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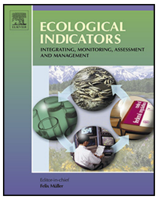

Vegetation maps based on remote sensing are informative predictors of habitat selection of grassland birds across a wetness gradient

A.G. Besnard[a,*], A. Davranche[b], S. Maugenest[a], J.B. Bouzillé[c], A. Vian[d], J. Secondi[a]

[a] *LUNAM University, University of Angers, GECCO (Group Ecology and Conservation of Vertebrates), 49045 Angers, France*
[b] *LUNAM University, University of Angers, LETG - LEESA, 2 Boulevard Lavoisier, 49045 Angers, France*
[c] *UMR Ecobio Equipe Dynamique des communautés, Campus de Beaulieu, 35042 Rennes, France*
[d] *IRHS, 2 Boulevard Lavoisier, 49045 Angers, France*

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ABSTRACT

Vegetation is a major environmental factor influencing habitat selection in bird species. High resolution mapping of vegetation cover is essential to model the distribution of populations and improve the management of breeding habitats. However, the task is challenging for grassland birds because microhabitat variations relevant at the territory scale cannot be measured continuously over large areas to delineate areas of higher suitability. Remote sensing may help to circumvent this problem. We addressed this issue by using SPOT 5 imagery and phytosociological data. We mapped grassland vegetation in a floodplain using two methods. We (i) mapped the continuous Ellenberg index of moisture and (ii) identified 5 vegetation classes distributed across the wetness gradient. These two methods produced consistent output maps, but they also provided complementary results. Ellenberg index is a valuable proxy for soil moisture while the class approach provided more information about vegetation structure, and possibly trophic resources. In spite of the apparent uniformity of meadows, our data show that birds do not settle randomly along the moisture and vegetation gradients. Overall birds tend to avoid the driest vegetation classes, i.e. the highest grounds. Thus, vegetation maps based on remote sensing could be valuable tools to study habitat selection and niche partition in grassland bird communities. It is also a valuable tool for conservation and habitat management.

1. Introduction

Delimiting zones of protection is a major issue of conservation programmes (McNeely, 1994; Moilanen et al., 2009). In order to identify core protection areas and optimize management, policy makers need robust background information like precise ecological requirements for target species. Grasslands present an interesting case in that respect because they often appear to human eyes as large expanses of uniform vegetation. For this reason, designing efficient protection areas in grasslands may seem challenging but this objective needs to be met. Due to anthropogenic changes, grassland birds are threatened in several part of the World (Azpiroz et al., 2012; Brennan and Kuvlesky, 2005; Tryjanowski et al., 2011; Tucker et al., 1994). Agri-Environmental Schemes (AES) were implemented in the 1990s within the European Union to subsidize grassland management compatible with breeding but many species have continued to decline (Kleijn et al., 2006). Precise knowledge of habitat selection for target species is therefore crucial to design new and more ecologically oriented AES measures in areas where conservation objectives partly failed.

Although their breeding habitat may seem homogeneous, grassland species do not settle at random in meadows. Spatial variations in density are frequently observed. For instance, many species are area-sensitive and avoid small fragments of habitats (Besnard and Secondi, 2014; Davis and Brittingham, 2004; Helzer and Jelinski, 1999). Even in larger patches, they tend to avoid landscape features like hedges because of higher predation risk (Morris and Gilroy, 2008). Vegetation itself offers various level of suitability for nesting. Vegetation structure is a major feature that influences the settlement of grassland birds (Fisher and Davis, 2010; Jacobs et al., 2012). Plant community largely determines arthropod assemblages (Schaffers et al., 2008) and therefore the quantity and quality of available trophic resources (Britschgi et al., 2006). Grassland birds tend to prefer areas with higher densities of flowers during the

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* Corresponding author. Tel.: +33 241 735 030.
E-mail addresses: aurelien.besnard@univ-angers.fr (A.G. Besnard), aurelie.davranche@univ-angers.fr (A. Davranche), sebastien.maugenest@univ-angers.fr (S. Maugenest), jan-bernard.bouzille@univ-rennes1.fr (J.B. Bouzillé), alain.vian@univ-angers.fr (A. Vian), jean.secondi@univ-angers.fr (J. Secondi).

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breeding season (Fischer et al., 2012). This preference may reflect higher prey availability to feed the young (Oppermann, 1990). Vegetation cover also determines predation risk (Ejsmond, 2008), particularly the ability of birds to hide their nests under the canopy (Whittingam and Evans, 2004). Therefore, grassland birds tend to select nest site with taller swards and denser vegetation (Davis, 2005). In addition, some species need herbaceous perches for foraging and territorial defence (Fischer et al., 2012; Oppermann, 1990).

Soil moisture is a major factor of grassland ecology (Price, 2002; Suzuki et al., 2006). It is considered as the main driver of vegetation patterns in most regions (Moeslund et al., 2013). Flood is a recurrent phenomenon that generates a wetness gradient and structures vegetation communities (Martinez and Letoan, 2007). However, wetness is also influenced by local environmental conditions like altitude, microtopography, or soil. Fortunately, vegetation has the property to integrate all the components of wetness (Goward et al., 1991). Mapping vegetation in relation to its affinity for moisture is expected to provide informative predictors to analyze habitat selection in grassland birds and improve the management of these habitats. Satellite remote sensing techniques are promising tools in this regard. They provide vegetation data with a spatial resolution high enough to analyze habitat selection in birds across ecological gradients. Furthermore, satellite images often cover geographical ranges large enough to delineate areas with different levels of conservation priority (Guo, 2004; Poulin et al., 2010).

We assessed two methodological approaches to describe the variation of grassland vegetation across the wetness gradient in floodplains. We used the Ellenberg moisture index that attributes a value to each vegetal species, corresponding to its affinity for soil moisture (Ellenberg et al., 1992). We computed a continuous wetness gradient based on the mean Ellenberg index of the local vegetation community to map the wetness gradient across a floodplain. In addition, we tested a discrete method to map vegetation classes as defined by the phytosociological approach (Tichý, 2002). A vegetation class is “a system of vegetal organisms with a floristic composition that is statistically repetitive” (Biondi, 2011). Each class may offer a specific level of suitability for birds depending on its physical properties and the various resources it provides. In grasslands, these vegetation classes may therefore be an informative proxy to describe habitat requirements of bird species. This approach may be easier to apply for managers since habitats are determined and their conservation prioritized according to vegetation associations, for instance in the European Union (Davies et al., 2004). Finally, AES are implemented in our study area to protect grassland and birds. We tested if AES types were related to vegetation community, i.e. the hydrological functioning of the floodplain, and if the spatial distribution of AES matched habitat selection of birds as described by vegetation.

2. Methods

2.1. Study area

The study area covers the floodplains of the Loire River and its main tributaries around Angers city in France (47.48, −0.56) (Fig. 1). Hydrological flow is relatively undisturbed by anthropogenic developments in contrast to other floodplains of similar size in Western Europe (Hesselink et al., 2003). Due to frequent floods, extensively managed grasslands still represent the main land cover type. Agricultural practices consist in mowing meadows once a year in June–July and in allowing low intensity grazing by cattle during vegetation regrowth. Considering the shallow slope of the ground, plant community mainly depends on soil wetness and submersibility. Owing to their management, these grasslands still host several patrimonial bird species, like the Corncrake (*Crex crex*), known to be highly sensitive to intensive agriculture (Green et al., 1997a). Many grassland bird species collapsed in the second part of 20th century, mainly due to the intensification of practices (more efficient machinery, fertilization, advanced mowing schedule). Agri-environmental schemes (AES) that were implemented locally mainly consisted in delaying hay mowing. The proportion of grassland under AES is quite high in the study area (45% in 2011). Several levels of AES measures are present in the study area, differing mainly by the earliest mowing date. For clarity, we aggregated parcels in two sets: those mown in June (3540 ha) and those mown in July (1571 ha). Mowing before July causes high mortality in broods (Broyer, 2007; Green et al., 1997b). Therefore, we considered that meadows mown in June were not suitable for the sustainable breeding of grassland birds.

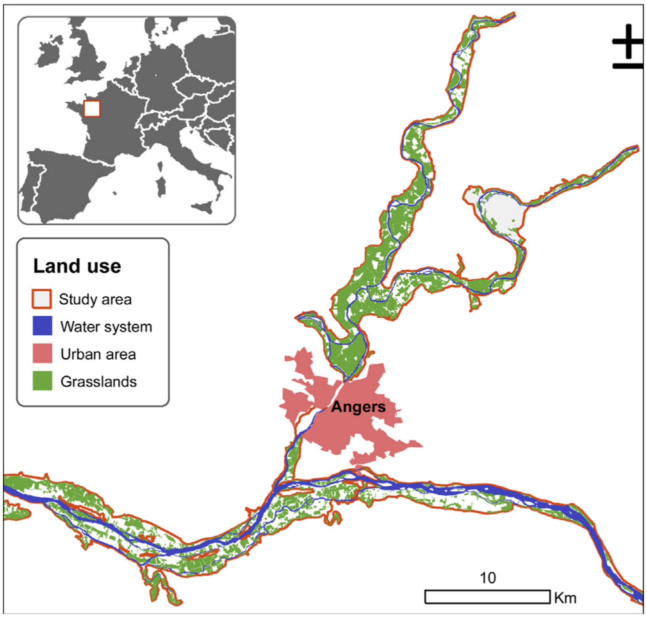

Fig. 1. Map of grassland distribution in the study area. The inset shows the location in Europe.

2.2. Vegetation relevés and phytosociological classification

We conducted phytosociological relevés on 107 plots to describe vegetation community across the whole study area. Survey was carried out from May 16th to June 10th 2011 to ensure the reliable identification of plant species. A plot was defined by the standard 16 m^2 quadrat method (Chytrý and Otýpková, 2003). Quadrats were selected in a larger zone of homogeneous vegetation to limit the environmental effects of other land cover bordering the pixel of the relevé during the remote sensing process. We sampled as many contrasting situations along the flooding gradient as possible basing on our knowledge of the study area. Sampling plots were positioned using a Differential Global Positioning System (DGPS), through a Trimble© Juno© SB. The estimated georeferencing error after post-processing was 6 m maximum. However it was lower than 4 m for 93% of plots. All species in the quadrat were identified using either a local specific flora (Corillon, 1981) or a vegetative flora (Eggenberg and Möhl, 2013) when necessary. Area covered by each species was evaluated using a Braun-Blanquet coefficient (Braun-Blanquet, 1964). We then classified relevés with JUICE software (Tichý, 2002), using the TWINSPAN method (Hill, 1979), including standard relevés from a previous study conducted in the same area (De Foucault, 1984) as referentials for the classification. This method classifies relevés according to their similarity in order to identify phytosociological taxa. We identified five taxa along the