

From fire suppression to fire management: advances and resistances to changes in fire policy in the savannas of Brazil and Venezuela

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Abstract

Anthropogenic fire has long shaped landscapes and livelihoods in South American savanna environments. With the growing recognition of the failures of fire suppression policies and the relevance of local peoples' practices, the Brazilian and Venezuelan governments have begun to shift to fire management policies in savanna ecosystems. Using case studies from protected areas in Cerrado and Gran Sabana, and results from two multi-stakeholder meetings held in Parupa (Venezuela) and Brasilia (Brazil), we identify advances, resistances and challenges to intercultural fire management in both countries. We show that the two regions host pioneer experiences in collaborative research based on improved dialogue and knowledge exchanges between scientists, institutions, Indigenous and local communities as well as fire management implementation including "controlled" and "prescribed" burnings. However, in some places, narrow understanding of the complexity and historical dynamics of local fire practices and the strong resistance to recognize the value of traditional fire knowledge might restrain effective participation of local communities. We argue that more collaborative research is necessary to support community owned solutions for intercultural and participative fire management in changing environmental and sociocultural contexts.

Key-words: fire-prone ecosystems; Cerrado; Gran Sabana; South America; traditional ecological knowledge; intercultural

Introduction

The incidence and severity of wildfires¹ have increased globally in recent decades, with serious impacts on greenhouse gas emissions, biodiversity and human populations (Hardesty et al. 2005). Six of the 12 South American countries have "Very high" or "High" wildfire incidence (with 1 hot spot detected per year for each 75 km² or less), including Brazil and Venezuela (White 2017). In the savanna ecosystems of South America, these wildfires are particularly damaging because of the co-existence of fire-resistant vegetation (grasslands and woodlands), where several species are dependent on or benefited by fires, with fire-sensitive vegetation (riparian forest, peat wetlands) (Bilbao et al. 2009; Walter and Ribeiro 2010). Such environments, that include the Cerrado of Central Brazil, the *llanos* of Colombia and Venezuela, and the white sand savannas of Amazonia (de Carvalho and Mustin 2017; Simon et al. 2009), are in countries known for their tropical rainforests. As such, savannas are scarcely protected and not valued for conservation, seen primarily as potential areas for agribusiness expansion (de Carvalho and Mustin 2017; Oliveira and Hecht 2016).

Anthropogenic fire has long shaped landscapes and livelihoods in savanna environments (Bond and Keeley 2005). Fire is used for multiple purposes by Indigenous, traditional and peasant farmer communities in such environments, for swidden cultivation (Eloy et al. In press), livestock raising (Lucio et al. 2014; Mistry 1998), hunting (Bilbao et al. 2010; Melo and Saito 2011; Welch et al. 2013), and managing non-timber product species (Mistry et al. 2005; Schmidt et al. 2007). Many local communities apply complex cooperative systems of burning in small savanna patches, producing seasonal mosaic landscapes (Bilbao et al. 2010; Eloy et al. 2016b; Welch et al. 2013), as also described in tropical savannas of Australia (Bird et al. 2008; Russell-Smith et al. 1997), South Africa (Parr and Brockett 1999) and Western Africa (Laris 2002). Such seasonal mosaic burning is recommended for its

¹ We are defining wildfires as uncontrolled fires, from both anthropogenic and natural origins, considering that the first tend to be increasingly more common than the latter in most ecosystems.

positive impacts on biodiversity, wildfire prevention and mitigation of carbon emissions (Bilbao et al. 2009; Russell-Smith et al. 2013; Welch et al. 2013). But traditional fire management systems in savanna environments are still poorly understood by western science standards that focus on quantitative fire ecology (Kull and Laris 2009; Mistry et al. 2016).

Despite fire-prone characteristics and traditional communities' practices, public policies in savanna ecosystems focus on prevention and firefighting (Durigan and Ratter 2016; Mathews 2005; Sletto 2008). Fire suppression policies and technologies have gained new importance in South America, in an emergent context of climate change mitigation (Eloy et al. 2012; Pollini 2009; Welch et al. 2013). In Brazil, fire prohibition and the criminalization of traditional communities is also used to legitimate the expansion of agribusiness that do not rely on fire use (Eloy et al. 2016a; Welch et al. 2013).

At the same time, the paradigm of "zero fire" in savannas is being questioned due to the growing recognition that fire should be managed for conservation in fire-prone ecosystems (Durigan and Ratter 2016). Fire suppression policies in South America are not only expensive but also ineffective because excluding fire leads to dry fuel accumulation and large wildfires, as described in the Brazilian Cerrado (França 2010), the Gran Sabana in Venezuela (Bilbao et al. 2010) and the eastern lowlands of Bolivia (McDaniel et al. 2005). Such policies contribute to the loss of traditional knowledge related to fire use and landscape management, and encourage conflicts over land and resources (Carmenta et al. 2013; McDaniel et al. 2005; Mistry et al. 2016; Sletto 2008; Sorrensen 2009).

Since the 1980s and 90s, fire has been reintroduced as a management tool in fire-prone ecosystems to (re)create seasonal mosaic landscapes in protected areas through early-dry season burning, and therefore avoid late-dry season wildfires. Based on geospatial technologies and modern ignition techniques, such models of "prescribed-burning" or "integrated fire management" (Myers 2006) are used in Australia (Russell-Smith et al. 2013),

Mediterranean ecosystems (Lambert 2010), and African savannas (Brockett et al. 2001; Goldammer et al. 2004). These policies commonly aim to build participatory decision-making models based on the incorporation of local knowledge related to fire use (FAO 2011). Indeed, the ecological rehabilitation of fire is, in some places such as Australia, based on new valuation and reinterpretation of Indigenous burning practices (Bird et al. 2008; McGregor et al. 2010; Russell-Smith et al. 1997; Russell-Smith et al. 2013).

But the successful integration of local and scientific knowledge into fire management policies remains controversial. In fact, "scientific rehabilitation" of fire does not guarantee the participation of local communities in decision-making, or a better dialogue with their knowledge (Ribet 2007). The institutionalization of joint Indigenous-government land management in Australia reveals many contradictions, which result from the subordination of Indigenous perceptions to those of external experts (Petty et al. 2015). Moreover, some dominant ecological ideas upon which fire management has been based in the past are being questioned at the present, such as, for instance, the idea that late-dry season fires must be banned (Laris et al. 2016), or that savannas are degraded forest caused by fire (Dezzeb et al. 2004). In this context, instead of "integrated fire management", some scholars argue for "intercultural fire management" (Rodríguez et al. 2013b) and, more recently, for "Intercultural and participatory management (MIPAFU)". This concept advocates the assurance of equitable participation of different stakeholders in the process of planning and decision making, based on the promotion of respect and mutual understanding amongst diverse stakeholders, with different knowledge, needs and worldviews (Millán et al. 2013). In fact, many Indigenous and other local communities shape and respond to resource and environmental governance drawing on their own cultural, political and philosophical traditions, and intercultural resource management means to *"take those traditions seriously as a starting point for understanding the nature of the problems and challenges"* (Howitt et al. 2013, 124).

In the context of the history of these debates, we aim here to understand the advances, resistances and challenges to intercultural fire management in Venezuela and Brazil. Both countries have since 2014 started to consider and implement fire management policies, through networks of research, expertise and international cooperation. In Brazil, this has involved the conception and implementation of the Cerrado-Jalapão project. Coordinated by the Ministry of Environment (MMA), co-funded by the German Cooperation Agency and piloted in three large (>150,000 ha) Protected Areas (PAs) located in the northern Cerrado², the objectives of this program are to: (i) change the predominant burning season in PAs, especially reducing the areas hit by late-dry season wildfires; (ii) protect fire-sensitive vegetation, such as riparian forests, from wildfires; (iii) enhance PA staff decision-making and fire management abilities and (iv) decrease conflicts between PA and local communities. The project also includes the fire expertise of an Australian specialist, research to analyze fire behaviour and practices in the PAs, and exchange visits between Australian and Brazilian park managers (Schmidt et al. 2016).

In Venezuela, since 1998, an intercultural and participative fire management experience in Gran Sabana, Canaima National Park (CNP), a region of 18,000 km² inhabited by Pemón Indigenous people, in Venezuela's south-east, -, has evolved as a result of a series of participative action-research projects³ funded by the national science-financing institution (FONACIT), and supported by national and regional government development institutions (CVG, CORPOELEC-EDELCA, and INPARQUES). The inclusion of Indigenous communities, fire-fighters, institutional and academic stakeholders in field research and experimentation, ancestral Pemón Indigenous fire knowledge, as well as the debate and dialogue about socio-ecological issues within CNP, allowed the development of articulated

² Firstly in Parque Nacional da Chapada das Mesas (PNCM) in Maranhão, Parque Estadual do Jalapão (PEJ) e Estação Ecológica Serra Geral do Tocantins (EESGT), and after, in several Indigenous Lands and other protected areas.

³ IAB (Interactions atmosphere - Biosphere of the 'Gran Sabana'), RISK (Risk factors in the reduction of habitats in Canaima National Park: vulnerability and tools for sustainable development), APOK (Ecological and traditional knowledge bases of fire of Pemón people: local solutions for global climate change problems).

knowledge for the foundation of a new fire management paradigm (Bilbao et al. 2010; Bilbao et al. 2017; Millán et al. 2013; Rodríguez et al. 2013a). Since 2015 and with funding by the British Academy (UK) work to formulate a legitimate intercultural and participative fire management policy in Venezuela has been expanded through collaboration with neighboring Brazil and Guyana.

In the past two years, the Brazilian and Venezuelan experiences have converged in several meetings and workshops arranged in the framework of these projects. We have organized and facilitated multi-stakeholder meetings on fire management in Parupa, Venezuela (2015)⁴ and in Brasilia, Brazil (2017)⁵ involving local Indigenous and traditional community representatives, scientists, environmental managers and government officials. In these meetings, we promoted reflective dialogue on fire management policy and practice; these discussions and exchanges led to the definition of future steps for action.

This paper is based on first hand experiences and data from our field notes, research diaries, as well as published papers, maps and technical reports produced by project staff and consultants on fire planning, management and evaluation. We also gathered data from fire management experiences in protected, Indigenous and Quilombola⁶ lands to produce an original map of the distribution of institutional initiatives in both countries. This allowed us to identify the key advances, challenges and limitations currently experienced in the two countries for intercultural fire management.

From fire suppression to fire management

A new dialogue

⁴ <http://projectcobra.org/participatory-and-intercultural-fire-management-network/>

⁵ <http://projectcobra.org/report-on-intercultural-and-participatory-fire-management/>

⁶ *Quilombolas* are commonly defined as the descendants of runaway slave communities (*quilombo*), that have territorial rights since the Brazilian 1988 Constitution (art. 68). The term *Quilombola* also involves the affirmation of cultural heritage, identity, autonomy and territorial rights of Afro descendant rural Communities in Brazil.

In Brazil and Venezuela, collaborative research based on improved dialogue between scientists, Indigenous and traditional peoples and fire management institutions allowed historic conflicts created by fire suppression policies to be overcome while creating new spaces for perspectives and knowledge exchanges (Eloy et al. In press; Mistry et al. 2016; Rodríguez et al. 2013a; Schmidt et al. 2016):

”Previously we were more excluded. But now with these experiences we are taken more into consideration. We have advanced in something very important for the respect of our culture” (Pemón Indigenous leader⁷, Venezuela).

“These findings open up space for dialogue. Before things were hectic here, we could not fell a tree, burn or work near the forest. There was research on golden-grass management [involving fire] and now there´s this research on swidden agriculture, and things have opened up. Now the PA managers have a different approach to us, I like this.” (Quilombola community member, Jalapão, Brazil)

The meetings in Parupa and Brasilia were opportunities to strengthen and reinforce the above initiatives, and promote learning among different stakeholders (local communities, scientists, government), as well as among Indigenous and traditional communities from other South American countries who gathered together for the first time. They highlighted the need for ‘safe’ spaces where those historically marginalized in fire decision-making could voice opinions and propose actions. Most community leaders who attended the meetings agreed that weakening of their traditional fire management systems could lead to increased wildfires.

Factors such as fuel accumulation (resulting from fire suppression and rural exodus), cultural changes, territorial reduction and conflict, climate change and the introduction of invasive grasses were identified as the prime causes of wildfires. Community leaders

⁷ After the workshop “Joining perspectives for the creation of a legitimate and effective environmental policy of fire management in Canaima National Park”, as part of the RISK project

recognized the need for partnerships and alliances to manage fires that are becoming increasingly difficult to control.

New legal frameworks and institutional positions

In Brazil, over 20 years of research in fire ecology was needed to convince decision-makers that the Cerrado is a fire-prone ecosystem and that fire suppression policies in PAs were ineffective (Miranda 2010; Pivello 2006). Federal legislation changed in 2012 and now explicitly allows the use of fire management for conservation purposes in both private and public protected areas within fire-prone ecosystems, exempting traditional communities from fire permits (Brasil, 2012). Such legal possibilities represented an advance in fire and conservation policy because *"it was from this moment that we were able to work fire use - and not only fire-fighting - in the Cerrado, with legal support"* (IBAMA-prevfogo official, pers comm). From 2013, the government started implementing community-run brigades (hiring local inhabitants); while ICMBio⁸ assumed the implementation of fire brigades in federal PAs, IBAMA-Prevfogo is responsible for Indigenous Lands, Quilombola Territories and agricultural settlements. In 2013, the MMA, ICMBio and IBAMA, with German cooperation, conceived the Cerrado-Jalapão project, which introduced the idea of "integrated fire management" (see below) and reinforced the community-run fire brigades. A national fire management policy, required by law and under review in Brazil, explicitly aims to include traditional fire management and its adaptive capacity to address current and future environmental challenges.

In Venezuela, since 1998, participative fire ecological research involving Pemón communities, scientists and public institutions began to address the failure of the "zero fire" strategy with the first recognition of sustainable fire management in CNP being the 2013

⁸ Since 2007, the Ministry of the Environment (MMA) separated two federal environmental agencies: Brazilian Institute of the Environment and Renewable Natural Resources (IBAMA) is responsible for environmental monitoring and licensing, and Chico Mendes Institute for Biodiversity Conservation (ICMBio) is responsible for the management of federal PA.

National Science and Technology Prize. In 2014, the initiative received the support of the environmental authority (MINEA) opening a direct communication channel with the head of INPARQUES and the leader of the National Parks Forest Fire-Fighter body. These circumstances boosted collaborative research activities and allowed the development of institutional participative and intercultural fire management strategies in PAs at national scale. CNP was given the highest priority due to its strategic environmental, cultural and economic (energy and tourism) importance. INPARQUES became one of the sponsors of the Parupa fire management meeting in 2015, and participated actively in the Brasilia meeting in 2017. In March 2017, INPARQUES' president declared that they had decided to adopt intercultural and participative fire management as part of their core policies and plans for the Venezuelan Protected Areas National System, extending its application to four additional National Parks .

Leading the way in participatory management of fire within protected areas

Brazil and Venezuela are pioneers in South America in setting up public policies for joint fire management in PAs. In both countries, the programmes involve collaboration between researchers, PA managers and local communities for wildfire prevention in fire-prone ecosystems, not only with firebreaks and fire-fighting brigades, but also with prescribed burnings, and an improved dialogue with local knowledge. Some cases of "integrated fire management" were reported in other Latin American countries⁹, but Brazil and Venezuela seem to be the most advanced in the institutionalization of this process.

In Brazil, there were some forays into adapting fire management operational plans based on Indigenous knowledge in 2007 and 2010 (Falleiro 2011); however, it was in 2014 that the Brazilian government sought to adopt the concept of Integrated Fire Management

⁹Some experiences of prescribed burnings are also running in fire-prone ecosystems of Mexico (Trejo and Reyes 2013) and Bolivia (http://incendios.fan-bo.org/Satrifo/wp-content/uploads/2015/11/Articulo_Quemas_preventivas.pdf).

(IFM)¹⁰ officially to reintroduce fire as a management tool in the Cerrado. Essential to the IFM programme are early dry-season fires implemented by fire brigades in fire-resistant ecosystems (grassland and savannas); brigades are trained in the use of new fire ignition technologies and biomass maps (on mobile phones and tablets) used to carry out these burns. Community meetings are integral to the approach, where new interfaces between "scientific" and "traditional" knowledge are experimented through participative planning tools (maps and burning calendars) and community agreements.

[figure 1 here]

Within the scope of the Cerrado-Jalapão Project, the IBAMA-Prevfogo¹¹ has developed a "traditional knowledge rescue" methodology, which involves a consultant who conducts community meetings to present the IFM proposal, make an initial survey of traditional fire uses (goals, calendars, locations) (Figure 1)¹², and plans, implements, monitors and evaluates prescribed burns. During meetings, satellite images (burn scars, biomass maps) are analyzed to determine together where fire brigades should burn. Fire brigade travel logistics are complex (vehicles limitations, long distances, bad roads), thus planning exercises allow for the day and burn locality to be established in advance (1 to 3 months).

Participative planning tools rely on the collective definition of general parameters that serve as a basis for planning future actions. PA managers and brigades differentiate "controlled burning" dedicated to production (i.e. helping a farmer to open a new swidden plot without risk) from "prescribed burning" which is related to early dry-season fire for reducing/fragmenting biomass and protecting forests (Figure 2), aiming to meet conservation needs.

¹⁰ Broadly defined, IFM includes the integration of science and fire management approaches with socio-economic elements at multiple levels (Myers, 2006). Some authors distinguish IFM from a more inclusive Community-based Fire management (CBFiM), which focuses on the active engagement of the community in the development and implementation of fire management strategies (FAO 2011).

¹¹The ICMBio and Naturatins, however, that focuses on Conservation Units (CU), did not incorporate this methodology as an institutional and systematic strategy, because all the CUs involved are under strict protection (IUCN category I), and despite being (or have been in the past) inhabited, this occupation is not recognized officially.

¹² This methodology results from IBAMA's own experiences (Falleiro et al. 2016), but seems also inspired by the "Participatory rapid appraisal" methods promoted under the CBFiM (FAO 2011).

[figure 2 here]

Instead of focusing on prescribed burning, Venezuelan institutions prioritize the recognition of Indigenous fire knowledge. For example, joint ecological experiments between Pemón Indigenous people, scientists and fire brigades helped to strengthen and regain traditional fire knowledge. Improved dialogue between fire brigades and the Pemón communities has led to knowledge exchange activities including the fire-fighters participating in controlled burns on Indigenous farms and learning experiences from the elders (Figure 3). A fire management plan for CNP is currently being promoted by INPARQUES which will involve Indigenous communities implementing their traditional fire practices, jointly deciding with scientists and fire-fighters on where, when and how to set fires.

[figure 3 here]

During the Parupa meeting, scientists, Indigenous communities and environmental managers accepted use of the term "*Manejo Intercultural y Participativo del Fuego*" (Spanish Acronym: MIPAFU), which differs from the more generic IFM term used in Brazil. The Venezuelan government did not benefit from international cooperation or funding, as was the case in Brazil. The change in approach happened gradually as a result of research programmes in ethno-ecology starting in 1998 (Bilbao et al. 2017). CNP became the emblematic case of the paradigm shift in fire policy away from the history of conflict between Indigenous communities and Park managers. The MIPAFU encourages the maintenance and rescue of ancestral Indigenous practices (patch mosaic burning in savanna and controlled burnings in forest ecosystems for cultivation), and adaptive learning through local knowledge, and scientific knowledge and institutional capacities. Hopefully these interactions will allow for the development of strategies to reduce the incidence of high magnitude fires caused by the effects of climate change. The suppression actions of forest fire-fighters will only be exerted in the case of large and uncontrolled wildfires.

Experiences of joint management of fire (called "IFM" or "MIPAFU") have rapidly spread since 2014, concentrated in the Cerrado biome and Amazonian savannas of Roraima and Venezuela. Very few PAs and Indigenous lands are supported by brigades (Figure 4), which show the importance of policies for managing fire with the inhabitants, and not relying only on formal brigades. In both countries, fire brigades are not sufficient for attending all the PAs, so government agencies prioritize areas based on past wildfire occurrence, conservation of vulnerable ecosystems and important water basins. For example, Caroní Basin (Canaima) produces 80% of the total electricity in Venezuela and is thus considered a priority.

[figure 4 here]

While, in Brazil, public institutions separate IFM actions between protected areas (ICMBio) and Indigenous or *Quilombola* lands (IBAMA-Prevfogo), in Venezuela, the federal conservation institution (INPARQUES) is building IFM plans in PAs that are superimposed on Indigenous or local traditional communities, prioritizing national parks where fire issues are important. Venezuela does not have a system of Indigenous brigades, but many PAs and Indigenous territories overlap, as the case of CNP, and consequently in these situations, Indigenous communities work as fire-fighters.

In both countries, there has been a concerted effort to work towards more participatory forms of governance for fire management. In Brazil, new values attributed to traditional fire knowledge have influenced the training of Indigenous and communitarian fire brigades, which had the benefit of not only giving local communities greater voice and representation in decision-making on fire management, but also of 'rescuing' traditional practices that had been lost (or almost lost) due to lack of use resulting from fire use prohibition and/or loss of traditional learning systems, for example in the Xerente Indigenous Territory (Xerente leader, pers. comm).

Resistances and limits

Resistances

Despite the paradigm shift from fire suppression to management policies at the federal level, there is still scientific and political resistance to this idea. First, in ecological and paleoecological sciences, the idea that South American savannas resulted from the degradation of forests due to fire (Dezzeb et al. 2004; Rull et al. 2015), especially in the savannas of the Amazon basin, was used by fire-fighting public bodies to maintain suppression policies. This was done without taking in consideration the value of traditional Indigenous knowledge as a sustainable tool for fire management and the complex interactions between fire and ecosystem dynamics (Bilbao et al. 2009; Leal et al. 2016). The idea of savannas as "degraded lands" promotes deforestation of these ancient ecosystems, and serves as a type of "green legitimization" to expand soybean and more recently eucalyptus plantations across already threatened traditional territories and protected areas (Bond 2016). In the Cerrado, anti-fire discourses are adopted by powerful agribusiness landowners interested in denigrating fire as part of a political narrative contesting Indigenous rights to land (Eloy et al. 2016a; Welch et al. 2013).

Secondly, in agricultural sciences, fire is an archaic and cheap tool, unproductive and harmful for the environment. It goes with the idea that people using fire are 'backward' and 'uneducated' themselves (Leonel 2000). For example, in Roraima and Amazonas (Brazil), local community burning practices are strongly criticized by agricultural state governmental institutions which have developed several initiatives to replace swidden cultivation systems with the use of tractors under the slogan 'technology is white, not Indigenous' (Emperaire and Eloy 2015; Oliveira Junior et al. 2005).

As a result, traditional and family farmers are caught between two fire-free farming system ideologies; the conventional technical assistance (mechanization, intensification), and "agroecological projects that bring "alternatives to fire" (extractives, agroforestry systems and

intensive pasture management), increasingly imposed through payments for ecosystems services (Eloy et al. 2012; Pollini 2009). Both are authoritarian and overlook local knowledge related to fire and landscape management in savannas. Moreover, these alternatives are not the best options for the environment, since they legitimize the conversion of native vegetation to monocultures and the spread of African exotic grasses that compete with native species.

Finally, in some places, the resistance comes from local communities. Following several decades of strong pressure for fire suppression, some members of Indigenous and traditional communities (especially the younger) have adopted the discourse of fire as a destructive force and support the idea of replacing fire by technology. During the meetings in Parupa and Brasilia, it was clear that overcoming past conflictive experiences and historic indoctrination of ‘external’ worldviews was necessary to stop loss of traditional knowledge and fostering collaborations:

“The young people today are very confused. It seems like we prefer the creole culture. We are forgetting about our own culture. It concerns most of all our children nowadays. We know that we have to educate them and we have the obligation to do it” (elder woman of Kavanayén, Gran Sabana).¹³

Limits and risks

Recognizing and incorporating the complexity of local fire uses commonly represents a challenge to environmental managers. Traditional fire management systems are characterized by multiple and sometimes opportunistic burning throughout the whole year linked to various social, ecological and spiritual purposes, which produce fine-grain scale mosaic landscapes (Bilbao et al. 2010). Thus, participative fire planning tools (maps, calendars) foster dialogue between stakeholders, but might elude the multiplicity of factors and concepts involved in fire management decisions.

¹³ *Cultura Pemón, el fuego que no debe apagarse*, (<https://www.youtube.com/watch?v=hIS2MifzRoY> or <https://www.youtube.com/watch?v=ePc3UB98IE4&t=34s>)

Moreover, the focus of fire brigades on early dry-season burning may undermine the traditional burning regime that spreads out over the year, including the late dry-season. A clear example is the different ways to manage and burn wet grasslands (*campos úmidos*) within the State Park of Jalapão region (Cerrado). Local communities reserve these areas for late dry season burnings to provide native pasture for cattle. For park managers, burning these areas is the key to protecting riparian and swampy forests (*veredas*) surrounded by these wet grasslands. In 2014, under the IFM program, the fire brigade undertook early dry-season burning of the wet grasslands. Such early burns not only impair the ability of traditional late dry-season fires to provide pasture but also attract the cattle to these areas where they might get stuck while the soil is still very wet. Instead of early dry-season fires, local ranchers claim the need for enhanced assistance from the fire brigades to carry out the late dry season fires in the wet grasslands, instead of a blanket prohibition on such fires. Such dissociation between fires prescribed for conservation purposes and the productive utility of fire might impair local community involvement in IFM programmes.

Furthermore, in some places, the fire brigades tend to turn local communities into beneficiaries of a service, rather than enhancing them to be responsible for the management of the land they live in. In both countries, the IFM experiences are mainly based on the formal training of brigades to perform specific tasks based on technical approaches and using specific equipment, often displacing the local communities (Indigenous, farmer/cattle ranchers, etc.) from the responsibility of fire management in the territories where they live. This problem was pointed by several participants of our meetings.

Indeed, IFM programs tend to consider local knowledge mainly for identifying "local demands for fire" (i.e. brigade intervention for assisting farmers to make "their" fire for productive objective) and "local habits", rather than integrating local fire and landscape knowledge in the very scientific understanding of fire behavior and of the impact of different

fire regimes on the ecosystems. The clear distinction between “controlled” and “prescribed” burning that is institutionalized in both countries¹⁴, reflects the simplification of traditional fire knowledge. Indeed, in Indigenous and traditional communities, burned patches are a response to a diversity of objectives (production, wildfire prevention, landscape management). For example, in the Jalapão region, the early dry season fires in dry grasslands and woodlands (“*cerrado*”, “*campina*”) are used to stimulate pasture regrowth as well as intentionally to prevent the late dry season fires from entering fire-sensitive riparian forests.

Finally, most fire management experiences and research on traditional uses of fire in South America has focused on Indigenous territories (Falleiro 2011; Melo and Saito 2011; Mistry et al. 2005; Welch et al. 2013), and little is known about the burning practices of non-Indigenous local communities that represent large territories, especially in Brazilian Cerrado. As a result, fire uses for cattle grazing tend to be simplified and blamed for changing fire regimes (Pivello 2006). In this context, an improved dialogue on agropastoral burning practices amongst scientists, government institutions and traditional farmers may have strong policy implications for IFM in this biome. Such a process is underway in the Jalapão region thanks to the innovative efforts of the managers of PAs to better understand and consider the complexity of and the rationales underpinning *quilombola* pastoral fire practices.

Discussion

Several authors have explored barriers to intercultural environmental governance. Despite supporting attempts to empower local communities, many misunderstandings and conflicts are generated by participatory approaches (Ellen et al. 2000; Fernando 2003). The possible instrumentalization of these processes can turn against the people who should benefit from them (Dunn et al. 1997; Harris and Hazen 2006). In many cases where the construction of

¹⁴ These two categories should be incorporated in the Brazilian fire management policy in Brazil, which is under final discussion. In Venezuela, “controlled fires” for agriculture purposes are not penalized, but there is no mention about prescribed fire used by indigenous or local farmers to avoid wildfires.

environmental "co-management" between scientists and local communities is affirmed, the latter play an extremely limited role, not only in decision-making, but also in the very scientific understanding of environmental problems (Nadasdy 1999). Epistemological differences and associated politics of representation strongly limit the engagement with Indigenous knowledge (Mistry and Berardi 2016). As a result, the "integration" of traditional knowledge with scientific knowledge generally means to translate it, and incorporate it within standardized methods of a centralized and quantitative science (Goldman et al. 2011).

In the case of fire management in South America, the reliance of fire policies on geospatial technologies such as remote sensing tends to exclude local knowledge and power over decision-making (Carmenta et al. 2013; Sletto 2008). Mathews (2005) also highlights how the rules prohibiting fire use in Mexico are formulated based on ignorance, and not information, creating a situation of systematic separation of the spheres of knowledge in several levels of governance.

In the case of Brazil and Venezuela, the anti-fire discourse has been clearly political, since the very existence of some institutions, especially agricultural assistance services, relies on ignoring local knowledge. However, federal environmental policy makers are conceiving new fire management policies with an increasing interest in understanding and incorporating local knowledge in fire management. Mainly inspired by the Australian experience, and fostered by ecological research and international cooperation (especially in Brazil), these policies are very innovative, but may present the same limits of the "integration" of local and scientific knowledge highlighted in the Australian model (Petty et al. 2015).

In Brazil, the focus on early dry-season burning, the enhancement of fire brigades, and the separation between "controlled" and "prescribed" burning may simplify local knowledge and strategies and reduce the local communities to beneficiaries of a "service". As described in a PA in the Pyrenees (France), the ecological reintroduction of fire is based mainly on

specialized knowledge and techniques, which rarely mobilize the residents' knowledge and decision-making abilities (Ribet, 2007). In South America, in a context of general loss of traditional knowledge, simplifying the complexity of fire knowledge may have serious implications for the ecological integrity of indigenous and traditional territories (Mistry and Berardi 2016).

Today, resource management, not just land rights, has become a new node of contestation, especially as carbon politics and other environmental services become more important in the structuring of and autonomy within local land uses by local populations. In savanna environments, fire management became a territorial issue; who decides where, when and how to use fire, and with what information? Thus, the recognition of the importance of traditional fire practices for environmental conservation may have strong territorial implications. In the Cerrado, most of the *Quilombola* and traditional populations live near or around PAs, and in a context of rapid expansion of agribusinesses and anthropogenic climate change, their territorial struggles rely not only on their legal rights and the affirmation of their cultural specificities, but also on their conservation efforts through the resilience of their production systems (Eloy et al. 2016a; Nogueira 2009). For example, in the Jalapão, environmental managers and researchers involved in the IFM program are gradually recognizing the environmental benefits and cultural importance of extensive cattle ranching systems based on native pastures, which are themselves preserved through traditional fire practices. As a result, *quilombola* leaders are using these arguments to reinforce their territorial claims in the region. The "protection" status of the CNP in Venezuela has favoured the preservation of the cultural practices of the Pemón Indigenous people, in contrast to what happens in other Pemón territories outside the Park, where the conflicts of land use and culture integrity prevail.

Conclusion

This paper highlights the significant advances in fire management policies in Brazil and Venezuela based on increased participation of local communities and engagement with traditional fire knowledge since 2014. However, our evidence shows some differences in the intercultural approaches and methodologies employed in these policy-making processes.

In Brazil the institutions have moved quickly from fire suppression to prescribed burnings in PAs, significantly reducing the occurrence of late dry-season wildfires (Schmidt et al. 2016), and giving new legitimacy for local fire practices, both in practice and law. Despite the new opportunities IFM opens for "rescuing traditional knowledge", the risk is to restrict the understanding of local fire management systems to meetings for deciding where to use early dry-season prescribed burning by the fire brigades.

In Venezuela, on the other hand, scientists, Indigenous communities and environmental managers converged on the idea of "*Manejo Intercultural y Participativo del Fuego*", which focuses on the promotion of dialogue spaces and collaborative research to overcome historical conflicts and reinforcing traditional fire knowledge and management. However, transforming these achievements into effective actions for fire management across the country remains a major challenge in a context of institutional instability.

Finally, "intercultural fire management" refers to the inclusion of local communities in management decision-making processes, but also in the very scientific understanding of ecosystem dynamics and relationships with fire. Rather than "integration" of scientific and traditional knowledge, it seems important to think about how to produce hybrid forms of knowledge (Goldman et al. 2011). In the case of fire, this means building collective experiments and monitoring systems on different ways to use fire, especially in disputed territories. More collaborative research is necessary to test community-owned solutions for fire management in changing environmental and sociocultural contexts.

Acknowledgments

We thank all the participants of the meetings in Parupa and Brasilia, the communities of the Jalapão Region (Mateiros, Tocantins state), IBAMA, ICMBio, Naturatins in Brazil, Pemón Indigenous people from Kavanayén, Forest Fire-fighters of INPARQUES and Parupa Scientific Station (CVG) in Venezuela for welcoming us and taking part in the research. In Brazil, this study was funded by Gesellschaft für Internationale Zusammenarbeit (GIZ) through the “Cerrado Jalapão” project. LE received research grant from the CAPES through the “Ciências sem Fronteiras” program (grant number: 88881.068021/2014-01). JM and BB were supported by the British Academy International Partnership and Mobility Scheme (Ref. PM130370) and the Woodspring Trust, UK, and Venezuelan FONACIT Risk and Apök Projects (Ref.2011000376 and G-2005000514).

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