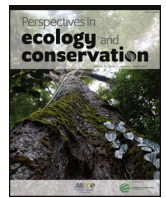




Perspectives in ecology and conservation

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Essays and Perspectives

Movement ecology research to advance conservation of South America's grassland migratory birds

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ABSTRACT

South America is home to some of the largest, most diverse grasslands on the planet, providing critical habitat for numerous plants and animals and vital resources for millions of people. Yet, at the dawn of the 21st Century, South America's grasslands are experiencing rapid, widespread and unprecedented impacts from activities such as pesticide use, drainage, urbanization, and conversion to industrial monocultures. In combination with the pervasive effects of global climate change, these impacts have the potential to ripple across grassland food webs in ways we still poorly understand. How do these impacts affect the behavior, ecology and population demographics of the numerous migratory birds that call these grasslands home? Given the historical lack of research on grassland birds across the New World, we know very little about how to best conserve them, much less which grassland migratory birds are currently impacted or likely will be in the near future. We argue that, by applying recent theoretical and technological advances in the field of movement ecology, rapid advances can be achieved in understanding grassland migratory birds in South America. We outline the current state of knowledge about grassland birds that migrate within South America, the main threats to their survival, and how the emerging field of movement ecology can contribute to understanding how to conserve and manage their populations. Only with information on the full annual cycle of these birds will we be able to formulate effective conservation and management plans to ensure the long-term viability of these unique species.

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Introduction

South America is home to a highly diverse array of grasslands, from relatively small grassland 'islands' located within larger forested landscapes, to high elevation Andean Puna and Páramo, to extensive lowland 'seas' of grass such as the south-temperate Pampas and tropical Llanos (reviewed by Vickery et al., 1999; Azpiroz et al., 2012). Given South America's status as the planet's cradle of bird diversity, it is not surprising that the continent's broad spectrum of tropical and temperate grasslands play host to a taxonomically, behaviorally and ecologically diverse set of bird communities, which have been adapting to these open ecosystems for millennia (Ribeiro et al., 2016).

Yet, with few exceptions, South America's grassland birds have been poorly studied. Although the last decade has seen an increase in research on grassland bird communities (e.g., Azpiroz and Blake, 2009; Di Giacomo et al., 2010; Medan et al., 2011; Isacch and Cardoni, 2011; Codesido et al., 2013; Dias et al., 2013; Dotta et al., 2015; Fontana et al., 2016), we still know very little about such basic aspects of their biology as life history strategies, winter habitat use, movements and evolutionary history (e.g., Jahn et al., 2009; Azpiroz et al., 2012), in large measure due to a lack of long-term, standardized schemes to monitor their populations. In most cases, we can only guess at the drivers of their population dynamics or of the effect on their populations of recent, widespread and rapid changes to their native habitats. Compared to many resident species, migratory birds in the Neotropics tend to have large wintering ranges (which has been shown in European breeding species to be negatively related to population declines, Gilroy et al., 2016) and lower habitat specificity, such that they have generally been of lower

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conservation concern than residents (Stotz et al., 1996). However, some grassland migratory birds are year-long habitat specialists, especially those occupying native grasslands and marshes, such as *Sporophila* seedeaters (Stotz et al., 1996; Silva, 1999).

We also know very little about the role of South American migratory birds within their ecosystems (but see Bravo et al., 2015). Migratory organisms, including birds, often provide key physical links between habitats and ecosystems, for example transporting genes and propagules (e.g., Viana et al., 2016a, reviewed by Viana et al., 2016b), which can influence gene flow and lead to the establishment of new species (Bauer and Hoye, 2014). Because of the large number of birds involved (i.e., millions of individuals) and distances they travel (i.e., hundreds to thousands of kilometers), many grassland migratory bird species in South America likely provide vital ecosystem services to the grassland system(s) they inhabit (e.g., Swainson's Hawks, *Buteo swainsoni*, feeding on grasshoppers while overwintering in south-temperate grasslands; Sarasola and Negro, 2005), as has been shown in other habitats (Şekercioğlu et al., 2016). Given their likely important role in maintaining intact, functioning grassland ecosystems, there is an intrinsic merit in understanding and conserving migratory birds in these systems. In turn, if the movement of grassland birds affects the functionality of grassland ecosystems, then understanding their movements provides vital important information on the best conservation practices for these ecosystems (reviewed by Mitchell et al., 2013).

There is growing recognition that understanding how organisms move in space and time is imperative to a full appreciation of their evolution, behavior and ecology, as well as an ability to identify their vulnerabilities on a rapidly changing planet (Marra et al., 2015; Wilcove and Wikelski, 2008). This new paradigm, combined with rapid technological and methodological advances in remote information gathering and analysis, is leading to rapid growth of movement ecology research (Nathan et al., 2008). In spite of the paucity of information on the movements of South America's grassland migratory birds, the application of existing movement ecology theories and tools for data collection and analysis can remedy this important gap in our knowledge of this group of birds and how to conserve them.

Our first objective here is to provide a brief overview of South America's grasslands and their migratory birds, outlining known or potential threats to their populations. Second, we describe how the field of movement ecology, including its theoretical framework and analytical methods can improve our understanding of South America's grassland migratory birds, and consequently, the information necessary to develop effective conservation and management planning for their populations. Although research at the species level is important for promoting grassland bird conservation (e.g., Azpiroz and Blake, 2009; Dotta et al., 2015), we focus here on movement ecology research at the individual and population levels, since an individual's behavior ultimately impacts processes at the population level. For example, populations can be negatively impacted when individual migrants do not correctly time their arrival on breeding grounds to match changes in food resource availability (Both et al., 2006).

A brief introduction to South America's grassland migrants

For the purposes of this discussion, we will focus on migratory birds occurring in three of South America's largest grasslands: (1) south-temperate grasslands of southeastern South America, including the upland grasslands (i.e., "campos de altitude") of southern Brazil, the Pampas of the Uruguay, Paraná-Paraguay and La Plata River basins, and the wet grasslands of the Chaco of northern Argentina and southern Paraguay (Fig. 1; for a review of these grasslands and their birds, see Azpiroz et al., 2012), (2) the campo

grasslands of the Cerrado ecoregion at the center of the continent (Fig. 1), and (3) the Llanos of the Orinoco River Basin in eastern Colombia and Venezuela (Fig. 1). Birds representative of several migratory systems occur in these grasslands:

- (1) South American temperate-tropical migrants (*sensu* Joseph, 1997), which breed in south-temperate grasslands and overwinter in campo Cerrado grasslands (e.g., Chestnut Seedeater, *Sporophila cinnamomea*; Tawny-bellied Seedeater, *Sporophila hypoxantha*; Tropeiro Seedeater, *Sporophila beltoni*; Repenning and Fontana, 2016), or more rarely, in the Llanos (e.g., Blue-black Grassquit, *Volatinia jacarina*; Fork-tailed Flycatcher, *Tyrannus savana*, Jahn et al., 2013).
- (2) South American cool-temperate migrants (*sensu* Joseph, 1997), which breed in Patagonian steppe and overwinter in south-temperate grasslands (e.g., Chocolate-vented Tyrant, *Neoxolmis rufiventris*; Gray-bellied Shrike-Tyrant, *Agriornis micropterus*).
- (3) Intra-tropical migrants, which breed, migrate and overwinter in tropical grasslands, including campo Cerrado grasslands (e.g., Lesser Elaenia, *Elaenia chiriquensis*; Guaraldo et al., 2016; Lined Seedeater, *Sporophila lineola*; Silva, 1995).
- (4) Nearctic-Neotropical migrants, which breed in the grasslands or arctic tundra of North America and overwinter in the Pampas (e.g., Upland Sandpiper, *Bartramia longicauda*; Bobolink, *Dolichonyx oryzivorus*; Renfrew et al., 2013).

Admittedly, such a categorization does not fully describe the full diversity of avian migration in South America's grasslands, since some species fit into more than one category. For example, Chaco Pipit (*Anthus chacoensis*) migrates wholly within south-temperate grasslands (Casañas et al., 2007). Additionally, partial bird migration, in which only some populations of a species are migratory, is common in South America (Chesser, 1994). Yet, this scheme provides a framework within which to draw comparisons and discuss research and conservation priorities.

Of 288 grassland bird species in South America, 46 (16%) are migratory (including Nearctic-Neotropical migrants, Chesser, 1994; Vickery et al., 1999). To the best of our knowledge, the South American grasslands with the largest prevalence of migratory species are the south-temperate grasslands of southeastern South America. Of 109 species that occur in those grasslands, 33 (30%) are migratory (including Nearctic-Neotropical migrants; Azpiroz et al., 2012). Hereafter, we focus on birds that migrate wholly within South America.

Primary threats to South America's grasslands and their migrants

South America's grasslands face a broad suite of human impacts, resulting in greater pressure on natural resources such as water and less space for native species. Large-scale agriculture and overgrazing by cattle are arguably the greatest threats. Extensive planting of soy (*Glycine max*), rice (*Oryza* spp.), non-native grasses and trees, and widespread burning especially threaten the grasslands of the Cerrado and Atlantic Forest biomes (Silva and Bates, 2002; Klink and Machado, 2005; Silva et al., 2006; Repenning et al., 2010), which are among the most threatened Neotropical grasslands (Stotz et al., 1996; Azpiroz et al., 2012).

In the Pampas, extensive planting of soy, rice and wheat (*Triticum* spp.) and of exotic tree species such as *Eucalyptus* sp. (Krapovickas and Di Giacomo, 1998; Dias et al., 2013) have greatly reduced native habitat (reviewed by Azpiroz et al., 2012), leading to significant changes in the composition of grassland bird communities (Dias et al., 2013). Replacement of cattle-grazing cropping systems by continuous cropping systems (Medan et al., 2011) has led to overgrazing by cattle, fire and erosion (Berretta, 2001). In Argentina, Uruguay and southern Brazil, avian richness and density

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