Forest Fires in Mexico and Central América[1]

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Abstract

Mexico and Central America are rich in biodiversity and contain approximately 73,000,000 ha of forest land, including ecosystems adapted to, and influenced by, fire. Nevertheless, due to excessive number of fires occurring due to poverty and a lack of forestry culture, 43 percent of causes are linked to agricultural activities with an average of 21,000 fires which annually affect 677,000 ha in the region. In 1998, some 56,731 fires affected 2,330,000 ha. Forest fires contribute to deforestation and contamination as well as influencing global climatic change, among other negative impacts. There are around 17,500 permanent fire-fighters in the region with varying levels of resources and technologies for different fire management tasks. In general fire fighting resources in the region are insufficient, although there have been important advances in many cases, with relevant support from several countries. However, the future scenario is one of more fires. It will be necessary to intensify international collaboration and also the search for finance schemes, to increase human resources and materials, training, prevention detection and fire fighting. Other possible parallel activities are the use of alternative agricultural technologies instead of fire, particularly in the tropics, and ecological integrated fire management, in appropriate ecosystems and areas and with emphasis on community participation, with the support of universities and research institutes, as well as international agencies.

Introduction

México, Central America, and the Caribbean account for 29 countries with a surface area of 264,774,000 ha, of which 79,443,000 ha (30 percent) are forest land. The rate of deforestation varies according to the country, although in general it is high. The average for the region is about a 1,037.000 ha/per annum or 1.3 percent per annum (FAO 1999). The population is 161,448,000 inhabitants.

Nevertheless, nine countries (Mexico, Belize, Guatemala, El Salvador, Nicaragua, Honduras, Costa Rica, Panama, and Cuba) account for almost 96 percent of the total surface area and 85 percent of the population. This paper will be based principally on those countries.

The natural scenario

Given the varied topography, with altitudes varying from sea level to 5,700 m, soils and climates, the region contains both tropical vegetation (such as the evergreen tropical forest, sub-evergreen tropical forest, deciduous tropical forest or savannah)

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[1] An abbreviated version of this paper was presented in the second international symposium on the economics of fire, planning, and policy: a global view, 19–22 April, Córdoba, Spain.

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and cold temperate (pinewoods, holm oak and Mexican fir, upland and alpine pastures) in addition to semi-arid zones (thorny scrub, for example). Mexico and Central America have 73,030,000 ha of forest land and plantations (*table 1*).

Table 1—*Forest resources in Mexico and Central America.*

Country	Land Surface (1000 ha)	Surface with forest (1000 ha)	Forest timber Biomass (ton/ha)
Belize	2,280	1,348	211
Costa Rica	5,106	1,968	220
El Salvador	2,072	121	202
Guatemala	10,843	850	371
Honduras	11,189	5,383	105
Mexico	190,869	55,206	54
Nicaragua	12,140	3,278	161
Panama	7,443	2,876	322
Region Total	241,942	73,030	95
World Total	13,063,900	3,869,455	109

Source: FAO (2002).

The biodiversity of the region is extremely rich. It comprises the "Meso-American biological corridor," which has important environmental, social, cultural and economic resources. Nevertheless there is strong social pressure, due to population growth and subsistence requirements of rural dwellers. In recent years greater importance is being attached to these areas by society in general, through evaluation by environmental services, greater public participation and the creation and importance of NGOs. Nevertheless, further international cooperation is required to strengthen and consolidate government efforts for the protection of forest ecosystems It should be recognised that regional management by the CCAD_CCAB and CCAP is important, in order to obtain resources from the international community. There is also a need for more determination on the part of institutions and resources to implement forestry policies in the face of the most serious environmental problem of the region: deforestation and forest fires.

The region contains vegetation adapted to fire, with frequent fire regimes (every two to ten years) and moderate regimes (superficial) as is the case of many pine woods, various holm oak woods, palm groves, pastures, savannah and wetlands. There is also vegetation with fire regimes characterised by relatively frequent fires (every 50 to 100 years) and intense, crown fires as in the case of much brushland. Finally there are catastrophic regimes which are infrequent, with fires occurring over centuries as in the Mexican fir forests (with crown fires) and the evergreen tropical forests (upland forests) and sub-evergreen (with subterranean or crown fires)

Despite the fact that there is a need for improvement in determining the causes of fire in the region, it is known that 3 to 12 percent are caused by lightning. In Mexico it is estimated that half of the 32 types of vegetation with 58 percent of forest surface, have fire regimes with return periods of up to 100 years.

Ecosystems adapted to frequent fires in Central America are those of the

savannah, palm groves and pinewoods of *Pinus tropicales, P. oocarpa* and *P. caribaea*. In the case of Mexico, Rodríguez and Fulé (2003) mention 35 species of pine with variously adapted to fire.

History of anthropic fires in the region

Due to its latitude, Mexico was the first place reached by ancient man some 40,000 years ago. From there he progressed to what are today the other countries of the region. Man used fire to clear a path in the thickets or to aid hunting by attracting game to areas of re-growth. With the discovery of agriculture in Meso-America thousands of years ago, another use of fire arose, that of cleansing the forest cover to establish cultivated crops. Over 3000 years ago the Olmecs and the Mayas evolved an efficient agricultural forest system for tropical areas, particularly those with stony shallow soils: the slash and burn method which, today, due to population increase as well as the atomisation of the land has reduced the period for which the land should lie fallow from several decades to two or three years, and it has now become a significant deforesting agent causing a risk of fire in tropical zones. Subsequent European influence included fire causes relating to pasture and with more intense exploitation of the forests. Currently the same fire causes prevail, i.e. agricultural fires.

The social factor

In all the countries of this region there is a considerable rural population engaged in agricultural, fishing and forest activities. However, poverty levels have always been high and have a tendency to rise. The Hemispheric Conference on Disaster Reduction in Costa Rica in 2001, reported that from 1990 to 1999 the number of those suffering absolute poverty in Latin America rose from 200,000,000 to 225,000,000. Twenty percent of those in the upper income bracket earn 20 times more than the poorest 20 percent , converting the region into world leader in terms of income inequality. Given the lack of options and forestry culture, the changes in the use of forest terrain into agricultural land, the burning of pastures and forests for the purpose of grazing (which in many cases may considered as overgrazing) and the practices of burning of agricultural land for the purposes of cleansing, fertilisation and disease control, as well fire used in slash and burn techniques, are very common and are the prime cause of forest fires.

In Mexico 41 percent of the surface area affected out of 32 states corresponds to Chiapas and Oaxaca, which have the two lowest development levels in the country including services, education and class differences.

Fire statistics

Each year on average some 21,000 registered fires affect approximately 677,000 ha (32.2 ha/per fire). The worst year in the history of the region was 1998, with 56,731 fires registered over 2,330,000 ha (41 ha/per fire), that is, the equivalent of 3 percent of forest surface and a surface area 2.25 times greater than the average annual deforestation rate for the zone (*table 2*).

Table 2—*Number of forest fires and surface area affected by fire and agricultural burning during 1998 in México and Central America*

Country	Number of Fires	Affected Forest Surface	Surface Affected by agricultural Burning	Total Surface Affected
Belize	656	22,960	16,400	39,360
Costa Rica	1,511	52,885	37,775	90,660
El Salvador	227	7,945	5,675	13,620
Guatemala	10,906	381,710	272,500	654,210
Honduras	9,594	335,790	239,850	575,640
Nicaragua	15,196	531,860	379,900	911,760
México	14,445	849,632	4,288,670	5,139,302
Panama	4,196	146,860	104,900	251,760
Total	56,731	2,329,642	5,345,670	7,676,312
Average 1998	7,091	291,205	668,209	959,539

Source: Forest Fires in Central America Workshop San Pedro Sula, Honduras, June 1998.

The agricultural surface affected in that same year was in the order of 5,346,000 ha, for a registered total (forest fires and agricultural burning) of 7,680,000 ha burnt, i.e. a surface area burnt equivalent to more than the total surface area of Panama.

For the whole 12 months of the year fires occur in some part of the region, although most take place between January and May. April is the month of greatest risk.

With regard to the causes, an average of 43 percent are related to agricultural activities (land cleansing, pasture burning to promote regrowth). Other important causes are smokers, bonfires, rubbish burning, deliberate fires due to disputes, hunters or other reasons, or to facilitate change of soil use which account for around 42 percent. Natural causes such as lightning vary between 3 to 12 percent according to the country. Forestry activity and other causes including unknown causes cover the remaining percentage.

One aspect of the impact of forest fire is an average emission of 1,000,000 ton CO_2/per month during the fire risk period of the tropical zones of the region (Wei et al. 1990).

Prevention

Physical, educational, and legislative prevention is implemented with varying degrees of intensity in the different countries of the region. Distribution of posters, pamphlets and educational material for schools, illustrating preventive measures as well as press and radio and television messaging, in addition to documentaries, are common measures, as are talks in schools and training and talks in rural communities including those at high risk. Opening of fire breaks is another common activity. In countries such as Honduras and México controlled burning is carried out.

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Fire-fighting resources

In different parts of the region the following or partial means of detection are used: Civil participation, land detection (fixed and mobile), aerial and satellite detection. Mexico, for example, has 190 look out points. With respect to satellite detection, NOAA provides information on the region's hot spots via internet. In the case of Mexico, CONABIO has formed close links with CONAFOR to provide detection of hot spots which are also carried out in Guatemala and which could extend to all of Central America. The Mexican SMN is beginning to provide a similar service in Mexico.

There is no precise data for all the countries and some do not even have official fire fighting teams with the work being carried out by volunteers. Between Mexico, Guatemala, Cuba and Costa Rica, there are 16,500 permanent fire fighting forces (Martínez 2002; SIPECIF 2002; Ramos 2003; Murullo 2002). It is estimated that the region has at least 17,500 permanent fire fighters of the principal agencies responsible.

The situation is also very variable in terms of material resources, in some cases there is a lack of specialised equipment. In most countries however, although quantities vary, there is agricultural equipment, specialised manual tools, back pack sprayers, protective clothing vehicles, and radio equipment. Some countries have portable meteorological monitors

The availability of land and air vehicles is also very variable. Cuba has PZL-M18 Dromeder air tankers and pump trailers (Ramos 2003). El Salvador has two helicopters (Ibarra and Marroquín 2002). Honduras uses fire department tankers (AFE 2002).

As a more detailed example, different areas of México have almost 50,000 sets of manual and specialised tools, 3,663 specialised minor teams, 684 geopositioners 249 camps, 334 control centers, 898 vehicles for fire fighting teams, 2,786 radio equipment sets, 55 airships for detection, and 49 combat helicopters (Martínez 2002). Last year a dozen pump trailers were incorporated.

The amount spent on forest fire programmes amounts to 8,000,000 de Quetzales in Guatemala (SIPECIF 2002), 60,000,000 lempiras in Honduras, 191,600,000 pesos (including central operational costs, fire team salaries, temporary employment programme, and administration operational costs) in México (Federal government only) (Martínez 2002), corresponding to US $987,654, US $3,348,214, and US $17,461,686, for a total of US $21,797,554 in these three countries.

Fire fighting organization

The main fire fighting body in Mexico is CONAFOR, the federal government, with the participation of state and municipal governments. The Secretary of National

Defence also participates, as do the owners of forest land, forestry industry organisations, forestry service professionals, agricultural producers, civil bodies (NGOs academics, businessmen, producers), rural confederations (including CNC and CCI,) all of whom, together with personnel from protected natural areas, make up the Forest Fire Prevention Programme.

Various institutional bodies are involved in fire fighting and fire prevention. In Costa Rica (Ministry of Environment and Energy, with the National Commission on Forest Fires), Cuba (Corps of Forest Rangers of the Ministry of Interior), Honduras (State Forestry Administration, COHDEFOR), Nicaragua (National Forestry Institute), México (National Forestry Commission), and Panamá (National Environment Authority, with the National commission for fire fighting and prevention). Cases with various institutions include Belize (Forestry and Army Department), El Salvador (Fire fighting forces, National Emergency Committee), and Guatemala (National Plan for the Prevention and Control of Forest Fires of the Ministry of Environment and Natural Resources, Secretariat for Executive Coordination of the Presidency, CONRED, Army, Nation Forestry Institute and the National Council for Protected Areas).

Almost all countries have a National Operations Center although not always at a state or provincial level.

Training and Education

Training courses for instructors directed at technicians and professionals from various Latin American countries and Spain delivered by the US Forestry Service with instructors from U.S.A. and Spain, and with the support of AID, in 1984 and 1985, in Marana, Arizona, were the basis of a chain reaction in Mexico which slowly strengthened due to the interest of the federal area for prevention and control of forest fires and the continuing possible of participation of U.S.A., Spain, and Canada. Little by little the level of competence of fire fighters was raised and the type and level of courses diversified.

Mexico currently holds an international course every year for 60 participants from Mexico and other countries which has been held since 1990. There are courses for emergency management (basic or intermediate) for helibucket handlers, and also 900 basic courses held annually for ejidos and communities, and a national course for National Defence Forces in addition to two courses for Mexican Air Force pilots who receive certification from the USFS.

There has been a similar trend in other countries. In Guatemala, for instance, 103 courses of varying levels were held in 2002 (most of these were for forestry fire fighters, two for training instructors and one for emergency management)) (SIPECIF 2002). In Honduras, 28 courses were held the same year, three given by international trainers and 25 with national trainers (AFE 2002). In Nicaragua, 33 courses were held annually between 1998 and 2002, training 226 technicians and instructors and 1,615 fire fighters (INAFOR 2002).

Although with varying levels of proficiency, technical professional and postgraduate education covers the theme of forest fires in respect of various topics at a regional level. In the case of Mexico, all degree level institutions of forestry science offer a course in forestry protection or at least include the subject. For example, the Forestry Science Division of the Autonomous University of Chapingo holds a course

on Forestry Protection (which is a compulsory subject), and another on the Use of Fire (an optional subject). Since 2000 the postgraduate programme at the same university has held courses on the Ecology of Fire and the Restoration of Forest Ecosystems (from 2001) (which includes themes on fire management), and a special question on the theme of smoke from forest fires. Another program which offers courses related to the subject is UAAAN, with a course on forest fuel management.

Research

Research into the subject is increasing, particularly in terms of the ecology of fire, due largely to the interest of national or international researchers, although there is still much to be done. A case in point is the fact that Autonomous University of Chapingo, CONACYT, CONAFOR, the Government of Mexico City and the Community of Santo Tomás Ajusco, are carrying out a project on the ecology of fire and integral fire management in tall pine forests (*Pinus hartwegii*), known as the Ajusco Project (*table 3*). In addition the University of Guadalajara, the University of Washington and the INIFAP are carrying out another project with an ecological and social focus in the Manantlán Reserve, Jalisco, which includes the creation of stereoscopic guides for forest fuels.

Another field in which there has been active research is that of GIS and spatial statistics applied to the problem of fires largely due to the efforts of CONABIO, INIFAP, the University of Colima, and the College of Postgraduates among others.

Table 3—*The Ajusco project*

Antecedents. The Federal District has a surface area of 150,000 ha, 35,000 ha of which comprise pine woods, holm oak, Mexican fir, pasture, and zerophyte scrub. Among the pinewoods, the most notable is *Pinus hartwegii*, or upland pine (also present in Guatemala), found between 2,200 and 4,000 m above sea level. In terms of number of fires, the Federal District on average is third at a national level, some years with more than 1,000 fires. Nevertheless, excellent fire fighting cover by the federal and Mexico city governments, and good available access reduced the surface area affected to 20th position. Here the causes of fire are mixed, in rural areas relating to agricultural activities, principally pasture, and fires generated by the urban population, one of the most populated on the planet, (bonfires and smokers) in addition to the pressure of growth of Mexico City and contamination. Since this area has an ecosystem well adapted to fire, which is of prime importance in terms of conservation and restoration, and since it comprises high mountain terrain and includes endemic and status species, in addition to its problem of forest fires, it is an area of particular interest in the application of the project. Some of the research for this project was also done on this type of ecosystem in other parts of the Federal District or in the State of Mexico.
Objective. The aim of the project was to contribute to use of fire which reconciles its ecological role in this ecosystem, enabling it to be used for moderate livestock purposes maximising the positive impact of controlled low intensity fire (diversity of species, greater secondary growth, recycling of nutrients, creation of seed beds, reduction of danger of forest fires, among others) and reduction of the negative impact of fire, which obviously has a more dramatic effect (death of trees, disease, deforestation, erosion, pollution). As it continues to be an option for the rural land worker, it is hoped that in future he will contribute to the reduction of forest fires in the area. The project is being developed principally by researchers carrying out their postgraduate theses and degrees.

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Continuation…

Methodology and Results. At 3,500 m above sea level, these were fringe areas with low intensity fires (in March) and experimental confined fires at the peak fire risk periods (May 2002), and a test area was left unburned. Results were obtained for a year but at least three more years will be studied in order to analyse the duration of the effects found. Below the main results are detailed.

Behaviour of fire. The prescribed fire early in the period and early in the morning, against the wind, and at a gradient (55 percent) spread at no more than 1/min, with flame length of 0.5 m. The flames of the fire at the hours of greatest risk and in full fire risk period, with the wind in favour and on a gradient, reached flame length of 6 to 8 m. and with propagation speeds of up to 60 and 80 m/min.

Radial growth of *P. hartwegii*. The width and growth ring formed the year following the fire was greater than the test area when only the lower third of the crown was affected by the heat of the fire (an effect of natural pruning which eliminates the lower branches, which, having less foliage are less efficient in photosynthesis, thus more is consumed than produced, as well as fertilisation from the ashes). Those with brunt crowns from 33 percent to 66 percent had narrower growth rings than the test area. (González and Rodríguez,).

Survival and susceptibility to disease. The survival of young trees (from 2 to 6 m in height) was not statistically significant between the areas of prescribed burning in March and the test area (96 percent in both cases). In the May fires, survival was 48 percent although in most dense areas this value was 0 percent due to greater accumulation of forest litter which, when burned, transmitted greater temperatures to the superficial roots of the trees, thus killing them (Castro and Rodríguez,).

Wealth and diversity of species and species indicative of burned areas. In summer with the rains which characterise the region, 12 herbaceous and shrub species were registered in the test areas and 21 in the areas of controlled burning or of fires. The most dominant species and those indicative of the burned areas are: *Penstemon gentianoides, Senecio callosus, Lupinus montanus, Eupatorium* spp., and *Senecio tolucanus* (Martínez and Rodríguez 2003). In general the wealth of species is low due to the high altitude of the area.

Planting in burned areas. Initial survival (6 months on from planting) of trees of the species planted in the treated areas did not significantly differ statistically between the test areas and those of the controlled fire in March (with 93 percent and 88 percent). The areas burned in May had a lower level of survival (60 percent) (Ortega and Rodríguez 2003).

Smoke from fires. Emissions of NO_X, SO_2 , and CO were, respectively, 9.37 Kg/ha, 2.84 Kg/ha, and 198.69 Kg/ha. *Senecio cinerarioides*, a species which appeared abundantly in many areas of the central region, affected by past fires in 1998, is the main cause of emissions of these gases. If such areas are burned again they will contaminate more than they would have if typical superficial fuels of these pinewoods had been burned. (Contreras et al. 2003).

Germination of *Lupinus bilineatus*. Seeds of this species remain dormant. Without treatment at 20 °C during the day and 15 °C at night with 12 light hours only 18 percent germinate. With fire scarification it rises to 39 percent with significantly different statistics (Martínez and Rodríguez,).

Existing projects and Initiatives

These are as follows:

- Meso-American Cooperation Programme. With the summit meeting of heads of states of the countries which are members of the Dialogue and decision Tuxtla IV.
- Meso-American Biological Corridor for consolidation with the participation of PNUD, GEF, GTZ, DANIDA, CCAD and the governments of Mexico, Belize, Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica, and Panama.
- United Nations World Food Programme. For mobilization of voluntary brigades in Honduras.
- Integrated Management of the Ecosystem in Indigenous Lands and of the in Central America. With the participation of the GEF.
- World Bank Central American Geographic Information with the participation of CATIE and CIAT.
- Regional Environmental Programme for Central America. Run by USAID.
- Emerging Plan for the Prevention and Control of Forest Fires at a national level (INAB).
- Training and Education Programme for Forest Fire Instructors (OFDA-AID).

Cooperation networks

These include:

- British-Nicaraguan Cooperation (NOAA, MARENA, INAFOR). For the detection of hot spots using satellites.
- Prevention and Control of Forest Fires in Meso-Amercia (CCAD-Tuxtla IV).
- Inter-American Information Network on Biodiversity (IABIN).
- Programme of hot spot detection using remote perception techniques. (CONABIO-CCAD).
- Central American Alliance for Sustainable Development (ALIDES).
- Working Group on Forest Fire Management (COFAN: U.S.A., Canada, and Mexico).

Future fire scenario

The future scenario, while current levels of activities and resources are maintained, is one of more fires and greater surface areas affected. This is true given existing investigation into global warming (which results in higher temperatures, less

humidity, the spread of more inflammable vegetation such as underbrush and pasture, reduction of forests, and greater presence of lighting on various areas of the planet) in addition to the effects of El Niño. In addition, given the fact that poverty is unlikely to be resolved in the region, the result is a greater presence of natural and anthropic fire.

It should be recalled that if tropical forests, a mainstay of biodiversity, are affected by fires, this will lead to a greater risk of fire until these areas are progressively converted to savannah and pasture.

Dealing with the probable scenario

Undoubtedly of prime importance in reducing the attack of fire is greater cooperation of agencies within the country itself and between countries, such as the search for financing schemes to reinforce prevention—pre-suppression and suppression with greater human, material, technical, technological and financial resources. For example, among the goals for future international cooperation: establishing regional mechanisms to ensure the contribution of technical and financial resources from the international community, for the purpose of strengthening and consolidating government efforts in the countries of the region for planning, prevention, detection and control of fires, which permits the training, and the formation of teams with specialised equipment as well as establishing systems in response to emergency management.

Another aspect is that of alternatives to fire in agricultural activity and the fact that it would be advisable to increase, particularly in tropical areas, slash and dig instead of slash and burn techniques. Another option is also greater incorporation of well-planned agricultural forest systems

However, there is an additional growing trend in various countries, through the initiative of academics and technical experts and with participation or initiative of other nations which has two components. The first is linked to the ecological role of fire, that formidable adversary which can be temporarily vanquished, but which cannot be excluded from the planet, since it has been present in vegetation for millions of years and most of the land ecosystems have developed variously depending on the frequent presence of fire or rarely its influence. Efforts are being made in scientific research and on an operational scale for the use of fire for ecological and forestry purposes.

It is also necessary to consider on one hand that man has frequently burned vegetation to excess, lowering its resistance to fire and degrading it. On the other hand, the exclusion of fire leads to an accumulation of fuel which will make the next fire more intense, more dangerous, and with a greater negative impact; in addition to being more expensive and difficult to control. A happy medium would be ideal, such as using fire but with a technical and scientific basis.

For example, TNC is starting controlled fires for ecological purposes in reserves such as La Amistad, Costa Rica; Madre de las Aguas, Dominican Republic, and Rio Bravo, Belize. In Mexico attempts are also being made in the ecological and integrated management of fire, via controlled burning of vegetation in fire regimes where fires are frequent but not intense and/or integrated fire management in the Parque Cumbres del Ajusco, and in reserves such as Manantlán, La Sepultura, La Encrucijada, El Ocote, Sierra de los Ajos, and la Sierra de Arteaga, with the

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