Agriculture, Ecosystems and Environment 183 (2014) 31–39

Contents lists available at ScienceDirect

Agriculture, Ecosystems and Environment

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

Human–Sheldgeese conflict in agricultural landscapes: Effects of environmental and anthropogenic predictors on Sheldgeese distribution in the southern Pampa, Argentina

J. Pedrana [a,*], L. Bernad [b,1], N.O. Maceira [b,1], J.P. Isacch [c]

[a] Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Grupo Recursos Naturales y Gestión Ambiental, Instituto Nacional de Tecnología Agropecuaria (INTA), Estación Experimental Agropecuaria Balcarce, Ruta 226 km 73.5, 7620 Balcarce, Buenos Aires, Argentina
[b] Instituto Nacional de Tecnología Agropecuaria (INTA), Estación Experimental Agropecuaria Balcarce, Argentina. Ruta 226 km 73.5, (7620) Balcarce, Buenos Aires, Argentina
[c] Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Instituto de Investigaciones Marinas y Costeras, Facultad de Ciencias Exactas y Naturales, Universidad Nacional de Mar del Plata, Funes 3250, 7600 Mar del Plata, Argentina

ARTICLE INFO

Article history:
Received 30 March 2013
Received in revised form
13 September 2013
Accepted 15 September 2013
Available online 16 November 2013

Keywords:
Human–Sheldgeese conflict
Southern Pampas
Landscape ecology
Habitat-suitability maps
Sheldgeese occurrence

ABSTRACT

Sheldgeese species are currently the subject of serious conservation concern and have been a source of historical conflict with agricultural interests. Here we assess the relative effects of environmental and anthropogenic predictors on Sheldgeese (Ruddy-headed Goose *Chloephaga rubidiceps*, Ashy-headed Goose *Chloephaga poliocephala* and Upland Goose *Chloephaga picta*) distribution in the southern Pampas at different spatial scales. These birds were declared an "agriculture plage" by the government and this conflict with humans has been so far resolved with species persecution. We evaluate whether its current wintering distribution is shaped by anthropogenic disturbances or whether it can be better explained by differences in topography and preference for wetlands, or by landscape composition and configuration. We characterized the study region using 17 potential predictors related to environmental, human and landscape characteristics. We built habitat-suitability models to examine the relative effect of the variables on the regional occurrence of Sheldgeese. We performed vehicle surveys in southern Buenos Aires province, in two years (2011–2012), surveying 9200 km of roads and recording 281 Sheldgeese flocks. Generalized additive models were used to model the presence/absence of Geese in 250-m cells. The habitat suitability models of Sheldgeese suggest that: (1) areas of low elevation surrounded by waterbodies are one of the main positive drivers of species distribution, (2) centers of human activity, which are regions with greater road accessibility, have a negative impact on species distribution, (3) heterogeneous landscape composed of croplands and grazing fields are preferred environments.

1. Introduction

Habitat loss and fragmentation, urbanization, introduction of exotic species and harvesting by humans are the most frequently types of human-induced changes affecting organisms all over the world (Vitousek et al., 1997; Pimm and Raven, 2000; Seabloom, 2002). Consequences of these anthropogenic effects pose a challenge for many species, which are forced to adapt in a very short time. Although the extent to which these environmental changes actually affect ecosystems and wildlife population processes is still largely unknown. It is clear how species respond to habitat structure and human pressures resulting from complex interactions and can be noticeable in many ways and at different spatial scales (Gehring and Swihart, 2003; De Angelo et al., 2011). For instance, current geographical ranges of some species may reflect not only their habitat preferences but also human disturbance (Caughley and Gunn, 1996; Pedrana et al., 2011). There is empirical evidence that many species avoid human disturbance and their population sizes can be negatively affected by human activities. As a consequence, there is an urgent need to understand their response toward human pressures at different spatial scales.

Multi-scale approaches have been traditionally employed in the study of habitat preferences (Johnson, 1980), since ecological patterns depend on the spatial scale at which they are analyzed (Wiens, 1989). The wide use of geographical information systems (GIS) and the development of more powerful statistical methods

* Tel.: +54 2266 439100.
E-mail addresses: jpedrana@yahoo.com.ar (J. Pedrana), lbernad@balcarce.inta.gov.ar (L. Bernad), nmaceira@balcarce.inta.gov.ar (N.O. Maceira), jpisacch@mdp.edu.ar (J.P. Isacch).
[1] Tel.: +54 2266 439100.

0167-8809/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.agee.2013.09.029

(Guisan and Zimmermann, 2000; Scott et al., 2002) have allowed researchers to develop new techniques to model species' expected distribution based on habitat preference, quality and availability, and then estimate the impact of anthropogenic predictors on the species distribution (Naves et al., 2003; Rhodes et al., 2006). This can be facilitated by species distribution models (SDM) which allow researchers to build empirical models. These link field observations to landscape-scale explanatory predictors selected from a set of ecologically plausible candidate variables, based on statistically or theoretically derived response surfaces (Jeganathan et al., 2004; Gottschalk et al., 2007; Rodríguez et al., 2007). The resulted distribution models are used to construct habitat-suitability models that are then mapped over the geographical space, creating habitat-suitability maps. Applications of SDM methods include quantifying environmental niches, assessing the impact of climate, land use, and other environmental changes on species distribution (cf. Scott et al., 2002).

After the European colonization, the temperate grasslands ecosystems of the Pampas region in Argentina have progressively become one of the most important regions of grain and beef production. The introduction of domestic livestock in the XVI century and agriculture by the end of the XIX century have intensely transformed the original landscape (Bilenca and Miñarro, 2004; Paruelo et al., 2005; Baldi et al., 2006). Several areas of the original Pampas grasslands were replaced by sown pastures for livestock and croplands, with a particular expansion of soybean in the last few decades (Grau et al., 2005; Aizen et al., 2009). This has led to a great loss and degradation of grassland habitat, producing a simplification of the landscape (Ghersa and Leon, 1998). Human-induced habitat homogenization in the Pampas agroecosystems, hunting pressures and introduction of exotic species have negatively affected many native bird species (Codesido et al., 2011; Azpiroz et al., 2012). However, certain grassland species may be more tolerant and even benefit from such changes, thriving in these new habitats. (Echeverría et al., 2006; Pedrana et al., 2008; Isacch and Cardoni, 2011). This could be the case with the three endemic migratory Sheldgeese species (Ruddy-headed Goose *Chloephaga rubidiceps*, Ashy-headed Goose *Chloephaga poliocephala* and Upland Goose *Chloephaga picta*). The geese winter mainly in the southern Pampas where they feed on crops and pastures (Blanco et al., 2003). The fact that these species are more flexible in their habitat preferences does not necessarily ensure their survival. Local farmers have traditionally decimated geese populations (Blanco and De la Balze, 2006). In1931 these birds were declared an "agriculture plague" by the Argentine government and have been consistently killed ever since (Blanco et al., 2003; Chebez, 2008; Petracci et al., 2010). Although there is limited data on Sheldgeese ecology, hunting of all species has been encouraged across the entire range, and allowed without restrictions (Martin et al., 1986; Blanco and De la Balze, 2006). Only as recently as 2008 all species were considered as endangered by the Argentine government (López-Lanús et al., 2008) and hunting was forbidden but is still promoted in several outfitters. The human-Sheldgeese conflict in agricultural landscapes and the endangered status of these species make it necessary to study the role of different environmental and anthropogenic drivers on the regional distribution of the species for a proper management of their populations. Our aim was to assess the relative effects of environmental and anthropogenic predictors on Sheldgeese distribution in the southern Pampas at the different spatial scales and to produce distributions maps of the species for the southern Buenos Aires province using habitat-suitability models. To do this we tested three different hypotheses that could account for the spatial distribution of Sheldgeese in the study area. The "environmental hypothesis" states that Sheldgeese distribution principally reflects the availability of lowland environments surrounded by water bodies (Summers and Grieve, 1982; Martin et al., 1986; Pedrana et al., 2011). This hypothesis predicts a higher probability of detecting this species in areas of low elevation close to streams and lakes. The anthropogenic disturbance hypothesis (hereafter "human hypothesis") presumes that illegal hunting and frequent disturbances are more frequent around areas of easy access and centers of human activity making these places less suitable for the species survival, and varies according to land use (e.g. croplands and pasturelands). According to this hypothesis there is a lower probability of Sheldgeese occurrence near urban areas and paved roads. The landscape composition and configuration hypothesis (hereafter "landscape hypothesis") postulates that the homogenization of the southern Pampas region through the conversion of native grasslands to croplands and sown pastures for livestock (Bilenca and Miñarro, 2004), affects Sheldgeese distribution. We tested the hypothesis that a combination of landscape metrics representing spatial heterogeneity can explain a large proportion of the variability on the occurrence of the species.

2. Material and methods

2.1. Study area

The study was conducted in the southern Pampas and Espinal of Argentina (between 36.46° to 41.04°S, and 63.39° to 58.62°W) with and extent of 106 000 km^2. The climate is subhumid-humid mesothermal with a mean annual temperature of 10 to 20 °C and a mean annual rainfall between 400 and 1600 mm (Soriano et al., 1991). The area is characterized by low to moderate undulations, which include the mountains of the Ventania System, dissected by lakes and marshes and large areas of crops and pastures for livestock grazing. Pristine vegetation was dominated by grassland steppes of several species of *Stipa* spp. and *Piptochaetium* spp. (Soriano et al., 1991) and Caldén forest, *Prosopis caldenia*, mainly in the south of the study area (Cabrera, 1994). However, this landscape has been intensively modified by anthropogenic activities. The main land use is agriculture (Paruelo et al., 2001), predominantly winter crops such as wheat (*Triticum aestivum*), oats (*Avena sativa*), barley (*Hordeum vulgare*) and rye (*Secale cereale*) and summer crops such as soybean (*Glycine max*), sunflower (*Helianthus annuus*), maize (*Zea mays*) and sorghum (*Sorghum graniferum*).

2.2. Study species

Sheldgeese species are migratory and endemic species of South America. From September to March they migrate to southern Patagonia (Argentina and Chile) where they breed and rear their chicks, while from April to August they winter mainly in the southern Pampas (Argentina), which is considered critical because of the interaction between species and agricultural activities. There is also a sedentary population on the Falkland Islands (Summers and Grieve, 1982; Summers and McAdam, 1993). Sheldgeese are herbivorous and feed on pastures or cereal crops (Summers and Grieve, 1982; Martin et al., 1986; Summers and McAdam, 1993). During the migratory season, and especially during winter, Sheldgeese are killed in large numbers due to unregulated hunting and persecution by farmers (Blanco and De la Balze, 2006; Petracci et al., 2010). Yet the magnitude of damage to crops or pastures caused by grazing geese has been studied only in the Falkland Islands (Summers and McAdam, 1993), where it has been suggested that livestock benefits geese by controlling shrub regeneration and maintaining a high proportion of green pastures, whereas sheep benefit by eating goose feces that have similar digestibility and nitrogen content to high-quality grass.

In the last decades, all Sheldgeese have shown evidence of marked decline in wintering areas (Blanco et al., 2003; Chebez,