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Global Forest Resources Assessment 2005 – Report on fires in the North East Asian (NEA) Region

by
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Comments and feedback are welcome.

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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.

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TABLE OF CONTENTS

1. Background

Following the release of the Global Forest Resources Assessment 2000 (FRA 2000) report in 2001, the global FRA process has now entered its next reporting cycle. FAO's Committee on Forestry (COFO) 2003 confirmed the directions of global FRA's that the Kotka IV Expert Consultation recommended in July 2002. Recommendations included the preparation of an update of the global FRA-data in year 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.

FRA 2005 also included thematic studies, including e.g. one on forest fire, forests and water, and mangroves. The thematic study on wildland and forest fire in 2005 is built on regional reviews on forest fire management in the International Strategy for Disaster Reduction (ISDR) Global Wildland Fire Networks (GWFN). The current report is a contribution and makes a review of the ISDR North East Asia (NEA) Region.

This Working Paper FM/6/E has been written by Mr Leonid Kondrashov and does not reflect any official position of FAO.

2. Introduction

The Northeast Asian (NEA) region covered by the ISDR Regional Northeast Asia Wildland Fire Network includes China, Japan, Republic of Korea, PDR of Korea and the Far East of the Russian Federation. This part of the world is highly diverse in socio-economic, ecological and nature management systems and trends, driving forces of development as well as in major problems to be solved in future.

The region is surrounded by oceans in the North, West and South, and has borders with the Central Asia region in the East. It is not appropriate to consider the whole of the Russian Federation to belong to NEA since Siberia and the rest of the country to the west are gravitating to Europe. Thus, including the whole Russian Federation in this analysis would change the real picture of the specific situation in NEA. The Far East of Russia currently has closer economic and trade connections with the NEA countries than with the most of the western parts of Russia.

Most of the NEA countries except Russia (Far East) have less than 0.6 hectare (ha) of forest per person. Despite the decline of the forests during the 1990s in NEA by 10.5 million ha, NEA countries are showing a positive trend, mainly due to afforestation efforts in China, where the forest coverage has increased from 8.6% to 16.55% during the last 50 years. Since 1973 the Republic of Korea has reforested 2 million ha, that constitutes for around 34% of total forest area.

In NEA, approximately 60% of forests are concentrated in mountain regions, on steep slopes which strongly hinder management and fire fighting.

3. Fire situation in the NEA region

When comparing the two periods 1988-1992 and 1998-2004 to identify forest fire trends in forest fire occurrence and their general impact from the end of 1980s shows the following changes in forest fire dynamics in the NEA countries, there is an observed increase in: (a) scale, (b) frequency, (c) area burned by forest fires, but with a great difference in countries in terms of: (d) economic damage, (e) cost of fire suppression, (f) efforts to regroup forces and attract voluntary fire fighters, (j) awareness of the general public and national/local politicians regarding fire management necessity to control wildland and forest fires.

The reasons for escalated fire activities are varied and difficult to document, but educated thought points towards more frequent periods of drought, caused by inter-annual climate variability or as consequence of regional climate change. Other factors are the population increase in or near the forests, transmigration, change of land use patterns and fire exclusion policies in fire-adapted ecologies.

Forest and wildland fires and their negative impact continue to be a major issue in NEA; wildfires influence the quality of life, land, air and water. Unacceptable resource losses and the spread of transboundary pollutants need immediate attention by the NEA nations and their international partners. If these negative impacts are not fully addressed, they will result in loss of sustainability of forests, public health and economic opportunities.

Fires in the NEA region have evidently resulted negatively in major ecosystems (e.g. productivity, soil condition, stability, carrying capacity, etc.) in fire-sensitive ecosystems and in the positive role of fire in fire-adapted ecosystems (e.g. surface fires in pine and larch forests, leading to fuel reduction and favouring ecologically adapted and economically valuable species).

Uncontrolled wildland and forest fires are the principal causes for deforestation and forest degradation in the NEA region. National and local fire statistics reveal the inter-annual variability in fire frequency or in fire sizes. For example, the Russian Far East experiences severe fire seasons every ten years and catastrophic fires every 22 years. In China, there is an increase of fires every three years; in Japan every four years, and in the Republic of Korea the sequence is every two or three years. Regionally, fire frequency varies depending on the dryness of the fuel and weather, lightning and human activities. Locally it varies depending on factors such as slope, exposure, and altitude. Forest fire is the natural phenomenon in conifer stands and large areas in the Far East burn nearly every year. Fires break out mainly between 10 a.m. and 4 p.m. and are usually contained between 9 p.m. and 6 a.m. the following day (Shu Lifu *et al.*, 2004). In the higher altitudes steep mountain areas of southwest China, for example, it is suggested to implement suppression of work in the early dawn period, since attempts to suppress fire during the night might result in casualties (Shu Lifu *et al.*, 2004).

3.1 Extent, number and types of fires/forests burned

A comparison of national statistics for the NEA countries shows an average burn of about 1 million ha of forests each year, during the period 1990-2004. The occurrence of forest fires varies depending on inter-annual climate variability and accumulation of combustible materials. However, the areas affected by wildfires and damage estimations show an increasing trend in recent decades.

The average annual number of forest fires in Japan is about 3 000. This annual number is almost equal to the number of fires in the Far East of the Russian Federation. However, sometimes the annual number of fires exceeds 4 000 in the Russian Federation. In the 1980s the Russian average burned area per fire was above 4 000 ha; in the 1990s the average was 2 300 ha.

In Japan the number of fires larger than 1 ha is 150 annually. During the last 20 years, the largest area affected by forest fires was about 1 000 ha. On the average there are six fires per year larger than 100 ha. Average areas burned by classes in Japan are as follows: (1) 100 ha and more – 0.2%; (2) 10 to 100 ha – 1 %; (3) 1 to 10 ha – 4%; (4) 0.1 to 1 ha – 20%; (5) up to 0.1 ha – 75%.

In the NEA region the main fire areas are Inner Mongolia, the mountain-boreal forest in the Northeast and the tropical southern parts of China, the western part of Japan (where secondary forests are widely spread), the Khabarovsk and Primorski Territories, Yakutia and Sakhalin areas in the Russian Far East. However, the whole area of the Far East contains zones of annual high forest fire danger. Also the areas with high population densities in mountain areas of South and North Korea are considered as high-risk fire zones. Most of the fire danger areas in NEA are located on mountain slopes where the fire behaviour has its own peculiarities and the access to fire hot spots is difficult.

In China, for example, the highest number and largest sizes of forest fires occur in five provinces: Heilongjiang, Inner Mongolia, Yunnan, Guangxi and Guizhon. Between 1950 and 1998, these five provinces had 42.5 % of all fires in China and 75% of the damaged area. The number of forest fires is also large in the forests of the southern China while the largest damage to forests is in Northeast and Inner Mongolia. Forest fires in the Northeast and Inner Mongolia spread quickly and over large areas. In China, during 1990-1999, an average annual number of 5 324 fires burned over an average of 122 036 ha of forests (if non-forest lands are excluded, then the average size of fires in these regions is 22.9 ha).

In China, peak fire seasons are in May and October in the Northeast, while in the southwest, the peak fire season is from January to April. In Northeast China and Inner Mongolia fires normally do not occur during times of high precipitation, humid air in summer and low temperatures with accumulation of snow and frozen land in winter. Thus, fires occur from mid-March to mid-June in spring, and from

mid-September to mid-November in fall. The highest fire rates are in May and October. In South and Southwest, fires occur from mid-November to the end of May. The highest fire occurrence is between February and April. In the Northwest – mainly in Xingiang Autonomous Region – summer and fall are most critical. The fire season lasts from the end of July to the end of September. The highest fire danger is registered in August and September. The evaluation of inter-annual variability of fire cases reveals cycles of extreme fire seasons every 5 and 10 years

As a rule, the forest fire situation is complex, especially during the peak fire season or when the density of fires is very high, like in Japan or Republic of Korea, where fire occurrence is often inter-related to population density.

Japan has 8 fires per year/1 000 km^2 (Satoh, 2005) and most fires occur during daytime, between 12:00 and 16:00 hours. Fires in Japan often occur in the same populated regions, like Osaka, Chiba, Saitama, and Aiti. The largest numbers of fires in Japan occur in the spring and winter (93%). In the Republic of Korea forest fires also frequently occur in the spring (68%) and in winter (22%) since they are drier periods than summer and fall. Fire risk periods cover the time between mid-February and mid- May in spring, and November to mid-December in autumn and early winter.

About 70% of NEA region are mountainous and hilly; in these areas fire behaviour develop in a specific way (from bottom to up) which decreases the danger for infrastructure located at the foot of the mountain, but in turn renders the work condition of firemen very difficult on these slopes. The fire propagation rate (rate of spread) on the slopes of 15 degrees and more is double than that of leveled terrain, and on the slopes more than 25 degrees, surface fires transit into the top of trees and become crown fires. Thus, it is recommended to prioritize fire combating on gentle slopes, watersheds and on the borders of inflammable sites.

This behaviour is clearly demonstrated in North Korea, where almost all forests are located on hills and mountain slopes. Two North Korea Provinces - Hwanghae and Hamgyong - have experienced the strongest influences of wildfires (10 357 ha and 32 054 ha, respectively). In 1996-1997, according to North Korea Statistical Bureau, the number of forest fires was 911 and an area of 46 017 ha was burned.

Recently, the sizes of forest are becoming larger in many cases in the Republic of Korea. The geographic distribution of forest fire spots over 30 ha in size are expanding all over the country. The Republic of Korea summarized the reasons for this as follows: distribution of tree species such as conifer (*Pinus densiflora* Sieb. et Zucc.); continuity of fuel arrangement; occurrence of wind speeds exceeding 5 m/s, sometimes reaching 9 m/s over; elevation of 420 m and over; length of slope exceeding 650 m.

The present official fire statistics in Russia only covers about 60% of the forest estate area. The Far East alone accounts for 249 million ha of unprotected forests (Shvidenko and Goldammer, 2001). This constitutes a visible discrepancy when comparing national official data and information received from international organizations monitoring Russian fires by satellites. Besides, fire experts consider that data on wildland fires in Russia are not always reliable (Shvidenko and Goldammer, 2001). However, even official statistics during the period 1996-2003 show that, in the Russian Far East, the number of fires increased constantly as well as the area burned. In the Far East of the Russian Federation, the forest fire season usually continues from April till the end of October. The Far East taiga is one of the largest contiguous forest areas in the world and it is very flammable from spring to fall.

3.2 Reasons

In NEA states, the human activities in the forest are expanding because of demographic and socio-economic changes in the developing countries of the region, as well as mainly cultural-aesthetic reasons in the developed ones. The origins of fires are invariably linked with various human activities such as: commercial (wood production), cultural-aesthetic spheres (photo hunting, health improving, ecological tourism, etc.) and arson. Fires are also caused by current non-burn policies in fire-adapted ecologies, by accidental burning, ecosystem types conversion (agriculture, pasture lands, industry and construction, forestry practice and plantations); non-wood products harvesters; cattle herders; adult and children tourists; road workers and railways; traditional use of fire (hunting, travel corridors); natural resources excavation and transportation; rural and urban population; and infrastructure development.

Wildland and forest fires overwhelmingly originate from human causes: 95 percent in China, 69.8 percent in 1980s and 70.8 percent in 1990s in Japan, and not lower in the Korean peninsula (79.1 percent in the Republic of Korea). Present harsh economic realities force the North Korean population to clear the forests in trying to collect wood for heating and cooking.

According to the government statistics, the share of human-caused forest fires in the Far East of Russia during the last two decades is between 60-80% (84% in 2004). The consequences of the economic development of the territory and its forest fund (the goal of the Federal Government is to export wood products for US$100 billion per year (exports today represent less than US$5 billion). This massive expansion of human activities may possibly result in an increasing number of human-caused fires in forests. The future construction of an oil pipeline from Siberia to the Pacific coast concerns also a wide range of forest fire specialists and ecologists. Besides, because of the vast expansion of forests and the lack of close supervision, illegal logging is increasing and some loggers try to cover up the traces by igniting live forest stands (to cut burned timber) or to cover their activities by burning the logged over area.

Table 1. Forest Fires in the Republic of Korea by causes.

Cause/Year	2000	2001	2002	2003	2004	Mean
Total number of fires	**729**	**785**	**599**	**271**	**544**	**5 861 (100%)**
Carelessness	312	354	217	93	250	245 (42%)
Weed burning	134	143	110	55	83	105 (18%)
Waste burning	68	47	58	24	47	49 (8%)
Smoking	63	88	60	43	51	61 (10%)
Visitor to ancestor's grave	47	45	63	31	22	42 (7%)
Children's firework	18	24	20	4	13	16 (3%)
Others	87	84	71	21	78	68 (12%)

Source: Myoung Soo Won *et al.* (2005)

The table shows that in the Republic of Korea most of forest fire causes are not related to production (logging) activities. They are mainly caused by human carelessness, tourism, agriculture and religious rites. The majority of fires appear close to populated areas, and they increase by 30-60% during week ends and holidays.

In Russia prescribed burning is at the pilot stage of its introduction as an official forest fire protection activity. Agricultural prescribed burning (e.g. pasture management) in Russia is estimated to a total of 30 million ha annually. Estimations for the Far East are about 1 million ha per year. Fire specialists point out that, in Japan in 1990s, several large forest fires developed because of unsuccessful initial fire suppression measures. In China, for example, in southwest forest areas, the method of prescribed burning to clear new farmlands and burning weeds has been transmitted from generation to generation (Shu Lifu, 2004).

3.3 Damages

Due to their damaging ecological, environmental and economic impact, NEA forest fires influence every component of the nature and society. The magnitude and risk of the impacts of wild fires vary from region to region and depend very much on the size, intensity, longevity and frequency of the incident.

The scale of the negative fire impact on the nature and society during the last decades (ecological damage, economic losses, money and resources spent on fire suppression) seems to be increasing. Impacts on human health are also estimated to be growing. The outburst of large scale forest fires in October 2004 in two regions of the Far East has resulted in the change of the atmosphere composition, not only in the hot spots, but also in neighbouring populated areas. For example, the city of Khabarovsk (700 000 people) has experienced a rise in the dust content from 0.5 to 2.3 mg/m^3 (4.6 times the maximum permissible concentration – MPC). The CO_2 concentration values which were at a range 7.3 to 7.7 mlg/m^3 have risen to 25.8 mg/m^3 (1.5 to 5.3 MPC). In 1998 the haze of Far East forest fires has been felt not only in the eastern part of Russia (6.5 million km^2), but also in China, the Korean peninsula and Japan, and affected the health of no less than 150 million people.

In the Republic of Korea, 89 percent of fire outbreaks and 99 percent of areas damaged by fire can be observed during spring.

Chinese Northeast accounts for just 5% of the number of forest fires in the country, but they account for 60% of national fire losses. In 1987, North Eastern China had 1.3 million ha burned and a significant loss of human lives and infrastructure in local communities. During the period 1959-1998, China's losses in fire fighting were about a hundred of human lives and five hundred injured. Significant human losses were also recorded in 1998 and 2003 in neighbouring Russia. Though large fires only account for 3% of all fires in the Far East, they account for 90% of all damage. In East Sea, Gangwon-Do, South Korea, huge property losses (US$83 million) and forest ecosystems disturbance were recorded in April 2000, after a disastrous forest fire which covered 23 794 ha in a mountainous area.

It is doubtful that existing methods of data collection provide a definite answer about the economic losses incurred by society due to forest fires. Thus, there exists a great dispersion in the evaluation of annual regional forest fire damages. For example, the existing Russian methodology of post-fire assessment is not able to give a full and detailed result. During spring, summer and autumn of 1998, wildfires ravaged an unprecedented 2.2 million ha of forests in the Far East. At that time, the damage was estimated at US$200 million. However, a recalculation of lost resources by using world market prices provides a more accurate picture of the damage which amounts to US$4.2 billion (Kondrashov, 1999). According to the information provided by the Forestry Agency, the amount of damage in 2004 in the Khabarovsk Territory was 9.6 million roubles (US$356 600) and a loss of 29 821 m^3 of wood; however, both estimates seem to be very conservative.

Table 2. Forest area burned in Japan 1988-2002.

Year	1988	1989	1990	1991	1992	1998	1999	2000	2001	2002
Area burned (ha)	3 200	2 100	1 300	2 700	2 300	800	1 000	1 500	1 800	2 600

Source: FAO (2005)

Chinese investigations in Heilongjiang Province and Yichun forest areas show that fire kills up to 40% of trees in mid-aged conifer forest; 50-60% of trees die in the mature forest; almost 100% die in forest or afforested areas younger than 15 years. The experience after the catastrophic fires in the Far East in 1998 when up to 120 million m^3 were burned, revealed that these stands remained suitable for commercial purposes only during a two-year post-fire period.

About 75 percent of the Far East forests are located in the permafrost zone. During dry summer months, permafrost thaws releasing moisture and mineral salts to surface soil layers and covering vegetation. In winter everything again freezes, the health of boreal forests is maintained through this process. Large-scale logging in these areas leads to artificial thawing of permafrost because large areas are opened to direct insolation. These clear-cut forests then become bogs. When permafrost is converted into a bog, the organic material is decomposing faster, and released methane is emitted from plants and the permafrost itself (release of trapped "paleogases"). Climate warming can lead to further permafrost melting and the emitted methane will further accelerate the warming process. Climate warming supports conditions that feed both forest fires and release of greenhouse gases into the environment. Generally, the temperate and boreal forests of NEA region account for more than two percent of global biomass burning and carbon emissions respectively. These emissions contribute to climate warming creating a cycle that constantly reproduces itself. Forest fires produce and emit so much heat that this can create a weather system of its own which induces conditions for more fires. This new weather system is created when air around a very intense fire heats and rises, the drought by the fire pulls in more surrounding atmosphere, and a wind pattern emerges from this cycle. Fires in the Far East region can break the prevailing weather balance, releasing huge amounts of carbon which had accumulated over centuries, in a short time.

There is growing concern that fires on permafrost sites will lead to a degradation or disappearance of forests. Severe local fires could break natural restoration processes because climate change predictions in the Far East suggest longer fire seasons and higher levels of fire danger. Increased fire risks in the boreal forests of Russia are a major threat to the global carbon budget.

It is apparent that NEA nations are experiencing similar wildlife fire trends, both in causes, burned areas and impacts. There are estimations that timber losses in the region, due to forest fires alone, are in the order of US$0.5-1 billion per year. As a result, recent problems caused by increased fire activity have reached serious proportions and become unacceptable; destabilizing local economies and ecologies.

Forest fire suppression is quite an expensive undertaking burdening the abilities of countries to cope with fire losses. Besides, excessive forest fire impact leads to forest substitution with less valuable species and grasslands.

The consequences and damage of catastrophic fires cover vast areas of some administrative units or even countries, and thus must be considered not only at the national but also international levels.

3.4 Prevention

All NEA countries aim at a wide introduction of preventive and fire awareness measures. Advanced fire management systems, including the use of remote sensing for detecting and monitoring fire, are in place in China, Russia, the Republic of Korea and Japan. The Republic of Korea is introducing a new ground-based system equipped with automatic cameras capable to cover 93% of total forest area (6 410 000 ha) for detecting forest fires. No other NEA country has a similar system. The use of such technologies in other countries should be explored in order to improve the situation. Given the size of the area to be monitored in the Russian Far East or the whole NEA Region, the use of satellites would be an economic alternative – with all technical constraints that currently exist (Ahern *et al.*, 2001). Images depicting wildland fires in DPR of Korea, received by the Moderate Resolution Imaging Spectroradiometer (MODIS) on the Aqua satellite in April 2004, revealed the burning of more than 130 fires. Although the detection of these fires, never confirmed by the DPR Korean authorities, the method shows the potential of advanced equipment in regional wildland fire monitoring.

Figure 1. On 16 April 2004 (left) and 3 May 2005 (center and right), numerous fires were detected in DPR Korea by the Moderate Resolution Imaging Spectroradiometer (MODIS) on the Aqua satellite during its daytime overpasses of the region. Their locations have been marked in orange (left) and red (right) or are visible as smoke plumes (center). In 2004 and 2005 the Korean Peninsula experienced a warm, dry spring. While many of the fires in this scene may be intentional agricultural fires, others represent forest fires or other wildfires (Source: NASA Earth Observatory, by courtesy of the Global Fire Monitoring Center (GFMC)).

The creation of green fire-belts and mineralized stripes of soil in Russia and China, air patrolling, fire watch towers, satellite monitoring, radio communication, are a common fire preventing method in all countries of NEA, except in DPR of Korea. The establishment of fuel breaks (greenbelts) is considered to be a very effective measure to prevent fire expansion (Shu Lifu, 1998; Telitsyn, 1988; Ostroshenko, 2000). These fuel breaks are buffer zones of 10 to 20 m width, on which hardwoods with low-flammability are grown commercially. In China, their total length is 172 100 km.

In Japan, the Republic of Korea and in the forest region of Daxinganling (China), as well as in the Khabarovsk Territory (Russia), a lightning detection and monitoring system has been established to identify and locate fires started by lightning.

In NEA countries, fire is an active tool for clearing land to plant crops, develop pastures, or establish forest plantations. It is admitted in the region that wildland fire, when carefully prescribed and skillfully managed, can also be less destructive to site quality than mechanical clearing methods since soil disturbance is minimized and there is no soil compaction by heavy equipment. Burnings (prescribed fires) are used to prevent forest fires of high intensity and to improve conditions of growth of forest trees. In China, for example, prescribed burning is the most widespread method used to eliminate weeds. Thus, prescribed fires are contributing to mitigate the forming of large forest fires in the Northeast, Inner Mongolia and Sichuan Province, Khabarovsk Territory and Primorski Territory (Russian Far East).

The majority of NEA countries have adopted a policy of fire prevention by awareness rising programmes and by training the local population. In connection with the awareness/education work, national agencies also need to develop radical measures to prevent catastrophic fires and to introduce most effective methods for their suppression. Currently, each NEA country has developed its own system for managing and preventing fires, in many cases by combining the potentials of federal and local communities.

3.5 Fire suppression

The states of NEA practice fire suppression despite often insufficient financing and technical support during exceptionally dry weather spells, thus forest fires can become uncontrolled and result into disasters. The suppression of fires requires the concentration of forces of the entire society but, even in these cases, it is often impossible to avoid losses, especially in mountainous and remote forest areas.

There are not so many differences in fire suppression techniques used in the NEA countries. However, management systems and the level of equipment used are quite different. For example, in Japan forest fires are eliminated by the urban fire and rescue services, because in such a densely populated country it is possible to reach forest sites in a relatively short time. The system of the Republic of Korea requires firefighters to reach the detected fire spots in any part of the country within half-an-hour by using helicopters.

The methods of bringing a forest fire under control in NEA states are as follows: direct attack on the burning fire edge; in parallel by constructing a fireline close by and parallel to the fire edge; and indirect attack by locating control lines at a considerable distance from the fire edge and burning out all fuel between the line and the front of the advancing fire.

Considering latest experiences from other parts of the world, Russia is currently changing its policy of total suppression of all forest fires. However, the application of a new forest fire management policy is delayed due to: ongoing changes in state forestry management, problems with the adoption of new Forest Code, uncertain allocation of authority, shortage of financing (in Russia the expenses of forest protection for 1 ha of forest are about US$0.07) and many technical problems. In addition, the economic situation in Russia has had a negative influence on the use or purchase of fire fighting machinery and equipment, including aerial assets. For example, in the Far East in 1988 the number of helicopters exceeded the 2005 fleet by 8 times, planes by 15 times, bulldozers by 2 times and manpower by 2-2.5 times. Now only, 88% of the protected areas are covered by episodic aerial patrol flights. In 1998, only 30-35% of fires were detected with the help of air forest teams (ten years ago – 95%) (Kondrashov, 2004). This unfavourable trend has drawn the attention of international organizations such as the World Bank and the US Agency for International Development (USAID) which are trying to supply machines and equipment within the framework of their projects.

Official Russian fire statistics for the past five decades typically report annual areas burned in the entire Federation between 0.5 and 1.5 million hectares, with very little inter-annual variability. In fact these values are an underestimation of the real situation of wildfires in Russia. There are two reasons for this: insufficient monitoring and registering of forest fires in the mammoth territories of North Russian and Siberia and in the Far East, and secondly the aspiration of local authorities to try to hide their inefficiency in combating fires. This inefficiency is often not technical, but rather related to lack of funds allocated locally for fire management.

In recent years, with the advent of international satellite coverage of Russian fires, in collaboration with Russian fire scientists, more realistic burned area estimates are being generated. For example, during the 2002 fire season, satellite imagery revealed that about 12 million hectares of forest and non-forest

land (wildland) had been affected by fire in Russia, while official sources reported only 1.2 million hectares of forest land and 0.5 million ha of non-forest land burned in the protected areas of 690 million hectares (Goldammer, 2003). During the early summer of 2003, remote sensing data indicated that a total wildland area affected by fire in Russia exceeded 22 million hectares (GFMC, 2003). Based on recent remote sensing data, it appears that the annual burned area in Russia can vary from 2 to 15 million hectares/year.

Japan and the Republic of Korea are forced to pay attention to any burning forest fire since uncontrolled fires can lead to losses and damages of infrastructure, human health and environment in the Wildland-Urban-Interface (WUI) areas. They also adopted protection strategies for local conditions in order to minimize the threat of catastrophic fires and to establish priorities for prevention activities to reduce the risk of fires spreading. The strategy also includes provisions for allocating suppression forces to improve the probability of rapid containment of fires in areas of high concern.

Ultimately, the solution for preventing a recurrence of large-scale uncontrolled burning depends on the ability of local government agencies to regulate land development and enforce restrictions in the use of fire as a land-clearing tool. Since the majority of uncontrolled wildland fires are caused by local rural populations, an effective fire prevention and control program will require a complete understanding of the cultural and socio-economic values, background and livelihoods of local peoples. Successful prevention of uncontrolled wildland fires requires the understanding, by local populations, of the economic and ecological benefits of fire prevention, and the securing of a strong commitment on their part to prevent intentional and carelessly started fires.

4. Stakeholder/Actors situation

4.1 Institutional and other capacities

Forest protection is an important component of the State policy, providing ecological sustainability for the country and preservation of “green” potential. Yet, in NEA region, legislation and ability to implement it differ from country to country. Major achievements have been made in countries of NEA with regard to their institutional framework. In China, Japan, the Republic of Korea, and Russia, a national and local Agenda 21 has been formulated. In addition, environmental plans or strategies have been developed, such as Japan’s Basic Environment Plan, Republic of Korea’s “Green Vision 21”, and the Democratic People’s Republic of Korea’s National Strategy for Conservation and Sustainable Use of Natural Resources, Russian Concept on Forestry Development.

In all countries, expenses have increased and progress has been achieved in virtually all areas of environmental protection, though to different extents. Recent initiatives such as the creation of the Presidential Commission on Sustainable Development in the Republic of Korea, which involves people from the business sector, academia and NGOs, seem to provide room for effective multi-stakeholder voice in policy implementation. China’s Forest Action Plan for country’s Agenda 21 of 1995 lays foundations for the establishment of sustainable and comprehensive forest ecosystems and a fully developed forestry industry by 2010. In Japan, the nation-wide Forest Plan (1996) and policy directions and guidelines for forest management were developed. From the DPR of Korea, no formal documentation is available. The 4th Forest Development Plan of the Republic of Korea (1998) laid the foundation for sustainable forest management by establishing more valuable forest resources, by fostering competitive industries and by maintaining a healthy forest environment.

Russia has well defined laws on forest protection. However, law enforcement is quite weak. There are not so many adherents in the society to a recently prepared Forest Code which could change radically the property and management system in the Russian forestry. The Far East is a part of the all-Russia forest fire management system, with two leading departments: the Federal Forestry Agency and the Aerial Forest Protection Service. Both organizations have subdivisions in the regions of the country. The Ministry of Emergency Situations is involved in extreme situations.

In most NEA countries, aircraft is used in two ways – as a tool to suppress fires (often as additional means to ground measures) and for fire detection. In Russia, during the last few decades, about 80-85% of all fires have been detected by aerial means and about 50% of them were suppressed within the first day. The South Korea Forest Service has increased the number of heavy/super heavy helicopters and arranged them into seven main offices and branch offices, for each district.

Fire management is a critical component of sustainable forest management. The World Conservation Union (IUCN) and the World Wide Fund for Nature (WWF) are advocating a more integrated approach to fire management, placing greater emphasis on seeking sustainable solutions, which incorporate the essential elements of forest fire management.

The organizational infrastructure in fire management has been strengthened in many countries and progress has been achieved in training, public education and fire risk estimation systems. However, in NEA the attempts to date have lacked a regional vision and focus and have been implemented without significant coordination. Thus, an enhanced effort is required in a variety of fields and spheres, like suppression technologies, integrated fire management planning, in refocused land clearing, settlement policies and practices and in the development of alternative land clearing methods.

The fire problem is a regional issue and need to be addressed in a coordinated manner on the basis and expertise of resources of individual nations Here technical assistance may have a key role to play together with the development of partners. Nowadays there are fewer federal (central) resources available and governments and agencies expect to obtain results from regionally-based governments, NGOs and partners. New models and roles of regional partnerships and cooperation, and in some cases, trilateral agreements, between the private sector, NGOs and national (local) governments are to be expected in the near future.

4.2 Responsibilities and Roles

The creation of new partnerships in managing forest fire events in NEA should receive high priority. Understanding this, the countries in NEA have ratified, accessed to or accepted most of the multilateral environmental agreements and conventions adopted prior to or after the 1992 UNCED. Despite this, there is still no international cooperation program in NEA developed in the field of forest fires; therefore there is a need to expand mutual cooperation activities in wildland and forest fires.

The importance of forestry research and education is widely recognized through NEA as a prerequisite for effective management of natural resources. Research, education and information systems are different across the region, dependent mainly on the availability of funding, other resources and facilities. Still, without exception, countries invest relatively less in forestry research than in related sectors such as agriculture. Even well known organizations with strong forestry traditions suffer from instability, brain drain, etc. In NEA, most institutions still dedicate much time and research effort to traditional fields of forestry, paying insufficient attention to inter-disciplinary issues including political, environmental and socio-economic problems.

Forestry research in the Far East is implemented by the industrial institutions, universities and by the Division of the Russian Academy of Sciences totalling approximately 400 scientists. Forestry research in China is carried out by the State Forestry Administration (SFA), universities and the Chinese Academy of Sciences. SFA supports research through the Chinese Academy of Forestry (CAF), provincial research institutes (30 provinces), and the Prefectural Forestry Research Institutes (251 research institutes). The CAF employs nearly 2 000 scientists, and over 1 500 forestry stations are located in the provinces. Japan's principal forestry research agency is the Forestry and Forest Products Institute (FFPRI). With its headquarters in Tsukuba, FFPRI has more than 120 laboratories distributed throughout the country, covering various fields. But in addition, there are more than 130 other organizations working in related fields. In the Republic of Korea, forestry research is carried out by the Korea Forest Research Institute (KFRI) and many universities, like in the Seoul National University. The total number of active research workers in NEA is around 3 500.

In order to address the consequences of forest fires in NEA, the work now needs to be targeted, coordinated and enhanced using well funded existing national and regional programs supported by countries in the region and by the international community. It is important to monitor and evaluate progress in the field of wildland fires to understand the impact on policies, programs and on the environment. The monitoring and evaluation will provide feedback for timely adjustments of policies and programs at all levels; to make national and local plans of action effective and responsive to national and local priorities; and to enable systematic analysis of progress in implementing ecological tasks at all levels.

4.3 Collaboration

These unacceptable resource losses and transboundary pollutants have had a positive impact on the collaboration between countries, first of all bilaterally, especially between neighbouring countries, like between Russia and China. A number of NEA countries have participated actively in the international dialogue on forests. This includes discussions initially in the Intergovernmental Panel on Forests (IPF), in the Inter-governmental Forum on Forests (IFF), and subsequently in the UN Forum on Forests (UNFF). For example, representatives of all NEA countries attended the Second Session of UNFF held in New York in March 2002, and again the Fifth Session of the UNFF in May 2005.

A number of countries from the region have also sponsored or hosted initiatives, sub-processes and meetings, directly contributing to this international dialogue. Forestry is periodically of interest in several general cooperation organizations and agencies. The regional economic groups also play roles in facilitating transboundary cooperation on issues that may arise (or require mitigation) in one country, but have an impact on neighbouring countries through cross-border effects. For the NEA countries it will be useful to investigate, for example, how countries from the Association of South-East Asian Nations (ASEAN) are dealing with the issue. The ASEAN Agreement on Transboundary Haze Pollution was signed in 2002 and entered into force on 25 November 2003 in response to problems created by forest and land-use fires. This Agreement provides a legal and institutional framework to cope with problems at national and regional levels, including prevention, monitoring, coordination, disaster assistance and investigations.

A variety of other regional forestry agreements, institutions, and *ad hoc* meetings promote international cooperation on forestry within the region. FAO, the International Tropical Timber Organization (ITTO), World Bank, United Nations Development Programme (UNDP), International Plant Genetic Resources Institute (IPGRI), International Network for Bamboo and Rattan (INBAR), WWF and IUCN (among others) have a wide range of forestry programmes or involvement in forestry. Some regional institutions such as the Asian Development Bank (ADB), Asia-Pacific Association of Forestry Research Institutions (APAFRI), Center for International Forestry Research (CIFOR), and International Center for Research in Agroforestry (ICRAF), Regional Community Forestry Training Center for Asia and the Pacific (RECOFTC), International Center for Integrated Mountain Development (ICIMOD) and South Pacific Regional Environment Programme (SPREP) have an important impact on promoting international cooperation. A wide variety of forestry-related non-governmental organizations (NGOs), functioning as an active tool of the civil society, also operate in the region and play important roles in facilitating dialogue and exchange.

In terms of regional forums, the FAO Asia-Pacific Forestry Commission (APFC) provides a unique opportunity for discussion of forestry issues relevant to the region. APFC reviews progress, discusses problems of mutual concern and sets new agendas. A variety of other regional forestry meetings occur, often on an *ad hoc* basis.

In 2002, the governments of Japan and Indonesia established the Asia Forest Partnership (AFP) to promote sustainable forest management in Asia, with focus on enforcement of forest legislation, improvement of governance, illegal logging and rehabilitation and reforestation of degraded lands both in ASEAN countries and in China, the Republic of Korea and Japan. AFP comprises 15 governments and nine NGOs working as partners.

A large number of bilateral and multilateral development projects are also implemented in the region. Japan is one of the main donor countries, both in the region and on a global scale, substantially contributing to forestry projects in the Asia-Pacific region.

The well known efforts of GFMC in establishing the UNISDR Global Wildland Fire Network for fire dissemination and exchange can, through increased cooperation, lead to an effective work on wildland fire management in the NEA region through the new NEA Wildland Fire Network.[1] GFMC's leadership role in the development of an international "fire coordination centre" will globally provide a leadership and direction in coordinating international fire prevention, training, monitoring, suppression and assessment activities.

Providing technical and development assistance in fire management activities is a very important goal in regional collaboration. Results could be achieved through a genuine cooperative spirit among NEA

[1] http://www.fire.uni-freiburg.de/GlobalNetworks/globalNet.html and http://www.fire.uni-freiburg.de/GlobalNetworks/Northeast-Asia/Northeastasia.html

nations – partnership requires a sharing of vision, values and resources. Another aspect of collaboration involves the private sector as a full partner.

The civil society must not forget the well developed network of active NGOs working in forestry or related fields. The global role of NGOs continues to grow: for example, Central America alone has 4 000 NGOs, receiving US$350 million annually from multiple funding sources. The expanding international networks of NGOs are influencing the agendas of governments and multilateral institutions to reflect previously ignored development and environmental concerns.

NEA region can actively use NGOs for the following activities:

- to plan and implement international seminars and conferences on wildfire problems alternately in NEA countries;
- to establish/join an international consortium for the implementation of fire management and training programs in countries such as in China, DPR of Korea, Russian Far East (fundraising, establishing local facilities for fire data banks, providing machines, equipment and technologies, and arranging for research works);
- to establish international working groups to analyze problems in the regions and to define most urgent tasks;
- to facilitate regular information flow, e.g. a regional wildland fire newsletter giving information about the work and plans of all actors, and other publications;
- to strengthen national networks and civil society efforts to monitor the implementation of ecological programs and plans;
- to improve public policy and legislation and strengthen cooperation with local and national governments to form partnerships;
- to provide training and assist in strengthening the capacity of community groups;
- to translate programs and plans into local languages and to assist in the transfer of effective communication technologies.

An example of international cooperation is the GEF (Global Environment Facility) Russian Far East Project “Forest Fire Management in Biologically Valuable Forests of Amur-Sikhote-Aline Ecoregion”. The project has the following components:

1. establishment of an ecoregion-wide integrated forest fire management system to include high conservation value forests (i.e. increase in the area of protection forests covered by the regional fire dispatch and monitoring system);

2. increase effectiveness of fire management in high conservation value forests through strengthened regulatory framework and interdepartmental coordination, integrated ecosystem management, and increased capacities to address catastrophic fires and their consequences (i.e. reduction in average burned area per fire in model areas); and

3. raise public awareness and support from the local population and communities to fire prevention and mitigation (i.e. increase in the number of equipped and trained volunteer fire groups and community participants in alternative land/ecosystem management programs).

It is an interesting fact that all components of civil society are involved in the implementation of this project.

4.4 Community involvement

The NEA region is undergoing a positive change with regard to society’s perception of the problem of wildland fires. However, people are not fully aware of the consequences of forest fires and they do not know their behaviour rules in the forest. In some NEA countries, the citizens have not yet reach that stage of civil society development, of self-organization and well-being, where they could independently voice their interests, including those in fire prevention. The implementation of regular fire prevention awareness activities among citizens requires identification of suitable structures and persons responsible for its implementation and coordination, as well as the existence of a legal enabling framework, developed methodology and stable financing. Still in many cases only governmental structures are allowed to fulfil needed coordinating functions and provide funds for this work.

At the same time, NEA countries have facilitated the development of environmental activism working with various social, age and professional groups, which, in the long run, have emerged as effective conservation advocates. The rise of environmental activism has paralleled a rise in social activism related to forest management and accessing local rights to natural resources, which is especially connected with the rights of indigenous peoples. Throughout the NEA region, people have begun to demand greater accountability in the way that forests are managed, and even more so, a direct say in forest management. Undoubtedly, the key trend relating to socio-economic aspects in forestry in NEA region relates to collaborative forest management.

The NEA countries have recognized the immense pressure forests are supposed to support in densely populated areas, meaning that authoritarian styles of centralized forest management are neither appropriate nor effective in meeting the broader forest management objectives of today. Resource constraints within governments also imply that centralized forest management systems are less effective than other means. Forest departments have increasingly found their management objectives unreachable, or seriously compromised, unless they empower communities and stakeholders to participate in decision-making. There are already existing mechanisms developed for increasing community participation in forestry activities.

Fire prevention at the community level traditionally involves instruments such as awareness-raising, public information and incentive elements (e.g. participation in benefits gained by successful prevention of destructive fires). Integrated fire management measures include fuel management, thus enabling people to proactively work in fire prevention. Some pilot products have been designed for application at the community level. Many villages in China and some other countries have developed community regulations and agreements and have successfully strengthened forest fire management at the local level. Widespread application or technology transfer, however, is still in its infancy stages.

The main measures to manage forest fires are to raise public awareness through publicity and educational activities, manage forest fires by legislation, firefighting team development, and develop enabling framework for the society to prevent forest fires, reinforce the infrastructure construction and fire preparedness in key fire danger zones. Local people may in some circumstances have extensive knowledge about fire management, which is well adapted to the local environment and therefore may be in a position to manage or prevent fires at the local scale without outside assistance. However, in the case of very large fires, communities often have inadequate training, experience and professional expertise in handling this kind of an emergency.

WWF and IUCN intend to work with grassroot organizations, in cooperation with the private sector and government agencies, to actively support Community-Based Fire Management (CBFiM) in NEA. This includes capacity building based on existing community practice, supplemented by more information (i.e. weather, maps, etc.) and with secured land rights.

In the Far East, USAID established the FOREST project concept devoted to forest fire prevention through changing people's behaviour in the forest. The Project has been working in Khabarovsk and Primorski Territories, Sakhalinsk and Irkutsk Regions and in Krasnoyarsk Territory for five years. It introduced an integrated approach to forest fire prevention awareness activities among local citizens. It incorporated three interdependent components: (1) development of educational campaigns and general awareness for targeted groups; (2) development of Fire Prevention Awareness Program for Pre-school and School Aged Children; (3) strengthening foresters' skills in communication/community participation.

At the very beginning, a baseline public opinion polling/audience research was conducted in Khabarovsk and Krasnoyarsk Territories and in Sakhalinsk Region. This research provided data for classifying the goals and causes for people who visited forests. It also revealed the level of awareness and the attitudes of people regarding forest fire problem. The data also showed habitual behavioural patterns of the citizens whilst in the forest and became the basis of the general awareness campaigns of the FOREST Project.

The follow-up focus group research made an exact "portrait" of various community groups and identified the risk groups, i.e. those sections of the population that cause most of the forest fires.

This work made it possible to conduct targeted campaigns aimed at changing behaviours of selected groups of forest visitors and users. The first targeted campaigns including video and radio spots, tip sheets and posters were directed towards hunters and fishermen, non-wood products collectors and picnickers. All in all 26 000 fact sheets, 2.5 million tip sheets and 45 000 posters were distributed, 8 forest recreation areas, 7 two-sided billboards (18 m^2 each), various types of souvenirs – badges,

pendants, stickers and shawls with fire prevention symbols, 6 sets of Tiger and Bear costumes for the conduct of community events were developed. Three hundred and thirty one workers of 232 forestry enterprises participated in trainings. Knowledge, skills and fire prevention materials received helped them to improve general awareness activities in their communities. The project developed a network of partners which comprised about 2 000 people in all five project regions, including 16 NGOs which also participated in the work. Local TV and radio companies were running six video and five audio public service announcements of the FOREST Project on donated air-time. More than 700 educators attended FOREST fire prevention seminars on School Aged Children Program, where 5 000 copies of this Program were distributed. Over 7 500 school children were trained in fire prevention based on this Program. An adapted version of this Program for kindergartens was issued and distributed.

Of course, the results of this work cannot become instantly apparent, change in behaviour and attitudes of people takes place gradually over decades. Nevertheless, the check polling results showed that in one year about 90% of people became familiar and were able to remember some elements of the implemented campaigns and 18% declared that they had changed at least one aspect of their behaviour in the forest within this period. As the FOREST Project shows, regular fire prevention awareness activities among the citizens cannot be implemented without respective laws and norms, stable finance and institutionalization. Furthermore, principles of financing and determination of structures responsible for the conduct of these activities must be fixed in normative acts (Kuzmichev *et al.*, 2004).

4.5 Needs and limitations

Major constraints faced by NEA countries in the field of forest fire management include the following:

- organizational and financial problems in implementing international cooperation, limited institutional and technological capacities;
- full implementation of measures and actions of Agenda 21 still remains a great challenge at the national and NEA level;
- lack of public awareness of wildland fire issues leads to human activities that put burdens on the environment, for example forest fires, pollution, depletion and degradation of natural resources;
- need for technical cooperation in many forms, training capacities, educational programs and combining the efforts of all components of civil societies;
- provision of a clear legal, institutional and financial base including the new measures in taxation;
- need for measures to increase the responsibility of civil society for the condition of the forests;
- enhancement of the capacity of government institutions, research entities, business and NGOs with regard to planning and implementation of sustainable development programs;
- development of institutional mechanisms that integrate both the developed and developing countries in NEA;
- overcoming the shortage of modern fire extinguishing equipment, insufficient use of satellite information and information technologies.

It is possible to overcome the above-mentioned limitations and constraints in combination with NEA regional efforts and resources.

5. Analysis and recommendations

NEA fire management experts have a sufficiently diversified picture of how to improve methods and modern technologies of forest fire prevention and suppression. There is also a clear perception of necessity to take into account the post-fire ecological consequences and their role in the global processes. Fire impact on forest ecosystems is now perceived as many-sided, not only harmful but useful as well, and practically as a necessary element in fire management. The main threat is still the build-up of large forest fires, which share has been increasing during the last 30-40 years.

5.1 Conclusions

1. The overall wildland fire situation in the NEA countries is complex and requires different targeted policies to address the underlying causes and the consequences of wildland fires;

2. A recent increase in large forest fires causing huge socio-economic losses has been observed;
3. It is widely understood that humans are the major source of forest fires and thus must be in the focus of all fire prevention work. Therefore, the increased work with the public is now becoming one of the main measures to prevent fires;
4. Specialists point out that while the experiences of developed countries, such as Japan, mirror those of many other countries in Europe and North America, the examples set by developing countries, such as China, where dedicated efforts are being made to rehabilitate and expand forest areas, provide optimism for other countries in the region, that they can, and will, similarly address their forestry challenges;
5. Most countries in the region have a relatively sound policy and legislative foundation from which to implement sustainable forest management. In general, the major problems are in countries' capacities and commitment to realize current legislation;
6. The increase in community participation in forest fire suppression work in the region over the past 20 years, though less than optimistic predictions, offer views that a lot of additional work in fire preparedness is needed to transform them into an effective tool in wildlife fire management;
7. Several general factors provide the foundation for cautious optimism over the future in wildland fire management in NEA region. It is first of all closely connected with the levels of development, information sharing and international cooperation. Along with the developed countries in the region, China is showing leadership in sharing information and experiences, as well as encouraging international collaboration;
8. NEA countries are in consensus that large forest fires can constitute a threat to all life in societies. Besides, the fires are contributing to international issues including transboundary pollution and raised CO_2 levels. Occurrence of forest fires also reflects changes in land management policies and practices and the transmigration of people, lack of valuation of the services forests provide;
9. Experts underline that the civil society, via political processes, must actively participate and even be in control of wildland fire management;
10. It is important for science to estimate the interface between the human dimension of fire and the changing global environment. The new fire science in the third millennium must be application-oriented and understood by the society, including policy makers;
11. Now it is quite clear that ecological policy-making processes will become most effective and responsive to priorities and needs if they (a) emerge from a broad base of political advice and from objective technical analysis of ecological conditions and trends; and (b) are implemented through partnership arrangements among local authorities, the private sector and NGOs;
12. There is still no regional data base on forest fires. Due to different approaches, the information by countries is not always compatible. There are steps launched by FAO and GFMC to create compatibility and both organizations developed special forms to be filled by country representatives. The will and governments support are needed to realize this idea. Usually data by countries contain only statistical information without analysis and forecasts. The active collection of data is continued by GFMC through the Regional Wildland Fire Networks and the recently launched Global Wildland Fire Assessment 2004;
13. Policy-makers are beginning to realize that continued emphasis only on emergency response will not prevent large and damaging wildfires in future years;
14. Wildland fires in NEA sometimes have such a scale that the individual country itself cannot solve the problem without international cooperation;
15. Active work on sustainable forestry practices with community-level involvement is a critical strategy for better conservation of natural resources and reduced wildfire impacts. A better understanding by policy-makers and the general public of the ecological, environmental, socio-cultural, land-use, and public health issues surrounding vegetation fires, is also very important;
16. UN and other international organizations and programmes, such as FAO, the World Meteorological Organization (WMO), World Health Organization (WHO), NGOs, as well as national governmental and non-governmental institutions, including academic, could actively participate in the networks. The recent efforts of many UN programmes and organizations are a positive step in this direction, but still much remains to be accomplished.

5.2 Recommendations

1. It is necessary to improve the quality of training for fire risk assessment (fire danger index) in the region;
2. There is a need to unify approaches to regional zoning according to forest fire risk;

3. Improvement of institutional capacities in the region because they are some of the weakest points in forest fire management;
4. Emergency preparedness and response programs must be coupled with better land-use policies and practices;
5. The traditional approach of dealing with wildland fires exclusively under the traditional fire-exclusion schemes must be replaced by an inter-sectoral and interdisciplinary approach;
6. Integrated programs and strategies must be developed to address the wildfire problem at its roots, while at the same time creating an enabling environment where appropriate tools are developed so that policy makers can become proactive in dealing with wildfire (Goldammer, 2001);
7. Fire prevention should become a priority in the forest protection system;
8. The application of prescribed fires and preventive controlled burnings as a measure of fuel management should be increased;
9. Advanced technologies for forecast and detection of fires and other information technologies should be introduced;
10. The interrelation of wildland fires with climate change and the global carbon cycle, the expected long-term socio-economic consequences and the change of forest resources should be studied;
11. International cooperation in suppressing forest fires should include not only common information exchange, etc, but also transfer of airplanes, forces and equipment from country to country. The main problems for the use of aerial means are operational costs and maintenance, but comparing the suppression cost with possible ecological and economic damage, a balanced solution must be found;
12. There is a need for provision of free access to global scale early-warning system for fire occurrence and fire risk. The establishment of fire management networks can be a very effective tool to support local communities in fire preparedness;
13. There is a need to support the Global Fire Monitoring Center (GFMC) and its worldwide network of partner institutions so that the global fire community can improve the capabilities in local, national, regional and global early warning and risk assessment, fire detection, monitoring, as well as regular assessments of wildland fires.

The goals of sustainable forest fire management are most likely to be achieved through:

- Adopting enabling approaches, forming partnerships and activating participatory mechanisms;
- Building capacity among partners;
- Monitoring and evaluating process and learning from each other's successful practices through networking and the use of modern information technologies;
- Developing international cooperation to facilitate the active participation at all levels of government and all relevant partners in decision-making, policy formulation, implementation and evaluation, and resource allocation.

The ideas of ecological sustainable development will be implemented through local, national, sub-regional and regional plans of action and/or other policies and programs drafted by interested parties and executed in cooperation at all levels and supported by the international community. This will go through enhancing policies, strategies and management practices; establishing and/or strengthening effective governance structures; contributing to more sustainable forms of environment conservation.

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