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Review

A SYSTEMATIC REVIEW OF TRENDS AND METHODOLOGIES IN RESEARCH ON THE EFFECTS OF WILDFIRES ON THE AVIFAUNA IN TEMPERATE FORESTS

REVISIÓN SISTEMÁTICA DE LAS TENDENCIAS Y METODOLOGÍAS EN LA INVESTIGACIÓN SOBRE LOS EFECTOS DE LOS INCENDIOS FORESTALES EN LA AVIFAUNA EN BOSQUES TEMPLADOS

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Summary.—Perceptions of the relationships between forest ecosystems and wildfires have evolved. The ecological role of wildfires is now recognised as essential for maintaining the functionality of fire-adapted forests. Although research on the impact of fire on fauna has grown notably, there is a lack of consensus on its global effects due to the variable responses of faunal communities across taxa. This review provides a bibliometric synthesis of wildfires and their impact on avifauna in temperate forests. It identifies patterns and gaps in research methodologies and offers recommendations for future studies. We employed quantitative and qualitative methods to analyse 52 studies on the effects of wildfires on avifauna in temperate forests from January 2000 to August 2022. We evaluated bibliometric data, sampling methodologies, fire disturbance assessments, fire severity levels and statistical analyses. Approximately 50% of the studies did not include fire severity levels, 38% did not use control areas or pre-disturbance data and only 60% employed statistical modelling. We recommend incorporating undisturbed reference areas and considering severity levels when designing avifaunal censuses, manage-

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ment plans and conservation activities in fire-affected areas.—Ramírez Sánchez, D., Seingier, G., De León Girón, G., Villada Canela, M., Steel, Z.L. & Rivera Huerta, H. (2025). A systematic review of trends and methodologies in research on the effects of wildfires on the avifauna in temperate forests. *Ardeola*, 72: 105-120.

Keywords: bibliometric analysis, birds, conservation, fire, impact factor, temperate forest, statistical method.

RESUMEN.—Las percepciones sobre la relación entre ecosistemas forestales e incendios han evolucionado. La intervención de incendios forestales se reconoce ahora como crucial para mantener la funcionalidad de bosques adaptados al fuego. Aunque la investigación sobre el impacto del fuego en la fauna ha crecido notablemente, no existe un consenso sobre sus efectos globales debido a las respuestas variables de las comunidades faunísticas entre taxones. Esta revisión proporciona una síntesis bibliométrica sobre los incendios forestales y sus efectos en la avifauna de bosques templados, identifica patrones y lagunas en las metodologías de investigación, y ofrece recomendaciones para futuras investigaciones. Utilizamos métodos cuantitativos y cualitativos para analizar 52 estudios sobre los efectos de incendios en aves de bosques templados desde enero de 2000 hasta agosto de 2022. Evaluamos datos bibliométricos, metodologías de muestreo, evaluaciones de disturbios por fuego, niveles de severidad del fuego y análisis estadísticos. Aproximadamente, el 50 % de los estudios no incluyeron niveles de severidad del fuego, el 38 % no usó áreas de control o datos previos a la perturbación, y el 60 % empleó modelización estadística. Recomendamos incluir áreas de referencia no perturbadas y considerar grados de severidad al diseñar censos de avifauna, especialmente para justificar las conclusiones del estudio, planes de manejo o actividades de conservación en áreas afectadas por incendio.—Ramírez Sánchez, D., Seingier, G., De León Girón, G., Villada Canela, M., Steel, Z.L. y Rivera Huerta, H. (2025). Revisión sistemática de las tendencias y metodologías en la investigación sobre los efectos de los incendios forestales en la avifauna en bosques templados. *Ardeola*, 72: 105-120.

Palabras clave: análisis bibliométrico, aves, bosque templado, conservación, factor de impacto, fuego, método estadístico.

INTRODUCTION

Our understanding of the dynamics between fire and forest ecosystems has evolved over the years, with the paradigm of natural area management undergoing substantial modifications, particularly concerning intensive fire suppression (Keeley *et al*., 1999; Bowman *et al*., 2009; Pausas & Keeley, 2019). Fire is essential for the proper functioning of various ecosystems (Kozlowski & Ahlgren, 1974; Richards *et al*., 1999; González *et al*., 2022; Steel *et al*., 2024; Jones & Tingley, 2022; Hessburg *et al*., 2007; Gill & Allan, 2008; Keane *et al*., 2008; Pausas & Vallejo, 2008; Keeley, 2009; Miller *et al*., 2012). Recent wildfire catastrophes and predictions indicating an escalation in fire incidents (Bowman *et al*., 2009, 2020; Jolly *et al*., 2015) have exerted mounting pressure on academics and land managers to devise mitigation strategies for this phenomenon. This surge has resulted in a plethora of case studies, reviews, syntheses and compilations on the effects of wildfire on fauna since the 1950s (Prodon & Pons, 1993; Brawn *et al*., 2001; Kennedy & Fontaine, 2009; Leidolf & Bissonette, 2009; Fontaine & Kennedy, 2012). One such strategy is the use of prescribed burns, which has gained attention as a potential tool to manage fire regimes and reduce the risk of uncontrolled wildfires. However, researchers have observed contrasting outcomes regarding the benefits of implementing surrogate wildfire interventions, such as prescribed burns, which can

either increase or reduce habitat diversity depending on the context (Schieck & Song, 2006; Prowse *et al*., 2017). This inconsistency has introduced uncertainty into proposed management actions. Indeed, Kennedy and Fontaine (2009) synthesised results from multiple studies in fire-dependent dry forests in the United States and found that, based on the available research, they were unable to provide definitive recommendations for prescribed burns or other fire-mimicking activities.

Given this uncertainty, studying bird responses to wildfire can provide valuable insights and reveal important patterns and trends in the overall health and dynamics of forest ecosystems, because birds are reliable indicators of change for multiple ecological processes (Dale & Beyeler, 2001). As scientists can gain valuable information by studying how bird populations and behaviours respond to fire events, there has been a notable increase in research on avian responses to wildfire (Blake, 1982; Aquilani *et al*., 2003; Saab & Powell, 2005; González *et al*., 2022). For example, research in this area can elucidate changes in habitat quality (e.g. Driscoll *et al*., 2021), biodiversity (e.g. Gill *et al*., 2003), and ecological resilience (e.g. Eisenberg *et al*., 2019), which are critical for developing effective forest management and conservation strategies.

Monitoring changes in bird populations and forests following wildfires is important for assessing ecosystem resilience and recovery. Prodon & Pons (1993) conducted a literature analysis that highlights the methodological challenges of observing post-fire dynamics through bird reponses. Their conclusions underscored the complexity of reviews and meta-analyses, emphasised a need for conclusiveness and encouraged the exploration of other methodologies in order to generate robust results. This call for new methodologies underscores the importance of analysing the current literature in shaping future research. It also presents researchers with opportunities to conduct studies with meaningful impacts. Leidolf & Bissonet (2009) furthered this call by emphasising the urgent need for critical reviews that evaluate the current understanding of bird responses to wildfire, rather than conducting research that statistically evaluates the results of case studies.

Temperate forests have experienced wildfires throughout their evolution. Given the prevalence and threats posed by fire, these forests are often subject to management and conservation policies. Furthermore, temperate forests also provide a valuable framework and important opportunities for studying the impacts of wildfires on ecologically diverse and globally relevant ecosystems, as well as opportunities to further natural resource management and conservation strategies that promote ecosystem resilience.

Unlike previous reviews that have focused on normalising results with statistics to identify patterns in bird census data, we aimed to evaluate the principal strategies and directions of the research on the effects of wildfires on avifauna. Our systematic review aims to make it easy for researchers to identify gaps in research methodologies. This review is divided into two sections: 1) a quantitative analysis following a bibliometric approach and 2) qualitative analyses, which we used to organise the methods of the published studies. Quantitative methods were initially employed to conduct a statistical analysis of the metadata obtained from Web of Science (WOS). Subsequently, qualitative methods were used to examine each article in depth, allowing for a richer and more contextualised understanding of the information. Our goals for quantitative research included identifying keywords and critical themes, key authors and the institutional networks that contribute to this field. The qualitative goal was to elucidate methods for conducting bird censuses, disturbance assessments, evalua-

tions of fire severity and statistical analyses. Finally, we offer recommendations for future research in these areas.

Methods

We employed the problem, intervention, comparison, and outcome (PICO) model (Supplementary material, Appendix 1, Table A1) to structure our search strategy and identify key terms.

Renowned for its discerning selection of indexed sources, WOS outperforms other scientific databases, including SCOPUS, ELSEVIER, Dimensions, Crossref, and Microsoft Academic (Visser *et al*., 2021). For our systematic review, we used WOS (search date: September 2022) and applied the following search criteria:

Inclusion criteria:

1. Publications in indexed journals.
2. Types of publications: original articles, syntheses, compendiums, chapters, books, meta-analyses and reviews.
3. Publications in any language.
4. Research conducted in geographical locations with temperate forest ecosystems.

Exclusion criteria:

1. Studies involving prescribed burns in any form. We ensured that the studies independently and carefully evaluated the ecological effects of wildfires, which differ significantly from those of human-controlled burns (Prowse *et al.,* 2017; Francos & Úbeda, 2021; Saab *et al.,* 2022).
2. Studies that did not consider bird census data.
3. Studies that included more than one kind of perturbation in the method design (e.g., studies that included areas affected by wildfires and logging).
4. Studies before the year 2000.

By employing these criteria, we ensured that our review focused solely on the effects of wildfires, which have unique ecological impacts that must be studied separately from human interventions.

The core aspects of this research revolved around three fundamental topics: birds, fire and temperate forests. We thoroughly analysed synonyms and related terms in the documents retrieved from the WOS database. To this end, we constructed a comprehensive and controlled vocabulary after searching for terms associated with these topics in a life science thesaurus (https://universoabierto.org/2016/05/31/tesauros-y-glosarios-disponibles-en-linea-2/, consulted August 2022). Supplementary material, Appendix 1, Table A2 presents the three primary topics and their synonyms.

Including the genus *Pinus* was pivotal in the search equation, as it is a key genus that resides in the vegetation that is characteristic of temperate forests. However, we did not exclude studies that did not include *Pinus*. We searched for controlled vocabulary words in the abstracts, titles and keywords. We formulated a canonical search equation using Boolean logic and the logical operators 'AND', 'OR', and 'NOT' (Supplementary material, Appendix 1, Table A2). To conduct searches in different manuscript sections, codes 'TI', 'AB', and 'AK' were used for the title, abstract and keywords.

We used the metadata within WOS to identify information in the following fields of the selected studies: author, title, source, sponsor, number of citations, accession number, author identifier, ISSN, PubMedID, abstract, address, affiliation, document type, keywords, WoS category, research, cited references, cited references count, usage count, highly cited, funding information, publisher information, page count, source abbreviation, IDS number, language and research area. We used the Biblioshiny application via the 'Bibliometrix' package (v. 3.0.4) in R v. 1.4.1103

(R Core Team, 2020). Biblioshiny was chosen for its capabilities in bibliometric data mapping and because it is recognised as one of the most comprehensive tools in bibliometric research due to its user-friendly interface (Silva *et al*., 2022). Biblioshiny is also recognised for allowing researchers to perform detailed bibliometric analyses, regardless of their level of expertise. To avoid pseudoreplication in the keywords section, we used a list of synonyms and grouped similar concepts (Supplementary material, Appendix 1, Table A3).

We decided to use studies from 2000 onwards, as this was the last year a comprehensive review on birds and fire was conducted (Lyon *et al*., 2000). Although valuable reviews were conducted later, such as those by Leidolf & Bissonette (2009) and Kennedy & Fontaine (2009), these did not fully meet our criteria. The review of Leidolf & Bissonette (2009) is a bibliometric synthesis that focuses on data of authors and journals and does not provide an in-depth review of the effects of fire on avifauna. Meanwhile, the review of Kennedy & Fontaine (2009) is more comprehensive, although it focuses specifically on dry forest ecosystems, which limits its applicability to other ecosystems.

Quantitative method

Bibliometric analysis can provide structured and data-driven insights into the state and evolution of a research field, facilitating strategic planning for future studies. We evaluated various studies using diverse descriptors related to authors, journals, impact factors and local citations. With Biblioshiny, we evaluated the impacts of journals and researchers, focusing on the number of articles per journal and citations per article (Wilczewki & Alon, 2022; Hirsch & Buela-Casal, 2014).

We conducted a keyword frequency assessment and co-occurrence analysis, as well as conceptual thematic mapping (Sedighi, 2006; Cobo *et al*., 2012; Sudolska, 2017). We examined the keyword usage frequency across studies and created a thematic map based on trends from 2000 to 2022 (Figure 3). Out of the keywords of the 52 scientific studies reviewed, we selected those that appeared at least three times, to analyse the connections among them. This criterion may have excluded some rare keywords, but it effectively reduced noise from overly specific terms found in case studies, thus enhancing the clarity of the connections. From the graphic results, we identified principal research interests and keyword clusters based on thematic groupings. To further ensure that the keywords of the articles accurately reflected the article content, we conducted a co-occurrence analysis. This analysis was also based on keyword frequency (detailed in Supplementary material, Appendix 2, Table B3).

Qualitative method

To be included in the qualitative analysis, a study was required to meet at least one of the following criteria: A) it evaluated the effects of wildfire on avifauna and addressed some effects at the community or species level. B) it explicitly characterised a fire-related factor by describing elements of the fire regime, such as the time elapsed since the fire, the extent of burned area or severity. C) it provided evidence of fire effects through descriptions, including the changes induced after the disturbance, the differences between control and disturbed areas or the fire history. D) it included bird data by presenting lists of surveyed bird species or other metrics of the avifaunal community.

For each study, we obtained the following information: the size of the burned area, fire severity level, comparisons between burned and unburned areas, time elapsed since the

fire, the protection category of the burned area, information on specific bird species or the bird community, the sampling method and the statistical analysis employed.

Results and discussion

We identified 217 documents in the initial WOS search. Only some of the papers were pertinent to research on the effects of wildfires on birds in temperate forests; many documents included key concepts but did not focus on their search topic. We read 217 abstracts and excluded non-pertinent research. We identified 85 documents, meticulously reviewed them to determine if they included avifauna variables and determined if they met the inclusion or exclusion criteria. Consequently, we identified 52 relevant articles on the impacts of wildfire on avifauna in temperate forests worldwide.

Bibliometric results

Over the study period, the growth rate of scientific article production was −3%, which reflected a decrease in publications since 2000. This decline may reflect a maturation of the research field, with researchers choosing to focus on expanding and refining existing knowledge rather than exploring entirely new topics. However, this decrease in publication output could also be attributed to a range of other factors, such as a reduced interest in the field, shifts in political priorities, changes in funding availability, or global

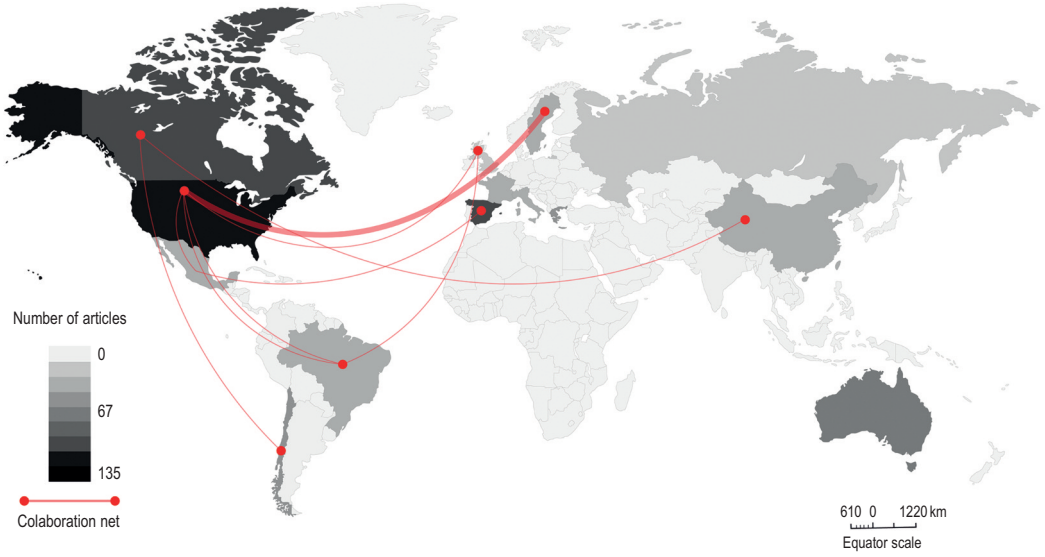

Fig. 1.—Map of collaborations among countries in research on the impacts of forest fires on temperate forests, employing birds as indicators. Greyscale intensity indicates the number of publications produced in each country. The red lines indicate collaborations among authors.
[Mapa de colaboraciones entre países en la investigación sobre los impactos de los incendios forestales en bosques templados utilizando aves como indicadores. La intensidad en escala de grises refleja el número de publicaciones producidas en cada país. Las líneas rojas señalan las colaboraciones entre autores.]

events impacting scientific production, including economic crises or the effects of the COVID-19 pandemic. Supplementary material, Appendix 2, Table B1 summarises the bibliometric data.

The most notable international research collaborations were observed between the United States and Sweden, followed by Brazil, the United Kingdom, Canada and Chile (Figure 1). Although collaborations existed among these countries, they accounted for only 15% of all research on the effects of wildfires on avifauna in temperate forests. This suggests that the remaining 85% of studies were conducted within individual countries without international collaboration. These results highlight a need for international collaboration to strengthen and optimise research efforts. For example, opportunities exist for collaborations among countries that share temperate forests that cross international borders (e.g., California, USA and Baja California, Mexico). It is notable that only one published document on this topic came from Mexico, despite 16% of its territory comprising temperate forest ecosystems (Rzedowski, 2006; CONABIO, 2014; Challenger, 1998) and fire playing a notable role in the country's forests.

The 52 documents were published in 30 indexed scientific journals by 182 authors. Biblioshiny evaluates author productivity by examining the correlation between the number of published documents and citations. Figure 2 illustrates author output throughout the years and offers insights into metrics such as published documents and the total number of citations received each year. From 2000 to 2022, the top five most productive authors were Lluis Brotons, Rodney B. Siegel, Craig R. Allen and David G. Angeler. The journals with the most outstanding performance regarding publications on the impact of fire on birds in temperate forests were *Condor*, *Forest Ecology and Management*, *American Midland Naturalist*, *Ecosphere* and *PLOS*

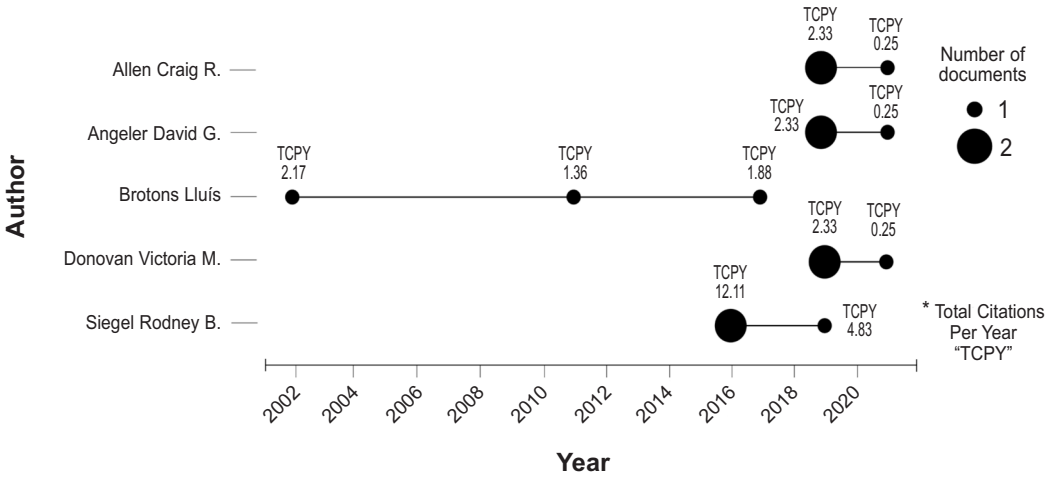

FIG. 2.—Authors with the highest productivity from 2000 to 2022. The black lines depict the publication timeline. The circles represent published documents, with large circles indicating two documents and small circles one document. TCPY: total citations per year.
[Autores con mayor productividad de 2000 a 2022. Las líneas negras muestran la línea de tiempo de publicación. Los círculos representan los documentos publicados, siendo los grandes indicativos de dos documentos y los pequeños de uno. TCPY: citas totales por año.]

ONE. This suggests that these journals are reliable sources that are frequently referenced in this field.

While these journals share the general goal of disseminating scientific research in environmental, agricultural and biological sciences, their publication focuses fall into four categories, according to Scimago Journal & Country Rank: 1) Ecology, Evolution, Behaviour and Systematics; 2) Animal Science and Zoology; 3) Ecology; and 4) Nature and Landscape Conservation. Thus, these journals have distinct editorial focuses despite sharing similar general objectives. These differences could influence where specific research on the impact of wildfire on birds is published. The diversity among these categories suggests that the impact of fire on avifauna in temperate forests spans multiple disciplines and encompasses multiple areas of study, from ecology and evolution to nature and landscape conservation. This breadth and depth provide opportunities for researchers to explore new avenues and collaborate across disciplines.

Keywords and thematic map

Of the 283 keywords compiled from the 52 scientific studies reviewed, the most frequently used were 'fire', 'fire severity', 'conifer forest' and 'avifauna'. This alignment with our strategic search confirms that the studies primarily focused on the impact of wildfires on avifauna in temperate forests.

The analysis of 283 key terms enabled us to create a strategic thematic map that provides an overview of the maturity of these themes, which have already been the subject of various studies (Figure 3). In the map, the themes are depicted as circles, whose size is proportional to the number of documents and associated local citations.

The thematic map has four quadrants:

1. Motor themes (upper right) are central and well-developed themes. In this case, the identified themes were habitat, disturbance and the temperate forests of Florida (USA). These themes reflect a growing research focus on fire disturbance, particularly in forests in Florida (USA).
2. Basic themes (lower right) are central but underdeveloped themes. The foundational themes include fire, the Bayesian multi-species occupancy model and remote sensing. These themes suggest that studies on the impact of fire on avifauna in temperate forests frequently employ advanced methods to estimate species density or abundance through Bayesian multi-species occupancy models, which continue to experience methodological development and expanded use.
3. Emerging or declining themes (lower left) are marginal and underdeveloped. Here, post-fire and ecological memories were identified. Post-fire, in particular, shows potential to become a motor theme, indicating an increasing focus on studying forest fires in temperate forests. This potential evolution of post-fire as a motor theme piques our interest and should inspire further research in this area.
4. Niche themes (upper left in the thematic map) are marginal but well-developed. No niche themes were identified in the strategic map.

The thematic analysis, which provided a structured view of research on the effects of fire on avifauna in temperate forests, serves as a comprehensive guide for identifying key research areas and shaping future research directions. This type of analysis prioritises topics by exposing gaps in the existing literature and can be used to inform conservation strategies and policymaking by highlighting

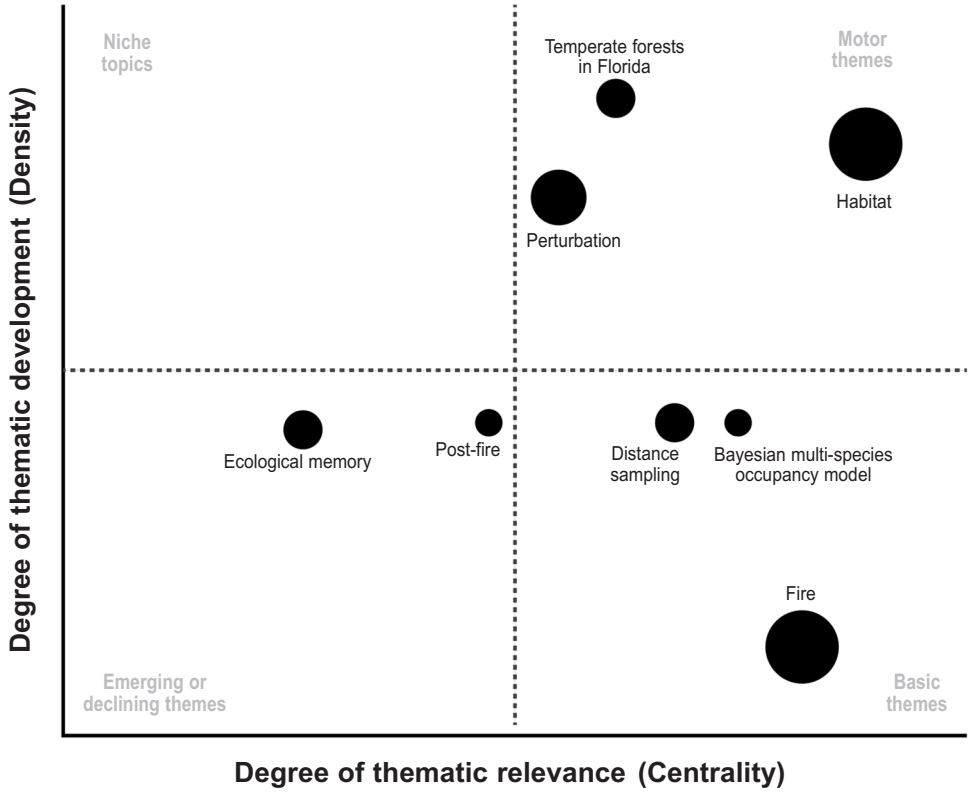

FIG. 3.—Thematic keyword map. Larger circle sizes indicate a greater co-occurrence of words connected to the main word node.
[Mapa temático de palabras clave. Tamaños más grandes reflejan una mayor coocurrencia de palabras asociadas al nodo principal.]

the most critical themes and findings. Thematic analysis can also be used to identify mature themes and those in development or decline within the field. This comprehensive assessment elucidated the methodologies used to analyse the data across studies.

Sampling method

Point counts were the favoured methodology for bird censuses (Supplementary material, Appendix 2, Table B4). Point counts are a relatively straightforward and cost-effective option for monitoring bird populations. This methodology yields valuable spatial and temporal data and enables efficient biodiversity assessments in different habitats (Ralph & Scott, 1981; Ralph *et al.,* 1993; Bibby *et al.,* 1998; Sutherland *et al.,* 2004). Consistency across counting methodologies facilitates data comparisons over time and among locations, allowing for long-term studies on bird populations that take advantage of published data. However, variability in bird detection, observer skill, weather conditions and vegetation presence, can introduce bias into the results (Ralph *et al.,* 1995).

From the description of the sampling designs collected during this review, the results

revealed a predominant trend towards the use of point counts for bird sampling, which considers both the advantages of its simplicity and its disadvantages related to potential bias (Buckland, 2006; Lee & Marsden, 2008). In some cases, by combining this technique with additional approaches and carefully considering contextual factors, researchers can maximise the utility of the collected data to gain a more complete understanding of the dynamics of bird populations in their natural environments (Watson, 2003; Thompson, 2002; Wheeldon *et al.,* 2019; Pérez-Granados & Traba, 2021).

It is essential to acknowledge the limitations associated with the use of point counts as well as other methods such as line transects or automated recording unit surveys. There does not appear to be a consensus as to the best survey method (Wilson *et al.,* 2000; Taulman, 2013) and, as noted above, each method is sensitive such factors as observer skill, weather conditions and vegetation presence that may bias the results (Ralph *et al.,* 1993). Their relative strengths and weaknesses should be weighed along with the specific study objective when assessing the impacts of fire on avian communities.

This trend was evident in the studies highlighted in this review, such as those by Kotliar *et al*. (2007); Rost *et al*. (2015); Flesch *et al*. (2016); Sitters *et al*. (2016); Smucker *et al*. (2005). These authors implemented a combination of point counts and additional methodologies to minimise potential bias. However, the vast majority of studies only used point counts. It is important to note that all methods have limitations and potential bias, so implementing a combination of techniques can improve the fidelity of the data.

Disturbance assessment

The attributes selected to assess fire disturbances are essential for understanding the effects of wildfire and for designing forest management strategies (Keane & Karau, 2010; Glikson, 2013; Scott *et al*., 2014; Pyne, 2016). The quality of the methodology determines the reliability and applicability of the results, directly influences the effectiveness of restoration strategies and minimises negative impacts (Brewer, 2005; Eidenshink *et al*., 2007; Keeley, 2009). Well-designed methodologies are critical for generating reliable and reproducible results, accurately interpreting data (Van Leeuwen *et al.,* 2010; Landi *et al.,* 2017) and reducing statistical bias.

Of the studies in this review, 42% (22 papers) included an unburned control area, whereas 38% (20 papers) did not. Only 9% (five papers) employed the complete Before-After-Control-Impact (BACI) methodology, which is a robust approach to assess the impacts of a disturbance (Supplementary material, Appendix 2, Table B4). Unburnt areas act as necessary points of comparison by establishing a baseline for evaluating the effects of multiple variables. Additionally, these baselines allow for cause-and-effect relationships due to fire disturbance to be identified. Therefore, it is imperative for researchers interested in studying the relationships between wildfire and the environment to consider including adjacent unburnt areas as controls in their methodological design. We recommend including a nearby, unburned area as a control area or obtaining pre-fire data when possible. The latter option is not always available due to the stochastic nature of wildfire events, making inclusion of a control area a more likely option.

Fire severity levels

Considering the variability in fire severity and the resulting changes in habitat structure within temperate forests, assessing fire

severity is essential for gaining a comprehensive understanding of its impact on the avifauna community. Out of the studies included in this review, 50% (26) employed a fire severity classification in their design, while half omitted this potentially critical information (see Supplementary material, Appendix 2, Table B4). These omissions risk over-simplifying the impacts of wildfire, as fire-induced changes to habitat avifauna populations can vary greatly due to burn severity. Thus, considering fire severity levels in studies can potentially lead to more effective conservation strategies and management practices.

Statistical analyses

Understanding the data analysis methodologies commonly employed in a particular field is essential for planning future studies. Supplementary material, Appendix 2, Table B5 summarises the statistical analyses used in the studies evaluated in this review. Supplementary material, Appendix 3, Table C1 lists statistical tests, models and post-hoc tests. Our review indicates a greater use of non-parametric models. While non-parametric models are best suited for non-normal data and small sample sizes, they can lack the power and precision of parametric models when underlying assumptions are met. Conversely, parametric models can offer more detailed insights but require assumptions about data distributions that may not always be satisfied. Most studies in this review utilised habitat and occupancy distribution models for data analysis.

Future studies should consider including additional variables and a control, such as data from unburned areas or data collected prior to wildfires, to generate a more reliable understanding of the impact of these disturbances, including their effects on habitat and occupancy distribution.

Conclusions

Our review of studies on the impacts of wildfires on avifauna in temperate forests reveals several key findings: 1) research in this field is dominated by a few countries, with the United States, Canada and Spain leading in the number of publications. International collaborations have been limited, highlighting the need for greater geographic diversity and more cross-border comparative studies. 2) The choice of statistical and sampling methodologies is fundamental. While current studies employ various statistical models, we strongly recommend using more robust approaches, such as the Before-After-Control-Impact (BACI) model, and methods that include unburned control areas. These approaches provide more accurate baseline data for assessing the direct and indirect effects of wildfires, ensuring the validity and reliability of research results. 3) It is essential to recognise that wildfires create a mosaic of disturbances of varying severity. Therefore, any study on wildfires should consider these levels of severity to generate a comprehensive understanding of the ecological processes involved. This approach will provide a more nuanced view of the impact of wildfires on avifauna in temperate forests.

With their rich biodiversity, temperate forests play an essential role in ecological processes at multiple scales. Wildfires, as a natural part of these ecosystems, induce environmental changes that can have cascading effects on ecological communities and the services these forests provide. It is imperative to study these effects, human interventions and the potential impacts of climate change in future scenarios.

Detailed knowledge of how wildfires affect avifauna in temperate forests should guide conservation efforts and the development of sustainable forest management strategies to enhance ecosystem resilience. In particular, this knowledge should inform the design of

fire management policies that protect biodiversity and the livelihoods of human communities that rely on forests, including their access to natural resources, economic stability and overall well-being. We recommend incorporating unburned reference areas in future studies, considering fire severity levels when planning bird censuses and species sampling, and conducting post-fire monitoring in the short and long term.

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Supplementary Electronic Material

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Appendix 1

Table A1. PICO Model. Strategy for compiling accurate information from the Web of Science database from studies on forest fires that impacted temperate forests and that employed birds as indicators of the effects of fire.
[Modelo PICO: Estrategia para recopilar información precisa de la base de datos Web of Science sobre estudios de incendios forestales que afectaron a bosques templados y utilizaron aves como indicadores de los efectos del fuego.]

Table A2. Parameters and search equation utilising the Web of Science database.
[Parámetros y ecuación de búsqueda utilizando la base de datos de Web of Science.]

Table A3. List of synonyms, grouping similar concepts.
[Lista de sinónimos, agrupados en conceptos similares.]

Table B2. Performance metrics for the scientific journals assessed in this review.
[Métricas de rendimiento de las revistas científicas evaluadas en esta revisión.]

Table B3. Key words frequencies in the studies included in this review.
[Frecuencias de palabras clave en los estudios incluidos en esta revisión.]

Table B4. Document attributes with their corresponding frequencies of occurrence in the final dataset of 52 documents.
[Los atributos de los documentos se presentan junto con sus frecuencias de ocurrencia correspondientes en el conjunto final de datos que consta de 52 documentos.]

Table B5. Statistical analyses identified in the final dataset of 52 documents.
[Análisis estadísticos identificados en el conjunto final de datos compuesto por 52 documentos.]

Appendix 2

Table B1. Significant findings have emerged from a comprehensive bibliometric analysis utilising data from Web of Science. This analysis encompasses 52 studies dedicated to investigating the impact of fire on avian communities within temperate forests.
[Hallazgos significativos de un análisis bibliométrico utilizando datos de Web of Science, que abarcan 52 estudios que investigan el impacto del fuego en las comunidades de aves en bosques templados.]

Appendix 3

Table C1. This table provides a summary of pertinent information extracted from the reviewed documents pertaining to research focused on forest fires and their impacts on temperate forests, with birds serving as indicators of fire effects.
[Esta tabla resume la información relevante de los documentos revisados de la línea de investigación sobre incendios forestales que afectaron a bosques templados y utilizaron aves como indicadores de los efectos del fuego.]

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