González *et al. Ecological Processes* (2022) 11:11
https://doi.org/10.1186/s13717-021-00357-7

Ecological Processes

REVIEW **Open Access**

Effects of fire history on animal communities: a systematic review

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Abstract

Fire is a natural agent with a paramount role in ecosystem functioning and biodiversity maintenance. Still, it can also act as a negative force against many ecosystems. Despite some knowledge of the interactions of fire and vegetation, there is no clear understanding of how different components of fire regimes (i.e., severity, history, or frequency) influence known patterns of animal communities. Therefore, we performed a systematic review on the global responses of arthropods, birds, mammals, reptiles, and amphibians to different fire regimes. Specifically, we focused on assessing how fire severity, history, and frequency modulate the effect of fire on the richness and abundance of faunal communities. We conducted a systematic review of 566 papers retrieved from the Scopus database. We also scrutinized all the documents included in the meta-analysis of Pastro et al. (Pastro et al. Glob Ecol Biogeogr 23:1146–1156, 2014). Our selection criteria excluded studies without data on species richness or abundance. We also excluded studies without adequate controls and those without information about the fire regime of the study zone. After careful examination, we used data from 162 studies to perform a quantitative meta-analysis. From the 162 studies meeting our selection criteria, nearly 60% of the studies are from North America, 25% from Australia, 11% from Europe, and 4% from the tropics. According to the ecological role of fire, 90% of the studies were carried out in fire-dependent ecosystems (i.e., conifer forests, natural savannas, pastures). Finally, 40% of the studies analyzed birds, 22% mammals, and 20% arthropods. The meta-analysis of the available evidence indicates that fire history is an important modulator of animal richness and abundance. Whether negative or positive, animal responses depended on the time since the last fire event. Considering that short-term studies may not capture such a long-term effect on fauna, this translates to more challenges at implementing fire management strategies. Whether or not we can anticipate the impact of the fire will then depend on future efforts to implement long-term research.

Keywords: Amphibians, Arthropods, Birds, Fire regime components, Mammals, Reptiles

Introduction

The impacts of fire on ecosystems depend on a set of interactions at spatial and temporal scales (Cochrane 2009). The natural fire regimes are characterized by fire intensity, duration, and extent, as well as the time of the year and frequency at which the disturbance occurs (Cochrane 2009; Pickett and White 1985; Shea et al. 2004). Climate change and anthropogenic activities increase the frequency and number of fire events worldwide, posing a significant threat to biodiversity (Aragão et al. 2008, 2018; Pausas and Keeley 2009; Armenteras and Retana 2012). When an aspect of the natural fire regime changes, it can alter the composition and structure of the vegetation, excluding different types of plants and strata (Archibald et al. 2013), and especially, fire-sensitive animal species (Peres 1999). However, to date, there is no clear understanding of how different components of fire regimes (i.e., intensity, history, or frequency) alter the composition of species in a community.

The history and severity have been identified as some of the most influential components of the fire regime that

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constrain the occurrence of terrestrial mammals (Roberts et al. 2011; Chia et al. 2015, 2016). Severe fires can result in direct mortality, especially of small organisms with limited mobility or dispersal ability (Chia et al. 2015). In addition, high-intensity fires eliminate most vegetation cover that can directly affect small mammal populations by increasing predation pressure (Leahy et al. 2015). In contrast, less severe fires that barely destroy the vegetation produce lesser animal mortality (Brehme et al. 2011).

Fire frequency and severity (Brotons et al. 2008; Plavsic 2014) affect the distribution and abundance of species (Chia et al. 2016), population sizes, and the availability of food and refuge resources (Litt and Steidl 2011; Plavsic 2014; Mowat et al. 2015), as well as several ecological interactions, such as competition and predation (Letnic et al. 2013). For example, Moretti et al. (2006) reported a higher resistance to single fire events than repeated fires for litter-associated saprophagous and saproxylophagous arthropods. Meanwhile, Fontaine et al. (2009) found that frequent fires promote a characteristic set of bird species in recently burned areas different from old burned areas in conifer forests in the northern United States of America.

Pastro et al. (2014) conducted a meta-analysis quantifying the effects of fire over the vertebrates biodiversity at community scale through the evaluation of the alpha and beta diversity; exploring different variables, such as the type of fire (prescribed or wild), the taxa (reptiles, mammals, and birds) and the ecoregion. This systematic literature analysis revealed the existence of species- or habitat-specific responses to fire that may mask the overall mean effect of fire on global diversity. Part of this variability might be attributed to differences in the fire regimes. Still, no systematic study has addressed how animal responses change at different regimes of fire disturbances to date.

Here we perform a systematic review on the responses of arthropods, birds, mammals, reptiles, and amphibians to different descriptors of fire regimes. We did not focus on species-specific responses, since a significant part of the literature encompasses community-level studies. Instead, we focused on assessing the effect on animal communities of fire severity—defined by the authors of the revised papers; history—defined by the time passed since the last fire event (in years); and frequency—defined by the number of times the area has burned. We focused on these components since their changes can promote different conditions to which native species are not adapted, thus increasing favorable and unfavorable conditions for native, invasive, or exotic species to establish (Litt and Steidl 2011; Russell-Smith et al. 2017). Our central hypothesis is that the impact of fire on the richness and abundance of all animal groups would be stronger as the time, since the last fire and the number of fires increased. First, we expect that longer fire intervals (> 10 years) increase fuel accumulation and the probability of more severe fires, which can promote high mortality rates of fauna (Kelly et al. 2011). Second, we expect severely affected sites will lack favorable conditions for fauna establishment due to the absence of vegetation to provide food and refuge resources (Chia et al. 2015). Third, high fire frequencies do not permit vegetation recovery, decreasing the availability of vital resources.

Methods

Literature search protocol

We conducted a systemic review of studies assessing the effects of fire on animal communities. In April 2018, we searched studies using the Scopus database employing the following combinations of keywords: (mammal* OR bird* OR reptil* OR arthropod*) AND (fire* OR (fire* AND vegetatio*) OR (burn*)) AND (richne* OR abundanc*). This search retrieved more than 14,000 documents, from which we selected only those scientific publications that were related to fire and fauna. Our initial screening and pre-selection process yielded 566 papers describing the effect of fire on fauna, or the faunal responses to past fire.

We scrutinized the 566 papers and the 200 studies evaluated by Pastro et al. (2014); and we selected only those meeting all the following criteria (Fig. 1): (a) Evaluate the effect of fire on the richness or the abundance of mammals, reptiles, amphibia, birds, and arthropods; (b) Have a before and after (i.e., comparison before and after the disturbance, Christie et al. 2019); a control-impact (i.e., comparison between control and fire-impacted sites after the disturbance, De Palma et al. 2018; Christie et al. 2019); or a before–after-control-impact (i.e., compare between control and fire-impacted sites before and after the disturbance Osenberg et al. 2006; Christie et al. 2019); (c) Possess a control treatment that had remained unburned for at least 25 years before the sampling date, since after that time, fire affected areas will present similar attributes to unburned areas (Henriques et al. 2006; Kelly et al. 2011); (d) Have information about the history of fire events (i.e., year and extension of the last fire); (e) Do not present an average value of the treatments with different fire histories (i.e., different years since the last fire event).

The selection process yielded 162 publications published between 1959 and 2018, 122 from the search in the Scopus database and 40 from Pastro et al. (2014) (Additional file 1: Appendix S1). These included 77 replicated studies (at least two control and two treatment plots or sites) and 85 unreplicated studies. We extracted the title, authors, authors affiliations, DOI,

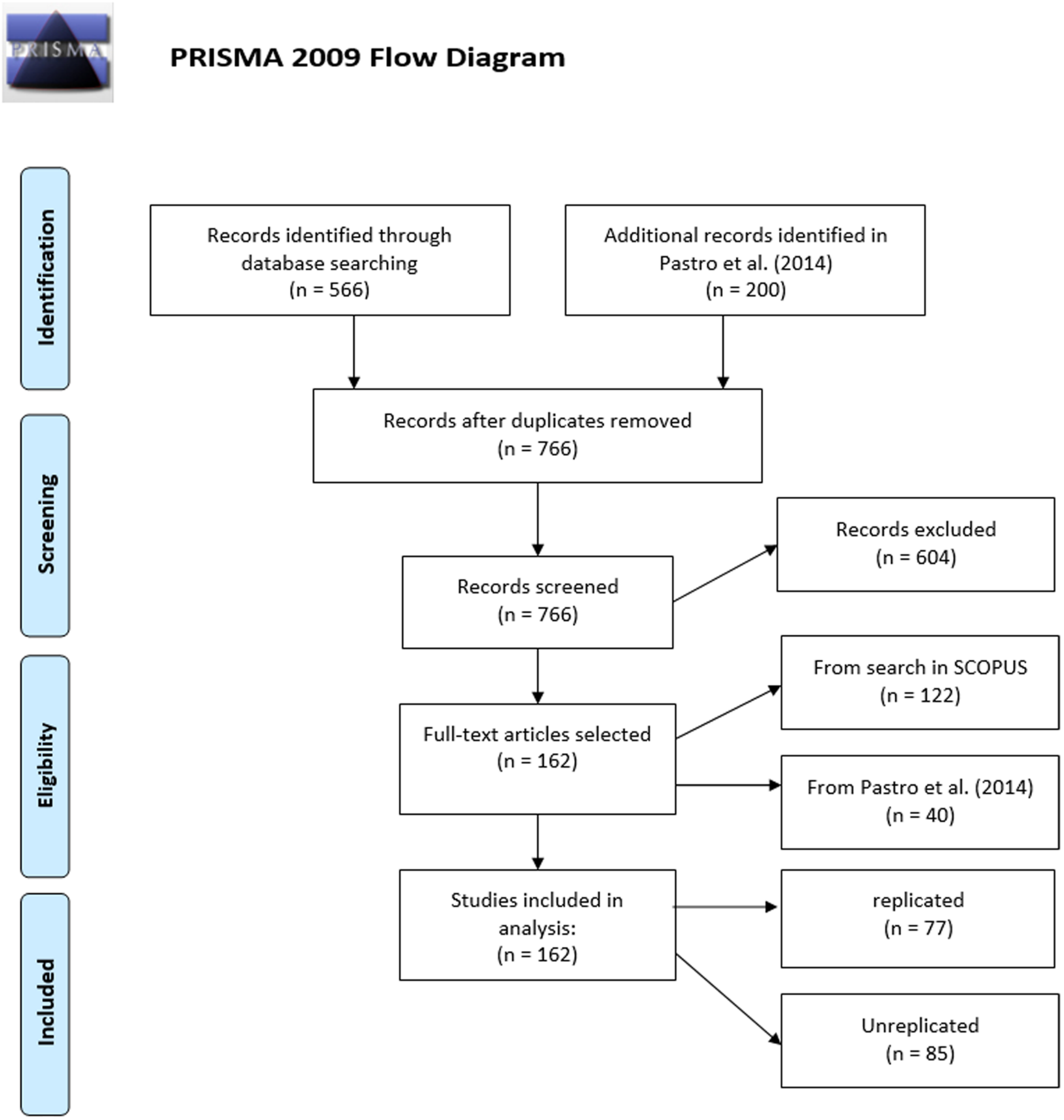

Fig. 1 PRISMA 2009 Flow Diagram from Moher et al. (2009)

general conclusions, implications for conservation or management, and richness and abundance values from each study. In our database, we annotated both richness values and estimations, such as those performed using CHAO or rarefaction methods. CHAO focuses on comparing accumulation curves asymptote (Chao and Chiu 2016), whereas rarefaction methods standardize the size and cover of samples (Chao and Jost 2012). Both technics contribute to inferring species richness and comparing the species richness values of different communities obtained with different sampling techniques. As abundance descriptors, we annotated raw counts, density estimations, and flock sizes (described in some bird studies). Finally, studies of reptiles and amphibians were aggregated into one category ('herpetofauna'), as study cases usually evaluate responses in this way. Unless otherwise mentioned, the effect of fire on species richness and abundance was analyzed for 145 and 127 studies, respectively (Additional file 1: Appendix S1 and Additional file 2: Appendix S2).

Explanatory variables

From each study, we also extracted information of the following categorical predictors: fire type (managed or wildfire), biogeographic region (Afrotropical, Australian, Indomalayian, Nearctic, Neotropical, Palearctic, and Subantarctic), country, continent, and the year of the fire event under study. We followed Shlisky et al. (2007, 2009) to classify each study according to the ecological role of fire: (i) fire-dependent (i.e., savannas and conifer forests), those in which the biota evolved in and adapted to the presence of fire; thus, fire is necessary for the maintenance of biodiversity and ecological processes; (ii) fire-sensible, those in which biota has not evolved in and adapted to the presence of fire; also, where climatic conditions are not proper for fire ignition (i.e., high humidity zones, most of these ecosystems are located at the tropics); or (iii) fire-independent (i.e., deserts), those in which fire has a low probability of occurrence due to the lack of fuel sources (Shlisky et al. 2007, 2009).

In addition, six variables were recorded as descriptors of the fire regime for each study: (i) fire severity (high, medium, and low) according to the information provided by the authors of each study; (ii) the time elapsed between the fire and the sampling event (measured in years and coded in the database as 'years.from.fire'); (iii) the spatial extension of the fire (in hectares); (iv) the number of times the area had burned before the sampling event ('burned.times'); and, if more than one event occurred in the area; (v) the time interval in which fire events occurred (in years—'Interval.of.time'); and (vi) the time interval separating their occurrence (in years—'interval.between.fires').

Effect size

Following Pastro et al. (2014), we used the log response ratio between burnt and unburnt areas as effect size. This effect size was calculated for each study to show the magnitude of the effect of the fire. This is estimated as the log-transformed ratio between values at burnt and unburnt—ln(Xe/Xc), where Xe and Xc represent the species richness or abundance at burnt and unburnt treatments, respectively (Rosenberg et al. 2000; Salo et al. 2010). Positive effect sizes (positive CIs) indicate that fire increases species richness or abundance, while negative effect sizes (negative CIs) indicate a negative impact. An effect size $\ln(Xe/Xc) \sim 0$ (with CI including 0) means that the fire has no effect. This metric was chosen over more traditional effect sizes, such as Hedges d or $\ln(R)$, because it does not require within-study variance (Salo et al. 2010). A large proportion of our data set consisted of unreplicated or pseudo-replicated studies in which within-study variance was not reported.

Data analyses

We first tested for context dependence on the responses due to fire type, fire ecology, biogeographical region, or community type. These four categorical variables are known to have some incidence on faunal responses; therefore, they can interact with the fire regime to produce unexpected responses (e.g., Pastro et al. 2014). The biogeographic region and the fire ecology, for instance, have a direct incidence on the faunal responses; species from fire-prone regions are generally more resilient to punctual fire events (Shlisky et al. 2009). The resilience of biological populations, on the other hand, is associated with traits, such as body size, diet, reproductive rate, and movement capacity (Sutherland and Dickman 1999; Santos et al. 2014), which exhibit a high variability among taxonomical groups (Litt and Steidl 2011). Finally, whether fires are set for management (prescribed fires) or wildfires (uncontrolled and spontaneous), the type of fire may interact with the fire regime, leading to synergistic responses. For example, prescribed fires can reduce fuel charges and favor vegetation types (Roberts et al. 2015), affecting fire regime components, such as history and severity.

After testing for context-dependency, we evaluated whether species richness or abundance respond to differences in the fire regime. As we had a skew distribution on some descriptors, we decided to recode them as categorical predictors, keeping a similar number of observations in each one. The time since the last fire event ('years.from.fire') was recoded in ten categories (<0.5, 1, 2, 3, 4, 5, 6, 7, 7–15, >15 years) that describe a gradient of recovery time. The greater the category, the less negative is expected to be the impact of fire on the fauna, as species would have more time to recolonize impacted zones. On the other hand, the number of times that the area had burned before the sampling event ('burned. times') was recoded in six categories (1, 2, 3, 4, 4–10, >10 times) that describe a gradient of intensity. The greater the number of times, the bigger is expected to be the impact of fire on fauna. We could not evaluate the effect of the other components (area, the time interval in which fire events occurred, and the time interval separating their occurrence), for more than half of the studies did not include the information required to estimate them.

To evaluate how fauna responses to fire changed according to the factors explained above, we used linear mixed-models fitted by maximizing the restricted log-likelihood (REML). We fitted one model per predictor, including the categorical predictor as the fixed effect and the publication I.D. as the random effect. We set I.D. as the random term to allow the fixed effects to vary for each study (I.D.), since most studies compared burned treatments against a single control treatment, leading to 'pseudoreplicates' nested within each study location. We also exclude the intercept estimation from the models, since intercept models for categorical predictors with more than two levels use one level as the reference, with which all other levels are compared. Then, removing the intercept allows determining whether each level is significantly different from zero rather than the less interesting reference level.

We estimate 95% confidence intervals (CI) of the effect size ln(Xe/Xc) to assess the levels of each categorical predictor. A CI > 0 points to a positive effect (increase) on species richness or abundance. Meanwhile, a CI < 0 points to a negative effect (decrease) (Rosenberg et al. 2000). Confidence intervals were estimated using the "confint.merMod" function (bootstrapping percentile method with 1000 permutations). Comparisons among category levels were performed using a log-likelihood test using the function 'anova' of the 'lme4' packages.

All analyses were performed using R 3.6.1 (R Core Team 2020). All the data (Additional file 1: Appendix S1) and coding used in this study (Additional file 4: Appendix S4) are available. All linear mixed-effects models were fitted using the R package 'lme4' (Bates et al. 2015).

Publication bias or assessment of the risk of bias

As a standard quantile plot method was not possible for the unreplicated studies, we also used the funnel plot method by plotting the sample size of all the experiments against their effect size ln(Xe/Xc). No evidence of publication bias was found with either of these methods (Additional file 3: Appendix S3).

Results

Effects of fire regime on faunal communities

We found that 60% of the reviewed studies came from America, most from the United States of America (≈ 200 studies), followed by Australia with 25% and Europe with 11%. Studies have mainly been conducted in Spain in the latter (Fig. 2). We identified that 90% of the studies are from fire-dependent ecosystems (e.g., eucalypt forests, pine forests, natural savannas, and grasslands). The remaining came from fire-sensitive ecosystems (e.g., tropical rainforests of South America). In addition, 40% of the studies explored the responses of bird communities, 22% of mammals, 20% of arthropods, and 14% included several taxonomical groups. The remaining 4% explored the responses of herpetofauna.

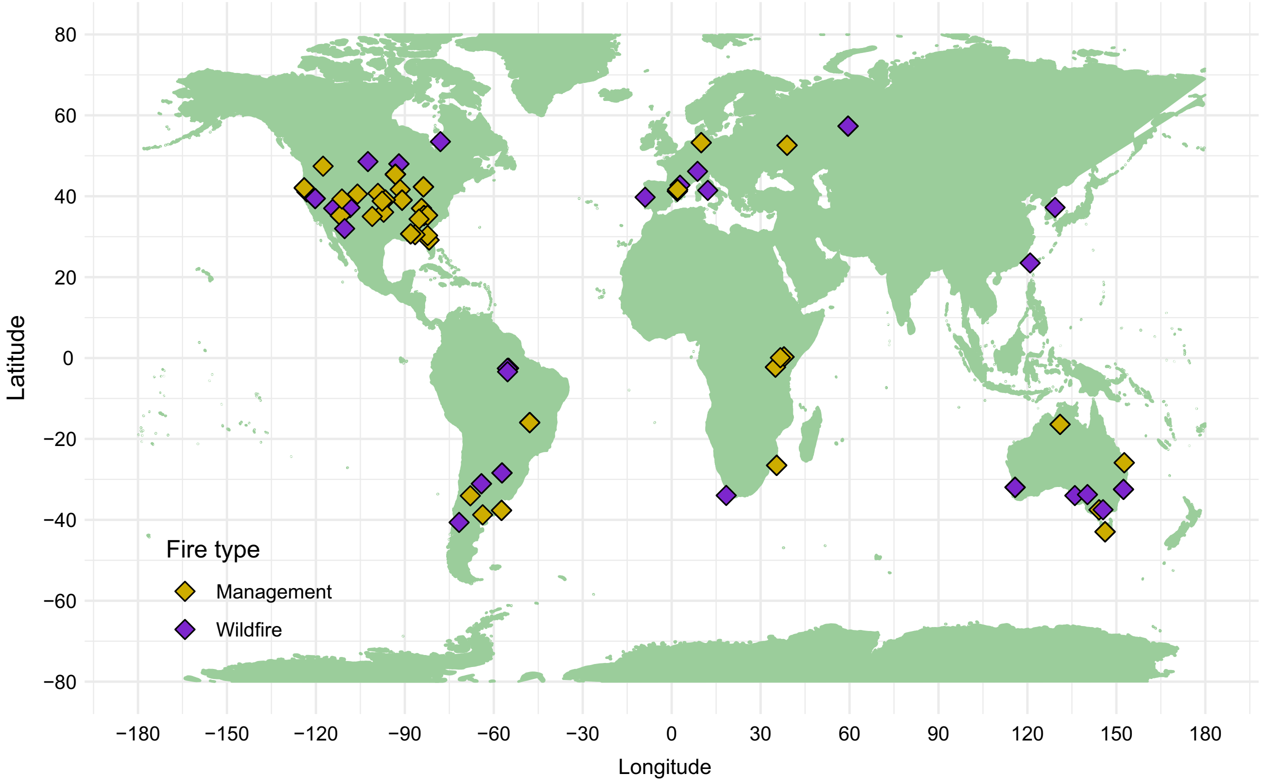

Fig. 2 Spatial distribution of the 162 studies included in the meta-analysis. The type of fire is represented using different colors: purple—wildfire, yellow—management

Effect of fire type, ecological role, biogeographical region, and community type

Linear mixed models revealed no apparent effects either of the fire type or fire ecology on the responses of faunal communities. The number of studies used to evaluate the effect of fire on species richness and abundance was 145 and 127, respectively. Fire-type, whether wild or managed, had no significant effect on richness ($\text{ANOVA}_{\text{df}=1,515,}$ $F=0.62$, $p=0.43$) or abundance of species ($\text{ANOVA}_{\text{df}=1,466,}$ $F=1.39$, $p=0.24$) (Fig. 3A). Likewise, the fire's ecological role had no positive or negative effect on richness ($\text{ANOVA}_{\text{df}=2,141,}$ $F=1.17$, $p=0.31$) or abundance of species ($\text{ANOVA}_{\text{df}=2,122,}$ $F=1.38$, $p=0.26$) (Fig. 3B). Notwithstanding, models hint towards a negative impact of fire on fauna from fire-independent systems (Fig. 3B), which can be confirmed after more studies are developed on this type of ecosystem.

Linear models indicated that the effect of fire is not consistent across biogeographic regions and types of animal communities (Fig. 4). The non-overlapping confidence intervals support a significant effect of fire in the Afrotropical region, where fire increases species richness (Fig. 4A). Likewise, non-overlapping confidence intervals indicated that fire harms the richness and abundances of mammal communities across different studies (Fig. 4B).

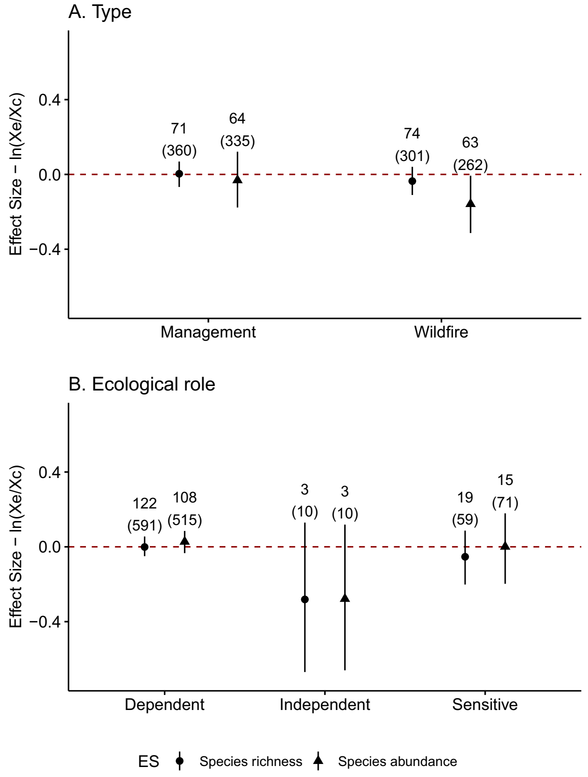

Fig. 3 Effect of fire type (**A**) and ecological role (**B**) on species richness and abundance. The circles represent the richness of species, and the triangles the abundance. The length of the lines represents the 95% confidence intervals. Numbers above dots represent the number of studies and, within parenthesis, the number of studied pseudo-replicas pooled to estimate the effect sizes

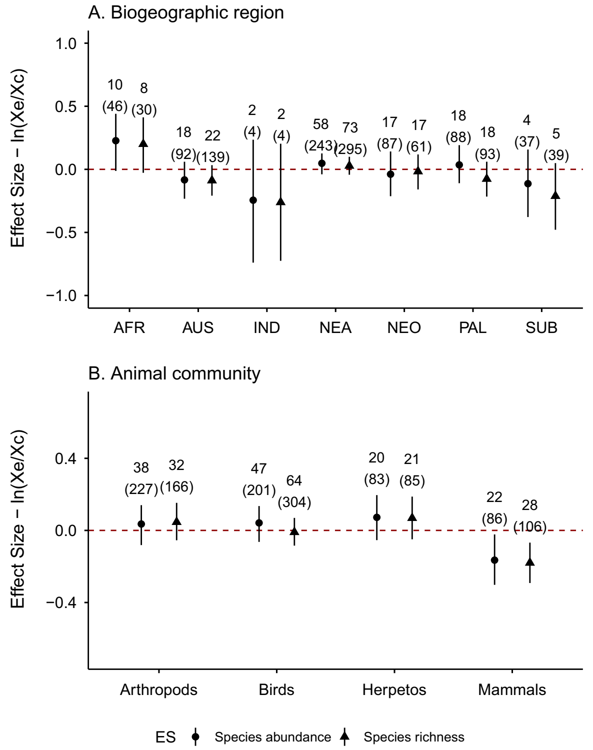

Fig. 4 Effect of the biogeographical region (**A**) and community type (**B**) on the richness and abundance of species. The circles represent the abundance of species, and the triangles the richness. The length of the lines represents the 95% confidence intervals. The numbers above dots represent the numbers of studies, and within parenthesis, the number of study pseudo-replicas pooled to estimate the effect sizes. *AFR* Afrotropical, *AUS* Australian, *IND* Indomalaya, *NEA* Nearctic, *NEO* Neotropical, *PAL* Palearctic, *SUB* Subantarctic

Effect of the fire regime: severity, history, and frequency

Linear models revealed no consistent effects of the fire regime components on the responses of faunal communities to fire. The effect of fire severity on species richness and abundance was evaluated for 52 and 44 studies, respectively. Low severity fires negatively affected species richness and abundance, while mid- and high-severity fires positively affected both diversity measures. However, we did not find a significant effect of fire severity on species richness ($\text{ANOVA}_{\text{df}=2,122,}$ $F=1.38$, $p=0.26$) or abundance ($\text{ANOVA}_{\text{df}=2,122,}$ $F=1.38$, $p=0.26$). Complementarily, our model provides evidence that species richness and abundance respond to the fire history: both increase as a function of the time since the last fire event (Fig. 5A, B).

Nonetheless, the limited number of studies did not allow us to statistically test for a relationship between the effect size and the years since the last fire. We found significant and adverse effects of fire on species richness after three, five, and 10–15 years when assessing the confidence intervals. Species abundance was also negatively affected in the last interval (10–15 years). Finally, and contrary to fire history, fire frequency did not have a significant and consistent effect on species richness and abundance (Fig. 6).

Discussion

This review systematically assesses how differences in the fire regime might modulate faunal responses to fire. To our knowledge, this is the first attempt to systematically evaluate how fire severity, frequency, and history influence the responses of vertebrate and invertebrate communities. By systematically reviewing 162 papers, our meta-analysis extended Pastro et al.'s (2014) findings to other regions and taxonomic groups and widely supported the notion that faunal responses to fire are not consistent across the world. Furthermore, the inclusion of fire regime components as modulators gave us insight into the origin of such inconsistency. For example, we found that whether negative or positive, animal responses depended on the fire history (number of years after the fire event). The importance of this component to explain faunal responses also suggests that species adaptability to fire needs to be considered together with the fire history when assessing the impacts of fire-related disturbances.

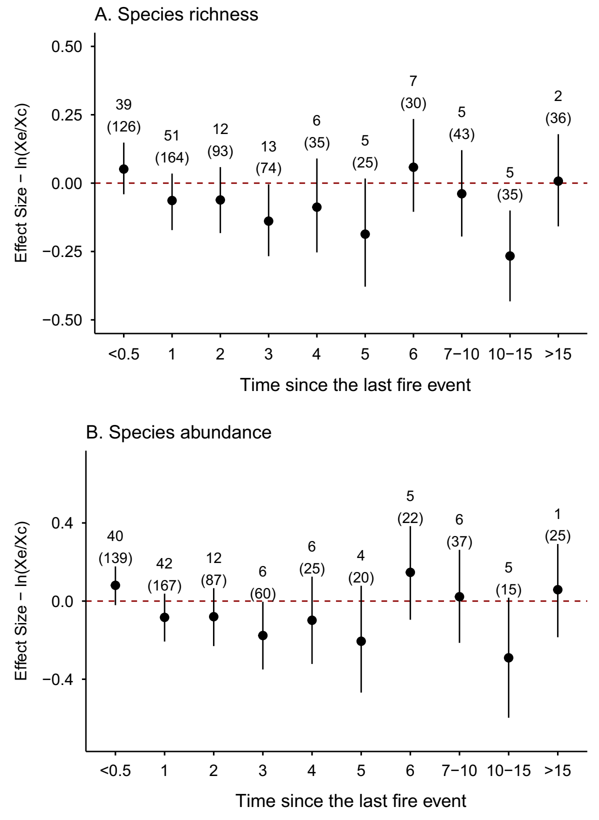

Fig. 5 Effect of fire regime—history—on the richness (**A**) and abundance (**B**) of species. The length of the lines represents the 95% confidence intervals. The numbers above dots represent the numbers of studies, and within parenthesis, the number of study pseudo-replicas pooled to estimate the effect sizes

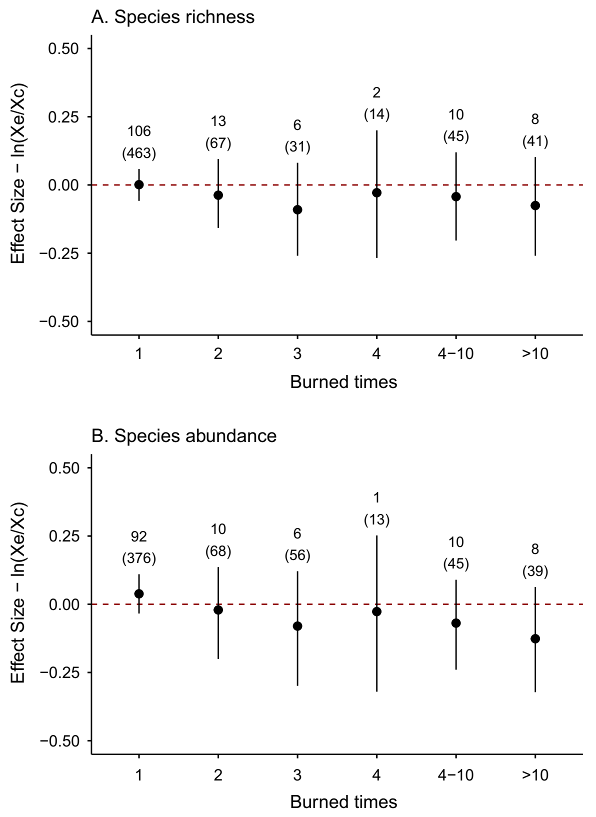

Fig. 6 Effect of fire regime—frequency—on the richness (**A**) and abundance (**B**) of species. The frequency is measured as the number of fire events in the study zone. The length of the lines represents the 95% confidence intervals. The numbers above dots represent the numbers of studies, and within parenthesis, the number of study pseudo-replicas pooled to estimate the effect sizes

The role of fire history

Fire history seems to substantially influence species richness and abundance among the three components evaluated in this meta-analysis. However, as evidenced when we assessed fire's severity and frequency, the effect sizes variance and direction (positive or negative) exhibit significant heterogeneity across the different levels (from 0 to 15 years after the last fire). This heterogeneity may emerge due to two additional factors outside the scope of this review. First, the successional trajectories of vegetation from different biogeographical realms. Different lines of evidence show that the abundance of mammals is linked to the successional stages of the vegetation, being generally the greatest abundance found at those stages that provide the most suitable habitat for species (Fox 1982; Briani et al. 2004; Henriques et al. 2006; González et al. 2021). Therefore, in line with our results, mammal responses can be negative or positive depending on how many years the forest requires to reach the most suitable successional stages.

Second, the richness and abundance of species with adaptations to fire may also explain the observed heterogeneity. Indeed, both the successional trajectory and species resilience to fire can interact synergistically to affect animal communities. It explains why faunal responses to fire can be positive or negative depending on the biogeographical region or the taxonomical group (though not statistically significant in most cases). Besides, it suggests that the taxonomical group and biogeographical region can be used as coarse descriptors of how ecosystems and species respond to wildfires (Kelly et al. 2012; Vieira and Briani 2013). For instance, in African savannas and pastures (fire-dependent ecosystems), the abundances of large herbivores such as gazelles, zebras, and wildebeests respond positively to fires. Therefore, populations tend to increase in recently burned areas due to an upsurge of seedlings (i.e., increases in forage quantity and quality) (Eby et al. 2014). However, this is a short-term response, since vegetation regenerates rapidly in these ecosystems; and after a few months, there are no differences between burned and unburned areas (Eby et al. 2014).

Current evidence shows that small mammal communities have the opposite response to fires. Burned areas reduce vegetation resources (i.e., food and refuge) and result in the dominance of a single species, decreasing the presence and abundances of others (Monadjem and Perrin 2003; Plavsic 2011). Furthermore, the fire was negatively associated with the species richness of native small mammals, since most of their life-history traits, habitat requirements, and refuges are provided by unburned forests or forests in advanced successional stages (Kelly et al. 2010; Fordyce et al. 2016). Moreover, fire reduces vegetation cover and increases predation pressure (Leahy et al. 2015).

Fire affects species richness and abundance (Fig. 5A), especially over bird communities. For example, bird richness and abundance decrease in unburned areas (Adeney et al. 2006) due to alterations in the vegetation structure that constrain the recovery of birds, even after a decade from the disturbance (Ding et al. 2008; Choi et al. 2014). In line with our results, such a pattern may be linked to the vegetation structure and composition postfire recovery. Burned areas tend to have a lower percentage of live trees and canopy cover and an understory dominated by grasses and herbs (Ding et al. 2008; Choi et al. 2014) that changes resource availability and how organisms respond to these environments.

Most studies were carried out in areas where prescribed fires are used for forestry management, i.e., the Nearctic region. Almost all taxonomical groups had been studied, especially birds and arthropods. Our results showed that species richness and abundance in this region were not significantly affected by fire, as found by multiple studies. For example, Bateman and O'Connell (2006) and Allen et al. (2006) found that in conifer forests—dominated by pines, the richness and total abundances of birds are not significantly affected by fire, as is also reported for oak forests (Blake 2005). However, according to the species, there are differential responses. Some species are strongly associated with complex vegetation structures of typically unburned areas, whereas others are favored by open habitats typically created by fire (Allen et al. 2006; Haney et al. 2008). Fire does not impact ground arthropods due to their ability for recolonization and the rapid accumulation of litter after fire events (Bess et al. 2002).

Several studies provide evidence on the ability of arthropods to recolonize post-fire patches. For example, ants are pioneers in recolonizing burned areas due to their generalist, opportunistic, and subterranean habits (Bess et al. 2002; Antunes et al. 2009). Meanwhile, beetles and arachnids are usually dominant in postfire areas (Antunes et al. 2009). However, the effects of fire over arthropod diversity can show differential responses. For example, Fattorini (2010) found that fire negatively affects the diversity and community structure of tenebrionid beetles. These patterns are also reported for soil microarthropods, which are negatively affected by a marked reduction of litter after accidental and prescribed fires (Čuchta et al. 2012). In the subantarctic region, Sasal et al. (2015) reported lower abundance and richness of different beetle assemblages between burned and unburned forests due to changes in resource availability. Similar patterns were observed in Mediterranean bird communities, as bird richness is not affected by fire, but the fire has negative effects when species replacement is assessed in heterogeneous mosaics (Herrando and Brotons 2002; Ukmar et al. 2007).

Caveats

Knowledge about the responses of fauna to disturbances such as fire is still incipient worldwide (Pausas 2019). This review has shown that, while fire regime patterns have been extensively studied in fire-dependent ecosystems of North America and Australia, there is still a knowledge gap in the tropical region. Besides, we found that faunal responses to fire regimes do not tend to be quantified or specified in most studies. Indeed, in our revision, we had to exclude over 300 published papers that considered the effects of fire over different animal taxonomical groups but failed to report any information regarding the fire regime components (i.e., frequency or history). As such, we advocate to focus future research efforts on fire-sensible ecosystems in the tropics and to describe the fire regime of study areas in greater detail.

This review showed that most fire-related studies used prescribed fires, whereas few studies have addressed the natural dynamics of fires within biogeographical regions (Fattorini 2010; Brehme et al. 2011; Čuchta et al. 2012). In addition, most studies were focused on a single taxonomical group (birds). Although these approaches are highly valuable and contribute to shedding light on the response mechanisms of animal communities to disturbance, they carry some constraints as well. For instance, they do not account for the pivotal aspects of communities and populations such as competition, predation, recolonization, and extinction processes and how these aspects are affected by the components of the fire regime.

Concluding remarks

Fire regime components have differential effects on biological communities; consequently, pervasive influence on the resilience of ecosystems across the world. However, to date, the magnitude of such effects is uncertain because of the scarcity of long-term studies. This meta-analysis found that most of the published papers have focused on studying short-term (i.e., 2–3 years after a fire event) responses of different communities to fire (Benson et al. 2011; Brehme et al. 2011; Plavsic 2011). In contrast, mid-term and long-term studies (4–5 and more than 5 years after the fire) are scarcer and focused on specific assemblages (Adeney et al. 2006; Allen et al. 2006).

As evidenced by the systematic analysis of the published record, the history of fire is an important modulator of animal diversity. The richness and abundance of animal communities are significantly reduced some years after the last fire event. In this sense, the short temporality of many studies probably influences the lack of significant effects of fire on animal communities (Brennan et al. 2005), which at the same time can be translated to more challenges at the implementation of fire management strategies (Doherty et al. 2016). Whether or not we can anticipate the effects of the fire will then depend on future efforts to implement long-term research.

Abbreviations

AFR: Afrotropical; AUS: Australian; CI: Confidence interval; ID: Identification; IND: Indomalay.; NEA: Nearctic; NEO: Neotropical; PAL: Palearctic; SUB: Subantarctic.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13717-021-00357-7.

Additional file 1: Appendix S1. Paper database.

Additional file 2: Appendix S2. List of scientific works that met our selection criteria for the analysis.

Additional file 3: Appendix S3. Funnel plot of the sample size of all the experiments against their effect size.

Additional file 4: Appendix S4. R Script to estimate effect sizes, perform linear models, and draw figures.

Acknowledgements

We thank Gabriela Cordoba and Francisco Luque for their collaboration throughout the selection and review process. In addition, we are incredibly grateful to Dr. Ralph Grundel of the U.S. Geological Survey and Dr. Philip Barton of The Australian National University for facilitating their detailed data and extra information. We also thank Thomas Richard Defler for the revision of the manuscript. Finally, we wish to thank the reviewers for their comments and suggestions that significantly improved the manuscript.

Authors' contributions

TMG and JDGT are considered equal contribution authors. TMG, JDGT, and DA conceived and designed the study; TMG and JDGT structured the databases; TMG and JDGT analyzed the data; TMG and JDGT led the writing with inputs from DA and AM. All authors contributed critically to the manuscript drafts and gave their final approval for publication.

Funding

TMG was funded by Colciencias 757 National Doctorate Scholarship, Universidad Nacional de Colombia through the Convocatoria Nacional para el Apoyo a Proyectos de Investigación y Creación Artística 2017–2018, the American Society of Mammalogists through the Latin American student field grant 2017, The Rufford Foundation—Small Grant, and L'Oréal-UNESCO for Women in Science Colombia 2018 scholarship.

Availability of data and materials

All data and coding used in this study are available.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Received: 19 July 2021 Accepted: 28 December 2021
Published online: 11 February 2022

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