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Tools for exploring habitat suitability for steppe birds under land use change scenarios

Laura Cardador [a,*,1], Miquel De Cáceres [a,b], David Giralt [a], Gerard Bota [a], Núria Aquilué [a,c], Beatriz Arroyo [d], François Mougeot [e], Carlos Cantero-Martínez [f], Lourdes Viladomiu [g], Jordi Rosell [g], Fabián Casas [d,e], Alba Estrada [h], Jorge Álvaro-Fuentes [i], Lluís Brotons [a,b]

[a] Forest Sciences Center of Catalonia (CTFC), Ctra. de St. Llorenç de Morunys a Port del Comte km 2, 25280 Solsona, Catalonia, Spain
[b] CREAF, Edifici C, Campus de Bellaterra (UAB), 08193 Cerdanyola del Vallès, Catalonia, Spain
[c] Centre d'étude de la forêt, Université du Québec à Montréal, C.P. 8888, Succ. Centre-Ville, Montréal, Québec H3C 3P8, Canada
[d] Instituto de Investigación en Recursos Cinegéticos (IREC)-(CSIC-UCLM-JCCM), Ronda de Toledo s/n, 13005 Ciudad Real, Spain
[e] Estación Experimental de Zonas Áridas (EEZA-CSIC), Carretera de Sacramento s/n, 04120 La Cañada de San Urbano, Almería, Spain
[f] Departament de Producció Vegetal i Ciència Forestal, Universidad de Lleida (UDL-Agrotecnio), Av. Alcalde Rovira Roure 191, 25198 Lleida, Spain
[g] Dpto. Economia Aplicada, Edifici B, Campus de Bellaterra (UAB), 08193 Cerdanyola del Vallès, Catalonia, Spain
[h] CIBIO/InBio Universidade de Évora. Casa Cordovil 2° andar, Rua Dr. Joaquim Henrique da Fonseca, 7000-890 Évora, Portugal
[i] Departamento de Suelo y Agua, Estación Experimental de Aula Dei, Consejo Superior de Investigaciones Científicas (EEAD-CSIC), Avda. Montañana, 1005, 50058 Zaragoza, Spain

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ABSTRACT

In this study, scenario development based on changes in key socioeconomic drivers (namely, the prices of conventional food products, rural development policies and agro-environmental regulations) was used together with resource-based habitat suitability models to develop plausible visions of future pathways of agricultural land use and evaluate their potential consequences on conservation of target species. Analyses focused on three steppe bird species in a protected Natura 2000 area, located in the Iberian Peninsula. Our results showed that changes in land use composition under different scenarios can have important effects on habitat suitability, but that the size of those effects would vary depending on species-specific requirements and spatial distribution of land use changes. Positive effects of some new crops in the study area (grain legumes and aromatic plants) on studied species were suggested by our analyses. A positive effect of aggregation of land use changes was also found for two of the studied species. Scenario building and forecasting using transferable inter-disciplinary knowledge can therefore improve our capability to anticipate future changes and provide timely advice towards long-term conservation planning in agricultural systems.

1. Introduction

Human activities cause multiple changes to ecosystems properties and functions resulting in important impacts on biodiversity and the associated services they provide (Pimm et al., 1995). In response to such changes, large-scale conservation efforts have been deployed to develop policies and management strategies to halt and reverse current biodiversity trends. The cornerstone of conservation policy instruments is the designation and management of protected areas with strict regulations of human activities (Margules and Pressey, 2000). However, in many cases, restricted area protection is not enough to preserve biodiversity because their conservation depends on human managed lands, such as agricultural landscapes (Benton et al., 2003; Donald et al., 2001). It is unlikely that enough protected areas will ever be designated in these kinds of systems due to economic, social and political limitations (Henle et al., 2008).

Human activities and interests are mainly determined by socioeconomic factors that are highly dynamic and often difficult to predict (Ewert et al., 2005). Conventional conservation strategies have not always taken into account the underlying

* Corresponding author. Tel.: +34 954232340.
E-mail addresses: lauracardador@ebd.csic.es, lcardador81@gmail.com (L. Cardador).
[1] Department of Conservation Biology, Estación Biológica de Doñana (CSIC), C/ Americo Vespucio s/n, 41092 Sevilla, Spain.

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dynamism of socioeconomic drivers and its potential consequences on biodiversity and management before changes occur (Sutherland and Woodroof, 2009). Rather, conventional conservation approaches have usually been problem-solving oriented and focused on reducing current conservation threats by building conservation strategies based on previous empirical experience and current socioeconomic conditions (Fischer et al., 2012). While this approach may be valuable in some cases, moving toward approximations that look more into the future, scanning potential socioeconomic developments and projecting their implications on biodiversity, may improve our capability to anticipate future changes and provide timely advice toward long-term conservation planning (Peterson et al., 2003; Sutherland and Woodroof, 2009).

Scenario development offers a methodology for thinking about possible complex situations that can occur in the near future (with more or less uncertainty) and their potential environmental consequences (Peterson et al., 2003; Lindborg et al., 2009; Mouysset et al., 2012). By allowing the comparison about potential future developments, scenarios can help to take actions to support the best options in the future, optimize strategies, for example by focusing on conservation efforts that are more likely to be successful under most scenarios, or be prepared to quickly adapt to unfavorable environments. However, when adopted, land use change scenarios have usually been based on land use trajectories derived simply from observed trends in land uses (e.g., Brotons et al., 2004; Seoane et al., 2006). Such approach appears limited, as land use changes are often largely determined by socioeconomic drivers with future variability not experimented yet, such as prices of food products, rural development policies or agri-environmental regulations (Westhoek et al., 2006; Bolliger et al., 2007), so a vast range of potential land use developments may exist (Mouysset et al., 2012; Princé et al., 2013).

Throughout Europe, agricultural intensification over last decades has led to biodiversity losses and population decline of several species associated with farmland habitats (Benton et al., 2003; Donald et al., 2001). Of particular concern has been the decline of steppe bird populations in the Iberian Peninsula, which is part of the western European stronghold of many of these species (Bota et al., 2005). Most conservation emphasis in these areas has so far been centered on avoiding negative effects of agriculture intensification on these species, usually based on paying farmers to maintain extensive practices (e.g., improvement and conservation of field margins, provision of fallow land or a delay of the cereal harvest date) through agro-environmental schemes (e.g., Brotons et al., 2004; Lapiedra et al., 2011). However, different land use developments may occur (Ewert et al., 2005; Westhoek et al., 2006), which stresses the necessity to be prepared for possible novel changes. As with other ecosystems, major uncertainties affecting the direction of future development in semi-arid farmland habitats relate to the societal role of economic objectives versus sustainability, equity and environment; and the emphasis on globalization versus regionalization in the future.

In this study, scenario development based on changes in these important socioeconomic drivers was used to develop plausible visions of future pathways of agricultural land use within a protected Natura 2000 area, located in the northeastern part of the Iberian Peninsula. Additionally, its potential consequences on habitat suitability for steppe bird species were evaluated. Analyses focused on three steppe bird species with high-conservation value at the European level (Annex I Directive 2009/147/EC), which still have important local populations in the study area (Estrada et al., 2004). Study species included the little bustard *Tetrax tetrax*, stone curlew *Burhinus oedicnemus* and calandra lark *Melanocorypha calandra.* These species have been considered as representative of steppe-like habitats in previous studies (Brotons et al., 2004; Bota et al., 2005), although variation in responses to vegetation structure and diet may affect species-specific habitat suitability at small spatial scales (Cardador et al., 2014a; Concepción and Díaz, 2011).

Our general aim is to highlight how scenario building and forecasting can help conservation planning. Our framework comprised three steps. First, the description of scenarios of agricultural land use change based on socioeconomic considerations and the local agronomic potential. Second, the stochastic allocation of land use changes associated with each scenario to spatial units, taking into account environmental (agronomical) constraints as well as different levels of spatial aggregation. Finally, the translation of agronomic scenarios into species-specific habitats by means of resource-based habitat suitability models previously developed and validated in the study area (Cardador et al., 2014a). The validity of our approach for conservation planning is discussed.

2. Methods

The agricultural land use scenarios were developed for an agricultural area with high conservation value for steppe bird species, located in the Catalan part of the Ebro basin (north-eastern Spain, 41°35′ N, 1°00′ W). It comprises around 65 km^2 of farmlands, included in a special protection area of the Natura 2000 network, a key policy instrument for continental wide biodiversity protection in Europe. The landscape is predominantly flat and low altitude and has a semiarid Mediterranean continental climate. Currently, the area is mainly occupied by rainfed agriculture in which winter cereals (barley and wheat) are the predominant crops with almost 70% of the surface, followed by typical Mediterranean tree crops such as almonds and olives (Table 1). Fallowing is residual in the area, as well as irrigated tree orchard plantations (Cantero-Martínez and Moncunill, 2012).

Table 1
Expected landscape-scale land use composition (% of total surface, by crop type) according to the three considered land use change scenarios and their sub-scenarios (NI = no irrigation, PI = with partial irrigation). Current landscape composition is also shown.

	Current (%)	Business as usual (%)		Liberalization (%)		Local markets (%)	
		NI	PI	NI	PI	NI	PI
Cereals	69	55	60	80	30	35	25
Fodder	7	0	0	5	5	0	0
Fallow land	4	0	0	0	0	0	0
Olive trees	7	20	20	5	20	25	30
Almond trees	12	5	0	5	15	10	10
Vineyard	0	5	5	5	20	20	20
Grain legumes	0	10	5	0	0	5	5
Oil seed crops	0	5	10	0	5	5	5
Fruit trees	1	0	0	0	5	0	0
Aromatic plants	0	0	0	0	0	0	5