Journal for Nature Conservation 45 (2018) 72–78

Contents lists available at ScienceDirect

Journal for Nature Conservation

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

Conservation of grasslands and savannas: A meta-analysis on mammalian responses to anthropogenic disturbance

Daniela Oliveira de Lima[a,b,*], Maria Lucia Lorini[a,c], Marcus Vinícius Vieira[a]

[a] Laboratório de Vertebrados, Departamento de Ecologia, Universidade Federal do Rio de Janeiro, Avenida Carlos Chagas Filho, 373, Cidade Universitária, CEP 21941-902, Rio de Janeiro, RJ, Brazil

[b] Campus Cerro Largo, Universidade Federal da Fronteira Sul, Rua Jacob Haupenthal, 1.580, CEP 97900-000, Cerro Largo, RS, Brazil

[c] Instituto de Biociências, Departamento de Ciências Naturais, Universidade Federal do Estado do Rio de Janeiro, Av. Pasteur 458, Prédio IBIO/CCET, Urca, CEP 22290-240, Rio de Janeiro, RJ, Brazil

ARTICLE INFO

Keywords:
Agriculture
Cattle ranching
Cropland
Fire
Shrub/woody encroachment

ABSTRACT

Grasslands and savannas are among the most degraded biomes in the world. These biomes face a diverse number of anthropogenic threats, and despite this scenario, little attention is given to their conservation and sustainable use. This meta-analysis aims to analyze the effect of anthropogenic activities on the abundance of native mammals in these grassy ecosystems. A systematic research in the literature was carried out in order to find studies that analyzed variations in abundance of mammals in response to an anthropogenic activity in any grassland, savanna or shrubland environment around the world. After filtering, 24 studies were analyzed, generating 202 effect sizes for five anthropogenic factors: cropland activities (32 effect sizes - ES); cattle ranching (58 ES); fire (30 ES); shrub/woody encroachment (56 ES) and urbanization (26 ES). Analyzed papers included field data from all continents. In general, mammalian abundance is decreasing under anthropogenic disturbance, as shown by the general effect size. This result highlights the need for more intense conservation programs in grasslands and savannas, since its species are under threat. When comparing the different anthropogenic threats, only cropland activities affected mammals significantly, reducing their abundance. The estimate of the mean effect of cattle ranching, fire, shrub/woody encroachment and urbanization on abundance of mammals did not differ from zero. However, for cattle ranching, fire and shrub/woody encroachment the mean effects measured had large confidence intervals, indicating that these mean effects could not be estimated accurately. Cattle ranching, fire and shrub/woody encroachment effects on mammalian abundance probably depend on their intensity and on the environmental characteristics of each ecosystem, and therefore each case must be analyzed in an ecosystem-specific perspective. Urbanization did not affect mammals, although this anthropogenic activity was analyzed only in two ecosystems where these urban areas do not cover bigger areas. Considering global necessity of maintaining and even increasing food production, we suggest that the cropland activities, which were the greatest threat to the abundance of mammals, should be used in a land sparing perspective. Meanwhile, cattle ranching could be used in a land sharing perspective, provided that cattle density will be restricted to such levels that could also guarantee the conservation of native species. Further studies regarding other taxa are desirable to confirm this recommendation considering the overall grassland and savanna biodiversity.

1. Introduction

Grasslands and savannas are ancient ecosystems that cover about 40% of ice-free lands and at least half of this area lost their original vegetation (Ramankutty, Evan, Monfreda, & Foley, 2008; White, Murray, & Rohweder, 2000). Consequently, many species are threatened and the environmental services of these ecosystems are reduced (Wen & Dong et al., 2013). Despite the high biodiversity and endemism of these ecosystems (Dengler, Janišová, Török, & Wellstein, 2014; Furley, 1999; Kier et al., 2005), little attention is given to their conservation. While forests largely have a strong appeal to the public opinion, grasslands and savannas are often taken as secondary successional stages, with a less important biodiversity and an opportunity for agriculture activities (Bond & Parr, 2010; Grau et al., 2015; Henwood,

* Corresponding author at: Campus Cerro Largo, Universidade Federal da Fronteira Sul, Rua Jacob Haupenthal, 1.580, CEP 97900-000, Cerro Largo, RS, Brazil.
E-mail addresses: daniela.ol.lima@gmail.com (D.O.d. Lima), mluc.lorini@gmail.com (M.L. Lorini), mvvieira@gmail.com (M.V. Vieira).

https://doi.org/10.1016/j.jnc.2018.08.008
Received 17 May 2018; Received in revised form 14 August 2018; Accepted 14 August 2018
1617-1381/

2010; Overbeck et al., 2007). This perception that grasslands and savannas are not quite important to conservation is perhaps also influenced by the fact that these ecosystems usually present high crop yields and also produce high-quality meat; resulting in a severe conservation status on these grassy biomes worldwide (Bond & Parr, 2010; Henwood, 2010; Veldman & Buisson et al., 2015).

Agriculture is considered the most important anthropogenic alteration and the primary cause of the biodiversity crisis worldwide (Maxwell, Fuller, Brooks, & Watson, 2016; Foley & DeFries et al., 2005; Green, Cornell, Scharlemann, & Balmford, 2005; Tilman & Clark, 2015; Tilman et al., 2017). The main pathway by which agriculture threatens biodiversity is through habitat loss and fragmentation (Fischer & Lindenmayer, 2007). Cattle are sometimes raised in natural vegetation on grasslands and savannas (Beck, Hernández, Pasari, & Zavaleta, 2015; Overbeck et al., 2007; Vavra, Parks, & Wisdom, 2007), however crop cultivation mostly leads to full conversion of natural vegetation into croplands. Additionally, croplands generally cause other significant environmental impacts, such as irrigation, fertilization and use of pesticides, making the impact of croplands severe and complex (Maxwell et al., 2016; Penuelas et al., 2013; Vörösmarty et al., 2010; Zhu, Schmehl, Mullin, & Frazier, 2014). Other relevant habitat loss caused on grasslands and savannas is urbanization (McKinney, 2008). Urbanization causes a very drastic and long lasting habitat loss (McKinney, 2002). Besides, urbanization effects also include increasing surface warming (Kalnay & Cai, 2003) and invasion by a great number of alien species (Devictor, Julliard, Couvet, Lee, & Jiguet, 2007; McKinney, 2008). Noting that climate change and biotic homogenization are, along with habitat loss, the main threats to biodiversity conservation.

It is widely recognized that cropland activities affect biodiversity, although the effects of prescribed fire and cattle ranching on grasslands and savannas are controversial. Grazing and fire are natural disturbances on these ecosystems and drivers of forest limitation on these grassy biomes (e.g. grazing: Gill, 2014; Weigl & Knowles, 2014; e.g. fire: Bond & Keeley, 2005; Morgan & Lunt, 1999; e.g. both: Veldman & Buisson et al., 2015). Although it is also largely demonstrated that these factors can strongly threaten biodiversity of grasslands and savannas when they are too frequent or to intensive (e.g. grazing: Hayes & Holl, 2003; Schmidt, Olsen, & Leirs, 2009; e.g. fire: Little, Hockey, & Jansen, 2013; Trollope, van Wilgen, Trollope, Govender, & Potgieter, 2014; e.g. both: Boakye, Little, Panagos, & Jansen, 2013; Kutt & Woinarski, 2007; Little & Jansen, 2015), which is common when fire and grazing are consequences of human activities. It is also important to highlight that, since fire and cattle ranching can influence forest expansion, these disturbances can interfere in shrub/woody encroachment, which is another important issue for grassland and savanna conservation. Shrub/woody encroachment can be defined as the increase in cover and biomass of indigenous woody or shrubby plants into grasslands and savannas (Van Auken, 2009). Once shrub/woody encroachment modifies the flora composition and structure, this disturbance can also modify animal composition and abiotic characteristics, threatening grassland and savannas biodiversity and functioning (Ratajczak, Nippert, & Collins, 2012; Veldman & Buisson et al., 2015). Notably in countries where native forest biomes are declining, there is a strong resistance to avoid shrub/woody encroachment on grassy biomes among the general and the scientific public, since the conservation policies always favor forest ecosystems in these countries (Grau et al., 2015; Overbeck et al., 2007; Veldman & Buisson et al., 2015). Considering the high levels of threat to grasslands and savannas worldwide, and considering that we still have controversial results and opinions over cattle ranching, fire and shrub/woody encroachment effects, there is an urgent need for scientific reviews on the effects of these disturbances on grassland and savanna biodiversity.

Grasslands and savannas provide large quantities of easily accessible food for herbivores supporting large herbivore densities and therefore high mammalian abundance and diversity. Mammals are often primary drivers of plant community structure and dynamics on grasslands and savannas, especially ungulates (Hayes & Holl, 2003; Knegt, Groen, Van Vijver, Prins, & Langevelde Van, 2008; Stahlheber & D'Antonio, 2013). These large herbivores influence flora richness, composition and diversity, and therefore they have an important role on shrub/woody encroachment (Gill, 2014; Owen-Smith, 1987; Weigl & Knowles, 2014). More than one thousand mammalian species are threatened with extinction (Ceballos & Ehrlich, 2002; Hoffmann & Belant et al., 2011; Schipper & Chanson et al., 2008) and almost 200 are Critically Endangered (Schipper & Chanson et al., 2008). This alarming information puts mammalian species in a highlighted position for biological conservation. Large body mass and slow reproductive rates are mammalian life history features that put them among the most threatened taxa (Davidson, Hamilton, Boyer, Brown, & Ceballos, 2009). Another issue that spotlights the importance of mammals on biological conservation is their potential use as flagship species (Leader-Williams & Dublin, 2000). Since they have a great influence on public opinion, conservation programs focused on mammals could raise more funds and attention.

Conservation practices need to deal with increasing levels of threats to biodiversity, uncertainty on specific pathways of species loss and ecosystems degradation and a limited budget. In this scenario, decision-making processes require mechanisms that combine available information and make robust and evidence-based recommendations (Pullin, Knight, Stone, & Charman, 2004, 2016). Quantitative reviews are strong tools to achieve this purpose (Sutherland, Pullin, Dolman, & Knight, 2004). Meta-analysis is a quantitative reviewing method that provides a formal statistical framework with which we can rigorously synthesize and compare the results of studies that have all tested the same particular hypothesis (Arnqvist & Wooster, 1995; Harrison, 2011). Meta-analysis has the potential to be very useful in ecology and conservation biology, as individual studies often present small sized samples and low statistical power due to expensive and hard fieldwork (Harrison, 2011).

Considering mammals as key species for grasslands and savannas functioning and conservation, and with the general goal of investigating whether and how grassland and savanna biodiversity is threatened, we performed a meta-analysis using mammals as an indicator of ecosystem conditions. Specific objectives were (1) to analyze the mean effect of anthropogenic activities on abundance of mammals' species on grasslands and savannas and (2) to compare the effect of five different anthropogenic activities previously known to threaten mammals: cropland activities; cattle ranching; fire; shrub/woody encroachment; and, urbanization. By achieving these goals, we can indicate evidence-based recommendations for grassland and savanna conservation.

2. Material and methods

2.1. Literature search

To identify published studies for our analysis, we searched *ISI Web of Knowledge, SciVerse SCOPUS* and *Google Scholar* covering the time period from 1966 to June 2018 (Fig. 1a). The keywords used were: ["*population loss*" OR "*population decline*" OR *extinction* OR "*loss of biodiversity*" OR "*biodiversity loss*" OR "*loss of species*" OR "*species loss*" OR "*species persistence*" OR "*population* increase" OR "*population persistence*" OR "*population abundance*"] AND [*mammal** OR *Marsupialia* OR *Insectivora* OR *Afrosoricida* OR *Artiodactyla* OR *Carnivora* OR *Chiroptera* OR *Cingulata* OR *Dasyuromorphia* OR *Dermoptera* OR *Didelphimorphia* OR *Hyracoidea* OR *Lagomorpha* OR *Macroscelidea* OR *Monotremata* OR *Perissodactyla* OR *Pholidota* OR *Pilosa* OR *Primates* OR *Proboscidea* OR *Rodentia* OR *Scandentia* OR *Soricomorpha* OR *Tubulidentata*] AND [*grassland* OR *savanna* OR *shrubland* OR *steppe* OR *prairie*]. We searched for these words in article titles, abstracts or keywords. To avoid the appearance of many articles focused on ancient species of megafauna, we excluded those articles that had the word *Pleistocene* in their title.

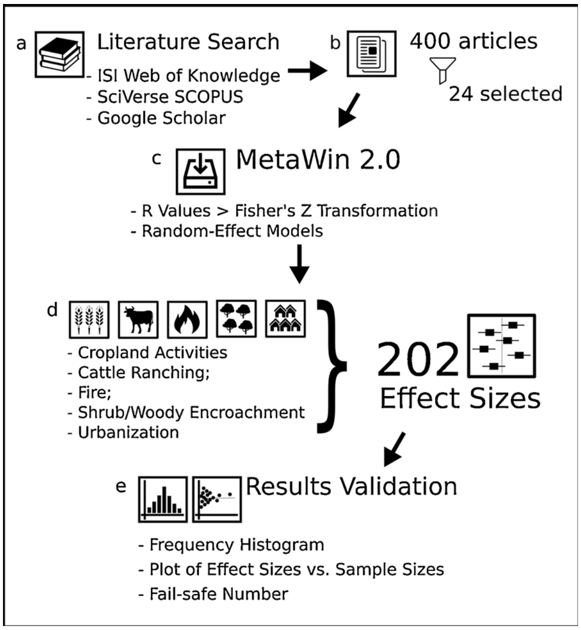

Fig. 1. Flow chart resuming the methods utilized in this meta-analysis.

Additional studies were found based on the references of these first papers.

More than 450 articles were analyzed, although, just 24 could be used (Fig. 1b). The main reasons to reject articles were: field analyses on a forest-like ecosystem; analyzing the effect of an anthropogenic disturbance on other taxonomic groups other than mammals; not analyzing the effect of an anthropogenic disturbance; presenting analyses that could not be used for meta-analysis, such as Bayesian analyses or when only the *p*-value from frequentist analyses is shown. From this last category of rejection, we tried to contact the authors and some of them replied us with the missing statistics values. Ecosystems considered within this meta-analysis should have had their vegetation dominated by grasses (Poaceae) or other graminoids (e.g. Cyperaceae, Juncaceae), excluding plant communities mostly composed of woody species. These ecosystems ranged from temperate grasslands, grassy deserts, seasonally flooded grasslands, tropical savannas and grasslands/shrublands/woodlands mosaics. Papers analyzing alien species were also rejected as we considered that only native species are valid surrogates to understand the effects of anthropogenic activities on biodiversity.

2.2. Anthropogenic activities analyzed

Five different anthropogenic activities were analyzed: cropland activities; cattle ranching; fire; shrub/woody encroachment; and, urbanization. We included papers that studied cropland activities comparing croplands with the adjacent natural ecosystem or analyzing the effect of different percentages of croplands on landscapes. We included papers relating the effect of cattle ranching on mammals by comparing different grazing intensities or by comparing places where the cattle were removed in the past at different stages. Regarding fire effect, papers included in this work related to the effect of fire on abundance of mammals by comparing burned and unburned places and by comparing places with different time since last fire. Papers that investigated shrub/woody encroachment included in this study were those that analyzed this encroachment by evaluating how abundance of mammals varied with different percentages of shrub/woody plants on landscapes. Similarly, papers regarding urbanization effects analyzed how abundance of mammals varied considering landscapes with different percentages of urban areas.

2.3. Data analyses

The effect sizes are statistics used in meta-analysis that provide a standardized, directional measure of the mean change in the dependent variable in each study. Most of the analyses of how mammalian abundance responds to different anthropogenic activities were done using regression analysis. The r value itself can be used as a measure of effect size, however, Fisher's z transformation was used in this meta-analysis for stabilizing the variance among coefficients (Harrison, 2011; Fig. 1c). Fisher's z transformation converts r values to a normally distributed variable z. Besides using the r values from the regression analyses, we also used data from ANOVA and t-test. That was possible because we obtained the r values through arithmetical transformations from F statistics and Student's t values using Meta-Win Calculator (Rosenberg, Adams, & Gurevitch, 2000). The direction of the effect size was indicated by the slope of the original regression analysis.

For each one of the studied species, we calculated its effect size (variable z) and its respective variance. The variance of each study is calculated based on the study sample size. Additionally, effect sizes are weighted by the variance of the estimate. Because variance decreases as sample size increases, this generally means that effect sizes based on larger study populations are given greater weight. For each anthropogenic activity, we calculated the mean effect size among all the species that were studied under this anthropogenic activity (Fig. 1d) and its confidence interval (95%) through bootstrap. The effect of anthropogenic activities was considered significant if its 95% effect size confidence intervals did not overlap zero (Rosenberg et al., 2000).

Data were analyzed using random-effect models (Raudenbush, 1994; Fig. 1c). These models assume that the variation in data also occurs because of random components between studies. Random-effect models are preferable in ecological data synthesis because it is nearly impossible to measure all the variables that can influence an ecological process (Gurevitch & Hedges, 1993). We used Q statistics (Hedges & Olkin, 1985) to analyze whether the variance among effect sizes is greater than expected by chance. There are three values associated with the Q statistics: the Q_{total}, which analyzes variations in the entire dataset; the Q_{bet}, which analyzes variations between different groups; and, the Q_{wit}, which analyzes variations within groups. Q_{bet} was used to compare the mean effect sizes among different anthropogenic activities.

When doing a meta-analysis it is always important to consider if any publication bias is impacting the general result. Published papers used to be biased by minimizing studies where no effect was observed or studies with samples of small sizes (Borenstein, Hedges, Higgins, & Rothstein, 2009). In order to check if this meta-analysis was influenced by any bias on published data, we used tree methods (Fig. 1e). First of all, we used the frequency histogram to verify if there is a depression on effect size distribution close to zero. This depression would suggest that there is a tendency to non-publication of non-significant results in the analyzed papers. We also analyzed the funnel plot of effect sizes vs. sample sizes, where each of the 202 effect sizes were plotted against the sample size of their original study. The expected pattern would be to have all the data symmetrically distributed around the mean effect size, presenting higher variations from this value in smaller-sampled studies than in larger ones. At last, we calculated the fail-safe number. This number is used to calculate how many studies with effect size close to zero would be necessary to change the general result (Rosenthal, 1979). In order to have robust results regardless of publication bias, the fail-safe number must be higher than $5n + 10$, where n is the total sample size of the concerned meta-analysis (Rosenberg, 2005; Rosenthal, 1979).

All analyses were performed with the statistical software MetaWin 2.0 (Rosenberg et al., 2000; Fig. 1c).

3. Results

We obtained 202 effect sizes from the 24 analyzed papers. Some

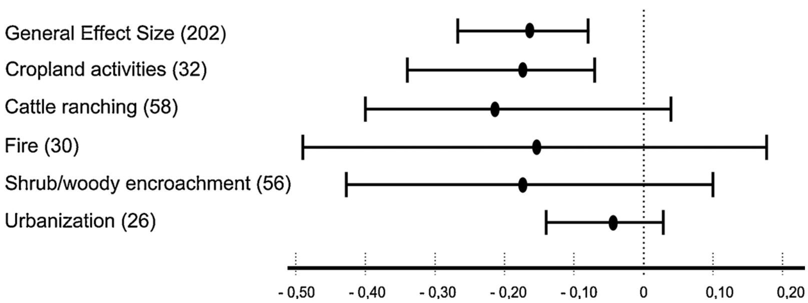

Fig. 2. General effect size and mean effect sizes of the different anthropogenic activities on mammalian abundance in grasslands and savannas for 202 species. Error bars represent the 95% confidence interval through bootstrap. The mean effect is considered significant when its confidence interval does not overlap zero. Sample sizes (numbers of effect sizes calculated for each anthropogenic activities) are given in the parentheses.

papers presented data just to one species, however some papers presented data to many species, and so, one effect size was calculated for each species. Cropland activities had 32 effect sizes from five different papers; cattle ranching had 58 effect sizes from 12 different papers; fire had 30 effect sizes from six different papers; shrub/woody encroachment had 56 effect sizes from four different papers and urbanization had 26 effect sizes from two different papers. Papers analyzed included field data from 11 countries and included all continents. These papers encompass several ecosystems, ranging from grasslands, grassy deserts, shrublands, savannas and grasslands/woodlands mosaics. Thirteen mammalian orders were studied, including seven placental orders and four marsupial orders. Detailed information regarding the analyzed papers is provided on supplementary material.

Anthropogenic activities are reducing mammalian abundance in the analyzed ecosystems, with a general effect size of −0.17 (95% confidence interval ranging from −0.27 to −0.08; Fig. 2). Regarding the different anthropogenic activities, all the mean effect sizes were negative, although only cropland activities also had its upper value of the confidence interval negative (cropland activities −0.18 / −0.34 to −0.07, mean effect size / 95% confidence interval by bootstrap; cattle ranching −0.22 / −0.40 to 0.04; fire −0.16 / −0.49 to 0.18; shrub/woody encroachment −0.18 / −0.43 to 0.10 and urbanization −0.05 / −0.14 to 0.03; Fig. 2).

The Q statistics showed that variance among effect sizes is not greater than expected by chance (Q_{total} = 191.52; p = 0.67; d.f. = 201). Even variance between different anthropogenic activities (Q_{bet} = 0,98; p = 0,91; d.f. = 4) or within different anthropogenic activities (Q_{wit} = 190.54; p = 0,61; d.f. = 197) are not greater than expected by chance. That is, anthropogenic effects of these different activities are comparable.

The histogram (Fig. 3) revealed a depression close to zero, which shows that it is very likely that studies that failed to show significant results were not published. However, funnel plot of effect sizes vs. sample sizes (Fig. 4) showed no skewness, no asymmetry, and calculated fail-safe number was larger than 5n + 10 [11 094 > (5 * 202) +10 = 1 020], both results supporting the robustness of this meta-analysis even when considering a possible lack of studies with no significant effects.

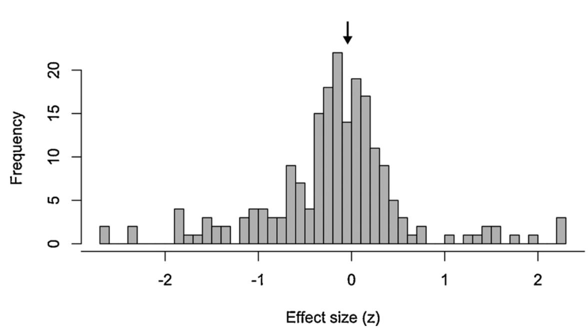

Fig. 3. Histogram showing the distribution of the effect sizes (r) testing the relationship between mammal abundance and antropogenic activities in grasslands and savannas for 202 species. The black arrow indicates a smaller frequency of published results with no significant effects.

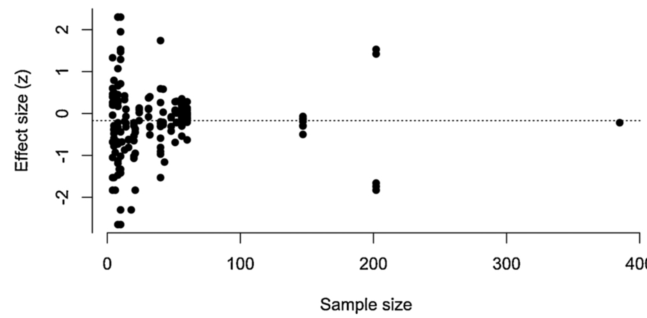

Fig. 4. Funnel plot - with no skewness, no asymmetry - of studies sample sizes and their respective effect sizes regarding the relationship between mammal abundance and antropogenic activities in grasslands and savannas for 202 species. The dotted line indicates the mean general effect size (-0.17).

4. Discussion

Anthropogenic activities are reducing abundance of mammals on grasslands and savannas, as shown by general effect size. This result corroborates a great number of studies that emphasizes mammal species as a worldwide threatened taxon (Ceballos & Ehrlich, 2002; Hoffmann & Belant et al., 2011; Schipper & Chanson et al., 2008). Recognizing that mammal species are under threat on grasslands and savannas also reinforces that these ecosystems need urgent conservation actions (Bond & Parr, 2010; Dengler et al., 2014; Henwood, 2010; Veldman & Buisson et al., 2015). Regarding the different anthropogenic factors that were analyzed, there is no evidence for significant heterogeneity between them. However, we decided to discuss separately these different anthropogenic activities, since Harrison (2011) stated that if there are good a priori reasons for supposing an effect of a moderator, it is worth considering this even when the Q statistics are not significant.

Cropland activities were the only variable with a significant and negative effect on the abundance of mammals. Agriculture, which includes croplands, is widely known as the main cause for biodiversity loss (Maxwell et al., 2016; Foley & DeFries et al., 2005; Green et al., 2005; Tilman & Clark, 2015; Tilman et al., 2017). Grasslands and savannas are intensely used for cropland activities, mainly because these ecosystems have flat and fertile soils and therefore generate satisfactory yields and high incomes. Consequently, grasslands and savannas have lost 70 and 50 percent of their area for agriculture, respectively (Ramankutty et al., 2008). This scenario set grasslands and savannas among the most threatened ecosystems and, at the same time, highlights their importance for food production (Henwood, 2010; Ramankutty et al., 2008). Here we face a global challenge: we need plans and actions to conserve natural areas, including grasslands and savannas, and, at the same time, we need to supply food for a growing human population (Godfray & Garnett, 2014; Green et al., 2005; Tilman & Clark, 2015). The necessity to conserve natural areas and produce food brings the discussion between land sharing and land sparing. Land sharing integrates both objectives on the same area employing food production techniques with small environmental impacts and land sparing uses high-yield farming techniques combined with full protection of natural adjacent habitats (Balmford, Green, & Scharlemann, 2005; Green et al., 2005; Phalan, Onial, Balmford, & Green, 2011). Considering the negative impact of croplands on mammal species found in this study, this activity should be realized in a land sparing perspective on grasslands and savannas, with the formal protection of natural adjacent areas.

For cattle ranching, another form of food production analyzed here, the estimate of its mean effect on abundance of mammals did not differ from zero. However, this topic deserves cautious interpretation, once several studies demonstrated that the consequences of cattle ranching vary with abiotic characteristics, cattle species and grazing intensity (Allington & Valone, 2011; Beck et al., 2015; Hayes & Holl, 2003; Jones, 2000; Schmidt et al., 2009). This great variance can be observed in our results as cattle ranching effects had a large confidence interval of its mean estimate even with a considerable sample size, which tends to diminish the confidence interval. Native megaherbivores maintained grassy ecosystems in many parts of the world before Pleistocene extinctions (Gill, 2014; Owen-Smith, 1987). Currently, livestock have replaced native herbivores in many of these ecosystems. Some authors argue that grasslands and savannas conservation can be planned with the presence of these exotic herbivores, and sometimes, these animals could even act as a conservation strategy, replacing the ecological role of the native herbivores in suppressing tree growth (Beck et al., 2015; Boldrini & Eggers, 1996; Stahlheber & D'Antonio, 2013; Weigl & Knowles, 2014). Although, as we stated above, this must be carefully considered. In a situation where livestock density is adapted to local carrying capacity and abiotic characteristics, and if native vegetation is not replaced by exotic pastures, cattle ranching could be an alternative to cropland activities on grasslands and savannas, allowing these ecosystems to maintain food production with, at least, a smaller environmental impact, in a land sharing perspective.

Shrub/woody encroachment and fire did not significantly affect the mean abundance of mammals. However, the estimated mean effects of both shrub/woody encroachment and fire had large confidence intervals, showing that these mean effects could not be measured accurately. We observed the same result for the effect of cattle ranching on the mean abundance of mammals. This pattern can be a consequence of an insufficient sample size for these three anthropogenic activities, or, this may indicate that the effect of these anthropogenic activities on mammals is very variable, depending on the intensity of the anthropogenic activity, on the overall ecosystem conditions and on which mammal species we are studying. Shrub/woody encroachment alters the vegetation composition and structure, and it is considered by many authors as an important threat to grassland and savanna biodiversity (e.g. Overbeck et al., 2007; Ratajczak et al., 2012; Van Auken, 2009). Fire is considered a natural form of disturbance on grasslands and savannas and it may play an important role in maintaining open ecosystems (Bond & Keeley, 2005; Veldman & Buisson et al., 2015). However, even though animals and plants from grasslands and savannas co-evolved with natural fire, a fire regime that promotes biodiversity in one system can threaten biodiversity in another (Boakye et al., 2013; Collins & Calabrese, 2012; Little & Jansen, 2015; Little et al., 2013). Prescribed fire and cattle ranching must be used cautiously, as they produce different landscapes as a result of their effect on the establishment of plant species and their relation with shrub/woody encroachment (Boakye et al., 2013; Collins & Calabrese, 2012; Kutt & Woinarski, 2007; Little & Jansen, 2015; Nangendo, Stein, Gelens, Gier, & Albricht, 2002).

Urbanization is one of the main threats to native ecosystems and their species (McKinney, 2002; Savard, Clergeaub, & Mennechez, 2000). Nevertheless, in this meta-analysis urbanization did not affect abundance of mammals. This anthropogenic disturbance had the smallest mean effect size and the smallest confidence interval, revealing that the mean effect size was measured accurately. On the other hand, urbanization effect was only studied in two papers, reflecting the reality of only two study sites and restricting the power of generalization of this result. On these two study sites, the absence of effect of urbanization on mammalian abundance may come from a proportional small area occupied by urban sites on these ecosystems. For instance, the coastal plateau of southwestern Portugal, one of the two study sites analyzed, is an arable landscape mainly devoted to irrigated agriculture and livestock production, with only small villages (Pita, Mira, Moreira, Morgado, & Beja, 2009). The Pampas biome, the other studied site, contains urban areas ranging from small villages to medium cities, but they cover only 3% of the analyzed area (Cordeiro & Hasenack, 2006). These proportional small urban areas probably affect mammals less than the agricultural activities that are realized in bigger areas in these biomes. It is also important to point out that due to the consumption patterns brought about by globalization, the population in urban areas does not necessarily consume local products, so environmental effects can occur over distant areas instead of only impacting the adjacent biome.

5. Conclusion

This article presents important information regarding the effect of anthropogenic activities on abundance of mammals in grassland and savanna biomes, evidencing that abundance of mammals is decreasing in the face of anthropogenic activities. This highlights the urgent need for conservation plans for these grassy ecosystems. Cropland activities were the only variable with significant effect on abundance of mammals, evidencing that cropland activities harm mammals in grasslands and savannas. The estimate of the mean effect of cattle ranching, fire, shrub/woody encroachment and urbanization on abundance of mammals did not differ from zero. However, for cattle ranching, fire and shrub/woody encroachment the mean effects measured had large confidence intervals, indicating that these mean effects could not be estimated accurately. There is an extensive discussion in the literature about the resilience of grassland and savanna biodiversity to these three disturbances, and there is no final conclusion. It seems that, in some cases, species from grassy biomes can coexist with prescribed fire and cattle ranching if they are not too frequent or too intense. Fire and cattle ranching also play a role on shrub/woody encroachment, as they influence plant community. Therefore, the effects and the use of cattle ranching, fire and shrub/woody encroachment must always be analyzed together, taking into account their frequency and intensity in an ecosystem-specific perspective. Considering grasslands and savannas management and the global necessity of maintaining and even increasing food production, low density cattle ranching could be practiced using the land sharing perspective. On the other hand, cropland activities, could be practiced if we have guaranteed that adjacent areas will be set aside for conservation purposes, in a land sparing perspective. We recommend further systematic reviews regarding other taxa to confirm this recommendation considering different aspects of grassland and savanna biodiversity. In addition, further field studies regarding mammals are also desirable, once most of the anthropogenic activities studied here had less than 10 papers analyzed.

Acknowledgments

We thank the authors for sending additional data to be analyzed in this paper. Rafael Loyola, Renata Pardini, Sandra Hartz and Juliana Motter for the comments and suggestions in the early version of the manuscript. Lucas Rodrigues Piovesan helped elaborating and improving the figures. We thank the editor and the reviewers for their valuable comments. CAPES/PNPD for a post-doctoral fellowship to MLL and CNPq for a research productivity fellowship to MVV.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.jnc.2018.08.008.

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