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The Current Fire Situation in the Russian Federation: Implications for Enhancing International and Regional Cooperation in the UN Framework and the Global Programs on Fire Monitoring and Assessment

Johann G. Goldammer[1], Anatoly Sukhinin[2], and Ivan Csiszar[3]

1. Introduction

During the last decade a number of international projects and programmes have been initiated to address the ecological role and the environmental and humanitarian impacts of wildland fires. Considering the importance of the role of Eurasia’s forests in the functioning of the global system and the potential threats by wildland fire to the sustainability of vegetation cover in the region the participation of the Russian Federation in these initiatives is crucial.

This paper reflects on some basic facts on the role and magnitude of wildland fires in the Russian Federation, including the Far East of Russia. It provides a retrospective on some projects that have been conducted between Russia and its international partners. Finally the contribution of the Russian Federation to cooperative initiatives under the UN framework and the global programs on fire monitoring and assessment are described

2. The Fire Situation in Russia During the Last Decade

The worlds total boreal forests and other wooded land within the boreal zone cover 1.2 billion ha of which 920 million ha are closed forest. The latter number corresponds to ca. 29% of the worlds total forest area and to 73% of its coniferous forest area (ECE/FAO 1985). The vast majority of the boreal forest lands of Eurasia are included in the Russian Forest Fund, covering ca. 900 million ha. Depending on the criteria used to define "boreal forest", the area of closed boreal forest in the Russian Federation varies from 400 to 600 million ha. These numbers correspond to a 43-65% share of the worlds closed boreal forest.

Wildfires from natural causes (lightning) constitute a very important ecological factor in the formation and sustainability of boreal forests. In interaction with the climate and local growing conditions fire controls the age structure, species composition, landscape diversity and mosaic of vegetation, as well as energy flows and biogeochemical cycles, especially affecting the global carbon cycle. In the history of Eurasia’s boreal forests fire has been used as a tool for land clearing, agriculture, hunting and pastoralism. During these historic times land-use fires often escaped control and spread as wildfires in the surrounding forest lands.

In the beginning of the 20th century the importance of fire application in the agricultural sector began to decrease. However, in spite of the reduction of traditional burning practices humans are still the most important source of wildfires; on average only 15% of fires in protected forests of Russia are caused by lightning.

[1] Global Fire Monitoring Center (GFMC), Max Planck Institute for Chemistry, c/o Freiburg University, Germany
[2] Sukachev Institute for Forest, Russian Academy of Sciences, Krasnoyarsk, Russian Federation
[3] University of Maryland, Department of Geography, U.S.A.

Whereas in the last century a reduction of wildfires has been observed in Western Eurasia (Norway, Sweden, Finland) an increasing fire occurrence has affected the Eurasian part of Russia and other countries of the Commonwealth of Independent States (CIS).

The official statistics show that in Russia between 20,000 and 40,000 fires occur annually affecting an area of 2 to 3 million ha of forest and other lands (Davidenko et al. 2003). They are detected and controlled only in the so-called "protected forests" and on the protected pasturelands. However, the use of the space-borne sensors such as the NOAA/AVHRR Advanced Very High Resolution Radiometer) and more recently Terra/Aqua/MODIS (Moderate Resolution Imaging Spectroradiometer), ENVISAT/MERIS (Medium Resolution Imaging Spectrometer) and Terra/ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer), permitted considerable improvement in the detection of active fires along with better estimation of areas burned and impacts, at a scale that suits practical purposes.

For example, before the 1980s it was believed that, on average, fires annually burned 1.5 million ha in the boreal forests on the territory of the former Soviet Union Recent investigations based on satellite imagery revealed that the magnitude of fires had been underestimated. Surveys using remote sensing ascertained that boreal zone fires burned annually an average of 8 million ha with considerable fluctuation between years. For example in 1987 satellite image evaluation revealed a total area burned in boreal forests and other land in the East-Asian regions of Russia of about 14 million ha (Figure 1).

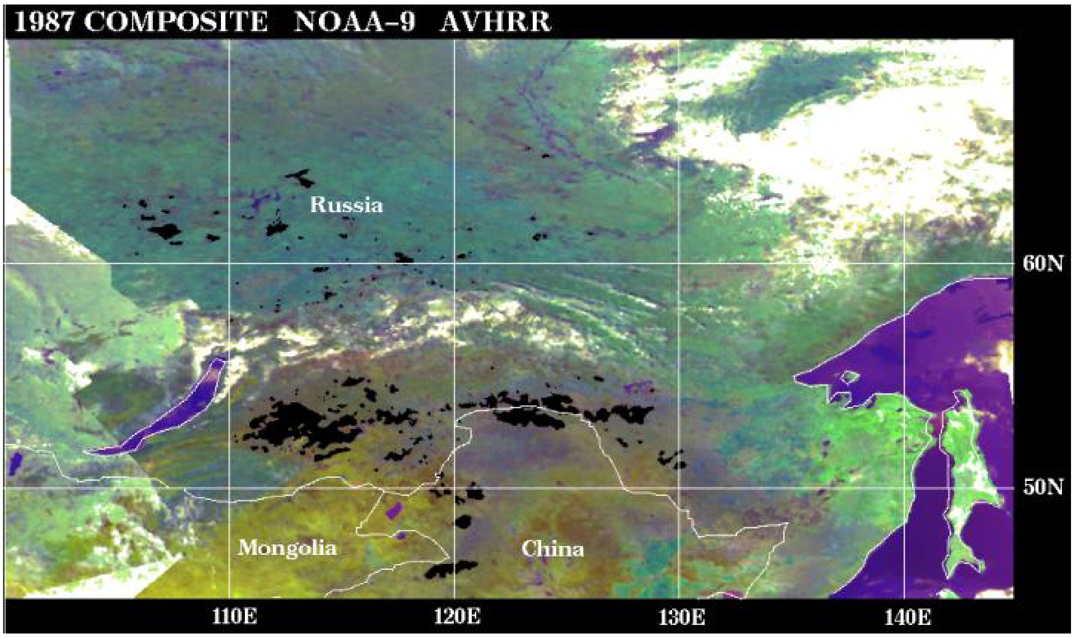


Figure 1. NOAA-AVHRR-derived burn scar map of the fire season of 1987 (Cahoon et al. 1994).

The Fire Seasons of 2002 and 2003

The fire seasons of 2002 and 2003 were extremely severe. Table 1 shows the magnitude of fires affecting the territory of the Russian Federation as reported by the government agencies and as depicted by satellite-based remote sensing.

Table 1. Comparison of wildland fire data for the Russian Federation: Agency reports vs. satellite-generated data. For details: See text.

Year	Agency Reports based on Ground and Aerial Observations			Satellite Derived Data (NOAA AVHRR) Based on Fire Counts and Derived Area Burned		
	Number of Fires Reported	Total Area Burned (ha)	Forest Area Burned (ha)	Number of Fire Events investigated	Total Area Burned (ha)	Forest Area Burned (ha)
2002	35,000	1,834,000	1,200,000	10,355	11,766,795	n.a.
2003	28,000	2,654,000	2,074,000	16,112	17,406,900	14, 474, 656

The table reveals the problems of accurate fire size and impact assessment. There are obvious discrepancies between the reported sizes of area burned by ground or aerial observations versus the data derived from satellite sensors. The area under protection and monitoring by *Avialesookhrana* covers a total of 690 million hectares of vegetated land, primarily forests. *Avialesookhrana* relies on aircraft and ground-based means to monitor ongoing fires and report fire summaries for daily updated statistics. The organization is facing severe financial and logistical constraints resulting in reduced availability of modern equipment, personnel and flight hours to adequately monitor and map fires from the air and on the ground. Thus, the reported total area affected by wildfires in 2002-2003 on the area of jurisdiction does not reflect the complete picture.

The Krasnoyarsk satellite receiving station at Sukachev Institute for Forest, now capable of downloading and processing both AVHRR and MODIS data, covers the Asian part of Russia, approximately one billion ha of vegetated land area between the Urals in the West and Sakhalin Island in the Far East. The surveyed area includes all vegetation types (forest, tundra, steppe, etc.). In this region the active fires depicted by NOAA AVHRR and derived burned area in 2002-2003, however, bears an uncertainty and must be adjusted. According to the Fire Laboratory there is an overestimation of areas burned by small fire events due to the system-inherent low spatial resolution of the AVHRR sensor. Deducing all fire events smaller than six AVHRR pixels (equivalent to 600 ha) would reduce the overall size of area burned in 2002 in the Russian Federation and Kazakhstan by ca. 16 percent. However, the Krasnoyarsk fire laboratory is using the most conservative algorithm of fire detection, and all high-temperature events are identified as a fire with a probability of 95%.

On the other hand there are fire events that were not recorded by the satellite due to cloud cover and sensor detection limits. This may partially compensate the overestimation of burned area assessments by fire event counts. Since the total size of the area burned in Asian Russia mainly depends on large fires the total range of error is assumed to be in the magnitude of 20 percent or less. The larger number of fires reported by *Avialesookhrana* is due to many small fires that either remain undetected by AVHRR or are within single pixels and hence are not counted separately (Csiszar et al., this volume).

Intercomparison of data generated by various institutions is needed to verify the fire datasets. For instance, comparison of the 2002 fire dataset for Irkutsk Oblast with the products of the Irkutsk Institute of Solar and Terrestrial Physics reveals similar levels of fire occurrence: The Krasnoyarsk Laboratory recorded 882 fire events affecting a total of 554,665 ha, whereas the Irkutsk Laboratory recorded 1055 fires affecting a total of 625,800 ha.

Other datasets are not yet directly comparable with the Krasnoyarsk data for the Asian part of Russia. For instance, the Global Burnt Area 2000 initiative (GBA-2000) of the Global Vegetation Monitoring (GVM) Unit of the Joint Research Center (JRC), in partnership with other six institutions, has produced a dataset of vegetated areas burnt globally for the year 2000, using the medium resolution (1 km) satellite imagery provided by the SPOT-Vegetation system to derive statistics of area burned per type of vegetation cover (GBA-2000). The global dataset available for the year 2000 provides area burned by nations. The dataset reveals a total area burned in all vegetation types of Russia during the fire season 2000 of 22.38 million ha, thereof 3.11 million ha of forest, 3.31 million ha of woodland, 5.3 million ha of wooded grassland, and 10.66 million ha of other land (including 7 million ha prescribed burning of croplands). The GBA-2000 number of 6.4 million ha of forest and woodland burned must be compared with the reported area burned for the *Avialesookhrana* region of 1.64 million ha (Avialesookhrana 2002) and for the Asian region of Russia (that is covered by the Krasnoyarsk satellite receiving station) of 9.7 million ha of all vegetation types (Sukhinin 2003, pers. comm.). A similar discrepancy was found for 1998: an analysis of the fires in Siberia depicted by satellite was 13.3 million ha – an area five time higher than the official statistics for the same year (Conard et al. 2002).

Based on the discrepancies between the different satellite datasets on the one side and conventionally collected fire data on the other side the question of absolute accuracy of satellite data seems to be of minor concern. Most important is to analyse and close the extremely large gap between the datasets of the operational users and the remote sensing institutions.

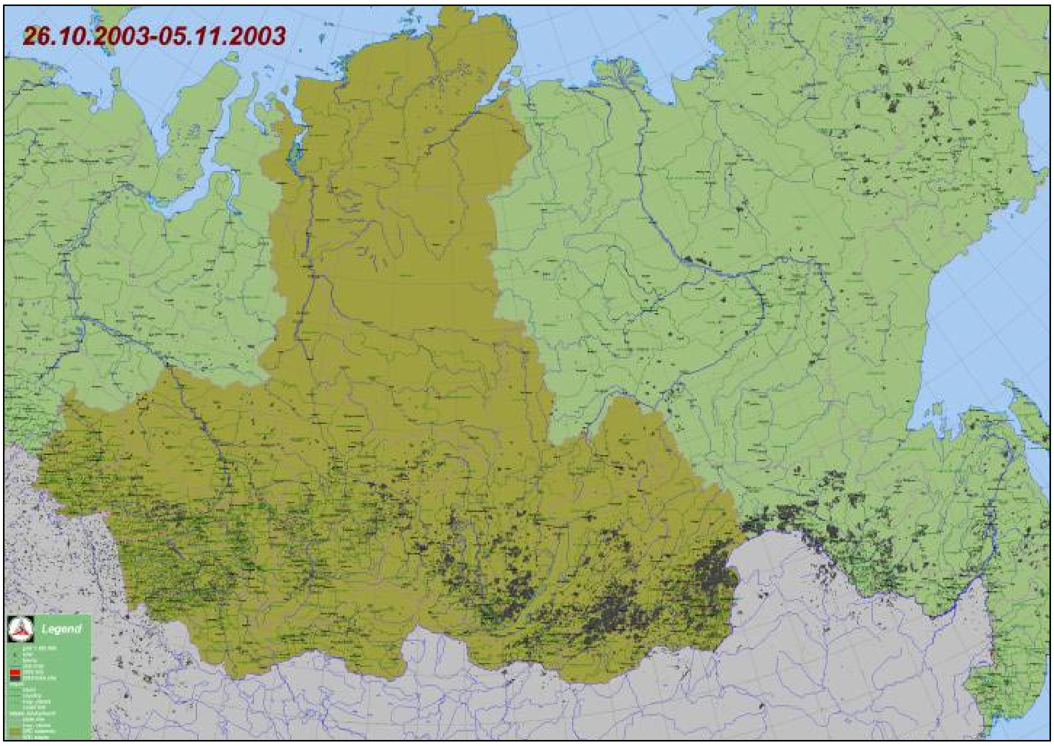


Figure 2. NOAA-AVHRR-derived burn scar map of the fire season of 2003. Source: Sukachev Institute for Forest.

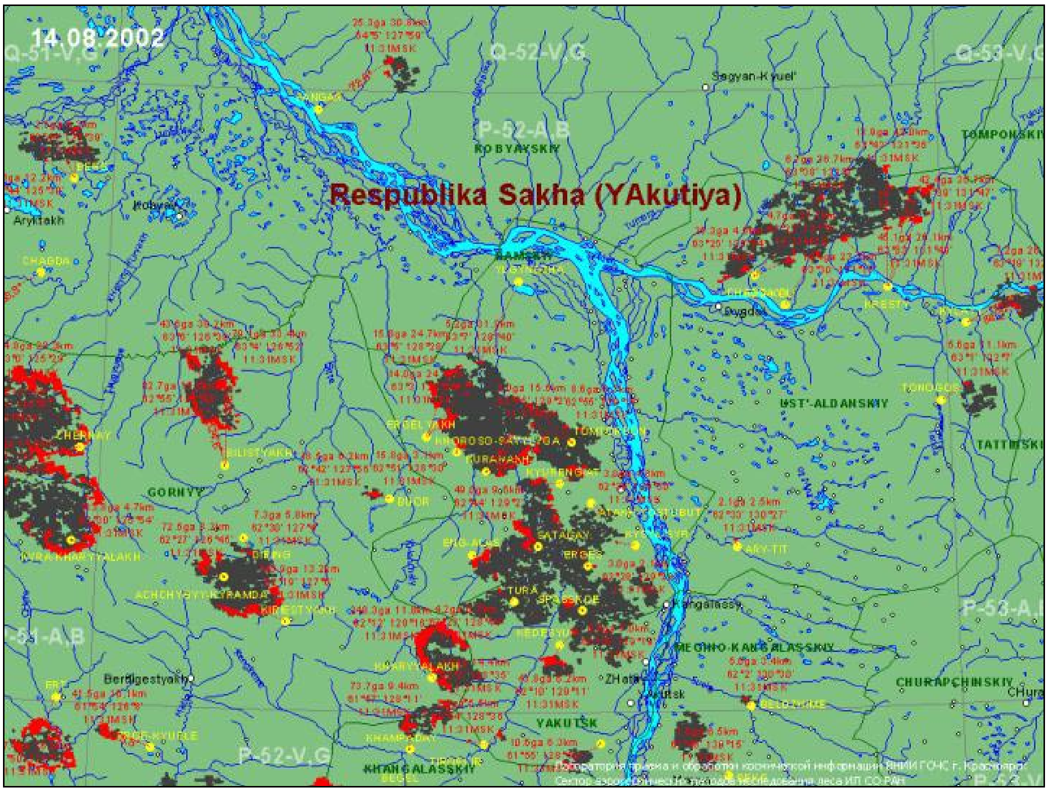


Figure 3. Example of a daily NOAA-AVHRR-derived burn scar map (Yakutia, 14 August 2002) generated by the Fire Laboratory of Sukachev Institute for Forest and displayed daily on the GFMC website.

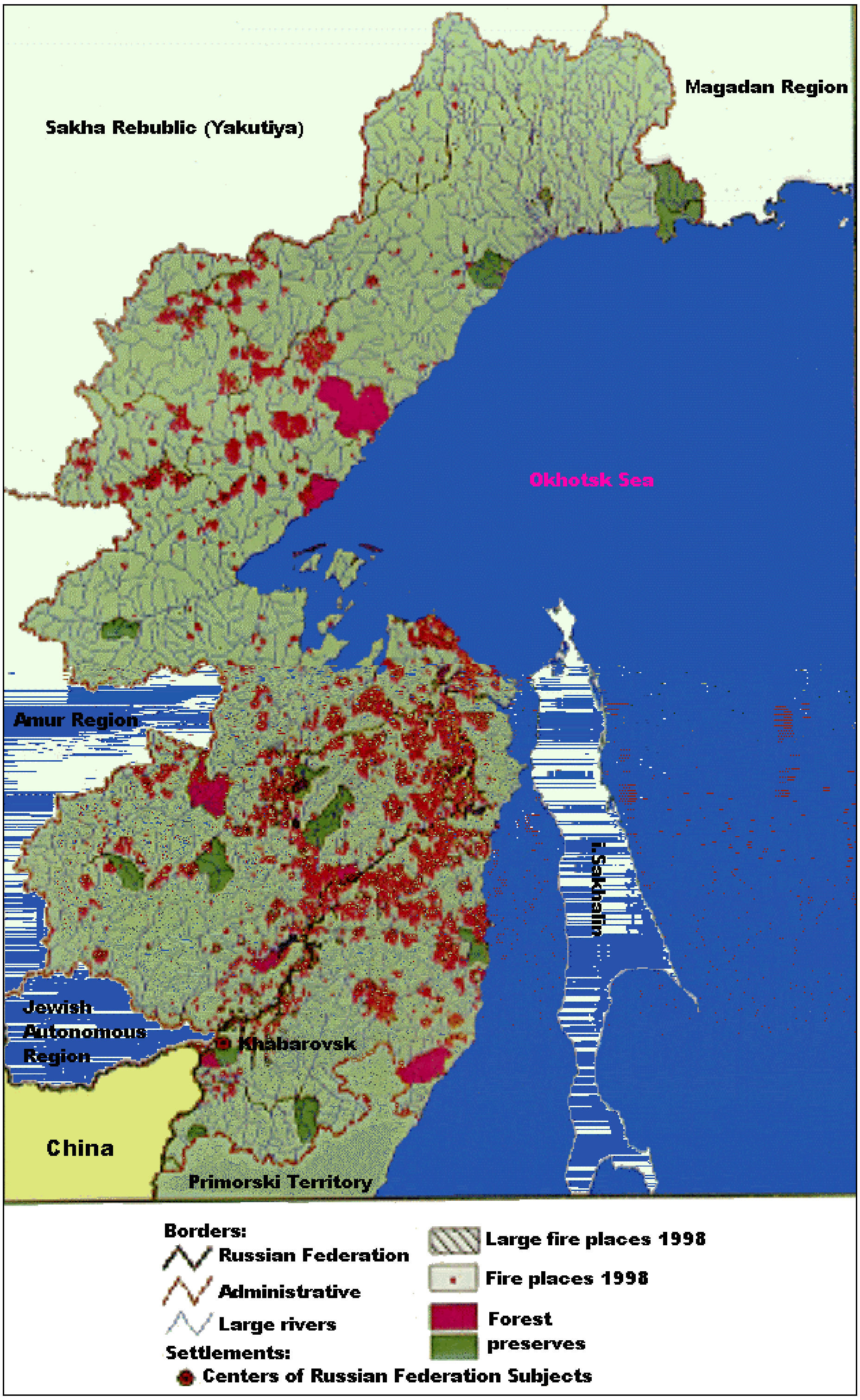


Figure 4. Forest fire map of Low Priamurya region at the end of the 1998 fire season. This fire map was digitised with the assistance of the Amur Design Office of the Russian Branch of the World Wide Fund for Nature (WWF). Source: Efremov and Sheshukov 2000.

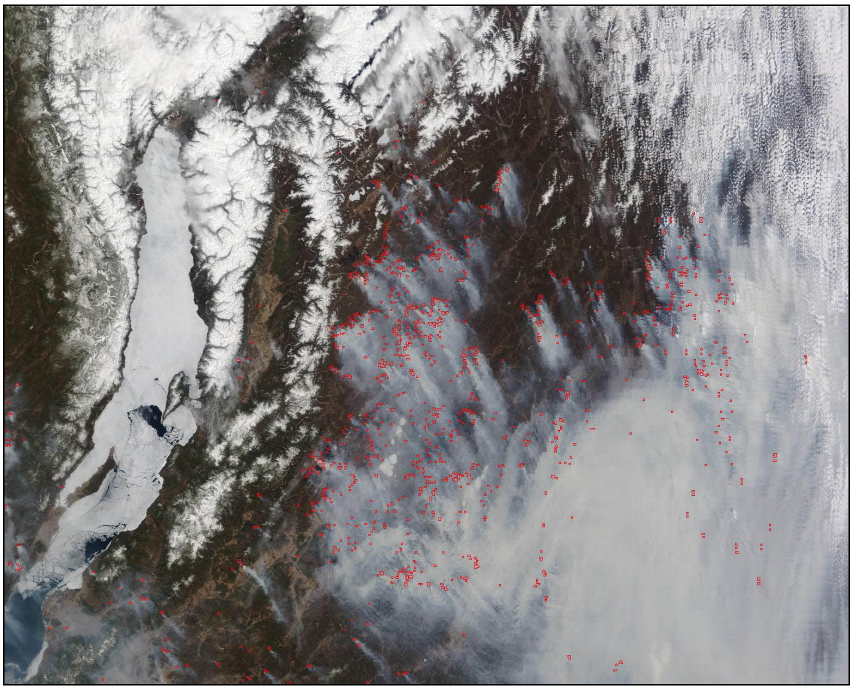


Figure 5. Fire activities on 8 May 2003 at 0400 UTC (11:00 local time) Southeast of Baikal Lake. Source: Moderate-Resolution Imaging Spectroradiometer (MODIS).

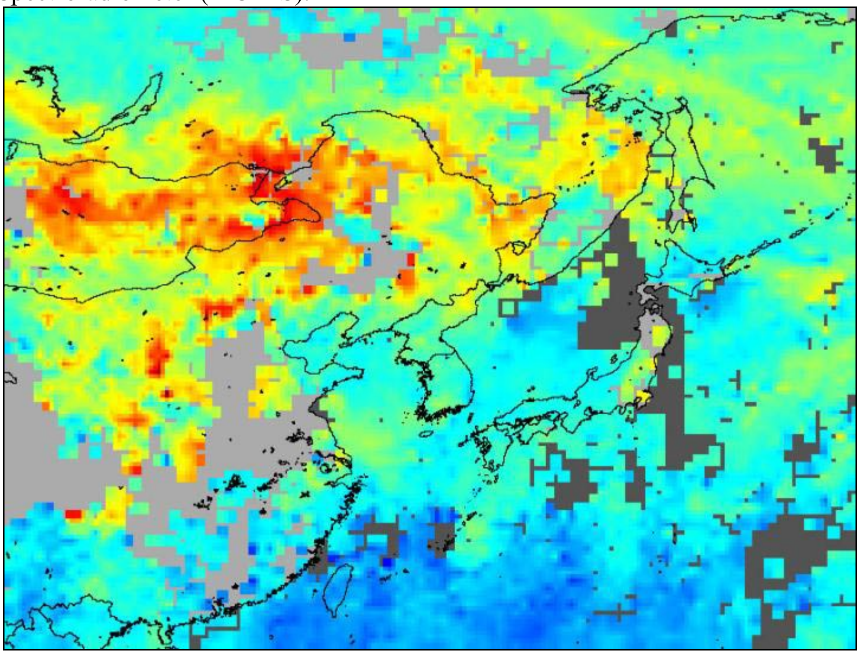
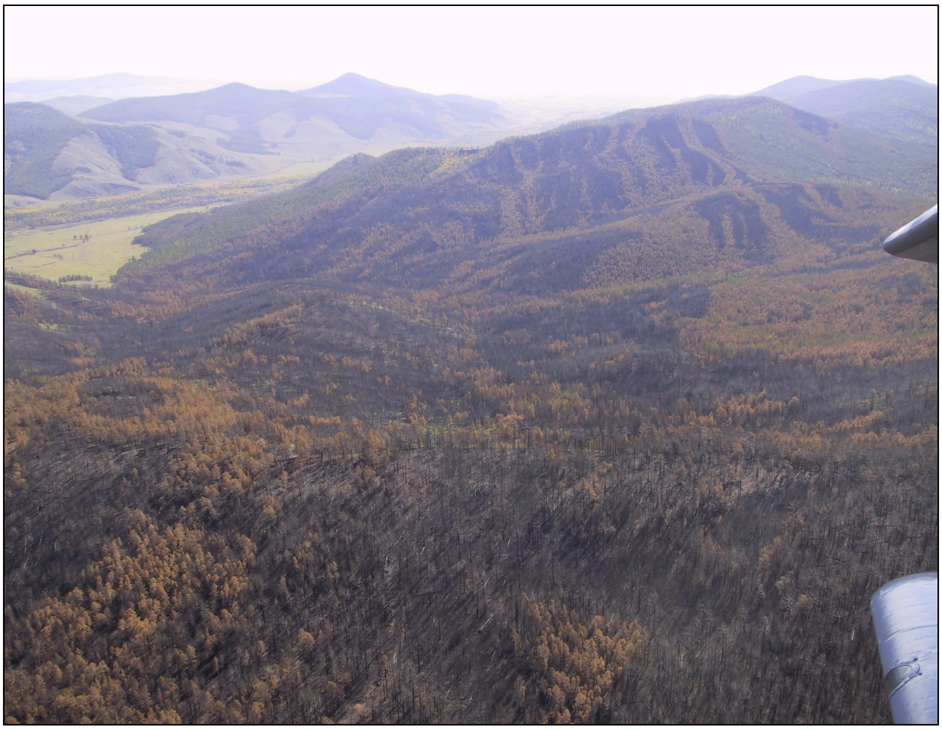


Figure 6. Accumulated carbon monoxide concentration for the period 3-8 May 2003 originated by smoke from wildland fires in the Transbaikal Region. The image shows measurements of carbon monoxide captured by the Measurements of Pollution in the Troposphere (MOPITT) sensor on the Terra satellite, with values ranging from zero (dark blue) to 360 parts per billion (red). Source: NASA Earth Observatory (http://earthobservatory.nasa.gov/)



Figures 7 and 8. Aerial view of forests in Buryatia Republic affected by wildfires in 2003 (aerial survey dated 15 September 2003). The upper photograph (5) shows the typical interface between steppe and agricultural lands and forests. The lower photograph (6) shows a significant amount of high-intensity fire scars resulting in extended destruction of forests due to the extremely dry weather conditions between mid 2002 and 2003. Photos: ©GFMC.

3. Implications of Wildland Fires in the Russian Federation on the Global Environment

3.1 Climate Change and Fire

Numerous scientific initiatives over the past years intended to clarify the role and importance of natural and anthropogenic fires in the forests and other vegetation on regional and global processes affecting the Earth system. The main issues addressed included:

- Recent changes of fire regimes due to anthropogenic and climate influences
- Carbon pools and carbon fluxes affected by changing fire regimes
- Improving of monitoring tools for assessing area burned and post-fire ecosystem development
- Role of fire on permafrost ecosystems, including release of ice-trapped paleo-trace gases by direct and indirect fire effects

Consequently several interdisciplinary research campaigns were initiated between 1993 and 2000, e.g. the Fire Research Campaign Asia-North (FIRESCAN), the IGBP Northern Eurasia Study and the project Fire Effects in the Boreal Eurasia Region (FIRE BEAR) (FIRESCAN Science Team. 1996, Goldammer and Furyaev 1996, Steffen and Shvidenko 1996, McRae et al. 2004). The most recent initiatives include the establishment of the Northern Eurasian Regional Information Network (NERIN), Siberian/Far Eastern Regional Network and the Western Russian / Fennoscandian Regional Network of the Global Observation of Forest Cover/Global Observation of Landcover Dynamics (GOFC/GOLD) programme and the Northern Eurasian Earth Science Partnership Initiative (NEESPI) (Csiszar et al., this volume).

Despite the high investments and research efforts the wildland fire science community has not yet a clear and holistic picture about the past, current and possible future role of vegetation fires at regional to global levels.

Climate-change models (Global Circulation Models - GCMs) have been used since the early 1990s to predict drought severity and consequently fire severity. One of these scenarios is provided in Figure 10. It is based on the GCM of the Canadian Climate Center (CCC) and compares fire severity rating across Russia under the current climate conditions vs. a projected climate-change scenario for the year 2030 (Stocks et al. 1998). This scenario, described in the caption of Figure 10, reminds us to the forest fire activity maps developed by Sukhinin et al. (2003). Figures 6a-e in this report use Sukhinin's maps for the 5-year period 1998 to 2002 to highlight the geography of inter-annual dynamics of fire activities. Spatial distribution of areas burned are given by different degree in the Eastern part of Russia derived from interpolated NOAA AVHRR data.

This comparison of maps visualizing observed and modelled fire severity on the one side and observed fire activity on the other side may help to understand that Russia is facing a problem that is co-determined by climate change and obviously by socio-economic changes that lead to more uncontrolled and destructive fires.

Figure 9a. Fire activity map of 1998

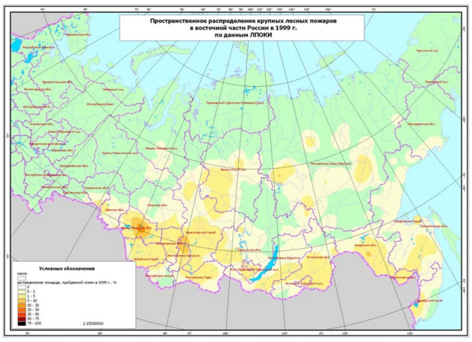


Figure 9b. Fire activity map of 1999

Figure 9c. Fire activity map of 2000

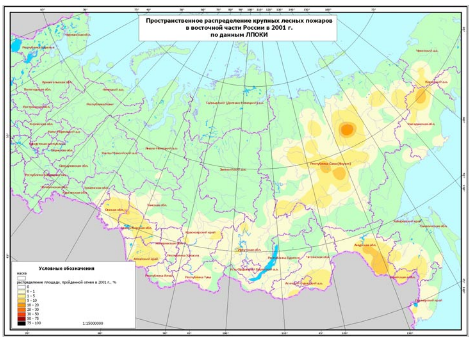


Figure 9d. Fire activity map of 2001

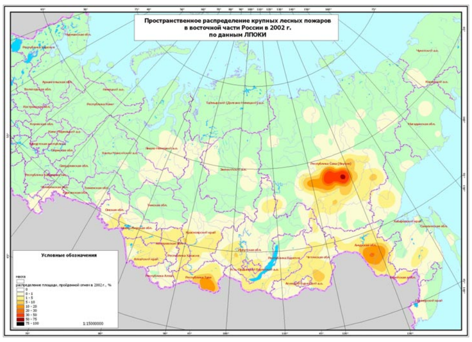


Figure 9e. Fire activity map of 2002

Figure 9a-e. Spatial distribution of areas burned by different degree in the Eastern part of Russia in the fire season of 1998-2002, derived from interpolated NOAA AVHRR forest fire data. Zones are delineated by colours that represent the ratio of the burned area to the total area marked by the colour. The fire activity map for 2003 is currently prepared by the Sukachev Institute for Forest and will be available by early 2004.

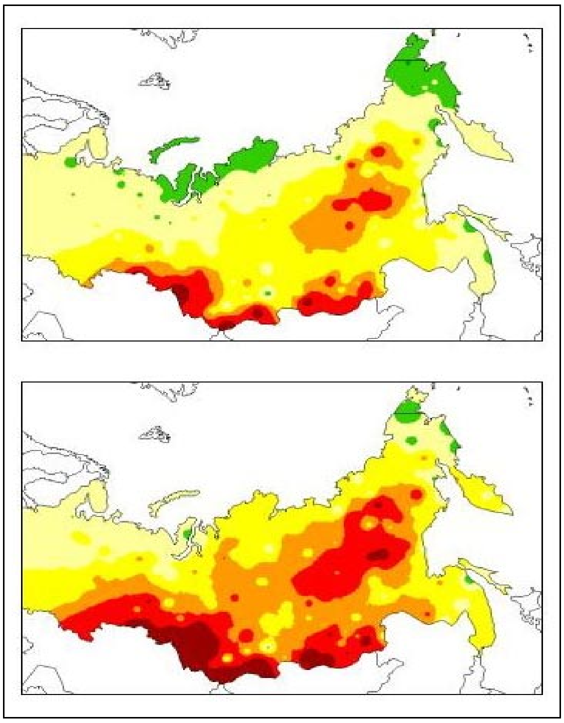


Figure 10. Seasonal fire severity rating across Russia under current climate conditions (upper) in comparison to a projected 2xCO_2 climate (lower), based on the Global Circulation Model (GCM) of the Canadian Climate Center (CCC). Note the significant increase in the severity and geographical extent of high to extreme fire danger conditions (9).

3.2 Peat Fires – an Increasing Problem in Russian Eurasia

According to the Wetlands International Russia Programme peatland fires are a common phenomenon in the Russian Federation (Minaeva 2002) and may contribute to about 10% of the total area burned (Shvidenko and Nilsson 2000). In late July 2002 a severe fire episode started that mainly affected the regions Tver, Vladimir, Ryazan, Nizhnij Novgorod, and the North-West region. On 31 July 2002 ABC News reported *"Muscovites awoke on Wednesday to find their city covered in smog with the smell of burning from wildfires raging outside the Russian capital. A slight easterly wind pushed the smoke toward the city, as far as the centre, but was not strong enough to disperse it, said meteorological experts quoted by Moscow Echo radio. Moscow media said the smoke posed a health risk to residents of the city. The authorities have identified 76 separate wildfires in the Moscow region, which has been affected for several weeks by a heat wave, Moscow Echo radio reported. According to the emergencies ministry, the surface area of forest on fire around Moscow has risen sharply in the past 24 hours, reaching ca. 100 ha, ITAR-TASS reported"* (ABC News 2002). On 6 September 2002 the European Water Management News (EWMN) reported that the number of peat and forest fires had doubled in Moscow Region within 24 hours. The resulting haze reduced the visibility to less than 100 meters in the Russian capital, and the concentration of carbon monoxide exceeded the norm by more than three times (European Water Management 2002).

The smoke pollution in Moscow Region between end of July and early September 2002 reached alarming levels and did not only cause a dramatic reduction of visibility but also had detrimental impacts on the health of the Muscovite population. It is well known that smoke from vegetation fires has a number of solid and gaseous constituents that dangerous to human health, e.g., particulates smaller than micrometers in aerodynamic diameter, formaldehyde, Polycyclic Aromatic Hydrocarbons (PAHs), or carbon monoxide (CO).

Most concerning are the impacts of particulates on the respiratory / cardiovascular systems. They cause, among other, respiratory infections in adults and acute respiratory infections in children, acute and chronic changes in pulmonary function, respiratory symptoms, asthma attacks, and cardiovascular diseases (WHO/UNEP/WMO 1999a, b). An increase of hospital admissions was noted in Moscow. At present no information is available on increased daily mortality due to peat fire smoke pollution.

Peatlands in Western Russia have been drained and used for agricultural purposes since the early 19th Century. As Minaeva (2002) stresses the fen peatlands were used as agricultural fields but are out of use now. Lands where peat was extracted were abandoned without recultivation and left to the management of local administrations of the *Rayons* which normally have no funds to properly manage and protect the former wetlands. In most cases the fires started outside the peatlands, caused by forest visitors, hunters, tourists, or by agricultural burning and burning activities along roads. Legislation is not clear, and there is no law enforcement. During the peak of peatland burning many people continued to visit the forests around Moscow, even when the fire situation was quite obvious.

Currently there are plans to restore peatlands by flooding. These plans that have been pushed by the Ministry for Emergency Situation (EMERCOM) but in many places are opposed by peat extractors or owners of *datcha* properties that have been established on former peatlands.

A recent paper by Bannikov et al. (2003) provides a in-depth case study of peat fires in Western Russia. The report reveals the problems arising from peat fires and the necessity to develop land-use plans that would avoid future fire and smoke disasters in Western Russia.

3.3 Impact of Russia's Vegetation Fire Emissions on the Global Carbon Cycle: Problems of long-term Assessments and a Case Study of 2003

3.3.1 The problem of determining the long-term atmospheric impacts and the fate of fire-released carbon

Numerous investigations in the past years have attempted to quantify the emissions from vegetation fires occurring in the Russian Federation and in other parts of the boreal zone to the atmosphere (for syntheses see Goldammer and Furyaev 1996, Kasischke and Stocks 2000). The general aim of many studies was to assess the area burned and the amount of organic matter combusted in order to calculate radiatively active trace gases and particles released to the atmosphere.

A recent example of such a study for the assessment of fire emissions in the Russian Federation is provided by Kajii et al. (2002). The authors used NOAA-AVHRR satellite data to quantify forest fires in boreal Siberia and northern Mongolia during April through October 1998, a year of extremely dry weather, in particular, in the Russian Far East. The total area burned was estimated to be 11 million ha with 350 million tons of biomass consumed and 176 million tons of carbon released into the atmosphere. The carbon released into the atmosphere was calculated to contribute 516 million tons of carbon dioxide (CO_2), 50 million tons of carbon monoxide (CO), 1.6 million tons of methane (CH_4), 1.1 million tons of non-methane hydrocarbons (NMHC), and 9.5 million tons of C particles as smoke. In addition, it was estimated that 1.8 million tons of nitrogen oxides (NO_x, as NO_2) were released.

However, calculations of emissions released by vegetation fires (= prompt release of carbon) do not allow to derive conclusions on the long-term fate of carbon – the most critical element determining the radiative characteristics of the atmosphere. Fire research has revealed the historic and cyclic nature of wildland fires in boreal ecosystems of Eurasia. Natural fire regimes are characterized by fires of various return intervals and severities. The return interval of fires in grasslands and steppe ecosystems is short, ranging between one and five years. As a result the fuel loads, fire intensities and severities in these fire ecosystems are low. Recurring fires play an important role in the dynamics of these open landscapes.

Surface fires in Siberia's fire-adapted coniferous forests also constitute a regularly occurring phenomenon which is considered important to maintain stability, productivity and carbon sequestration potential of these ecosystems.

Fires of high intensity and high severity that involve destruction of forest stands with subsequent ecosystem regeneration (stand-replacement fires) are also a typical feature of the complex ecosystem composite of boreal Eurasia and must not necessarily lead to forest loss or reduction of carbon sequestration potential at long-term. However, ecosystem recovery after high-severity stand-replacement fires requires a much longer time span.

Replacement of coniferous stands by deciduous stands, for instance, may also not lead to a significant reduction of the terrestrial carbon pool. Thus, the sequestration of carbon in post-fire growth follows different cycles and pathways.

It is obvious, however, that the combined effects of extrinsic disturbance factors such as climate variability or climate change, land-use practices and ecosystem manipulations may negatively affect site productivity and "carbon carrying capacity" of ecosystems. The formation of "green deserts" are a consequence of inappropriate logging practices, sometimes combined with wildfire occurrence, and represent just one example of the effects of multiple disturbances that may lead to irreversible ecosystem degradation and consequently to a loss of carbon to the atmosphere. The same refers to the peatlands impacted by drainage, extreme drought and fire. Fires burning deeply or completely consuming organic terrain layers lead to a net release of carbon to the atmosphere and biosphere.

In conclusion it must be stated that it is prohibitive to derive from any area affected by fire alone that these events will contribute to long-term changes in the atmosphere. However, if a trend of changes in fire regimes (change of fire severity and/or fire-return intervals, and ecosystem recovery patterns) is observed it is permissible to derive changes of secondary fire impacts such as the influence of a net increase of carbon to the atmosphere.

3.3.2 The Year 2003 – An Indicator of Changes in Fire Regimes and Fire Impacts ?

The year 2003 turned out to represent an example of an extreme fire year in which the combined effects of

- extreme drought
- reduced capabilities of the fire management establishment
- inappropriate forest management involving extended clearcuts, and
- the socio-economic conditions in the regions and neighbouring countries

may have initiated a development which potentially will lead to a net loss of forest cover and contribution to atmospheric changes.

Most affected by drought were the regions Northwest and Southeast of Lake Baikal. Extremely low precipitation was recorded in the 10-month period between August 2002 and May 2003 in Buryatia Republic (total rainfall: 36.0 mm) and Chita Oblast (45.7 mm)[4]. Besides these precipitation data a vegetation health map generated by NOAA AVHRR satellite data shows a dramatic picture of vegetation stress and drought on 1 June 2003 – a situation much more extreme as compared to 1987, the last extreme drought and fire year in the Transbaikal Region (Figure 11).
In the same year 2003 the Aerial Forest Fire Service *Avialesookhrana* continued to be faced with insufficient budgets for operations. Thus, the organization had to reduce aerial observation flights that are crucial for early detection of wildfires and rapid response. Aerial surveys are also important for mapping of fire effects. Thus, with the reduced budgets it was not possible to suppress wildfires in an early stage. Consequently the wildfires grew large in size and became uncontrollable in most cases.

Another aggravating factor of the wildland fire theatre in the region around Lake Baikal, especially in Buryatia and Chita, is the increasing occurrence of arson fires. The underlying causes for arson fires are deeply rooted in the economic development of Southeast Russia, Mongolia and neighbouring China. The depletion of China's forest resources and the increasing demand for timber products on the market in China have created an enormous pressure on the forest resources of Mongolia and the Russian Federation. Observations in the Russian Federation and in Mongolia indicate that Chinese timber dealers have encouraged or bribed local people to set fires to forests in order to increase the permissible salvage logging areas and thus increase the timber export to China. In addition extended illegal logging and timber export has been observed during two on-site inspection missions in Mongolia and the Russian Federation by the first author during 2003.

A fourth factor contributing to the overall degradation of forest sites are the consequences of large clearcuts. In the dark coniferous taiga forests in northern part of Siberia large-scale clearcuts of the 1990s nowadays show no natural regeneration of forest. This is also observed in some southern light taiga forests where the combination of removal of seed trees, clearcut sizes extending the aerial seed transport distance for pines (ca. 500 m) and recurrent fires have resulted in large unforested areas dominated by pure grass stands. These "green desert grasslands" are maintained by regular fires – a phenomenon that has been observed at large scale in Mongolia and China.

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[4] Weather data were supplied by the Regional Avialesookhrana Airbases in Buryatia and Chita, with the kind assistance of Mr. Yevgheny Shuktomov, Mr. Anatoly S. Netronin and Viacheslav Lantsev.

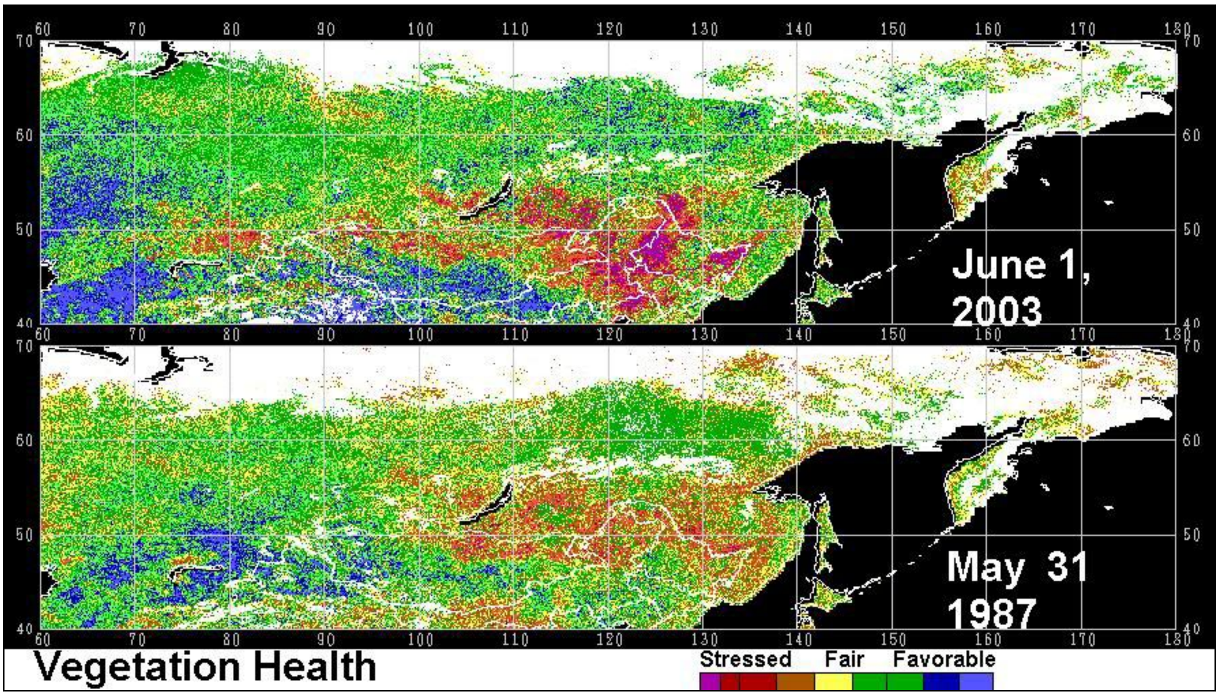

Figure 11. Vegetation health maps of Southern Siberia, Mongolia and Northern China on 1 June 2003 and 31 May 1987. The images is a colour-coded map of vegetation condition (health) estimated by the Vegetation and Temperature Condition Index (VT). The VT is a numerical index, which changes from 0 to 100 characterizing change in vegetation conditions from extremely poor (0) to excellent (100). Fair conditions are coded by green colour (50), which changes to brown and red when conditions deteriorate and to blue when they improve. The VT reflects indirectly a combination of chlorophyll and moisture content in the vegetation and also changes in thermal conditions at the surface. This new approach combines the visible, near infrared, and thermal radiances in a numerical index characterizing vegetation health. This approach is extremely useful in detecting and monitoring such complex and difficult-to-identify phenomenon as drought. The VT values below 35 are used for identifying vegetation stress which is an indirect drought indicator. The VT is very useful for early drought detection, assessing drought area coverage, duration, and intensity, and for monitoring drought impacts on vegetation and agricultural crops. For technical details for the background of the tool see Kogan (1997) and: http://orbit-net.nesdis.noaa.gov/crad/sat/surf/vci/index.html. Map courtesy F. Kogan, NOAA.

The combination of the impacts of an extreme drought, the decrease of fire management capabilities, in some cases also consequences of large clearcuts, and the increasing pressure of arson fires resulted in a fire season which may contribute to severe degradation of forest lands affected.

In order to assess the impact of the 2003 fires the regions Irkutsk, Chita and Buryatia three methods were used:

- Analysis of official reports of *Avialesookhrana*
- Satellite-derived data (NOAA AVHRR) based on fire counts and derived area burned, by the Sukachev Institute for Forest
- An aerial survey in the regions most affected by wildfires in September 2003

Table 2 shows the data of the *Avialesookhrana* reports and the satellite-derived data for forest and non-forest lands affected by fire in 2003. The aerial observation show that the share of forests affected by crown fires in Irkutsk was 17.4%, in Buryatia 11.9% and in Chita 1.5%, totalling 66,963 ha in the three regions.

The satellite-derived area burned for the same region provides a total area affected by fire almost ten times higher than the assessments by aerial observations. However, the satellite data do not allow to differentiate areas affected by fires of various severities, e.g. surface fires versus crown fires (stand-replacement fires). Considering the conservative assessments by the aerial surveys and the aerial survey conducted in Buryatia and Chita in September 2003 it was concluded that about 20% of the burned forest land in Irkutsk Region and Buryatia, and at least 10 percent in Chita – if not more – were affected by crown fires due to the extremely dry fire-weather conditions. The relative discrepancy between stand-replacement fire data by aerial observations in the three regions of ca. 70,000 ha versus satellite-derived area burned by high severity forest fires of about 2.3 million ha is larger than the relative discrepancy between the total area burned as assessed by aerial and space observations of 1.3 and 9.8 million hectares respectively.

Table 2. Comparison of wildfire data for the regions Irkutsk, Chita and Buryatia during the fire season of 2003: Agency reports vs. satellite-generated data. For details: See text.

Region	Agency reports based on ground and aerial observations				Satellite-derived data (NOAA AVHRR) based on fire counts and derived area burned			
	Number of fires reported	**Total forest area burned (ha)**	**Thereof area burned by crown fires (ha + %)**	**Non-forest area burned (ha)**	**Number of fire events investi-gated**	**Total forest area burned (ha)**	**Thereof area burned by crown fires (adjusted %) (ha)**	**Non-forest area burned (ha)**
Irkutsk	3244	184,201	32,184 (17.4%)	19,348	2,154	1,962,000	392,000 (20%)	85,000
Buryatia	2432	186,398	22,232 (11.9%)	6,853	1,887	3,390,000	678,000 (20%)	133,000
Chita	2441	853,004	12,547 (1.5%)	62,417	2,884	3,860,000	368,000 (10%)	365,000
Total Baikal Region	6117	1,223,603	**66,963 (5.5%)**	88,618	6,925	9,212,000	**1,456,000 (av. 16%)**	583,000

Table 3 provides a scenario of carbon release pulses to the atmosphere of various intensities and lifetimes. The assessment is based on area burned as depicted by NOAA AVHRR and processes by the Sukachev Institute for Forest (active fire product, this paper) and fuel consumption (FIRESCAN Science Team 1996, Stocks and Kauffman 1997, MacRae et al. 2004) and ecosystem recovery scenarios by vegetation type and fire severity.

Table 3. Prompt (pyrogenic) and net release of carbon from forest and non-forest ecosystems affected by wildfires in Irkutsk, Chita and Buryatia regions during the fire season of 2003. For details: See text.

(next page)

Fuel type and fire type	**Area burned in 2003 (ha)**	**Available fuel consumed by fire (F) and subjected to post-fire mortality (M) (t/ha dw)**	**Ecosystem and fuel load recovery period (equivalent to atmospheric residence time in the atmosphere) (years)**	**Prompt release of carbon by fire per area unit (t/ha) & Total 2003 (Tg) (4)**	**Post-fire release of carbon due to mortality and decay (t/ha) Total by recovery period) (years)**	**Net release of carbon due to reduction of sequestration potential (5) (Tg) (4)**
Grassland, Steppe Surface Fire	583,000	F: 4-6 M: --	F: 1	2-3 -- **1.17 - 1.75 Tg**	-- --	 --
Pine-Grass Forest Surface Fire(1)	3,878,000	F: 4-6 M: --	F: 1	2-3 -- **7.76 - 11.63 Tg**	-- -- --	 --
Pine Forest Surface Fire(1)	3,878,000	F: 8-30 M: 40-75	F: 10-25 M: 100+	4-15 -- **15.51 - 58.17 Tg**	-- **155.12 – 290.85 Tg**	-- --
Pine Forest Stand-Replacement Fire, long-term recovery (2)	728,000	F: 30-40 M: 50-150(2)	100-200+	F: 15-20 M: 25-75 **10.92 – 14.56 Tg**	-- **18.2 – 54.6 Tg**	-- --
Pine Forest Stand-Replacement Fire, no recovery (2)	728,000	F: 30-40 M: 50-150 (2, 3)	∞ no recovery (green desert)	F: 15-20 M: 25-75 **10.92 – 14.56 Tg**	-- **18.2 – 54.6 Tg**	**18.2 – 54.6 Tg**
Resulting Total Carbon Release to the Atmosphere						
Total Carbon Released				**Prompt pyrogenic release in 2003** **46.28 – 100.67 Tg**	**Successive release (various recovery periods)** **191.52 – 400.05 Tg**	**Net release** **18.2 – 54.6 Tg**

Notes: The scenario is based on the following assumptions:

(1) It is assumed that half of the 7,756,000 ha forests affected by surface fires burned with low intensity in the grass layer only and did not cause post-fire mortality. The remaining 50% were burned by medium- to high intensity surface fires consuming larger amount of surface fuels. Despite the adaptation of these forest to regular surface fires the post-mortality due to fire and secondary stresses due to the drought condition s of 2003 will lead to a post-fire mortality of 20-25% of the standing trees which are then subjected to decay.

(2) Half of the stands affected by stand-replacement fires are salvage-logged (harvested timber considered neutral concerning carbon release) and will regenerate naturally (due to close proximity to seed sources, under the assumption that appropriate logging practices will exclude harvesting of undamaged stands); the other half is salvage-logged but deteriorating to open grassland due to lack of seed sources and/or subsequent short-return interval fires.

(3) Carbon release by decay as a consequence of post-fire mortality in stand-replacement fire sites which were subsequently salvage-logged (ca. 50% max.) is considered to be equal to average logging slash decay (range: 50-150 t dw /ha).

(4) Total carbon release is expressed in Teragram (Tg) (1 Tg = 1 million t).

(5) Net release of carbon is calculated by the net loss of carbon sequestration capability by a site degraded due to multiple factors such as fire, climate change, and human intervention. The calculation is simplistically based on the assumption that 50% of the dry weight of the phytomass combusted is released to the atmosphere. In reality a major portion of this carbon is deposited in land and water ecosystems, practically in the form of non-degradable elemental carbon.

This carbon emissions scenario for 2003 represents a crude approach towards an assessment of the short-term to long-term effects of fire on carbon release and the possible post-fire sequestration patterns. In this scenario the ecosystem recovery mechanisms, however, are hypothetically optimistic, i.e. assuming that ecosystem degradation will be restricted to only half of the forest area affected by stand-replacement fires.

In reality, however, the currently practiced exploitation of forests in Southern Russia involves non-sustainable practices governed by the interests of oligarchs, bribed local structures, influence of the mafia and of criminal acts of foreign exploiting firms, sanctioned by the governments of neighbour countries.

Thus, the prospects for the future development of increasingly fire-affected forests are not encouraging.

The use of earlier investigations to determine area burned and carbon fluxes for monitoring the impacts of wildland fires must be considered. The example of a quick look at comparing fire scar maps of the 1987 fire season with the fire season of 2003 shows a strong overlap of the area burned Southeast of Lake Baikal (Figure 12). The reasons for a repeated large-scale fire situation in this region within 16 years can be attributed to the cyclic fire occurrence in grasslands and grass-forests. The overlap of area burned as depicted by AVHRR can also be a problem of low resolution. It should be considered to reprocess the historical data with the same algorithms that have been used recently.

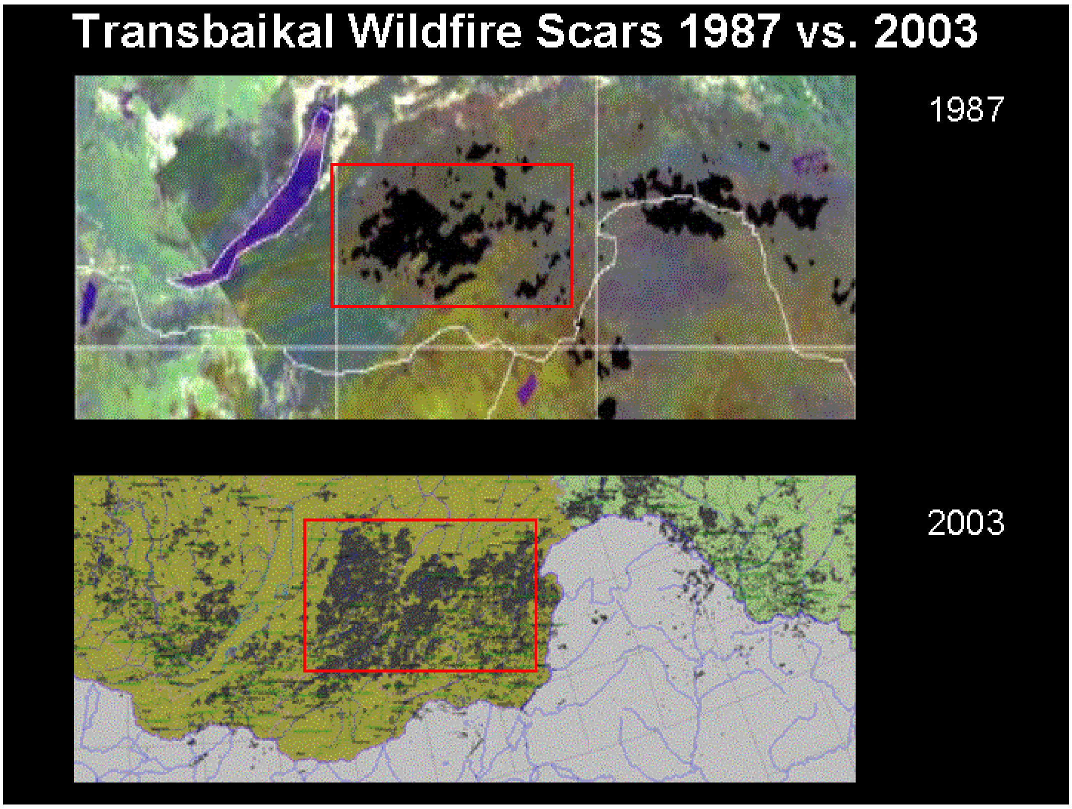

Figure 12. Comparison of the NOAA-AVHRR satellite-derived area burned in the region Southeast of Lake Baikal in 1987 (Cahoon et al. 1994) and 2003 (Sukhinin 2003). A major overlap of the area affected by fire during both episodes implies the necessity to revisit the datasets and the conclusions concerning the consequences of the fires on ecosystems and carbon fluxes.

4. Towards Enhancing International Cooperation in Fire Management

The magnitude of wildland fire occurrence in the Russian Federation and other countries in the boreal zone during the last decade have created a considerable attention in the international community, especially in the various institutions and groups involved in forest monitoring. In addition international organizations have become aware of the ecological and economic importance of the global boreal forest and role of its terrestrial carbon pool for the stability and functioning of the global atmosphere.

Beginning in 1991 a large number of cooperative projects between the Russian Federation and Western countries have been initiated to address common interests in forest fire research, including aspects of atmospheric and climate research. Annex I of this paper provides an overview of these activities between 1991 and 2003 that reveals that joint research has made tremendous progress during the last decade, especially in the fire ecology research and remote sensing of wildland fires (see also the contribution by Csiszar et al., this volume).

However, regardless of the scientific progress a deficit has been noted worldwide in appropriate prevention, preparedness and response measures to reduce the increasing destructiveness of wildland fires. Countries in transition from centrally planned economies to market economies, including the Russian Federation, have suffered a decline in institutional and economic capabilities to meet the challenges arising from these changes. Thus, it was recognized in the early 1990s to create mechanisms within the United Nations to exchange views and provide expert advice to governments and international organizations to enhance joint efforts in reducing the negative impacts of wildland fires on the environment and humanity.

In the 1980s the Russian Federation was invited to become member of the FAO/ECE/ILO Team of Specialists on Forest Fires. Since 1993 the Team was successful in organizing a series of focussed conferences aimed at proving advice to the fir management community and to policy makers. Most important was the strategic meeting "Forest, Fire, and Global Change" held in Shushenkoe, Russian Federation, in 1996 (Goldammer 1996). It laid the foundation for a comprehensive strategic vision for international cooperation in fire management (Annex II).

Four years later a first proposal was submitted to the United Nations system to establish an inter-agency and inter-sectoral body under the auspices of the UN International Strategy for Disaster Reduction (ISDR), to be mandated to serve as an advisory body on wildland fire to the UN on one hand, and as an outreach arm of the UN to regions and countries on the other hand. In accordance with the Framework for the Implementation of the International Strategy for Disaster Reduction (ISDR) the World Conservation Union (IUCN), the Global Fire Monitoring Center (GFMC), and the UN-FAO/ECE/ILO Team of Specialists on Forest Fire, proposed to create an interagency "Working Group on Wildland Fire". This proposal was in line with several declarations made in international conferences after Shushenskoe 1996. The proposal intended to bring together both the technical members of the fire community and the authorities concerned with policy and national practices in wildland fire management to realise their common interests of fire risk management and disaster reduction at global scale. The UN Inter-Agency Task Force for Disaster Reduction (IATF) at its second meeting on 11 October 2000 agreed to establish the Working Group on Wildland Fire (Working Group 4 [WG-4]).

The Working Group represented an interagency and inter-sectoral forum of UN and other international agencies and programmes. One of the priority activities of WG-4 was:

- Establishment of, and operational procedures for, a global network of regional- to national-level focal points for early warning of wildland fire, fire monitoring and impact assessment, aimed at enhancing existing global fire monitoring capabilities and facilitating the functioning of a global fire management working programme or network.

At the 2nd meeting of WG-4 (3-4 December 2001) it was decided to give priority to the establishment of the "Global Network of Regional Wildland Fire Networks" (Figure 13 and 14).

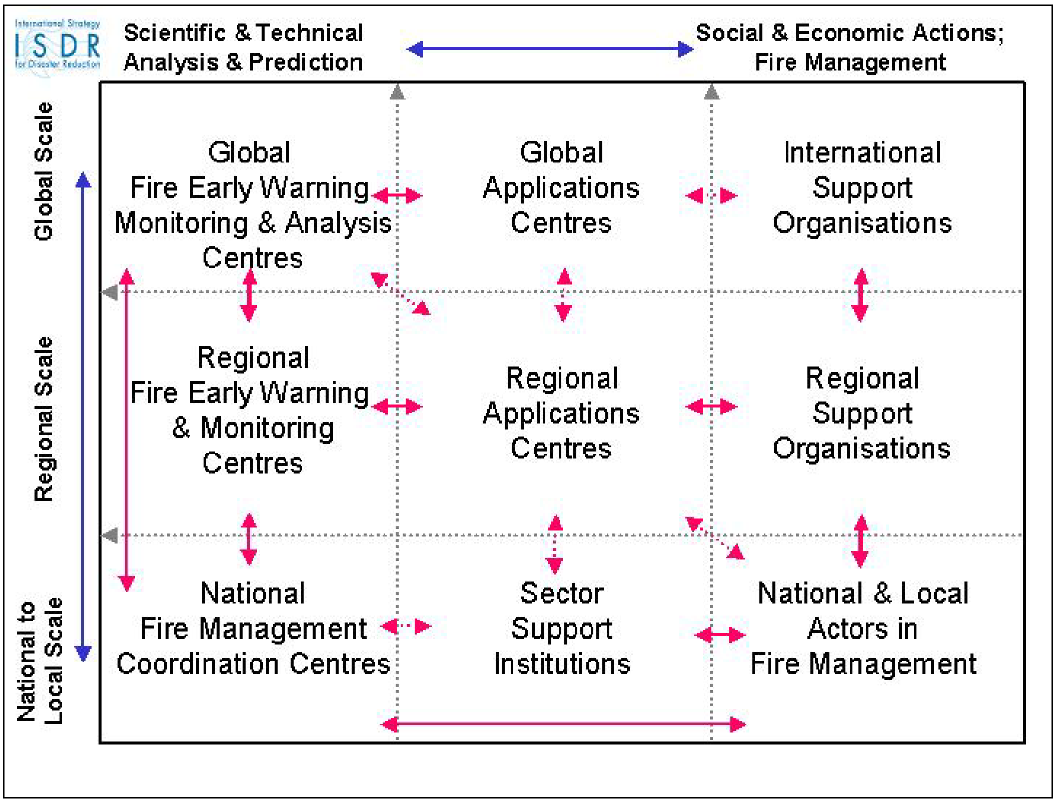

Figure 13. Schematic view of relationships and multi-directional flow of information, data, knowledge and advice in a global wildland fire network.

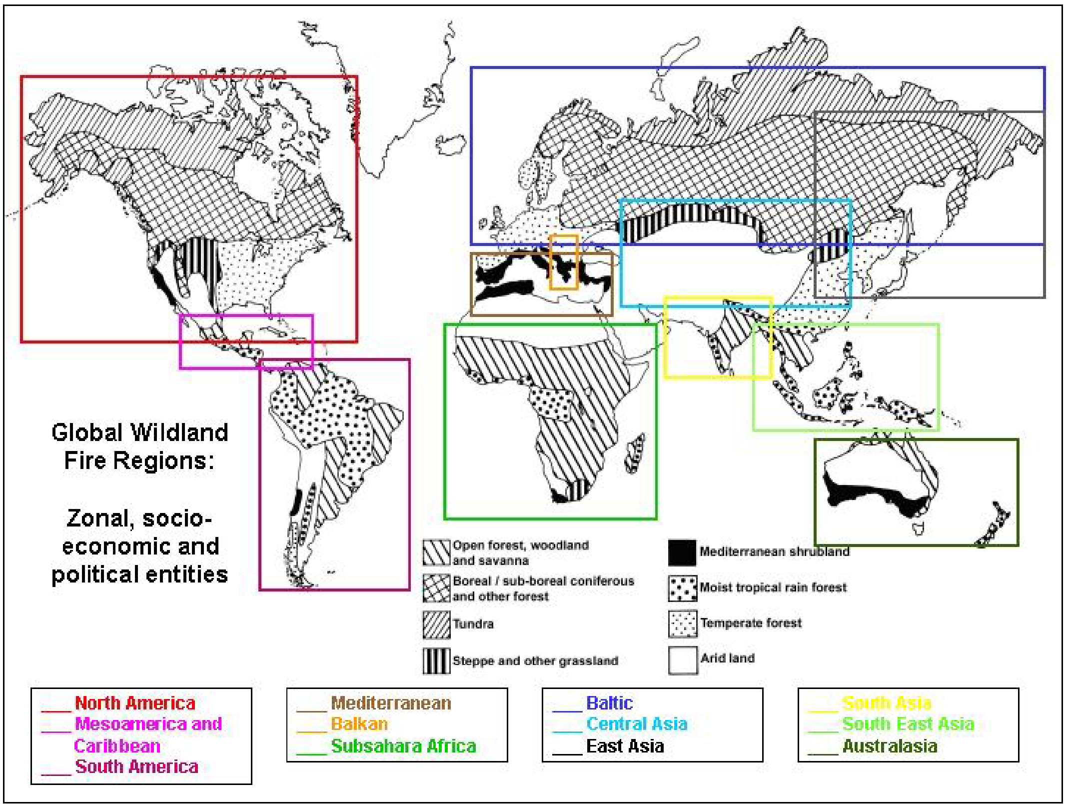

Figure 14. Delineation of regions within the Global Wildland Fire Network. Due to the size and inter-zonal extent of its territory the Russian Federation is encouraged to participate in three regional networks (Baltic, Central Asia, East Asia).

The "Global Wildland Fire Network" consists of a set of informal or formal regional network structures that are in place or will be initiated during the process of formation. The envisaged timeframe for setting up the network was 2002-2003. The International Wildland Fire Summit (Sydney, 8 October 2003) was used as a platform to convene representatives from regional networks. The strategy agreed by the Summit ("Strategy for Future Development of International Cooperation in Wildland Fire Management") included the following agreement[5]:

> *"The Regional Wildland Fire Networks will be consolidated, developed and promoted through active networking in information sharing, capacity building, preparation of bilateral and multilateral agreements, etc. This process will be facilitated through regional Wildland Fire Conferences and Summits in cooperation with the International Liaison Committee and the UN-ISDR Working Group on Wildland Fire".*

During the Summit a side meeting was held on 5 October 2003 with the regional fire management groups functioning under the auspices of the UN:

- ISDR Working Group on Wildland Fire (Russia member)
- UN ECE/FAO/ILO Team of Specialists on Forest Fire (Russia member)
- Fire Management Working Group, FAO North American Forestry Commission (NAFC)
- Forest Fire Group of FAO *Silva Mediterranea*

A key output of the joint meeting was the recommendation to create a successor body of the working Group (which was limited to two years lifetime) under the auspices of the UN. The GFMC reported to the 8th Meeting of the UN-ISDR Inter-Agency Task Force for Disaster Reduction (5-6 November 2003) and recommended:

> *"The Working Group suggests the IATF to support the further establishment and strengthening of the Global Wildland Fire Network as a key instrument to foster the international dialogue und efficient cooperation in the arena wildland fire. Given the inter-sectoral nature of wildland fire and the number of UN agencies and programmes involved, as well as other international organizations and civil society, it is suggested to maintain an advisory body for the UN within the IATF."*

The proposal has been accepted by the IATF to create a **Wildland Fire Advisory Group** (WFAG) under the auspices of the ISDR. The WFAG will represent an advisory body to the UN system aimed at:

- providing technical, scientific and policy-supporting advice to the UN family through the International Strategy for Disaster Reduction (UN-ISDR) and the IATF, and
- acting as a liaison between the United Nations system, the Global Wildland Fire Network and its supporting partners.

It is envisaged to work with supporting partners of the WFAG will be

- UN agencies and programmes
- UN conventions (notably UNCBD, UNCCD, UNFCCC)
- Collaborative Partnership of Forests (CPF) and the UN Forum on Forests (UNFF)
- Other international organizations
- Non-government organizations, notably the IUCN-TNC-WWF Global Fire Partnership
- Government agencies
- Inter-governmental institutions and agreements
- Civil society
- Academia

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[5] http://www.fire.uni-freiburg.de/summit-2003/introduction.htm

- International Liaison Committee (ILC) of the series of International Conferences on Wildland Fire
- Global Fire Monitoring Center (GFMC) acting as convener and secretariat

On behalf of the ISDR-WG-4 / Wildland Fire Addvisory Group the Global Fire Monitoring Center (GFMC) is continuing to facilitate the functioning of the Global Wildland Fire Network by supporting the establishment of Regional Wildland Fire Networks and enhancing inter-regional communication and cooperation.

The GFMC will liaise with existing operational and proposed international networks, notably:

- UN-mandated regional teams (ISDR Wildland Fire Advisory Group, ECE/FAO/ILO Team of Specialists on Forest Fire, Fire Management Working Group of the FAO North American Forestry Commission, Forest Fire Group of FAO *Silva Mediterranea*)
- FAO Forest Department
- Global Observation of Forest Cover - Global Observations of Landcover Dynamics (GOFC-GOLD) Fire Implementation Team (a subset of the Global Terrestrial Observing System - GTOS)
- Advisory Group on Environmental Emergencies (AGEE) and the Joint Environment Unit of the United Nations Office for the Coordination of Humanitarian Affairs (OCHA) and the United Nations Environment Programme (UNEP)
- Biomass Burning Experiment (BIBEX) of the International Geosphere-Biosphere Programme (IGBP), International Global Atmospheric Chemistry (IGAC)
- International Union of Forestry Research Associations (IUFRO) 8.05 Forest Fire Research

The active participation of the Russian Federation in all of the international groups, including those working under the auspices of the United Nations, ensures that experiences and views can be shared concerning international cooperation in reducing the negative effects of fire on the environment and humanity.

5. Conclusions

Based on examples of the most recent fire seasons this paper aimed to highlight problems and trends of wildland fire occurrence and impacts in the Russian Federation. The paper reveals that much work has been achieved to prove scientifically that sustainable functioning of the boreal forest is threatened. However, additional in-depth application of remote sensing monitoring tools is required to consolidate our understanding of current and future trends.

The situation in Russia is quite similar to the current fire situation in tropical forests: Interaction or cumulative effects of multiple stress factors (wildfire, climate extremes, human interventions…) are resulting in impoverishment of the ecological functioning and the economic productivity of the boreal forest. In addition human populations are becoming increasingly vulnerable to the effects of vegetation cover degradation by fire and other stresses.

It is therefore important that joint efforts of the community of wildland fire scientists and managers direct the attention of governments, international organizations and policy makers to respond to this escalating situation. The tools, mechanisms and collaborative agreements that are in place must receive adequate support to meet the challenges ahead.

The outcomes of the International Workshop "New Approaches to Forest Protection and Fire Management at an Ecoregional Level" (Khabarovsk, Russia, 9-12 September 2003), as presented in this volume, reveal that the situation in the Far East and other regions of Russia has been carefully analysed and that the proposed measures point to the right direction.

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ANNEX I

Calendar of Cooperation Activities between the Fire Establishment of the Russian Federation and International Partners during the Period 1991-2003

Right from the beginning of the opening process of the Soviet Union and the Russian Federation fire scientists, engineers and managers began an intensive exchange program with Western countries. A short narrative calendar of these events reveal the broad range of activities. Details of regular exchange visits between firefighter crews and delegations with Russia are not included..

1991 First exploratory visit of a joint German-US mission to the Soviet Union. Subsequent integration of Soviet / Russian fire management personnel and scientists into technical and scientific networks, such as the UN-FAO/ECE Team of Specialists on Forest Fire and the research conducted under the International Geosphere-Biosphere Programme (IGBP)

1992 Set up of a joint Fire Working Group of the International Boreal Forest Research Association (IBFRA)
- Initiation of the Russia-US exchange programme of fire management personnel

1993 First East-West scientific conference "Fire in Ecosystems of Boreal Eurasia" at the Academy of Sciences, Siberian Branch, Krasnoyarsk, with the participation of all boreal countries
- First international fire research campaign in Siberia (Fire Research Campaign Asia-North [FIRESCAN])
- First NATO Advanced Science Institute (ASI) on Science and Technology Policy in Novosibirsk, with joint German-Russian participation
- Preparation of satellite downlinks (NOAA AVHRR) for forest fire monitoring (joint activity with NASA)

1995 Russian participation at the XX World Congress of the International Union of Forestry Research Organizations (IUFRO), Forest Fire Research Group 8.05.00; Tampere, Finland (July 1995)

1996 UN-FAO/ECE Conference "Forest, Fire and Global Change", Shushenskoe, Russian Federation
- Launch of the IGBP Northern Eurasia Study (Yakutia 1996, Central Siberia 1997) with participation of fire scientists

1997 Preparation of the TACIS project "Improvement of Forest Fire Response System" with subsequent implementation 1999-2001

1998 Participation of Russia in the UN-FAO/ECE First Baltic Conference on Forest Fires, Poland

1999 TACIS/IGBP-supported workshop "Fire on Ice", Khabarovsk, Russian Federation (see below)
- TACIS project information website established on the Global Fire Monitoring Center (GFMC) homepage
- Preparation of the NASA-US Forest Service funded research project on "Effects of Fire on Carbon Sequestration, Global Climate and Ecosystem Processes" (field implementation in 2000)
- Formation of a Fire Group within the programme "Global Observation of the Forest Cover" (GOFC) of the Committee of Earth Observation Satellites (CEOS) with Russian participation, followed by a boreal focus workshop in Novosibirsk (2000)

2000 Procedures of regular information flow from Russia to the Global Fire Monitoring Center (GFMC) establish through partnerships with Avialesookrana, the Sukachev Institute for Forest (Krasnoyarsk), and the Institute for Solar Terrestrial Physics (Irkutsk)
- International Fire Management Training Course at the Global Fire Monitoring Center (GFMC), Germany, with Russian and US participation (April 2000)

- UN meeting and international exercise "Baltic Exercise on Fire Information and Resources Exchange - BALTEX FIRE 2000" in Finland, with Russian participation (June 2000)
- GFMC fact finding mission on forest fire research and management in Western Siberia in support of the TACIS Russia Forest Fire Information System, Avialesookhrana; Ekaterinburg, Tjumen and Pushkino, Moscow Region (August 2000)
- First German Forum on Disaster Reduction, with demonstration of the concept of international fire brigades, with Russian participation (Avialesookhrana) and the Russian-German consortium "Helion Procopter" (September 2000)
- Meeting of the NATO-Russia Joint Scientific and Technological Cooperation Committee on "Forecasting and Prevention of Catastrophes" with German-TACIS participation (October 2000)
- Begin of funding and implementation of the project "Fire Effects in the Boreal Eurasia Region" (FIRE BEAR), a forest fire research study located in central Siberia funded by NASA's Land Change Land Use Change Science Program.

2001 Implementation of the Eurasian Fire Danger Rating project in cooperation between GFMC, Canadian Forest Service, Avialesookhrana and Sukachev Institute for Forest
- First exchange program with GFMC staff (integration of three junior GFMC staff in fire crew in Tjumen Aviabase, August 2001)
- Meetings of leaders of Avialesookhrana and GFMC, Protocol and Cooperation Agreement signed, at GFMC, Germany (November 2001)
- Russia appointed member of the Working Group on Wildland Fire, United Nations International Strategy for Disaster Reduction (UN-ISDR), Inter-Agency Task Force for Disaster Reduction; first Working Group meeting, UN Geneva (December 2001)

2002 Initial meeting of the Northern Eurasian Earth Science Partnership Initiative (NEESPI), Moscow (February 2002)
- Second meeting of the UN-ISDR Working Group on Wildland Fire, GFMC (March 2002)
- Russia appointed member of the International Liaison Committee (ILC) of the 3rd International Wildland Fire Conference and International Wildland Fire Summit. Two ILC meetings with Russian participation in Sydney (August 2002) and Portugal (November 2002)
- Consolidation of Northern Eurasian Regional Information Network (NERIN), Siberian/Far Eastern Regional Network and the Western Russian/Fennoscandian Regional Network of the Global Observation of Forest Cover/Global Observation of Landcover Dynamics (GOFC/GOLD) programme

2003 All-Russian Forestry Congress with GFMC participation at Round Table on "Key Ways of Protection of Forests from Fire in the Russian Federation", State Kremlin Palace, Moscow (February 2003)
- Fourth Meeting of the International Liaison Committee (ILC) in preparation of the 3rd International Wildland Fire Conference and International Wildland Fire Summit, Melbourne, Australia (March 2003)
- Follow-up planning meeting of the Northern Eurasian Earth Science Partnership Initiative (NEESPI), Suzdal (April 2003)
- GFMC Russia mission: (1) Routine meetings with Avialesookhrana; (2) 5th International Scientific Conference "Wildland Fires: Initiation, Spread, Suppression and Ecological Consequences" (Krasnoyarsk Region); (3) Revisit of the Bor Forest Island Fire Experiment of 1993 (Krasnoyarsk Region) (June-July 2003)
- International Workshop on New Approaches to Forest Fire Management at an Ecoregional Level; Khabarovsk (September 2003)
- GFMC survey of areas burned in Chita and Buryatia Regions, Russian Federation, during the fire season of 2003; Irkutsk, Ulan Ude, Russia (September 2003)
- Russian delegation participates at the 3rd International Wildland Fire Conference and International Wildland Fire Summit; Sydney, Australia (October 2003)
- Preparation of installing a satellite downlink for the Moderate-Resolution Imaging Spectroradiometer (MODIS) at the Remote Sensing Laboratory, Sukachev Institute for Forest, Krasnoyarsk, for forest fire monitoring.

Annex II

Conclusions and recommendations by the ECE/FAO/ILO Seminar on "Forest, Fire, and Global Change" (Shushenskoe, Russian Federation, 1996)

In 1996 the *ECE/FAO Seminar on Forest, Fire, and Global Change* was organized jointly by the Federal Forest Service of the Russian Federation and the ECE/FAO/ILO Team of Specialists on Forest Fire. During the seminar the following topics were addressed:

- 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.

The recommendations of the seminar put main emphasis on the development of internationally agreeable standards and procedures for building a global database on wildland fires and an operational global vegetation fire monitoring system. Since the findings of the international group of wildland fire specialists have been followed up only partially it is proposed to re-evaluate the recommendations. The following general statement and those conclusions and recommendations are taken from the meeting report.[6]

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.

[6] The full report of the meeting has been published in International Forest Fire News No.15, p. 40-47.

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 Appendices 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.

Appendix I (to Annex II)

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

Appendix II (to 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 of information ***
	alpha	*beta*	*gamma*	*delta*	*eta*	
Regional/National (fire)						
1.Budget resource requirements	X	X			X	A
2.Daily to annual fire activity	X	X	X		X	DWMA
3.Long term trends	X	X	X		X	A
4.Interagency agreements	X				X	DWMA
5.Resource allocation	X	X	X		X	DWM
Regional/National (non fire)						
6.Assessment monitoring	X	X				A
7.Air qualitypolicy regulations	X	X		X		A
8.Global change policy regulations	X	X	X			A
9.Habitat change	X	X	X			A
International (fire)						
10. Intergovernmental assistance	X	X	X		X	DWMA
International (non-fire)						
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.

Appendix III (to Annex II)

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

A. Current State of Fire Inventory

- Data consisting of individual fire reports are developed by many nations, but many regions of the world are not covered.
- Only ECE and EU nations have established mechanisms to share data.
- Current shared data consists of statistics aggregated from individual fire reports.
- 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 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.
- A parsimonious inventory has been identified which can be utilized by all nations (see statement on standardized fire inventory).
- There needs to be international agreement to provide fire inventory (similar to the FAO global forest inventory).

C. Implementation

- 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?
- 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
- 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.
- 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.
- 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.