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Review

Ecosystem services provided by wildlife in the Pampas region, Argentina

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ABSTRACT

The expansion and intensification of human activities in the Argentinean Pampas have affected birds and mammals that inhabit the agroecosystems, threatening their populations and aggravating their conflicts with humans. On the other hand, they play different roles in the provision of Ecosystem Services (ES). Therefore, identifying and understanding the relationships between species and humans, and the delivery of ES is crucial for sustainable management of the environment. The objectives of this study were to identify ecological functions of birds and mammals and its conflicts with human activities reported by previous articles in the Pampas region; and to link these ecological functions as indicators of the potential ES provided by these species. We performed two systematic and structured searches of articles using Scopus bibliographic database, one for the ecological functions and the second one for conflicts. From the first search, we found 145 studies and 34% of them reported ecological functions, 78% were about birds and the rest about mammals. The Regulation and Maintenance ES were the most reported type and involved the provision of nutrients and pest control, with birds of prey and carnivorous mammals as the most mentioned groups. Provisioning ES were related to the provision of leather from legal hunting and genetic material, and Cultural ES were associated to species conservation. From the conflict search, we found 23 studies that mentioned negative interactions in the Pampas region, mostly with birds and associated to agricultural production damages. Many species mentioned as important ES providers, are also involved in conflicts, causing some discomfort to people. Therefore, the integration of wildlife, with its benefits and damages, could be a powerful argument to achieve the coexistence of wildlife into a landscape shaped by anthropogenic activities.

1. Introduction

Natural ecosystems have been increasingly threatened by anthropogenic factors (urbanization, mining, deforestation, chemical and light pollution, introduction of exotic species) all around the world (Borges et al., 2019). In particular, the expansion and intensification of agricultural activities have reduced wildlife natural habitats (Foley et al., 2005). Many of these species are been persecuted and killed by ranchers claiming them as "agricultural pests" (Abba et al., 2009; Pedrana et al., 2014, 2015; Soler et al., 2004) and others suffered from indirect effects of agricultural practices, such as poisoning or the loss and/or fragmentation of their habitats (Bilenca et al., 2012; Ogada, 2014; Ripple et al., 2015).

Wildlife species are an essential part of an ecosystem, playing different roles in the provision of Ecosystem Services (ES), defined as the benefits that humanity can obtain from a natural process of the ecosystem (Balvanera et al., 2006; Díaz et al., 2005; Green and Elmberg, 2014; Whelan et al., 2008). Consequently, the anthropogenic changes in the quality and availability of natural habitats are threatening these benefits (MEA, 2005).

There is an extensive bibliography that recognizes a great amount of ES provided by birds and mammals (Clark et al., 2016; Gaston et al., 2018; Lacher et al., 2019; Whelan et al., 2008). These groups comprise a great diversity of species with very different habitat behaviors and requirements, fulfilling important roles in the ecosystems (Davidson et al., 2012; Green and Elmberg, 2014; Sarasola et al., 2016; Whelan et al., 2008; Williams et al., 2018). These groups of animals are related to the three types of ES defined by the Common International Classification of Ecosystem Services (CICES): Provisioning; Regulation and Maintenance; and Cultural (Haines-Young and Potschin, 2013).

As Provisioning ES, birds and mammals are harvested for human consumption and subjected to sport and subsistence hunting. In addition, their feathers and leather are used for clothing and accessories (Buij et al., 2017; Green and Elmberg, 2014). Many studies highlight the role of birds and mammals in Regulation and Maintenance ES. For example, frugivorous and

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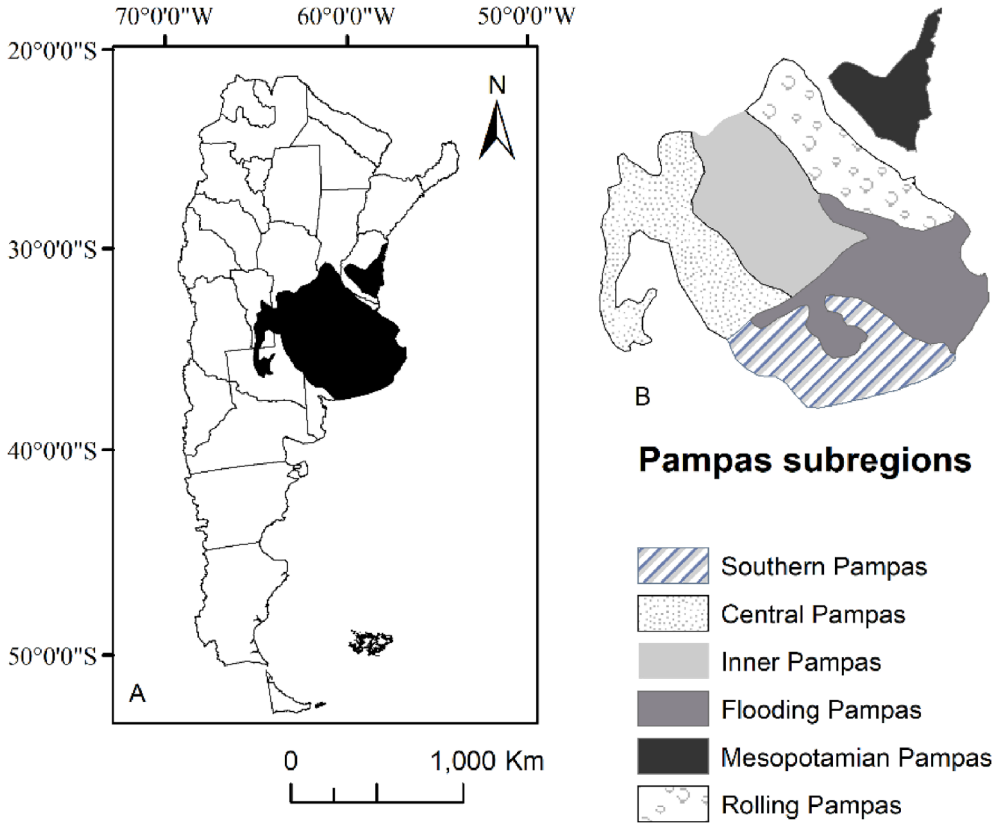

Fig. 1. Study area. A) Argentina with the province division (white) and the Pampas region (black); B) Pampas region and its ecological sub-regions.

nectarivorous bat and lemur species regulate forest floral diversity through their role as seed dispersers and pollinators (Dew and Wright, 1998). Also, large aggregations of birds contribute to the input and nutrient flow of an ecosystem (Whelan et al., 2008), and many insectivorous and carnivorous animals (raptors, bats and carnivorous mammals) predate on detrimental special for local agriculture and livestock (Dew and Wright, 1998; Donázar et al., 2016). Finally, burrowing mammals help water filtrarion and soil mixing by building their dens (Davidson et al., 2012) and increase the organic and inorganic nutrients available in the soil, providing a better quality fodder for cattle (Villarreal et al., 2008). Lastly, birds and mammals can provide Cultural ES, by being a source of inspiration for photography and art, spiritual and cultural heritage. Also their presence encourages environmental education and eco-tourism (Dew and Wright, 1998; Green and Elmberg, 2014).

A large proportion of the Earth's terrestrial surface is influenced by agriculture; therefore, its contribution to biodiversity is critical in long-term conservation of wildlife populations (Batáry et al., 2011; Tallis et al., 2009). In general, agroecosystems are managed to optimize provisioning ES, such as food, fiber and fuel. However, these benefits depend upon regulating ES, which are threatened by human activities (Foley et al., 2005; MEA, 2005; Rey Benayas and Bullock, 2012). Well-managed agricultural landscapes comprehend all types of services (MEA, 2005; Müller et al., 2019) and the interaction with natural areas is of great importance to achieve food security and maintain environmental integrity and resilience (Poppy et al., 2014).

Considering the huge impact that birds and mammals have on the human well-being, it is important to recognize the ES provided by these groups in agroecosystems. For this, it is useful to recognize key "ecosystem services providers". Understanding their ecology, how animals select their resources (food and habitat) and their responses to environmental changes, could help to identify the ES provided by them, which are of importance for agricultural production and environmental integrity (Zaccagnini et al., 2011). On the other hand, it is important to take into account the negative interactions between them and people as well, because conflicts are one of the main threats that species are facing nowadays (Dickman, 2010). Therefore, having a clear identification and understanding of these relationships is crucial for the sustainable management of the environment (Birkhofer et al., 2018).

The Pampas region in Argentina is a temperate grassland ecosystem and one of the richest agricultural areas of the world for grain and beef production (Baldi et al., 2006; Bilenca and Miñarro, 2004; Soriano et al., 1991). Several areas of the original grasslands were replaced by sown pastures for livestock and croplands, with a particular expansion of soybean within the last decades (Aizen et al., 2009; Grau et al., 2005). This reduction of natural habitats has increased the overlapping between species of birds and mammals and the anthropogenic activities, threatening wildlife populations (Azpiroz et al., 2012; Codesido et al., 2011). Consequently, these changes have negatively affected the potential ES that these species could provide, even before they are identified and valued. Therefore, it is important to identify the different ES provided by birds and mammals and their conflicts to help achieve an integration between conservation and agriculture production.

The aim of this study was to identify which species are key "ecosystem services providers" of the Pampas region and highlight their potential ES provided by them. The specific objectives were: 1) to identify ecological functions of birds and mammals and their conflicts with human-activities in the Pampas region reported by previous articles; and 2) to link these ecological functions with potential ES provided by these species.

2. Methodology

2.1. Study area

The Pampas region is located in the central east of Argentina and comprises 398966 km^2 (including south of Entre Ríos, Córdoba and Santa Fe, north of La Pampa and almost the entire Buenos Aires province) (Soriano et al., 1991) (Fig. 1a). This region is divided into six ecological sub-

Table 1
Classification of potential Ecosystem Services (ES) provided by species of birds and mammals following the CICES classification (R: Regulation and Maintenance, P: Provisioning, C: Cultural services) (Haines-Young and Potschin, 2013). Table modified from CICES V4.3 (January 2013).

ES	Classes and examples
P	Reared animals and their outputs (meat, milk, cheese)
	Game including commercial and subsistence hunting for food
	Materials for direct use or processing (fibers, skin, bones, medicines, ornamental uses)
	Materials for agricultural use (fodder, manure and fertilizer)
	Genetic materials for biochemical industrial and pharmaceutical processes and for bio-prospecting activities (wild species used in breeding programs)
	Animal-based resources for energy production (dung, fat, oils, cadavers for burning)
	Physical labor provided by animals (horses, elephants etc.)
R	Lifecycle maintenance, habitat and gene pool protection (pollination, seed dispersal, maintaining nursery populations and habitats)
	Pest and disease control
	Maintenance of bio-geochemical conditions of soils including fertility, nutrient storage, or soil structure (including biological, chemical, physical conditions)
C	Experiential use of animals (birdwatching)
	Physical use of animals (leisure hunting)
	Intellectual and representative interactions (scientific, educational, cultural heritage, entertainment, aesthetic)
	Spiritual and/or emblematic: symbolic (emblematic animals or national symbols) and sacred/religious
	Other cultural outputs: existence (enjoyment provided by wild species) and bequest (willingness to preserve animals and their ecosystems for the experience and use of future generations, moral/ethical perspective or belief)

regions according to precipitations and soil quality: Rolling Pampas, Mesopotamian Pampas, Inner Pampas, Central Pampas, Flooding Pampas and Southern Pampas (Fig. 1b) (Soriano et al., 1991). The average annual temperature of the region is between 14 and 20 °C and precipitations vary between 700 and 1200 mm, decreasing from northeast to southwest (Matteucci, 2012). The landscape is characterized by low to moderate undulations, which includes mountain systems, lakes and marshes and most of the original grassland has been replaced by cereal crops and pastures (Aizen et al., 2009; Grau et al., 2005).

2.2. Literature search

2.2.1. Ecological functions and ecosystem services

We performed a systematic and structured search of articles using Scopus bibliographic database on 21 March 2017, to identify ecological functions of birds and mammals in the Pampas region. Three searches were carried out, one for each type of ES (Provisioning, Regulation and Maintenance and Cultural). These had no restrictions on the year of publication and were done using different combinations of terms based on CICES (Haines-Young and Potschin, 2013). The searches were done with the following terms. For the Provisioning ES: [((argen*) and (pampa*) and (mamma* or bird*) and (service* or use* or provision* or game* or meat* or skin* or leather* or hunt* or bone* or fertiliz* or rear* or product* or fiber* or ornamen* or fodder* or biochemic* or indust* or medi* or gen*))]. For the Regulation and Maintenance ES: [(argen*) and (pampa*) and (mamma* or bird*) and (service* or habit* or ecolog* or use* or diet* or regul* or nutrient* or fertil* or poliniz* or dispersal* or control* or pest* or disease* or seed* or soil* or trophic*))]. Finally, for Cultural ES: [((argen*) and (pampa*) and (mamma* or bird*) and (watching* or ecoturism* or tourism* or hunt* or research* or heritage* or cultural* or aesthetic* or symbols* or ritual* or spiritual* or entertain* or conserv* or ethical* or moral*))].

We obtained a total of 405 studies (169 for Provisioning, 164 for Regulation and Maintenance, and 72 for Cultural ES). All studies found were gathered and repeated ones were eliminated. After we examined the title and abstract of each one, we identified 101 studies that met the criteria for our analysis. We believed that the literature search represents correctly the knowledge of ES provided by birds and mammals in the Pampas region, but we were aware that relevant articles were omitted. Therefore, for further exploration and completion, we included 44 mores studies checking the cited literature and including local journals that did not appear in Scopus bibliographic database.

2.2.2. Conflicts

Two systematic and structured searches were done, using Scopus bibliographic database on 1 May 2019 in order to find all published articles that mention conflicts between birds and/or mammals and human activities in the Pampas region. The searches had the following terms: [((argen* or pampa*) and (farm* or crop* or agro* or pasture* or grass* or graz* or agri* or wetland* or livestock* or ecosystem*) and (wildlife* or fauna* or bio* or diversity* or mammal* or bird*) and (damage* or conflict))] for the first one, and [((argen* or pampa*) and (agroecosystem* or agricult*) and (wildlife* or fauna* or diversiy* or biodiversity* or mammal* or bird*) and (damage* or conflict))] for the second one. Within the two searches, 303 articles were included, all of them gathered and eliminated in case they were repeated. Secondly, the traditional screening method was performed (consisting of examining the title and abstract), obtaining 20 studies meeting our criteria to focus on the negative effects that mammals or/and birds caused to humans activities or the conflict generated within their well-being in the Pampas region. Additionally, we included 3 mores studies, checking the cited literature and including local journals that did not appear in Scopus bibliographic database.

2.3. Data extraction

The systematic review search for the ecological functions of birds and mammals in the Pampas region resulted in 145 citations (Appendix A). Each of these articles was reviewed entirely and a questionnaire was answered. The questionnaire was made following the classification made by CICES (Haines-Young and Potschin, 2013) and taking into consideration the categories that include the ES (Table 1). The questionnaire also included details on the species identity and the land uses where the study was conducted. Land uses were grouped into eight categories: agriculture (A), grazing lands (G), mixed areas (landscapes with crops and grazing lands, A-G), interface urban–rural (I), forests (F), wetlands (W), grasslands (GR) and natural reserves (NR). Category I included the environments surrounding landfills, airports and urban areas. The NR was considered as a different category, due to the different management practices and protection degree. These details are important to check, as agricultural activities have a strong influence on the remaining natural areas (the natural reserves, grasslands and wetlands) as they are immersed in the agroecosystem landscape.

The systematic review search for the conflicts of birds and mammals in the Pampas region resulted in 23 citations (Appendix A). All of them were reviewed entirely, from which we obtained details on the species identity, the type of conflict and the land uses where the conflict occurred.

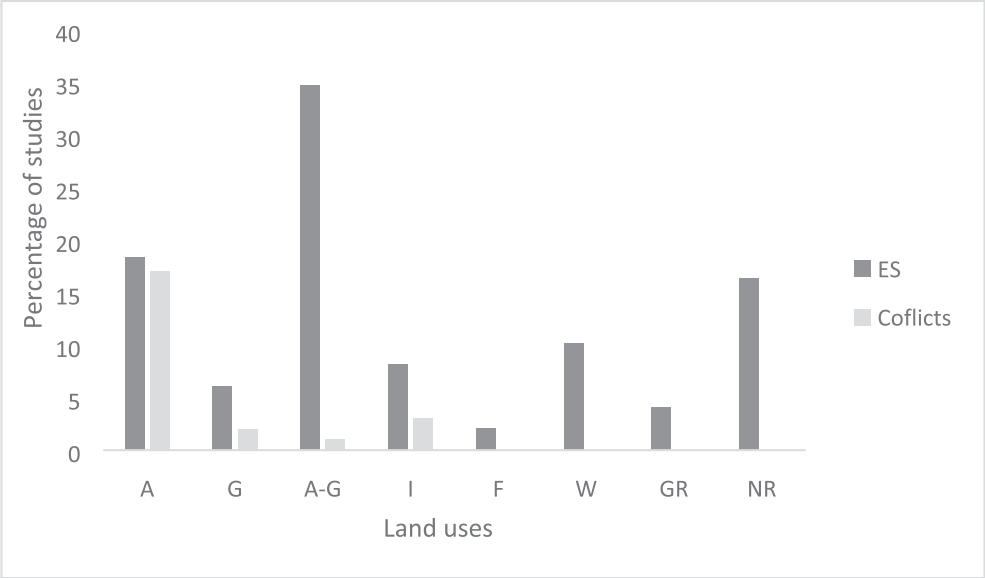

Fig. 2. Percentage of studies with different land uses in the agroecosystems of the Pampas region used in the literature review of Ecosystem Services (ES) and conflicts. Agriculture (A), grazing lands (G), mixed areas (A-G), interface rural–urban (I), forests (F), wetlands (W), grasslands (GR) and natural reserves (NR).

3. Results and discussion

3.1. Ecological functions provided by birds and mammals in the Pampas region

From the 145 reviewed studies, only 34% of them reported ecological functions of birds or mammals that highlight potential ES provided by them (Appendix A). Regarding the classification of ES, we identified Regulation and Maintenance in 38 studies, Cultural in 11 and Provisioning in only 3 of them (some articles mentioned more than one ES). Within all articles, 78% were about birds and the rest about mammals. In our review, we found that ecological functions of wildlife were performed in a great variety of land uses present in the Pampas region (Fig. 2).

3.1.1. Regulation and Maintenance ecosystem services

Potential Regulation and Maintenance ES had the highest reported cases within our study. These ES involved the provision of nutrients and maintenance of the soil biogeochemical conditions and pest and disease control by birds and mammals (Table 1). The process of provision of nutrients and maintenance of the soil biogeochemical conditions was reported in one study (Josens et al., 2009). This article showed a correlation between waterbirds abundance and the concentration of nutrients (phosphorus and nitrogen) in wetlands. This suggests the potential impact of these communities in the contribution of nutrients to the soil (Josens et al., 2009). Although within this research we did not find any article of mammals regarding similar contributions, the roles of burrowing mammals is well-studied in other regions of Argentina (Arias et al., 2005; Contarde, 2019; Villarreal et al., 2008). Studies done around the world recognized that burrowing mammals can enhance plant nitrogen uptake, facilitate water filtration and increase soil organic matter and inorganic nutrients (Black and Montgomery, 1991; Davidson et al., 2012). Davidson et al. (2012) mentioned the role of the Plains Vizcacha (*Lagostomus maximus*), an endemic herbivore of South America (Llanos and Crespo, 1952), which is present in the Pampas region. However, due to eradication campaigns, this species has nearly disappeared from most of the distributional range (Navarro et al., 1997) thus, minimizing the potential benefits that they could provide to soil conditions.

The process of pest and disease control was reported in 37 studies and all of them involved diet analysis. We found that birds and mammals are providing Regulation and Maintenance ES as they consume rodents, insects and/or plants considered detrimental on agricultural activities. This means that they directly provide benefits to people by controlling major vectors of diseases and plagues and sanitizing the environment by eating dead animals (Table B.1, Appendix B). Birds were the most mentioned group in relation to this service (78%) while mammals appeared in only 22% of the studies. Raptors (69%) was the most mentioned group of birds, and carnivores (63%) within mammals. It is worth noting that a great number of rodents, which are vectors of different diseases, were reported in the diet of raptors and the Pampas fox (*Lycalopex gymnocercus*) indicating an active role as pest controllers. The diet consumption of the Barn Owl (*Tyto alba*), the Red-backed Hawk (*Buteo polyosoma*) and the White-tailed Kite (*Elanus leucurus*) showed a preference for rodents (Bó et al., 2007). Besides, the Burrowing Owl (*Athene cunicularia*) predated over *Calomys musculinus* (Bellocq, 1987), which has an epidemiological interest, since this rodent was described as a reservoir of the Junin virus causing the Argentine Hemorrhagic fever (Polop et al., 2003; Sabattini et al., 1977). Other consumed rodents were the *Ratus ratus, Oligoryzomys flavescens* and *Akadon azarae* that were registered as infected or to have a high seroprevalence for the Leptospirosis bacteria (Colombo et al., 2018; Lovera et al., 2017; Ricardo, 2018). In addition, rodents of the genus *Oligoryzomys* were hosts of the Hanta virus, which causes the severe pulmonary syndrome (Andreo et al., 2014; Polop et al., 2003). Other reported diseases that could be transmitted by rodents are mycosis, triquinosis (with a secondary infection to humans), chorioomeningitis (with *Mus musculus* and *Mus domesticus* as reservoirs) and infections caused by *Streptobacillus moniliformis* and *Spirillu minus* from the *Ratus ratus* bite (Polop et al., 2003).

Several insects which are associated with crop damages were found in birds and mammals' diets in the Pampas region (Table B.1, Appendix B). Different species of the Scarabaeidae family (*Cyclocephala signaticollis, Dibolocelus palpalis, Dyscinetus* sp., *Philocloenia bonaerensis; Sulcophanaeus menela*, etc.), locally known as "Gusano blanco", were included in the diet of the Chimango Caracara (*Milvago chimango*) (Biondi et al., 2005), the Brown-hooded Gull (*Larus maculipennis*) (Ghys and Favero, 2004) and the Spectacled Tyrant (*Hymenops perspicillatus*) (Pretelli et al., 2014). These can cause significant reductions in wheat and sunflower (Abadia et al., 2017; Casuso et al., 2017) which means that their removal could bring economic benefits (Alvarado, 1983; Álvarez Castillo et al., 1993; Rizzo, 1997). These birds, as well as the

Southern crested Caracara (*Caracara plancus*), predated on weevils (family Curculionidae) which affect sunflower (Casuso et al., 2017) and wheat yield, bringing losses up to 31% (Abadia et al., 2017).

The Noctuidae, commonly known as owlet moths, cutworms or armyworms, are also recognized as agronomic pests (Abadia et al., 2017; Aragón, 2002; Casuso et al., 2017; Urretabizkaya et al., 2010). In our literature search, we found that this group of insects was predated by the Spectacled Tyrant (Pretelli et al., 2014) and the Greater Rhea (*Rhea americana*) (Comparatore and Yagueddú, 2007; Comparatore and Yagueddú, 2016). In addition, the Swainson's Hawk (*Buteo swainsoni*), the Chimango Caracara and the Brown-hooded Gull were identified as predators of grasshoppers (Biondi et al., 2005; Canavelli et al., 2001; Ghys and Favero, 2004; Goldstein et al., 1999). These insects belong to the Acrididae family and especially the acridoideos, locally known as "Tucuras", have become an agricultural plague. Other birds, such as the Great Egret (*Ardea alba*), the Cocoi Heron (*Ardea cocoi*) and the Pampa Finch (*Embernagra platensis*), eat insects as one of the main items in their diet (Montalti et al., 2005; Pretelli et al., 2012).

Regarding mammals, the Screaming hairy Armadillo (*Chaetophractus vellerosus*) and the Southern long-nosed Armadillo (*Dasypus hybridus*) have insects as one of the most important prey items in their diet (Abba et al., 2011; Abba and Cassini, 2010). Also, the most abundant item in the Molina's hog-nosed Skunk (*Conepatus chinga*) diet was the Coleoptera (Castillo et al., 2014). Most of these studies do not reach species level identification. We believe that identifying which species of insects and the number of items included in birds and mammals' diet might be essential to highlight the role as insects' controllers. Nowadays, the controls are made with synthetic insecticides and this entails a strong environmental, social and economic impact. Therefore, it is essential to adopt other complementary alternatives to chemical control in agricultural production. The study of targeted species as biological controllers might help to reduce the use of chemicals against plagues.

The Chimango Caracara (Biondi et al., 2005) and the Aplomado Falcon (*Falco femoralis*) (Baladrón et al., 2012; Bó, 1999) predated on birds considered pest for crops, such as Psittacidae and Columbidae families. Examples are the Eared Dove (*Zenaida auriculata*) (Casuso et al., 2017) and the *Myiopsitta* sp. which feed on sunflower grains and perch in the sunflower capitula, causing the grains to fall (Casuso et al., 2017). Casuso et al. (2017) reported that almost half of the plants consumed by the Monk Parakeet (*Myiopsitta monachus*) belonged to cultivated seeds, principally corn and sunflower. While the other half belonged to important weeds, such as Field Bindweed (*Convolvulus arvensis*) and the Black Medic (*Stellaria media)* (http://rian.inta.gov.ar/atlasmalezas). Booman et al. (2009) also found that some species of rodents (*Akodon azarae, Oligoryzomys favlenscens, Calomys* sp.) and the *Monodelphys dimidiate* eat seeds that are considered weeds. Therefore, despite the damages these species might cause, they also contribute to the agroecosystems by removing harmful species. Future studies should focus on evaluating the cost and benefits of these species to understand the overall results.

Greater Rhea is an important weed controller, eating vegetal plagues (Comparatore and Yagueddú, 2007; Comparatore and Yagueddú, 2016; Martella et al., 1996), such as the Black Medic, that represents an important problem in winter crops and pastures, and Wild Oat fruits (*Avena fatua*), a weed in wheat and barley crops (Miralles et al., 2014). The Greater Rhea also eats various species of thistles such as *Carduus acanthoides, Cirsium vulgare, Cynara cardunculus,* and of other weeds such as *Solanum sisymbriifolium, Conyza bonariensis* and Ryegrass (*Lolium* sp.) (Comparatore and Yagueddú, 2007; Comparatore and Yagueddú, 2016; Martella et al., 1996). Currently, Ryegrass is an important agronomic nuisances because it is resistant to glyphosate (Gigón et al., 2017; Vila-Aiub et al., 2008).

Scavengers benefit humans in multiple ways. For instance, the removal of animal debris before putrefaction plays an important hygienic role, as it helps to stabilize food webs, accelerate nutrient recycling and remove potential sources of infectious disease transmission (Cortés-Avizanda et al., 2016; Sebastián-González et al., 2019; Whelan et al., 2008). The Chimango Caracara, the Southern crested Caracara (Biondi et al., 2005; Montalvo et al., 2011; Vargas et al., 2007), the Pampas Fox (Canel et al., 2016; Castillo et al., 2011; Farias and Kittlein, 2008; García and Kittlein, 2005) and the Molina's hog-nosed Skunk (Castillo et al., 2014) are facultative scavengers in the Pampas region. The carrion items found in their diets varied from domestic animals, such as cows (*Bos taurus*), sheep (*Ovis aries*), horses (*Equus caballus*) and pigs (*Sus scrofa*) to fish and birds. Biondi et al. (2005) explained that the presence of fish in the Chimango Caracara diet belonged to discarded fish from sport fishing, a very common activity in the area. The role of scavenger as ES providers are studied around the world (Sebastián-González et al., 2019). Recently, it was found that human impacts are the dominant factor shaping the scavenger communities worldwide, even more important than climate variables (Sebastián-González et al., 2019). Taking into consideration that the Pampas region has one of the most rapidly expanding agricultural frontiers (Baeza and Paruelo, 2020), future studies will need to focus on the effects that anthropogenic factors have on the scavengers' communities, in order to identify the importance of these animals in agroecosystems.

Some ecological functions were not found in our review, for example seed dispersal, although it is recognized to be among the most important ES provided by birds (Whelan et al., 2008). The Mountain Lion (*Puma concolor*), which is widely spread in Argentina, was recognized to have a role in seed dispersal in La Pampa province (Sarasola et al., 2016). This study highlighted another important role of apex predators, besides being key elements in food webs and ecosystem functioning through competition and depredation. Furthermore, mammals and birds can act as ecosystem engineering providing refuge for other species (Davidson et al., 2012; Machicote et al., 2004) but we were unable to find studies of such examples.

3.1.2. Provisioning ecosystem services

Potential Provisioning ES were found in three studies. One study corresponded to provision of leather from the legal hunting of Pampas foxes and European Hares (*Lepus europaeus*) (Giarratano and Kristensen, 2012). We did not consider this activity as a cultural service as CICES does, since the leather of these animals have an economic value. The Pampas Fox commercial hunting in Argentina is regulated in each province, applying provincial law or adhering to the National law of Protection and Conservation of Fauna (N° 22421). The European Hare is exotic and the most important game animal in Argentina (Fujita and Calvo, 1981; Grigera and Rapoport, 1983). Giarratano and Kristensen (2012) highlighted the unsustainable way in which hunting practices take place in the Pampas region. Hunting controls are necessary in order to ensure species conservation and to quantify the profitability of this activity along the commercial circuit (Loveridge et al., 2006).

The other two studies corresponded to the provision of genetic material (genetic studies). One was focused on gene flow between subpopulations of Pampas Deer *(Ozotoceros bezoarticus*) (González et al., 1998), while the other one on bio-prospering activities in wild and captive Greater Rhea populations (Alonso Roldán et al., 2011).

3.1.3. Cultural ecosystem services

We found 11 studies related to Cultural ES provided by birds and mammals. These articles included the Neotropical Otter (*Lontra longicaudis*) (Guichón and Cassini, 2007), the Pampas Deer (González et al., 1998), the Pampas Meadowlark (*Sturnella defilippii*) (Tubaro and Gabelli, 1999; Zalba et al., 2009), the Greater Rhea (Alonso Roldán et al., 2011; Bellis et al., 2004; Giordano et al., 2010), migratory shorebirds (Blanco et al., 2004) and waterbirds (Josens et al., 2009, 2012). All of them were related to species conservation in different environments, linked with the bequest services or the willingness to preserve them (Table 1).

All around the world people are interested in watching large

concentrations of wildlife (Green and Elmberg, 2014). Therefore, species that attract people's attention could be used as flagships for the conservation of a particular environment and/or other species (Bowen-Jones and Entwistle, 2002), exerting pressure on governments to protect them. An example in our study area, is the "Campos del Tuyú National Park" (Buenos Aires province), created in 2009 to conserve the Pampas Deer (www.parquesnacionales.gob.ar). This deer acted as a flagship species, not only because it is the only charismatic deer in the region that lives exclusively in grasslands, but also because it helps achieve the protection of the environment and other species. This National Park is also an important non-reproductive area for migratory bird population (Blanco et al., 2004)

Regarding large aggregation of animals, birdwatching is another wildlife-based recreation activity done in the Pampas region. An important area for birdwatching is "Mar Chiquita Biosphere Natural Reserve" (Buenos Aires province), which was declared a Man and Biosphere (MAB) reserve by the United Nations (UN) Education, Scientific and Cultural Organization (UNESCO) Program in 1996. The human interest in bird watching is very well-known (Green and Elmberg, 2014) and in the study area there are several birds watchers clubs (locally named as COAs- Club de Observadores de Aves) associated with different NGOs. These groups organize regular bird observation sessions and they record their sightings in citizen science platforms, such as eBIRD.

Other Cultural ES are opportunities for recreation and tourism (MEA, 2005) but we did not find any study on this matter. Auer et al. (2018) highlighted that the presence of wild animals, especially birds, is one of the attributes of the rural landscape that sustains Cultural ES for recreation and tourism in the southeast of the Pampas region. Natural areas, such as hills and lagoons, are valued by local people for their views and natural vegetation, which is associated with more biodiversity (Auer et al., 2018). Rural recreation and tourism could be important economic drivers in this area that would favor biodiversity conservation (Auer et al., 2018; Buijs et al., 2006; Plieninger et al., 2013).

Sport hunting is one of the oldest known recreational activity using wildlife. Some studies have suggested that legal and regulated sport hunting can benefit the development and economy of local communities, thereby promoting the protection of wildlife resources as well as the ecological and economic sustainability (Bowyer et al., 2019; Organ et al., 2010). Boulé and Mason (2019) showed that to create effective policy recommendations regarding wildlife hunting, it is important to include the local hunters' perspective and situate these discussions historically. Although it was not mentioned in any study, many species are under hunting pressure in the Pampas region, such as ducks (like the Yellow-billed Pintail *Anas georgica,* and the Yellow-billed Teal *Anas flavirostris*), tinamous (like the Spotted Nothura *Nothura maculosa* and the Brushland Tinamou *Nothoprocta cinerascens*), doves and pigeons (such as the Eared Dove and the Spot-winged Pigeon *Patagioenas maculosa*).

3.2. Conflicts of birds and mammals in the Pampas region

From the 23 reviewed studies that reported conflicts, the great majority were about birds (70%) and the rest about mammals, mostly in agricultural fields (Fig. 2). Within birds, the Monk Parakeet was the most mentioned species (56%) and it is among the most important pest species causing damage to crops in the study region (Bruggers et al., 1998; Calamari et al., 2018; Canavelli et al., 2012, 2013, 2014; Dardanelli et al., 2016). Other birds such as the Eared Dove, the Spotted-winged Pigeon and the Picazuro Pigeon (*Patagioenas picazuro*) (Bruggers et al., 1998; Calamari et al., 2018; Dardanelli et al., 2016) were also considered agricultural plagues. Crop damages and consumption were mentioned related to waterbirds such as *Dendrocygna* sp, *Netta* sp, and *Chloephaga* sp (Bruggers et al., 1998). Particularly for sheldgeese (Ruddy-headed Goose *Chloephaga rubidiceps*, Ashy-headed Goose *Chloephaga poliocephala* and Upland Goose *Chloephaga picta*) its conflict with the agricultural activities was mentioned in several studies (Gorosábel et al., 2019; Pedrana et al., 2014). Since 1931, these species have been considered agricultural pest, although their damages to wheat (*Triticum* sp.) were evaluated, without finding evidence of yield reductions (Gorosábel et al., 2019). Another species widely accused of causing damage to crops is the Greater Rhea and as a consequence, local farmers have historically hunted them (Martella and Navarro, 2006; Pedrana et al., 2015).

In this review, we found other problems related with birds. Damage to ornamental and native plants, interference with utility poles and other man-made structures, noisiness, introduction of diseases and parasites, and aeronautical accidents were associated with parakeets (Marateo et al., 2015; Romero et al., 2016). The risk of aeronautical accidents was also related to doves (Marateo et al., 2015) and waterfowl, as well as problems in landfills and the risk of transmitting diseases and contaminants (Bruggers et al., 1998; Marateo et al., 2013).

Regarding mammals, we found that the Pampas Fox and the Mountain Lion are involved in human-carnivore conflicts. These species are persecuted by humans because they are accused of predating on domestic animals or livestock (Lucherini et al., 2004, 2018). Although cattle killing may be overestimated by local people, the interaction between the Mountain Lion and humans can produce significant losses for cattle ranchers (Lucherini et al., 2018). Therefore, this relationship should be considered in conflict mitigation strategies.

Rodents are common in conflicts with people and are considered harmful because they damage crops, stored goods, and infrastructure and also transmit zoonotic diseases (Lovera et al., 2015). Finally, the Xenarthrans also appeared in the conflict review since farmers complained that they damage silo bags, consume crops and their dens interfere with farming practices (Abba et al., 2015; Carlini et al., 2016).

Further studies on the damage produced by wild animals and their association with human activities need to be addressed to identify management priorities. Specially in cases were the conflict species are in the danger of extinction, such as the Ruddy-headed Goose, or have important roles in the ecosystems, such as top-predators.

4. Conclusion

The concept of ES (MEA, 2005) provides a useful tool to bridge biodiversity conservation, ecosystem functions, human benefits and development needs (Müller et al., 2019; Tallis et al., 2009). Based on our review and in accordance with many authors around the world (Balvanera et al., 2006; Díaz et al., 2005; Green and Elmberg, 2014; Whelan et al., 2008), birds and mammals play key roles in a wide variety of ES in the Pampas region. Most of the ES found in the reviewed studies are related to regulation process of the ecosystems such as biological control of detrimental species for humans. Provisioning and Cultural services were not equally represented, finding very few studies that addressed these ES. Particularly, Cultural services are perceived in different ways, depending on the social-economic and cultural context (Buijs et al., 2006) and are much harder to quantify than the others (Burkhard and Maes, 2017). Yet, we could identify the importance of natural areas or reserves in the provision of Cultural ES.

The negative interactions have to be included in decision-making processes and in land use planing (Ceauşu et al., 2019; Dickman, 2010). Particularly in situations like the Pampas region, where many of the mentioned species are important ES providers and are also involved in conflicts causing some discomfort to people. The majority of the conflicts found in this study were related to agricultural production damages. However, many of the species that caused those damages were involved in the regulation of other detrimental species in the same environments. Therefore, conservation studies should focus not only on the damages but also on people's perception. Studies on conflict-perceptions that quantify wildlife damage and monitor rates and causes of wildlife mortality would portray a more comprehensive picture of how

significant a conflict is to people and wildlife (Dickman, 2010). This could be a way of incorporating people's perspective of wildlife (positive and negative) in management plans.

Although this review was focus on the Argentinean Pampas, the study area is part of the Río de la Plata grasslands, which includes Uruguay and Rio Grande do Sul in Brazil as well (Soriano et al., 1991). The agricultural practices and the expansion of its frontiers in these countries have the same negative consequences on species and the remaining natural areas (Baeza and Paruelo, 2020; Modernel et al., 2016). Based on these, and on the similarities in the species occurrences (Bilenca and Miñarro, 2004), the identification of key species providers of ES could be used as a starting point to work on new conservation and sustainable measurements at a regional level. Together with quantitative data, this information could be implemented to monitor their populations and predict the ES provision. The reduction of those benefits could help to increase the awareness of the negative effects of the current agricultural practices.

Handling human–wildlife conflicts without compromising animal populations or human welfare is a great challenge that requires a delicate balance of agricultural extension and wildlife conservation (Ceauşu et al., 2019; Dickman, 2010; Treves et al., 2006). Identifying the potential ES provided by wildlife and understanding the conflicts between them and people, is a powerful argument to fit wildlife into a landscape shaped by anthropogenic activities and could be a way for wildlife population to coexist with human interests, favoring its conservation.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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References

Abadia, B., Abbate, P.E., Álvarez, C., Aramburu Merlos, F., Barraco, M., Bartosik, R., Bujan, J., Campaña, L.E., Cardos, M.J., Cardoso, L., Carmona, D., Calviño, P., Correndo, A.A., de la Torre, D., Divito, G., Ernst, O., Faberi, A.J., Fraschina, J.A., García, F.O., González, L., Hoffman, E., Leaden, M.I., Maciel, G., Manetti, P., Monzon, J.P., Salvio, C., Sautua, F., Tourn, S.N., Tulli, M.C., 2017. Manual del Cultivo del Trigo, 1era edición. Acassuso: International Plant Nutrition Institute, Argetina.

Abba, A.M., Cassini, G.H., Galliari, F.C., 2011. Nuevos aportes a la historia natural de la mulita pampeana *Dasypus hybridus* (Mammalia, Dasypodidae). Iheringia - Ser. Zool. 101, 325–335.

Abba, A.M., Cassini, M.H., 2010. Ecological differences between two sympatric species of armadillos (Xenarthra, Mammalia) in a temperate region of Argentina. Acta Theriol. 55, 35–44. https://doi.org/10.4098/j.at.0001-7051.083.2008.

Abba, A.M., Vizcaíno, S.F., Cassini, M.H., 2009. Eto-ecología y conservación de tres especies de armadillos (*Dasypus hybridus, Chaetophractus villosus* y *C. vellerosus*) en el noreste de la provincia de Buenos Aires, Argentina. Edentata 8, 41–47. https://doi.org/10.1896/020.010.0101.

Abba, A.M., Zufiaurre, E., Codesido, M., Bilenca, D.N., 2015. Burrowing activity by armadillos in agroecosystems of central Argentina: Biogeography, land use, and rainfall effects. Agric. Ecosyst. Environ. 200, 54–61. https://doi.org/10.1016/j.agee.2014.11.001.

Aizen, M.A., Garibaldi, L.A., Dondo, M., 2009. Expansión de la soja y diversidad de la agricultura argentina. Ecol. Austral 19, 45–54.

Alonso Roldán, V., Navarro, J.L., Gardenal, C.N., Martella, M.B., 2011. May captive populations of Greater Rhea (*Rhea americana*) act as genetic reservoirs in Argentina? Zoo Biol. 30, 65–70. https://doi.org/10.1002/zoo.20314.

Alvarado, L.J., 1983. Daños de insectos de suelo en semillas de plantas cultivadas. Informe Técnico N° 180. Balcarce, Argentina.

Álvarez Castillo, H.A., López, A.N., Vincini, A.M., Carmona, D., Manetti, P.L., 1993. Relevamiento de los insectos del suelo de cultivos de papa del sudeste bonaerense. Boletín técnico N° 118. Balcarce, Argentina.

Andreo, V., Neteler, M., Rocchini, D., Provensal, C., Levis, S., Porcasi, X., Rizzoli, A., Lanfri, M., Scavuzzo, M., Pini, N., Enria, D., Polop, J., 2014. Estimating hantavirus risk in southern Argentina: A GIS-based approach combining human cases and host distribution. Viruses 6, 201–222. https://doi.org/10.3390/v6010201.

Aragón, J.R., 2002. Insectos Perjudiciales de la Soja. INTA Marcos Juarez. IDIA XXI 3, 75–82.

Arias, S.M., Quintana, R.D., Cagnoni, M., 2005. Vizcacha's influence on vegetation and soil in a wetland of Argentina. Rangel. Ecol. Manag. 58, 51–57. https://doi.org/10.2111/1551-5028(2005)58<51:viovas>2.0.co;2.

Auer, A., Nahuelhual, L., Maceira, N., 2018. Cultural ecosystem services trade-offs arising from agriculturization in Argentina: A case study in Mar Chiquita Basin. Appl. Geogr. 91, 45–54. https://doi.org/10.1016/j.apgeog.2017.12.025.

Azpiroz, A.B., Isacch, J.P., Dias, R.A., Di Giacomo, A.S., Fontana, C.S., Palarea, C.M., 2012. Ecology and conservation of grassland birds in southeastern South America: A review. J. F. Ornithol. 83, 217–246. https://doi.org/10.1111/j.1557-9263.2012.00372.x.

Baeza, S., Paruelo, J.M., 2020. Land Use/Land Cover Change (2000–2014) in the Río de la Plata Grasslands: An Analysis Based on MODIS NDVI Time Series. Remote Sens. 12, 381. https://doi.org/10.3390/rs12030381.

Baladrón, A.V., Bó, M.S., Cavalli, M., Martínez, G., 2012. Comparación de la dieta de dos especies de rapaces ornitógafas, el Halcón perdiguero (*Falco femoralis*) y el Vari (*Circus cinereus*), en la región Pampeana de Argentna. Boletín Chil. Ornitol. 18, 62–67.

Baldi, G., Guerschman, J.P., Paruelo, J.M., 2006. Characterizing fragmentation in temperate South America grasslands. Agric. Ecosyst. Environ. 116, 197–208. https://doi.org/10.1016/j.agee.2006.02.009.

Balvanera, P., Pfisterer, A.B., Buchmann, N., He, J.S., Nakashizuka, T., Raffaelli, D., Schmid, B., 2006. Quantifying the evidence for biodiversity effects on ecosystem functioning and services: Biodiversity and ecosystem functioning/services. Ecol. Lett. 9, 1146–1156. https://doi.org/10.1111/j.1461-0248.2006.00963.x.

Batáry, P., Báldi, A., Kleijn, D., Tscharntke, T., 2011. Landscape-moderated biodiversity effects of agri-environmental management: A meta-analysis. Proc. R. Soc. B Biol. Sci. 278, 1894–1902. https://doi.org/10.1098/rspb.2010.1923.

Bellis, L.M., Martella, M.B., Navarro, J.L., Vignolo, P.E., 2004. Home range of greater and lesser rhea in Argentina: Relevance to conservation. Biodivers. Conserv. 13, 2589–2598. https://doi.org/10.1007/s10531-004-1086-0.

Bellocq, M.I., 1987. Selección de hábitat de caza y depredación diferencual de Athene cunicularia sobre roedores en ecosistemas agrarios. Rev. Chil. Hist. Nat. 60, 81–86.

Bilenca, D., Codesido, M., Fischer, C.G., Carusi, L.P., Zufiaurre, E., Abba, A., 2012. Impactos de la transformación agropecuaria sobre la biodiversidad en la provincia de Buenos Aires. Rev. del Mus. Argentino Ciencias Nat. Nueva Ser. 14, 189–198. https://doi.org/10.22179/REVMACN.14.189.

Bilenca, D., Miñarro, F., 2004. Identificación de áreas valiosas de pastizal en las pampas y campo de Argentina, Uruguay y Sur de Brasil (AVPs): programa pastizales Fundación Vida silvestre Argentina. Buenos Aires, Argentina.

Biondi, L.M., Bó, M.S., Favero, M., 2005. Dieta del chimango (*Milvago chimango*) durante el período reproductivo en el Sudeste de la provincia de Buenos Aires. Argentina. Ornitol. Neotrop. 16, 31–42.

Birkhofer, K., Rusch, A., Andersson, G.K.S., Bommarco, R., Dänhardt, J., Ekbom, B., Jönsson, A., Lindborg, R., Olsson, O., Rader, R., Stjernman, M., Williams, A., Hedlund, K., Smith, H.G., 2018. A framework to identify indicator species for ecosystem services in agricultural landscapes. Ecol. Indic. 91, 278–286. https://doi.org/10.1016/j.ecolind.2018.04.018.

Black, T.A., Montgomery, D.R., 1991. Sediment Transport by Burrowing Mammals, Marin country. California. Earth Surf. Process. Landforms 16, 163–172.

Blanco, D.E., Lanctot, R.B., Isacch, J.P., Gill, V.A., 2004. Pastizales templados del sur de América del Sur como hábitat de aves playeras migratorias. Ornitol. Neotrop. 15, 159–167.

Bó, M.S., 1999. Dieta del halcón plomizo (*Falco femoralis*) en el sudeste de la Provincia de Buenos Aires. Argentina. Ornitol. Neotrop. 10, 95–99.

Bó, M.S., Baladrón, A.V., Biondi, L.M., 2007. Ecología Trófica De Falconiformes Y Strigiformes. Tiempos de Síntesis. Hornero 22, 97–115.

Booman, G.C., Laterra, P., Comparatore, V., Murillo, N., 2009. Post-dispersal predation of weed seeds by small vertebrates: Interactive influences of neighbor land use and local environment. Agric. Ecosyst. Environ. 129, 277–285. https://doi.org/10.1016/j.agee.2008.09.009.

Borges, P.A.V., Gabriel, R., Fattorini, S., 2019. Biodiversity Erosion: Causes and Consequences, in: Leal Filho, W., Azul, A., Brandli, L., Özuyar, P., Wal, T. (Eds.), Life on Land, Encyclopedia of the UN Sustainable Development Goals. Springer, Cham, pp. 1-10. https://doi.org/10.1007/978-3-319-71065-5.

Boulé, K.L., Mason, C.W., 2019. Local Perspectives on Sport Hunting and Tourism

Economies: Stereotypes, Sustainability, and Inclusion in British Columbia's Hunting Industries. Sport Hist. Rev. 50, 93–115. https://doi.org/10.1123/shr.2018-0023.
Bowen-Jones, E., Entwistle, A., 2002. Identifying appropriate flagship species: The importance of culture and local contexts. Oryx 36, 189–195. https://doi.org/10.1017/S0030605302000261.
Bowyer, R.T., Boyce, M.S., Goheen, J.R., Rachlow, J.L., 2019. Conservation of the world's mammals: status, protected areas, community efforts, and hunting. J. Mammal. 100, 923–941. https://doi.org/10.1093/jmammal/gyy180.
Bruggers, R.L., Rodriguez, E., Zaccagnini, M.E., 1998. Planning for bird pest problem resolution: A case study. Int. Biodeterior. Biodegrad. 42, 173–184. https://doi.org/10.1016/S0964-8305(98)00046-8.
Buij, R., Melman, T.C.P., Loonen, M.J.J.E., Fox, A.D., 2017. Balancing ecosystem function, services and disservices resulting from expanding goose populations. Ambio 46, 301–318. https://doi.org/10.1007/s13280-017-0902-1.
Buijs, A.E., Pedroli, B., Luginbühl, Y., 2006. From hiking through farmland to farming in a leisure landscape: Changing social perceptions of the European landscape. Landsc. Ecol. 21, 375–389. https://doi.org/10.1007/s10980-005-5223-2.
Burkhard, B., Maes, J., 2017. Mapping Ecosystem Services, Advances in Life Course. Research. Pensoft Publishers, Sofia. https://doi.org/10.1016/s1040-2608(08)00018-x.
Calamari, N.C., Canavelli, S.B., Cerezo, A., Dardanelli, S., Bernardos, J.N., Zaccagnini, M.E., 2018. Variations in pest bird density in Argentinean agroecosystems in relation to land use and/or cover, vegetation productivity and climate. Wildl. Res. 45, 668–678. https://doi.org/10.1071/WR17167.
Canavelli, S.B., Aramburú, R., Zaccagnini, M., 2012. Considerations for reducing conflicts around damage of agricultural crops by Monk Parakeet (*Myiopsitta monachus*). El Hornero 27, 89–101.
Canavelli, S.B., Branch, L.C., Cavallero, P., González, C., Zaccagnini, M.E., 2014. Multilevel analysis of bird abundance and damage to crop fields. Agric. Ecosyst. Environ. 197, 128–136. https://doi.org/10.1016/j.agee.2014.07.024.
Canavelli, S.B., Maceda, J.J., Bosisio, A.C., 2001. Dieta del aguilucho langostero (*Buteo swainsoni*) en su área de invernada (La Pampa, Argentina). Hornero 16, 89–92.
Canavelli, S.B., Swisher, M.E., Branch, L.C., 2013. Factors Related to Farmers' Preferences to Decrease Monk Parakeet Damage to Crops. Hum. Dimens. Wildl. 18, 124–137. https://doi.org/10.1080/10871209.2013.745102.
Canel, D., Scioscia, N.P., Denegri, G.M., Kittlein, Y.M., 2016. Dieta del zorro gris pampeano (*Lycalopex gymnocercus*) en la provincia de Buenos Aires. Mastozool. Neotrop. 23, 359–370.
Carlini, A.A., Soibelzon, E., Glaz, D., 2016. *Chaetophractus vellerosus* (Cingulata: Dasypodidae). Mamm. Species 48, 73–82. https://doi.org/10.1093/mspecies/sew008.
Castillo, D.F., Birochio, D.E., Lucherini, M., Casanave, E.B., 2011. Diet of adults and cubs of *Lycalopex gymnocercus* in Pampas grassland: a validation of the Optimal Foraging Theory? Ann. Zool. Fennici 48, 251–256. https://doi.org/10.5735/086.048.0406.
Castillo, D.F., Luengos Vidal, E.M., Casanave, E.B., Lucherini, M., 2014. Feeding habits of Molina's hog-nosed skunk in the Pampas grassland of Argentina. Mammalia 78, 473–479. https://doi.org/10.1515/mammalia-2013-0020.
Casuso, M., Simon, C., Cavalleri, J., Pérez, G., 2017. Guía práctica para la identificación de plagas del cultivo de girasol, 1era edición. Ediciones INTA, Chaco, Argentina.
Ceauşu, S., Graves, R.A., Killion, A.K., Svenning, J.C., Carter, N.H., 2019. Governing trade-offs in ecosystem services and disservices to achieve human–wildlife coexistence. Conserv. Biol. 33, 543–553. https://doi.org/10.1111/cobi.13241.
Clark, K.L., Branch, L.C., Hierro, J.L., Villarreal, D., 2016. Burrowing herbivores alter soil carbon and nitrogen dynamics in a semi-arid ecosystem. Argentina. Soil Biol. Biochem. 103, 253–261. https://doi.org/10.1016/j.soilbio.2016.08.027.
Codesido, M., González-Fischer, C., Bilenca, D., 2011. Distributional changes of landbird species in agroecosystems of central Argentina. Condor 113, 266–273. https://doi.org/10.1525/cond.2011.090190.
Colombo, V.C., Gamietea, I., Loffler, S.G., Brihuega, B.F., Beldomenico, P.M., 2018. New host species for Leptospira borgpetersenii and Leptospira interrogans serovar Copenhageni. Vet. Microbiol. 215, 90–92. https://doi.org/10.1016/j.vetmic.2018.01.007.
Comparatore, V., Yagueddú, C., 2007. Diet of the Greater Rhea (*Rhea americana*) in an agroecosystem of the flooding Pampa. Argentina. Ornitol. Neotrop. 18, 187–194.
Comparatore, V., Yagueddú, C., 2016. Diet of the Greater Rhea (*Rhea americana*) in an agroecosystem of the flooding Pampa. Argentina. Ornitol. Neotrop. 24, 13–20.
Contarde, C.B., 2019. Caracterización espacial y patrones de actividad en una colonia de vizcachas (*Lagostomus maximus*) de la zona serrana del centro de Córdoba. Universidad Nacional de Córdoba, Tesis de Licenciatura.
Cortés-Avizanda, A., Blanco, G., Devault, T.L., Markandya, A., Virani, M.Z., Brandt, J., Donázar, J.A., 2016. Supplementary feeding and endangered avian scavengers: Benefits, caveats, and controversies. Front. Ecol. Environ. 14, 191–199. https://doi.org/10.1002/fee.1257.
Dardanelli, S., Fandiño, B., Calamari, N.C., Canavelli, S.B., Zaccagnini, M.E., 2016. ¿Eligen las palomas y cotorras los lotes de soja (*Glycine max*) en emergencia? Un caso de estudio en agroecosistemas de Entre Ríos. Argentina. Rev. Mex. Biodivers. 87, 1308–1314. https://doi.org/10.1016/j.rmb.2016.09.006.
Davidson, A.D., Detling, J.K., Brown, J.H., 2012. Ecological roles and conservation challenges of social, burrowing, herbivorous mammals in the world's grasslands. Front. Ecol. Environ. 10, 477–486. https://doi.org/10.1890/110054.
Dew, J.L., Wright, P., 1998. Frugivory and Seed Dispersal by Four Species of Primates in Madagascar's Eastern Rain Forest1. Biotropica 30, 425–437. https://doi.org/10.1111/j.1744-7429.1998.tb00076.x.
Díaz, S., Tilman, D., Fargione, J., 2005. Biodiversity Regulation of Ecosystem Services. In: Hassan, H., Scholes, R., Ash, N. (Eds.), Ecosystems and Human Well-Being: Current State and Trends. Island Press, Washington DC, pp. 297–329.
Dickman, A.J., 2010. Complexities of conflict : the importance of considering social factors for effectively resolving human – wildlife conflict. Anim. Conserv. 13, 458–466. https://doi.org/10.1111/j.1469-1795.2010.00368.x.
Donázar, J.A., Cortés-Avizanda, A., Fargallo, J.A., Margalida, A., Moleón, M., Morales-Reyes, Z., Moreno-Opo, R., Pérez-García, J.M., Sánchez-Zapata, J.A., Zuberogoitia, I., Serrano, D., 2016. Roles of raptors in a changing world: from flagships to providers of key Ecosystem Services. Ardeola 63, 181–234. https://doi.org/10.13157/arla.63.1.2016.rp8.
Farias, A.A., Kittlein, M.J., 2008. Small-scale spatial variability in the diet of pampas foxes (*Pseudalopex gymnocercus*) and human-induced changes in prey base. Ecol. Res. 23, 543–550. https://doi.org/10.1007/s11284-007-0407-7.
Foley, J.A., Barford, C., Monfreda, C., Kucharik, C.J., Howard, E.A., Chapin, F.S., Bonan, G., Asner, G.P., Daily, G.C., Gibbs, H.K., Prentice, I.C., Patz, J.A., Helkowski, J.H., Coe, M.T., Ramankutty, N., Snyder, P.K., DeFries, R., Carpenter, S.R., Holloway, T., 2005. Global Consequences of Land Use. Science 309, 570–574.
Fujita, H.O., Calvo, J.O., 1981. Las exportaciones de productos y subproductos de la faunas silvestre en el quinquenio 1976–1980. Idia 397, 1–26.
García, V.B., Kittlein, M.J., 2005. Diet, habitat use, and relative abundance of pampas fox (*Pseudalopex gymnocercus*) in northern Patagonia. Argentina. Mamm. Biol. 70, 218–226. https://doi.org/10.1016/j.mambio.2004.11.019.
Gaston, K.J., Cox, D.T.C., Canavelli, S.B., García, D., Hughes, B., Maas, B., Martínez, D., Ogada, D., Inger, R., 2018. Population abundance and Ecosystem Service provision: the case of birds. Bioscience 68, 264–272. https://doi.org/10.1093/biosci/biy005.
Ghys, M.I., Favero, M., 2004. Espectro trófico de la gaviota capucho café (*Larus maculipennis*) en agroecosistemas del sudeste de la provincia de Buenos Aires. Argentina. Ornitol. Neotrop. 15, 493–500.
Giarratano, M., Kristensen, M.J., 2012. La caza comercial en Benito Juárez y Tandil. In: Ulberich, A. (Ed.), Estudios ambientales III: Tandilia y el sudeste bonaerense. Universidad Nacional del Centro de la Provincia de Buenos Aires, Centro de Investigaciones y Estudios Ambientales, pp. 37–44.
Gigón, R., Vigna, M., Yanniccari, M., 2017. Manejo de malezas problema Raigrás (Lolium spp.) Bases para su manejo y control en sistemas de producción. REM - AAPRESID, Rosario, Santa Fé, Argentina.
Giordano, P.F., Navarro, J.L., Martella, M.B., 2010. Building large-scale spatially explicit models to predict the distribution of suitable habitat patches for the Greater rhea (*Rhea americana*), a near-threatened species. Biol. Conserv. 143, 357–365. https://doi.org/10.1016/j.biocon.2009.10.022.
Goldstein, M.I., Lacher, T.E., Woodbridge, B., Bechard, M.J., Canavelli, S.B., Zaccagnini, M.E., Cobb, G.P., Scollon, E.J., Tribolet, R., Hooper, M.J., 1999. Monocrotophos-induced mass mortality of Swainson's hawks in Argentina, 1995–96. Ecotoxicology 8, 201–214. https://doi.org/10.1023/A:1026496331396.
González, S., Maldonado, J.E., Leonard, J.A., Vilá, C., Duarte, J.M.B., Merino, M., Brum-Zorrilla, N., Wayne, R.K., 1998. Conservation genetics of the endangered Pampas deer (*Ozotoceros bezoarticus*). Mol. Ecol. 7, 47–56. https://doi.org/10.1046/j.1365-294x.1998.00303.x.
Gorosábel, A., Pedrana, J., Bernad, L., Caballero, V.J., Muñoz, S.D., Maceira, N.O., 2019. Evaluating the impacts and benefits of sheldgeese on crop yields in the Pampas region of Argentina: A contribution for mitigating the conflicts with agriculture. Agric. Ecosyst. Environ. 279, 33–42. https://doi.org/10.1016/j.agee.2019.04.002.
Grau, R.H., Ade, M.T., Gasparri, I.N., 2005. Globalization and soybean expansion into semiarid ecosystems of Argentina. Ambio 34, 265–266. https://doi.org/10.1579/0044-7447-34.3.265.
Green, A.J., Elmberg, J., 2014. Ecosystem services provided by waterbirds. Biol. Rev. 89, 105–122. https://doi.org/10.1111/brv.12045.
Grigera, D.E., Rapoport, E.H., 1983. Status and Distribution of the European Hare in South America. J. Mammal. 64, 163–166. https://doi.org/10.2307/1380771.
Guichón, M.L., Cassini, M.H., 2007. Riparian wildlife richness along the Luján River. Ecol. Austral 17, 81–87.
Haines-Young, R., Potschin, M., 2013. Common International Classification of Ecosystem Services (CICES): Consultation on Version 4, August-December 2012. EEA Framew. Contract No EEA/IEA/09/003.
Josens, M.L., Escalante, A.H., Favero, M., 2009. Seasonal Variability of Waterbird Assemblages in Relationship to Habitat Characteristics in a Pampas Wetland. Waterbirds 32, 523–530. https://doi.org/10.1675/063.032.0405.
Josens, M.L., Escalante, A.H., Favero, M., 2012. Diversity, seasonality and structure of bird assemblages associated with three wetlands in the Southeastern Pampas, Argentina. Ardeola 59, 93–100.
Lacher, T.E., Davidson, A.D., Fleming, T.H., Gómez-Ruiz, E.P., McCracken, G.F., Owen-Smith, N., Peres, C.A., Vander Wall, S.B., 2019. The functional roles of mammals in ecosystems. J. Mammal. 100, 942–964. https://doi.org/10.1093/jmammal/gyy183.
Llanos, A.C., Crespo, J.A., 1952. Ecología de la vizcacha (*Lagostomus maximus maximus* Blainv.) en el nordeste de la provincia de Entre Ríos. Rev. Investig. Agric. 6, 289–378.
Lovera, R., Fernández, M.S., Cavia, R., 2015. Wild small mammals in intensive milk cattle and swine production systems. Agric. Ecosyst. Environ. 202, 251–259. https://doi.org/10.1016/j.agee.2015.01.003.
Lovera, R., Fernández, M.S., Jacob, J., Lucero, N., Morici, G., Brihuega, B., Farace, M.I., Caracostantogolo, J., Cavia, R., 2017. Intrinsic and extrinsic factors related to pathogen infection in wild small mammals in intensive milk cattle and swine production systems. PLoS Negl. Trop. Dis. 11, 1–20. https://doi.org/10.1371/journal.pntd.0005722.
Loveridge, A.J., Reynolds, J.C., Milner-Gulland, E.J., 2006. Does sport hunting benefit conservation? In: Macdonald, D.W., Service, K. (Eds.), Key Topics in Conservation Biology. Oxford University Press, Oxford, pp. 224–241.
Lucherini, M., Guerisoli, M.M., Luengos Vidal, E.M., 2018. Surplus killing by pumas *Puma concolor*: rumours and facts. Mamm. Rev. 48, 277–283. https://doi.org/10.1111/mam.12135.

Lucherini, M., Pessino, M., Farias, A.A., 2004. Pampas fox (*Pseudalopex gymnocercus*). In: Sillero-Zubiri, C., Hoffman, M., MacDonlad, D.W. (Eds.), Canids: Foxes, Wolves, Jackals and Dogs. Status Survey and Conservation Action Plan, Gland, Switzerland and Cambridge, pp. 63–68.

Machicote, M., Branch, L.C., Villarreal, D., 2004. Burrowing owls and burrowing mammals: Are ecosystem engineers interchangeable as facilitators? Oikos 106, 527–535. https://doi.org/10.1111/j.0030-1299.2004.13139.x.

Marateo, G., Grilli, P., Bouzas, N., Ferretti, V., Juárez, M., Soave, G.E., 2015. Habitat use by birds in airports: a case study and its implications for bird management in South American airports. Appl. Environ. Res. 13, 819–831. https://doi.org/10.15666/aeer/1303.

Marateo, G., Grilli, P., Bouzas, N., Jensen, R., Ferretti, V., Juárez, M., Soave, G., 2013. Uso de hábitat por aves en rellenos sanitarios del noreste de la provincia de Buenos Aires. Argentina. Ecol. Austral 23, 202–208.

Martella, B., Navarro, L., 2006. Proyecto Ñandú. Proyecto Ñandú. Manejo de Rhea americana y R. pennata en la Argentina, in: Bolkovic, M. L., Ramadori, D. (Eds.), Manejo de Fauna Silvestre en la Argentina. Programas de uso sustentable. Dirección de Fauna Silvestre, Secretaría de Ambiente y Desarrollo Sustentable, Buenos Aires, pp. 39-50.

Martella, M.B., Navarro, J.L., Gonnet, J.M., Monge, S.A., 1996. Diet of Greater Rheas in an agroecosystem of central Argentina. J. Wildl. Manage. 60, 586–592. https://doi.org/10.2307/3802076.

Matteucci, S.D., 2012. Ecorregión Pampa. In: Morello, J., Matteucci, S., Rodriguez, A.F., Silva, M.E. (Eds.), Ecorregiones y Complejos Ecosistémicos Argentinos. Orientación Gráfica Editora, Buenos Aires, pp. 391–445.

MEA, 2005. Millennium Ecosystem Assessment. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC.

Miralles, D.J., González, F., Abeledo, L.G., Serrago, R.A., Alzueta, I., García, G., de San Caledonio, R., Lo Valvo, P., 2014. Manual De Trigo y Cebada Para El Cono Sur: procesos fisiológicos y bases de manejo, 1era edición. Orientación Gráfica Editora, Buenos Aires.

Modernel, P., Rossing, W.A.H., Corbeels, M., Dogliotti, S., Picasso, V., Tittonell, P., 2016. Land use change and ecosystem service provision in Pampas and Campos grasslands of southern South America. Environ. Res. Lett. 11, 1–22. https://doi.org/10.1088/1748-9326/11/11/113002.

Montalti, D., Ferman, L.M., Camperi, A.R., Soave, G.E., Arambarri, A.M., Darrieu, C.A., 2005. Winter Diet of Great Pampa-Finches Embernagra platensis in Guaminí Lagoon. Argentina. Acta Ornithol. 40, 79–82. https://doi.org/10.3161/068.040.0103.

Montalvo, C.I., Tallade, P.O., Fernández, F.J., Moreira, G.J., Rafuse, D.J., De Santis, L.J.M., 2011. Bone damage patterns found in the avian prey remains of crested caracara *Caracara plancus* (Aves, Falconiformes). J. Archaeol. Sci. 38, 3541–3548. https://doi.org/10.1016/j.jas.2011.08.021.

Müller, S.M., Peisker, J., Bieling, C., Linnemann, K., Reidl, K., Schmieder, K., 2019. The importance of cultural ecosystem services and biodiversity for landscape visitors in the biosphere reserve Swabian Alb (Germany). Sustainability 11, 1–23. https://doi.org/10.3390/su11092650.

Navarro, J.L., Rosati, V.R., Fraire, E.C., 1997. Incidencia de Vizcacha (*Lagostomus maximus*) en en cultivo de soja. Mastozool. Neotrop. 4, 137–144.

Ogada, D.L., 2014. The power of poison: Pesticide poisoning of Africa's wildlife. Ann. N. Y. Acad. Sci. 1322, 1–20. https://doi.org/10.1111/nyas.12405.

Organ, B.J.F., Mahoney, S.P., Geist, V., 2010. Born in the Hands of Hunters: the North American model of wildlife conservation. Wildl. Prof. 4, 22–27.

Pedrana, J., Bernad, L., Maceira, N.O., Isacch, J.P., 2014. Human-Sheldgeese conflict in agricultural landscapes: Effects of environmental and anthropogenic predictors on Sheldgeese distribution in the southern Pampa. Argentina. Agric. Ecosyst. Environ. 183, 31–39. https://doi.org/10.1016/j.agee.2013.09.029.

Pedrana, J., Bernad, L., Maceira, N.O., Isacch, J.P., 2015. Conflict between the Greater Rhea and humans in agricultural landscapes: Implications for conservation of the last large herbivore of the southern Pampas. Emu 115, 335–344. https://doi.org/10.1071/MU15049.

Plieninger, T., Dijks, S., Oteros-Rozas, E., Bieling, C., 2013. Assesing, mapping and quantifying cultural ecosystem services at community level. Land use policy 33, 118–129.

Polop, J., Priotto, J., Steinmann, A., Provensal, C., Castillo, E., Calderón, G., Enría, D., Sabattini, M., Coto, H., 2003. Manual de control de roedores en municipios. Monografía, Universidad Nacional de Río Cuarto, Serie Enfermedades Transmisibles.

Poppy, G.M., Chiotha, S., Eigenbrod, F., Harvey, C.A., Honzák, M., Hudson, M.D., Jarvis, A., Madise, N.J., Schreckenberg, K., Shackleton, C.M., Villa, F., Dawson, T.P., 2014. Food security in a perfect storm: Using the ecosystem services framework to increase understanding. Philos. Trans. R. Soc. B Biol. Sci. 369, 20120288. https://doi.org/10.1098/rstb.2012.0288.

Pretelli, M.G., Cardoni, D.A., Isacch, J.P., 2014. Diet of Nestling Spectacled Tyrants (*Hymenops perspicillatus*) in the Southeast Pampas Region. Argetina. Wilson J. Ornithol. 126, 754–759. https://doi.org/10.1016/j.wpi.2007.04.006.

Pretelli, M.G., Josens, M.L., Escalante, A.H., 2012. Breeding Biology at a Mixed-Species Colony of Great Egret and Cocoi Heron in a Pampas Wetland of Argentina. Waterbirds 35, 35–43. https://doi.org/10.1675/063.035.0104.

Rey Benayas, J.M., Bullock, J.M., 2012. Restoration of Biodiversity and Ecosystem Services on Agricultural Land. Ecosystems 15, 883–899. https://doi.org/10.1007/s10021-012-9552-0.

Ricardo, T., 2018. Evaluación del riesgo de Leptospirosis en asentamientos marginales ribereños de Santa Fe, Argentina, mediando un enfoque "Una Salud". Tesis de Doctorado. Facultad de Ciencias Veterinarias, Universidad Nacional del Litoral.

Ripple, W.J., Newsome, T.M., Wolf, C., Dirzo, R., Everatt, K.T., Galetti, M., Hayward, M.W., Kerley, G.I.H., Levi, T., Lindsey, P.A., Macdonald, D.W., Malhi, Y., Painter, L.E., Sandom, C.J., Terborgh, J., Van Valkenburgh, B., 2015. Collapse of the world's largest herbivores. Sci. Adv. 1, e1400103. https://doi.org/10.1126/sciadv.1400103.

Rizzo, H.F., 1997. Catálogo de insectos perjudiciales en cultivos de la Argentina. Hemisferio Sur, Buenos Aires, Argentina.

Romero, I.P., Codesido, M., Bilenca, D.N., 2016. Nest Building by Monk Parakeets Myiopsitta monachus in Urban Parks in Buenos Aires, Argentina: Are Tree Species Used Randomly? Ardeola 62(2), 323-333. https://doi.org/10.13157/arla.62.2.2015.323.

Sabattini, M.S., Gonzalez de Rios, L.E., Díaz, G., Vega, V.R., 1977. Infección natural y experimental de roedores con virus Junin. Medicina (Buenos Aires) 37, 149–159.

Sarasola, J.H., Zanón-Martínez, J.I., Costán, A.S., Ripple, W.J., 2016. Hypercarnivorous apex predator could provide ecosystem services by dispersing seeds. Sci. Rep. 6, 1–6. https://doi.org/10.1038/srep19647.

Sebastián-González, E., Magalhães Barbosa, J., Pérez-García, J.M., Morales-Reyes, Z., Botella, F., Olea, P.P., Mateo, P.T., Moleón, M., Hiraldo, F., Arrondo, E., Donázar, J.A., Cortés-Avizanda, A., Sel, N., Sánchez-Zapata, J.A., 2019. Scavenging in the Anthropocene: human impact drives vertebrate scavenger species richness at global scale. Glob. Chang. Biol. 25 (9), 3005–3017. https://doi.org/10.1111/gcb.14708.

Soler, L., Carenton, J.M., Cáceres, C., Pérez, P., Fleita, A., Taboada, A., Miller, G., Gonzalez, R., 2004. La conservación de los carnívoros silvestres del Nordeste Argentino a través de la participación de los pobladores locales. Imagen y respuestas de los lugareños rurales hacia los predadores. MEMORIA: Manejo Fauna Silv. en Amaz. y Latinoamérica 634–644.

Soriano, A., León, R.J.C., Sala, O.E., Lavado, S., Deregibus, V.A., Cauhepé, M.A., Scaglia, O.A., Velázquez, A., Lemcoff, J., 1991. Río de la Plata Grasslands. In: Coupland, R.T., Keeley, J. (Eds.), Ecosystems of the World 8A, Natural Grasslands, Introduction and Western Hemisphere. Elsevier, New York, pp. 367–407.

Tallis, H., Goldman, R., Uhl, M., Brosi, B., 2009. Integrating conservation and development in the field: Implementing ecosystem service projects. Front. Ecol. Environ. 7, 12–20. https://doi.org/10.1890/080012.

Treves, A., Wallace, R.B., Naughton-Treves, L., Morales, A., 2006. Co-Managing Human-Wildlife Conflicts: A Review. Hum. Dimens. Wildl. 11, 383–396. https://doi.org/10.1080/10871200600984265.

Tubaro, P.L., Gabelli, F.M., 1999. The decline of the Pampas Meadowlark: Difficulties of applying the IUCN criteria to neotropical grassland birds. Stud. Avian Biol. 19, 250–257.

Urretabizkaya, N., Vasicek, A., Saini, E., 2010. Insecto Perjudiciales de Importancia Agronómica. Lepidópteros. Ediciones INTA, Buenos Aires.

Vargas, R.J., Bó, M.S., Favero, M., 2007. Diet of the Southern Caracara (*Caracara plancus*) in Mar Chiquita Reserve. Southern Argentina. J. Raptor Res. 41, 113–121. https://doi.org/10.3356/0892-1016(2007)41[113:dotscc]2.0.co;2.

Vila-Aiub, M.M., Vidal, R., Balbi, M.C., Gundel, P.E., Trucco, F., Ghersa, C.M., 2008. Pesticide residues in beeswax samples collected from honey bee colonies (*Apis mellifera L.*) in France. Pest Manag. Sci. 64, 366–371. https://doi.org/10.1002/ps.

Villarreal, D., Clark, K.L., Branch, L.C., Hierro, J.L., Machicote, M., 2008. Alteration of ecosystem structure by a burrowing herbivore, the plains vizcacha (*Lagostomus maximus*). J. Mammal. 89, 700–711. https://doi.org/10.1644/07-mamm-a-025r1.1.

Whelan, C.J., Wenny, D.G., Marquis, R.J., 2008. Ecosystem services provided by birds. Ann. N. Y. Acad. Sci. 1134, 25–60. https://doi.org/10.1196/annals.1439.003.

Williams, S.T., Maree, N., Taylor, P., Belmain, S.R., Keith, M., Swanepoel, L.H., 2018. Predation by small mammalian carnivores in rural agro-ecosystems: An undervalued ecosystem service? Ecosyst. Serv. 30, 362–371. https://doi.org/10.1016/j.ecoser.2017.12.006.

Zaccagnini, M.E., Thompson, J.J., Bernardos, J.N., Calamari, N., Goijman, A., Canevalli, S., 2011. Valoración de servicios ecosistémicos. Conceptos, herramientas, y aplicaciones para el ordenamiento territorial, in: Laterra, P., Jobbagy, E.G., Paruelo, J. (Eds.), Valoración de Servicios Ecosistémicos: Conceptos, herramientas y aplicaciones para el ordenamiento territorial. Ediciones INTA, Buenos Aires, pp. 185–219.

Zalba, S.M., Sanchez, R., Cozzani, N.C., 2009. Priorities for the conservation of an endangered grassland bird: Clues from its nesting biology. Ornitol. Neotrop. 20, 35–46.