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INTEGRATED FIRE MANAGEMENT IN BRAZIL: LAWFUL ACT IN THE PYROCENE

MANEJO INTEGRADO DO FOGO NO BRASIL: ATO LÍCITO NO PIROCENO

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Abstract
The Anthropocene is characterized by human impact on a geological scale, altering natural processes and triggering severe ecological crises. In this context, the Pyrocene highlights the central role of fire in environmental degradation, linking large-scale wildfires to global warming and extreme events. In Brazil, fire has traditionally been part of the cultural and environmental heritage of Indigenous peoples, quilombolas, and traditional communities, but "zero fire" policies in the late 20th century ignored its importance, increasing the risk and intensity of wildfires. A paradigm shift has been taking place in Brazil since the early 21st century with the consolidation of Integrated Fire Management (IFM), which combines traditional and scientific knowledge in the controlled use of fire for environmental conservation purposes. IFM is a set of preventive and firefighting practices that form the basis of the National Policy on Integrated Fire Management, linking it to the principle of sustainability. IFM integrates firefighters, managers, and researchers. Experiences with IFM show benefits such as minimizing wildfires, regenerating vegetation, and preserving biodiversity. With a legal framework and participatory governance, IFM has been consolidated as an innovative socio-environmental strategy to address the challenges of Pyrocene.

Resumo
O Antropoceno caracteriza-se pelo impacto humano em escala geológica, alterando processos naturais e provocando gravas crises ecológicas. Nesse contexto, o Piroceno destaca o papel central do fogo na degradação ambiental, associando queimadas de grande escala ao aquecimento global e a eventos extremos. No Brasil, o fogo integra, tradicionalmente, o acervo cultural e ambiental de povos indígenas, quilombolas e comunidades tradicionais, mas políticas de "fogo zero" no fim do século XX ignoraram sua importância, aumentando o risco e a intensidade dos incêndios florestais. A mudança de paradigma tem ocorrido no Brasil desde o início do século XXI, com a consolidação do Manejo Integrado do Fogo (MIF), que une saberes tradicionais e científicos no uso controlado do fogo para fins de conservação ambiental. O MIF é um conjunto de práticas preventivas e de combate, fundamento da Política Nacional de Manejo Integrado do Fogo, que o vincula ao princípio da sustentabilidade. O MIF integra brigadistas, gestores e pesquisadores. Experiências com o MIF mostram benefícios como minimização de incêndios florestais, regeneração da vegetação e preservação da biodiversidade. Com arcabouço jurídico e governança participativa, o MIF se consolida como estratégia socioambiental inovadora para enfrentar os desafios do Piroceno.

Keywords: Integrated Fire Management. Pyrocene. Sustainability.

Palavras-chave: *Manejo Integrado do Fogo. Piroceno. Sustentabilidade.*

1 INTRODUCTION

The intensification of the climate crisis and forest fires with impacts on conservation units, productive activities, urban areas, and ecosystems, requires a revision of the traditional legal paradigm. The law can no longer rely solely on the Enlightenment framework of human development; it must effectively incorporate the ecological dimension. In this sense, it is necessary to construct normative foundations that render the principle of sustainability applicable to environmental protection, while also considering emerging fields of research aimed at addressing climate change.

Integrated Fire Management (IFM), recognized as a socio-environmental policy instrument, has historical roots that long predate the legal debate over its prohibition, incentive, or regulation. It is a traditional practice that dates back to times when its use was primarily a cultural expression, closely associated with traditional knowledge linked to biodiversity. Only from the mid-1980s onward— especially with the inclusion of Article 8(j)[1] of the 1992 Convention on Biological

Diversity—was it valued and safeguarded in the international legal sphere as a significant expression of cultural and environmental heritage.

In recent years, Brazil has recorded a significant increase in forest fires. The severity of the problem was recently evidenced in the Pantanal and Amazon biomes, where images of injured fauna and smoke reaching distant urban centers reinforced public awareness of the urgency of the issue. The scenario reflects the concept of the "Pyrocene", characterized by the conjoint action between global warming, environmental degradation,

[1] "Each Contracting Party shall, as far as applicable […], subject to its national legislation, respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity and promote their wider application with the approval and involvement of the holders of such knowledge, innovations and practices; and encourage the equitable sharing of the benefits arising from the utilization of such knowledge, innovations and practices" (Brasil, 2000, p. 11–12, free translation). In the original: "Cada Parte Contratante deve, na medida do possível e conforme o caso, […] em conformidade com sua legislação nacional, respeitar, preservar e manter o conhecimento, inovações e práticas das comunidades locais e populações indígenas com estilo de vida tradicionais relevantes à conservação e à utilização sustentável da diversidade biológica e incentivar sua mais ampla aplicação com a aprovação e a participação dos detentores desse conhecimento, inovações e práticas; e encorajar a repartição equitativa dos benefícios oriundos da utilização desse conhecimento, inovações e práticas".

and the accumulation of combustible material, resulting in a cycle that intensifies fires and compromises water availability, food production, and climate stability, with serious consequences for biodiversity, as well as human populations, particularly those facing socioeconomic vulnerability.

This research seeks to analyze Integrated Fire Management (Manejo Integrado do Fogo, IFM) as an expression of traditional Brazilian culture, especially in regions of smaller-scale biomes—such as fields and shrublands—where the practice can contribute significantly to biodiversity preservation and conservation. It stands in contrast to uncontrolled forest fires, which lead to severe ecological damage ranging from greenhouse gas emissions and the intensification of global warming to the extinction of fauna and flora species, with direct repercussions on the occurrence of extreme natural events and the worsening of environmental, social, and individual losses. Within this context, IFM should be examined not only as a cultural phenomenon but above all as a strategy of environmental public policy in Brazil, which in turn requires a robust legal framework capable of clearly distinguishing the practice of controlled fire use from the occurrence of wildfires. Given this framework, IFM emerges as an interdisciplinary response that integrates traditional knowledge, technological development, preventive actions, and environmental education, while also constituting an object of legal analysis. The need for conceptual and practical reconfiguration imposed by the onset of the Pyrocene requires the legal system to be updated in both its principles and instruments in order to address the complexity of fire management for ecological purposes within the Brazilian territory.

Given the multifaceted nature of the phenomenon, this study adopts a qualitative and explanatory approach, grounded in dialectical reasoning with an emphasis on interdisciplinarity. To this end, legal and non-legal doctrinal articles devoted to IFM were consulted, along with federal and state legal norms that compose the current regulatory framework on the matter. Considering that regulation is relatively recent, no case law analysis was included. The text is organized into two sections, in addition to the Introduction and the Conclusions. The first addresses Pyrocene and IFM as practices for social and environmental sustainabil- ity. The second focuses on the characterization of IFM as a lawful legal fact in light of the Brazilian normative order.

2 PYROCENE, SUSTAINABILITY, AND INTEGRATED FIRE MANAGEMENT

The current phase, in which nature remains the main supplier of resources to satisfy human needs and in which economic activities play a decisive role in shaping the planet's future, is identified as the Anthropocene. This is a geological period[2] in which the influence of human actions has reached a scale comparable to natural forces, significantly altering the physical, chemical, and biological structure of the Earth. This recognition arises from the acknowledgment that interventions such as large-scale industrialization, mechanized and intensive agriculture, urban expansion, mining, and the massive use of fossil fuels have irreversibly modified essential ecological processes.

Recognition of the Anthropocene[3] also entails understanding that impacts such as ocean acidification, biodiversity loss, and changes in the hydrological cycle are not isolated phenomena, but rather part of a single systemic picture in which human activity is the driving force. In this sense, the concept breaks with the view of a passive environment and reinforces the idea that the very continuity of human life depends on the capacity to consciously manage the effects of its actions on the planet.

In this scenario, the advance of economic development has reached a point that directly threatens the future viability of human life and other species, requiring a rigorous examination of the actual capacity of the principle of sustainable development to balance economic growth and environmental preservation. Historically, the notion of sustainability gained strength in the 1980s with the publication of the Brundtland Report, later becoming central in international conferences such as Rio-92 and Rio+20, and being incorporated into Brazil's 1988 Constitution and subsequent environmental legislation.

[2] "Geology usually employs capital letters in 'Era,' 'era,' and 'age,' notions that are not interchangeable for this discipline, unlike what occurs in History. In the humanities, one may call it, without incurring error, 'industrial era,' 'industrial age,' or 'industrial epoch.' This is not so in geology, a science in which it is a mistake to confuse 'era' with 'age,' because each era is composed of several ages. Even so, it is quite frequent that communicators prefer to use the term 'era' (in lowercase) for Anthropocene or Holocene" (Veiga, 2019, p. 11, free translation).
In the original: "A Geologia costuma usar maiúsculas em 'Era', 'Época' e 'Idade', noções que para essa disciplina não são intercambiáveis, ao contrário do que ocorre com a História. No âmbito das humanidades, se diz, sem risco de erro, 'época industrial', 'era industrial' ou 'idade industrial'. Não é assim na Geologia, ciência para a qual é erro crasso confundir Época com Era, pois cada Era é composta de várias Épocas. Mesmo assim, é bem frequente que comunicadores deem preferência ao termo 'era' (com minúscula) para Antropoceno ou Holoceno".

[3] Thus, some suggest that the term Capitalocene (Carvalho; Magalhães, 2024) would more accurately reflect a reality in which economic development encounters no limits to the extraction of natural resources.

According to Krenak (2019), the Anthropocene should in itself lead to a paradigm shift, replacing the historical logic of unlimited consumption and exploitation with an attitude committed to the protection of life and a relationship of interdependence with the natural environment. The author cautions that by leaving a sufficiently deep mark on the planet to define a geological epoch—and maintaining it even after the disappearance of humankind—we contribute to the exhaustion of the vital bases that allowed humans to prosper and feel they inhabited an "ordinary house", which should be collectively cared for. This warning implies recognizing that throughout the process of economic expansion, prac- tices and ways of life not aligned with the market system have been gradually ostracized, thereby reducing the diversity of possible social and environmental solutions.

The Anthropocene bears affinity with the concept of sustainable development, despite it having historically prioritized "human development" over "natural sustainability". Such bias helped bring to light the environmental crisis diagnosed by scientific studies and confirmed by concrete phenomena such as extreme heat and cold waves, massive storms, floods in both urban and rural areas, prolonged droughts, and—with particular relevance for this study—the exponential increase in the occurrence of large-scale forest fires. The repetition and intensification of these events led to the emergence of a specific concept within the Anthropocene itself: the Pyrocene, that is, the "Age of Fire". This formulation shifts the focus to the central role of fire in the transformation of ecosystems and in the worsening of the climate crisis.

According to Pyne (2023), just as the advance of glaciers once drove the Earth into an Ice Age, so too the current, large scale and uninterrupted burning is propelling the planet into a Fire Age. This proposed approach redefines the Anthropocene from the standpoint of fire as a primordial ecological element for humankind—its ability to control fire—and offers a narrative that encompasses the long historical relationship between humans and fire, while projecting implications for the future in the context of climate change, accelerated biodiversity loss, alterations in ocean chemistry, and the rise in global sea levels.

The Pyrocene is the result of research that integrates data on global warming, records of large fires, and studies on interactions between these phenomena, with the aim of determining the extent to which human activity, in causing or expanding burning, accelerates processes such as species extinction, the intensification of seasonal patterns,

and the scarcity of freshwater. In this sense, uncontrolled fire synthesizes the convergence of factors described as the Anthropo-Capitalo-Pyro- cene.

Boff (2024) argues that the Anthropocene already designates human beings as the primary threat to the biosphere; the Pyrocene, in turn, represents the most destructive manifestation of this threat, since rising temperatures and the uncon- trolled spread of fires—especially the so-called "megafires"—have the potential to render life on the planet unviable. This interpretation broadens the analysis beyond immediate causes, linking the problem of fire to global economic structures and insufficient environmental governance. The growing intensity of forest fires in all Brazilian biomes, including even the wettest, such as the Pantanal, demonstrates that the response capacity of conventional firefighting systems has been exceeded.

Human factors that increase the incidence and severity of fires manifest themselves both diffusely—as a consequence of climate change and environmental degradation—and directly, through localized practices. Deforestation for agricultural expansion and land grabbing in the Amazon are significant examples; the removal of trees leads to the accumulation of branches, leaves, and dry vegetation, creating fuel material that, under conditions of low humidity, heightens the risk of severe fires[4]. Standing forest, by contrast, sustains moist microclimates and physical barriers that make fire spread more difficult[5]. However, recent fires in the Amazon, a region where fire has historically been a relatively rare phenomenon, indicate that the biome has entered the Pyrocene circuit.

[4] Researchers from Ibama (2024, p. 167, free translation) observed that "Amazonian land did not evolve under the influence of fires, and most of its trees possess no natural adaptations to fire. Consequently, forest fires cause high mortality among large trees, affecting both the structure and the biodiversity of forests".
In the original: "as florestas de terra firme da Amazônia não evoluíram sob a influência de incêndios, e a maioria de suas árvores não apresenta adaptações naturais ao fogo. Portanto, os incêndios florestais causam alta mortalidade de árvores grandes, impactando a estrutura e a biodiversidade das florestas".

[5] "According to the fire monitor, most of what burned in the Amazon between January and October 2024 comprised forest formations (40%), fields (12%), and flooded fields and forests (11%). Only one-third of the area destroyed was pastureland. However, more than half (55%) of the fire outbreaks detected through September began precisely in these cattle-raising areas—most of which (86%) were cleared since 2015. This indicates that the majority of fires originated in regions used for agriculture before spreading into areas of native vegetation. Currently, 14% of the Amazon forest has already been converted to grassland for cattle grazing" (Martins, 2024, free translation).
In the original: "Segundo o Monitor do Fogo, a maior parte do que queimou na Amazônia entre janeiro e outubro de 2024 era de formações florestais (40%), campos (12%) e campos e florestas alagáveis (11%). Apenas um terço da área destruída era de pastagens. Mas mais da metade (55%) dos focos de incêndio identificados até setembro começaram justamente nessas áreas de criação de gado bovino – a grande maioria delas (86%) aberta a partir de 2015. Isso significa que a maior parte dos incêndios começou em regiões onde há atividades agropecuárias mas se espalhou por áreas de vegetação nativa. Atualmente, 14% das florestas da Amazônia já foram substituídas por capim para alimentar bois e vacas".

Fire management in Brazil has deep roots in the history and culture of the peoples who have traditionally inhabited its territory, being closely connected to social organization, food production, and the symbolic relationship with the landscape. Since time immemorial, traditional peoples and communities, such as Indigenous groups, quilombolas, and others, have incorporated fire as a central element into their systems of production and environmental management. In these communities, the presence of fire extends beyond strictly material purposes, also taking on spiritual, communicative, and cultural functions, while serving as a technical tool for managing native vegetation at different scales through both collective and individual practices.

In many Brazilian regions, fire is the primary technology for releasing nutrients from plant biomass, fertilizing the soil, and optimizing agricultural cultivation. Field burning is carried out with particular care, involving the construction of firebreaks and the precise selection of season, time of day, temperature conditions, soil moisture, and wind direction. Burning is a skill reserved for those who have mastered the technique, with the moment of burning constituting a community event of cultural significance. The intensity and frequency of fire management are decisive for plant succession after cultivation, directly influencing soil fertility and the biodiversity of the agricultural ecosystem. In the Cerrado, for example, fields opened in peatland and moist areas, such as riparian forests, require additional precautions, such as controlling the water level, to prevent un- derground fires (Eloy et al., 2021).

In pyrophytic ecosystems, such as the Cerrado and Southern Grasslands, the use of fire plays a key role in maintaining ecological processes and sustaining the cultural relationship of traditional communities with their territories. Over time, Indigenous knowledge of fire management was transmitted to other groups, such as the sertanejos of the Cerrado and the Southern Grasslands, who incorporated the practice into the management of native pastures for extensive cattle ranching. This knowledge, oriented toward the management of natural pastures, may also have absorbed African influences, brought by enslaved peoples and their descendants. Today, traditional fire management of natural pastures is still practiced by small ranchers, particularly in southern and midwestern Brazil. In the Cerrado, geraizeiro, quilombola, fecho de pasto, and sempre-viva gatherer communities stand out for maintaining the centuries-old tradition of using fire as a sustainable management tool (Eloy et al., 2021).

The misinterpretation of traditional fire management practices led to the adoption of government programs based on "zero fire" policies of total suppression, which disregarded the cultural, ecological, and productive relevance of controlled fire use (Durigan; Ratter, 2016). In this political-legal context, economic and ecological interferences significantly altered how traditional communities could engage with fire. Deforestation, environmental degradation, and climate change are among the decisive material factors; the paradigm of "zero fire"; and socioeconomic processes such as rural exodus, sedentarization, and the expansion of monocultural agribusiness.

In Brazil, the strengthening of forest fire protection programs gained momentum after the promulgation of the democratic Constitution in the late 1980s, which led to the creation of specialized structures focused on prevention and suppression. Among these initiatives was the establishment of the Centro Nacional de Prevenção e Combate aos Incêndios Florestais (Prevfogo – National Center for the Prevention and Fighting of Forest Fires) within the Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA – Brazilian Institute of En- vironment and Renewable Natural Resources). Nevertheless, attempts to prohibit controlled fires, especially in the final decades of the twentieth century, resulted in excessive accumulation of fuel loads, which in many cases triggered large fires, generating high suppression costs and conflicts with local communities.

From the beginning of the twenty-first century, however, understanding grew that fire must be used as a conservation instrument in pyrophytic ecosystems. Even in more sensitive ecosystems, such as tropical rain forests, including the Amazon, recent changes in fire regimes have revealed the need for stronger integration of fire management into environmental policies.

The failure of total fire suppression policies, along with management experiences in other countries, has led the Brazilian state to develop a national policy focused specifically on fire management as an instrument of socio-environmental conservation. It is not taboo to go back and fetch what you forgot[6]. In this context, changes in federal legislation, such as the introduction of Law No. 12.651/2012, explicitly allowed the use

[6] "Sankofa is a concept derived from the Akan people of West Africa that highlights the importance of learning from the past to build the future. In Akan language, the African proverb expressing the concept is expressed as, 'so wo were fi na wosan kofa a yenki,' which translates in the English language to, 'it is not taboo to go back and fetch what you forgot'" (Stanley; Chukwuorji, 2024, p. 1).

of fire for the purpose of conserving native vegetation, whose ecological characteristics are evolutionarily associated with the occurrence of fire (Brasil, 2012).

This new approach involves the use of prescribed burning and, in some cases, the non-suppression of natural ignitions, with the aim of conserving biodiversity in pyrophytic or fire-resistant environments. Also, the concept of IFM was consolidated, which seeks, on the one hand, to recognize and reintroduce fire as a management tool and, on the other, to establish participatory models of decision-making, incorporating both scientific and traditional knowledge.

Unlike the Cerrado or the savannas of Latin America, where plant species have evolved with fire-specific adaptations such as thick bark or seeds whose germination depends on heat, Amazonian vegetation is more sensitive to flames. This vulnerability tends to grow with increasing degradation and the accumulation of fuel biomass. Degraded areas are at higher risk of fire than preserved areas, which increases the potential for ecological and socioeconomic losses.

Given this scenario, IFM emerges as an important strategy for mitigating risks and promoting adaptive coexistence with fire in ecosystems where it plays an ecological role, while protecting more vulnerable areas. It is an approach that combines the traditional knowledge of Indigenous peoples and local communities, the management practices of fire-adapted ecosystems, monitoring technologies, and the integrated planning of territorial use (Falleiro et al., 2021).

IFM encompasses measures ranging from prescribed burning to reduce fuel loads, to community brigade training, and the establishment of alert and rapid response systems. According to Toledo and Bizawu (2024), the main technical measures include the construction of firebreaks, the planned management of fuel biomass, the installation of sensors and alarm systems, the use of controlled burns at strategic times, and the creation of infrastructure to facilitate access for firefight- ing teams. In Brazil, experiments conducted at Chapada das Mesas National Park, Jalapão State Park, and Serra Geral Ecological Station demonstrate that, when implemented with community participation, IFM has reduced the annual burned area and increased the native vegetation regeneration (Fidelis, 2022).

IFM has been adopted with the objective of reducing the incidence of fires, protecting plant formations more sensitive to flames, such as forests, and minimizing conflicts between environmental management and local communities in protected areas

of the Cerrado (Schmidt et al., 2018). It is important to emphasize that this strategy, which employs fire as an instrument of landscape management, is not yet institutionally applied to private properties, where legal reserve areas are found. A long-term study in the Cerrado, conducted over decades of monitoring, revealed that the absence of periodic burning led to changes in vegetation structure, with grassland areas being overtaken by woody species—a phenomenon known as woody encroachment (Gonçalves et al., 2021).

This transformation leads to the loss of biodiversity associated with open environments, since the high floristic diversity of the Cerrado is concentrated primarily in its non-woody vegetation (Amaral et al., 2022). In a Cerrado enclave located in the Amazon, it was found that fire plays a decisive role in determining the structure and composition of bird communities (Coelho et al., 2023). The suppression of fire and the consequent alteration of savanna vegetation structure cause significant changes in avifauna, favoring typical forest species to the detri- ment of those associated with open ecosystems.

In southern Brazil, particularly in areas known as Campos de Cima da Serra and Campos Gerais, fire is often used to eliminate accumulated dry biomass during the winter, when frosts can occur and cause vegetation die-off, especially among grasses (Brunel et al., 2021). The practice of rapid, low-intensity burn- ing—regionally called sapecada—in those regions, promotes plant regrowth after winter. In this way, fire management constitutes an essential resource for biodiver- sity conservation in the Southern Grasslands (Overbeck et al., 2022).

This scenario underscores the need for legal hermeneutics capable of effectively integrating the protection of life, environmental conservation, and a balanced relationship between humans and other species. The schools of thought supporting this new environmental ethics converge in rejecting models that privilege unilateral resource exploitation and in requiring that legal practitioners master conceptual foundations capable of guiding legal solutions consistent with contemporary social and environmental demands. In this sense, sustainability, understood as a fundamental norm grounded in environmental ethics, constitutes both the theoretical and practical basis for policies and instruments such as IFM. Its recognition as a legal principle with normative density eliminates vague interpretations and ensures its application in judicial decisions, public policies, and administrative regulations. Sachs (2009) specifies that for sustainability to be effective, it must include interdependent social, cultural, environmental, political, and

international dimensions, which, when articulated, enable the reconciliation of development with biodiversity conservation and ecological stability. International examples reinforce this perspective. In Canada, the FireSmart Program combines preventive management with public education (Asfaw; Christianson; Watson, 2022). In Portugal, recent forest planning policies seek to integrate fire as a management element following a sequence of devastating fires (Assembleia da República, 2017).

Law No. 14.944/2024, in its Article 3, sets out a comprehensive set of objectives that embody this integration: to prevent and reduce the impacts of forest fires and the improper use of fire; to promote controlled, prescribed, or traditional uses of fire, respecting environmental and sociocultural diversity; to foster environmental education aimed at preventing and reducing social and environmental vulnerability; to hold accountable those responsible for unauthorized and improper uses of fire; to employ prescribed burning in the control of invasive species; to integrate fire management guidelines with environmental and territori- al management actions; and to recognize and strengthen the traditional practices of Indigenous peoples and quilombola communities by defining prevention and suppression strategies adapted to the specificities of each territory (Brasil, 2024). The articulation of these objectives with the dimensions of sustainability[7] brings the Política Nacional de Manejo Integrado do Fogo (PNMIF – National Policy on Integrated Fire Management) closer to the model of participatory and integrative environmental governance, involving multiple actors and levels of action.

The social function of property, set forth in Article 3, II of the law, establishes a direct link between the legal regime of land and compliance with ecological standards, reinforcing the convergence between the postulate of sustainability and the application of IFM (Brasil, 2024). By requiring land use to meet criteria of preservation and rational

[7] Froehlich (2014, p. 165, free translation), in a work that sought to refine doctrinal concepts on the dimensions, points out: "The literature under analysis presents various dimensions of sustainability, namely: the economic, the social, the environmental, the cultural, the spatial, the institutional, the political, the moral, the legal, and the technical dimensions. Thus, it is evident that there is no consensus on which dimensions should be assessed. Yet three dimensions are regarded as essential and are most commonly addressed by authors: the economic, the social, and the environmental. Therefore, it is consensual that there must be interrelationships among the dimensions, and that indicators restricted to only one of them do not reflect sustainability".
In the original: "A literatura examinada apresenta várias dimensões de Sustentabilidade: a econômica, social, ambiental, cultural, espacial, institucional, política, moral, legal e técnica. Desse modo, percebe- se que não há um consenso sobre quais dimensões devem ser mensuradas. Porém três dimensões são comuns entre os autores e consideradas essenciais: econômica, social e ambiental. Portanto, é consensual que deve haver inter-relações entre as dimensões e que indicadores que ficam restritos a apenas uma dimensão não refletem a sustentabilidade".

resource use, the law introduces a civil dimension of sustainability, with direct implications for property law and environmental management. Thus, in a context marked by the effects of the Pyrocene and the need to update the foundations of law, the importance of the principle of sustainability is reaffirmed as a guide both for classical legal relations and the formulation and implementation of innovative public policies capable of responding to contemporary socio-environmental challenges in an integrated manner.

3 PUBLIC POLICIES OF INTEGRATED FIRE MANAGEMENT IN BRAZIL

Research has pursued the path of overcoming the paradigm that places the human being as the exclusive center of law, instead proposing environmental ethics, through the postulate and dimensions of sustainability, as a new line of thought. It is a matter of rethinking the role and relevance of the human being on the planet, in dialogue with the preservation of the natural environment and of all beings, not only humans, that inhabit it.

Present and future concerns do not replace human dignity with another val- ue. The defense of dignity remains indispensable, especially because it has not yet been fully realized[8]. The objective is to broaden the focus toward the effective sustainability of other beings and the environment, conceiving them in integra- tion, both through a horizontal valuation that recognizes the importance of all, and the combination of ancestral and technological, community-based and legal, environmental and juridical knowledge.

In this context, the management and use of fire must be understood as re- quiring the integration of diverse forms of knowledge and multiple actors. It is within this scenario that IFM emerges, a coordinated set of procedures centered on the strategic use of fire as an ally in the prevention and suppression of forest fires[9].

[8] As recognized by the UN Human Rights Council in October 2021: "Recognizes the right to a safe, clean, healthy and sustainable environment as a human right that is important for the enjoyment of human rights" (UN, 2021, p. 3)".

[9] "Historically, fire exclusion and control actions have been prioritized, rather than prevention and management, with contestable efficiency and the occurrence of large fires, as in the Parque Nacional das Emas in 2010 (123,200 hectares burned, 93% of the Park), in the Chapada dos Veadeiros National Park in 2017 (85,500ha, 36% of the Park) and the Chapada dos Guimarães National Park in 2019 (7,250ha, 22% of the Park).The exclusion of fire, even of natural origin, coupled with the departure of rural communities with reduced use of environments, added to the difficulties in authorizing the use of fire to maintain their livelihoods, has intensified conflicts, which resulted in accumulation of fuel in large continuous areas and in occurrence of fire at the end of the dry season, when fires are more intense, severe, of large proportions

Increasingly present in the vocabulary of environmental protection agencies, the term "IFM" has also gained ground in academic settings. Its diffusion stems from the recognition that fire management requires an interdisciplinary approach, integrating technical, scientific, and traditional knowledge. Law No. 14.944/2024 recognizes that the controlled and adaptive use of fire, when technically planned, can contribute both to biodiversity conservation and to the protection of communities (Brasil, 2024).

The denomination reflects this core value: "Integrated" denotes the articulation among social, ecological, cultural, economic, and legal dimensions in the application and study of fire as a prevention tool, while "management" refers to the set of procedures and techniques for the use of fire. Such integration is analogous to the holistic approach inherent to the dimensions of sustainability. This stands in contrast to the historical policy of total fire suppression, which disregarded the fact that ecosystems such as the Cerrado depend on periodic burning to sustain their ecological dynamics.

IFM may be conceptualized as a set of practices aimed at preventing and combating forest fires. In Brazil, there are documented cases of success in regions where MIF actions have reduced the area and intensity of burns, and in the Pantanal, where prescribed burns at the beginning of the dry season minimize severe wildfires. In the Amazon, however, adoption faces barriers due to the high sensitivity of vegetation to fire and land conflicts that exacerbate risks.

In all cases, the common thread is the understanding that fire—when man- aged with technical foundations, local knowledge, and legal support—can be an ally in environmental conservation. The central purpose is to reduce fire-related threats to human livelihoods and biodiversity, without losing sight of its ecological and economic role in various ecosystems (Myers, 2006).

The defining feature of IFM is its preventive character, structured as a coordinated set of actions aimed at avoiding the outbreak of fires. Among these, prescribed burning and environmental education programs stand out, combining community traditional knowledge with the legal framework of management as a public policy, especially under the new legislation. Such actions are based on using fire at the appropriate time and in the appropriate manner, according to ancestral knowledge[10]; on the application of science

and difficult to control. This altered the natural fire regime causing loss of biodiversity, soil, water and climate change" (Berlinck; Lima, 2021, p. 129).

[10] As in the traditional practice of "coivara", the ancestral activity of preparing a small plot of land for planting. Coivara involves cutting and burning the vegetation on the plot to clear it and subsequently

and technology[11]; and on the principle of sustainability[12], which guides the compatibility among environmental protection, public safety, and biodiversity conservation.

IFM includes, for example, the application of prescribed burning techniques carried out by specialized brigades and the Fire Department; the promotion of environmental education and outreach activities on preservation methods with local communities; and the incorporation of diverse areas of knowledge, such as the study of fire-susceptible species at certain times of the year or landscape planning, which may involve the removal of invasive species and the visual appreciation of monuments. There is also the economic dimension since the prior execution of controlled burns can significantly reduce public expenditures on firefighting[13]. In essence, it represents the practical application of a true Ecology of Fire[14].

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fertilizing the soil with the ash and residues left by the burn. Elders traditionally knew the precise season and moment to burn a section of forest underbrush without causing large-scale fires.

[11] As in georeferencing, which relies on drones to verify the perimeters to be managed, and in the very fire data collected by satellites.

[12] "As such, given its core essence in strengthening environmental protection mechanisms, sustainability is elevated to the category of a fundamental principle and the most important norm of the legal system—on the same or even a higher level than human dignity itself—being a normative postulate that (i) guides the relationship among norms, avoiding conflicts that could result in environmental harm; (ii) provides an interpretive foundation for application by the judge; (iii) serves as an integrative element specific to the concrete case; and (iv) operates as an effective element of environmental protection" (Macedo, 2023, pp. 162–184, free translation).

[13] "Because they are planned, prescribed burning activities tend to facilitate the participation of a larger number of volunteers compared to extensive wildfires, since such actions can be scheduled in advance. They also offer major safety advantages, as prescribed burns usually behave with less intensity and greater predictability than uncontrolled fires. The empowerment of civil society in carrying out actions for the conservation of our protected areas enables better team training and reduces the vulnerability and discontinuity of the work, which is often left to government agencies subject to frequent budget cuts and, consequently, not always supported with adequate technical resources in this regard" (Silva, 2019, p. 1, free translation).

In the original: "Atividades de queima prescrita, por serem programadas, tendem facilitar a atuação de maior número de voluntários se comparado aos grandes incêndios, já que é possível agendar essas ações planejadas. Ainda, com elevados ganhos na segurança, já que as queimas prescritas tendem a se comportar de forma menos intensa e mais previsível que os incêndios. O empoderamento da sociedade civil na implementação de ações em prol da conservação das nossas unidades permite a melhor qualificação das equipes e reduz a vulnerabilidade e descontinuidade dos trabalhos, situação a que frequentemente são submetidas as agências governamentais em função de costumeiros cortes de orçamento e, consequentemente, de pessoal, nem sempre com bom respaldo técnico nessa definição".

[14] "At present, the administrators of PARNA Serra do Cipó face a difficult dilemma: should they manage controlled burning in predetermined regions and seasons, thereby periodically reducing the field's fine fuel biomass and resulting in less intense fires, or should they suppress fire entirely, thereby facilitating successional processes but exposing the park to the risk of sporadic, high-intensity wildfires? The answer to this conservation dilemma lies in the central purpose of conservation science: to maintain the evolutionary potential of species in their natural habitat. This presupposes safeguarding the integrity of the ecosystem, preserving species, their interactions (both among species, as well as between them and the physical environment), and, ultimately, the ecological processes themselves" (Ribeiro; Figueira, 2011, p. 222, free translation).

In the original: "No momento atual, os administradores do PARNA Serra do Cipó encaram um difícil dilema: gerenciar queimadas controladas, em regiões e estação pré-determinadas que reduziriam periodicamente a biomassa de combustível fino dos campos, resultando em incêndios de menor intensidade

From this comprehensive perspective, fire can act as an ally—for example, by clearing areas through the controlled burning of dry vegetation or fuel material—or, conversely, it can assume the role of a villain, causing significant damage depending on factors such as the technique employed, the location, the timing, and the way it is used. Among brigade members, a common maxim is: Fire is a good servant but a bad master (Simpson; Speake, 2009).

The participation of local communities is essential within this framework, underscoring the cultural dimension of sustainability[15], as the procedures involved in IFM incorporate communities from the surrounding areas to be protected— Indigenous, riverside, and farming populations in general—as in the case of the Projeto Brigadas Amazônia (Amazon Brigades Project)[16], given that

> Forest brigade members are often respected figures within their communities. Once trained, they become advocates for raising awareness about the risks of forest fires and about safe fire management practices. Moreover, they are able to educate other community members on the importance of fire prevention, including the proper way to conduct agricultural burns and the avoidance of risk behaviors,

ou combater o fogo na sua totalidade, facilitando os processos sucessionais, porém, sujeitando o Parque ao risco de incêndios esporádicos e de grande intensidade? A resposta para esse dilema conservacionista repousa no grande objetivo da ciência da conservação que é o de manter o potencial evolutivo das espécies em seu habitat natural. Isso pressupõe manter a integridade do ecossistema, preservando as espécies, suas interações (tanto entre espécies, quanto entre essas e o ambiente físico), enfim, os processos ecológicos".

[15] Regarding the "criteria" of sustainability, there is the cultural dimension, which seeks "changes within continuity (a balance between respect for tradition and innovation)" (Sachs, 2009, p. 85, free translation). In the original: "mudanças no interior da continuidade (equilíbrio entre respeito à tradição e inovação)".

[16] "Together, in 2019, the Amazon Brigades Project engaged in firefighting, monitoring, and fire- awareness activities across 354 areas in the Juruá Basin, including the Alto Juruá Extractive Reserve, the Riozinho da Liberdade Extractive Reserve, and the Gregório State Forest along the Juruá, Envira, and Tarauacá rivers. The team engaged in dialogue with local communities about the main challenges of balancing subsistence and economic agricultural activities, including the solutions identified by the communities themselves to reduce the impacts of fire use on public health and human well-being. SOS Amazônia also organized a workshop to train 19 brigade members under the instruction of the Acre State Military Fire Department, from which 12 members were selected to work in the municipalities of Feijó, Tarauacá, and Marechal Thaumaturgo" (Brigadas da Amazônia…, 2019, free translation).
In the original: "Juntos, em 2019, o projeto Brigadas Amazônia trabalhou no combate, monitoramento e conscientização da atividade fogo em 354 áreas na Bacia do Juruá, incluindo a Reserva Extrativista Alto Juruá, a Reserva Extrativista do Alto Juruá, a Reserva Extrativista Riozinho da Liberdade, a Floresta Estadual do Mogno e a Floresta Estadual do Rio Gregório abrangendo os rios Juruá, Envira e Tarauacá. A equipe dialogou com os comunitários sobre os principais desafios da conciliação saudável de suas atividades agrícolas de subsistência e econômicas, incluindo as soluções apontadas pelos próprios comunitários para reduzir o impacto do uso de fogo na saúde pública e bem-estar humano. A SOS Amazônia realizou também uma oficina para formação de 19 brigadistas sob instrução do Corpo de Bombeiros Militar do Estado do Acre, na qual foram selecionados 12 brigadistas para atuarem nos municípios de Feijó, Tarauacá e Marechal Thaumaturgo".

> such as careless cigarette disposal and bonfires lacking adequate precautions[17] (Toledo; Bizawu, 2024, p. 14, free translation).

Besides, in specific contexts of environmental management and conservation, fire can play a necessary role[18]. In such cases, it is used to reproduce conditions similar to natural occurrences for phytosanitary purposes, such as the control of plant and animal species or the prescribed burning of accumulated vegetation—popularly referred to as "bush"—which is often responsible for spreading large-scale fires during the critical winter and dry season. In this sense, research conducted in partnership with local residents and users of conservation units in Jalapão, shows that recovering traditional fire practices and mapping changes in land use over time are essential steps toward understanding fire dynamics in the Cerrado, favoring the integration of traditional and scientific knowledge in the management of protected areas and in the conservation of the biome (Borges et al., 2016).

This approach breaks with the paradigm that fire is necessarily harmful, enabling its analysis and use as an ally in specific human activities and, above all, as a tool for fire prevention. When applied under control and at the appropriate time, for example, in summer or fall, until May, in the Southeast region—fire consumes excess fuel material, reducing the volume of dry vegetation that could feed large wildfires in July, August, and September. It is therefore a strategic management practice that reverses the logic of total suppression and relies on planned use to reduce risks.

The challenge, however, is still formidable. Population growth and the expansion of urban and agricultural areas continue to encroach upon already environmentally fragile

[17] In the original: "Os brigadistas florestais são frequentemente membros respeitados de suas comunidades. Ao receberem treinamento, eles se tornam defensores da conscientização sobre os riscos de incêndios florestais e práticas seguras de manejo do fogo. Ademais, eles podem educar outros membros da comunidade sobre a importância da prevenção de incêndios, incluindo a forma correta de realizar queimadas agrícolas e como evitar comportamentos de risco, como o descarte inadequado de cigarros e a realização de fogueiras sem precauções adequadas".

[18] "Fire-independent ecosystems are those in which fire generally plays a minor or unnecessary role. These ecosystems are too cold, wet, or dry to burn. Examples include deserts, tundras, and tropical forests in environments which do not present defined seasons. Fire only becomes a threat when significant changes in these ecosystems are triggered by land-use activities, invasive species, or climate change" (Myers, 2006, p. 3, free translation).
In the original: "Os ecossistemas independentes do fogo são aqueles em que o fogo normalmente exerce um pequeno papel ou é desnecessário. Esses ecossistemas são demasiadamente frios, molhados ou secos para queimar. Como exemplos, temos: os desertos, as tundras e as florestas tropicais em ambientes que não apresentam uma estação definida. O fogo torna-se uma ameaça somente se ocorre mudanças significativas nestes ecossistemas desencadeadas pelas atividades de uso da terra, pelas espécies invasoras ou pelas mudanças climáticas".

territories, placing pressure on conservation units that often function as islands under intense anthropic influence. In many cases, this pressure translates into intentional or accidental fires that spread uncontrollably. The worsening of climate change—with rising average temperatures and declining rain- fall—makes vegetation more susceptible to combustion, resulting in more intense and violent fires that threaten transitional zones between urban, rural, and natural areas and demand increasingly urgent responses (Belo, 2018).

The hypothesis presented in this work proposes introducing the concept of IFM into the legal-academic debate, exploring its normative framework and suggesting possible results: (i) its grounding in the principle of sustainability, as an ecological protection measure; (ii) its integration into legal science through the dimensions of sustainability, which, like IFM itself, are intrinsically multidisciplinary and interconnect different actors; and (iii) its recognition as a public policy, consolidated by Law No. 14.944/2024, which establishes the PNMIF (Brasil, 2024), one of the main theoretical landmarks of this study.

Law No. 14.944/2024 was enacted to regulate Article 40 of Law No. 12.651/2012 (the Forest Code)[19], with the objective of promoting interinstitutional coordination that enables the lawful and organized application of integrated fire management, thereby restoring its cultural and ecological role. The need for this specific legislation arose from the finding—based on technical and legal analyses—that effectively addressing forest fires requires normative security for decision-making by competent authorities. It enables

[19] "Article 40. "The federal government shall establish a national policy for the management and control of burning, and for the prevention and suppression of forest fires, which shall promote institutional coordination aimed at replacing the use of fire in rural areas, controlling burning, preventing and suppressing forest fires, and managing fire in protected natural areas. Paragraph 1. The policy referred to in this article shall provide instruments for analyzing the impacts of burning on climate change and land-use change, ecosystem conservation, public health, and wildlife, in order to support strategic forest fire prevention plans. Paragraph 2. The policy referred to in this article shall take into account climate change scenarios and potential increases in forest fire risk. Paragraph 3. The policy referred to in the caput of this article shall include a program for the use of agricultural aviation in firefighting across all types of vegetation" (Brasil, 2012, free translation).
In the original: "Article 40. O Governo Federal deverá estabelecer uma Política Nacional de Manejo e Controle de Queimadas, Prevenção e Combate aos Incêndios Florestais, que promova a articulação institucional com vistas na substituição do uso do fogo no meio rural, no controle de queimadas, na prevenção e no combate aos incêndios florestais e no manejo do fogo em áreas naturais protegidas.
§ 1º A Política mencionada neste artigo deverá prever instrumentos para a análise dos impactos das queimadas sobre mudanças climáticas e mudanças no uso da terra, conservação dos ecossistemas, saúde pública e fauna, para subsidiar planos estratégicos de prevenção de incêndios florestais. § 2º A Política mencionada neste artigo deverá observar cenários de mudanças climáticas e potenciais aumentos de risco de ocorrência de incêndios florestais. § 3º A Política de que trata o caput deste artigo contemplará programa de uso da aviação agrícola no combate a incêndios em todos os tipos de vegetação".

the use of fire within a cooperative framework involving federal, state, and municipal public administrations as well as civil society organizations, including volunteer brigades. By inserting itself into this normative framework, the law fulfills the role of regulating the activity, establishing parameters that clarify issues such as the exclusion of unlawfulness and the responsibilities of public authorities, always in dialogue with the principle of sustainability.

In this sense, the law enumerates, in an exemplary manner, structuring prin- ciples, among which stand out the "social function of property" (Art. 3, item II) and "the integration and coordination of public and private institutions, civil society, and public and private policies in the promotion of integrated fire management" (Art. 4, item I). The legal text also recognizes and values ancestral knowl- edge[20], as well as the ecological function that fire plays in the development of certain biomes and ecosystems—elements that this research likewise underscores as central (Brasil, 2024).

Among the objectives set forth in Article 5, items VI and XI are particularly noteworthy:

> […]
> VI – to promote environmental education, with a focus on the prevention, causes, and environmental and socioeconomic consequences of forest fires, as well as on alternatives to reduce social and environmental vulnerability.
> […]
> XI – to recognize, respect, and foster the traditional and adaptive use of fire by Indigenous peoples, quilombola communities, and other traditional communities, and to define, in a participatory manner and according to the specificities of each people and community, prevention and suppression strategies for forest fires in their territories21 (Brasil, 2024, free translation).

[20] "Art. 3, X – the recognition and respect for sociocultural autonomy; the valorization of protagonism; the protection and strengthening of knowledge, practices, and systems of sacred, traditional, and adaptive uses of fire; and the customary forms of natural resource conservation by Indigenous peoples, quilombola communities, and other traditional communities" (Brasil, 2024, free translation).
In the original: "Art. 3, X – o reconhecimento e o respeito à autonomia sociocultural, à valorização do protagonismo, à proteção e ao fortalecimento dos saberes, das práticas, dos conhecimentos e dos sistemas de uso sagrado, tradicional e adaptativo do fogo e às formas próprias de conservação dos recursos naturais por povos indígenas, comunidades quilombolas e outras comunidades tradicionais".

21 In the original: "[…]
VI – promover o processo de educação ambiental, com foco na prevenção, nas causas e nas consequências ambientais e socioeconômicas dos incêndios florestais e nas alternativas para a redução da vulnerabilidade socioambiental;
[…]
XI – reconhecer, respeitar e fomentar o uso tradicional e adaptativo do fogo por povos indígenas, comunidades quilombolas e outras comunidades tradicionais e definir, de forma participativa e de acordo com as especificidades de cada povo e comunidade tradicional, as estratégias de prevenção e de combate aos incêndios florestais em seus territórios".

These provisions reinforce the connection between the management policy and the multiplicity of areas and dimensions that make up sustainability.

The new policy also encourages priority investments in technological research aimed at fire management. In the legal field, particular mention should be made of the work of the Scientific Initiation Group at Centro Universitário Dom Helder, which submitted a bill to the Municipal Executive of Belo Horizonte authorizing the use of prescribed burning in the city's green areas. In addition, the law provides for the creation of the Comitê Nacional de Manejo Integrado do Fogo (COMIF– National Committee on Integrated Fire Management), a deliberative and advisory body linked to the Ministry of Environment and Climate Change (MMA – Ministério do Meio Ambiente e Mudança do Clima), designed to coordinate and guide the implementation of the policy across the national territory.

With a medium- and long-term perspective, the central goal is to prepare Brazil to confront the effects of climate change more effectively, strengthening the guidelines of the principle of sustainability. The aim, therefore, is not only to reduce the intensity and frequency of fires, but also to preserve native vegetation, restore degraded areas, especially those linked to agroecology and family farming, and use the culture and energy of this primordial element of the planet—fire—, in a conscious and strategic way.

Several Brazilian states have also established specific regulations to govern the use of fire. In Mato Grosso do Sul, for example, Decree No. 15.654/2021 established the State Integrated Fire Management Plan and, in Article 38, Chapter IX, item VI, provides for the replacement of native fields with cultivated pastures, as well as the adoption of mixed and rotational grazing as strategies to reduce the need for fire in management (Mato Grosso do Sul, 2021). However, the replacement of native pastures under this rationale proves contradictory, as it entails abandoning a conservation management tool, making way for significant impacts on the biodiversity of the Pantanal (Garcia et al., 2021). Far from eliminating fire risk, such a measure promotes the expansion of exotic species with high invasive potential in cultivated pastures (Barbosa; Pivello; Meirelles, 2008).

In Minas Gerais, Decree No. 47.919/2020 regulates the use of fire for forest fire prevention and suppression within and around conservation units, including Reservas Particulares do Patrimônio Natural (RPPNs – Private Reserves of Natural Heritage) established by the State Government (Minas Gerais, 2020a). Article 5 recognizes fire as

a management tool for wildfire prevention and establishes the Burn Plan for Prescribed Burning (Plano de Queima Prescrita) as a planning instrument, to be prepared by a professional trained in forest fire prevention and suppression, in accordance with Article 1, item II of Ordinance IEF No. 86/2020 (Minas Gerais, 2020b). Joint Resolution SEMAD/IEF No. 2.988/2020 defines criteria for the use, monitoring, and control of fire in agropastoral, forestry, or phytosanitary activities, as well as for scientific and technological research (Minas Gerais, 2020c). Article 2 restrictively enumerates the situations in which con- trolled burning is permitted through technical recommendation, while Article 5, II limits the use of fire in legal reserve areas (Tomas et al., 2024).

According to Tomas et al. (2024), in Mato Grosso, State Bill No. 728/2020 proposed the State Fire Control Program (Programa Estadual de Controle do Fogo), whose definitions, principles, guidelines, objectives, and instruments closely resemble those established under the PNMIF. The text authorizes the use of fire in areas whose characteristics justify its application (Article 19, I) and, in §2 of the same article, albeit implicitly, admits the possibility of prescribed burning in legal reserve areas with fire-dependent ecosystems, provided it is authorized by the competent environmental agency and preceded by the analysis of an IFM plan.

In Tocantins, Law No. 3.594/2019, which establishes the Política Estadual de Uso Sustentável do Capim-Dourado e do Buriti (State Policy for the Sustainable Use of Golden Grass and Buriti), defines concepts such as controlled burning, wild- fire, and integrated fire management (Tocantins, 2019). The statute authorizes the use of fire to stimulate golden grass flowering in public or private humid fields, including legal reserves and permanent preservation areas. However, it does not clarify the use of burning for other purposes in legal reserve areas, even though it provides for its use on private lands (Tomas et al., 2024).

In São Paulo, Law No. 17.460/2021 created the Política Estadual de Manejo Integrado do Fogo (State Integrated Fire Management Policy), establishing objectives, concepts, principles, and guidelines. However, provisions related to the implementation, creation, and attributions of the State Integrated Fire Management Committee were vetoed by the governor at the time (São Paulo, 2021). The State is currently discussing the regulation of integrated fire management in conservation units, though revision and norm-setting will occur only after effec- tive implementation. Another relevant statute, Law No. 10.547/2000, regulates the use of fire for agricultural, pastoral, and forestry

purposes, without addressing management in legal reserve areas, stipulating only the expansion of firebreaks to protect them when controlled burning is authorized (São Paulo, 2000). Decree No. 56.571/2010, which regulates this law, limits the use of fire to agricultural, pastoral, and forestry production activities, therefore, not contemplating ecologi- cal purposes (São Paulo, 2010).

In short, IFM constitutes a comprehensive, complex, and multidisciplinary set of actions that simultaneously address both the risks and the potentialities of fire. It is a strategy that incorporates prevention through a systemic and integrative perspective, establishing itself as a pioneering, creative, and distinctive theme for legal analysis and application.

4 CONCLUSIONS

The signs of global ecological transformation are increasingly evident, and the role of legal research now includes the task of providing clear scientific founda- tions and precise contours for addressing the issues that arise from them. Concrete reality—as revealed by the impacts of recent floods in southern Brazil and the intensification of forest fires across the country—underscores the urgency of normative and operational responses that are effective in the face of the contemporary environmental crisis.

Just as, in other historical moments, law incorporated scientific and philosophical foundations to embed ethical and collective principles in the construction of its institutions, a new stage is now required. It is necessary to confront unprecedented challenges and to propose practical solutions to the relationship between society and the natural world, providing both theoretical grounding and legal certainty to instruments such as IFM. The task is to articulate a framework that ensures legal support for preventive and conservation actions that employ fire as a tool, while recognizing its cultural, ecological, and socioeconomic roles.

In this sense, two axes stand out. The first is the advancement of Pyrocene research—a specific phase of the Anthropocene in which fire and its consequences are central to the environmental crisis, driven by climate change and ecosystem degradation. The second is the affirmation of the principle of sustainability as a legal foundation of the PNMIF, not only because of its role in ecological protection, but also because of its

multidimensional nature, which connects law to different fields of knowledge and to social participation.

By combining traditional practices with modern technologies, IFM unites volunteer firefighters, environmental managers, and researchers from the natural and social sciences, drawing on different bodies of knowledge to develop adaptive and effective solutions. In this way, the logic of "zero fire" is overcome, and the controlled use of fire is incorporated as a strategy for both prevention and conservation. Successful experiences in Brazil demonstrate that prescribed burning, when carried out at the appropriate time and in the proper manner, coupled with monitoring, environmental education, and the strengthening of community belonging, is capable of reducing risks, conserving biodiversity, and lowering public expenditures on firefighting.

The expression "integrated fire management" synthesizes this approach: "Integrated" refers to the articulation among social, cultural, ecological, economic, and legal dimensions, while "management" implies qualified technical procedures. This conception directly aligns with the systemic model proposed by the dimensions of sustainability and with the participatory environmental governance provided for in Law No. 14.944/2024 (Brasil, 2024).

Through the PNMIF, the Brazilian legal system updates itself to address the challenges of the Pyrocene, promoting adaptive management that respects socio- cultural diversity, values traditional knowledge, recognizes the ecological role of fire, and fosters cooperation among different actors and knowledge systems. In this way, IFM emerges as a pioneering field in legal thought, weaving together tradition, science, technology, and community participation into an innovative strategy capable of reshaping environmental practices and strengthening the socioecological resilience of Brazilians.

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Authors' Contribution

Both authors contributed equally to the development of this article.

Data availability

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