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INTERNATIONAL FOREST FIRE NEWS

No. 37
January – December 2008

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Call for contributions

Readers of the International Forest Fire News are warmly invited to send written contributions to the editor at the above address. These may be in the form of concise reports on activities in wildland fire management, research, public relations campaigns, recent national legislation related to wildfire, reports from national organizations involved in fire management, publications or personal opinions (letters to the editor). Photographs (black and white) and graphs, figures and drawings (originals, not photocopies, also black and white) are also welcome. Contributions are preferably received by e-mail.

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Due of the time lag between editing and print/distribution of IFFN, readers interested in meeting announcements are kindly requested to visit the Internet version of this issue for update and short-term announcement of meetings (continuously updated) and other global news on http://www.fire.uni-freiburg.de

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EDITORIAL

In Southeast Europe, notably on the Balkan Peninsula, the summer of 2007 was extremely dry and hot – the consequence of a jet stream pattern, which in 2007 was flowing further south as compared to average years, allowing low pressure systems to sweep over Western / Atlantic Europe and warmer air, pulled from Africa, flowing to Southeast Europe. This weather pattern resulted in extraordinary high meteorological fire danger on the Balkan Peninsula. And indeed – many countries of the region experienced extremely large and severe wildfires affecting whole landscapes – forests, open land vegetation types including protected areas, agricultural and pasture lands. Apart of environmental damages many cultural assets and residential areas were affected by wildfires and resulted in high economic losses and caused injuries and loss of lives of firefighters and rural inhabitants.

In some countries multiple large wildfires prompted governments to call for assistance from their immediate neighbors and at international level.

The Global Fire Monitoring Center (GFMC) requested the country focal points of the UNISDR Regional Southeast Europe / Caucasus Wildland Fire Network to evaluate the 2007 fire season. The results are presented in this volume of International Forest Fire News.

Two additional contributions from fire research projects are included in this volume – one covering conceptual model of a forest fire management information and decision-support system for Brandenburg State, Germany. The other contribution is addressing the wildland-urban interface fire problem of Greece.

Freiburg – Geneva, December 2008 Johann G. Goldammer

Forest Fires in Greece 2007

1. A First Assessment of the 2007 Wildfires

1.1 Extent of the fires

No official data for 2007 available at the time of writing this report. According to the European Forest Fire Information System, about 270,000 hectares of vegetation in Greece had been affected by wildfires by mid-September. This figure exceeds by far any previous record. The vast majority, 184,000 hectares, went in just four days, between 24 and 27 August 2007.

Most of the fires occurred in the south of Greece, in Peloponnese. Burned area mapping by the laboratory of forest management and remote sensing of the School of Forestry of the Aristotelian University of Thessaloniki, in cooperation with the World Wide Fund for Nature (WWF), completed by the end of September, produced an estimate of 177,265 ha, specifically for Peloponnese. Forest and other natural areas accounted for 55% (97,618 ha) of the total burned area while agricultural areas reached 16,432 ha. More than 30,000 ha burned are classified as Special Protection Areas of the NATURA 2000 network.

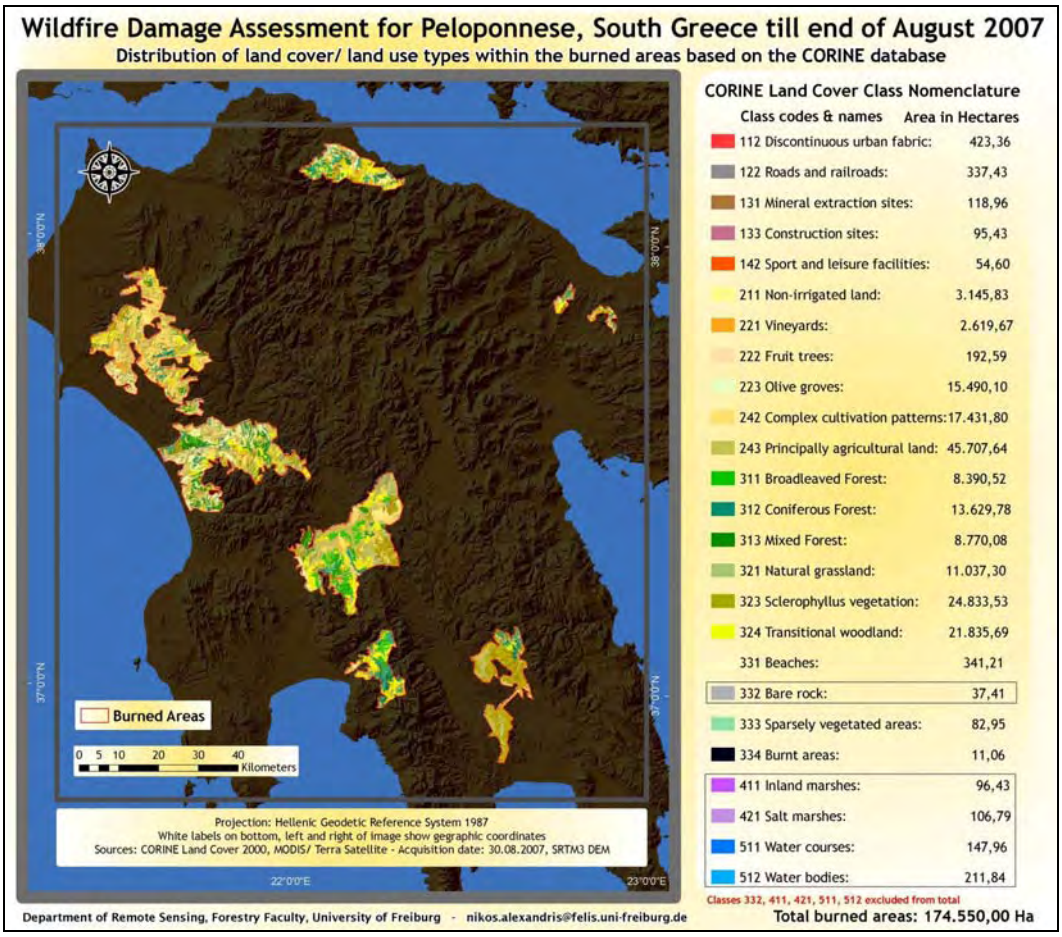

Figure 1. First quick assessment of the area burned by CORINE land cover classification at the end of August 2007. Source: Nikos Alexandris, Global Fire Monitoring Center (GFMC) and Department of Remote Sensing, Freiburg University.

1.2 Causes of the wildfires

There is lack of reliable data on fire causes in Greece, especially after 1997, when the responsibility of firefighting was transferred from the Forest Service to the Hellenic (Greek) Fire Corps. Earlier statistics

from the Forest Service, however, reveal that around the late 1980s to the early 1990s the vast majority of fires were due to human causes (Table 1).

Table 1. Wildfire cause statistics of the Forest Service 1988-1993

Fires Causes	1988 (%)	1993 (%)	1968–1993 (%)
Lightning	**2.6**	**2.7**	**2.4**
Accidental causes	**3.1**	**2.5**	**3.5**
1. Power lines	0.8	1.0	0.7
2. Engine sparks	1.4	1.0	2.1
3. Use of explosives	0.3	---	---
4. Army target shooting	0.6	0.5	0.7
Negligence	**27.3**	**28.2**	**36.0**
1. Stubble burning	11.8	9.0	16.0
2. Cigarettes	4.0	2.1	8.7
3. Garbage burning	4.2	2.5	3.9
4. Workers in the countryside	3.8	4.0	3.2
5. Recreationists and hunters	1.6	0.8	1.3
6. Other known causes	1.9	9.8	2.9
Deliberate causes	**33.5**	**18.0**	**29.2**
1. Rangeland improvement	15.6	6.6	---
2. Arson			
Deliberate (for profit, revenge, etc.)	17.2	10.8	---
By people with reduced mental capacity			
Children	0.3	0.2	---
Pyromaniacs	0.2	0.2	---
Other psychopaths	0.2	0.1	---
Mentally retarded	0.0	0.1	---
Unknown or suspected causes	**33.5**	**48.6**	**28.9**
Total	**100**	**100**	**100**

Table 2 is based on more recent data from the Greek Fire Corps and refers to only those cases that were investigated by the corresponding Fire Investigation Department and a report was sent to court. Obviously, this is not a complete un-biased sample.

Table 2. Fire cause statistics for the period 2000 to 2005 from the website of the Greek Fire Corps (www.fireservice.gr)

Cause	2000	2001	2002	2003	2004	2005	Total	Percent
Unknown	628	714	469	640	721	532	3,704	37.60%
Arson due to negligence	481	835	409	453	553	437	3,168	32.16%
Deliberate arson	297	389	209	359	398	300	1,952	19.81%
Accidental	4	2	2	15	9	1	33	0.33%
Natural	80	235	182	233	158	107	995	10.10%
Total	1,490	2,175	1,271	1,700	1,839	1,377	9,852	100.00%

In short, more than 95% of the fires are due to human causes. There is a general tendency of people to believe that most fires are deliberate, started by people who want to achieve gains on public land, taking advantage of the lack of a complete land cadastre, or want to build homes in forested areas where this is prohibited. Although the existence of such motives cannot be questioned in some cases,

there is a multitude of other reasons behind deliberate arson. Negligence is the most common cause. Education of people about fires is relatively poor. Furthermore, the general belief that “arsonists” are the overwhelming reason behind the fires, which is “cultivated” by the mass media, leading to indifference and negligent behavior of the people, does not help in reducing the number of fires that are due to negligence.

1.3 Description of selected extreme fires in 2007

In summer of 2007 Greece faced a very difficult fire season. Signs about the difficulty of the fire season were evident early on. Snowfall in winter was deficient, making it impossible for many ski areas to operate. Rainfall was also well below normal. A few rainy days in May did not solve the problem as they were followed by an early heat wave in the last days of June.

The difficult conditions were obviously the main contributing factor to the large fire disasters that the country faced. Some of the most notable ones are described below.

The fire on Parnis Mountain

The fire on Parnis Mountain, a few km NW of Athens that burned most of the Parnis National Park. The fire started in the area of Dervenohoria in the evening of 27 June 2007, at a distance of 15 km from the National Park. The cause were electric sparks from the overloaded power utility network that had been trying to cope with the high demand for electric power for the air conditioning units, as people were trying to find relief from the first – early – heat wave of the summer. Two large fires in central Greece, the first in the area of Agia on mount Ossa, that claimed two civilian lives, and the second on the extremely beautiful and highly visited Mount Pelion in Magnesia, as well as many other smaller fires, did not allow massive initial attack by aerial means. The fire potential was underestimated and firefighting efforts during the day of the 28 June 2007 were not of the urgency that would be expected for such a fire. In the evening, the fire passed the last open spaces at the base of Parnis and started a quick run in the draws of the mountain that were occupied by Aleppo pine (*Pinus halepensis*) forest at elevations below 800 m and fir forest (*Abies cephallonica*) above that. It created a huge convection column and rushed to the top of the mountain defying all efforts to control it.

The fire finally burned 5,600 ha including 2/3 of the precious Parnis National Park. More important, it created great concern for the people of Athens who felt that they lost an important natural reserve and recreation area which also helped to regulate the climate of the city and to filter the air they breathe.

The fire near the village of Doxaro, Rethymnon, Crete

On 11 July 2007, three seasonal firefighters lost their life while firefighting near the village of Doxaro, in the prefecture of Rethymnon, in Crete. A fourth firefighter sustained extensive burns and died in a hospital a few days later.

The fire was probably due to arson. Such events are common in Crete where shepherds regularly burn (illegally) the low thorny shrubs (mainly *Sarcopoterium spinosum*) called “phrygana” on the overgrazed rocky land, in an effort to stimulate growth of new palatable forbs and grasses for their goats. It started at 13:20 in an area such low shrubby vegetation bordering agricultural vegetation. According to the official announcement of the Greek Fire Corps, the total firefighting forces mobilized were 11 fire trucks with 30 firefighters, a Kamov-32 helicopter, two Canadair amphibian water bombers, and two hand crews of 8 firefighters each. It is unlikely that all these forces were on the fire at the time of the accident.

Figure 1. The draw through which the main fire entered into the core of the Parnis National Park late in the evening of 28 June 2007. The true fir (*Abies cephallonica*) forest burned completely. Average fire spread during this run was estimated at 4.5 km/h. Photo: G. Xanthopoulos.

The wind was not very strong and fire behavior in the phrygana vegetation did not appear threatening. The accident happened just before 17:00h. Based on the images projected on TV reports and on interviews of firefighters immediately after the accident, the firefighters tried to control the fire at the bottom and left side of a narrow steep canyon, using hoses from a fire truck that had stopped mid-slope on an unpaved road. They achieved this and retreated back on the road while there were small flames at some points on the opposite site of the canyon where the vegetation had not burned. Four firefighters of one of the two hand crews moved on that slope trying to extinguish these small flames with backpack pumps. At that moment the fire moved unexpectedly to unburned fuels under them at the bottom of the canyon. Helped by the nature of the fine fuels, the steep slope (more than 40%) and probably a wind gust, the fire became intense in seconds and started moving upslope towards the four firefighters. They started running but they made the choice to run along the steep slope moving further into the canyon where the fuels had not burned. The fire accelerated in the canyon behind them. They shouted for help on the radio. This is when their colleagues near the truck realized they were in grave danger but they could no react in the smoke-filled environment of the canyon.

The three firefighters fell after running for about 200 m. The fourth firefighter managed to climb a little further and protect him in a little cave-like depression. According to the TV reports he suffered damage to his lungs in addition to receiving second degree burns over 40% of his body. Based on the accounts of the firefighters who witnessed the evolution of the accident, the time between the blow-up and the fatality was not longer than five minutes.

The four firefighters were 34 to 40 years old with 5-7 years of experience. According to their comrades they all were in good physical shape. Although it will be a long time before any official investigation reports, it appears that the two main reasons behind this accident are topography (box-canyon, Y-shaped near the point where the firefighters fell) and light flashy fuels. A third factor that may have played a critical role, since it was mentioned in some witness reports, is the firefighting activity of the Kamov-32 helicopter which produces a very strong downdraft. If it did make a drop in the canyon close to the area where the firefighters were operating, it could very well be the cause of the fire spotting to unburned fuels below the four firefighters and starting the blow-up.

The fire on Hymettus mountain

This fire was not important because of its large size but because it took place only three weeks after the fire on Parnis Mountain, on 16 July 2007, at the base of mount Hymettus, in an area that is practically in contact with the east side of Athens. It received extensive live coverage by the media and increased further the feeling of insecurity of the people.

The fire started at about 03:00pm in a well-guarded area next to the ring road of Athens, occupied by an Aleppo pine forest-park, under high wind conditions (45 km/h). In the 30 minutes that were needed for the aerial means to arrive it progressed quickly, unhampered by the suppression efforts of the ground forces, while the people watched, either from their balconies or from the live TV coverage. Then the aerial means arrived (6 Canadair water bombers, two Erickson and one MI-26 heavy lift helicopters) and taking advantage of the short distance to the sea (8 km) they controlled the fire in less than an hour. The final burned area reached 36 ha.

Fires in high elevation forests

Fires in high elevation forests, consisting of species like *Pinus nigra*, *Pinus sylvestris*, *Abies cephallonica*, *Abies alba*, etc. are quite uncommon in Greece. They usually occur for a short period at the end of the summer (August / early September) when these forests dry-out and before the first rains of autumn. The lack of snow and reduced rainfall of 2007 increased the probability for such fires much earlier. The fire on Parnis Mountain in late June was one such example.

Between July 19 and 5 August 2007, associated with the second heat wave of the summer, a series of fires erupted in high elevation forests, mainly in northern Greece, including many fires near the border with Albania most notable being the fire on Grammos mountain close to the city of Kastoria, a fire near the village of Kristallopigi of the prefecture of Florina, and a fire near the village of Amarantos, near the city of Konitsa in the prefecture of Ioannina; a fire on Belles mountain and another on Rodopi mountain both of them near the border with Bulgaria; and a fire on Pieria mountain in central Macedonia. In southern Greece, the fir forests on Parnassos and Elikonas mountains and near Fteri village in the prefecture of Achaia were also on fire.

Some of these fires continued burning for more than ten days. The amphibian water bombers are generally ineffective when fighting fires in these forests due to the long distance to the sea. Although heavy lift helicopters operated on these fires, their numbers were limited due to the high demand in many simultaneous fires. More important, water drops cannot fully extinguish fires in these forests that have thick canopies and deep humus and litter layers. Intervention by well-trained ground forces is absolutely necessary. Lack of well trained and sufficient in number hand crews in combination with poor tactics (for example, no use of fire to control fire) proved to be a major shortcoming. The nearly complete dependence of the Fire Corps ground forces on using water from fire trucks for putting out forest fires proved a major weakness in these areas that lack a dense road network.

On 5 August 2007 a cold front that passed over north Greece produced a lot of rain. In some places, especially in NW Greece, there was even heavy flooding. This helped to put out the fires in the mountains of north Greece. It also helped these areas to avoid what was to happen in the forests of southern Greece within the next month.

The fire of Aigialia

As the fires at the high elevation mountains were in progress, a series of fires also erupted in many parts of central and south Greece. Between 18 and 23 July 2007 attention was concentrated on the fires in the prefecture of Corinth, near the villages of Mapsos and Hiliomodi including the ancient site of Acrocorinthos – the ancient Acropolis of Corinth, a large fire near the city of Nafpaktos on the north coast of the golf of Corinth and a devastating fire on the tourist island of Kefallinia in the Ionian sea.

In the morning of 24 July 2007, a fire near the village of Kounina in Aigialia, an area along the north coast of Peloponnese in the prefecture of Achaia, caused huge devastation. The fire had been announced as “under control” the previous evening but re-started because the site was not attended properly. Being on a long steep slope and faced with delayed and inadequate initial attack, it accelerated quickly and very soon started threatening the villages in its path.

Within the next four days, the fire nearly reached the top of the north slope of the Panahaiko mountain burning more than 30,000 ha of forest and agricultural land, destroying more than 70 homes in many villages and killing three old civilians -a shepherd who tried to save his flock and two women who were unable to move and leave their home when it caught on fire- and large numbers of livestock. Furthermore, this fire demonstrated that the firefighting mechanism was unable to cope with the load imposed on it and was showing signs of collapse.

The fire of Penteli

On 16 August 2007 a fire started around 10:00am am near a monastery on the slope of Penteli Mountain, the northeast boundary of the Athens basin. The initial ground attack failed. The northeast wind, blowing at about 25 km/h moved the fire front toward the Vrilisia and Nea Penteli suburbs of Athens. The fuel was mostly regenerating pine forest after a 1982 fire. The combination of heavy fuel and dry conditions with a medium wind resulted in the development of strong, nearly vertical, revolving convection column above the fire. The aerial means could not make water drops because of erratic winds and smoke, so the fire moved unchecked toward the two suburbs. Also, the rotation of the column resulted in a sideways spread of the fire flank in a west direction towards Kifissia and Ekali two of the richest suburbs of Athens.

At about 12:30pm the wind became stronger reaching approximately 35 km/h. The smoke column leaned forward, making it a wind-dominated fire (Rothermel, 1991), and the aerial means were able to start making drops. By that time, however, the fire had reached the settlements. By the end of the day the fire was partially controlled, after burning tens of houses and destroying an estimated 800 ha of precious forest. Again, all this was reported live on TV, making people wonder about the fire suppression mechanism's ability to protect them.

Figure 2. The fire of Penteli reaching the suburbs of Athens on 16 August 2007 at 12:47pm. Photo: Miltiadis Athanasiou.

Figure 3. Explosive fire behavior as the fire of Penteli, on 16 August 2007, is reaching one of the suburbs making police, firefighters and the public run for safety. Source: Footage offered to the Institute of Mediterranean Forest Ecosystems and Forest Products Technology by the Public TV Channel NET.

Figure 4. Explosive fire behavior as the fire of Penteli, on 16 August 2007, reaches one of the suburbs where it destroyed many houses. Source: Footage offered to the Institute of Mediterranean Forest Ecosystems and Forest Products Technology by the Public TV Channel NET.

The fires in Peloponnese and Evia

From 24 to 28 August 2007 a series of fires that started in the south part of Greece burned as if there was nothing and no one to control them. Within those days Greece faced its worst forest fire disaster ever both in regard to the size of burned area and to the loss of life and property. The damages were beyond imagination.

Fire danger had been extreme. Temperatures above 39°C for three days were followed by a day of strong winds with velocities of 50-70 km/hr winds and extremely low relative humidity. In addition to all these, the vegetation was severely water stressed. There had been no rain in southern Greece for the whole summer, and, for the first time on record, there had been three heat waves during the summer: the first in late June, the second in July and the third in August, just before the onset of the disaster. The level of water stress of the vegetation is reflected in predawn water potential measurements for August, made near Athens over a five-year period (Table 3) (Xanthopoulos et al., 2006). The summers of 2003, 2004 and 2005 had at least one rainfall event. In 2006, the last rainfall came in early in July. The water potential showed a pronounced drop by late August 2006, when two major fires occurred in Kassandra Peninsula (Northern Greece) and in the area of Mani in south Peloponnese. Although there had been some rain in late May 2007, June and July had been dry.

Table 3. Predawn water potential measurements of three Mediterranean species in Attica, in August of the years 2003-2007

	Water potential (bar)				
Species	**5 August 2003**	**4 August 2004**	**7 August 2005**	**23 August 2006**	**9 August 2007**
Pinus halepensis	-7.3	-6.5	-9.0	-23.7	-21.0
Quercus coccifera	-19.0	-20.0	-14.5	-28.5	-34.5
Cistus creticus	-20.5	-43.6	-26.0	-61.0	-45.0

When fires starting in this explosive situation were faced with ineffective initial attack from the ground, the stage was set for disaster. Two fires started on 23 August 2007, one on Mount Parnon east of Sparta and the other on Mount Taygetos west of Sparta in Peloponnese. They soon raged out of control. A new fire erupted the next day (24 August 2007) near the towns of Oitylo and Areopolis, roughly 30 km south of the fire of Taygetos. This fire caused the first six deaths and attracted the attention of the Fire Corps and the media – until news of massive fatalities at a new fire in Ilia (Western Peloponnese) came that afternoon.

As the news about the deaths started adding up, coordination started failing. New fires that started in other parts of Ilia, Arcadia, Messinia, Corinthia in Peloponnese, and on Evia Island north of Athens did not receive a proper initial attack. They escaped and started growing quickly. They were not attacked methodically. Fire trucks were sent to the villages in the way of the fires to protect them. Evacuations were ordered or spontaneously started from panic. The perimeters of all fires were practically abandoned. The fires grew and some united with each other. The large fleet of aerials did not offer effective help partly because of the extreme conditions (on some occasions Canadair planes were not able to operate safely due to the wind and smoke) but also because ground forces below them could not finish extinguishing the fire.

For the next four days, aerial and ground forces were seen as ineffective, thanks to the large number and size of fires and the countless pleas for help, many of them relayed through the 24-hour live TV coverage. The planes and helicopters were sent in for a few drops only to then be called-off to another fire.

Not realizing that tactical firefighting was doomed to fail, the Fire Corps kept pushing people to evacuate villages indiscriminately. They should have coordinated capable villagers to prepare their homes and agricultural fields (such as clearing grasses in their olive groves) in advance, fight flanking fires with their agricultural equipment or protect themselves in the village. To its credit, the government declared a general state of emergency, mobilized the army and asked for international help.

The fires in Ilia started merging with each other by 26 August 2007. The situation turned critical as the first aerial reinforcements from other countries started arriving. One of the fires reached the ancient

site of Olympia, which was surrounded by mature pine forest. The site and its museum were barely saved by focused ground forces, strong aerial support and an on-ground automatic sprinkler system installed before the 2004 Olympic Games that only worked partially. All the forest around it, however, burned down.

Things started to improve by 27 August 2007 as relative humidity increased substantially, the wind calmed and the temperature dropped. Locals, realizing they would be homeless if they abandoned their villages, often refused to evacuate and stayed to defended their homes (which are generally built with stones or bricks and reinforced concrete) and cultivations. Officers of the Forest Service with forest workers started building firebreaks and performing small scale firing-out operations. A ground crew from Cyprus that came to help, successfully used backfiring techniques on Evia Island, to the surprise of the reporters who had never witnessed this technique being used by the Fire Corps. A French hand crew did the same on Parnon Mountain. Heavy equipment from the army created firebreaks on relatively flat ground.

By that time, a huge aerial fleet was operating in the skies over Peloponnese and Evia. Twenty-three airplanes and 18 helicopters from European Union and non-European Union countries supplemented the Greek aerial forces, forming arguably the largest aerial firefighting fleet operating anywhere. Significant international ground forces also started to arrive, creating a model of solidarity that hopefully will be repeated if another country finds itself in need.

Taking advantage of the calmer winds, the firefighting forces brought most of the fires under partial control in the next few days. However, the Greek TV channels were showing battles against fire re-starts along the large fire perimeters until the 5th of September. Much of their footage looked as a textbook example of the ineffectiveness of aerial firefighting when it is not followed by well-coordinated ground firefighting (Xanthopoulos, 2007a).

Figure 5. Explosive fire behavior in Ilia. The type of fuel, a mix of *Pinus halepensis* forest and olive groves is visible. Photo: Miltiadis Athanasiou.

Figure 6. A crown fire burning *Pinus halepensis* forest in Ilia on 25 August 2007. Photo: Miltiadis Athanasiou.

Figure 7. A photo showing two fires mixing with each other in Ilia on 25 August 2007. The smoke of another fire behind the camera is visible at the top of the photo. Photo: Miltiadis Athanasiou.

Figure 8. Large convection column in Ilia on 25 August 2007. Photo: Miltiadis Athanasiou.

1.4 Fire Damages in 2007

Eleven people had died before the huge fires at the end of August. The toll includes two Canadair CL-415 pilots who were killed on 23 July 2007 when they crashed while fighting a fire near the town of Styra on Evia Island. Then, the devastating fires of August claimed sixty six lives more. Most of the dead were caught in the open, either trying to flee or surrounded by the fire as they were trying to save their property. This death toll of seventy seven lives far exceeded anything that the country had experienced in the past (Xanthopoulos, 2007b).

Figure 9. Fire behavior in maquis in Arcadia on 31 August 2007. A spot fire that has started growing is visible to the left of the main fire. Photo: Miltiadis Athanasiou.

More than 110 villages were destroyed leaving thousands of people homeless, surrounded by blackened land. The government tried strongly to handle the situation on the public relations side. It announced increased support for the people whose properties were destroyed. It also talked about an organized arson plan, without, however, presenting any evidence.

More than 2/3 of the prefecture of Ilia burned. Large areas also burned in the prefectures of Arcadia, Laconia, Messinia, Corinthia, and on the island of Evia. Much of the burned area is agricultural, mainly olive groves. Estimates about the total financial damage of these fires vary tremendously as they are influenced by politics. An independent estimate by the international assessment firm Standard & Poors brought the damage in the range 3-5 billion €, corresponding to 1.4-2.4% of the gross national product of the country.

Figure 10. A well maintained olive grove in Arcadia that survived the fire. Photo taken on 1 September 2007 by Miltiadis Athanasiou.

As mentioned earlier, the total burned area exceeded 270,000 ha. The fire in Ilia exceeded 45,000 ha, breaking the all time record set in Aigialia only a month earlier.

The government won the elections on 16 September 2007. After that it continued providing support to the affected population. Aid also came from other countries such as Cyprus, from the private sector of economy (construction companies, banks, communication companies, etc.) and from private citizens and volunteer organizations. The government also initiated urgent burned area rehabilitation works trying to reduce damages due to flooding. Given the size of the burned areas it was not possible to protect all areas before the autumn rains. Significant damages occurred, especially in Ilia, but huge disasters and loss of lives have been avoided so far (December 2007).

The environmental damages are heavy. It is known that Mediterranean ecosystems are resilient to fire. However, the size of the burned areas is important. In this case the size is huge, being to a large extent the result of successful fire suppression in the previous “easy” fire years. Given this size soil erosion and flooding potential are much heavier than ever before. Wildlife has difficulty finding refuge and food. Seed sources for non-fire adapted species are often many kilometers away and will probably result in changes in vegetation composition. This is more of a problem in the high elevation forests where natural regeneration of *Abies* spp. is far from certain and even artificial regeneration through planting of seedlings cannot guarantee reestablishment of *Abies* stands.

It should be noted that the huge losses of 2007 followed a series of relatively “good” fire seasons, after the also disastrous fire season of 2000. The heavy investments on the fire suppression mechanism in the previous years appeared to have solved the problem. However, as explained below, this was far from true.

1.5 Fire prevention measures in 2007

The difficulty of the 2007 fire season was not hard to predict. It was evident by the end of February and the government tried to respond to it. Unfortunately, although the General Secretariat of Civil Protection produced a very successful daily next-day fire danger prediction map, the fire prevention mechanism of the country that includes among others the local authorities, the Forest Service, the Local Civil Protection officers, etc., proved inadequately prepared to take advantage of it. The efforts and funding spent were clearly not enough to make a difference.

Public preparedness proved to be extremely poor. Television and radio messages were relatively few and poor, and did not manage to alert and sensitize people. It suffices to note that in many cases in Peloponnese, the locals flocked the coffee shops in the villages discussing and watching the 24 hour coverage on TV as the fire burned their neighboring villages, instead of clearing vegetation around their homes before it was the turn of their village to be overrun by the fire.

Also, forest roads and firebreaks that would logically have to be prepared for such a fire season in a timely manner were not properly attended. Funding funneled from the General Secretariat for Civil Protection to the Regions of the country for such tasks, was inadequate and did not get in the proper hands (Forest Service) in time. The local authorities that mostly received such funds did not always act effectively or even properly.

1.6 Response to fires in 2007: Fire suppression

The Greek government, officially realizing the difficulty of the fire season of 2007 increased the number of contracted heavy-lift helicopters. However, this was not followed by efforts to strengthen the ground forces accordingly both in regard to training and preparedness and in terms of the number of seasonal employees. Furthermore, an unusually large number of Fire Corps officers retired in March as a result of the yearly evaluation of the top ranking officers.

During the fire season these shortcomings became evident. Neither the central coordination centre in Athens nor the local commands performed well especially in regard to achieving effective initial attack. Firefighters on the ground often found themselves without guidance or a specific plan to follow. Without these and proper material support their effectiveness was often very poor. Although the media tried to avoid blaming the firefighters, there was a lot of criticism towards the top officers of the Fire Corps for the obvious inadequacies and mistakes that contributed to the disaster.

2. National Cooperation in Responding to the 2007 Fires

2.1 Role / action of agencies at national and provincial level

The national cooperation in responding to the 2007 fires was relatively poor. The long-term problem of fuel build-up, which has been worsening in the last decades as the young people are abandoning the countryside and the Forest Service has been unable to manage forests appropriately – itself deteriorating in personnel, organization, funding, and morale after losing the responsibility for fire suppression to the Fire Corps in 1998 (Xanthopoulos, 2000) – has not been addressed by any means. Even locally, there was no effort of the Forest Service, the Local Authorities and the people to work together in the direction of preparing defensible space around the villages. In the publicity battles played on the mass media there was little room for fire science or the voice of true experts.

The Fire Corps personnel suffered a lot during the fire season. They did put a lot of effort and often stressed themselves to their limits but the result of their efforts was very poor. Their shortcomings in their own organization scheme, training, planning, manning etc., were further compounded by their poor level of cooperation with the other agencies, such as the General Secretariat for Civil Protection, the Forest Service, and even the Armed Forces (except for the Air Force which operates the Canadair water bombers). They also did not do a good job in organizing and supporting local volunteers and incorporating them in their plans.

The Army was mobilized by the government to support the Fire Corps only after the major part of the disaster in Peloponnese had already taken place. As a result its contribution was quite limited.

2.2 Role / action of local communities

The passiveness and even indifference exhibited by many people living in the affected areas were a real surprise to all those closely observing the evolution of the events. It is also difficult to explain. A possible explanation may be that the people were influenced by a sense of total disaster and inability to do anything that was reported by the TV stations. Little if any useful guidance was offered during the critical period of the last days of August. It was only after the first 2-3 days that local Forest Service officers with forest workers and some locals, realizing the breakdown of the suppression mechanism, started to act, clearing parcels of land and burning-out areas to stop the perimeter of fires that was otherwise unattended, and protect communities and properties.

3. International Cooperation

3.1 Receiving assistance

As mentioned earlier, the international help that was received by Greece was substantial. It consisted mostly of aerial resources but ground crews were also sent to help with firefighting operations. The European Union Civil Protection passed the Greek requests for help to the other EU countries. The Greek Prime Minister also communicated directly with the Russian president and secured additional Russian aerial resources to those contracted from the beginning of the season, including, for the first time, a Beriev-200 amphibian water bomber. The resources that arrived and operated in Greece in the last days of August and the first days of September are shown in Table 4.

Greece did not provide assistance to a neighbor country in 2007.

Table 4. A list of the countries that offered help with firefighting and the type of resources they contributed. Source: Official announcement of the Greek Fire Corps.

	Aerial Resources		**Ground Resources**	
Country	Airplanes	Helicopters	Personnel	Vehicles
France	4		72	
Spain	4			
Italy	1			
Croatia	1			
Turkey	1			
Portugal	1			
Russia	1			
Romania		1		
Serbia	7		55	7
Germany		5		
Switzerland		4		
Netherlands		3		
Austria	3	2		
Norway		1		
Sweden		1		
Slovenia		1		
Cyprus			139	14
Israel			60	
Hungary			19	5
Albania			4	1
Bulgaria			46	5
International Volunteers			7	
Total	**23**	**18**	**402**	**32**

4. Analysis and Recommendations

There is no question that the fire season of 2007 was a very difficult one in Greece. However, it cannot be considered unique, and it would be very simplistic to attribute the disaster to “extreme conditions due to climate change”. For example, the period 1992-1994 was so rainfall-deficient that the water reserves of Athens dropped to such alarming levels that special measures had to be taken to reduce water consumption. Fires were difficult in those years and lives were lost (Xanthopoulos, 2007b) but the burned area remained at about 60,000 ha for each of the three years.

If adverse conditions are not the only one to blame for this disaster one should look for other contributing reasons. In the opinion of this author such reasons are the specific errors described earlier, but also some long term weaknesses of the current fire management scheme:

Firefighting organization (Greek Fire Corps) operational weaknesses:

- Heavy reliance on aerial means support during initial attack, which has led to relative complacency of the ground crews. Unfortunately this approach failed in 2007 due to the quick acceleration of the fire and the lack of timely and adequate aerial support due to the large number of fires.
- Inadequate dispatching and coordination by the central coordination centre in Athens.
- Lack of sophistication in coordinating large scale firefighting operations. Use of maps, fire behavior prediction tools, fuel maps etc., if any, is limited. Without good coordination by well trained and experienced officers, the often heroic efforts of the firefighters are wasted
- Nearly total reliance of ground forces on water for extinguishing the fire. Use of hand tools is limited and there is no provision for use of fire for fire control (backfire, or even burning-out). As a result, effectiveness in areas with few roads (such as in high elevation forests) was very low.
- The huge budget spent for forest firefighting every year is used mainly for contracting helicopters. Very little funds are diverted for other important purposes such as modern training, purchasing personal protection equipment, obtaining additional tools for alternative fire operations (e.g. portable pumps, drip torches, etc.).

Flawed overall fire management organization:

- The Forest Service, after losing forest firefighting responsibility to the Fire Corps in 1998, has practically been excluded from fire management operations. Although, according to the law it is still responsible for fire prevention, its deteriorating status and lack of funding preclude any serious work on this.
- Forest management has nearly been abandoned for the same reasons. The result is increasing biomass in the forest. The abandonment of villages by younger population contributes further to the problem of fuel build-up.
- Forest road condition has been constantly deteriorating due to lack of funding for maintenance.

The problems have been obvious for sometime and have been explained in writing many times (Xanthopoulos, 2000, 2004, 2007c). However, as firefighting is more straightforward and impressive, it has not been possible to this date to convince decision makers about the need for a balanced approach that will involve all players in a system that will maximize their contribution towards an integrated and effective fire management scheme. It can only be hoped that the disaster of 2007 will bring second thoughts, realization of the flaws, and changes in the right direction. Otherwise, if emphasis is given only on increasing the firefighting capacity quantitatively, acquiring or contracting more aerial means and hiring more firefighters, it will not be long before Greece will experience another round of disaster.

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Forest Fires in Bosnia and Herzegovina: Statistics 2003-2007

Forest fire statistics for in Bosnia and Herzegovina for the period from 2003 to 2007 are provided in Tables 1 and 2.

Table 1. Forest fires in the Republic of Serbska

Year	Number of fires	Burned are (ha)	Burned Timber		Damage (CM)
			Number of Seedlings (in Afforestations)	m^3	
2003	476	21,403		243,336	7,288,186
2004	90	630		146	282,253
2005	105	494		712	196,350
2006	84	1,988,050		73	151,540
2007	567	17,952		27,859	2,880,718
Total	**1,322**	**42,467**		**272,125**	**10,799,047**

Note: CM – Convertible Marks (1CM = 0.5 Euro)

Table 2. Forest fires in the Federation Bosnia and Herzegovina

Year	Number of fires	Burned are (ha)	Burned Timber		Damage (CM)
			Number of Seedlings (in Afforestations)	m^3	
2003	894	36,383	67,442	14,402	45,623,119
2004	145	688	29,300	5,746	1,349,385
2005	195	793	155,970	2,529	1,433,240
2006	220	1,969	105,519	233	1,722,084
2007	932	13,742	326,440	40,017	9,574,263
Total	**2,386**	**53,575**	**684,671**	**62,927**	**59,702.091**

Note: CM – Convertible Marks (1CM = 0.5 Euro)

One of the biggest current and future forest fire problems in Bosnia and Herzegovina are unexploded ordnance (UXO), remnants from the civil war. The total forested territory contaminated by UXO in the country is ca. 220,000 ha. In the Federation Bosnia and Herzegovina alone the area of UXO-contaminated forests is estimated about 127,129 ha, equivalent to 9.9% of the total forest land. Furthermore there are spots in the country that are contaminated by radioactivity resulting from the use of uranium-depleted ammunition by NATO.

Figures 1 and 2. Sites contaminated by UXO and not yet cleared in Bosnia and Herzegovina are marked with warning signs.

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Forest Fires in Bulgaria 2007

The forest lands in Bulgaria comprise of 4,089,762 hectares (ha) and occupy 37% of the territory of the country. 3,691,868 ha (89 %) of those are classified as wooded lands.

During the last seven years more than 100,000 ha of forests were affected by wildfires. 2007 was the second worst year in the history of the Bulgarian forests with 1,479 forest fires and 43,000 ha burned after the devastating fire season of 2000 (1,710 forest fires and 57,406 ha burned).

The peak of situation was in the period 19 to 30 July 2007. In that time the weekly averages of FWI for Bulgaria was the highest in Europe. Disaster situation was declared in 11 municipalities on the territory of five regions (Stara Zagora – 4, Lovech – 3, Haskovo – 2, Smolian 1, Pazardjik –1).

In year 2007 were clearly delineated typical for our country two peaks for the number of the fires. The first of them was in March and the second during July and August.

The main reasons for the forest fires during 2007 are as follows:

- Carelessness – 78%
- Deliberate or Arson – 5%
- Natural – 1%
- Unknown – 16%

The immediate loses for Bulgarian forests in 2007 are calculated on the amount of 5 million Euro (not including the budget for the restoration of the burned areas.

During the fire disaster 51 houses were burned, 21 families were evacuated, three persons died, 14 were affected, 6 of them were firefighters.

In the end of July 2007 Bulgaria requested assistance through:

- The EU Civil Protection Mechanisms / Monitoring and Information Center (MIC) – as a Member State
- NATO Euro-Atlantic Disaster Response Coordination Centre (EADRCC) – as a Member State
- Russia – on the basis of a bilateral agreement

We received 3 proposals from:

EU – Offer from a private company
NATO – Assistance from the Republic of Turkey
Russia – Aircraft with crew

In the first days of August a firefighting aircraft Il-76 was sent from Russia to Bulgaria and operated in Stara Zagora and Haskovo regions.

During the summer of 2007 Greece requested assistance through the EU Civil Protection Mechanism and by neighbor countries. In September 2007 Bulgaria deployed five fire trucks with 49 fire fighters to Greece.

Table 1. Forest fire statistics for Bulgaria for the period 1998-2007

Year	Total number of fires	Total burnt area (ha)	Burnt forest lands (ha)	Caused by human activities (number)	Natural causes (number)	Unknown causes (number)
1998	578	6,967	6,060	147	6	425
1999	320	8,291	4,198	84	9	227
2000	1,710	57,406	37,431	385	18	1,307
2001	825	20,152	18,463	187	19	619
2002	402	6,513	5,910	150	7	245
2003	452	5,000	4,284	281	9	162
2004	294	1,137	881	172	5	117
2005	241	1,456	1,456	125	7	109
2006	393	3,540	3,540	190	9	194
2007	1479	42,999	42,999	1163	18	298
Mean	**669**	**15,346**	**12,522**	**288**	**11**	**370**

Figures 1-3. Wildfire prevention and preparedness measures in Bulgaria include green fuel breaks in reforestation areas (left) and fire hazard (fuel) surveys in the different forest types. Photos: GFMC:

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Editorial Note

Readers are encouraged to download the report about the “Eastern European, Near East and Central Asian States Exercise on Wildland Fire Information and Resources Exchange 2005” (EASTEX FIRE 2005), which was hosted by Bulgaria, 20-22 April 2005 (IIFN No. 33, 6-9; online: http://www.fire.uni-freiburg.de/iffn/iffn_33/03-IFFN-33-EASTEX-FIRE-2005-Report.pdf

Forest Fires in Croatia 2007

The 2007 Fire Season in Comparison to the last Decade

During the past decade Croatia experienced a number of extreme fire years, notably in 1998, 2000 and 2003 with record burned areas of more than 100,000 ha of all types of wildlands (high forest, other forested lands, agricultural lands, other wildlands) affected by fire. The preliminary data of 2007 reveal that the total burned area was less (Table 1). However, the fire season in Croatia in 2007 was extraordinarily severe. The Fire Weather Index (FWI) was high or very high on 92% of the days in the period between 20 June and 20 September 2007. Between 20 July and 5 August a minimum of 45 fires occurred per day simultaneously, with a maximum of 85 fires on 29 July.

In neighboring Bosnia and Herzegovina the situation was also severe and resulted in 33 wildfires passing the borderline near the towns of Vrgorac, Metković and in the Dubrovnik-Cavtat Region.

On 30 August 2007 an extremely intense wildfire overrun a crew of firefighters on Kornati Islands resulting in 12 fatalities and one severely injured. At the time of writing this report the detailed circumstances that lead to this tragic disaster are not yet known.

Table 1 shows the causes of the fires during the last decade. The data of 2007 will be completed in the 2008 report (see following contribution in this issue of IFFN).

The economic fire damages are shown in Table 2. The data of 2007 are preliminary. More details will be given in the 2008 report (see following contribution in this issue of IFFN).

Fire Prevention and Preparedness Measures

After a warm winter season with abundant vegetation growth and high fire hazard in all vegetation types it was anticipated that the fire season 2007 would become severe. After late winter / spring fires an extremely hot summer made public awareness raising necessary, especially during the summer.

At the same time the numbers of operational forces were increased from 5,000 firemen to 6,200 firemen, including reinforcements by special police forces; the Army was prepared to intervene. The Government of the Republic of Croatia increased the average annual fire fighting budget of € 2 Million by additional € 1 Million.

Fire Response in 2007

With more than 3,600 operational firemen activated (including the reinforcements of 2400 Army and Police forces distributed in 45 locations in the Mediterranean areas of Croatia and 250-350 firemen on stand-by in the continental units, the following aerial firefighting assets were activated:

- 4 CL-415
- 1 AT 805F
- 4 to 6 helicopters (Mi-8)

Special emphasis was given to inter-agency cooperation between local fire service units, local and regional Government and the National Protection and Rescue Directorate, Ministry of Interior, Ministry of Defense and the Croatian Forest Service. Local communities were involved in providing logistical support for dislocated fire units, surveillance and patrolling.

International cooperation

Receiving assistance

- No assistance was requested and received in by Croatia 2007

Providing assistance

- Bosnia and Herzegovina	12 September 2007	2 CL 415 and 34 firemen/8 vehicles
- FYR Macedonia	24-26 July 2007	1 CL 415
- Greece	29 August - 3 September 2007	1 CL 415

Analysis and recommendations

- The warm winter did not stop vegetation growth, resulting in high fuel loads and in a large number of fires during last winter/spring season.
- The numbers of fires in summer 2007 were similar to the average number of fires during the summers from 1998 to 2006, but the burned area was 26% higher

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Table 1. Causes of wildfires in Croatia 1997-2007: Number of wildfires, area burned and damages.

Year	No. of Fires	Deliberate or Arson	Accidental or Negligence	Other and Unknown
1997	3.775	115	2697	963
1998	5.408	83	3892	1433
1999	3.832	142	2816	874
2000	7.797	123	6654	1020
2001	4.024	63	2859	1102
2002	4.692	56	3364	1272
2003	6.924	93	4723	2108
2004	2.855	41	1886	928
2005	3.368	35	2328	1005
2006	3.574	217	2596	761
2007	5.206	n/a	n/a	n/a

Table 2. Landscape fires in Croatia 1997-2007: Number of wildfires, area burned and damages.

Year	Total			Agriculture			Forest Lands			Forests			Other Wildlands		
	No. of Fires	Area (ha)	Damage (€)	No. of Fires	Area (ha)	Damage (€)	No. of Fires	Area (ha)	Damage (€)	No. of Fires	Area (ha)	Damage (€)	No. of Fires	Area (ha)	Damage (€)
1997	3.775	42.10	n/a	1,305	11.376	3,763,288	1,084	13,526	74,219,041	683	6,819	72,503,562	1,386	3,675	N/a
1998	5.408	123.63	n/a	2,561	52.695	13,736,301	1,181	29,131	35,644,110	711	17,691	26,471,781	1,666	12,676	19,470,274
1999	3.832	20.03	19,518,356	1,363	7.276	3,443,014	846	4,225	5,522,329	386	1,659	3,467,671	1,623	4,304	5,030,685
2000	7.797	176.13	n/a	3,119	42.357	27,986,986	1,620	46,255	n/a	730	27,407	91,391,096	3,058	41,271	n/a
2001	4.024	38.04	74,382,055	1,360	7.046	3,084,247	856	10,790	18,046,301	358	1,818	2,767,671	1,808	9,415	35,205,205
2002	4.692	85.44	34,249,589	2,383	61.846	11,009,041	843	10,499	8,050,959	329	5,997	6,627,534	1,466	2,600	7,138,630
2003	6.924	104.95	n/a	2,345	36.961	7,193,973	2,160	29,212	n/a	560	13,305	n/a	2,419	9,567	74,689,863
2004	2.855	12.22	14,027,671	772	3.016	1,727,808	760	3,237	4,789,863	198	1,466	3,106,438	1,323	2,735	2,720,137
2005	3.368	27.07	12,883,836	1,082	13.321	3,011,507	936	5,653	3,791,781	185	1,044	2,540,548	1,350	2,449	2,288,767
2006	3.574	24.71	15,163,836	1,114	10.862	2,382,466	887	5,930	3,476,438	250	1,694	1,365,068	1,573	1,993	5,828,493
2007	5.206	67.68	n/a							565	19,110				

Forest Fires in Croatia 2008

Following the 2007 of forest fires in Croatia the 2008 reports provides the consolidated (final) statistical data for 2007 and 2008.

1. Extent: Number, Area and Types of Forests and Other Vegetation affected by Fire

Table 1. Fire in forests and other wooded lands

Year	Ownership	Number of fire	Area (ha)		Causes										
			High forest	Other forest land	Human disregard	Electric lines	Traffic	Forest activities	Agricultural activities	Mines	Lightning	Arson	Self combustion	Other	Unknown
2007	State	293	1,858	11,979	13	5	5	2	42	-	7	23	2	8	186
	Private	38	1,990	3,385	4	1	-	-	-	-	-	-	-	-	33
	Total	331	3,848	15,364	17	6	5	2	42	-	7	23	2	8	219
2008	State	228	1,352	5,336	15	6	8	3	23	2	6	6	-	4	155
	Private	56	276	300	10	1	-	1	7	-	-	-	-	-	37
	Total	284	1,628	5,636	25	7	8	4	30	2	6	6	-	4	192

Source: Ministry of Regional Development, Forestry and Water Management

Table 2. Fire in agricultural lands

Year	Area (ha)	Number of Fires	Damage (€)
2007	37,603	2,213	8,265,321
2008	29,189	1,691	7,209,352

Source: Ministry of Interior

Table 3. Fires in other open areas

Year	Area (ha)	Number of fire	Damage (€)
2007	5552	1483	2,369,769
2008	3002	1214	3,881,509

Source: Ministry of Interior

Description of Selected Extreme Fires in 2008

Between June and October 2008 there were 2,673 fires with highest number of 815 fires in August. During August 7,325 firemen and 2,143 vehicles were involved in fire suppression. The total duration of interventions was 3,159 hours.

Forest fires by size in the period June to October 2008:

< 5 ha	81.30%
5-10 ha	4.34%
10-100 ha	5.25%
>100 ha	0.47%

The occurrence of the largest forest fires (10-100 ha) was in September.

Forest fires 2008 by active suppression time:

< 4 hours	88.72%
4-12 hours	5.98%
> 12 hours	4.39%

The fire danger index in the country between June and October 2008 is provided in Figures 1 and 2.

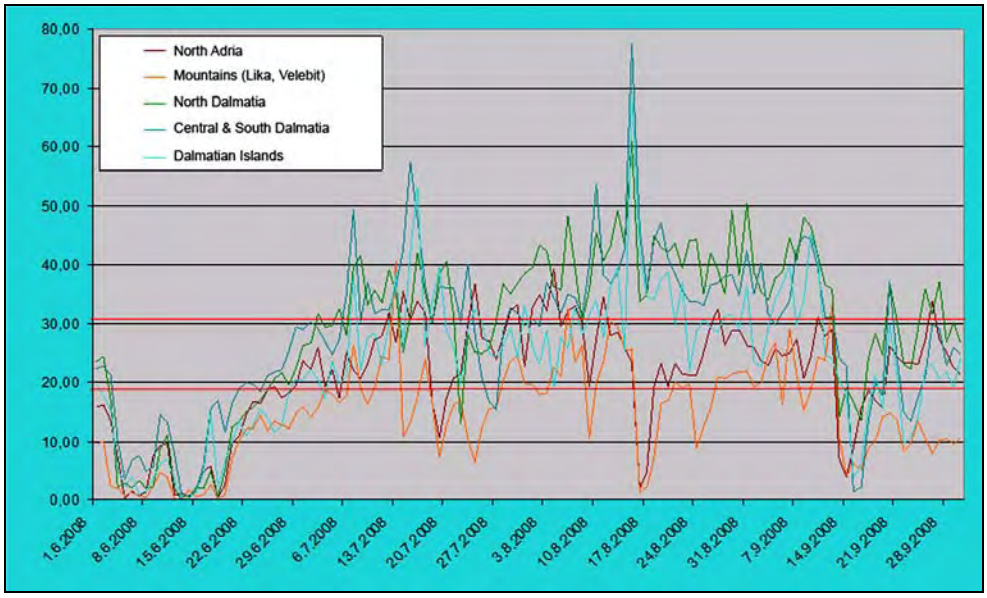

Figure 1. Fire danger index in coastal regions of Croatia during the period June to October 2008

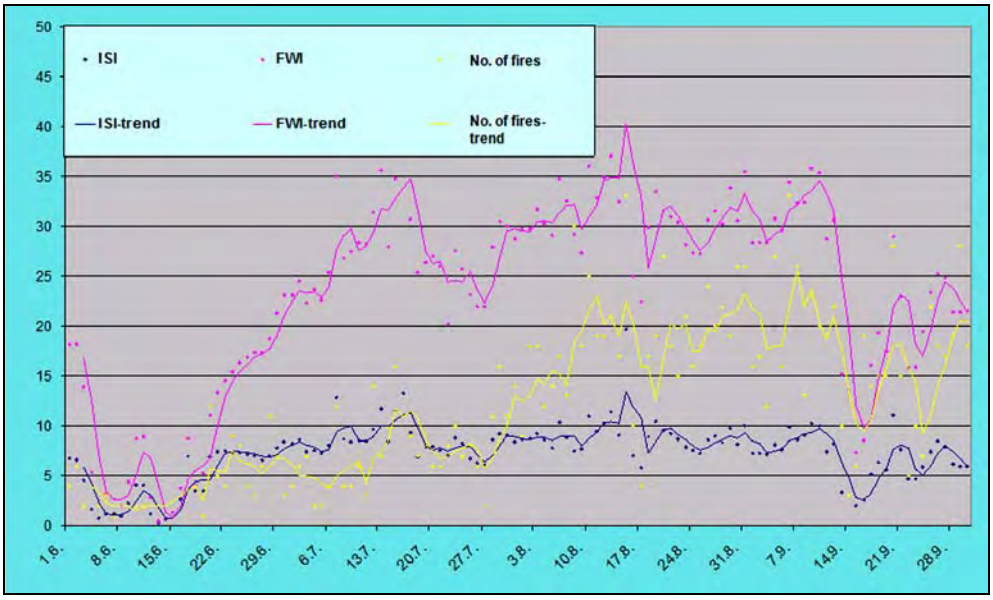

Figure 2. Forest fires number and fire danger index during the period June to October 2008

2. Fire Damages in 2008

Forest and forest lands	-	37.0 m €
Agricultural lands	-	7.2 m €
Other open space	-	3.9 m €

3. Fire Preparedness and Response in 2008

- The Government of the Republic pf Croatia released / reserved 2.5 m € for suppression
- 6,000 firemen in total (3,600 operative firemen, 2,400 voluntary firemen, army, police forces distributed on 45 locations)
- 250-350 firemen in pre-alert in continental part of the country
- 4 CL-415
- 1 AT 805F
- 5 AT 705FF
- 4-6 helicopters (Mi-8)

4. National Cooperation in Responding to the 2008 Fires

Role / action of agencies at national and provincial level

- Cooperation of local fire service units, interventional fire units, local Government (local / regional / county level)
- Cooperation of National Protection and Rescue Directorate, Ministry of Interior, Ministry of Defense, Croatian Forest

Role / action of local communities

- Logistical support for dislocated fire units
- Surveillance and patrolling of wildlands

5. International Cooperation

Receiving assistance

There was no request for receiving assistance 2008.

Providing assistance

Assistance was provided to Bosnia and Herzegovina on 9 September 2008 by 2 CL-415, 15 firemen and 7 vehicles.

6. Analysis and Recommendations

In 2008 the number of forest fires was 17.8% higher as compared to 2007 but the size of areas burned were 64.17% less. Preventive measures and public awareness rising should be more focused in future.

Sources

Data were provides by the Ministry of Regional Development, Forestry and Water Management, the National Protection and Rescue Directorate and the Ministry of Interior

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Mine Fields and UXO Contamination in Croatia: Summary for 2008

On 31 December 2008, the overall mine suspected area of the Republic of Croatia totaled 954.5 km^2 (including 4.7 km^2 of areas contaminated with cluster ammunition of KB-1 and MK-1 type that is not classified as mine suspected area according to the valid regulations and standards), extended through 111 towns and municipalities and was marked with 14,986 mine warning signs (Fig. 1)

Figure 1. Mine suspected areas in Croatia

Mine search and demining operations in 2008 resulted in releasing the area of 33,109,979 m^2 out of which 20,883,364 m^2 through mine search and 12,226,615 m^2 through demining (Fig. 2).

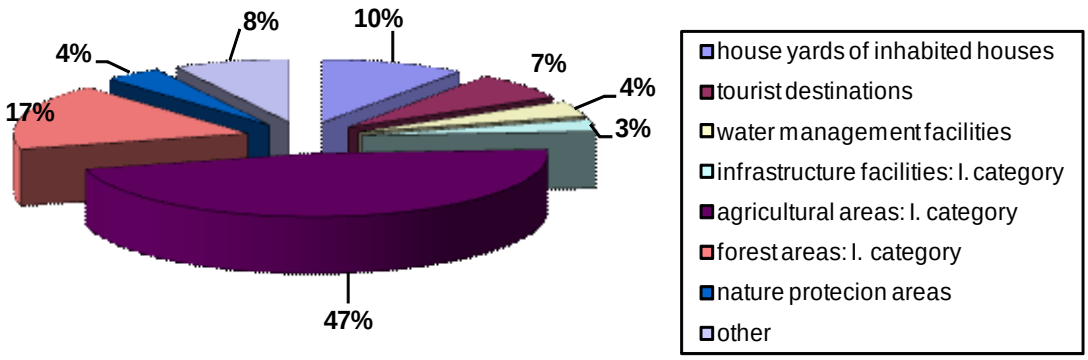

Figure 2. Structure of searched and cleared mined areas

Parallel to the operations of mine search and demining of mine suspected areas performed by accredited legal entities and non-governmental organization "Norwegian People's Aid", survey teams of the Croatian Mine Action Centre performed in 2008 the revision of general survey of the entire mine suspected area in the Republic of Croatia. On 1 October 2008, the revision of the entire mine suspected area was finished. By applying criteria determined by Standard Operating Procedures (SOP 01.01.) mine suspected area was reduced for 9.4 k m^2. These activities resulted in reduction of mine suspected area of the Republic of Croatia in 2008 in the size of 42.5 km^2. Average weekly realization amounted to 662,200 m^2. There were 1,805 pieces of antipersonnel mines, 2,617 pieces of antitank mines and 3,402 pieces of unexploded ordinances found and destroyed.

Quality assurance over completed mine search and demining operations in 2008 was conducted by 12 Quality Control Officers and 23 Quality Assurance Monitors performing the control sample search. There was the total of 338 quality controls over completed mine search and demining operations performed on 3,778 control samples totaling 587,939 m^2 equal to 1.68% of the total searched and demined area. Also, there was the total of 918 quality assurances during the execution of mine search and demining operations performed.

Financial resources for mine search and demining operations, in total 43.5 m € have been contributed from State Budget, donations and IBRD loan. Average price of all mine search and demining operations contracted in 2008 was 1.06 €/m^2 + VAT, what represents a decrease of 8.1% in relation to 2007. The reason for the price decrease is projecting bigger projects on agricultural areas where demining machines can be used intensively.

In 2008, there were 6 mine incidents registered involving 7 persons (Fig. 3). During 2008, there were incidents registered involving 3 deminers of commercial companies. Two persons were killed out of which one deminer while 4 persons suffered major bodily injuries.

Relevant state administration authorities were involved in solving the problems of mine victims relating to medical rehabilitation. Other forms of assistance were conducted mostly by nongovernmental sector and financing was ensured by different donations of the international or domestic subjects. In 2008, there were different one-time projects of financial support and education (scholarships, legal and psycho-social and medical support, orthopedic aids) realized with the purpose of mine victim assistance. There were also summer and winter workshops organized for children and young people mine victims.

Mine victims are entitled to health care and acquisition of orthopedic aids to the amount covered by the Croatian Health Insurance Institute. However, there are certain problems detected in the programs of psycho-social rehabilitation of victims and their employment.

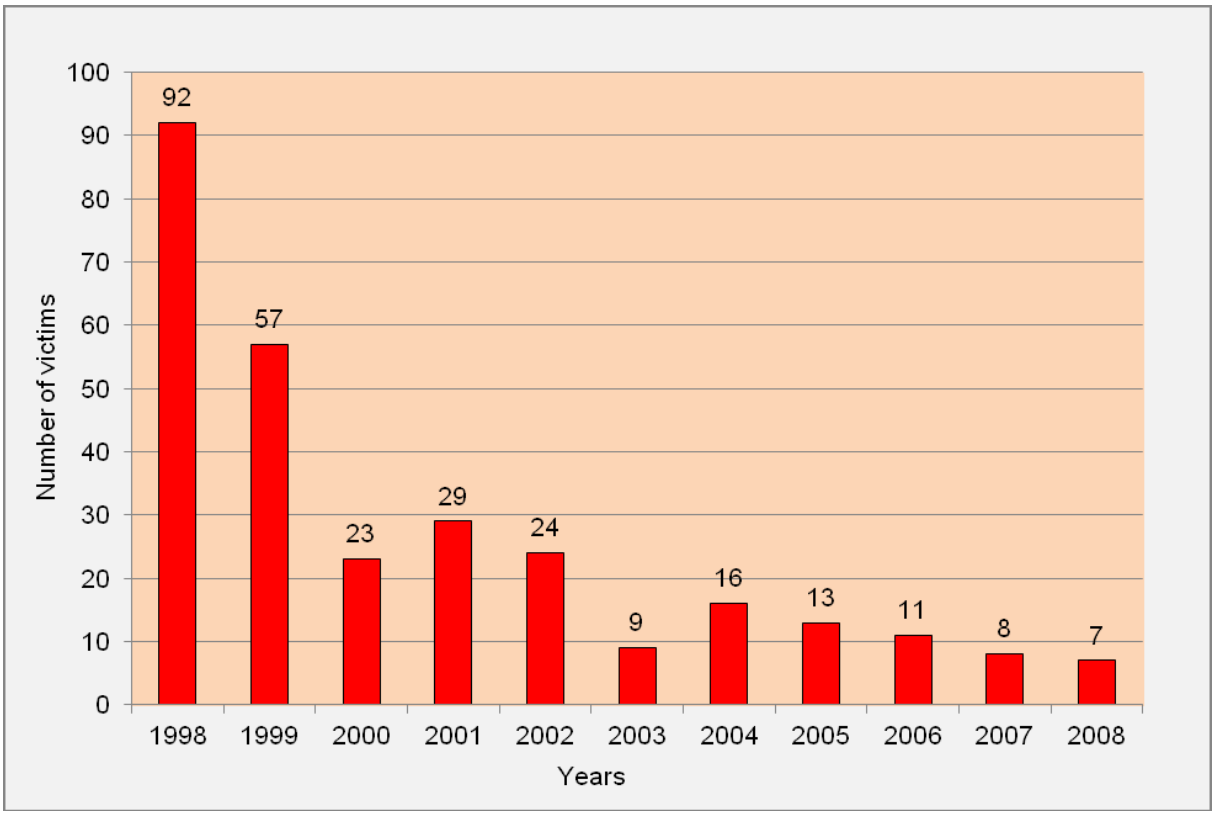

Figure 3. Number of mine victims in Croatia (1998-2008)

In 2008, the emphasis was put on presentation of Croatian experience in mine action within the international mine action community and diplomatic posts in the Republic of Croatia. Establishment of the cluster that integrates experience and capacities of the Croatian Mine Action Centre, CROMAC-CTDT, commercial demining companies and equipment manufacturers resulted in realization of an initiative of the Croatian Mine Action Centre, Ministry of Foreign Affairs and European Integration and Trade and Investment Promotion Agency. Uniting all demining subjects in the Republic of Croatia opened the door to exporting the Croatian know-how and technologies to foreign markets i.e. countries facing the mine problem. First results became evident through expressing interest by Turkey, Yemen, Georgia and Egypt in strengthening of co-operation.

The position of mine warning signs is one of the basic elements of mine information system presented on mine-contamination maps (https://misportal.hcr.hr) submitted to state administration bodies, local and regional self-administration, police administrations and other natural and legal entities upon request.

Pursuant to the official data, there are still a lot of forest areas which are contaminated with land mines and unexploded ordinances.

Because of that a great forest areas are not covered with management activities and their degradation process is still going on. Also, in context of forest fires, in contaminated areas of high fire danger, because of the lack of preventive measures in these areas, forest fires are very frequent. The biggest problem on these areas is forest fires suppression. It is made only with the air forces. As suppression on contaminated areas is not very effective without use of ground forces, in “fire years” Croatia has very, very big burnt areas. Fires are also damaging mines (a few of them are activated by fire) what is very dangerous for demining operators.

Table 1. State-owned forest areas contaminated with mine fields and UXO

Regional Forest Office	Mine Field Area (MFA) (ha)	Timber volume on MFA (m^3)	10 year felling on MFA (m^3)	Forest roads (km)	Total forest/forest land area (ha)	Mine field areas (%)
Koprivnica Buzet	0	0	0	0.00	135,718	0.00%
Vinkovci	6,178.67	873,907	162,711	0.00	72,344	8.54%
Osijek	11,908.38	1,437,674	516,980	0.00	77,159	15.43%
Našice	3,556.52	940,545	101,410	0,00	82,997	4.29%
Požega	461.65	71,793	2,412	0.00	51,450	0.90%
Bjelovar	2,792.01	641,384	32.444	0.00	131,664	2.12%
Zagreb	94.41	24,714	2.560	0.30	81,154	0.12%
Sisak	10,265.94	1,917,816	245,534	0.00	87,935	11.67%
Karlovac	2,379.41	428,779	13,289	0.00	82,883	2.87%
Ogulin	5,721.82	1,588,386	245,427	29.10	60,580	9.45%
Delnice	55.22	22,290	3,440	0.00	96,293	0.06%
Senj	65.52	18,627	--	0.00	109,659	0.06%
Gospić	36,351.62	6,664,546	965,666	11.10	315,141	11.54%
Split	50,982.27	312,203	--	0.00	559,974	9.10%
Nova Gradiška	10,341.00	3,339,486	410,280	48.20	74,036	13.97%
Total	**141,154.44**	**18,282,150**	**2,702,153**	**88.70**	**2,018,987**	**6.99%**

To help solving problems with contaminated forest areas and protect naturally regenerated forest areas, Croatian Forests ltd., as the enterprise which is managing 2.7 million ha of state-owned forest, are contributing annually with 5-7 m €.

Sources

(1) Croatian Mine Action Center (www.hcr.hr)
(2) Ministry of Regional Development, Forestry and Water Management

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Republic of Albania – Fire Report 2007

1. Introduction

Albania, with a small territory of 28,750 km^2, is one of the European countries with rich vegetation, which originated during the Tertiary era. Today's vegetation of Albania is composed of endemic relic vegetation and of species that have invaded from neighboring regions thought migration, having phytogenetic similarities with floristic elements of neighboring countries. Albania is a mountainous country with higher topographic and climatic variety than the other European countries: 52% of its surface is on elevation between 600 and 700 m above sea level with prevailing steep slopes (ca.30%). Thus, ca.90 % of its surface is subject to severe erosion. The northern, north-eastern, south-eastern and central areas are characterized by hilly-mountainous terrain; whereas the north-southern/costal area along the Adriatic and Ionian coast is lowland.

Climate extremes range from extreme cold winters in the northern, north-eastern and south-eastern areas to very hot and dry summer along the coast. Rainfall regimes vary from north to south and from coast to inland. There are fewer rainy days in the south that in the north, but months without rainfall can occur at any time of the year, as it is typical for the Mediterranean climate. Local precipitation differences lead to diverse vegetation patterns. Forests occupy 1.025 million ha, with a standing volume of about 82 million m^3 and an average annual growth of 1.4 m^3 per ha (this is very low compared with many country of Central Europe). The management regime of the forest areas is as follows:

- 460,950 ha are high forest (46% of the total forest area) consisting of 171,850 ha coniferous and 289,370 ha broadleaved species
- 332,250 ha coppice forests (29% – mainly oaks)
- 257,850 ha shrub lands (25%)

Taking into account the functions of the forest areas, 193,000 ha perform a protective function while the rest (836,650 ha) are productive forests.

The reforms in the forest sector have been very rapid and with big changes regarding the ownership of the forests and pasture lands. During the transition period, 60 % of the forests area and more than 70 % of the pasture areas have been transferred to the property of local governments and local communities. This rapid change has caused a lot of problems that have to do with the lack of capacity and resources of the local governments in fire management. Furthermore, the lack of experience in forest fire suppression is noted during the fire season.

Fire Impacts

The negative fire impacts are very large in the conifer forests and less in coppice and shrubs. The main negative impacts are the erosion after the fire occurrence in the area burned, the destruction of the regeneration cover, the influence in land structure and water regime circle. Farther more there are impacts on diminution of the forest productivity. With all the characteristics mentioned above the forest ecosystems in Albania are very sensitive from the fire. Only in the coastal forest protection belt, surface fires in pine stands have the role of maintenance and as a measure of controlling the fire propagation. In the sites affected by fire especially in the natural pine forests in the North of the country in the districts of Puke, Kukesi, Mirdita we can see that the vegetation cover after the fire is very different from the pre-fire vegetation.

In the southern part of the country, traditionally for centuries, the fire is used as a tool of cleaning and regeneration of pastures. In these sites the long use of fire has resulted in significant changes of the ecosystems. One of the main impacts is the favoring of the establishment of annual grasses and the disappearance of biennial and perennial plants.

Figure 1. A fire near Tuç, Puka District, severely burned natural pine forest (*Pinus nigra*) The fires started on 19 July 2007 and was suppressed 5 days later on 24 July 2007 after burning area 27 ha (Photo: G. Hoxhaj).

Figures 2 and 3. During the extremely dry summer of 2007 wildfires affected all types of forests, e.g. the pine (*Pinus nigra*) forest Qafa e Barit, Puka District, or the beech (*Fagus sylvatica*) forest in Malesi e Madhe District (Photos: G. Hoxhaj).

It was noted that the regeneration of the shrubs is very fast after the fires, depending of the severity and the intensity of the fires in these sites. One of the main problems arising from severe fires in these sites is the erosion and the water regime in the first years.

Considerable damages were observed in the fauna, and change of behavior of animals and birds. Altogether it is underlined that the fire impacts in the Albanian forest are predominantly negative in all ecosystems and land-use systems.

2. Assessment of Fire Situation in the Country

Extent: Number, area and types of forests and other vegetation affected by fire

The year 2007 has been the most severe year regarding the number of fires and area affected by forest fires in Albania. A national emergency situation was declared and the government created an inter-ministerial committee “Central Unit for Civil Emergencies” (CUCE), led by the vice-prime minister. The committee brought together all the state agencies that are responsible for the disaster management including forest fires. A national coordination centre was established at the operational centre of General Staff of the Armed Forces. This centre coordinated all the human and logistic resources all over the country.

During this very difficult period firefighting resources from the Ministry of Defense, Ministry of Interior, Ministry of Environment, Forest and Water Administration (Forest Service), Prefectures, and Local Government were coordinated. To be ready for e rapid intervention, more than 200 soldiers from the Army were dispatched to four regions, nearby the most important forest areas, two in the north two in the south. This has helped a lot during the days of severe fires.

The firefighting operations were mainly lead by forest service specialists. Effective use of the resources was noted in many cases. However, there were also cases of lack of coordination and control of the situation. Local governments and local communities in general have been very passive.

The Ministry of Interior, responsible for the management of civil emergencies, requested assistance through the Monitoring and Information Center (MIC) of the European Commission and other international organizations (e.g., NATO) for aerial support and other means.

Some brief evaluation of the resources received from other countries:

- Ukraine supported Albania with a fixed-wing firefighter aircraft type Antonov 32 (AN-32). Evaluation: very expensive and inefficient due to performance characteristics.
- Aerial support from Italy with 2 Canadair water bombers provided professional and very successful operations. This aerial support from Italy was received under a bilateral government agreement on civil emergencies cooperation.
- The German government, following a request of the Albanian Government, provided two light helicopters. Their helibucket capacity was 500 l of water. The helicopters operated in the northern part of the country in firefighting operation near the Drini River and in the area surrounding Tirana. To facilitate their flights the crew was accompanied by an Albanian pilot from the Albanian Air Force. According to our evaluation the operations were not very effective due to the need to refuel in the centralized fuel depot in Tirana as well as the low carrying capacity of water.

Table 1. Wildfire statistics for Albania 1997-2007

Year	Total No. of Fires on Forest, Other Wooded Land, & Other Land	Total Area Burned on forest, Other Wooded Land, & Other Land (ha)	Area of Forest Burned (ha)	Thereof area of "Forest 1" (ha)	Thereof area of "Forest 2" (ha)	Thereof area of Open Steppe / Grassland and Pastures (ha)	Thereof area of "Peat Swamp / Wetlands" (ha)	Human Causes (% of No.)	Natural Causes (% of No.)	Unknown Causes (% of No.)
1997	735	1847								
1998	601	680								
1999	628	689								
2000	915	3675								
2001	327	1434	941		941	493		100		55
2002	140	690	650		650	40		99	1	63
2003	771	6359	4419		4419	1948		95	5	57
2004	143	1473	491		491	982		100	0	40
2005	174	3241	300		300	1740		100		61
2006	176	1081	108		108	303		98	2	60
2007	1190	12120	5857		5857	6263		97	3	71
Average	580	3329	1824		1824	1681		98.5		53.7

Causes of wildfires, reasons or underlying causes of human-ignited fires

The year 2007 was the most problematic and severe year so far concerning the occurrence of an extremely large number and area affected by forest and pasture fires in Albania. The total surface affected by fires according to the forest police data is around 40,000 ha. The causes of fires in 2007, recorded by the forest police, were:

- Intentionally set fires: 218
- Fires caused by negligence: 128
- Unknown causes: 843

In 180 cases, the forest service has sent a request for penal responsibility to the prosecution office. Around 40 persons have been accused for intentional damage of property by fire. Until now no one is detained in prison.

Description of selected extreme fires in 2007

During the 2007 fire season every day in all over the country we have had around 40-50 cases of wildfires. Some of the fires were put out after 3 or 5 days. The most affected areas were in the regions of Puke, Mirdita, Dibra and Kukes. In the Dibra district the most affected area was the National Park of Lura. The fires in this region lasted at least 15 days. There have been severe fires due to the composition of the forest, topography, high temperatures, long draught, and lack of human resources to intervene by fire extinction. In this region the most important problem was the consequence of the rural exodus – the lack of human resources because the area is abandoned by people. The causes of fires in these regions were also exclusively by humans, some intentionally set fires, some caused by negligence. Due to the characteristics of the area it was very difficult to find the violators.

Fire damages in 2007

The most important factor that has created the fire emergency situation during 2007 was the long drought period, accompanied by a large number of ignitions. The other reason that had had a strong impact on the situation was the above-mentioned abandonment of the rural areas from the population. This trend of rural depopulation is resulting in:

- Lack of human resources to be involved on fire suppression operations
- Accumulation of vegetation (succession; fuel accumulation) in the forests and pastures as a result of abandoning the traditional, intensive use of territory.

Another problem was the use of fire as traditional tool for land management like burning of agricultural wastes after harvesting the crops and the burning of winter pastures. Although it is recognized that fire is an essential tool for agriculture and pastoralism it is observed nowadays that the lack of skill and awareness of fire danger during droughts, as well as insufficient people to collaborate in safe burning are resulting in escaped, uncontrolled fires.

In some areas where the level of poverty is high we noted that fires had been set by purpose in order to be employed in fire suppression operations. In some areas fires have been set as a result of conflict of ownership or over the use of the territory. In the region of Puka some fires have been set as a reaction to the decision of the Forest Administration to sell the timber to private companies. The bigger damages have been caused by wildfires in 30 years-old pine afforestations.

During 2007 the political situation has been calm. The local government and the local community have played a very important role during this situation. There have been causes of good and bad examples – but unfortunately more bad examples, e.g. because of negligent performance of the head of the commune and the indifferent attitude of the local people to help in fire operation. It has also been noted that the operations of voluntary units in communes and villages failed due to the low motivation, insufficient organization and unclear responsibility of the structures. The fire observation and information system of the Forest Service has been weakened as a consequence of low availability of observers and lack of communication equipment.

There is an overall lack of infrastructures, logistics and capacities for fire management. There are few trained people only, and they are insufficiently equipped. The coordination between the state agencies, which had had failed at the beginning of the season, was improved very much during the functioning of the Central Unit for Civil Emergencies.

Fire prevention measures in 2007

To prevent the forest wildfire the Ministry of Environment, Forest and Water Administration (MEFWA) and its dependent structures from top down have performed the below listed actions:

- Since the beginning of the year 2007 the MEFWA has developed the yearly National Plan for Forest and Pasture Fire Management (NPFPFM). A coordination unit has been established at MEFWA.
- On 2 June 2007 a national workshop was organized in Shkodra city with representatives of all stakeholders of state agencies and non-government organizations to discuss the improvement of the coordination of the actions to prevent and suppress forest fires.
- Based on its legal mandate MEFWA issued an edict, which places obligation on all state agencies at regional level and all local government units to take prevention measures for prevention and suppression of forest fires.
- Following the rules set by the NPFPFM all Forest Service Directorates (FSD) in districts developed own fire management plans at local level.
- Voluntary units for forest fire suppression operations in every village have been organized by the Forest Service.
- In the National Forest Parks and Protected Areas a supplementary observation system was established during weekends.
- A TV advertisement spot was broadcasted to inform the public about the damages caused by forest fires. The spot was transmitted in several national and local TV channels. Some leaflets and information mails were distributed to local communities.
- The MEFWA invited local population to be very cautious using fire during the day and to actively participate in fire suppression operations.
- The mobile telephone companies were encouraged to distribute attention messages to their entire clients concerning the fire danger.

Response to fires in 2007: Fire suppression

During the fire season all the personnel of the forest police – on average about 1000 staff every day – and all logistic capacities have been involved in prevention and suppression of forest fires. Around 60 transportation trucks and six light trucks have been involved in fire operations. In some districts caterpillars and water tenders were hired to suppress fires.

3. National Cooperation in Responding to the 2007 Fires

Role / action of agencies at national and provincial level

The roles of government agencies that are involved in the forest fire management are:

National level:

- The Ministry of Environment, Forest and Water Administration (MEFWA): Prevention, suppression and post-fire rehabilitation. MEFWA played the lead role on the management of the forest fire situation in 2007. Following the initiative and request of MEFWA the Central Unit for Civil Emergencies was set up. The ministry has managed the human and material resources of the Forest Service to meet the needs and limitations of the fire situations.
- Ministry of Interior: Prevention and suppression. The Directorate of Civil Emergency and the General Directorate of Fire Protection and Rescue have been very important actors in the coordination of resources on the large fires.

- Ministry of Defense: Suppression. The ministry served as a facility centre for the Central Unit for Civil Emergencies and as a resource for human forces ready to intervene on forest service request.
- Ministry of Agriculture: Prevention.

Regional level:

- Prefectures of the regions: Coordination of all state agencies resources on regional level.
- Forest Service Directorate (FSD): Prevention, suppression and rehabilitation. The FSD has managed the human and material resources of the Forest Service according to the needs and limitations of the situation.
- Fire Fighting Units (FFU): Suppression. The FFU has helped the forest service to suppress forest fires in the cases where the access to the fire theatre by fire trucks was possible.
- Army units: Suppression. The Army forces have helped with human support on the most dangerous and critical situations.
- Local Government (LG): Prevention, suppression and rehabilitation. LG helped the Forest Service to organize the local community to support fire suppression.

Role / action of local communities

The Local Communities (LC) have a very important role on the fire management. Based on the fact the all forest fires have been caused by humans, the involvement of LC was considered as a key issue for the success of fire suppression operations. Several LC provided valuable support in the fire suppression operations, especially in the southern part of the country where their involvement prevented the spread of the fires. In most of the cases, however, the LC have been very passive and they have asked for financial support to be involved on fire suppression operations. The experience in the 2007 fire season revealed that there are fundamental limitations regarding the LC involvement in fire management. There is a lack of responsibility for LC for fire prevention, lack of experience, and logistic support. There is no coordination with other structures / agencies. An aggravating factor was that even private forest / land owners had been very passive during the fire season, even on their own property.

4. International Cooperation – Receiving and Providing Assistance

During the 2007 fire season Albania cooperated with several countries through direct agreements or through international organizations. The Directorate of Civil Emergencies (DCE) in the Ministry of Interior is responsible for this cooperation and coordination.

During the critical fire situations DCE has asked for help from Greece, Italy and the Monitoring and Information Center (MIC) of the European Commission and the North Atlantic Treaty Organization (NATO).

The first aerial support was provided by Ukraine, with an AN-32. This operation was rather expensive and inefficient. The payment for the operations was covered by the Albanian Government and the embassy of the United States of America to Albania.

Aerial support was provided by Italy with two Canadair airplanes. These airplanes have been very successful in fire suppression operations. The aerial support from Italy was a result of a bilateral government agreement on civil emergencies cooperation. The request for assistance was made from the Directorate of Civil Emergencies to the Italian counterpart. The response of the Italians was based on their domestic emergencies and available resources for out-of-area missions. The Albanian part secured the full accommodation of the cabin crews of the planes and refueling of the aircraft during the operations and for the return to Italy.

Figure 4. In August 2007 two CL-415 from Italy supported the firefighters in Puka District. The aerial photo shows a waterbomber operating over a pine forest near Kryezi village, Puke district (Photo: G. Hoxhaj)

Following a request of the Albanian Government Germany provided two light helicopters. Their helibucket capacity was 500 l of water. The helicopters operated in the northern part of the country in firefighting operation near the Drini River and in the area surrounding Tirana. To facilitate their flights the crew was accompanied by an Albanian pilot from the Albanian Air Force. According to our evaluation the operations were not very effective due to the need to refuel in the centralised fuel depot in Tirana as well as the low carrying capacity of water.

Support from Poland and the Czech Republic by hand tools for fire fighters was very welcome!

Along the border region with Greece there was good cooperation in exchanging information, and in a few cases aerial support.

The assistance provides to our neighbors consisted information exchange for the fire situation in the border area and on the availability of our water resources to the aerial operators inside Albania.

5. Analysis and Recommendations

In 2007 all forest fires have been caused by humans. Negligent performance of the Local Communities and lack of responsibility by Local Government structures was noted. After more than 55% of the forests have been transferred to the property of the Local Communities there is still much to be done to raise their attention to and responsibility for fire prevention and suppression:

- During the year 2007 forest fires have caused the highest damages ever recorded in the country, with severe negative impacts on the social, economic and natural environment;
- Fire prevention measures have not been effective;
- Due to the low level and performance of observation and information systems the response to fires has been weak and has resulted in aggravated situations;
- Lack of logistic support and efficient coordination of fire suppression operations in the field, lack of stringent command and control;
- National cooperation in responding to the 2007 fires (inter-agency, involvement of civil society) became effective at the moment of establishment and functioning of the Central Unit for Civil Emergencies.

Problems identified

- Lack of support and interest from the local communities to prevent and suppress forest fires;
- Lack of human resources in rural areas;
- Low efficiency of human and material resources. There are resources, including helicopters, that cannot be dispatched and used due to lack of coordination, experience and some low-cost investments;
- Lack of logistic support and difficulties of effective use of these resources for the state agencies and local community;
- Lack of knowledge on effective and efficient use of aerial support and coordination of aerial and land interventions;
- Steep and fragmented topography and difficulties to access the forest areas;
- Vacuum of ownership and responsibilities between central and local government;
- Lack of responsibility for fire prevention and suppression in private forests;
- Traditional use of fire as a tool for forest and pasture management resulting in escaped wildfires;
- Missing adequate legal framework regarding the land management after fire;
- Lack of community involvement in forest fire management;
- Lack of effective fire management plans based on the real condition of every region, district or community;
- Need for the establishment of initial attack units, to be located in the most fire-endangered forest areas;
- Lack of an effective fire detection and observation systems;
- Need to improve the effective use of tools and equipments that are used by the Forest Service;
- Improvement of strong collaboration between local government, NGOs, forest owners and international agencies is required;
- Need to rise of public awareness regarding the forest fires;
- Need to improve the legal framework;
- Need to regulate the legal use of fire as a land management tool, based on the traditional use of fire, advanced ecological and environmental considerations and a clear regulatory concept;
- Need to enhance international exchange of experience, information and strong collaboration in the region;
- Need to systematically investigate fire causes in order to develop adequate strategies in fire prevention;
- Implementation of the action plan of the national strategy for forest fire management. Develop visions and a strategy to meet the challenges of fire management in Albania in the future, a country in which demographic and climate changes will increasingly affect natural ecosystems and land-use systems resulting in increased vulnerability to wildfires.

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Republic of Serbia – Forest Fires in 2007

1. Statistical Data

On the Balkan Peninsula the fire season of 2007 was extremely severe – and Republic of Serbia was one of the countries most affected. Tables 1 and 2 provide comparative statistical data for the period 2005 to 2007 and details for the 2007 fire season.

Table 1. Wildfire occurrence and causes in Republic of Serbia 2005 to 2007

Year	Total No. of Fires on Forest, Other Wooded Land, & Other Lands (ha)	Total Area Burned on Forest, Other Wooded Land, & Other Land (ha)	Area of Forest Burned (ha)	Area of Other Wooded Land Burned (ha)	Human Causes (% of No.)	Natural Causes (% of No.)	Unknown Causes (% of No.)
2005	15	63	53	10	100	0	0
2006	29	569	537	31	94	0	6
2007	482	34,001	16,582	17,414	80	2	18

Table 2. Detailed fire statistics for Republic of Serbia 2007

No. of Fires on Forest & Other Wooded Land	Total Area Burned on Forest, Other Wooded Land							Type of forest fires	
	State forest			Private forest			Total Area Burned on Forest, Other Wooded Land, & Other Land (ha)	Crown (ha)	Surface (ha)
	Area of Forest Burned (ha)	Area of Other Wooded Land Burned (ha)	Total Area burned (ha)	Area of Forest Burned (ha)	Area of Other Wooded Land Burned (ha)	Total Area burned (ha)			
487	7,878	4,682	12,560	8,709	12,732	21,441	34,001	2,837	31,164

Causes and other factors influencing wildfires

In 2007 the forest fires in Serbia were 80% caused by humans. Like in previous years agricultural burnings were the main reason. Climate change is also influencing the forest fire situation. Very low level of rainfall in the period autumn-winter 2006-2007 and in spring-summer 2007 as well as unusual high temperatures – the highest recorded since the last 100 years – created favorable conditions for wildfire ignition and severe fire behavior. Figure 1 reflects that extremely dry and hot summers that occurred between 1990 and 2007 resulted in high areas burned.

During the year we had two critical periods when wildfires burned all over the country. The first extreme fire situation happened in April, caused in most cases by agricultural burning, after autumn and spring without rainfall. The second extreme fire situation occurred in July. At that time the drought period continued while high temperatures reaching at maximum in urban regions (44-45°C) and more than 30°C in the mountains. A detailed breakdown of fire occurrence in 2007 is provided in Table 3.

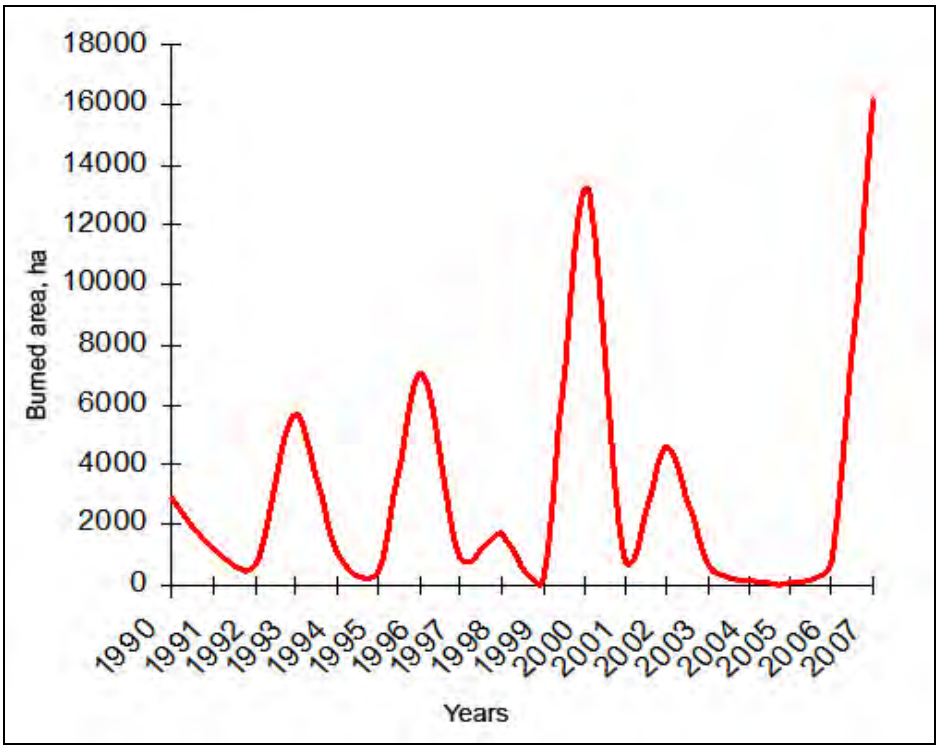

Figure 1. Forest areas burned in Serbia 1990-2007. Source: Directorate of Forests, Republic of Serbia

Table 3. Number of fire and size of burned areas by month in 2007

Month	No. of Fires in Forests and Other Wooded Land	Total Area Burned on Forest and Other Wooded Land (ha)
January – April	231	3946
May	2	69
June	23	357
July	208	28,773
August	7	856
Total	**487**	**34,001**

Preliminary data of damages caused by wildfires

Compared with damages in earlier years maximum damages of forests were experienced in 2007 (direct damages, indirect, costs of recovery and total costs) (Tab. 4). National Parks and protected areas were extremely affected by fires (Tab. 5).

Table 4. Damages (€) caused by wildfires affecting forests in Republic of Serbia

Total Area Burned of Forests and Other Wooded Lands (ha)	Area of Forest Burned (ha)	Direct Damages (€)	Indirect Damages (€)	Costs of Extinction-Blackout (€)	Recovery & Rehabilitation (€)	Total Costs (€)
34,001	16,582	4,336,039	20,902,118	422,863	5,869,811	31,530,831

Table 5. Most significant fires affecting protected areas and National Parks of Serbia in 2007

National Park	Number of Fires	Total Area Burned on Forests and Other Wooded Lands (ha)
PE NP Đerdap	82	707
PE NP Tara	5	95
SRN Deliblato Sands	1	592
Nature Park Stara Planina	5	1,390
Total	90	2,784

2. Action Taken in 2007

Fire prevention measures

Usual measures were carried out in the beginning of the year, according to the Fire Protection Law and Forestry Law:

- Public enterprises prepare plans of protection against forest fires and convey them to the commanders of units of fire department in the Ministry of Internal Affairs, as well as to commanders of fire brigades and representatives of the Community.
- Republic forest inspectors in January-March control the plans, objects and equipment for forest fire protection.

Also, the Directorate of Forests and the Sector for Fire Prevention and Rescue improved cooperation in the beginning of the year. Seminars with were organized with all subjects involved in forest fire protection in which the current state, equipment and communication improvement were analyzed.

New measures were established in preparedness and expectation of heat and drought escalating in summer:

- A Fire Suppression Headquarters was established by the Government and also at local level
- Public enterprises established active attendance during 24 hours.
- In July 2007 the Forest Sector organized daily press conferences in order to inform and appeal public.

Figure 2. Public awareness signs and billboards are visible throughout the country (Photo: GFMC)

Response to fires

Pursuant to Law of Fire Protection and Law of Forestry the Republic Serbia has organized forest fire suppression according to the scheme provided in Figure 2.

When the lookout observers (foresters) detect a forest fire, they immediately inform the fire warden unit, headed by the forest officer. The crew goes to the site of the forest fire and undertakes the initial fire suppression. The action of forest fire fighting is directed by the chief forest officer, who is in permanent contact with the officer on duty within the local forestry enterprise. If it is estimated that the unit cannot extinguish the fire on their own, they inform the Fire Department of the Ministry of Internal Affairs of Serbia. Then, pursuant to the Fire Protection Law, the action of forest fire suppression is undertaken by the Commander of the fire crew unit.



Figures 3 to 5. Fire observation towers are equipped with camera systems, as demonstrated to visitors of UNISDR Regional Southeast Europe / Caucasus Wildland Fire Network and the Global Fire Monitoring Center (GFMC) during a field assessment in August 2007 (Photos: GFMC)



Figures 6 to 8. Hand tools are efficient and effective means for suppressing surface fires and cutting fire lines (Photos: GFMC and Directorate of Forests)

If the fire develops to a large-scale fire, the responsible officers at the Headquarters of the Public Enterprise are informed, i.e. the Executive Director of the Sector for Forestry and Wildlife Management. The authorized sector of the Headquarters can demand the engagement of the Army and also of other institutions to assist in fire suppression. In the case when several institutions participate in the suppression of forest fires, it is obligatory to form the Fire Suppression Headquarters, consisting of the leadership of all institutions involved.

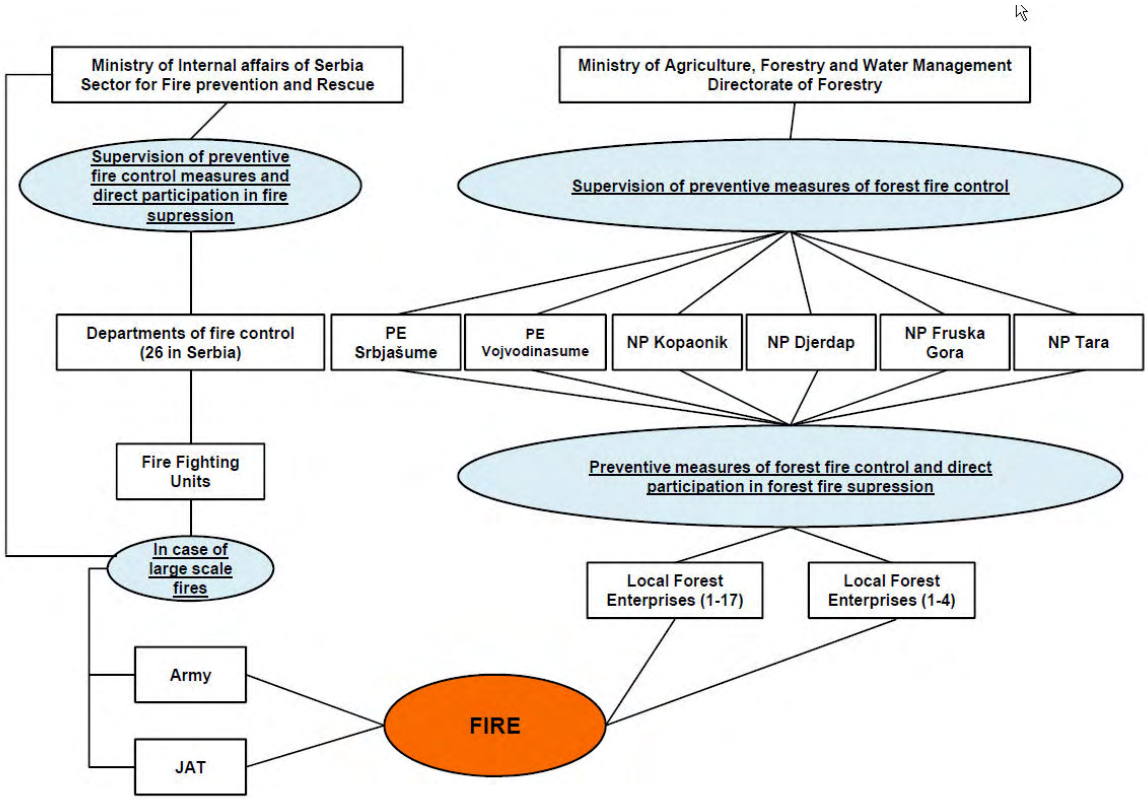

Figure 9. Organization of forest fire suppression in Republic of Serbia

Organizational structure and units/persons responsible for organization of protection from forest fire and extinction in PE "Srbijašume" or PE "Vojvodinašume" are:

- General direction – Sector for Silviculture and Forest Protection
- Forest estate – The officer responsible for silviculture and forest protection
- Local forestry enterprises or Forest Managing Unit (FMU) – Chief of the FMU
- Forest section – The responsible forest engineer
- Operation units – The responsible forester

Moreover, regular police, Army, hunters, organized in Hunting Association of Serbia, participated in fire suppression this year, as well as local population and others.

3. National Cooperation in Response to the 2007 Fires

Cooperation between Sector of forestry (MAFWM – Directorate of Forests, Public Enterprises and National Parks), the Ministry of Internal Affairs (Sector for Fire Prevention and Rescue) and the Ministry of Defense was very efficient.

Civil society didn't have important role in fire suppression this year. The highest number of volunteers traditionally exists in AP Vojvodina, but this year the number of forest fires there was small. Also, in another part of the Republic civil society representatives serving as volunteers are engaged more on an individual basis and thus their overall role is less significant.

The role and involvement of local communities in earlier years was more active than in 2007.

4. International Cooperation in Response to the 2007 Fires

The Ministry of Internal Affairs had a good cooperation with Republic of Bulgaria in managing several fires that were crossing the borders between the two countries.

Receiving assistance

Republic of Serbia received assistance from Russia by a deployed Iljushin-76, which we used in fire suppression in July, at locations where the ground forces could not stop the fires for long time and the fire size had grown to large areas. The airplane was used in the following places: Stara planina, Svrljiške planine, Kuršumlija Deliblatska peščara (Fig. 3).

Figure 10. Aerial suppression by the Russian IL-76 of extended fires in the mountains of Serbia (Photo: GFMC archive)

Providing assistance

Ministry of Internal Affairs of Serbia, Sector for Fire Prevention and Rescue sent in Greece help which include 55 firemen and 6 special motor vehicles for fire suppression.

Figures 11 and 12. View of open lands and forests affected by wildfires in Republic of Serbia in 2007 (Photos: Directorate of Forests and GFMC)

5. Analysis and Recommendations

The following problems have been identified:

1. Inadequacy in the application and outdated legal principles regarding to the protection of forest fires
2. Lack of human resources for prevention and suppression measures
3. Inadequate material and technical equipment of all subjects to enforce measures for fire protection
4. Lack of educational measures for firefighters and personnel of headquarters
5. Lack of means for communication
6. Weak information of the public
7. Most of forests are not enough accessible by roads and insufficient extent of firebreaks

Recommendation are given for enhancing effectiveness for international cooperation

1. Organization of training courses for firefighters and personnel of headquarters
2. Definition of procedures for receiving and providing assistance from neighbor countries and other countries
3. Establishment of unique terms definition and elements for data base

References / Sources

1. Ministry of Agriculture, Forestry and Water Management, Directorate of Forests
2. Public enterprises Srbijašume and Vojvodinašume
3. National Parks Tara, Fruška Gora, DJerdap

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Forest Fires in Former Yugoslav Republic of Macedonia in 2007

1. Statistical Data of the Fire Season 2007

At the end of the 2007 the extreme fire season was evaluated. The following provides a summary of the national assessment.

Table 1. Extent: Number, area and types of forests and other vegetation affected by fire. Source: P. E. "Macedonian forests"-Skopje (1999-2007).

Year	Number of Fires	Burned Area (ha)	Burned Timber Volume (m^3)	Suppression Costs (€)	Total Costs (€)
1999	69	2,414.80	1,950.00	32,512.00	372,921.00
2000	476	46,235.73	711,782.00	976,142.00	15,642,775.00
2001	161	6,263.30	88,260.00	66,810.81	9,851,849.00
2002	65	1,186.30	24,661.28	15,193.10	298,902.00
2003	144	1,068.88	10,987.00	44,607.87	251,527.00
2004	94	892.05	4,322.30	23,214.55	1,469,090.00
2005	182	1,368.00	1,063.00	42,018.11	411,181.10
2006	138	2,085.95	12,978.00	45,311.20	2,437,914.46
Total	**1,329**	**61,515.01**	**856,003.58**	**1,245,809.56**	**30,736,159.56**
Average	*166*	*7,689.38*	*107,000.44*	*155,726.2*	*3,842,019.95*
2007	**652**	**35,248.60**	**617,678.67**	**386,852.46**	**21,494,700.40**

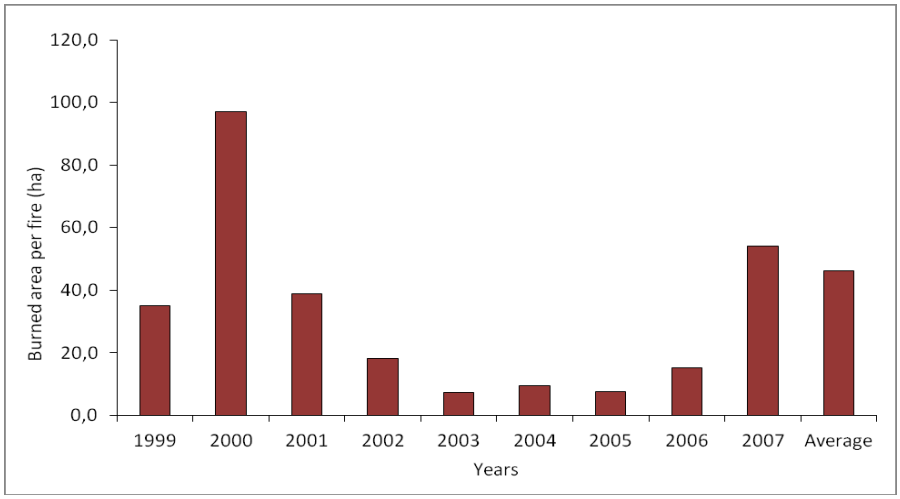

Figure 1. Average burned area per fire (1999-2007)

2. Causes of Wildfires

The most important causes of fires in the year 2007 were: burning of stable fields, burning of pasture lands and negligence-along to roads and railways. Special category is arson: due to illegal logging and politically motivated.

3. Selected Extreme Fires in 2007

Bitola fire: 23 to 26 July 2007
In the period of four days more than 5,000 ha of 45-50 years old pine afforestations were burned. *Comment:* Very bad organization of the fire suppression action even few airplanes and helicopters and about thousand fire-fighters had been engaged in the action.

Berovo fire: 24 to 28 July 2007
In the period of five days about 1,500 ha of high quality natural pine forests were burned. *Comment:* The burned area has very high potential of soil erosion. Reason of the fire (unofficially): Arson (illegal logging)

Figures 2 and 3. Extreme fire weather and behavior led significant environmental damages
Photos: GFMC

4. Fire Prevention Measures

On the beginning of the fire season TV spots and information on the local radio stations were broadcasted and information in newspapers regarding increased fire danger published. Apart of these measures, it was declared that during the fire season any access to the forest for all citizens except foresters was prohibited.

5. Crisis Management Structure at Local and National Level

The structure of the disaster management (responsible for fire suppression) at local and national level during forest fires in 2007 is shown in Figure 2. The main weakness of the organization was the lack of coordination and cooperation between Crisis Management Centre (CMC) and Directorate for Protection and Rescue (DPR). The result of that was disorganization during actions of suppression and very low efficiency although were engaged big number of fire-fighters, airplanes and helicopters.

It should to be emphasized the lack of hand tools and all kind of equipment needed for fire suppression, especially the lack of special off road vehicles for initial attack.

Table 2. Engaged trucks and machines in the period 18 July to 5 August 2007 (Source: CMC)

Date	Fire Trucks	Off-road Vehicles	Bulldozers	Tankers
18 July	18	15	0	0
19 July	21	19	2	0
20 July	34	27	0	0
21 July	21	31	2	3
22 July	44	40	3	0
23 July	32	85	7	0
24 July	55	65	9	4
25 July	49	76	14	5
26 July	37	61	13	2
27 July	29	48	16	1
28 July	18	21	6	0
29 July	9	14	2	0
30 July	12	40	3	1
31 July	6	39	13	1
01 August	1	0	2	0
02 August	4	0	0	0
03 August	1	0	2	1
04 August	6	0	0	0
05 August	0	0	0	0

Table 3. Engaged human resources in the period 18 July to 5 August 2007 (Source: CMC)

Date	DPR	Army	Fire Brigades	Public Enterprises	P.E. Macedonian Forests	Local Citizens	Total
18 July	50	30	46	0	62	73	261
19 July	0	0	69	0	154	37	260
20 July	0	32	144	5	142	197	520
21 July	21	236	80	24	131	131	623
22 July	55	376	171	31	154	336	1.123
23 July	25	400	174	176	400	511	1.686
24 July	886	380	238	92	582	930	3.108
25 July	749	296	178	129	428	660	2.440
26 July	672	147	148	81	390	621	2.059
27 July	455	88	93	65	446	579	1.726
28 July	132	237	103	21	151	264	908
29 July	183	301	32	9	101	245	871
30 July	117	298	47	84	138	86	770
31 July	237	208	35	51	127	132	790
01 August	155	217	11	47	65	18	513
02 August	70	120	27	65	5	10	297
03 August	43	180	144	77	0	17	461
04 August	50	180	24	59	28	53	394
05 August	0	0	0	18	0	0	18

Table 4. Engaged airplanes (Source: CMC)

Type of Aircraft	Days
Fire Suppression Tasks	
2 Helicopters Mi – 17	9
3 Airplanes AN – 2	11
Fire Monitoring	
Helicopter – Bel	7
Airplane – Zlin 242 L	6

6. National Cooperation in Responding to the 2007 Fires

Generally, local citizens were included in the actions of fires suppression (cf. Tab. 3). However, their involvement was very bad organized and without proper equipment and tools.

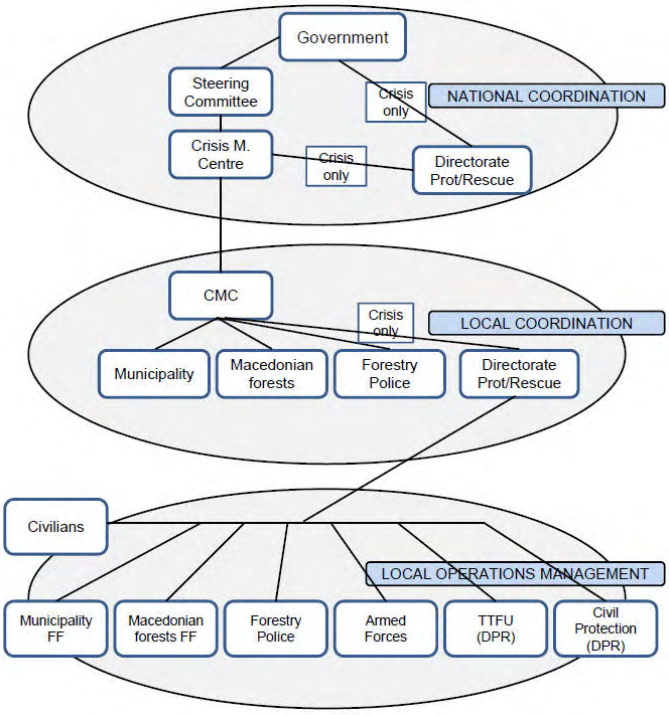

Figure 2. Disaster management structure in Macedonia (2007)

7. International Cooperation

Receiving assistance

Table 5. Assistance received in 2007 (Source: CMC)

Type of Aircraft	Assistance Provided by	Days
Canadair CL-415	Croatia	3
Canadair 32	Turkey	6
Helicopter – Bell 412	Slovenia	6
Helicopter – UH 1D	Germany	6

Providing assistance

Although the situation in the Republic of Macedonia was extremely bad, tree fire trucks with crows were provided to help Greece. Unfortunately, due to political reasons, after 12 hours waiting on the Greek border the offered assistance was denied.

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Joint UNEP / OCHA Environment Unit

Ecological Damage Assessment of the Wildfires in the Former Yugoslav Republic of Macedonia in 2007

Joint Mission by the UNEP-OCHA Joint Environment Unit, UNEP, UNDP and GFMC

Executive Summary

Between July and August 2007 the Former Yugoslav Republic of Macedonia (FYR Macedonia) experienced extended wildfires, which severely affected forests and other vegetation on an area exceeding 50,000 hectares (ha). By end of July 2007 the damages in fire-affected forests as well as the costs for suppression already amounted 21 million Euros. At the time of compiling this assessment there were no damage figures available for the month of August 2007. Although nearly 200 people were forced to evacuate from Bitola direct impact on residential areas has been thankfully minimal. Damage to infrastructure has been relatively slight. However, there were quite a few occasions were damage to these areas (communities and public infrastructure) was only averted at the very last moment.

In response to the request of the Government of FYR Macedonia, UNDP, in a cooperative effort with the Joint UNEP / OCHA Environment Unit, UNEP and the Global Fire Monitoring Center (GFMC), a mission was deployed to FYR Macedonia to assess the damages of the wildfires in FYR Macedonia in 2007 and to recommend action for future fire disaster risk reduction. The GFMC was deployed through the Joint UNEP/OCHA Environment Unit. The mission was implemented between 27 August and 7 September; the field assessment team was deployed between 29 and 31 August 2007. The field assessment was conducted in the most fire-affected regions. These regions were also representative for the fire occurrence and fire effects throughout the whole country. Agencies and individuals involved in wildfire prevention and suppression were consulted in all regions visited.

All wildfires were consequences of human activities, e.g., agricultural burnings, careless use of fire, and in some cases suspected arson. Extremely dry, hot and often windy weather conditions prevailing during the whole fire season created extreme fire situations and often made firefighting impossible. This situation is aggravated by the consequences of the rural exodus. The widespread abandonment of land cultivation is resulting in increasing loads of unused combustible materials in forests and former agricultural and pasture fallow lands. With a reduced presence of the young generation of rural population and average over-aging of the rural communities, the human resources available for fire prevention and fire suppression activities are dramatically dwindling.

Report prepared by the Global Fire Monitoring Center (GFMC)
by
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Edited for IFFN – 30 September 2007

The prime responsibility in fire prevention and initial fire suppression in the state-owned forests is with the Public Enterprise “Macedonian Forests”. This basic responsibility is very appropriate. However, there are expectations by non-state landowners that P.E. Macedonian Forests would also be responsible for fire prevention and control on non-state forest and other lands. Legally this expectation cannot be met due to a lacking mandate, although the P.E. Macedonian Forests is usually and informally responding to all wildfires regardless of land ownership. However, human and technical resources for fire management of P.E. Macedonian Forests are inadequate to professionally and successfully suppress forest fires.

Besides a lack of trained personnel, most of the firefighting equipment is outdated, obsolete and overall insufficient. This severe underfunding and under equipping extends beyond fire management itself into areas of communications, basic office equipment, even office space.

Secondly and very much related to the scale of damage witnessed the general crisis-management system is requiring a severe overhaul. There is a great need for unity and a systematic approach to crisis management The fires of 2007 have highlighted a picture of competing mandates, duplication of efforts, coordination and leadership clashes both at local and central level. Key preparatory activities are performed in isolation to others, the evident expertise the country has in various areas related to the crisis management system is either under-utilized or left outside the system altogether.

It is therefore recommended that a number of measures to be taken to overcome the institutional weaknesses and to improve capacities in fire management. The proposed measures include:

- Launch of a fire management capacity building programme for FYR Macedonia and initiation of a capacity building training programme at regional level; assistance to be sought e.g. through the Environment and Security Initiative (ENVSEC), the Joint UNEP / OCHA Environment Unit, UNDP, Council of Europe (CoE) through its Euro-Mediterranean Major Hazards Agreement (EUR-OPA) and GFMC
- Strengthening the fire management capabilities of P.E. “Macedonian Forests”
- Establishment of adequately trained and equipped voluntary rural fire brigades
- Call for a National Round Table on Fire Management to be supported by UNDP, GFMC and the UNISDR Regional Southeast Europe / Caucasus Wildland Fire Network
- Replacement of obsolete and procurement of sufficient firefighting equipment for the local fire services and P.E. “Macedonian Forests” (provision of model units for wildland fire response, fully equipped with vehicles, tools and personal protective equipment); assistance to be sought through UNDP and national agencies
- Upgrading fire research and training at the Forestry Faculty in Skopje and conduct regional fire management summer schools
- As the FYR Macedonia is aiming at joining the EU, request of a “Twinning” (or Twinning Light) project between FYR Macedonia and an EU member state, to adapt Macedonian legislation and practical procedures in forest and fire management.
- Development of a regional strategy on cooperation in wildland fire management and establishment of a Balkans Regional Fire Monitoring Center; assistance to be sought through UNDP, GFMC and the UNISDR Regional SE Europe / Caucasus Wildland Fire Network, flanked by ENVESC and CoE / EUR-OPA
- Convene a “Regional Balkan Wildland Fire Crisis Conference” (or “Summit”), in which highest-level possible government commitment should be sought, under the joint auspices, among other, of UN specialized agencies and programmes (UNDP, UNEP, the Joint UNEP / OCHA Environment Unit, FAO), the European Commission, Council of Europe / EUR-OPA, ENVESC, OSCE and NATO, and facilitated by the UNISDR Global Wildland Fire Network and its regional network, the UNISDR Regional Southeast Europe / Caucasus Wildland Fire Network, with the main objective to:
    - Address the underlying causes of increasing threats of wildfires to the environment and society, notably the consequences of land-use change and climate variability
    - Outline the need for the development of national policies and strategies addressing land-use, forestry and forest protection, nature conservation and fire management
    - Elaborate agreement for strengthening fire management capabilities in the region through standardized and joint regional training and introduction of improved technologies for wildfire suppression
    - Development of border-crossing mechanisms and agreements on mutual assistance in fire emergency situations

1. Introduction

In July-August 2007 the FYR Macedonia was severely affected by extended forest fires and fires occurring in other vegetation. The extreme size and impacts of fires were determined by the extremely dry weather conditions on the one side, and the lack of human and technological resources for fire management on the other side.

In response to the request of the Government of FYR Macedonia UNDP, in a cooperative effort with the Joint UNEP / OCHA Environment Unit, UNEP and the Global Fire Monitoring Center (GFMC) deployed a mission to FYR Macedonia to assess the damages of the wildfires in FYR Macedonia in 2007 and to recommend action. This report focuses on one of the three parts of that mission: the ecological damage. Other aspects (socio-economic and crisis management) of the mission are examined separately. As this report on ecological damage is designed to also be prepared as stand-alone version there may be a little duplication in the areas of damage.

The mission was implemented between 27 August and 7 September; the field assessment team was deployed between 29 and 31 August 2007. The field assessment was conducted in the most fire-affected regions. These regions were also representative for the fire occurrence and fire effects throughout the whole country. Agencies and individuals involved in wildfire prevention and suppression were consulted in all regions visited.

This report provides a summary of the on-site assessment and investigations in the FYR Macedonia and recommendations for action for future prevention, response and mitigation of wildfires.

2. Mission Narrative

After a preparatory meeting on 27 August 2007 the field mission started on 28 August 2007 and ended with a debriefing at the Center for Crisis Management (CMC) on 1 September 2007. The complete mission report including a detail mission narrative is available in the original report.[1]

3. Results of the On-Site Investigations and the Field Assessment

3.1 The 2007 fire season: Climatic conditions

In summer 2007 the jet stream was flowing further south as compared to average years, allowing low pressure systems to sweep over Western / Atlantic Europe. Warmer air was pulled from Africa, which was affecting South-eastern Europe for weeks. Appendix 1 provides an example of a pressure chart, which is illustrating the reasons for the flow of hot air masses from Africa to the Balkans.

The extreme heat and dryness is reflected by the weekly averages of fire danger level, which were determined by the Joint Research Center (JRC) using the Fire Weather Index (FWI). An example for the month of July for Europe, including the Balkans, is provided in Appendix 1.

An exact comparison of climatological information for FYR Macedonia (long-term average weather data vs. weather data of 2007) is not yet possible due to the lack of evaluated weather data of the current year. However, the high temperatures recorded in summer of 2007 exceeded by far the long-term average temperatures for the summer months. Appendix 1 provides the long-term climatic conditions for a post-mission evaluation.

3.2 Preliminary summary of area burned by vegetation types

Detailed data on area burned and number of fires in August 2007 are not yet available. The fires recorded until the end of July 2007, however, indicate that the area burned by wildfires in 2007 most likely will be higher than in the most recent extreme fire year 2000.

Unfortunately the statistical data collected by various agencies or units – both long-term as well as in 2007 – are inconsistent and probably not comparable. Different sources of fire statistical data come up

[1] http://www.fire.uni-freiburg.de/GlobalNetworks/SEEurope/FYROM-2007.pdf

with different numbers – see datasets provided by the Ministry for Internal Affairs (MIA) for the period 1989-2005 (Tables 2 and 3) vs. the data compiled by P.E. “Macedonian Forests“ for 1999-2006.

The mission had the impression that the data compiled by the Public Enterprise “Macedonian Forests” are the most reliable. With a burned area of more than 32,000 ha recorded by end of July 2007, the total area devastated by fire in 2007 most likely will exceed the area burned in the extreme fire year 2000, during which ca. 46,000 ha of forests and other lands had been burned. It is assumed that the total area burned may exceed 50,000 ha.[2]

3.3 Fire causes

In many cases the causes of the fires are unknown. However, local briefings revealed that agricultural burnings, especially straw residual burning caused many fires, as it usually happens in late summer. Other fires may have been caused accidentally. Arsonists have set some fires. However, there is limited proof, except for two fires in Berovo and Katlanovo, which were set intentionally and which are currently investigated.

The long-term average data show that about 65% of wildfires in Macedonia were caused due to negligence, 7.5% were ignited intentionally and lightning caused only 2%. For 25.5% of fires, the causes were unknown due to difficulties in determine the cause. It is strongly assumed, however, that the majority, if not all, of the fires with unknown origin were started by people.

The farmers, who were using fire, most likely have not been aware of the extreme weather conditions, especially the influence of wind, which caused the spread of land-use fires and created high-intensity wildfires that were difficult to control.

3.4 Fire impacts on vegetation, environment and secondary disasters

An overview of the specific fire impacts is given in the following:

Forests

The degree of ecological and economic damages varied by forest types. High-value forests, such as natural or planted pine forests (*Pinus nigra*, to a lesser extent *P. sylvestris*), have been severely damaged (destroyed) by fire in many places. The “severity” of fires (i.e. the deep fire impact on the forest floor and soil cover; the consumption of all burnable material on the forest floor as well as damage of destruction of tree crowns) was often a result of extreme drought, strong winds and topography (on steep terrain high-intensity, up-slope moving fires are developing very fiercely). Most of the fire-affected pine forests will not regenerate sufficiently be natural regeneration, and need to be re-forested. The value of the partially burned timber (the tree stems are charred by fire) is reduced. The costs of salvage logging and preparation of the land for restoration / sanitation amount to ca. 1000 € / ha. It means that the costs for rehabilitation of 1000-ha burns (such fire sizes have been reported in many forest districts) will amount to 1 million Euro. This magnitude of costs must be kept in mind when judging the investments necessary for appropriate fire prevention and control measures.

As pine reforestations are very sensitive to fire, it should be considered to use different species for reforestation, e.g. oak species (*Quercus* spp.). Oaks are also affected by fire but have a good potential of regenerating naturally (from sprouting). Thus, fire affected oak stands may not require high investments for rehabilitation.

High-altitude forests with different tree species, e.g. spruce and fir species have not been visited during the assessment mission. However, there are reports of fires burning in national parks in which such forests may have affected by fire. In general, these mountain forests are very sensitive to fires, and fires represent of threat to biodiversity and mountain ecosystem stability.

[2] According to a quick satellite survey by the JRC a total of 36,492 ha of lands were affected by fire by end of August 2007, of which 30,645 ha were forest lands (84%):
http://effis.jrc.it/documents/2007/EFFIS_Newsletter_2_2007.pdf

The forest fire damage assessment by the Public Enterprise “Macedonian Forests” estimates a damage of forest products and the costs for fire suppression in the magnitude of 21 Million Euro (as of end of July 2007).

For private forest owners the situation can be rather difficult. The majority of the ca. 60,000 private forest owners have very small forests; the average size is 0.5 ha. One farmer interviewed by the mission team lost the whole forest on his property of 3.5 ha. For such a case a fire can be economically very disastrous.

Other lands

Degraded forests affected by fire in some cases have a history of earlier fires and land-use. The economic value of degraded forests and brushland is less than the high-value forests.

Only a limited amount of agricultural lands or other cultivated lands have been affected by wildfires. The team noticed some viticulture and fruit tree plantations damaged by wildfires. The authorities in general did not report major damages in agricultural crops.

Infrastructures

In some places damages of infrastructures were reported and observed, e.g. some burned power and telephone masts. In general there was limited damage, although it was observed that many electric power lines were near or even over burned vegetation. The potential of damages, however, was very high, but was successfully prevented by fire suppression efforts. The TV tower at Katlanovo (near Skopje) was threatened by fire in July 2007, but successfully protected.

Near Gevgelija a short section of railway sleepers burned, but could be repaired at short notice. At the fires near Katlanovo the highway and tunnel had to be closed for several hours in order to avoid traffic safety problems due to fire and smoke.

Most endangered was the coal-fired electric power plant Oslomej near Kicevo. The fires burned nearby this power plant and created some spotting fires, which were falling on the main per plant facility. The fire personnel prevented the ignition of the facility. Burning of this power plant could have caused enormous direct and indirect damages (e.g. loss of electricity with subsequent economic losses in the region or even countrywide).

Social / humanitarian (public health, safety and security)

In a number of regions the loss of some buildings was reported, e.g. some weekend houses. In the outskirts of Bitola a small informal settlement of the local Roma population was partially burned down, several barracks were destroyed or damaged. The authorities evacuated 178 persons from the fire scene. There were no casualties. While some of the evacuees were allowed to return after the fire, a total of 32 persons are currently still hosted in a holiday resort and are waiting for decisions and actions by the city of Bitola to provide new housing ground and to assist building of barracks. Details on the fire impact on the Roma community in Bitola are provided in the tandem report.

Other regions reported about losses of private houses and equipment, e.g. in Berevo the loss of one house, one weekend house and one tractor was reported. In Strumica the authorities reported the loss of several barns and cattle stable.

The Red Cross units were actively participating in the fire and rescue operation in several places where peri-urban or village sites were endangered by fire, e.g. in Bitola and Kicevo. The Red Cross gave advice to people to protect themselves from heat stress. Although severe smoke pollution was reported in the call for international assistance (Appendix 3), the regional representatives of the Red Cross and other authorities did not consider smoke pollution and health risk as a major problem during the fire crisis.

The fire and forestry units reported about several critical situations in which firefighters were threatened by the wildfires, e.g. during fires burning near Prilep where firefighters were trapped by fire. However, no casualties were reported. For comparison: in Croatia six firefighters were killed and seven severely injured in a fire in the last week of August 2007. (Note: By 6 September the number of fatalities in Croatia has increased to 11 firefighters.)

In conclusion it can be stated that unlike the situation in Greece, where more than 64 people had been killed by fires and more than 3000 houses burned during the fire episode of August 2007, the humanitarian consequences of wildfires in FYR Macedonia were less severe.

However, the potential for higher losses was there, including the long-term effects of smoke pollution (damage through inhalation of smoke particles, with the risk of short-term effects on elderly and young people and those suffering cardio-vascular diseases, asthma, etc., or long-term effects such as cancer).

Other damages: Secondary damages and disasters

It is very likely that considerable damage will be caused by secondary events. Bark beetles most likely will infest pine forests, which were partially damaged by fires. The expected mass infestation will result in additional damages affecting surrounding unburned forest stands.

In most areas fires burned on steep terrain (slopes). The high severity of fires has burned the protecting humus layer and removed the grass-herb vegetation. In some places the fires penetrated the ground through burning of old tree stumps and roots. The effects of these hot-burning fires make these slopes very prone to soil erosion, with the consequence of loss of soil and nutrients. This will be a major impediment for regeneration and reforestation.

Once heavy rainfalls in autumn-winter will hit these burned sites, it is expected that massive surface runoff will lead to floods, landslides, mudslides and rock falls. The downstream effects of heavily burned sites may become more disastrous than the direct fire damage in terms of timber losses and reforestation costs.

Specific issues: UXO threat to human security

Many forest sites and non-forest lands in the Balkan region are contaminated by land mines and unexploded ordnance (UXO) from recent conflicts. In FYR Macedonia the threat of UXOs to be triggered and exploded by forest fire is stemming from World War I. Most contaminated is the former line of contact of 1917 between Strumica and Bitola (LoC between the Austro-Hungarian, German, Bulgarian and Turkish forces in the North and the Antanta Union in the South), where large numbers of grenades and mines are threatening firefighters and civilians. During the fires in July 2007 more than 70 explosions of ammunition were recorded in the immediate vicinity of Bitola, but no casualties occurred.

3.5 Fire management

The following summary is concentrating on the technical fire management capabilities. An analysis of the general Crisis Management System in light of the forest fires can be seen in the separate report (including some aspects of multi-stakeholder involvement at a local/national level).

Wildfire prevention and preparedness

The prevention of forest fires is the task of the forest owner (Law on Forests, 1997). The Public Enterprise “Macedonian Forests” plays an important role in this regard. However, the enterprise is allocating very limited resources for technical fire prevention measures, e.g. for creating firebreaks, pruning of trees alongside roads, planting of greenbelts, or construction and operation of fire watch towers.

The economic situation of private forests is rather difficult. The average small size of the forest properties, usually intermixed with forests of other owners, makes fire prevention measures extremely difficult, not to say impossible, unless agreement can be reached by a group of forest owners of a forest complex.

During the field mission it was noted that only very few billboards and other public education / information materials have been posted. Some leaflets addressing forest fire risk were presented by the authorities in Kicevo, including materials in Albanian language.

Wildfire response: Fire suppression

Forest owners have the primary responsibility for fire response. Since private forest owners have limited to none capabilities in fire suppression, the Public Enterprise “Macedonian Forests” is serving *de facto* as the only acting entity to initially respond to fires (initial attack) regardless of forest ownership. P.E. Macedonian Forests is actually acting like a public body (“Forest Service”) although it does not have a mandate or budget to do so. P.E. Macedonian Forests is acting because there are no resources in private or community forests to respond to fire.

If a fire cannot be suppressed P.E. „Macedonian Forests“ calls the local Fire Service for support and the Directorate for Protection and Rescue is involved. In a declared “disaster situation” (emergency / crisis dimension of a fire) the Crisis Management Center is responsible for coordinating fire fighting. This task includes the coordination of foreign assistance, e.g. targeting foreign aerial resources to the fire to be suppressed.

The mission received several reports from the regions (e.g., Struga) that private landowners expected that P.E. Macedonian Forests should fight fires also on private lands. These landowners did not participate in fire fighting.

In almost all regions it was reported that there are insufficient to none volunteers for firefighting. Some exceptions, however, indicate the potential for volunteer involvement: In Kicevo-Krusino it was reported that a fire, which broke out on 26 July 2007 in the afternoon, the local population was immediately through the local media. Immediately about 400 to 500 people assisted the foresters, fire services and the armed forces in combating the fires and saving very valuable forest resources. In Tetovo a representative of a volunteer group of Brevenica reported the availability of volunteers, which at moment have no budget and no equipment at all.

Equipment, professional competence and firefighters personnel safety

In all regional meetings visited (Annex: itinerary map of field assessment mission) the representatives of the agencies involved (P.E. Macedonian Forests, Fire Services, DPR, CMC) reported in detail about the available technical / equipment resources to combat fires. The reports reveal that the equipment for fire suppression in forests and other lands outside villages and towns are absolutely insufficient. Compared to international standards the available resources almost nil.

In many regions the total amount of equipment included a small number of fire swatters (fire beaters) and backpack pumps. In some regions one single vehicle for transport of personnel was available. In some regions vehicles were borrowed or made available by private persons.

The units dispatched to fight forest fires do not have any specific training for capacitating the personnel to carry out fire suppression professionally and – most importantly – safely.

In all regions it was reported that units, which did not have any tools for fire suppression, had to attack fires burning with extreme intensities.

Rehabilitation of fire-affected lands

It was noted during the mission that P.E. Macedonian Forests was already working on preparations for post-fire sanitation cutting (salvage logging and removal of fire-damaged trees to reduce bark beetle infestations in burned pine stands) and reforestation.

The rehabilitation of forests damaged by high-severity fires (fires burning deep into organic terrain and depleting the soil from protecting humus and vegetation cover) must receive highest priority on order to reduce the degradation or loss of soils due to erosion and increased surface water runoff. Reforestation must receive priority in watersheds where heavy rainfalls may cause floods and destabilization of mountain slopes.

International cooperation in fire suppression

During the fire crisis in 2007 the government requested international assistance. Appendix 5 provides an overview of the assistance given by countries and donor organizations. Aerial fire fighting resources were received from some countries. The efficiency of foreign aerial firefighting missions

varied. In the case of the fire near Kicevo the deployment and aerial attack of a Croatian Canadair CL-215 was particularly successful.

During the fire crisis in the whole Balkan region numerous fires crossed national borders. This was also the case in FYR Macedonia. Authorities in Struga reported about border-crossing fires from Albania. They reported that there were no official communication channels with Albania, and that all action at the border had to be done in an unofficial way. There is also no communication with the authorities in Kosovo.

During the peak of the fire crisis in Greece, the government of FYR Macedonia offered assistance to Greece by sending a mixed firefighter team with the most experienced personnel. The Greek authorities, however, did not allow the fire crew to cross the border.

4. Conclusions

4.1 General: Implications of changing socio-economic conditions and regional climate on fire regimes and institutional capabilities in fire management

The fire assessment mission team has been confronted the dramatic social, economic and political changes in the rural space of the FYR Macedonia. Most visible during the mission were:

Consequences of the rural exodus

- Reduction in agricultural and pastoral activities
- Reduction in the overall use of biomass
- Together with increasing size of fallow lands with bush and forest encroachment, the reduced utilization of biomass constituting an increasing availability and continuity of fuels available to wildfires
- Villages becoming over-aged and even completely vacated due to the exodus of the young generation to the cities
- Decrease of availability of young, active rural population ready to prevent and suppress fires

Consequences of political and structural changes in the society

- Institutional weakening of the authority and efficiency of the forestry authorities
- Degraded financial capabilities of the fire and rescue services and other stakeholders concerned directly or indirectly with fire prevention and control
- Impoverished private forest and land owners with virtually non-existing capability on fire prevention and control

Consequences of climate extremes such as in 2007

- Unprecedented heat wave
- Extreme desiccation of forests and other vegetation
- Extended dry season without rainfall
- Occurrence of strong dry and hot winds favouring the intensity, spread and uncontrollability of wildfires
- Neighbouring countries are similarly affected, with consequences on reduced availability of foreign fire disaster assistance

Consequences of fires on the country and the environment

- As a consequence of these developments the territory of the country is becoming increasingly vulnerable to fire
- The effects of fire on the natural environment in the country constitute a major threat to the sustainability of forests, forestry and the role of forests in the stability of the country's environment and society.

By evaluating the multiple and cumulative effects of human-driven and natural developments on the vulnerability of FYR Macedonia to fire, and the whole Balkan region respectively, it is concluded that highest political priority should be given to strengthen the protection of forest and other vegetation

resources against the increasingly detrimental impacts of fire on ecosystem stability and society in the country and its neighbors.

Decisive action is urgently needed.

4.2 Current fire situation and fire management capabilities in FYR Macedonia

As a consequence of the weakened financial capabilities of all stakeholders concerned, the fire management capabilities in the country are extremely poor. In all regions visited and forestry and fire service units inspected the Fire Assessment Mission Team witnessed the almost non-existing capabilities in fire management.

Almost all local branches and fire service units had extremely small amounts of hand tools, often overaged and not functioning, limited to none means of transport, especially lack of off-road vehicles for transport of firefighters, no suitable fire trucks and limited amount of water tenders. There is no adequate personal protection equipment for the safety of firefighters available.

Special training required for professional forest (wildland) fire fighters does not exist in the country. Firemen are exclusively trained in structural fire fighting, or management of hazardous materials, but there was no indication of availability of training materials or procedures in forest fire fundamentals and suppression.

Several regional authorities underscored the lack of personnel, which is required by the Law on Local Self-government: “Fire Protection Provided by the Territorial Fire-fighting Units” i.a.w. the Law on Fire Protection (Official Gazette of the Republic of Macedonia No. 67/04), especially considering Article 6, which is stipulating the minimum number of firemen in the fire protection units i.a.w. the number of inhabitants of municipalities.

The responsible units of P.E. “Macedonia Forests” and the fire services reported that they were tackling large forest fires of sizes of up to several hundred or more than thousand hectares with virtually not tools at all. In some cases firemen had to use / borrow private vehicles to drive to the fire front.

4.3 Needs for improvement of fire management capabilities

The weak status of the forestry authorities and other forest owners, notably the private forest owners, as well as the catastrophically inadequate equipment, operational means and training of the fire service and rescue units require a swift and massive response towards the improvement of professional capacity and equipment of the authorities concerned with fire protection. The investments that will be required will be rather moderate.

5. Recommendations

5.1 Fire management training in FYR Macedonia

Given the lack of professional training of forestry and fire service personnel in the country is recommended to conduct a fire management capacity building programme for FYR Macedonia.

Given the fact that the countries in the Balkan region are suffering similar problems of shortcomings in fire management, and the fact that many fires are crossing the borders between all Balkan countries, it is strongly suggested to initiate a capacity building training programme at regional level. The programme should first focus of “training for trainers” from the Balkan countries.

This is in line with the recommendations of the UNISDR Regional Southeast Europe / Caucasus Wildland Fire Network and, among other, the recommendations of the 2007 UNDP-UNEP Fire Mission to Kosovo. [3]

[3] UNDP / Joint UNEP/OCHA Environment Unit / GFMC, Fire Situation Assessment Kosovo, Final Report, 15 August 2007 (on file at Joint UNEP/OCHA Environment Unit and GFMC)

Given the interest and already existing engagement of the Environment and Security Initiative (ENVSEC) in addressing the increasing fire problem in the region – in particular with involvement of GFMC, UNEP and OSCE and considering the potential interests of NATO – it is recommended to implement this programme under the financing and implementation scheme of ENVSEC.

The Joint UNEP / OCHA Environment Unit and the Council of Europe (CoE) through its Euro-Mediterranean Major Hazards Agreement (EUR-OPA) have indicated a strong interest to partner in such a programme.

At academic level it is strongly suggested that the Forestry Faculty in Skopje should receive additional resources to enhance fire research and training of forestry students. Training courses for forestry students could also be conducted in conjunction with universities from neighbouring countries, e.g. in joint summer schools. This kind of academic training could be possibly financed by ENVSEC.

5.2 Fire management organization

The fire season of 2007 revealed that the land managers (forest managers, managers of other lands), who have primary responsibility for fire prevention and initial attack, need to be strengthened in performing their duties.

It is strongly recommended that the P.E. “Macedonian Forests” shall be strengthened through provision of professional training and equipment in order to improve forest fire prevention, preparedness and initial suppression capabilities.

Considering the increasing degradation and destruction of the forests of the country as a consequence of climate extremes, socio-economic changes and fire, as well as secondary damages or disasters following the fire, it should be considered to elevate the status of P.E. “Macedonian Forests” to a National Forest Service mandated to have primary responsibility and supervisory functions for forestry and forest protection, notably fire protection, in the whole country.

This would follow the principle of “land managers being responsible for fire management”. The negative experiences in other countries, notably in Greece, where urban-focussed fire services have prime responsibility for rural fire management, should be taken into consideration when taking decision to strengthen the land manager’s capabilities.

However, the improvement of efficient support of the professional and voluntary fire services to P.E. “Macedonian Forests” is very crucial.

Given the need on the one side, and the availability / willingness of civil society on the other side, to involve civil and voluntary engagement on forest fire management it is urgently recommended to implement Article 22 (1) (11) of the Law on Local Self-government: “Fire Protection Provided by the Territorial Fire-fighting Units” i.a.w. the Law on Fire Protection (“Official Gazette of the Republic of Macedonia” No. 67/04), especially considering Article 7, which is stipulating:

(1) For the purpose of extinguishing fires in woods and open spaces, under circumstances of increased danger of occurrence of such fires, the municipalities – at a request of the Protection and Rescue Directorate – shall <u>engage seasonal firemen</u>, who operate as part of the units of Article 5 herein. Priority in engaging seasonal firemen is given to firemen working in <u>voluntary firefighting units and associations</u> in which they have been active for at least two years.

It is recommended that UNDP to sponsor the national dialogue necessary for the development of a national fire management strategy. A National Round Table on Fire Management could be facilitated through the GFMC and the UNISDR Regional Southeast Europe / Caucasus Wildland Fire Network. This network can contribute with relevant expertise.

5.3 Fire suppression hardware

As reported by local / regional authorities and confirmed by the Mission, the firefighting equipment in FYR Macedonia is obsolete. In most regions the firefighting equipment is outdated, often broken.

Besides a need for fire management training there is a need to strengthen the technical capabilities of the Fire Services by upgrading the fire suppression hardware

It is suggested that UNDP take the lead to support the country in resources mobilization and procurement of services and equipment for improving fire management capabilities. This project would constitute the hardware delivery and should be closely coordinated with the “soft” component of capacity building of human resources, tentatively to be covered by the ENVSEC / CoE EUR-OPA mechanism (cf. 5.1). The hardware to be purchased would constitute a number of model units for wildfire response, fully equipped with vehicles, tools and personal protective equipment (PPE).

The purchase of hardware component through a UNDP initiative should support the Government of FYR Macedonia in making decisions for further investments in forest fire management.

5.4 Rehabilitation and securing the stability of fire-damaged forests and other lands

The rehabilitation measures to be taken in order to secure regeneration or reforestation of fire-damaged lands and to prevent secondary pests (e.g., bark beetle infestation) or secondary disasters and other detrimental post-fire effects (loss of topsoil and soil nutrients by erosion; landslides, mudslides, flash floods and extended floods as a consequence of increased surface runoff) need to be planned carefully. This task is primarily conducted by P.E. “Macedonian Forests”. The decision about the future stocking of the fire-damaged lands must be taken carefully. Pine reforestations will continue to be vulnerable to wildfire, particularly on areas with limited access, e.g. on steep terrain and lacking forest roads. It is strongly recommended to analyze the historic and potential natural vegetation of fire-affected sites in order to avoid reforestation with the wrong species (e.g. pine reforestations in places that should better be reforested with oak species), and to consider future climate conditions and the overall wildfire risk.

Securing of the stability of fire-damaged stand must include carefully sanitation cuttings, particularly for the prevention of mass outbreaks of bark beetles in fire damaged opine forests. Attention should be paid, however, to avoid cutting of partially fire-affected trees (scorched trees) which could survive if properly protected from bark beetle infestation. Monitoring of bark beetle populations with pheromone traps is recommended.

Sensitive watersheds must be reforested with highest priority in order to prevent the loss of soil and excessive surface run-off of water during heavy rainfall events. P.E. “Macedonian Forests” must be provided the necessary funding to implement the rehabilitation of the damaged areas during the winter 2007-2008.

5.5 Proposal for a EU Twinning project for fire management

As the FYR Macedonia is aiming at joining the EU, it should be considered to initiate a “Twinning” (or Twinning Light) project between FYR Macedonia and a EU member state, to adapt Macedonian legislation and practical procedures in forest and fire management. The GFMC and the Forestry Faculty of Skopje / UNISDR Regional SE Europe / Caucasus Wildland Fire Network are available to facilitate the development of a Twinning request.

5.6 Proposal for a coordinated regional (Balkan) fire management strategy

The concurrent problems and needs of all neighbouring Balkan countries to improve fire management capabilities are implying a regional approach to be taken in which the limited capabilities of the Balkan countries to encounter the fire problems would be strengthened by coordinated, collective and mutually enabling action. In 2006-2007 the UNISDR Regional SE Europe / Caucasus Wildland Fire Network developed a draft regional strategy on cooperation in wildland fire management, which is offering an initial concept of regional cooperation (Appendix 5). There is a need to further develop the strategy at inter-governmental level.

UNDP, through the GFMC and the UNISDR Regional SE Europe / Caucasus Wildland Fire Network, flanked by ENVESC and CoE / EUR-OPA, could support the endeavors to strengthen the regional dialogue and networking.

Concrete proposals for immediate action, e.g. the establishment of a Regional Fire Monitoring Center for the Balkan region or the inclusion of the Balkan languages into the international Wildland Fire Management Glossary could be implemented relatively swiftly and at moderate costs.

5.7 Proposal for a Balkan Regional Fire Crisis Conference or Summit

At the time of delivery of this report the fire season in the FYR Macedonia and neighbouring countries is almost over. From Bulgaria in the North down to Greece in the South of the Balkans all countries have suffered an unprecedented severe fire season in 2007. The severity of the fire season was an expression of the accumulated societal, economic and environmental changes in the region – and this should be evaluated. Decisive action must be taken to address the underlying causes for the extreme fires and to reduce the increasing vulnerability of forests and society to fire.

The Balkan countries have recognized the inter-connectedness and interdependence of the natural space and its protection efforts. The autumn rains have begun. The region should not go to hibernation. Instead, it is suggested to call urgently for a “Regional Balkan Wildland Fire Crisis Conference” (or “Summit”), in which highest-level possible government commitment should be sought. The summit should

- Address the underlying causes of increasing threats of wildfires to the environment and society, notably the consequences of land-use change and climate variability
- Outline the need for the development of national policies and strategies addressing land-use, forestry and forest protection, nature conservation and fire management
- Elaborate agreement for strengthening fire management capabilities in the region through standardized and joint regional training and introduction of improved technologies for wildfire suppression
- Development of border-crossing mechanisms and agreements on mutual assistance in fire emergency situations

The Global Fire Monitoring Center (GFMC) through the UNISDR Global Wildland Fire Network and its regional network – the UNISDR Regional Southeast Europe / Caucasus Wildland Fire Network – are available to facilitate this process.

This crisis summit should be co-sponsored by those who have been involved in mastering the fire crisis in the region in 2007 and / or are available to assist the region to build capabilities in fire management. It is suggested that the main actors to be invited to provide joint auspices would include, among other, UN specialized agencies and programmes (UNDP, UNEP, the Joint UNEP / OCHA Environment Unit, FAO), the European Commission, Council of Europe / EUR-OPA, ENVESC, OSCE and NATO.

6. Appendices

1. Weather pattern 2007 and data long-term average climatological data
2. Forest fire statistical data (long-term and 2007 fire season)
3. Satellite reconnaissance of fires and international assistance
4. Photographs of the mission

Appendix 1

Weather Pattern 2007 and Long-term Average Climatological data

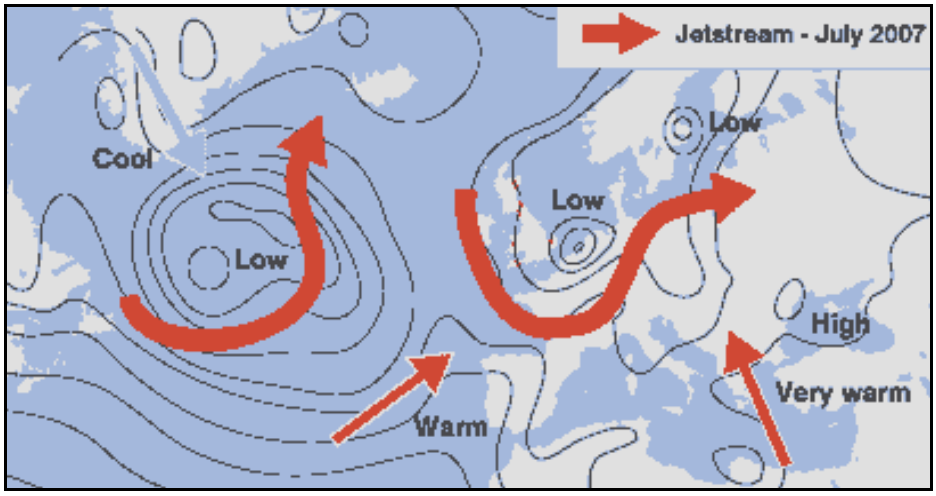

Figure 1. In summer 2007 the jet stream was flowing further south as compared to average years, allowing low pressure systems to sweep over Western / Atlantic Europe. Warmer air was pulled from Africa, which was sweeping over Southeastern Europe. Example of pressure chart: 24 July 2007. Source: UK Met Office

Table 1. Climatological information for FYR Macedonia: Average weather data provided by WMO

Month	Mean Temperature °C		Mean Total Rainfall (mm)	Mean Number of Rain Days
	Daily Minimum	Daily Maximum		
Jan	-3.6	4.0	36	10
Feb	-1.3	8.4	36	9
Mar	1.9	13.6	40	10
Apr	5.4	18.6	40	10
May	10.0	23.9	60	11
Jun	13.0	27.4	46	10
Jul	14.8	29.8	34	7
Aug	14.6	30.0	27	6
Sep	11.4	26.1	36	6
Oct	6.3	19.5	42	7
Nov	1.4	11.2	56	9
Dec	-2.2	5.3	51	11

Source: WMO http://worldweather.wmo.int/090/c00199f.htm#wxforecast

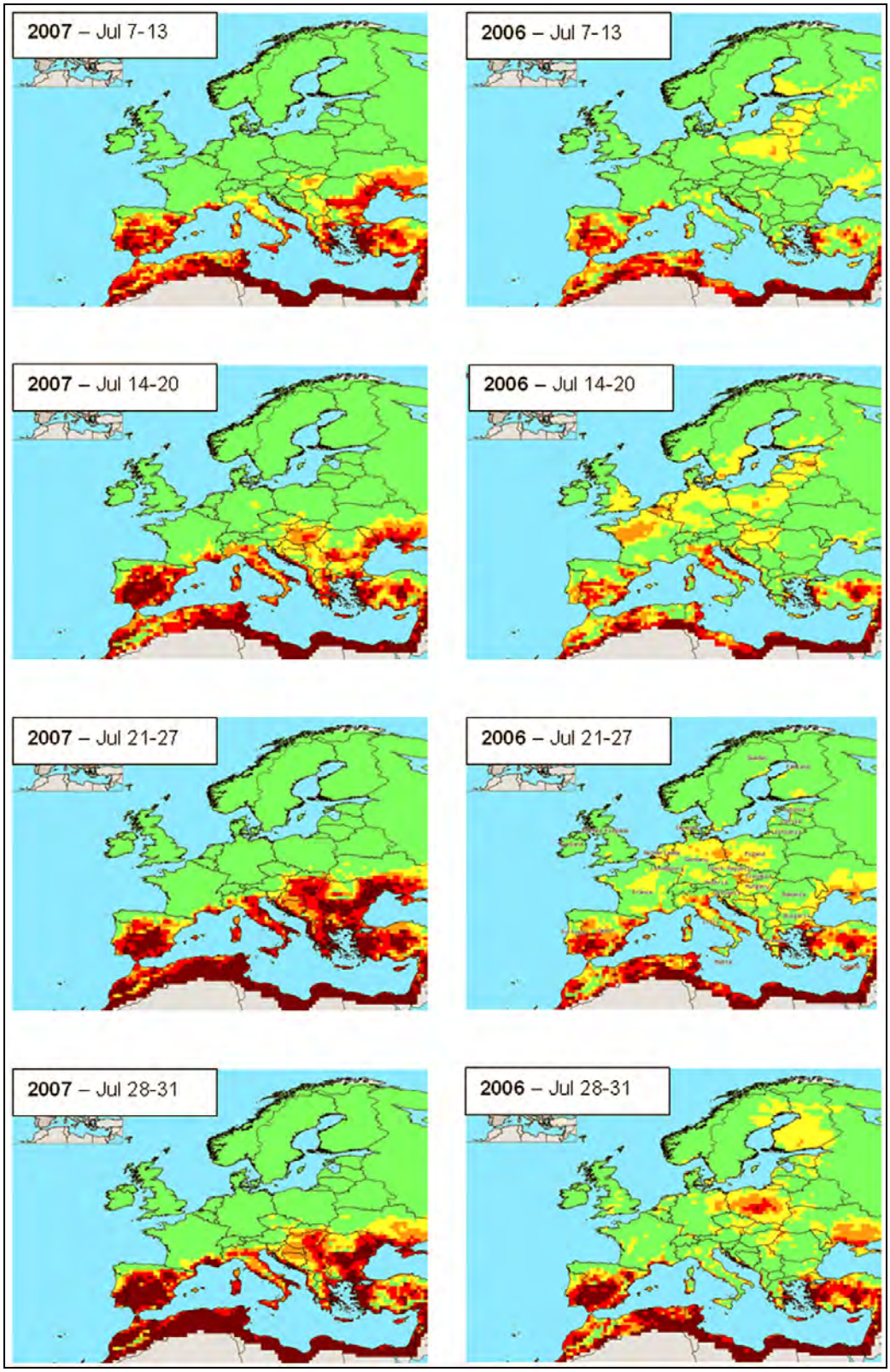

Figure 2. The extreme heat and dryness in the Balkan region is reflected by the weekly averages of fire danger level, which were determined by the Joint Research Center (JRC) using the Fire Weather Index (FWI). An example for the month of July for Europe including the Balkans (left column) as compared to 2006 (right column) has been extracted from the European Forest Fire Information System (EFFIS) Newsletter No. 7 (6 September 2007).

Appendix 2

Forest Fire Statistical Data: Long-term and 2007 Fire Season

Table 2. Overview of forest fires in the FYR Macedonia for the period 1 January to 31 July 2007. Source: Private Enterprise "Macedonian Forests". Note: 1 Euro = 60 denars. The total damages / costs of 1,255,626,112 denars correspond to 21 million Euro.

	Administrative Unit	Number of Fires	Burned Area (ha)	Burned Timber (m^3)	Suppression Costs (denars)	Total Damages / Costs (denars)
1	Malesevo - Berovo	17	1548.8	163931.0	567,556.00	75,265,125.45
2	Ravna Reka - Pehcevo	23	424.0	800.0	436,001.00	1,815,285.00
3	Osogovo - K.Palanka	15	179.7	1436.2	254,054.00	13,104,280.00
4	Kratovo - Kratovo	4	105.0	3300.0	245,719.00	1,621,159.00
5	Osogovo - Kocani	17	403.1		544,287.00	544,287.00
6	Serta-Stip	6	443.6	8446.0	342,000.00	80,534,800.00
7	Plackovica - Radovis	19	486.8	4236.0	441,100.00	1,920,900.00
8	Plackovica - Vinica	43	733.0	2000.0	750,370.00	4,802,675.00
9	Belasica - Strumica	33	2346.8	816.0	431,304.00	520,584.00
10	Salandjak - Valandovo	6	28.5	184.0	55,500.00	398,650.00
11	Kozuv - Gevgelija	14	1855.2	31254.0	565,560.00	16,583,041.77
12	Demir Kapija - D.Kapija	8	124.5	615.0	200.,00.00	687,610.00
13	Bor - Kavadarci	12	245.5	197.0	334,869.00	8,077,429.00
14	Crn Bor - Prilep	18	664.0		502.,07.00	502,107.00
15	Babuna - Veles	47	2396.9	40196.0	2,688,137.00	66,572,582.00
16	Sumarstvo - Sv. Nikole	7	93.0		475,800.00	475,800.00
17	Kajmakcalan - Bitola	10	6022.0	132020.0	727.,60.00	298,013,230.00
18	Bigla - Demir Hisar	24	1165.6	42444.3	1,158,305.50	14,852,867.63
19	Lipa - Krusevo	2	462.0	21489.0	47,650.00	8,997,462.00
20	Prespa drvo - Resen	6	110.0		225,860.00	375,860.00
21	Galicica - Ohrid	15	452.3	1826.0	279,952.00	3,115,129.00
22	Jablanica - Struga	16	632.0	350.0	478,860.00	478,860.00
23	Stogovo - Debar	5	28.0	195.0	18,000.00	388,500.00
24	Lopusnik - Kicevo	55	1696.8	14640.0	1,506,054.00	80,474,289.50
25	Sandanski - M.Brod	32	1374.5	34022.5	1,422,720.00	49,608,975.00
26	Sar - Gostivar	17	1395.2	26317.2	334,689.00	15,818,196.00
27	Lesnica - Tetovo	41	1739.4	9417.0	176,285.00	125,956,647.60
28	Karadjica - Skopje	52	3297.9	46397.5	2,736,250.00	361,380,750.00
29	Kumanovo - Kumanovo	12	1831.0	5395.0	1,017,740.00	22,461,160.00
30	Golak - Delcevo	13	379.9	80.0	277,870.00	277,870.00
Total		**589**	**32,665**	**592,005**	**19,243,360**	**1,255,626,112**

Table 3. Number of forest fires in FYR Macedonia for the period from 1989 to 2005 (Source: Ministry for Internal Affairs - MIA)

Land Use	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total	Average
Deciduous	33	65	9	57	111	68	9	15	26	26	256	395	58	26	25	22	13	**1 214**	*71.4*
Coniferous	11	43	6	32	50	23	3	18	36	20	34	133	26	5	22	22	18	**502**	*29.5*
Mixed	31	73	11	98	141	65	9	40	78	73	82	454	60	21	41	26	20	**1323**	*77.8*
Shrub forests	9	37	4	26	43	14	0	5	10	11	-	-	7	4	0	1	1	**172**	*10.1*
Other	11	23	8	22	45	25	3	12	24	21	80	205	14	3	8	2	6	**512**	*30.1*
Total-forests	**95**	**241**	**38**	**235**	**390**	**195**	**24**	**90**	**174**	**151**	**452**	**1187**	**165**	**59**	**96**	**73**	**58**	**3723**	*218.9*

Table 4. Burned area in FYR Macedonia for the period from 1989 to 2005 (Source: MIA)

Land Use	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total	Average
Deciduous	172.2	1 987.6	49.5	904.4	6 034.3	1 486.3	47.5	54.3	271.0	160.9	1062.2	16 182.9	2 468.7	472.3	491.7	890.00	766.5	33 502.3	*1 970.7*
Coniferous	40.5	1260.6	5.7	208.2	1 368.2	2 523.1	1.3	100.6	1 299.7	156.7	332.1	1 660.5	1 007.7	5.2	115.6	92.87	227.1	10 405.67	*612.1*
Mixed	118.8	876.4	35.9	7 632.9	4 446.8	1 471.8	5.4	429.8	652.7	1 282.1	343.2	17 345.4	2 888.6	111.1	3 025.8	589.18	2985.7	44 241.58	*2 602.44*
Shrub forests	1 258.8	1 214.0	345.0	359.6	462.9	174.3	0.0	85.0	1 138.3	21.5	0.0	0.0	77.5	44.5	0.0	1.50	1.0	5 183.9	*304.9*
Other	43.1	421.8	7.7	285.1	2 111.6	146.2	51.2	316.4	2 12.1	268.0	254.5	2 739.7	224.3	26.0	303.2	10.50	36.3	7 457.7	*438.7*
Total-forests	**1 633**	**5 760**	**444**	**9 390**	**14 424**	**5 802**	**105**	**986**	**3 574**	**1 889**	**1 992**	**37 929**	**6 667**	**659**	**3 936**	**1 585**	**4 017**	**100 791**	***5 929***

Appendix 3

Satellite Reconnaissance of Fires and International Assistance

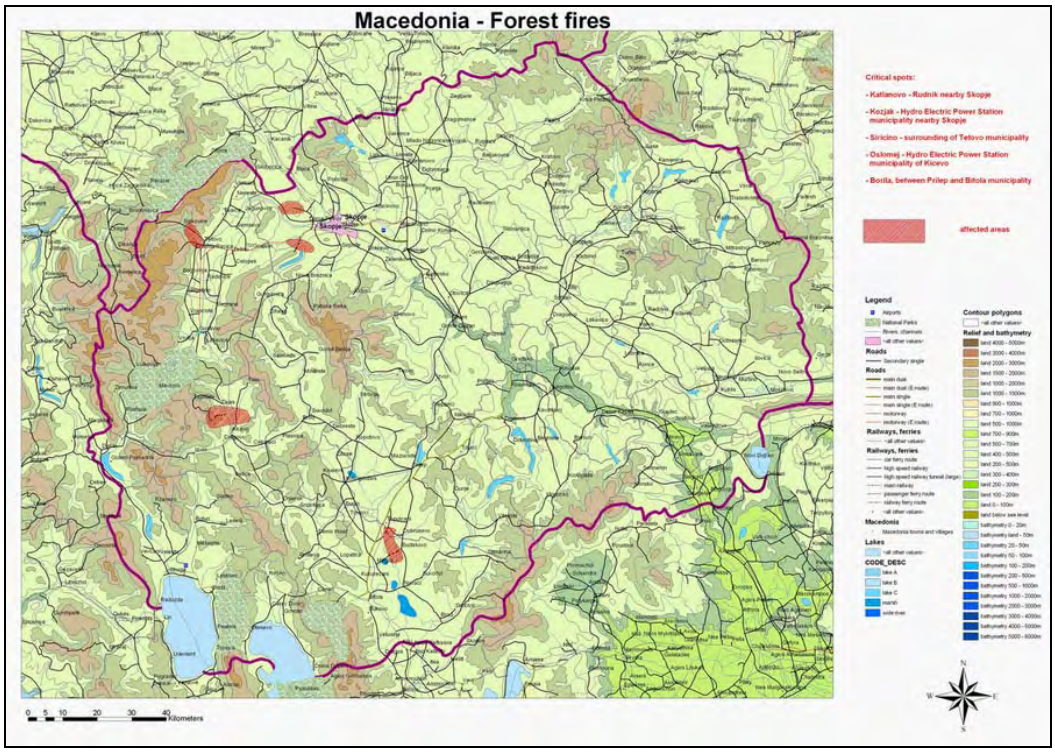

Figure 3. Fire location map provided by Relief Web (27 July 2007)

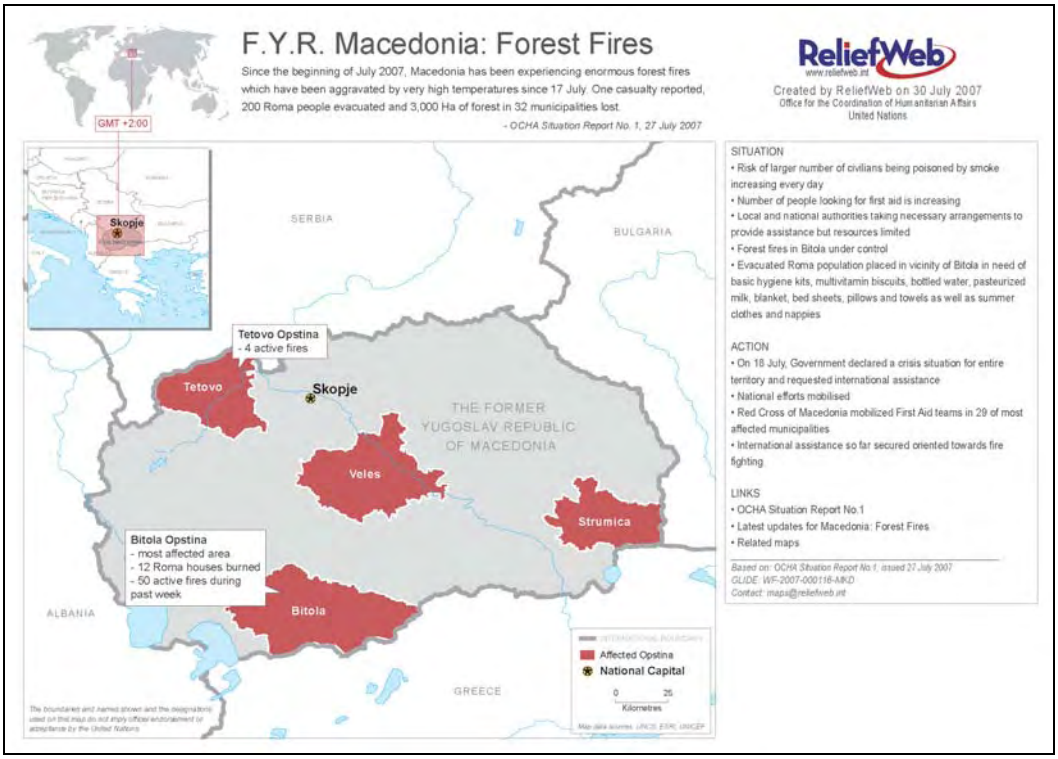

Figure 4. Fire location map provided by Relief Web (30 July 2007)

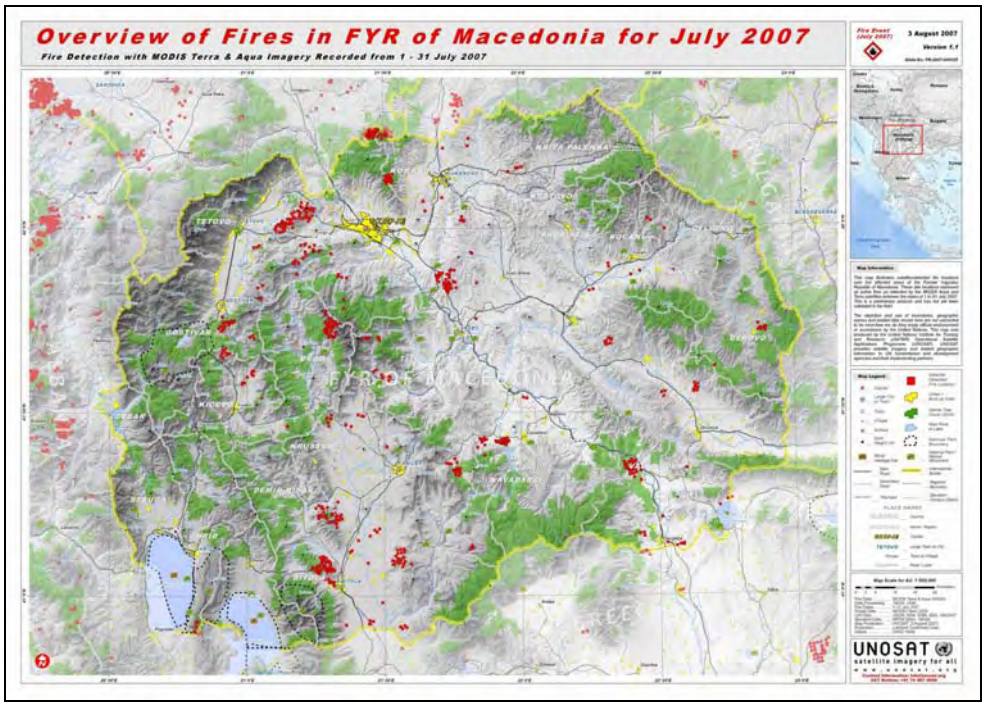

Figure 5. Fire location map provided by UNOSAT for the period 1-31 July 2007

Table 5. Received assistance for the fire crisis situation in 2007

Received Assistance for the Wildfire Crisis Management						
	State or Institution	**Assistance in FF equipment**	**Assistance in expertise**	**Financial assistance**	**Value ($US)**	**Value (€)**
(1)	**Norway**	FF equip.				494,963
(2)	**Sweden**	FF equip.	2 experts		110,375	
(3)	**France**	1 FF vehicle	6 experts			
(4)	**Austria**	FF equip.	2 experts			7,100
(5)	**Germany**	FF equip.				50,000
(6)	**Poland**	FF equip.				110,000
(7)	**Czech Rep.**	FF equip.				
(8)	**U K**	FF equip.	4 experts			
(9)	**Estonia**	/				31,956
(10	**Denmark**	FF equip.				
(11	**Israel**	FF equip.				
(12	**Lithuania**	FF equip.				
(13	**UNDP**	/		100,000	100,000	
(14	**UN OCHA**	Relief items		30,000	30,000	
(15	**UNICEF**	Relief items		100,000	100,000	
(16	**USAID**	/		50,000	50,000	
				Total	**390,375 $US**	**694,000 €**

Appendix 4 - Photographs

Selected photographs illustrate main fire phenomena encountered during the field mission.

Burned pine forest on a site with high erosion risk

Fire-affected informal settlement of Roma at the outskirts of Bitola

Infrastructure, e.g. telephone lines and electric power transmission lines at risk

Unexploded Ordnance (UXO) collected in the surroundings of Bitola and stored in the Army Base Bitola: During the fires in July 2007 more than 70 explosions of WW-I grenades and other UXO were recorded nearby Bitola.

The electric power plant Oslomej near Kicevo was at threat to be affected by wildfires burning at the very edge of the facility (left in the photograph) by burning embers (spot fires) falling out on the structures of the power plant.

Wildfires in Turkey 2007

1. Number, Area and Types of Forests and Other Vegetation Affected by Fire

Turkey is a country with a land mass of 77.079 million hectares (ha), of which 21.2 million hectares is forested, representing about 27.2 per cent of country's total land area (Orman Genel Müdürlüğü - OGM, 2007). About 12 million ha of forested lands is subjected to and under the threat of forest fires. Fire has always had a pervasive influence on forests of Turkey and their management, consuming thousands of hectares of forest land annually resulting in high suppression costs and causing great damages in lost timber, real estate and recreational values, and even loss of life.

Forest fire activity in the country is highly correlated with weather conditions, land use practices and vegetation associations (Canakcioglu and Ozkazanc, 1997). The most fires occur where Mediterranean climate with high temperatures and low to nonexistent precipitation during fire season is predominant in the southern and western Anatolia. In the period 1937-2007, a total of 82,556 fires burned a total of 1,582,590 ha of forest land. This represents 1,163 fires on 22,290 ha annually with an average area burned per fire of 19.17 ha (OGM, 2007).

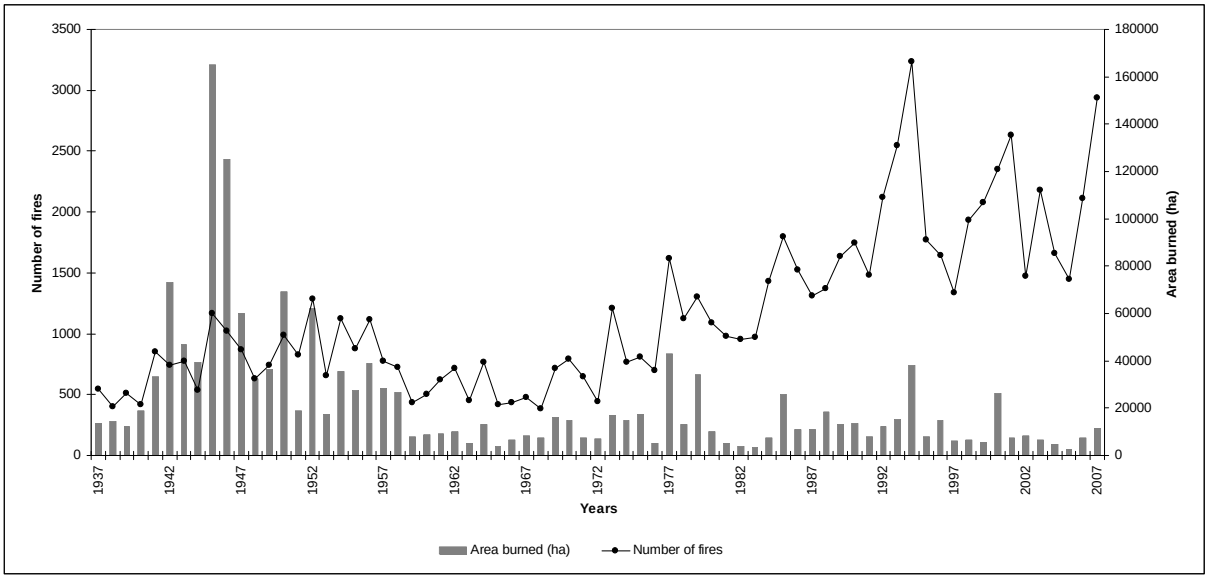

Figure 1. Forest fires in Turkey between 1937 and 2007 (Source: OGM 2007)

Average annual fire loss according to the last 10 year's data is about the 0.00061 % (Sixty one in One hundred thousand). This is a very low value compared to other countries in the Mediterranean Basin. Biggest damage was in Çanakkale (0.00183), and followed by Muğla (0.00171) İzmir (0.00139), Adapazarı (0.00130), Adana (0.00129) and Antalya (0.00118). In the period 1998-2007, a total of 20,702 fires burned a total of 87,913 ha of forest land. This represents 2070 fires on 8791 ha annually with an average area burned per fire of 4.25 ha (OGM, 2007).

As can be seen from the figures, there has been a gradual increase in the number of fire starts and a decrease in area burned. This may seem contradictory, but it is not. Thanks to the technological advances and the lack of recognition of the ecological roles of fires in forest ecosystems, fires have been successfully kept out of these systems over the last several years.

2. Causes of Wildfires

Majority of forest fires in Turkey are caused by people. Human-caused fires account for 94 to 97% of all fires, while natural agents are responsible for the remaining 3 to 6%. People-caused fires can be examined under three broad categories – voluntary, involuntary, and unknown fires. Of the human-caused fires, according to the recent statistics, 14 per cent is classified as arson, 58 per cent as negligence and carelessness, 5 per cent accident, and 23 per cent as unknown (Bilgili et al., 2004).

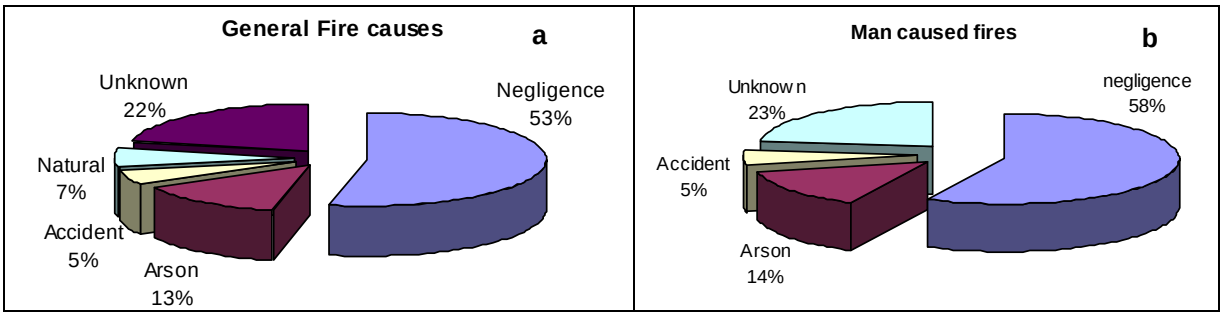

Figure 2. Fire incidences by causes: (a) general, (b) human caused fires

According to the last ten year's statistics, fire causes are: negligence and carelessness, 48 per cent; arson, 14 per cent; lightning, 4 per cent; and unknown, 34 per cent (OGM, 2007).

According to the last year's (2007) statistics, fire causes are: negligence and carelessness, 55 per cent; arson, 16 per cent; lightning, 11 per cent; and unknown, 18 per cent (OGM, 2007) (Fig. 3).

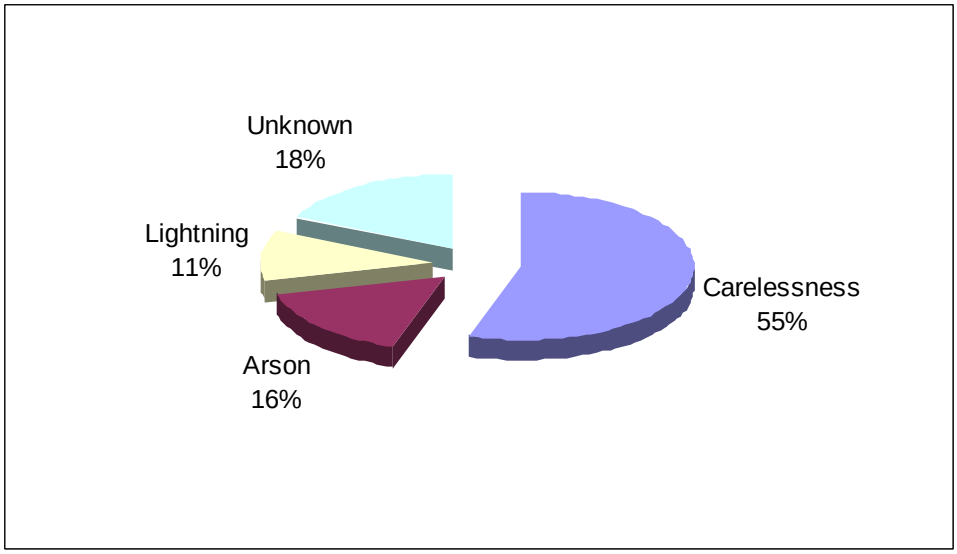

Figure 3. Fire incidences by causes in 2007

Arson fires are set for several reasons. About 7.8 million people live in 20,974 villages in or near forests (Anonymous, 2007). Socio-economic life standards of most of these people are well below the national average. People with low income and low life standards see the forests as an earning ground for their sustenance. Therefore, people set fire in the forest to create jobs that will earn them some provision or manipulate vegetation to improve and produce useful plants for their animals to graze. Personal conflicts between people and forestry officials or between shepherds or different villagers have also been reported to have been a cause for fires.

When examined in detail, it is very obvious that fire causes are closely related with land management activities, standards of living, population dynamics and associated public policies. Thus, to better understand the underlying causes of fires, the subject should be examined in relation to these factors.

3. Extreme Fires

Table 1 shows the fires burned in 2007 exceeding 100 ha. Almost all fires started in the high fire season when relative humidity was relatively low and temperature high. Coupled with the rugged topography, high winds in almost all large fires augmented the rapid acceleration of fire spread.

Table 1. Fires burned in 2007 exceeding 100 ha

No.	Regional Directorate	State Forest Enterprise	Forest Conservation Unit	Date	Time	Forest Type	Area burned (ha)
1	Balikesir	Balikesir	Balya	25/8/2007	16.15	HF	100
2	K.Maras	Antakya	Yayladagi	28/7/2007	13.30	DF-DC	105
3	Kutahya	Emet	Hisarcik	25/7/2007	14.10	HF	110
4	Istanbul	Vize	Cerkezkoy	25/8/2007	12.00	HF-DF	112
5	Bursa	Bilecik	Osmaneli	28/6/2007	15.25	HF	127
6	Denizli	Usak	Usak	18/7/2007	10.55	HF-DF-DC	130
7	Antalya	Kas	Saklikent	6/9/2007	14.15	HF-DF	140
8	Adapazari	Golcuk	Karamursel	9/7/2007	13.00	DF	144
9	Izmir	Manisa	Manisa	15/8/2007	10.20	HF-DF	156
10	Bursa	Bursa	Kestel	24/8/2007	14.00	HF-DF	168
11	Antalya	Kumluca	Akdag	21/6/2007	11.00	HF-DF	185
12	Adana	Osmaniye	Hasanbeyli	16/7/2007	16.30	HF	187
13	Balikesir	Balikesir	Akdogan	25/8/2007	15.15	HF	196
14	Mugla	Milas	Milas	15/7/2007	11.55	HF-DF-P	223
15	Amasya	Vezirkopru	Karacam	12/8/2007	14.00	HF	272
16	Adana	Saricam	Saricam	23/8/2007	17.00	P	283
17	Izmir	Izmir	Bornova	15/8/2007	11.20	HF-DF	290
18	Mugla	Milas	Bodrum	7/7/2007	11.05	DF-HF	308
19	K.Maras	Antakya	Yayladagi	16/7/2007	15.30	HF-DC	317
20	Antalya	Manavgat	Selale	8/7/2007	9.40	HF-P	321
21	Antalya	Kas	Kasaba	23/7/2007	14.50	HF-DF	324
22	Kutahya	Simav	Sogut	25/7/2007	14.45	HF	380
23	Mugla	Kemer	Kemer	19/5/2007	19.00	HF-P	390
24	Antalya	Tasagil	Burmahan	24/8/2007	11.00	HF-DF	513
25	Mersin	Gulnar	Pempecik	16/7/2007	15.45	HF	911

HF: High Forest; DF: Degraded Forest; DC: Degraded Coppices; P: Plantation

3. Fire Damages

80% of the forest fires occurred between June and October. Most of the fire damages in 2007 occurred in Mugla, Izmir, Kütahya, Antalya and Adana Regional Forest Directorates.

The budget allocated in the year 2007 for suppressing forest fires was 155 million Euros (225 million USD). Available resources included 838 fire trucks, 29 helicopters, 20 airplanes, 780 fire look-out towers, 144 water tankers, 142 bulldozers, 38 loaders, 126 graders, 115 trailers, 52 caravans, 717 motorbikes, 8,472 radio, 650 fire crews (of 5-7 men). As needed new resources are being added and new technologies adopted. These forces are allocated to each district based on fire danger levels and area in question. In addition, 1,756 km of tower road, 18,559 km fuel breaks, and 8,899 km fire breaks are in place. There are also 600 water ponds and pools.

4. Fire Prevention Measures

The year 2007 has seen more activities concerning fire prevention, pre-suppression and suppression. Many educational, social programs have been launched to increase the level of public awareness

concerning the forest fires. Many ponds have been constructed and water tankers bought in 2007. These have come in handy in fighting many potentially disastrous fires. Fire crews have been strengthened with new recruits.

5. Response to Fires

All fires have been attended to and dealt with according to the fire control plan prepared for each district. These plans envisage all the steps from observation to control and to mop-up of fires.

Figure 4. A village damaged by wildfire (Photo: OGM)

Figure 5. OGM firefighters in action (Photo: OGM)

6. National Cooperation in Responding to the Fires

Role of agencies at national and provincial level

Fire management in Turkey is a state responsibility. Duties are carried out by the state forest enterprises functioning under regional directorates. Fire control policies have been developed around a strong emphasis on total fire control as a response to destructive fires. Regardless of the high costs involved, it is the forest service department's responsibility and policy that all the required activities are planned and implemented immediately.

Risk is associated with ignition, and risk abatement involves raising the level of awareness of general public and various responsibility groups to the dangers of ignition and subsequent forest fires through education and enforcement. It is of the opinion of the forestry service that a strongly favorable public opinion is a vital necessity in any effort to reduce the number of people-caused fires.

Role of local communities

Local people are responsible by law to immediately to respond to a fire situation when and if requested. The response of the local people and communities to a fire has risen considerably in recent years. This has mostly been a result of the changing attitudes towards forest resources and of the success of the public awareness campaigns.

Non-governmental organizations help raise the level of awareness of general public and various responsibility groups to the dangers of ignition and subsequent forest fires through education and conducting/supporting relevant activities. These activities involve seminars, TV/radio programs, practical field work, and suggestions brought to the attention of policy makers.

Academia has a very important role in all aspects of fire management. However, their effectiveness has been fairly limited. Only in recent years, however, have the scientific studies been increasingly conducted and the results obtained put into practice. The most important step in this regard has been step taken for the establishment of a National Fire Danger Rating System.

7. International Cooperation

The Balkan region has seen one of the worst fire seasons in recent history. Many countries have suffered extreme losses. This has necessitated the international cooperation in fighting forest fires. In this regard, Turkey has sent help to neighboring countries (Tab. 2).

Table 2. Countries that received help from Turkey in fighting fires in 2007

Country	Resources
Syria	2 aircrafts, 4 helicopters
Greece	1 aircraft
Macedonia FYROM	1 aircraft, 2 helicopters

8. Analysis and Recommendations

Recent fire events have made it extremely clear that fire is a phenomenon beyond the national boundaries and requires immediate international attention to mitigate its negative effects and understand its ecological role in forest ecosystems. This calls for a genuine cooperation of all parties somehow affected from fires.

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Republic of Armenia – Forest Fires in 2007

Introduction

In this short report a brief assessment of fire situation in the country is given reflecting the situation by the end of 2007.

Table 1. Fire statistics of the Republic of Armenia 1998-2007

Year	Total Number of Wildfires	Number of Forest Fires*	Forest Area Affected (ha)	No. of other Vegetation Fires	Area of Other Vegetation Affected (ha)
1998	1403	32	322.65		
1999	1162	13	68.07		
2000	1203	35	25.04		18.9
2001	1290	13	126.87		139.8
2002	1003	4	5.4		0.2
2003	974	4	0.4	133	3.52
2004	1271	2	1.5	459	12.0
2005	1124	10	20.125	280	25.35
2006	1241	10	299.5	951	34.36
2007	832	1	12.5	655	

***** Note: Mainly in juniper, oak and pine forests

Wildfires in 2006-2007

One of the extreme fires happened in the summer of 2006 in Meghri region, when almost 190 ha of forest and around 80 ha of vegetation were burned. The cause is unknown. The fire conditions were determined by the extremely and unusually hot, dry and windy weather conditions during summer 2007. After the emergency call, the regional authorities mobilized the fire fighting forces to suppress the fire, which took 10 days. One person was injured. Mainly oak trees suffered from the fire.

In 2007 the only fire in the territory of the Republic of Armenia occurred in the area of Yerevan forestry territory during the summer. The territory was afforested between 2004 and 2007. The main area that was burned, however, was grass and shrub vegetation, and no harm was caused to forest cultures. The fire was responded swiftly by personnel of the forest and fire services. The economic damages were negligible.

Causes of wildfires

The main reasons of forest and wildfires in the territory of the Republic of Armenia are human-ignited fires, mainly fires escaping from stubble burning or burning of post-harvest residuals on croplands, or sometimes accidental ignitions.

Fire Damages

The fire damages in Armenia have been estimated for the decade 1998-2007 (Tab. 2).

Table 2. Estimation of fire damages in the Republic of Armenia 1998-2007

Fire damages				
Year	**Forest fires**		**Other fires**	
	Arm Dram	**US Dollars**	**Arm Dram** (millions)	**US Dollars**
1998	1,507,246	2,843		
1999	698,736	1,318	119.4	221,930
2000	1,396,199	2,649	411.6	781,020
2001	55,652,250	101,555	108.9	198,700
2002	314,500	600	221	384,350
2003	no damage	no damage	146.7	248,645
2004	975,178	1,735	318.9	567,440
2005	15,707,375	33,491	235.2	501,500
2006	500,241,800	1,106,729	382	845,130
2007	no damage	no damage	331	945,700

Figures 1 and 2. Typical wildfires on agricultural and pasture lands in Armenia caused by crop residual and intentional pasture burning. Photos: GFMC.

Fire prevention measures in 2007

According to the “Civil Defense Action Plan 2007” of the Ministry of Agriculture of the Republic of Armenia the regional branches of the state enterprise “Armenian Forest” (*Hayantar*), a non-profit organization, in Vayots Dzor and Lori regions of Armenia organized training in 2007 on “The suppression of fires and the organization of liquidation of their consequences”. The training was organized for the regional authorities and emergency agency employees.

Action of agencies at national, provincial and local levels

Every year *Hayantar* is preparing and distributing to its regional branches a plan of action for fire prevention and preparedness. The plan includes particularly the construction of emergency routes (roads) and maintenance / repair of the old roads, as well as the creation and maintenance of firebreaks.

The regional offices of *Hayantar* and local authorities are undertaking every year a number of activities, which include:

- Awareness raising and preparedness of the local population to the activities concerning the prevention and suppression of forest fires
- Provision of equipment and transportation, including replenishment of fuel stocks for transportation
- Preparation of rules on service, food and provision of drinking water for the supply of firefighters
- Provision of 24-hour duty in the buildings of *Hayantar* local offices and forestry units
- Organization of fire patrols in forests
- Preparation of the fire-fighting equipment and transport means for standby for quick response to a fire alert
- Forbidding the entrance of the population to the forests during the high fire-danger periods of the year

International cooperation

In 2007 there was neither assistance received from neighbor countries and other countries nor assistance provided to neighbor countries and other countries

Analysis and recommendations

At the local and provincial levels there is a need to establish separate groups in Syunik, Tavoush and Lori regions of the Republic of Armenia – the regions with the main concentration of forests – which will be fully equipped with fire-fighting equipment, transportation etc.

At the local and provincial, as well as national level there is a strong need of modern technical equipment, including fire-protection equipment, communication means and personal protective equipment (clothing), as well as transportation. Administration buildings and foresters houses are insufficiently equipped with technical and communication means.

There is a need for meetings and workshops on technical issues on national, regional and international levels. There is a need for reforestation of lands affected by the fires, joint fire research, and regional cooperation in fire, water and related environmental management.

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Review and Analysis of 40 Years of Fire Damages in Forests and Rangelands of the Islamic Republic of Iran (1968-2007)

Introduction

Out of the territory of the Islamic Republic of Iran of 136 million hectares (ha) the share of forests is 14,202,559 ha. Rangelands are covering an area of 90 million ha. 62% of the forest lands (8,855,870 ha) are located in the Zagros mountain range, and 13 percent (1,847,886 ha) in the North of the country, and the remainder (3,549,086 ha) distributed all over the country. The forest cover corresponds to 0.2 ha per capita (for comparison: globally the forest cover per capita is 0.8 ha). Iran is on 4th place of forest cover of the countries between northern Africa and Middle East.

Table 1. Forest surface in the North and the South of Iran by forest type (in ha)

Forest Type	Forest Area in other Parts of the Country (ha)	Forest Area in the North of the Country (ha)	Total	Percent (%)
Dense Forests	755,777	940,826	1,696,603	12
Semi- Dense Forest	286,846	593,927	3,400,773	23.9
Sparse Forest	7,842,183	313,133	8,155,316	57.4
Wetlands Forest	30,400	-	30,400	0.2
Planting Forest	919,468	-	919,468	6.5
Total	12,354,673	1,847,886	14,202,559	100

The area of forests in Iran has been reduced by half during the last 30 years. There are many reasons to destroy forests but one of the most important ones is fire. Fires are also affecting rangelands. The use of fire and inability to control are the main reasons for fire damages.

Materials and methods

Wildland fire statistics were collected (fire cases and burnt area) in all regions of Iran (29 provinces). Statistical data from provinces were compared and thus sensitivity to fire of provinces evaluated.

Discussion

Table 2 shows that, for example, the average of daily burned surface in the year 1968 was 3.94 ha. This daily rate has reached 122 ha in 1977. Thus, during 30 years, this amount has increased 31 times. In 2007 it decreased to 76.7 ha due to improved monitoring, protection and control by the forests and rangelands organization.

The comparison statistical data shows an increase of the average of burnt surface of forests and rangelands since the decade 1968-1976 by 7.5 times in the recent three decades (Table 2).

Table 2. Number of fire cases, burnt surface in ha, burnt surface average during 40 years per day

Time Period	Number of Fires	Total Area of Forests and Rangelands burned (ha)	Average Surface Burned in each Fire (ha)	Area Burned in each Fire (ha)	Damages (million $US)
1968-1976	701	21,643	30.9	5.9	5.0
1977-1986	1,210	68,302	56.4	18.7	15.9
1987-1996	3,635	148,943	41	40.8	34.6
1997-2006	10,426	162,191	15.6	44.4	37.6
Totals and Averages	**15,972**	**401,079**	**36**	**27.45**	**93.1**

Causes of wildfires

The causes of wildfires in natural vegetation in Iran are classified as follows:

a) Human factors:

Intentional burning:
- To provide more space for agriculture and animal breeding
- Local and racial conflicts
- Conflicts between people and government and guards of natural resources

Accidental and negligent fires:
- Inattention of tourists
- Inattention of farmers, shepherds, hunters, charcoal makers, mine workers, nomads and villagers
- Throwing incendiary materials by passengers
- Inattention to using residues and pieces of trees products for creating fire
- Using fire to control harmful insects, birds and reptiles
- Use of fire by honey collectors during exploitation of natural and artificial beehives
- Explosion of dynamite by road construction and, drilling mining companies
- Children and narrow-minded people
- Fireworks in the forests and rangelands
- Military activities (use of tracer bullets and exploding land mines)
- Garbage burning
- Smokers
- Car accidents
- Explosions caused by gas pipelines crossing forests and rangelands

b) Non-human causes:

- Lightning

According to the data provided by the Organization for Forests and Rangeland Protection 2,483 fire cases that occurred between 1968 and 1992 reveal the distribution of causes (Table 3).

Table 3. Causes of wildfires in forests and rangelands of Iran

Fire Causes	Number of Fires	Percent
Intentional fire	292	11.7
Negligence	1,185	47.7
Unknown cause	995	40.1
Lightning	11	0.5
Total	**2,483**	**100**

Fire seasons

The fire seasons differ in regions throughout the country. The fire season in the northern forests and rangelands of Iran begins with the foliage loss in autumn and the influence of warm Mediterranean winds which rise temperature and decrease moisture. This situation lasts until the beginning of snow fall in winter (from 1 October to 20 December).

In other parts of country this season starts with decreasing humidity and rising temperatures from 15 April to 20 November.

Different provinces of country are divided to three groups according to sensitivity to fires:

1. Very critical provinces: These provinces are at the first place for number of fire cases and burnt surface – Kordestan, Lorestan, Fars, Kermanshah and Ilam.

2. Critical provinces: Golestan, Kohgilloyeh and Bovairahmad, Chaharmahal and Bakhtiary, and Boushehr.

3. Low-risk provinces: Mazandaran, Hamedan, Hormozgan and all other provinces except the above-listed.

Analysis of damages of forests and rangelands in the past 40 years

The calculation of damages in terms of money is difficult or almost impossible concerning the intangible benefits, e.g. emotional benefits of forests like pleasure of recreation in the natural environment, damage to natural flora and fauna, soil and water resources.

However, it is possible to calculate damages of some products such as wood, provender, cosmetic and medicinal plants. All financial damages have calculated $US 93.1 million during the last 40 years (without considering spiritual, non-tangible benefits).

According to Table 4 the annual area destroyed by fire amounts to about 10,027 ha of forests and rangelands. But the velocity of increase of these damages has been 31 times as much from 1968 until 1997. The total burned level was 1,442 ha in 1968, while this amount has been 44,596 ha in 1997.

Table 4. Calculation of burned surfaces and financial damages in $US

Time Period	Number of Fires	Burned Area (ha)	Damages ($US)
1347-1386 (1969-2008) (accumulated)	15,972	401,079	93.1 million
Average annual damages	399	10,027	2.3 million

Problems and barriers to improve the protection of natural resources

The main problems for insufficient protection of nature include:

- Disagreement between responsible land management authorities: Although in Iran forests and rangelands must be controlled by the Organization for Forests and Rangeland Protection there are four zones for organizing environmental protection considering native cultures of Iran. In some regions forests and rangelands have been divided among native people, and this process is continued. There is no coordination between native tribe groups and the Organization for Forests and Rangeland Protection.

- Lack of resources: Due to the lack of security guards the Organization for Forests and Rangeland Protection offenses against forest regulations cannot be encountered. In some cases officers and workers of the Organization for Forests and Rangeland Protection cannot do anything because of poverty of people. For example in provinces which tribes are living, most of people are earning for their livelihood by harvesting and selling forests and rangeland products. Preventing this will result in increase of unemployment in those regions.

- Transition and changes of jurisdiction and management responsibility from the Ministry of Natural Resources to the Ministry of Agriculture, and the separation of the Ministry of Agriculture from the Ministry of Jihad, and again merging them, were harmfully affecting the state of nature protection in Iran.

Suggestions for possible solutions

The following recommendations are given for improving natural resources and avoiding detrimental wildfires:

- Training of staff of the Organization for Forests and Rangeland Protection must be improved. Financial resources must be provided for the Organization for Forests and Rangeland Protection. Specialists must be trained at various levels, including training by institutions for higher education. For example throughout Iran there is no specialist who has a higher education in the field of forest fire science and / or management.
- The establishment of a National Fire Management Center in Iran is necessary. This Center should be connected to the Global Fire Monitoring Center (GFMC), which at present does not have classified information about fires occurring in forests and rangelands of Iran.
- In various regions of Iran trees which are resistant to fire must be recognized and be used as green fire protection belts.
- Improvement of training, research and administrative capabilities by appropriate funding to pay more attention to forest and rangeland fire in Iran.
- Adding the subject of wildland fire science and management to the subjects offered by Iranian universities.
- Prioritize definition and protection of high-risk wildfire zones in Iran, and for post-fire recovery of forest and rangelands affected by fire.

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Advance Publication of Wildland Fire Statistics for Russia 1992-2007

This advance publication is serving the increasing demands for statistical data on forest fires and fires burning other vegetated lands in the Russian Federation. Please see the sources and explanation of different datasets in the footnotes of the table.

Table 1. Comparative fire statistics for total vegetated area and forest area burned in the Russian Federation in the period 1996 to 2005, based on agency reports and remote sensing.

Year	Agency Reports based on Ground and Aerial Observations [1]			Satellite-Derived Data (NOAA AVHRR) Based on Fire Counts and Derived Area Burned [2]			
	Number of Fires Reported	Total Area Burned (ha)	Forest Area Burned (ha)	Total Number of Fires (events investigated)	Total Area Burned (ha)	Number of Forest Fires	Forest Area Burned (ha)
1992	17 617	885 541	497 819				
1993	14 478	1 098 889	719 352				
1994	14 783	644 737	488 430				
1995	17 615	412 029	322 710				
1996	22 623	2 209 654	1 789 583	7 006	4 723 430	3 544	3 164 410
1997	23 090	861 148	643 969	3 402	3 546 870	1 580	2 376 490
1998	15 931	3 000 569	2 365 017	6 046	8 977 640	2 808	6 015 260
1999	18 138	711 799	533 150	7 835	4 566 080	3 639	3 059 220
2000	13 447	1 117 799	898 911	7 982	6 147 300	3 440	4 118 490
2001	14 561	1 220 305	792 357	6 335	5 212 800	3 050	3 490 560
2002	19 066	1 856 730	1 204 757	10 178	10 626 170	4 462	7 130 340
2003	21 699	2 634 722	2 071 057	15 707	17 937 800	8 852	14 510 230
2004	16 729	532 184	424 404	7 862	4 445 530	3 411	3 080 300
2005	10 923	963 000	706 900	19 526	9 288 550	7 114	5 180 400
2006	14 930	1 842 114	1 179 766	21 744	13 105 264	10 468	8 490 840
2007	9 776	1 082 517		23 024	9 975 250	10 069	6 468 880

Note: Starting in 2007 *Avialesookhrana* is providing only total area burned data

[1] Agency data provided by the Aerial Forest Protection Service *Avialesookhrana* of Russia for the fire-protected forest land under the jurisdiction of the Federal Forest Agency (Federal Forest Fund). In the average these statistical data represent ca. 90% of fires recorded statistically. The remainder of ca. 10% is data collected within the responsibility and jurisdiction of other agencies, e.g. the National Park Service.

[2] Satellite data provided by the Sukachev Institute of Forest, Remote Sensing Laboratory, Russian Academy of Sciences, Siberian Branch, Krasnoyarsk, Russian Federation, courtesy A. Sukhinin. The Krasnoyarsk satellite receiving station is covering the Russian Federation between the Ural Mountains in the West and Sakhalin Island in the East and recording fires and area burned independent of landownership. Compared to the data published in 2006 (Goldammer, 2006), this table includes updated and corrected data of burned areas based on a revision of the NOAA AVHRR database, using Landsat-7-ETM images. It was found that non-corrected NOAA data provide area burned exceeding 27% in comparison with Landsat data. The recalculation of data derived from active fire data involved the application of sub-pixel multi spectral methods for estimating the area of small fires and for correcting the areas of large fires. The daily geoposition of each fire line (fire edge) of fires, which continued several days, was corrected. In conclusion it is stated that due to low spatial resolution of AVHRR and the non-precise geolocation of AVHRR-derived fire sites a systematic mistake led to an overestimate of the burnt area as published earlier (Goldammer, et al. 2005). Values of burnt areas have been corrected for the Siberian Federal District, Yakutia and Far East. The number of fires was also corrected by combining separate single active fire signals with the nearest cluster of recorded

The following maps show examples of regular updates of fire information in the Russian Federation by the Global Fire Monitoring Center (GFMC). The examples are taken from the daily SITREP of 7 May 2007: http://www.fire.uni-freiburg.de/GFMCnew/2007/05/0507/20070507_ru.htm.

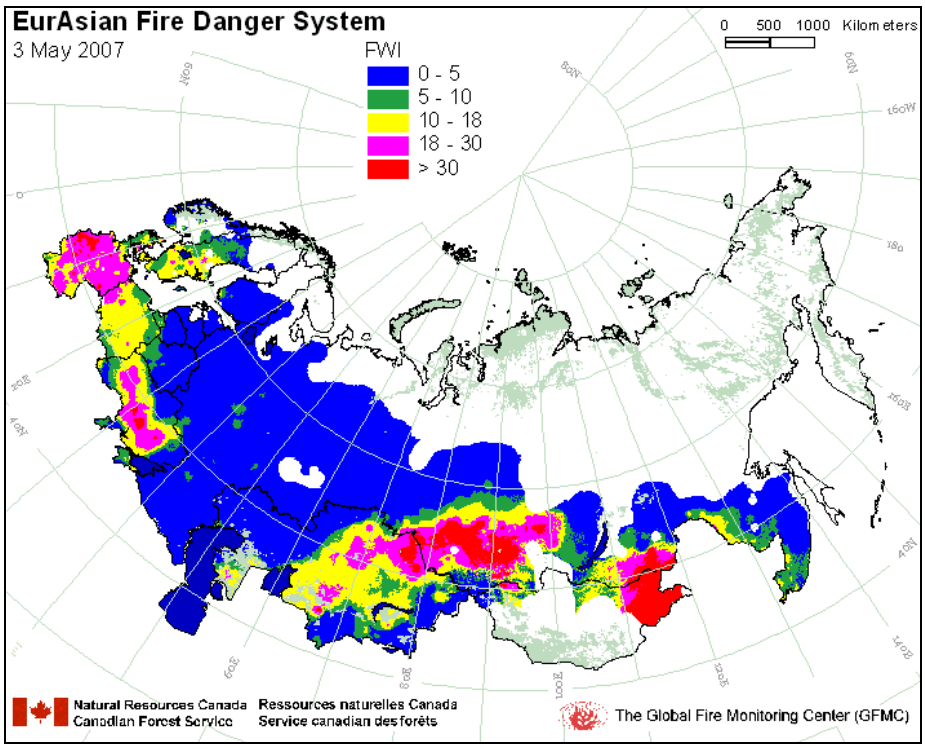

Figure 1. The Eurasian Fire Weather Information System is based on the Canadian Forest Fire Danger Rating System (CFFDRS) produced by the Canadian Forest Service and accessible through the Global Fire Monitoring Center (GFMC). This map shows a typical daily forecast of the Fire Weather Index (FWI) for 3 May 2007.
Source: GFMC (http://www.fire.uni-freiburg.de/fwf/eurasia1.htm)

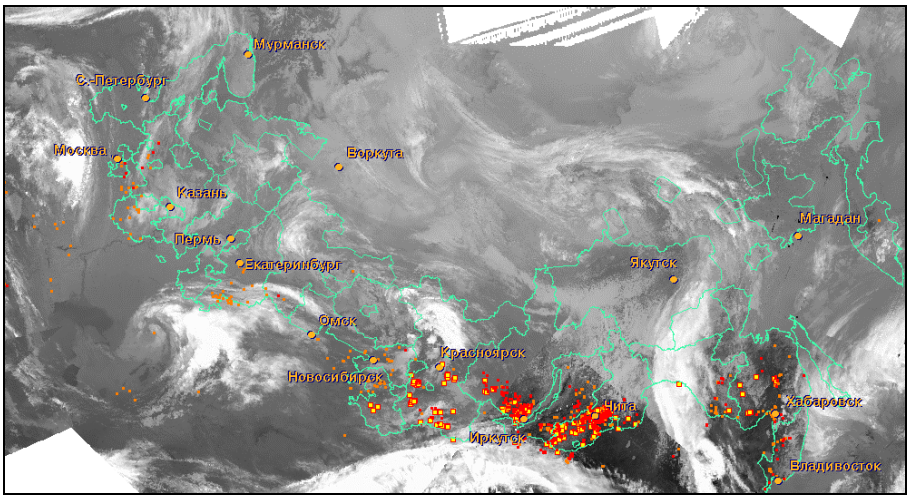

Figure 2. This satellite (NOAA 12&14 AVHRR) composite of 7 May 2007 (04:00 GMT) is an example of daily satellite images published by *Avialesookhrana*. The red squares indicate locations of active fires depicted by the MODIS sensors.

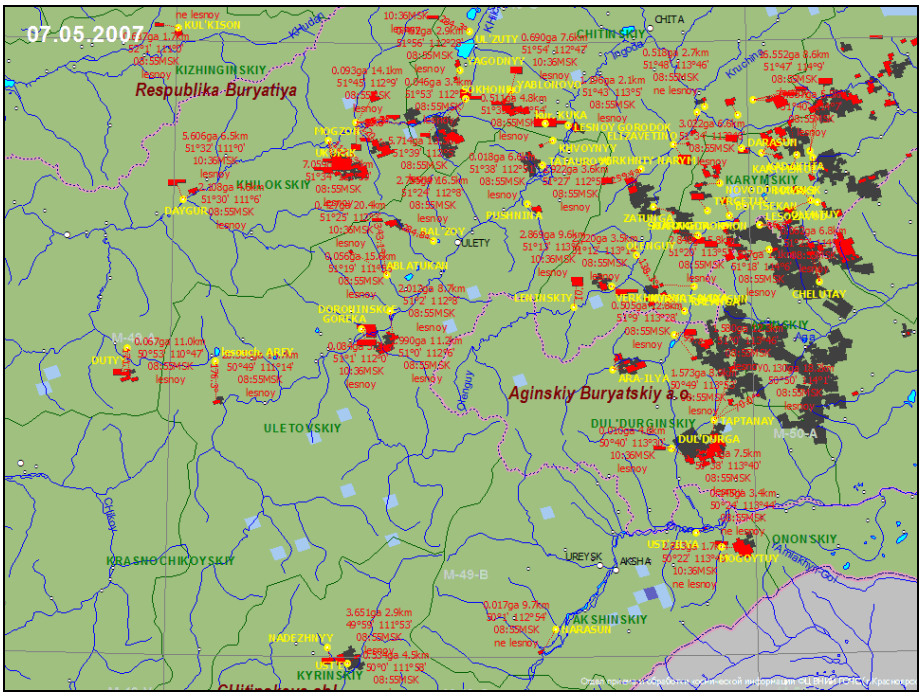

Figure 3. Example of a detailed fire maps produced by the Fire Laboratory of the Sukachev Institute of Forest, Krasnoyarsk, in collaboration with the Emergency Situation Monitoring and Forecasting Agency, Krasnoyarsk. The maps are produced on the base of satellite data (classification by the NOAA AVHRR). They show the fire locations (by latitude and longitude) and the area affected by fire (red signature = active fires of the day; black = area burned during previous days, size in ha). The red arrow at each fire location points to the nearest populated place. The active fires are derived from the MODIS sensors.

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RESEARCH & TECHNOLOGY

An Innovative Conceptual Model of a Forest Fire Management Information and Decision-Support System for Brandenburg State, Germany

Abstract

Research and development conducted within the Forest Fire Cluster of the German Research Network on Natural Disasters is built on a number of separately evolved concepts that were integrated in a cooperative research project. The Forest Fire Cluster has the responsibility of three major components. The first component consists of an innovative conceptual model for a fire information system and decision-support for early warning, monitoring, information management and simulation of wildfires in pine forests of Brandenburg State, Germany. The second component provides the link between the locally applicable system and a global fire information system provided by the Global Fire Monitoring Center (GFMC). The third component includes modelling of historic occurrence and future trends of fire occurrence due to regional climate change and is implemented by an associated project of the Potsdam Institute for Climate Impact Research (PIK), and it is published separately.

The first component is composed by a number of different modules. Firstly, it includes the adaptation of established fire behavior simulations models (BEHAVE, FARSITE) implemented by the Fire Ecology Research Group. For the first time a fire behavior model has been applied for the specific conditions of pine forests in the eastern, continental part of Germany, including the interspersed heathlands that constitute an important carrier of a wildfire at landscape level. The characteristics of these forests are quite typical for temperate-hemiboreal pine forests of Eurasia. Secondly, it includes a fire detection component (Automated Fire Detection System - AWFS) implemented by the German Aerospace Center (DLR). The development of the AWFS meets the requirements for fast, cost-effective and reliable fire detection system. And thirdly, it includes a fire danger rating and forecast system implemented by the (German Meteorological Service - DWD). The national fire-danger rating system has consolidated during the project lifetime. During the research project the work of the Global Fire Monitoring Center (GFMC) constituted the link from national to international levels.

The value added by the research project is a mutual support of individual research projects and their final merging into a comprehensive decision-support tool for fire management. Insight gained by the research project concerning the operational use of satellite remote sensing information in the management of active wildland fires will be useful for the development of urgently needed operational spaceborne fire systems.

Keywords: Forest fire, wildland fire, decision support, fuel classification, fire behavior, fire weather, fire detection, fire modelling, dispatch, remote sensing.

1. Introduction

The current high probability of forest fire occurrence in Brandenburg, Germany resulting in part from low precipitation, sandy soil sites with low water-holding capacity, and the fire hazard of the prevailing fire-prone pine forest stands, might further increase due to climatic change (Thonicke and Cramer, 2006). The cluster “Forest Fire” within the German Natural Disaster Research Network (DFNK) analyses current fire hazards and provides tools required for advanced operational decision support for wildfire response. This cluster research has the responsibility of three major components. The first component consists of an innovative conceptual model for a fire information system and decision-support for early warning, monitoring, information management and simulation of wildfires in pine forests of Brandenburg State, Germany. This component includes the adaptation of established fire behavior simulations models (BEHAVE, FARSITE) implemented by the Fire Ecology Research Group, a fire detection component (Automated Fire Detection System – AWFS) implemented by the German Aerospace Center (DLR) and a fire danger rating and forecast system implemented by the (German Meteorological Service - DWD). The second component provides the link between the locally applicable system and a global fire information system provided by the Global Fire Monitoring Center (GFMC). The third component includes modelling of historic occurrence and future trends of fire occurrence due to regional climate change and is implemented by an associated project of the

Potsdam Institute for Climate Impact Research (PIK); the report of the third component is published separately.

Accordingly, the structure of this work follows this general cluster scheme and it is presented in sections each one corresponding to a specific issue raised in each component. To help the readers follow we briefly present this general scheme which it is distinguished into the research components for building a fire information system and the implementation of the fire information system. The former consists of three modules that is fire behavior simulation models, automated fire detection system, and fire danger rating and forecast system. The concepts, methods and results of each one of these modules are presented in details in the following corresponding sections. The implementation of the fire information system operates as an umbrella and intends to put together all modules by providing a common basis for their requirements and needs.

What it is aimed by the implementation of the forest fire management information and decision-support system is a multi-function based system to cover not only the fire behavior modelling-simulation part but to cover also various research and applied issues in wildland fire management. This fire information system could be also utilized as a warning solution by estimating fire risk potential given that a network of weather stations can be online connected with it. The ability to simulate a real process under hypothetical scenarios can help to acquire a prior knowledge about the effects and outcomes resulting from such processes and contribute for a better fire management and planning. An optimized dispersal of fire fighting forces especially under conditions of limited resources can be achieved by utilizing a prior knowledge of fire behavior acquired by the simulation. The fire simulation provides a lot of insight of what has to be expected from a particular fire situation, not only in terms of the physical parameter of a fire (rate of spread, intensity). The simulation on a landscape scale allows the prediction of fire direction and its behavior in the field setting. Dispatching of firefighting resources will be made much easier and effective.

2 Forest and Heathland Characteristics in Brandenburg, Experimental Site of 2001

The Forest Fire Experiment 2001 was conducted at various forest stands that have characteristics typical for extended pine forest stands in Brandenburg State, Germany. For the development of a fire behavior model specific data are essential. As data like fuel load, rate of spread, flame length, temperatures and fire weather were not existing, live burning experiments were conducted to collect these input-data.

The experimental sites of 2001 are owned by Vattenfall Mining Europe (former Lausitzer Braunkohle AG) open-cast coal mining enterprise near the city of Cottbus (51°47'03"N, 14°24'20"E). The location and characteristics of the experimental plots, each between 0.3 ha and 1 ha surrounded by a clearcut buffer zone, provided suitable conditions in terms of safety for an experimental forest fire. Three of the plots were up to 100 years old low-productivity Scotch pine (*Pinus sylvestris* L.) stands with minor dimensions, typical for the region. The fourth plot was a 15-years old *P. sylvestris* stand. The fuel bed at all four plots consisted mainly of grass (*Calamagrostis* spp., *Deschampsia* spp.), forest litter and dead downed woody material. The fuel load (available fuel for the experimental fire) varied from 5 to 15 t ha^{-1}.

For the validation of a heathland fire model experimental fires were conducted in continental heathlands (*Calluna vulgaris* (L.) Hull.) in the Federal Forest Service District Lausitz in summer 2002. For these experimental fires the Federal Forest Service provided three plots (0.5 ha each) with homogeneous *C. vulgaris* cover.

The purpose of a heathland model was to include the heathland-forest interface in the decision support system in case of catastrophic wildfires. Open sites covered by heather vegetation located between forest complexes are suitable to rapidly carry a wildfire from a burning forest to the adjoining forest stand. The fuel loads on the heathland plots ranged between 9 and 15 t ha^{-1}.

Both experimental areas are located in the south-eastern part of Brandenburg State, a region with a very low level of precipitation and sandy soils with little water storage capacity. The climatic conditions for both experimental sites are as follows:

Climatic zone:	medium-dry lowland climate
Average temperature (Cottbus):	8.8 °C
Average annual temperature scale:	19.3°C
Average annual precipitation (Döbern):	627 mm
Precipitation during the vegetation period:	316 mm

The combination of the site characteristics with the inherent characteristics of the *P. sylvestris* stands and the *C. vulgaris* ecosystems result in a high wildfire hazard. Figure 1 provides a scene of the forest fire experiment conducted for the research project in 2001 that shows the spatial arrangement of surface and live crown fuels that lead to high-intensity crowing fire.

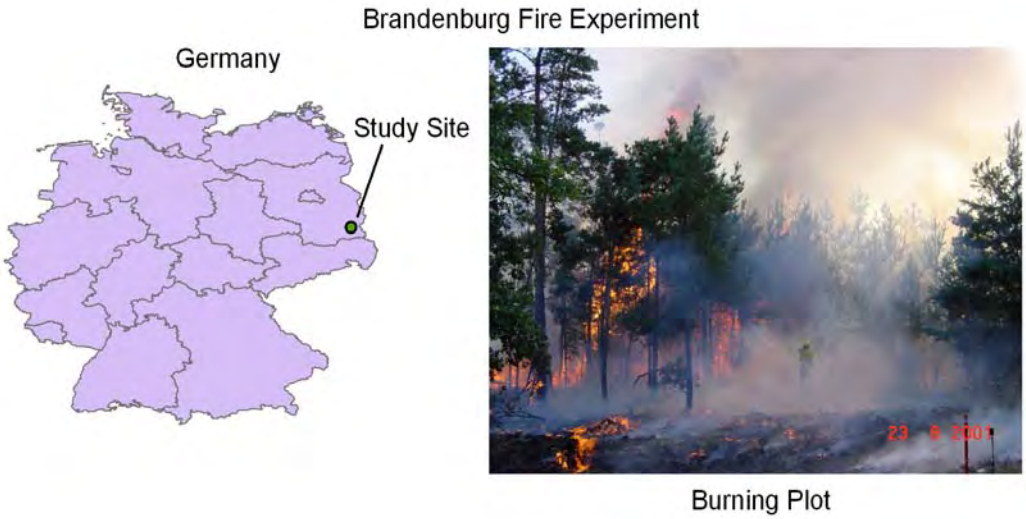

Figure 1. View of one of four burning plots of the Brandenburg Fire Experiment, 23 August 2001. The experimental site was structured inhomogeneously, thus allowing to observe a range of different fuel and fire behavior conditions.

3 The Research Components for Building a Fire Information System

3.1 Automated Fire Detection System AWFS

The Automated Fire Detection System AWFS (Kührt et al., 2000) provides the fire detection and location component of the Forest Fire Management Decision-Support System (Fig. 3). The AWFS was designed to meet the following technical requirements specified by German forest authorities:

- Automatically recognize smoke formation of 10 m expansion within a radius of 10 km and within 10 minutes after becoming visible
- High reliability in respect of fire recognition
- Acceptable rate of false alarms
- Localize the source of the fire
- Easy maintenance
- Automatic transmission of smoke data to a control center
- Full record-keeping of all events
- Data transmission to control center must enable the operator to independently evaluate the potential hazard
- The costs should be lower compared with the conventional method (fire detection towers operated by personnel)

Technical systems for forest fire detection use CCD cameras, infrared sensors, and spectrometers for detecting the smoke gases, laser backscattering, or other methods. AWFS tested in Germany is a system based on a high-resolution Frame Transfer CCD camera with special red-free filter which was

originally developed for space missions (Michaelis et al., 1999). AWFS detects fire by the trail of smoke within some minutes after its visibility. One system controls an area of about 300 square kilometers. The camera scans the forests from the top of the observation tower. The pictures are resolved with 14 bits and transmitted via optical fibers to the computer unit which is located in the tower. Here they are analyzed by specially developed software. At any detected smoke formation, compressed pictures and further details (time, position) are reported to the control center, where they are processed in a PC and displayed on a monitor. With a number of computer-assisted supports the operator is able to make reliable decisions.

3.1.1 Tests and results

AWFS was installed and tested on three observation towers in the State of Brandenburg, Germany, during the four forest fire seasons (1999-2002) and with special test activities. One of these activities was the Brandenburg fire experiment on 23 August 2001.

Each of the more than 120 fires which arose in the observed region of about 1000 km^2 during the test period was recognized within some minutes. The false alarm rate due to special weather conditions and harvest activities (dust clouds) commonly remained below 2 %, which is well acceptable for the operator who evaluates the alarms of several systems and calls the fire brigade.

The absolute bearing exactness of every camera is better than 1°. Therefore, several systems can locate the source of fire with approximately 100 m at a distance of 10 km. An impressive example for the precision of locating fires was a smoke signal of a structural fire in a small town in Brandenburg State, several kilometres away from the observing towers. With the intersection of bearings from two towers and the use of the digital map it was possible to determine the name of a short street in the town where the fire had started. The fire department was alerted immediately.

In the forest fire experiment in 2001 AWFS detected all four experimental fires within one revolution of the camera, i.e. within seven minutes. In one case the alert was already given about one minute after the smoke came up.

3.2 Fire Behavior Simulation Models

Since no adequate models exist to describe fire behavior under central European conditions, models developed and successfully applied in other regions had to be used and adapted. The standard software BEHAVE developed at the U.S. Forest Service Intermountain Sciences Laboratory (Rothermel, 1972) provided an appropriate tool, especially since they are representative for homogenous ecosystems and fuel arrangements. Predicted fire behavior parameters from the BEHAVE model were compared with those observed in Brandenburg's pine forests and heathland fires.

In a subsequent step, a fire dispatching and modelling system was created with FARSITE (Finney, 1998) at the forest district level. The FARSITE model contains the same algorithms and formulas as BEHAVE, but can be used to simulate fire on a range of landscape features with different fuel models using a GIS-approach. Thus, the data have to be prepared in raster format. The input data sets contain information about elevation, slope, aspect, fuel type, crown closure, stand height and crown bulk density (Finney, 1998). The fire itself is modelled as a moving elliptical wave, the shape of this ellipse is determined by wind and topography (Huygens’s principle, cf. Richards, 1990, 1995).

The work presented in this section describes the construction and testing of new and appropriate fuel models through fuel inventory and comparisons of predicted versus observed fire behavior parameters. Fuel models are one of the basic inputs to fire behavior simulation modelling and they are described by a number of parameters associated to fire propagation dynamics.

3.1.2 Field inventories

Fuel sampling within 35 pine stands in the region was conducted with the transect method by (Brown, 1974). A classification of fuels is possible into one of the four time-lag classes (1, 10, 100 or 1000 hours). The time-lag is defined as the time period required for a fuel particle to reach approximately 63% of the difference between the initial moisture content and the equilibrium moisture content in a different milieu (see Byram, 1963). This characteristic of the fuel particle is strongly correlated to its diameter, so in fire management one estimates the time-lag period by measuring the particles´

diameter. Dead and downed woody fuels have been grouped into classes that reflect the rate at which they can respond to changes in atmospheric conditions (i.e., 1-hour = <0.6cm, 10-h = 0.6-2.5 cm, 100-h = 2.5-7.6 cm and 1000-h = 7.6-20.3cm diameter).

Additionally, grass and duff sampling was done on 0.5 m^2 plots within the stands. The entire above-ground material was sampled to determine the oven-dry weight (load per ha).

The pine stands were classified using cluster analysis into six groups. Factors determining grouping were stand age and the time since last thinning. In young pine stands (<20yrs.), the litter layer consisted mainly of 1- and 10-h fuels, while grasses were not established yet. Older stands (21-40 yrs.) are structured similarly, but with higher amounts of available fuels. In later stand stages (41-60 yrs.) grasses and shrubs invade due to increased light availability on the forest floor. Old stands are characterized by thick duff layers, a continuous grass layer and less dead and down material. Very high amounts of dead and down material was observed in stands where thinning was conducted before their fifth year. Usually, thinning take place from stand age 35, so that younger stands are not affected. For detailed information on fuel classification in pine stands and other parameters included in the modelling process see Hille and Goldammer (2002).

Heathlands are rather homogenous fuels of a single species. The shrub *Calluna vulgaris* is classified as 'live woody fuel', dead parts of the plants and litter beneath them are considered as 1-h fuels.

Two of the created fuel models were actually validated in the field. Fuel model 23 was tested during a forest fire experiment in summer 2001 (Goldammer et al., 2001). The heathland model 26 was validated in summer 2002. Descriptions of all fuel models developed are summarized in Table 1.

3.2.1 Experiment results – Fuel model validation

Figure 2 shows the simulation results with the measured fuel and weather data during the fire as input into the BEHAVE-model and the observed fire characteristics. For the conditions measured during the fire, the BEHAVE-model calculates a fast increase of fire spread for higher wind speeds, the pine model #23 being more influenced by wind speed than the heathland model.

We observed a high variance of observed spread rates, which was caused by fuel inhomogeneity and short-time changes in wind speed. Therefore, the observed values are visualized by ranges (ellipsoids in Fig. 2). For the pine model #23, the simulated fire spread for a range of wind speeds (line in Fig. 2) goes right through the cloud of observed fire spread (ellipsoids). In heathlands, the predicted rate of spread is below the observed average spread by ~20%.

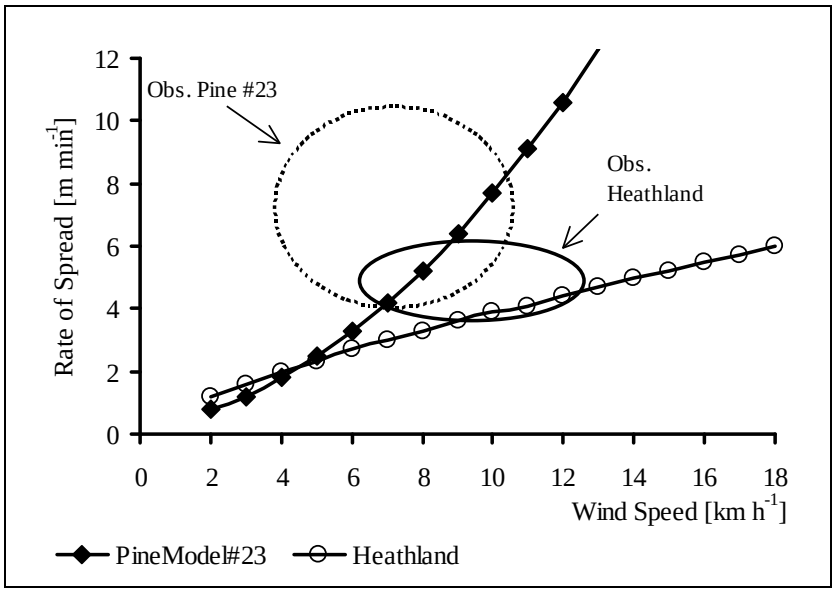

Figure 2. Simulated fire spread (lines) for the two tested fuel models and the observed data from the fire experiments (ellipses). Due to a high variation in wind-speed during the experimental burns, it was impossible, to measure the exact wind-speed and the time when rate-of-spread measurements were taken. Therefore the range of wind speed during the experiment and the measured spread rates are presented here.

Given the high variability of fuel and wind, the fire behavior is well met with the two models. Especially for the pine model #23, the calculated spread rates and flame lengths (data not shown) are in range of the observed values. We therefore assume that also the other created fuel models for pine stands (Tab. 1) will give reasonable results in predicting fire behavior, although they are not validated yet.

Table 1. Fuel models for pine stands of different age and continental heathlands. Fuel loads of the different fuel classes were used as the main input parameter in FARSITE. Fuel model 25 corresponds to all stands independently from their age.

Model	Stand Type	Grass	1-h	10-h	100-h	Live woody	Fuel bed depth
#		t ha^{-1}					m
21	<20 yrs.	0	7.81	7.61	0	0	0.15
22	21-60 yrs.	0	8.06	11.7	4.09	0	0.2
23	61-100 yrs.	0.78	8.13	13.43	2.56	0	0.2
24	>101 yrs.	0.54	11.61	17.84	1.02	0	0.15
25	Thinning <5 yrs.	0.42	10.27	20.57	6.47	0	0.3
26	Heathland	0	3.20	0	0	9.60	

3.2.2 Simulation results – Model application

Using the results and the gained experience of the BEHAVE modelling, a FARSITE simulation was created. On a 1000 ha former military bombing range, covered with pine forests and extensive heathland areas (Federal forest in the Lausitz region, Eastern Germany), fuel and stand information was collected to allow a classification by fuel models specified in Table 1 (see also Burgan and Rothermel, 1984).

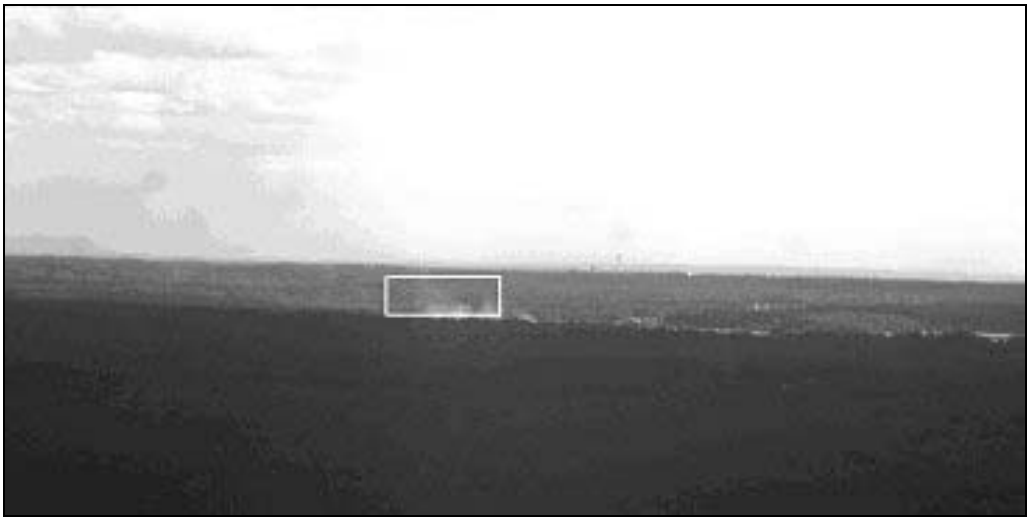

Figure 3. Screenshot of the workable FARSITE 2-D landscape view. Colours represent different fuel models. Forest roads and fire barriers are displayed as grey thin and thick lines, respectively. Two ignitions are modelled for 6 hours under dry weather conditions with strong winds from the west. The two fires are not stopped by forest roads, only the wide fire barriers of bare mineral soil (30 m wide) are able to stop fire's spread.

For the fire simulation, a digital landscape was created, using available information such as maps, digital elevation models, stand boundaries, roads etc. A raster grid of 6 x 6 m was chosen to be able to represent even small compartment and fire breaks (which are 30m wide in reality) within the study area. Figure 4 shows the workable raster view of parts of the simulation area.

The FARSITE model is very useful in extreme fire weather situations, where several fire suppression resources have to be positioned at places where they can reach high effectiveness. One scenario is presented in Figure 4: Under dry conditions in late summer (Temp. 30° C, RH below 50 % and strong winds from the West [17 km h^{-1}]) two ignitions were observed by the Automated Fire Detection System (cf. para. 3.2). The coordinates are imported into FARSITE and the simulation runs for six hours.

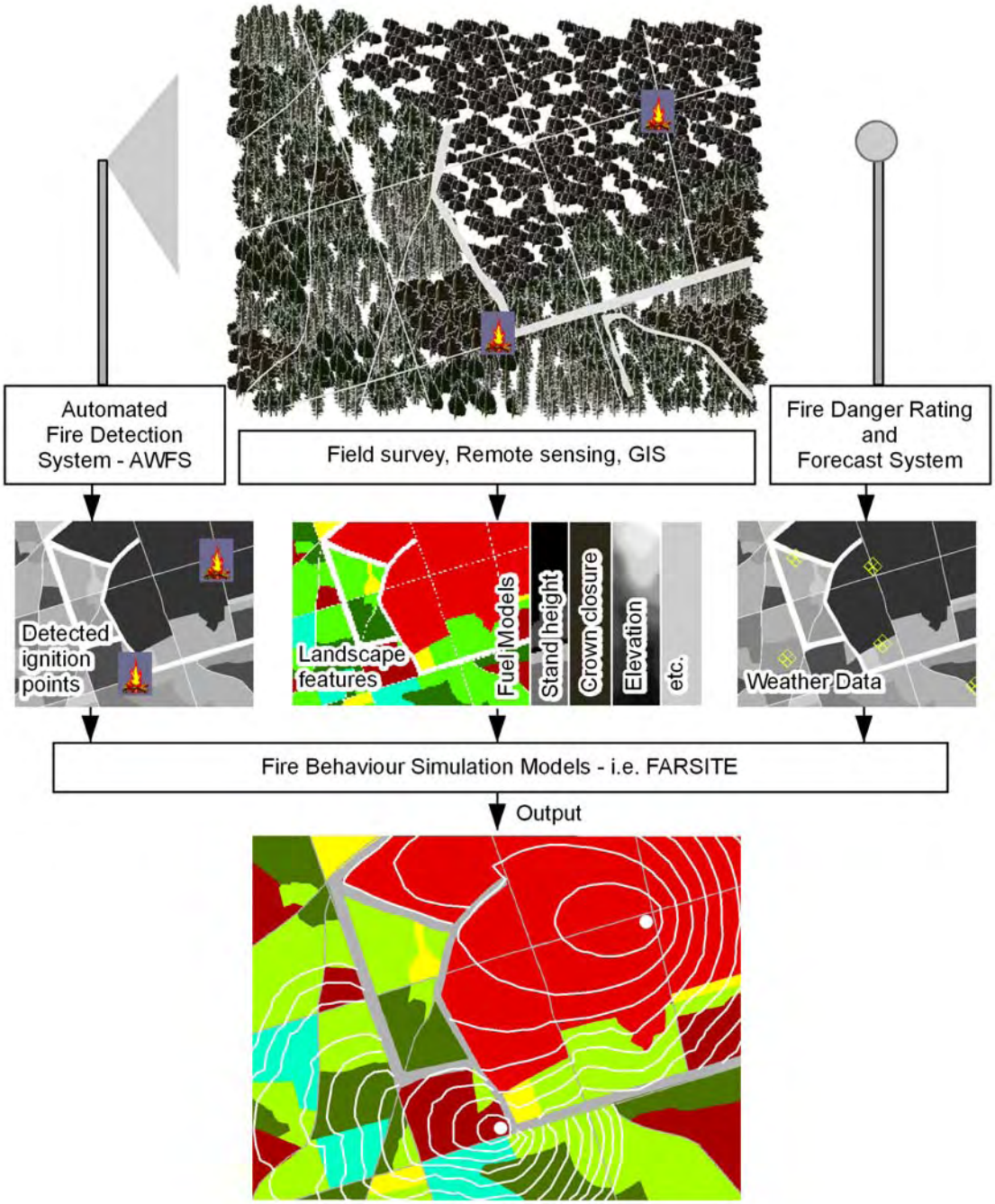

Figure 4. Visual impression of forest fire smoke detection by the AWSF at start of the 2001 Brandenburg fire experiment.

FARSITE calculates the expected spread of the fire in 30-minute intervals, presented as thin white lines in Figure 4. The model outputs reveal that the forest roads are not able to stop or slow down the

fire. The fast fire spread in the heathland (Mod. 26) makes suppression very difficult and dangerous. Therefore fire suppression resources have to be positioned at the wide fire barriers (30 m wide fuel breaks) in the sampling area (grey areas).

The second ignition in the southern part of the test area occurred in a pine forest. Here, the spread is slower, but without suppression activities, the fire would not stop at the forest roads, too. Under a situation, where suppression forces are limited, one would decide to locate all engines around the forest fire and trust on the effectiveness of the fire barriers, which will stop the heathland fire according to the simulation.

3.3 Fire Danger Rating and Forecast System

It is commonly known that some of the facets of weather support the ignition and propagation of forest fires: on the one hand, lightning strikes may directly ignite fires, and on the other hand, precipitation and evaporation affects the water content of dead and living vegetation and therefore indirectly controls the success of anthropogenic ignitions. Additionally, air motion influences the oxygen supply of the source of the fire and the spreading of the fire. Finally, fair weather means that the number of people frequenting the forests increases and permits a broad spectrum of activities of foresters and farmers (on neighbouring farmland), so that the number of potential ignition sources (fire risk) increases. In order to prevent fire losses, the objective of the national weather services is to forecast the weather-dependent forest-fire risk and to issue fire-weather warnings to fire-fighting agencies, forest authorities, emergency services and the public when the weather becomes critical.

3.3.1 Implementation of the national to local fire-weather danger forecast

Within the framework of the German Weather Service (Deutscher Wetterdienst – DWD) operational forest-fire danger forecast are currently using domestic and foreign fire-weather ratings, such as the German M-68 index and the Canadian Fire-Weather Index (FWI) (Wittich, 1998). The indices, together with additional meteorological information, are sent to forest authorities and disaster control centres of the Ministries of Interior of the Federal States of Germany so that they can issue the necessary instructions.

During the fire season the DWD daily issues the M-68 index via the internet under http://www.dwd.de/WALDBRAND (Wittich, 2002). Figure 5 shows the danger-rating chart for Germany on 5 June 2002, containing five risk levels (level 1 = low danger, ..., level 5 = extreme danger). Clicking on one of the ~ 200 station circles, one can get a time series over several days, which is composed of the current-day index, the index of two previous days and that of three forecast days, thus illustrating the temporal course of the forest-fire potential.

For the implementation of a local decision-support system based on automatic fire detection and modelling of fire behavior precise on-site real-time fire weather data are required to obtain a realistic model output. In an optimized system weather data would gathered automatically through a dense network of weather stations, transmitted to the data processing center and integrated into the decision-support system. Alternatively, fire weather data could be obtained at or near the fire site by a mobile weather station or by ground personnel using a mobile fire-weather kit. Taking into account the local variability of fire-weather data the latter alternative will meet the demands of on-site weather information.

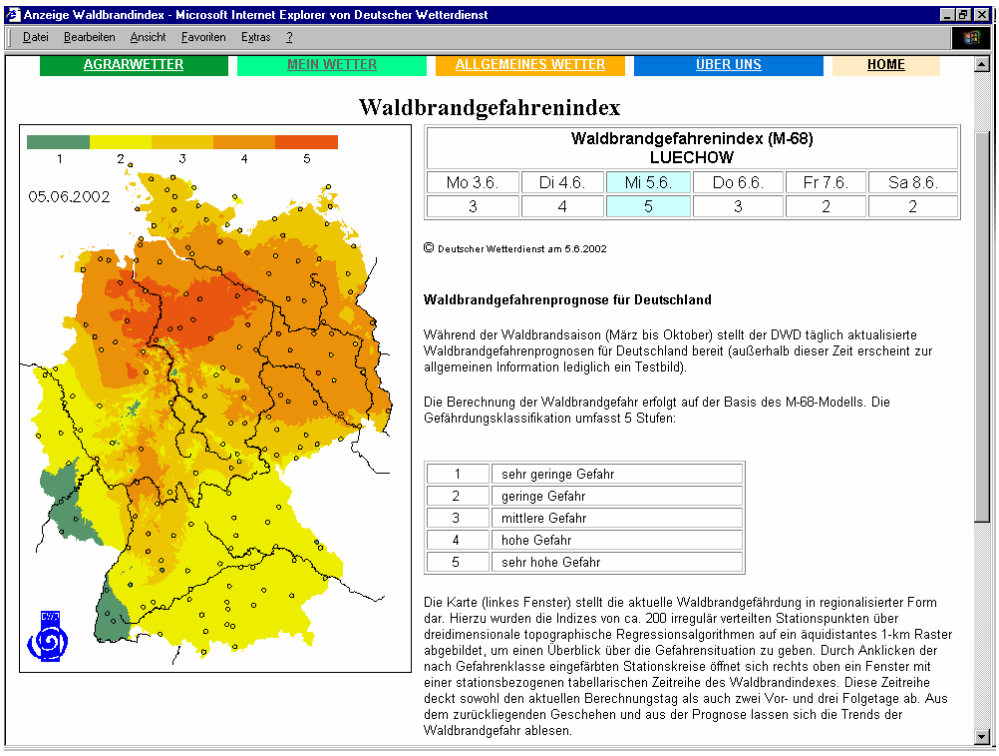

Figure 5. Example of the German Weather Service (DWD) fire-weather / fire-danger forecast via the internet for 5 June 2002. During the fire season a map provides a daily overview for Germany's territory. The system allows the retrieval of the fire danger index (M-68) for individual stations to obtain the fire-danger forecast for the current day (right hand example: Luechow, 5 June 2002), for the past two days and the next two days.

An overview of fire danger at regional level, e.g. for assessing fire danger in Europe and the neighbouring countries, is provided by the Eurasian Experimental Fire Weather Information System generated of the basis of the Canadian Forest Fire Danger Rating System (CFFDRS) by the Northern Forestry Centre, Canada, for the Global Fire Monitoring Center (GFMC). The system allows downloading a number of Fire Weather Index Components (Fine Fuel Moisture Code – FFMC, Duff Moisture Code – DMC, Drought Code – DC, Initial Spread Index – ISI, Buildup Index – BUI, and the Fire Weather Index – FWI) and Meteorological Data (Fig. 6). This regional system is still operating on a provisional basis due to the lack of automated inputs from hourly weather observations, especially in Russia. The Canadian Forest Service is working on a Global Experimental Fire Weather Information System to be displayed at the GFMC in late 2003.

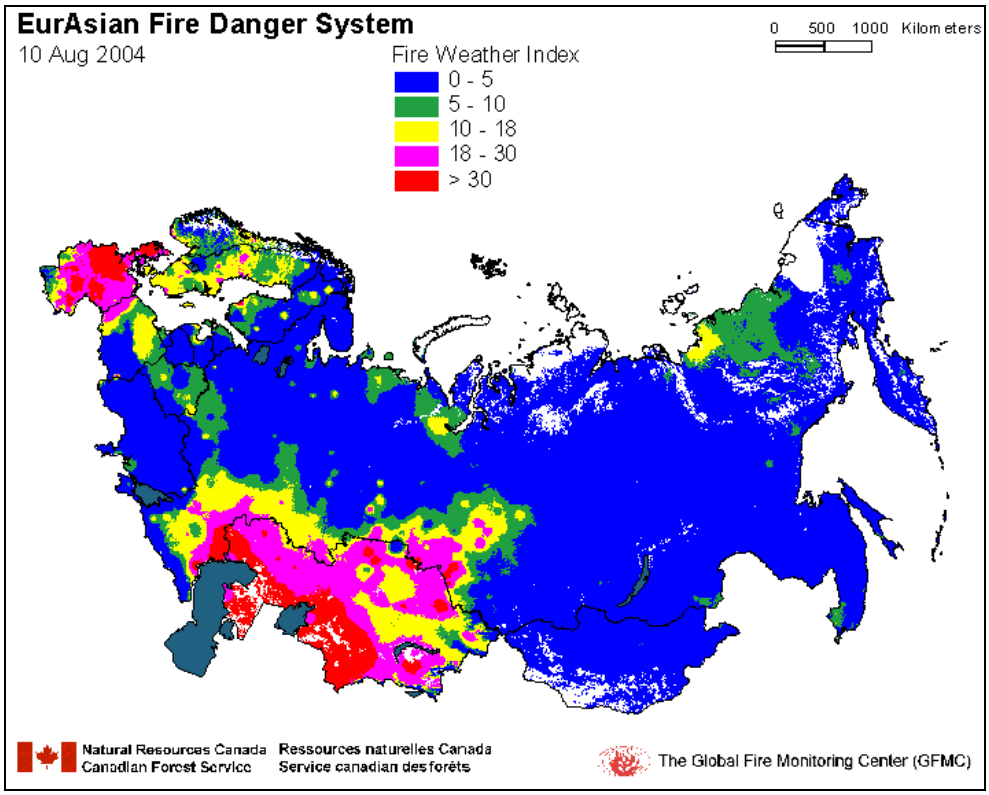

Figure 6. Example of a daily fire weather index map of the Eurasian Experimental Fire Weather Information System generated on the basis of the Canadian Forest Fire Danger Rating System (CFFDRS) by the Northern Forestry Centre, Canadian Forest Service, for the Global Fire Monitoring Center (GFMC).
Source: http://www.fire.uni-freiburg.de/fwf/eurasia.htm

4. Implementation of the Fire Information System

Theoretically, data and information about what it is considered as fire structural parameters (i.e. fuel, weather, and topography), contain the descriptive (i.e. attributes) as well as the spatial (i.e. coordinates) component. The spatial component sets up the basic requirements to consider it as a geographical information system (GIS); for instance, descriptive information of fuel is spatially distributed within the geographical extent of the study area.

Conceptually, the integration of all the necessary information under a common processing scheme presupposes firstly the necessary compatibility among different data layers. To maintain spatial information of any descriptive parameter in a digital form, a number of different alternatives are available including, among others, the format of the data (i.e. raster vs. vector type), the type of spatial objects (i.e. point, line or polygon), the type of measurements (i.e. nominal, ordinal, interval, or ratio), and the spatial resolution or scale (DeMers, 1997).

4.1 Integration of fuel data, fire behavior model, weather and fire detection data in a GIS

Primary observations and data referring to the structural parameters of wildland fires may exist in multiple types and multiple scales. Their integration under a common scheme might be prohibited because of several incompatibilities. For instance, elevation gradients, as well as weather data are better represented by continuously data using the raster data type. However, their primary data source may considerable differ. For instance, fire weather observations are provided at specific points in space that correspond usually to meteorological weather stations. To convert point observations into continuous surfaces by filling the gaps in the between unsampled sites, interpolation procedures have to be applied, like inverse distance weighting, nearest neighbors, splines, or geostatistics (Burrough and McDonnel, 1998). On the other hand, road network and firebreaks, which are depicted as linear or polygon objects depending on the scale level, are introduced into the fire information system as vector or raster type. To allow however their co-processing with other spatial information, as for instance for

fire behavior modelling, vector objects should be converted to raster objects by considering during the conversion process the maintenance of the original information.

In addition to the fire structural parameters information, the fire behavior model and the fire detection and monitoring system are another two critical components of a fire information system. Fire behavior, formally is defined as “the manner in which a fire behaves as a function of the variables of fuel, weather and topography”. The fire behavior modelling phase enables us to simulate a real fire event and allows us to test hypothetical scenarios about its propagation, and suppression strategy. A fire can be inserted and simulated into fire behavior modelling system either manually by the system operator or automatically if this system is connected online to an appropriate fire detection system. Apart from the input of the ignition source, real data referring to fire propagation can also be introduced into the system so that the modelling phase of the system be continuously supplied with the updated information for validation and self-correction.

GIS, by providing tools, resources and a proper organizational context to gather, manage and process spatial referenced information (Burrough, 1986), can support the integration of fuel data, fire behavior model, weather data, and the fire detection system. The main functional process that has to be resolved is the data management including collection, homogenization, maintenance and future update of the information. Information may come from completely different sources, and be different in scale, content, accuracy, etc. To enable the integration of such different spatial layers of information under a common functional schema, certain procedures have to be implemented and supported.

4.2 New space-borne fire information - decision support systems (a successful demonstrator mission and proposed next steps)

In principle, a fire information – decision support system should support the requirements of the input, maintenance, update and processing of the appropriate information. Concerning the data management subsystem, the ability to work independently under a semi-automatic or fully automatic mode, when possible, is very important. Furthermore, its ability to receive online information about input (i.e. fire weather data) as well as output data (i.e. fire behavior) is another important aspect. Remote sensing and GIS, being complementary tools for gathering and processing data and information, could be the heart of the data management subsystem. Remote sensing can contribute to generation of the information to support the requirements of updated and spatially distributed information. Various remote sensing applications can be found in literature for estimating fuel parameters and fire risk before the fire (Chuvieco and Congalton, 1989; Leblon et al., 2002), for detection and monitoring during a fire (Bourgeau-Chavez et al., 1997; Kasischke et al., 1993), and for burned land mapping and post fire effects assessment after the fire (Jakubuskas et al., 1990; Koutsias and Karteris, 1998).

The research project provided an opportunity to test the advanced spaceborne Bi-Spectral Infrared Detection (BIRD) sensing system for the detection and characterization of high-temperature events (HTE). BIRD is the first space borne sensor that offers the capability to provide daytime detection of small fires with areas exceeding ~15 m^2 and to estimate their radiative energy release. For fires with areas exceeding ~0.15 ha, an estimation of the effective fire temperature and area is also feasible. This capability of BIRD is especially important for the detection of small fires. A quantitative comparison showed that BIRD’s Hot Spot Recognition System is an order of magnitude more sensitive than other available space borne sensors used for active fire remote sensing (Oertel et al,. 2004a).

In addition, the high sensitivity of the BIRD IR sensor system allows the characterization of low intensity surface fires in forests (under canopy) which are difficult to be detected by other satellite systems (Oertel et al, 2004b; Zhukov et al., 2005). During the project's scientific forest fire experiment the Advanced BIRD Airborne Simulator (ABAS) was used to test the capabilities of this new spaceborne fire detection and characterization system (Oertel et al., 2002) before BIRD was launched to the orbit in October 2001. The results of the tests of ABAS (Fig. 7) and the semi-operational utilization of BIRD in summer 2003 (Fig. 8) confirmed the capabilities of the new sensor system, the BIRD Hot Spot Recognition System. An integration of prospective BIRD type operational sensors with the prototype decision-support system would provide an opportunity to generate information of additional value for a fire management decision support system.

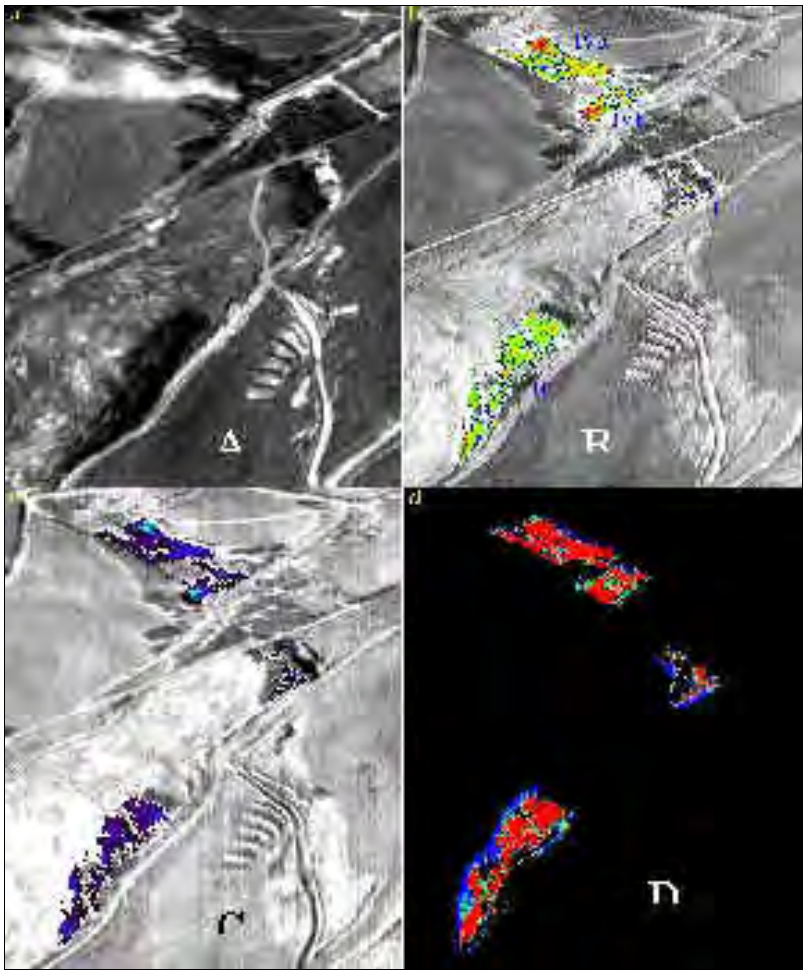

Figure 7. Fragments of an ABAS scene showing the experimental fires in the burning and smouldering Plots I, II und IV of the Brandenburg forest fire experiment on 23 August 2001.

Based on the recent and unique experience with the BIRD demonstrator mission in 2001 – 2004, an operational and commercially based Fire Recognition Satellite System (**FIRES**) is proposed to be developed. FIRES shall consist of four BIRD-like identical satellites, which detect, classify, and geo-reference fire data on board and broadcast the information in real time down to wildland fire managers and agencies. On earth, information on fire location and intensity to be provided by the prospective FIRES constellation satellites shall be received and visualized on-line with mobile, hand-held receivers similar to GPS-receivers (**Fire-GPS**). This tabulated, very compact fire information shall be received instantaneously within the reach of one of the FIRES-satellites radio transmitter to deliver in real time precise information on the spread and intensity of a fire front, thus allowing verifying and updating the outputs of the fire spread model (Oertel and Ruecker, 2005).

Further, the BIRD mission in general and its Hot Spot Recognition System in particular are precursors of the prospective Fire detection and monitoring IR Sensor, the ***InfraRed Element*** *foreseen as a multiple flown payload passenger of the planned ESA satellites "Sentinel 2" and "Sentinel 3" which are part of the Space Component – (ESA/PB-EO(2005)93) – of the European initiative on Global Monitoring for Environment and Security (GMES).*

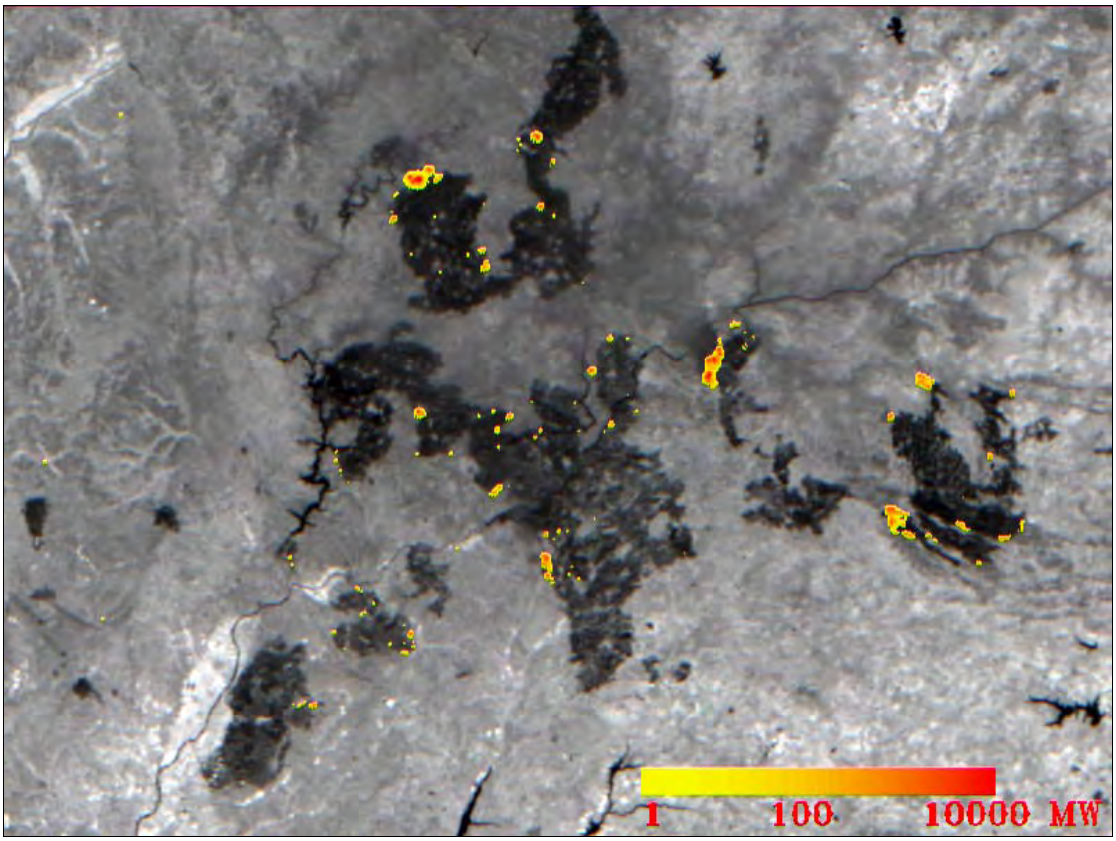

Figure 8. Example of a BIRD fire product image fragment showing forest fires in the center of Portugal on 4 August 2003. The fire radiant power is color-coded in Megawatt per pixel and is overlaid on the black and white background showing the dark fire scars.

5. Conclusions and Outlook

Research and development conducted within the Forest Fire Cluster of the German Research Network on Natural Disasters is built on a number of separately evolved concepts that were integrated in a cooperative research project. For the first time a fire behavior model has been applied for the specific conditions of pine forests in the eastern, continental part of Germany, including the interspersed heathlands that constitute an important carrier of a wildfire at landscape level. The characteristics of these forests are quite typical for temperate-hemiboreal pine forests of Eurasia. Thus, the results of this work can be easily adapted to neighbouring countries where similar pine forests cover large areas, e.g., Poland, Belarus, and the Russian Federation. The development of the AWFS meets the requirements for fast, cost-effective and reliable fire detection system. The national fire-danger rating system has consolidated during the project lifetime. During the research project the work of the Global Fire Monitoring Center (GFMC) constituted the link from national to international levels. Besides the function of a support body for the development of national to international policies and fire management strategies the *modus operandi* of the GFMC provided an opportunity to implement the regional Eurasian Experimental Fire Weather Information System in cooperation with the Canadian Forest Service and to test the BIRD satellite mission in various vegetation types around the world. The concept of the German Natural Disaster Research Network (DFNK) provided an exemplary opportunity to conduct multi- and interdisciplinary fire research and has contributed to establish a new and unprecedented collaborative culture of wildland fire science in Germany. The value added by the research project is a mutual support of individual research projects and their final merging into a comprehensive decision-support tool for fire management. Insight gained by the research project concerning the operational use of satellite remote sensing information in the management of active wildland fires will be useful for the development of urgently needed operational spaceborne fire systems (Ahern et al., 2001).

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Analysis of the Wildland-Urban Interface Fire Problem of Greece

Abstract

During the last 30 years Greece gradually acquired a serious wildland-urban interface fire problem, mostly intensified around metropolitan areas and touristic locations. Extensive urbanization of a large part of the rural population for economic reasons, unplanned touristic development and ever increasing demand for summer housing from the middle-class urban households have created acute human pressure for land use change through fire and, subsequent, encroachment on public wildlands. At the same time, human settlements engulfed by wildland vegetation and forest land fragmentation in a mosaic of agricultural, forest and rural areas have created increased fire hazard and fire suppression planning difficulties. The following measures are proposed for alleviating the problem: (a) Establishment of legislature pertaining to the regional and urban planning of wildland-urban intermix areas; (b) Strict regulations regarding the location of the waste disposal sites and other public and private enterprises of human activities in forest lands; (c) Legislature for fire safety regulations for houses and residents in the wildland-urban interface; (d) Special forest management practices pertaining to the 'peri-urban forests' (wildlands that surround urban settlements). All silvicultural treatments and management practices will set as priority the protection of the urban structures that they surround; and, (e) Development of particular fire-safety planning and installations designed for cultural monuments and antiquities that are surrounded by forest vegetation constituting the natural setting of the monument and part of its scenic beauty.

Keywords: Peri-urban forest, wildland/urban interface, fire, Mediterranean, Greece.

1. Introduction

Greece has a severe wildland fire problem which has significantly augmented during the last 30 years. Almost 80% of the total number of fires occurs at the Mediterranean zone which extends from the coastal line to an elevation of approximately 800 m, including all the islands. This area combines the typical Mediterranean climate (pronounced hot and dry period during the summer, mild winters with most of the total rainfall) with flammable vegetation types comprised of drought resistant and fire-adapted evergreen / broadleaved sclerophyllous shrublands (maquis) and low-elevation coniferous forests of Aleppo pine (*Pinus halepensis* Mill.) in the mainland, and Calabrian pine (*Pinus brutia* Ten.) in the islands. Also, due to the fact that in the Mediterranean zone of Greece takes place most of the country's economic activities (90% of touristic development, 70% of industry, 40% of agricultural activities, most urban development), over 70% of the total population is concentrated in these areas. This has resulted in an ever increasing human pressure on the natural environment for land use change, which is reflected by the high frequency of arsons and 'unknown'-cause fires in the wildlands. The intermix of human settlements with natural ecosystems created a severe wildland-urban interface fire problem that has become a major issue of political debate and confrontation, due to the public awareness and mass media attention especially during the summer months when most fires occur. We will analyze the wildland-urban interface fire problem of Greece in terms of its current status, causes and possible mitigation measures.

2. Causes of the Wildland-Urban Interface Fire Problem of Greece

Greece has undergone significant social changes over the last 30 years (since the 1970s) which created and aggravated its wildland-urban interface fire problem:

1. Large parts of the population from mountainous areas migrated to the major urban centers (internal migration). The 'urbanization' of Greece resulted in half the population residing in only two cities (Athens, Thessaloniki).
2. There was significant but unplanned touristic development all over Greece and, particularly, the Greek islands, resulting in a continuous construction of holiday resorts and hotel accommodations in the wildlands without any fire safety infrastructure.
3. There has been a 'fashion'- trend in most middle class urban families for acquiring a 'vacation house' near the sea for summer vacations.

4. Human activities in the forests have increased due to the enhanced accessibility that resulted from an extended forest road network in combination with the ever increasing number of private cars.
5. Numerous municipal waste disposal sites have been arbitrarily established on public forest lands.
6. There has been extensive intermix of agricultural areas, forest lands and rural settlements over large areas in the Greek Mediterranean countryside, creating a 'mosaic' of different land uses and fire hazards.

All these reasons resulted in tremendous pressure for land use change of wildlands for urban, touristic and agricultural development in the Mediterranean areas. Given the fact that Greece still lacks a national cadastre (register) and land use classification mapping, the public forest lands were the first to be attacked by arsonists aiming at the destruction of the natural vegetation through fire and, subsequently, the encroachment and conversion of the burned areas to urban settlements or agricultural areas. In most cases, law enforcement procedures for the eviction of intruders from the burned wildlands are time-consuming and ineffective. On the contrary, in many cases followed a 'legalization' of the encroachment on the burned public wildlands by the Greek government for 'social reasons', thus creating an additional motive for arson. Consequently, in Greece the most densely inhabited or touristically developed areas are fire-stricken (Attica peninsula with Athens metropolitan area, Thessaloniki with the Chalkidiki peninsula, Kavala, Aegean and Ionian islands, Crete, Magnesia and Evia) with severe fire rural/urban interface problem which coincides with high fire frequency and areas burned, mostly attributed to arson or unknown causes.

The wildland/urban fire interface problem of Greece first became apparent when a large, wind-driven fire on 4 August 1981, in the northern suburbs of Athens, resulted in the destruction of many luxurious residences. In 1985, numerous arsons destroyed the peri-urban forests that surrounded Kavala, in Northern Greece. In 1995, a large fire (6500 ha) in the Penteli mountain at the outskirts of Athens metropolitan area, burned approximately 100 structures causing panic to the population. Another fire at the same mountain in 1998 was equally destructive and received huge media attention and public awareness, thus creating a severe political issue. Multiple arsons burned most of the aesthetic forest that surrounded Thessaloniki in July 1997. Numerous fires devastated large areas of public pine forests at the Chalkidiki peninsula in 1981, 1985 and 1990, resulting in the development of numerous summer cottages and villas in the burned areas without urban planning. Additionally, significant economic losses result every year from fires that burn at the rural/urban interface and expand from forest areas to adjacent agricultural lands (mostly olive groves, grapevines, and wheat fields).

Finally, in most cases, the natural fire regime has been altered in the wildland-urban interface due to increased fire frequency, thus adversely affecting biodiversity and ecosystem processes in these areas. Also, expanding urbanization has resulted in wildlife habitat fragmentation.

3. Particularities of Fire Suppression in the Wildland-Urban Interface

Fire suppression in the intermix context of urban and wildland is complicated and particular. In some instances, wildlands constitute enclaves within urban environments, and suppression proceeds within the general context of urban firefighting. In other cases, houses form small 'islands' within a 'sea' of public wildlands, and wildfires must be controlled as ancillary functions to general wildland fire control. In other words, the mixture of wild, urban, agricultural, public and private lands prevents either urban or wildland fire strategies (Pyne et al., 1996).

Perhaps the really unresolved issue is not so much the suppression of an isolated structural fire but the protection of structures within the context of a true fire intermix (Weise and Martin, 1994). Ethical instincts and legal structures impose the preferential protection of houses (not to mention their residents) even if this means that the overall fire continues to propagate freely. Perimeter control is problematic; counterfiring is almost impossible; prescription control unthinkable. No clearly articulated strategy exists (NWCG, 1989). Instead, firefighting resources, especially engines, are massed and dispatched to protect structures. Control of structural fires differs from control of wildland fires in several respects (Radke, 1983). There is, first, the question of people, victims who may need medical attention, residents who need evacuation, onlookers who may require restraint. There is also a matter of fire behavior. Compared to wildland fires, fuel loads in structures are heavier, fuel moisture lower, residence time longer, and fire build – up more rapid (Fischer and Arno, 1988). A review of past wildland-urban interface fires showed that most structures were lost or damaged when they were not

separated from the surrounding flammable vegetation, built in steep (over 50%) slopes, and the firefighting forces had poor access to the structures, limited water supply, and they arrived late (Moore, 1981).

When a fire occurs, it is often unclear to what extent suppression should emphasize the saving of property or the containment of the spreading fire. It is likely that fire management will focus on just such issues in the coming decade (Gale and Cortner, 1987).

4. Proposed Measures for Alleviation of the Wildland-Urban Interface Fire Problem

The wildland-urban interface fire problem of Greece can be alleviated with a combination of institutional and technological measures:

1. Establishment of legislature pertaining to the regional and urban planning of wildland-urban intermix areas. These regulations should provide for restricted areas were construction is not allowed due to high fire risk, for maximum housing density per unit of wildland area, for adequate road network density for easy accessibility of all structures, for evacuation routes and sites in case of emergency. Also, strict regulations should apply regarding the location of the waste disposal sites and other public and private enterprises of human activities (open mines, amusement parks, picnic areas, nature trails, etc.).
2. Establishment of fire safety regulations for houses and residents in the wildland-urban interface. The residents will be obliged to apply all fire safety regulations at their own expense for their house (clearing vegetation, provide extra sources of water, use appropriate building materials) with severe penalty for the violators.
3. Jurisdiction by legislature should be granted to the firefighting forces regarding the selection of the appropriate fire strategy for optimal results (i.e., choice of fire protection priorities, forced evacuation of people from residences, destruction of fences and gardens, use of private water sources, curfew of vehicle circulation).
4. Assignment of a special category in forest management practices pertaining to the ‘forests at the urban interface’. These forests should not be managed on a traditional ‘sustained yield’ basis or as purely ‘protective forests’, but rather as ‘peri-urban forests’ (wildlands that surround urban settlements) and, therefore, all silvicultural and management practices will focus on the protection of the urban structures that they engulf. In other words, the primary management objective of the ‘peri-urban forests’ is the protection of the human lives and structures that reside in them, and secondary, the aesthetics of the landscape. These objectives should be clearly described and imposed by specific and regulatory guidelines issued by the Forest Service.
5. Provisions for extra water supply and intensive urban silvicultural practices (pruning, thinning, fuel removal and isolation, breaking of horizontal continuity, etc) should be applied in all peri-urban forests. Special underground installations for ample water supply should be established in the wildland areas prior to urban development.
6. Special fire-safety planning and installations should be designed and established for cultural monuments and antiquities that are surrounded by natural vegetation of high aesthetic value, constituting the natural setting of the monument and part of its scenic beauty (Ancient Olympia, Mount Athos, etc.). In such cases, all fire suppression measures should aim at adequately protecting the monument without disturbing the natural beauty of the site (Dimitrakopoulos, 2000).

5. Conclusions

During the last 30 years Greece acquired a serious fire problem at the wildland-urban interface, mostly intensified around metropolitan areas and touristic locations. Internal migration, touristic development and need for summer housing have created increased human pressure for land use change through fire and, subsequent, encroachment on public wildlands. Legislative and regulatory measures regarding the function and management of ‘peri-urban forests’ need to be imposed by the State and Municipal authorities for fire hazard reduction and the protection of human settlements.

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