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Reader Information no. 1

In this article Johann Georg Goldammer gives a brief overview on the global wildfire problem. Dr Goldhammer is head of the Fire Ecology and Biomass Burning Research Group of the Max-Planck-Institute of Chemistry (Mainz, Germany). He is editor of the ECE/FAO "International Forest Fire News" and member of various international committees involved in wildland fire and global biomass burning research and development programmes.

A global overview of the forest and wildland fire problem

THE DESCRIPTION of the global wildfire scene in a relatively condensed overview is a challenging task. However, this article attemps to summarise briefly the major facts on occurrence and impacts of wildfires, and aspects of prevention and control technologies. In order to facilitate the understanding of the wildland fire manager's language, a few terms used in the context need to be clarified and defined.

The phenomenon of natural and man-caused vegetation fires is not restricted to forests. Large areas of other vegetation are regularly affected by fire, eg brushlands, grasslands, savannahs, etc. These fires are usually defined as "wildland fires". The term "wildfire" is used for uncontrolled and undesired fire in all kinds of vegetation, including forests. Fire is also used as a tool in vegetation management, a procedure called "prescribed burning". The term "fuel" describes the combustible biomass in forests and other ecosystems.[1]

Precise data on the overall global amount of fires on forest and other land is not available. Within the ECE region (embracing all countries of Europe, and in North America and the USSR) fire statistics have been collected systematically since 1982.[2] These data (Table 1) show that the highest fire burden within Europe is on Spain, Portugal, Italy and Greece.

The vast majority of wildfires in Europe is caused by man; only one per cent to three per cent of all fires are started by lightning. The Mediterranean countries suffer most of the arson fires, driving the European average of intentionally started wildfires to an average of around 50 per cent of all known causes. Negligence is the other major source of fires.

In the northern environment of America, Europe and Asia lightning fires occur more frequently. The inaccessible wilderness lands of Alaska, northern Canada and Siberia allow large-scale spread of wildfires, thus explaining the extended size of fire-affected lands in those remote northern areas (Table 1). Exact data on forest and wildland-fire in the USSR are not available. However, the wildfires of 1987 in north-east China (1.3 million hectares) and southern Siberia (>2.0 million hectares) demonstrate the potential of large conflagrations.[3]

The remaining vegetated lands are in the tropics and sub-tropics. Most of the lands in the lower latitudes suffer an increase of population pressure and socio-economic problems. In the less developed rural areas of the world fire is being used as a primary tool in vegetation treatment.[4]

Fires set in slash-and-burn agriculture and for forest conversion purposes often escape and spread, uncontrollable, over large distances. The 1982-83 fires in Borneo are a drastic example. During a prolonged drought, triggered by the "El Niño-Southern Oscillation" phenomenon, more than five million hectares of rain forest (primary and secondary forests) in the Malaysian and Indonesian parts of Borneo were affected by wildfire which had escaped from shifting cultivation burnings.

The fires in the Amazon Basin are another striking example. During the peak of the fire activities of 1987-88, it was assessed by satellite imagery that in each burning season about 20 million hectares of lands in Amazonia (Brazil) was fired, 40 per cent being primary rain forests. (The remnant was repeated burning for completing forest conversion and to maintain pasture lands.)

More frequent fires occur in the open and drier forests (seasonal deciduous and semi-deciduous forests). These forests are adjoining, north and south, to the moist evergreen tropical forest and gradually develop into savanna ecosystems (tree, shrub and grass savannas):

All these open vegetation types are characterised by seasonal availability of easily flammable surface fuels (leaves, grasses). Here fires are mostly set for improving grass yield during the dry season. The uniformity of fuels allows large-scale development of surface fires which may often exceed several hundred square kilometres. According to our latest estimates it is assumed that more than one billion hectares of savanna-type vegetation (including open forests) are burning every year throughout the lower latitudes.

Recurrent

In many of tropical savanna ecosystems as well as in the lightning-fire biota of the temperate and boreal zone, fires are rather a recurrent phenomenon which has its place in the natural development of vegetation. This includes extreme high-intensity crown fires in northern coniferous forests which occur in long cycles (several hundred years) and represent both the end of the forest development and its regeneration for a new life cycle.[5]

However, in the densely populated areas of the globe the damage of forest and other vegetation resources by fire involves severe ecological consequences. Increased erosion, surface water run-off and landslides may lead to decrease of productivity and instability of landscapes and may induce a process toward savannisation and desertification.

In most parts of the world the ecological damage is not defined or assessed in terms of economic loss. The valua-

A wildfire raging in the northern boreal forest of Canada.

tion of economic losses, however, is available for the managed forest land (commercial forests) of the ECE region. During the period 1985-87 an annual average of 43,000 wildfires on about 700,000 hectares caused (reported) losses of about US$500 million. The annual mean expenditure for prevention and control of fires was about US$200 million.

Another environmental aspect of forest and wildland fires is related to the impact of fire emissions on the atmosphere. A recent study has summarised the state of knowledge on the atmospheric chemical effects of tropical biomass burning.[6] The data show that a large part of those gaseous emissions which contribute to global warming ("greenhouse effect") are emitted by fires from slash-and-burn agriculture, permanent deforestation and savanna burning.

Detrimental

The total amount of prompt carbon release to the atmosphere from tropical biomass burning may exceed five gigatons (five billion metric tons) compared to about six gigatons of carbon emitted by all fossil fuel burning sources. It must be noted, however, that a part of the carbon is re-sequestered by regrowth of vegetation.

Altogether, the impact of all forest and wildland fires must be considered as detrimental to the shrinking natural resources of the earth.

The answer to the fire problem in wildlands and managed forests is extremely complex. A generalised scheme for minimising the negative effects of wildfires cannot be given due to various facts explained earlier.

This refers especially to those vegetation types which have been affected by fire for a long time (so called "fire climax ecosystems"). Some forest types, such as some Australian eucalyptus forests or those North American coniferous forests which contain species tolerant to low to medium intensity surface fires, may even require a frequent treatment by prescribed fire in order to keep the fuel load down and to reduce the crown fire hazard (high intensity fires). The exclusion of periodic fire from such fire-maintained forests or grasslands would eventually lead to an "unwanted" development of less productive and less valuable lands.

Other wildland areas, such as nature parks (national parks, nature reserves, wilderness areas), require the integration of natural forces, among which lightning fire is a significant one. The partial, periodic or even complete disturbance by fire is then considered as an important ecological event. The Yellowstone fires of 1988, however, have demonstrated that wildfires classified as "natural prescribed fires" may leave considerable amounts of National Park land burned, and cause emotional dispute and controversy among fire experts and the public.

The majority of forests in Europe and in other regions of the world are managed according to the principles of sustained yield and multiple-use concepts. The protection of those forests against unwanted wildfires is imperative. However, the success of fire protection varies from country to country.

The main fire protection focus is on the prevention aspect. Prevention measures embrace two target groups, the forest users and the forest managers. The public is the main forest user — and the main cause of accidental and arson fires. Negligence, as the major cause of fires, ranges from thrown-away cigarettes and unguarded camp fires to children playing with fire and unintentionally starting a forest conflagration.

Target group

Fire prevention campaigns concentrate primarily on the target group of negligent and unaware fire starters. In many countries symbols have been created to raise public awareness and to visualise fire's destructiveness. The best known fire prevention symbol is "Smokey Bear", a forest animal telling the children that they are the ones responsible for preventing forest fires ("Only YOU can prevent forest fires")[7]. According to a survey, Smokey Bear and its message are known by 98 per cent of US citizens.

The prevention of arson fires set for land speculation purposes, an especially severe problem in some Mediterranean countries, has been encountered by appropriate legislation. New laws in some of the Mediterranean countries generally provide a prohibition of construction activities on burned lands, regardless of fire cause and land ownership. These regulations have helped considerably to bring down such intentional land-use conversion fires.

Technical prevention measures reduce ignition sources, eg spark arresters mandatory in some countries for forestry equipment (chainsaws, trucks and other vehicles) and for the railway system. High-fire hazard zones along roads, railway and power lines are cleaned regularly in order to reduce the fuel load, the flammability of vegetation and to make access and fire suppression on these defence lines easier.

Fuel management

Wildfire hazard reduction in forests is targeted to decrease flammability and to slow down the potential spread and intensity of wildfires. This is accomplished by silviculture and fuel management methods, eg planting less flammable understorey trees or other plants, reducing the crown fire risk by removing "fuel ladders" (dead branches in the lower part of the tree trunks) and reducing the overall load and potential energy release of surface fuels.

Such fuel reduction measures embrace the use of prescribed fire (cleaning forests by underburning), mechanical equipment (shredder-type machines which chip and compact the unutilised downed woody material) and even by prescribed grazing (intensive treatment and use of the grass layer under open tree stands).

Because of the land-use changes in woodlands and extensively treated wildlands of central and southern Europe, this kind of fuel management becomes critical. The replacement of intensive use of fuel wood for heating and cooking by cheap fossil energy and the abandonment of grazing practices have led to considerable accumulation of combustible fuels and wildfire hazard.

Intensive fuel treatment on the whole potentially endangered area often is economically and technically not feasible. Fuel management investment thus concentrates on "fuel breaks" which divide or "break up" the continuity of large wildland fuel complexes. Such

Table 1: Number, area and average size per year of fires on forest and other wooded land 1980-1988 (Source Reference 2)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1980-88 ave
Total number of fires (1000)										
Europe	38.2	46.3	38.8	34.6	42.3	54.3	36.4	39.8	48.2	42.1
Southern Europe a	30.2	41.0	29.1	26.3	32.2	47.6	28.3	34.5	40.2	34.4
North America	164.8	199.3	110.6	104.1	191.0	147.9	145.8	158.4	164.0	154.0
Total area of fires (1000 ha)										
Europe	541.2	768.5	451.1	504.7	397.2	1058.3	581.5	447.6	515.1	585.0
Southern Europe a	530.0	760.0	438.3	495.1	379.6	1049.8	570.9	440.1	505.7	574.4
North America	6076.2	7105.1	2277.1	1987.7	1995.3	2882.8	2241.6	3102.7	3635.5	3478.2
Average area of fire (ha)										
Europe	14.2	16.6	11.6	14.6	9.4	19.5	16.0	11.2	10.7	13.8
Southern Europe a	17.5	18.6	15.0	18.8	11.8	22.1	20.2	12.7	12.6	16.6
North America	36.9	35.6	20.6	19.1	10.4	19.5	15.4	19.6	22.2	22.1

(a) Cyprus, France, Greece, Israel, Italy, Portugal, Spain, Turkey and Yugoslavia.

Table 2: Range of highest and lowest number of forest fires and area burned in selected countries (Source Reference 2)

Country	Number of fires				Area burned			
	Highest		Lowest		Highest		Lowest	
	Year	Number	Year	Number	Year	Hectares	Year	Hectares
Austria	1976	547	1970	81	1976	474	1987	53
Czechoslovakia	1976	1 795	1977	225	1972	2 837	1977	107
Finland	1959	1 419	1962	117	1960	23 872	1983	100
France	1976	9 800	1970	1 902	1976	88 344	1972	16 441
Germany, Fed Rep of	1976	5 433	1987	484	1975	8 768	1985	242
Greece	1988	1 650	1976	590	1985	105 450	1976	8 389
Ireland	1984	1 194	1970	54	1984	1 450	1983	170
Israel	1988	1 334	1986	577	1988	14 430	1986	671
Italy	1985	18 664	1972	2 358	1981	242 218	1972	27 303
Norway	1974	2 257	1987	286	1984	2 846	1973	101
Poland	1976	3 827	1977	642	1976	6 961	1977	680
Portugal	1988	9 678	1979	1 609	1985	146 255	1988	25 829
Spain	1985	12 284	1966	1 443	1985	486 327	1971	34 945
Turkey	1985	1 793	1968	387	1977	43 076	1983	3 556
Yugoslavia	1971	1 718	1966	262	1985	42 791	1966	1 001

fuel breaks have a width between 10 metres and 200 metres, depending on the terrain and the expected fire behaviour of the untreated surrounding vegetation. On the fuel breaks the combustible surface fuels are mechanically treated and burned out, and the tree layer is thinned and pruned in order to prevent crowning fires. The open structure of fuel breaks provides improved accessibility for ground fire suppression forces.

In most countries the responsibilities for forest and wildland fire protection are shared by different agencies. Forest fire prevention, eg fuel management, construction of fire breaks and fuel breaks, construction of look-out towers, ground and aerial patrols, etc, are usually with the forest services and other land management bodies.

The fire control responsibility is often with the fire brigades which are under the ministries of the interior. Some countries have set up special forest fire brigades, eg Italy, Spain, the United States and the USSR. In general these special fire-fighting units are responsible for the public lands; other rules refer to community and private forest lands.

Forest brigades

In Spain a forest fire brigade (seven to ten workers) for each 5,000 hectares of high fire risk and for each 10,000 hectares of moderate risk is considered as sufficient. Specialised fire brigades, eg smokejumpers, or airborne suppression equipment is mostly concentrated on central bases and despatched over larger distances. In some countries private contractors offer aerial fire suppression services, eg in Canada or the United States. Other countries usually involve military personnel and aircraft for airborne fire control.

A broad range of wildfire suppression techniques and technologies have been developed for a variety of fire problems and problem fires. The conceptual approaches taken by individual countries depend mainly on the accessibility of the forest and wildlands.

For example, in what was the Federal Republic of Germany, a very dense forest road network (average 35 million hectares, in the fire-endangered pinelands, usually situated on flat terrain, generally much higher) provides easy access to the fire scene. The central European forest roads are generally designed for heavy logging trucks, thus allowing all-weather driving even for heavy urban fire trucks.

For off-road transport of extinguishants (water, retardants, foaming agents) four-wheel drive vehicles with a limited payload capacity of extinguishants have been developed. Light all-terrain vehicles with slip-on fire-fighting units are increasingly used in many countries. These light multi-purpose vehicles can be used for fire patrols and initial attack. During the off-fire season the slip-on tank can be removed, and the vehicle may be used for other tasks in the forestry enterprise.

Wildland fire suppression relies on two main principles — the spread of fire may be stopped by separating fuels or by cooling and knocking down the flames. In the average wildland fire scene, water is the resource most lacking, and the average environmental conditions during the fire season are characterised by high temperatures, low air humidity and low moisture content of fuels.

Spanish forest fire brigade consisting of seven trained forest workers equipped with hand tools, backpack pump and fire resistant clothing.

The lack of water resources requires ground-based fire attack techniques without any water. A variety of hand tools has been developed for that purpose, all mainly designed to create fire lines for separating fuels (eg by rakes, axes, the specially designed Pulaski and McLeod tools) or to cover fuels (with dirt and dust).

Hand-tool kit

In remote areas, where fire-fighters are despatched either by air (descending either by parachute or from a helicopter) or by long-distance walking, light-weight and multi-purpose hand tools are mandatory. Recently, a hand-tool kit has been developed which provides the whole variety of tools for scraping, digging and trenching to be mounted on one heavy-duty handle; the set fits into a backpack (total weight six kg) which can be carried for long distance walking and smoke-jumping.[8]

The general limitation of water resources in the wildland fire-fighting scene has led to the development of special wildland fire-fighting retardants and foams which increase the fire extinguishing capability of water.

Fire retardants are chemicals designed to influence the viscosity of water, coat the fuels and react with heat by releasing extinguishing gases. The efficiency of retardants may be short to long-term duration (up to many weeks).

Foaming agents have recently received more interest. The mixing ratio for a synthetic agent to produce medium-expansion foam for wildland fire application is less than 1 per cent, whereas the mixing of conventional retardants requires between ten per cent and 20 per cent.

In addition to the despatching of fire-fighters, aircraft are used for delivery of extinguishing loads. Scooping planes are generally designed to use plain water. Recent development of foam injection systems, however, allow the on-board mixing of additives without the need to return to a land base.

Fixed-wing airplanes still use mainly fire retardants to be premixed at the air attack base. A large variety of fixed-wing firebombers is in use. Some are military or other transport planes modified for permanent fire suppression tasks (eg the Conair operated CD 6B, capacity 11,300 litres). Other cargo planes can be converted to fire planes during the hot season.

Two types of fire-fighting kits have been developed for the C-130 Hercules and the C-160 Transall, both cargo planes flown by the military in many countries. The Modular Airborne Fire Fighting System (MAFFS) for the C-130 consists of a pressurised water discharge kit (11,300 litres), the Messerschmidt-Bölkow-Blohm fire-fighting kit is a gravity-operated 12,000 litre tank for the C-160.

Smaller planes such as the Canadair CL-215 scooping plane (5,400 litres), the Grumman Tracker S2G (3,500 litres) or the Thrush Commander (1,500 litres) are being flown in many countries.

A Canadair CL-215T in action. It can scoop up over 6,000 litres of water in just 12 seconds, fly directly to the fire for a drop, which can be repeated for up to 15 hours without returning to base.

Versatility

The versatility of helicopters in wildland fire control operations is becoming recognised more and more. Besides being used for aerial survey of fires, as command platform or for transporting fire crews, helicopters are also used for fire extinguishing. Helibuckets are filled with water by hovering over a water source (river, lake, swimming pool, or transportable basin) and dipping the bucket into the water or by taking it up by pumps. The helibucket capacity ranges from 250 to 1,500 litres. The 1500 litre version (eg the German Smokey II) requires a heavy transport helicopter (such as the CH-53).

Explosives are used for fire line construction and for direct fire attack. Water gel explosives offer a safe, low-cost alternative to machine or hand-built fire lines. The explosive is pumped into tubing and laid over fuels or left on the ground. The explosion defoliates bushes and trees and produces a trench or at least exposes the mineral soil (fireline width between one and two metres).

Fire suppression by explosives is practised in the USSR and was also tested in Germany. Depth charges are placed into drilled holes, covered by earth, in front of the fire seam. The explosive charges are blown up in the immediate vicinity of the approaching fire front for extinguishing the fire by the blasting impact and the dirt and dust covering effect.

Wildland fire-fighting involves a variety of safety risks which are mainly due to the conditions of fuels, terrain, fire weather and fire behaviour and are permanently subject to variation and unpredictability. Special training curricula on fireline safety for wildland fire-fighters were developed in North America and are presently made available for other regions of the world.

Most important is the knowledge of fire behaviour influenced by the varying environmental, fuels and terrain conditions. The influence of heat stress or toxic carbon monoxide on the fire-fighter's safety is one of the focuses of special safety training. First aid training also receives high priority.

Special clothing

Specially designed clothing for the wildland fire-fighter has been developed. The non-flammable shirts and pants are of a bright colour (preferably yellow or red) in order to make the fire-fighters highly visible in the field.

When the United Nations declared the 1990s as the "International Decade for Natural Hazard Reduction" it was the first time that besides earthquakes, landslides, windstorms, volcanoes and floods, wildfire conflagrations were recognised as disasters requiring international involvement.[9]

Some examples have been set during the past years, such as the mutual support between Canada and the United States, or the fire control efforts of American specialists in Mexico and Argentina.[10]

The spectacular success of German helicopters fighting last year's disastrous wildfires on Mount Athos, Greece, was one of the striking examples justifying the setting up of regular international fire brigades and relevant international agreements.

Striking example

Extreme wildfire situations are irregular events unlikely to happen in neighbouring countries at the same time. The costly installation of high-tech airborne fire suppression equipment and permanent availability of highly specialised personnel thus could be shared by many countries. The creation of a Pan-European fleet of fire-fighting aircraft and fast deployment airborne fire brigades could be a challenge worth investigating and following up.

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A Polish PZL Dromader dropping a 1500-litre load of water with foaming agents.