

To Burn or not to Burn?

The History behind the Construction of a New Paradigm of Fire Management in Venezuela through Interculturality: Local Actions of National and Regional Impact

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“... ‘Look, son, do not go ahead of me.’ Why did the old wise man say that?

Because if on the journey one goes ahead, you are more likely to trip up. There could be an animal, there could be a snake or a spider that bites you. But don’t go behind me either. If you do, you won’t be able to see what I am seeing, as I am in front of you. So, one has to be very careful. That is why our grandparents said that we must walk together hand in hand. In that way we both can see what is ahead and we won’t trip up. This is my advice to the institutions, academy and government - let’s all hold on to grab each other to walk together, so no-one trips up...”

Sr. Valeriano Contasti, President of Elders Council of Kavanayén Indigenous Community, and natural leader of the community for more than 30 years, during the closure speech of the workshop: “Design of action plans on climate change: Integrating perspectives from the local Indigenous with academy and institutions in Canaima National Park” Venezuelan Institute of Scientific Research, Altos de Pipe, Gran Caracas, Venezuela January 23 to 25, 2017

ABSTRACT – The presence of a savanna-forest vegetation mosaic in the Gran Sabana, Canaima National Park (CNP), has been more than an academic controversy since the 1980s through to the 2010s in Venezuela. Scientists, Park administrators and officials from institutions devoted to protect the Caroní river basin within the limits of the Park, argued that the presence of savannas under a tropical rainfall regime that could support humid forests was due to the fire practices used by the local Pemón Indigenous communities. This misconception justified applying fire suppression policies, aimed at putting out all types of fires in CNP, especially the “compulsive burning” (thus so called by some scientists) by Pemón people in forest areas. This paper describes the initiatives, pursued for more than 20 years, to consolidate intercultural and participatory fire management in the CNP, Gran Sabana, which evolved as result of several participatory action-research projects coordinated by academics, and supported by national and regional public development institutions. The inclusion of Pemón Indigenous communities, firefighters, public officials, and academics in field research and joint experimentation, as well as in debates and dialogues on socio-ecological issues relevant to CNP, allowed the development of articulated knowledge and actions that were the foundations of a new paradigm of fire management and strategies for climate change mitigation and adaptation. Since

2015, these actions have been further extended to neighbouring countries of the Guiana Shield in the Northern Amazonia and other regions of Latin-America, with the collaboration and support of Venezuelan, British and other European institutions.

Keywords: Indigenous fire knowledge; integration of scientific, indigenous, and technical knowledge; integrated fire management; Canaima National Park; Northern Amazonia.

Queimar ou não Queimar?

A História da Construção de um Novo Paradigma de Manejo do Fogo na Venezuela por meio da Interculturalidade: Ações Locais de Impacto Nacional e Regional

RESUMO – A existência do mosaico de vegetação savana-floresta na Gran Sabana, Parque Nacional Canaima (PNC), representou mais do que uma polêmica na academia da Venezuela, no período de 1980-2010. Pesquisadores, administradores do Parque e funcionários de outras instituições encarregadas de proteger a bacia do rio Caroní, dentro do Parque, argumentaram que a presença de savanas em regime de chuva tropical típico de florestas úmidas era uma decorrência das práticas de uso do fogo utilizadas pelas comunidades indígenas Pemón. Essa falsa premissa justificou a aplicação de políticas de supressão, destinadas a apagar todo tipo de fogo no PNC, especialmente as “queimadas compulsivas” (assim chamadas por alguns pesquisadores) em áreas florestais, realizadas pelo povo Pemón. Este artigo descreve as iniciativas realizadas ao longo de mais de 20 anos para consolidar o manejo intercultural e participativo do fogo no PNC que evoluíram a partir de diversos projetos de pesquisa-ação participativa coordenados por acadêmicos e apoiados por instituições públicas nacionais e regionais. A inclusão de comunidades indígenas Pemón, bombeiros e funcionários públicos durante a execução de experimentos de campo, bem como em debates e diálogos sobre questões socioecológicas, permitiu o desenvolvimento de conhecimentos e ações articuladas que foram, posteriormente, os alicerces de um novo paradigma do manejo do fogo e de estratégias de mitigação e adaptação às mudanças climáticas no PNC. Desde 2015, essas ações foram estendidas aos países vizinhos do Escudo das Guianas, ao norte da Amazônia, e a outras regiões da América Latina, com o apoio de instituições venezuelanas, britânicas e outras instituições europeias.

Palavras-chave: Conhecimento indígena sobre fogo; integração de conhecimento científico, indígena e técnico; manejo integrado do fogo; Parque Nacional Canaima; Amazônia Norte.

¿Quemar o no Quemar?

La Historia detrás de la Construcción de un Nuevo Paradigma de Manejo del Fuego en Venezuela a través de la Interculturalidad: Acciones Locales de Impacto Nacional y Regional

RESUMEN – La existencia del mosaico de vegetación sabana-bosque en la Gran Sabana, Parque Nacional Canaima (PNC), ha representado más que una controversia académica en Venezuela, en el período 1980-2010. Científicos, administradores del Parque y funcionarios de otras instituciones encargados de proteger la cuenca del río Caroní, dentro del Parque, argumentaban que la presencia de sabanas bajo un régimen pluvioso tropical típico de bosques húmedos, se debía a las prácticas de fuego utilizadas por las comunidades indígenas Pemón. Esta falsa premisa justificaba la aplicación de políticas de supresión, destinadas a apagar todo tipo de fuegos en el PNC, especialmente las “quemadas compulsivas” (así denominadas por algunos científicos) en zonas forestales, por parte del pueblo Pemón. Este artículo describe las iniciativas realizadas durante más de 20 años, para consolidar el manejo intercultural y participativo del fuego en el PNC que evolucionaron como resultado de varios proyectos participativos de investigación-acción coordinados por académicos y apoyados por instituciones públicas nacionales y regionales. La inclusión de las comunidades indígenas Pemón, los bomberos y los funcionarios públicos durante la ejecución de experimentos en campo, así como en debates y diálogos sobre temas socio-ecológicos, permitió desarrollar conocimientos y acciones articuladas que fueron luego los cimientos de un nuevo paradigma de manejo del fuego y de estrategias de mitigación y adaptación al cambio climático en el PNC. Desde 2015, estas acciones se han extendido a países vecinos del Escudo Guayanés, al norte del Amazonas, y otras regiones de América Latina, con el apoyo de instituciones venezolanas, británicas y otras europeas.

Palabras clave: Conocimiento indígena del fuego; integración de conocimientos científicos, indígenas y técnicos; manejo integral del fuego; Parque Nacional Canaima; Amazonia norte.

Introduction

Fire is a natural phenomenon of terrestrial ecosystems, occurring on all continents of our planet (Bowman *et al.*, 2009; Bilbao *et al.*, 2020; FIRMS, 2021). It is associated with human evolution, from prehistoric times to agricultural activities and the formation of cultural landscapes (Mouillot & Field, 2005; Pausas & Keeley, 2009; GFMC, 2013; Bowman *et al.*, 2011). The area affected by fires annually ranges between 300 and 400Mha (GFMC, 2013; GFMC, 2019; IUFRO, 2018) with an average of 341Mha (1997-2011), or 2.6% of the entire global land area (Chatenoux & Peduzzi, 2013; van Lierop *et al.*, 2015; Giglio *et al.*, 2018).

Fires have a significant impact on the production of carbon dioxide and other greenhouse gases (CH₄ and N₂O) that contribute to climate change (Randerson *et al.*, 2012). From 1997 to 2016, biomass burning from different ecosystems produced CO₂ emissions (2.2 10¹⁵ g C yr⁻¹), equivalent to 23% of global fossil-fuel CO₂ emissions in 2014 (Le Queré *et al.*, 2015; Boden *et al.*, 2015; Van der Werf *et al.*, 2017). Approximately 84% of global carbon emissions originate in the tropics. Sixty two percent is from tropical savannas, underlining the importance of fire as a driver of biogeochemical cycles and ecosystem processes in tropical ecosystems, particularly in savanna areas (Van der Werf *et al.*, 2017). Savannas were the ecosystems, at the global level, with higher mean values of fire attributes (ignitions, size, duration, expansion and speed) relative to the other fire types (boreal forest, temperate forest, deforestation, agriculture) during 2003-2016 (Andela *et al.*, 2019).

However, not all fires are the same. Millions of people across the world use fire in managed or controlled ways. This could be for social, cultural and economic reasons, linked to livelihoods including swidden cultivation or rotational farming, hunting, gathering of materials and food collection (Mistry *et al.*, 2005; Bilbao *et al.*, 2010; Ziegler *et al.*, 2011; Huffman, 2013; Welch, 2014; Archivald, 2016; Eloy *et al.*, 2018; Nikolakis & Roberts, 2020). A wildfire, on the other hand, is any uncontrolled fire in combustible vegetation that occurs in the countryside or wilderness area. Wildfires usually differ from other fires by their extensive size, the speed at which they can spread out from source, potential to change direction unexpectedly, and their ability to jump gaps such

as roads, rivers and fire breaks (Bowman *et al.*, 2009; GFMC, 2013; GFMC, 2019). In some countries, large wildfires are becoming the most common expression of wildland fires at present. For example, in the United States, it is estimated that 3% of fires are responsible for 95% of the area burned (Short, 2014).

The main global drivers of wildfires today are increases in the length of the fire weather season and drought duration and intensity due to climate change, demographic and land use change, and policies that are not consistent with the socio-environmental realities of the territories and entrenched in a history of fire suppression. This has led to a new dynamic of fires: an increasing frequency of wildfires of high intensity that fall into the category of “mega-fires” that exceed the containment and fighting capacity of fire-fighting services, retreating only when the weather or fuel conditions change (Tedim *et al.*, 2018; Bilbao *et al.*, 2020). Mega-fires differ from the large wildfire; they transform ecosystems and habitats, have severe socio-economic impacts, and generate substantial costs in human lives and fire suppression efforts, reaching regional disaster level (Fidelis *et al.*, 2018; Moreno *et al.*, 2020a; Bilbao *et al.*, 2020). Recent examples of mega-fires are in the Pantanal (Brazil, 2020, 3.2Mha, 22% of the territory; Mega, 2020), Delta del Paraná (Argentina, Jan-Sept 2020, 330000ha, 14% of the territory; MAyDS, 2020), and California, Oregon and Washington (the USA, 2.5MHa, Bloch *et al.*, 2020). In general, fires in South America have peaked from February to June and from August to October 2020, with these nine months having the highest numbers of fires since 2011. During March, April and May 2020 respectively, fire hot pixels were 20%, 49% and 10% higher than previously registered highs since 1998 (Anderson *et al.*, 2020).

In the past decades, most Latin American countries adopted ‘zero-fire’ policies to avoid and control virtually any fire type. These policies focus on fire-fighting techniques such as fire brigades, technical support (e.g., helicopters and trucks), predictive fire risk modelling, and environmental education programs, to dissuade Indigenous and, in general, rural peoples from burning (Eloy *et al.*, 2019; Mistry *et al.*, 2019; Ponce *et al.*, 2020). However, the region’s fire exclusion and fire-fighting policies have frequently failed in operational, ecological, and socio-environmental terms, especially in fire-dependent areas, such

as grasslands and savannas. The main criticisms made of fire suppression policies are that they do not take into account the ecological and cultural role of fire in many ecosystems of the world, and to date, have been ineffective at reducing the area burnt (Eloy *et al.*, 2019; Mistry *et al.*, 2019; Ponce *et al.*, 2020; Bilbao *et al.*, 2020; Durigan, 2020).

What can the alternative be? Is it possible to avoid catastrophic wild to fires (wildfires) fires under conditions where fire-dependent and fire-sensitive ecosystems coexist? Can fire be managed in coexistence with local populations who rely on it for subsistence practices?

New paradigms of fire management have emerged both in South America and in other regions of the world, which show themselves to be more effective in socio-environmental and economic terms than suppression policies, especially under conditions of extreme climatic events. This new approach to fire is based on the recognition of the diversity of knowledge, expectations, interests and needs (biological, social/cultural and economic), emphasizing the importance of intercultural dialogues and healthy governance systems to sustain decisions on the use or not of fire (and define where, when and what to burn) (Myers, 2006; Bilbao *et al.*, 2010; Durigan & Ratter, 2016; Falleiro *et al.*, 2016; Bilbao *et al.*, 2019; Mistry *et al.*, 2019; Barradas *et al.*, in press; Bilbao *et al.*, 2020).

This article tells the story of the collective construction of a new fire management paradigm in Venezuela, starting from suppression policies to adopting a participatory and intercultural approach to fire management. This process initiated in Canaima National Park (CNP), a protected area of 30,000km² that lies at the centre of the geologically ancient Guiana Shield of Venezuela in the northern Amazonia basin of South America. The CNP is comprised of a vegetation mosaic of dense evergreen submontane and montane forests and savannas, and high tepui (tabletop) meadows and shrublands, and constitutes a globally strategic area for ecosystem conservation due to its high biodiversity richness and the presence of globally threatened endemic species (766 species, IUCN Red List Ecosystem). Because of its geological and physiographical singularity, in addition to its biological and cultural value, CNP was declared a UNESCO World Heritage Site in 1994. This strategic area protects part of the Caroní Basin's headwaters, influencing the hydrological stability

of the Guri Reservoir which generates 80% of the country's hydroelectric power. The CNP is also home to the Pemón Indigenous people. They inhabit and manage the extensive territory of the Park, particularly the sizeable eastern savanna region called the 'Gran Sabana'. Forest is also an essential ecosystem for the Pemón culture due to its high provision of resources (fruits, firewood, crafts, construction material, medicines), water and soil organic matter for shifting cultivation practices.

Conservation policies undertaken in past decades in CNP have dismissed traditional fire management by the Pemón Indigenous peoples, leading to the dangerous build-up of fuel that promotes catastrophic wildfires. Together with global climate, socio-cultural and demographic changes in the Park, the impacts on the unique biocultural landscape of CNP are potentially devastating. Therefore, a coherent fire management plan is crucial for conserving this threatened landscape and the Indigenous communities that depend on it for their survival.

Description of the area

The Canaima National Park (CNP, 5°20'0"LN, 61°30'0"LW), located to the southeast of the Orinoco River in the border with Brazil, is the second largest park of Venezuela (3MHa). The CNP forms part of the Guayana Massif, which is one of the most ancient geological formations on Earth (3000 million years) and extends over a large area of the northern Amazonia Basin (Figure 1). The Park, created in 1962, sits on the ancestral territory of the Indigenous Pemón, who have occupied the region since prehispanic times (Perera, 2000; Gassón, 2002). According to the national census (INE, 2011), this Indigenous group's total population was estimated at 30,148 people, of which more than three quarters live within the Park's perimeter-making it the fourth largest Indigenous group numerically in the country. CNP is also the National Park with the largest number of inhabitants in the country.

The frequent occurrence of fires is of great concern in CNP, where large treeless savannas occur despite the fact that forest is the predominant vegetation type in the park (Delgado *et al.*, 2009). The actual vegetation cover is considered by some authors to be a transitional stage in a long-term process of degradation, originally caused by fires, and conditioned by high vulnerability of forests,

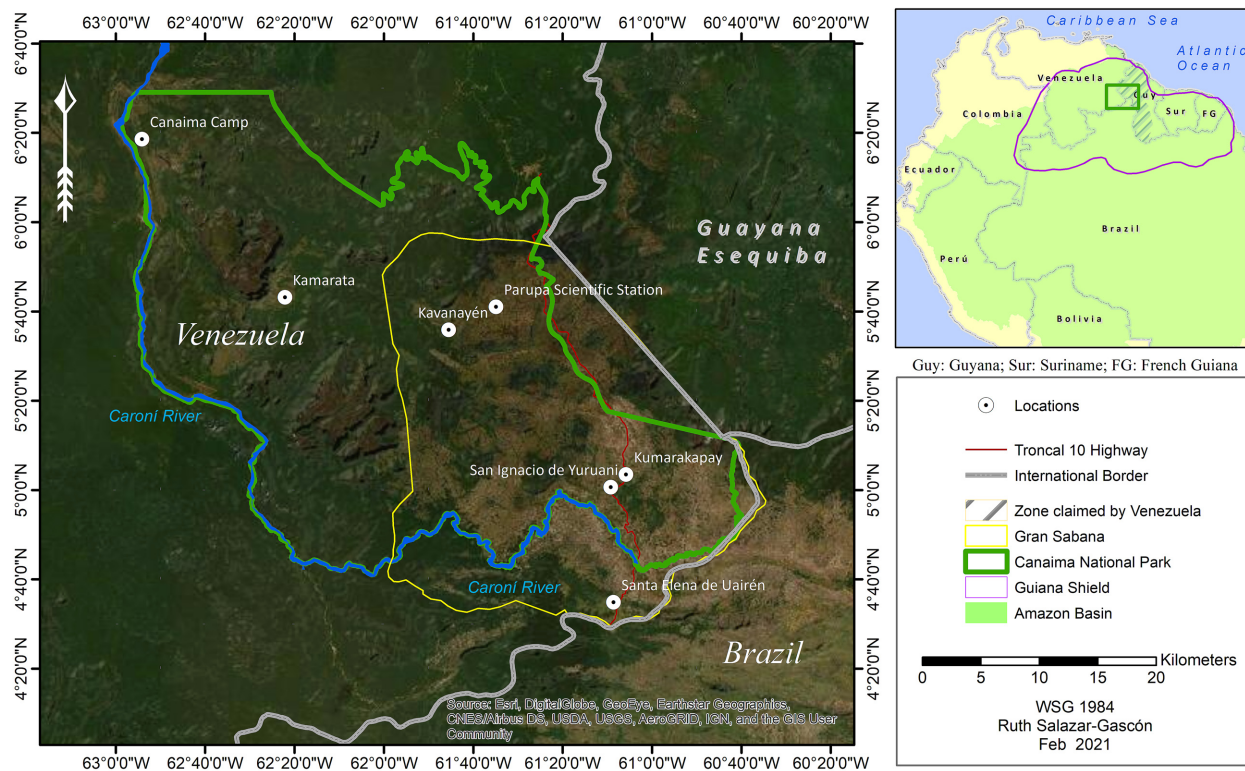


Figure 1 – Location of Canaima National Park. Dark green areas indicate woodland ecosystems and beige one’s savannas. Data base: Red Amazónica de Información Socioambiental (RAISG, 2020: <https://www.amazoniasocioambiental.org/>), ECOSIG y EDELCA.

soils and episodic drought stress (Hernández, 1999; Fölster *et al.*, 2001; Dezzeo & Chacón, 2005; Hernández & Castellanos, 2006; Rull, 2009; Hernández *et al.*, 2012). On the other hand, the local population, the Pemón community, depend on fire for their livelihood and sustain that fire use is a cultural right (FIEB, 2007).

The ‘Gran Sabana’ plateau, excluding the tepui tops, shows an altitudinal N-S gradient from 1,500 m.a.s.l. in Sierra de Lema to 800 m.a.s.l. in Santa Elena de Uairén, on the Brazilian border. The climate can be considered tropical humid to very humid and submesothermic for the whole region, with annual precipitation between 1,500 and 4,000mm and average annual temperatures between 17°C and 22°C. The rain pattern is seasonal in the Gran Sabana, with a wet season from May to December and a drier period from January to April (Hernández, 1994; Huber & Febres, 2000).

The vegetation is dominated by “Terra firme” and riparian forest, representing 60% of the

total vegetation cover (Delgado *et al.*, 2009). Both types of forests are evergreen with a mountain type and submesothermic (800-1,500 m.a.s.l.), and constitute the region’s most used ecosystems by the local Indigenous population. This latter issue contributes to increasing the already high spatial heterogeneity of these forests, which results in clusters of forests with different heights, levels of structural complexity and associations with secondary forests, scrub or savannas, not always related to changes in landforms or soil texture (Dezzeo, 1994; Hernández, 1994; Bilbao *et al.*, 2011a; Figure 1).

On average, 70% of wildfires originate in the Gran Sabana’s savanna areas (Gómez *et al.*, 2000; Bilbao *et al.*, 2010). In consequence, savannas and ecotonal savanna-forest zones represent the most exposed areas to the action and degradation of wildfires. The ecotonal savanna-forest areas are also very vulnerable due to the presence of a diversity of forest tree seedlings (Bilbao *et al.*, 2011a).

Fire suppression policies in Canaima National Park, Venezuela

In 1980 the national hydroelectric company CORPOELEC (formerly EDELCA) and CVG (acronym in Spanish for Venezuelan Guayana Corporation) created a program for fire suppression and combat, framed within a policy of fire exclusion in the region to protect and conserve the vegetation of the Caroní basin, including CNP. The program was born as a response to the impact of a long history of wildfires in the region, especially during the intense dry seasons of 1979 and 1980, which affected extensive areas of forests, shrublands and savannas, shocking public opinion and the media. Park administrators and the hydroelectric company's perception and major concerns were that forest cover loss was associated with big wildfires, their potential effect on hydrological soil erosion and the increase of the amount of sediments that could be deposited downstream in water bodies and dams. Thus, in 1981, with the approval of the formally competent institutions, a PCIV (acronym in Spanish for Vegetation Fire Control Program) was created, with CORPOELEC in charge of the prevention, detection, combat and investigation of wildfires in the region. Additionally, an Intensive Protection Area (API, acronym in Spanish) was established (21,100km²) according to the priorities of CORPOELEC (Hernández, 1984). The API included the drainage network of the Caroní river, integrated by the sub-basins of the Karuay, Aponwao, Yuruaní, Kukenan, Arabopo and Ikabarú rivers (Gómez *et al.*, 2000; Millán, 2015).

Since its creation, the main objective of the PCIV has been to reduce the impact of fire on vegetation (mostly the forest), regulate the transport of sediments to avoid erosion, and "minimize burning and ensure adequate fire management" by the Pemón Indigenous communities (Galán, 1984; Gómez *et al.*, 2000; Rodríguez, 2004). For this purpose, the PCIV has been training its staff in technical aspects of prevention, detection, firefighting, and the PCIV Information System (Todd, 1985; Figure 2a and 2b). The PCIV Brigade, also called the 'Carlos Todd' Initial Attack Brigade, were named in honor of Ing. Carlos Todd, a pioneer member of PCIV Brigade, who promoted research and the use of to combat wildfires in the region. The Brigade focus on early interventions against wildfires; most of their members are Pemón Indigenous members, many of whom have been in service since its creation, for more than 30 years.

This characteristic has been of great importance for the good performance of the program since its members have an in-depth knowledge of the territory and the motivations, location and periodicity of the cultural practices of fire use carried out by the Pemón. However, Indigenous Pemón PCIV members can only reach the rank of Chief of Brigades or Coordinator, with higher positions going to non-Indigenous people based outside the Park. Therefore, fire policy is defined at higher hierarchical levels, sometimes outside the Gran Sabana, at the company headquarters.

Despite the enormous organisational efforts, high professionalism and commitment by all the staff of Carlos Todd Initial Attack Brigade and the significant investment made by the regional government during the last thirty years in the development of infrastructure, and the provision of equipment and personnel for the program of fire control in the Park, on average only 13% of the 1000 to 3000 fires reported per year can be effectively fought (Gómez *et al.*, 2000; EDELCA-CORPOELEC, 2008).

This program has also had social costs, stemming from the historical conflict over fire with the Pemón Indigenous communities. The institutional narrative elaborated by CORPOELEC during these years led to a public image of the Pemón people as being responsible for the wildfires, and stigmatizing the traditional practice of burning as the source of the "fire problem". Both assumptions are summarized in the qualifying adjective of "quemones" (from "quemar": to burn, it stands colloquially for "burners", "those who burn", a pejorative term (Rodríguez *et al.*, 2013; Bilbao *et al.*, 2017) or "compulsive burners" (Rull, 2009), which were popularly applied to the Pemón.

On the other hand, Pemón people, independent of their age, perceived that the conservation and preservation policies and programs advanced by the different public agencies, placed them at a crossroad: "If we cannot make the burnings, nor work in the conucos (small Indigenous cultivation area inside the forests), how shall we eat?" Additionally, they wondered why was it that now fire turned out to be wrong while they had been using it in the same manner for thousands of years (Bilbao *et al.*, 2019). However, some of them, especially the younger ones, admitted the loss of the elders' traditional knowledge of fire use and the sense of the burnings. Thus, they posed



Figure 2 – a) Forest firefighters from the Carlos Todd Initial Attack Brigade creating a firebreak to control a wildfire in the western sector of the PNC. b) Fighting a vegetation wildfire in the vicinity of the Roraima Tepuy in 2007 (Photographs a and b by PCIV). c) Pemón Indigenous, from Para-biologist program, registering air and soil temperatures after fire spread through an experimental fire plot. d) Some Indigenous participants from the Para-biologist course, firefighters from the Vegetation Fire Control Program of the hydro-electrical Company (CORPOELEC-EDELCA) and the research team from the Simón Bolívar University (USB) in charge of the IAB (Interactions Atmosphere – Biosphere) project (Photographs c and d by USB team).

the need of recovering traditional knowledge as a form of “not losing the credibility of the Pemón nation as the guardian of the savanna”.

Building a new fire management paradigm

In Venezuela, since 1999, initiatives for the consolidation of intercultural and participatory fire management in the Gran Sabana, Canaima National Park (CNP), evolved as a result of a series of participatory action-research projects coordinated

by the Simón Bolívar University, financed by the Ministry of Science and Technology and supported by national and regional public development institutions. The inclusion of Pemón Indigenous communities, firefighters, government institutional actors and academics in field research and joint experimentation on fire behaviour, as well as the debate and dialogue on socio-ecological issues of the CNP, led to the development of articulated knowledge and actions resulting in the foundation of a new paradigm of fire management and strategies for climate change mitigation and adaptation. Since 2015 these actions have been further extended

to neighbouring regions of the Guiana Shield of Brazil and Guyana with the collaboration and support of Venezuelan, British and other European institutions. In the same year, the Intercultural and Participatory Fire Management Network (or Parupa Network) was founded to strengthen and enhance the above-mentioned initiatives and to learn among the different stakeholders (local communities, scientists, government).

In the following sections, we summarise the main developments to date.

4.a. The first steps. Long-term fire experiment on the savanna-forest gradient in Gran Sabana. For the first time, the academy becomes an ally of Indigenous peoples in the topic of fire

- **IAB Project:** *Interactions Atmosphere – Biosphere of the ‘Gran Sabana’, Bolívar State, Venezuela (Figure 3).*

Various impacts of extreme severity have been attributed to fire, for example, intense processes of degradation of the vegetation, loss of buffer capacity to resist extreme climatic phenomena, soil degradation, changes in the water balance, tourism-related degradation, sediment increase in water courses, alteration of biogeochemical cycles and biodiversity loss. Due to the strategic importance of this region, both political and economic, these types of threats constituted a deep concern for local, regional, national or international institutions dedicated to conservation. Thus, one of the motivations to perform experimental studies on fire and its impacts on ecosystems was the lack of evidence of the real impact of fire on plant and soil components, the relevance of climatic variables and combustible material on the behaviour of fire as well as their historic effect on ecosystems.

To understand the actual dynamics of fire in the region, a long-term fire experiment was initiated in 1999, as part of the IAB multidisciplinary project, funded by the Ministry of Science and Technology (Bilbao *et al.*, 2009; Bilbao *et al.*, 2010; Millán *et al.*, 2013; Bilbao *et al.*, 2017). The experiments allowed an evaluation of the behaviour of fire and its effects under different treatments of frequency and period of burning during the dry season; they were conducted by simulating Indigenous burning practices on a savanna-forest gradient (where 70% of all fires start) in conjunction with members of

the Indigenous community and CORPOELEC’s fire brigades (Figure 4 a).

The long-term fire experiment was carried out using permanent plots (5°41’08.8”N - 61°31’39.9”O) in the north of the ‘Gran Sabana’ (one of the areas with higher fire incidence), in a savanna-gallery forest gradient characteristic of the region (Figure 4b). The experiment compared the behaviour of fire and its effects on vegetation and soil in 31 burns carried out in 21 plots of 0.5ha distributed according to a randomized block design with three replicates according to the burning treatments: a) different periods during dry season; b) different annual fire frequencies; c) control areas without burning (with fire exclusion from 1 to more than 12 years).

All the decisions regarding time of the day, meteorological condition adjustments, ignition onset and fire extinction were carried out according to the technical knowledge of the PCIV brigades, and traditional knowledge from Pemón people from different communities. The long-term biomass recovery and the effect on soils after the burns were carried out by periodic biomass and soil collections throughout the study period (Bilbao *et al.*, 2009; Bilbao *et al.*, 2010).

The results of the fire experiment (Bilbao *et al.*, 2009; Bilbao *et al.*, 2010; Bilbao *et al.*, 2011a) evidenced the following aspects:

1. Fire can occur in a broad range of climatic conditions and of combustible material characteristics.
2. Contrary to widespread belief, the burns are highly variable regarding intensity and behaviour and, in general, show low combustion efficiency. None of the 31 experimental burns was the same, breaking the myth that fire, when it occurs, is calamitous, contesting the belief that fire absence is always a good thing.
3. The wind velocity, accumulation of dead material, and leaf and stem biomass of the herbaceous layer constitute the main factors that contribute to fire behaviour increasing fire line intensities, burn efficiencies and fire propagation.
4. Due to the low recovery of biomass after a fire, the combustible material does not sustain annual burns, which are only possible every 3 to 4 years and, rarely, every two years.

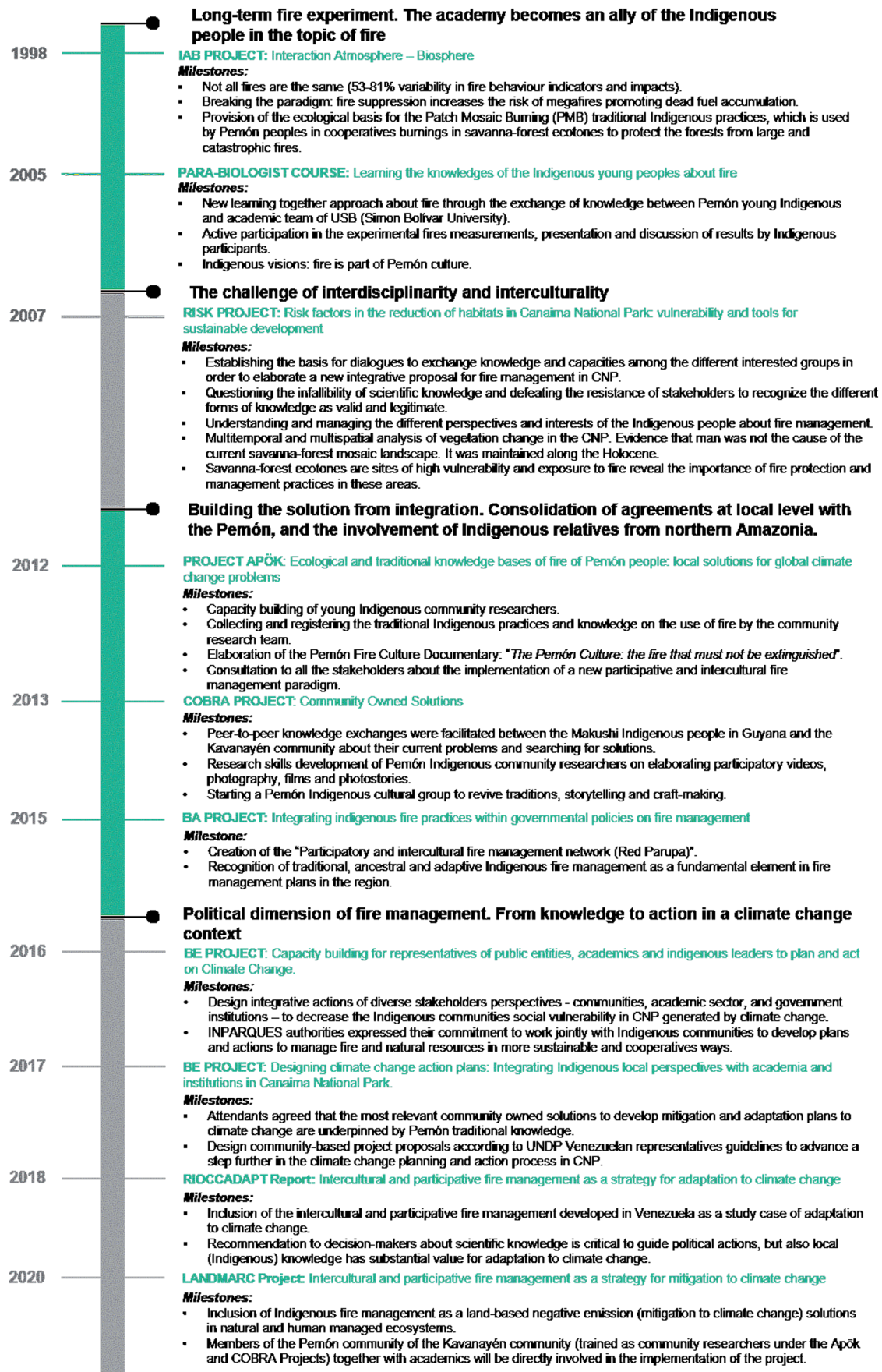


Figure 3 – Timeline and milestones building a new fire management paradigm along the last two decades in Venezuela (1998-2020).

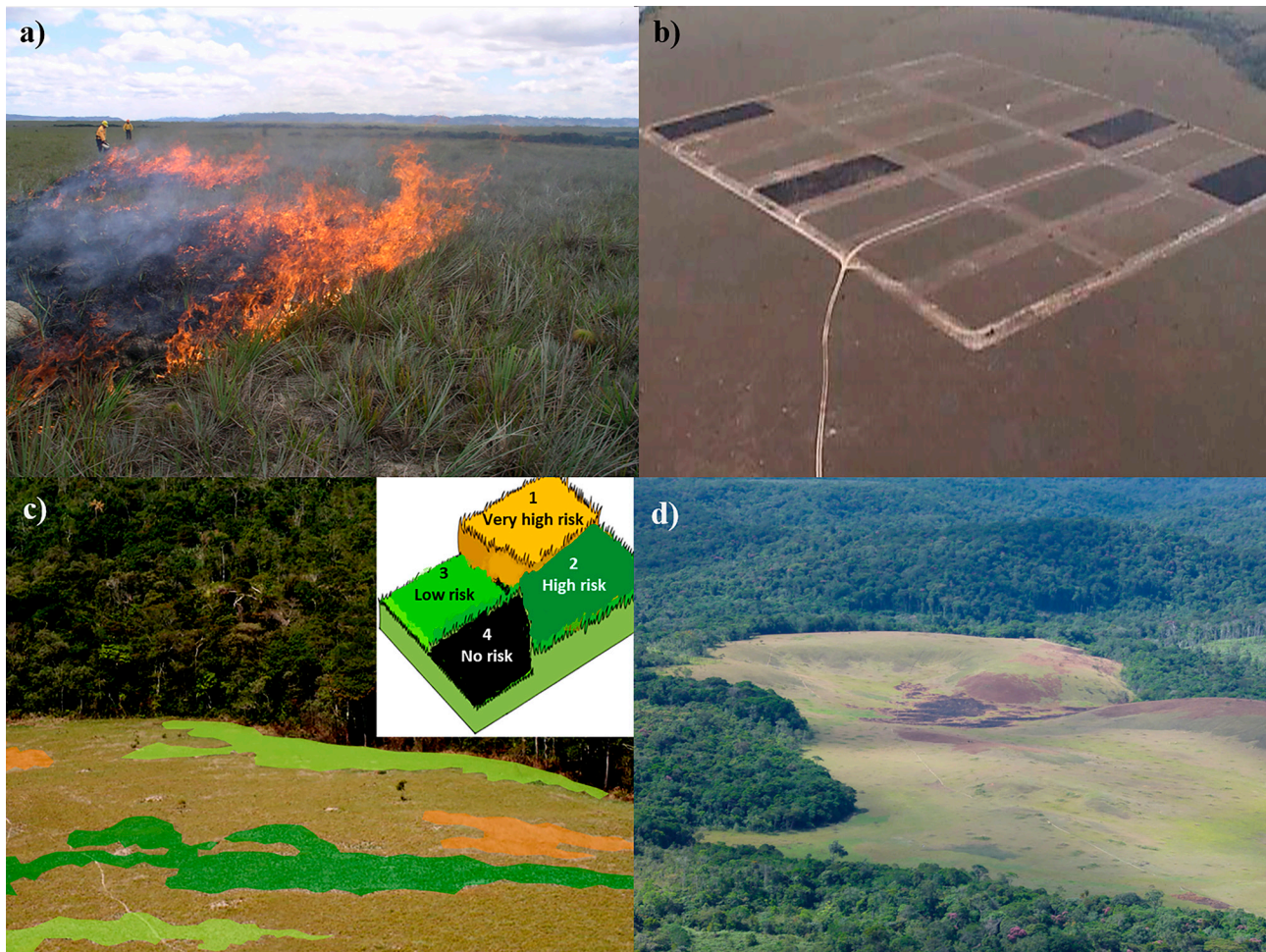


Figure 4 – Experimental burns initiated by Indigenous Pemón firefighters (Photography by Bibiana Bilbao); b) Aerial view of the long-term fire collaborative IAB experiment plots (Photography by Rafael Salas); c) and d) Different views of Indigenous Patch mosaic burnings (PMB) (Photography by Ruth Salazar-Gascón).

- When savannas are left undisturbed for more than four years since the last burn and reach biomass $>600 \text{ g m}^{-2}$ and a green/dry ratio >1 , they are more vulnerable and exposed to a greater risk of wildfire occurrence and spread.

These results suggested that the savanna vegetation in CNP allows the creation of a mosaic of patches with different fire histories; at the same time, these patches can be used as firebreaks to reduce the risk of larger fires, especially in the most vulnerable areas and those with high diversity, such as the savanna-forest ecotones, which, in turn, are the entry routes of fire into the forest. This technique is referred to as patch mosaic burning (PMB; Parr & Brocket, 1999; Bilbao *et al.*, 2009, 2010; Figure 4 c and d).

The discovery and characterisation of the ecological basis of the PMB technique was one of the most significant results of the study. This technique used by the Pemón for millennia produces a savanna landscape in different stages of succession, which acts as natural firebreaks when a wildfire reaches the border of a previous burned patch. This strategy avoids catastrophic wildfires in the most vulnerable areas of ecotones (Bilbao *et al.*, 2009; Bilbao *et al.*, 2010; Bilbao *et al.*, 2011a; Figure 4 c and d).

Many paradigms were broken by these experiences, the most important being that the Pemón Indigenous peoples were the incendiaries; by contrast, we showed that they were in fact the “masters of fire”. In conclusion, the academic knowledge together with the traditional Pemón

knowledge opened the possibilities of a new fire management scheme in Canaima National Park, under the ancestral Pemón system of ‘fire controls fire’. This strategy contradicted those adopted by governmental agencies of the Park that used fire exclusion leading to the risky accumulation of dead combustible material that can promote the occurrence of wildfires of considerable magnitude and extension.

However, it was also clear that besides to suppression policies, the Indigenous acculturation processes had become another threat to traditional practices in the use of fire by Indigenous communities. This was promoted initially by religious missions and later by formal school education, as well as changes in the socio-economic patterns of Pemón communities. The acculturation process’s main consequences were revealed by the use of fire by some young members of Pemón communities, who did not follow the underlying knowledge of the grandparents about how, where, and what for it should be used (Bilbao *et al.*, 2010; Rodríguez *et al.*, 2013; Bilbao *et al.*, 2017; Bilbao *et al.*, 2019).

Thus, from this analysis we understood the importance not only of the ecology but also of the human dimensions as part of the conflict regarding the use of fire in the region. Likewise, the low effectiveness in the management of fire was revealed in the lack of connections among state institutions in CNP, Pemón Indigenous communities and information generated in academic institutions, as well as the articulation of knowledge.

The publication of the results (discussed in this section) from the article by Bilbao *et al.* (2010), earned the authors the National Award 2013 for Best Scientific Work and Innovation in Venezuela.

- **Course for Para-biologists**, *learning the knowledge of the Indigenous young people about fire (Figure 3).*

In February 2005, the leading author of this paper was invited to participate as a speaker in the “Para-biologist Training Program for the Pemón People”, organised by “The Nature Conservancy-Venezuela”, together with the Universidad Experimental de Guyana (UNEG) and Fundacite Guayana, at the Parupa Scientific Station, Gran Sabana Authority of the CVG. This Program

consisted of the training of fifteen young Pemón, from different regions of their territory and ethnic groups: Arekuna, Taurepán and Kamaracoto. Selection criteria for the Indigenous participants was based on having had some form of educational training. The topic of the course was “Non-forest ecosystems and the management of savannas”; to define the concept of savannas and describe the environmental and biological parameters that determine the existence of savannas and other non-forest ecosystems.

It is crucial to mention that fire related issues were not included in the course. Fire was still a taboo subject to deal with, both for the communities that felt historically stigmatised and “blamed” for the use of fire in the Park, and for the Park authorities, which did not want to re-start the “fire conflict” with the Pemón communities in the Park. However, on a personal level, Bibiana Bilbao considered it impossible to talk about the ecology of the Gran Sabana, particularly in savanna ecosystems, without including fire. So, she considered to add to the aims of the course: “*the importance and use of fire in savanna management and other ecosystems*”.

This activity represented an enormous challenge. Despite having taught at the University (to undergraduate and graduate students) and having been a primary and secondary school teacher, Bibiana Bilbao felt that it was not fair to assume the role of teacher on this occasion. How was she going to teach the Pemón people about savannas and fire? Perhaps they were the ones that should teach her. Hence, she decided then to implement a knowledge exchange dynamic, sharing her knowledge with them, and they agreed to share their knowledge with their colleagues and with her. At that time Bibiana Bilbao and her team were engaging in the long-term fire experiment on the permanent plots of the savanna-forest gradient near Parupa Station. She invited the course participants to accompany the 2005 experimental burns and the corresponding measurements of fire behaviour (rate of propagation, flame height, fire temperature profiles, intensity, burning coefficients, among others), meteorological variables (air and soil humidity and temperature, solar radiation, wind speed and direction) and combustible material (species composition, accumulated biomass, green to dry ratio, and moisture content). She and her team also gave the participants initial training on the use of the equipment and methodology for

measuring different variables, as well as the use of computers for data analysis and results presentation (Figure 2 c and d).

After the participation in the experimental burns and the visit to different plant communities of grasslands, ferns, forests and savannas in the area, a discussion about the role of fire in the dynamics of ecosystems was organised. The participants of Para-biologist course presented the results obtained during the experimental burns and participated actively in the discussion and debates. Some relevant conclusions related to fire during the discussions were:

- 1- At no time was fire mentioned as a disturbing element in the savanna, despite repeated questions regarding the determining drivers of savanna dynamics. For them, fire is part of the savannas, like plants and soil.
- 2- Fire is an important management tool in the establishment of conucos (itinerant agriculture) and hunting practices in forest and savanna-forests ecotones. Fire is an essential part of their culture.
- 3- Several participants stated that various traditional practices in these activities are being lost within the Pemón communities, making it more difficult to control fire and its effects, especially under recent climate changes and weather variability.
- 4- The use of fire in different practices has increased, due to the increase of food demand, contributing to a greater fire frequency and area of impact.
- 5- They mentioned the expansion of the savannas and a marked reduction in the forest area due to a more intensive agriculture and hunting practice.

Bibiana Bilbao noticed the exchange of knowledge that took place was one of the most fascinating experiences of her entire career as a researcher and teacher. It was also very stimulating and enriching to see the interaction between Indigenous participants, and students and technical staff of the laboratory from USB. The firemen of the CORPOELEC Program also participated in this activity and taught them many practices and knowledge about how to control and avoid the spread of fires. For the first time in the Park, they all had the opportunity to learn from each other.

These experiences were the seeds that showed the need for the next project to be not only interdisciplinary (a step beyond the multidisciplinary nature achieved in the IAB project), but also intercultural, with the active participation of Indigenous people, Park administrators, firemen and in general all stakeholders in the Park. In addition to these two challenges, a third requisite that became evident was the need to carry out action-research. How could one move from knowledge to action? Trying to answer this question, the “Risk project” was born.

4.b. The challenge of interdisciplinarity and interculturality. Building the bridge between Indigenous and ecological knowledge, as well as of institutions around the fire theme

- **Risk Project:** *Risk factors in the reduction of habitats in Canaima National Park: vulnerability and tools for sustainable development (Figure 3).*

The Risk Project aimed at establishing the basis for dialogues to exchange knowledge and capacities among the different interested groups in order to elaborate an integrative proposal for fire management in CNP. The notion of risk was strategically used in the heading of the project proposal to call the attention of our prospective funder, the National Science Council, about the importance, novelty, and opportunity of the project. We wished to emphasize the increasing vulnerability with regard to interconnected technological, social and natural risks of catastrophic potential, the uncertainty with respect to the patterns and frequency of natural disasters due to environmental change, and the growing importance of the symbolic connotations of risk. We wanted to explore an increasingly significant approach brought to us by one of our co-authors (Hebe Vessuri), who had previously been related to the Millenium Ecosystem Assessment, and was a member of the scientific boards of the International Risk Governance Council (IRGC), the International Science Council (ICSU)´s Committee on Scientific Planning and Review, and the International Human Development Program on Global Change (IHDP). She brought to us examples showing a valuable mindset change with regard to science and scientific authority. Scientific knowledge

in modern history had been almost universally considered an undisputed public good. Now, it was also perceived as potentially producing risks and dangers so far unthinkable. Technological development was already incorporating notions of uncertainty, ambiguity and complexity (Renn, 2008).

Placing the issue of governance within a broader agenda that contemplated the cultural strengthening of Pemón Indigenous communities through their active participation in knowledge exchange and sharing, changed our research perspective. It gave a clearer focus on the need to develop capacities and strategies that went beyond a simple discourse about the practice of multidisciplinary and presented challenges such as (a) understanding and managing the different perspectives and interests of the people involved relative to problems at different scales and their impacts in the management and governance of conflicts; (b) defeating the resistance of stakeholders to recognize the different forms of knowledge as valid and legitimate; (c) reconciling the different social and political contexts involved in these processes; and (d) developing a research approach based on deepening a critical learning focused on the construction of communication bridges indispensable for a permanent “translation” process between disciplines, knowledge fields, communities and management and decision-making institutions.

To meet these challenges, we developed a series of actions, mainly within the framework of the Risk Project and in cooperation with other initiatives.

- 1) The promotion of safe meeting spaces to enable the construction of a knowledge dialogue among Indigenous communities and institutions about fire management in CNP (Figure 5). The first achievement of the project was the implementation of a symposium entitled “Institutional, ecological and sociocultural perspectives on the fires of Canaima National Park” and the workshop “Bringing together perspectives for the creation of a legitimate and effective environmental policy for the management of fire in Canaima National Park”. Both were carried out in the VII Venezuelan Congress of Ecology in Ciudad Guyana November 5-9, 2007 (García & Bilbao, 2007; FIEB, 2007). In the symposium, representatives of

the Pemón people participated for the first time as stakeholders, and eight chiefs from different communities joined the event. This first workshop aimed at analysing the scientific (academic) knowledge, Indigenous wisdom and different perception of fire and its effects in the region and constituted the first meeting of this type in the country, especially because of the participation of Indigenous people.

Among the main conclusions of the workshops was the need to acquire knowledge about fire and its effects in CNP and develop tools for an effective management and use in the region.

- 2) To complete this last objective, a risk analysis approach was followed (considering the vulnerability, exposure and risk of ecosystems). In this sense, to better understand the role of fire in ecosystems, studies were carried out in the short, medium and long term and at different spatial scales. The process of building this new knowledge was carried out with the support and participation of the Indigenous communities.

Here is a summary of the main results and conclusions of the studies carried out in this sector:

- 2a- Studies in different locations in Canaima National Park, both in the eastern part – Gran Sabana – and in the western region, revealed oligotrophic, highly acidic soils, generally sandy in texture, and very low organic matter content, even in forested areas (Pedraza *et al.*, 2009; Salazar-Gascón *et al.*, 2012; Bilbao *et al.*, 2013). Despite these nutrient limitations, Indigenous soil management techniques seemed very useful for agricultural activities, especially when considering that Indigenous people settled in the area millennia ago. Studies of the effect of fire on savannas’ and forests’ soil component revealed a soil nutrient availability increase and a marked decrease in the toxic aluminium acidity (Salazar-Gascón *et al.*, 2012; Bilbao *et al.*, 2012; Lares, 2015). The use of fire by Indigenous people in shifting cultivation practices, throughout the tropical region, is a practice known for the efficiency of transferring nutrients from plant biomass



Figure 5 – a) Meeting between the Indigenous community members of Kavanayén, Canaima National Park, and representatives of the Risk project. b,c) Working group made up of elders and youth from the Pemón indigenous communities (Photographs a, b and c by Diego Bilbao). d) Pemón Indigenous grandfathers and e) Pemón Indigenous participants in one of the assemblies with the Kavanayén community (Photographs d and e by Adriana Millán). f) Risk Project working group (Photography by Diego Bilbao).

(the main component that stores nutrients) for the fertilization of soils.

2b-Since forests are the primary source of ecosystem services (such as climate and hydrological cycle regulators, soil conservation, etc.) and natural resources for the Pemón people, we evaluated if these ecosystems were at risk, including their vulnerability and degradation levels. Likewise, if this is happening, what are the

degradation rates and at what time scale are they occurring? And finally, what is the role of fire in these processes?

To answer these questions, we studied the history of vegetation changes at different time scales: millennial-scale (paleoecological studies), decadal-scale (through remote sensing studies) and in periods of a decade or less (through remote sensing and the aforementioned long term fire experiments) corresponding to several locations

in the western sector (Gran Sabana) and eastern CNP (Canaima).

Paleoecological Studies:

Palaeoecological reconstructions based on the analysis of pollen, spores and microcarbons were obtained from five sedimentary records located in the N-S altitudinal gradient of the Gran Sabana, in shallow lagoons, riparian forest and fern systems. The radiocarbon ages of the records ranged between 7500- and 1200-years BP (Leal, 2010; Leal & Bilbao, 2011; Bilbao *et al.*, 2011b).

High levels of Poaceae pollen (grasses, the dominant herbaceous component of the savannas) were present along all the paleorecords in the Gran Sabana sites. This indicates that large areas of savanna, comparable to the actual ones, have existed in this region since the Early-Middle Holocene (around 7500 BP-before present). The only exception in this regard was the record located on the Gran Sabana's border, which has remained forested during millennia. Furthermore, the peat bog from "Parupa" showed that woody elements' density was higher in a drier period under more frequent/intense local fire regimes than the actual precipitation and fire conditions. In "El Oso" locality, savannas were more extended in the past than in the present, reaching up to 60% of total counts of pollen during 3,400 to 1,900 years BP, after forest species pollen types started to increase slowly.

Our results suggested that extensive treeless savannas comparable to the current ones have occurred in the region for long periods. This means that the current proportion of forests and savannas present in the Gran Sabana have varied very little in the past 10,000 years (Leal, 2010; Leal & Bilbao, 2011; Bilbao *et al.*, 2011b; Leal *et al.*, 2013; Leal *et al.*, 2016).

Decade scale studies:

Vegetation coverage and land use maps of CNP Eastern sector (Gran Sabana) were obtained for the 1987-2007 period using Landsat Thematic Mapper TM / ETM + images with 30m resolution. Based on these maps analyses of vegetation change trajectories were performed through time (woody versus non-woody or herbaceous vegetation; Delgado-Cartay *et al.*, 2007; Higgins *et al.*, 2010).

Results revealed that secondary forests were the most dynamic ecosystems in the eastern sector of CNP and showed the most significant number of trajectories: 1) towards the formation of new conucos areas (agricultural areas), 2) remaining as secondary forests, 3) degrading towards mixed communities or savannas, and 4) recovering towards a state similar to primary or mature forest. Despite all these changes, the total area occupied by the different land-cover classes remained stable and the Gran-Sabana land-cover in 2007 is remarkably similar to what it was in 1987.

Considering the historical debate that has been associated to the human fire uses as the origin of the Gran Sabana landscape, composed by a mosaic of forests and savannas, we did not expect the land-cover distribution to remain constant. Likewise, this contrasts with dramatic shifts in landcover observed in other tropic forest regions over comparable periods of time and even at present (Nepstad *et al.*, 2001; Achard *et al.*, 2014; Barni *et al.*, 2015; Clerici *et al.*, 2020).

Another study based on the analysis of satellite images, in the western sector of CNP, indicated for a similar period of time, 1986 and 2006, an average rate of 0.064% forest cover loss within CNP limits (Flantua, 2008; Flantua *et al.*, 2013). For the same period in the external buffer zone (about 10km away from CNP borders) the mean observed loss of forest was 0.18% of the original wooded cover. This was almost three times higher than the loss rate registered within the Park. Similar annual rates of 0.16% in forest cover reduction were also recorded in the north western limits of the CNP where deforestation is probably caused by the illegal extraction of wood for commercial uses. This last figure contributed significantly to increasing the average value of forest loss for the entire CNP, which would have been even lower than the 0.064% registered (Flantua & Bilbao, 2007; Flantua, 2008; Flantua *et al.*, 2013).

These findings do not support the allegedly called "recent sabanization" process in the Gran Sabana due to Indigenous traditional activities, especially when considering that vegetation changes have occurred throughout the Holocene probably under changing climate conditions.

This leads to the conclusion that although it is possible that human beings have not played any determining role in the origin of the savannas of

Gran Sabana in CNP, they may have contributed to their maintenance through the use of fire, especially during humid periods when forest expansion processes in the region could have been favoured (Mendez, 1999; Leal *et al.*, 2016).

This last conclusion has profound implications in the current scenario of Global Environmental Change. Fire needs to be managed to avoid large fires in CNP that affect vulnerable plant communities such as riparian forests which provide vital environmental services in the area. The development of fire management plans in CNP must give priority to the contact zones between riparian forests and savannas since these systems have a more significant recurrence of fire and constitute principal sites of natural forest restoration (Bilbao *et al.*, 2010; Bilbao *et al.*, 2011a; Bilbao *et al.*, 2017).

The Risk project (“Risk factors in the reduction of habitats in Canaima National Park, Venezuela: vulnerability and tools for sustainable development”) received, in October 2010, the Europe Award for Innovation for Sustainable development in Venezuela (awarded by the Goethe Institute, the Spanish embassy in Venezuela, the French embassy in Venezuela, the British Council, the Delegation of the European Union in Venezuela and the Academy of Physical, Mathematical and Natural Sciences).

4.c. Building the solution from integration. Consolidation of agreements at the local level with the Pemón, and the involvement of Indigenous relatives from Northern Amazonia

- **Apök project** (fire in Pemón Language): *Ecological and traditional knowledge bases of fire of Pemón people: local solutions for global climate change problems (Figure 3).*

This project was part of a national portfolio of strategic research projects on climate change, promoted by the Ministry of Science and Technology of Venezuela. Apök project attended various interests and motivations expressed previously within the framework of Risk project either by the Indigenous community or the officials from national conservation institutions. Thus, the leaders and the council of elders of the Pemón Arekuna community, expressed publicly their concerns as demographic, sociocultural and educational

transformations have affected the traditional ways in which grandparents share their knowledge to new generations (Bilbao *et al.*, 2014; Bilbao *et al.*, 2019). As in many Indigenous cultures around the world, the system of knowledge transmission in Pemón culture is based on oral communication. Therefore, they identified the need to record in written or audiovisual manner their traditional practices about fire and in general their natural resources management. Likewise, the Risk Project identified the importance of promoting traditional practices of Indigenous fire, as a conservation tool for CNP laying the groundwork to build a new paradigm of fire management in the Park.

Considering the processes of ancestral knowledge loss faced by Pemón people, Apök project implemented several activities focused on the Arekuna community of Kavanayén in CNP:

- 1- The project started by setting a team of young community researchers, who were in charge of carrying out the process of gathering Indigenous ancestral knowledge and practices in relation to the use of fire, itinerant agriculture and hunting. The focus was to interview the community elders or grandparents, who are considered a living heritage of knowledge and traditions of the Pemón people. The Indigenous community researchers received training on the techniques for conducting interviews and on the collection and documentation of the information obtained. The decisions in relation to the grandparents to be interviewed and the questions being asked were jointly discussed with project researchers. The community researchers conducted all the interviews in Pemón language, and the information obtained was transcribed and validated afterwards with the interviewees (Figure 6a, 6b and 6c). During this process, several assemblies were carried out in the community to inquire further into relevant issues regarding the use of fire brought up in the interviews, as well as to present the advances of the project.
- 2- Following the request made by the Pemón community, a video documentary: “*Pemón Culture: The fire that must not be extinguished*” was done in the framework of the Apök project (Bilbao *et al.*, 2014). The production team submitted the video’s



Figure 6 – a) Community researchers and teachers of Kavanayén Agricultural Technical School (ETAK) carrying out soil and ash sampling tasks in the community school conuco in Kavanayén Indigenous community (photography by Dimana Shiskova); b) Worktables where grandfathers of the Pemón community validated the information collected by community researchers; c) Presentation of the worktable results about Indigenous traditional fire management (photographs b and c by Maiquel Torcatt); d) Community researchers conducting interviews for participatory videos (photography by Cobra team).

content to the approval of a community assembly. The documentary included interviews with youngsters, adults and elders revealing the importance of Pemón traditional knowledge about fire, as well as the threats and concerns resulting from interrupting these Pemón's practices in CNP's ecosystems (Figure 7). In November 2013, the video was completed and shown for the first time in the community, who was grateful and satisfied with its content. The video was also shown in the film forum: "To burn or not to burn: breaking the paradigms of the use of fire in the conservation of tropical ecosystems", organised by Apök Project, at the X Venezuelan Congress of

Ecology, celebrated in Mérida. This event allowed a valuable live communication exchange between Indigenous members of the community who attended the forum and academics.

- 3- In the framework of Apök, we also started to conceptualize collectively a new fire management paradigm for CNP. The proposal included the ancestral knowledge and practices of the Pemón about the use of fire, the development of scientific knowledge concerning the ecology of fire developed previously in the IAB and Risk projects, as well as the technical capabilities of the PCIV and entities in charge of fire control in the CNP.



Figure 7 – a) Indigenous community researcher interviewing one of the grandfathers during the filming of the documentary “Pemón Culture: the fire that must not be extinguished” (<https://youtu.be/ePc3UB98IE4>), (photograph by Adriana Millán). b) Indigenous community researchers in the process of collecting ancestral knowledge related to the use and management of fire (photograph by Sofía Marín).

The participative process was based on: 21 interviews (with PCIV brigade members and workers from the CORPOELEC Environmental Management Unit, Bolívar region), as well as four workshops (with members of the Pemón community of Kavanayén and Pemón brigade members of the PCIV). These activities showed how both Pemón community members and the institutions were willing to work together to design a management strategy that respects and considers Pemón traditions and knowledge. Participants agreed and highlighted the use of fire as a conservation strategy based on the implementation of prescribed burns, application of ancestral Pemón fire management practices, and support of academics. The use of participatory and adaptive approaches and the development of research programs accordingly, are fundamental to the new fire management approach (Millán *et al.*, 2013; Millán, 2015).

- **COBRA Project.** *Community owned solutions.*

During the APOK project, another project to promote traditional knowledge was initiated. Project COBRA, funded by the European

Commission, aimed to enable and disseminate grassroots solutions to complex environmental management and governance problems in the Guiana Shield, South America using an action research approach. As part of the project, peer-to-peer knowledge exchanges were facilitated; in this case between the Makushi in Guyana and the community of Kavanayén. More specifically, through participatory video and photography, films and photostories were screened and discussed, and this led to Kavanayén starting a cultural group to revive traditions, storytelling and craft-making (Tschirhart *et al.*, 2016). In addition, the project helped to build capacity in Kavanayén on the use of participatory video, thus adding to the growing suite of research skills developed by previous projects in CNP.

- **British Academy Project.** *‘Integrating Indigenous fire practices within governmental policies on fire management’* (Figure 3).

The results of the compendium of sustained actions described above set the stage for the First Regional Meeting of Intercultural Management for the Participatory Management of Fire, celebrated between July 8 and 11 of 2015. The meeting took place at the Parupa Scientific Station in the ‘Gran Sabana of CNP, where Pemón and Yekuana communities met and exchanged with Makushi,

Wapishana and Kayapo Indigenous peoples from Brazil and Guyana (Figure 8 a and b; Bilbao & Mistry, 2015; Bilbao *et al.*, 2019). These groups face similar fire issues, and the meeting helped them to recognize the necessary steps to promote their ancestral knowledge. In addition, researchers and representatives of institutions from Venezuela, Brazil and the United Kingdom participated in the meeting. Furthermore, this meeting resulted in agreements for the design of a plan of fire management based on the autochthonous

knowledge of the Pemón people and the rescue of their ancestral traditions (INPARQUES Oficial, 2015; Más VERDE DIGITAL, 2015; Notiambiente, 2015; Bilbao & Mistry, 2015; Bilbao *et al.*, 2019; Bilbao *et al.*, 2020).

This initiative was developed in the framework of the project ‘Integrating Indigenous fire practices within governmental policies on fire management’ funded by the British Academy, a research funder from the United Kingdom. The aim of the project was to develop a ‘case’ for integrating



Figure 8 – a) Presentation of methodological aspects of the workshop held at the Parupa Scientific Station in July 2015 for the creation of Intercultural and Participatory Fire Management Network b) INPARQUES (Acronym in Spanish of National Parks Institute) forest firefighter presenting the results of the working group on current fire management in Canaima National Park (photography by Cobra Collective Indigenous researchers). c) Member of Indigenous Pemón community presenting the results of fire management working group at the British Embassy workshop (1) held at the Venezuelan Institute of Science and Technology (IVIC), (photography by Maiquel Torcatt). d) Park ranger (and member of the Indigenous Pemón community) and INPARQUES forest firefighter, presenting the results of fire management working group at the British Embassy workshop (2) held at the headquarters of the INPARQUES forest-firefighter department, (photograph by Ruth Salazar-Gascón).

Indigenous fire practices within government fire management policy by combining existing data from experimental burns and participatory research on Indigenous land practice knowledges, and collecting new data on fire impact inside and outside Indigenous lands, and stakeholder perspectives. The 'Intercultural and Participatory Network of Fire Management', or 'Red Parupa' was one output from this collaboration between Royal Holloway University of London and the Universidad Simón Bolívar (Bilbao & Mistry, 2015; Bilbao *et al.*, 2019).

4.d. Political dimension of fire management. From knowledge to action: plans and networks in a climate change and regional context

- **British Embassy Projects:** *"Promoting the design and implementation of a national Climate Change plan in Venezuela"*, and *"Capacity building for Venezuelan civil servants, academics and Indigenous leaders to plan and act upon Climate Change"* (Figure 3).

Several studies and evidence show how Indigenous land use practices, including fire use, conserve carbon and maintain biodiversity (Trauernicht *et al.*, 2015; Mistry *et al.*, 2016; Roos *et al.*, 2016; Russell-Smith *et al.*, 2017; Bilbao *et al.*, 2020). Controlled and appropriate use of fire can contribute to soil fertilization and vigour of vegetation recovery and net productivity (Bilbao *et al.*, 2017). Knowledge about the Indigenous uses and management of fire are critical to inform the design of climate change mitigation and adaptation strategies.

Thus, to promote participatory and sustainable fire management within climate change policies in Venezuela, funded by The British Embassy (BE) in Caracas and supported by the Instituto Venezolano de Investigaciones Científicas (IVIC) and INPARQUES National Parks authorities Firefighters Body, two workshops were held during the 2016-2017 and 2017-2018 periods.

The participative methodology used in these two workshops aimed to facilitate knowledge and experience exchange among participants and included: expert presentations, video exhibits, proposed questions and exercises addressed by small discussion groups, participatory audiovisual

techniques (i.e. drawings, storyboard design, dramatizations, short video recordings) as well as plenary discussions. Five different discussion groups composed of Indigenous participants, researchers and public servants were organised according to the following thematic areas: 1) Food sovereignty; 2) Management and conservation of water resources; 3) Fire management; 4) Biodiversity, and 5) Social vulnerability and socio-productive activities.

The activities of both workshops are described below:

BE Workshop 1: *"Climate change action plans design: Integrating local Indigenous, academic and institutional perspectives in Canaima National Park, Venezuela"* (Figure 8A)

The aim of the first workshop was to design a Climate Change action plan to integrate local solutions and scientific research into public policies for long-term intercultural sustainable management in Canaima National Park. Eighty participants belonging to six Indigenous, fifteen academic, nine government, and two NGO organizations attended the first training workshop.

This first workshop helped academics and managers approach and understand the world-views, beliefs and values of Pemón Indigenous culture and acknowledge Indigenous ancestral fire and natural resources management in public policy instruments to manage CNP. Similarly, this workshop provided strength to Indigenous participants to safeguard their ancestral knowledge since this is a crucial factor to resist adverse situations that currently affect them. Academics and public managers expressed great interest in the mechanisms used to articulate diverse knowledge and capacities in the process of building up an interdisciplinary and intercultural model of knowledge and research on climate change. They also showed interest in designing integrative actions of diverse stakeholders' perspectives – communities, academic sector, and government institutions – to decrease the Indigenous communities' social vulnerability in Canaima National Park generated by climate change.

Particularly, INPARQUES authorities expressed their commitment to work jointly with Indigenous communities to develop plans and actions to manage fire and natural resources in more sustainable ways.

BE Workshop 2: *“Development of intercultural and participatory tools for the implementation of mitigation and adaptation plans to climate change in Canaima National Park.” (Figure 8B)*

This second workshop was a follow-up activity derived from the agreements reached in the previous one. This project offered a set of training activities organised in an intensive workshop to increase the stakeholders’ capacities to implement action plans based on adopting local solutions to mitigate and adapt to climate change in CNP. The workshop allowed scientists, government authorities, and Pemón Indigenous leaders to understand basic climate science, build maps of institutional climate change networks, and design local climate change solutions, exploring some international bilateral and multilateral financial cooperation opportunities. Fifty-three participants belonging to twenty-six different Indigenous, academic and government organisations as well as from two British academic organisations attended and actively participated in this training workshop.

During the workshops, especially designed group activities reinforced some key concepts about climate change (i.e., mitigation, adaptation, resilience, greenhouse gas emissions impacts, among others), as well as planning and project design on local climate change adaptation (i.e., identification and characterisation of local and national stakeholder networks, local socio-environmental problem identification, community owned solutions, project design).

Attendants agreed that the most relevant community owned solutions to develop mitigation and adaptation plans to climate change are underpinned by Pemón traditional knowledge. The traditional agricultural practices and fire management, and the respect and preservation of forest vegetation of CNP, among others, are deeply rooted positive cultural aspects in the Pemón people, which are compatible with natural resources conservation and CO₂ emissions reduction.

The workshops dynamics allowed a thorough mapping of all stakeholders involved in fire management and conservation in CNP. This helped clarify the responsibilities and strategic relevance and put into context the role each agency and the community itself has or may have to address local

problems. As a result, participants agreed that past and current individual stakeholders’ interventions were ineffective and caused conflict; instead, coherent and integration action policies need active cooperation networks of institutions and communities supported on knowledge exchange. Therefore, communication, organisation and cooperation are necessary to generate collectively responses that are both adaptive and flexible to problems related to climate change.

The workshops promoted an increasing willingness and disposition from representatives of Indigenous communities, scientists and government institutions to work cooperatively with each other, to comply with policies, programs and projects to mitigate and adapt to Climate Change in Canaima National Park. The attendance of high government authorities from INPARQUES, the Environment and Risk Management Ministries, and the British Embassy demonstrated respect and expectation.

National authorities who participated in the workshops acknowledged the need to devise a new institutional framework to guide government authorities in meeting commitments in designing policies and strategies to deal with the complexities and challenges climate change demands.

The results of these Workshops also provided relevant information to feed the next Venezuelan Communication on Climate Change. However, the most significant advance was the proposal of Indigenous communities’ active participation in developing the Third National Communication on Climate Change supported by IPCC Venezuelan representatives.

One of the workshop’s significant achievements was that participants had the opportunity to design community-based project proposals according to UNDP Venezuelan representatives’ guidelines to advance a step further in the climate change planning and action process in CNP.

The intercultural knowledge exchange experience around fire management in CNP shows that the inclusion of communities and relevant stakeholders nurtures and speeds up viable policy design and implementation, setting up the lead for a new socio-environmental governance process to address climate change challenges in Venezuela.

4.e. Expanding our frontiers. The impact at the regional level. Venezuela as a case study

Along the implementation of the mentioned projects, the interaction with Indigenous leaders, students, researchers, and public institutions in national and international meetings as well as the formal publication of the projects findings allowed to recognize that beyond Venezuela's borders similar problems derived from fire suppression policies occurred. This has inspired some initiatives promoted by different communities and institutions in Venezuela and neighbouring countries in support of changing fire suppression policies and laws. The drafting of two new bills in South American countries in 2019 (one submitted to the Brazilian National Congress, and another to the Colombian National Congress), are examples of these efforts aiming to enact new national policies based on integrated fire management to replace the "zero fire" provisions still in force today in both countries (Mistry *et al.*, 2019; Bilbao *et al.*, 2019; Bilbao *et al.*, 2020; Pardo & Bilbao, 2020). In Venezuela, the Firefighters Body from INPARQUES has reoriented its philosophical doctrine in order to adopt integrated intercultural fire management practices devised jointly in the participative workshops promoted along recent years.

- **RIOCCADAPT report.** *Adaptation to Climate Change Risks in Ibero-American Countries (Figure 3)*

Another significant achievement is the inclusion of the case study of Venezuela in the RIOCCADAPT report (<http://rioccadapt.com/>, Moreno *et al.*, 2020b) in the chapter dedicated to Wildfires (Bilbao *et al.*, 2020). The purpose of the RIOCCADAPT report was to assess the climate change adaptation actions being carried out in the member countries of the Red Iberoamericana de Oficinas de Cambio Climático (Ibero-American Network of Climate Change Offices or RIOCC), i.e., Spanish- and Portuguese-speaking countries in the Americas, the Caribbean, and the Iberian Peninsula. The Network gathers the national climate change offices of the Environment Ministries of the Ibero-American countries. RIOCC is a collaborating partner of the Nairobi Work Program from the United Nations Framework Convention on Climate Change. Its goal is to

assist Parties, particularly developing countries, and facilitate informed decision-making by governments on practical adaptation measures to respond to climate change adequately.

The experiences acquired in Canaima National Park in the construction of an intercultural and participative fire management as a strategy for adaptation to climate change were included in the RIOCCADAPT report as one of the successful case studies related to fire management and climate change adaptation in the Ibero-American region. This exercise implied contextualizing adaptation actions in terms of vulnerabilities, exposure of socio-ecosystems and risks and impacts of climate change, including recommendations about most effective measures to help governments anticipate its effects, and be prepared to protect the most vulnerable aspects and build more resilient societies (Moreno *et al.*, 2020a; Bilbao *et al.*, 2020). CNP case study was included in this report as an example of good practice on how to build socio-environmental policies starting from a bottom-up process. For the first time in the Ibero-American region, a recommendation was made to take into account and learn from local knowledge and practices (Indigenous and rural) to develop climate change adaptation strategies about the problem of fires, which is severely affecting the entire region. A key recommendation to decision-makers derived from this experience is that scientific knowledge is critical to guide political actions, but also local (Indigenous) knowledge has substantial value for adaptation to climate change. CNP case showed also that regional cooperation, dialogue and exchange of information and experiences among countries is also crucial to face these global and complex crises.

- **LANDMARC Project.** *LAND-use based Mitigation for Resilient Climate pathways (Figure 3)*

To be able to fulfil the Paris Agreement and meet the world's climate goals research, policy and markets are increasingly looking at land-based negative emission solutions. Funded by the European Commission, the nineteen LANDMARC consortium partners, across 14 countries and 5 continents, will spend the next four years (2020-2024) working to enhance understanding in the area by providing better estimates of the realistic potential of land-based negative emission

solutions in agriculture, forestry, and other land-use sectors. This project includes 16 specific LMT case studies in four continents.

In order to explore the potentialities of Indigenous fire management as a land management technology (LMT), the Cobra Collective and Simón Bolívar University will lead a case study in Venezuela building on previous CNP experiences, seeking to open up discussions and share lessons to provide the basis for developing continental narratives and scenarios in the Americas. This is the only case study included in the LANDMARC project in which the management of Indigenous fire for agricultural purposes and forest protection was proposed to be considered an LMT. Since fire has been historically viewed as an element of deforestation and emitter of greenhouse gases, Canaima National Park's experiences represent an unusual and innovative alternative for fire management to mitigate climate change. Members of the Pemón community of the Kavanayén community (trained as community researchers under the Apök and COBRA Projects) together with academics will be directly involved in the implementation of the project. From our perspective, this is a well-deserved and earned acknowledgement of their valuable knowledge and protection of their Indigenous ancestral practices.

In our opinion, these unique characteristics represent significant achievements derived from a long trajectory of joint efforts around the socio-environmental role of fire in CNP.

Conclusions

Numerous empirical studies in different contexts have shown the negative effects in the long term of the command-and-control management approach. These works demonstrate that the elimination of perturbations and variability of ecosystems end up eroding their resilience and regeneration capacity (Folke *et al.*, 2002). The practice of fire suppression as a control mechanism (especially in ecosystems that have evolved with fire) not only has favored the occurrence of more damaging wildfires, but also land management agencies are devoting ever greater resources to suppressing fires leading to what Gunderson and Holling (2002, cit. Butler & Goldstein, 2010) call a "rigidity trap" of pathological resistance to novelty and innovation. This practice has dominated the

wildland fire management strategies in the United States for nearly 100 years, although in the last decade fire scientists have called for an end to the war against fire on the wildlands (Butler & Goldstein, 2010).

The combination of scientific and traditional Indigenous knowledge constitutes a promising strategy to develop environmental policies for an efficient management of fire and the restoration of degraded areas. Likewise, this strategy might be successful for the conservation of forests as well as for the mitigation and adaptation to climate change and the conservation of the cultural integrity of the Pemón people. Integrating scientific and Indigenous knowledge was one of the main challenges addressed by the Risk, Apök and more recent projects, whose goals were to define long-term actions required for the sustainable use of resources, respecting the laws and legal framework of Canaima National Park as well as the sovereignty and rights of the Pemón Indigenous communities.

There has been a paradigm change in the approaches to fire management and the practices of some environmental managers in several South American countries, including Venezuela and Brazil. Thus, from the suppression and combating of fire as the predominant management policy, important advances have been made towards a recognition of the social and cultural uses of fire by Indigenous and local communities, and the understanding of ecological phenomena, as a basis for the design of new management instruments. The next challenge is to strengthen and promote intercultural and participatory processes through the development of intercultural platforms that allow dialogue and exchange of knowledge and skills between all stakeholders involved. This should involve a management instrument that ensures equitable conditions of participation and implementation of all stakeholders, in their various fields of action (from the planning of prescribed fires to their implementation and monitoring) and the exchange of experiences and consolidation of cross-border fire management Programs.

We consider that this approach will allow us to address new challenges and the search for solutions in several areas: a) from the environmental point of view: climate change and land-use change are generating transformations in the patterns of fire regime and behaviour producing mega-fires that cannot be addressed through isolated initiatives. It is necessary to develop a framework for local, national

and regional consultation; b) from the cultural point of view: Indigenous and local rural communities are suffering from processes of acculturation accelerated by external pressures related to the denial of their traditional practices, loss of territory, migrations, incorporation into productive systems foreign to their own ways of life, among others. A new intercultural and participatory governance must focus on the legitimization of Indigenous knowledge of traditional fire use and its active incorporation in the design and implementation of fire and natural resource management policies in their territories, as well as the promotion of the process of rescuing their traditional practices and knowledge and the strengthening of forms of knowledge transfer between generations; c) from the institutional point of view: the customary implementation of institutional policies designed top-down, with good purposes, but often with a lack of knowledge of the socio-environmental realities of territories, have historically failed in the application of inclusive and effective programs in fire management and control. Despite the important changes of paradigms addressed by several institutions in Venezuela, it is necessary to reinforce and extend these experiences to a greater number of institutions and to promote, from the legal and practical point of view, inclusive fire management policies; d) from the methodological point of view: achieve the effective participation of actors with different perspectives on the use and management of fire through intercultural interfaces that generate bridges of understanding and cooperation. This would be an excellent opportunity to generate effective cross-border concerted actions in fire management, strengthening institutions and increasing technological and cultural exchange.

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