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AGEE-4527; No. of Pages 10

ARTICLE IN PRESS

Agriculture, Ecosystems and Environment xxx (2013) xxx–xxx

Contents lists available at ScienceDirect

Agriculture, Ecosystems and Environment

journal homepage: www.elsevier.com/locate/agee

Effects of landscape, land use and vegetation on bird community composition and diversity in Inner Anatolian steppes

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ARTICLE INFO

Article history:
Received 3 August 2012
Received in revised form 6 November 2013
Accepted 7 November 2013
Available online xxx

Keywords:
Grassland birds
Agricultural landscape
Grazing
Land abandonment
Multivariate analysis
Turkey

ABSTRACT

We present here the first systematic study on drivers of bird community composition and diversity in Anatolian steppes (Turkey), an environment important for populations of threatened grassland birds yet underrepresented in conservation networks. We focused on one million hectares of mountainous land with a long and varied land use history, and collected quantitative data on breeding birds as well as environmental, vegetation, landscape and land use parameters at 32 sites. Data were analyzed by canonical correspondence analysis (CCA) and hierarchical partitioning to understand avian community structure and reveal major drivers of observed patterns. Bird communities in high-altitude steppes of inner Turkey showed patterns in species richness and community composition that were best explained by an altitudinal gradient and by human activities. Steppe birds occurred most often in cropland abandoned 20–50 years ago with good coverage of erect leafy plants while overall avian diversity tended to increase with reduced grazing pressure and with nearby presence of rural settlements. CCA results revealed a contrast between highly heterogeneous anthropogenic environments in warmer and drier land with woody elements, and treeless steppes at higher elevations that were, apart from transhumant grazing, little influenced by human activities. The former sites were characterized by the occurrence of several grassland birds along with a variety of generalist species, some of which required the presence of trees, while the latter sites were less diverse but usually with a higher proportion of steppe-dependent birds in their composition. To conserve steppes for birds, we recommend as key actions to maintain the current landscape mosaic, sustain low to moderate grazing levels and use our findings in developing a network of protected areas.

1. Introduction

Birds of open landscapes such as grasslands, farmlands and steppic areas have declined more than other species in Europe in the last few decades (BirdLife International, 2013). Such declines are widely believed to be driven by agricultural intensification and the subsequent deterioration of habitats (Donald et al., 2001) as well as by the progressive abandonment of marginal agricultural land (Sirami et al., 2008).

Bird diversity and community composition respond strongly to productivity and its environmental drivers such as altitude and temperature at large scales (Böhning-Gaese, 1997; Waide et al., 1999). For birds of open landscapes, it has been shown that vegetation structure (Donald et al., 2001; McCracken and Tallowin, 2004; Suárez-Seoane et al., 2002), heterogeneity at habitat and landscape levels (Benton et al., 2003) and human activities such as agricultural management and grazing intensity (Atkinson et al., 2005; Batáry et al., 2007) are important drivers of species diversity and abundance.

Steppes in Turkey, represented by natural or semi-natural dry grasslands, cover an estimated 28 million hectares, which correspond to 35% of the country's territory (Kün et al., 1995). These plant species-rich communities have been maintained in a semi-natural state for centuries through grazing by domestic animals, repeated conversions to cropland and abandonment, and other management practices (Çetik, 1985). Destruction of grasslands by ploughing and degradation by excessive grazing are well-recognized threats to the ecosystem (Peart, 2008). They were experienced to an extreme between 1950 and 1980 in Turkey as a consequence of the national agricultural policies of that period (Kazgan, 2003). Accelerating emigration of the rural population since the 1950s (Akgündüz, 2008) and an increased competition from global markets (Kazgan, 2003) resulted in abandonment of marginal lands and a decline in grazing levels.

The consequences of land abandonment and changes in agricultural land management on birds are well documented in Europe (MacDonald et al., 2000; Sirami et al., 2008). However, despite the

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http://dx.doi.org/10.1016/j.agee.2013.11.006

fact that Turkey houses important populations of European and southwest Asian steppe species (Burfield, 2005), the impact of such changes is hardly known in Turkey. Many native steppe-dependent species such as great bustard (*Otis tarda*), little bustard (*Tetrax tetrax*), pallid harrier (*Circus macrourus*), saker falcon (*Falco cherrug*), and lesser kestrel (*Falco naumanni*) are species of European concern (SPEC-1) (BirdLife International, 2004). Although the conservation of Anatolian steppes is vital to achieve continental-scale conservation success, there is not yet a single protected area designated and managed specially for steppe conservation (Şekercioğlu et al., 2011).

Here we attempt to explain steppe avian diversity at a regional scale by focusing on environmental, vegetation, landscape and land use determinants of bird diversity and composition. We chose birds as target taxonomic group since they are good general indicators for wildlife (Gregory et al., 2008) and provide useful information about trends in land use change in agricultural landscapes (Donald et al., 2001). Specifically, we address the following questions: (1) What are the drivers of bird community composition and diversity in Anatolian steppes? (2) Is there a major effect of land use change on bird community composition and diversity during the past 50 years? (3) Are vegetation parameters known to be important for grassland bird community composition and diversity in other regions also valid for Inner Anatolian steppes? The answers can both fill an important information gap and provide baseline information for conservation of birds living in steppes of Turkey.

2. Materials and methods

2.1. Study area

The study area is a 1,062,554 ha mountainous land located on the transition between Central and East Anatolia in Turkey (38°20′–39°40′ N, 36°50′–38°40′ E), covering parts of Sivas and Malatya provinces (Appendix S1). The altitude of the rugged terrain varies from 850 m a.s.l. in river valleys to 2800 m a.s.l. on the mountain tops. The study area is characterized by cold, snowy winters and warm, dry summers (annual mean temperature 3.7–13.3 °C, annual mean precipitation 409–671 mm; based on Hijmans et al., 2005. The climate is classified as Semihumid Continental (İyigun et al., 2013).

The natural vegetation of the study area has been classified as forest-steppe, indicating the assumed naturalness of at least some of the steppes (Noirfalise, 1987; Zohary, 1973). However, other studies consider the steppes of the study area as secondary vegetation, originating from former woodlands composed of *Quercus*, *Juniperus*, *Pyrus*, *Crataegus* and *Amygdalus* species (Louis, 1939; Walter, 1956). Today, the land cover mainly consists of steppes, mostly on the slopes (49%); croplands of mostly cereal, apricot or legume cultivation on the plains (26%); woodlands of *Quercus* spp., *Juniperus* spp. and *Pinus sylvestris* with patchy distribution on uplands (9%); and sparsely vegetated, steep slopes (15%) (Kınıkoğlu, 2008).

Four district centers and 409 villages, each with less than 100 people, are inhabited by 151,767 people in total (İLEMOD, 2007). The main source of income is agriculture with a 67% share (TÜİK, 2012). About 30,000 cattle and 150,000 sheep and goats graze the region (İLEMOD, 2007) although these numbers were much higher before rural emigration started (TÜİK, 2012). Following emigration, over the last 20–60 years, the amount of cultivated land declined sharply and continues to do so. Similarly, livestock densities have decreased: the highest-known past livestock densities for sites ranged from 400 to 5357 dry sheep or equivalent (mostly sheep and various races of cattle) per 1000 ha, but have declined by 40–100% in most areas.

2.2. Data collection

2.2.1. Survey design

We adopted a cost-effective method for survey design, i.e. gradsect sampling, ending up with 32 environmentally different sites sampled for birds as well as variables related to abiotic environment, vegetation, landscape and land use (Gillison and Brewer, 1985). Gradsect sampling is similar to stratified sampling but fewer geographic transects, i.e. gradsects, are drawn across the main landscape gradients for surveying to increase cost-effectiveness (Hirzel and Guisan, 2002).

To determine the survey points, we first stratified the study area based on the environmental factors that we knew to be influential in vegetation, species distribution and land use, i.e. aridity, soil type, soil depth and geology (Böhning-Gaese, 1997; Gellrich and Zimmermann, 2007; Hamzaoğlu, 2006). We used Thornthwaite precipitation effectiveness index (Thornthwaite, 1931) calculated from relevant WORLDCLIM maps, which incorporate altitude in the models (Hijmans et al., 2005), and divided it into six aridity classes. We obtained relevant soil and geology maps from the Department of Geological Engineering of Middle East Technical University. We used five major soil types, three soil depth classes and three bedrock types; then intersected these layers to obtain ecosections, i.e. environmentally different sub-areas (Appendix S1). The resulting 58 ecosections were overlaid with the map of the steppes, and those 34 ecosections selected included at least 500 ha of steppes. We identified that two diagonals drawn across the study area represent two main gradients along which different ecosections were concentrated within short distances. We targeted to sample one site in each ecosection along the gradients but finally used only 32 of them as two were not accessible. We selected sites to be surveyed randomly within homogeneous polygons identified from satellite images for each ecosection. At each survey site, we sampled two replicates with more than 90% herbaceous coverage and separated by at least 200 m from each other.

2.2.2. Bird surveys

Bird surveys took place once on each replicate, during the breeding season, in early June 2009. We used point counts as they are commonly used for estimates of bird abundance or community composition, and for compiling useful data on bird-habitat relationships (Bonthoux and Balent, 2011). With a fixed-radius point count approach, adult birds were recorded within two distance bands (within and outside 50-m radius around replicate center point), separately in the first five and the following three minutes. Two experienced birdwatchers stood at the replicate centers, waited for birds to settle then started surveying at the same time. They identified birds visually or based on vocalizations, took additional notes about habitat use, signs of breeding, age of birds, and flyovers. We followed BirdLife Checklist Version 5.1 for bird taxonomy and nomenclature (BirdLife International, 2012).

2.2.3. Vegetation parameters

We collected vegetation data within the same 50-m radius around each replicate center point. We set 10 random quadrats of 2 m × 2 m dimensions. In each quadrat, we recorded percent cover of plant species with more than 10% coverage, considered to characterize vegetation structure and land cover best. We classified plant species into eight growth forms as short basal, semi-basal, long basal, erect leafy, cushions, tussocks, dwarf shrubs and shrubs (Cornelissen et al., 2003), and percent coverage of each growth form was used as a parameter. For vegetation structure, we recorded herbaceous vegetation cover, herbaceous vegetation height and shrub density. Since coverage and height varied much at some sites,

Please cite this article in press as: Ambarlı, D., Bilgin, C.C., Effects of landscape, land use and vegetation on bird community composition and diversity in Inner Anatolian steppes. Agric. Ecosyst. Environ. (2013), http://dx.doi.org/10.1016/j.agee.2013.11.006