



UNITED NATIONS  
ECONOMIC COMMISSION FOR EUROPE



FOOD AND AGRICULTURE ORGANIZATION  
OF THE UNITED NATIONS



# **INTERNATIONAL FOREST FIRE NEWS**

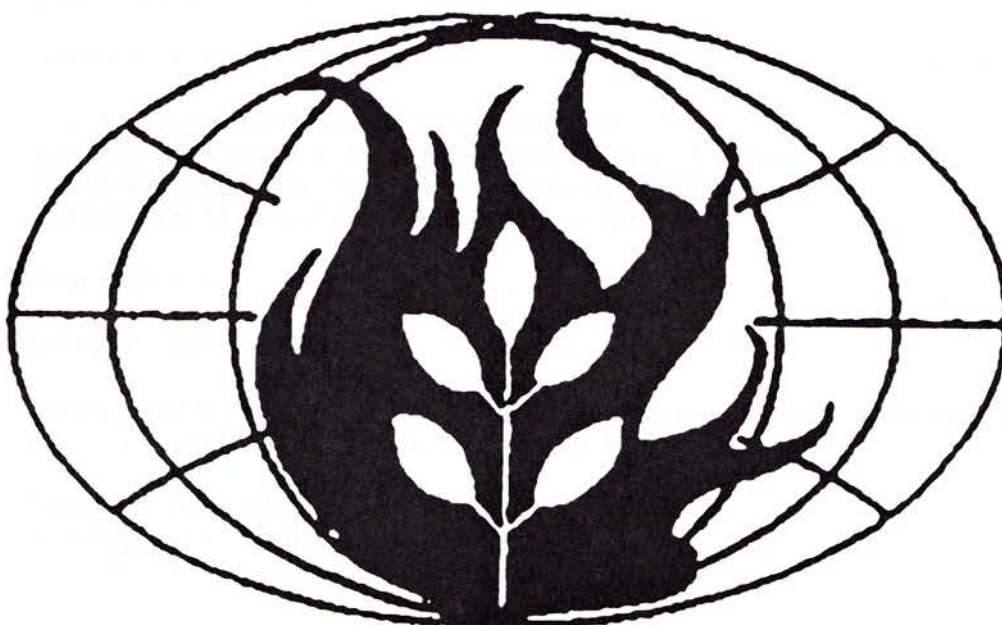
No. 15 - September 1996



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# **INTERNATIONAL FOREST FIRE NEWS**

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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, 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 (non-encoded ASCII file)** or on **diskettes (WP 5.1)**. Figures and photographs should be submitted by mail.

The deadlines for submitting contributions to the biannual issues are: **15 May and 15 November**.

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**Focus Impact of Biomass Burning on the Atmosphere and Biosphere**  
**("Biomass Burning Experiment" [BIBEX])**



**The International Boreal Forest Research Association (IBFRA)**  
**Stand Replacement Fire Working Group**



**The International Association of Wildland Fire**



## EDITORIAL

The wildfire season of 1996 started as usual. In January, the dry, cool winter season along the southern Alps brought suitable conditions for fires in the steep chestnut stands of Ticino (southern Switzerland) and in northern Italy. February and March saw extended fires all over continental Southeast Asia, between Viet Nam, Thailand, and Burma, simultaneously with the West African savanna fires. April and May engulfed Mongolia's steppes and Canada's forests with flames, and most smoke came from Siberia's *taiga* in June and July. Finally, this month, the West coast of the U.S.A. virtually exploded in wildfires.

The biogeographic rhythm of the wandering global fire belt was as usual. The size of fires too. However, a one-hectare fire in Switzerland was locally given the same amount of space in the media as did the 10-million ha fires scorching Mongolia. Worldwide the fires in California and Oregon attracted more media coverage than this year's Siberian *taiga* fires.

This issue of International Forest Fire News provides insights into wildfire basics, research and management of those nations which were affected by small and by big fires, namely Israel and Switzerland (special reports) and Mongolia. The reports reveal that the large fires in Mongolia in 1996 caused much more economic and social problems than did the 1250-ha fire along the Jerusalem-Tel Aviv highway in Israel in 1995. Nevertheless, the importance of this fire event in this small country is significant, especially under the light of the tremendous reforestation efforts over many decades.

At the FAO/ECE Seminar "Forest, Fire and Global Change", hosted by the Government of Russia in August 1996, equal attention was given to fires in all vegetation zones, countries and societies of the globe. The conclusions and recommendations elaborated by the seminar participants are given in this issue. The results of the UN seminar show that the international community of wildland fire scientists, managers and policy makers unanimously underscored the necessity for enhancing global cooperation in wildland fire. Standardization and complete global coverage of fire data collection (fire monitoring, fire inventories) and mutual assistance programs for long-term programmes as well as quick-response disaster management are required.

The UN seminar was not the end of international collaborative activities in this year. In December, a regional meeting with international participation will specifically address the cooperation in fire management in mainland and insular South East Asia. It is hoped that the neighbours in this region, with support through international projects, will push a process which will finally lead to better sharing of fire management resources and capabilities and improve the understanding of the transboundary role of fire on the environment and on societies. The organizer of this meeting - the ASEAN Institute for Forest Management - is calling for participation - see pages 65-66 of this issue.

Freiburg, 23 August 1996

Johann G. Goldammer

## ISRAEL SPECIAL

*Forests and Forest Fires in Israel*

**Introduction:** Only 3.7 percent of Israel's territory is covered by forest, either natural or man-made. The Mediterranean climate is predominant in about 40 % of Israel and around 70% of man-made forests are located in this region. Thus, the forested areas are proportionately very low, when compared to other Mediterranean lands such as Spain (13.8 %), Portugal (28.7 %), Cyprus (16.6 %) or Morocco (8.0 %) (Velez 1988). Even these limited forest areas were achieved only after an extended afforestation effort which was first carried out by the British Mandatory government and the Jewish National Fund (JNF). After 1949, when Israel became an independent state, forests were planted by the Government and by the Jewish National Fund. These bodies are responsible for the planting and maintenance of almost all the man-made forests in Israel. Most of the Mediterranean vegetation, including the forests which covered Israel-Palestine in the past, was destroyed by overgrazing and over-cutting, thus not allowing natural vegetation to recover. Over-cutting of woods by the Ottoman Government of Palestine also suppressed vegetation regeneration.

In 1949, the Jewish National Fund faced the enormous task of maintaining natural vegetation and adding new forests to the bare land. In 1995, forests covered 826,598 dunams (82,659 ha). According to the outline of the national plan for forestation, by the year 2020, 161,864 ha will be covered by forests, namely, the present forest areas will double in size (Jewish National Fund 1995).

**Biogeography of Forest Fires in Israel:** Forest fires have always been frequent in Israel. In the past (1950s, 1960s), agricultural burning (deliberate fires lit to burn wild vegetation in order to prepare fields for cultivation) was one of the main causes of fires; negligence and burning cigarettes were secondary causes. An important category was, then, and still is, "unknown causes for fires". It is most likely that many of the unknown causes were actually human-caused fires, but in most of the cases the fire investigators were unable to establish a clear link between human factors and the fire. Other factors found responsible for fires in the late 1950s and early 1960s were: military training, agricultural waste burning, hikers, campers and smokers. Table 1 presents the size and distribution of forest fires in Israel between 1985 and 1995.

Mediterranean forests consist of oaks and bushes. They differ from grazing areas and wildlands, which have no trees, but are covered with grasses and small bushes.

Table 1 points to some interesting features in the pattern of forest fires in Israel. First, most of the fires take place in the man-made forests and not in the natural Mediterranean forests and wildlands. However, the burnt area in the wildland and natural forest is very extensive, perhaps because the fire fighters do not hurry to put out these fires, or because they start in remote areas and are reported relatively late, after extensive damage has already occurred. Because the species in the natural Mediterranean forest are relatively fire resistant, these fires cause minor damage. As Table 1 points out, the variation in the size of burnt area is wide: it could range between 671.4 ha (1986) to 14,430 ha (1988).

The easterly hot dry windy weather known as *Khamsin* is the most dangerous weather type for forests and many forest fires start in this type of weather. Kutiel (1992) found that all the major forest fires in the Mount Carmel region took place in *Khamsin* type of weather and that strong easterly winds were blowing in the very large fire on Mt. Carmel in September 1989 which affected 600 ha of natural and planted forests. Other very large fires on the Carmel in 1983, 1989 and 1990 spread very rapidly because of the *Khamsin* conditions.

**Fire Causes:** The first and most important cause of forest fires in Israel is arson (Table 2). In the 1980s and early 1990s arson comprised about one-third of all forest fires in Israel -- a very large proportion. Some of the sources for this arson were identified as the work of criminals whose sole aim was to collect insurance money. Many cases of arson in the late 1980s, however, were directly related to the Palestinian uprising (*Intifada*). Palestinians used fire as a means of their resistance movement as early as the 1920s, 1930s and 1940s, but in the 1980s it was adopted as a highly visible action against the Israeli occupation in the West Bank. Arson was found to be easy to execute: all one had to do was cross the old border, which was unguarded and open to all, start a fire in one of the many forests which straddle the mountainous areas near the border, and then disappear. The occurrence of forest fires in areas adjacent to the old "Green Line" border between Israel and

the West Bank was very frequent: in the years 1988-1990 between 288 and 388 forest fires were caused by arson and took place in areas near the old pre-1967 border (Kliot and Keidar 1992). In some of the fires which took place in northern Israel, Israeli Arab Palestinians were found to be responsible. These fires were extremely remarkable because 1988 was also rich in precipitation and, as a result, the vegetation concentration was highly combustible. *Intifada*-induced arson gradually faded out as the uprising started to die out in the early 1990s.

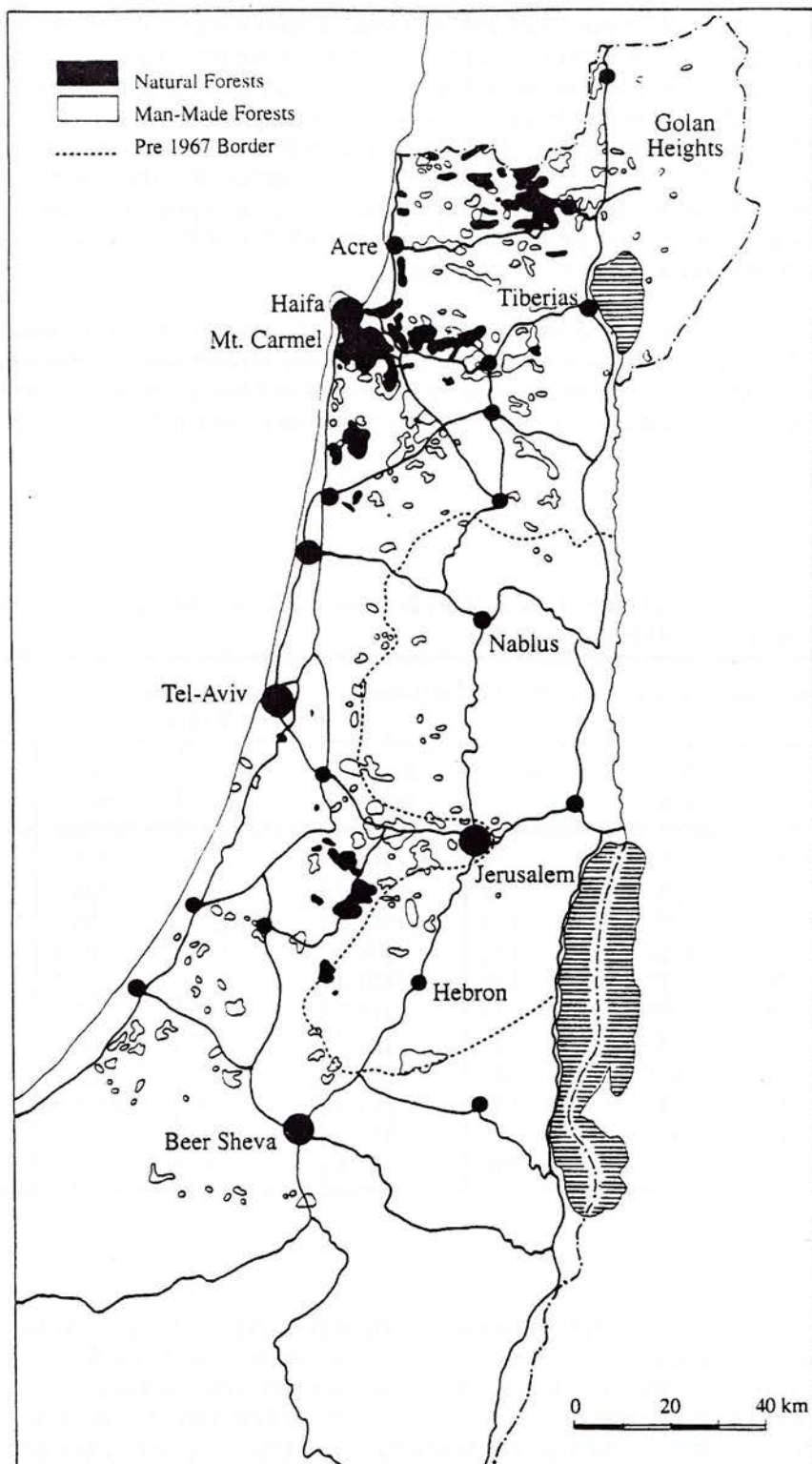


Fig.1. Distribution of forests in Israel in 1990

The origin of fires in Israel reveals a prominent human element, through both negligence and incendiaryism, but also by arson. Most of the other causes of forest fires in Israel are classified as incendiary: hikers who light fires, military units in training, farmers, are among the major instigators of accidental fires. Table 2 presents data on the catalytic agents of fires in Israel in selected years. There are five major incendiary causes for forest fires in Israel. First is the military: Army units who train with live ammunition in fire ranges near wildlands and burning waste in army camps cause, on the average, 5-6 percent of the fires.

This type of fire prevails in northern Israel and the Golan Heights where many of the training areas (and forests) are located. A second category of accidental forest fires are the fires started by hikers and people who visit the forests for recreational purposes. Recreation in JNF forests became very popular in the second half of the 1970s, as changes in the patterns of leisure activities were taking place among the Israeli public. As a result of a successful effort to re-educate people who hike or camp in the JNF forests, figures for this type of fire have been greatly reduced. A third grouping of fires is that of agricultural fires, namely fires which were accidentally started by farmers who burn agricultural waste, such as dry wood and vegetation, or other refuse which is a by-product of their everyday activities. Finally, the number of fires caused by arson, namely fires set with the sole intention of destruction, is on the rise.

One important factor which may exacerbate the human nature of fires are natural conditions. The first such condition has to do with the vegetation associations present in the Mediterranean ecosystems. After repeated forest fires the dominant plants and plant associations in both oak and pine groves are changed and replaced by a brush cover, small bushes and grass. Eventually, after some years, the pine will regain its hold.

**Tab.1.** Size and distribution of forest fires in Israel between 1985 and 1995. Source: Jewish National Fund, Forest Department, 1985-1995 Reports.

Year	Man-made Forests		Natural Mediterranean Forests		Grazing Lands and Wildlands		Total Burned area
	No.	Area (ha)	No.	Area (ha)	No.	Area (ha)	Area (ha)
1985	553	416.0	74	345.0	227	715.0	1476.0
1986	416	252.2	53	92.9	108	326.3	671.4
1987	626	867.7	113	541.3	317	2735.0	4335.6
1988	704	1018.0	142	1806.0	430	1328.6	14430.9
1989	559	617.3	112	1150.6	272	4276.7	6315.9
1990	686	505.6	133	1247.7	392	4013.6	849.1
1991	433	386.3	77	286.2	187	2807.8	3595.6
1992	544	608.3	140	1583.7	373	4508.2	5700.2
1993	518	388.0	142	1185.0	279	5595.8	7168.8
1994	443	358.8	112	539.2	209	2628.9	3529.9
1995	556	1354.2	116	564.3	346	6234.8	8153.3

The policy of afforestation, which did not introduce many varied species of tree to the Israeli forests, led to monospecies forests which grow over extensive and continuous areas, causing the fires to spread very easily and widely. Meteorological factors, such as dry and windy summers, create suitable conditions of humidity in vegetation for a minor source of heat to be the origin of a large conflagration. And as already mentioned, years rich in precipitation leave lush, but highly combustible vegetation; thus, forest fires after rainy years are extraordinarily damaging. The accumulation of combustible material in all types of forests, naturally enhancing the probability of many powerful fires, is another very influential factor.

Fig.2. Causes of forest fires in Israel 1987-1995

Year	1987		1988		1989		1990		1991		1992		1993		1994		1995	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Causes																		
Military	333	9	55	4.41	45	4.70	50	2.82	39	5.57	48	4.51	52	5.52	32	4.18	37	3.63
Agricultural					27	2.82	92	5.08	62	8.86	141	13.25	94	9.98	88	11.51	112	10.99
Hikers	296	8	38	3.05	53	5.54	661	37.34	38	5.43	67	6.29	81	8.60	85	11.12	120	11.77
Burning waste	445	12	86	6.90	78	8.15	76	4.29	26	3.71	77	7.23	61	6.48	74	9.68	77	7.55
Afforestation, planned fires	148	4	35	2.81					23	3.29	44	4.19	29	3.08	16	2.09	15	1.47
Arson	519	14	390	31.32	288	30.12	388	21.92	212	30.28	199	18.70	207	21.99	153	20.02	199	19.52
Other			119 <sup>a</sup>	9.55	129 <sup>b</sup>	13.49	78 <sup>b</sup>	4.40	39	5.57	67	6.29	66	7.01	61	7.98	64	6.28
Unknown	1965	53	522	41.92	336	35.14	425	24.01	261	37.29	421	39.56	351	37.30	255	33.37	395	38.76
Total	3709	100	1245	100	956	100	1770	100	700	100	1064	100	941	100	764	100	1019	100

<sup>a</sup> - Includes agricultural fires<sup>b</sup> - Includes planned fires

**Conclusions:** In conclusion, the catalytic agents of forest fires in Israel are only slightly different from the causes of fires in other Mediterranean countries. Lightning as a cause of fires is more important in other Mediterranean countries than in Israel, but negligence and incendiarism are similar in their relative importance in both Israel and other Mediterranean countries. Arson comprises a large grouping in Israel compared to other Mediterranean countries. The most important category of forest fires in Israel and in the Mediterranean at large, are fires whose catalytic agents remain "unknown", as detecting unequivocally the causes of fires is often an impossible task. Improvement in forest fighting technology and in forest management has been found to be useful in reducing the damage caused by forest fires in Israel.

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- Velez, R. 1988. Forest Fires in the Mediterranean countries. Documentos Del Seminario Sobre Metodos Y Equipos Para La Prevención de Incendios Forestales, Madrid: ICONA, pp.50-59.

### *Jerusalem Corridor Fire Update*

Since my initial report (IFFN No.13, July 1996, p.16), a great deal has happened, both with regard to a more detailed determination of the fire's effects and in the area of planning and management activities for the regeneration the burned area. In this update I will summarize our efforts in the following areas:

- a. Fire effects
- b. Report by a soil conservation expert
- c. Initial planning
- d. Management activities already carried out
- e. Detailed restoration plan
- f. Utilization of a Geographic Information System for planning and management support.

**Fire Effects:** The burned area has been determined to be 1250 ha. This is considerably less than the initial estimate of 2000 ha, but it still ranks as the largest forest fire in Israel's history, and about one percent of our forested area. This can be broken down into 400 ha of open areas, 100 ha of natural forest (maquis) and 750 ha of planted forest, about half of which was more than 30 years old. The planted stands were mostly conifer (pines and cypresses) while the natural forest included oaks, pistachios, carobs and olives. A significant fraction of the conifers was killed without the canopy being burned as the fire raced along the ground. For the most part, the broad-leaved trees were not killed and many are now vigorously resprouting. During the first winter after the fire there was little flooding, and only slight damage to forest roads in sensitive areas. A total of twenty-five houses that were partly or totally destroyed are being rebuilt with government financial assistance.

**Hydrology and Soils Analysis:** During the initial planning stage after the fire, the Jewish National Fund (JNF), Forest Department, received an offer of assistance from the Chief of the USDA Forest Service to send a person experienced with fire rehabilitation to visit Israel. Mr. Bruce McCammon, a regional hydrologist with the Forest Service arrived in late summer and spent two weeks visiting the burn site, for visual surveys and soil testing, and meeting with JNF experts. The JNF presented two questions for which they wanted specific thoughts and recommendations:

1. What should be done with the remaining dead vegetation?
2. How can "buffer zones" be established near population centres to minimize future damage from wildfires?

Mr. McCammon's report included an immediate fire rehabilitation assessment, recommendations for dealing with remaining dead vegetation, and planning suggestions for future fire protection.

It was necessary to evaluate the fire's intensity, since burn intensity is strongly correlated with the development of emergency watershed conditions. The fire exhibited characteristics typical of a wind-driven fire that moved rapidly across the area, sometimes in the crown and sometimes on the ground. For this reason and because there was sparse ground cover in many places, the burn was characterized by low to moderate burn intensities. Even in areas where the entire canopy was consumed, the short fire residence time resulted in only partial consumption of the ground vegetation and did not create hydrophobic soils.

As a result of the lack of hydrophobic soils and the extensive surface rock cover (creating surface roughness) in the area, the report concluded that accelerated surface erosion in the burned area should not be a significant problem. In the most sensitive areas, the greatest potential for erosion will occur during the first year after the fire due mostly to the loss of overstorey and understorey canopy. Sprouting of deciduous species is already common in the burn area. Extensive terracing in the area also reduces surface flow rates. Mr. McCammon recommended protecting the terraces and chipping and spreading remaining limbs on terraced slopes. This is particularly important for steep slopes located above the Tel Aviv-Jerusalem highway. To prevent rock-fall on the highway, dead trees should be felled and oriented perpendicular to the slope.

With regard to the remaining dead vegetation, the report recommended to remove commercial conifers. Their limbs as well as the smaller non-commercial conifers and burnt broadleaf stems should be chipped and spread on-site to provide protection and additional nutrients for the soil. Broadleaf trees which resprout vigorously need to be pruned or grazed to prevent the development of a dense thicket. This can become impassable and is also a significant fire hazard.

Finally, it was recommended to establish "buffer zones" near settled areas to reduce fire initiation or spread. These plantings are characteristically composed of species that are shorter, less susceptible to ignition, and planted at a lower density than normal. The understorey can be maintained to minimize fire risk through a combination of grazing, mechanical methods and prescribed fire.

**Overall Planning Guidelines:** The planning unit in the Central Region of the JNF Forest Department has moved quickly and by October 1995 completed overall planning guidelines for the restoration of the burned area. These guidelines delineate five major landscape elements which exist in the burned area and must be taken into account in its restoration.

1. **Planted Conifer Forest With Natural Woodland Understorey:** Establishment density will vary according to intended use (denser in campgrounds). Natural conifer regeneration will be utilized where possible. Planted conifers will include: Brutia pine, Aleppo pine, Stone pine and Cypress. Where the broadleaf (evergreen and deciduous) understorey establishes well, it should be encouraged through selective thinning of the conifers.
2. **Natural Woodlands:** Existing groves need to be maintained by pruning them as they resprout in order to prevent the development of a dense thicket.
3. **Olive Groves:** Existing groves need to be maintained through cultivation and pruning. When the need arises they should be "filled out" by transplanting mature trees from other areas of the Central Region.

4. Orchards: These are small in total area but have great scenic potential as they adjoin the major highway. To reduce maintenance costs, it is recommended that these be restored as "quasi-orchards" containing Palestinian and Atlantic pistachios, Worm oaks and Stone pines.

5. Buffer Zones: These act as barriers to reduce the likelihood of fire ignition and spread near and into settled areas. Their forest density will be kept low (300-400 stems/ha), and ground fuels loading will be kept at a minimum through ploughing, grazing, and the use of herbicides where necessary.

These five zones were mapped for use as a framework for the detailed restoration plan. In addition, planning guidelines were established including focus on the unique physical characteristics of the area (topography, terraces, landmarks, and lookout points), stress on the importance of utilizing local flora, and the need for long-term recreation and tourism planning in the fire-affected areas.

**Management Activities:** Our initial management conception has been to perform the minimum actions required which accord with the overall planning guidelines and, at the same time, to gather detailed field data to support the continuing planning process. With this in mind, some 7000 tons of commercial timber have already been harvested, priority being given to slopes above the main highway. Of about 5000 tons of slash and non-commercial conifers and broadleaf trees, about two-thirds being chipped and spread as mulch and the rest used to stabilize particularly sensitive slopes. Some 100 ha of natural broadleaf groves have been treated (i.e., dead wood pruned and chipped; Fig.2). These are now vigorously resprouting.

Detailed surveys have been completed of the following characteristics:

- natural vegetation types
- natural vegetation regeneration
- lithography
- soil types
- terraced areas (ancient and modern)

These data are being digitized and will be available as map layers through our GIS unit (see below).

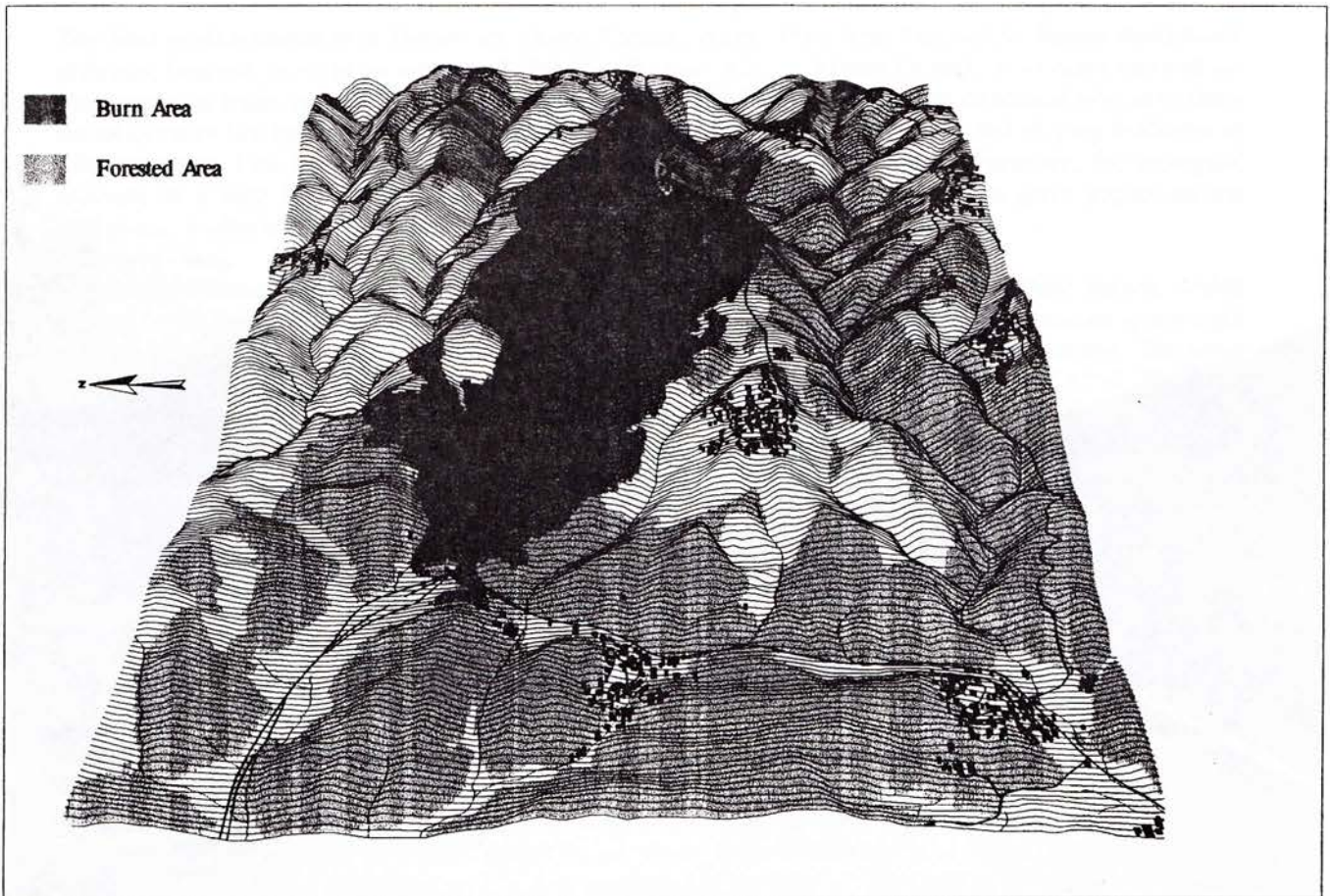
**Detailed Restoration Plan:** Due to the scenic and historic importance of the fire site, an internationally known landscape architect, Shlomo Aronson, was chosen to draw up a detailed restoration plan.

There are two general stages to this planning process: data collection (during which time an overall concept is formulated) and drawing up of the plan itself. The first stage is nearly complete. Data collected include those from the four surveys mentioned above and, in addition:

- slopes
- aspects
- geomorphology
- archaeological sites
- historical sites
- recreation and tourism sites
- infrastructure, existing and planned (water, electrical, sewer, telephone, roads)

The development of an overall concept takes these background data together with an integrated sense of the site's characteristics as a landscape unit. Among these characteristics are:

- geographically, a transition area from the foothills to the Judaic mountains.
- the beginning of the "ascent to Jerusalem" for both pilgrims and tourists.
- an area where fierce battles were fought to break the blockade of Jerusalem during Israel's Independence War.
- an area richly endowed with natural and man-made terraces attesting to its agricultural importance.



**Fig.1.** A three-dimensional map showing the burn area, surrounding forest, and nearby settlements (black squares). The view looks east, up into the hills in the direction of Jerusalem. Ignition occurred in the small patch closest to the viewer, west of the intersection.

The final plan must weave these elements and their implications together. The high potential for recreation and tourism is clear. Yet this must be reconciled with the need to preserve the natural resources and protect the great beauty of an area whose visual impact alone can hardly be exaggerated.

**GIS Unit:** From the first stages of planning immediately after the fire, the GIS Unit of the JNF Forest Department has been an invaluable tool. Luckily, the Israel Mapping Authority's National GIS Project had already completed digital mapping of the area with the burn site, giving us the basic background of topography, roads and settlements. Thus, within a few weeks after the fire, a basic map of the burned area was already made available to foresters and planners. By the time the US Forest Service hydrologist arrived, he was provided with additional GIS maps including watershed boundaries, soil types, soil conservation zones, and an analysis of visibility from the main highway. The GIS Unit has provided the standards for the data collection on which the detailed restoration plan will be based, and will be the major producer of maps for this plan. Since a Digital Terrain Model (DTM) was available from our national mapping authority, GIS analyses became the "data source" for such layers as slope, aspect, and topography. Essentially all the site data mentioned in this report are being stored as data layers by the unit for future analyses. Maps are generally produced by a plotter in colour to provide maximum information with optimal clarity. To give some idea of the GIS's potential contribution to planners, I have included a three-dimensional perspective of the burned site (Fig.1).



**Fig.2.** Salvage logging along the Tel Aviv - Jerusalem Highway in October 1995 (Photo: J.G.Goldammer)

**A Final Note:** The results of fire are not only negative, especially in a Mediterranean biogeographical zone with a long history of anthropogenic (man-caused) fires. In this context, it is noteworthy that in the burn area there have appeared many brightly flowering geophytes, especially those in the tulip and orchid families, in places where they were thought to have disappeared.

**Acknowledgements:** This report relies heavily on extracts and summaries from the reports listed below, other internal Forest Department documents, and conversations with the Hanoch Zoref, the forester responsible for the burned area:

- Ben-Moshe, M. 1996. Thoughts on the restoration of the Jerusalem Corridor burn area. Shlomo Aronson Architects, internal memo <in Hebrew>.
- McCammon, B.P. 1995. Evaluation and recommendations for short-term rehabilitation and long-term recovery of the Jerusalem Corridor Fire. Internal USDA Forest Service report, prepared for the JNF Forest Department.
- Projects Division, Jewish National Fund. 1996). Up from the ashes: the regeneration of the Sha'ar Hagai forests.
- Tauber, I. 1996. Aid for the Jerusalem Corridor Restoration Plan by the Forest Dept. G.I.S. Unit. Forestry Data Unit, internal memo <in Hebrew>.

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*Post-Fire Recovery of an East Mediterranean Aleppo Pine Forest Ecosystem*

The East-Mediterranean pine forests on Mount Carmel, Israel, have been exposed to human disturbance including frequent fires for as long as 60,000-70,000 years. Fire on Mount Carmel, as in other parts of the Mediterranean basin, is caused mainly by human activity and it has been playing an ecological role, ever since the adoption of fire by mankind. Therefore, it is a main factor affecting communities and shaping landscape in this ecosystem. Fire is a common disturbance of short duration (only few hours). However, the ecological recovery is a very long process which may last several decades. In addition to its great impact on the ecosystem, it affects also human society.

The Mediterranean ecosystem on Mount Carmel has asymmetrical seasonality. The rainy season, which overlaps with the cool season, is relatively short, being only four months long. The dry season spans eight months and for almost half of the year it is accompanied by high ambient daytime temperatures. The mean annual temperature is 20°C with mean temperature differences between winter and summer of 12°C. The mean annual precipitation is 700 mm but over several years, which can be consecutive, it may fall to 500 mm or even less. As in other Mediterranean-type ecosystems, the long, dry and hot season has a significant impact on food quality and its water content. Thus organisms in these ecosystems are exposed to wide seasonal changes in nutrition qualities and may face potential dehydration.

However, these habitats typically are inhabited by species of palaearctic origin. The mixed pine and oak forests in this relatively dry ecosystem may be important for the survival of small mammals and others, as they provide food and thermal protection by reducing direct radiation mainly during the long warm and dry season.

The September 1989 fire destroyed about 300 ha of natural forest of Aleppo pine (*Pinus halepensis*), which was a part of the Carmel National Park and Nature Reserve, open to the public for leisure purposes. The pine trees formed the upper story of the forest while the oak (*Quercus calliprinos*) and other evergreen shrubs formed the lower one. The forest was located (33°44' N; 35°01' E), at an altitude of 320 m, and about 7 km from the Mediterranean seashore. The destruction by fire of the forest, which was a favourite recreation site, caused a national trauma resulting in public donations of about three million U.S. Dollars. The Ministry of Environmental Affairs established a scientific professional committee, that was to advise the managing authorities how to restore the burnt forest. Earlier studies on the resilience to fire in this ecosystem in Israel were limited to the recovery of plants but no data were published on the recovery of the fauna. Several teams of scientists from different disciplines joined in an effort to achieve a comprehensive understanding of resilience to fire in this ecosystem. As ecologists we addressed the following question: "What is the appropriate way to treat the post-fire habitat in order to enhance the restoration the original forest community?" However, different designation and public land uses may require different forest structures and therefore other forms of management should be applied.

A group of biologists (Dr. M. Broza, Dr. A. Haim, Dr. I. Izhaki and Dr. G. Ne'eman) representing various disciplines from the Department of Biology, University of Haifa at Oranim, designed an ecological study using the same plots. In order to suggest an appropriate management regime, three treatments were applied to the burned habitat: (1) Burned trees were left untreated; (2) Burned trees were cut down, the trunks were removed but the smaller twigs were left in small piles in the plots; (3) burned trees were cut down, the trunks and the smaller twigs were removed from the plots. In addition to censuses carried out in the post-fire habitat, plots of Aleppo pine forest in the vicinity, which to our knowledge were not burned in the last century, were also sampled as control. The research started in the summer of 1990 (almost one year after the fire) and lasted for three years. The vegetation, micro soil arthropods, passerine birds and small mammals (rodents and shrews) were monitored in the different plots in order to define species composition, density and also percentage of cover of the vegetation. The effect of seedling thinning of *Pinus* and *Cistus* was also studied.

The results of the vegetation survey (Ne'eman et al 1995) revealed that cutting or removing the burned trees had less influence on species composition and cover than the natural process of recovery. The thinning of seedlings positively affected their height, biomass and survival. Since pine seeds germinate in the first winter following fire, no classical species succession was recorded. However, the recovery of the vegetation was due to changes in species dominance and life form structure, *Pinus halepensis* trees replacing *Cistus* dwarf shrubs. The large burned pine trees affected the spatial pattern of seedling recruitment (Ne'eman et al. 1992).

Thirty three species of passerine birds were recorded during fall, winter and spring (1991-1994). A relative marginal habitat alteration was caused by logging pine trees with control burned forest. The most significant difference in avian community level was found between the unburned forest and the burned one, and between the first (1-2 years) and the successive periods (3-5 years post-fire) (Izhaki and Adar 1996). In unburned pine forest 80% of the soil microarthropods were of the order Acarina and Collembola, the rest belonged to other 18 orders. In the second post-fire years, only 11 orders were presented. *Protura*, *Paupoda*, which were common in the unburned forest disappeared, while pseudococcid *Rhizoecus* sp. which were rare in the unburned forest flourished after fire (Broza et al. 1993).

The recovery of the small mammal fauna was by succession. In the first stages, the post-fire habitat was invaded by granivorous species which occur in open areas close to the margins of the forest but are not forest dwellers. This group included three different species (two members of the family Gerbillidae *Gerbillus dasyurus*, and *Meriones tristrami* and one of the family Muridae *Mus macedonicus*). During the third year after fire, populations of the two omnivorous wood-mice species (*Apodemus flavicollis* and *A. mystacinus*) and of the insectivorous shrew (*Crocidura suaveolens*) were established in burned plots of various treatments. Therefore, it was concluded that post-fire recovery of small mammal populations was through succession and this was correlated with the changes in vegetation and other primary consumers in the habitat. Species richness and diversity were highest during the third and fourth years after the fire when populations of both invading and forest dwelling small mammals (apart of the black rat *Rattus rattus*) were present in the plots. It is important to note that recovery in untreated burned plots, at the early stages, seemed to be the fastest. The elapse of time after fire was the most significant factor affecting the recovery of small mammal populations (Haim et al. 1996). The results of the study illuminated the effects of different management regimes on the post-fire recovery of the ecosystem in a short time range. As the elapse of time after fire was found to be the major factor affecting the recovery, our study was extended for another period of three years. Since the expected rate of changes slows with time, plots in similar pine forest, that were burned eleven, twenty, and fifty years ago were selected for monitoring. The same environmental and biotic components as for the 1989 fire are being studied at present. Preliminary results show that biodiversity in all groups decreases with time. It seems as if a period of about half a century is required for a full recovery of this type of ecosystem.

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### *Lightning Fire Modelling at Tel Aviv University*

Recently Dr. Colin Price joined the Department of Geophysics and Planetary Sciences of Tel Aviv University. In continuation of his work at NASA's Goddard Institute for Space Studies (GISS) in New York he will devote part of his time to studying the possible implications of future climate change on natural lightning-caused forest fires.

While at NASA, Colin Price developed an empirically-based model to predict the monthly frequency and area burned of lightning-caused fires in wilderness areas (Price and Rind, J. Clim., 1994). This simple model uses climate variables (precipitation and potential evaporation) together with information on thunderstorm frequencies to predict the monthly mean number of lightning-fires, together with the area burned by these fires in a certain wilderness area.

The simplistic climate/fire model was then placed into the NASA/GISS global climate model to estimate the possible implications of future global warming on natural fire frequencies. Not only did the drought conditions in the climate model increase dramatically as the model climate warmed (Rind et al., J. Geophys. Res., 1990), but the lightning frequencies in the model also increased dramatically (Price and Rind, J. Geophys. Res., 1994). Although the fire model and the global climate model have significant limitations in their quantitative predictive ability, the general trends of more lightning-produced fires in a warmer climate are believed to be fairly robust.

At present Dr. Price is working on improving the simplistic fire/climate model by using improved fire/lightning data available in Canada. Since the majority of lightning-fires presently occur in high latitude regions (boreal forest), the Canadian data will be extremely valuable in understanding how climate change will impact future fire frequencies.

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## **SWITZERLAND SPECIAL**

### *Forest Fire Research in Switzerland*

#### **Part 1: Fire Ecology and History Research in the Southern Part of Switzerland**

#### **Introduction**

In Switzerland most forest fires occur in the southern part, a small region of 4000 km<sup>2</sup> (9.8% of the total national area) with a forest cover of 44% (176,000 ha). An average of 740 hectares of woodland in southern Switzerland burn annually, generally during the dry winter period, but recently also during the summer seasons.

The southern part of Switzerland is situated in a small basin, closed toward the north and the west (Alps) and open toward the south and the east (Po Valley). This geographical situation with the mountainous barrier on the

one hand and the open plain of the Po Valley on the other hand modifies the atmospheric currents of air. The western currents, which are normally humid and relatively warm, are often shunted to the north, the polar and subpolar air masses from the north have to pass over the Alps and arrive at the foot of the Alps in central and southern Ticino relatively dry and mild. The southwestern, southern, southeastern and eastern air masses can arrive in Ticino relatively directly, which means that the currents from the south often bring heavy rainfall and from the east cold air masses in winter and hot air masses in summer. The climate therefore is characterized by dry and sunny winters with periods of north-foehn (main time of forest fires) but also by occasionally strong snowfalls, by wet springs and autumns and by sunny summers with very heavy falls of rain (thunderstorms).

The typical vegetation under the climatic conditions in this region are chestnut forests on acid soils, deciduous broadleaved mixed forests on limestone and beech forests at altitudes between 800 and 1300 m a.s.l..

In 1992 the FNP Sottostazione Sud delle Alpi (FNP SdA), a branch station of the Swiss Federal Institute of Forest, Snow and Landscape Research, started its research on forest fires by creating a wildfire database including all information available on forest fires in southern Switzerland. Since that time several research topics about forest fires and their management have been under study at the FNP SdA.

In this first contribution about forest fire research in Switzerland we will report on the ongoing studies on fire ecology and fire history research in the southern part of the Swiss Alps which are being conducted at the FNP SdA in close collaboration with other Swiss research groups.

### **Forest fire history of this century in southern Switzerland**

In 1992 a forest fire research project (Conedera et al. 1995) was started within the scope of the Swiss National Research Programme 31 (NRP 31) "Climate Change and Natural Disasters". The NRP 31 project made it possible to reconstruct on the basis of more than 5300 fire-events the pattern of forest fires in the present century and also to study the relationship between weather and forest fires.

The most notable aspect of the development of the fire regime in this century is the general increase in the occurrence of fires since the sixties (Fig.1), with a marked rise of fire occurrence in summer (May to November) since the 1970s (Fig.2). This change cannot be explained simply through the analysis of particular meteorological factors or the inclusion of the major anthropogenic causes. Rather it must be seen in relation to the rapid changes in the socio-economic conditions on the southern side of the Alps. These have led to an acceleration of the increase in the area of forest, an abrupt cessation of litter utilisation, and other agricultural activities, as well as a drastic reduction in the exploitation of timber since the post-war years.

Consequently, the amount of fuel has increased. This in turn has reawakened fire to its role as a natural regulator of the biomass in the forest ecosystems, a role which will certainly become more influential in the future, when we regard the natural evolution already taking place in the forest ecosystems of the chestnut belt towards mixed deciduous broadleaved forests. Further, the probable consequences of a possible climatic warming with a concomitant shift of the vegetation zones at fairly high altitudes would render forest fire one of the most important factors in bioregulation.

Another remarkable aspect of forest fire behaviour in southern Switzerland is that nearly all forest fires are surface fires. Crown fires occur very rarely. In connection with the increase in the occurrence of fires in summer since the seventies, ground fires as well as surface fires combined with ground fires have also increased (Fig.3).

Figure 4 shows the burned area per year in southern Switzerland. Although there is a relationship between the number of forest fires and the burned area, high frequency of forest fires does not always correspond to extensive burned areas. Vice versa, during years with relatively few forest fires extensive areas can burn (Figs.1 and 4, for example 1970, 1976, 1984, 1989). An annual average of 0.4% of the total forest cover burns, in extremely dry years up to 4.1% (1973) can be destroyed by forest fires.

These results show that studies on the ecological aspects of forest fires in southern Switzerland should be intensified, because the ecological effects, especially of winter fires (December to April), which are dominant in the southern part of Switzerland, are still little known.

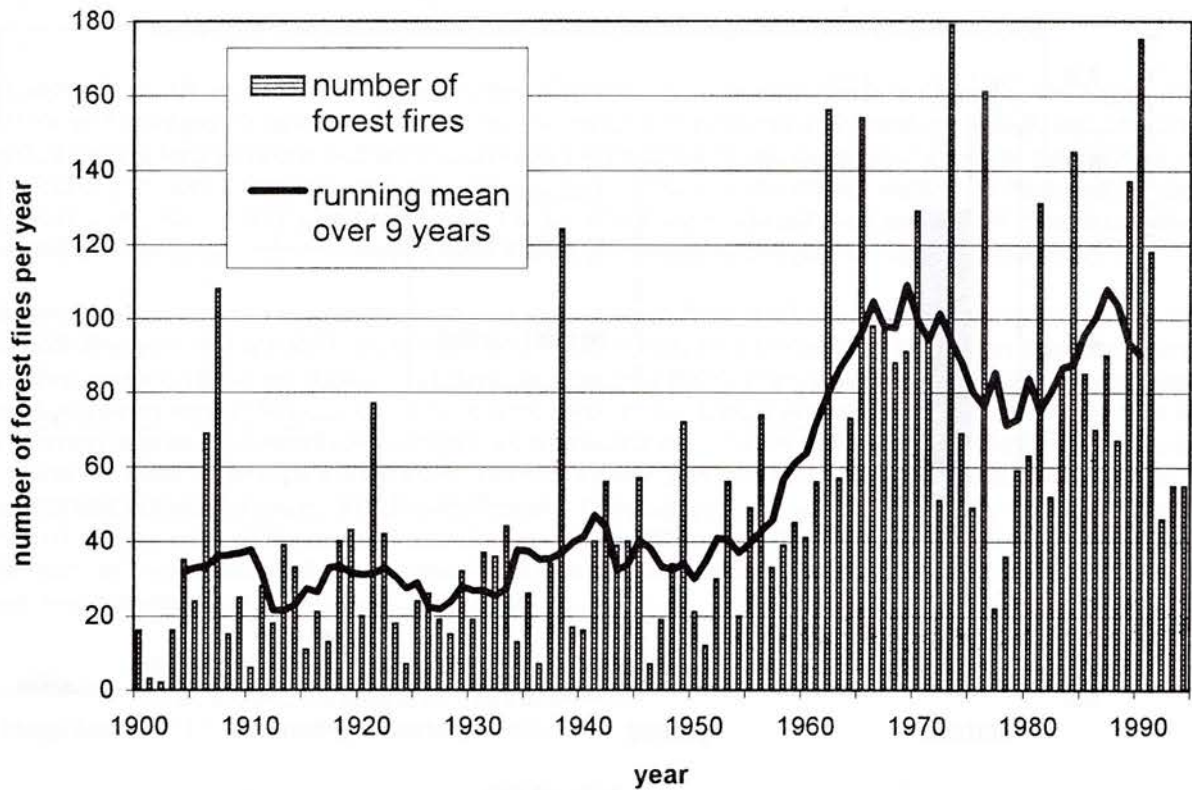


Fig.1. Evolution of the annual number of forest fires in southern Switzerland

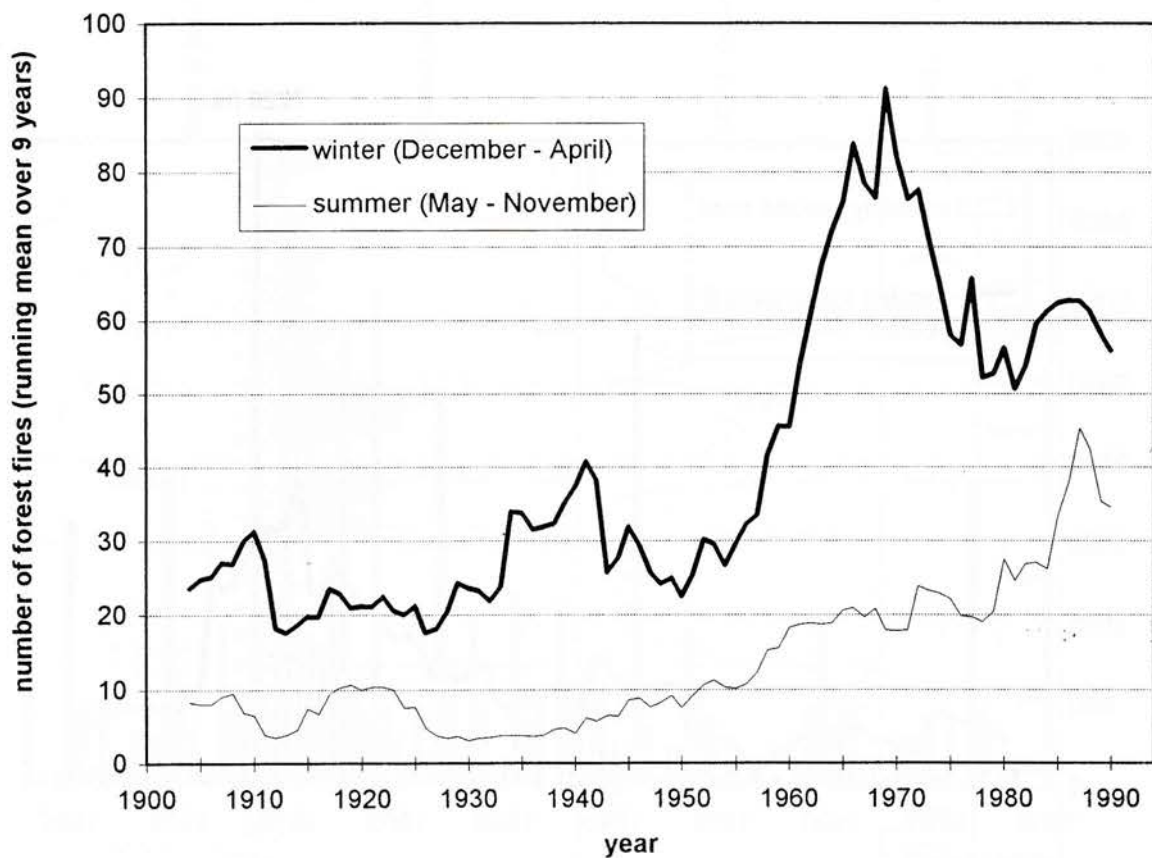


Fig.2. Evolution of the occurrence of forest fires during the winter and summer periods in southern Switzerland

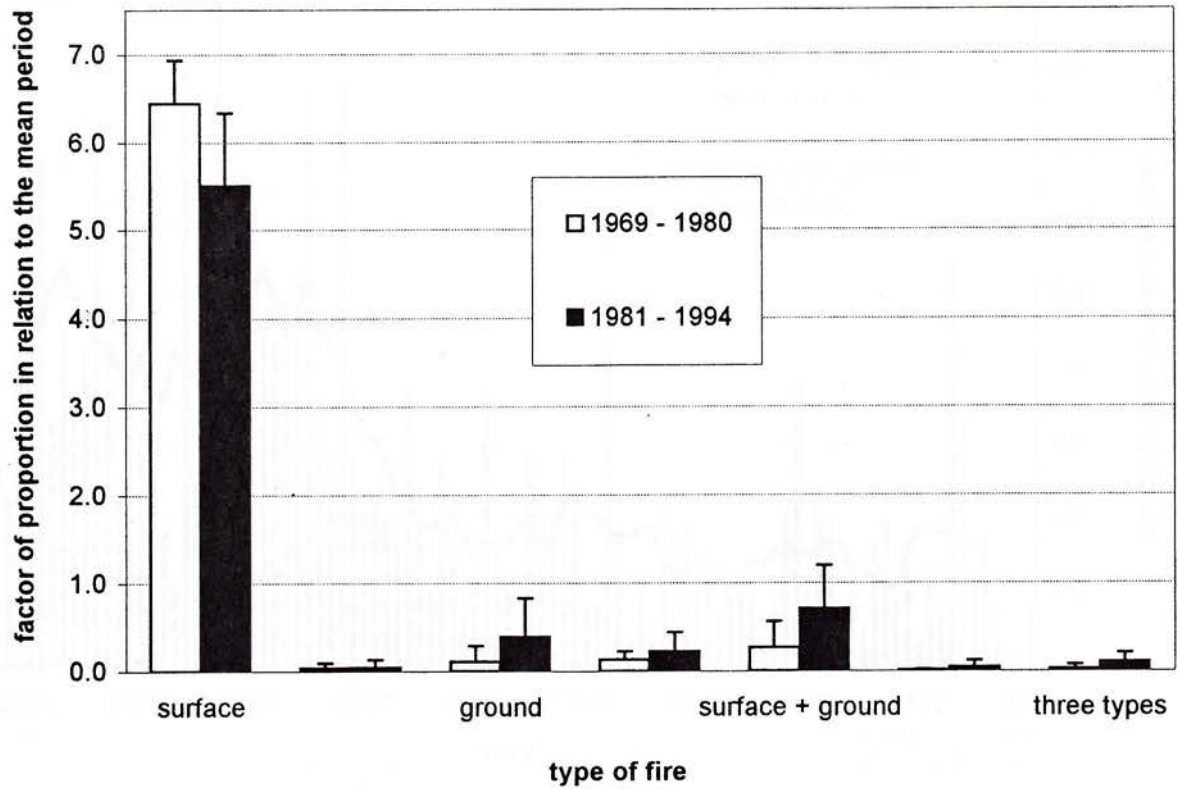


Fig.3. Evolution of the distribution of types of forest fires in southern Switzerland

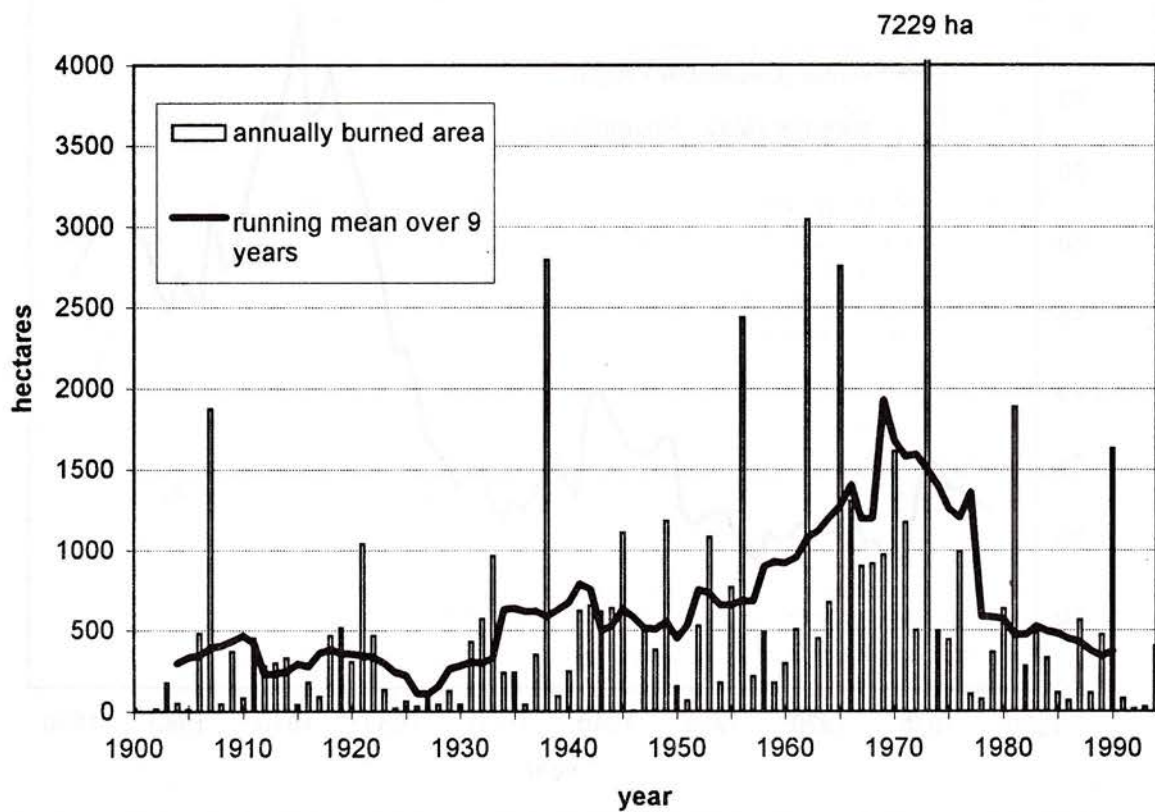


Fig.4. Evolution of the forested area annually burned in southern Switzerland

### Forest Fire Paleohistory and Vegetation Paleoecology in Southern Switzerland

As shown by Clark et al. (1989) in southwestern Germany, and Odgaard (1992) in Denmark, the vegetation history in the temperate latitudes of Europe can be influenced by forest and heathland fire. Paleoecological methods reveal long-term tree and shrub succession following forest fire and may also answer the question as to whether past forest fires are anthropogenic, climatic, or both. Early human impact can be traced by the proportion of pollen of crop plants and weeds. On the other hand pollen and plant macrofossil records can also be used to reconstruct timberline fluctuations indicating temperature changes during the Holocene.

Because little is known of the fire paleohistory of the southern Alps, the University of Bern started a study of the lake sediments of Lago di Origlio in southern Ticino (416 m a.s.l.) in order to reconstruct past forest fires and their possible effects on vegetation (Tinner and Conedera 1995). Continuously deposited un laminated silty gyttja sediments with a thickness of 13.15 m were cored in the deepest part of the lake at a water depth of 6 m. Terrestrial plant macrofossils and silty gyttja were radiocarbon dated by AMS-techniques by K. van der Borg (Utrecht) in order to provide a time scale. The radiocarbon ages in Figure 5 are presented as conventional uncalibrated radiocarbon years BP (Before Present). Charcoal analysis was carried out by means of image analysis and the areas of the charcoal particles (bigger than  $75 \mu\text{m}^2$ ) in the pollen slides per sediment volume ( $10^6 \mu\text{m}^2/\text{cm}^3$ ) were calculated. These values were then compared with the results of pollen analysis (% of total sum or pollen grains/ $\text{cm}^3$ ).

Lago di Origlio (416 m a.s.l.)  
Tinner, W. and Conedera, M. 1995 (modified)  
Coring: 1-12-1994, W. Tanner, W. Tinner, L. Wick

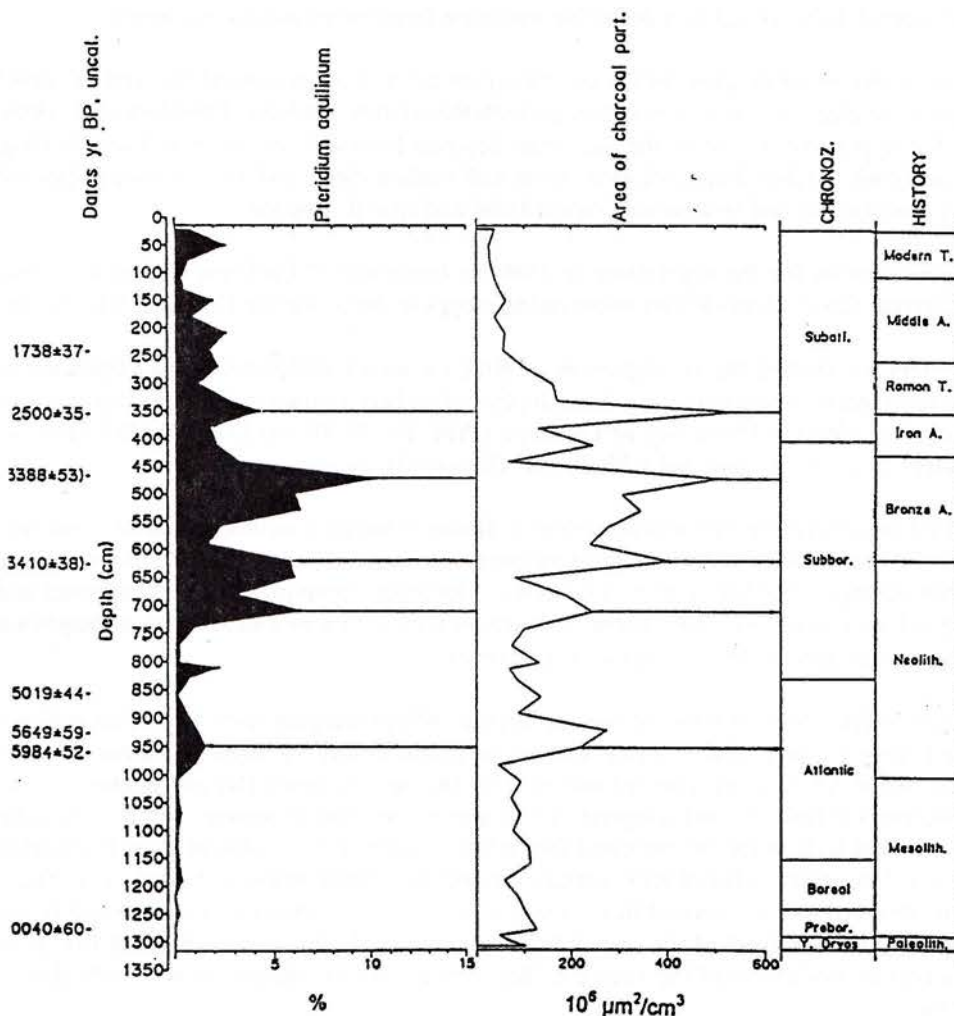


Fig.5. Spores of *Pteridium aquilinum* and concentration of charcoal areas in the lake sediments of Lago di Origlio in southern Ticino.

The preliminary results of pollen analysis and radiocarbon dating suggest an undisturbed stratigraphy from the Younger Dryas to the present. The fire history of Lago di Origlio can be subdivided into four major periods. The first period probably corresponds to the end of the Paleolithic and to the Mesolithic and is characterized by low charcoal values. The second period covers the Neolithic and shows medium charcoal values. The highest charcoal values occur in the third period, probably during the Bronze and Iron Ages. Finally, the fourth, lasting from Roman to Modern Times, shows rapidly decreasing charcoal values. During this last period the charcoal curve reaches its Holocene minimum. The first big peak in the charcoal curve is dated shortly after 6000 BP (ca. 4950 BC dendrocalibrated) in the period of the Early Neolithic. The most intensive forest fires around Lago di Origlio during Holocene seem to have been anthropogenically induced. Strong indications for this assumption are regular findings of pollen grains of *Plantago lanceolata*, *Cerealia* and other plants of managed habitats since ca. 5000 BP (Tinner and Conedera 1995). Possibly the Neolithic, Bronze Age and Iron Age farmers used fires for clearing forest in southern Switzerland.

All marked peaks in the charcoal curve since the Neolithic correlate with decreases of tree pollen, indicating that trees around Lago di Origlio suffered great damage by forest fires. The damaged trees were mainly *Abies alba*, *Fraxinus excelsior*, *Ulmus*, and *Tilia*. In contrast, *Pteridium aquilinum*, *Corylus*, and since the Subboreal *Calluna*, were able to spread after fires (Fig. 5 and Tinner and Conedera, 1995). Around 2200 BP, at the end of the Iron Age, even the relatively fire-tolerant stands of *Alnus glutinosa* t. (t.=pollen type) were reduced, providing space for the introduction of *Castanea sativa*. With the spreading of *Castanea* (up to 46 % pollen) after 2000 BP the charcoal curve strongly decreases. Probably, forest fires were no longer useful to farmers but rather endangered the cultivation of *Castanea sativa*.

The vegetation changes since the Neolithic, caused most probably by anthropogenic forest fires, are considerable: the forests around Lago di Origlio became strongly thinned, and *Abies alba* disappeared from the surroundings of the lake between 5000 and 4000 BP. The strong reduction of *Ulmus*, *Tilia*, and *Fraxinus excelsior* t. at around 4000 BP led to a definitive transition from mixed-oak to oak forest.

Similar investigations are in progress in the central-alpine dry-climate region of Switzerland (the Valais). In order to compare the charcoal contents in sediments with the wildfire database (Conedera et al. 1993; Marcozzi et al. 1994), the uppermost 47 cm of the lacustrine deposits from a frozen core in Lago di Origlio will be continuously analyzed. Higher time resolution, more radiocarbon dates, and further coring sites will allow us to refine our investigations and to approach successional and spatial questions.

**Forest fire consequences for the vegetation:** In 1990 the University of Lausanne studied the consequences of fires on the chestnut forest vegetation on south facing slopes in detail for the first time (Delarze et al. 1992).

In 1994 and 1995 we studied the consequences of fires on mixed deciduous forest vegetation on southern slopes, on chestnut forest vegetation on northern slopes and on beech grove vegetation. During these two years we worked together with the University of Lausanne (Prof. Dr. P. Hainard, Dr. R. Delarze), with Dr. M. Marchetti (Italeco S. p. A., Roma) and with Dr. G. Carraro (Dionea S. A., Locarno).

We used 100 m<sup>2</sup> phytosociological plots according to Braun-Blanquet's method, made in areas hit by various fire frequencies. At the same time dendrological measurements were recorded for each plot in order to calculate an index of fire damage from fire scars on tree barks. Moreover, these measurements allowed analysis to be made of the basal area (area in square metres of the cross-section of a tree stem at breast height and inclusive of bark) for some tree species under different fire regimes.

For appreciation of the site conditions we used ecological indices (ranging from 1 to 5) according to Landolt. In Switzerland almost every higher plant species is characterized by eight of these empirical indices, representing its needs for soil moisture (F) and basicity (R), soil nutrients (N) and humus contents (H), soil dispersion (D), average light (L) and temperature (T) during the growing season, and continentality (K). The effect of fire on these indices can be estimated through the species composition of plots from different zones. We analysed our data using statistical tests, mainly variance and factor analysis. No effects of fire on the total basal area was observed, but we noticed that some tree species were substituted by more fire resistant ones in the most frequently burned areas of the mixed deciduous forests. In this case, indices of fire damage are not adapted for a correct evaluation of the situation. But they are for the almost monospecific and fire tolerant chestnut forests.

The consequences of fire on the vegetation physiognomy are almost the same everywhere. Fire leads to a lessened tree cover, which results in more light reaching the ground, a steeper temperature gradient in the soil, and an increased continentality. Therefore, species diversity usually increases shortly after a forest fire. Some species are almost always favoured by fires (*Pteridium aquilinum*, *Robinia pseudoacacia*, *Rubus fruticosus* s.l., *Galeopsis tetrahit*) while others are almost always curbed (*Hedera helix*, *Corylus avellana*, *Fraxinus* spp. and *Tilia cordata*).

It was possible to represent most different post-fire reaction patterns (acidification, loss or enrichment of nutrients and humus content, increase or decrease of humidity of the sites, etc.) as a function of forest type, fire frequency, slope aspect and time elapsed since the last fire.

Some of these post-fire effects on the vegetation and on the soils will have to be discussed again in the light of the soil erosion study which is in our programme.

**Soil erosion and runoff after forest fires:** After forest fires, which frequently break out in the steep colline-submontaneous belt between 200 and 1000 m a.s.l., the ground surface lies partly bare because most of the vegetation, the litter and also the organic matter on the ground surface have been at least partly burned.

Different ecological effects on the forest ecosystems can be observed depending on natural conditions (precipitation, soil, topography, etc.), the fire intensity, the fire frequency, the elapsed time since the last forest fire, the type of forest fire, the size of the burned area, and the moment of the fire outbreak during the vegetation season. Beside the vegetation and the organic matter the microorganisms of the soils and the mycorrhizal fungi, which can stabilize the soils, can also be destroyed while varying physical and chemical changes of soil parameters can lead to a destabilisation of the soils. Under these conditions the sandy and acid Haplic Podzols (after FAO classification) in the region of the chestnut belt, which are relatively poor in nutrients, are exposed to increased runoff, soil erosion, and nutrient loss.

A soil erosion project was started in November 1995 and will be realized in the next three years in close collaboration with the Faculty of Geography of the University of Basle.

The knowledge of sediment yield (quantity per unit area and time) and runoff rates is of primary interest for the valuation of soil degradation after the first and repeated forest fires. The soil erosion process therefore will be studied by using testplot (3m x 10m) measurements as well as a process-oriented geoecological methodology on representative chestnut forest land burned under natural conditions. By using sediment traps and tubes for catching eroded material, ash, and runoff it will be possible to quantify and also to qualify materials transported from burned slopes as well as from unburned slopes, where we will also install testplots. Thus we will be able to distinguish between natural (unburned plot) and fire-induced (burned plot) erosion.

The quantification of sediment yield rates, runoff and nutrient loss is being done for the first time on burned slopes in Switzerland and is therefore an important aspect of this project.

The landscape ecological approach being used considers the geoecological factors soil, georelief, climate, vegetation and also the anthropogenic influences, and therefore supplies quantitative data on larger burned areas. With the extrapolation of the data received at "plot scale" to "burned area scale", by using soil erosion models we can create for example soil erosion risk maps, which will be an important instrument in fire management policies.

Another important aim of this soil erosion project is to see if we can detect a correlation of soil erosion and runoff rates with the meteorological parameters, other geoecological factors, and fire-induced parameters such as fire intensity or the elapsed time since the last forest fire. A further aspect is the comparison between actual and earlier soil erosion rates, which we hope to find out with the help of charcoal analysis of different horizons of soil profiles. With that it should also be possible to calculate tolerable soil loss rates, which is important with regard to the proposal for eventually necessary soil conservation practices.

First results of the testplot measurements on 65% to 90% steep chestnut coppices near Mte Brè s. Locarno at 900 m a.s.l. and near Tenero - Contra at 550 m a.s.l., where it was burning in November 1995 and in April 1996 respectively, show that there is a high runoff rate from the slopes at Mte Brè s. Locarno, where it burnt

five times during the last 30 years. The runoff rate under very similar precipitation conditions is also higher in relation to the slopes at Tenero - Contra, where it burnt for the first time this century. With the runoff more nutrients leave the burned areas compared with the unburned areas. Plots on slopes with similar natural conditions but affected by different fire intensity show that higher fire intensity correlate with higher soil erosion rates and also higher nutrient loss.

The first soil erosion events, which could be observed and measured during May and June, are still low. This is not surprising because the really erosive precipitations in the southern part of Switzerland happen during summer. Higher amounts of sediment yield and runoff rates are therefore to be expected in the coming months.

Because this study only started last November it is too early to present final results, but it seems that fire intensity as well as fire frequency (probably also the elapsed time since the last forest fire) play a very important role in erosion processes as well as the erosivity of the precipitation, the erodibility of the soils, the topography, the vegetation cover, and the human activities (silviculture).

**Perspectives for the future:** The study on the occurrence of forest fires together with the construction of an information system formed a decisive first step in the intensification of interdisciplinary studies on the ecological effects related to forest fires on the southern side of the Swiss Alps. In future it will also be necessary to intensify team-work on an international level, with regions and countries which have similar problems with forest fires, to seek common solutions.

For this year it is planned to start a project which will examine the influence of forest fires on invertebrate biodiversity in chestnut forests on the southern slopes of the Swiss Alps. The role of forest fires in regulating forest biomass and in initiating adaptation processes in plants and animals will be studied. The aim is to find out what effects single and repeated forest fires have on the faunistic biodiversity in the chestnut forest ecosystems in southern Switzerland.

We also plan to initiate studies on the effects of forest fires on other ecosystem components, such as mycorrhizal fungi or humus fractions in the near future.

**Conclusion:** Ecological fire research studies in other parts of the world show that forest fires are often a driving evolutionary force and sometimes even an important prerequisite for sustainable biodiversity. A closer look at the situation in Switzerland will show whether such circumstances are also valid for this region, where most fires take place during the dormant season.

Although forest fires in southern Switzerland seldom became a threat to the life and property of local residents and tourists, some problems can originate from forest fires in connection with the protective function of the forest, soil conservation or economic aspects of the timber industry. Therefore extensive and expensive measures are taken to prevent and fight fires under all circumstances.

With the ongoing studies about the ecology of forest fires we hope to elaborate a decisive instrument to support the authorities responsible for fire management and fire-brigades, because it is our intention to aim at a more differentiated fire management strategy for southern Switzerland.

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### *Wildfire Ecology and Management Course, Zurich, Switzerland, 3-4 April 1996*

This event was organised by the Department of Forest and Wood Sciences, Federal Institute of Technology (FIT), Zurich, Switzerland, in close cooperation with the Fire Ecology Research Group, Max Planck Institute for Chemistry and University of Freiburg, Germany. The main objective was to arouse forestry students' interest in wildfire ecology, and to provide a forum for the exchange of current research findings. The seminar was attended by approximately 30 participants.

The following topics were treated: Basic aspects of wildfire ecology and the Siberian forest fire experiment (J.G. Goldammer); Dendrochronological methods for reconstruction of fire history (W. Ortloff); Cultural and fire history of Tiveden National Park, Sweden (H. Page); Effects of wildfire on regeneration of the vegetation in the semiarid Chaco, NW-Argentina (A. Kull); Ecological impact of forest fires in Ticino, S-Switzerland (P. Marxer); Statistical prognoses of forest fires in the Southern Alps and the Mediterranean region (D. Mandallaz); Modelling of fire risk in Central Siberia (G. Buchholz); Inflammability of dominant plant species in Andino-Patagonia (B. Weindler); Global effects of wildfires on atmosphere and climate (J.G. Goldammer). The programme was completed by an excursion to a burned site in the Alps in Summer (guided by R. Jecklin, District Forest Officer).

This kind of seminar was held for the first time within the scope of the new curriculum for forest sciences in Switzerland. It clearly demonstrated the potential of this fascinating topic, using interdisciplinary approaches to a complex phenomenon of high regional and global significance.

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## COUNTRY NOTES

## ARGENTINA

*The 1995-96 Wildfire Season in Patagonia*

The 1995-96 wildfire season in Patagonia, Argentina (September - April) was the worst in nine years. A total of 120,000 ha of forest, wildland and steppe were affected by approximately 500 fires (Tab.1).

The reason for this dramatic development was the extended drought period with extremely high drought codes. Over five months, there was nearly no rainfall, e.g. the area around Esquel (Province of Chubut) had only five rain days with 28 mm precipitation from 24 October until 13 March. An extreme situation arose especially in the second half of January with multiple fire occurrences and large fires.

The forest area (native forest and reforestation) in the Patagonia region of Argentina forms a 70 km wide and 2200 km long strip, in places interrupted, along the Andes. The northern part, the provinces of Neuquén, Río Negro and Chubut, have a continental climate, and the southern part, Santa Cruz and Tierra del Fuego, a maritime one, with rains evenly distributed over the year. The distribution of forests under different climatic conditions is reflected in Table 1, column "native forest". 95 percent of the wildland fires occurred in the three northern provinces and only 5 percent in the two southern provinces.

**Tab.1.** Wildfire statistics for September 1995 to April 1996 for the Patagonia Region of Argentina

Province	Number of Fires	Vegetation Type Affected by Fire (ha)				Total Area Burned, by Province (ha)	Total Area Burned, by Province [% of all Patagonian Provinces]
		Native Forest	Reforestation	Shrubland	Grassland (Steppe)		
Neuquén *	65	2,168	12	0	87,784	89,964	75 %
Rio Negro	164	2,194	417	55	4,857	7,523	6 %
Chubut	148	4,914	28	1,074	434	6,450	6 %
Santa Cruz	18	39	0	0	4,875	4,914	4 %
Tierra del Fuego	23	2	0	0	17	19	- %
National Parks **	83	10,944	0	0	0	10,944	9 %
Total Number of Fires	501						
Area (ha)		20,261	457	1,129	97,967	119,814	
Percent		17 %	(0,4) %	1 %	82 %	100 %	100 %

\* arranged from N to S

\*\* 8 National Parks are distributed over all the are

82 percent of the affected surface corresponded to grasslands (steppe) especially in the northern province Neuquén. Within this vegetation type, the burned area per fire was the largest with more than 1,400 ha. In second position in terms of burned area are fires in native forest with about 20.000 ha in total.

It is noticeable is that the fires occurred more often in areas that were burned already before, about 40 years ago.

At present the succession vegetation reached a high development stage of shrubs, the prevailing species being *Nothofagus antarctica*. For these reasons fires unfortunately affect in increasing numbers old native forest or patches of old trees and leave behind larger and larger disturbed areas, which are the potential risk areas for future wildfires.

Only a few areas with shrubby vegetation and reforested areas were affected by fires.

The distribution of wildfire causes shows the dominating role of man made sources (more than 90 percent of all fires registered in Patagonia). But the origins of the fires varied strongly by regions. While almost all fires in the Río Negro area in the south were caused by men, climatic reasons (lightning) accounted for 46 percent of the fires in Neuquén province.

**Tab.2. Causes of Wildfires in Patagonia**

Causes	Quantity of fires [%]
Intentional	45.8
Negligence	25.3
Undetermined	15.3
Lightning	9.0
Agricultural Burning	4.6

The largest wildfires happened in mountain native forests in remote areas with difficult access, but the more dangerous fires happened in the area of S.C. Bariloche (Rio Negro) due to arson. By 19 January 1996 problem fires were being reported from all three northern Patagonian provinces. Wildfires concentrated around the area of S.C. de Bariloche city, the main tourist resort in Andean Patagonia which called the attention and concern of the national government in Buenos Aires. The impromptu reaction of the central government and the lack of cooperation between local organizations and other national institutions (National Parks, military forces, etc.) led to poor and ineffective firefighting. Extreme fire conditions in neighbouring provinces Chubut and Neuquén restricted the availability of regional resources and mutual assistance.

A positive attitude of the national government towards the reorganisation of administrative responsibility for wildfires has been the corollary of this season's fires. The responsibility will be allocated at the national level to enable a better response to wildfires in future.

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## GHANA

*Bushfires in Ghana*

*"As far as the bushfires continue, the grasshoppers cannot congratulate each other"*

A popular Dagomba Saying <sup>1</sup>

**Introduction**

The issue of bushfire (wildfire) appears as a central theme in this report because bush burning is one of the challenging 'man versus environment' conflicts in Ghana. Burning is embedded in the cultural values and traditional farming systems of the people. The effects of bushfire on rural livelihoods and on the ecosystem in Ghana are increasingly becoming extensive and damaging. However, it has been difficult to reduce or completely eliminate bushfires.

The difficulties of eliminating bushfires completely means that there is need for a clear understanding of the causes and effects of bushfires so that bushfire policies can address the undesirable effects with respect to forestry, arable agriculture, rangelands, soil conservation and wildlife. Although bushfires have played some part in agricultural production and in accelerating environmental degradation especially in the fragile savanna ecosystem, this issue has largely been ignored in decisions affecting the environment compared to tropical deforestation and desertification which have received considerable attention in environmental discussions.

Like many hazardous phenomena which occur occasionally, bushfires which appear as headlines in mass media reports during the dry season seem to be forgotten when the risk disappears with the onset of the rains. Consequently, there is very little in the form of published data and information concerning the frequency, intensity, duration and effects of bushfire on the environment and human welfare in Ghana.

This factor undoubtedly undermines the country's ability to prevent, control and completely eliminate bushfires in the fragile ecosystems which are threatened by drought and desertification.

**Ghana: An Overview**

Ghana, a former British colony in the West Coast of Africa has a land surface area of about 23.9 million km<sup>2</sup>. The population was just over 12 million in 1984 with an average density of 52 persons/km<sup>2</sup>. In 1995, the population was estimated to be 15.5 million with a growth rate of 3 percent per annum.

The country may be divided into six major ecological zones (Fig.1). However, for convenience and for the purpose of this paper, it may be categorised into two. These are the closed forest (high forest or closed canopy forest) zone covering about 34% of the country (8.22 million ha) and the savanna zone of an area 15.62 million ha or about 66% of the land area.

The closed forest is floristically very rich and diverse and contains a large reserve of commercial timber species. About 2/3 of the country's human population and economic activities are concentrated in this zone. The savanna vegetation has evolved under conditions of annual bush fires, which has increased by human activities. The vegetation consists of short grasses with scattered fire-tolerant trees. The closed forest and savanna ecosystems in Ghana continue to experience major biophysical environmental changes, which are generally degradational in character, and closely associated with production pressures including slash-and-burn agriculture, uncontrolled bush burning and hunting to meet the food and nutritional needs of the growing population. It is estimated that only about 2 million hectares of the closed forest, made up of about 1.7 million hectares within Forest Reserves and 0.3-0.5 million hectares outside the legally reserves forests, have not been modified through cultivation, bushburning, deforestation etc. The agricultural land forms about 57 per cent of the total land area of which about 18 per cent was cultivated in 1990 under slash-and-burn agriculture. In the last two decades, bushfire has become one of the most dramatic of the natural and anthropogenic forces which have shaped the biotic community. This is so especially in the fragile savanna regions where biodiversity has decreased and the existing vegetation has been destroyed, or disturbed by fire resulting from human activities such as agriculture, including livestock and hunting.

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<sup>1</sup> Dagomba is one of the largest tribal groups in the Northern Region in Ghana.

The socio-economic profile of the rural population in the northern savanna zone (few employment opportunities, high illiteracy rate, low household incomes and uncertainty of tenure) shows the causes which lead to bushfires or wildfires. The practice of bush burning is so deeply ingrained in the traditional farming system that trying to suppress it would mean cutting off the means of subsistence of small-scale farmers who do not have adequate funds to employ labour for land clearing.

Clearly, measures are urgently needed to control the use of fire to ensure maintenance of biodiversity, protect wildlife and habitat for and vegetation enhancement. This requires an understanding of the causes, effects and characteristics of bushfires in Ghana and strategies that can be adopted to prevent and control the effects of bushfires on the ecosystem.

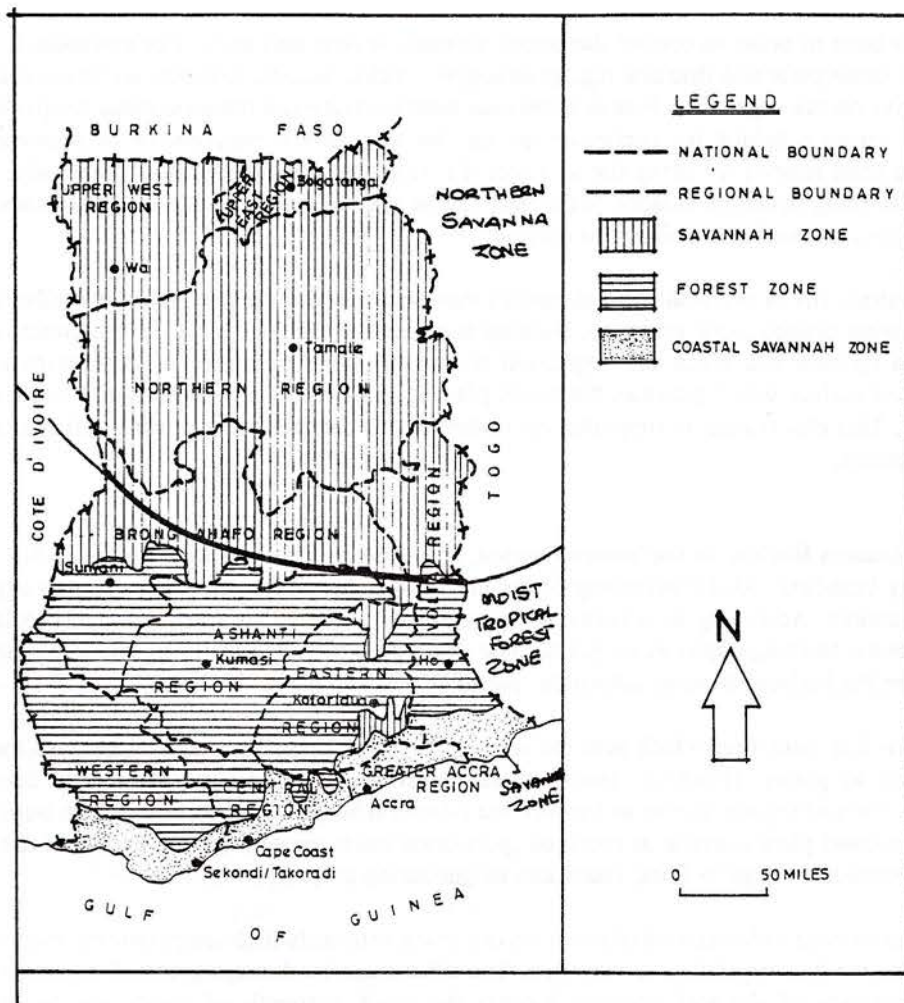


Fig.1. Ecological zones of Ghana

**Bushfires in the Forest Vegetation Zone:** Throughout Ghana, bushfires have exacted a heavy toll of death and unquantifiable suffering on people and animals and have adversely affected the environment. There are several factors which cause bushfires and villagers have good reasons for using fire. However, some of these fires if not properly controlled end up in causing serious damage. Although bushfires occur in the forest areas, they are not as frequent and extensive as in the Savannah Zone. In the forest zone bushfires are extensive in the outer margins of the forest where the drying effects of the Savannah conditions are felt most. This may be particularly the case where the soils are dry and desiccation is rapid.

Fire is widely accepted throughout the country as being a valuable tool in the management of natural vegetation, agriculture including livestock production and in other land use systems. In the past and even in

some instances today hunters, herdsman, farmers and cigarette smokers are the primary recipients of blame for uncontrolled and indiscriminate bush burning. Many bushfires in the forest zone are deliberately started during the dry season. In many areas, farmers and hunters do so to facilitate access by men and animals. Many farmers use fire to reduce the fuel load or combustible litter in order to reduce the potential frequency and intensity of late dry season fires.

Foresters cause bushfires to maintain or achieve a plant composition which is optimal for a specific management objective. For example, in the Guinea and Sudan Savanna regions foresters and range managers cause bushfires to promote the growth of forage for livestock. Sometimes fire becomes a good management tool for facilitating and promoting the introduction of exotic species such as improved forage species into the vegetation. Most herdsman believe that bush burning improves the acceptability and nutritional value of trees and other species (e.g., grasses) for grazing and browsing.

Some farmers also burn in order to control dangerous animals, insects and pests. For example, it is used to destroy or control some pests and diseases (eg. grasshoppers, ticks, locusts, anthrax) and livestock parasites which live and thrive on the vegetation. Fire is sometimes used to create conditions suitable for particular land use systems or to create a habitat for particular species, for recreational purposes or to promote tourism. Although there are good reasons for using fire as a tool if it is uncontrolled or set indiscriminately, its effects can be damaging. Burning in certain seasons of the year can be very destructive not only of vegetation but soil structure and composition, and it increases soil erosion.

In the forest ecosystem, fire is practically the cheapest means available for clearing slash and felled trees from fields to create a larger planting area for crops. Burning is essential for a good crop with minimum of labour. Farmers share the opinion that when the vegetation is burned, large quantities of nutrient-rich-ashes are deposited on the soil surface which provides the newly planted crops with the benefits of the biomass that has grown on the site. This observation is supported by studies which confirm the availability of nutrients (e.g., ash) for growing plants.

**Bushfire in the Savanna Region:** In the Savanna region, soil and vegetation deterioration is caused by human activities especially bushfires. At the beginning of the dry season, herdsman often start fires to stimulate the growth of young shoots. According to herdsman, the regrowth or young offshoots are more palatable and contain more nutrients. Burning improves ranges because grazing animals frequently are found concentrated on burned areas where the herbage is more accessible, palatable and nutritious.

Studies have shown that farm fires which heat the soil to 200°C are actually beneficial because the increase nutrient availability to plants. However, temperatures in excess of 400°C are detrimental because they completely destroy the soil organic matter and reduce the cation exchange capacity. Fires which burn large tree trunks or destroy heaped plant material at confined spots often reach temperatures in excess of the threshold value resulting in serious damage to flora, fauna and neighbouring property.

However, bushfires causing volatilization of nutrients can reach extremely high temperatures, especially at the end of the dry season when vegetation is very dry. The effects can be damaging to soil structure and plant stability. A deterioration of the soil structure hinders the quick regrowth of plants and facilitates crust formation.

Burning of bush and grass in savanna occurs either spontaneously by lightning or often by man for agricultural purposes (e.g., to facilitate the growth of new grass for livestock) and for hunting. Bushfires are more extensive in the savanna where a number of factors are responsible for the frequency and extensiveness of the fires. The grasslands, by their geographic locations, have a prolonged dry period which extends from October-April which results in a more thorough drying up of vegetation and soils. The intensity of the sun is generally felt with sparse vegetation. Wind speed is generally high. The importance of grazing is particularly significant in this region. Therefore the need for fresh green grass leads to the tendency of herdsman to burn off dry and undesirable vegetation (grasses) and to promote the growth of pasture.

Hunting is also an important economic activity in the savanna ecosystems, and most hunters set fires to drive out game in hunting. In the forest ecosystem, indiscriminate bush burning has been one of the major factors in

the change of forest to woodland, woodland into savanna and savanna to shrubland. The Sudan and Guinea grasslands are anthropogenic climax communities maintained by grazing, bush burning and crop cultivation, and they will revert to scrub and then woodland and forest if these controlling factors are removed.

In Ghana, using fire in hunting is mainly for meat. Therefore, problems arise from the lack of alternative sources of protein/meat and wildlife by-products. They also result from ignorance of better techniques of hunting.

Since meeting protein needs of households leads to misuse and abuse of fire, incentives should be given to individuals who engage in activities which promote livestock productive to produce more meat so as to reduce the pressure on wildlife.

**Drought and Bushfires:** Climatic factors, especially rainfall, vegetation and wind speed play an important role in bush burning. Weather extremes and rainfall variability make the natural vegetation vulnerable to wildfires. Where the wet season is short, lasting only three to five months, and where potential evaporation exceeds rainfall for most of the year, the natural vegetation becomes vulnerable and gets destroyed by bushfires which occur annually. Thus, the Sudan and Guinea savanna areas in the country experience more extensive and frequent bush fires than the moist, humid rain forest zone.

In the semi-arid zone, drought often aggravates bushfire or triggers them off, although four human activities - slash-and-burn agriculture and shifting cultivation, livestock production and hunting - are the most immediate causes. In Ghana, bushfires are more extensive and widespread in the semi-arid savanna regions where the rainy season is short and rainfall variability is high.

**Record of Bushfires in Ghana:** There are few records on bushfires, especially fires ignited by lightning in Ghana. Data on anthropogenically caused fires dating back to the pre-independence era are also lacking. However, records of bushfires in Ghana can be traced to the frequency of drought periods because most drought years are accompanied with widespread bushfires. Droughts have obviously been occurring since the beginning of the 19th century. However, it was only after 1970 that the problem of drought and associated bushfires came into the forefront of natural concern for the environment.

Available records show that during the 1982-83 harmattan season, about 35 per cent of crops were destroyed by bushfire. In 1984-85, about 145 bushfires were reported in the northern savanna zone alone. The crops most affected were rice and maize. The average size of farms affected was ca. 50 ha, with the largest covering about 10 ha.

Ghana experienced serious bushfires during the catastrophic Sahelian drought (1973-74) and again in the period 1984-1985. Available data on the 1984-85 bushfires in all the country's ecological zones show clearly that the Guinea and Sudan savanna areas suffered the most impact with loss of vegetation, standing crops, farms, wildlife, habitat, human lives and property.

**Bushfire legislation in Ghana:** The National Environmental Policy recognises past qualitative and quantitative deterioration in land cover (forest and savanna) and wildlife resources due to frequent and uncontrolled burning of bush. In recognition of the beneficial effects of fire as a management tool, especially in the traditional farming systems and the detrimental impacts which often accompany its abuse or misuse, legislative controls were introduced in 1983. In 1988, the National Environmental Action Plan (NEAP) was initiated to put environmental issues on the priority agenda. The Environmental Protection Agency (EPA) also designed policy actions to prevent and control bushfires that cause significant or irreparable damage to habitat, flora, fauna and ecological balance.

**Tab.1.** Incidence of bushfires in Ghana (1984-85)

No	Region	Main Vegetation	Main Crops	Number of Fires (1984-85)	Percent of Total (1984-85)	Rank
1	Western	Semi-deciduous Forest	Timber, Cocoa, Cocoyam	46	4.6	10
2	Central	Coastal Savanna	Maize, Cassava	92	9.1	8
3	Greater Accra	Coastal Savanna	Maize, Cassava	68	6.9	9
4	Eastern	Semi-deciduous Forest	Cocoa, Oil palm	96	9.6	7
5	Volta	Semi-deciduous Forest	Cocoa, Root Crops	107	10.6	5
6	Ashanti	Semi-deciduous Forest	Cocoa, Timber, Cocoyam, Plantain	104	10.3	6
7	Brong Ahafo	Transitional Zone	Cocoa, Timber, Maize	110	10.9	4
8	Northern	Savanna	Rice/Millet Guinea Corn	145	14.5	1
9	Upper East	Savanna	Sorghum/Millet	125	12.4	2
10	Upper West	Savanna	Sorghum/Millet	112	11.1	3

Source: Environmental Protection Council

**Anti-Bush Fire Law:** In 1983 an anti-bushfire law (PNDC Law 46), was promulgated to prohibit the setting of fires except for certain agricultural, forestry and game management purposes. The purpose of the law is to protect land cover, wildlife and habitats.

In 1984 a National Anti-Bush Fire Committee was established and charged with:

- (a) ensuring that government is informed and advised on all matters relating to prevention, control and fighting of bushfires;
- (b) to set up guidelines for the establishment and operation of regional, district, town and village Anti-Bushfire committees;
- (c) to provide technical advice to these committees; and
- (d) to monitor their activities and operations.

The importance of education and the responsibility of the various communities can not be over-emphasised. Despite these efforts, very little has been achieved in preventing and controlling bushfires because the beneficial uses of fire in agriculture to the individual far outweigh the harm it does to common property resources.

The Forestry Department, Environmental Protection Agency, the National Fire Service and the Community Fire Volunteer Squads lack resources to implement fire policies. In the past, it was difficult to implement fire prevention and control laws, because the 1983 Bush Fire Law did not entrust its execution to any specific government agency. The power and authority of traditional rulers who enforced local rules and regulations on the use of fire in the past has been reduced by education, modernisation and urbanisation. Thus traditional norms in the use of fire appear to have broken down under modernisation with damaging environmental consequences. The role of the Ghana National Fire Service as the training agency needs logistic support as well as incentives. Making laws forbidding the cutting and burning of bush is easy; however, stopping cultivators and hunters from burning is not. Therefore, the capacity of district and local institutions to deal with the problem of bushfire should be enhanced to enable local people enforce fire policies consistent with the national prospects for sustainable development.

In searching for ways of ameliorating bushfire problems, planners and decision makers must pay more attention to preventive measures rather than cure. Penalties for abusing fire prevention and control laws should be harsh to serve as a deterrent. Farming systems based on prescribed burning must be intensified in the country to reduce the hazard of bushfires. However, effective prevention and control of bushfires demand proper enforcement of rules and regulations by local people.

Two major policies can be pursued to address the problem of bushfires in Ghana. The first involves policies to reduce indiscriminate burning through community education and environmental awareness programmes. The second involves encouraging prescribed burning. Prescribed burning, however, appears to be the most promising and viable option in the long term because it allows local people to use fire in a beneficial way only.

**Conclusion:** There are many factors and causes of uncontrolled bush fires. Among the natural and anthropogenic causes of bushfires, it appears that human activities, especially in agriculture (including hunting and livestock production), are the primary causes of indiscriminate and uncontrolled bush fires in Ghana.

Although it is a fact that the Guinea and Sudan savanna areas are most threatened by widespread bush fires, the forest zone is also vulnerable during prolonged droughts. Therefore, policies, strategies and measures to prevent and control bushfires in Ghana should pay attention to both the savanna and forest zones with active support and commitment from local people.

In the past development planners too often tended to ignore local people in decisions affecting their environment and wellbeing. The 'top-down' approach must give way to the 'bottom-up' approach which insists that local people must be fully involved in deciding how to tackle the problem of bushfires.

In developing bushfire policy, the aim should be to burn for conservation purposes or to meet clearly defined objectives such as reclaiming unmanaged grassland or to prevent the invasion of grassland by trees and shrubs. However, the development of good fire policy and plans and their successful implementation will depend on a thorough knowledge of the area (i.e., biophysical, socio-economic etc) through research and also the support of local people.

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*Note from the Editor:*

*This contribution by Dr. Nsiah-Gyabaah had to be shortened in order to meet the standards of IFFN reports. The full text of the paper which includes in-depth information on ecological conditions of Ghana as well as on the ecological effects of fires can be obtained from the author or from the Editor's desk.*

## MONGOLIA

### Wildfires in Mongolia 1996

#### Introduction

During the months of March and April, 1996, Mongolia began to experience wildland fire events significantly exceeding normal activity levels for this period of time. The fire activity intensified in late April and continued unabated through the month of May, burning extensive areas of forest and grazing land. In mid May, a request for assistance was received at the U.S. Office of Foreign Disaster Assistance (OFDA). Ray Dionne, Disaster Operations Officer from OFDA, and Deanne Shulman, Fire Management Specialist from the United States Forest Service, were dispatched to Mongolia to assess the fire situation, and identify critical needs and problems impacting the effectiveness of the Mongolian response to this emergency situation. During the period 21 May to 5 June, 1996, they consulted with Mongolian government officials responsible for the management of the fire disaster, conducted aerial reconnaissance of heavily impacted fire areas, participated in fire logistic support missions, interviewed firefighters, and met with the American Ambassador, U.S. Agency for International Development personnel, and the International Donor Community.

#### The Mongolia Wildland Fire Environment

Mongolia has a land area of 1,566,371.52 square kilometres, a land area slightly larger than Alaska. The average altitude of the country is about 1,600 m a.s.l., making it one of the highest countries of the world.

The majority of forested land is located in the northern half of the country and covers approximately 10% of the total land base. Fires occur primarily within three vegetative zones: the taiga forest zone, the mountain forest steppe zone, and the steppe zone. The Mongolian taiga zone, occurring only in the northernmost areas of the country, is the southern edge of the vast Siberian taiga forest, the largest contiguous forest system on earth. These boreal coniferous forests are composed primarily of Siberian Larch (*Larix sibirica*, 70%), and Siberian Pine (*Pinus sibirica*, higher elevations). Mosses and lichens provide abundant ground fuels. The mountain forest steppe zone covers 25% of Mongolia and is comprised of both steppe (grassland) vegetation found on the drier slope aspects and mixed coniferous hardwood forest of pine, larch, and birch (*Betula platyphylla*) with a grass understorey on the cooler, moist northern slopes. The topography is characterized by hilly, mountainous terrain separated by wide river valleys. The mountain steppe zone occurs in a belt across the northern portion of the country. The extensive grasslands of the steppe zone covers nearly the entire far eastern part of Mongolia and extends westward in a belt through the central portion of the country. The topography of the steppe zone ranges from gently rolling to flat terrain. In a typical year, the majority of fires occur in the grasslands or grass understory of the steppe and mountain steppe zones.

Weather patterns create two distinct fire seasons in Mongolia. Spring weather is dominated by strong, dry winds. These spring winds can become very fierce and it is not uncommon for airplane traffic bound for Ulaanbaatar to be diverted to other cities due to wind during the spring. These winds are characteristic from March through June and can create intense fire potential in the dry, dead grass from the previous fall. July and August are generally rainy and produce new grass growth. During September and October, the new grass dries and again becomes available fuel for wildfire. Winters tend to be bitterly cold and dry.

Table 1 shows the number of forested acres burned each year from 1978 to 1994 (1995 Natsagdoogiin and Lamjabin, Information On Group Training Course in Reforestation Promotion Leader "Forestry, Forest Industries, Unpublished Report).

#### The Situation in Spring 1996

**Fire Conditions:** An unusually dry winter (1995/96) resulted in significantly lower than average fuel moisture in the grasslands and forests of Mongolia. The strong, spring, northwest winds quickly spread any fire ignition through the tinder dry and readily available fuels. The primary ignition source of these forests are the local inhabitants, through careless use of fire or discarded cigarettes. Much of the adult population in Mongolia smoke cigarettes. During spring, many people derive extra income by collecting deer antlers in the forest and selling them. Careless smoking while involved in this activity can result in ignitions in forested areas.

**Tab.1.** Forested area burned annually in Mongolia

Year	Forest Area Burned (x 1000 ha)
1978	987.63
1979	66.17
1980	107.16
1981	4.61
1982	153.54
1983	87.25
1984	156.13
1985	33.31
1986	28.57
1987	143.26
1988	2.19
1989	17.40
1990	649.54
1991	63.86
1992	390.54
1993	205.10
1994	119.95

**Fire Damage:** Information gathered from briefings in Ulaanbaatar with Deputy Prime Minister Purevdorj, Chairman of the State Emergency Commission and General Damdinsuren, Deputy Chairman of the State Emergency Commission and Chief of Civil Defense Committee of Mongolia indicated the following as of 30 May 1996 <sup>2</sup>:

- There were a total of 352 fires in the country, of which 22 had been extinguished, 94 were contained, and 36 remained uncontrolled.
- A total of 3.5 million hectares of forested land and 5.9 million hectares of grassland was burned. Most of the fire activity was in the northern thirteen provinces. One fire in the taiga zone of northern Huvsgol region had a 128.7 kilometre front in the Mongolia portion, and extended across the border into Russia.
- There had been 23 fatalities, including six persons killed while involved in fire suppression activities. Sixty people had been treated for serious burn injuries.
- 168 gers (Mongolian traditional dwellings) were destroyed leaving 750 people homeless.
- 7,800 animals died in the fires, and many fences, range improvements, and water developments destroyed.
- Over 2000 telephone poles were burned, severing some communication links to provincial areas.

Personal observations from aerial reconnaissance and interviews with field personnel conducted on 25, 26 and 29 May in the Tov and Selenge province indicated immense areas burned in both forest and grasslands with intense, stand-replacing crown fires in approximately 10% of the burned forested areas. Many of the fires were in remote, high elevation locations with limited accessibility. Smoke covering the region limited full utilization of the few aircraft available. The extent of pasture land burned will have immediate adverse impacts on the available grazing land of nomadic herdsman. Discussions with various officials indicate that a fire season of this magnitude and devastation has never occurred within their career span, although Chief of Civil Defense

<sup>2</sup> Update information: see pp. 35-36 of this issue

General Damdinsuren stated that 30 or 40 years ago there was a fire season of a similar catastrophic proportion. Old fire scars and mosaic regeneration patterns observed from the air indicate a history of stand-replacement fires in these forested ecosystems.



Fig.1. Daily updates of fire activities were provided by the National Remote Sensing Center. The photograph shows the fire status map of 27 May 1996 (Photo: D.Shulman)

#### The Government of Mongolia Response

**Emergency Response Organization:** The State Emergency Commission is chaired by the Deputy Prime Minister and has overall responsibility for dealing with the fire emergency situation. This commission consists of representatives from all the ministries. The Chief of the Civil Defense Committee is the Deputy Chair of the State Emergency Commission. The mission of the Civil Defense Committee is to protect human lives and properties from natural disasters. In a wildfire emergency situation, the Civil Defense Committee is responsible for all operational aspects of fire suppression efforts. The provincial branches of the Civil Defense Committee do not have full-time employee staff. Civil Defense representatives are in a reservist status and are activated in a civil defense capacity only in the event of an emergency incident. The Civil Defense organisation includes approximately 200 smokejumpers based in seven northern provinces. It also includes approximately 100 specialized rescue personnel who are trained firefighters.

In response to the fire situation, the State Emergency Commission declared a "state of emergency". Special coordination groups were established in local areas impacted by the fire situation to direct suppression efforts and provide humanitarian relief as needed. The military and police forces were mobilized to fight the fires as were thousands of local people. Border troops near Russia were also mobilized. All available resources were mobilized in the fire suppression effort, which on a daily basis ranged from 3,000 to 10,000 firefighting personnel and from 1,000 to 3,000 vehicles. Local individuals were conscripted to fight fire and were organized in crews under the leadership of military personnel or other officials.

**Priority Criteria for Resource Commitments:** Priority fires for the limited suppression resources were determined based on the fire's proximity to population centres and threat to National Parks and Strictly Protected Areas. Due to the limited resources available and the number and magnitude of active fires, it was determined that some remote fires would have no suppression activity.

**Intelligence Gathering:** The Ministry of Nature and Environment maintains a very modern Information and Computer Centre that compiles environmental data. This includes meteorological, water quality and pollution data. NOAA computerized satellite imagery is used for meteorological purposes and environmental monitoring. During the wildfire emergency, fires were mapped daily using computerized satellite imagery. The fires were then numbered and listed by province and county with the latitude and longitude indicated for each. The map and list were sent daily to the Civil Defense Commission and the Ministry of Nature and Environment. Another service that the computer centre provided was meteorological data for the Mongolian Hydrometeorological Service, Weather Modification Centre "Khuryin Shim". Other fire situation intelligence data were gathered through information from the field. Generally, this information was two days old by the time it was received in Ulaanbaatar. There was no radio communication from the fires to the local command centres. Information from the fires was carried by people on horseback or vehicles to local command centres and then telephoned to Ulaanbaatar.

**Aircraft and Equipment:** Aircraft committed to the firefighting effort included four military MI-8 helicopters utilized for logistic support and firefighter transport only. These helicopters were not equipped for tactical uses such as bucket drops or rappelling. An AN-26 airplane was used to "cloud seed" in an effort to produce rainfall. AN-2 aircraft were used by smoke jumpers and military paratroopers to parachute to remote fires. There are no airtankers in the country.

A country-wide inventory list provided by the Civil Defense Committee dated 28 May 1996 indicates the following firefighting tools and equipment:

**Tab.2.** Inventory list of firefighting tools and equipment available in Mongolia during the 1996 wildfire episode

Type of Equipment	Number	Type of Equipment	Number
Backpack pumps	153	Air Blower	110
Rakes	34	Burnout Equipment	14
Shovel	34	Chainsaw	10
Axe	23	Vehicle Mounted Pump and Tank	16

Fire fighting equipment observed include home-made "swatters" (pieces of tire rubber, linoleum, perforated metal, or felt attached to the end of a wood handle), five gallon backpack pumps (Russian made), two and a half gallon pressurized agricultural type water sprayers (Russian made), small steel rake-like brooms, air blowers (donated by the People's Republic of China), and kerosene burn equipment. Wet clothes and tree boughs were the primary tools used to beat out the edges of the fire.

No safety equipment or fire resistant clothing was observed (with the exception of one smokejumper wearing a yellow Nomex shirt that was given to the smokejumper unit in 1990 when a UN sponsored United States team installed a parachute manoeuvring simulator for the smokejumpers in Ulaanbaatar, USDA Report 9151-2803-MTDC).

**Strategy and Tactics:** The non-professional firefighters (military, police, and locals) used direct flanking attacks by beating out the edges of the fire perimeter. This method can be effective in light wind conditions and grassy, light fuels. It is considerably less effective in the heavier ground fuel conditions of the taiga forests in

the north, or windy conditions. The smokejumpers and trained firefighters were utilizing indirect backfire and burn out techniques where appropriate to control the fire.

Cloud seeding to enhance precipitation was used to suppress fires where weather conditions met required parameters. The Weather Modification Centre had cloud seeded twenty times during the spring to assist in fire suppression. Meteorologists at the Ministry for Nature and Environment Information and Computer Centre analyzed satellite imagery to determine which clouds may be favourable for cloud seeding. This information is sent to the Weather Modification Centre of the Hydrometeorology Service. Silver iodide "bullets" are fired from either an AN-26 airplane or the ground into the selected clouds to form a nucleus for raindrop formation.



**Fig.2.** Smiling young fire-fighting supporters demonstrate home-made fire swatters. Photo: D.Shulman.

**Logistics:** A communication schematic provided by the Civil Defense Commission shows short-wave radios located at seven smokejump bases in the northern provinces. Civil Defense communications between Ulaanbaatar headquarters and the province capitals is done by telephone. Communications directly to or from fire locations are carried out by people on horseback or vehicles. The smokejumper units have "line of sight" radios (Russian made) with a maximum 6 mile range depending on terrain, with which they can communicate with each other and aircraft directly overhead.

There were three MI-8 helicopters utilized for logistic missions. Equipment and supplies were transported by vehicle or animal to the fire locations. Crates of canned meat and tools were observed being transported on helicopter logistic missions, but local firefighters complained of inadequate food supplies, sleeping bags, and tents.

### **Identified Problems**

**Economic Constraints:** The fragile market economy and limited emergency government funds available to support the fire fighting effort significantly impacted the fire suppression operation. Smokejumper fire detection patrol flights, normally scheduled based on a fire danger rating, were delayed this year due to funding shortages for aircraft fuel. Fires that could have been detected early and suppressed while small were not detected until they became large. Smokejumper units were understaffed due to low pay and hazardous duties. The normal contingent is 300 smokejumpers. This year, however, Civil Defense could only attract 200 smokejumpers. In the transition economy, all purchases must be made in cash. Cash to pay for aircraft fuel was a continuing problem. Food and local transportation to fires was coordinated and organised at local command centres, but lack of funds to buy fuel and purchase food locally caused considerable supply and distribution problems. Local firefighters continued to receive salaries from their regular employers. Those firefighters recruited from the ranks of subsistence herdsman were provided food while fighting fires.

**Communications:** The Civil Defense Committee lacks basic communication equipment to effectively manage an emergency incident of any kind. This lack impedes the flow of adequate, accurate, and timely information between field personnel and individuals responsible for resource allocation, strategic planning, and logistic support decisions. In a rapidly changing, geographically dispersed emergency incident such as a widespread wildfire, up-to-date information is crucial for decision makers.

**Disaster Management:** An emergency situation of this magnitude requires an incident management structure that incorporates specialists and workers from all spheres of the government and local populations. There was no clear emergency management structure to develop an overall strategic plan, implement the plan, and provide logistic support and financial expertise to support the operation. Lack of a strategic plan and logistics problems were resulting in inefficient use of firefighting resources. Information relating to specific daily costs of supporting the fire suppression effort was difficult to obtain, frustrating members of the international donor community requiring a cost analysis to justify recommendations for cash donations.

### **Additional Information**

A chronological narrative of specific daily activities during this assessment is documented in the Trip Report on file at the U.S. Office of Foreign Disaster Assistance. The full text of the Mongolia Wildfire Assessment Technical Report is also on file at OFDA.

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### ***Mongolia Fire Update***

In August 1996 the editor of IFFN received an update of information on the fires of 1996 provided by the Mr. Erdenesaikhan Naidansuren National Remote Sensing Centre which belongs to the Ministry for Nature and Environment of Mongolia:

From 27 February to 3 June 1996 a total of 386 forest and steppe fires broke out in 115 places over Mongolia and total of 2.3 million ha of forest, 7.8 million ha of pasture land have been affected by these fires. More than 7000 livestock, 210 houses, 560 communication facilities and 576 facilities for livestock were devastated by the blaze, leaving many peoples homeless. Also 25 people died and 65 were seriously injured by this fires. The Government of Mongolia quoted environmental damage of US\$ 2 billion as preliminary estimation.

The development of space technology has provided a new method for forest fire monitoring, especially using meteorological satellites, which have received great attention because of their wide view, high observation frequency and low cost. All staff of the National Remote Sensing Center from the beginning to end of fire conflagration have worked with high efficiency to serve all organizations involved in disaster management. At this time our center received and processed NOAA AVHRR imageries which allowed precise fire location. People in the entire country are now recognizing the importance of satellite remote sensing data for wildfire prevention and fighting. At present we are working on the evaluation of the economic and environmental damages caused by the wildfires. There are several problems like restoration of forests, establishment of powerful fire prevention systems, improvement of satellite fire monitoring equipment and lack of the natural disaster monitoring experts by satellite.

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## NEPAL

### *Forest Fire in Nepal*

**Introduction:** Forest fire is considered as a problem in forest management systems. In mixed forest of sal in Terai (flat area in southernmost east to west belt of Nepal), the fire season starts from mid-March and the fires burn the forests 1-3 times till the end of May. All fires are surface fires.

In clause (b), Section 49 of Forest Act 1993, "starting a fire, or doing anything that may cause a fire accident" in National forest is prohibited. In Clause 1.(b), Section 50 of the Act, any person who commits such an offence shall be punished with a fine of not more than NRs. 10,000, or with imprisonment for a term not exceeding one year, or with both. This is the only one legal provision for fire control but it is still ineffective because it is extremely difficult to identify the offender.

From general observations in the Rautahat district (Terai) in 1995, it was found that about 90 percent of the forested area in the plain was burnt out. This condition is more or less similar in all Terai districts.

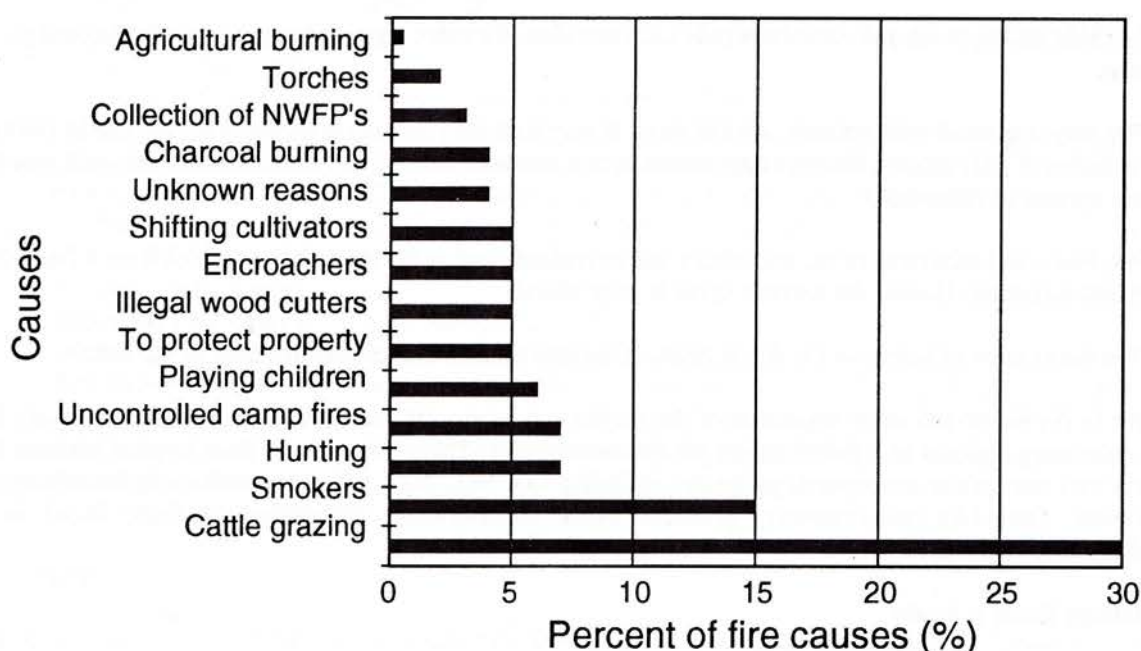
Broadleaved stands and mixed stands comprise mostly deciduous forests. Normally, they appear in drier areas such as in Terai, Siwaliks, on mountainous slopes where soils are relatively dry with distinct dry season.

During the dry season (March to May) most tree species in Terai totally shed their leaves. The great amount of dry leaves and small twigs which accumulate on the forest floor accompanied by grass and under-growth species which turn dry during the time serve as fuel for the outbreak of forest fires.

**Forest fire problems / constraints:** There is no single fire control plan in Nepal yet. There is no proper accounting of fire. In the annual programme of District Forest Offices (Terai) they have some fire control programmes which are insufficient and some which are ineffective. Every year in the dry season (March - May) fires invade the forests and burn uncontrolled. They are due to:

- lack of resources;
- lack of extension education for the local people;
- lack of specific fire control rules and regulations; and
- lack of specific fire control organization.

**Causes of forest fires:** There are no statistics on fire in Nepal yet. By the experience of key persons, an attempt is made to give the general picture of the quantity of fires by individual causes in Figure 1.



**Fig.1.** Distribution of causes of wildfires in Nepal. Explanation of some categories:

Cattle grazing: burning for stimulation of new grass

Illegal wood cutters: burning of stumps to hide evidence

NWFPs: collecting non-wood (minor) forest products, e.g. honey, trophies, etc.

Torches: burning of wood or rubber, for travelling by night

Agricultural burnings: escaped fires

Cattle grazing for new grass and smokers alone share about 45 percent of fires among all known causes of forest fires. Natural causes (e.g. thunderstorms) of fire are not reported. About 64 percent of fires are set by people intentionally, about 32 percent of fires are due to accidental/carelessness, and about 4 percent by unknown causes.

**Economic Impact of Forest Fires:** When fire burns it has a number of effects which are negative to the economy which will eventually affect the people and the nation as a whole, as described in the following lines: It kills the regeneration. It destroys non-wood forest products (NWFPs). Sometimes it reaches villages causing huge losses in properties and life. Some District Forest Offices (DFOs) of Nepal issue licenses for hunting like DFO, Rautahat. When the forest is burned, the number and kinds of wildlife will be reduced.

There are plenty of fallen and standing dry trees in the forest. At present, this is the main source of royalty from the forestry sector. The fire burns this national property. Sometimes it burns wooden bridges in the forest. It destroys the natural beauty of the forest. It accelerates the consequences of soil erosion.

**Ecological Impacts of Forest Fires:** Fires disturb ecological cycle and adversely affect the bio-diversity in the particular ecosystem by the following impacts:

- Soil nutrients: Some nutrients are volatile and burnt off by a fire and these either evaporate or are leached.
- Soil texture: Rises and falls of temperature may change soil texture. It affects the water holding capacity of the soil. Rises of soil temperature may kill the soil micro-organisms.
- Repeated fire may change species composition creating fire hardy species.
- Fire kills undergrowth and sometimes pole size trees also. It creates a gap in age gradation in the younger age group.
- Fire may trap small wild animals and kill them. It may lead wild animals to escape from the site in question. In addition, it kills infants, destroys eggs resulting in a narrower base in the population structure and may lead some species to extinction.
- Fire burns and kills most of the microflora and microfauna within the top soil layer which have a function of nutrient recycling. Hence, the nutrient cycle is jeopardised.
- Fire burns most of the litter on the forest floor. It reduces organic matter leaving ashes in the soil.

Fires in the forest and other vegetation of the tropics and subtropics and the changing tropical land-use have an increasing regional and global impact on the environment. The smoke plumes from tropical biomass fires carry vast amounts of atmospheric pollutants, including CO, NO<sub>x</sub>, N<sub>2</sub>O, CH<sub>4</sub>, non-methane hydrocarbons, and aerosols. Smog-like photochemistry produces ozone concentrations comparable to those found in the industrialised regions.

### Findings From a Study

This study was conducted in Manahari in Makwanpur district (inner Terai). The area is situated at an altitude of 300 m a.s.l. The method used was experimental burning in small areas and observations were made in uncontrolled burning areas as well during March - April. Three samples of fuel were randomly collected from the burning area, and the green weight was measured immediately and the samples were sent to laboratory for calculating the oven dry weight. Discussions were held with forestry professionals and rural people to compile their knowledge and experience.

Fires set by cattle grazers for stimulating new grass growth and careless smokers alone account for about 45 percent of all known causes of forest fires. Natural causes (e.g. thunderstorms) of fires are not reported. About 64 percent of fires are caused by people intentionally, about 32 percent by accidentally/carelessness, and about 4 percent by unknown causes. Preventive measures could be the solution for a fire control programme.

The fuels are mostly continuous, and one to four layers of leaves of sal (*Shorea robusta*) and other species comprise about 95 percent of the volume, of which sal leaves account for about 90 percent. Other surface fuels are twigs and grasses. The volume of the available fuel was found to be 10.7 tonnes oven dry weight per hectare (air dry weight of 11.7 t/ha). The moisture content of the fuels at the time of analysis was found to be 10 percent. The fuel type (i.e. forest cover type) is mixed forest comprising 70 percent sal, 10 percent asna (*Terminelia alata*), and 20 percent other species. The fuel type pattern is more or less homogeneous with some natural (streams, small rivers, etc.) and cultural (roads, foot trails, etc.) barriers. The rate of spread of the fire in experimental burnings in Manahari forest area (Terai) in the given conditions was found to be about 0.25 m/min and the form was found to be elliptic. The flame height was found to be about 25 cm.

## Recommendations

It is recommended that the Department of Forests of Nepal should immediately prepare a district level Forest Fire Management Plan (FFMP). More than 90 percent of the activities should be based on fire prevention activities and the rest on fire suppression activities, research and accounting of fire.

Within the Forest Department a functional organization should be established. The organization be responsible for fire prevention, human resource development, law enforcement, and fire research. Collection of fire statistics should include:

- number of fires and area burned (yearly)
- number of fires by each cause
- area burned by each cause
- fire distribution by forest vegetation zones
- size distribution of forest fires
- duration of forest fires
- monthly distribution of forest fire incidents throughout the year

Because of the limited resources and poor communication infrastructures, prevention activities, which are the most economic way of reducing fire damages and losses, could be the most important function of fire control services for Nepal. The most important elements of fire prevention would be:

- Primary school education
- Extension programmes - general public education;
- Workshops among political leaders and members of administrations;
- Enforcement of laws, regulations, rules, and restriction for fires and their communication through sign boards and warning notice boards;
- Fuel management - fire line construction and control burning along the firelines and forest tracts and roads; and
- Clear demarcation of forests.

## Conclusions

This study is entirely focused on the Terai situation. In Terai the main species is **sal** mixed with **asna** and other species. The fire season begins in mid-March, and the fires burn the forests 1-3 times till the end of May. All fires are surface fires.

The Department of Forest of Nepal is the responsible governmental organization for fire control. However, due to the lack of resources, lack of specific fire control rules and regulations, lack of extension education for the local people, and lack of a specific fire control organization within the frame of the Department, it is not functioning well with regard to the fire control activities. Preventive measures could be the solution for the fire control programme. That is why local NGOs and other groups should be utilized for extension activities. Village Fire Control Group (VFCG) should be formed and motivated by a responsible organization. Statistical information and research activities are almost nil in Nepal. Such data are most important for fire control planning.

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## NEWS FROM FAO/ECE

## Joint FAO/ECE/ILO Committee on Forest Technology, Management and Training

*Seminar on "Forest, Fire, and Global Change"*  
*Shushenskoe (Russian Federation), 4-9 August 1996*



The seminar on Forest, fire, and global change was held in Shushenskoe, at the invitation of the government of the Russian Federation from 4 to 9 August 1996. Participants from the following countries attended: Austria, Canada, Germany, Norway, Poland, Portugal, Russian Federation, South Africa and United States of America. The following non-governmental organizations were represented: International Union of Forestry Research Organizations (IUFRO); the International Boreal Forest Research Association (IBFRA), Stand Replacement Working Group; and the International Global Atmospheric Chemistry (IGAC) Project, of the International Geosphere-Biosphere Programme (IGBP).

The seminar was addressed by the chairpersons of the seminar, Mr. D.I. Odintsov, Deputy Chief of the Russian Forest Service and Mr. J.G. Goldammer (Germany), leader of the FAO/ECE/ILO Team of Specialists on Forest Fire. Mr. Odintsov welcomed the participants on behalf of the Deputy Prime Minister, Mr. A. Zaverukha. The seminar was also addressed by Mr. A. Amerhanov, Deputy Minister of Environment and Nature Protection and Mr. J. Najera of the Timber Section of the UN-ECE Trade Division. Mr. S.A. Arichin, Deputy Governor, welcomed the participants on behalf of the Administration of the Province of Krasnoyarsk. The participants of the seminar elected Mr. D.I. Odintsov (Russian Federation) and Mr. J.G. Goldammer (Germany), Co-Chairmen.

The leader of the ECE/FAO/ILO Team of Specialists on Forest Fire presented basic thoughts on the scope of the seminar and on global cooperation in fire research, management and policy development. He described past and ongoing activities and achievements in (a) international exchange of information, through International Forest Fire News (IFFN) and the publications produced by the International Association of Wildland Fire (IAWF); (b) fire research programmes, through the mechanisms of the International Geosphere-Biosphere Programme (IGBP/IGAC) and the International Boreal Forest Research Association (IBFRA); (c) international collection of fire data through ECE/FAO, FAO, the European Union EU and the fire science community; and (d) development of international policies and programmes, the ITTO Guidelines on Tropical Forest Fire Management and the International Decade for Natural Disaster Reduction (IDNDR). He underscored the need for further expanding international collaborative efforts in fire research, management and policy development and expressed his confidence that the results of the seminar will help to support this process.

During the seminar invited and voluntary papers were presented by fire scientists, managers and representatives from administrations and international organizations, on the following topics:

- Assessments on the extent of land areas affected by fire (forest and other land)
- Assessment of damages caused by wildfires

- Clarification of the role of forest fires in
  - (a) land-use and land cover changes
  - (b) ecosystems and in maintaining biodiversity
  - (c) global carbon nutrient and water cycles
  - (d) forests affected by industrial and radionuclide pollution
  - (e) ecosystems affected by climate change
- Forest fire management, fire intelligence and equipment
- New spaceborne fire sensors

Based on these contributions the seminar formed working groups which prepared a general statement, conclusions, and recommendations which were included in a report and adopted by the seminar participants (see below). The publication of the proceedings will be carried out by the FAO/ECE/ILO Team of Specialists on Forest Fire. The recommendations of the seminar will be presented to the appropriate bodies of the United Nations through the FAO/ECE fire team.

The participants warmly congratulated the Russian authorities and organizers for the excellent arrangements made for the seminar and study visits and expressed their appreciation for the generous hospitality offered. At this point the team leader and co-chairman of the conference once again wants to express his thanks to the major players organizing the conference, Mr. Dimitri I. Odintsov, Deputy Chief, Federal Forest Service of Russia, for providing all necessary resources of the Federal Forest Service of Russia; Mr. Eduard P. Davidenko, member of the FAO/ECE team and science and technology officer of the Aerial Forest Fire Center of Russia *Avialesookhrana*, for preparing the conference over a 2-years period; Mr. Nikolay A. Andreev, Chief of *Avialesookhrana*, and Mr. Nikolay A. Kovalev, Chief of the Krasnoyarsk regional base of *Avialesookhrana*, for providing the infrastructures for the conference; Mr. Vassilij A. Tolmachev, Russian Forest Service Shushenskoe, and Mr. Vladimir I. Chestera, Krasnoyarsk Forest Committee, for hosting the conference in Shushenskoe and during the field trips.

The Editor



**Fig.1.** Shushenskoe airport - location of a fire management technology exhibition in conjunction with the FAO/ECE fire seminar - showing welcome greetings to the delegates.



**Fig.2.** The amphibious multi-purpose aircraft and water scooper Beriev BE-12P on ground display in Shushenskoe airport (technical information on the BE-12P: see IFFN No.11, July 1994)



**Fig.3.** Aerial extinguishant drop by BE-12P during the field demonstration in Shushenskoe.

**Conclusions and recommendations of the Seminar on  
"Forest, Fire, and Global Change"  
Shushenskoe (Russian Federation), 4-9 August 1996**

**1. General Statement**

**The Role of Fire in the Global Environment**

I. Both anthropogenic and natural fires are an important phenomenon in all vegetation zones of the globe. Their impacts, however, are not uniform. Fires may lead to the temporary damage of forest ecosystems, to long-term site degradation and to alteration of hydrological regimes which may have detrimental impacts on economies, human health and safety.

II. As a consequence of global population growth and land-use changes, the cumulative effects of anthropogenic disturbances, and the over-use of vegetation resources, many forest types, which over evolutionary time periods became adapted to fire, are now becoming more vulnerable to fire.

III. On the other hand, in many vegetation types, of the temperate, boreal and tropical ecosystems, fire plays a central role in maintaining the natural dynamics, biodiversity, carrying capacity and productivity of these ecosystems. In many parts of the world sustainable forestry and agricultural practices as well as pastoralism depend on the use of fire.

IV. Vegetation fires produce gaseous and particle emissions that have significant impacts on the composition and functioning of the global atmosphere. These emissions interact with those from fossil fuel burning and other technological sources which are the major cause for anthropogenic climate forcing.

V. Global climate change is expected to affect fire regimes and lead to an increase of occurrence and destructiveness of wildfires, particularly in the boreal regions of continental North America and Eurasia.

VI. Fire control has been the traditional fire policy in many parts of the world. An increasing number of countries have adopted fire management policies instead, in order to maintain the function of fire in removing the accumulation of fuel loads that would otherwise lead to damaging wildfires, and in order to arrest succession at stages that are more productive to humans than are forests and brushlands that would predominate in the absence of fire.

VII. In many countries, however, inappropriate choices are made - often because the responsible authorities and managers are not provided adequately with basic fire information, training, technologies and infrastructures. Large-scale wildfire disasters which occurred in the past years, especially in the less developed countries, may have been less severe and extended if national fire management capabilities had been developed and assistance through the international community provided.

VIII. Although the global fire science community has made considerable progress to investigate global impacts of fire, using available and developing new technologies, no international mechanisms exist for systematically collecting, evaluating and sharing global fire information. There are also no established mechanisms at the international level to provide fire disaster management, support and relief.

IX. Therefore the participants of the FAO/ECE/ILO Seminar on "Forest, Fire and Global Change" adopted the following conclusions and recommendations:

**2. Conclusions**

X. The economic and ecological impact of wildland fire at local to global levels has been demonstrated at this seminar. The possibility of major world disasters, such as the transfer of radioactive materials in wildland fire smoke, and the substantial loss of human life in recent fires, has been scientifically documented. The lack of, and need for, a global statistical fire database, by which the economic and ecological impact of fires could be spatially and temporally quantified, was identified. Such a reliable database is essential, under

current global change conditions, to serve sustainable development and the urgent needs of fire management agencies, policy makers, international initiatives, and the global modelling community.

XI. Similarities in wildfire problems throughout the world are evident, particularly increasing fire incidence and impact coupled with declining financial resources for fire management, underlying the urgent need to coordinate resources at the international/global level in order to deal effectively with impending major wildland fire disasters.

XII. As climate change is a virtual reality, with predicted significant impacts at northern latitudes, seminar participants recognize that boreal and temperate zone fire activity will increase significantly in the future, with resulting impacts on biodiversity, forest age-class distribution, forest migration, sustainability, and the terrestrial carbon budget. It is essential that future fire regimes in these regions be accurately predicted, so informed fire management decisions can be made.

### 3. Recommendations

XIII. The seminar participants draw the attention of the Joint Committee to this serious situation and to expeditiously consider the following recommendations:

- A. Quantifiable information on the spatial and temporal distribution of global vegetation fires is urgently needed relative to both global change and disaster management issues. Considering the recent various initiatives of the UN system in favour of global environmental protection and sustainable development, the ECE/FAO/ILO Seminar on Forest, Fire and Global Change strongly urges the formation of a dedicated United Nations unit specifically designed to use the most modern means available to develop a global fire inventory, producing a first-order product in the very near future, and subsequently improving this product over the next decade. This fire inventory data will provide the basic inputs into the development of a Global Vegetation Fire Information System.

The FAO should take the initiative and coordinate a forum with other UN and non-UN organizations working in this field, e.g. various scientific activities of the International Geosphere-Biosphere Programme (IGBP), to ensure the realization of this recommendation.

The information given in the Annexes I to III (Draft Proposals for the Development of a Standardized Fire Inventory System) to these recommendations describe the information requirements (classes of information, information use), the establishment of mechanisms to collect and distribute fire inventory data on a global scale.

- B. The development of a satellite dedicated to quantifying the geographical extent and environmental impact of vegetation fires is strongly supported. Such an initiative is currently being evaluated by NASA, and this seminar strongly recommends that this and similar initiatives (e.g., NOMOS sensor on MIR space station) be encouraged and supported.
- C. A timely process to gather and share information on ongoing wildfire situations across the globe is required. The creation of a WWW Home Page to handle this information flow is recommended. This could be coordinated with an ongoing G7 initiative, the Global Emergency Management Information Network Initiative (GEMINI), which includes a proposal to develop a Global Fire Information Network using the World Wide Web.
- D. Mechanisms should be established that promote community self reliance for mitigating wildfire damages and would also permit rapid and effective resource-sharing between countries as wildfire disasters develop. Since the United Nations Disaster Relief Organization (UNDRO) is an organization recognized and established to coordinate and respond to emergency situations, including wildfires, it is recommended to entrust this organization, in collaboration with the United Nations Educational, Scientific and Cultural Organization (UNESCO), to prepare the necessary steps. The measures taken should follow the objectives and principles of the International Decade for Natural Disaster Reduction (IDNDR).

- E The unprecedented threat of consequences of fires burning in radioactively contaminated vegetation and the lack of experience and technologies of radioactive fire management requires a special, internationally concerted research, prevention and control programme. Such programme should be implemented under the auspices of the FAO/ECE/ILO.
- F. The Wildland Fire 97 International Conference in Canada should be used as a forum to further promote the recommendations of this seminar. This can be realized through co-sponsorship of this conference by the FAO, UNDRO, UNESCO, IDNDR and the ECE/FAO/ILO Team of Specialists on Forest Fire.

## **Annex I**

### **Draft Proposals for the Development of a Standardized Fire Inventory System**

#### **I. Preamble**

A Vegetation Fire Inventory System at both national and international levels serve a large number of practical needs:

- 1 Regional - national fire management**
  - a budget - resource requirements
  - b daily to annual tracking of activity compared to normal
  - c long-term trends
  - d interagency - intergovernmental assistance
  - e changes in long term trends
- 2 Regional - national non-fire**
  - a integrated assessments - monitoring of fire impacts on other resources
  - b policies and regulations on
    - i air quality
    - ii global change
    - iii biodiversity ?
    - iv ?
- 3 International use of fire inventory**
  - a updated forest inventory; availability of timber; fire integrated in resource availability salvage
  - b market strategies
  - c import- export policies - strategies
  - d food and fibre availability rangelands
  - e interagency - intergovernmental assistance agreements
  - f national security
  - i food and fibre assessment grass and fodder
    - ii water supply and quality
  - g research
    - i global change
    - ii integrated assessments monitoring
  - h international treaties agreements
    - i UNCED
      - climate convention
      - biodiversity
    - ii CSD, IPF
    - iii Montreal protocol on ozone
    - iv IDNDR, others
- 4 Economic data utility national, but not international compatibility of assumptions**

## Annex II

## Information Requirements

## A. Classes of information

## alpha type

- fire start and end dates
- fire location (lat, long; resolution?)
- fire size
- cause of fire

## beta type

- fuels - biome classification
- fuel loading forest inventory, age class, size class

## gamma type

- fire characterization (crown, surface, etc.)
- fuel consumption
- structural involvement (wildland urban interface)

## delta type (current ECE/FAO)

- number of fires
- area burned (by forest type)
- cause of fires (number)

## epsilon type

- gas and aerosol emission data

## eta type

- total expenditure of fire programme
- total fire suppression costs
- total direct losses of merchantable timber, structural losses

## B. Decision Space Table

Information use		Information type					Frequency
		alpha	beta	gamma	delta	eta	
<b>Regional/National (fire)</b>							
1	Budget resource requirements	x	x				A
2	Daily to annual fire activity	x	x	x			DWMA
3	Long term trends	x	x	x			A
4	Interagency agreements	x					DWMA
5	Resource allocation	x	x	x			DWM
<b>Regional/National (non fire)</b>							
6	Assessment monitoring	x	x				A
7	Air quality policy regulations	x	x			x	A
8	Global change policy regulations	x	x	x			A
9	Habitat change	x	x	x			A
<b>International (fire)</b>							
10	Intergovernmental assistance	x	x	x			DWMA
<b>International (non-fire)</b>							
11	Treaties and agreements	x	x	x	x		A
12	National security	x	x	x			DWM
13	Research		x	x	x	x	A
14	Market import/export forecasting	x	x		x	x	A

D = daily; W = weekly; M = monthly; A = annual

### **C. Parsimonious Fire Inventory**

Intergovernmental assistance at bilateral or regional level does not require a global data base. These agreements are regional and may differ in requirements from one region to another. If we exclude national security, we need only annual data for a global database. The gamma data type is assembled from the alpha data so there is no need to report this separately. The beta data on fuels can be obtained from other inventories, but must be standardized. The gamma data type will also require development of international standards before it can be considered. All vegetation fires must be included in this data base.

## **Annex III**

### **Establishment of Mechanisms to Collect and Distribute Fire Inventory Data on a Global Scale**

#### **A. Current State of Fire Inventory**

- A Data consisting of individual fire reports are developed by many nations, but many regions of the world are not covered.
- B Only ECE and EU nations have established mechanisms to share data.
- C Current shared data consists of statistics aggregated from individual fire reports.
- D Data from remote sensing is rapidly becoming available, but only for fires that can be defined by either heat signature or by fire scars on the landscape.

#### **B. Issues**

- A A large number of uses of an international fire inventory have been identified in fire management, environmental policy and agreements, and in economic growth of nations.
- B A parsimonious inventory has been identified which can be utilized by all nations (see statement on standardized fire inventory).
- C There needs to be international agreement to provide fire inventory (similar to the FAO global forest inventory).

#### **C. Implementation**

- A Fire inventory at the global scale should consist of individual fire data of date of fire start and end, location of fire, size of fire, and cause of fire. Fire location from individual fire reports normally report origin of fire. Remote sensed data are more likely to report centre of burned area. Should fire reports contain centre rather than origin, in addition to origin?
- B Two additional forms of data will be needed in the future, biome classification and fire characterization. Standard for these additional information will need to be developed
- C Rapid electronic communication is available for nearly all parts of the globe. Fire inventory data can be made available through World Wide Web. FAO is an appropriate centre to compile and distribute these data.
- D Remote sensed data will need to be placed in the same format as individual fire reports and be made available on World Wide Web. Images can also be made available through WWW. Appropriate potential centres for compilation and distribution of these data are ISPRA (EU) or NASA's EOS-DIS.
- F Those nations which cannot provide data in electronic format, should agree upon a hard copy format which can be scanned and readily placed in electronic format.

## FAO Committee on Mediterranean Forestry Questions - *Silva Mediterranea*

### *Activities of the Forest Fire Network in 1995*

The year 1995 has been a period of review for the programme of activities concerning the Forest Fire Network. The new Coordinator of the Network, Mr. Ricardo Vélez, sent in January a draft of a new programme of activities in order to verify the availability of the "focal points" of the Network in every country. The answer has been irregular, sometimes dramatic, like that from Iraq informing that all forest areas were outside of the Government control, so without any forest fire management. There is evident need for reshaping the composition of the "focal points" roster. *Silva Mediterranea* has a very limited budget, so its activities have to be those developed by the specialized teams working in every country, with the Committee playing the role of animator.

In February, as a result of the personal connections helped by the Network, a group of Greek experts visited Spain in order to learn about the forest fire organization and, specifically, experience in the utilization of the amphibious aircraft CL-215 T with turboprop engines. G.Xanthopoulos was the technical leader of the group. The ICONA staff in Madrid provided all the information requested.

In April a meeting was held in Geneva to coordinate the collection and presentation of statistics on forest fires by the ECE Timber Committee, the FAO *Silva Mediterranea* and the DG VI of the EU (see IFFN No.13, July 1995, pp.29-31).

In June the Mediterranean Agronomic Institute of Chania (MAICh) organized a short course on forest fire management, coordinated by A.Dimitrakopoulos, with D.G.Xanthopoulos (Greece), R.Vélez (Spain), R.McAlpine (Canada) and J.Agee (USA).

Also in June ICONA (Spain) published a summary of results of the socio-economical research developed in the last three years on "Motivations of arson and traditional practices for the use of fire in woodlands". It is recommended that this summary is translated into other languages of use in the Mediterranean Region, to serve as a basis for a future "Workshop on prevention of deliberate fires in woodlands".

During the summer the connections established in the Mediterranean Region facilitated the support provided by Italy and France to fight forest fires in Attica (Greece). Portugal requested assistance from Spain. However, the requests were all made when the circumstances in Spain were critical and all resources were committed in its own suppression activities. In September a French mission, headed by Mr. P.Michaut, visited ICONA (Spain) to obtain information on the application of new technologies for forest fire management in Spain.

In October the University of Bari (Italy) organized a short course on **Planing of Forest Fire Management Activities**, developed by V.Leone (Italy) and R.Vélez (Spain).

Also in October a meeting for the evaluation of the INRA research programme on forest fires, headed by Mr. J.-Ch. Valette, was held in Avignon (France). This programme concentrates on three foci:

- Start and spread of a fire. Improvement of the risk indices and fire behaviour modelling;
- Fire impacts on forest trees;
- Forest fuel management.

During the month of October a new training video was finished by ICONA (Spain) on "Preventive silviculture". Spain has developed a series of videos with 14 titles, as a basic tool for the training of all personnel. A special edition in French and in English is in preparation, in order to allow its utilization in all Mediterranean countries.

In November the Mediterranean Agronomic Institute of Montpellier finished the edition of the proceedings of the Workshop CIHEAM/FAO/*Silva Mediterranea* on databases on forest fires and their uses, held in December 1993. These proceedings have been published in Options Méditerranéennes N° 25 (see p.64 of this volume).

As a follow-up of the 1993 Workshop a Course on Practical Applications of Forest Fire Data Bases is being organized for April 1996 by the Mediterranean Agronomic Institute of Saragosse with FAO *Silva Mediterranea* and the Spanish Ministry of Agriculture. In this course a practical training will be given on the EU data base (DG VI), the EGIF data base (Spain) and the PYROSTAT data base, developed by the Mediterranean Agronomic Institute of Chania (MAICH).

Another activity in 1996 will be the publication of a **Manual of Forest Fire Management** (in French) with the cooperation of FAO, the MAI Saragosse and the Spanish Ministry of Agriculture.

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## NEWS FROM FIRE RESEARCH

### *The GOES-8 Automated Biomass Burning Algorithm (ABBA) Introducing New Capabilities for Monitoring Diurnal Fire Activity in the Western Hemisphere*

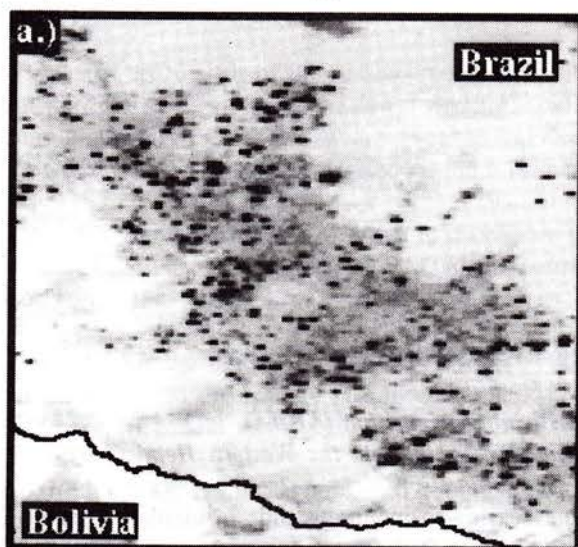
During the past decade the utility of geostationary remote sensing to monitor trends in biomass burning in South America was demonstrated with the Visible Infrared Spin Scan Radiometer Atmospheric Sounder (VAS) on board GOES-4 through -7. The GOES VAS Automated Biomass Burning Algorithm (ABBA) was originally developed at the Cooperative Institute for Meteorological Satellite Studies (CIMSS, UW-Madison) to locate and provide estimates of sub-pixel fire size in an effort to determine trends in biomass burning throughout the Amazon Basin during the 1980s using geostationary platforms.

The GOES ABBA is a dynamic multispectral thresholding algorithm which utilizes regional thresholds derived from the satellite data (visible, 4, and 11 micron bands) to locate fire pixels and incorporates ancillary data to correct for water vapour attenuation, surface emissivity, and solar reflectivity and subsequently solves for subpixel fire size and mean fire temperature. The algorithm is based on the sensitivity of the 4 micron band to high temperature subpixel anomalies and is an expanded version of a technique originally developed by Matson and Dozier for NOAA AVHRR. Once the GOES ABBA locates and processes a fire pixel, it is categorized according to vegetation type and various burning characteristics. Multi-year (1983, 1988, 1989, 1991, 1994, and 1995) applications of the GOES ABBA in South America have indicated the unique ability of the geostationary platform to monitor diurnal signatures in fire activity as well as regional variability in fire activity from year to year.

In April 1994, the first in the series of NOAA's next generation of geostationary satellites (GOES-8) was launched providing a new capability for diurnal monitoring of subpixel fire activity associated with wildfires, prescribed burns, and agricultural applications throughout the Western Hemisphere. For the first time, the GOES-8 imager makes it possible to monitor diurnal variability in fire intensity with 4 micron imagery every 15 minutes over the continental United States and half-hourly elsewhere. The higher spatial and temporal resolution, greater radiometric sensitivity, and improved navigation of GOES-8 offer many advantages over earlier GOES platforms for fire monitoring. The infrared window bands on the GOES-8 imager used for fire detection have been improved considerably. The short-wave window (4 micron) has four times and the long-wave window (11 micron) has twice the spatial resolution available on previous GOES platforms while maintaining similar radiometric performance. The improved capability to detect individual fires with GOES-8 is demonstrated in Figure 1. Figure 1a shows a GOES-8 4 micron image covering Rondonia in Southwest Brazil and a portion of Bolivia at 1745 UTC on 25 August 1995. Hundreds of individual fires are evident as

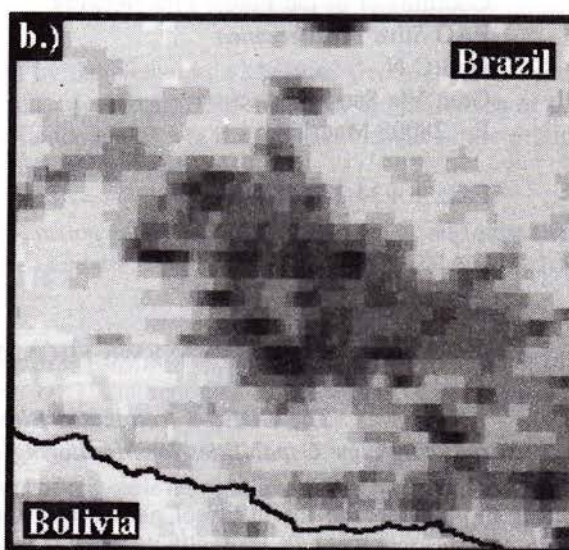
dark hot spots. Although a direct comparison of GOES-8 and GOES-7 in South America during the 1995 burning season was not possible due to the westerly location of the GOES-7 platform, Figure 1b shows similar data from GOES-7 for 29 August 1988. It is possible to see much more detail in the GOES-8 data, including land features and localized fire activity.

## GOES-8 August 1995



UW-Madison SSEC/CIMSS

## GOES-7 August 1988



**Fig.1.** GOES-8 (a) and GOES-7 (b) 4 micron imagery of a section (550 x 350 km) of the state of Rondônia, Brazil, along the Bolivian border on 25 August 1995 and 29 August 1988, respectively. The dark hot spots in both images indicate subpixel burning. The improved resolution of the GOES-8 imager provides more detailed information on localized fire activity.

The GOES ABBA was recently redesigned to take advantage of the improved capabilities of the GOES-8 instrument. Data obtained in South America in September 1994 and limited case studies in North and Central America were used to develop and implement the initial GOES-8 ABBA for applications in South America. The new GOES-8 ABBA enables monitoring throughout South America and includes an expanded surface vegetation classification scheme (based on the World Ecosystems Map, Olson, 1989-1991) and associated 4 and 11 micron emissivity factors. It utilizes GOES-8 visible data in an effort to screen sub-pixel cumulus cloud contamination. In addition NMC model estimates have been incorporated into the algorithm to account for water vapour attenuation in the 4 and 11 micron bands.

An initial version of the GOES-8 ABBA was operational for the 1995 Smoke Cloud and Radiation field programme in Brazil (SCAR-B, 15 August-15 September 1995) providing diurnal (3-hourly) information on the location, size, and mean temperature of subpixel fires as well as smoke transport. During SCAR-B, UW-Madison provided the mission scientists in Brazil with GOES-8 satellite imagery, GOES ABBA fire products, meteorological observations, and NMC model output via the UW-Madison SSEC SCAR-B web site.

## GOES-8 ABBA Diurnal Fire Detection in South America

Date: 24-Aug-1995

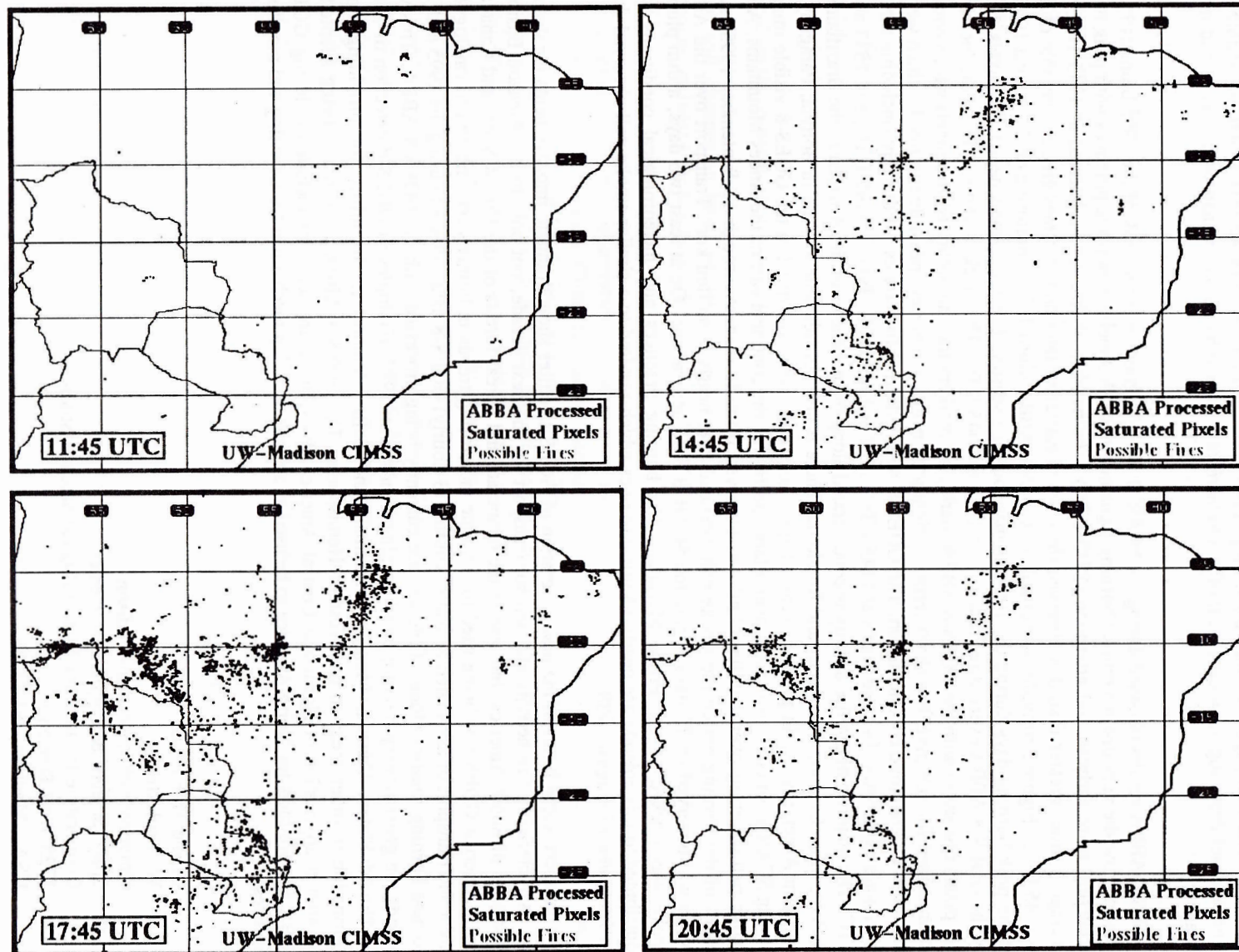


Fig.2. The markers indicate fires detected by the GOES-8 ABBA on 24 August 1995 at 1145 UTC, 1445 UTC, 1745 UTC, and 2045 UTC

The web site consisted of three components: GOES-8 imagery loops (3-hourly visible and infrared), GOES-8 ABBA products, and the McWEB forecasting tool. The web page provided daily plots of fire locations at peak burning times (1145, 1445, 1745, 2045 UTC) for the region extending from approximately 40° to 70°W and from the equator to 30°S. A text summary of daily peak fire statistics from the GOES-8 ABBA was also available. The web page contained a morning (1145 UTC) and afternoon (1745 UTC) GOES-8 visible image with outlines depicting the areal extent of smoke/aerosol coverage based on an analysis of visible and infrared imagery.

GOES-8 ABBA results obtained during the SCAR-B field programme at the peak of the 1995 biomass burning season show the very distinct diurnal burning signature in South American burning practices with peak burning occurring from early to mid-afternoon (1745 UTC). The number of fire pixels detected at 1745 UTC is on average 3 times greater than that observed three hours earlier or later and 20 times greater than that observed at 1145 UTC. Figure 2 provides an example of GOES-8 ABBA diurnal fire monitoring on 24 August 1995, one of the peak burning days during the 1995 biomass burning season. The four panels depict fire pixels detected by the GOES-8 ABBA every three hours from 1145 to 2045 UTC. The black markers indicate the locations of fire pixels processed with the GOES-8 ABBA; dark gray markers indicate saturated fire pixels which could not be processed for sub-pixel fire characteristics; light gray markers represent possible fire pixels which were not processed due to cloud contamination. The GOES-8 ABBA diurnal fire counts for this day (including saturated pixels) are as follows: 148 fire pixels at 1145 UTC, 1282 at 1445 UTC, 3946 at 1745 UTC, and 1533 at 2045 UTC. The majority of the fire activity is concentrated along the perimeter of the Amazon in the Brazilian states of Pará, Mato Grosso, Amazonas, and Rondônia. There is also considerable activity in Bolivia, Paraguay, and Northern Argentina. As in previous years, large smoke palls were identified in the GOES-8 visible imagery. During SCAR-B smoke was evident over a large portion of the continent east of the Andes Mountains. A large smoke pall covering over 4 million km<sup>2</sup> was observed from 21 August through 11 September 1995. At the height of the burning period the smoke pall extended over nearly 7 million km<sup>2</sup>. Transport over the Atlantic Ocean was observed on 13 days during the SCAR-B field programme. On at least two days, a thin plume of smoke was tracked to the Prime Meridian. The burning practices and meteorological conditions which contributed to this episode are nearly identical to ones which resulted in a similar smoke pall observed during the last week of August 1988.

The enhanced capabilities of the new generation of GOES satellites show dramatic improvements for detecting and characterizing fire activity and aerosol transport for the next decade, not only in the Amazon Basin and grasslands of South America, but also in the temperate and boreal forests of the United States and Canada. In South America GOES-8 is being used to continue monitoring trends in biomass burning and to catalogue the extent and transport of associated aerosols. Diurnal (3-hourly) GOES-8 data collected during the 1995 and 1996 biomass burning seasons (June - October) are currently being processed with the GOES-8 ABBA. This work extends the geostationary monitoring of burning trends from 1983. Examples of GOES-8 detection of fires in the United States, Canada, Mexico, Guatemala and Belize demonstrate its utility for providing similar information in other areas in the Western Hemisphere. The GOES-8 ABBA is currently being adapted for operational application in North and Central America. Possible future activities include producing GOES-8 ABBA fire products for North America to be used as an early warning mechanism for detecting and monitoring wildfires.

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## *The Large Scale Biosphere-Atmosphere Experiment in the Amazonian (LBA)*

### **Background**

Despite widespread concern and increased international efforts at conservation, the world's tropical forests continue to disappear. Of vital importance in developing sustainable management and exploitation systems for tropical forests are the questions as to how far human intervention affects the forest's basic capacities to renew themselves and how to safeguard the basic ecological processes such as biological productivity and nutrient and water cycling. Altered cycles of water, energy, carbon and nutrients, resulting from the changes in the Amazonian vegetation cover, are expected to have climatic and environmental consequences at local, regional and global scales. To understand these consequences and to mitigate their negative effects, enhanced knowledge is needed of the functioning of both the existing natural forest systems as well as systems which have already been converted to various other forms of land use or secondary regrowth.

### **Summary of LBA**

The Large Scale Biosphere-Atmosphere Experiment in the Amazonian (LBA) is an international research initiative lead by Brazil. LBA is designed to create the new knowledge needed to understand the climatological, ecological, biogeochemical, and hydrological functioning in the Amazonian, the impact of land use change on these functions, and the interactions between the Amazonian and the Earth system. LBA is centred around two key questions that will be addressed through multi-disciplinary research, integrating studies in the physical, chemical, biological, and human sciences:

- \* How does the Amazonian currently function as a regional entity?
- \* How will changes in land use and climate affect the biological, chemical and physical functions of Amazonian, including the sustainability of development in the region and the influence of Amazonian on global climate?

In LBA emphasis is given to observations and analyses which will enlarge the knowledge base for Amazonian in six general areas: Physical Climate, Carbon Storage and Exchange, Biogeochemistry, Atmospheric Chemistry, Hydrology, and Land Use and Land Cover. The programme is designed to address major issues raised by the Climate Convention. It will help provide the basis for sustainable land use in Amazonian, using data and analysis to define the present state of the system and its response to observed perturbations, complemented by modelling to provide insight to possible changes in the future.

The Atmospheric Chemistry Component will provide a foundation of knowledge to determine the exchange of greenhouse gases, oxidants, and aerosols between Amazonian and the global atmosphere, to understand the relevant processes, and to assess the related implications of rapid development in the region. The observations will be used to address the following key questions:

- \* What are the biosphere-atmosphere fluxes of greenhouse gases, oxidants, and aerosols (including their precursors) over the range of ecosystems in Amazonian?
- \* What are the net export fluxes of greenhouse gases, oxidants, and aerosols from Amazonian to the global atmosphere?

The experimental plan for the atmospheric chemistry component of LBA combines long-term ground-based measurements and intensive two-month aircraft campaigns. The ground-based components have the following objective:

*"To determine the concentrations of key reactive and greenhouse gases and aerosols at key surface sites in Amazonian, and define the primary influences on those concentrations".*

In order to address this objective, the suite of measurements should include a range of indicator species for biomass burning (e.g. CO, acetylene, methyl chloride) and industrial activity (CFCs, other halocarbons), along with key reactive species (NO<sub>x</sub>, O<sub>3</sub>), biogenic reactive hydrocarbons (isoprene), and greenhouse gases (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O). An important feature of the measurements will be direct observation of FLUXES for species where possible, to provide information on the role of Amazonian forests and agriculture.

A network of 2-6 ground-based sites will be established for long-term observations of atmospheric chemistry and biosphere-atmosphere exchange. Concentrations and fluxes of CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, O<sub>3</sub>, CO, NO<sub>x</sub>, non-methane hydrocarbons, reactive sulphur gases, and aerosol particles will be measured at the smallest scales using chamber methods and at landscape-scale using towers. Flux measurements will emphasize direct (e.g. eddy correlation or eddy accumulation) observations for accessible species (CO<sub>2</sub>, O<sub>3</sub>, NO<sub>x</sub>, NO<sub>y</sub>) with similarity approaches for other gases (e.g. N<sub>2</sub>O, CO, non-methane hydrocarbons, sulphur gases) designed to gain leverage from, and be calibrated by, the direct flux measurements. Measurements will continue for several years to define episodic, seasonal, and interannual variations of trace species, and measurements should be as continuous as possible, to observe variations and to define seasonal changes.

The sites will be strategically located along ecological and meteorological gradients, and in most cases will coincide with flux towers installed for the carbon and biogeochemistry components of LBA.

A background site is desirable at a coastal location (e.g. Fortaleza) where air from the tropical Atlantic can be routinely measured. Observations at this site will help characterize the marine end-member for air entering the Amazon basin. Flux measurements are not needed at this site, but data on CO<sub>2</sub>, CO, N<sub>2</sub>O, O<sub>3</sub>, NO<sub>x</sub>, NO<sub>y</sub> and other medium- and long-lived species are needed.

The ground-based observations, and the aircraft campaigns to be undertaken in LBA, offer only limited spatial and temporal coverage. Application of 3-D chemical tracer models will be essential to assimilate the measurements, in order to quantify fluxes within and across the boundaries of the Amazon Basin. These models will use assimilated meteorological observations (e.g., from a 4DDA model) and include a chemical simulation capability. The observed biosphere-atmosphere fluxes and data from the marine station will help provide the required boundary conditions for this analysis. Simulation of species concentrations measured aboard the aircraft will serve to test and refine the models. In addition to their importance for post-campaign data interpretation, the models will play a key role in pre-campaign planning by identifying locations most suitable for siting the observations.

**More information can be obtained from the LBA Website at:**  
<http://yabae.cptec.inpe.br/lba/>

***International Cooperation in Boreal Forest Fire Research:  
The IBFRA Stand Replacement Fire Working Group***

The Stand Replacement Fire Working Group (SRFWG) was one of the first working groups created under the International Boreal Forest Research Association (IBFRA), and to date it has been the most active. Following an organizational meeting in Siberia in 1992, the IBFRA SRFWG has strongly promoted and facilitated cooperative international and multi-disciplinary boreal forest fire research between Russia and western boreal countries. A number of collaborative studies dealing with global change/fire issues, remote sensing, fire behaviour, fire danger rating, fire history and fire ecology and effects have been initiated. A major conference and field campaign was carried out in central Siberia in 1993, with follow-up research activities in 1994 and 1995. Major cooperative fire experiments in 1997 in northern Canada and 1998 in central Alaska are in the advanced stages of planning, while further interdisciplinary fire experiments in Siberia are being planned in conjunction with a major IGBP Northern Eurasia Study.

**Introduction:** Forest fire has been the dominant disturbance regime in global boreal forests for millennia, shaping and maintaining these ecosystems to the point that boreal forests naturally require forest fires to exist. Fire-adapted boreal conifer species now live in classic fire-dependent ecosystems, requiring periodic, large-scale, stand-replacing fires to maintain their existence. Development of the world's boreal zone over the past century has resulted in boreal countries creating fire management strategies that attempt to rationalize

recreational and industrial interests, and concern for public safety, with the natural role of fire in boreal forests. Although North American and Eurasian boreal countries have been substantially isolated for many decades by political differences, they have developed similar fire management strategies, that have been successful in limiting fire impacts in high-value areas while permitting, intentionally or otherwise, fires to exert their natural dominance over much of the global boreal zone. This is particularly true in northern Canada, northern Siberia, and large areas of Alaska. Intensive forest management in Scandinavian countries has, conversely, virtually eliminated fire from boreal ecosystems in Sweden, Norway and Finland.

Although North American and Russian fire research and fire management specialists had sporadic contact during the past four or five decades during the Cold War, the relaxation of political tensions in the 1990s presented the opportunity to pursue cooperative fire research initiatives. Following the "White Sea Declaration" that resulted from the 1990 International Symposium on Boreal Forests in Arkangelsk, Russia, the International Boreal Forest Research Association (IBFRA) was formed in 1991 at a meeting of Russian, American, and Canadian representatives in Mezghorje, Ukraine. Two priority research areas (Inventory, Monitoring, and Classification of Boreal Forests, and Global Climate Change and Ecosystem Function of Boreal Forests) were established at that meeting. Each research area was to be supported by a number of working groups, and the first to be established under the Climate Change/Ecosystem Function Research Area was the Stand Replacement Fire Working Group (SRFWG). Although the IBFRA framework has been expanded to currently encompass three research areas, the SRFWG, now under the Ecosystem Function, Anthropogenic Impacts and Global Change Research Area, remains one of the most active of IBFRA initiatives.

**Stand Replacement Fire Working Group Guiding Principles:** Members of the SRFWG met for the first time in May 1992 in Krasnoyarsk, Russia to develop a number of hypotheses that would guide future cooperative research initiatives between Russian and western forest fire scientists. The approved general hypothesis is as follows:

*"Given that North American and Eurasian boreal forests have similar ecosystem processes, the causes and consequences of variability in fire regimes are similar and easily transferable among the boreal forest ecosystems of Canada, Russia, and the United States of America."*

Under this general hypothesis eight specific hypotheses were developed to focus research activities in future years. These hypotheses dealt with fire behaviour, fire ecology, ecosystem processes and response to fire, climate change and fire, and the spatial and temporal distribution of large fires. These specific long-range hypotheses envisioned international, multi-disciplinary research teams conducting a coordinated and sequenced series of experiments addressing these issues (Fosberg 1992)

While the IBFRA SRFWG was formulating research strategies, a concurrent initiative was under way to promote cooperative fire research activities between Russia and western countries. In 1991 two western fire scientists visited Krasnoyarsk and toured fire operations sites in Siberia (Pyne 1992). Among their recommendations following that trip, they proposed an international fire conference and field campaign in Siberia in the near future. During the SRFWG organizational meeting in Krasnoyarsk in 1992 it was decided that sponsorship and participation in this conference and field experiment should be the first priority of the SRFWG, and both events were scheduled for 1993.

**Research Activities to Date:** During the summer of 1993 an international conference was held in Krasnoyarsk, Russia, bringing together a large number of fire research scientists from Russia, North America, Europe and China for the first time. This conference "Fire in Ecosystems of Boreal Eurasia", financially sponsored by the Volkswagen Foundation, aimed to present, discuss and publish the state of knowledge on fire in boreal ecosystems, with special emphasis on Eurasia. Over 40 papers dealing with many aspects of fire ecology, fire behaviour, fuels classification, fire meteorology, modelling and global change were presented. The proceedings were published as a monograph (Goldammer and Furyaev 1996; see page xx of this volume).

Following the Krasnoyarsk Conference a field experiment, Fire Research Campaign Asia-North (FIRESCAN) was organized under the joint sponsorship of the IBFRA SRFWG and the IGBP International Global Atmospheric Chemistry Project (IGAC). The purpose of FIRESCAN was to conduct a high-intensity stand

replacement fire under controlled conditions, permitting Russian and western fire scientists to compare research methodologies while monitoring the fire, and during preburn and postburn measurements. Specific objectives included documenting fire behaviour relative to prevailing weather conditions, characterizing prefire and postfire vegetation and fuels, chronicling the fire history of the site and the surrounding landscape, characterizing trace gas and aerosol emissions within the smoke column, and establishing a number of research plots on the site for long-term follow-up research on ecosystem responses (mortality, recovery, succession, biological diversity, nutrient cycling, soil respiration, and carbon accretion) following a high-intensity fire. The preliminary and complete results of the Bor Island Fire were published in 1994 and 1996 (FIRESCAN Science Team 1994, 1996). In addition, many papers dealing with FIRESCAN were presented at the IUFRO XX World Congress in Finland (IUFRO 1995).

In the summer of 1994 a small group of fire scientists from Russia, Canada, Germany and the USA returned to Bor Forest Island to conduct first year mortality measurements and to establish additional permanent ecological sampling plots. A number of permanent plots were also established on another, less-intense fire that occurred in 1992 near the Angara River. Further measurements were made at these sites in 1995 and 1996. Plots at both locations will be monitored periodically for many decades.

A NOAA AVHRR satellite downlink was established in Krasnoyarsk in 1994, permitting much better coverage of large fire activity, particularly in the more remote regions of Siberia where previous coverage was scant. During the summer of 1994 ground-truthing was carried out on four large 1992 fires in central Siberia, evaluating the accuracy of NOAA AVHRR imagery in mapping the areal extent of large boreal fires.

An evaluation of the performance of the Canadian Forest Fire Danger Rating System (CFFDRS) in Russia was also initiated in 1994. Fire scientists in Krasnoyarsk are cooperating with Canadian fire researchers to assess the suitability of the CFFDRS in the Russian boreal zone, particularly Siberia. Analysis of ten years of weather data from the Krasnoyarsk Region was undertaken in 1994.

Cooperative efforts in the area of forest fire behaviour modelling were also initiated in 1994. The Canadian government translated a large Russian book "Mathematical Modelling of Forest Fires and New Methods of Fighting Them" by Anatoly Grishin of Tomsk University. North American fire scientists visited Grishin in Tomsk in 1994 to establish linkages for future collaborative research activities, particularly the physical modelling of high-intensity crown fires. An international conference "Mathematical and Physical Modelling of Forest Fire and Ecology Problems", was held in Tomsk in July 1995. A number of North American fire modellers participated, and the conference proceedings are being published (Grishin and Goldammer 1996).

**Future Activities:** During the early summer of 1997 fire scientists from Canada, Russia, the United States and Germany will conduct a series of high-intensity experimental crown fires in a *Pinus banksiana* forest in the Canadian Northwest Territories. The purpose of these fires will be to advance the state of knowledge of fire behaviour modelling. Detailed instrumentation will be used in an attempt to fill some of the critical gaps that exist in adequately modelling high-intensity fires. Burning plot establishment and detailed preburn fuel sampling was carried out at this site in 1995 and 1996. A number of collaborative publications will result from this cooperative international undertaking.

A comparison of the spatial and temporal distribution of large Russian and Canadian boreal fires will be undertaken in 1996, using both statistical and remote sensing data. With the new NOAA downlink fully operational in Krasnoyarsk, and with the Internet greatly enhancing data sharing capabilities, Russian and western fire scientists will cooperate in determining the extent and impact of large boreal fires, concentrating on the previously unmonitored remote regions of Siberia. This will require cooperative evaluation of NOAA AVHRR satellite imagery, and a sharing of technology and research capabilities. Ground-truthing, through higher-resolution satellite imagery and airborne mapping, will continue. In addition, field tests are planned in the development of a new fire sensor recently launched on the PRIRODA platform and incorporated in the MIR Space Station.

The appraisal of the suitability of the CFFDRS for use in Russian forests will continue in 1996, analyzing fire weather and fire danger patterns across Russia for the 1980-95 period. In addition, near real-time mapping of fire danger levels in Russia will be demonstrated, using daily weather transmitted over the Internet. If interest

warrants it, a proposal to implement the CFFDRS in Russia will be written and submitted to various funding agencies.

In the summer of 1996 the United Nations seminar "Forests, Fire and Global Change", sponsored by the Russian Federation and the FAO/ECE/ILO Team of Forest Fire Specialists (with many SRFWG members), was held in southern Siberia. The goals of this seminar included assessments of the extent and damages caused by wildfires throughout the world, the development of standardized methodologies for collecting and archiving fire data at a global scale, and the development of mechanisms for international cooperation in fire and disaster management (see report on p.xx of this volume).

Planning is also well under way for a whole watershed prescribed burn, scheduled to take place in central Alaska in the summer of 1998. Entitled FROSTFIRE, and co-sponsored by the IBFRA SRFWG, this experiment will involve conducting a high-intensity 700 hectare prescribed fire on a catchment of the Caribou-Poker Creek Experimental Watershed just north of Fairbanks, Alaska. This catchment consists of steep north-facing slopes dominated by *Picea* underlain by permafrost, and steep south-facing slopes where *Betula* predominates. Hydrological measurements have been conducted at this site for decades, and will be continued after the fire as part of a suite of fire impact studies which will include detailed fire ecology and effects investigations. Thorough fuels and fire behaviour documentation will permit linkages between fire behaviour (fuel consumption/intensity) and postfire impacts. This will be a long-term study, closely linked with the Long Term Ecological Research (LTER) Program in the United States.

Additional fire experiments will be conducted jointly with scientists collaborating in the IGBP Northern Eurasia Study. It will be a joint effort of scientists representing several IGBP Core Projects, the Biospheric Aspects of the Hydrological Cycle (BAHC), International Global Atmospheric Chemistry (IGAC), and Global Change and Terrestrial Ecosystems (GCTE) Projects. The unifying theme of the IGBP Northern Eurasia Study is the terrestrial carbon cycle and its controlling factors, and the study's overall most important objective is to determine how these will change under the rapidly changing environmental conditions projected under global change (Steffen and Shvidenko 1996). The IGBP Northern Eurasia Study will consist of an integrated set of experimental and observational studies at a number of scales, modelling and aggregation activities, and supporting databases and GIS capabilities. The major elements are transects and network sites, a water, energy, and carbon flux study, and detailed studies of disturbance regimes.

The fire component of the IGBP Northern Eurasia Study will have four components: (i) fire manipulations at individual forest sites; (ii) a series of campaigns based on aerial and spaceborne research platforms; (iii) the construction of a fire database, relating the frequency, extent, and intensity of fires to vegetation and climatic conditions for present and historic conditions; and (iv) development of aggregated models of forest fire frequency and extent, responsive to global change variables.

First, fire will be used as a treatment in manipulative experiments at intensive study sites within transects. These experiments will measure the effects of fire on successional vegetation dynamics, particularly on the composition of the regrowth forest, and will determine the effects on soil and vegetation nutrient dynamics. Special attention will be given to the effects of fire on permafrost sites, and to the emission characteristics and black carbon formation of peat fires and other less-explored forest fuel types.

Second, more research campaigns similar in framework to FIRESCAN and other IBFRA/SRFWG initiatives are required to couple air and spaceborne measurements of biogenic trace gas and aerosol emissions with pyrogenic sources. The newly established NOAA AVHRR receiving stations in Krasnoyarsk, Yakutsk and Khabarovsk will play an important role in identifying fires in real time or on post-campaign reconstruction.

Third, given the importance of fire in long-term and large-scale ecosystem dynamics, a comprehensive, ecologically-oriented fire database for Northern Eurasia is essential. This database will build on the National Resources GIS developed by the Russian International Forestry Institute and should include, in a geographically-explicit format, the timing, areal extent, frequency, and intensity of fires, as well as the state of vegetation and the climatic conditions associated with each fire. A strong component of paleo-fire and fire history research will link information from tree ring fire chronologies and densitometric analyses with palynological and charcoal data in peat layers and lake sediment cores. This project will be a major inter-Core Project link, providing the base for reconstruction of past fire regimes.

Fourth, the ultimate goal will be the development of a model of changes in fire frequencies and patterns with global change. Such a model must be responsive to natural disturbances such as lightning, and to fire patterns caused by socio-economically-driven land use changes.

## Summary

The past five years have been very productive for the Stand Replacement Fire Working Group of the IBFRA. Recognizing the necessity of operating within an international, multidisciplinary framework, the IBFRA SRFWG has forged close cooperative relationships with the IGBP community, with the UN Team of Forest Fire Specialists and the International Union of Forest Research Organizations, and is a co-sponsor of the International Forest Fire News. Many of the goals outlined at our initial meeting are being realized. Cooperative field programmes have been initiated, and conferences and meetings have been organized to promote exchanges of information and ideas. There is strong reason to be optimistic that this progress will continue, as Russian and western fire scientists have much in common and many things to learn from each other. Funding difficulties present some obstacles, but computer networking, and the strong desire of fire scientists to work together, offsets this problem somewhat. Cooperative international boreal forest fire research is now a reality, and the future looks promising.

This summary paper is a report jointly prepared by B.J.Stocks, J.G.Goldammer, M. Fosberg, S. Conard, and E. Valendik. Main references are:

FIRESCAN Science Team 1994. Fire in boreal ecosystems of Eurasia: first results of the Bor Forest Island Fire Experiment, Fire Research Campaign Asia-North (FIRESCAN). World Resource Review 6: 499-523.

FIRESCAN Science Team 1996. Fire in ecosystems of boreal Eurasia: the Bor Forest Island Fire Experiment, Fire Research Campaign Asia-North (FIRESCAN). In Biomass Burning and Global Change (ed. J.S. Levine), MIT Press, Cambridge, MA (in press).

Fosberg, M.A. 1992. IBFRA Stand Replacement Fire Working Group. Int. Forest Fire News (ECE/FAO) No. 7 (August 1992). pp6-8.

Goldammer, J.G., and Furyaev, V.V. (eds.) 1996. Fire in Ecosystems of Boreal Eurasia. Kluwer Academic Publ., Dordrecht, 528 pp.

Grishin, A.M., and Goldammer, J.G. (eds.) 1996. Mathematical and Physical Modelling of Forest Fire and Ecology Problems. Physics of Combustion and Explosion (in press) <in Russian>.

IUFRO (ed.) 1995. IUFRO XX World Congress, Tampere, Finland, 6-12 August 1995. Abstract Vol., S1.09.00 Forest Fire Research Sessions, pp. 86-94.

Pyne, S.J. 1992. The Russian fire establishment: impressions from a study tour. Int. Forest Fire News (ECE/FAO) No. 6 (January 1992), pp. 3-4.

Steffen, W.L., and Shvidenko, A.Z. (eds.) 1996. The IGBP Northern Eurasia Study: Prospectus for Integrated Global Change Research. The International Geosphere-Biosphere Program: A Study of Global Change. International Council of Scientific Unions (ICSU), IGBP Stockholm (in press).

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CDN - Sault Ste. Marie, Ontario P6A 5M7

## IGAC/BIBEX      *Minutes of the BIBEX Steering Committee Meeting (8 May 1996)*

As announced in IFFN (January 1996) the last open BIBEX Steering Committee Meeting was held in conjunction with the European Geophysical Society XXI General Assembly, The Hague, 8 May 1996. Topics discussed are briefly summarized:

### 1. Report by the Chairman

M.O.Andreae reports that the scientific results of the **Southern African Fire-Atmosphere Research Initiative (SAFARI)** will be published in a special issue of the Journal of Atmospheric Chemistry (in the last quarter of 1996); a comprehensive book reporting about the results and implications of SAFARI will be published by the University of Witwatersrand Press, South Africa, in early 1997. He also reported about the International Biosphere-Geosphere Programme (IGBP) congress in Germany (spring 1996) during which the activities of BIBEX received attention and high grades. He underscored the new IGBP policy of promoting interdisciplinary research programmes between the "IGBP Core Projects" (see item 3).

### 2. EXPRESSO

An update of planned activities of the **Experiment for Regional Sources and Sinks of Oxidants (EXPRESSO)** was given by J.P.Lacaux (initial details on EXPRESSO: see IFFN No.12, January 1995, pp. 27-28). The first phase of the research campaign will be conducted in November/December 1996. EXPRESSO contact is:

Dr. Jean-Pierre Lacaux  
Laboratoire d'Aerologie OMP  
14 Avenue E. Belin  
F - 31400 Toulouse

### 3. FIRESCAN

J.G.Goldammer reports about the **Fire Research Campaign Asia-North (FIRESCAN)** and the activities of the IBFRA Stand Replacement Fire Working Group (see report in this issue of IFFN, pp. 55-59). FIRESCAN will provide the fire component within the **IGBP Northern Eurasia Study** (details: see last IFFN No.14, pp.37-40). The IGBP Northern Eurasia Study will be a major inter-core project activity of IGBP. The prospectus of the study is now available:

*W.L. Steffen and A.Z. Shvidenko (eds.) 1996. The IGBP Northern Eurasia Study. Prospectus for Integrated Global Change Research. The International Geosphere-Biosphere Programme: A Study of Global Change (IGBP) of the International Council of Scientific Unions (ICSU). IGBP Report No. 37, IGBP Stockholm, 95 p. (ISSN 02848015).*

Cost-free copies (English and Russian) can be obtained through the IGBP Secretariat in Stockholm:

IGBP Secretariat  
The Royal Academy of Sciences  
Box 50005  
S-10405 Stockholm

The next planning meeting for the East Siberian part of the IGBP Northern Eurasia Study, including the fire research component, will be held in Yakutsk, 6-9 October 1996.

### 4. SEAFIRE

J.Goldammer reports on the **South East Asian Fire Experiment (SEAFIRE)**. SEAFIRE will provide a fire-

related research forum within the planned **Integrated SARCS/IGBP/IHDP/WCRP Study "Land-use Change in SE Asia"**. An initial planning meeting of this study was held in Bangkok, May 1996. The final science plan is being prepared at present. SEAFIRE contact is J.G.Goldammer. More information on the objectives of the SE Asian Land-Use Change Study can be obtained through:

Dr. Beverly Goh  
Program Manager  
Southeast Asia Regional Committee  
for START (SARCS) Secretariat  
Institute for Environmental Research  
Chulalongkorn University  
Bangkok 10330  
THAILAND

Fax: ++662-255-4967  
Tel: ++662-218-8126  
e-mail: gohbpl@chulkn.chula.ac.th

The next SEAFIRE planning meetings will be held in conjunction with the **13th Conference on Fire and Forest Meteorology**, 27-31 October 1996, Lorne, Australia (see conference announcement in the last issue of IFFN) and during the **ASEAN Conference on Transboundary Pollution and its Impacts on the Sustainability of Tropical Forests**, Kuala Lumpur (Malaysia), 2-4 December 1996 (see announcement on p.65 of this volume).

## 5. East African Fire Research

Ecological and atmospheric chemical aspects of fire in East African grasslands so far were beyond the scope of the SAFARI/EXPRESSO programmes. A new initiative is formed under BIBEX which aims to investigate the consequences of fire occurring in the fertile grassland of East Africa on the regional atmosphere. A small field campaign with ground and aerial sampling components and a remote sensing study is now in preparation. The research will be conducted in Kenya in October 1997, in close cooperation between the Kenyan Academy of Sciences, the Max Planck Institute for Chemistry (Germany), the University of Fort Hare (regional coordinator; contact address: see below), the Canadian Forest Service, Fire Research, Ontario Region, and the NASA Langley Research Center. Contact address:

Prof. Dr. Winston S.W. Trollope  
Faculty of Agriculture  
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Fax: ++27-404-31730  
Tel: ++27-404-22063  
e-mail: winston@ufhcc.ufh.ac.za

ZA-Fort Beaufort 5720, Republic of South Africa

## 6. Fire Experiments in Canada and USA in 1997 and 1998

B.J.Stocks reported about the planned fire experiments in Canada and USA (report was presented by J.G.Goldammer). During the early summer of 1997 fire scientists from Canada, Russia, the United States and Germany will conduct a series of high-intensity experimental crown fires in a *Pinus banksiana* forest in the Canadian Northwest Territories. The purpose of these fires will be to advance the state of knowledge of fire behaviour modelling. FROSTFIRE is a fire experiment to take place in Alaska, scheduled for 1998. Details on both experiments are given in this volume (pp.55-59).

## 7. LBA

Outline and scope of the **Large-Scale Biosphere-Atmosphere Experiment in the Amazonian (LBA)** were presented (details: see this volume, pp.54-55).

*The scientific BIBEX sessions at the EGS meeting were held on 7 and 8 May. Abstracts of the sessions are published in the pages of the Annales Geophysicae (European Geophysical Society), Supp. II to Vol.14, Part II "Hydrology, Oceans, Atmosphere & Nonlinear Geophysics.*

*J.G.Goldammer, Rapporteur*

## RECENT PUBLICATIONS

**Fire and Plants**

Large regions of the world are regularly burnt either deliberately or naturally. However, despite the widespread occurrence of such fire-prone ecosystems, and the considerable body of research on plant population biology in relation to fire, until now there have only been limited attempts at a coherent conceptual synthesis of the field for use by students and researchers. Most other books either talk about fire ecology in passing or only look at fire in the context of one part of the world. This book redresses the situation. Knowledge of the population biology of plants in relation to fire has developed sufficiently to provide a reasonable framework for predicting the consequences of particular fires for community structure and dynamics. Studies of fire ecology contribute to many areas of current research in ecology, including the importance of disturbance for maintaining diversity, non-equilibrium dynamics, time-lags and historical events such as determinants of community composition. An understanding of plant population biology as affected by fire is of immediate applied importance in forestry, conservation and range management.

William J. Bond is a Professor in the Department of Botany, University of Cape Town, South Africa. He has wide interests in the ecology of plants and the use of ecological principles in conserving and utilizing natural resources. Brian W. van Wilgen is an ecologist in the Division of Forest Science and Technology at the Council for Scientific and Industrial Research (CSIR), South Africa. He has worked on the fire ecology of all major fire-prone ecosystems of southern Africa. He has a strong interest in the use of fire for managing ecosystems.

The authors have filled an important gap in the fire science literature. The monograph is designed to clarify fire-related processes and to answer phenomenon-oriented questions in fire ecology. Thus, it fills a critical gap for all of those interested in basic questions of fire ecology, independent of specific vegetation communities. While many of the processes described are from South Africa's Cape Floral Kingdom, the home geographic region of the two authors, these examples show not only the importance of the natural role of fire in these ecosystems, but also the excellence of fire research achieved in that part of the world.

The Editor

*Bond, W.J., and B.W. van Wilgen. 1996. Fire and plants. Population and Community Biology Series 14. Chapman and Hall, London, 263 pp. (ISBN 0-412-47540-5).*

**Back on the Book Market: Updated Second Edition of "Introduction to Wildland Fire"**

Twelve years after the first publication of Stephan J. Pyne's "Introduction to Wildland Fire" the second edition is now available. It provides a comprehensive resource for studying the fundamentals of fire behaviour, its ecological effects, and its cultural and institutional framework. This new edition, co-authored by Patricia L. Andrews and Richard D. Laven, expands and updates the coverage of the field and explores the subject of wildfire management in a broad scientific, technical, and social context. Written by recognized authorities on fire management, it presents the fundamental physics and chemistry of fire, fire behaviour, wildland fuels, the interaction of fires and weather, the ecological effects of fires, the structure of fire management programs, planning efforts, suppression strategies, prescribed fires, and international/global fire research and management. The new edition also includes such current problems as the burning of the Amazon rain forest and the implications of the recent drought-related fires that have plagued urban areas bordering on wilderness land.

Throughout the book the authors keep the subject of fire itself central. They begin by identifying, clarifying, and consolidating the basic concepts and literature of fire as a natural occurrence in the environment. General principles are illustrated with reference to specific events, and the natural incidence of fire is related to its cultural causes and effects. The book provides foresters, range scientists, environmentalists, ecologists, and administrators of federal and state agencies with an authoritative and comprehensive resource.

There is a distinct difference between the first and the second edition of the volume. The subtitle "Fire management in the United States" of the first edition of 1984 indicated that at that time the focus was on the U.S.A. The second edition has a much broader scope. It has widened its perspective towards a global scale, not only from the point of view of fire management, but also in the context of impacts of vegetation fires on

the global biosphere and atmosphere. This makes the book voluminous, a rich, comprehensive and updated sourcebook on global fire.

J.G.Goldammer

*S.J.Pyne, P.J.Andrews, and R.D.Laven. 1996. Introduction to Wildland Fire. Second edition, John Wiley & Sons, New York-Chichester, 769 pp. (ISBN 0-471-54913-4).*

### **Fire in Ecosystems of Boreal Eurasia**

The boreal forest - or Taiga - of Eurasia is a classical fire ecosystem. Covering over 1.2 billion hectares of the Northern Hemisphere it is the earth's largest contiguous forest. Up until now, comprehensive research on the role of fire in the boreal Nordic countries and North America has been available in the western world, while there was known little about the largest portion of the world's boreal forests which are situated in Russia (43-65%) and which has for a long time not been open to the international research community. With the end of the Cold War, the way has been cleared for international research in Eurasia.

A new book "Fire in Ecosystems of Boreal Eurasia" is the result of the international conference held at the Sukachev Institute for Forest, Russian Academy of Sciences, Krasnoyarsk, June/July 1993. The conference was sponsored by the VOLKSWAGEN Foundation, the International Boreal Forest Research Association (IBFRA), and the International Global Atmospheric Chemistry (IGAC) project. For the first time, the astronomical feat of compiling an in-depth presentation of Russian fire science has been achieved by Johann G. Goldammer (Max Planck Institute for Chemistry/Freiburg University, Germany) and Valentin V. Furyaev (Sukachev Institute for Forest, Russia). Although the book contains articles primarily from the former USSR and the Russian Federation, it also provides recent material from boreal North America and the Nordic countries.

This volume covers all aspects of fire science, divided into eight chapters: History and Patterns; Statistics and Dynamics; Geographical Analysis; Pyrological Classification of Landscape; Sites and Fuel Types; Fire Characteristics: Behaviour and Modelling; Ecological Effects of Fire; and Fire, Atmosphere and Climate Change.

With the wide range of topics and issues presented, along with the tremendous amount of references available, this book is not only recommended but should be essential reading material for anyone interested in fire and fire management of boreal ecosystems.

G. Buchholz

*Goldammer, J.G., and V.V.Furyaev (eds.) 1996. Fire in ecosystems of boreal Eurasia. Kluwer Academic Publ., Dordrecht, 528 pp. (ISBN 0-7923-4137-6, hardbound, NLG 335.00/GBP 147.50).*

### **Proceedings of the 1993 "Fire in Wilderness and Park Management Symposium" now available**

The Fire in Wilderness and Park Management Symposium was held from 30 March through 1 April 1993, in Missoula, Montana, USA. It was sponsored by the U.S. Department of Agriculture, Forest Service, the Bureau of Land Management, the National Park Service, the U.S. Fish and Wildlife Service, the National Wildfire Coordinating Group, the Wilderness Society, the Renewable Resources Foundation, the Society of American Foresters, and the University of Montana.

Maintaining the primeval character of wildernesses and national parks with fire as a natural process is controversial. How can fire be allowed to play its natural role without unacceptable consequences? In 1983, a major symposium in Missoula on wilderness fire gave impetus to wilderness fire management programmes. In 1988, extensive fire in wildernesses and national parks brought national attention to the problems of meeting wilderness goals with fire.

This symposium, one decade after Missoula's first major wilderness fire conference, examined past lessons and future opportunities. The presentations and discussions were centred around three major themes:

- Are goals and policies being met?
- Understanding and managing constraints.
- Implementing programmes and future opportunities.

A major change over the past 10 years is the recognition that different approaches to managing fire are needed to satisfy the goals and constraints of large and small wilderness areas in remote and some not-so-remote locations.

The symposium was attended by 421 fire managers, wilderness managers and members of the general public. The presentations included 26 papers and six panel discussions. A poster session of 65 exhibits was scheduled for one evening. The posters and ten commercial exhibits were available for viewing throughout the symposium.

Managers have made significant progress in returning fire to wilderness and parks since the prescribed natural fires were first allowed in the 1970's. Because fire is a primary ecological force, its presence is often essential to preserve the natural character of wilderness areas. In most situations, however, managers must consider how fire will affect recreation, safety, existing plant communities, endangered species, air quality, and adjacent non-wilderness land. This symposium should help managers deal with the challenge of using fire to maintain primeval conditions while satisfying other wilderness goals and constraints.

The proceedings of the symposium include 75 papers dealing with fire in wilderness and park management:

*Brown, J.K., R.W. Mutch, C.W. Spoon, and R.H. Wakimoto (tech. coords.). 1995. proceedings: symposium on fire in wilderness and park management; 1993 March 30-April 1; Missoula, MT. Gen. Tech. Rep. INT-GTR-320. Ogden, Utah: USDA Forest Service, Intermountain Research Station, 283 pp.*

#### **User's Guide to the Canadian Forest Fire Behaviour Prediction (FBP) System**

This is a user-oriented guide to the Canadian Forest Fire Behaviour Prediction (FBP) System, which provides a systematic method for predicting forest fire behaviour. The FBP System mathematically expresses and integrates many of the major factors that are known to influence fire behaviour. It uses information regarding fuels, weather, topography, foliar moisture content, and the type and duration of prediction to produce estimates of 15 wildfire behaviour characteristics such as rate of spread, fire intensity, fuel consumption, type of fire, crown fraction burned, area, perimeter, and fire shape. Numerous diagrams, examples, and exercises are used to explain the structure, features, and processes of the FBP System. Written in an easy-to-understand style, it can be used as an explanatory reference, an individual self-study guide, or a workbook in classroom situations.

*Hirsch, K.H. 1996. Canadian Forest Fire Behaviour Prediction (FBP) System. User's Guide. Nat. Resour. Can., Can. For. Serv., Northwest Reg., North For. Cent., Edmonton, Alberta. Spec. Rep. 7. 122 pages, 51 figures, CDN \$14.95 (ISBN 0-660-16389-6; ISSN 1188-7419).*

This publication may be purchased from: UBC Press, University of British Columbia  
6344 Memorial Road  
CDN - Vancouver, British Columbia V6T 1Z2  
Fax: +1-800-668-0821

A microfiche edition of this publication may be purchased from:  
Micromedia Ltd.  
240 Catherine Street, Suite 305  
CDN - Ottawa, Ontario K2P 2G8

## **Forest Fires in the Mediterranean Region. Constitution and Use of Databases**

Numerous countries in the Mediterranean region have established databases on the forest fires in their area. Several have adopted a common core of information that is made available to all. This makes it possible to compare the effects and the causes of fires in the different countries concerned.

A Silva Mediterranea Forest Fire Management Network workshop was held from 30 November to 4 December 1993 in Montpellier (France) in relation with other bodies (FAO/ECE, EEC, CIHEAM and other national networks), with a view to developing the use of these databases. The contributions given by the workshop participants are published now.

Several papers show the benefits of the common core data that enable comparison according to country and region of the damage caused by fire, the most critical periods (seasons, months, days and times) and the causes (accidental, criminal or natural), which are far from being uniform. These analyses lead to the drawing up of various methods for reducing the risks to suit each case: informing the public, collaboration with farmers, development of areas where dangerous fires start, surveillance, repressive measures, etc.

Various improvements are proposed to refine knowledge of causes in the light of local customs, to improve damage assessment by using a GIS and national inventory data to estimate the cost of reconstitution of the vegetation.

Several technical papers show that more detailed analyses of the data on fires combined with data from other sources (existing or to be set up) with possible use of a GIS make it possible to estimate intervention costs and optimise the use of firefighting facilities, to assess development of the edges of roads and motorways, to assess and map risks, to optimise prevention operations (tracks, firebreaks, breaks in fuel, water points, the geographical distribution of investments and control facilities in particular, etc.) and model the progress of fires.

The papers are included in the publication "Options Méditerranéennes, Série A: Séminaires Méditerranéennes, No. 25" and can be ordered through the Institut Agronomique Méditerranéen de Montpellier. The price (including postage) is 220 FF, to be paid to:

Institut Agronomique Méditerranéen de Montpellier  
3191, route de Mende  
BP 5056  
F - 34033 Montpellier Cedex 1  
Fax: ++33-67 54 25 27

## **The Effects of Brush Fires on Vegetation: The Aubréville Fire Plots after 60 Years**

With decreased deforestation in the tropical environment and the search for sustainable development and the reforestation efforts which have followed, it is necessary to look at the long-term effects of fire on the vegetation. Unfortunately this kind of research is very limited, making the research described below all the more essential in shedding valuable light on this important issue.

The study of Dominique Louppe, N'Klo Oattara and Alassane Coulibaly focuses on the analysis of a sample plot in Aubréville, Côte d'Ivoire, established in 1936 to examine the phenomenon of 'savannization'. The questions asked were:

- Is the savanna in central and northern Côte d'Ivoire anthropogenic or edaphic?
- What role does fire play in the creation and maintenance of savannas?

The study area was divided into three plots consisting of "total fire protection", "early fires" (fires set at the start of the dry season) and "late fires" (at end of the dry season). Since the beginning of the experiment seven inventories have been made resulting in the following findings:

- 1) Without fire a semi-deciduous rainforest could re-establish itself in less than 60 years.
- 2) Late fires are the most damaging ones for wooded vegetation with the likely event that only large specimens survive or that they altogether disappear, to be followed by grassy savanna.
- 3) With early fires soil fertility is decisive. On fertile soils a closing of the forest cover is possible, while still vulnerable to fire in extreme dry seasons. On poor soil the establishment of a forest is unlikely.

The results of this study have indicated the importance of fire management and protection in the search for successful reforestation efforts in the tropics. The importance of this study is especially highlighted since it is the oldest trial plot in Africa.

G. Buchholz

*Source: Louppe, D., N.Oattara, and A.Coulibaly. 1995. The effects of brush fires on vegetation: the Aubréville plots after 60 years. Comm. For. Rev. 74 (4), 288-292.*

## MEETINGS PLANNED FOR 1996-97

### MALAYSIA

#### *AIFM Conference on Transboundary Pollution and its Impacts on the Sustainability of Tropical Forests Kuala Lumpur (Malaysia), 2-4 December 1996*

**Background of the Conference:** Transboundary pollution has become a great concern in South-East Asia. It poses ecological risks, economic degradation, affects human health and has permanent environmental impacts on the local, regional and international scene. Forest fires, open burning, motor vehicles and industrial emissions, hazardous wastes and ship-borne pollution, are among major causes of the transboundary pollution, and are expected to keep on rising in the future.

Forest fires in particular, have received wide attention in recent years in the ASEAN region and have caused thick haze (*jerebu*) over the capital cities of Kuala Lumpur, Singapore and other densely populated regions. In the years 1982-83, 1987, 1991 and 1994 the haze was staying for weeks, jeopardising the health of nations and posing a threat to traffic safety. Billions of dollars worth of flora and fauna, particularly timber, have been lost in smoke with the double irony of causing air pollution along the way. The losses of biodiversity are high. Rapid development in the environmental sphere has called for urgent ASEAN cooperation to shape international perspectives in environmental management and professionalism to address transboundary pollution. This conference could be the first of its kind organised in the ASEAN region, not because of the lack of necessity but imminent realisation of its hazardous effect on air quality and human welfare.

At the ASEAN Meeting on the Management of Transboundary Pollution, in June 1995, ASEAN Member Countries agreed to collaborate actively to develop expertise and capability to minimize the effects of transboundary pollution. The world must maintain a minimum standard of environmental healthiness conducive for sustaining the forest. Immediate attention must be taken to address the problem and maintain the clean air that we breathe. The world must enjoy the freshness of natural forest and allow it to flourish and prosper. There is a complex relationship between transboundary pollution and the sustainable management of the tropical forest, or isn't there? Indeed, whichever way we look at it, there is a real need for a multi-disciplinary and integrated resource management planning approach to tackle the issue. It is with this in mind that the Institute is organizing a conference to discuss and solicit practical solutions to address the impact of transboundary pollution on the sustainability of the tropical forest. It is hoped that the conference will recommend a pragmatic approach, techniques and procedures to help us sustain clear blue skies and safely enjoy the air that we breathe and the water that we drink.

**Organizer:** The conference is organized by the ASEAN Institute of Forest Management (AIFM) and co-sponsored by the Malaysian Timber Council (MTC); the Max Planck Institute for Chemistry, Biogeochemistry

Department, Fire Ecology and Biomass Burning Research Group/Freiburg University, Germany; the Integrated Forest Fire Project (IFFM) - Indonesia-German Technical Cooperation, supported by GTZ; the ECE/FAO/ILO Team of Specialists on Forest Fire (United Nations, Geneva); the International Global Atmospheric Chemistry (IGAC) Project (IGPB), Focus Impact of Biomass Burning on the Atmosphere and Biosphere, the South East Asian Fire Experiment (SEAFIRE); and the International Union of Forest Research Organizations (IUFRO), Subject Group S.1.09 Forest Fire Research.

The AIFM was established in 1986. It has a mission to become a centre of excellence in tropical forest management, and to provide the ASEAN member countries with the technology and expertise in upgrading their capabilities in sustainable forest management.

**Objectives:** This conference is being held to provide a forum with leading public and private agencies, specialists and resource persons to discuss issues, programmes and strategies surrounding transboundary pollution and sustainable development of tropical forest. The objectives of the conference are to

1. review forest-related causes of transboundary pollution, and the effects of this pollution in Southeast Asia;
2. examine the effects of all types of transboundary pollution on tropical forests in Southeast Asia;
3. exchange information and experiences regarding new methods and tools for forest fire management;
4. discuss and recommend priorities for changes in policy, research, forest fire management and training; and
5. explore opportunities for international and interagency cooperation.

**FIREXHIBIT '96:** As forest fires have been identified as one of the major concern in relation to haze problem, it has been decided that the international showcase of forest fire equipment and technology be included in the conference agenda. This operative trade show and exhibition will be dedicated to the conference delegates for two days and will offer live demonstrations and hands-on technical sessions. The show will be an exceptional opportunity to see the latest in fire suppression equipment, services and technology.

### **Conference Programme**

#### **Day 1: Monday, 2 December 1996**

SESSION A: Airborne Pollution - Transboundary Effects on Tropical Forests  
SESSION B: Terrestrial Pollution Effects on Tropical Forests

#### **Day 2: Tuesday, 3 December 1996**

ASEAN FIRE FORUM: Fire Research and Management Activities Within the ASEAN Region - How to Activate, Coordinate and Implement a Strategy?

Facilitated by:

GTZ-Integrated Forest Fire Management Project and Max Planck Institute for Chemistry, Fire Ecology and Biomass Burning Research Group, Germany

#### **Day 3: Wednesday, 4 December 1996**

SESSION C: Forest Fire and Smoke Management  
SESSION D: Research and Development in Forest Fire Management  
SESSION E: Resolutions

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50400 Kuala Lumpur  
MALAYSIA

## CANADA

*The 2nd International Wildland Fire Conference  
 "Wildland Fire Management and Sustainable Development"  
 25-30 May 1997, Vancouver, British Columbia Canada*

Wildland fire directly influences the social, economic, and environmental health and well-being of all nations. The world's forests, grasslands, and shrub ecosystems continue to be threatened by and experience the effects of wildland fire. Finding the balance between fire's natural cycles, environmental preservation, and sustainable development presents on-going challenges to wildland fire policy makers and managers throughout the world.



In May of 1997, international public and private agency delegates will gather together in Vancouver, Canada, for the 2nd International Wildland Fire Conference, to share information, discuss issues, and exchange programs and strategies within the conference's theme of "Wildland Fire Management and Sustainable Development". Conference plenary sessions will focus on the social, economic, and environmental impact of wildland fire, with moderators and key note speakers from Canada, the United States, Australia, Brazil, Chile, South Africa, Germany, Russia, and other countries. The Conference will also feature FireInfo 97, a two-day information exhibit and poster session, and WorldFire 97, a global perspective on world wildland fire programs. Not since the inaugural wildland fire conference in Boston in 1989 has there been a gathering of the world's wildland fire community so relevant to anyone interested in the role of fire within the evolving concept of sustainable development. Set against the wilderness backdrop of Vancouver's Pacific Coast mountains, the 2nd International Wildland Fire Conference is an important international event not to be missed.

*FireExpo 97: An International Showcase of Wildland Fire Equipment, Services, and Technology  
 28-30 May 1997, Abbotsford, BC, Canada*

FireExpo 97, the trade show component of Wildland Fire 97, is an international showcase for fire equipment manufacturers and suppliers, fire service contractors, fire suppression agencies, and other wildland fire-related services and technology providers. More than 300 exhibitors will gather at Tradex, a state-of-the-art exhibition facility, and at the Abbotsford International Airport, home of the world famous Abbotsford International Airshow and Airshow Canada, just over an hour from downtown Vancouver.

FireExpo 97 opens on 28 May with a full day of indoor and outdoor product demonstrations and technical sessions devoted exclusively to the delegates and guests of the 2nd International Wildland Fire Conference. These world leaders in fire management and policy development will see the very latest wildland fire equipment, services, and technology. While FireExpo 97 will be of particular interest to wildland fire specialists, it will also have important relevance to structural fire experts, as more people set up recreational and permanent homes in and around wildland areas, and the incidence of interface fires increase. FireExpo 97 will open to the fire management community at large on 29 and 30 May, bringing expected attendance for this unprecedented trade show to more than 5,000 user, buyer, and investor representatives from local municipalities and international wildland fire organizations. General admission is available for one or both of these two days.

### *WorldFire 97: A Global Perspective on Fire Programs*

To conclude the 2nd International Wildland Fire Conference on 30 May, delegates and international key note speakers will participate in WorldFire 97, a global look at the issues of wildland fire management and sustainable development from the unique perspectives of successful fire programs and multilateral collaboration initiatives from around the world. This final day global forum will provide world wildland fire specialists with a crucial opportunity to share and learn from the experiences of the past, to explore the issues of the present, and face both the common and unique challenges of the future, as an international collective from the world's major fire regions.

For further information on the 2nd International Wildland Fire Conference, FireInfo 97, WorldFire 97, and for conference registration, please contact the conference secretariat:

Events by Design  
#601 - 325 Howe Street  
CDN - Vancouver, British Columbia V6C 1Z7

Fax: ++1-604-669-7083  
Tel: ++1-604-669-7175  
e-mail: 74117.273@compuserve.com

For further information on FireExpo 97, or to request FireExpo 97 exhibitor information, please contact the FireExpo 97 secretariat:

International Wildfire Association of BC  
Box 2279  
Clearbrook Station  
CDN - Abbotsford, British Columbia V2T 4X2

Fax: ++1-604-824-0100  
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### **FROM THE PRESS**

#### *Greater Hing'an Forests After the Fire of 1987*

by Liu Qi

"Located at the northernmost end of China, the Greater Hing'an forests are beautiful, rich and pollution-free. In its thousands of square miles of boundary, rows of mountains are covered by immense forests... In summer, the forests show greater charms when mountain breeze breathes, trees send forth delicate fragrance, streams murmur and flowers bloom."

This description about the Forests is written by a travel brochure. It represents a nice imagination of people who have never been there. As one of an journalists' group missioned to cover a Sino-German technical cooperation project, "Rehabilitation of the Burnt Areas in Greater Hing'an Forests", I rejoiced when in late May we visited a piece of forests that had not suffered fire devastation in 1987. Though simple roads as well as electrical wire network curve through the forests, though clouds of yellow dust were raised when vehicles passed by, tier upon tier of green shows quietly the enchantment of the forests. During the long journey across the vast forest, we, urban dwellers, asked for a stop frequently to take photos and have a greedy breath of 100 percent fresh air. We were immensely charmed when we cruised in the sea of green.

But, good time lasted only a half day in our 8-day trip to the Greater Hing'an Forests.

For the most of the time we spent there, we saw continuous hills with either low bushes of dreadful appearance or horrifying carbon black stumps, or groups of brown black trunks---the withered life that still stands upright to witness the fire disaster of 6 May 1987.

### **Thought on the Fire Disaster**

The extraordinarily serious fire that began on 6 May 1987 hurled down 100 more kilometres of forests in one night and destroyed forests of 1.2 million hectares, in 31 tree farms in two counties in 28 days. After nine years the bitterness is still well remembered by local people who turn pale at the simple mentioning of "6 May Fire". It is hard to imagine that the horrible "6 May Fire" made the railway melt, turned paper money in safes into ashes and television sets buried into metal lumps. Piles of quality timber a long railway disappeared after the fire as the ashes had been blown away...

At Mohe County town, the disaster center, people set up a special memorial hall for the "6 May Fire". At another small town in the forest, Tuqiang, a middle-aged couple who run a grocery can tell us in lively detail the "doomsday" then:

At nightfall, people in the town saw an odd scene. Red light mixed with black smoke covered the sky and came nearer and nearer. "Fire tongues like giant red hawks skimmed over tree tips...it went even faster than train". It has been estimated that the maximum fire speed reached 50 kilometres per hour and the air current generated by the fire reached fresh gale scale. Local people had never experienced such a horrible fire. They had no idea of how to escape. Some people dived into cellars in their houses and were suffocated to death. The male members of one family went up hill to fight the fire, leaving nine females to death. Some people moved to a small river with their household belongings and even livestock and survived. The scene, as the couple described, was just like "people ran away when Japanese invaders came to the village in the forties". Afterward, on every 6 May people at the town go to the small river to practise worship. "6 May" is also served as "A Day to Think of the Fire Disaster" in the forest area.

### **No more tall trees**

People in the forests saw their output comparable to that of a township, their population to a county and the area to a province in richer south China. The vast virgin forests just like a green rise at the eastern part of the Euro-Asia Continent, have made invaluable contribution to ecology and environment for the area and even for the world.

The climate in the forest is cold. Annually frost-free season lasts only 90-100 days. This makes trees there grow very slow. A tree from seedling to valuable timber normally call for one century or more.

Before "6 May Fire", there are trees, 20-30 meters high, everywhere. The fire has burned one-sixth of the total forest stands and left only low bushes. The offerings of Nature, which have accumulated in thousands of years, were destroyed in one moment by human beings themselves.

The loss of wildlife in the forest area was also significant. People in the forests have long been pride of the wildlife in the forests. Nowadays, however, this abundance and harmony between human being and wildlife is but a by-gone dream.

The degeneration of the ecological system in the forests have also brought about rare natural disasters. 1990 broad-leaf pine caterpillar disaster spread to an area of one million hectares. The 1991 extraordinary flood inundated two-third of Tahe township of Tahe County with an average water level of two meters. In 1994, there came another drought, which made young growths dead on a large scale. Five million 3-4 year-old trees had been destroyed in this disaster.

Besides, environmental problems like global warming makes the forest ecology harder to recover. Decades ago, there used to have a heavy snow in May to cover dry leaves on the ground, and in June there used to come another heavy rain, which allowed the forests to tide over the dangerous period of fire in spring. But, the May snow here has become more and more rare. Though there have no significant fire disaster after the 1987 fire the forest grounds are covered with thick fallen leaves, which makes it more and more likely to have another

big fire. In the forest area, we saw fire warning slogans everywhere. A regular cordon is placed during the dangerous period of fire in spring and autumn.

### **Easy to destroy, hard to rebuild**

Green Great Hing'an Forests have safeguarded the earth faithfully for thousands of years. Under the pressure of economic demand, the government had initiated three campaigns of development in the forests after 1949. The first two in 1955 and 1958 had little success and the third endeavour launched in 1964 had achieved great results. Humans began to resettle in the forests at last. A place with several tents accommodating the pioneers for forest development in 1964 have expanded as a capital city of the forest area, Jiagedaqi, which means "A place which has *Pinus sylvestris*" in the language of Erogen nationality, the dwellers in the forests. In the process, the vitality of the forests had been taken away little by little as more and more old trees were cut down.

For several decades, the only reason of people's presence in the forests is tree-cutting. Under this practice, one hill after another, with heavy tree coverage, became nude.

Only in the recent 10 or more years especially after the fire disaster of 1987, people became aware of the damage they impose on the forests, and their terrible destruction to the forest ecology. In the 1990's, tree cutting is controlled at 30 percent. It is believed that in this way the forests are capable of self-recovery and have little influence on forest ecology.

It is said that, there is an old "model worker" in the forests who had enjoyed his fame for the huge amount of trees cut. In recent years, though in his 80's, he vowed to plant the same amount of trees he had cut and was granted new honours by the local authority.

It is easy to cut down trees, but it is hard to plant and grow trees. As the time for a tree to grow calls for centuries, how can the human beings turn the thousands of bare hills into green in several years? A Fire '87 burned 1 million hectares...

According to a schedule of rehabilitation of the burnt areas, the local authority plans to rejuvenate the forests in three phases in nine years. 17 percent will be done by man and the remaining is left to nature itself. It is told by the local authority that after nine years' endeavour 180,000 hectares of young growths have been set up. Nevertheless, the remaining area is far too gigantic a job for the human beings.

To conduct large-scale rehabilitation under harsh climate and fragile ecology, the technical establishment in the forests can not stand equal to the challenge. The local authorities try to seek outside assistance for practical technologies of a broad spectrum, from seedlings growing to youth growth management, in which the Sino-German technical project launched in 1993 could serve as a model.

### **Few foreigners come into the forests**

The Germans, with a hawk nose, blue eyes and hay hair other than black, brought people in the small forest town Tuqiang with lasting curiosity and excitement.

Those foreigners complained, their expectation to experience the unique folk characters of a Chinese small town in the depth of the forests was spoiled by the excessive curiosity of local Chinese. Wherever they went, there surely were lots of eyes on them. To people in the town, "we are animals rarer than dinosaurs". Their only choice to spend their spare time was to stay at the well-equipped apartments.

What can be done in the apartment?

"Read books," humorous Mr. Rudolf Reichwein, a tree-farm owner in Germany, answered while he raised up his hands over his head, "The head will grow horns if you don't read books for a long time." In robust health, Mr. Reichwein looked full of energy, liked to make fun. He often stretched his neck and imitated the cry-out of a woman vendor in the town, "Mai-dou-fu-lou-----" (sell bean curd). In the eyes of his Chinese counterparts, he is a funny fellow.

Besides Mr. Reichwein, we met two other Germans. Mr. Julius Durst, the coordinator of German experts group in the project, is head of an administrative agency for a forest area. Slim Dr. Michael Mussong, has also participated in other projects in Shanxi Province and at an island on the Pacific Ocean. Dr. Mussong likes to play Chinese chess, often have hot fights with a waiter at the apartment building.

The three came to executive the Sino-German technical cooperation project, "Rehabilitation of the burnt areas in Great Hing'an Forests area".

They came to China with a strict and realistic approach, a world-famous German spirit. Working together with their Chinese counterparts, first of all, they studied 81 sample spots across the burnt area and got well-presented, first-hand information. They applied the unique practice of GTZ (German Agency for Technical Cooperation), underlined several items as of the primary importance, such as breeding enough quality seedlings, adopting practical new technologies for rehabilitation and enhancing the quality of Chinese professionals. Afterwards they worked out annual or seasonal schedules, accurately demonstrated the locations and area for experiments, seedlings, tools, equipment and the quantity of human resource, listed in detail comparative experiments for different seedlings, seasons and tools. Almost every local expert and official we met expressed their admiration for the German experts.

The three German experts said that an important reason for their coming is the challenge they had never faced before. They hoped to enrich their professional experience through this project in the forest area, a place with harsh climate and too large area needed to rehabilitate. No example can be borrowed across the world.

Also, it's another pleasure for them to go to a little inn in town to have cups of beer occasionally, they added.

Germany is the largest bilateral supporter to China in forest industry. At the very beginning of Fire'87 in the Great Hing'an Forests, the country offered cash assistance of 30 million Deutch marks. Aimed to explore a quick and effective way of rehabilitating the burnt area from Germany with advanced forest technology and equipment, the two countries began to initiate the Sino- German technical cooperation project in the autumn of 1993 for 8-10 years. GTZ (German Agency for Technical Cooperation) and the Ministry of Forest Industry of China were charged to execute the project.

In 1988 a fire in the Yellowstone National Park in the United States burned one million hectares of forests. Americans set a 100-year timetable to recover the burnt area. In China, however, German and Chinese experts expected to shorten the time to about 50 years by a comprehensive approach.

Financed by two million Deutsch marks of free grant from Germany, the first phase of the project has been accomplished this year. Nine German experts, eight Chinese experts and 17 technical assistants have participated in this phase of work and achieved lots of valuable results in the past three years. For the second phase the German government will put in another two million marks. At the end of our visit to the Great Hing'an Forests, a letter of intent for the second phase was signed by experts of the two countries.

"Lofty Great Hing'an, the green forests, are vast in territory and rich in natural resources, which make you come to appreciate the greatness of Nature ... warmly welcome guests all around the world, please come to have a visit."

The travel brochure have offered warmhearted invitation to visitors. I hope, under the continuous endeavour of local people along with international assistance, the beauty of the forests could be restored. By then, there surely will be more and more visitors to share magnificent nature in the vast forest area.

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