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Grassland winners and arable land losers: The effects of post-totalitarian land use changes on long-term population trends of farmland birds

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ABSTRACT

Biodiversity loss is an ongoing problem of European farmland and recent studies show that causes of this loss may vary among regions. At the same time, Eastern European post-totalitarian countries hold key part of farmland biodiversity within Europe but drivers of its changes remain poorly known due to lack of studies based on long-term data from this region. To fill this gap in our knowledge, we investigate how the post-totalitarian transformation of agricultural management, resulting in widespread land abandonment, affected land cover composition and, in turn, long-term changes of farmland bird populations in an Eastern European former communist country, the Czech Republic. Besides intensification in the most productive areas, we hypothesized that two scenarios might occur: (i) loss of farmland area resulting from its transformation to forests, successional habitats or built areas, (ii) conversion of highly energy-demanding arable land to extensively managed grassland. CORINE land cover data supported the second scenario with a massive gain of grassland area at the expense of arable land, while changes in areas of forest and successional habitats were only slight. This land cover change corresponded well with population increase of grassland birds and population decline of arable land birds, whereas mean population change of species associated with shrub and trees habitat was close to zero. These patterns are quite unique within biodiversity studies reporting declines of grassland bird species in North America and Western Europe, or shrub encroachment accompanied with increasing abundance of shrub-dwelling species in Southern Europe and South Africa. We suggest that the results found in the Czech Republic may also hold in other post-totalitarian Eastern European countries. Based on our findings, we recommend that the agri-environmental schemes applied in the Czech Republic, which focused mainly on grasslands and were only minimally represented on arable land, should now target on halting continuous decline of biodiversity on arable land.

1. Introduction

Despite considerable effort to shift the agricultural management from production to environmental friendly farming (Batáry et al., 2015), agriculture remains among the most important factors causing deterioration of European biodiversity (Butler et al., 2007). Its pervasive negative impacts are well mirrored in population trends of farmland birds (Reif, 2013; Voříšek et al., 2010) which indicate health of entire farmland ecosystem (Gregory et al., 2005). At the same time, current commitments of EU agricultural politics are unambitious, but provide space for flexibility at the national level (Chiron et al., 2013; Pe'er et al., 2014). From this perspective, it is important to recognize regional-specific drivers of farmland bird populations in Europe (Báldi and Batáry, 2011). In this respect, Eastern European countries are particularly important because they are strongholds of farmland biodiversity but our knowledge about its determinants remains poor in this region (Sutcliffe et al., 2015).

One of the most profound agricultural changes in Eastern European countries was the transition from practices conducted under totalitarian government to production of food within competitive free market economy which took place in 1990s

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(Sarris, 1999). Since the practices under totalitarian economy were both labour and energy intensive but largely inefficient, opening the economy resulted in a steep drop in agricultural intensity expressed as per hectare consumption of pesticides and fertilizers, as well as in abandonment of less productive areas (Sutcliffe et al., 2015; Tryjanowski et al., 2011). These agricultural changes were followed by recovery of bird populations in some regions (Gregory et al., 2005), but this pattern was only weak and limited over time elsewhere (Reif et al., 2011). Consequences of this transformation are still relevant to present day agricultural practices and thus potentially important as drivers of farmland bird populations (Kamp et al., 2011; Koleček et al., 2015; Sanderson et al., 2013).

The Czech Republic is an Eastern European former communist country. The changes described above were particularly strong there due to prevalence of very large farms managed as state holdings thus being largely inefficient and poorly competitive after socioeconomic transformation (Sklenička et al., 2014). This situation contrasts to, for example, Poland, where privately held small farms were always the key part of agricultural sector even during the time of totality (Bański, 2011). Surprisingly, decline of farmland birds did not reverse after 1990 in the Czech Republic suggesting the existence of some other drivers than agricultural intensification (Reif et al., 2008). In this respect, change in areas of major land cover types is among the most promising candidates which could result in simple reduction of the amount of habitat available for farmland bird species.

To elucidate this issue, we focused on changes in farmland bird populations and land cover in the Czech Republic from the end of 1980s to 2010. We might expect that after 1990, market forces lead to more efficient, intensive use of farmland in the most productive areas where arable land cultivation pays. In less productive agricultural areas, we hypothesize that two alternative scenarios of land cover changes could take place after 1990 as a consequence of agricultural transition. First, farmland could be abandoned and converted to other kinds of land uses including forestry, building development or remained unused and thus exposed to secondary succession towards scrub and trees followed by forest development, which is the terminal successional stage in this climatic zone (Neuhäuslova', 2001). The first scenario was frequently reported from the Mediterranean region (Clavero et al., 2011; Laiolo et al., 2004; Sirami et al., 2008). It was also claimed from the Czech Republic (Reif et al., 2008, 2013), but without tests on empirical data. Second, farmland may be not completely abandoned by agricultural cultivation, but the agricultural practices would change from highly energy-demanding croplands, such as cereals, to less demanding grasslands managed as pastures or meadows. Some indications for this scenario exist from the Czech Republic based, for example, on data about uptake of grassland-based agri-environmental schemes (Kovář and Víta, 2009). However, a quantitative analysis of land cover changes at the country level that would either confirm, or reject this scenario is still lacking. This analysis is the first aim of this study.

In respect to farmland bird population changes, the first scenario should result in decline of species associated with open habitats (arable land or grassland) and increase of species breeding in closed habitats (shrub and trees). Under the second scenario, by contrast, we expect decline of species associated with arable land and population increase of grassland species. Although one could argue that these two habitats are occupied by a common set of farmland bird species, Teillard et al. (2014) have recently shown that grassland and arable land host largely different sets of species responding sensitively to changes of the extent of their preferred habitat. The second aim of this study is to test these two alternatives using data on farmland bird population changes and habitat use collected within large-scale breeding bird monitoring schemes in the Czech Republic.

2. Materials and methods

2.1. Land cover changes

We used CORINE Land Cover (CLC) database to express changes of major land cover types relevant for farmland birds in the Czech Republic (Heymann et al., 1994). Specifically, we used data from the CLC 1990–2000 Change database (http://www.eea.europa.eu/data-and-maps/data/ds_resolveuid/e68ea8e6-ce904769a727539ef37f8c75) and the CLC 2000–2006 Change database (http://www.eea.europa.eu/data-and-maps/data/ds_resolveuid/f497a90b18dc496b823e3b71137eff7a) for changes between 1990 and 2000, and between 2000 and 2006, respectively. We assumed that these land cover changes can be reflected by bird population changes for the time periods with bird data available with some degree of time lag (see Section 2.2). To have an impression about baseline land cover of the Czech Republic, we used CLC 1990 database (http://www.eea.europa.eu/data-and-maps/data/corine-land-cover-1990-raster-2). Although 1990 is the year of the fall of totalitarian government and the beginning of the process of socioeconomic transition in the Czech Republic, we suggest that this year can be taken as a reasonable baseline for the state of land cover reflecting the situation before deep changes in agricultural management occurred. Moreover, we are not aware of any other large-scale land cover data being available for this purpose.

We extracted both absolute and relative change of following land cover types between respective time periods (i.e. between 1990 and 2000, as well as between 2000 and 2006): forest, arable land, grassland, successional habitats and urban habitat (summed area of these habitats accounts for 98.7% of total area of the Czech Republic according to CLC data for 1990). Moreover, because a marked loss of arable land was anticipated (see Section 1), we also identified the land cover types replacing the arable land.

2.2. Bird population changes

We obtained data for 34 farmland bird species breeding in the Czech Republic (Supplementary Table 1). Seventeen of these species are included in the Farmland Bird Index (Supplementary Table 1) to generate annual Pan-European indicator of environmental health (Gregory et al., 2005), but we also considered 17 other species due to their clear association to farmland habitats in the Czech Republic (Hudec and Šťastný, 2005; Šťastný and Hudec, 2011). Our selected farmland bird species had good record in long-term censuses focused on changes of bird populations and data about their fine-scale habitat use also exist (Reif et al., 2010). These species form two subsets differing in the origin of abundance data.

First, for nine species only data on breeding population size estimates based on breeding bird distribution mapping were available. This mapping took place in 1985–1989 and 2001–2003 and covered the whole country (Šťastný et al., 2006). These data were already used for several studies focusing on changes in national breeding bird populations (Koleček et al., 2010; Reif et al., 2009; Voříšek et al., 2008). For each mapping period, an estimate of the total breeding population size of each species was constructed (see Voříšek et al. (2008) for more details). These estimates take uncertainty into account by providing minimum and maximum values of estimated population size of each species when maximum population size estimate is usually two times higher than minimum population size estimate in most species. For further analysis, we calculated geometric mean of minimum and maximum values for each species in a given time period (i.e. 1985–1989 and 2001–2003). Since the species covered solely by