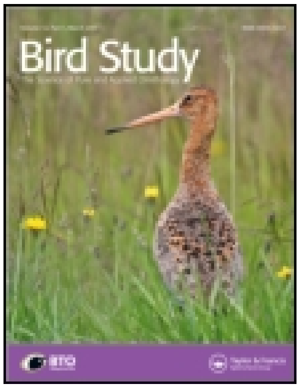

Bird Study

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/tbis20

The past and future of farmland birds in Hungary

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Published online: 22 Jun 2011.

Bird Study (2011) **58**, 365–377

REVIEW ARTICLE

The past and future of farmland birds in Hungary

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Capsule Populations of birds on farmland are larger and more stable in Hungary than in the UK and may provide baseline targets when planning population restoration programmes in more intensively farmed regions of Europe.
Aims To review the available evidence on farmland bird populations and their changes over the past century in Hungary, and to compare this with similar data for the UK.
Methods Published papers and grey literature were searched to determine long-term bird population trends for birds on farmland in Hungary, and for research evidence on the relationship between farmland management and bird diversity in Hungary.
Results Population density of common farmland birds is higher and trends are more positive in Hungary compared to the UK. These findings correlate with the recent change to generally less intensive agriculture in Hungary. However, while the birdlife associated with farmland in Hungary can be considered to have high diversity and density, it is still lower than it was in the first half of the 20th century and earlier. The few studies available showed that low-intensity traditional management promotes a rich biodiversity in both grasslands and arable systems in Hungary. Agri-environment schemes were introduced when Hungary joined the EU in 2004; however, their influence on biodiversity has not been systematically monitored.
Conclusions Insights emerging from farmland bird research in those European countries which still practice extensive agricultural techniques could be used to set general baseline targets for restoring biodiversity in regions where farmlands are now intensively managed. At the European scale urgent tasks are to: (1) investigate the relationships between management and bird diversity and density on a much wider geographical scale, (2) evaluate the geographical generality of the existing evidence base (which is mainly based on studies conducted in more intensively farmed regions), and (3) enhance the policy impact of conservation research.

It is widely accepted that agricultural intensification is a major reason for the large-scale loss of farmland bird populations in Europe (e.g. Donald *et al.* 2006). Monitoring programmes throughout Europe have documented the negative population trends of different species (e.g. Gregory *et al.* 2004, Newton 2004, De Laet & Summers-Smith 2007), and others have investigated the background mechanisms of population declines (e.g. Atkinson *et al.* 2004, Hart *et al.* 2006, Siriwardena *et al.* 2007, Field *et al.* 2008, Revaz *et al.* 2008). However, most studies come from only a few countries in Western Europe which have similar climate and biogeography. Furthermore, there is limited scientific evidence from many farmland types and regions of Europe on the effects on birds of management and landscape (Fig. 1). There are at least three reasons why expanding farmland research in Europe is an urgent task and why knowledge from traditionally used, species rich farmlands is important.

First, there is a large variability of climate, biogeography and biodiversity in Europe. The geographically restricted research to date therefore covers only a small part of the variability (Schifferli 2000, Donald *et al.* 2002, Kleijn & Báldi 2005, Whittingham *et al.* 2007,

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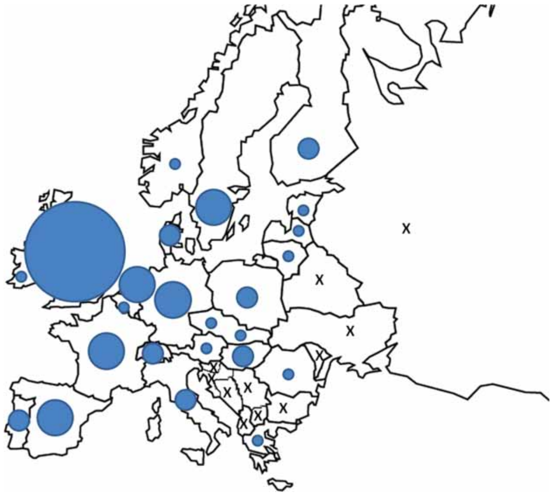

Figure 1. Number of published scientific papers on farmland bird biodiversity research per country in Europe. A search was made on ISI Web of Science on 24 April 2009, using ('agricultur*' OR farmland) AND ('species richness' OR biodivers*) with Address = (country by country), then a search for 'bird' within hits. Time span is from 1975 to date of search. The area of circles proportional to the number of papers: largest circle is for UK, and refers to 2167 hits. Large circles are for France (52), Netherlands (50), Germany (42), Spain (42) and Sweden (35). Medium circles are for 7 countries between 12 and 16 hits. Small circles are 12 countries with 1 to 9 papers. X refers to searches which found no records (12 countries).

Liira *et al.* 2008, McAlpine *et al.* 2008, Nagy *et al.* 2009, Zanini *et al.* 2009, Hartel *et al.* 2010, Schaub *et al.* 2011). Understanding the effects of variability on farmland biodiversity is a key issue for effective management. An example of contradictory results from different regions is the different habitat selection of Sky Larks *Alauda arvensis*. They prefer small fields in France (Eraud & Boutin 2002), as opposed to large homogeneous landscapes in Hungary (Batáry *et al.* 2007, Erdős *et al.* 2007, Nagy *et al.* 2009).

Secondly, large sums of money have been invested with the aim of improving biodiversity on the impoverished intensive farmlands of Western Europe. The objectives of agri-environment schemes (AESs) designed to achieve such improvements are poorly defined only in general terms, e.g. restoring species rich farmlands, and this is a common shortcoming in most restoration/improvement projects (Hobbs 1999, Miller & Hobbs 2007, Kleijn & Sutherland 2003). One of the main background problems is that proper definitions of the desired extensive farming systems are missing (Dallimer *et al.* 2009). Patterns and processes at times when farmlands were used at a low intensity and were species-rich are unknown or poorly documented in most Western European countries. This gap can be partly filled by scientific evidence from the still diverse traditional farmland systems in countries of Central and Eastern Europe, if adapted to local environmental, cultural and economic conditions (Attwood *et al.* 2009). Using evidence from the still-traditional European farming systems, it may be possible to establish key rules which underlie the relationships between management and biodiversity. This can help to define clear goals and to set the aims of baseline farming (Lennartsson & Helldin 2007). A baseline farming system should set targets in biodiversity, landscape heterogeneity and local management intensity. Prescriptions may be usefully based on data from traditional systems and their adaptation to the conditions in a new biogeographic region. However, caution is needed, as species' biology and community composition might differ between regions.

Thirdly, the dynamics of most ecological systems are complex and non-linear, and sudden shifts in state are expected at certain thresholds (Fahrig 2001, Sasaki *et al.* 2008, Suding & Hobbs 2009, Swift & Hannon 2010). Curvi-linear changes are well-known in agro-ecology (Chamberlain *et al.* 2000, Sasaki *et al.* 2008, Kleijn *et al.* 2009, Geiger *et al.* 2010), and are illustrated by the population declines of farmland birds such as Tree Sparrows *Passer montanus* or Corn Buntings *Emberiza calandra* in the UK (Gregory *et al.* 2004). Finding the thresholds in farmland management, e.g. at what level of intensification farmland biodiversity will collapse and at what level it is still sustainable, is essential for farmland conservation. However, with knowledge mostly from intensive farmlands, the determination of threshold values is unfeasible. Identification of thresholds can orient policymakers towards the most threatened farming systems, where biodiversity is close to collapse, and hence in need of urgent action.

Therefore, the understanding of management and landscape effects on farmland biodiversity in a wide range of different agricultural systems of Europe is a vital next step towards proper management and restoration of species rich farmlands. In this review, we focus on Hungary and the UK, to illustrate the striking differences in agricultural practice and farmland biodiversity. We chose Hungary due to the availability of data to us, and the UK, because this is the best studied country regarding long-term data on farmland birds (Fig. 1), the strong influence of ornithology on policy, and, finally, because UK solutions have strong influence at the EU level. In addition, details are presented on Hungarian farmland birds, partly from lesser known publications, in order to provide more evidence from this region, to contribute to a less biased knowledge of

European farmland biodiversity. Specific aims of this review are to:

- evaluate changes in agriculture and farmland bird populations in the last 150 years with the aim of identifying key issues in policy and economics in Hungary, with data from the UK to provide context,
- present long-term population changes of farmland bird species in Hungary,
- show the current state and predict the future of farmland bird populations in Hungary, and
- provide some more general information on the relationships between birds and farming in Central Europe.

HUNGARIAN AGRICULTURE, LAND USE AND FARMLAND BIRD POPULATIONS IN THE LAST 150 YEARS

Variation in farmland across Europe is partly a consequence of history (Pain & Pienkowski 1997). Effective management of farmland birds needs to be placed into a historical context in which the roots of present population trends can be identified, and where we can learn from previous experience. The 20th century provided several 'experiments', when large-scale agricultural changes occurred in Central Europe (Tryjanowski 1999, Báldi & Faragó 2007, Flade *et al.* 2008, Reif *et al.* 2008, Pullin *et al.* 2009, Stoate *et al.* 2009). In Hungary, the changes in the economy which followed had a considerable impact on agriculture. In the 1950s, about 1 million small family farms were forced to combine into a few thousand large state farms or cooperatives (collectivization) (Ángyán *et al.* 2003). After this amalgamation, agriculture intensified in the 1970s, e.g. field size and the use of agrochemicals increased (Ángyán *et al.* 2003). As far as changes in biodiversity can be assessed, farmland birds declined during the period of intensive socialist agriculture in the 1970s and 1980s (Báldi & Faragó 2007, Reif *et al.* 2008). In 1989, the socialist regime collapsed. Agriculture changed from centrally regulated to a market regulated economy. This led to increased farmland biodiversity during the transition due to extensification and abandonment [e.g. 80% decline in fertilizer application (Báldi & Faragó 2007, Liira *et al.* 2008, Reif *et al.* 2008)]. Finally, the introduction of the EU's Common Agricultural Policy (CAP) was the last large-scale change in agriculture in 2004 when Hungary joined the EU. As the CAP has been designed from a Western European perspective, its effect is controversial, partly because it provides unprecedentedly high funding for wildlife friendly management via AESs, but has also encouraged intensification of agriculture (EEA 2004). The Hungarian farmland bird population index has been declining since 2005 (Fig. 2, Báldi & Szép 2009), but current analyses suggest an increase in 2008 (Tibor Szép, pers. comm.). Thus, there is no clear fingerprint of the introduction of the CAP.

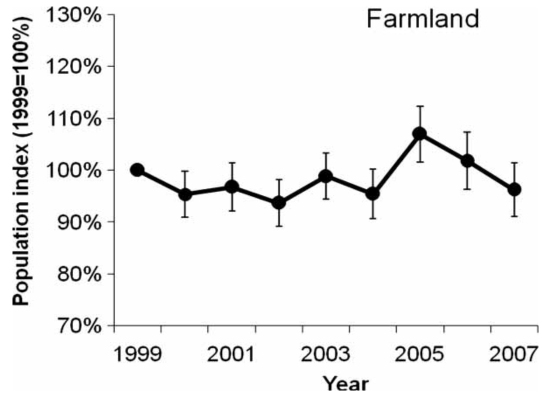

Figure 2. Change in farmland bird population index based on 16 species between 1999 and 2007 in Hungary based on the Common Bird Census (modified from Báldi & Szép 2009).

Land use and farming intensity

One of the most diverse farmland habitats in Hungary is grassland. Most of it is secondary, as the natural land cover in the absence of humans is primarily forests (Fekete & Varga 2006). However, during the millennia of human land use forests were converted to pastures and arable land. In the last two centuries, both grassland and arable areas decreased (Figs 3 & 4), whereas forest and built-up areas increased. Despite the steady decline of arable and pasture habitat area, the productivity of these lands varied considerably (Figs 3 & 4). Livestock density was about 1600 head/1000 ha of permanent pasture a century ago (about 350 head/1000 ha agricultural area, Fig. 3). It halved during World War II, but increased again to about 2000 during socialism. After the collapse of this system, however, it declined to nearly 1000 head/1000 ha of permanent pasture. The corresponding UK value is more than twice as high (Table 1).

Cereal yield was 1000–1500 kg/ha before the 1960s (Fig. 4). From then on, yield increased exponentially up to about 5000 kg/ha in the 1980s. After the collapse in 1989, it decreased to 3–4000 kg/ha. The current UK wheat yield is around double that in Hungary (Table 1).

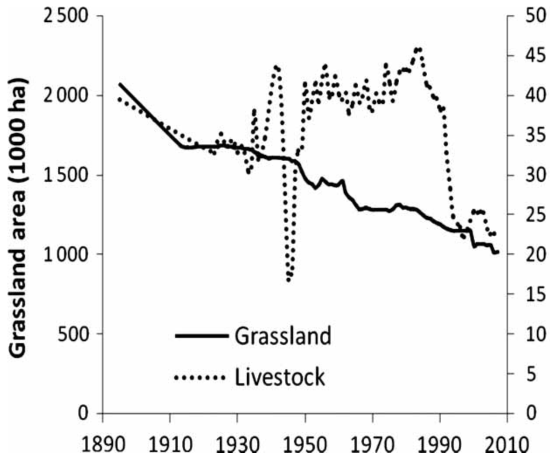

Figure 3. Area of grassland (in 1000 ha), and livestock density (number on 100 ha agricultural area) in Hungary from 1895. Data are from the Hungarian Central Statistical Office (URL: http://www.ksh.hu).

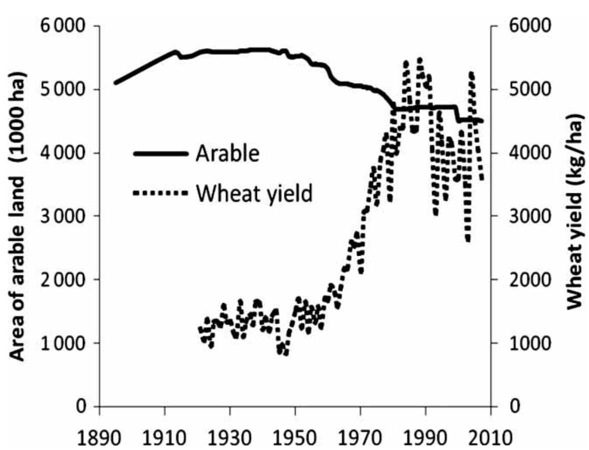

Figure 4. Area of arable land in Hungary from 1895 (in 1000 ha), and the yield of wheat from 1921 (in kg/ha). Data are from the Hungarian Central Statistical Office (URL: http://www.ksh.hu).

Other UK agriculture statistics also indicate a much higher productivity than in Hungary (Table 1). This difference is most pronounced in chemical use, e.g. artificial fertilizer application in grasslands (Table 1).

Birds in changing farmland

How have economic changes influenced farmland bird populations over the past century via land use and management intensity? Long-term or historical data are available for five farmland bird species in Hungary. For three species hunting statistics are available. The reliability of such sources are often criticized, as data reports are based on estimates, may be biased by subjective factors and cannot be repeated. In addition, societal changes during the included period were dramatic; thus hunting pressure and reporting accuracy both fluctuated largely. This should be considered if quantitative baselines for management are compared among countries. However, our aim in presenting old hunting bag data is not to provide population estimates, but to show that a century, or even less time ago, now globally threatened, and/or dramatically declining species were regularly hunted in large numbers. This is to illustrate the richness of farmland birdlife in historical Hungary.

The hunting bag of the now endangered Great Bustard *Otis tarda* was around 500 individuals/year at the turn of 19th and 20th centuries in Hungary (Fig. 5), probably indicating a large population of tens of thousands of individuals. Recent numbers include only 1200 individuals (Bankovics 2005). We have detailed data on Great Bustards in the Hungarian Little Plain (Kisalföld) region in NW Hungary. This population was estimated at around 900 individuals in the 1900s. It was halved by the 1950s, and was a few tens around 1990. Faragó (2005) argued that the loss of this Great Bustard population is the consequence of many factors including winter food shortage in extreme harsh winters, flooding of nests, land-use changes, mainly afforestation, and changes in crop structure (loss of half of the suitable cereal habitats, which were converted to sugar beet, alfalfa, maize and sunflower) and an increase in predation (Faragó 2005). A similar decline was observed in Poland (Tryjanowski *et al.* 2009a).

Corncrakes *Crex crex* are another globally threatened species, inhabiting grasslands and responding negatively to intensive management (Berg & Gustavsson 2007). The recent population estimate for Hungary is 500–1200. At the turn of the 20th century, however, the average yearly hunting bag was >2000 individuals (Fig. 5), indicating a breeding population probably many times larger than the recent one.

The population of Grey Partridges *Perdix perdix* increased for nearly half a century, indicated by the number of individuals (Fig. 5). These were calculated from hunting bag statistics, using the 1960–1970 data on both hunting bag and population estimate data to determine their ratio. We then used this ratio to calculate the number of individuals from historical hunting bag data (Csányi 2008, Faragó 2009). This analysis assumes that the behaviour of hunters (individually and collectively) has been constant. If hunters have become more efficient over time, the decline could have been larger than is depicted here. The population

Table 1. Characteristics of agriculture in Hungary and the UK. [*Source*: FAOSTAT (URL: http://faostat.fao.org/), downloaded on 15 May 2009, if not indicated otherwise.]

	Hungary	UK
Country area (1000 ha)	9303	24 361
Farmland area (1000 ha)	5860 (63% of country)	16 976 (69%)
Arable area (1000 ha)	4602 (49%)	5,753 (24%)
Grassland area (1000 ha)	1059 (11%)	11,173 (46%)
Fertilizer use on grassland (kg/ha)	<5 % fertilized at all[1]	110[2]
Fertilizer use on arable crops (kg/ha)[3]	115.3	303.7
Pesticide use (kg/ha)[4]	1.1	5.8
Distribution of main farming types[5]	19% granivores, 17% mixed crops–livestock, 16% mixed livestock, 15% permanent crop, 15% field crop	52% grazing livestock, 14% field crops
Average farm size (ha)[5]	26	81
Number of tractors (per 1000 ha)[6]	117 600 (2.0)	500 000 (2.9)
Milk yield[6]	61 938 Hg/An	67 917 Hg/An
Wheat yield[6]	3920 kg/ha	7748 kg/ha
No cattle/1000 ha permanent pasture[6]	718.5	936.1
No sheep/1000 ha permanent pasture[6]	1144.7	3245.2

[1] Nagy (1998).
[2] Data for N only, and from Agricultural Industries Confederation (URL: http://www.agindustries.org.uk), Fertilizer Statistics 2006.
[3] Nutrient (NKP) content of used fertilizer on temporary and permanent crop. Data from the EarthTrends – The Environmental Portal of the World Resource Institute (URL: http://earthtrends.wri.org/searchable_db /).
[4] Amount of total pesticide used per hectare of arable and permanent cropland. Data from the EarthTrends – The Environmental Portal of the World Resource Institute (URL: http://earthtrends.wri.org/searchable_db/).
[5] Council for the Rural Area, Utrecht, The Netherlands (URL: http://www.rlg.nl/cap/sheets.html).
[6] Tractor numbers, yields, and livestock numbers are averaged for 2000–2007.

trend of partridges changed parallel with a moderate decrease of pastures, and an increase in arable area (Figs 3–5). From the 1930s the population has been declining, with a peak after the collapse of socialism (Fig. 5, Báldi & Faragó 2007).

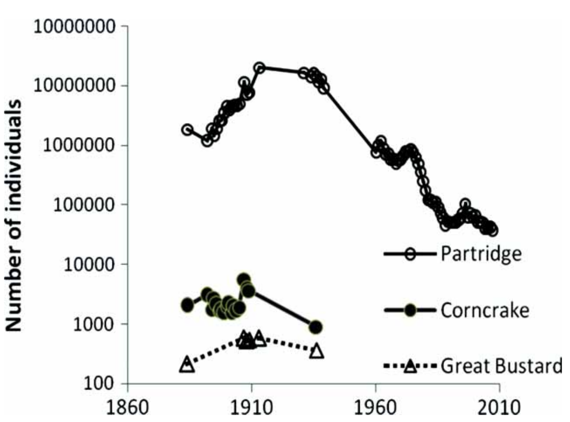

Figure 5. Number of shot Great Bustards and Corncrakes, and the population size of the Grey Partridges in Hungary (Csányi 2008, Faragó 2009). The population size for partridges is available from 1960. The ratio of number of shot individuals and population estimate between 1960 and 1970 was used to calculate the population estimates for earlier data from the hunting bag records. The last figure for Great Bustards and Corncrakes is averaged for 1935–38.

White Storks *Ciconia ciconia* use farmland for foraging in Hungary. Their trend showed a sharp decline until the 1970s, then stabilized with some fluctuations (Fig. 6). The unique nesting site requirements of this species (i.e. chimneys, and more recently electricity pylons), together with land-use changes driven by the demand

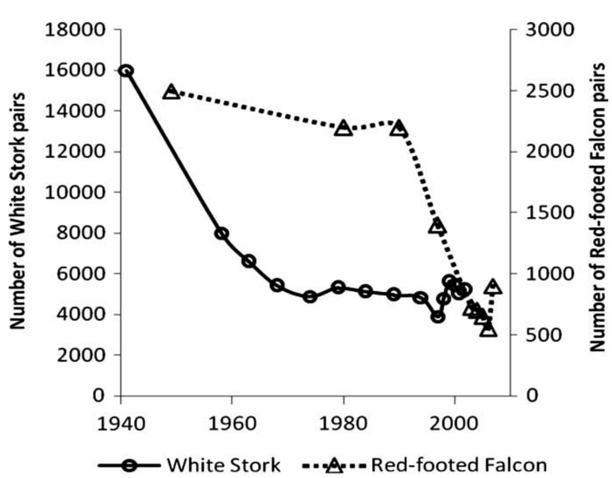

Figure 6. The estimated number of breeding pairs of White Storks (Lovászi 2004) and Red-footed Falcons (Fehérvári *et al.* 2009) in Hungary.

of agriculture for the drainage of wet meadows, the main feeding sites of the stork, has probably had an additional influence on White Stork abundance Lovászi 2004, see also Tryjanowski *et al.* 2009b for description of similar changes in Poland).

A different pattern of decline is apparent in Red-footed Falcons *Falco vespertinus*, a farmland raptor species. They declined moderately until the 1990s, but subsequently the population collapsed (Fig. 6). This trend is explained by their dependence on Rook *Corvus frugilegus* nests for breeding. Rooks decreased by 90% followed by an eradication campaign in the 1980s (Fehérvári *et al.* 2009). Hence, while four of the five population trends can be related directly to agricultural intensification (Great Bustard, Corncrake, Grey Partridge, probably White Stork), the decline of Red-footed Falcons has a different cause.

In the Czech Republic farmland bird population trends between 1982 and 2003, before and after the collapse of socialist agriculture in 1989, cannot be explained solely by agricultural intensification (Reif *et al.* 2008). In the Czech Republic, Romania and also in the Baltic states, the abandonment of agricultural production was an important factor shaping farmland bird populations (Herzon *et al.* 2006, Kuemmerle *et al.* 2009, Reif *et al.* 2008). We can conclude, therefore, that the relationship between population declines and agricultural change has been driven by different mechanisms across Europe. These differences may result from the largely non-overlapping ranges of agricultural change in the UK and in Hungary (Fig. 7), and from the different

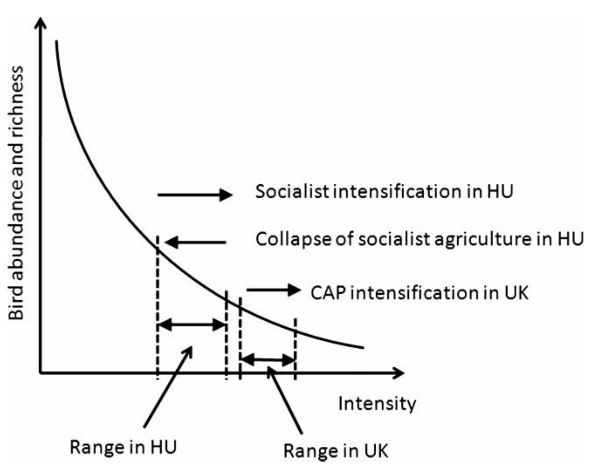

Figure 7. A hypothetical figure to show the non-linear relationship (Kleijn *et al.* 2009) of farmland management intensity, and abundance and species richness of birds explaining the differences between Hungary (HU) and the UK.

species sets in the two countries. Further research in a wider geographical range of farmland may help to understand this relationship. For example, we suggest that important lessons are to be learned by studying the relationships between bird populations and agricultural practices in Romania or Ukraine on the still traditionally used farmlands, or in Western Russia (East European Plain) on small private and large farms.

Farmland bird populations and trends in Hungary

The state of common farmland bird populations in Hungary, their numbers, densities and trends are compared with the UK (Table 2). Roughly one-third of the 18 species considered had larger populations in the UK than in Hungary (Burfield & van Bommel 2004). However, once population sizes are corrected for the agricultural area, 15 out of 18 show a higher density in Hungary, some species by orders of magnitude, for example Red-backed Shrikes *Lanius collurio* and Eurasian Tree Sparrows *Passer montanus* (Table 2). Similar differences are obvious if population trends are compared. From the 16 species with trend data available for both countries, none are declining in Hungary, while 12 are declining in the UK.

More recent and detailed data are available from the Hungarian Common Bird Census program (Szép & Nagy 2006) initiated in 1998. This census employs stratified random site selection (Szép & Nagy 2006). Some 300, 2.5 × 2.5 km UTM (Universal Transverse Mercator coordinate system) squares are surveyed each year. In the last ten years, the farmland bird population index (geometric mean of trend of farmland bird species) was stable (Szép & Nagy 2006, Báldi & Szép 2009). The trends of individual farmland bird species listed in Table 2 vary: there is no overall trend in most species (10 species), partly due to a lack of trend change within the ten-year time window. For two species (Stone Curlews *Burhinus oedicnemus* and Black-tailed Godwits *Limosa limosa*) no trend was calculated. Three species have declined moderately (Barn Swallow *Hirundo rustica*, Crested Larks *Galerida cristata*, Sky Larks), while three have moderately increased (Northern Lapwings *Vanellus vanellus*, Tree Sparrows, Yellow Wagtails *Motacilla flava*). Because agricultural intensification is still below the Western European level (Table 1), there is some hope that this rich and more or less stable avifauna (Fig. 2) can be saved by appropriate measures in the form of AESs.

Table 2. Comparison of characteristics of common farmland bird status between Hungary and the UK (*Source*: Burfield & van Bommel 2004). Minimum and maximum population size and trend estimates (1990–2000) are given for Hungary and the UK. The density of species per 100 ha agricultural area is also given.

English name	Scientific name	SPEC[1]	Min Hun pop.	Max Hun pop.	Min UK pop.	Max UK pop.	Hun pop./100 ha	UK pop./100 ha	Hun pop. trend	UK pop. trend
Barn Swallow	*Hirundo rustica*	3	220 000	320 000	726 000	726 000	4.61	4.28	0 (0–19%)	+ (18%)
Black-tailed Godwit	*Limosa limosa*	2	400	1500	40	48	0.02	0.0002	F[2]	– (19%)
Common Kestrel	*Falco tinnunculus*	3	3500	5000	36 800	36 800	0.07	0.22	0 (0–19%)	– (28%)
Common Starling	*Sturnus vulgaris*	3	710 000	990 000	804 000	804 000	14.51	4.74	0 (0–19%)	– (33%)
Common Whitethroat	*Sylvia communis*	4	210 000	320 000	945 000	945 000	4.52	5.57	0 (0–19%)	+ (41%)
Corn Bunting	*Emberiza calandra*	2	165 000	225 000	8500	12 200	3.33	0.06	0 (0–19%)	– (47%)
Crested Lark	*Galerida cristata*	3	190 000	340 000	0	0	4.52	0	+ (20–49%)	
Eurasian Sky Lark	*Alauda arvensis*	3	730 000	900 000	1 785 000	1 785 000	13.91	10.51	0 (0–19%)	– (15%)
Eurasian Tree Sparrow	*Passer montanus*	3	2 000 000	2 800 000	68 000	68 000	40.96	0.40	0 (0–19%)	– (38%)
European Goldfinch	*Carduelis carduelis*	non	690 000	910 000	313 000	313 000	13.65	1.84	0 (0–19%)	+ (36%)
European Turtle-dove	*Streptopelia turtur*	3	165 000	215 000	44 000	44 000	3.24	0.26	0 (0–19%)	– (42%)
Northern Lapwing	*Vanellus vanellus*	2	93 000	150 000	137 000	174 000	2.07	0.92	0 (0–19%)	– (15%)
Red-backed Shrike	*Lanius collurio*	3	540 000	670 000	0	5	10.32	0.00	0 (0–19%)	– (45%)
Stone Curlew	*Burhinus oedicnemus*	3	150	250	214	227	0.003	0.001	0 (0–19%)	+ (81%)
Whinchat	*Saxicola rubetra*	4	95 000	180 000	11 000	22 100	2.35	0.10	0 (0–19%)	– (21%)
Woodpigeon	*Columba palumbus*	4	77 000	110 000	2 570 000	3 160 000	1.60	16.88	+ (20–49%)	+ (17%)
Yellow Wagtail	*Motacilla flava*	non	150 000	225 000	11 500	26 500	3.20	0.11	0 (0–19%)	– (50–79%)
Yellowhammer	*Emberiza citrinella*	4	630 000	855 000	792 000	792 000	12.67	4.67	0 (0–19%)	– (34%)

[1] SPEC: SPecies of European Conservation concern. 1, Globally threatened species; 2, European species that have unfavourable conservation status; 3, global species that have unfavourable conservation status in Europe; 4, species with favourable conservation status in Europe, but whose populations are mainly in Europe; non, Species without SPEC category (Burfield & van Bommel 2004).

[2] F means largely (>20 %) fluctuating population size, but no clear trend.

Effects of farmland management

In contrast to the UK, there have been no detailed studies of management effects on farmland birds in Hungary in the last century. Below we briefly review the evidence, which can be used to guide the design of effective AESs. Simay *et al.* (2006) compared bird populations of very extensively grazed areas (100 horses and cattle on 2400 ha) and heavily used pastures (1200 sheep on 300 ha) in the Hortobágy National Park. In the majority of bird species they found no difference in the number of breeding pairs. Báldi *et al.* (2005) found equally rich farmland bird assemblages on paired samples of extensively and intensively grazed pastures in three regions of the Hungarian Great Plain. However, when focusing on grassland specialist bird species, then both species richness and the number of territories were negatively affected by higher grazing pressure (Batáry *et al.* 2007, Erdős *et al.* 2009). On a wide range of management intensities, Verhulst *et al.* (2004) showed that both species richness and abundance of grassland birds peaked on abandoned and extensively grazed land, followed by lower figures on intensive grasslands, and minima on fertilized meadows. In another Central European grassland system, extensive grazing maintained the most diverse bird assemblages (Nikolov 2010). Studies from Britain support the view that grassland improved by, for example, large amounts of fertilizer (Table 1) hold much poorer bird assemblages (Vickery *et al.* 2001, Newton 2004). Hence, the present levels of grazing pressure in Hungarian lowland grasslands are appropriate to maintain biodiversity, while improvement by fertilizer application should be avoided. Support for chemical-free products, ecotourism, or even hunting could contribute to a more balanced rural economy and the conservation of biodiversity.

Viszló & Karsa (2007) argued that the best timing for mowing semi-natural grasslands for many grassland birds, such as Yellow Wagtails, Stonechats *Saxicola torquata* and Whinchats *S. rubetra*, is around 20 June, after chicks have fledged, but when the hay gathered is still nutritious for livestock. They also suggested a slow mowing speed, and the use of a game-disturbing chain on the front of the tractors, which effectively chases away hiding species, such as Common Quail *Coturnix coturnix* (Viszló & Karsa 2007). The prescription of AESs for the protection of Great Bustards allows early mowing only, before 25 April. Lóránt *et al.* (2008) systematically searched conventional and AES fields, and found that early mowing also improved the nesting success of species other than Great Bustards, such as Sky Larks, Yellow Wagtails and Corn Buntings. Although the two studies suggested different mowing dates, they agreed that mowing should avoid the main breeding season of ground nesting farmland birds. The setting of a mowing date, which allows all meadow birds to survive and breed successfully, seems to be a complex, and presumably unattainable task, due to differences of breeding dates and the occurrence of second broods in some species, such as Sky Lark and Quail, resulting in the continuous presence of nests in grasslands until late summer (Breeuwer *et al.* 2009).

On larger spatial scales, Batáry *et al.* (2007) and Erdős *et al.* (2007) showed that an increasing length of boundaries (between land covers/habitats), i.e. increasing heterogeneity, has a negative influence on the density of grassland specialist species. This suggests that heterogeneity, which is usually favoured in the farmland biodiversity literature (e.g. Benton *et al.* 2003) may not be adequate in all farmland bird species in Europe (Batáry *et al.* 2011). However, local-scale heterogeneity, such as structured and diverse vegetation, does seem to benefit birds, which have been shown to avoid heterogeneity at the landscape scale in Hungary (Erdős *et al.* 2009).

Few studies have investigated farmland birds on non-grassland habitats in Hungary. Along a gradient of increasing fertilizer application from 0 to 240 kg N/ha/year, Kovács-Hostyánszki *et al.* (2011) found no significant trend between fertilizer input and farmland birds in winter cereal fields. This weak reaction of bird diversity in arable fields to fertilizer use contrasts with studies from Western Europe (e.g. Stoate *et al.* 2001). It can be explained by the generally low intensity of agriculture, and/or by the rich supply of semi-natural habitats in the landscape. In the Baltic states Herzon *et al.* (2008) showed clear negative effects of intensive farmland management on bird populations at a county level. Verhulst *et al.* (2004) studied the avifauna of vineyards comparing abandoned, intensive (= homogeneous), and extensive (=heterogeneous) sites. Most bird species and individuals occurred on extensive and least on intensive fields in the famous Tokaj vine region. Birds profit from the heterogeneity of extensive sites (small fields, fruit trees, shacks, etc.), as expected from data in Benton *et al.* (2003), although chemical use there was similar to the use in intensive vineyards.

In grasslands, recent grazing practices seem to have slight effects on farmland birds in general, although they have significant effects on grassland specialists which breed and forage on the ground. However, intensification in terms of fertilizer application significantly reduces farmland bird populations. Regarding arable and other crop types, the lack of information is obvious, and no solid conclusion can be drawn. There is an urgent need for research, since more than half of Hungary is covered by arable land; therefore, the conservation of farmland birds largely depends on management practices there.

Studies on wintering farmland birds are almost non-existent in Hungary. Comparisons with the UK would be rewarding in species differing in migratory habit, such as Sky Larks (which are resident in the UK and migratory in Hungary). Field *et al.* (2007) compared the winter bird populations on conservation tillage with conventional arable fields in Western Hungary. They generally found that conservation tillage can be attractive to seed-eating birds. Erdős *et al.* (pers. comm.) found that wintering farmland birds prefer stubble fields, where seeds of the former crops (mainly sunflower) were left after harvesting, possibly due to inefficient machinery. Inadequate technology was probably the reason why Common Cranes *Grus grus* used to overwinter in Hungarian arable fields, foraging on leftover maize seeds (Végvári 2002). Therefore, food seems to play a key role in winter survival of farmland birds in Hungary, which is similar to the results found in the UK (Siriwardena *et al.* 2007, Siriwardena 2010). Intensification by advanced technology and machinery may have a detrimental effect on wintering birds, unless it is mitigated by AESs to improve winter food supply. However, such AESs may not be efficient, as examples from the UK suggest (Siriwardena 2010).

Missing research for policy

Despite a promising increase in farmland bird research in Hungary, including several more unpublished research and restoration projects, there are no direct links among the key players. The agricultural ministry, leading most of the agri-environment programmes, does not support farmland biodiversity research, nor does it consider conservation biology knowledge in a systematic manner. On the contrary, in the UK the responsible authority (Defra) has been a major supporter of relevant research to explore the effects of existing or planned AESs. The main flow of information from researchers to decision makers is via nature conservation organizations ranging from national parks to non-governmental organizations (NGOs), who are involved in making often local decisions according to regulations. However, this depends on personal contacts and the enthusiasm of individual nature conservationists and NGOs. Except for a few Environmentally Sensitive Areas, the monitoring of the effects of AESs in Hungary is still in the design stage, despite the fact that AESs began in 2004 (Stoate *et al.* 2009). This missing link to policy makers hampers the application of scientific results for the improvement of future agri-environment measures (IEEP 2008).

DISCUSSION AND CONCLUSIONS

Lessons from the past

The area of farmland habitats in Hungary has been decreasing for more than a century. Agricultural productivity, such as cereal yield and livestock density (Figs 3 & 4), has varied greatly and reflected political changes, including World War II and the intensification and subsequent collapse of socialist agriculture. Therefore, the first lesson to be learnt is that level of agricultural production seems to be more important than land use as an indicator of large-scale changes in agriculture.

The second lesson is that country-wide, drastic interventions can have positive effects on farmland birds. The collapse of socialist agriculture resulted in the restructuring of agriculture. Agrochemical use drastically declined (e.g. an 80% decrease in fertilizer use), the number of land owners increased by three orders of magnitude, and governance changed from central to market regulation (Báldi & Faragó 2007), i.e. a complete change in agricultural focus, from production and management to trade and ownership. However, during several years of transition, the ownership of much land and the availability of subsidies were uncertain. Thus management ceased, which resulted in an increase in abandoned land. Similar patterns were described from other Central European countries, such as Estonia, where 25 % of arable fields were abandoned (EEA 2004), and Poland, where 2 million ha of farmland (11%) were abandoned (Orłowski 2005). In Romania, 21% of farms were abandoned due to declining returns from farming, tenure insecurity and demographic shifts in agricultural population (Kuemmerle *et al.* 2009). As shown in the UK (Henderson & Evans 2000), the fallow lands that resulted from these changes can provide good nesting and summer and winter foraging habitat for farmland birds, but they become less suitable as abandoned land eventually turns to scrub. As a result, Central European farmland bird population indices increased by 20–30% in the 1990s (Gregory *et al.* 2005).

The third conclusion is that although present Hungarian farmland biodiversity is high, it has been even higher in the past. The very few examples from other Central

European countries support the generalization of this result to the Central European level (Tryjanowski 1999, Orłowski & Ławniczak 2009).Therefore, the determination of a baseline farming system is a great challenge. Which former historical state of farming system should be used as an example, and how may this fit into the current economic and social environment? The answer could be somewhat arbitrary and will depend on nature conservation priorities. Research in areas which are more extensive than those carried out recently in Hungary may provide some answers to these questions. Many farmlands in, for example, Transylvania (Romania) are still managed without fertilizer even on arable fields, using traditional mixed farming, and a great variety of field types occur in the rural landscape (Ruprecht 2006, Hartel *et al.* 2010).

Lessons from Central Europe for general farmland bird ecology

The uneven distribution of farmland biodiversity research in Europe is a major shortcoming in understanding and effectively conserving farmland biodiversity. The lack of research in Central European countries which have less intensive farming may hamper the design of effective AESs there. On the other hand, the research bias towards systems with an intensive agriculture, as commonly found in Western Europe, may impede the establishment of less intensive baseline farming systems in Western Europe. The extension of research to less-intensive parts of Central Europe might overcome in part the lack of knowledge of how traditional agriculture influenced biodiversity decades ago in the, recently intensified, Western European farmlands. Populations of farmland birds in Hungary might provide a useful baseline for setting conservation targets in the UK and elsewhere. However, due to variations in the biotic and abiotic environment, these may serve best as general reference points rather than precise targets.

Farms in Central Europe may be considered as extensive traditional baseline systems. However, the determination of a baseline is still difficult, due to time lags in the response of biodiversity to management and landscape changes. Studies addressing the effect of land use history or management change usually confirm that there is an extinction debt, which is the delayed species loss due to conversion of species rich habitat (e.g. Chamberlain *et al.* 2000, Sarah *et al.* 2004, Helm *et al.* 2006, but see Adriaens *et al.* 2006). Therefore, a baseline farming system should have been stable and without major changes for some time. However, in view of the large variations of farmland history in Hungary, and probably elsewhere in Central Europe, such stable systems are unlikely to exist except for remote areas.

Another important issue is the identification of landscape and management thresholds at which farmland bird populations suddenly collapse. In general, such a single threshold for a landscape does not exist (Fahrig 2001), and the long-term trajectories of five bird species in Hungary seem to support this, as the shape of decline is different between them. Several studies have shown that semi-natural habitats in the intensive agricultural matrix may be vital for bird populations (e.g. Berg 2008, Giralt *et al.* 2008, Rodriguez & Bustamante 2008, Batáry *et al.* 2010). Regarding management, Kleijn *et al.* (2009) in a European-scale study demonstrated that plant species richness in grassland declines exponentially if nitrogen is added, while in arable systems the decline is less drastic (see also Billeter *et al.* 2008). Geiger *et al.* (2010) found exponential relationships between yield and species richness in plants, carabids and birds.

We have demonstrated that farmland bird populations increase even on a large spatial scale if the economic background changes drastically, such as when the socialist regimes in Central Europe collapsed, although this was obviously not a deliberate conservation measure. We therefore expect that such 'broad-and-deep' measures will have considerable effects on farmland birds. This conclusion has theoretical relevance in understanding the relationship between biodiversity and farmland management. In reality, not only large-scale but also small-scale 'narrow-and-deep' changes away from intensive farming can increase bird numbers (Henderson *et al.* 2009). These might include, for example, reduction in fertilizer use and increase in crop diversity and the introduction of non-crop fields at a farm scale.

In the last decade, populations of Hungarian farmland birds were large and remained more or less stable. The task is to maintain or improve this situation. There would seem to be a requirement to prevent both intensification and abandonment, the major threats to Central European farmlands (Stoate *et al.* 2009), while maintaining income for farmers. Recently, considerable funding has become available for environment and land management (IEEP 2008). Using this fund with other possibilities, such as ecotourism, producing organic food, hunting, etc., has the potential to provide income for farmers. For example, nearly one-third of Hungary is under AES. Intensification, on the other hand, may generate even higher incomes for farmers than AESs, but AESs could still provide economically viable alternatives for them. The reason is partly the unpredictable commodity prices due to market fluctuations and partly climatic variability (note that only a few percent of the Hungarian agricultural fields are irrigated during the warm and dry continental summers).

For successful conservation of farmland birds, there is a need for research evidence to design prescriptions. This is currently not available for two main reasons. First, although AESs were introduced in 2004, no large-scale monitoring programme is yet running to monitor the effects on biodiversity. Secondly, there is no allocated national funding for research on the management–biodiversity relationship, e.g. the environmental impacts of single area payments have not been evaluated (IEEP 2008).

Despite the relative stability of farmland bird populations in the short term, the long-term decline of grasslands and the loss of grazing livestock (Fig. 3) pose a serious threat. If the decline continues, half of these high biodiversity value grasslands will disappear within 50 years. Therefore, it can be argued that agricultural policy in Hungary and other Central European countries should change, and the conservation of traditional and high biodiversity value farmlands should be the primary target. Effective AESs based on scientific evidence and supervised by experts based on data from monitoring schemes should determine conservation priorities to maintain the internationally important populations of farmland birds in Central European countries. Here the focus should aim for the maintenance of existing habitats, while in Western Europe habitat features need to be restored. The EU-level policy should encourage this process, highlighting the need for extensive farming systems in Europe.

ACKNOWLEDGEMENTS

We thank Yann Clough, Irina Herzon, Gavin Siriwardena, Piotr Tryjanowski and an anonymous reviewer for extremely valuable comments on earlier drafts of the paper, and Tibor Szép and the Monitoring Centre of BirdLife Hungary for recent data on farmland bird trends. The paper writing was partly supported by the Hungarian Scientific Research Fund (OTKA 81971) and the Hungarian Academy of Sciences (Lendület program). PB was funded by the Alexander von Humboldt Foundation and the Helmholtz Association (VH-NG-247).

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(MS received 17 August 2010; revised MS accepted 12 May 2011)