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Article

Coordinación institucional para la realización de quemas prescritas y quemas controladas en México

Institutional coordination of prescribed and controlled burns in Mexico

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Resumen:

En México, diversas instituciones gubernamentales, académicas y asociaciones civiles, han impulsado el manejo del fuego como una estrategia para minimizar los impactos negativos de los incendios forestales y maximizar sus efectos positivos. Entre sus propósitos están mantener la ocurrencia de estos eventos en el intervalo de variación de los regímenes naturales de fuego para cada ecosistema. Para realizar manejo del fuego se pueden llevar a cabo quemas prescritas y quemas controladas, que consisten en la aplicación intencional del fuego con objetivos concretos. En México se ha dado impulso recientemente a estas prácticas, pero a la fecha se cuenta con poca información sobre la coordinación entre las instituciones involucradas en su ejecución. Sin embargo, su generación es fundamental para mejorar el éxito de las mismas, a partir del principio del manejo adaptativo. En este trabajo se describe la heterogeneidad institucional involucrada en el desarrollo de cinco quemas controladas y prescritas, y se contrasta con la atención a un incendio forestal. En diferentes regiones del país se identificaron brigadistas de Conafor, brigadistas locales, académicos e integrantes de Organizaciones de la Sociedad Civil que desempeñan papeles distintos durante las quemas. Por ello, es necesario considerar la diversidad institucional existente en el país y la importancia de que dichas instituciones logren acuerdos que permitan a diferentes actores participar en la ejecución tanto de quemas prescritas, como controladas.

Palabras clave: Conafor, ejidos y comunidades indígenas, incendios forestales, manejo del fuego, organizaciones no gubernamentales, universidades.

Abstract:

Fire management in Mexico has been promoted by various governmental and academic institutions, as well as organizations of civil society, as a strategy to minimize the negative impacts of forest wildfires and maximize the positive effects of fire. One of its objectives is to keep the occurrence of forest fires within the range of variation of natural fire regimes for each ecosystem. Prescribed burns and controlled burning are tools that can be conducted to accomplish fire management goals. In Mexico there has been a recent promotion of these practices, but there is little information on institutional coordination in their execution. It is essential to generate this information in order to improve these practices, following the principle of adaptive management. In this paper we describe the institutional heterogeneity involved in five controlled and prescribed burns in Mexico, and compare them to that experienced during a forest wildfire. It was found that, in different regions of the country, members of both Conafor and local brigades, academia, and organizations of civil society played different roles during the burns. It is necessary to consider the institutional diversity of the country and the importance of these institutions in order to reach agreements that may allow different actors to participate in the execution of prescribed and controlled burns.

Key words: Conafor, *ejidos* and indigenous communities, fire management, forest wildfires, non-governmental organizations, universities.

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Introduction

Forest wildfires are one of the main causes that affect the structure, composition and functioning of ecosystems in Mexico (Rodríguez-Trejo, 2015). However, fire suppression and firefighting may lead, in the long term, to changes in the dynamics of ecosystems, which will in turn render them more prone to catastrophic wildfires (Pyne *et al.*, 1996; Stephens and Ruth, 2005). In Mexico, a fire suppression and firefighting policy promoted since the first half of the XXth century prevails, although, in practice, it was not effectively implemented. Today, governmental and academic institutions, as well as organizations of the civil society have highlighted the importance of moving towards "integral or integrated" fire management strategies (Jardel-Peláez *et al.*, 2010; Rodríguez-Trejo *et al.*, 2011).

The fire management approach is based on a holistic, integral and adaptive perspective which implies the inclusion and participation of various actors that will take into account the distinctive features of the ecosystem (Jardel-Peláez *et al.*, 2010; McCaffrey *et al*., 2012; Bosomworth *et al*., 2015; Diaz *et al*., 2015). This approach must include both, technical interventions by professionals and specialized technicians, and institutional and communication interventions between the various actors involved (Jardel-Peláez *et al.*, 2010). Fire management as a social process requires the active participation of the various stakeholders through their institutions.

Fire management is a key component of sustainable forest management (Agee, 1993; Jardel-Peláez *et al*., 2010; Pérez-Salicrup *et al*., 2016). One of its basic objectives is directed toward the management or restoration of fire regimes within their natural or historical variation interval (Jardel-Peláez *et al*., 2010). It is meant to preserve habitats and ecosystems with an emphasis not only in patterns (e.g. diversity, structure, amount of standing biomass) but also in the processes that generate these patterns (Karki, 2002; Jardel-Peláez *et al*., 2014; Pérez-Salicrup *et al*., 2016). This implies documenting the ignition sources, as well as the frequency, intensity, severity and magnitude of the fire in each ecosystem; it also implies

seeking sustainable solutions through fire management plans (Semarnat, 2009). This leads to the implementation of actions to prevent and fight wildfires. For this purpose, actions can be carried out to maintain the occurrence of fire, controlling it and using it as a tool to achieve the concrete goals and objectives of fire management (Moscovich *et al*., 2014).

Among the strategic actions that are part of fire management are prescribed and controlled burns, both of which consist in applying fire intentionally, under known conditions, based on the fuel loads, the topography and weather (relative humidity, temperature, wind) (Semarnat, 2009).

Prescribed burns aim to concrete objectives based on a prediction of the behavior of fire, such as to promote natural regeneration or reduce the fuel loads to a desired percentage (Semarnat, 2009; Rodríguez-Trejo, 2015). In general, a burn of this type develops under controlled guidelines; in addition, it requires a detailed knowledge of the area to be burnt, the burning method and technique to be used, the climate factors, the topography, and the fuels present in the site, in order to attain the posed objectives through the burn (Ramos, 2010).

Controlled burns consist in the use of fire in an area delimited by control lines (firebreaks, black lines, wetlines, or others), without planning the behavior of the fire or its long-term impact on the ecosystem (Ramos, 2010).

The objectives of prescribed burns, include the reduction of fuel loads, soil conservation, site preparation, control of undesirable species, regeneration of fire-dependent taxa, and even improvement of the aesthetics of the landscape (Stephan *et al*., 2012; Scott *et al*., 2014; Knapp *et al*., 2015; Rodríguez-Trejo, 2015; Stavi *et al*., 2017).

By reducing the amounts of fuels and by interrupting their continuity, the intensity and speed of fire propagation are modified; this facilitates control of fires and reduces the danger of subsequent forest wildfires (Knapp *et al*., 2005; Ramos, 2010). It should be noted that fire management does not necessarily imply the execution of prescribed or controlled burns. In landscapes with high fuel loads, it is desirable to start by reducing

these through mechanical means. In those ecosystems whose dynamics do not include fires, it is best to avoid burns (Hardesty *et al*., 2005).

Both types of burns are considered within the Mexican Official Norm NOM-015-SEMARNAT/SAGARPA-2007 (NOM-015), which establishes the technical specifications of the methods for using fire in forests and agricultural land (Semarnat, 2009). The norm distinguishes between prescribed and controlled burns as the only two methods for the use of fire, but it fails to integrate the cultural diversity of the actors to implement them. Likewise, it does not take into account the variety of traditional uses of fire, such as the controlled burns carried out by a large number of farmers (Martínez-Torres *et al*., 2016). For this reason, in Mexico, documenting the diversity of participants in prescribed or controlled burns and the institutional interactions between them constitutes a challenge.

The application of prescribed and controlled burns according to the technical considerations stipulated in NOM-015 has been promoted since the 1970's (Sánchez-Córdova and Dieterich, 1983; Rodríguez-Trejo *et al*., 2011). However, their development across the country is heterogeneous, with areas where their use is more widespread and regions where they are not practiced. Furthermore, there are few previous records to systematically document the participation of different institutions in these practices (Flores *et al*., 2011; Rodríguez-Trejo *et al*., 2011).

Because the reintroduction of fires in itself can become a disturbing factor (Hardesty *et al*., 2005), it is important to keep record of the sites where these types of burns have been carried out, as well as to learn from experience, according to the adaptive management approach (Christensen *et al.*, 1996).

The study of the dynamics and interactions within and between governmental institutions would promote the development of new perspectives on fire management, including the preparation of communities in the face of fire hazards, as well as the creation of alternatives for the management of forest fuels (Toman *et al*., 2006; McCaffrey *et al*., 2012). Based on the enormous socio-ecosystemic diversity existing in Mexico (Challlenger, 1998), it may be assumed that the institutions involved in the prescribed and controlled burns will differ according to

the social stakeholders present in each region. This diversity of actors and institutions may have an impact on the differential characteristics for the development of the burns, which are relevant to the success of these practices (McCaffrey *et al*., 2012). This study documents the institutional interactions during the five prescribed and controlled burns in four states of the Mexican republic, and they are contrasted with one wildfire in a different state. Furthermore, it characterizes those aspects of the institutional relationships that may contribute to their development, as well as those that may hinder them. These considerations may contribute to the success of prescribed and controlled burns involving the participation of governmental institutions, the civil society, the academic sector, and communal lands (*ejidos*) and local communities.

Materials and Methods

Four prescribed burns and a controlled burn were carried out between November 2016 and April 2017, to document the institutional response in the north, center and south of Mexico. An active wildfire was also considered. The burning units were selected in terms of their distribution (Table 1, Figure 1), and the plans for the execution of the burns by various institutions, as well as the facilities provided by the land owners to conduct them.

Table 1. Location, vegetation type and characteristics of the five prescribed and controlled burns, plus a forest fire, in Mexico, 2016-2017.

Location/Type of burn	Surface (hectares)	Geographical coordinates	Vegetation type	Characteristics of the burns/wildfire
El Pinito, Agua Prieta, Sonora/ Prescribed burn	193.66	31°10.89' N 108°54.84' W	1. *Juniperus* forest with natural grasslands and *Arctostaphylos pungens* 2. *Quercus-Juniperus* forest with natural grasslands	Flanking fire technique, initially against the direction of the wind and subsequently in the direction of the wind in order to close the burning unit. Participation by 23 individuals. Propagation speed of 0.91 km h^{-1}, and flame height of 4.94 m.
Evans Canyon, *Sierra Los Ajos, Cananea, Sonora*/ Prescribed burn	18.3	30°58.56' N 109°57.52´ W	3. *Quercus-Juniperus* forest 4. *Quercus* forest	Backing fire, burn in strips broadening the black strips, and flanking fire with lateral advance. Participation by 23 individuals. The moisture content of the fuels rendered ignition difficult.
Ejido Nuevo León, *Tizimín*, *Yucatán*/ Prescribed burn	0.78	21°19.71' N 87°34.96' W	1. Tasiste palm *(Acoelarraphe wrightii)* 2. *Cladium jamaicense* grassland susceptible to flooding	Flanking fire technique. Participation by 29 individuals. Propagation speed of 0.60 to 0.87 km h^{-1}, and flame height of 3.3 to 9.5 m.
Ejido Ahuacapán, *Sierra de Manantlán* Biosphere Reserve, *Jalisco*/ Prescribed burn	7.3	19°37.54' N 104°18.89' W	*Pinus douglasiana* forest with residues of forest exploitation	Backing fire, burn in strips in areas with a low propagation speed, and ascending fire in the direction of the wind in order to close the burning unit. Participation by 30 individuals. Propagation speed of 0.15 km h^{-1}, and flame height of 2.9 m.
Cerro del Quinceo, *Morelia*, *Michoacán*/ Controlled burn	1.18	19°14.30' N 101°15.49' W	1. Natural grassland 2. *Quercus deserticola* forest	Backing fire and burn in strips. Participation by 40 individuals. Propagation speed of 0.38 to 0.60 km h^{-1}, and flame height of 4.75 m.
Ejido Sacxán, *Chetumal*/ Active fire	971.85	18°34.44' N 88°41.05' W	1. Low subperennial forest 2. Medium subperennial forest	Propagation speed of 0.06 to 0.12 km h^{-1}, and flame height of 0.8 m.

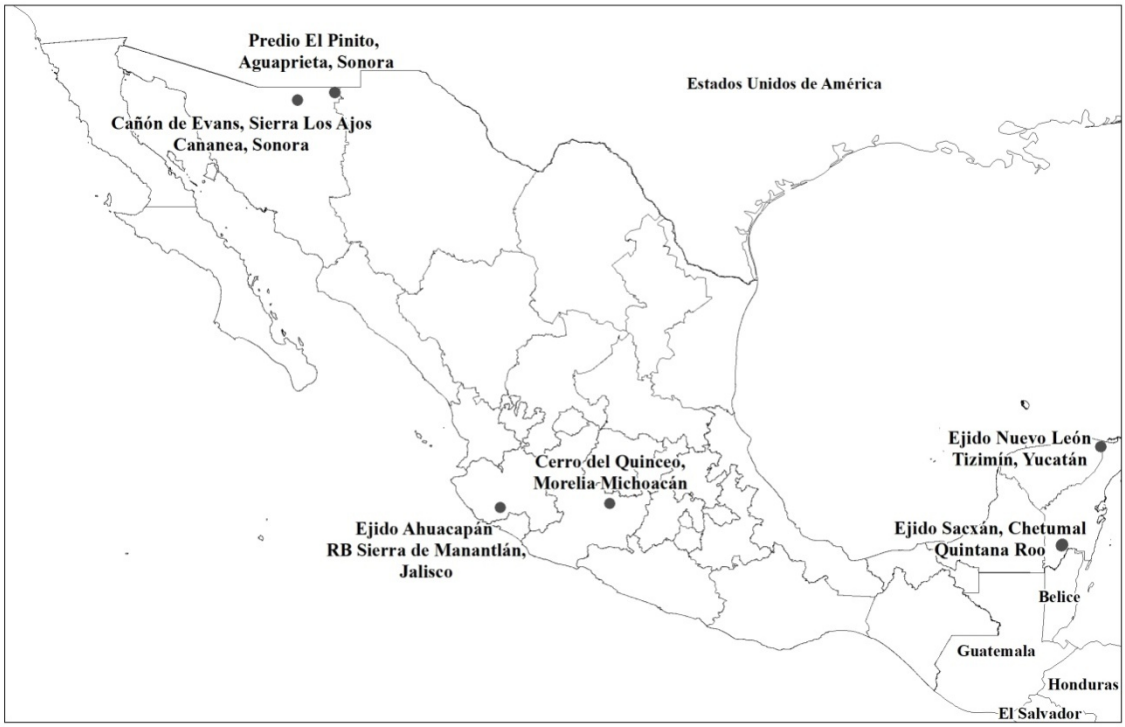

Figure 1.Location of the sites of the prescribed and controlled burns and of a forest fire in Mexico, 2016-2017. *Ejido Sacxán*, in *Quintana Roo*, was the site of the forest wildfire, while prescribed and controlled burns took place in the rest of the sites.

Five state management offices of the *Comisión Nacional Forestal*, Conafor (National Forestry Commission), *Instituto de Investigaciones en Ecosistemas y Sustentabilidad*, IIES-UNAM (the Institute for Research on Ecosystems and Sustainability), *Centro Universitario de la Costa Sur de la Universidad de Guadalajara* (DERN-IMECBIO, U. de G.) (the Departament of Ecology and Natural Resources of the South Coast University Center of the University of Guadalajara, *Pronatura Península de Yucatán A.C., Comisión Nacional de Áreas Naturales Protegidas*, Conanp (the National Commission of Natural Protected Areas), as well as local communities and *ejidos* participated. These institutions belong to government agencies, organizations of the civil society, the academy, and the social sector (*ejidos* and communities), whose representatives own the plots where the burns took place (Table 2).

Table 2. Locality, objectives of the burns, name/type of the participating institution and activities of each institution in five prescribed and controlled institution, and a forest wildfire in Mexico 2016-2017.

Locality	Objectives	Institutions and type of participating institutions*: activities carried out by these
El Pinito, *Agua Prieta, Sonora*	1. To provide training and education for firefighting brigades. 2. To reduce the fuel loads in order to prevent catastrophic fires. 3. To promote the regeneration of native grasses.	Conafor- *Sonora* (FG). Site choice, site preparation, creation of the Incident Action Plan (IAP) and execution of the burn. IIES - UNAM (A). Measurement of forest fuels and monitoring of fire environments, sampling of combustion environments. Conanp-*Sonora*. Choice of the site and termination of the burn.
Evans Canyon, *Sierra Los Ajos, Cananea, Sonora*	1. To reduce fuel beds in order to prevent catastrophic fires. 2. To reduce the hazard for the *Ajos nuevos* camp. 3. To promote the regeneration of native grasses. 4. To improve the habitat for wildlife.	Conafor - *Sonora* (FG). Site choice, site preparation, execution of the burn, creation of the IAP. IIES-UNAM (A). Measurement of forest fuels and monitoring of fire environments. Conanp –*Sonora*. Site choice and termination of the burn.
Ejido Nuevo León, Tizimín, Yucatán	1. To provide training for local brigades in the fighting of forest fires. 2. To assess the behavior of fire and the factors in the consumption or forest fuels. 3. To reduce the fuel loads in order to prevent catastrophic fires.	Conafor - *Yucatán* (FG). Coordination of the burn, creation of the IAP. Pronatura-*Península de Yucatán*, A.C. (NGO). Logistic coordination, contact with the *ejido*. *Ejido Nuevo León*, Municipality of *Tizimín, Yucatán* (*E*). Preparation of the plot with firebreaks. IIES-UNAM (A). Measurement of forest fuels and monitoring of fire environments.
Ejido Ahuacapán, Sierra de Manantlán Biosphere Reserve	1. To reduce the fuel loads generated by forest exploitation. 2. To promote the regeneration of pines in areas affected by forest exploitation. 3. To provide training for communal land brigades.	Conafor - *Jalisco* (FG). Definition of objectives, ignition method, termination and escape routes. Conanp (FG). Definition of objectives, ignition method, termination and escape routes. *Ejido Ahuacapán*, municipality of *Autlán de Navarro*, *Jalisco* (E). Definition of objectives, ignition method, termination and escape routes. DERN-IMECBIO, U. of G. (A). Definition of objectives, ignition method, termination and

		escape routes. Measurement of forest fuels before and after the burn, creation of the IAP, and monitoring of the fire environments.
Cerro del Quinceo, Morelia, Michoacán	1. To reduce the fuel loads in order to prevent catastrophic fires. 2. To spread the use of prescribed burns among the society 3. To reduce the surface fuel load per hectare by 50 %.	Conafor - *Michoacán* (FG). Site preparation, burn coordination, development of the IAP. IIES - UNAM (A). Creation of the IAP, monitoring of the fire environments, measuring of forest fuels and monitoring of the fire environments. COFOM (SG). Assistance in coordinating the burn. Municipality of *Morelia* (MG). Assistance in controlling the burn.
Ejido Sacxán, Chetumal	1. To control and terminate the forest fire.	Conafor - *Quintana Roo* (FG). Fighting of the forest fire. IIES-UNAM (A). Measurement of forest fuels and monitoring of fire environments.

*Type of institution: A = Academic; FG = Federal Governmental; SG = State Government; MG = Municipal Government; NGO = Non-Governmental Organization; *E* = *Ejido*.

The planning and execution of the burns was based on the Incident Command System (ICS), in which an Incident Action Plan (IAP) was created for each burn, based on the guidelines of the National Forestry Commission (Conafor) in Mexico. Before each burn, participating institutions met to plan each burn and to assign the activities and responsibilities as established in each Incident Action Plan (Table 2). Fire behavior was monitored during the execution of each burn (Table 2). Once field work was finished, the participants met in order to identify the failures and successes of the burns. In the case of the monitored fire, the behavior of the fire and the institutional coordination of the brigades that participated in its control and termination were also described.

Results and Discussion

The objectives differed between burns (Table 2). In four of the prescribed burns, emphasis was made on the need to use them to train the local firefighting brigades. In the state of *Sonora*, members of the state brigades of Conafor and Conanp received training. The same was true in *Michoacán*; in addition, collaboration with members of the brigades of Conafor-*Michoacán*, of the Forest Commission of the State of *Michoacán* (Cofom) and of the municipality of *Morelia* was promoted. In *Jalisco*, training was provided to the brigade of *ejido Ahuacapán*, and in *Yucatán*, to a communal-land brigade coordinated by Pronatura A.C. This common interest in training the staff of brigades in prescribed and controlled fires reflects the need to generate more practical experience in this type of fire management activities.

The coordination of federal delegations of Conafor with agents of both state and municipal governments, as well as with local authorities (*ejidos* and communities), varied between the various sites. It is usually believed that only federal institutions have the technical capacity to plan fire management (Gutiérrez-Navarro *et al*., 2017). However, the execution of burns with a strong component of empirical knowledge by members of both governmental and non-governmental institutions of different levels, farmers and fire users has been documented (Rodríguez-Trejo *et al*., 2011; Martínez-Torres *et al*., 2016; Gutiérrez-Navarro *et al*., 2017). For this reason, if burns are used for training purposes, their development will vary in terms of the participants involved and their knowledge of the territory. Clearly, it is desirable to gain from the local expertise in the development of burns when local inhabitants are willing to become involved in these practices.

The case of *Jalisco* was singular: a communal-land brigade, with the support of the *academia* (DERN-IMECBIO, U. of G.), carried out a burn for very concrete purposes associated to timber extraction; although, by request of a federal entity (Conanp), the plan for the burn was developed by Conafor-*Jalisco* (Table 2). The participation of a local brigade allowed the integration of the local empirical knowledge in the execution of the burn. It is equally important to bear in mind that the

participating academic institution has a history of several years of research on fire ecology issues in the region, and of establishing bonds with the local communities. This example is very relevant, as it brings to light the development of a relationship of mutual trust, which has been identified in social researches as an obstacle in the collaboration between governmental entities and the population (McCaffrey *et al.*, 2012).

In this regard, the academic institutions play a significant role in establishing bonds with the communities and *ejidos* where they carry out their research (Rodríguez-Trejo *et al*., 2011).

The burn in the state of *Yucatán* was promoted and organized by Pronatura *Península de Yucatán*, A.C., in coordination with *ejido Nuevo León*, *Yucatán*. Although Conafor-*Yucatán* was in charge of generating the burn plan and of managing the incident with the participation of the members of the *ejido* and of an organization of the civil society, it previously incorporated the empirical knowledge of the inhabitants of the site. Given the knowledge of the behavior of the fire by the local communities, it is desirable to repeat this type of experiences elsewhere.

In other countries, work with the communities and organizations of the civil society has been vigorously promoted in the past few years, primarily in order to create strategies for adaptation to fire by the communities (Toman *et al*., 2006; McCaffrey *et al*., 2012). In Mexico, there are still few examples of the relationships between communities and civil organizations for fire management. Probably the most important is the Fire Management Apprenticeship Community (CAMAFU), promoted by the Mexican Fund for the Conservation of Nature (Rodríguez-Trejo *et al*., 2011). However, further promotion of this type of institutional relationships is required.

The extension and the vegetation types affected in each burn varied according to the type of ecosystem, land tenure, and the facilities provided by the land- owners and the technical abilities of the participating institutions (Table 1). The burns in the state of *Sonora* were the most extensive, followed by those carried out in *Jalisco*. In *Michoacán* and *Yucatán* they took place on small surfaces, given the objectives of these burns, but also because the land tenure prevented more extensive burns.

The issue of land tenure is particularly important in Mexico (Warman, 2001); it has been singled out as a key factor in the occurrence of forest fires and in the organization of communities for fire management (Heyerdahl and Alvarado, 2003; Sheridan *et al*., 2015). Because forest wildfires do not respect property boundaries, and because their management must be incorporated to the management of socio-ecosystems and territories, the institutional coordination should allow the execution of prescribed and controlled burns in larger areas and thereby enable a better control of the fuels.

The wildfire that took place in *Quintana Roo* covered a much larger surface area than the prescribed and controlled burns (Table 1). It was fought by the brigades of the Conafor-*Quintana Roo* delegation, with the support of community and army brigades.

IIES-UNAM was invited to characterize fuel beds both in unaffected sites and in those places where the fire had already been put out. This experience proved that the exercise of carrying out prescribed and controlled burns can facilitate interinstitutional communication for addressing fires. Furthermore, it evidenced the importance of burns as a means to prevent forest wildfires.

Low and medium deciduous forests, where the fire occurred, have been pointed out as ecosystems that are sensitive to fire (Semarnat, 2009). For this reason, it would be very helpful to increase understanding of fire on these ecosystems, which would involve follow up studies on the site.

A strategy to be considered in this regard is, precisely, that of profiting from active forest fires to characterize the behavior of fire and the unburned adjacent places in order to quantify the fuel beds; this requires providing firefighting brigades with a special training and special equipment for measuring fuels. Another action would be to train special brigades for the exclusive task of measuring the fuels and the parameters associated with the behavior during the fire season in a given region.

The logistic coordination in sites where the participation of the various state delegations of Conafor was relevant, as the burn plan had to be developed, the use of vehicles and equipment had to be coordinated, and all the participants had to be

assigned tasks. Collaboration in prescribed and controlled burns generates interinstitutional contacts that will facilitate the coordination in the face of forest wildfires. However, it also catalyzes the development of future prescribed and controlled burns. This synergy between institutions may help overcome one of the main drawbacks of prescribed and controlled burns: their high economic cost. The cost of suppressing and fighting wildfires has been proven to be much higher in the long run than the cost of their prevention (Penman *et al.*, 2016). In Mexico, the lack of research on this matter makes it impossible to assess the costs of prescribed and controlled burns compared to that of forest wildfires.

A common objective of all burns was to reduce the fuel load, which was successfully accomplished. However, the proportion of fuels consumed varied between burns, according to the type of vegetation and the type of burn. Nevertheless, it is important to highlight that not all ecosystems require frequent low-intensity fires, and therefore, the development of prescribed and controlled burns should not be oversimplified and proposed for all ecosystems in Mexico (Jardel-Peláez *et al.*, 2014). Furthermore, the perception of the management of fuels by communities and by landowners through burns should be included (Toman *et al.*, 2006).

In all prescribed and controlled burns, situations that notably favored interinstitutional collaboration were detected. The first was the willingness to profit from the empirical knowledge of local inhabitants and brigade members during the execution of the burns. The second factor was the resolution of the various institutions to carry out the exercise jointly and assume their responsibility to follow the burn plan.

The participation of the academic sector was constant in all the burns and during the forest fire. Given the need to consolidate the research on fire management across the country, it will be very helpful to obtain the largest possible amount of knowledge. Although this task entails a challenge in terms of institutional collaboration, this connection offers the opportunity to bring the academic sector closer to the land- owners and to those who manage fires on forest land (Rodríguez-Trejo, 2015). For this purpose, we propose the promotion of a strategy to systematize the information generated in the various exercises of this kind that are carried out in the country. The collected information must include not only the quantitative characteristics of

forest fuel beds and of the behavior of the fire but also aspects of the participation by institutions and by all the stakeholders.

Finally, it should be noted that in Mexico, like elsewhere, it will soon be necessary to promote institutional collaboration in peri-urban areas, where firefighting will require the collaboration of fire brigades and civil protection officers. While the former are trained to fight forest fires, the latter usually receive training in fighting urban fires. Institutional coordination in these events will be essential to put out the fires and ensure the physical integrity of those who fight them.

Conclusions

In each site, prescribed and controlled burns were carried out with the participation of various institutions. This reflects the institutional heterogeneity existing in Mexico, which in turn is a reflection of the particular characteristics of each region. If we add to this the diversity of ecosystems, it is clear that prescribed and controlled burnings must be executed within a flexible framework that will take into account the particularities of each locality and will avoid institutional homogeneization.

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Conflict of interests

The authors declare no conflict of interests.

Contribution by author

Diego R. Pérez-Salicrup, Ruben Ortiz Mendoza, Erika Garduño Mendoza, Héctor Leonardo Martínez-Torres and Karla A. Oceguera Salazar: first draft of the manuscript, coordination of the work and participation in the four burns and the forest fire, editing of the first draft of the document; Shatya Quintero Gradilla and Faviola Castillo Navarro: editing of the manuscript and coordination of the burn in *Jalisco*; Ernesto Alvarado Celestino and Armando González Cabán: editing of the manuscript, participation in the conception of this study and in the research Project request form, counseling on the field work to be carried out.

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