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RUSSIAN FEDERATION FIRE 2002 SPECIAL

PART I

The Wildland Fire Season 2002 in the Russian Federation
An Assessment by the Global Fire Monitoring Center (GFMC)

Introduction

In 2002 international media focussed on the fire episodes in the United States of America and Australia. A series of extreme wildfires affected more than 3 million hectares (ha) of wildlands and populated areas in the USA. In Australia more than half of the 154,000 ha of Australia's Capital Territory (A.C.T.) was left charred and 530 houses burned after the 2002-2003 fire episode. In neighbouring Victoria 1.14 million ha forest and bush land were affected by wildfires during the same period. These events raised public concern about the trend of increasing wildland fire severity and the inability of control. The dry summers in the northern and southern hemispheres revealed the changing exposure and vulnerability of ecosystems and society in two countries that are considered to be world leaders in wildland fire management.

A similar trend towards increasing fire problems, however, is also observed in other regions of the world, especially in the boreal zone of Eurasia, predominantly on the territory of the Russian Federation and neighbouring Kazakhstan, Mongolia and the North of the People's Republic of China. In August / September 2002 extended smoke pollution from peat fires and forest fires in the European part of the Russian Federation was covered by international media, especially in the neighbouring smoke-affected countries, but otherwise there was a limited international interest on wildland fires in the Eurasian region.

The Global Fire Monitoring Center (GFMC) monitored the situation over the whole year 2002. The regular updates during the fire season are published three times per week on the GFMC website under *Current & Archived Significant Global Fire Events and Fire Season Summaries*” (1). Besides regular reports by the Aerial Forest Protection Service *Avialesookhrana* (Ministry for Natural Resources of Russia) the GFMC published observations of forest fires in Russian Asia, the largest part of the Russian Federation, using satellite data received by the Fire Laboratory of the Sukachev Institute for Forest, Russian Academy of Sciences, Krasnoyarsk. Figures 1 and 2 provide examples of daily and 10-days fire occurrence and up-to-date burned area maps.

Early warning of wildland fires is provided by the Eurasian Experimental Fire Weather Information System (example: Figure 3). The system has been developed by forest fire researchers from Canada, Russia and Germany is displayed on this website starting 18 July 2001. Complete information and a set of daily fire weather and fire behaviour potential maps covering Eurasia (the Baltic Region, Eastern Europe, countries of the Commonwealth of Independent States, and Mongolia) can be accessed through the GFMC (2).

After the fire season the GFMC encouraged its partners in the government institutions and the academia of the Russian Federation to evaluate the fire season. Retrospective analyses of the 2002 fire season have been prepared for this special GFMC report by *Avialesookhrana*, the Fire Laboratory of the Sukachev Institute for Forest (Russian Academy of Sciences, Krasnoyarsk), the Soil Science Faculty, Lomonosov State University (Moscow), and this summary assessment by the GFMC.

Fire Reports: Discrepancies between Ground, Aerial and Space Surveys

The first two reports authored by the Aerial Forest Protection Organization *Avialesookhrana* and the Krasnoyarsk Fire Laboratory reveal the problems of accurate fire 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 of 1.834 million ha (1.2 million ha forest land and 0.634 million ha non-forest land) on the area of jurisdiction does not reflect the complete picture.

The Krasnoyarsk satellite receiving station 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 was 11.7 million ha in Russia and 2.8 million ha in neighbouring Kazakhstan. The burned area derived from AVHRR fire counts, 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 (= 1 km^2 or 100 ha). 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 meanwhile is using the most conservative algorithm of fire detection, and all high-temperature events are identified as a fires with probability 95%.

On the other hand there are fire events that were not recorded by the satellite due to cloud cover. This may partially compensate the overestimation of burned area assessments by fire event counts. Since the total size of 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.

Intercomparison of data generated by various institutions is needed to verify the fire datasets. For instance, comparison the 2002 fire dataset for Irkutsk Oblast with the products of the Irkutsk Institute of Solar and Terrestrial Physics reveals a similar magnitude of fire occurrence: The Krasnoyarsk Laboratory recorded 882 fire events affecting a total of 554,665 ha, whereas the Irkutsk Lab 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 and to derive statistics of area burnt per type of vegetation cover (3). 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 forest, 3.31 million ha woodland, 5.3 million ha wooded grassland, and 10.66 million ha other land (including 7 million ha croplands). The GBA-2000 number of 6.4 million ha forest and woodland burned must be compared with the reported area burned for the *Avialesookhrana* region of 1.64 million ha (4) 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 (5). A similar discrepancy was found for 1998: An analysis of the fires in Siberia depicted by satellit was 13.3 million ha – an area five time higher than the Avialesookhrana statistics for the same year (6).

Concluding from 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.

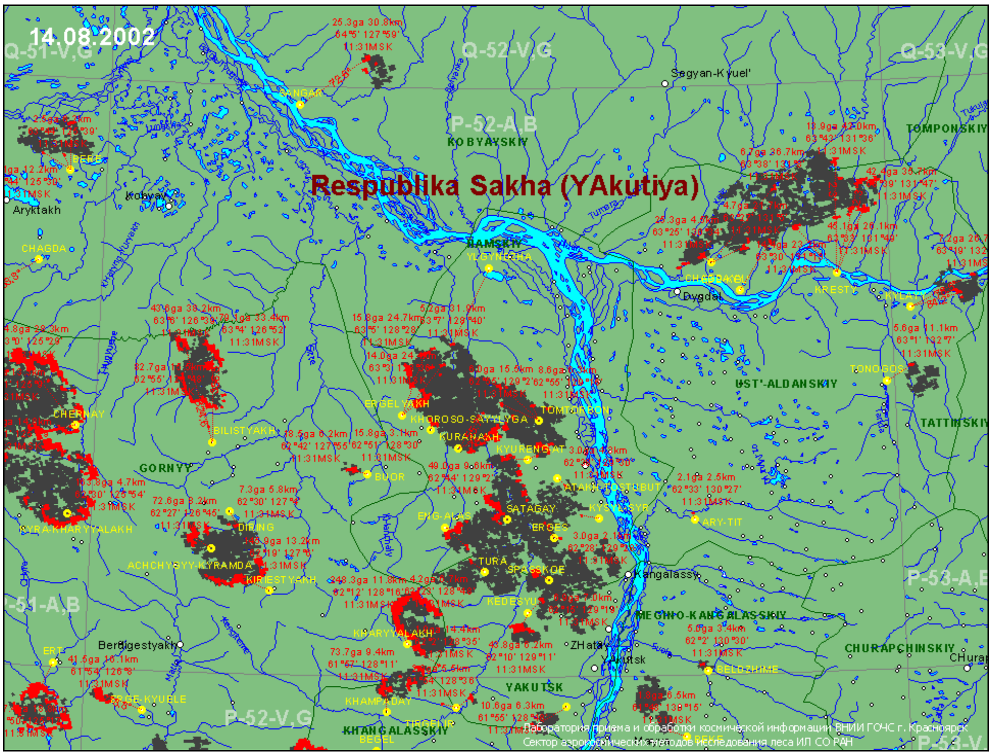

Figure 1. Example of a fire activity and burned area map produced daily by the Fire Laboratory, Sukachev Institute for Forest (Russian Academy of Sciences, Krasnoyarsk) and published by the GFMC. This example shows the situation in a fragment of Yakutyia Republic on 14 August 2002.

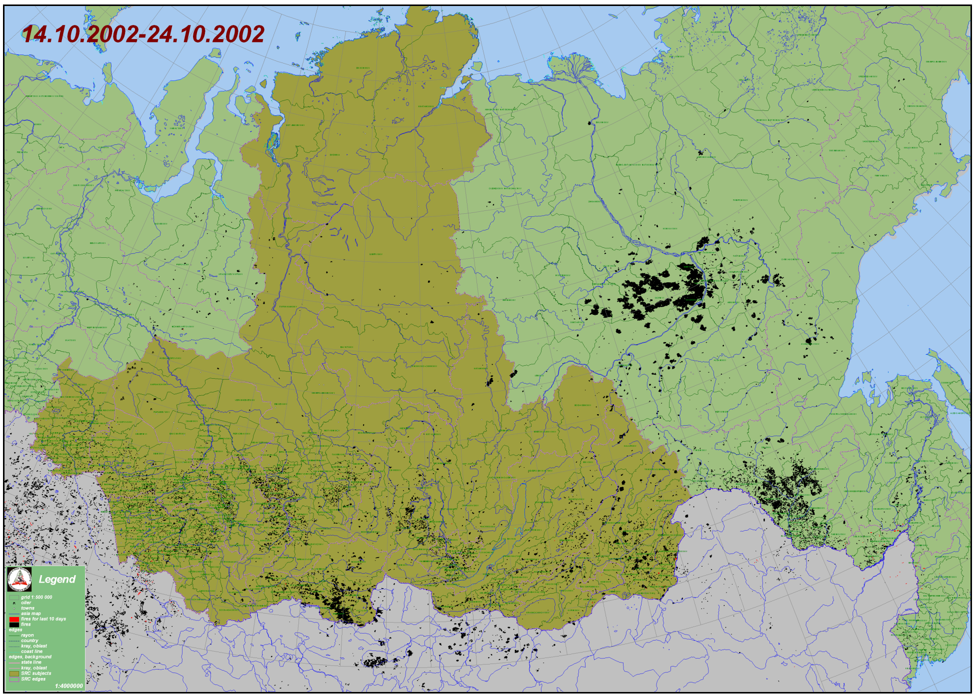

Figure 2. Example of a map showing 10-days active fires and total up-to-date burned area. These maps are produced by the Fire Laboratory, Sukachev Institute for Forest (Russian Academy of Sciences, Krasnoyarsk) and published three times per week by the GFMC. This example shows the distribution of fires at the end of the fire season 2002.

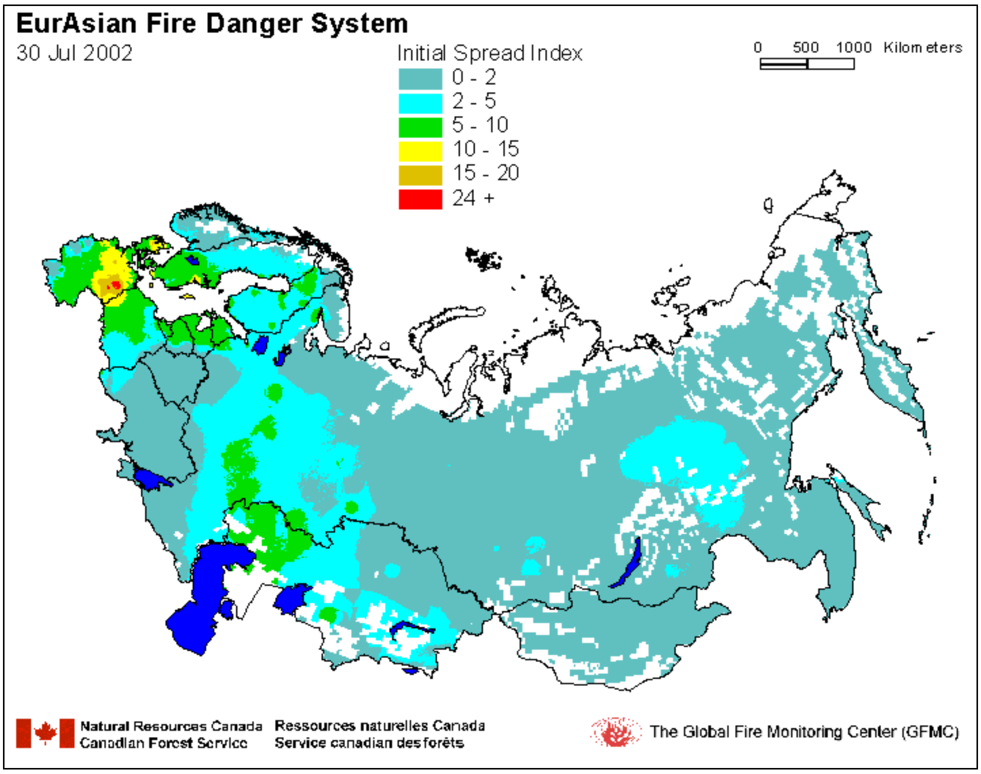

Figure 3. An example of the daily Experimental Fire Weather Index (FWI): 30 July 2002. The system is still lacking sufficient inputs of weather data from some of the countries covered. Therefore the system is currently updated by the Canadian Forest Service and will be put back in service during the 2003 fire season.

Fire Characterization and Fire Impacts

Inaccurate fire reports and statistics constitute a major impediment for the evaluation of the forest fire situation in the country and a problem for appropriate strategic planning in forest fire management and in forestry in general.

However, even more important is another fundamental problem which relates to the use of observational fire data and fire reports for operational purposes and for decision support in fire suppression. There is a lack of applied methods and procedures for real-time assessment of fire characteristics such as fire behaviour and fire severity, neither by operational application of remote sensing methods nor by the conventional observations from the air and on the ground. However, some progress has been made through recent research efforts to characterize forest fires of different intensities in central Siberian pine forests (7).

Such real-time observational information is essential to support decision making in an ongoing fire situation, e.g. supporting decisions to let burn a fire of low or moderate intensity for (a) economic reasons, (b) setting priorities to action other fires that need priority response, or (c) utilizing the expected beneficial impacts of the fire on the forest ecosystem (e.g., fuel reduction, silvicultural reasons, etc.). Figures 4 and 5 provide examples of different fire intensities in a *Pinus sylvestris* forest in Central Siberia.

There is also a lack of applied methods and procedures for short-term assessments of fire damages that would allow to generate more useful qualitative statistical information in addition to counting of fire events and quantifying total size of area affected by fire. The reporting and statistical evaluation system used by *Avialesookhrana* allows to distinguish area burned by surface vs. crown fires. With some restrictions this allows at least to conclude that an area affected by crown fires will be partially or completely damaged. However, fire reports provided for statistical evaluation do not include information on economic, ecological or fire-management related consequences of surface fires.

Figure 4. Typical surface fire of medium frontal fire intensity levels ranging between 1500 and 5000 kW/m. Location: Bor Forest Island Experiment, Central Siberia, July 1993 (8).

Figure 5. Ground view of typical high-intensity surface/intermittent crown fire behaviour with frontal fire intensity levels of 25,000 to 28,000 kW/m. Location: Bor Forest Island Experiment, Central Siberia, July 1993 (8).

The use of Geographic Information Systems (GIS) allows at least to determine in which kind of vegetation type the fires have been burning. Fire maps laid over the vegetation classification maps reveal that during the 2002 fire season wildfires mainly affected stands of Siberian larch (*Larix sibirica*) in the Republics of Yakutyia and Tyva, and in Amur Region (Figures 6-8).

Inter-Annual Variability of Hotspot Regions

The 2002 fire report by Sukhinin et al. provides a forest fire activity map for the year 2002. Figures 9a-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.

These maps of the past five years that cover central Russia demonstrate how the centres of large and disastrous fires are moving through the Asian part of Russia. It is interesting to note that the concentration of hotspot regions in the Southern part of Siberia and Western-Central Yakutyia remind to the fire severity scenarios that have been predicted by climate-change models (Global Circulation Models - GCMs) since the early 1990s. 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 (9).

The observational data and the scenarios have important implications on the national fire management policy, i.e. the organizational arrangement of forest fire protection in the Russian Federation, and provide arguments for maintaining a strong federal component in forest fire management. No single province (i.a.w. the Russian nomenclature: Oblast, Krai, Respublika, Autonomous Region) can handle alone these extreme fire situations. The extremely large and severe fires that have been experienced in the past 15 years always required response through the centrally managed capabilities of the Federal Forest Service and its operational wing *Avialesookhrana*.

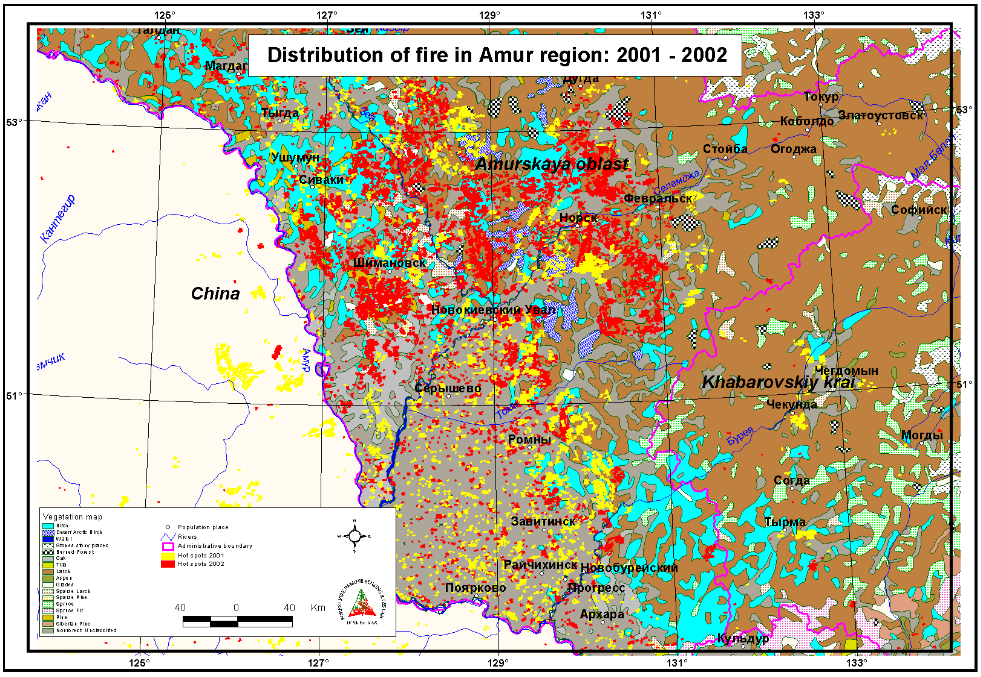

Figure 6. Vegetation type affected by wildfires in Amur Region during the fire season 2002. The colours indicate: brown - larch forest, light blue – birch, grey – non-forested. Source: A. Sukhinin, Fire Laboratory, Sukachev Institute for Forest, Russian Academy of Sciences, Krasnoyarsk.

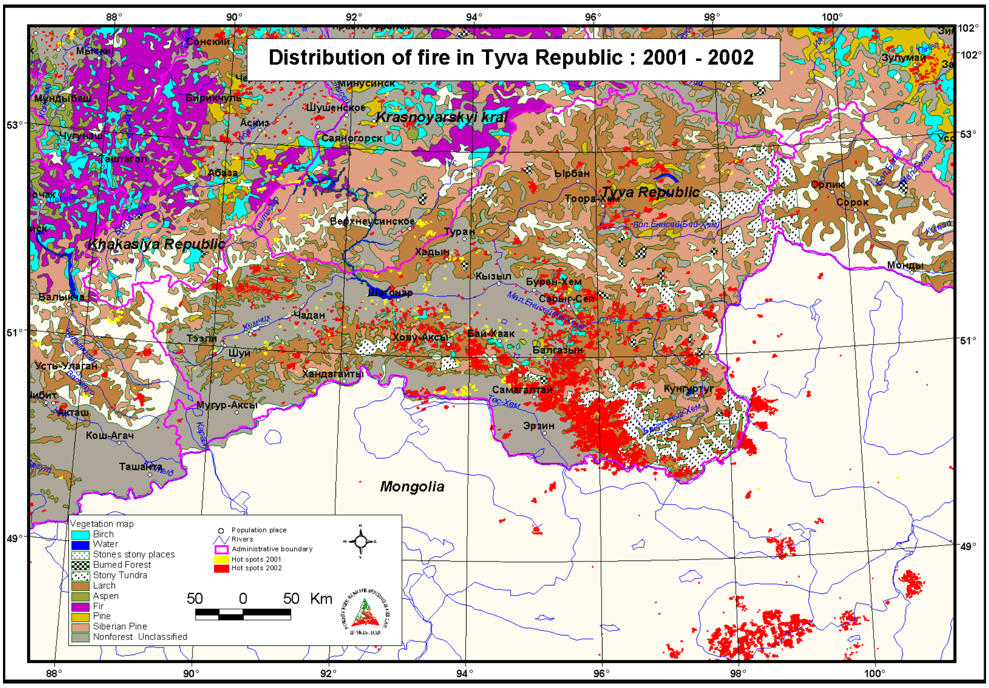

Figure 7. Vegetation type affected by wildfires in Tyva Republic during the fire season 2002. Source: A. Sukhinin, Fire Laboratory, Sukachev Institute for Forest, Russian Academy of Sciences, Krasnoyarsk.

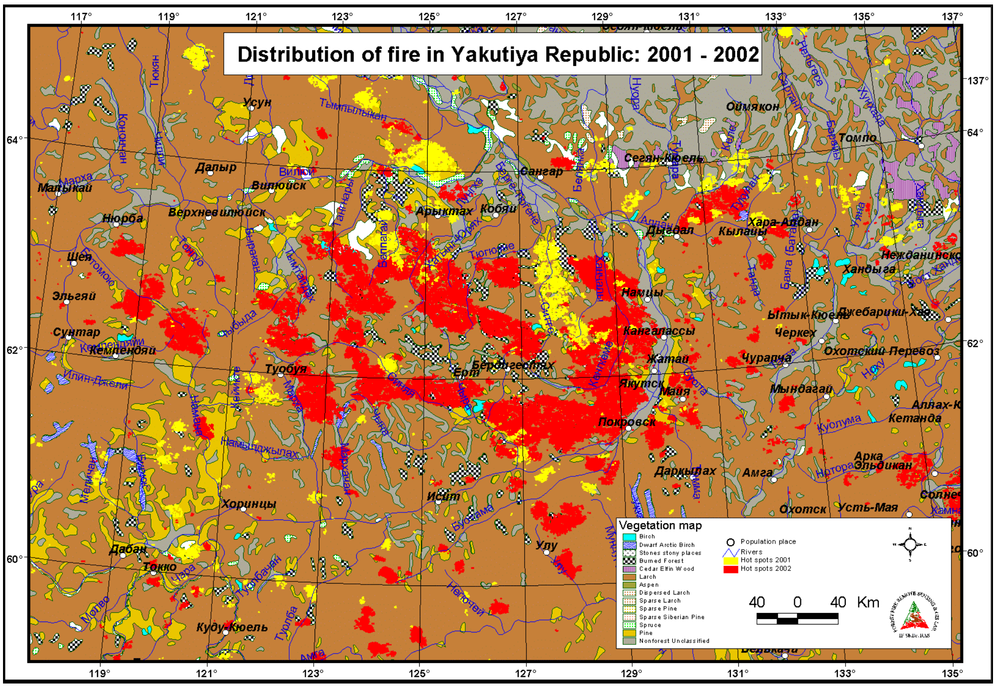

Figure 8. Vegetation type affected by wildfires in Yakutyia Republic during the fire seasons 2001 (yellow) and 2002 (red). The forest cover predominantly affected by fire in this part of Yakutyia is Siberian larch forest (brown colour). Source: A. Sukhinin, Fire Laboratory, Sukachev Institute for Forest, Russian Academy of Sciences, Krasnoyarsk.

Peat Fires – an Increasing Problem in the Boreal Zone

According to the Wetlands International Russia Programme peatland fires are a common phenomenon in the Russian Federation (10). 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"* (11). 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 (12).

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 (13, 14). 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.

Peat lands in Western Russia have been drained and used for agricultural purposes since the early 19th Century. As Minaeva (10) 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. The paper by Bannikov et al. in this special report 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.

Russia's Peatlands and Forests – A Carbon Bomb?

The implications of emissions from fires in the boreal system on atmospheric and climate have received increased attention by the science community. Numerous case studies, models and estimates on the contribution of fires in the circumpolar boreal forest zone have been produced over the past 15 years. One of the most recent research efforts investigated the contribution of the fires of 1998 in Siberia on the emissions of greenhouse gases to the atmosphere (17). According to the detailed observations by satellite mapping and fire impacts the authors conclude that the fires that affected 11 million ha. About 350 million t of phytomass were consumed by these fires and released close to 180 million tons (t) of carbon to the atmosphere which contributed to the formation of 520 million t of carbon dioxide, 50 million t of carbon monoxide and other radiatively active trace gases and aerosol particles. This case study may serve as an example to be used for extrapolating emissions of other years, e.g. the year 2002. Based on the average amount of phytomass burned per area unit of 30 t / ha – a number that reflects reasonably well the fuel consumption in many forest ecosystems – the fire emissions from Russia during the 2002 fire season would be in the same order of magnitude compared to the fire emissions calculated for Siberia in 1998 (in 2003 fires on 11.7 million ha of forests and other vegetation in Asian Russia would also consume tentatively 350 million t of phytomass and release ca. 180 million t of carbon to the atmosphere).

Figure 9a. Fire activity map of 1998

Figure 9b. Fire activity map of 1999

Figure 9c. Fire activity map of 2000

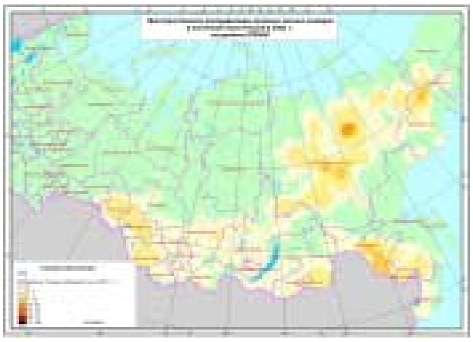

Figure 9d. Fire activity map of 2001

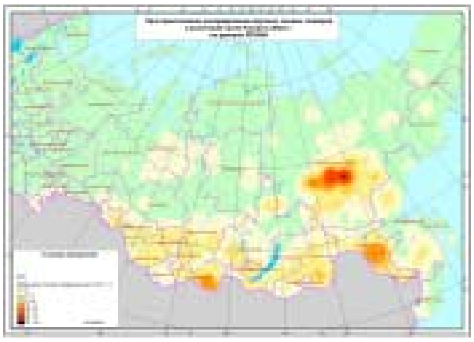

Figure 9e. Fire activity map of 2002

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.

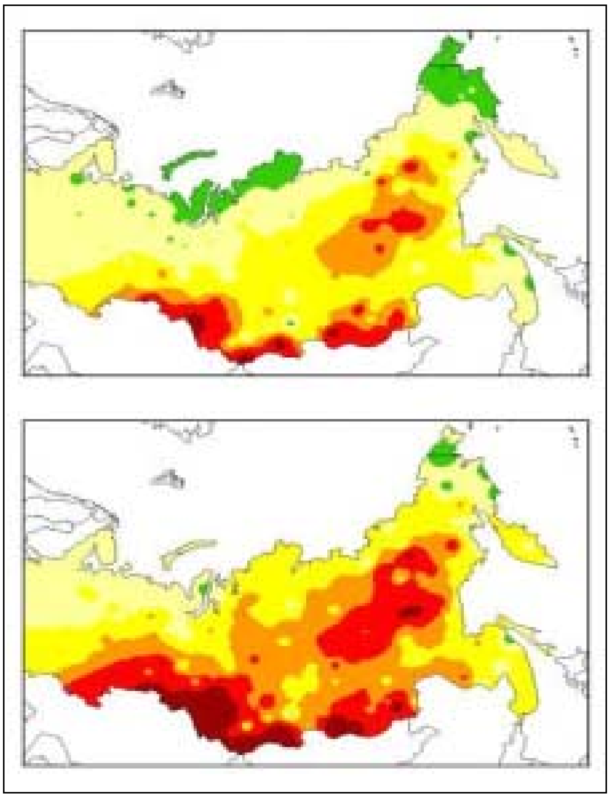

Figure 10. Seasonal fire severity rating across Russia under current climate conditions (upper) in comparison to a projected 2xCO_2 climate (lower), based on the Global Circulation Model (GCM) of the Canadian Climate Center (CCC). Note the significant increase in the severity and geographical extent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

Figure 11. Firefighters combat the flames in a peat bog in a forest about 160 km from Moscow, on 1 August 2002. Source: Associated Press / The Russia Journal (15).

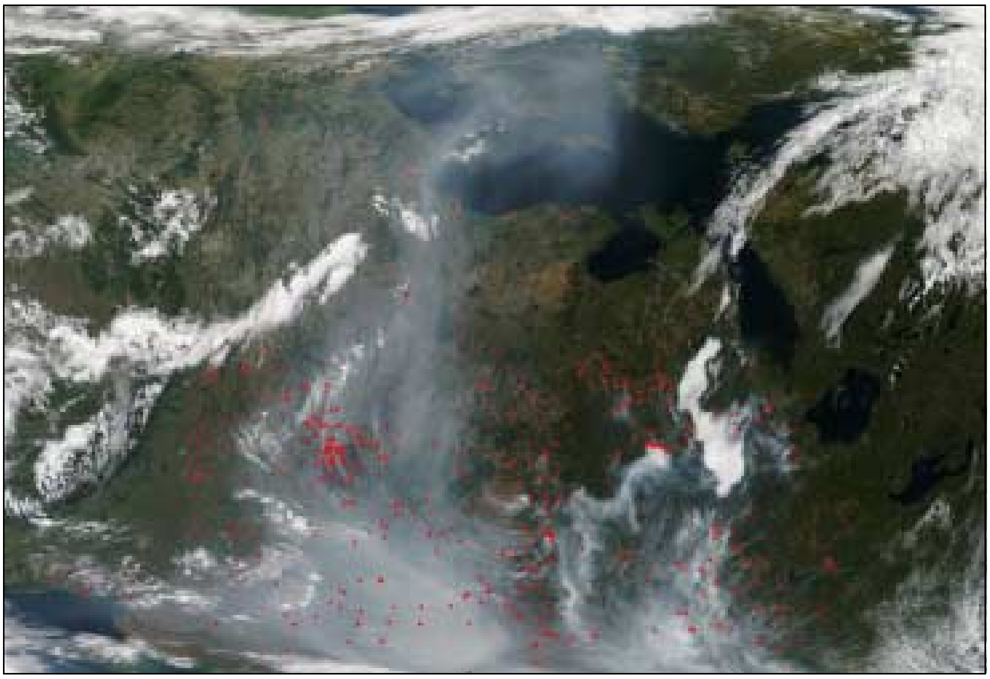

Figure 12. Satellite scene (MODIS composite) of Western Russia on 4 September 2002. The heat signatures of the peat and forest fires are given in red colour. The smoke plumes (light blue haze) stretch from Western Russia to Belarus, Poland and the Baltic Sea. Source: True-colour image by Moderate-Resolution Imaging Spectroradiometer (MODIS), resolution 2 km (16).

As it is predicted by Global Circulation Models the impact of climate change will affect mostly the Russian Federation. Longer and more extreme forest fire seasons will be more frequent in future. As a consequence it is likely that more fires will burn in forests and in dried peatlands. Extreme droughts will also lead to an increasing danger of occurrence of high-intensity and high-severity fires in those forests where long-term fire suppression has resulted in the built-up of combustible material.

Based on the assumption that climate-change predictions will become reality the area affected by wildfires in the Russian Federation, mainly in Siberia, will increase by at least 50 percent or double over the next three decades. Taking the 2002 satellite data as a baseline the average forest area burned during the next decade fire may exceed 15 to 20 million ha per year. This number is a conservative assessment considering the fact that the above-cited Global Burnt Area 2000 (GBA-2000) product provides already a total of more than 20 million ha burned in the year 200.

Assuming that these future fires on 15-20 million ha per year will become predominantly high-intensity fires and also affect deep organic layers, the amount of fuel consumption will exceed 50 tons per ha, equivalent to 25 tons of carbon. The emission of this amount of carbon will contribute to the greenhouse effect if the forest is destroyed and will not recover. Additionally more than 50 tons of carbon may be released by post-fire decay of the fire-affected forests. A size of 15 to 20 million ha burned forest will release 375 to 500 million tons of carbon by fire and 750 million to 1 billion tons of carbon released by decay of forest biomass after fire. In accordance with global standards the "value" of each ton of excess carbon released by fire-destructed forest is 10 $US. The predicted release of this amount of carbon thus has a damage potential of 7.5 to 10 billion $US per year.

However, this number reflects only the main constituent of radiatively active greenhouse gases and aerosols. Other ecological damages are not included here. We assume that the long-term damages by forest destruction through high-intensity fires will lead to additional losses in the sector of socio-economy of more than 300 to 400 million US-Dollars per year.

The health effects of fire emissions on rural and urban populations have not yet been expressed in costs. However, we assume that fire smoke caused by forest fires has contributed to a dramatic health impact on people, such as in the Far East in 1998 and especially in Moscow Region in 2002.

These assumptions do not yet include further consequences of regional warming. The expected melting of permafrost sites, possible drying of large peat-swamp areas will have further repercussions on future fire scenarios. One of the possible consequences of permafrost melting and fire in Eastern Siberia would be the disappearance of extended regions of larch forests. The loss of potential forest area would significantly reduce the carbon storage potential of the region.

It must be clarified at this stage that these numbers are assumptions based on an extrapolation of the current trend. However, the concerns about this trend is shared by those who have observed a comparable development in the tropical forests during the last 15 years.

Towards an Amended Fire Management Policy and Strategy

The current status of the forest fire situation and the trends as defined in this assessment are challenging the development of a fire management policy and a strategic fire management plan that takes into account the manifold human-caused and natural factors that exert an enormous pressure on Russia's forests.

An amended fire policy is required that should address the upcoming threats by two major principles. First, the future fire management policy should be based on sound ecological principles, i.e. the integration natural fire and the active use of prescribed management fires, where applicable, to stabilize forest ecosystems. Second, the Ministry for Natural Resources should give highest priority to improve national to regional fire management capabilities by adequate training of personnel and supply of financial resources to restore and improve the fire management capabilities of the Federal Forest Service.

Beginning in the early 1990s the Russian Federation has been an active partner in a number of international programmes in the field of forest fire. Joint fire research programmes are underway since 1992-93 (18). In 1993 and 1996 Russia was host of the International Conferences "Fire in Ecosystems of Boreal Eurasia" and "Forest, Fire and Global Change" (FAO/ECE) (19, 20). Russia through *Avialesookhrana* is member of the FAO/ECE/ILO Team of

Specialists on Forest Fire (21) and the Working Group on Wildland Fire of the United Nations International Strategy for Disaster Reduction (ISDR) (22). Russia also contributed to the FAO Global Forest Fire Assessment 1990-2000 (23). Currently Russia is also member of the International Liaison Committee for the preparation of the 3rd International Wildland Fire Conference and the Global Wildland Fire Summit that will take place in October 2003 (24).

These international activities have contributed to a better understanding of the environmental, social and economic significance of forest fires in Eurasia, especially the implications of a change of fire regimes on the sustainability of forests, atmosphere and climate. Thus, there is a growing international interest to jointly work with Russia in the field of fire science, management and policy development during the coming years. The Round Table "Key Ways of Protection of Forests from Fire in the Russian Federation" at the All-Russian Forestry Congress in Moscow, 24-28 February 2003, will provide an opportunity to develop common visions for synergies in cooperation and sharing of solutions.

IFFN/GFMC contribution submitted by:

Johann G. Goldammer
Director, The Global Fire Monitoring Center (GFMC)
Coordinator, United Nations International Strategy for Disaster Reduction (ISDR), Working Group on Wildland Fire, and FAO/ECE/ILO Team of Specialists on Forest Fire
Max Planck Institute for Chemistry
c/o Freiburg University
D-79085 Freiburg
GERMANY

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