



## Indicators of the impact of land use changes using large-scale bird surveys: Land abandonment in a Mediterranean region



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### ABSTRACT

Developing sound indicators of biodiversity impact has been identified as a critical step towards our understanding of how global change components are affecting the environment across the globe. Land abandonment is recognized as a major component of global change in the Mediterranean basin, however, we lack adequate, quantitative, indicators of its impact on biodiversity. An appealing approach to develop biodiversity indicators is the use of large-scale bird monitoring projects, an important source of information that is already available in many countries. In this study we develop a method to quantify the impact of the two main processes associated with land abandonment in the Mediterranean region, namely the abandonment of farmland, which produces a shift from cultivated land to open natural habitats, and the encroachment by vegetation usually associated with reductions in livestock grazing and wood harvesting practices. We used data from bird atlas and monitoring schemes in Catalonia (north-east Iberian Peninsula) to characterize species' population response to these processes by means of detecting quantitative changes in relative abundances along a gradient ranging from habitats not affected by a given driving force to those that arise as a consequence of such force. We then generated multi-species indicators of the impact of these land use changes using these specific population responses to calibrate the relative contribution of each species in the composite index. The temporal patterns depicted by the two indicators in the period 2002–2011 show that vegetation encroachment did have a significant impact on bird communities, whereas any noticeable effect of farmland abandonment on bird populations was observed. The methodology proposed here could be employed to develop indicators capable to track biological impacts of land use change on an annual basis and inform decision-makers about the rate of increase or decrease on wildlife populations.

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### 1. Introduction

A general consensus exists that anthropic alterations of ecosystems are dramatically affecting biodiversity and that as a result there is a need to establish indicators that can measure the rate of biodiversity loss and determine the effectiveness of actions aimed at halting and reversing it (Landres et al., 1988; Noss, 2005; Collen

et al., 2008; Butchart et al., 2010). One of the main approaches to generate these summary statistics is to use population trends from existing wide-scale monitoring schemes (Buckland et al., 2005; Gregory et al., 2005; van Swaay and van Strien, 2005). Unlike the classical focus of conservation that centres on rare and localized species, common species usually reported in monitoring schemes can be very appropriate to produce indicators of biodiversity change at large scale due not only to practical reasons but also to their importance in ecosystem structure, functioning and services (Gaston and Fuller, 2008).

Within this context, birds are undoubtedly the taxonomic group that has spawned most research (e.g. Gregory et al., 2005; Devictor et al., 2008; Gregory et al., 2009; Butler et al., 2012; Le Viol et al.,

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2012). A number of reasons exist that make birds good candidates for generating these indicators: they are very sensitive to environmental change, bird data can be obtained 'low-cost' (particularly when volunteer ornithologists are involved), recognized field and analytical methods exist to handle data on birds, birds play important roles in ecosystem services for humans and, finally, the ease with which birds can be used as communication tools (Gregory and van Strien, 2010). In addition, the existence of well-established, large-scale monitoring projects covering many countries and even continents – in Europe tens of thousands of survey plots in up to 25 countries currently produce data (PECBMS, 2012) – is another very practical reason for attempting to generate sensitive indicators using bird data. These monitoring projects allow reliable annual population indices and trends for common species at national and European level to be obtained, from which several multi-species indicators can be generated on a regular basis (Gregory et al., 2008; PECBMS, 2012).

Wild-bird composite indicators derived from large-scale monitoring data have recently become a tool of political relevance in many EU countries. In particular, the farmland bird index, a multi-species indicator that summarizes population trends for the avifauna of agricultural areas across Europe on the basis of data generated by the Pan-European Common Bird Monitoring Scheme (PECBMS, 2012), has been adopted by the European Union as a baseline indicator under its Rural Development Regulations and as a Sustainable Development and Structural Indicator (European Environmental Agency, 2007; Gregory and van Strien, 2010). This is actually the first indicator based on species' population trends to be included in EUROSTAT (<http://epp.eurostat.ec.europa.eu>). Indicators based on data from bird monitoring schemes have also been developed at European, national and regional level for evaluating the general state of non-farmland ecosystems such as woodland, urban and wetland habitats (e.g. Gregory et al., 1999; DEFRA, 2002; Zbinden et al., 2005; Gregory et al., 2008; Herrando et al., 2012). Nevertheless, information obtained by state indicators could be complemented by means of indicators of impact of specific pressures, which would allow for better (1) understanding of the underlying processes affecting biodiversity, (2) quantifying its impact, (3) development of tools for communication and decision-making (Gregory et al., 2005; Mace and Baillie, 2007).

Land-use change has been identified as a major driver behind biodiversity changes worldwide (Sala et al., 2000). In the Mediterranean basin, land abandonment in less productive areas has been one of the most relevant changes in land use in recent decades and the footprint on ecosystems of decreased human activity has been reported to affect dramatically biodiversity (Ostermann, 1998; Blondel and Aronson, 1999; Suarez-Seoane et al., 2002; Sirami et al., 2008). However, despite the fact that evidence of the effect of this process has been reported from numerous locations, only a few quantitative meta-analyses have been conducted at regional level (Sirami et al., 2008), and no attempt has ever been made to generate indicators capable of monitoring the impact of this change on biodiversity on an annual basis and a large scale. Therefore, developing these indicators could be particularly interesting in the Mediterranean basin, which is one of the biodiversity hotspots in the world (Myers et al., 2000), and where birds may have a great potential for such purpose because they constitute the taxonomic group with the highest number of monitoring schemes (EuMon, 2014).

In this study, we analyze the impact of land abandonment by splitting this driving force into two different but related processes. First, we defined agriculture abandonment as the process whereby active crop production breaks down and leads to the spontaneous transformation of farmland into wild open habitats such as grassland and low shrubland (Bonet and Pausas, 2007). Then, we defined vegetation encroachment as the increase in density, cover and

biomass by indigenous woody or shrubby plants that induce the maturation of vegetation into forest cover. In the Mediterranean basin, vegetation encroachment seems to be closely associated with reductions in livestock grazing and activities related to woody fuel extraction (Lasanta-Martínez et al., 2005). These two processes have occurred mainly in mountain Mediterranean areas in which income from the land has progressively fallen and, consequently, has led to greater rural depopulation (Blondel and Aronson, 1999; Pinto-Correia and Vos, 2004).

As a means of developing indicators of the effects of agricultural abandonment and vegetation encroachment on birds at a large scale, we combined species' population responses to these driving forces with species' population trends in order to establish composite ecologically meaningful indexes. We developed an analytical framework to obtain these species' population responses based on the generation of spatially explicit hypotheses relating habitat data with either abundance data from a common bird monitoring scheme or presence/absence data from a bird atlas. We then adapted the methodology developed by Gregory et al. (2009) to generate multi-species indicators that measure the impact that farmland abandonment and vegetation encroachment have had on the avifauna of a Mediterranean region in recent years.

We used data from Catalonia, a Mediterranean region in which farmland, shrubland and forest state indicators based on bird monitoring projects are updated on an annual basis following the principles adopted in other European countries (Gregory and van Strien, 2010). During the period 2002–2011 the farmland and the forest indicators were roughly stable, while the trend of the shrubland indicator, assessed as the geometric mean of the population indices of 15 species associated with natural open habitats, was clearly negative (ICO, 2012). Hence, this represents an interesting study area, for which indicators of the effects of land abandonment may potentially allow a better understanding of patterns shown by its biodiversity.

## 2. Methods

### 2.1. Study area

This study was carried out in Catalonia, a region of c. 32,000 km<sup>2</sup> situated in the north-east of the Iberian Peninsula in which farmland and areas of natural vegetation each cover almost half of its surface area (Fig. 1).

### 2.2. Data sources

#### 2.2.1. Bird data

Both long-term monitoring data and atlas data, based on the surveillance of breeding bird populations, were employed in this study. The Catalan Common Bird Survey (SOCC) is an ongoing monitoring scheme that was started in spring 2002. It collates data from around 300 monitoring transects (each with a length of 3 km) scattered throughout Catalonia that are walked twice in each breeding period (from April 15 to June 15); the maximum number of individuals in the two censuses was retained as an estimate of relative bird abundance for each species. This scheme embraces two types of field methodology, standard (35%) and extended (65%) transects. In extended SOCC transects collaborators place all birds observed in one of three bands (0–25 m, 25–100 m or >100 m from the line transect), while in the standard SOCC no distance allocation is attempted. Although we analyzed both standard and extended SOCC data to assess annual population indices and trends for each bird species (see Section 2.4), we only used data from the more spatially explicit extended SOCC to derive estimates of the response by bird populations to the processes of farmland abandonment and

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