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Relationship between land-use intensity and species richness and abundance of birds in Hungary

Jort Verhulst [a,*], András Báldi [b], David Kleijn [a]

[a] *Nature Conservation and Plant Ecology Group, Wageningen University, Bornsesteeg 69, 6708 PD Wageningen, The Netherlands*
[b] *Animal Ecology Research Group of the Hungarian Academy of Sciences, Hungarian Natural History Museum, Ludovika tér 2, Budapest H-1083, Hungary*

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Abstract

When Hungary, together with nine other central and eastern European countries, enters the European Union in 2004 two major threats will arise to the birds inhabiting agricultural landscapes. Marginal agricultural land may be abandoned, while the remaining area may suffer from intensification. To assess the effects of these threats breeding birds were monitored in abandoned, extensively and intensively used vineyards and grasslands in Hungary using point counts to determine species richness and density. Species numbers and bird density were highest in extensively used vineyards, while bird diversity was highest in abandoned vineyards. Abandoned vineyards were rich in species and individuals, mainly woodland species, whereas intensively used vineyards had both fewer species and individuals than the other two vineyard types. In grassland, four management types were distinguished, abandoned, extensively, intensively grazed and both intensively grazed and fertilised grassland. Extensive grassland harboured most species, bird density and diversity being highest at the abandoned site which was covered by bushes and contained many non-grassland species. Intensively grazed fields had lower species numbers, lower density and diversity than extensively grazed grassland but were still much more species rich and diverse than the fertilised fields. Our results suggest that extensively used farmland holds the highest diversity and abundance of farmland birds. Conservation efforts aimed at farmland birds should therefore focus on maintaining extensive farming systems.

Keywords: Birds; Farmland; Intensification; Abandonment; Conservation; Vineyards; Grassland; CAP

1. Introduction

The decline of western European farmland birds in recent decades has been well documented (Tucker and Heath, 1994; Tucker, 1997) and was linked primarily to the intensification and industrialisation of agriculture (Tucker and Heath, 1994; Tucker, 1997; Siriwardena et al., 1998; Chamberlain et al., 2000; Benton et al., 2003). In the European Union, intensification was to a large extent steered by the Common Agricultural Policy (CAP; Donald et al., 2002). The CAP was initiated in 1957 with the aim to increase agricultural production, to ensure sufficient food for all inhabitants and a fair standard of living for people engaged in agriculture. The CAP resulted in a polarisation of production areas and a loss of mixed farming. Although it has prevented some low-intensity systems with high biodiversity from being abandoned, the CAP has also lead many marginally economic areas to be abandoned (Bignal, 1998). The CAP has

* Corresponding author. Tel.: +31-317-484672; fax: +31-317-484845.
E-mail address: jort.verhulst@wur.nl (J. Verhulst).

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also encouraged homogenisation of the farmland and many non-agricultural features such as hedgerows and woodlands have been removed (Lefranc, 1997).

In central and eastern European countries (CEECs) the rate of increase in agricultural productivity between 1960 and 1980 was similar to that of the EU Member States. After the collapse of the state support in the former communist countries in the 1990s, agricultural output dropped sharply (Donald et al., 2001). However, even before the fall of communism, state support in the CEECs was generally lower than it was in the EU resulting in a less intensive agriculture. Low-intensity farmland habitats are far more widespread in eastern than in western Europe (Tucker and Evans, 1997) and farmland birds have suffered smaller declines in central and eastern Europe than in the EU (Donald et al., 2001). Now that the CEECs are about to enter the EU, their farmland birds may face the same hazards as in the EU: intensification and abandonment (Tucker and Heath, 1994; Lefranc, 1997; Tucker, 1997; Heath and Evans, 2000; Suárez-Seoane et al., 2002).

This paper aims to assess the potential effects of the CAP in the CEECs. The relationship between land-use intensity and species richness and abundance of breeding farmland birds is therefore studied in Hungary. The country is dominated by agriculture, with 50% arable land, 25% other agricultural activities, including vineyards, grassland and forestry (Ángyán et al., 2001). Many of Hungary's characteristic birds depend on farmland (Márkus, 1993; Tucker and Evans, 1997). The study focuses on vineyards and grassland which are important from a conservation point of view and threatened by both intensification and abandonment (Molnár and Vajda, 2000; Roudna, 2002).

In 2000, vineyards covered 1.1% (104,000 ha) and grassland 11% (1,048,000 ha) of the utilised agricultural area (Hungarian Central Statistical Office, 2002). Vineyards are important from a landscape point of view. The Tokaj region has been marked as an UNESCO World Heritage Site, yet little is known about their bird abundance and diversity. Grassland (puszta) is likely to expand in Hungary (Ángyán et al., 2001) and contains a rich and unique avian life (Faragó, 1995; IUCN, 2002).

This paper tries to determine the effects both of intensification and abandonment on bird species richness and abundance in grasslands and vineyards.

2. Materials and methods

2.1. Vineyards

The vineyards studied were situated in the Tokaj region (northeastern Hungary) on the slopes of the lower Zemplén mountains (48°25′N, 21°20′E). Vineyards have covered the area for centuries. Some of the vineyards have been abandoned, while recently the management of others has been intensified after foreign investment. Abandoned areas were rather homogeneous and covered with grasses and bushes (mainly *Rosa* spp.) other parts being more heterogeneous with some small managed parts. The extensive vineyards were very heterogeneous. Many of the parcels were small and contained a lot of different landscape elements like fruit trees, hedgerows, forested slopes, houses, grasslands and vegetables. Intensive vineyards were very homogeneous, and contained few landscape elements. Average field size was large (ca. 20 ha) and the surface levelled to make it accessible for large machines.

The three differently managed vineyard types were selected all randomly through the area. A total of 22 observations were made in intensively used vineyards at five different locations. Another 22 observations were made at 10 locations in extensively used vineyards of 10–30 ha. Only 12 observations were made at 10 different abandoned vineyards of less than 5 ha.

2.2. Grassland

The second part of this research was conducted on the Peszéradacs meadows, part of the Kiskunság National Park (37°51′N, 19°15′E), and on farmland in the direct vicinity. It is a sandy, rather dry area (annual rainfall of 525 mm) situated on the plain between the Danube and Tisza rivers. Birds were surveyed on grassland with four different land-use intensities: abandoned, extensively grazed, intensively grazed, and intensively grazed and fertilised (henceforth called fertilised).

Abandoned and extensive grassland were located in the National Park, intensive and fertilised categories on private farms, within 25 km of the Peszéradacs meadows. All sites were under the same climatic and geological conditions and management for at least the last 5 years.

A small part of the meadows, on the edge of a forest, had not been grazed or mown for 20 years. This part is covered with bushes, mainly *Crataegus* spp. and *Rosa* spp. Due to its small size, only four observations were made, a number too small to be compared with the other grassland types. It nevertheless is an indication of the changes in avifauna following abandonment.

In extensively grazed grassland 23 observations were carried out on 1200 ha meadow that ranged from dry to wet and contained scattered bushes, trees and reed beds. Cattle grazed it intensively up to 1996, when it became part of the National Park. Parts of the grassland were mainly grazed (0.4 cow/ha), some were mown and there was no clear distinction between these two.

Intensively grazed grassland (1 cow/ha) was located on two farms, one of 100 ha about 2 km east of the extensive grassland, the other (600 ha) 25 km south of it. On each farm 12 observations were carried out. Chemical fertilisers were not applied, and the 100 ha grassland had more trees, hedgerows, ditches and flowering herbs than the 600 ha grassland.

Nine observations were made in a fertilised grassland situated 10 km northwest of the Peszéradacs meadow. The site received 50–100 kg chemical fertilisers per hectare per year. Some 85 ha were mown each year in June, while some 15 ha were grazed with a density of 2 cows/ha. The vegetation cover was dense, high and dominated by grass species with some scattered trees and bushes on the edge.

2.3. Point count method

As for the Hungarian National Common Bird Census (Szép and Nagy, 2002), the point count method (Bibby et al., 1992) was used to survey breeding birds. All individual birds within points with a radius of 100 m were counted. The distance to observed birds was estimated with a range finder (Bushnell, Overland Park, USA). All points were visited twice in 2002, once in April for early breeders, once in May for species that arrived later. The 10 min counts were conducted under good weather conditions. Observations began at sunrise and lasted 4–5 h. Disturbances were avoided as much as possible.

Moskát (1987) found that 20 points would be sufficient to find most species (over 90%) in central European deciduous forests. Since visibility is far better in grassland and vineyards than in forests, 20 points were considered to be largely satisfactory.

2.4. Analysis

The highest number of individuals of each species of either the April or May count was used to estimate densities per 10 ha and species diversity and evenness (Shannon's H and J indices). Conservation status of the birds in Europe was derived from Tucker and Heath (1994), with "SPEC 1" for species that are globally threatened, conservation dependent or data deficient; "SPEC 2" for species with unfavourable conservation status in Europe whose global populations are concentrated in Europe; "SPEC 3" for species with unfavourable conservation status in Europe whose global populations are not concentrated in Europe and "SPEC 4" for species with a favourable conservation status in Europe whose global populations are concentrated in Europe.

The danger of pseudo-replication existed for grassland because observation sites were located in just one or two fields. However, these fields were all at least 100 ha whereas individual point counts were about 3 ha in size. Therefore, the point counts were considered to be independent. Selecting fields further apart would have resulted in marked differences in environmental conditions and management which would have hampered interpretation of what caused observed differences.

Data were analysed by analysis of variance. When significant effects of land-use type were found, t-tests were used to test for significance of differences between pairs of means. To keep type I errors within bound a probability of 0.99 ($\alpha = 0.01$) was used when performing the various pair-wise comparisons. If variables were not distributed normally or if variance of the errors was not constant data were subjected to ln-transformation prior to analysis.

3. Results

3.1. Vineyards

The number of bird species sighted hardly increased beyond seven observations in abandoned vineyards and beyond 14 observations in extensively and

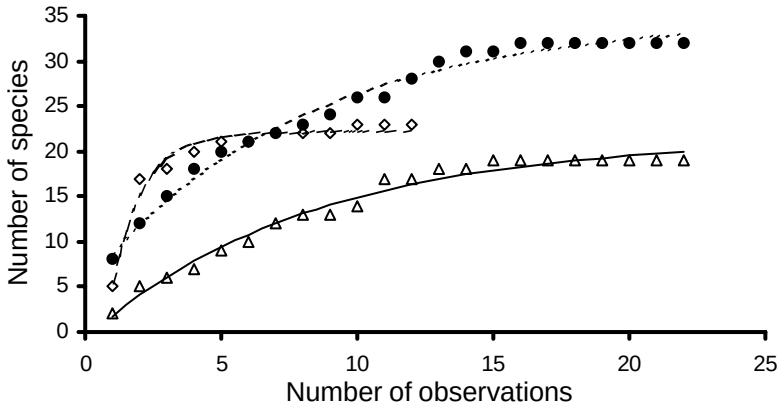

Fig. 1. Relationship between number of observations and number of bird species in vineyards of different land-use intensity: (◇) abandoned; (●) extensive; (△) intensive vineyards.

intensively used vineyards (Fig. 1), suggesting that the sample size was sufficient. Extensively used vineyards have significantly more bird species than abandoned and intensively used ones (Table 1). Abandonment did not result in significant bird declines, whereas intensification resulted in significantly lower abundance and diversity compared to extensive vineyards.

Tree sparrow, black redstart and song thrush (Table 2) were most frequent in extensive vineyards. Abandoned vineyards had higher densities of corn bunting, barred warbler and stonechat but lower densities of greenfinches and European serins than extensive vineyards. Intensively used vineyards had almost six times the number of skylarks and twice the number of linnets compared to extensively used vineyards (Table 2). Some rare woodlarks were observed in the intensively used vineyards only. The densities of song thrush, blackbird, black redstart and tree sparrow were >75% lower in intensive compared to extensive vineyards (Table 2).

3.2. Grassland

The number of bird species sighted hardly increased beyond 13 observations in extensively and intensively used grassland (Fig. 2) indicating that sample size was sufficient. The sample sizes of abandoned and, to a lesser extent, fertilised grasslands were not sufficient to give a representative account of their bird communities. Care must be taken with the interpretation of the results for these two grassland types.

Extensively grazed grassland were significantly more diverse and supported significantly higher numbers of species and individuals than both intensively grazed and fertilised grassland (Table 3). However, abandoned grassland contained more species and individuals than extensively grazed grassland. Skylark, yellow wagtail and winchat occurred in high densities on extensively grazed grassland (Table 4), wader species black-tailed godwit, curlew and redshank were observed exclusively on extensive grassland albeit in low densities.

Table 1
Mean (±S.E.) bird species richness, abundance, diversity (Shannon's *H*) and evenness (Shannon's *J*) per point in abandoned, extensively and intensively used vineyards

Vineyard type	*n*	Species richness	Abundance	Diversity	Evenness
Abandoned	12	5.7 b (0.91)	9.6 ab (1.42)	1.47 a (0.153)	0.68 a (0.043)
Extensive	22	7.0 a (0.58)	13.3 a (1.45)	1.63 a (0.105)	0.68 a (0.042)
Intensive	22	3.2 c (0.38)	6.4 b (0.55)	0.96 b (0.087)	0.54 a (0.044)

Within columns different letters indicate significant differences at $P < 0.01$.

Table 2
Numbers of individuals per 10 ha and SPEC conservation status of the most abundant species and species with a high conservation status in abandoned, extensively and intensively used vineyards

Bird species	Abandoned ($n = 12$)	Extensive ($n = 22$)	Intensive ($n = 22$)	SPEC conservation status
Skylark *Alauda arvensis*	1.59	0.14	0.87	3
Linnet *Carduelis cannabina*	3.71	4.63	8.10	4
Goldfinch *Carduelis carduelis*	0.00	0.14	0.87	4
Greenfinch *Carduelis chloris*	1.06	2.75	0.87	4
Yellowhammer *Emberiza citrinella*	1.59	0.58	0.14	4
Robin *Erithacus rubecula*	0.80	0.43	0.00	4
Chaffinch *Fringilla coelebs*	0.27	2.03[a]	0.00	4
Red-backed shrike *Lanius collurio*	2.92	3.18	1.16	3
Woodlark *Lullula arborea*	0.00	0.00	0.29	2
Corn bunting *Miliaria calandra*	3.98	0.29	0.14	4
Tree sparrow *Passer montanus*	0.53	10.71	2.46	–
Black redstart *Phoenicurus ochruros*	0.27	1.59	0.29	–
Stonechat *Saxicola torquata*	1.86	0.43	0.43	3
European serin *Serinus serinus*	1.86	5.79[a]	3.18	4
Turtle dove *Streptopelia turtur*	0.27	0.87	0.00	3
Whitethroat *Sylvia communis*	0.80	0.29	0.00	4
Barred warbler *Sylvia nisoria*	3.45	0.43	0.00	4
Blackbird *Turdus merula*	2.12	2.03	0.29	4
Song thrush *Turdus philomelos*	1.06	2.17	0.29	4

[a] Including foraging flocks.

Abandoned grassland were characterised by high densities of corn buntings, stonechats and red-backed shrikes. These species were observed in trees and bushes used for nesting, singing or as a perch and were practically absent in other grassland types. Skylarks were rarely observed in abandoned grassland while they were common in all other grassland types. Intensively grazed grassland contained a subset of the bird community observed in the extensive grasslands, only skylark and winchat being found in considerable densities. Still, these were 30 and 61% lower, respectively, than in extensive grassland. None of the common species was observed with highest abundance in intensively grazed grassland. Fertilised grassland

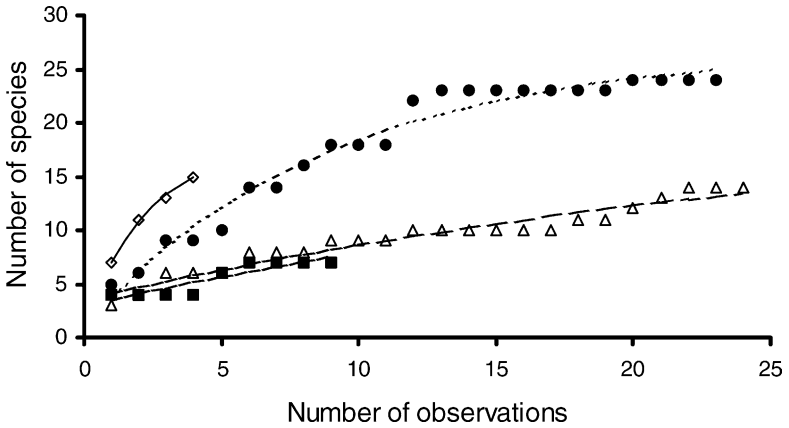

Fig. 2. Relationship between number of observations and number of bird species in grassland of different land-use intensity: (◇) abandoned; (●) extensive; (△) intensive; (■) fertilised grassland.

Table 3
Mean (±S.E.) bird species richness, abundance, diversity (Shannon's *H*) and evenness (Shannon's *J*) per point in abandoned, extensively, intensively grazed and fertilised grassland

Grassland type	*n*	Species richness	Abundance	Diversity	Evenness
Abandoned	4	8.3 b (0.75)	15.8 b (1.93)	1.92 a (0.072)	0.70 a (0.032)
Extensive	23	4.7 a (0.40)	10.2 a (0.69)	1.29 a (0.097)	0.56 a (0.041)
Intensive	24	2.5 c (0.29)	5.5 c (0.78)	0.78 b* (0.104)	0.47 a (0.063)
Fertilised	9	1.9 c (0.30)	3.1 c (0.59)	0.43 b** (0.190)	0.44 a* (0.174)

Within columns different letters indicate significant differences at $P < 0.01$.
* Means calculated from two points less.
** Mean calculated from three points less.

Table 4
Number of individuals per 10 ha and SPEC conservation status of the most abundant species and species with a high conservation status in abandoned, extensively grazed, intensively grazed and fertilised grassland

Bird species	Abandoned ($n = 4$)	Extensive ($n = 23$)	Intensive ($n = 24$)	Fertilised ($n = 9$)	SPEC conservation status
Sedge warbler *Acrocephalus schoenobaenus*	0.00	1.25	0.00	0.00	4
Skylark *Alauda arvensis*	0.80	10.10	7.03	6.72	3
Linnet *Carduelis cannabina*	4.77	0.00	0.00	0.00	4
Greenfinch *Carduelis chloris*	3.98	0.00	0.00	0.00	4
Quail *Coturnix coturnix*	2.39	0.14	0.13	0.35	3
White stork *Ciconia ciconia*	0.00	0.14	0.13	0.00	2
Red-backed shrike *Lanius collurio*	4.77	0.14	0.00	0.00	3
Lesser grey shrike *Lanius minor*	0.00	0.14	0.40	0.00	2
Black-tailed godwit *Limosa limosa*	0.00	0.69	0.00	0.00	2
Corn bunting *Miliaria calandra*	11.94	2.08	0.93	0.71	4
Yellow wagtail *Motacilla flava*	3.98	8.30	0.93	1.06	–
Curlew *Numenius arquata*	0.00	0.69	0.00	0.00	4
Great tit *Parus major*	5.57[a]	0.00	0.00	0.00	–
Winchat *Saxicola rubetra*	3.18	4.71	1.86	0.00	4
Stonechat *Saxicola torquata*	4.77	0.00	0.00	0.00	3
Starling *Sturnus vulgaris*	0.00	0.14	3.05[a]	0.00	–
Redshank *Tringa totanus*	0.00	0.14	0.00	0.00	2
Lapwing *Vanellus vanellus*	0.00	0.83	0.40	0.00	–

[a] Adults with fledglings.

had a subset of the species present at intensive grassland and their densities were lower. No winchat was observed.

4. Discussion

4.1. Vineyards

Bird species richness and abundance were highest in extensively used vineyards. The high diversity is probably due to the small scale of these vineyards and the variety of landscape elements. Tree sparrow, black redstart and song thrush were common in extensive vineyards. The first two species often nest in buildings, the last species in bushes and shrubs. Species common in forests (blackbird, chaffinch) or typical of open landscapes (skylark, stonechat) were also observed here. Thus the heterogeneity of extensively used vineyards allows species from a wide range of ecosystems to co-occur. Habitat heterogeneity is generally considered one of the most important determinant of farmland biodiversity (Isenmann and Debout, 2000; Benton et al., 2003).

The bird community of abandoned vineyards differed from extensive vineyards in subtle ways only.

On the less accessible slopes abandonment resulted in a vegetational shift towards shrubland which was reflected by the occurrence of species like barred warbler and red-backed shrike, typical of wood- and shrublands. On the more accessible slopes abandoned vineyards were regularly used for livestock grazing which may explain the relatively high numbers of skylarks. The virtual absence of tree sparrows and black redstarts was probably due to the absence of sheds and buildings.

Most notable in intensive vineyards was the absence (barred warbler, chaffinch) or low abundance (blackbird, song thrush, yellowhammer) of species that were relatively common in extensive vineyards. Intensively used vineyards had a more open character than the other vineyards, due to their large field size. Skylarks probably benefited from this. In general, the removal of hedgerows, fruit trees and shrubs has resulted in a loss of feeding, resting and nesting habitats thus in population declines (Lefranc, 1997; Suárez et al., 1997; Donald et al., 2001, 2002).

4.2. Grassland

The abundance and species richness of birds in extensive grassland was higher than in intensively grazed and fertilised but lower than in abandoned grassland. Ground nesting birds of open landscapes occurred in extensive grassland exclusively (black-tailed godwit, curlew, redshank) or in high densities (skylark, yellow wagtail). The low grazing intensity of the extensive grassland resulted in low rates of nest loss due to trampling (Beintema and Müskens, 1987). Unfertilised, structurally diverse and species rich vegetation such as in the National Park generally reduced the risk of nest discovery by predators (Vickery et al., 2001) and supported higher numbers of prey items than improved grassland (Rushton et al., 1989; Vickery et al., 2001).

The higher species richness and abundance of abandoned grassland may be explained by their greater heterogeneity and structural diversity and were probably underestimated as they were based on only four observations (Fig. 2). Abandoned sites consisted of a mosaic of grassland and bush suitable for grassland (yellow wagtail), shrubland (red-backed shrike) and woodland (great tit, greenfinch) species.

On both intensively grazed and fertilised grassland, species richness, abundance and diversity were significantly lower than on extensively grazed grassland. The same set of species that was observed in extensively grazed grassland occurred in intensively grazed and fertilised grassland but the densities were an order of magnitude lower. However, the sample size in fertilised grasslands was considerably smaller (Fig. 2). The density of yellow wagtail and winchat declined by 89 and 61%, respectively, from extensively grazed to intensively grazed grassland. Winchat was not observed on fertilised grassland. In western Europe, skylark, yellow wagtail and winchat all suffered 50–90% declines in population size between 1950 and 2000 (Busche, 1994; Hagemeijer et al., 1996; Chamberlain and Crick, 1999; van't Hoff, 2002) attributed to land-use intensification (Donald et al., 2001, 2002). However, for grassland birds, the main cause of the decline may be habitat deterioration after improved drainage, increased levels of fertiliser applications and increased stocking densities (Beintema et al., 1997; Vickery et al., 2001).

5. Conclusions

The productivity of Hungarian agriculture dropped significantly after the fall of the socialist system. Farmers with 100–300 ha farms do not use chemical fertilisers and pesticides because they are not profitable (Podmaniczky et al., 2000), which probably preserved a rich bird community. Farmland birds that have recently suffered serious declines in western Europe are still very abundant even on intensively used Hungarian farmland. The Hungarian shift from extensive to somewhat less extensive already resulted in a significant reduction in bird species richness and abundance.

In western Europe, the CAP has increased the level of both intensification and land abandonment in agriculture (e.g. Diáz et al., 1997; Pain and Pienkowski, 1997; Suárez et al., 1997; Chamberlain et al., 2000; MacDonald et al., 2000; Donald et al., 2001, 2002; Suárez-Seoane et al., 2002). The introduction of the CAP is likely to speed up the intensification of Hungarian agriculture and to result in significant areas of farmland being abandoned.

The current study provided one of the first examples that intensification in central and eastern European countries results in population declines of farmland birds similar to what has occurred in western Europe in the past decades (Busche, 1994; Hagemeijer et al., 1996; Chamberlain and Crick, 1999).

Although abandonment of extensive farming systems is believed to have negative consequences in terms of biodiversity (Diáz et al., 1997; Suárez et al., 1997; MacDonald et al., 2000; Suárez-Seoane et al., 2002), species richness and abundance in abandoned vineyards and grassland of Hungary generally had not decreased. There was a shift, however, from farmland birds in extensive vineyards and grassland to shrub- and woodland species on abandoned sites. This shift can be expected to progress as vegetation succession continues towards forest ending up in farmland species being replaced by woodland species entirely on abandoned farmland. In terms of biodiversity or species richness, abandonment may not necessarily result in losses, but may have adverse effects similar to intensification on the conservation of rare and threatened birds.

A possible way to counteract the adverse effects of the CAP could be the use of agri-environment schemes. Large numbers of farmers have joined the National Agri-Environmental Program introduced in Hungary in 2002 and farmland birds will benefit most from measures aimed at the conservation of existing extensive farming systems.

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