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Predicting the fate of French bird communities under agriculture and climate change scenarios

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ABSTRACT

The use of forward scenarios to forecast the environmental implications of potential changes in climate and land use is a useful tool for policy development. In this paper, we projected the potential responses of bird communities to both climate and agricultural changes. We created four scenarios of agricultural changes (current trends, biofuel development, livestock extensification and agricultural extensification), each developed at national or regional level of policy-making. We further considered three climatic scenarios (A1B, A2 and B1) from among the IPCC 4th Assessment Report scenarios. We assessed changes in bird communities based on the predicted changes in agricultural land use and climatic suitability using various indicators, including the European Farmland Bird Indicator (FBI) and the Community Specialisation Index (CSI). We found that trends in the different indicators differed greatly from each other depending on the agricultural scenarios and policy-making scale. Our results suggest that public policies that promote extensive agricultural practices are more appropriate for improving the fate of bird communities in agricultural landscapes, especially with the regionalisation of agricultural policy. These results provide a readily accessible visualisation of the potential impacts of land use and climate change on farmland bird communities.

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1. Introduction

Anthropogenic climate change is recognised as one of the key drivers of current biodiversity changes (Rosenzweig et al., 2008). Observed biodiversity responses to global warming include changes in local population dynamics (Silllett et al., 2000), as well as shifts in phenologies (Both et al., 2006) and fluctuations of species ranges (Thomas et al., 2006). In addition to impacts on individual species, climate change also affects the fundamental composition of ecological communities (Davey et al., 2012; Devictor et al., 2012). In the future,

anthropogenic climatic change is expected to result in warmer global conditions, with different scenarios predicting temperature increase from 1.8 °C to 4 °C (IPCC, 2007). Consequently, once potential range shifts and species extinction rates have been predicted under various climate change scenarios (Jetz et al., 2007; Thuiller et al., 2005), a priority is to tailor to management to mitigate the effects of climate change (Hulme, 2005).

Forecasted changes in climatic conditions imply that the distribution of a species will shift if it is able to spatially track climatic conditions (Barbet-Massin et al., 2012). In addition to climate, many factors also affect species occurrence. For

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example, fragmentation of suitable habitats can impair range shifts, especially for species with highly specialised habitat requirements (Warren et al., 2001). The availability of such suitable habitats will depend on land-use and farmland cover changes. Local management is rarely considered in discussions on facilitating range shifts, perhaps because many species distribution models assume that only dispersal limitation prevents species from occupying habitats that are predicted to become climatically suitable (Huntley et al., 2010).

Furthermore, land-use change is also an important form of human-induced global pressure that affects biodiversity (Sala et al., 2000). The modification and management of landscapes to produce food and fibre or other agricultural commodities for human consumption represents one of the most severe and widespread threats to global biodiversity (Foley et al., 2005). In Europe, agriculture is the most widespread form of land use, covering 45% of the total land area (FAO, 2009). This is of concern because there is increasing evidence linking agricultural intensification and the decline of biodiversity over the last decades (Kleijn et al., 2009; Stoate et al., 2001), and this is particularly well documented for farmland bird populations (e.g. Butler et al., 2007; Donald et al., 2001).

Despite the implementation of agri-environment schemes – financial incentives to farmers for adopting environmental friendly agricultural practices – recent evidence has suggested mixed results regarding their positive impact on biodiversity (see Kleijn, 2006; Kleijn et al., 2011; Princé et al., 2012). Over the next decades, the structure of agricultural production and spatial patterns in agricultural land use in Europe are expected to face major changes due to trends in global trade, technology, demography and policies (Busch, 2006). Indeed, the increasing demand for food production, the introduction and expansion of bio-energy crops, the modernisation of agriculture, the abandonment of grazing, and even crop specialisation, are all factors that may affect farmland cover within shrinking agricultural areas. In this context, the need to reconcile agricultural production and biodiversity by both integrating environmental considerations into future agricultural policies and improving existing conservation measures is of the utmost concern (Wilson et al., 2010).

In this article, we address these major issues by exploring the potential responses of bird communities to various scenarios of land-use/cover changes within projected climatically suitable ranges of bird species. We focused on breeding birds since they have been widely used as indicators of biodiversity status and trends (e.g. Butler et al., 2010; Gregory et al., 2009). The recent development of large-scale monitoring schemes, especially for birds, provides valuable wildlife monitoring data at national and even multi-national scales. As a result, biodiversity indicators such as the Farmland Bird Indicator (FBI) are widely used (e.g. Doxa et al., 2010; Gregory et al., 2005; Mouysset et al., 2012; Scholefield et al., 2011) and has been adopted as a Structural and Sustainable Development Indicator by the European Union (EU, 2005). Other indicators are also valuable, such as the Community Specialisation Index (CSI) (see Julliard et al., 2006) that discriminates ordinary communities of generalist species that are more resilient to perturbations, from specialised communities with more specialised species that are especially sensitive to global change (Devictor et al., 2008).

We first used the Special Report on Emissions Scenarios (SRES) to integrate likely changes in species climatic suitability based on species distribution models (SDMs) (Barbet-Massin et al., 2012), and changes in agricultural area based on the IMAGE model (MNP, 2006), inside future climatic niches. We then built up farmland cover scenarios at a fine spatial scale, exploring different combinations of agricultural policies and environmental commitments for 2050, to further link bird abundances to crop/grass proportions. Farmland cover scenarios are based on realistic evolutionary trends of European agriculture, corresponding to arrangements between market trends, technology, public policies, including agri-environmental and agricultural policies. Thus, we considered a ‘Biofuel’ scenario, an ‘Extensification’ scenario and a ‘Livestock Extensification’ scenario, that we compared to a ‘Status Quo’ scenario. The latter corresponds to a “business as today” scenario, in which we continue with the same dynamics. Moreover, given the high regionalisation of main crop productions in France (Agreste, 2011), we were also interested in testing the impacts of sublevels policymaking on bird communities. Therefore, we developed two of the farmland cover scenarios at different level of policy implementation (national or regional). We expect that climate and farmland area changes may have a negative impact on the bird community as a whole. However, we question whether or not changes in farmland cover at a fine spatial resolution can reduce or offset the impact of global changes, or if the fate of bird communities mainly depends on broader environmental changes.

2. Methods

More than half of France is covered by agriculture areas, with wide regional disparities (see Fig. A1 in Appendix A). Croplands represent about 66% and grasslands 34% of the French agricultural area (Agreste, 2011). France is divided into 713 Small Agricultural Regions (SAR) that range from 11 to 4413 km² (source: National Institute of Statistics and Economic Studies, INSEE; www.insee.fr). SARs are relatively homogeneous in terms of their agro-ecological and economic characteristics (Agreste, 2011), which makes them particularly well suited for statistical analysis and forecasting.

2.1. Agricultural area data

We used data on the proportion of French agricultural area, i.e., the proportion of land occupied by farmland habitats. This is the proportion of an SAR covered by (1) herbaceous or cultivated pasture, (2) cultivated and managed areas, and (3) mosaic cropland/natural vegetation. These variables were derived from the 19 land cover types (by grouping SAR classifications into combined categories) available in the IMAGE 2.4 model (MNP, 2006) at a 0.5° resolution grid (≈55 km) for all decades since 1960. The IMAGE 2.4 model assumes human population and macro-economy as key drivers for establishing physical indicators in both the energy/industry system and the agriculture/land-use system for assessment of changes in land cover (MNP, 2006). To be consistent with current climatic variables (used in this study

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