Changes in agriculture and the status of birds breeding in European farmland

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Farmland, covering about half of Europe's land area, is the major breeding habitat for a quarter of the European avifauna. The increase in intensity of farming management practices in recent decades has had a strong impact on the rural landscape and also adversely affected the quality of farmland habitats by reducing the supply of food and other resources such as nest sites. This in turn has influenced the distribution and density of birds in farmland, but also their feeding ecology, breeding success and survival. Thus, the present conservation status of farmland is more critical than that of any other habitat in Europe, and a high proportion of declining and endangered species depend on farmland for breeding. Declines in bird populations are most marked in recent decades, in geographical regions farmed most intensively and in farmland specialists. More recently, small areas of farmland have been taken out of production for economic reasons, especially in western Europe. Some species have shown rapid behavioural responses to this reduced intensity of farming, but despite a growing area of set-aside it remains to be documented whether such measures are sufficient to halt or even reverse negative population trends. By contrast, intensity of future agriculture might continue to grow in the western Mediterranean and increase substantially in east and south-east Europe, at the expense of many farmland species in their global population strongholds.

Originally, the European landscape was dominated by woodland with some clearings caused by fire, storms or flooding and maintained by grazing by large herbivores. In the last few thousand years, however, man's farming activities opened the countryside and created a mosaic of hedgerows, woods, pastures and arable fields, new grounds for plants and animals of open and semi-open areas (Goriup 1988). Rural landscapes were of a high habitat and structural diversity as long as farming intensity was low. In the 20th century, however, traditional farming changed to a more productive agriculture by altering farmland structure for the use of machinery and by applying chemicals to improve the yield. This drastic impact on an entire ecosystem and within less than a century influenced the living conditions of farmland fauna and flora. Intensification of agricultural land use modifies habitat diversity, field size, crop availability and food supply, which may affect bird species diversity, distribution and density as well as bird feeding ecology, breeding success and survival (Bezzel 1982, O'Connor & Shrubb 1986, Tucker & Heath 1994, Pain & Pienkowski 1997). Consequently, a high proportion of characteristic farmland birds suffered heavy losses in distribution and numbers, whereas a few generalist species increased. However, differences in patterns and timing of population trends, between and within species, geographical regions or even countries argue against single and simple explanations (Siriwardena *et al.* 1998, 2000).

This paper summarises work on density of farmland birds in relation to habitats in rural landscapes, reviews the status of species breeding in European farmland compared to other habitats and recent population trends in different regions of Europe in relation to actual and future agricultural practice.

REVIEW OF BIRDS AND FARMLAND IN EUROPE

Agricultural land use and density of breeding birds

Density and distribution of birds breeding on agricultural land is influenced by the availability of crops, meadows, pasture and other farmland habitats. Moreover, evidence from an array of species and from many countries suggests that the impacts of intensive farming are the main reasons for recent declines in abundance of species in modern farmland (Tucker & Heath 1994, Tucker 1997, Potts 1997). To assess which habitats in a rural landscape best predict species diversity and breeding bird abundance, census data have been compared with relevant farmland variables, by correlating the availability of agricultural habitats and farming intensity with species densities. Fuller *et al.* (1997) reviewed the results and discussed their biological significance, limitations and short-comings. They and Schifferli *et al.* (1999) analysed data from farmland in Britain (12 species) and in Switzerland (5 species), respectively. Some 20 to 60% of variation between study plots in densities of the Skylark *Alauda arvensis*, Whinchat *Saxicola rubetra*, Tree Pipit *Anthus trivialis*, Red-backed Shrike *Lanius collurio* and Yellowhammer *Emberiza citrinella* were explained by 2 to 4 habitat variables. For

the Yellowhammer, for example, density in both countries was associated positively with the extent of arable land and hedgerow density. Both habitats are important for breeding. Yellowhammers nest in the lower stratum of hedgerows and forage mostly in cereal crops (Biber 1993a, 1993b, Lille 1996, Kyrkos *et al.* 1998, Stoate *et al.* 1998).

Skylark abundance was negatively correlated with hedgerow density and positively with arable land. Like several other ground-nesters, it avoids the proximity of hedges and other vertical structures, where nest predation may be higher (Berg & Pärt 1994, Söderström 1999). The positive correlations of Skylark density with the extent of cereal crops are typical for intensively farmed landscapes in central and western Europe, but not for grasslands or for European farmland as a whole (Glutz von Blotzheim & Bauer 1985). Skylarks are most abundant in upland and semi-natural grassland with low and sparse vegetation, holding up to 13 territories per 10 ha (Schläpfer 1988, Jenny 1990, Wilson *et al.* 1997, Chamberlain & Gregory 1999). In modern farmland with densely growing meadows mown at short intervals, densities are 0.5 pairs per 10 ha or lower; sparse vegetation suitable for foraging is available primarily in arable crops and at an early stage of growth. Thus, most of the correlations of habitat availability and species density have been backed by studies on habitat requirements for foraging and nesting. However, as landscape descriptions are usually crude and as particular habitats are often small or absent on many census plots, effects of habitat variables may not become apparent.

Conservation status of birds breeding in different habitats

The evidence from ecological studies suggests that bird species associated with farmland are affected most by recent changes in land use. We therefore compare below the status of species of different habitats. The current distribution of 513 bird species breeding in Europe, their population sizes and recent trends are documented in Hagemeijer & Blair (1997), their actual conservation status is given in Tucker & Heath (1994). To compare different regions with differing agricultural systems, I focus here on those 260 species which regularly breed in more than 10 of the 43 countries covered by these two publications. This criterion excludes 253 species, which are mostly the rare or localised ones, recent newcomers and introductions as well as species reaching the edge of their distribution in Europe.

To compare the status of farmland birds with those of other habitats, each of the 260 species was assigned to its major breeding habitat. Thrushes and tits, for example, were considered here as woodland species, although they commonly nest in farmland and gardens. To minimise unclear cases, habitats were defined broadly: wetlands including the sea; woodland and scrubland; farmland. Eleven species confined to uplands or tundra, nine nesting in rocks, cliffs or large buildings, and three breeding in a very wide range of habitats were pooled in 'other habitats'. The number of species peaks in wetlands, which hold 35% of the 260 species considered, followed by woodlands (30%), farmland (26%) and other habitats (9%).

Overall, 68% of the 260 species exceed 10,000 breeding pairs, their populations have not decreased markedly and they are not localised in distribution; Tucker & Heath (1994) therefore consider their status as 'secure'. The populations of the remaining 82 species are classified as vulnerable, declining or endangered (27% of 260 species), or they are rare or merely locally distributed (4%). Fig. 1 illustrates the status of the 260 species by habitat. Overall, 71 species are declining, vulnerable or endangered; 11% of them depend on woodland as their major breeding habitat, 35% on wetlands and 48% are farmland birds. In the avifauna of woodlands and wetlands, most species are 'secure' (85% and 67%, respectively). Farmland with 68 breeding species has the largest proportion of declining, vulnerable and endangered species (50%; woodlands 10%, wetlands 27%). This habitat and its avifauna are the most crucial ones for bird conservation.

Recent population trends in farmland birds

Hildén & Sharrock (1985) provided trend estimates for 377 bird species in 30 European countries and compared the European results with data from Finland (Hildén *et al.* 1988). They analysed questionnaires sent to national experts who scored the changes of the breeding populations of their country as 'increasing', 'stable', 'decreasing' or 'unknown', respectively, in the period of the 1950/60s to the 1970s. Sixty-five percent of 68 farmland species were scored as stable in a majority of countries. For 21 species (31%) the countries with declining populations exceeded those with positive trends by a third and for merely 4% of species did the positive clearly outnumber the negative trends.

In Fig. 2 the results are compared with data from 1970-1990 in Hagemeijer & Blair (1997) and Tucker & Heath (1994). Twenty-five percent of farmland species remained stable in both (partly overlapping) periods; 32% previously considered to be stable (Hildén & Sharrock 1985) are now declining and 31% previously declining are continuing to decrease. Only 2 species increased in both periods (3%) and 6 with previously stable populations increased in 1970-1990. There are thus six 'winners', for which the population trends improved, and 22 'losers', for which it deteriorated, suggesting that breeding conditions for farmland birds changed again for the worse in the 1970s.

Since the analyses of Hildén & Sharrock (1985), long-term quantitative monitoring schemes of breeding bird

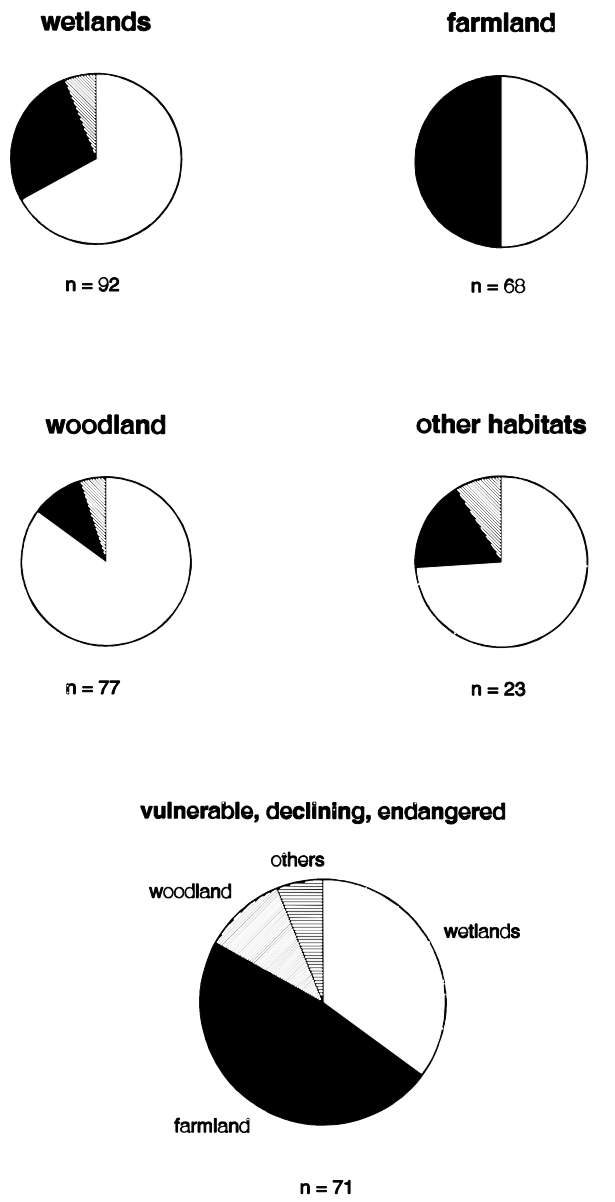

Figure 1. Status of 260 bird species in Europe by major breeding habitats. Threat status according to Tucker & Heath (1994); proportions of species in each category are given for each habitat (secure species: white; vulnerable, declining or endangered species: black; localised or rare species: dark shading). Bottom: 71 vulnerable, declining or endangered species, grouped by habitat. *n* = number of species.

populations have been established in some 15 countries, mainly in northern and western Europe (Marchant *et al.* 1997). Analyses of annually recorded long-term data generally confirm the critical status of farmland birds, as demonstrated by Hildén & Sharrock (1985). However, there are considerable differences in patterns and timing of trends, between and within species and countries. Populations of species that breed primarily in farmland are more likely to decline than generalist species. In southern Sweden, 9 of 21 typical farmland species declined markedly compared to 3 of 27 species with a large proportion of the population living in other habitats (Robertson & Berg 1992). Fuller *et al.* (1997), combining atlas and census data on birds breeding on lowland farmland in Britain, documented a breeding range contraction for 24 of 28 farmland birds; range losses of farmland birds was larger than for species associated with any other habitat. Fifteen out of 18 species were less abundant in 1990 than in 1970. Siriwardena *et al.* (1998) found significant declines, by 30% on average, in the abundance of 13 farmland specialists. However, the abundance of 29 more generalist species underwent an average increase of 23%. Work from other countries in the western part of Europe generally agrees with these conclusions (The Netherlands, Saris *et al.* 1994; central Europe, Flade 1994, Bauer & Berthold 1997; Finland, including other animal taxa, Hanski & Tiainen 1988; Switzerland, Zbinden 1989).

There are few studies on long-term and large-scale quantitative monitoring from eastern Europe to compare with western countries. Moreover, population trends in countries varying widely in area and bird population size are difficult to combine. To evaluate the possibilities of obtaining a breeding population trend index for geographical regions and for Europe as a whole, Van Strien & Pannekoek (1998) analysed monitoring data on six farmland species from seven countries. The Lapwing *Vanellus vanellus* has a population stronghold in the UK and The Netherlands. Until 1983, it decreased in western Europe, largely owing to the changes in the UK (Shrubb & Lack 1991), and has maintained a more stable population at a lower level since the mid-1980s. The trend from 1978 to 1997 was 0.984, equivalent to a decrease of about 2% per year. The populations in eastern Europe, which are much smaller, showed an almost identical trend of 0.977. Skylark, Whinchat, Yellowhammer and Linnet *Carduelis cannabina* showed a negative trend in the western countries included in the analyses (Van Strien pers. comm.). The Whitethroat *Sylvia communis* was the only species to increase on western farmland. The monitoring data from

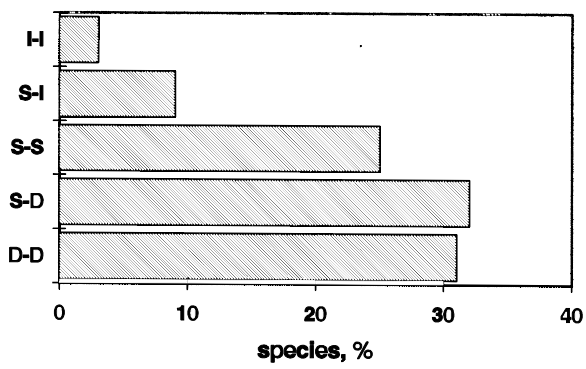

Figure 2. Population trends in 68 farmland bird species in Europe, 1950/60 to 1980 (from Hildén & Sharrock 1985) and 1970-1990 (from Tucker & Heath 1994, Hagemeijer & Blair 1997). D: declining, S: stable and I: increasing (e.g. S-I: stable in first, increasing in second period).

eastern Europe were less conclusive and did not differ significantly from those of the western countries. To sum up, there is convincing evidence for a marked decline of populations in farmlands of western Europe; more data are needed especially from the eastern half of Europe to document differences between countries and regions with differing farming practices.

Farming practice and bird population trends in geographical regions

To compare recent population trends and farming practice in geographical regions, the European countries were grouped into five regions (Table 1), according to national land use for agriculture. Statistics collated by the Food and Agriculture Organisation (FAO) of the United Nations are available on the Internet (www.fao.org). Data from 1994 for 28 countries are used here to characterise farming practice in the five European regions.

Overall, a third of the European land area is woodland and almost half is used for agriculture (definitions of variables in Table 1). However, there are considerable regional differences. N Europe is mostly covered by woodland (56%). Farmland accounts for merely 9%; most of it is arable land, defined in the FAO statistics as under temporary and rotational agricultural use as crops, pasture or meadows for mowing (cf. Table 2). In the other parts of Europe, farmland covers 55-56% of the land area. In NW Europe farmland is made up of arable land and permanent pasture in almost equal proportions. NE farmland is dominated by arable land (76%) and 22% are permanent pastures. The SW and SE regions both have a relatively high proportion of vineyards, orchards and other permanent crops, which are largely confined to Mediterranean countries (e.g. Portugal 19%, Italy 18%, Greece 12%); slightly more than half of southern farmland is arable and about a third is pasture.

Livestock density, mechanisation and the use of fertilisers, key indices of the intensity of the impact of agriculture on the rural landscape, are highest in the western half of Europe. N and NW Europe apply more than twice as much fertiliser and hold 2-3 times more cattle, pigs and sheep per unit area than eastern countries (Table 2). In NE and SE Europe, 18% and 26%, respectively, of the human population depend on agriculture, compared to below 5-10% in N and NW Europe. Eastern Europe relies much more on physical man-power than the highly mechanised west. Although these farmland variables are obviously a very crude and general indication of regional farming practice and intensity, they indicate a declining trend of farming impact from north and west to south and east, respectively.

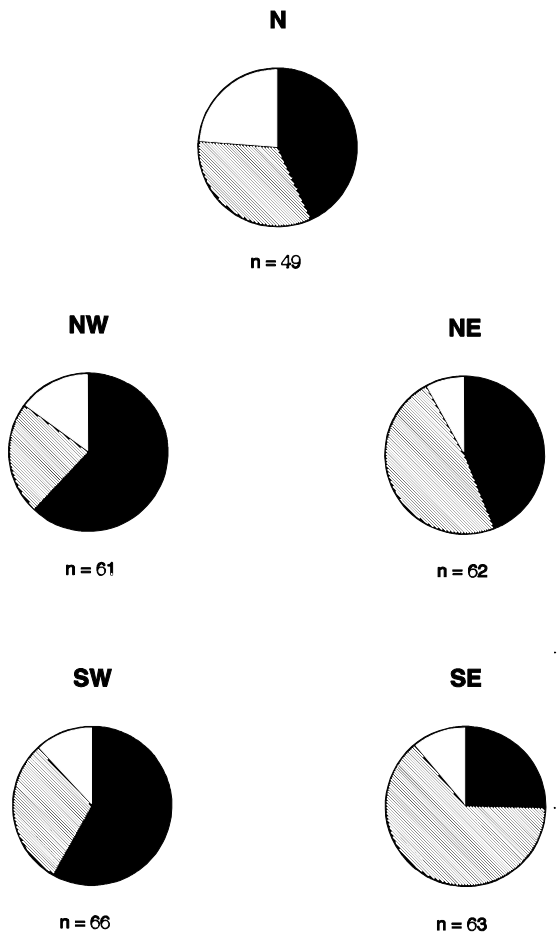

Figure 3. Trends in geographical regions of Europe, in 1970-1990, of 68 bird species breeding in farmland. Declining (black), stable (shading) and increasing species (white) as a percentage of the species commonly occurring in each region. Regions are defined in Table 1, *n* = number of species.

Bird population trends in geographical regions

As agricultural practice and especially farming intensity have a profound impact on the avifauna, it is to be expected that population trends of farmland birds differ between geographical regions according to their agriculture. To compare recent population changes given in Hagemeijer & Blair (1997) and Tucker & Heath (1994), the trends of 68 farmland species were examined in relation to the five geographical regions defined in Table 1.

Of the farmland species breeding in a region, 23% (NW Europe) to 63% (SE Europe) did not show a consistent trend (Fig. 3). The declining species clearly outnumber the increasing species in all five regions. However, the percentage of declining species is highest in the NW and decreases both southwards and eastwards. Thus, 62% of farmland species are declining in NW Europe, where farming is most intensive, compared to 25% in SE Europe, where livestock density and the use of machines and fertilisers are much lower.

Table 1. Definitions of geographical regions of Europe, and of agricultural variables used for FAO statistics.

Term	Definition
Agricultural variables	
Agricultural area:	total of arable land, permanent crops and permanent pasture
Arable land:	under temporary crops, meadows for mowing or pasture, land under market and kitchen gardens, land temporarily fallow
Permanent crops:	occupy land for long periods, e.g. orchards, vineyards
Permanent pasture:	used > 5 years for herbaceous forage crops
Fertiliser:	quantity of all plant nutrient consumed in agriculture
Tractors:	number in use
Agricultural population:	all persons depending on agriculture, hunting, fishing or forestry
Geographical regions of Europe	
N	Norway, Sweden, Finland, Denmark
NW	United Kingdom, Ireland, Belgium, The Netherlands, Luxembourg, Germany, Switzerland, Austria
NE	Poland, the former Czechoslovakia, Estonia, Latvia, Lithuania, Hungary
SW	Portugal, Spain, France, Italy
SE	Croatia, Slovenia, Greece, Bulgaria, Rumania, Turkey

Variation in trends may also be found on a national scale, e.g. in countries with marked differences in farming intensity due to pronounced altitudinal gradients. In Switzerland, 205 species have bred in the 20th century, amongst them 60 farmland birds. Forty-four percent of the total avifauna and 38% of the farmland species have a secure status; 45% and 57%, respectively, figure on the Red List of endangered breeding species, as their populations declined in recent decades (Zbinden *et al*. 1994, Schmid *et al*. 1998). Most affected are the bird populations in the intensively farmed Swiss Plateau, where previously widespread species have declined (e.g. Skylark) or virtually disappeared (e.g. Tree Pipit; Schmid *et al*. 1998). Particularly vulnerable are species confined to the lowlands (e.g. Woodchat Shrike *Lanius senator*), as their distribution is limited by altitude. By contrast, birds breeding in a wider range of altitudes seem to maintain viable populations at higher elevations, where farming is less intensive (e.g. Tree Pipit, Whinchat, Schifferli 1993). The Whinchat was widespread in the grasslands throughout Switzerland until the 1930s, but thereafter declined on the Plateau (Glutz von Blotzheim 1962). By 1972-76 it was recorded in 82% of 468 Atlas squares of 10x10 km, by 1993-96 in 67.5%, including 24 'new' records, but it was missing in 86 squares still occupied in the first Atlas period (Fig. 4). Most of the deserted squares were situated in the Plateau where the

Table 2. Land use and farming statistics for Europe and its regions in 1994. Data from FAO (1999).

	Region					Overall
	N	NW	NE	SW	SE	
Agricultural area (1,000 ha)	9,457	47,307	39,058	80,498	82,932	259,252
% of land area	8.9	55.7	56.5	56.1	55.5	46.8
Arable (% of farmland)	87.9	47.6	75.5	55.1	57.1	58.7
Permanent crops (%)	0.1	1.0	2.7	11.5	6.9	6.4
Permanent pasture (%)	12	51.5	21.8	33.4	36.0	35.0
Woodland (% land area)	56.3	22.5	31.7	28.6	27.3	33.0
Fertiliser (Mt/km^2)	14.4	15.0	6.1	10.9	3.6	8.7
Tractors per km^2	7.3	5.7	4.3	4.6	2.1	4.1
Cattle per km^2	65	98	37	42	25	47
Pigs per km^2	162	132	84	54	22	67
Sheep per km^2	34	115	8	64	81	69
Agricultural population						
per km^2	14	13	33.5	15	39	25
% of total	5.5	3.4	18.1	7.5	25.9	11.5

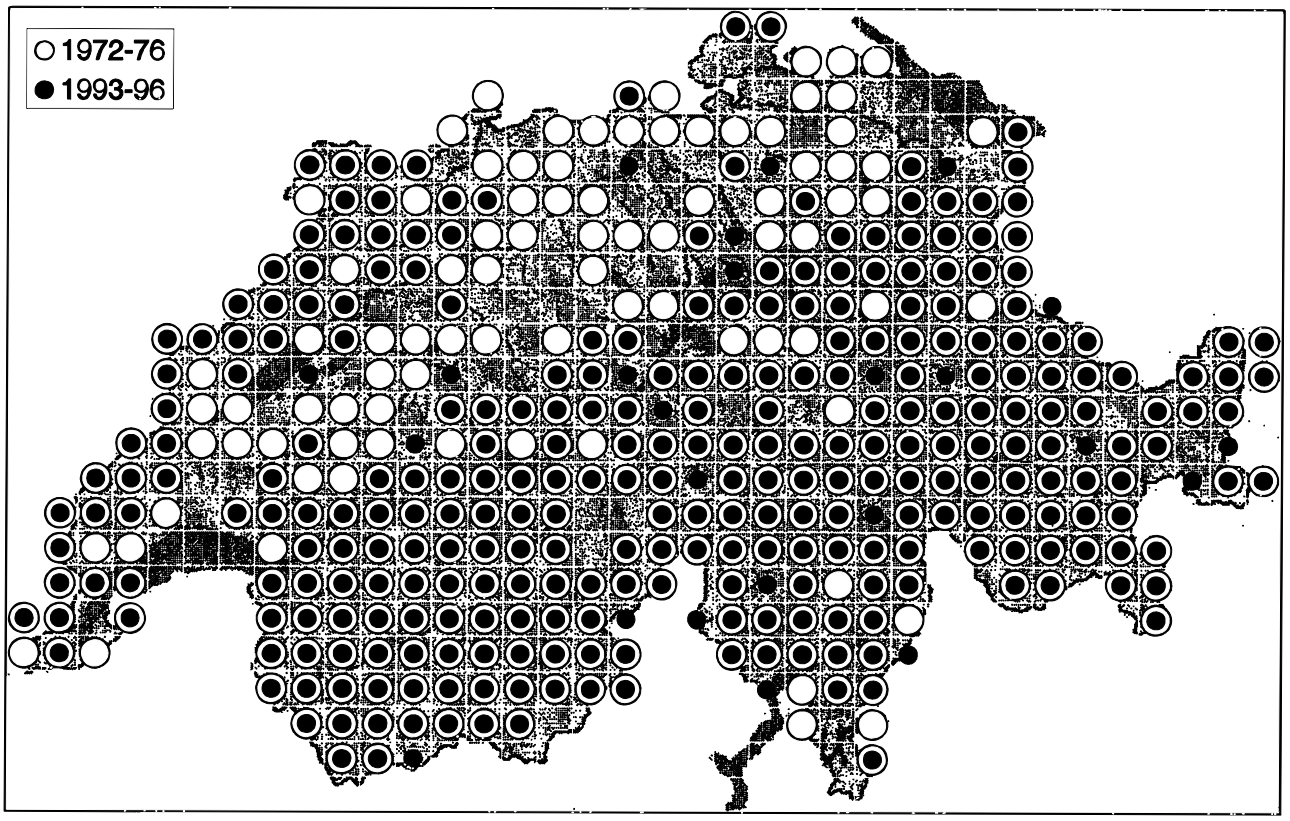

Figure 4. Breeding distribution of the Whinchat *Saxicola rubetra* in Switzerland in squares of 10x10 km. Open circles: occupied in 1972-76 only (from Schifferli *et al.* 1980); black dots: occupied in 1993-96 only (from Schmid *et al.* 1998); both symbols: squares occupied in both periods.

Whinchat has now virtually disappeared (Schifferli *et al.* 1980, Schmid *et al.* 1998).

In conclusion, farmland birds are the most threatened group of birds and almost half of Europe's threatened species depend on farmland as a major habitat. Considering the 195 endangered species of Europe and taking the migrating and wintering period into account, Tucker & Heath (1994) estimate that some 60% depend on rural landscape at least sometimes in their life cycle. A very substantial proportion of the avifauna is therefore affected by changes in the structure of rural landscapes and in agricultural practice. Since about half of Europe is cultivated as farmland, habitat modifications occur on large areas and hence significant parts of the breeding grounds are affected. Moreover, as agriculture follows internationally co-ordinated management policies, habitat changes may be very rapid. For these reasons, the avifauna of rural landscapes is of prime conservation concern.

Set-aside and organic farming

In recent years and mainly in the EU, land has been taken out of production, or is farmed at a lower intensity. Several studies have tested for postulated positive effects of organic farming and set-aside areas. A comparison of organic and conventional farms in Britain showed consistently higher bird densities on organic farms throughout the year (Chamberlain *et al.* 1995, Fuller 1997). This confirms the results of an earlier study in Denmark during the breeding season, where the total bird density on organic farms was approximately twice as high and the majority of species were more abundant than on conventional farms (Petersen 1994, Christiansen *et al.* 1996). Comparing the abundance of breeding farmland birds in central Sweden, Berg & Pärt (1994) found significantly higher numbers of Skylark, Linnet, Whitethroat and Whinchat in set-aside plots bordering forest edges than in cereal fields; however, the most important factor to explain bird abundance was the structure of the forest edge. Henderson & Evans (2000) review data from the UK that show higher densities of breeding and wintering birds of several species on set-aside than on surrounding farmland. Schifferli *et al.* (1999), comparing 65 census plots predominantly farmed at high, medium and low intensity, reported higher densities of Whinchat, Tree Pipit, Red-backed Shrike and Yellowhammer on the study areas that were farmed less intensively.

In a few cases, the same plots were surveyed before, during and after a change from conventional to 'biological' farm production. This set-up may be considered as a field experiment to test hypotheses. On a farm in southern Germany (Laussmann & Plachter 1998), five new farmland species colonised the 150-ha plot already in the first year after the change in land management (House Martin

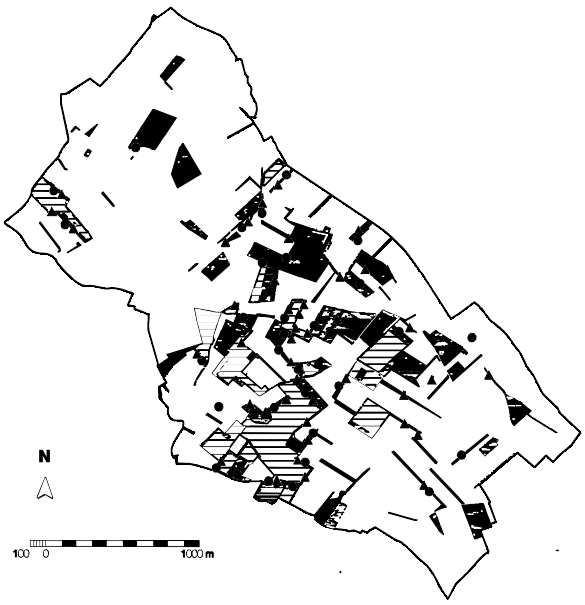

Figure 5. Distribution of the Whitethroat *Sylvia communis* (triangles, 44 pairs) and the Stonechat *Saxicola torquata* (dots, 35 pairs) in rural landscape in the vicinity of Geneva, SW Switzerland in 1996 (613.5 ha). Hedges (3.0 ha) and small woods (5.4 ha) are in black; fallow land (17.3 ha), nature reserves (2.3 ha) and habitats for ecological compensation in grey shading (wild-flower strips 10.3 ha, meadows farmed at low intensity 33.1 ha); gravel pits are cross-hatched (53.0 ha). From Jenny *et al.* (1997).

Delichon urbica, Red-backed Shrike, Grey partridge *Perdix perdix*, Quail *Coturnix coturnix*), or in the second year (Tree Pipit). From 1991 to 1995, the total number of breeding pairs increased steadily from 212 to 339. Similar results were obtained in Switzerland, where a network of strips of wild flowers and fallow land was built up. Numbers of Corn Bunting *Miliaria calandra*, Stonechat *Saxicola torquata*, Whitethroat and Quail increased in parallel with the area of these new habitats, and pairs settled in close proximity to them (Fig. 5). Skylark territories that included wild-flower strips were smaller and the nestlings grew and survived better than those without. Structurally diverse wild-flower strips, which had a rich food supply, were visited preferentially by Skylarks feeding young (Weibel 1998) and by Kestrels *Falco tinnunculus* in winter (Buner 1998). Nevertheless, it remains to be seen whether such measures are sufficient to halt or even reverse negative population trends.

Changes in farming practice and perspectives

A comparison of the FAO farmland statistics from 1994 with those of 1975 reveals profound changes within the last decades (Table 3). The area in agricultural production fell by 5%. Permanent crops and pastures as well as arable land decreased by 9%, 6% and 4%, respectively. In the same period, the total woodland area of Europe increased by 2%. Areas taken out of agricultural production tended to turn into woodland, at the expense of farmland-dwelling species. The number of tractors in use, considered here as an indicator of mechanisation, remained almost constant in N and NW Europe, increased by 43% in the SW and more than doubled in the NE and SE. The agricultural population decreased, by a quarter in eastern Europe, and by half in Fenno-Scandinavia and the western regions. Although the number of cattle was reduced in all regions by 10% (SW) to 40% (NE), the amount of livestock grew, again except for NE and SE Europe.

In the three southern countries that joined the EU in 1981 (Greece) and 1986 (Spain, Portugal), livestock density, mechanisation and the use of fertilisers increased from 1975 to 1994. If this pattern of agricultural development continues in these EU members and if it is repeated in eastern European countries negotiating with the EU for membership, then large areas still farmed at a low intensity may be converted to modern farmland.

Table 3. Changes in agricultural variables by geographical region of Europe, 1975 to 1994; changes are given in % of values of 1975. For definition of variables see Table 1.

	Region					Overall
	N	NW	NE	SW	SE	
Agricultural area	-7	-10	-4	-6	+1	-5
Arable	-7	-5	-5	-1	-3	-4
Permanent crop	+20	-37	+15	-10	-6	-9
Permanent pasture	-10	-13	-3	-12	+7	-6
Woods, forests	0	+6	+3	+7	-2	+2
Fertilisers	-28	-19	-69	+12	-23	-23
Tractors	+5	-5	+148	+43	+138	+39
Cattle	-20	-14	-40	-10	-26	-19
Pigs	+28	+8	-15	+43	-10	+9
Sheep	+45	+54	-55	+34	-17	+10
Human agricultural population	-45	-45	-22	-52	-26	-35

Southern and eastern Europe hold at present substantial proportions of farmland bird populations (Tucker & Heath 1994, Hagemeijer & Blair 1997). Some 50-70% of the European population of the Lesser Kestrel *Falco naumanni* and the Great Bustard *Otis tarda* breed in Spain, Portugal and Turkey. The Baltic States, Poland, the former Yugoslavia, Romania and Bulgaria account for up to a quarter of the singing male Corncrakes of Europe (Heredia *et al*. 1996, with action plans for these 3 globally threatened species). More than two thirds of the population of the Green Woodpecker *Picus viridis*, the Woodlark *Lullula arborea* and the Woodchat Shrike breed in south-western Europe (Hagemeijer & Blair 1997). The Lesser Grey Shrike *Lanius minor* has its major strongholds in south-eastern Europe (mainly Romania), the Black-tailed Godwit *Limosa limosa* in north-western Europe (largely The Netherlands). All these species are declining or vulnerable and more than half their global populations is concentrated in Europe (Tucker & Heath 1994). Changes in farming in these areas are therefore affecting vital parts of their global populations.

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