Forum Article

The Present Status of Fire Ecology, Traditional Use of Fire, and Fire Management in Mexico and Central America

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ABSTRACT

Traditionally, forest fires in Mexico, the Caribe, and Central America have been perceived, by both urban and some rural societies and government agencies, only as destructive phenomena. Certainly 40% of forest fires originate from agricultural and pastoral practices. However, there are many native rural communities that make a refined use of fire, harmonizing food production and care for the environment. In the past couple of decades, however, a slight and gradual change in perspective has occurred, such that for fire managers, preserves managers, researchers, and non-government organizations, the fire ecology as well as the management of fire by rural communities have been incorporated into what is now referred to as "integral fire management." This term may be defined as the fusion of firefighting and prevention with the ecological use of fire and community fire management in order to preserve nature and to make the land productive. In initiating the implementation of integrated fire management, key roles have been played by national and regional governmental agencies, international and regional non-governmental agencies, as well as research universities and institutes.

Keywords: Central America, fire management, forest fires, integral fire management, Mexico

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INTRODUCTION

The region of Central America, the Caribe, and Mexico is comprised of 33 countries, but nine of them have 96% of the region's forest surface. The territory includes slightly over 268 million hectares. The forest areas cover 92.6 million hectares and the annual deforestation rate is on the order of 546200 ha. The population is nearly 187 million people, 31% comprise the rural population, 40% of which live in extreme poverty. Every year, 677000 ha are affected by forest fires, 43% of which are caused by agricultural activity and are linked to poverty and to the lack of forest management. During the record year of 1998, nearly 57000 fires covered 2330000 ha (Ramos-Rodríguez 2007, Martínez-Domínguez and Rodríguez-Trejo 2008, FAO 2009).

The Central American countries have many coincidences in their histories. These histories may be divided into prehispanic, colonial, independence, and modern periods. During the prehispanic period, the region was inhabited by many different Native American cultures that made use of fire, mostly for agricultural or agroforestry purposes. The main crop was maize. Most of the cultures were conquered by Spain by the sixteenth century, their native human populations were decimated, and the survivors saw their worlds vanish. The natives were the servants of feudal systems dominated by the conquerors. The Catholic Spaniard friars protected the native populations. That was the beginning of the colonial period, when crops other than maize and cattle were introduced. Cattle raising also introduced of a new type of fire to induce resprouts to feed the cattle. The use of fire for agriculture; agroforestry; and cattle, sheep, and goat raising remained dominant throughout the colonial and independence periods. Today, these activities include the dominant traditional uses of fire and are an important cause of forest fires (Rodríguez-Trejo and Sierra-Pineda 1992, Paz 1993). The fires of both cultures, Native American and Spaniard, merged to form the present traditional use of fire that has both benefits and drawbacks.

Although it may seem simple to define what the traditional use of fire is, it is actually not that simple to do. In this work, traditional use of fire means the use of fire by rural communities as part of their livelihoods and cultural backgrounds. However, it must also be pointed out that there are rural communities that use fire but lack or have lost traditional and valuable knowledge about fire. Rural communities are comprised of persons of native or mixed native and European (mestizo) descent.

Historic advances in fire management, particularly since the 1980s, include growth in the capacity to fight forest fires. During the 1980s, the US Department of Agriculture's Forest Service and the US Agency for International Development (USAID), as well as the Spanish and Canadian governments, assisted the forest services of Mexico and other countries of the region in initiating a formal training plan, which currently continues to have an active training role. These organizations have also provided financial and technical support during periods of extreme fire activity in the region.

Intentional and accidental burning of forests has been punished since colonial times. The official "classical" view of fire protection was adopted during the nineteenth and twentieth centuries, with the establishment of organizations and agencies specifically to prevent and fight forest fires. For instance, in Mexico, a forest service was established in 1861 (Verduzco-Gutiérrez 1959), and Miguel Ángel de Quevedo, head of the Junta Central de Bosques, pushed forward forest protection in Mexico from the 1900s to the 1930s, inspired by the forestry and fire protection programs from France and the United States (Gutiérrez-Palacios 1989, Simonian 1995). Presently, the general public perception is that, because of the conservation and economic value of forests, fire must be excluded from them. This is the "classical" view.

By the 1960s, a more academic fire ecology view started to permeate from American and a few Central American and Mexican researchers. For example, one of the pioneers was Professor Gerardo Budowski (1966) from Costa Rica, who made valuable fire ecology observations on fire ecology and fire effects in palm (*Corozo olerifera* [Kunth] L.H. Bailey) savannas in Costa Rica, pine (*Pinus caribaea* Morelet) forests in Nicaragua, pine (*Pinus oocarpa* Schiede ex Schltdl.) forests in Mexico, and teak (*Tectona grandis* L.f.) plantations in Trinidad.

Presently, the ideals of fire management in the region are to maintain appropriate fire regimes and to restore degraded areas, conserve biodiversity, reverse deforestation, maintain and promote the forms of subsistence and local economies, reduce catastrophic fires, and increase the use of prescribed fires with ecological and productive objectives. In a sustainable conservation and productive context, these ideals form the basis for integral fire management (Rodríguez-Trejo *et al.* 2000, Myers 2006). Of course, integral fire management is an important part of forest, ecosystem, and land management.

Although forest fire researchers are scarce in the region, scientific and technological research has increased; the topic of wildfire is one of the most published in the forest sector of the region. For example, the number of books published on the subject per decade increased from two to seven from 1980 to 2000 (e.g., Rodríguez-Trejo 1996, Rodríguez-Trejo *et al.* 2000, Villers-Ruiz and López-Blanco 2004*a*, Flores-Garnica *et al.* 2006, Flores-Garnica 2009). It is estimated that more than 150 scientific or technical articles on fire in these countries have been made by national or international authors in the past decade.

The 1998 fire season brought about changes in the policies and practices of fire management, such as a more diverse firefighting training, the beginning or improvement of fire agencies in several states, and more research on forest fires. By 2000, a new generation, comprised of chairmen of a few governmental agencies and non-governmental organizations and researchers, started to launch the basis and initial steps for an evolution in fire management of the region. They sought to promote research and practice of fire ecology, community fire management in rural zones, and integral fire management, combining the latter two with prevention and firefighting.

THE ACTORS AND THEIR ROLES

Institutions of teaching and research that have participated in this change in different ways have been the Universidad Autónoma Chapingo, the Universidad de Guadalajara, the University of Washington, the Instituto Nacional de Investigaciones Forestales, the Universidad de Pinar del Río, and the Universidad Autónoma Agraria Antonio Narro. Instrumental non-government organizations (NGO) include The Nature Conservancy and Fondo Mexicano para la Conservación de la Naturaleza. In addition, the Mexican government (Comisión Nacional Forestal and Comisión Nacional de Áreas Protegidas), as well as the governments of Honduras and Guatemala, among others, have played a role. Presently, it is the federal protection programs that lead this change in fire management by inserting it into forest management and forest ecosystems management.

These organizations have made many contributions. It should be pointed out that all of the organizations have led the way in integral fire management in their respective work areas. The NGOs have gone beyond financing by contributing to research or have financed research; the federal governments (fire protection organizations and biodiversity conservation organizations), besides leading and generating policies, laws, and operations, have promoted analysis and direction. The institutions of teaching and research, along with investigating and including these topics in the univer-

sities, thus contributing to the formation of new generations with a new mentality with respect to fire, have also participated actively and operatively in fire management. Together, all of these organizations form a synergy of effort and policy determination that would be less effective if any one of them were to not participate. However, even in the absence of one or more of the organizations, the effort would continue.

Teaching and Research Institutions

The University of Guadalajara works in close association with the University of Washington. These institutions have carried out research on fire management and ecology mainly in the forests of the reserve of Manantlán, Jalisco, where there is a record of carbon deposits that denote the presence of fires for thousands of years (Figueroa *et al.* 2008). In coordination with the University Antonio Narro, the institutions have collaborated on a photoseries of forest fuels for the reserve and for the Sierra de Arteaga, Coahuila (Alvarado *et al.* 2008). They are also working on a project for making a photoseries for the tropical forests of the reserve Selva El Ocote, Chiapas. Their leading investigators have been Ernesto Alvarado (University of Washington) and Enrique Jardel-Pelaez. Ernesto Alvarado participated in the MILAGRO project, which involved studies of forest fire smoke in central Mexico (Yokelson *et al.* 2007). They have also collaborated on a proposal for fire regimes for Mexican ecosystems (Jardel-Pelaez *et al,* 2009), an integral fire management guide, and the initiation of applying principles of integral fire management at the Sierra de Manantlán reserve. These institutions have participated with instructors in workshops organized by NGOs such as The Nature Conservancy (TNC) and Fondo Mexicano para la Conservación de la Naturaleza (FMCN). In coordination with the FMCN, they also organized a workshop on the needs for research. Many of the principal protagonists in Mexico were invited, and the following topics were considered top priority by the participants: fire regimes, forest fuels, fires and global climatic change, community use of fire, and integral fire management (Jardel *et al.* 2010). The proceedings of the workshop include an important sample of the work of a new generation of fire researchers from Mexico.

By the 1980s, Jesús Sánchez Córdova started working on fire effects at the Instituto Nacional de Investigaciones Forestales (Sánchez-Córdova and Dieterich 1983, Sánchez-Córdova and Zerecero-Leal 1983). Later, Dr. Germán Flores Garnica and his work group modeled forest fuels and fire behavior in geographic information systems (Flores-Garnica and Omi 2003, Flores-Garnica and Moreno-González 2005, Flores-Garnica *et al.* 2009) and determined environmental fire effects (Alanís-Morales *et al.* 2009, Benavides-Solorio *et al.* 2009). Dr. Flores also worked on a smoke project with the US National Aeronautics and Space and Administration (NASA) and is the Mexican scientific representative to the North American Forest Commission. Dr. Flores edited the most recent book in the region on this topic (Flores-Garnica 2009), which focused on environmental effects of forest fires and included the participation of many of the specialists of the region.

The Universidad de Pinar del Río, Cuba, has a team of researchers focused on several forest fire issues. Their most important fire researcher, Dr. Marcos Pedro Ramírez-Ramos, has for several years been organizing an international seminar on forest fires as part of the annual international forestry congress celebrated in Cuba. He publishes frequently on forest fires and fire management in Cuba (e.g., Ramos-Rodríguez and González-Menzonet 2004, Ramos-Rodríguez and Viana-Soares 2004).

The Universidad Autónoma Chapingo launched its Ajusco project in 2000, which included fire ecology, integral fire management, and restoration of burned areas. At first it was

oriented to forests of Mexican mountain pine (*Pinus hartwegii* Lindl.) of Central Mexico, seeking to obtain information about a single ecosystem rather than about parts of different ecosystems. The first stage was developed in various localities with themes such as the effect of crown scorch on diameter growth (González-Rosales and Rodríguez-Trejo 2003), as well as the study of smoke (Contreras-Moctezuma *et al.* 2003). The second stage concerned experimental fires with different intensities and in different periods, starting in 2002, with studies of the effects on the diversity of species of the understory at different times (Espinoza-Martínez *et al.* 2008, Martínez-Hernández and Rodríguez-Trejo 2008, Islas-Madrid *et al.* in press), as well as tree survival (Rodríguez-Trejo *et al.* 2007*a*, Vera-Vilchis and Rodríguez-Trejo 2007) and a proposal for fire regimes of Mexican ecosystems (Rodríguez-Trejo 2008). Other topics researched are tree regeneration (Juárez-Martínez and Rodríguez-Trejo 2003) and the diversity of birds in pine-oak forests affected by fire (L.P. Ponce-Calderón, Universidad Autónoma Chapingo, unpublished data), along with economic effects in the landscape quality (Romo-Lozano *et al.* 2006).

The Ajusco project has also dealt with the effect of fire in sensitive ecosystems such as the tropical forests of southeastern Mexico, analyzing the reduction of the diversity of arboreal species in areas that suffer catastrophic fires (Maldonado-Méndez *et al.* 2009), as well as the flammability of tropical fuels (Neri-Pérez *et al.* 2009). In addition, the project has also included the development of a brief photoseries of forest fuels for plantations in the vicinity of the university campus (Arumí-Molins 2009). In May of 2010, 23 graduate or undergraduate theses had been written, and 11 are currently in progress in 10 states of Mexico, most in the central zone of the country. This project analyzed the fire ecology of several of the pines (Rodríguez-Trejo and Fulé 2003) and oaks in Mexico and Central America, which, in Mexico, include 47 and 170 species, respectively. It was proposed that fire regimes in the oak forests can be inferred from morphological and phenological characteristics and ecological types of trees and forests (Rodríguez-Trejo and Myers 2010). An instructor from the University of Chapingo (UACH) has also participated in the fire management workshops offered by The Nature Conservancy and the Mexican Foundation for Nature Conservation in Mexico and Central America.

The UACH has developed a workshop with the Mexican National Commission on Forestry (CONAFOR) in Tlaxcala state to conduct basic training in the prevention and fighting of forest fires and the integral use of fire. The workshop was directed toward the campesinos (farmers), for which the results of the Ajusco project had been adapted. In addition, the Forest Sciences Division (DICIFO) of the UACH was responsible for the analysis of the program and forest fire season of the CONAFOR for the periods 2003, 2004, and 2007 (UACH-CONAFOR 2004, 2005, 2008). For the first time in Mexico, national economic and performance efficiency estimates at the national level were obtained (papers derived from such works are: Rodríguez-Trejo *et al.* 2006, 2007*b*), and maps were made of forest fuel loads, fire risk indices, and of priority protection areas for the Yucatán Peninsula after Hurricane Dean in 2008 (Rodríguez-Trejo, University of Chapingo, unpublished data). The DICIFO (Forest Sciences Division) of the UACH offers a course in forest protection, which started by the 1950s. At the graduate level, the fire ecology course has been taught since 2000, probably for the first time in Mexico. Historically the Forest Sciences Division has a long tradition of research on fire protection and fire effects (e.g., Aguirre-Bravo 1978, Aguirre-Bravo and Rey-Contreras 1980).

The National Autonomous University of Mexico (UNAM) has a relevant research program on fire danger, fire behavior, and fire effects at La Malinche volcano, in the states of

Puebla and Tlaxcala, Mexico This program is led by Dr. Lourdes Villers-Ruiz (Villers-Ruiz and López-Blanco 2004*b*, Villers-Ruiz 2006).

Numerous international researchers have contributed fire information about the region. Dr. J.H. Dieterich (Dieterich 1983, 1985) started the dendrochronological studies in northern Mexico. Dr. Armando González-Cabán, along with Dr. David Sandberg, advocated for the use of prescribed fires in the zone in the 1980s, participated in training and research, and organized regional meetings (González-Cabán and Sandberg 1989). Dr. J. Hudson, who along with Professor M. Salazar in Honduras, has carried out studies of effects of prescribed fire on pines of that country (Hudson and Salazar 1981). Dr. Richard Minnich and Dr. Ernesto Franco-Vizcaíno have studied fire regimes in the shrublands and forests in southern California and northern Mexico (Minnich *et al.* 1993, Minnich and Bahre 1995, Minnich and Chou 1997, Minnich and Franco-Vizcaíno 1999). Dr. Peter Z. Fulé worked on dendrochronology and fire regimes in pine and pine-oak forests in Mexico, as well as on the influence of the El Niño Southern Oscillation on fire regimes (Fulé and Covington 1997, 1998, 1999; Fulé *et al.* 2000). Dr. Scott Stephens has made significant contributions in fire ecology, comparing forest fuels and fire regimes in stands of Jeffrey pine (*Pinus jeffreyi* Balf.) of southern California and northern Baja California (Stephens *et al.* 2003, Stephens 2004, Stephens and Gill 2005, Stephens and Fry 2005). Dr. Sally Horn used evidence of carbon and pollen to establish the long-term history of forest fires in forest stands of the Dominican Republic, Costa Rica, and Panama (Horn 1989, 1997; Horn and Kappelle 2009). Dr. William Gould studied the relationship of fire and vegetation dynamics, as well as forest structure and forest fuels in Central America and the Caribbean (González *et al.* 2008, Gould *et al.* 2008, Meddens *et al.* 2008). In 2008, he edited a special issue of the journal *Ambio,* wherein fire ecology was examined in various ecosystems of Puerto Rico, Dominican Republic, Virgin Islands, the United States, and Mexico. Dr. Joseph O'Brien has investigated fire ecology in tropical pines in Central America, along with the interactions between forest structure and forest fires in the same region (Myers *et al.* 2004, 2006; O'Brien *et al.* 2008). Dr. Heidi Asbjornsen has studied the impacts of fire on cloud forests that are sensitive to fire (Asbjornsen *et al.* 2005, Asbjornsen and Wickel 2009, Gallardo-Hernández *et al*. in press). Dr. Matt Dickinson has been interested in the potential application of models of propagation of underground fires of boreal zones in tropical ecosystems of Central America. Similarly, Dr. Ron L. Myers has studied fire ecology and fire regimes in pine ecosystems in the Dominican Republic, Central America, North America, and worldwide, and has worked and written on integral fire management (Myers *et al.* 2004, 2006; Myers 2006; Myers and Rodríguez-Trejo 2009; Rodríguez-Trejo and Myers 2010) . Dr. Stephen J. Pyne made a study trip to central Mexico in 1998, in the worst fire season of the region until now, and manifested his ideas of fire management and the relevance of understanding fire ecology there (Pyne 1999, 2000; Rodríguez-Trejo and Pyne 1999).

Non-Government Organizations

The Nature Conservancy has been one of the key actors in the evolving process of fire management in the region. Its program, Fire Management in Latin America led by Dr. Ron L. Myers, recently ended, unfortunately. In 2001, this program hosted the first workshop on forest fires in Tuxtla Gutierrez, Chiapas, Mexico. This workshop, which had the participation of researchers, officials of the system of reserves, fire management officials, and other non-government organizations of countries of the region, led to other workshops of integral fire management and prescribed fires, with important advances in Honduras, Guatemala, Belize, the Dominican Republic, Cuba, and

Mexico. Dr. Myers and his program have been of great influence and support for the exchanges in fire management techniques across the region. Among his pupils are Estuardo Girón of Guatemala and Victoria Pantoja Campa from Mexico. These two young fire managers have carried out important work in various Central American countries as well as in their own countries.

In Honduras, The Nature Conservancy has had particular influence. Dr. Ron Myers has even talked with and convinced the president of that country of the need to use prescribed fires and integral fire management. Honduras began to advance in this direction, but political problems related to the end of the president's term in office made this step slower. To this date they have achieved, among other things, technical regulations for integral fire management, and their technicians have participated in workshops that have been offered in the region.

In Guatemala, Dr. Myers' TNC workshops have had a strong influence in developing fire management programs in communities within biosphere reserves (Chavajay and Girón-Solórzano 2008, Monzón-Alvarado and Girón-Solórzano 2008). They began with prescribed fires for reducing fire risk and maintaining grasslands associated with Mexican mountain pine. They have also developed many different workshops in rural communities for evaluating the contrast between prescribed fires and forest fires.

The Mexican Foundation for Nature Conservation, with financial resources from the US Agency for International Development and the US Forest Service, have contributed to the guidance of integral fire management, and financed operational and research projects for the training, equipping, and monitoring of rural community fire-fighting crews, as well as helping with diagnostics and the development of specialized workshops for training.

Federal Governments

During the past decade, the Mexican National Commission on Forestry (CONAFOR) progressively strengthened its program of forest fire fighting and prevention, provided opportunities for research, and accepted the views of researchers and NGOs regarding the vision of ecological fire management and, later, integral fire management. Presently it leads this movement. It has worked on different projects with the universities and TNC and carries out the most extensive program of prescribed fires in the country, although they are still not abundant. One of these was made for ecological purposes in the Los Fresnos Ranch, in northern Mexico, which covered approximately 1000 ha (Raygoza *et al.* 2006).

Another continuing initiative will be lobbying the Secretariat for Agriculture (SAGARPA) for help in reducing the agricultural use of fire. The CONAFOR, according to its Forest Fire Manager (Alfredo Nolasco, Mexican National Forestry Commission, personal communication), develops the national fire management policies to move from prevention and fire fighting to fire management. The adoption of these policies by high level officials in the Mexican government's Commissions on Forestry and Protected Areas, as well as Environment (SEMARNAT) and Agriculture Secretariats is still pending. The National Commission on Forestry is hoping that these officials, as well as the public, understand that fire management is an integral part of forest management and the conservation of biological diversity. The revision of the forestry law in Mexico is pending, although new regulations, such as the update of the official norm on use of fire (SEMARNAT 2009), incorporate broader elements that are closer to the national reality on the use of fire by rural communities, as well as to the fire ecology of its fire-maintained ecosystems. Another challenge is to transcend the six-year presidential terms so typical in Mexico because policies may change radically from

one term to another. In addition, the capacity for fire management needs to be developed in the three levels of government: federal, state and municipal, and rural communities. It is important to incorporate the results of scientific research and the concept of fire regimes into the decision making process and to establish strategies on the short, middle, and long terms in order for society to understand and support fire management.

The National Commission of protected Natural Areas (CONANP) has evolved, first from beginning to participate actively in the protection against forest fires, to the understanding of fire ecology and its integral management, to now having taken a leadership role in conservation and fire management. Presently, this commission has fire fighters and experts in prescribed fires in the region. Specialists such as Victor Negrete Paz (who unfortunately passed away recently) and José Velázquez have made valuable intellectual and field contributions for continuing the development of integral fire management. They led the development of integral fire management plans for their leading reserves (Pizaña-Soto *et al.* 2004, Cruz-López and Negrete-Paz 2007, Negrete-Paz *et al.* 2008, Velázquez-Martínez and Rodríguez-Chávez 2009) and provided ways to incorporate rural communities in such integral fire management. Adrián Méndez has pushed forward regulations on integral fire management into CONANP.

INDIGENOUS POPULATIONS, RURAL COMMUNITIES, AND FIRE

In the mountains surrounding the archaeological zone of El Tajín, Veracruz, Mexico, there is a panorama that is common throughout Central America. Slash and burn practices occur alongside archaeological ruins in a large portion of the vegetation of warm zones. This provides a window to a time when this agroforest system began to be practiced more than two thousand years ago. Current practices there give us an idea of the ancient use of fire as a tool and as a technology. In this region, there is also a vast cultural diversity, represented by over 75 ethnic groups. Among them are communities that make good use of fire, as well as those that make poor use of it.

These technologies, in particular that of slash and burn, have been investigated since the 1950s by a very distinguished professor of ethnobotany and his team of the former National School of Agriculture (ENA), now the Universidad Autónoma Chapingo—Dr. Efraín Hernández-Xolocotzi (Hernández-Xolocotzi 1959). At the present time, there is a renewed interest in the study of fire use technology by the rural communities. An example of this is the doctoral research carried out by Mary Huffman of the University of Colorado (she works for TNC), in the La Sepultura Reserve, Chiapas, in a community detected by Víctor Negrete-Paz and José Domingo Cruz-López. The community is the ejido Corazón del Valle, which has empirically refined a technology of controlled fires that permits both grazing and the maintenance of their ocote chino (*Pinus oocarpa* Schiede ex Schltdl.) stands, the most extended tropical pine in Mexico. Huffman has determined that the farmers consider 40 variables when they make use of fire; for example, if the wind is strong enough to be heard, the controlled fire should not be conducted (Huffman 2010).

In another study, Faustino Hernández-Santiago, a Master's student at the UACH, studied the slash and burn practices in the forests of Lacey oak (*Quercus glaucoides* Small) and pine at his birthplace, Santa Catarina Estetla, in the mountains of Oaxaca, Mexico. There the oaks are cut in relatively small areas, piling the resulting fuels to be burned before the arrival of the summer rains. The piles are dispersed throughout the terrain and are burned with caution, so as not to cause fires in the adjacent forest. The ash from the piles is dispersed over the sloped terrain by the wind and rain. The ash provides nutrients for the crops

and, during the next 2 yr to 3 yr, maize and beans are sown shortly before the rains, after which the oaks are allowed to recover. Meanwhile, other areas are worked in a similar fashion, but not extensively, thus the pine-oak forests dominate the landscape and the patches of crops are temporal (Hernández-Santiago 2010).

These examples, common in Central America, represent non-destructive human activities that have modified the natural fire regimes in the region. The practices have the purpose of supporting subsistence food production, but their philosophy is to conserve the forest. These are technologies that have been applied adequately and responsibly, and with the consensus of the community. On the other hand, the poor use of fire is widespread and evident throughout the region. In many parts, the producer simply burns grasslands of the forests at high a rate of spread and intensity to cover the largest surface before the fire-fighting crews arrive. As a result, they have enough new growth to complement feed for livestock, mostly cattle, but also sheep and goats. In these fires, many trees die and erosion is propitiated, along with the contamination generated by smoke.

In central Mexico, there is an environment that is favorable for integral fire management, but this process is barely beginning. Many communities make poor use of fire to the point that about one half of fires are due to agricultural causes while another 25% are of urban origin, caused by cigarettes, matches, and campfires. For instance, each year Mexico City is among the entities with the most fires; it is not surprising that it occupies first place with over 1000 fires. However, in affected surface it is in approximately fifteenth place, given that normally fires are very small because they are quickly put out. The entity has two strong organizations of fire management: federal, represented by the CONAFOR, and that of the government of Mexico City, the Natural Resources Commission (Comisión de Recursos Naturales, CORENA). The commission, with nearly 1000 personnel including professionals and volunteers, represents the largest force in the country with respect to the forest surface to be protected (approximately 50 000 ha). The UACH's Ajusco Project was also developed in this area, and thus it is one of the zones in Mexico with the most information on fire ecology and effects.

The scenario of fire-maintained ecosystems, broad rural use of fire, altered fire regimes, strong fire fighting capabilities, and research data availability, is ideal for carrying out low intensity prescribed fires. The Ajusco project has demonstrated that low intensity prescribed fires generate greater diversity of species in the understory, do not cause significant additional mortality within the stand, reduce the risk of high intensity fires, and produce forage for livestock. It is evident that the environmental impacts of prescribed fires are less severe than those of wildfires, and the use of fire is undoubtedly a better option than uncontrolled wildfire for forage production. The idea is that the use of fire for improved forage should be moderated. Thus, integral fire management is beginning to take hold, which, without eliminating prevention and fire fighting, results in more prescribed fires with ecological purposes and forage production for the community, and also allows an open, park-like environment. After the immediate effects of the fire have passed, the visual quality suffers little in these high-demand recreational areas of Mexico City inhabitants

As part of the Ajusco project of the UACH in central Mexico, Manuel Román Chavarría-Sanchez, using muhly (*Muhlenbergia macroura,* [Kunth] Hitchc.), associated with Mexican mountain pine as indicator species, determined that one year after the application of prescribed fires, grass cover was lower, although of higher forage quality. Over the localities burned under prescribed fires, three grazing intensities were applied: severe, moderate, and null (Chavarría-Sánchez 2009).

Analyzing areas burned by prescribed fires or wildfires in different years, Héctor Ortiz-Contla found that the best forage quality is achieved two years after the fire. Fire use was centered only on the forage objective, without considering adverse impacts of fire. He also studied the community use of fire in the area (Ortíz-Contla 2009).

SOME LESSONS LEARNED IN CENTRAL AMERICA

Without a doubt, there is strength derived from working with different organizations, including rural communities, fire managers, systems of reserves or protected natural areas, universities and research institutions, and non-government organizations, among others. This plurality provides more resilience for the maintenance of the change toward integral fire management.

Another lesson is that there are many communities that make good use of fire, thus the mistaken stereotype ("lack forestry culture") of forest fires caused mainly by the rural communities is beginning to change. Also, there is more sensitivity to their poverty and fire use as part of their livelihoods. At the same time, it has been established that the traditional knowledge of fire use present in these communities should be taken into consideration and employed in the new methods of fire management. Therefore, it is necessary to carry out further research of this traditional knowledge in the different ecological and cultural zones of the region.

CHALLENGES

Some of the principal challenges are to better understand the traditional use of fire by the rural communities and to identify those that apply good use of fire and invite them to extend this practice to other communities. For example, in Mexico, government programs of communities training other communities on forestry issues are already established. There is also a need to increase fire fighting capacity, and especially the practice of prescribed fires, as well as certification in both areas. Another challenge is to improve understanding of fire regimes. There are general proposals of fire regimes for part of the region, but it is necessary to work in more detail within the ecological regions and ecosystems. It is also necessary to convince more universities to participate in the ecological and social research of fire in the different regions of the countries and to educate the public to understand and support integral fire management. The final challenge is to connect in a sustainable way, classic fire management that has been centered on prevention and fire fighting, with the ecological use of fire and, above all, with fire management of the rural communities.

The great poet of Chiapas, Mexico, Jaime Sabines, was not an expert on fire use, but a fragment of his poem "Adam and Eve," published in 1952, anticipates integral fire management:

> *The trunk was burning when the rain stopped. The lightning defeated it and went in. Now it is a harmless ray. We will keep it here and feed it leaves and plants. I like the fire. Put your hand closer; it caresses you or burns you; you can know how far its friendship goes.*

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