Prescribed burning in a protected area as part of integrated fire management. Photo: CeMAF

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Integrated fire management in the Brazilian Cerrado: advances and challenges

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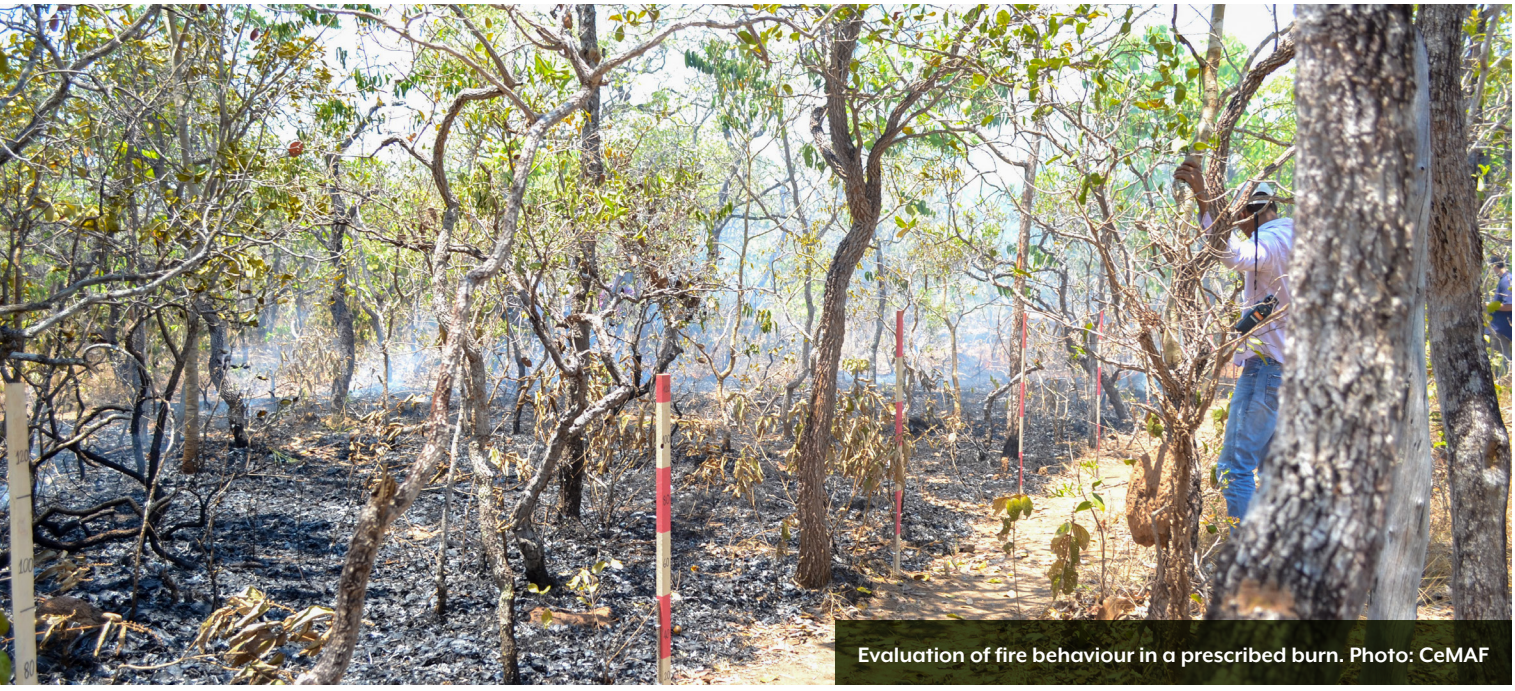
"The results of integrated fire management actions show that zero-fire policies have not resolved the problems arising from forest fires and irregular burn."

Introduction

Fire is an important evolutionary agent for plants and has played a considerable role in the distribution of savannas across the world. Fire-prone plant formations, in areas including savannas, cover about 40% of the earth's surface (Bond et al. 2005). The Brazilian Cerrado, which covers an area of 2,036,448 km^2, the second-largest biome in the country, is an example of an environment that has fire-dependent types of vegetation. Several adaptations to fire are the hallmark of the endemic flora of the Cerrado, including arboreal and herbaceous species with ability to store water and nutrients, thick bark, sparse branches and thick leaves, among other characteristics. Despite the dependence on fire and the presence of fire adaptation mechanisms in savanna environments such as the Cerrado, however, the increase in the frequency of high-intensity fires, especially in the late dry season, has negative effects on the ecosystem through increased plant mortality (Oliveras et al. 2012).



Evaluation of fire behaviour in a prescribed burn. Photo: CeMAF

Fire in the Cerrado is generally not attributed to natural ignition, and there is no doubt that human activity has been the main cause of forest fires over the years (Coutinho 1990). People have always used fire, either as a good tool used by traditional and indigenous populations for their subsistence, or in bad ways, such as the irresponsible burning of pastures in the critical months of the dry season. This latter practice is one of the main causes of forest fires in the Cerrado biome.

Managing the use of fire

Integrated fire management (IFM) is not a new practice in Brazil; it has been carried out since prehistoric times. The use of fire as a management tool was later passed from indigenous peoples to the *sertanejos* (people from northeastern Brazil) in the Cerrado and Campos Sulinos regions. Fire was used for managing native pastures in extensive cattle raising (Pivelo 2011). Indigenous peoples continued to use fire for hunting, religious rituals, land management for agriculture, pest control and fuel management. The use of controlled fire is also important in maintaining gardens, adding nutrients to the soil, eradicating pests and weeds, and preventing more severe fires (Levis et al. 2018). The uses of fire in territories of indigenous communities (*quilombolas*) and other traditional communities also include symbolic acts, confirming their relationship with the landscape, and involving collective and cultural practices at various scales (Posey 1985).

It is important to highlight not only the existence of "good" fires resulting from traditional management practices that were carefully carried out, but the fact that people have always over-used fire in land occupation, deforestation, burning of residues and pasture management. The increase in uncontrolled wildfires resulting from these irresponsible burning practices has became increasingly apparent. Consequently, fire in general is considered as something that should be avoided.

The Forest Code of 1934 was the basis of the fire prohibition policy, and it considered traditional fire practices as an enemy to be fought. This policy was further enforced from the 1980s on to limit deforestation in tropical forests. It also applied in grasslands and savannas, in spite of scientific and cultural evidence that the role of fire in such ecosystems is fundamentally positive (Durigan and Ratter 2016).

Changing ways of thinking

With an increased number of policies prohibiting the use of fire and the consequent accumulation of combustible material, the frequency and severity of forest fires have increased, especially in protected areas. Large and frequent fires have also highlighted the financial and resource limitations of the public institutions responsible for controlling them (Barradas et al. 2020). It should be noted that the consequences of such policies had already been seen in other countries, such as the United States, South Africa and Australia.

In 2012, the views of public institutions regarding how to deal with fire started to change, shifting away from

fire exclusion policies in protected areas, primarily in the Cerrado, to a concept of fire inclusion. This transition was completed in 2014, with the first pilot projects for integrated fire management in various protected areas. This first pilot projects were driven by the Cerrado-Jalapão project, carried out through a partnership between the Governments of Brazil and Germany..

So despite integrated fire management being ancient, its reclamation as a practice to prevent forest fires in protected areas in Brazil is very recent. And controlled burning combined with traditional knowledge, to be used in biodiversity conservation, still lacks approval as an official public policy. IFM also required strengthened operational and technical capacity.

Changing legislation

Historically, Brazilian policy on the use of fire focused on restricting its use. Since the 1600s, fire has been a concern to public institutions and society in general, with specific regulations that restricted the use of fire in brazilwood forests and agricultural fields. The Forest Code of 1934 prohibited the use of fire for the most purposes, and in some cases the use of fire was defined as a crime subject to a fine or even imprisonment. The subsequent Forest Code, in 1965 (Law No. 4771), continued with the same prohibitions. However, despite banning fire in forests, both measures justified the use of fire in agropastoral or agroforestry practices, if permission was established through an Act of government.

The country's first national park was created in 1937. In 1979, national parks were regulated, with measures that prohibited practices that could cause fires in conservation units, although the use of managed fire was allowed in certain circumstances. Then in 2012 a revision of the Forest Code (Law No. 12,651) allowed the use of fire in protected areas for the conservation of fire-adapted ecosystems, provided that the specific use of fire was described in their management plan.

Most recently, in 2018, Bill No. 11,276 was drafted to bring a new legal perspective to IFM strategies by establishing a national policy for integrated fire management. This would lead to the establishment of regulations for the use of fire as a practice for preventing and fighting forest fires in natural areas, and for the use of fire by traditional populations such as *quilombolas*, indigenous people, and family farmers. However, this bill has not yet been fully approved, and ratification by the Brazilian Federal Senate is still pending.

Organizational structure

Fire management in Brazil is carried out at federal, state, municipal and private levels. At the federal level are two main executing agencies: the Brazilian Institute of the Environment and Renewable Natural Resources (IBAMA), and the Chico Mendes Biodiversity Institute (ICMBio). ICMBio is responsible for managing conservation units under the government's jurisdiction, including the hiring of fire brigades. The federal government also created the National System for the Prevention and Combat of

Institutional partnerships support the development of research and improvement of tools for integrated fire management activities. Photo: CeMAF

Scientific research activities carried out in prescribed burning actions of integrated fire management. Photo: CeMAF

Forest Fires, which is coordinated by IBAMA. This aims to develop integrated programmes to monitor, prevent and fight forest fires. It is also responsible for developing and disseminating information about controlled fire management techniques, carrying out staff training and raising public awareness of the risks of inappropriate fire use.

Monitoring

Monitoring the behaviour and dynamics of fire provides extremely important information for public managers in deciding on actions to take related to integrated fire management. Most national forest fire monitoring is carried out by the National Institute for Space Research. Its Queimadas programme undertakes research in and develops innovative products, processes and geo-services for monitoring and for modeling the occurrence and propagation of fire. Monitoring includes the detection of fire-prone ares in vegetation. It also includes spatial and temporal analyses of fires through the Burning Database system (BDQueimadas), which automatically updates data daily, with free and open access to all maps, tables, graphs and other information. Another important tool is the MapBiomas platform, which provides time series data (since 1985) on land use and cover, deforestation, fire scars, and regeneration, among other factors. Mapping of fire scars, for example, includes annual and monthly data, frequency of occurrence, classification of coverage and objective of the fire. Monitoring is also carried out at the state level; see Box 1.

Box 1. Centre for Environmental Monitoring and Fire Management

In the State of Tocantins, 90% of which is in the Cerrado biome, annual monitoring is carried out for all of its 139 municipalities. The Centre for Environmental Monitoring and Fire Management (CeMAF) at the Federal University of Tocantins records data on fire scars and forest fires. This information is used by state and municipal authorities in the implementation of public policies, and in firefighting and fire prevention strategies. The centre was conceived of as a place for developing instruments and methodologies to support actions that prevent, reduce and combat forest fires and irregular burning. Combining research, teaching and extension actions, it brings together scientific knowledge on the implications of fire in the Cerrado, trains personnel, and disseminates information on fire management. CeMAF is affiliated with the Global Fire Monitoring Center (GFMC) in Germany and is part of one of its eight regional centres, the South America Regional Fire Management Resource Center. CeMAF has annual maps from 2000 to the present year, and maps with almost monthly frequency for some places. Based on mapping data, an average of 3.2 million hectares, or approximately one-eighth of the state, burns every year.

Tools and technologies for fire management

With the decriminalization and reintroduction of the use of fire by public institutions, experiences over recent years have made apparent the need for more and better tools. These deficiencies are gradually being addressed, and new methodologies have increasingly provided greater accessibility and ease of operation, both for public managers and for the teams who work on the front line of fire management, firefighting and fire prevention.

This includes remote sensing for mapping combustible material. It provides data on the physiological condition of vegetation (i.e., dry or green), which is of considerable importance in planning prescribed burning in protected areas. The information can also be accessed by indigenous people and other residents through smartphones. Drones are another tool that help improve procedures and decision-making in various ways.

Challenges

Despite increased understanding of the benefits of integrated fire management in the Cerrado, little is known about different environments, including fire-sensitive ones. In addition, it is necessary to validate existing methodologies and develop new tools in order to facilitate the planning of actions.

Despite the general recognition by ecologists that total fire suppression is not beneficial to the maintenance of savanna ecosystems, there is still a need for clear guidelines on how to use fire. There remains a policy gap in dealing with fire, especially outside protected areas. Legal regulation is essential, not only to define the rules to be followed, but to provide greater legal certainty for fire management actions.

Integrated fire management in protected areas has been implemented and accepted only recently, and decision making in response to forest fires in Brazil by government agencies has generally been more reactive than proactive. IFM is still not widely accepted in conservation debates in Brazil.

Although there has been visible progress with the implementation of integrated fire management, it is still restricted to protected areas, and is not carried out in privately owned areas. This is an issue that still needs to be resolved, since most forest fires start in private areas.

Furthermore, little is known about the effects of climate change on traditional fire-use regimes or on the practice of prescribed burning. Research is needed to define more specific criteria for the use of fire under various climate change scenarios, and to assess the potential for integrated fire management actions to reduce greenhouse gases.

Conclusions

Integrated fire management involves a set of techniques, principles and methodologies that allow the use of fire

Different institutions working together to collect information on biomass and fire behavior after prescribed burns in the Cerrado, Jalapão region, Tocantins. Photo: CeMAF

in order to achieve economic, social and environmental benefits. It has legal support in the 2012 Forest Code, which allows the use of fire in places or regions whose circumstances justify the use of fire in agropastoral or forestry practices, with authorization from the responsible environmental agency.

In the Brazilian context, integrated fire management can play a fundamentally important role. By including local knowledge, IFM is sustaining an ancestral practice for reducing forest fires and conserving ecosystems. For effective integrated fire management in private areas, however, it is necessary to develop programmes that include land owners, and to evaluate ways of expanding the proposed system.

Reintroducing integrated fire management in the Cerrado has brought new tools and technologies that improve planning and implementation. Investment in research and development must be continuous, in order to advance technologically, and to train technicians, traditional communities and land owners. And it remains essential to reconcile new technologies and methodologies with traditional knowledge about fire management.

More scientific knowledge is also needed regarding greenhouse gas emissions from the traditional use of fire, and to assess the climate change mitigation potential of integrated fire management practices.

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