



# Forestry Department

Food and Agriculture Organization of the United Nations

## Fire Management Working Papers

### Global Forest Resources Assessment 2005 – Report on fires in the South American Region

*by*

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March 2006

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Working Paper FM/5/E  
FAO, Rome, Italy

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The purpose of these papers is to provide early information on on-going activities and programmes, and to stimulate discussion.

Comments and feedback are welcome.

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For quotation:

FAO (2006). Global Forest Resources Assessment 2005 – Report on fires in the South American Region. Fire Management Working Paper 5. [www.fao.org/forestry/site/fire-alerts/en](http://www.fao.org/forestry/site/fire-alerts/en)

## FOREWORD

Fires impact upon livelihoods, ecosystems and landscapes. Despite incomplete and inconsistent data, it is estimated that 350 million hectares burn each year; however, the nature of fires determines whether their social, cultural, environmental and economic impacts are negative or positive. Up to 90 percent of wildland fires are caused by human activities primarily through uncontrolled use of fire for clearing forest and woodland for agriculture, maintaining grasslands for livestock management, extraction of non-wood forest products, industrial development, resettlement, hunting and arson - thus any proactive fire management needs to adopt integrated, inter-sectoral, multi-stakeholder and holistic approaches. The situation varies markedly in different regions of the world.

As a supplement and complement to the Global Forest Resources Assessment, 2005, this working paper is one of a series of twelve prepared by regional and country contributing authors to provide a greater depth of data and information on fire incidence, impact, and management issues relating to the twelve UN-ISDR Regional Wildland Fire Networks around the world.

The working paper series assesses the fire situation in each wildland fire region, including the area extent, number and types of fires and their causes. The positive and negative social, economic and environmental impacts are outlined. Prediction, preparedness and prevention as key elements in reduction of the negative impacts of fire, rapid response to extinguish fire incidents and restoration following fires are addressed.

The working paper series also addresses institutional capacity and capability in wildland fire management, including the roles and responsibilities of different stakeholder groups for prevention and suppression, particularly the unique role of community-based fire management.

From these working papers, a FAO Forestry Paper on Fire Management will synthesize the highlights from each region, but also provide a global summary of important lessons that can be used in fire management in the future. These papers are a valuable resource in the process to prepare the Fire Management Code, the Global Strategy to Enhance International Cooperation in Implementing the Fire Management Code and associated capacity building.

## **ACKNOWLEDGEMENTS**

This working paper is the product of a global team of dedicated people willingly giving of their time and specialist expertise within each of the twelve UN-ISDR Regional Wildland Fire Networks.

María Isabel Manta Nolasco, as the author, obtained key information and data for this working paper from Argentina, Bolivia, Brazil, Colombia, Chile, Ecuador, Guyana, Paraguay, Peru, Suriname, Uruguay, Venezuela and French Guiana.

We also wish to acknowledge the dedicated work of Claudia Scholz and Johann G. Goldammer, Global Fire Monitoring Center (GFMC), for contributing materials and for reviewing this working paper.

Additionally, we wish to thank Michèle Millanès for the excellent editing and formatting undertaken.

To all persons who contributed to this working paper, we express our grateful thanks.

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## 1. Background

Following the release of the Global Forest Resources Assessment 2000 (FRA 2000) report in 2001, the global FRA process has entered its next reporting cycle. Recommendations from the Kotka IV Expert Consultation in July 2002 on directions of global FRA's were confirmed by FAO's Committee on Forestry (COFO) in 2003. It included to embark on an update of the global FRA for the year 2005 (FRA 2005) and to increasingly involve countries directly in the assessment and reporting, in particular to submit national reports on the status and trends of a range of forestry parameters. More information about FRA 2005 is available at [www.fao.org/forestry/fra](http://www.fao.org/forestry/fra).

FRA 2005 also includes thematic studies, including e.g. forest fire, forests and water, and mangroves. The thematic study on forest fire is built on regional reviews of forest fire management through the UN International Strategy for Disaster Reduction (UNISDR) Global Wildland Fire Network (GWFN). The current report is a contribution and makes a review of the South American region.

This Working Paper FM/5/E has been written by Mrs María Isabel Manta Nolasco and does not reflect any official position of FAO.

## 2. Introduction

In the light of the current knowledge available, it is well established that forests are more than wood and non-wood products. Forests need to be protected, not only with the aim of maintaining their biological diversity, but also because forests are the most important air-cleaning factors on our globe, apart from the oceans. They act as carbon sinks and as physical air filters. They contribute to avoid floods and to reduce the erosion process by retaining precipitation in the soil.

However, increasing human settlements and road infrastructures, as well as changes in land uses, result in a series of obvious effects on climate change and on the wildfire risk, producing an increase of threats to the rural population, fire fighters and rescuers. Loss of human lives was extremely high during summer 1998, when at least 700 people died. Moreover, the vulnerability of the forests has now reached such a magnitude that, beyond this level, further burnings would seriously endanger these ecosystems and their sustainable management. On average, in the 1990s in South America, about 25 000 wildfires have burned a surface of 4.3 million ha every year (based on Appendix 1, Table 1).

This paper provides an overview, covering the last 25 years, of the wildfires situation in the ten most affected countries, although the availability of information for French Guiana, Guyana, and Suriname was very limited. The report describes detection, prevention and suppression capacities of each country at national and international levels. It reports on the impacts that wildfires have had on the region and its population, and on national and international collaboration. It also covers the needs and limitations of fire management related to the decision making at national and international levels.

## 3. Fire situation in the region

Wildfires are present at all ecosystems of South American countries, extending from 12°N to 56°S. The frequency, intensity and time distribution of wildfires during the year are variable in response to different human factors such as cultural practices, population density, tourism affluence and characteristics of fire suppression activities. In addition to the human factors, the wildfires are affected by environmental factors such as the occurrence of the *El Niño* event, droughts and, in some occasions, lightning storms.

The biggest tropical rainforest extension of the world can be found in the South American region, reaching almost 885 million ha located in the Amazon basin, and another 85 million ha in the system formed by the Orinoco and Parana catchments, representing 95% of the continent's total forest cover. Such ecosystem contains an extraordinary biodiversity: Brazil, the first country in the world in biodiversity, followed by Colombia (ranked in 4<sup>th</sup> position) and Peru (7<sup>th</sup> position). This biodiversity is protected in natural areas with several categories. To this respect it could be mentioned that the countries of this Region protect the forth part of the world's tropical rainforests. A substantial part of

tropical evergreen forests are located in Peru, Colombia, Ecuador, Venezuela, French Guiana, Guyana, Suriname and Bolivia, but the vast majority of these forests is located in Brazil.

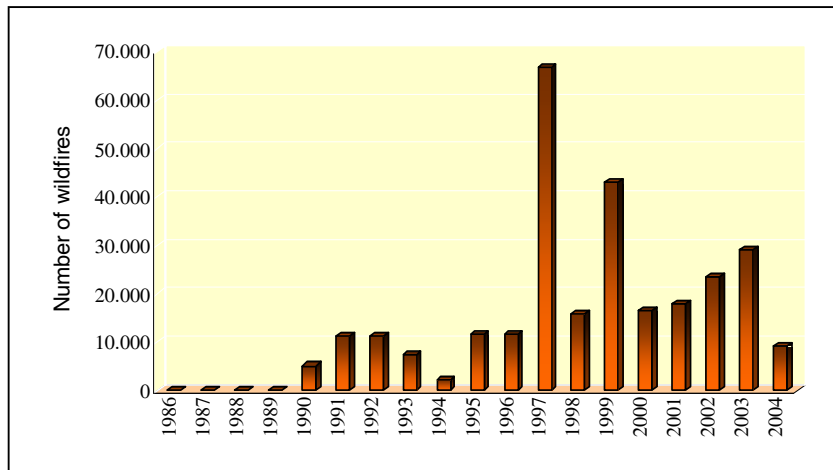
Temperate forests are located primarily in Argentina, Chile, Paraguay and southern Brazil, covering only 5 percent of the continent's forests. In the Andean mountains (7 250 km long), other terrestrial ecosystems exist, associated to the highest glacial in tropical latitude. The glacial originates from the most important watersheds in the Region: Amazon and Orinoco rivers. Thus, the continent spans a vast area from the coastal dry forest in Brazil and Peru to the temperate rainforests (*Nothofagus* spp.) of Tierra del Fuego. The regional vegetation ranges from virtually non-vegetated areas in the Atacama desert to lushly profuse vegetation within the wetter parts of the Amazonian rainforest.

### 3.1 Extent, number and types of fire and forests burned

Data samples of wildfire occurrence in the region during the last 25 years are shown in Appendix 1, Table 1. Although the search for information for this paper has been exhaustive, national statistics are not complete, because data are often unavailable, non-existent or inaccurate, like in Bolivia, Ecuador and Paraguay. Furthermore, most countries do not distinguish the different forest types in the affected areas. This bottleneck makes it difficult to elaborate the national and regional wildfire statistics in an accurate manner. Nevertheless, even considering that the situation is still uncertain, an increasing trend in the occurrence of wildfires during the last 25 years can be observed.

**Table 1.** Annual number of wildfires and burned area in South America 1986 to 2004

Year	Number	Area burned (ha)
1986	13	58.00
1987	8	15 040.00
1988	9	60 927.00
1989	65	13 509.00
1990	5 201	45 698.00
1991	11 279	9 759 804.00
1992	11 280	654 224.00
1993	7 533	1 861 720.00
1994	2 339	1 688 040.00
1995	11 490	979 165.00
1996	11 572	564 674.00
1997	66 807	5 585 369.00
1998	15 877	1 137 305.00
1999	43 016	13 592 352.00
2000	16 401	2 891 799.90
2001	17 966	4 888 276.40
2002	23 519	2 607 460.46
2003	29 158	3 667 639.85
2004	9 191	430 418.19



**Figure 1.** Annual number of wildfires in South America (based on Appendix 1, Table 1)

### **Fires reported for the past three decades**

At least 51.7 million ha of forests, other wooded lands and other vegetation, mainly growing in wildland and protected natural areas, were burned during the last 31 years. Most of them correspond to other wooded lands (26%), followed by other lands (20%) and forests (17%).

The main areas affected are grasslands growing in wildland and protected natural areas of Argentina, Bolivia, Chile and Uruguay (20%) and not intensively managed savannas, shrublands and wildlands of Brazil (Cerrados), Bolivia, Colombia, and Venezuela (13%). Twelve percent of the burned areas are not intensively managed native tropical rainforests, mainly in the Amazon watershed.

Darien gap zone in Colombia (Silva, 2003) and peat in high lands of Peru have also been affected by fires. Additional wildfires, which affected several countries especially in 1998, have been reported (Nepstad *et al.*, 1999, 2001) from forests throughout Southern, Central, and Eastern Amazonian watersheds. Unfortunately there is no quantitative data on the numerous wildfires which occurred across the Guyana Shield, Suriname and Guyana. Wildfires in the tropical rainforests, which traditionally have not been affected by fires, have increased due to the deforestation, land use changes and landscape fragmentation.

The reported burned area in forest plantations was about 120 000 ha in the last three decades. Pines and eucalypts have been the species most affected by these wildfires, with frequent lightning occurrence. The biggest plantation fires were observed in Argentina, Chile, Uruguay, Venezuela and Ecuador. As the plantation dimensions have increased, problems related to wildfires have emerged (FAO, 1998) and plantations have started to be considered as dangerous forests (Galindo, 2005; Carrere, 2004).

### **Extent and number of fires in the 1990s**

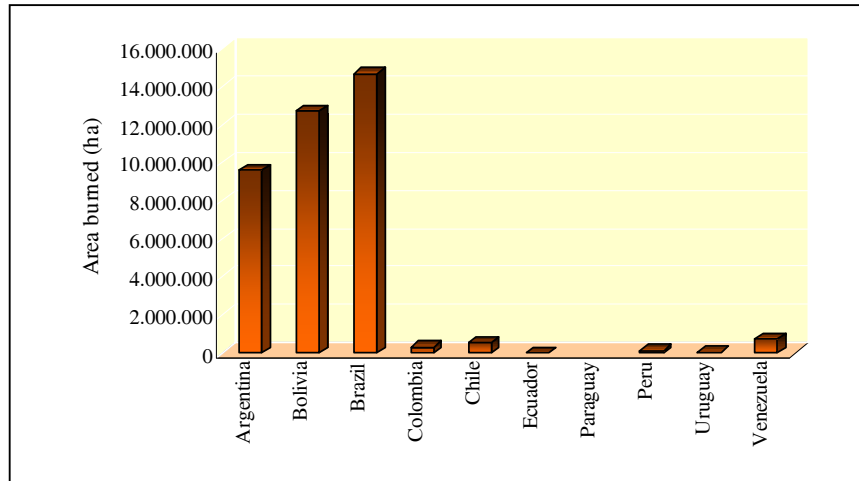
The results presented in Appendix 1 show that, in the 1990s, a total of 38 715 870.90 ha was affected by wildfires in South America. During this decade, an average of 4.3 million ha of surface was burned by 25 000 wildfires every year (Figure 2). If comparative analyses between different countries in the region were made, Brazil would have the largest burned area even if data cover only five years, followed by Bolivia and Argentina respectively. On the contrary, due to the scarcity of data, Ecuador and Paraguay appear to have less area affected by wildfires.

The fires that occurred near the urban-wildland interface have become a significant problem during the last decade. This problem is disturbing the normal life in the main cities of Argentina, Chile, Uruguay and Ecuador. The new situation has also increased the risk for fire fighters, because it is more difficult to fight these fires (Viegas, 1977; Lopez *et al.*, 2002).

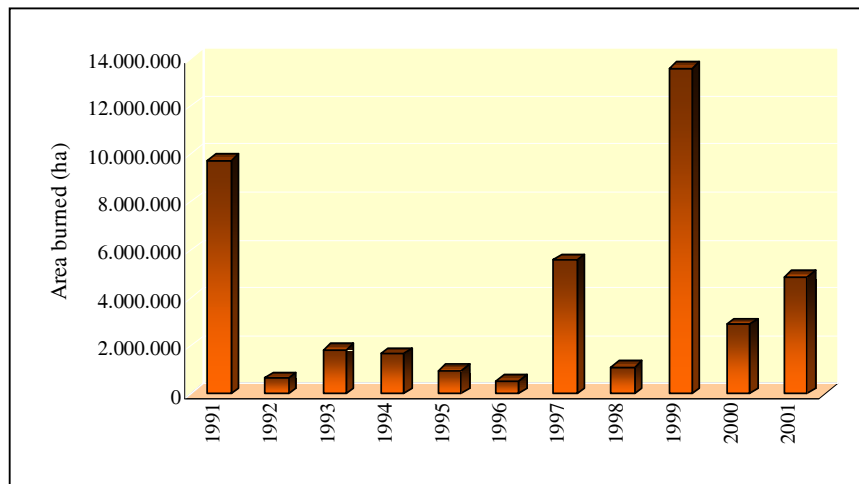
The analysis of the wildfire time series shows that the greatest areas affected by wildfires in the entire period were observed in the years 1991, 1999 and 2001 (Figure 2). The "fire season" varies according to the rainy season onset. Fires occur mainly in autumn and winter, associated with the dry seasons (North of Argentina, Bolivia, Brazil, Colombia, Chile, Ecuador and Peru). In the territories where the dry season occurs in early summer and late spring, wildfires start mainly between January to May and June to December (South of Argentina, Colombia, Chile, Uruguay, and Venezuela).

Due to the severe droughts (and *El Niño* events) that occurred during 1992, 1993, 1997 and 1998, an increase of both the number of wildfires and the total area affected was noted, causing enormous costs to the region in terms of economic losses and environmental damages (Martinez and Cordero, 2003; UNEP, 2002). In the Amazonian State of Roraima, 1.1 million ha of undisturbed forest was burned, only in 1998 (Barbosa and Fearnside, 1999). Additionally the intentional pasture maintenance fires probably exceeded 20 million ha burned in the Brazilian Amazon (Linden, cited by UNEP, 2000), and 2.6 million ha of savanna forest and 1.4 million ha of Amazonian rainforest in Bolivia were burned in 1999. In 2003, in the Roraima State, *El Niño* provoked a long drought period and 200 000 ha of tropical rainforest were burned again.





**Figure 2.** Area of forest burned in South American countries in 1990s (based on Table 1, Appendix 1)



**Figure 3.** Annual area of forest burned in South America during the 1990s (based on Table 1, Appendix 1)

### 3.2 Causes of fires

The available information (Appendix 1) reveals that 85.5% of the wildfires which occurred in the region were caused by human activities. The vast majority of wildfires result from fires escaped from pasture and agricultural land maintenance activities, as a result of forest clearance, logging and hunting, rubbish, cooking or waste burning activities as well as arson and accidents.

Nepstad *et al.* (1999) stated that a combination of slashing with drought is causing an increase of the tropical rainforest flammability. Areas affected by slash and burn are not commonly included in the wildfires national statistics, but even though it could be the cause of 60% increase in the area burned in the Amazon countries. In addition the selective extraction of wood causes an increase in the fuel flammability rate because of the solar light penetration to the fuel bed on ground and an increase of fuel load due to woody logging debris. The superficial wildfires also produce an increase in the wood flammability leading to a very dangerous circle in which the forests – in particular in the Amazon – are

more flammable during every new fire season. In addition, due a heavy drought, even the wettest rainforests may become flammable. Most of the wooded lands in the East and South parts of the Amazon are exposed every year to severe droughts, particularly during *El Niño* events.

The public agrarian policies are lacking the adequate planning and control mechanisms to promote the expansion of the agricultural and livestock borders and are causing great-scale transformation areas from rainforests to grazing areas and soya crop extensions, especially in Brazil, Bolivia, Colombia, Ecuador, Paraguay, Peru and Venezuela.

Small producers constitute only the fore front of the colonisation of virgin territories. Afterwards the ownership changes to livestock, agro-industrial and forestry companies, which continue the intensive exploitation of these lands at large scale.

Another policy acting in favour of wildfires occurrence is the construction of pipelines, gas pipelines and highways in Brazil, Colombia, Ecuador, Peru and Venezuela. These activities affect even the protected natural areas. A report from the United Nations Environment Programme (UNEP) (2002) indicates that the agro-industrial, mining and transport policies prevail over the forestry and are indirectly promoting wildfire occurrence. Policy makers are not yet conscious that a reasonable action for achieving financial advantage in the short time turns out to be a bad solution on a long-term basis.

Lightning or other natural causes account for 5.5% of wild fires and they are present in the central and southern part of Patagonia (Rodríguez, 2000), in the "*cerrado*" of Brazil (Mutch, 2003), in the savanna biome of Colombia (Silva, 2003) and in the oriental part of Venezuela. Tropical thunderstorms are commonly accompanied by heavy rains that preclude the ignition of fires by lightning most of the time.

The unknown causes account on average for 9% of the total number of fires.

### **3.3 Damages**

During the 1990s, an increasing number of fires was reported in most countries. These wildfires have caused serious environmental disasters, they have killed and injured people, burned hundreds of homes and destroyed several villages and towns.

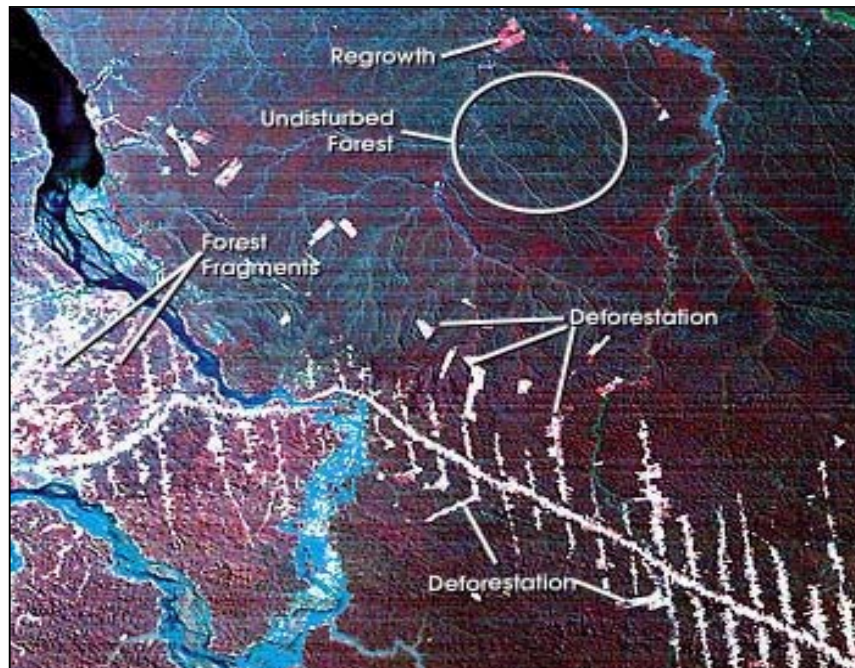
Wildfires in the Region have a significant impact in terms of losses of human lives. In fact, volunteers, fire fighters and civilians living around the burned areas perished due to the flames or by suffocation. At least 742 people lost their lives and other 429 people were injured as a consequence of these wildfires. The highest tribute was paid by Brazil in the Roraima wildfires where 700 people died (UNEP, 2002). In addition, the smoke produced by wildfires caused thousands of respiratory and cardiovascular problems, in particular numerous cases of constrictive and obstructive lung disorder have appeared; the number of cases of asthma, pneumonia, bronchitis, acute laryngitis, bronchiectasis and conjunctivitis jumped up dramatically. Respiratory diseases have caused the death of children and aged persons in Sucre (Bolivia, 2004). Mutch (2003) estimated that the number of people hospitalised with breathing problems increased by 3.2% during the burning period in the Amazonian region.

The widespread wildfires are changing the landscape of tropical rainforests. This may be the greatest impact of wildfires on the region. Once they have been affected by wildfires, the ecosystems are unable to support the plants and animals species that lived within them. The situation has become severe in Brazil, Bolivia, Venezuela, Colombia, Ecuador, Paraguay and Peru (Figure 3). In French Guyana, French Guiana and Suriname the changes are less visible. The effect of fires on temperate forests and savanna are serious, but these ecosystems are fire-adapted at different degrees and the interrelation between fire and vegetation within them is reasonably well understood. On the contrary, the effect of fires in sensible ecosystems like tropical rainforests is extremely severe. If the current fire incidence levels remained stable or increase, many rainforests would be replaced by some vegetation less diverse and more fire-tolerant. Single or sporadic wildfires normally support a mosaic structure and raise a variety of flora and fauna, but the negative part of the balance will prevail in case of frequent and uncontrolled burnings. Reiterative wildfires which occur in short-time intervals support grassland, which often forms a fire climax (Cwielong, 2000). Whereas a large single fire does not always lead to a disaster, the cumulative effects of frequent wildfires may do so. Negative effects on large groups of animals such as birds, mammals and reptiles have also largely increased, even if such groups and many mobile animals are able to escape the flames. Many research activities

carried out in Brazil show that the animals may not survive these frequent wildfires due to the reduction of the availability of their resources and habitats.

Problems caused by the air pollution from large fires are becoming more and more important due to their potential effect on human health and the release of greenhouse gas emissions. In the last decade the smog released by these wildfires darkened big cities (i.e Buenos Aires, Roraima, Sucre, Tarija y Santa Cruz) as well as small towns (Pucallpa, Madre de Dios, in Perú), causing severe long-lasting respiratory problems and disturbed the aerial traffic (i.e Rio Branco, Porto Velho, Conceição do Araguaia, Carajás, Marabá and Imperatriz in 1995). Furthermore, researchers from the Buenos Aires University (UBA), Catholic University (UC) and National Council of Science and Technology (CONICET) have observed that the smoke from Africa crossed the Atlantic Ocean and arrived in Colombia, while the smog released in Bolivia brought air pollution to the state of Acre (Brazil) in 1999. Smog released in Brazil polluted at its turn the air of Paraguay and Peru and the smog emitted in Paraguay affected the air condition of Argentina (Figure 4). The trans-boundary dimension of the air pollution caused by wildfires and burning makes necessary the setting up of a strategy for their control, based on the general consensus among the different countries within the Region.

In relation to the greenhouse gas emissions, Barbosa and Fearnside (1999) have estimated that around 3.5-4.0 tons of carbon were released as CO<sub>2</sub> for each hectare burned in Brazil, so around 4.4 million tons of CO<sub>2</sub> and 800 000 tons of CO<sub>2</sub> were respectively released in 1998 and 2003. Wildfires affected primary forest in Roraima; while for Bolivia, Martínez and Cordero (2001) indicate that 82.64 million tons of CO<sub>2</sub> were released from savanna forest burnings, followed by grasslands burnings. In Colombia savanna burnings are also recognized as a major contributor to the release of greenhouse gases (Silva, 2003).



**Figure 3.** Deforestation, agricultural burning and wildfires are changing the landscape of tropical rainforests of Amazonian (Reproduced with permission from D. Nepstad)



**Figure 4.** Smoke plume from a wildfire in Paraguay  
(Reproduced with permission from J. Pérez)

Additional negative impacts of wildfires on the environment are the soil erosion processes that occurred at the Andean mountains, tropical and temperate forest and also at coastal areas. These erosion processes caused floods and landslides, as it has been quantitatively registered in Bolivia, Brazil, Colombia, Chile, Ecuador, Peru and Venezuela (UNEP, 2003). All these processes together caused by wildfires affect the water cycle, the pollution burden of the atmosphere and also the dynamics of the atmospheric circulation. Andreae *et al.* (2004) have found that heavy smoke from forest fires in the Amazon produced a reduction of the cloud droplet size and a shift of the final precipitation. Thus, detrained pollutants and water vapour would have profound radiative impacts on the climate system. The invigorated storms release the latent heat at high altitudes in the atmosphere, which should substantially affect the regional and global circulation systems.

The assessment of the damages produced by wildfires include economic (medical costs, timber and erosion losses, airport closures, etc.) and environmental costs, but the real costs of wildfires in the region are, in fact, unknown. This is mainly due to a lack of data and analysis of the reported damages. The resulting damage due to the carbon released from Brazil and Bolivia in 1997-1998 and 1999 respectively, can be crudely estimated to have reached US\$1.19 billion (Martinez and Cordero, 2003; UNEP, 2002).

### **3.4 Wildfire prevention**

In the region various prevention activities are under development, but there is a need to adopt clear and updated political decision. Wildfire prevention activities can be divided into the following components: extension and training activities, early warning systems, detection and monitoring, statistics and sustainable land-use and forest management practices.

**Extension and training activities** at municipal level are the most outstanding prevention activities in some South American countries. Public and private campaigns were launched in Bolivia, Brazil, Chile and Ecuador after the occurrence of big wildfires, aimed at making people fully aware of the damages caused by wildfires. These campaigns included public meetings and targeted seminars addressed to the cattle rancher associations, farmers, municipal forestry units, local social groups, indigenous communities and general public. The mass media was also used in these campaigns, including radio, television, posters, bulletins, etc. Such messages benefit from the slogans that had been distributed

to the population. The messages show the risks and threats of the reiterative fires and seek to convince people of the importance of fire prevention activities.

In Brazil the National System for Wildfire Prevention and Suppression (PREVFOGO) programme is in contact with farmers, through the Enterprises of Technical Assistance and Rural Extension (EMATER) and State Organisms of Environment (OEMA), administering rural extension and educational programmes in order to reduce the number of wildfires caused by agricultural burning practices in Amazonian and savanna ecosystems. The Farmer Forestry Development Project, (FAO-Ministry of Environment), PRECINFO and several non-governmental organizations (NGOs) (Nature and Pro-wood Foundation; Arco Iris-IUCN [World Conservation Union], ECOCIENCIA) have carried out campaigns to sensitise people in 850 local communities in Andean and oriental coast regions of Ecuador, making mainly use of the mass media (5 000 posters and 15 000 booklets, stickers and radio broadcasts). In addition, the Prefecture of Santa Cruz in Bolivia has organized at least 27 workshops on prevention since 2000 (Horstman, 2003). The Valle de Cauca Autonomous Corporation (CVC) and Unified National Command (CNU) organizations have similar activities in Colombia (2004) and Venezuela respectively.

A second main topic in wildfire education is training on prescribed burning. In this respect, CARE-Bolivia has organized public meetings and seminars on this matter since 2000. In Brazil, the Arc of Deforestation Programme (PROARCO) has organized training courses for farmers dealing with prescribed burning and forcing regulations regarding the use of fire in land management. In Ecuador several organizations (Forestry Ecuadorian Institute on Wildlife and Natural Areas (INEFAN), Participative Development in the Andean, Andean Native Forest Programme, CARE-PROMUSTA, PAFE project, Austro International Plan and Authorities of Guayas Province), involving more than 17 institutions, have organized courses since 1996 for a total of 1 100 farmers. In Colombia, different workshops on prescribed burning were organized for a total of 230 farmers and a national booklet on "Wildfires prevention on prescribing burning" was published (Ospina, 2003).

In Argentina, the Secretariat of Agriculture, Livestock, Fisheries and Food is conducting prescribed fires in forest plantations through research and extension projects like the Patagonian Andes Forest Research and Extension Center (CIEFAP). Although Chile was improving the application of prescribed fires and transferring this knowledge to small landowners that used fire before the 2000s, the current policies and practices of the main forest Chilean companies aim at reducing the number of prescribed fires as much as possible, limiting them to circumstances where there are no other options available.

Some alternative practices for the use of mechanical methods, which are more acceptable for the local communities, are carried out. In the same way, in Bolivia some workshops on prescribed burning and alternative practices of using mechanical methods (chippers/biting machines) at the community level (Martínez and Cordero, 2003) have been presented by the Ministry of Sustainable Development and Planning and FIDES Foundation. For example, the Integral Foundation for Development (FIDES) organized a seminar on prescribed burning addressed to 23 official and private institutions and other organizations (Horstman, 2003).

In Brazil, Chile and Ecuador, the importance of the information about wildfire in primary and secondary schools has been emphasised by the regional Secretariat of Education and Ministry of Education respectively.

NGOs are also carrying out capacity building activities oriented to primary school teachers in rural areas. In Argentina and Venezuela, these activities include public meetings, courses and seminars. Furthermore a pre-school programme will be put in place by the National Fire Protection Association of the United States of America in Bahía Blanca, Argentina. This programme was built up more than 20 years ago and has been successfully applied in the USA.

The areas of knowledge related to wildfires and prescribed burning are not taken into account in the primary education curricula in the cases of Bolivia, Peru, Paraguay and Uruguay.

Referring to the superior level of education, most of the Universities include fire management in their curricula, either as mandatory or voluntary subject. In the case of Chile, nearly 15 Universities have had mandatory courses on wildfires, although during the last decade some of them have not offered these courses anymore (Sanhueza, 2005). This trend is also observed in Uruguay (Tamburi, 2004), while in the case of Ecuador three universities (Loja, Ibarra and Técnica del Norte) have incorporated the topic on wildfires in their curricula. In Peru, only one university offers fire management as a

mandatory subject and another as optional related to wildfires and prescribed burning. It is important to quote that the universities in the region do not have a curricula in technical education, master or doctorate degree on wildfire prevention and fighting.

Finally, in relation to the capacity building and training activities on wildfire management and operations, the Training Programme of PREVFOGO in Brazil aims at training technicians, preparation of educational programmes with practical contents, confection of teaching materials and setting up of Regional Training Centers. Furthermore in Colombia, the "National Programme on Capacity Building in Wildfires Prevention, Control and Mitigation" and the "Environmental Education and Public Information Programme" have been planned, while in Chile and Argentina (Celiz and Domínguez, 2003) some companies from the private sector started offering capacity building in wildland fire management.

**Early warning systems** of high risk conditions for wildfire occurrence are operationally running in different countries since the 1990s, while other countries have just recently started to have access to the technology demanded by this activity. Due to the use of satellite-based sensors, that produce maps and written reports on fire danger rating and fire weather forecasts at national and state level, early warning systems are common in many countries.

The National Meteorological Service of Argentina (Argentina Air Force) provides two fire indices that are daily updated at 18:00 UTC (Universal Time Coordinated), being available on internet (Combustion Risk Index and Haines or Convectivity Index). The forecasted index rates for the day D+1 are issued every day and followed by a six risk-levels scale. The Meteorological Service of Uruguay issues the forest fire danger rating in a three-risk levels scale, for the current day and the next day (D+1), for every meteorological station in the country making use of the Nesterov Index. Peru is interested in adapting the Fire Weather Index component of the Canadian Forest Fire Danger Rating System for the national wildfire early warning system. In addition, some Federal States and private enterprises of Brazil are working with their own fire danger rating systems

In Bolivia, in the framework of the Sustainable Forest Management Project (BOLFOR), a wildfire web page has been developed containing information from the Early Warning System of Wildfires (SATIF). This information is regularly updated, including satellite-derived fire information and daily fire occurrence maps. The Agrarian Superintendence has built up a burning monitoring system based on the National Oceanic and Atmospheric Administration (NOAA) satellite imagery (non geo-referenced) which issues reports on the detected burnings throughout the country in grasslands, protected areas, communal lands and forestry reserves (Horstman, 2003). In Brazil, PREVFOGO through the National Institute of Meteorology (INMET) produces written early warning reports, while Pro Arc of Deforestation (PROARCO), through the Brazilian National Institute for Space Research (INPE), monitors the points with high fire danger rates from the Normalized Difference Vegetation Index values integrated with meteorological parameters and near-real time observed and predicted fire risk maps are provided on the internet (Brazil, 2005, 2005a).

The National Meteorological Services of Colombia and Chile present specific warnings of the wildfire potential occurrence for the current day and the next day D+1, making an indication of those regions which would have higher probability of being affected. The Directorate of Hydrographical Basins of Venezuela issues special daily reports during the fire season. The Meteorological Services of Bolivia, Paraguay and Peru, however, do not provide this service to the Institutions or to the general public.

**Wildfire detection and monitoring activities** in the Region are carried out making use of traditional and modern technologies. In Chile, Colombia and Venezuela, fire detection is done by spotting towers, aircraft and ground patrols, and requires substantial infrastructure and high coordination. Especially in the Amazonian watershed, fire detection from airplanes is possible only in specific circumstances, because it is expensive and very limited due to clouds and heavy smoke during the fire.

Simultaneously, several projects and programmes currently running in Argentina, Bolivia, Brazil and Colombia are using new technology for fire detection and monitoring purposes. The use of satellite sensor systems for fire detection has been made for the Geo-stationary Operational Environmental Satellite (GOES) and Advanced Very High Resolution Radiometer (AVHRR) of the NOAA satellite. The AVHRR-NOAA and GOES sensors have each different strengths (resolution, data collection capacity and frequency of the observation) for fire detection, but AVHRR images have become the most widely-used data source for tropical fire detection and it is incorporated into several monitoring projects. For instance, the Brazilian satellite (SCD-1) collects important environmental data and

information for meteorological research purposes at the Center for Weather Forecasts and Climate Studies (CPTEC). This information, in conjunction with other information available from international sources, provides tools and maps for hot spot monitoring, which are easily accessible daily on the internet (Brazil, 2005b). It is important to mention that the CPTEC also produces hot spot maps for the neighbouring countries (Bolivia, Paraguay and Peru), but many states and municipal agencies of each country, including Brazil, are not equipped for using and verifying these products nor making in-field assessment of the satellite information quality (Setzer, 2004).

The building up and improvement of the **wildfire statistics** databases are other activities related to the fire prevention. With them one can study wildfire causes and allocate the suitable resources to trouble spots. In Argentina, the Native Forests Resources Direction is responsible for the national wildfire statistics management. In Brazil, the Federal Conservation Units are making a detailed registration of the stored information. In Chile, the *Corporación Nacional Forestal* (CONAF), and in Uruguay the National Directorate of the Fire Service, are in charge of the national wildfire statistics. In Uruguay, the National Directorate of the Fire Service also carries out investigations on wildfire causes (Tamburi, 2004), while in Chile the National Police investigates the causes.

Institutions in Colombia (*Antioquía Autonomous Corporation* - CORANTIOQUIA), Ecuador (*Loja Municipality*) and Peru (*Universidad Nacional Agraria La Molina* - UNALM), intend to get statistics at state, municipal, and national levels, but they do not have the official responsibility for them (Polanco and Javier, 2002; Manta and León, 2004). Bolivia and Paraguay do not have any database containing wildfire statistics, which makes it impossible to determine the fire trend and to make an analysis of the fire causes.

When referring to the **sustainable land use** to reduce wildfire hazards in the region, one often refers to forest management practices and maintenance of preserved areas for protecting the biodiversity, and the use of these areas by native people.

All countries have approved laws and established strategies and plans to develop forestry management practices, but only some of them have reached the adequate structure to organize sustainable forest management practices in right terms. The voluntary forest certification seems to be a strong incentive for forest protection in the Amazon watershed. The concessions managed by Bolivian forestry firms have built strong links with local communities in forested areas and have been able to coordinate actions for a successful detection and control of the fires before they reach the forest (Martínez and Cordero, 2003). By March 2003, more than 800 000 ha of forest were already certified in the departments of Santa Cruz, Beni and Pando (Hortsman, 2003).

In Brazil, the public network is being organized including concession, administration and monitoring systems. In addition to this, investments have been made in order to develop a major forest vigilance system (SIVAM), which is a fundamental tool for obtaining information in real time on deforestation in the Amazon region. Furthermore, there is a civil network - the Brazilian Society of Silviculture (SBS), which promotes the formation, restoration and sustainable use of the wooded lands. In Peru, the existing annual operative plan for forest concessions is not fully implemented yet (Manta and León, 2004).

In Argentina, for the management of forest plantations, a national forest management programme administered by federal provinces is in force. In Chile, the private owners must submit a forest management plan for their property, including both internal and perimetral firebreaks and an annual maintenance programme for firebreaks. In Brazil, the three big private forest enterprises have elaborated their own forest management plans in the same way. The Face Programme of Forestation S.A. (PROFAFOR) in Ecuador has made some efforts in firebreak building since 1993. In addition, Venezuela maintains 124 km of firebreaks in its National Parks (Conde, 2005).

In terms of protected worldwide natural heritage, the South American region tops the world list in terms of land percentage (almost 42%) with nearly 4 million km<sup>2</sup> of protected areas. Brazil, Colombia and Venezuela have three out of the ten largest protected areas in the world. The institutions in charge of wildfire management intend to establish and support actions to combat wildfires in protected natural areas. The responsible institutions proceed in coordinated (Argentina, Brazil and Chile) or in an isolated way (Bolivia, Colombia, Ecuador, Paraguay, Peru and Venezuela). For example, the National Parks Administration of Argentina has allocated increased budgets for the infrastructure and has improved facilities and equipment under the coordination of the Fire Management Programme (PNMF). In Brazil, PREVFOGO is developing fire management plans for IBAMA's Conservation Units to use suppression and prescribed fire to minimise adverse impacts on



ecosystems in protected areas (Batista, 2005). In Chile, CONAF undertakes similar actions in its protected natural areas (Sanhueza, 2003).

### **3.5 Fire suppression**

Thousands of wildfires are reported every year in South America. These fires cause devastating damages and are becoming extremely difficult to control.

Argentina, Brazil and Chile usually combine their resources of terrestrial and aerial wildfire fighting.

In Chile, CONAF has a long experience in terrestrial and aerial fighting against wildfires at national level. The ground units are typically composed of 8 to 20 completely equipped and trained professional fire fighters who operate manual tools, fire equipment and mechanised equipment with high safety standards. Furthermore the fire fighters are paid for the job and they are fully devoted to the task. All available tactics and strategies are utilized, with sophisticated equipment including water bombers. Furthermore, helicopters are employed in all steps (transport, bucketing and heli-attack) for which medium-size planes are at their disposal. The forestry enterprises are in charge of the initial attack on their properties, but have also terrestrial resources.

Argentina is divided into federal provinces, which all have a legal obligation for fighting against wildfires. However, when complex fires threaten to overrun the province fire fighting systems, the law stipulates that the assistance from PNMF can be requested. PNMF is in charge to provide training to the personnel, coordinate the suppression activities as required by regional authorities and to organize aerial attack operations.

In Brazil, PROARCO and PREVFOGO combat wildfires and inappropriate prescribed burnings. They provide full coordination, establish strategic task forces and distribute resources to priority areas of the country. The fighting strategy of PROARCO is based at different levels of responses to wildfires. The first level of response is municipal, undertaken by volunteer fire fighters and volunteer prescribed burning brigades, composed of people from local communities. The second level of response is the state level, including Civil Defence brigades and State Fire fighters. The national level is used only in large wildfire situations. PREVFOGO is also providing training on ground and aerial attack methods for pilots and prepare voluntary brigades to carry out tasks in conservation units to work with authorities to ensure that the wildfire regulations are being met (Raposo, 2005).

One factor which contributes to the large wildfires in the Amazon watershed is the lack of efficiency of air attacks. The smoke dispersed by the tropical forest canopy makes it difficult to locate fire lines and it intercepts much of the water and fire suppression agents that are dumped on fires.

Colombia, Uruguay and Venezuela do not have enough aerial suppression capabilities and they mainly use ground suppression techniques. In Uruguay, wildfire fighting is primarily concentrated on forest plantations. The initial response comes from the plantation owners, but when severe fires arise, additional assistance is provided by the National Direction of city fire fighters, the Public Works Department and the Defence Ministry.

Venezuela has several operation centres that support local fire response organization. The ground attack is made by traditional methods with small crews of trained fire fighters from Voluntary Fire Fighters (Simón Bolívar-Caracas Company, SAR-Edo and Miranda-Ocumare del Tuy Company), which have helicopters for transporting fire fighters.

Even though Colombia is mainly a mountainous territory, there is no aerial support for fire suppression. The ground attack strategy is carried out at three different response levels: municipal, state and national. There are several governmental agencies and emergency services, not necessarily well prepared for wildfire suppression, which participate in this task.

Bolivia, Ecuador, Paraguay and Peru do not have professional ground fire fighter crews, but instead they have voluntary brigades of local communities, some brigades at protected natural areas and also intermediate corps of voluntary fire fighters with basic training and equipment. The following institutions are currently operating: in Bolivia, the *Universidad Católica de Bolivia* (UCB) and the Assistance and Rescue Service (SAR)-Cochabamba Companies (250 volunteers); in Ecuador, the Quito, Guayaquil and Pichincha companies; in Paraguay, the Asunción company; and in Peru, the Cuzco and Lima companies (27 specialised volunteers). In case of wildfire, the suppression task



forces include a set of emergency services and governmental agencies (City Firefighters Corps, Civil Protection Centres, State Environment Agencies, National Red Cross, National Police, Army and Air Force), of which most are working without any command structure and interagency agreements.

In order to improve the fighting activities against wildfires, training courses have been implemented by Governments and NGOs in several countries. In particular, Brazil, Chile and Ecuador are outstanding in such initiatives. These activities are only partially implemented in Bolivia and very limited in Paraguay and Peru. PROARCO is the leader organization in the Amazon and provides courses and training aimed at improving the use of prescribed burning and the suppression activities when fires escape. The main need for improving fire suppression comes from rural areas and PROARCO has to integrate several institutions and NGOs at Municipal and State levels for the task.

In Bolivia, BOLFOR and the Eastern Ecology Association (ASEO) have supported capacity building courses for communitarian crews (35), including wildfires control, equipment, management and legal issues.

In the case of Ecuador, rural communities (around 1 200 people), owners of forestry estates and native leaders are trained to form fire suppressing crews. There are also temporary and permanent community crews for wildfires monitoring and suppression, which protect the coast (Pichincha-Cerro Blanco; Ecological Reserve of Churute Mangrove Swamp) and the high lands (Quito). Additionally, training activities were undertaken since 1992 for the fire fighters of Guayaquil, University of Manabí, Forestry District of Guayas and for the Civil Defence crews. In Loja, the Committee for Fighting Against Wildfires and Wildfire Suppression Operations have just been initiated recently.

In addition the Office for Disaster Assistance of the United States Agency for International Development (OFDA-USAID) gives short and basic courses (Forestry Fire Fighter, Prevention and Control of Wildfire and Training for Instructors) mainly in Bolivia, Colombia, Chile, Ecuador, Paraguay, Peru and Venezuela. It has also started offering courses on Incident Command System in Colombia, Chile, and Venezuela. This capacity building programme aims to achieve a multiplying effect by training leaders who will train more people in their countries. This office also provides support to the countries through donations: basic training equipment and tools and equipment for wildfires terrestrial control (Horstman, 2003).

#### **4. The state of actors**

In most of the South American countries, the natural resources policy is mainly oriented in favour of agrarian, mining and transport activities. Nevertheless, the forest cover extension of the individual countries varies from 90-95% in Guyana, French Guiana and Suriname to less than 5% in prairie-dominated territory of Uruguay. Because of the low contribution rate of the forestry sector to the gross domestic product (with exception of Bolivia, Brazil and Chile), the forestry administration holds a low economic and political power and a low hierarchical position in the administrative agrarian structure, or in the case of Colombia and Ecuador, it is virtually non-existent (Silva, 2003; Galindo, 2005). The governments have only a basic perception of wildfire and agricultural burning issues and setting up an adequate fire prevention policy has not been resolved in the Region.

The political agenda related to wildfires is mainly a result of the reaction against the occurrence of a catastrophic event, or is connected with the interests of the political parties, not being in general a part of a process of development nor assessment of national needs. There is also instability and unproductiveness of politics due to changes of governments and problems with corruption around the region, which facilitate the land use transformation from wooded lands to other land use, i.e. in Bolivia (Hortsman, 2003) and Peru (Manta and León, 2004).

In these different national policies context, types of organization (centralised or federal) and specific biophysical, economic, cultural and social characteristics, countries have developed various ways of wildfire prevention and fighting. Collaboration at local, national and international levels and local community participation has also been tested.

##### **4.1 Institutional and other capacities (prevention and suppression)**

The strength or ability of the institutions engaged in wildfire management can be divided into the following elements: institutionalisation, legislation and regulation rules, setting up plans and

programmes, availability of specialised human resources, inputs, equipment and infrastructure and research programmes oriented to wildfire management.

The institutionalisation of wildfire management varies according to the **responsibilities and roles** of the organizations in charge, the hierarchy within the public structure, the management capacity, the available technology and the economic resources. For example, the total yearly budget invested in fire prevention and fighting in Chile has reached US\$22 million to protect 3 million ha of plantations. Ninety-five percent of the budget are devoted to detection and fighting operations while just only 5% are devoted to prevention activities. One third of the total investment is covered by the state and the remaining two thirds by private forestry enterprises (Sanhueza, 2004).

Brazil obtained a loan from the World Bank (US\$15 million) in 1998 to support the PROARCO programme for preventing and suppressing large-scale wildfires in the southern part of the Brazilian Amazon (Mutch, 2003), but many countries like Bolivia, Ecuador, Paraguay and Peru have very limited resources available.

Argentina, Bolivia, Brazil, Chile and Uruguay have one national government organization responsible for wildfire management (Table 2 below) whereas Colombia, Ecuador, Peru and Venezuela have several organizations. In Paraguay there is no national government organization responsible for wildfire management.

The responsibility of wildfire management in Colombia is shared by several organizations, but operationally, prevention and suppression tasks are carried out at three distinct levels (national, state and municipal); these operations depend on the management and resources of each level. The absence of a forest service has resulted in the distribution of fire protection responsibilities among multiple governmental agencies, which only pay attention to the wildfire issue in case of severe fire seasons.

By mid-2002, the institutional group Prevention, Control and Mitigation of Wildfires (PRECINFO) was created in Ecuador, with the objective of creating a new plan against forest fires and improving the management capabilities of the state and municipal organizations. In Peru the wildfire suppression and prevention national system has not been established yet, despite the existence of a law which ordered its creation since 2001.

In Venezuela, the National Unify Council (CNU) policy is to use economic incentives for wildfire prevention activities (UNEP, 2002) and to support one national system of strategic coordination and decentralised operation. In Paraguay, the policy makers do not consider wildfires and agricultural burnings as a national problem and do not have any responsible organization for them. The bodies which are working on wildfires are the National Forestry Service and the Secretariat for the Environment, which are respectively dependent of the Ministry of Agriculture and the Ministry of Environment.

Many countries have created and established a legal framework, both national and international into their **legislation on wildfires** to strengthen the institutional structures and define functions and duties of wildfire management.

The summary of texts, which deal either specifically or partly with wildfires, prescribing burnings or fire management, is shown in Appendices 2 and 3.

The governments of the region use different legal tools on wildfires and prescribed burning, dealing with material, forestry, civil and penal aspects. These norms do not integrate under a specialized law for wildfires, but correspond to a set of norms promulgated by different institutions in each country (FAO, 2004).

**Table 2.** Countries, plans and national government organizations responsible for wildland fire management in South America (2005)

Country	Wildfire Management Plan or Programme	National Government Organisations Responsible	Other Government Organizations related with wildfire
Argentina	National Fire Management Plan (since 1997)  National Parks Programmes	Secretary for Sustainable Development and Environmental Policies, Ministry of Social Development and Environment Affairs	Government of the Federal provinces National Parks Administration Native Forests Resources Directorate
Bolivia	Prevention and Suppression Plan of Forest Superintendency	National Service of Civil Defense, Ministry of National Defense	Defence Civil Centers Voluntary Corp of firefighters and SAR (since 1993) Voluntary brigade of firefighters (UCB) Red Cross Forest and Agrarian Superintendency Ministry of Sustainable Development and Planning
Brazil	PROARCO, 1998 PREVFOGO, 1989	Brazilian Institute of Environment and Renewable Resources (IBAMA), Ministry of Environment	Military Corp of City Firefighters and Civil Defense Brigades State centres and superintendence of IBAMA Voluntary brigades of local communities
Colombia	National Prevention, Suppression of wildfire and Restauration of devastated Areas Plan (2002)	National Comission Adviser to Prevention and Mitigation of Wildfires (1997)	National Prevention and Awarness Disaster System Environment System (Ministry of Environment, Dwelling and Territorial Development) Municipal, Departamental and National Comission Voluntary Brigades of Municipality, Departamental and Regional Centres IDEAM, National Red Cross National Police, Army and Air Force
Chile	Fire Management Programme (1982)  Civil Protección Plan ACCEFOP Plan	Forestry National Service Cooperation (CONAF) Ministry of Agriculture (1970)	Private forestry sector (60% of forestlands are private) Local Communities National Police
Ecuador	National Fire Management and Wildfires Programme (1991)	Ministry of Environment Civil Defense Service PRECINFO (2002)	Army Provincial, and District Government Corp of Voluntary Firefighters Voluntary brigades of local communities
Paraguay			Corp of Voluntary Firefighters National Forest Service Secretary for Environment
Peru	National Control and Prevention of Wildfire Plan (It has not developed)	Wildfire Control and Prevention National System (It has not developed)	National System of Civil Defense Corp of Voluntary Firefighters and Voluntary brigades Army, Ecological Police Administration of Protected Natural Areas Regional Directorates of Agriculture
Uruguay		National Directorate of Firefighters Ministry of Interior	Department and Ministry of Defense General Forestry Directorate Corp of Voluntary firefighters
Venezuela	Fire Management Programme (since 1970)	Unified National Command - CNU (2001)	National Guard Voluntary brigades of local communities National Institute of Parks

In the South American region, at least 153 national legal texts exist, 57 of them being specifically devoted to wildfires and prescribed burning, and the rest generally deals with forestry issues and to some extent forest cover. However, most of the national government organizations related to wildfire management are not able to apply them because of different factors: incompleteness of the regulations, lack of rules which develop the specific procedures for implementation of the laws and regulations, and finally the fact that the provisions do not clearly appoint mandate or legal responsibility of a reference body. For instance, in the case of Peru, the national wildfire suppression and prevention system has not implemented its function and regulation since 2001.

As part of the previous considerations, there are gaps in the forestry laws in most countries. Because of legal dispositions, wildfires are only a set of declarations which do not carry any operational guidelines or operating plans. Countries also lack suitable mechanisms for inter-institutional and international coordination and they do not have any budget or enough human resources to face this problem.

In spite of the exuberance of laws, the implementation capability of countries concerning the fire problem is very limited. Nevertheless, Chile escapes this observation because of the coherence of its long-term objectives and the existence of clear and complete regulations. The procedures are in force and different and severe penalties have been established in case of infractions to the law.

Land use change is a critical problem in South America. The three main land uses are: agriculture, ranching and selective logging. Each one increases the wildfire risk in the Amazon Region (UNEP, 2002). In order to reduce both the risk and the extension of wildfires caused by agricultural burning, the governmental organizations responsible for fire management (in Bolivia, Brazil, Chile, Ecuador and Venezuela) have specific and general legal tools, which allow them to regulate the agricultural burning activities and in this way, are trying to reduce the wildfire incidence, e.g. agrarian.

The Bolivian Agriculture Service granted 858 authorisations for prescribed burning for a total area of 1.1 million ha during 2000-2002 (Horstman, 2003).

Organizations responsible for wildfire management in countries like Argentina, Colombia, Paraguay, Peru and Venezuela have not yet established specific agreements with their respective Ministries of Agriculture. This situation is increasing the land use transformation, which leads to higher deforestation rates and increases wildfire risk.

In many countries, the absence of specific procedures law enforcement established by the wildfires Penal Code makes it difficult to punish people for illegal burnings even in the case of state-protected areas. The only case of application of a penal punishment before 2004 happened in Cordova (Argentina), but only after a trial which lasted several years (Econoticias, 2004). In Uruguay two people have recently been declared guilty of intentionally causing a wildfire, but the sentence arrived many years after the fire occurrence (Econoticias, 2005).

Results from decentralization and communities' participation applied in countries like Argentina, Bolivia, Brazil, Colombia, Chile, Ecuador and Venezuela, are remarkable. In the case of Ecuador, economic incentives are allocated to this topic so that municipal and state (provincial and departmental) authorities are performing the functions, which traditionally were under the responsibility of the national authorities.

Nevertheless, in order to get desired results, a national agreement on coordinated wildfires management action of the decentralized governments is required. Additionally local governments have to be strengthened with specialized and stable personnel. The existence of clear and accurate regulation is important to allow suitable transference of politic and economic power to reduce wildfire incidence in the South American region,

Most of responsible organizations have made efforts in developing **plans and contingency programmes against wildfires** at national, state and municipal levels (see Table 2).

The organizations responsible of wildfire management in Argentina, Brazil, Colombia, Chile, Ecuador, and Venezuela have implemented national plans and programmes. Argentina's National Fire Management Plan (PNMF) integrates, coordinates and supports the actions taken by the provinces. The National Parks Administration and the Federal Government of the six main regions ask the institutions with specific jurisdictional responsibility to elaborate their respective wildfire plans, leaving

the establishment of an operation plan at state level. These plans should then be updated every 3-5 years (PNMF, 2001).

As a result, the provinces of the Patagonia region have become the best structured of the country by succeeding in creating suitable prevention and fire-fighting systems. These systems train and move annually around 400 fire fighters (Rodríguez, 2000). The National Coordination of PNMF is now working on setting standards throughout the whole country with all different aspects of fire management, such as training, certification programmes, fire danger rating and prevention guidelines (Dentoni, 2003).

In Brazil two large programmes on wildfire and prescribed burning are currently underway. These programmes were triggered by the numerous adverse effects that originated from uncontrolled fires. The first one is PREVFOGO, which is responsible for the national policies on prevention and suppression of wildfires and prescribed burning, including the activities related to educational campaigns, training, monitoring and research. This programme is also oriented to the assessment of fire effects on ecosystems, public health and atmosphere. PREVFOGO programme has technical, administrative and financial autonomy. The second one, PROARCO was implemented in the "Arc of Deforestation" in the southern Amazon (3 000 km by 600 km) where timber harvest, agriculture and other land management practices have greatly increased the wildfire risk. The main objectives of this programme are the control of agricultural burnings and the prevention and suppression of wildfires in order to avoid deforestation in the Arc. PROARCO has promoted the partnership among federal, state and municipal institutions, NGOs and other agencies. They have also favoured the decentralization of actions to local level, to achieve a better protection of the Amazon rainforests. Individual States in Brazil (Paraná) have also developed plans for the protection of forests from wildfires (Cavalcanti, 1998).

Chile's Fire Management Programme has been carried out for more than 30 years by CONAF, through actions of fire prevention, detection and suppression all over the country. CONAF protects the country's forest heritage, such as parks and forest reserves and small- and medium-sized industrial forestry companies. In case of large wildfires, once the coordination with local governments has been achieved, they coordinate the human and material resources to combat these fires. All these actions are undertaken through a single national standard in wildfire fire-fighting operations plan (ACCEFOP), which permits the coordination with the responsible of the Civil Protection Plan when wildfires go beyond the local response capability. Additionally the private forest owners (60% of forestland) must submit yearly a wildfire plan for their property, including prevention and suppression activities, which is reviewed and controlled by specialists from CONAF (Sanhueza, 2003).

Venezuela has a Fire Management Programme (FMP) which was endorsed by different organizations, but having no coordination among them up to the moment that the National Unifying Council (CNU) was constituted. The FMP is mainly oriented to the realization of different prevention activities (i.e., extension, training, education and wildfire detection, as well as forest management practices and preserved areas protection) and to a less extent to wildfire suppression activities, for which it does assign duties to the different organizations which integrate it in a decentralized way.

Colombia's Prevention and Suppression of Wildfire Plan is the most recently developed (2002) and is aimed at strengthening the organizations at the municipal, state, national and international levels at short-, medium- and long-term (25 years). In order to set these objectives, the above mentioned plan intends to carry out the following actions: optimise the mechanisms of inter-institutional management, define programmes for prevention, control and restoring, enhance the education and public information processes, support capacity building and training processes addressed to the responsible institutional agents, impulse the processes of knowledge and adoption of suitable technologies, and finally strengthen the processes for wildfire statistics information gathering. Other contingency plans against wildfires are being developed at some protected natural areas (National Natural Park Sumapaz).

The National Fire Management and Wildfires Programme of Ecuador aims to regulate the fire use of farmers at the national level (Galindo, 2005). A pilot programme is ongoing in the province of Loja. A plan also exists to extend the programme to municipal scale (Quito y Guayas) and into protected natural areas (i.e., Ecological Reserve of Churute Mangroves and the Lago Park). In addition, some private forestry programmes (PROFAFOR) are developing and funding their own contingency plans for wildfires.

In Bolivia, the Civil Defence and Corps of Fire fighters are the responsible organizations for wildfire suppression, but are not included in the national wildfire management plan. The Forest Service assumed the responsibility of monitoring, preventing and suppressing wildfires, leading to an overlapping of competences between the organizations.

In several countries, specialized human resources, equipment and infrastructure are devoted to fire suppression organizations since they have also been the ones responsible for wildfire management. Among all South American countries, Chile is the only one having complete resources for wildfire suppression (ground and aerial), while Argentina, Brazil, Colombia and Venezuela are ranked in an intermediate level of development. These countries are now improving their infrastructure, equipment and professional skills of their human resources for wildfire suppression through training activities and inter-agency procedures. In Bolivia, Ecuador, Paraguay and Peru, these aspects are at a basic level.

In Chile, CONAF and forestry firms involve dedicated staff of 2 500 persons: 140 ground hand/engine crews, 24 helicopter crews, 153 motorcycle prevention specialists, 25 dispatch centres and 241 lookout towers. In Argentina, the PNMF has a dedicated staff called "national brigade" and has allocated funds to hire, train and equip more than 950 temporary fire fighters for new brigades. Besides this, the number of people in charge of the operational and support tasks has also been substantially increased (Rodríguez, 2000). PROARCO can mobilise 500 fire fighters from any place in Brazil (Carvalho, 2002) and has a total of 3 000 dedicated staff (FAO, 1998).

In Uruguay, approximately 1 250 city fire fighters are maintained (Mutch *et al.*, cited by UNEP, 2002), of which 150 are temporary (from January to March). In Paraguay there are in total around 350 fire fighters, but just a small part of them has been trained on wildfires. In Venezuela more than a dozen of professional fire fighters have received international training, and in Peru 27 instructors have been trained in basic prevention and control of wildfires (OFDA, 2004).

In Colombia there are also professional fire fighters and instructors for wildfire prevention and control (OFDA, 2001). The Ministry of Environment, Dwelling and Territorial Development (MAVDT) and the Inter-American Bank for Development (IBD) strengthened the institutional capabilities of nine departmental corporations and built up a quick response network for 18 different corporations and 11 national parks. Four manuals, lookout towers, fire fighter crews, crew bosses and incident commanders are available, as well as a manual for teachers (Ospina, 2003).

In Bolivia, the National Service of Civil Defense (SENADECI) and the Office for Disaster Assistance (OFDA), and in Ecuador the NGOs, have allocated at least US\$70 000 for training activities addressed to local communities.

Wildland fire research programmes are included in the National Strategy for Fire Management in Brazil involving the National Meteorological Institute (INMET), the Paraná Federal University (UFPR), Brasilia University (UnB), Sao Paulo University (USP), Visosa Federal University (UFV), Brazilian Agricultural and Range Research Institute (EMBRAPA), Geographic and Statistic of Brazilian Institute (IBGE) and the Minas Gerais Central Electric Company (CEMIG). In Colombia the Hydrology, Meteorology and Environment Research Institute (IDEAM) is involved. In these countries the responsible organization has been appointed to deal with this subject. In other countries, some research activities have been carried out without an official mandate, like the University of Loja in Ecuador (since 1985) and the National Agrarian University La Molina (UNALM) in Peru (since 2004), where research on ecological effects of wildfires and wildfire danger rating systems are respectively being conducted. In addition, the National Institute for Research and Technology Development (ININDITEC) in Peru is conducting a research on trans-boundary air pollution between Peru and Brazil.

#### **4.2 Collaboration (local / national / international)**

Some responsible agencies and NGOs have made efforts for activating strong and effective wildfire campaigns, but despite they have encountered problems with large wildfire situations in which national and international assistance is required.

An overview on agreements which are currently in place for mutual support within countries and between countries of the region are given in the Appendix 4. Chile has the highest number (6) of agreements of the region. It has also a standard annual operating plan, which details how to

accomplish emergency assistance within the country at international level. In Bolivia, Ecuador, Paraguay, Peru, Uruguay and Venezuela, clear agreements have not been established yet.

Although widespread emergencies in recent years in all regions of the world have underscored the importance of having international agreements established in advance of the fire occurrence, Argentina and Chile are the only nations with operative bilateral emergency agreements in the South American region (see Appendix 4). But even if countries do not have any prearranged agreements, many national and international agencies and organizations (i.e. National Meteorological Services of Argentina and Venezuela, and Air Operations Training at the National Interagency Fire Centre in Boise, Idaho) have successfully integrated their activities for fighting against Roraima and Colombia's wildfires in 1998, as well as during the fires which occurred at the beginning of 2005 in Uruguay (80 fire fighters from the National Emergency System from Brazil) and in Paraguay (3 air-tankers from Argentina and 20 fire fighters from Brazil).

From the analysis of wildfire incidences along the year, overlaps in "fire seasons" during one period of the year exist in Bolivia, Brazil, Ecuador and Peru (June to December) and two periods in Argentina, Colombia, Chile, Uruguay and Venezuela (June to December and January to May). This overlapping can affect greatly the availability of the international assistance.

In order to strengthen the institutional capacity, some countries have developed several types of non-emergency agreements with international cooperation (see Appendix 5). Colombia and Chile are using such mechanisms for wildfires prevention most intensively in the Region.

International collaboration in the region is also expressed through joint research programmes on wildfires. International research organizations with regional counterparts are developing advanced research dealing with causes, effects and behaviour of tropical wildfires. Additionally the future evolution of the Amazon rainforest landscapes, in the current context of land fragmentation and land cover changes, is studied, e.g., Nepstad *et al.* (1999, 2001), Pinard *et al.* (1997, 1999), Peres (1999), Goldammer (1999), Biddulph and Kellman (1998), Johns *et al.* (1996), Kauffman *et al.* (1994) and Uhl and Kauffman (1990).

The use of remote sensing data is another priority research field. Several institutions and projects like the National Commission for Space Activities (CONAE), EMBRAPA, Fire and Environmental Applications Research (FERA), the Regional Atmospheric Modelling System (RAMS) of Colorado State University and the University of Sao Paulo and the Cooperative Institute for Research in the Atmosphere (CIRA) of Colorado State University, are using remote sensing for detection, monitoring, and suppression of wildfires, as well as on monitoring the transport of biomass burning emissions through South America (GFMC, 2005).

However, there is a critical point related to the effectiveness of detection and suppression activities in Amazon rainforest, which has not yet been solved by any international research cooperation.

Three cooperation networks have been established in the region to foster the international cooperation on wildland fire management and research. The Latin-American Tele-detection and Wildfires Network (REDLATIF) was established at the end of 2002 in Bolivia. Its goal is to join the efforts from the Latino-American community through the results obtained from the numerous projects which make use of remote sensing and geo-spatial technologies for wildland fire monitoring and management. This network is highly related with the programme GOF/GOLD-Fire (Global Observations of Forest and Land Cover Dynamics) which is supported by the University of Alcala de Henares, Spain, the UN Office for Outer Space Affairs (UNOOSA), the European Space Agency (ESA) and CONAE. Several active members involved in this network in Argentina, Bolivia, Brazil, Chile and Peru have started validating the methodologies for fire spotting within the countries.

The second one is the Regional South America Wildland Fire Network. In June 2004, representatives from the South American countries met in Curitiba (Brazil), to formally establish partnerships and a regional network to promote international cooperation on wildfire management. The network has active members in Argentina, Brazil, Colombia, Chile, Ecuador, Paraguay, Peru and Venezuela. Its establishment was promoted by the United Nations Development Programme (UNDP), the UN International Strategy for Disaster Reduction (UNISDR) through the Global Fire Monitoring Centre (GFMC) and is actively supported by FAO.

The third network is the Latin American and the Caribbean Fire Learning Network. It is supported by The Nature Conservancy (TNC) and is just beginning to undertake wildland fire management

activities in the Region. The main goals are to provide scheme aimed at restoring ecosystems degraded by fire, and maintaining natural fire regimes in fire-adapted ecosystems.

Additionally in 2001 an electronic forum for forestry protection was launched in Brazil. In this forum people are devoted to forest protection, especially to wildfire protection. Participants come from different sectors of society in South America (Brazil, 2005).

### **4.3 Community involvement**

Local populations, particularly those who live in rural areas and suffer the negative impacts of wildfires most directly, have started to promote sensitiveness campaigns against wildfires.

The communal activities in wildfire management include the formation of local volunteer fire fighter brigades. Bolivia has a model of registering and monitoring information of the slash and burn authorisations at municipal level. At this structure the key people from each community are involved (Martínez and Cordero, 2003). In Brazil, the Amazon Working Group (GTA) has a network of more than 300 organizations, which in 1998 conducted a large-scale programme of field-courses, with the goal of encouraging farm community leaders to form wildfire brigades in their own communities (Nepstad *et al.*, 1999b). Additionally, the government is preparing local brigades through PREVFOGO to prevent and fight wildfires in the conservation units. The local brigades work with authorities to ensure that the regulations are being followed.

In Chile, every fire season local communities are installing their own firebreaks in the high-risk interface areas, making use of the national network programmes against wildfire (Sanhueza, 2003). In Ecuador, a remarkable success was obtained in a project for training and equipping volunteer fire fighter brigades in all forestry districts of the country from 1985 to 1996. Unfortunately this task has not continued due to the reorganization of the National Forest Direction (Galindo, 2005). Additionally the protector of the wooded lands of Quito and Pichincha integrates volunteer students from secondary school to carry out patrol activities, control visitors and establish guided routes for tourists. They also succeeded in organizing several ecological clubs at several schools.

In many countries, the private sector is contributing to strengthen fire fighting groups. In Chile, the private forestry industry is a good example of this participation, as well as in Argentina where an increasing number of private consortiums exists which are strongly interested in active cooperation with the State organizations to improve the wildfire protection of their forests. Owners of small forest plantation properties in Ecuador have achieved the establishment of local volunteer fire brigades during the dry season and the obligation to maintain ways of access to wooded land and firebreaks. In Argentina and Bolivia, local communities are largely involved in safety activities in interface areas, in protection of the fauna and flora against wildfire and in some forestry and protection clubs.

### **4.4 Needs and limitations**

As a result of the assessment of the different aspects of wildfire management issues in the member countries of the South American Region, the following needs and limitations have been detected:

- In most of the countries, the wildfire issue is not a high priority in policy agendas.
- There is a need to revise the policy and the tools for the regulation of the agro-industrial, mining and transport activities, because they contradict the wildfire prevention policies. They create confrontational situations, leading to higher frequency of wildfires and consequently to high economical and environmental losses in the member countries.
- Most countries in the region are not able to provide necessary financial funds to establish wildfire protection programmes.
- It is necessary to review, modify and add laws, regulations and rules on wildfires and agricultural burning. The laws and regulations could be divided into wildfire prevention, suppression and restoration measures, besides legal obligations of citizens.
- In some countries, due to political and social pressure, the organizations in charge of wildland fire management have inappropriate personnel, material resources and equipment. In most cases this is the result of a complex, fragmentary and non-institutionalized governmental structure. This decreases the organizational capabilities inside the countries and between different countries.



- Some of the responsible agencies or organizations are in charge of an excessively wide range of duties and competences in relation to their human, material and economic resources. This leads to a reduction of their credibility in front of the general public, which demands the agencies to take full responsibility for all the assigned tasks.
- A low level of integration of the different actors, mainly related to fire prevention tasks, leads to an increase of the associated costs and to inefficiency in the countries of the region.
- There is a lack of highly-qualified human resources to set the requirements at different decision-making levels in wildland fire management, as well as absence of a national system for capacity-building and accreditation in fire management. A significant part of the qualified people with international specialization in the administrative sector is dealing with tasks which differ from their education.
- Although the topic of wildfires has been incorporated into school programmes and educational formation curricula in some countries, the handling of the topic is heterogeneous inside and among the countries.
- The frequency of wildfires often depends proportionally on the population density, but the extension and educational campaigns can reduce the risk significantly. In the areas where the population increases constantly, fire prevention measures should also increase.
- The wildland fire terminology must be defined and used more homogeneously.
- There is a need for creating and maintaining a common and high-quality database that allows a quantitative determination of forest types and other ecosystems affected by wildfires and land-use fires.
- There is also a need to gather information for analyzing gaps and needs of action in wildland fire prevention and suppression, and to determine the causes of the inefficiency of fire management, as well as the economical losses due to fires.
- It would be convenient to set up a common early warning system for the whole region, aimed at achieving an harmonisation of the different scales used to rank the wildfires risk values. This would lead to a better collaboration at local, national and international levels.
- In general, remote sensing may be useful for mapping fires, but aerial detection and suppression of fire in tropical forests are still inadequate. For this reason it is necessary to improve technologies and human resources.
- Because the municipalities and forestry enterprises are the basic organizational units in every country, they should become responsible for registering wildland fires as part of wildfire prevention and control plans in all countries of the region.
- Appropriate equipments and tools are necessary for the fire fighters for their personal security and work efficiency, particularly during the initial response phase. It is very frequently observed that the weight and dimensions of the available tools are very inappropriate for the task.
- Several administrations think that the airplanes represent the answer to combat wildfires in tropical forests. However, due to clouds and thick foliage of the forest, the effects of aerial attacks are very limited in many forest types of the region.

## **5. Analysis and recommendations**

### **5.1 Analysis**

- Wildfire is a common problem in all countries of South America, therefore there is a need to outline common policies.
- As a consequence of inadequate policies and the influences of domestic, regional and international economies, wildfire incidences and application of fire in land-use change have increased notably during the last years, becoming a more difficult problem to manage socially, economically and environmentally.
- In most of the countries the general and specific legislation dealing with wildfires is characterized by incomplete regulations and by the lack of clear and precise Standard Operation Procedures (SOP). The rules are confusing, contradictory and inapplicable, and this leads to high economic losses and creates conflicts between institutions.
- The inefficiency in most of the organizations responsible for wildland fire management is because the suppression has been prioritized over the prevention activities. Clearly, the importance of fire suppression in any fire management strategy should not be underestimated, but prevention and education have to lead all wildland fire management programmes in the region. In addition prevention is less expensive than suppression and has

- the added benefit of reducing the costs of fire damage and cost of restoration of devastated areas.
- Statistics are the basic tool for prevention, but the region does not have suitable databases. Four factors explain the reason for this situation:
    - Different wildland fire terminology and database formats are used;
    - Most of the countries elaborate quick statistics to provide answers to the administrative and political requirements, but nobody judges the effectiveness of prevention, suppression and values the wildfire damages;
    - Wildfire statistics are unavailable or inaccurate because most of the responsible organizations do not register information, or there is no official organization in charge;
    - Only three countries of the region are analysing causes of wildfires (Brazil, Chile and Uruguay).
  
  - Reasons why the organizations are not able to suppress wildfires successfully in most of the countries are the following:
    - The command centres try to produce daily plans, but the planning processes are more like reports, rather than directing priorities to guide field commanders;
    - More experience and training is needed in the Incident Command System (ICS) in Argentina, Brazil, Colombia and Venezuela;
    - Institutions in Bolivia, Ecuador, Paraguay, Peru and Uruguay must know the command system structure to confront wildfire incidents and develop necessary logistics for an appropriate wildfire management at local, state, national and international levels;
    - In several countries contradictory orders and frequent public controversies among the senior staff have also contributed to the failure of operations. The solution to this problem is to establish a suitable command structure, inter-agency agreements and frameworks for planning and distributing the resources to combat future wildfires more efficiently and more successfully;
    - During fire suppression operations, communication is lacking between the three levels: headquarters, a mobile command centre around the wildfire and on the ground fire fighters;
    - In most of public and voluntary organizations of several countries, there are no highly-trained professional fire fighters that respond to wildfire incidents and train other crews. In addition, the professional crews of fire fighters need to receive wildfire training prior to the fire season, including city fire fighters whose training is more geared to structural fire fighting. Many voluntary fire fighters and city fire fighters need to train up to reach the standards of fire fighter crews. Voluntary brigades also need to be well equipped to serve as first responders to fire emergencies.
  
  - To improve the wildland fire management, new regulations are required, which will be consistent with the ones beyond the boundaries of the countries. The importance of consistency between politicians and regulation instruments is clear, because many of the effects of wildfires have trans-boundary dimension.
  - The reduced state budgets and low scientific and technological development are recognized as increased wildfires in Andean and rainforests. Therefore, South American countries are in an unfavourable situation to develop and transfer suitable technology.
  - In the last three decades, at least 290 000 fires have burned 51.7 million ha. This is why it is necessary to have a strong and stable organization that guarantees the validity of the politicians and management of wildfires in every country.
  - Forecasts of the consequences of the slow but sustained global and particularly regional climate change predict large wildfires in the region. Countries need and have the obligation to be prepared to face an increase of wildfire activities under new scenarios.
  - The answer to the enormous environmental challenges of the Andean and Amazon countries is to strengthen their political position with bilateral agreements or develop and integrate networks. These alliances will give advantages and possibilities to strengthen capacities for wildland fire management.

## 5.2 Recommendations

- To strengthen national integration and contribute to define regional positions, in order to develop common objectives, projects and programmes at national and regional levels. It will allow the implementation of regional strategies on wildfires, politics for coherent and shared uses of resources, and improve the access to international financing sources.
- To strengthen the coordination among different actors and institutions in countries to improve the use of resources as well as efficiency and effectiveness of wildland fire management.
- To stimulate a better participation of the various stakeholders in taking decisions, assigning responsibilities for reduction and restoration of the areas affected by wildfires, sharing budgets and giving access to information sources.
- In order to strengthen the prevention of wildfires, it is recommended to incorporate the topic of wildland fires in all levels of education, exploring new forms of education and taking the traditional knowledge into consideration.
- Since agricultural burning in South American countries can degrade forest resources rapidly, it is recommended to teach prescribed burning techniques to farmers.
- Countries with small capacity in wildland fire management like Bolivia, Ecuador, Paraguay, Peru and Uruguay could make an effort to improve their institutions through collaboration between themselves and between countries like Argentina, Brazil, Chile and Colombia, to adapt some of the policies and programmes which have given good results.
- It is necessary to put emphasis on training and specialization of fire fighter crews and use of ground equipment, before undertaking aerial suppression programmes. It is also necessary to establish programmes for professional instructors and exchange experiences learned inside and outside the countries of the region.
- Due to limitations of equipment for ground and aerial attacks in tropical rainforest and mountain range of the Andes, it is necessary to develop more suitable equipment and tools for fire fighting in the region.
- The links with the international cooperation upon the Andean-Amazonian region must be improved.

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## APPENDICES

### Appendix 1. Data samples of wildfire occurrence in the region during the last 25 years (in the case of Peru – since 1970)

Years	Total No. of Fires on Forest, Other Wooded Land, and Other Land	Total Area Burned on Forest, Other Wooded Land, and Other Land	Area burned on Forest	Area burned on native forest	Area burned on plantation and native protected forest	Area burned on Other Wooded Land	Savanna and Shrubland burned. Not intensively managed and protected	Savanna and Shrubland burned. Intensively managed and protected	Area burned on Other Land	Natural and protected Grassland burned	Peat, Swamp and Wetlands burned	Human Causes	Natural Causes	Unknown Causes	N° of dead people	N° of injured people
		(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(%)	(%)	(%)		
<b>Argentina</b>																
81-90		1.101.760,00	55.370,00													
1991	4.787,00	465.200,00														
1992	4.787,00	465.200,00														
1993	343,00	1.792.336,00	1.278.966,00									54,00		46,00		
1994	773,00	1.011.749,00	861.434,00									72,00	7,00	21,00	25	
1995	4.146,00	730.946,00	370.917,00									69,00	6,00	25,00		
1996	4.119,00	450.677,00	185.388,00									64,00	13,00	23,00		
1997	4.774,00	281.984,00	98.369,00									66,00	7,00	27,00		
1998	8.765,00	890.784,00	283.494,00									65,00	17,00	18,00		
1999	10.587,00	714.621,00	178.034,00									61,00	7,00	32,00	2	
2000	10.596,00	2.810.093,31	953.847,20	943.655,05	10.192,15	1.388.686,45	1.388.670,20	16,25	467.559,66	467.559,66		53,65	6,92	39,43		
2001	7.878,00	4.694.504,62	995.828,45	975.472,69	20.355,76	2.851.813,56	2.851.602,86	210,70	846.862,61	846.862,61		46,95	8,30	44,74	8	
2002	15.182,00	2.260.709,34	806.870,38	782.619,74	24.250,64	1.030.798,20	1.030.744,35	53,85	423.040,76	423.040,76		41,04	5,78	53,18		
2003	18.832,00	3.152.856,80	1.020.132,16	1.004.789,34	15.342,82	933.693,07	927.149,98	6.543,09	1.199.031,57	1.199.031,57		46,89	5,60	47,51		
<b>Bolivia</b>																
1987		15.000,00														
1999	31.245,00	12.749.475,00	1.384.822,00	1.384.822,00		3.156.071,00	541.103,00	2.614.968,00	7.342.998,00	7.265.429,00	77.569,00	99,90	0,10	0,00		
2004	1.000,00															2



<b>Brazil</b>									
81-90		27.960,00							x
1991		9.033.861,00							x
1994		562.000,00							x
97-98	45.000,00	5.053.800,00	1.139.400,00		3.814.400,00		100.000,00	100.000,00	x 700
2000	150,00	43.314,00			43.314,00				x
2001	276,00	51.392,00			51.392,00				x
2002	337,00	157.665,00			157.665,00				x
2003	387,00	401.324,00	200.000,00		201.324,00				x
2004	222,00	42.044,00			42.044,04				x
<b>Colombia</b>									
1986	13,00	58,00							x
1987	8,00	40,00							x
1988	9,00	927,00							x
1989	65,00	13.509,00							x
1990	66,00	190,00							x
1991	146,00	39.817,00							x
1992	188,00	16.084,00							x
1993	46,00	495,00							x
1994	125,00	1.087,00							x
1995	571,00	7.915,00							x
1996	336,00	9.549,00							x
1997	10.289,00	164.736,00							x
1998	971,00	52.351,00							x
1999	353,00	4.210,00							x
2000	83,00	5.451,00			4.144,33				x
2001	1.030,00	87.188,60	1.534,86		85.653,74				x
2002	193,00	74.314,07	10.396,40	9.554,00	842,00	63.917,67	59.596,67	4.321,00	x
2003		13.398,97	2.852,53			10.546,44			x
2004	96,00	12.915,00	2.021,04						x

<b>Chile</b>											
88-89	5.359,00	48.227,00									
1990	4.114,00	25.545,00	7.308,00			18.237,00		88,70		11,30	
1991	5.193,00	50.273,00	13.578,00			36.695,00		90,41		9,59	
1992	4.786,00	24.224,00	3.807,00			20.417,00		91,31		8,69	
1993	6.114,00	49.981,00	16.343,00			33.638,00		91,40		8,60	
1994	621,00	65.606,00	21.052,00			44.554,00		92,09		7,91	
1995	5.354,00	26.174,00	7.588,00			18.586,00		91,80		8,20	
1996	5.886,00	40.082,00	19.083,00			20.999,00		91,61		8,39	
1997	5.487,00	43.595,00	2.015,00			23.445,00		96,79		3,21	
1998	5.329,00	90.888,00	64.147,00			26.741,00		94,90		5,10	
1999	683,00	101.691,00	50.898,00			50.793,00		93,10		6,90	
2000	5.252,00	17.182,59		1.147,45	3.087,62	5.292,00	5.166,35	82,00	1,20	16,60	96
2001	5.374,00	10.917,92		690,55	1.594,60	2.299,68	3.339,08	88,50	0,70	10,80	59
2002	6.701,00	90.069,05		31.281,66	22.241,72	13.156,32	13.040,29	80,70	1,40	17,90	100
2003	7.572,00	41.987,73		4.748,76	6.002,05	11.892,04	14.424,13	73,00	0,10	26,90	5 32
2004	6.430,00	50.687,19		6.096,99	10.806,44	14.486,10	12.690,45	66,20	0,40	33,40	142
<b>Ecuador</b>											
81-92	1.093,00	33.151,65		26.697,90	2.014,23		2.512,66	1.031,96	88,00	0,00	12,00
94-01		1.418,00			1.418,00						
2004	428,00	265.562,00						99,00			

<b>Paraguay</b>										
1988		60.000,00								
<b>Peru</b>										
73-80		307,94								x
81-90	18,00	4.522,06								x
1991	3,00	8.520,00								11
1992	1,00									6
1993	4,00	1.612,00								x
1994	5,00	1.150,00								x
1995	9,00	4.050,00								x
1996	1,00	760,00								2
1997	4,00	86,00								x
1998	57,00	75.441,00								x
1999	1,00	15.000,00								x
2000	5,00	11.003,00								x
2001	120,00	160,00								100,0
2002	111,00	259,00	68,00	23,25	44,75		191,00	71,00	120,00	100,0
2003	162,00	8.853,35	230,35	61,25	169,10		8.623,00	7.743,00	880,00	100,0
2004	47,00	537,00	2,00	2,00	0,00		205,00	5,00	200,00	100,0
<b>Uruguay</b>										
81-90		8.240,00								x
1995	521,00	2.367,00								x
1996	472,00	1.147,00								x
1997	974,00	1.667,00								x
2000	124,00	635,00								x
2001	39,00	64,26								x
03-04	172,00	4.195,50			1.200,00					x

<b>Venezuela</b>													
1990	1.021,00	19.963,00										87,00	
1991	1.150,00	162.133,00										87,00	
1992	1.518,00	148.716,00										87,00	
1993	1.026,00	17.296,00										87,00	
1994	815,00	46.448,00										87,00	
1995	889,00	207.713,00										87,00	
1996	758,00	62.459,00										87,00	
1997	279,00	39.501,00										87,00	
1998	755,00	27.841,00										87,00	
1999	147,00	7.355,00										87,00	
2000	191,00	4.121,00										87,00	
2001	3.249,00	44.049,00										87,00	
2002	995,00	24.444,00										87,00	
2003	2.205,00	49.219,00										87,00	
2004	968,00	58.673,00										87,00	
<b>Total</b>	<b>289.366,00</b>	<b>51.673.261,95</b>	<b>8.896.396,37</b>	<b>6.311.062,63</b>	<b>615.300,92</b>	<b>13.633.829,46</b>	<b>6.845.993,20</b>	<b>2.626.112,89</b>	<b>10.388.511,60</b>	<b>10.260.915,56</b>	<b>179.800,96</b>	<b>742</b>	<b>429</b>
<b>(%)</b>													
			<b>17,22</b>	<b>12,21</b>	<b>1,19</b>	<b>26,38</b>	<b>13,25</b>	<b>5,08</b>	<b>20,10</b>	<b>19,86</b>	<b>0,35</b>		
<b>Sources</b>													
1	Tesolin (1993) and Musse (1999)										13	Prevention and Awareness Disaster Direction, cited by Muñoz (2005)	
2	FAO (2001)										14	Haltenhoff cited by UNEP (2002)	
3	Esper (2005)										15	Sanhueza (2003)	
4	Musse, cited by UNEP (2002)										16	Sanhueza (2005)	
5	Martinez and Cordero (2003)										17	Galindo (2005)	
6	Bolivia (2005)										18	Ecuador (2004)	
7	Barbosa and Fearnside (1999); Barbosa (2003); Nelson cited by UNEP (2002)										19	Manta y León (2004)	
8	Batista (2005)										20	INRENA (2005); PRONAMACHS (2005)	
9	Batista (2005); Barbosa (2003)										21	Tamburi (2004)	
10	Silva (2003)										22	Tamburi (2004); Carrere(2004)	
11	Ospina (2003)										23	PNUMA (2003)	
12	Meteorology and Environment Research Institute, cited by Muñoz (2005)										24	Conde (2005)	

## Appendix 2. Specific legal framework on wildfires in countries of South America

Country	Specific wildfire legislation
Argentina	<p>Resolution 700, 1999 November 8. It creates the Registry of Producers Partnerships for the fire prevention and its control in forests plantations.</p> <p>Resolution 222, 1977. It creates the Organs Executives for the National Plan of Management of the Fire, Composed by a National Main Center and six Regional Centers.</p> <p>Decree 1.381, 1996. It lists tasks of the Direction of Native Forest Resources will have to execute, among them "to supervise and to attend the Wildfire management plan"</p> <p>Decree 710, 1995. It details tasks for the Prevention and Control of Wildfires. Articles: 34, 35, 36.37.38 and 39.</p>
Bolivia	<p>Resolution 42. It rules prescribed burning of grassland and it prohibits any burning in no agriculture land or areas protected by the forest law.</p> <p>Resolution special 131, 1997 June 9. It Rules of clearings and prescribed burning in Agriculture.</p> <p>Resolution 135, 1997. It rules the Forest Protection and specifies preventive measures in the forest management, including actions against wildfires.</p>
Brazil	<p>Norm 94 (IBAMA), 1998 July 9. It establish process for the authorizations of prescribed burning. IBAMA its in charge of developement of this process.</p> <p>Acre State; Order 346, 1999 September 15. It establishes rules to avoid and prevent wildfires in the State of Acre.</p> <p>Decree 2.959, 1999 February 10. It Establishes measures to be applied for suppressing wildfires.</p> <p>Decree 2.661, 1998 July 8. It rules fire fighting during sylvo-pasture activity.</p> <p>Law 9.605, 1998 February 12. It establishes imprisonment of 2 to 4 years by crimes against animalwild due wildfires.</p> <p>Decree 97.635,1989 April 10. It regulates article 27 of New Forestry Code concerning wildfires.</p> <p>Order 292, 1988 October 12. It approves the format for obtaining the authorization to prescribed burning.</p> <p>Order 231, 1988 August 8. It rules wildfire fighting according to article 26 of New Forestry Code (Act No.4.771).</p>
Colombia	<p>Decree 1.105, 2001. It creates the Commission for the prevention, mitigation and wildfire control of the department of the Cauca Valley.</p> <p>COMPES 3.125, 2001. It establishes Regional and Municipal plans of contingency for wildfire must be formulated; andto consolidate the National Network of the Regional Centers and implementation of the mechanisms and systems of detection and monitoring of wildfires.</p> <p>Decree 2.340, 1997 September 19. It establishes advisory boards for the prevention and mitigation of forest fires at National, Regional and local level.</p> <p>Law 322, 1996. It creates the National System of Firefighting, having specified that the firfighters are in charge of all kind of fires.</p> <p>Decree 2.762, 1973 December 31. It creates the National Council of Prevention and Control of wildfires.</p>
Chile	<p>Criminal Code, Article specific to wildfire 155</p> <p>Forest Law, Decree 4.363, 1931. It Considers a crime, the illegal use of fire as an intentional act on wildland.</p> <p>Law 18.348, Article specific to wildfire 3, 4, 5, 16, 17. Its the application of norms to prevent and control fire on prescribed burning and its use in rural areas.</p> <p>Law 18.362, It establishes the National System of Protected Natural Areas, prohibes to make fires, and determines civil responsibility.</p> <p>Decree 133, 1992; It establishes norms of hunting in wildlands. It lists prohibited methods of hunting and legallise any prohibited methods of hunting.</p> <p>Decree 100, 1990; It determines uses prohibits of fire,of burning piles, of burning detrimental vegetal species, prescribed burning and wildfires.</p> <p>Decree 301, 1984; It rules norms on camping to avoid wildfires and administrative proceedment of the Sanitary Code.</p> <p>Decree 733, 1982; It approves and norm the prevention and suppressing wildfires</p> <p>Decree 276, 1980; It establishes the rules on slash-and-burn and presumes civil responsibility by damages caused for the use of fire, according to the regulations.</p> <p>Law 15.231, It attributes the competence of the judges to the local police to investigate the offences to the Criminal Code.</p> <p>Decree 1.099, 1940; Earth Ministry, it regulates prescribed burning complementing therefore Decree 276 of the Ministry of Agriculture.</p> <p>Decree of force of Law 251, 1931; Ministry of Landuse, it establishes special norms of judicial procedure in fire incidents.</p>

### Appendix 3. General legal framework on wildfires in countries of South America

Country	General wildfire legislation
Argentina	Law 22.351, Title II, Chapter II art. 18, Section p, It establishes that the norms of the National Law 13.273 will be applied to the National Parks. Law 13.273 (Forest Defense), 1948 September 30; Articles specific to wildfire: 19, 20, 21, 22, 23, 24.
Bolivia	Law 1.700 (Forest law), 1996 July 12; Article specific referring to forestry delicts: 42. Government act 24.453, 1996 December 21; It regulates the New Forest Law. Article specific to wildfire: 87. The National Constitution demands respect and protection of the wildlands properties and interests of the community The Criminal Code deprive freedom from 2 to 6 years to the people who causes fires in grassland, agriculture and forest land. It sanctions no preventing actions for fire extinction. Law of Nature Conservation and its regulation, to protect and to conserve the natural atmosphere and resources, regulating the human action. Law for the Reduction of Risks and Attention to Disasters, to react in an opportune and effective way to the events caused by natural technological and human threats. The Law of Popular Participation. It recognizes, promotes and consolidates the process of popular participation for the environment protection. Law of Municipalities. It refers to the Mayorships attributions to preserve and to conserve the local environment and its ecosystems.
Brazil	Supreme Decree 3.179, It establishes penalties until US\$ 1500 for burning out of law an hectare or fraction of wildland. Resolution Conama 11, 1988 December 14; It establishes protective measures for protected areas. Articles specific to wildfire: 3, protected and preservation areas and ecosystem of wildfires. "Federal Law 6.938, 1981" (Second Forestal Code); Articles related to wildfire area: 2, 14, 15. Order 1.846, 1970 October 26; It establishes forest protective measures and implementing New Forestry Code. Act No. 4.771. Forest Federal law 4.771, 1965 (Forest code); It establishes that the use of fire may be justified in agroforestry and forestry activities. It is referring to Forest management; wildfires and forest protection measures
Colombia	Law 599 (Criminal Code), 2000; It considers wildfires like a crime of Public danger. Sanctions of 2 to 10 years and penalties of one hundred to five hundred minimum wages. Decree N° 948, 1995; Air pollution regulations establish the use of fire in the agricultural sector is controlled. Law 99, 1993; Creation of the National Environment System and the Ministry for Environment Affairs is established. Ley N° 46, 1988; Creation of the National Disasters Prevention System and a Fire-Fighting System is established Decree 93, 1988; It Establishes the National Plan for the Prevention, Attention, Mitigation and Recuperation of wildland from natural or anthropogenic disasters. The Political Constitution, 1991; establishes a sustained development human within a frame of Nature Protection. Decree 919, 1989; It establishes that the territorial plans, must contemplate the elaboration of plans of contingency for the attention of National, Regional and Local disasters. Law 46, 1988; Its creates the National System for the Prevention and Attention of Disasters.
Chile	Criminal Code, Article specific about wildfire caused by human behaviour: 474, 476, 477, 482, 495 and 496

**Appendix 3 (continued):** General legal framework on wildfires in countries of South America

Country	General wildfire legislation
Ecuador	<p>Ministerial agreement 55, 2001 October 23; the Ministry of Environment sends regulations to transfer the competences to the sectional governments, and by means of Ministerial Agreement it settles down that the competences of the forest sector are transferred to the local governments, including the wildfire suppression.</p> <p>Decree 948, 1995; Air pollution Regulations. the use of fire in Agricultural sector is controled by this sector.</p> <p>Forest Law was reviewed in 1999; Its related to the Natural Areas and Wildlife.</p> <p>Decree 340, 1998 November 30; It Declares National Priority to the forest activity and orders to improve its development.</p> <p>Criminal Code; It will be sentenced with jail of 3 to 6 years to the people responsable of an intentional wildfire.</p> <p>The Political Constitution declares of public interest the conservation of the Biodiversity and the Sustainable Management of the Natural Resources.</p>
Paraguay	
Peru	<p>Decree 38 (Rules of Law 26834), 2001; Lineaments of the National Plan of Prevention and wildfire control in Protected Natural Areas.</p> <p>Decree 14 (Rules of Law 27308), 2001 April 9; Articles specific to wildfire: 15,18, 19, 21, 29, 30, 31, 51, 53, 54, 59, 356, 363, 365, 366, 381.</p> <p>Law 27.308, 2000 July 15; Its second Law of Forestwild and Animalwild. Articles specific to wildfire: 4, 27, 35, 37.</p> <p>Criminal Code; The person who produces wildfire in legally protected places will be sentenced with prison for one to 3 years at most with posibility to be extended to a maximum of 4 years and 4 months.</p> <p>Decree 613, 1990 December 7; Articles generals to wildifire I, II.</p> <p>National constitution, 1993; the state defines the National Environment Policy and promotes the right and sustained use of its Natural Resources.</p> <p>Law 25.268, 1990 June 20; Its declares of public necessity and national interest the protection, preservation and reforestation of grassland that exists in the country (Articles specific to wildfires: 2, 3, 4, 5)</p>
Uruguay	<p>Forest Law, 1987; Defense and protection of native forests and plantations. It promotes the establishment of forest plantations.</p>
Venezuela	<p>Criminal Code for Nature Protection, 1992 January 2. Articles specific to wildfires: 48, 49, 50, 51, 52, 59.</p> <p>Decree 1.221, 1990 November 2; Rules for Environment. Articles specific to wildfires: 7, 8, 9.</p> <p>Decree 1.333, 1969 February 11; Rules for the Forest, Soil and Water Regimen. Articles specific to wildfires: 60, 61, 62. They are refered to afforestation/reforestation; timber extraction/logging; land clearing; agro-forestry; institution; classification/declassification; mountain area;institutions; forest management forest conservation; classification and declassification</p> <p>Forest Law, 1970.</p> <p>Forst Soil and Water Law, 1966 January 26. Articles specific to wildires: 26, 27, 28, 29, 30, 31, 32, 33.Contents: water conservation zone; Catchment, watershed; land use planning; environmental planning; timber extraction/logging; land clearing; wildfires; afforestation/reforestation; and institution; forest management; agro-forestry/sylvo-pasture"</p>
Guyana	<p>Forests Act, 1953 May 2; It was consolidated in 1973. Articles specific to wildires: 15, 16, 42. Contents: public forest; timber logging and extraction, wildfires; offences/penalties"</p>

**Appendix 4. Wildfire emergency agreements by countries**

Emergency Agreement Type	Country	Agreement Partner Descriptions	Purpose of agreement
In country	Argentina	PNMF with some Provinces	Coordination
		PNMF with Argentine Air Force	Cooperative
	Bolivia	Prefecture of Santa Cruz with BOLFOP proyect (1992)	Cooperative agrement for early warning
	Brazil	State Superintendencies of IBAMA with private and public organizations like Corps of Firefighters (Some states)	Cooperative
	Chile	National government with regions	Coordination
		National government with private sector	Coordination
		Bilateral Agreements between Regions	Coordination
		Bilateral Agreements between Regions and Private Sector	Cooperative
		Private to Private Sector Agreements	Coordination
		Other Agreements with Armed Forces, Fire Brigades etc	Cooperative and coordination
	Colombia		
	Ecuador	National Forest Direction with Army	Cooperative
	Paraguay		
	Perú	No agreement	
	Uruguay	National Direction of Firefighters with General Forest Direction	Cooperative
Venezuela	National Government with local organizations	Cooperativeand coordination	
Bilateral agreements	Argentina	Argentina with Chile (1997)	Cooperation in cases of catastrophes
		Argentina with Chile (1967)	Protection of border against wildfires
	Bolivia	No agreement	
	Brazil	Brazil with Bolivia (Proposed Agreement)	Protection of border against wildfires
	Chile	Chile with Argentina (1967 and 1997)	
	Colombia	No agreement	
	Ecuador	No agreement	
	Paraguay	No agreement	
	Perú	No agreement	
	Uruguay	No agreement	
Venezuela	Venezuela with Chile (Proposed)	Cooperation in cases of catastrophes	
Multilatera agreements		There no exists	



**Appendix 5.** Fire management assistance agreements (non-emergency) by countries of the South America Region. Source: FAO (2001a)

Non Emergency Type	Country	Agreement Partner Descriptions	Purpose of agreement
Protocols	Argentina		
	Bolivia	National Service of Civil Defense with OFDA (USDAID)	Technical assistance in basic training
	Brazil	IBAMA with Forest Service, USDA (1999)	Cooperation in wildfires and environment changes in tropical ecosystems
	Chile	CONAF with PNMF, Argentina	Mutual Assistance in suppressing activities at local level
		CONAF with NSW Rural Fire Service, Australia	Cooperative Assistance
		CONAF with Spain	Cooperative Assistance
	Colombia	MAVDT with ITTO (Proposed)	Technical assistance for implementing National prevention Plan
		MAVDT with OFDA (USAID)	Technical assistance in basic training
		MAVDT with Programa Environmental Invesments-BID	Financial assistance for strenghtening institutional capacity
		MAVDT with AECI (2001)	Technical assistance in environmental education and training
	Ecuador	Company of Corp of Firefighters with OFDA (USAID)	Technical assistance in basic training
	Paraguay	Asunción company of Corp of Firefighters with OFDA, USAID	Technical assistance in basic training
	Perú	INRENA/UNALM with IBAMA, Brasil (2004)	Technical assistance
Cusco company of Corps of Firefight with OFDA (USAID)		Technical assistance in basic training	
Uruguay	National Emergency System with CONAE (Argentina:2003)	Technical assistance in early warning system (Implemented in 2005)	
Venezuela	Company of Corp of Firefighters with OFDA (USAID)	Technical assistance in basic training	

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Working Paper FM/2	<i>International Wildland Fire Management Agreements Template.</i> Tom Frey, Ricardo Vélez Muñoz. January 2004.
Working Paper FM/3	<i>Legal Frameworks for Forest Fire Management: International Agreements and National Legislation.</i> Fernando Fernández Arriaga, Frédéric St-Martin, Tom Frey, Ricardo Vélez Muñoz. March 2004.
Working Paper FM/4	<i>Community-Based Fire Management in Spain.</i> Ricardo Vélez Muñoz. April 2005.
Working Paper FM/5	<i>Report on Fires in the South American Region.</i> María Isabel Manta Nolasco. March 2006.
Working Paper FM/6	<i>Report on Fires in the North East Asian Region.</i> Leonid Kondrashov. March 2006.
Working Paper FM/7	<i>Report on Fires in the Baltic Region and adjacent countries.</i> Ilkka Vanha-Majamaa. March 2006.
Working Paper FM/8	<i>Report on Fires in the Mediterranean Region.</i> A.P. Dimitrakopoulos and I.D. Mitsopoulos. March 2006.
Working Paper FM/9	<i>Report on Fires in the Sub-Saharan Africa (SSA) Region.</i> Alexander Held. March 2006.
Working Paper FM/10	<i>Report on Fires in the South East Asian Region.</i> B.J. Shields, R.W. Smith and D. Ganz. March 2006.
Working Paper FM/11	<i>Report on Fires in the Balkan Region.</i> Nikola Nikolov. March 2006.
Working Paper FM/12	<i>Report on Fires in the Caribbean and Mesoamerican Regions.</i> A.M.J. Robbins. March 2006.
Working Paper FM/13	<i>Report on Fires in the Australasian Region.</i> P.F. Moore. March 2006.
Working Paper FM/14	<i>Report on Fires in the South Asian Region.</i> A.M. Benndorf and J.G. Goldammer. March 2006.
Working Paper FM/15	<i>Report on Fires in the North American Region.</i> R. Martínez, B.J. Stocks and D. Truesdale. March 2006.
Working Paper FM/16	<i>Report on Fires in the Central Asian Region and adjacent countries.</i> Johann G. Goldammer. March 2006.