

Understanding Fire Through Ethnoecology in Brazil

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Abstract This study provides a detailed analysis of the historical context of fire management in Brazil from the perspective of ethnoecology. The study aims to identify traditional fire management practices in Brazil, examining their interactions with ethnoecology and their impacts on biodiversity conservation. The review adopted a systematic approach that began with the formulation of a clear research question: “What are the traditional fire management practices in Brazil from an ethnoecological perspective, and what are their impacts on biodiversity?” The results highlight the uneven distribution of studies across Brazilian biomes, with a greater concentration of research in the Cerrado and Amazon regions, while significant gaps were observed in other biomes such as the Atlantic Forest and Pantanal. Recent advances in research on fire management by traditional communities underscore the importance of local knowledge as an essential tool for the sustainable management of Brazilian ecosystems. Nevertheless, traditional fire management practices have historically been marginalized by public policies. This review emphasizes the need to more broadly integrate these practices into environmental management strategies, recognizing their significance for biodiversity conservation, landscape management, and cultural revitalization. Such integration is increasingly urgent given the growing threats to Brazil's biomes.

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Introduction

Fire management has been a fundamental practice across various cultures throughout human history, particularly among Indigenous peoples and traditional communities who rely on sustainable methods to ensure the renewal of natural resources and the stability of ecosystems (Bowman et al. 2009; Mistry et al. 2005). In this context, the term *traditional* refers specifically to fire use practices developed and transmitted by these groups as part of their cultural, spiritual, and subsistence relationships with the land—often termed *cultural burning* in the literature (Eriksen and Hankins 2014; Lake and Christianson 2019). Indigenous peoples are recognized as the original inhabitants of a territory, with their own social organization, languages, and customs. Traditional communities—such as Quilombolas, extractivists, and

riverine populations—are groups that maintain cultural practices and ways of life closely linked to the sustainable use of natural resources, even if not Indigenous by origin (Brazil 2007).

These traditional practices are distinct from modern prescribed burning or controlled fire, which involves the planned and deliberate application of fire under specific environmental conditions and according to a pre-defined plan to achieve ecological or land management objectives (Fernandes and Botelho 2003; Food and Agriculture Organization of the United Nations 2006). Nonetheless, both approaches share the recognition of fire as a tool for regulating vegetation, controlling pests, fertilizing soil, creating favorable conditions for the regeneration of native plant species, and avoiding catastrophic wildfires. These ecological functions benefit not only

wildlife and agricultural systems, but also the availability of sovereign or wild tended foods used in traditional diets (Anderson 2013; Berkes et al. 2000; Bond and Keeley 2005; Dos Santos et al. 2021; Miranda et al. 2009; Pyne 2001; Russell-Smith et al. 2009). Rooted in long-standing ecological knowledge and customary stewardship systems, traditional fire management plays a vital role in sustaining biodiversity and maintaining ecosystem balance.

However, despite recent advances such as the approval of the National Policy on Integrated Fire Management (Brazil 2024), Brazil still faces significant challenges in effectively implementing fire governance across its diverse regions and biomes—particularly in areas where traditional practices remain criminalized or poorly understood. Uncontrolled wildfires in the Cerrado, especially when they affect fire-sensitive environments such as gallery forests and riparian zones, have drawn attention due to their severe and often long-lasting ecological impacts (Durigan and Ratter 2016). Unlike cultural burns—low-intensity and purposefully managed according to seasonal and ecological indicators—these wildfires are unplanned and can irreversibly damage biodiversity and ecosystem structure.

In the Amazon, studies by Berenguer et al. (2014) and Aragão et al. (2018) reveal that wildfires have generated emissions and forest degradation that undermine previous advances in reducing deforestation. Similarly, the Pantanal—a fire-dependent ecosystem—has suffered from unregulated burning that occurs outside of traditional or natural fire regimes, resulting in significant ecological imbalances affecting flood cycles, soil fertility, and species composition (Hardesty et al. 2005). The increase in such wildfires in recent years is often associated with illegal deforestation and the expansion of agricultural frontiers. In these regions, fire is frequently used to clear vegetation for pasture or crops; when conducted illegally and without proper control, it increases the risk of fires spreading beyond intended boundaries, threatening biodiversity, carbon stocks, and aquatic systems (Martins et al. 2022; Nepstad et al. 2006; Welch et al. 2013). These uncontrolled fires stand in stark contrast to traditional fire management, which is carefully planned and executed by Indigenous peoples and traditional communities in harmony with the natural cycles of the landscape (Eloy et al. 2019).

Over the past 20 years, scientific research on fire management in Brazil has significantly expanded, with an increasing number of studies aiming to integrate ethnoecological perspectives into conservation practices and sustainable management. Ethnoecology, which explores the local and traditional ecological knowledge of communities that have historically managed their territories, has demonstrated the value of controlled burning practices, particularly among Indigenous peoples and traditional communities, as an effective strategy for maintaining biodiversity and controlling large-scale wildfires (Berkes et al. 2000; Bird et al. 2008; Eloy et al. 2019; Mistry et al. 2005; Schmidt et al. 2018; Trauernicht et al. 2015). The intensification of wildfires over the last decades, with severe impacts on human populations, biodiversity, and greenhouse gas emissions, underscores a global concern regarding fire management (Hardesty et al. 2005). This type of management is especially relevant in biomes such as the Cerrado, which is fire-dependent, and in certain ecosystems within the Amazon, where the controlled use of fire can promote ecological resilience and facilitate the regeneration of native species. It also prevents the accumulation of flammable biomass, which can lead to uncontrolled fires during dry seasons (Bilbao et al. 2010; Schmidt et al. 2016).

The ethnoecological approach to fire management involves the integration of ecological knowledge rooted in the cultural practices, cosmologies, and long-term environmental observations of Indigenous peoples and traditional communities. As a discipline, ethnoecology is particularly valuable because it bridges scientific and traditional knowledge systems, offering insights into how fire is understood, used, and regulated outside conventional technical frameworks (Eloy et al. 2019; Mistry et al. 2005; Posey 1985). In Brazil and Australia, case studies have demonstrated how Indigenous and local knowledge systems can inform and enhance fire governance and biodiversity conservation strategies, contributing to more inclusive, context-sensitive, and ecologically effective management (Ens et al. 2015; Peroni and Hanazaki 2002).

By emphasizing the value of plural knowledge systems, the ethnoecological perspective challenges top-down, standardized approaches and reinforces the importance of recognizing sociocultural diversity and

localized fire regimes. These ethnoecological practices, grounded in generations of observation and interaction with the environment, promote a holistic view of ecosystems and landscape dynamics. When guided by traditional ecological knowledge, fire is applied in low-intensity and targeted ways—reducing fuel loads, preventing large-scale wildfires, and maintaining habitat heterogeneity to support biodiversity. Recognizing fire management as a sustainable practice integrated with traditional knowledge thus offers a promising pathway for ecosystem governance. This approach has already been empirically tested, as shown in recent studies such as Falleiro (2024), which demonstrates the practical effectiveness of incorporating local knowledge into fire management strategies. This review aims to analyze the current state of scientific research on this topic, highlighting the importance of traditional fire management practices and their implications for biodiversity conservation and the development of more inclusive and effective public policies. Specifically, it seeks to address the following research questions: (1) How has traditional fire management been characterized in the scientific literature? (2) What are the documented ecological and sociocultural benefits of these practices? (3) To what extent have they been incorporated into public policy frameworks in Brazil?

Methodology

This literature review was conducted following the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method (Galvão et al. 2022). The research aimed to identify traditional fire management practices in Brazil, considering their relationship with ethnoecology and impacts on biodiversity conservation. The review was structured in multiple stages, from formulating the research question to synthesizing the results and assessing the quality of the included studies.

Initially, a clear research question was defined, as required by PRISMA guidelines, to guide the systematic review. The question explored: 'What are the traditional fire management practices in Brazil under an ethnoecological perspective and their impacts on biodiversity?' This approach ensured a focused and directed search, facilitating the inclusion of relevant studies on the topic. Specifically, the review was guided by the following research questions: (1) How has traditional fire management

been characterized in the scientific literature? (2) What are the documented ecological and sociocultural benefits of these practices?, and (3) To what extent have they been incorporated into public policy frameworks in Brazil?

The search was performed across four primary databases: SciELO, Web of Science, Google Scholar, and Scopus. A combination of terms in three languages (English, Portuguese, and Spanish) was used to maximize the scope of the research. The keywords employed were: (1) "traditional knowledge" AND "fire" AND "Brazil", (2) "historical use" AND "fire" AND "Brazil", and (3) "fire management" AND "Brazil". These keywords were translated to both Portuguese and Spanish. They were selected for their relevance to the study of fire management from an ethnoecological perspective in Brazil, encompassing both traditional knowledge and the historical use of fire by local communities. A temporal scope of the last 30 years (1993 to 2024) was defined to analyze the evolution of the topic, considering the growing debate around traditional practices and the integration of these approaches into environmental management and conservation policies.

Inclusion/Exclusion Criteria

Inclusion criteria considered research articles addressing the historical use of fire by human communities, focusing on traditional fire management practices and their impacts on ecosystems. Only studies published in Portuguese, English, and Spanish were included. Broader studies, such as those on general management practices, were included for extracting specific data on fire usage. Studies using duplicate datasets were excluded. Articles offering more detailed and comprehensive information were prioritized. Excluded works included studies not directly related to the topic, those lacking relevant data for the review, as well as abstracts, book chapters, and entire books, which were excluded due to difficulties in ensuring consistent peer-review standards and comparability with journal articles, as well as limitations in accessing complete and standardized metadata for systematic analysis.

Screening

Each database was examined independently. In SciELO, 78 articles were found, of which 35 were included after applying the screening criteria. From Web of Science, 90 articles were retrieved, with 42 selected for final analysis. Google Scholar initially

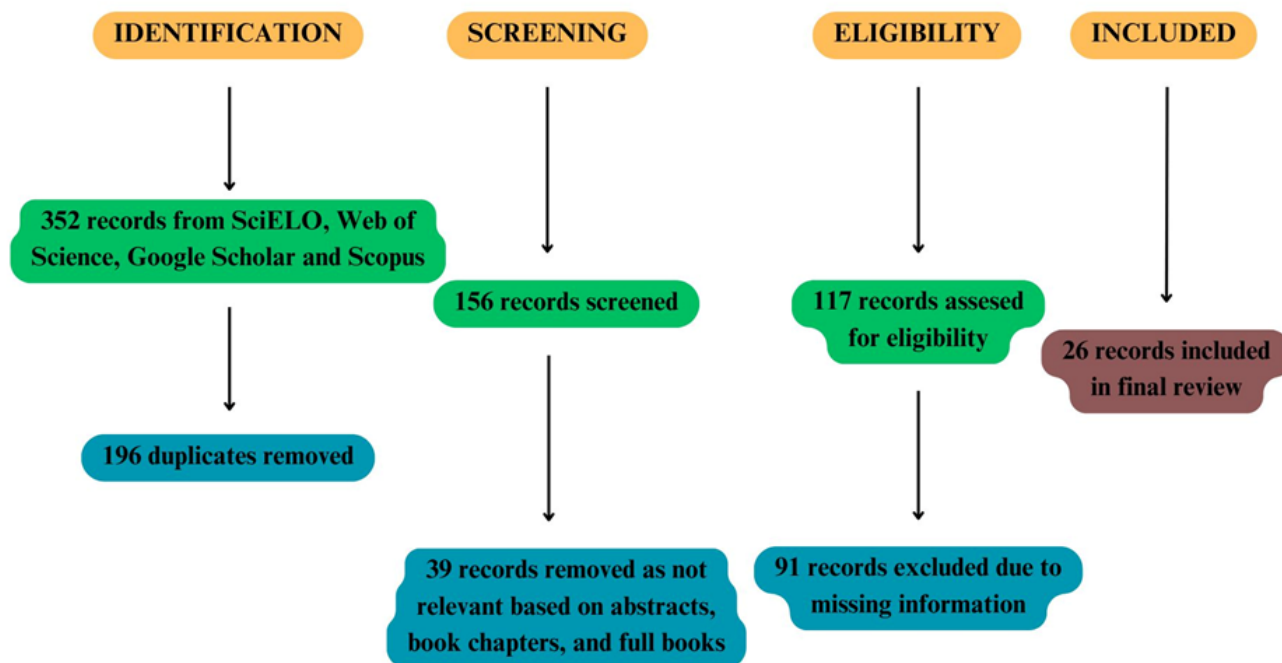


Figure 1 PRISMA flow diagram used in the screening process of studies that investigated traditional fire management practices in Brazil, considering their relationship with ethnoecology and impacts on biodiversity conservation.

returned 150 articles, of which 60 were deemed relevant after screening. Finally, Scopus identified 34 articles, with 19 included after final screening (Figure 1). In total, 26 articles were included in the review after removing duplicates and applying inclusion/exclusion criteria. The variables analyzed in the selected studies include author(s), year, title, journal, and biome (Table 1).

Advances in Research on Fire Management by Traditional Communities

The growing body of literature on fire management by Indigenous and traditional communities in Brazil reveals not only a significant increase in scientific interest in recent decades but also a broader shift in how fire is understood—not as a universal threat, but as a potential ecological tool shaped by context, knowledge, and culture (Brasil 2007). This trend has intensified particularly after 2011, with publication peaks in 2016 and 2021 (Figure 2), reflecting growing concern with climate change, wildfire risk, and the recognition of traditional knowledge in biodiversity conservation and landscape governance (Artaxo 2019; Berkes et al. 2000; Bowman et al. 2009; Costa and

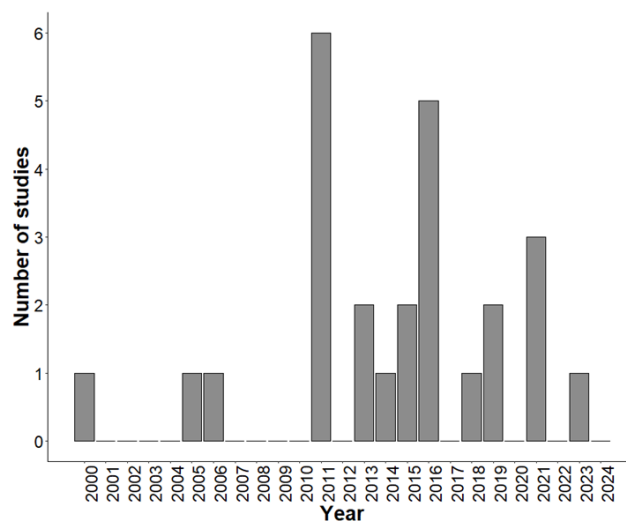


Figure 2 Temporal distribution of studies on the historical use of fire by human communities in Brazil, focusing on traditional fire management practices and their impacts on ecosystems under an ethnoecological perspective between 1993 and 2024. The years 1993 to 1999 were omitted from the figure as no publications were recorded for this period. Distribution of studies on fire management in Brazil between 1993 and 2024.

Table 1 List of articles and information on variables analyzed for the review. All = Amazônia + Caatinga + Cerrado + Pampa + Pantanal.

Author(s)	Year	Article title	Journal	Biome
Leonel, M.	2000	O uso do fogo: o manejo indígena e a piromania da monocultura	<i>Estudos Avançados</i>	Amazônia/Cerrado
Mistry, J., et al.	2005	Indigenous Fire Management in the cerrado of Brazil: The Case of the Krahô of Tocantins	<i>Human Ecology</i>	Cerrado
Nepstad, D., et al.	2006	Inhibition of Amazon Deforestation and Fire by Parks and Indigenous Lands	<i>Conservation Biology</i>	Amazônia
Schmidt, I. B., et al.	2011	Fogo e artesanato de capim-dourado no Jalapão - Usos tradicionais e consequências ecológicas	<i>Biodiversidade Brasileira</i>	Cerrado
Ribeiro, M. C. and Côrtes-Figueira, J. E.	2011	Uma Abordagem Histórica do Fogo no Parque Nacional da Serra do Cipó, Minas Gerais – Brasil	<i>Biodiversidade Brasileira</i>	Cerrado
Pivello, V. R.	2011	The Use of Fire in the Cerrado and Amazonian Rainforests of Brazil: Past and Present	<i>Fire Ecology</i>	Cerrado
Melo, M. M. and Saito, C. H.	2011	Regime de queima das caçadas com uso do fogo realizadas pelos Xavante no Cerrado	<i>Biodiversidade Brasileira</i>	Cerrado
Falleiro, R. M.	2011	Resgate do manejo tradicional do Cerrado com fogo para proteção das Terras Indígenas do oeste do Mato Grosso um estudo de caso	<i>Biodiversidade Brasileira</i>	Cerrado
Fidelis, A. and Pivello, V. R.	2011	Deve-se Usar o Fogo como Instrumento de Manejo no Cerrado e Campos Sulinos?	<i>Biodiversidade Brasileira</i>	Cerrado/Pampa
Welch, J. R., et al.	2013	Indigenous Burning as Conservation Practice Neotropical Savanna Recovery amid Agribusiness Deforestation in Central Brazil	<i>Plos One</i>	Cerrado
Melo, M. M. and Saito, C. H.	2013	The Practice of Burning Savannas for Hunting by the Xavante Indians Based on the Stars and Constellations	<i>Society & Natural Resources</i>	Cerrado
Welch, J. R.	2014	Xavante Ritual Hunting: Anthropogenic Fire, Reciprocity, and Collective Landscape Management in the Brazilian Cerrado	<i>Human Ecology</i>	Cerrado
Welch, J. R.	2015	Learning to hunt by tending the fire Xavante youth, ethnoecology, and ceremony in Central Brazil	<i>Journal of Ethnobiology</i>	Cerrado
Oliveira, L. N., et al.	2015	Use of multispectral imaging in the evaluation of burnings and forest fires in krahôlandia indigenous land (2003-2014)	<i>Floresta</i>	Cerrado
Mistry, J., et al.	2016	Community owned solutions for firemanagement in tropical ecosystems casestudies from Indigenous communities of South America	<i>Philosophical Transactions of the Royal Society</i>	Amazônia/Cerrado

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Author(s)	Year	Article title	Journal	Biome
Borges, S. L., et al.	2016	Fire management in Veredas (<i>Palm swamps</i>) new perspectives on traditional farming systems in Jalapão, Brazil	<i>Ambiente & Sociedade</i>	Cerrado
Abreu, F. A. and Souza, J. S. A.	2016	Dinâmica Espaço-temporal de Focos de Calor em Duas Terras Indígenas do Estado de Mato Grosso: uma Abordagem Geoespacial sobre a Dinâmica do Uso do Fogo por Xavantes e Bororos	<i>Floresta e Ambiente</i>	Cerrado
Schmidt, I. B., et al.	2016	Implementação do Programa Piloto de Manejo Integrado do Fogo em três Unidades de Conservação do Cerrado	<i>Biodiversidade Brasileira</i>	Cerrado
Falleiro, R. M., et al.	2016	As Contribuições do Manejo Integrado do Fogo para o Controle dos Incêndios Florestais nas Terras Indígenas do Brasil	<i>Biodiversidade Brasileira</i>	Cerrado
Batista, E. K. L., et al.	2018	An evaluation of contemporary savanna fire regimes in the Canastra	<i>Journal of Environmental Management</i>	Cerrado
Carmenta, R., et al.	2018	Forbidden fire: Does criminalising fire hinder conservation efforts in swidden landscapes of the Brazilian Amazon?	<i>The Geographical Journal</i>	Amazônia
Eloy, L., et al.	2019	Seasonal fire management by traditional cattle ranchers prevents the spread of wildfire in the Brazilian Cerrado	<i>Ambio</i>	Cerrado
Falleiro, R. M., et al.	2021	Histórico, Avaliação, Oportunidades e Desafios do Manejo Integrado do Fogo nas Terras Indígenas Brasileiras	<i>Biodiversidade Brasileira</i>	All
Welch, J. R. and Coimbra Jr., C. E. A.	2021	Indigenous fire ecologies, restoration, and territorial sovereignty in the Brazilian Cerrado: The case of two Xavante reserves	<i>Land Use Policy</i>	Cerrado
Xerente, P. P. G. S. and Oliveira, R. C. S.	2021	Abordagem Indígena sobre Manejo Integrado do Fogo em Terras Indígenas no Estado do Tocantins	<i>Biodiversidade Brasileira</i>	Cerrado
Carvalho, E. V., et al.	2023	Fogo no Cerrado em terras indígenas Xerente (Tocantins) pesquisa de opinião em comunidade indígena	<i>Boletim do Museu Paraense Emílio Goeldi - Ciências Naturais</i>	Cerrado

Thomaz 2021; Eloy et al. 2019; Falleiro et al. 2024; Mistry et al. 2005).

This evolution in research coincides with evidence that the fire season in South America has expanded by approximately 33 days over the past 35 years, affecting tropical forests, savannas, and grasslands (Jolly et al. 2015). The increasing frequency of wildfires—driven by climate change, illegal deforestation, and the expansion of agricultural frontiers—has caused severe environmental degradation, particularly in biomes such as the

Cerrado, Pantanal, and Amazon (Silvério et al. 2019). In the Cerrado, wildfires are concentrated at the end of the dry season and the beginning of the rainy season, severely affecting gallery forests and fire-sensitive environments (Durigan and Ratter 2016; Instituto Nacional de Pesquisas Espaciais 2024).

In contrast to destructive wildfires, traditional fire management involves controlled, low-intensity burns guided by ecological indicators, seasonal patterns, and culturally embedded practices. Ethnographic case studies exemplify this: the Krahô people in Tocantins

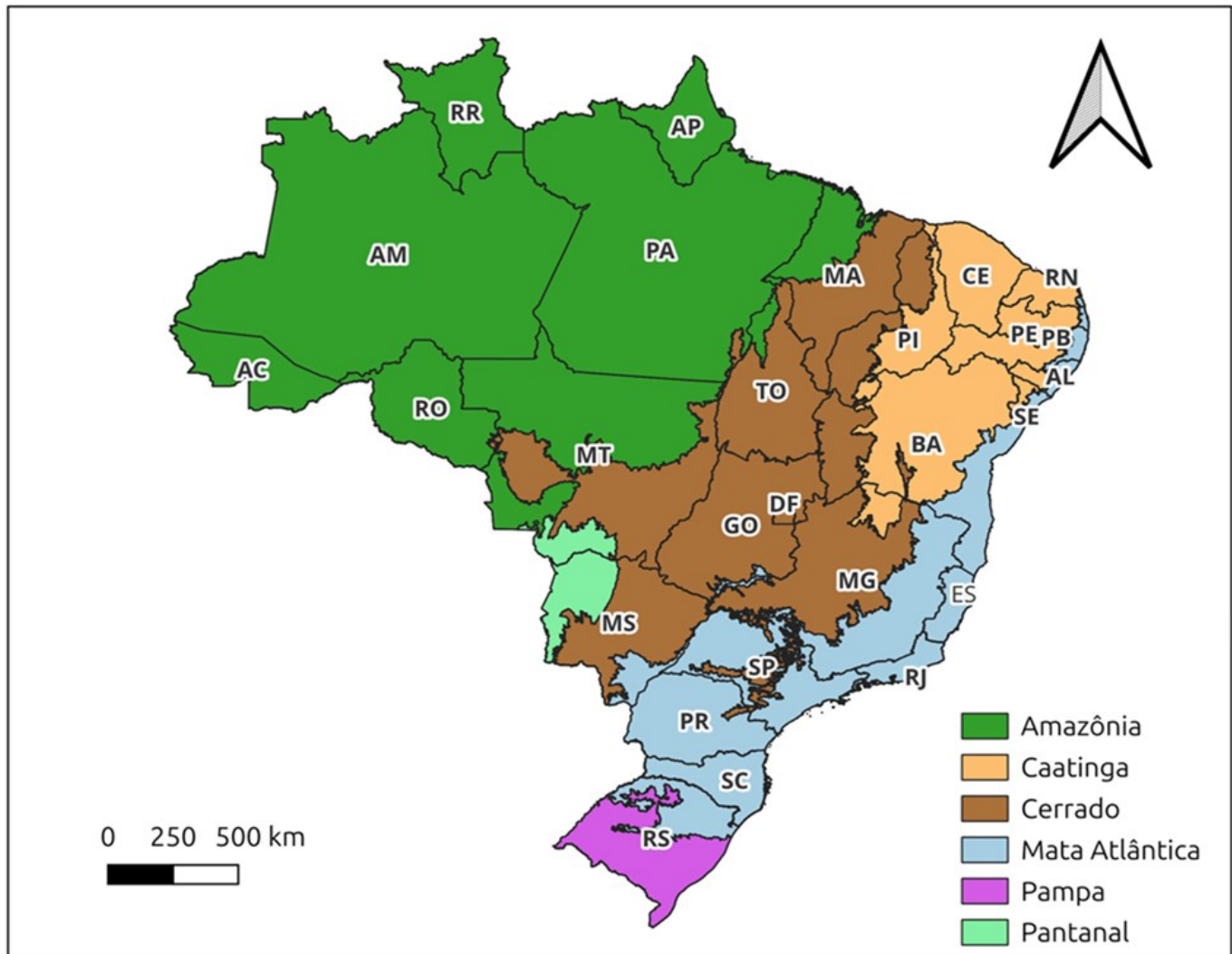


Figure 3 Spatial distribution of Brazil's terrestrial biomes with state boundaries: Amazon (dark green), Caatinga (orange), Cerrado (brown), Atlantic Forest (light blue), Pampa (purple) and Pantanal (light green); state boundaries shown as thin black lines; projection WGS84. Source: IBGE (2012).

use rotational burns for vegetation regeneration and hunting, following ancestral fire calendars (Mistry et al. 2005); the Xerente (Falleiro et al. 2021) and Xavante (Carneiro Filho et al. 2021) employ fire strategically to manage trails, protect sacred sites, and sustain resource use. These practices, rooted in traditional ecological knowledge (TEK), contribute to ecosystem heterogeneity, reduce fuel loads, and help prevent large-scale wildfires. Fidelis and Pivello (2011) argue that fire suppression policies may even heighten ecological vulnerability in fire-adapted regions like the Cerrado.

Despite growing recognition, several studies (Eloy et al. 2019; Fernandes et al. 2021) highlight persistent

political and institutional challenges that hinder the effective integration of traditional fire regimes into public policy. While initiatives such as the BRIFs (Brigadas Federais) have begun incorporating Indigenous participation (Falleiro et al. 2021), these efforts remain limited in scale and institutional support. The approval of Law 14.944/2024 (Brasil 2024), which establishes the National Policy on Integrated Fire Management (Política Nacional de Manejo Integrado do Fogo – PNMIF), marks a legal advance by formally recognizing traditional fire knowledge and promoting adaptive and participatory fire governance. Yet, implementation gaps and institutional resistance continue to restrict broader

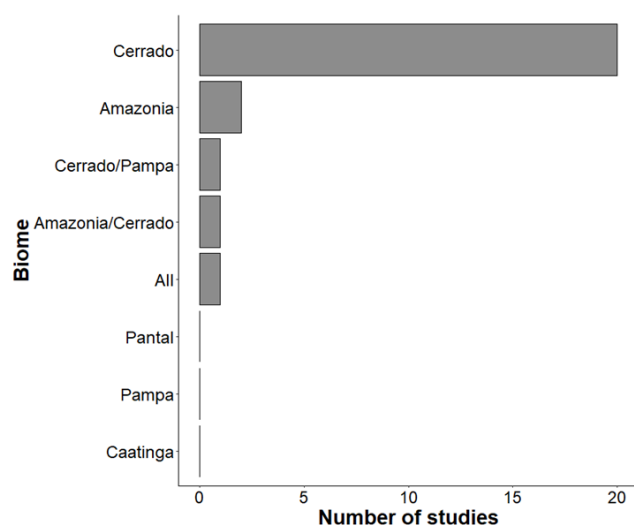


Figure 4 Number of studies assessing the historical use of fire by human communities, focusing on traditional fire management practices and their impacts on ecosystems, published by Brazilian biome. All: Amazon + Caatinga + Cerrado + Pampa + Pantanal.

adoption within environmental governance frameworks.

This combination of scientific advancement, policy interest, and socio-environmental urgency has made both fire management and fire prevention central subjects of academic inquiry. Studies such as Eloy et al. (2019) and Mistry et al. (2005) show that traditional regimes increase ecosystem resilience by limiting fuel accumulation and maintaining habitat diversity. In the Brazilian Cerrado, the cyclical burning strategies employed by the Krahô and Xerente align with ecological signals and have proven effective in reducing wildfire risk (Falleiro et al. 2024). These insights reinforce the importance of culturally informed fire governance and the need for strategies that value local autonomy, sociocultural diversity, and sustainability.

Distribution of Studies on Fire and Ethnoecology Across Biomes

The analysis of the distribution of studies conducted across different Brazilian biomes provides valuable insights into research priorities and current environmental concerns (Figure 3). The Cerrado stands out as the biome with the highest number of studies, totaling approximately 20 publications, a significantly higher number than in other evaluated biomes. The Amazon follows, with about seven times

fewer studies than those conducted exclusively in the Cerrado (Figure 4). Other categories include research covering multiple biomes, such as Cerrado/Pampa and Amazon/Cerrado, as well as generalist studies that do not focus on a specific biome (category "All"). However, biomes such as the Caatinga, Pantanal, and Pampa show either no studies or an extremely low number of them (Figure 4), suggesting significant research gaps regarding fire management in these regions.

The Cerrado has been attracting increasing academic attention not only due to its unique biodiversity and the environmental challenges it faces—such as land conversion for agriculture and the impacts of fire management policies—but also because of the maintenance of large areas of Indigenous lands within fire-dependent ecosystems, which continue to be managed through traditional practices. The emphasis on studies conducted in this biome may be related to the recognition of fire regimes' importance in maintaining Cerrado biodiversity and ecological functioning (Klink and Machado 2005; Melo 2007; Mittermeier et al. 2005).

On the other hand, the Amazon remains a key area of scientific interest, mainly due to pressures related to deforestation, climate change, and conservation policies (Nepstad et al. 2006; Steward 2018). It is important to note, however, that prescribed burning management in the Amazon is limited to savannah-like areas of the biome—such as Amazonian grasslands and farmlands—as the forested areas are highly fire-sensitive. The traditional use of fire by Indigenous communities in the Amazon has been a subject of study, reinforcing the need to understand the interactions between culture and conservation (Carmenta et al. 2018; Uriarte et al. 2012).

The lack of studies focusing on biomes such as the Caatinga and the Pantanal raises questions about research gaps and the need for greater scientific attention in these regions, especially considering their contrasting fire regimes—while the Caatinga is generally fire-independent, the Pantanal is a fire-dependent ecosystem where fire plays a key ecological role. The Caatinga, for example, harbors biodiversity adapted to semi-arid conditions and features traditional fire management practices that could provide valuable insights into sustainable conservation strategies. The Pantanal, in turn, faces challenges related to water management and habitat conserva-

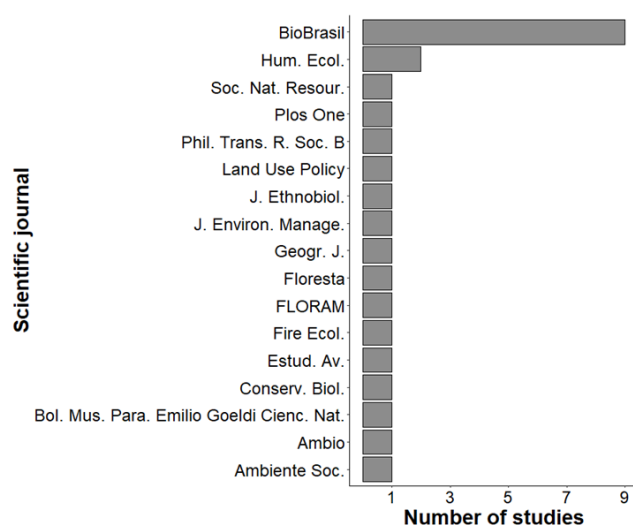


Figure 5 Number of studies assessing the historical use of fire by human communities, focusing on traditional fire management practices and their impacts on ecosystems, published by scientific journal. BioBrasil = Biodiversidade Brasileira, Hum. Ecol. = Human Ecology, Soc. Nat. Resour. = Society & Natural Resources, Phil. Trans. R. Soc. B = Philosophical Transactions of the Royal Society B, J. Ethnobiol. = Journal of Ethnobiology, J. Environ. Manage. = Journal of Environmental Management, Geogr. J. = The Geographical Journal, FLORAM = Floresta & Ambiente, Fire Ecol. = Fire Ecology, Estud. Av. = Estudos Avançados, Conserv. Biol. = Conservation Biology, Bol. Mus. Para. Emilio Goeldi Cienc. Nat. = Boletim do Museu Paraense Emílio Goeldi. Ciências Naturais, Ambiente Soc. = Ambiente & Sociedade.

tion, making research advances essential for supporting environmental management policies (Silva et al. 2019).

This uneven distribution of studies reflects not only scientific interests but also the social, political, and environmental dynamics shaping conservation priorities in Brazil. The need for interdisciplinary approaches that integrate ecology, social sciences, and public policy is crucial to developing effective conservation and fire management strategies that respect traditional knowledge and promote the sustainability of Brazilian biomes. In summary, the analysis of study distribution highlights the predominance of research in the Cerrado and Amazon, while other biomes remain relatively understudied. This finding underscores the importance of directing future efforts toward expanding knowledge on fire use in different

ecological and cultural contexts, ensuring a more balanced and sustainable environmental management approach.

Distribution of Studies on Fire and Ethnoecology: Analysis of the Number of Studies per Scientific Journal

The distribution of publications across scientific journals provides important insights into the platforms researchers use to disseminate studies on fire management and Brazilian biomes (Figure 5). Among the analyzed journals, *Biodiversidade Brasileira* stands out as the most prominent, reflecting its emphasis on biodiversity conservation, sustainable management, and the integration of traditional knowledge. Its predominance suggests not only strong academic interest but also a strategic effort to reach policymakers and stakeholders engaged in environmental governance. The journal's focus, its thematic issues on fire, and its management by a government institution make it an accessible and practical outlet, especially for public servants who may face constraints related to time, funding, or language. Publishing in such journals enhances the visibility and applicability of research findings, increasing their likelihood of influencing policy formulation and conservation strategies.

In addition to *Biodiversidade Brasileira*, other journals such as the *Journal of Ethnobiology* and *Human Ecology* also play a significant role, demonstrating a broad and multidisciplinary landscape in this research field. These journals emphasize the social, ecological, and cultural dimensions of fire, reinforcing the complexity of fire management as both an environmental and sociocultural issue. The variety of publishing venues reflects emerging research trends and growing interest in integrating ethnoecological perspectives into conservation. This shift suggests a reorientation of scientific priorities toward valuing local knowledge and promoting inclusive, culturally sensitive approaches. Overall, analyzing the number of studies per journal not only reveals dominant research platforms but also illustrates the dynamic interplay between science, society, and policy in addressing fire governance and biodiversity conservation in Brazil.

General Patterns in Traditional Fire Management Practices in Brazil

The reviewed literature reveals several recurring themes and patterns regarding traditional fire

management practices (TFM) in Brazil, particularly in the context of ethnoecology and biodiversity conservation. These patterns encompass (1) the cultural foundations and ecological knowledge guiding fire use among Indigenous and traditional communities; (2) the conflict between traditional practices and restrictive contemporary fire policies; (3) the ecological benefits of traditional fire regimes, such as wildfire prevention and biodiversity maintenance; (4) spatial and temporal variations in fire practices across regions and peoples; and (5) the limited incorporation of traditional fire management into public policy frameworks. Each of these points is examined in the sections below to demonstrate the complexity and importance of integrating traditional knowledge into broader environmental governance.

Traditional fire management practices are deeply rooted in the cultural and ecological knowledge of Indigenous and local communities. For instance, the Xavante people in the Cerrado biome use fire for hunting, landscape management, and cultural ceremonies, which not only sustain their livelihoods but also promote biodiversity and ecosystem health (Melo and Saito 2011, 2013; Welch et al. 2013, 2014, 2015). Similarly, the Krahô people employ fire to create mosaic landscapes that enhance both ecological and cultural resilience, while supporting traditional activities such as hunting, gathering, and ceremonial practices (Mistry et al. 2005). These practices demonstrate a sophisticated understanding of fire as a tool for maintaining ecological balance and strengthening cultural identity, whether grounded in Indigenous Knowledge—embedded in long-standing cosmologies and territorial governance—or in Local Knowledge systems, such as those associated with swidden agriculture and smallholder land management.

A recurring theme across the studies is the tension between traditional fire management practices and modern, often restrictive, fire policies. For example, Carmenta et al. (2018) highlight how anti-fire narratives in the Amazon marginalize smallholder farmers who rely on fire for subsistence slash-and-burn agriculture, leading to socio-economic and ecological disconnects. It is important to note that this refers specifically to agricultural fire use, not to broader landscape-scale fire management. Similarly, Fidelis and Pivello (2011) critique the prohibition of fire in protected areas of the Cerrado and Campos Sulinos, arguing that such policies disrupt natural fire

regimes and exacerbate biodiversity loss. These studies underscore the need to reconcile traditional fire use with contemporary conservation goals.

Several studies highlight the ecological benefits of traditional fire management. For instance, controlled burns by Indigenous communities in the Cerrado and Amazon can reduce the risk of large wildfires, promote vegetation recovery, and help maintain habitat diversity (Schmidt et al. 2016). In the Jalapão region, traditional fire practices support the sustainable harvesting of golden grass (*Syngonanthus nitens*), a culturally and economically important resource used in handicrafts, and contribute to the conservation of wetland ecosystems (Schmidt et al. 2011). Other cultural tending practices include the use of fire to clear trails for collective use, stimulate the growth of medicinal and edible plants, renew pasture areas for communal livestock, and mark seasonal cycles through fire-linked rituals. These findings challenge the prevailing view of fire as solely destructive and highlight its potential as a conservation and cultural management tool when used appropriately.

Spatial and temporal patterns of fire use vary significantly across different biomes and communities. For example, Oliveira et al. (2015) document the extensive use of fire in the Krahôlandia Indigenous Territory, where fire is strategically applied to manage resources and maintain cultural practices. In contrast, Abreu et al. (2016) observe distinct fire regimes in the Bororo and Xavante Indigenous Lands, reflecting differences in cultural practices and land use. These variations underscore the importance of context-specific approaches to fire management that respect local knowledge and ecological conditions.

Despite the demonstrated benefits of traditional fire management, its integration into formal conservation policies remains limited. While important initiatives such as the BRIFs Program explicitly incorporate traditional knowledge as a central element (Falleiro et al. 2021), broader fire management discussions still underrepresent Indigenous perspectives, highlighting the need for more inclusive and participatory policies (Mistry et al. 2016). The marginalization of traditional practices often stems from a lack of understanding and recognition of their ecological and cultural value. Programs like the Integrated Fire Management (IFM) and Indigenous Brigades (BRIFs) represent positive steps toward bridging this gap, but their success

depends on sustained collaboration between Indigenous communities, researchers, and policymakers. For example, in the Xingu Indigenous Territory, IFM strategies have been co-developed with local communities to prevent large-scale fires and protect agroforestry plots and sacred areas. Similarly, BRIFs have been successfully implemented among the Krahô people in Tocantins, where Indigenous brigadiers combine traditional knowledge with formal training to manage fire regimes and monitor biodiversity.

The reviewed studies collectively call for a paradigm shift in fire management policies, advocating for the integration of traditional knowledge with scientific approaches. Pivello (2011) and Fidelis and Pivello (2011) propose that fire should be recognized as a natural and necessary ecological process in fire-adapted ecosystems like the Cerrado. Similarly, Carmenta et al. (2018) and Welch et al. (2013) emphasize the importance of participatory approaches that involve local communities in decision-making processes. Future research should focus on developing adaptive management strategies that balance ecological, cultural, and socio-economic objectives, ensuring the sustainability of both ecosystems and traditional practices.

Traditional Fire Management in Brazil: Bridging Indigenous Knowledge, Ecological Sustainability, and Policy Challenges

The analysis of traditional fire management practices in Brazil reveals the complex interplay between cultural heritage, ecological sustainability, and policy frameworks. These findings highlight the intricate relationship between Indigenous and local communities and fire as a tool for landscape management, biodiversity conservation, and socio-economic resilience. However, the integration of this traditional knowledge into contemporary environmental policies remains a significant challenge. The reviewed literature underscores the deep cultural and ecological significance of fire for Indigenous and traditional communities. The Xavante and Krahô peoples exemplify the use of fire as an adaptive strategy for hunting, agricultural management, and ecosystem maintenance (Melo and Saito, 2011, 2013; Welch et al. 2013, 2014, 2015). For instance, the Xavante use fire to flush out game such as armadillos (*Dasylops novemcinctus*) and deer (*Mazama* spp.), and to prepare areas for the planting of traditional crops like manioc (*Manihot esculenta*) and yam (*Dioscorea* spp.).

The Krahô employ controlled burns to promote the regrowth of grasses and stimulate the flowering of useful plants such as golden grass (*Syngonanthus nitens*). These practices help maintain a mosaic of vegetation types that support species like the blue-winged macaw (*Primolius maracana*) and cerrado-endemic flora, thereby enhancing both biodiversity and cultural landscapes. The ecological benefits of traditional fire use, such as reducing large-scale wildfires and maintaining habitat heterogeneity, challenge the dominant perception of fire as purely destructive (Nepstad et al. 2006; Schmidt et al. 2011, 2016).

One of the most pressing issues emerging from these studies is not merely the conceptual conflict between traditional fire practices and contemporary fire management policies—especially as public policies increasingly recognize the value of traditional knowledge—but rather the practical challenges in implementing these policies effectively, including budgetary and institutional constraints. Modern conservation strategies often prioritize fire suppression, overlooking the ecological necessity of fire in fire-adapted biomes such as the Cerrado (Fidelis and Pivello 2011). The prohibition of fire use in protected areas can disrupt both natural and culturally established fire regimes—such as those maintained through traditional or prescribed burning—leading to an accumulation of combustible biomass and, consequently, more intense and uncontrollable wildfires.

This regulatory disconnect marginalizes traditional knowledge systems and undermines the socio-economic viability of Indigenous and rural livelihoods that rely on fire for subsistence agriculture and sustainable resource management (Carmenta et al. 2018). However, the potential of traditional fire management as a conservation tool is increasingly documented across various regions of Brazil. Studies show that controlled burns conducted by Indigenous communities help reduce the frequency and intensity of catastrophic wildfires, promote vegetation regeneration, and support sustainable harvesting practices (Santos et al. 2021; Schmidt et al. 2011). A notable example is found in the Jalapão region, where traditional fire use has contributed to conserving wetland ecosystems and enabling the sustainable extraction of golden grass (*Syngonanthus nitens*). This plant is used by local communities—particularly women artisans—to produce handcrafts such as baskets, hats, and decorative items that hold both

**Table 2** Regional Variations in Traditional Fire Management Practices in Brazil.

Region	Community/Group	Fire Use Purpose	Ecological Context
Cerrado	Quilombola / Rural	Pasture renewal, vegetation	Fire-adapted savanna with seasonal
Amazon	Indigenous (e.g., Krahô)	Swidden agriculture, spiritual	Humid forest, fire-sensitive
Pantanal	Local cattle herders	Fuel load reduction, aquatic plant	Wetland biome with fire-flood
Caatinga	Smallholder farmers	Clearing brush, promoting forage	Semi-arid region with frequent droughts
Atlantic Forest	Traditional agroextractivist	Selective burning in restinga or transitional forests	Humid biome with fragmented fire-prone areas

cultural value and economic importance. Controlled burns are strategically applied to stimulate the regrowth and flowering of golden grass, ensuring its availability without depleting natural stocks. These findings reinforce the need to reassess fire management policies and formally incorporate controlled burning as a legitimate and effective conservation strategy.

The spatial and temporal variability of fire use among different Indigenous peoples—recognized as the original inhabitants with distinct cultural identities and traditional communities—such as Quilombolas, extractivists, and riverine populations, who also maintain deep-rooted, place-based knowledge systems—highlights the necessity of context-specific fire management strategies. The contrast between fire regimes in the Krahôlandia Indigenous Territory and the Bororo and Xavante Indigenous Lands illustrates the diverse ecological and cultural factors influencing fire use (Abreu et al. 2016; Oliveira et al. 2015). This diversity is further evidenced by multiple other Indigenous groups engaged in traditional fire management practices across different Brazilian biomes—such as the Xerente, Paresi, Irantxe, Myky, Nambikwara, Karajá, Tapirapé, Kayapó, Apinajé, Javaé, Guarani-Kaiowá, Terena, Kadiwéu, Ofayé, Kanela, Gavião, Pankararu, Ticuna, Tukano, and Yanomami—as documented in Table 2 of Falleiro et al. (2021). This variation necessitates tailored management approaches that consider local ecological conditions, cultural practices, and community needs. For example, in the Cerrado, fire is often used cyclically to renew pastures and stimulate native plant regeneration, while in the Amazon, fire is more restricted to small-scale clearings for swidden agriculture and spiritual rituals. In the Pantanal, fire is used to manage aquatic-grassland interfaces and

reduce fuel loads before the dry season. A summary of these regional differences in traditional fire management practices is provided in Table 2. Despite the ecological and cultural benefits of traditional fire management, its integration into national conservation policies remains insufficient, often due to standardized approaches that overlook local variability. The limited inclusion of Indigenous knowledge in fire governance reflects enduring institutional preferences for Western scientific paradigms, often at the expense of local ecological expertise (Falleiro et al. 2021; Mistry et al. 2016). While programs like Integrated Fire Management (IFM) and Indigenous Fire Brigades (BRIFs) indicate a shift toward more inclusive approaches, structural challenges persist in establishing truly equitable collaborations.

The reviewed literature advocates for a paradigm shift in fire management policies that acknowledges fire as an essential component of ecosystem health and resilience, rather than simply as a threat to conservation (Fidelis and Pivello 2011; Pivello 2011). Researchers emphasize the importance of participatory approaches that include Indigenous and local communities in fire management decision-making (Carmenta et al. 2018; Welch et al. 2013). Future research should prioritize developing adaptive management strategies that balance ecological sustainability, cultural heritage, and socio-economic resilience. Policymakers must recognize Indigenous fire knowledge as a valuable asset and integrate it into broader environmental governance frameworks. The results of this study reaffirm the significance of traditional fire management practices in Brazil, demonstrating their role in promoting biodiversity conservation and cultural sustainability. However, achieving a holistic and effective fire governance

system requires policy reforms that acknowledge the value of traditional ecological knowledge. By fostering interdisciplinary collaboration and participatory management approaches, Brazil can develop fire management strategies that align with both conservation objectives and Indigenous rights. Embracing traditional fire practices as part of the solution rather than as a problem is essential for ensuring the resilience of both ecosystems and traditional communities in the face of environmental change.

Conclusion

The reviewed literature underscores the critical role of traditional fire management practices in promoting biodiversity conservation and cultural resilience in Brazil. These practices, rooted in centuries of ecological knowledge, offer valuable insights for addressing contemporary environmental challenges. However, their integration into formal conservation frameworks requires a shift in policy paradigms, greater recognition of Indigenous rights, and collaborative approaches that bridge traditional and scientific knowledge. By embracing these principles, Brazil can develop more effective and inclusive strategies for managing fire in its diverse biomes, ensuring the preservation of both ecological and cultural heritage.

Fire management in Brazilian ecosystems is a complex and multifaceted issue that requires differentiated approaches to address the ecological and cultural specificities of each biome. Traditional fire management practices, developed over generations by Indigenous and local communities, have proven essential for fostering resilient landscapes and conserving biodiversity in regions such as the Cerrado. These local knowledge systems provide a robust foundation for developing sustainable management programs, such as Integrated Fire Management (IFM), which seeks to align traditional practices with current conservation needs.

However, the implementation of fire management policies in Brazil still faces significant barriers, including a lack of interinstitutional coordination and insufficient recognition of traditional practices within legal and governance frameworks. Strengthening fire governance in Brazil will require confronting historical biases and promoting equitable partnerships between Indigenous communities, researchers, and policymakers. Recent initiatives such as IFM and BRIFs offer promising steps in this direction, but

their long-term success hinges on the formal recognition of traditional knowledge systems as essential to effective environmental management.

Finally, sustainable fire management should be understood as a low-cost and effective strategy to address ecological and social challenges. The incorporation of adaptive approaches that account for the characteristics of each biome and local knowledge will enable the creation of more resilient landscapes, contributing to both environmental sustainability and the preservation of traditional cultures in Brazil.

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