebs*	957	+++	-	+++	+++	+++	LCT(2)***
Declining		13	13	10	6	8	
Increasing		16	16	20	24	24	

[1] Population of the species was stable at a very low level 1995-1999
N = no time effects
L = linear trend
LC = linear trend, significant differences between study areas
LT = linear trend with significant changepoints, number of changepoints are given in brackets
LTC = linear trend with significant changepoints, significant differences between study areas, number of changepoints are given in brackets
N/A = all models rejected with significance P<0.05, expert judgement used for estimation of trends
0 = stable (change does not exceed 5%)
+ or - = slight increase or decline (change between 5 and 20%)
++ or -- = moderate increase or decline (change between 20 and 50%)
+++ or --- = strong increase or decline (change exceed 50%)
F = fluctuating
*, **, *** = model goodness-of-fit (significance of likelihood ratio test - P>0.95, P>0.99, P>0.999 accordingly)

increases can be associated with the general increase of forest and shrub areas in Latvia due to encroachment of abandoned lands. No such increase can be observed in species groups of agricultural and wetland habitats where the proportion of species having declining trends is larger and differences between the study areas are more pronounced.

Jelgava & Blidene have larger numbers of declining species than the other two areas (Tab. 4). Teichi had the smallest number of such species, half of which were those declining in all areas. This area also had the largest number of increasing species, the difference being due mainly to species of agricultural habitats.

4. Discussion

A six-year period is too short a time span to indicate clear trends that would describe current tendencies for the farmland bird populations for the whole of Latvia. A large proportion of the changes are caused by yearly fluctuations in numbers due to the influence of various abiotic and biotic factors such as weather conditions (both in wintering areas and breeding grounds), availability of a variety of resources, and nesting success in the previous breeding season (Wiens 1989, Fuller 1994). This conclusion mostly applies to species whose best models do not include the study area as a significant covariate (Tab. 4). However, the large proportion of species whose changing patterns differ significantly between the study areas suggests that local processes play very important roles. These changes in breeding bird populations during the study period chiefly have been caused by changes in distribution of agricultural habitats and various landscape features and by changes in farming intensity. In this respect, all the study areas have undergone different scenarios of development.

The only area that experienced decreases not only of the area of active arable lands (Tab. 2), but also of farming intensity, was Teichi. However, the decrease of arable lands was balanced by increase of sown grasslands, and the decrease of meadows by the increase in abandoned lands. Thus the proportion of cultivated and uncultivated areas remained approximately the same. As the total number of species did not increase we believe that the increase of the mean number of species registered per point in this study area occurred due to the increase of shrub-dominated habitats and the decrease of farming intensity. Although encroachment by bushes took place both in ditches and abandoned lands, it did not affect negatively open habitat species, yet here the increase in abandoned lands was more pronounced (Tabs 2 and 4). However, if this area continues to develop this way, it inevitably will lead to a reduction of total open area and a decline of open habitat species.

The other area with low farming intensity (Skulte) has experienced an increase of arable land (*cf* winter cereals) and a strong decrease of grassland areas. The increase in farming intensity has been insignificant and shrub encroachment has been recorded both for abandoned fields and ditches. Unlike Teichi, this area did not experience any rapid increase in the number of species registered per point. Rather, decreases were observed of several typical agricultural species that were increasing in Teichi.

The two westernmost areas are similar to each other; both are more intensively farmed than others and experienced further intensification during the study period, as expressed by increases of yields and of the area of arable land. However, the areas differ very much in their landscape structures, proportions of farmland habitats and the change pattern of shrub-dominated habitats. Nevertheless, in both areas more than twice as many species are decreasing than in Teichi, most of them being associated with agricultural habitats. Although farming intensity is not even close to that in EU countries yet, we expect many private farmers will start, or have started, to use western farming practices that have been a principal cause of declines of most farmland bird species populations in western Europe. Our results, however, are based on the state statistics that are biased towards state and statutory farms, and therefore cannot show the full picture. Although all shrub-dominated habitats decreased in Blidene, it is interesting to note that the species associated with them continue to increase. We explain this paradox as a result of the still-continuing expansion of these habitats in Latvia as a whole, due to widespread encroachment of former arable lands, thus providing these species with ideal living niches, increasing their reproductive success to allow overproduction to export surplus birds to neighbouring sub-ideal habitats.

Acknowledgements. We would like to thank Andris Avotinš, Ivars Kabucis, Oskars Keišs, Vija Kreile, Otars Opermanis and Elga Strazdina for participation in the fieldwork by counting the birds or describing the habitats. We are grateful to Arco van Strien for providing us with TRIM 3 software. The study was funded by the Danish Ministry of Environment and Energy and Danish Cooperation for Environment in Eastern Europe.

References

Anonymous. 1996a. Agriculture in Latvia 1991-1995. – Stat. Bulletin. CSB. Riga.

Anonymous. 1996b. Agricultural farms in Latvia 1995. – Stat. Bulletin. CSB. Riga.

Anonymous. 1997. Agricultural farms in Latvia 1996. – Stat. Bulletin. CSB. Riga.

Anonymous. 1998. Agricultural farms in Latvia 1997. – Stat. Bulletin. CSB. Riga.

Anonymous. 1999a. State of environment report 1998. – Environmental Consultancy and Monitoring Center. Riga.

Anonymous. 1999b. Agricultural farms in Latvia 1998. – Stat. Bulletin. CSB. Riga.

Anonymous. 2000. Agricultural farms in Latvia 1999. – Stat. Bulletin. CSB. Riga.

Aunins, A., Petersen, B. S., Priednieks, J. & E. Prins. (2001). Species-habitat relationships in Latvian farmland. – Acta Ornithologica 36: 55-64.

Chamberlain, D. E., Fuller, R. J., Bunce, R. G. H., Duckworth, J. C. & M. Shrubb. 2000. Changes in the abundance of farmland birds in relation to the timing of agricultural intensification in England and Wales. – J. Applied Ecol. 37: 771-788.

Donald, P., Green, R. & M. F. Heath. 2001. Agricultural intensification and the collapse of Europe's farmland bird populations. – Proc. R. Soc. Lond. 268: 25-29.

Flade, M. & K. Steiof. 1990. Population trends of common north-German breeding birds 1950-1985: an analysis of more than 1400 census plots. – Proceedings of 100th International Meeting, Deutschen Ornithologen-Gesellschaft, Bonn 1998

Fuller, R. J. 1994. Relating birds to vegetation: influences of scale, floristics and habitat structure. pp. 19-28. In: E. J. M. Hagemeijer & T. J. Verstrael. (Eds). Bird Numbers 1992. Distribution, monitoring and ecological aspects. Proceedings of the 12th International Conference of IBCC and EOAC, Noordwijkerhout, The Netherlands. – Statistics Netherlands, Voorburg/Heerlen & SOVON. Beek-Ubbergen.

Fuller, R. J., Gregory, R. D., Gibbons, D, W., Marchant, J. H., Wilson, J. D., Baillie, S. R. & N. Carter. 1995. Population declines and range contractions among lowland farmland birds in Britain. – Conservation Biology 9: 1425-1441.

Pannekoek, J. & A. Van Strien. 2001. TRIM 3 Manual. TRends and Indices for Monitoring data. Research paper no. 0102. – Statistics Netherlands, Voorburg.

Priednieks, J., Aunins, A., Brogger-Jensen, S. & E. Prins. 1999. Species-habitat relationship in Latvian farmland: studies of breeding birds in changing agricultural landscape. – Vogelwelt 120 Suppl.: 175-184.

Saris, F., Van Dijk, A. J., Hustings, M. F. H., Lensink, R. & C. W. M. Van Scharenburg. 1994. Breeding birds in the changing agricultural environment in the Netherlands in the 20th century. pp. 75-85. In: E. J. M. Hagemeijer & T. J. Verstrael (Eds). Bird Numbers 1992. Distribution, monitoring and ecological aspects. Proceedings of the 12th International Conference of IBCC and EOAC, Noordwijkerhout, The Netherlands. – Statistics Netherlands, Voorburg/Heerlen & SOVON. Beek-Ubbergen.

Wiens, J. A. 1989. The ecology of bird communities. Vol. 1. Foundations and patterns. – Cambridge University Press, Cambridge.