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# INTERNATIONAL FOREST FIRE NEWS

**No. 32**
**January – June 2005**

***Special Issue on Russia***

**UNITED NATIONS**

ECE/TIM/IFFN/2006/1

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## Note



## Abstract

This special edition of International Forest Fire News presents the papers given at the international conference "New Approaches to Fire Management at an Ecoregional Level", Topics covered include: the current state of forest fire management in Russia, including policy changes that need to occur in order to adapt from the model of “full suppression” to a policy of fire prioritization, and how best to manage fire in protected forests. The papers focus on Siberia and the Russian Far East, but there is also information on the transport of radioactive material by wildfires in the Chernobyl accident area and on the history of Russia’s Aerial Forest Protection Service – Avialesookhrana.

## Keywords

Forest fire, wildfire, Russia.

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All IFFN contributions published between 1990 and this current issue are accessible through 77 country folders and other special files on the GFMC website.

**Call for contributions**

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

Contributions are preferably received by e-mail.

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

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

# ACKNOWLEDGEMENTS

The Secretariat takes this opportunity to thank the editor of the IFFN, Professor Johann G. Goldammer of the Global Fire Monitoring Centre (GFMC) and his team for preparing this issue of IFFN.

The Secretariat also wishes to express its appreciation to the national and international agencies who work together and are co-sponsoring the IFFN and GFMC: Deutche Gesellschaft für Technische Zusammenarbeit, the International Boreal Forest Research Association Fire Working Group, the International Global Atmospheric Chemistry Project, the International Union of Forestry Research Organizations, the United Nations International Strategy for Disaster Reduction, the U.S. Department of the Interior Bureau of Land Management, the World Bank Disaster Management Facility, and the World Conservation Union.

## PREFACE

Although fires are now commonly recognized as an important element of natural ecosystem dynamics and increasingly used as a modern ecosystem management tool – they remain an important factor threatening forest resources and ecosystems, especially in the East of the UNECE region – in Siberia and the Far East of the Russian Federation. The on-going economic and administrative reforms in Russia include a redistribution of public forest management responsibilities between federal, regional and local levels of government – including in fire management. The Russian Government has realized the need to focus more strongly on fire prevention in its public financing priorities. It has also recognized the importance of ecological functions of natural fires and shifted from the previous policy of total fire suppression to a more modern policy of fire prioritization. All these changes were spelled out in the decisions of a high-level international conference "New Approaches to Fire Management at an Ecoregional Level" jointly held by the Ministry of Natural Resources and the World Bank in Khabarovsk in September 2003 and subsequently reflected in the new "Concept of Forest Fire Protection in the Russian Federation" that was adopted by the Ministry for Natural Resources in 2004.

This special issue of International Forest Fire News publishes the English versions of key presentations given at the conference and focussing on the region. Most importantly, IFFN is publishing the new "Concept of Forest Fire Protection in the Russian Federation" as approved by the Federal Forestry Agency of Russia (2004). Together with an important contribution on the problem of fires occurring in radioactively contaminated forests this issue of IFFN is another important contribution towards a better understanding of the complexity of forest fire issues in the eastern part of the UNECE region.

The issue of forest fires is of increasing importance, notably because of their influence on climate change through carbon emissions and because climate change will make the ECE region's forests more vulnerable to forest fire.

I hope that the International Forest Fire News (IFFN), produced by UNECE in cooperation with many environmental and fire-related agencies will help the forest fire community improve their understanding of the complex ecological and social issues underlying these problems, and communicate to the policy community the importance and urgency of these issues.

Marek Belka
Executive Secretary
UNECE

# EDITORIAL

Although fires are now commonly recognized as an important element of natural ecosystem dynamics, they remain the single most important factor threatening Russia's forest resources and ecosystems, especially in Siberia and the Far East with their low population density and large distances, and need to be properly managed. The period of transition from centrally-planned to market-based economy in the 1990s and early 2000s has substantially weakened viability of the formerly strong and highly centralized system of forest management and conservation in Russia, including its fire management system that previously had been targeted at full fire suppression. The on-going economic and administrative reforms include a redistribution of public forest management responsibilities between federal, regional and local levels of government – including in fire management. The Government has already realized the need to focus more strongly on fire prevention in its public financing priorities. It has also recognized the importance of ecological functions of natural fires and shifted from the previous policy of total fire suppression to a more modern policy of fire prioritization. All these changes were spelled out in the decisions a high-level international conference "New Approaches to Fire Management at an Ecoregional Level" jointly held by the Ministry of Natural Resources and the Bank in Khabarovsk in September 2003 and subsequently reflected in the new "Concept of Forest Fire Protection in the Russian Federation" that was adopted by the Ministry for Natural Resources in 2004.

At the conference the 'intellectual' launch of the design of the project "Fire Management in High Conservation Value Forests of the Amur-Sikhote-Alin Ecoregion" took place. The objective of the proposed project is to strengthen conservation of critical, non-economically accessible forests of high conservation value in the Amur-Sikhote-Alin Ecoregion of the Russian Far East through improved forest fire management, and reducing frequency, size and intensity of catastrophic fires. The Project – to be financed by the World Bank and the Global Environment Facility (GEF) – will cover all protected areas and other forest areas managed for conservation purposes in the ecoregion, including Primorsky Kray, Khabarovsk Kray, and Jewish Autonomous Oblast.

The complete set of conference contributions by Russian and international fire scientists and managers has been edited by Valentin V. Furyaev and been published in Russian language in the following volume:

> *Fire management at an ecoregional level. International experience and new approaches in forest sector reforms. World Bank and Program on Forests (PROFOR). Alex Publishers, Moscow (ISBN 5-9618-0007-5).*

This special issue of International Forest Fire News publishes the English versions of key presentations given at the conference and focussing on the region. They were edited by the Johann G. Goldammer, Editor of IFFN, with the kind support by Marina I. Smetanina and Andrey V. Kushlin, both World Bank, Moscow.

In addition the full project concept "Fire Management in High Conservation Value Forests of the Amur-Sikhote-Alin Ecoregion" is published in this special IFFN issue. Most importantly, IFFN is publishing exclusively the new "Concept of Forest Fire Protection in the Russian Federation". A significant contribution of Sergey Dusha-Gudym on "Transport of Radioactive Materials by Wildland fires in the Chernobyl Accident Zone", a paper presented at the 3rd International Wildland Fire Conference (Sydney, 2003), has been edited for publication in this issue. Finally, Nikolay A. Kovalev is reflecting about the History of Russia's Aerial Forest Protection Service Avialesookhrana at the occasion of the 10th Anniversary of Avialesookhrana's Air Fleet celebrated at Avialesookhrana's Headquarters, Pushkino, 15 September 2004. This contribution is complemented by an address to the anniversary presented by the Global Fire Monitoring Center (GFMC).

Johann G. Goldammer
Editor, IFFN
Global Fire Monitoring Center
Max Planck Institute for Chemistry
Freiburg University/United Nations University

## Welcome Address to the Forest Fire Management Conference

*Gennady Apanasenko*
First Deputy to the Plenipotentiary Envoy of the President of Russia in the Far Eastern Federal District

Dear Participants of the Conference,
Ladies and Gentlemen,

I am glad to greet you in the capital of the Far East Federal District at the International Conference on Forest Fire Management organized by the Ministry of Natural Resources jointly with the World Bank.

I would like to extend appreciation to the specialists of the Russian forest sector, the executive authorities of the Subjects of the Russian Federation, scientists and experts from the USA, Canada, Germany, i.e. to all who responded and is taking part in the Conference, to those who are not indifferent to the destiny of Russia's forests.

This Federal District is among the Districts with the highest forest fire incidence rates in the Russian Federation. The annual number of forest fires keeps on growing. For eight months of the current year alone, 3,575 fires have occurred with their total area exceeding one million hectares.

Fire inflicts enormous losses on the regional economy, natural wealth, and is a factor threatening the economic security of the country and having dangerous effects on human health.

Several joint meetings were held by the Office of the Authorized Representative of the President of the Russian Federation in the Far East Federal District with the Ministry of Natural Resources of the Russian Federation, and the regional executive authorities: in 2002, such meetings were held in Magadan and Vladivostok, and this year – in Khabarovsk in the framework of the Interagency Commission. The implemented activities included management and control measures to ensure timely financing of preparatory operations, interagency coordination of effort during the preparation to the fire season and in the course of fire fighting. In Russia, the first Regional Forest Fire Centre was established in Khabarovsk. Its goal is to prevent and fight forest fires and to coordinate activities of the authorities and forest services, and to maneuver resources among the regions in the Federal District.

Today, it may be noted that our joint efforts produce certain benefits.

Forest fire operations have come to be better financed. In spite of adverse weather conditions and increased number of fires, the total area of burned land dwindled by 2.7 %, and the burned area of forested land decreased by 22 % in the Far East Federal District. This year, the average area of a fire got reduced by 27.5 % compared to the previous year.

However, I deem that there is yet a lot to work ahead of us, and among other things, there is a need to address institutional issues in order to refine the mechanism of coordinating the efforts of all the authorities, services and agencies to prevent and fight forest fires.

I am absolutely sure that the Conference recommendations will be usefully applied under the Sustainable Forestry Pilot Project and the GEF Project as well as for the development of a National Forest Fire Strategy.

I wish successful work to the Conference participants. Thank you for attention

# Problems and Prospects of the Regional Forest Fire Policy Implementation in the Southern Far East

*Sergey A. Zrazhevsky*
Vice Governor, Khabarovsk Kray Government

Ladies and Gentlemen,

Let me welcome the Conference participants on behalf of the Governor of the Khabarovsk Kray, Victor Ivanivich Ishayev, and the Kray Government, and express the hope that this event will be fruitful and result into relevant decisions. The issue considered by the Conference is of great importance not only for the Russian Far East, it affects the environment in the entire Asian Pacific Region. We appreciate that experts from the USA, Canada and Germany have joined Russian specialists to take part in the Conference.

Our commitment to the conservation and replenishment of the Far East forests, to a great extent, defines the life standards in this territory as a whole with the central and southern areas of the Khabarovsk Kray, the Primorsky Kray and the Jewish Autonomous Oblast where about 4 million people live on an area of around 1 million $km^2$. In this ecoregion, the flora is represented by 23 forest formations consisting of 150 forest types, over 200 tree and shrub species, and its extraordinarily diverse fauna includes about 300 species of birds and 70 mammal species. The ecoregion has an already developed ecosystem with its unique vegetation and wildlife.

The ecoregion still contains forest ecosystems that have disappeared in the neighbouring countries of China, Korea, and Northern Japan. However, human activities, and many years of industrial timber harvesting have significantly disturbed the forests in the south of the Far East and their ecological balance.

The southern areas of the Far East are exposed to higher forest fire hazard and incidence. Periodically returning extremely dry seasons, the abundance of forest fuels, mountainous terrain poor accessibility of the areas and the severe wind regime – all these precondition the high probability of forest fire occurrence, fast fire spread, and the difficulties of fires fighting. About 78 % of the Forest Fund area is referred to the highest classes of natural fire hazard.

Suffice it to say that during an average fire season, the total burned area is 2 to 3 times vaster than the annual area of industrial logging and still vaster during the driest seasons. In the Khabarovsk Kray alone, the 1976 fires burned an area of over one million ha, and in 1982, the burned area exceeded 2 million.

The change of the country's economic system lowered the life standards for a significant part of the population, particularly, in rural areas, and made people use the taiga as a source of incomes. Forests have become a site of mass visits. This is coupled with the "underdeveloped and too soft" legal framework for punishing those who are to be blamed for fire incidence, and due to this, as much as 75 – 80 % of all fires are human-induced fires.

In such a context, to reduce the fire occurrence rates is a most important challenge not only for the public authorities, but the whole society. The fire records for this year (2003) testify to the effect that the year has exceeded the average annual levels of fire incidence and may be called a year of high fire incidence. As of 1 September 2003, almost 1,800 fires occurred in forests and nature reserves in the Jewish Autonomous Oblast, Khabarovsk and Primorsky Krays. They burned 330,000 ha. It means that these three regions accounted for 53 % of all fires, and 34 % of the total area burned in the Far East. In the southern part of the Far East, the average annual number of fires reaches 1,000 with the area burned amounting to about 200,000 ha.

Significant efforts are undertaken by the Forest Service of the Ministry of Natural Resources of the Russian Federation, the regional executive authorities, units of the Ministry of Emergency Situations of the Russian Federation to prevent and combat this calamity. A fire detection system is operational and includes satellite monitoring. Hundreds of various machines, aerial units, thousands of ground-based forest protection workers, and staff from local enterprises are involved in fire fighting. Guards are placed on the roads leading forests, and the public access to the taiga is closed.

All these organizational measures are taken jointly with units of the Ministry of Natural Resources of the Russian Federation, the Far East Aerial Fire Centre (‘Airbase’), the Ministry of Emergency Situations, and also involve law enforcement bodies.

At the same time, we have not yet achieved due efficiency in this work. In the Khabarovsk Kray alone, the annual costs of fire fighting vary from Rbl. 100 million to 200 million, and the aggregated losses from fire are estimated at several hundred million roubles.

As of today, the forest service has no more than 55 % of the amount of fire machinery, equipment and fire fighting tools required according to the established standards. The wear-out of the logistic and technical resources has is as high as 60 %, with practically no new modern equipment and radio communications available.

In our opinion, great losses are caused by delays in fire detection and fighting within the first three days after the incidence of a fire. This is primarily accounted for by the curtailed operations of the Far East Aerial Forest Fire Center and lack of mechanized mobile teams of fast deployment. Therefore, fires are rapidly spreading, and it is next to impossible to cope with large fires, so this turns into a problem.

A particularly tense period was recorded in the Kray in the third decade of this July when after the four-months of drought, up to 100 – 105 fire were burning at the same time. There emerged a threat to a number of settlements. Central areas of the Kray and the City of Khabarovsk were covered with dense smoke for a fortnight.

Under such conditions, with resources of the forest fire units depleted, it became again obvious that the existing regional policy of long-term lease of the bulk of industrial forests was really a right decision. In the Khabarovsk Kray, 80 % of the Forest Fund passed into long-term lease tenures for 25 – 49 years.

The Kray and Rayon Commissions for Emergency Situations managed to attract about 2,000 people, up to 470 various machines (including 130 heavy bulldozers, 110 tractors and cross-country vehicles, 50 fire engines and water carriers, and up to 20 aircraft) from the lessees and other enterprises. The joint efforts and the August monsoon rains put an end to the critical fire situation.

There are other statistics in favour of long-term lease of the bulk of industrial forests. This year, 1,030 forest fires have occurred in the Kray, with the area burned amounting to 280,000 ha, including 117 fires in leased forests, where they burned 43,200 ha which is, respectively, only 11 % and 15 % of all the fires.

I deem it necessary to say that the currently persistent underfunding (both for preparatory operations and during fire seasons proper) limits the effectiveness of the whole work and reduces its efficiency. We are constantly colliding with significant accounts receivable in this area.

In the recent years, the intervals between the years of catastrophic fires have got shortened from 10 to 12 years to 6 to 8 years, in the south of the Khabarovsk Kray. Due to this, it is evidently vital to improve and strengthen the forest protection system to make it capable of preventing destructive impact of fire on forests. It should be built upon effective prevention coupled with rapid detection and fighting of fires while their areas are still small. In this context, in fire-prone areas, the forest guard should include both mobile fire teams equipped with cross-country and all-terrain vehicles and sets of module forest fire-fighting equipment, and mechanised teams with heavy bulldozers.

There is a need to revise the programmes of equipping *leskhozes* with forest fire machinery and tools. The prepared programme: *Forest Protection against Fire for 2004-2010* is rather of a theoretical and advisory nature, and is in no way supported financially.

We hope that the Khabarovsk-based Far East Regional Forest Fire Coordination Centre (newly established on the basis of the Far East Aerial Forest Fire Centre / Airbase) will help improve the performance in terms of timely fire detection and suppression, reduce the damage inflicted by fire on the environment, ecology and human health.

In the southern part of the Far East, the implementation of the forest fire policy could be substantially supported by the GEF Project of Fire Management in High Biodiversity Value Forests in the Amur-Sikhote-Alin Ecoregion, so we welcome this project and are ready to render all possible assistance.

This project can play an important role for the programmes of improving the systems of fire management, monitoring and prevention, as well as for public awareness/information activities in local communities to prevent forest fires. It can ensure better coordination among Russian and international fire research programmes. Efforts should be focused on improving the system of early warning based on weather events forecasts; timely planning; and distribution of financial resources. There is a need to improve anti-fire arrangements in protected areas and fire prevention and suppression technologies.

We expects that project outcomes will include strengthened capacity of the forest fire services and the Far East Regional Forest Fire Coordination Centre through improved quality of satellite and ground observation data processing, forest fire monitoring, and forecasting, development of up-to-date communications, information support and fast response.

## Preliminary Results of Forest Protection and Renewal in 2003
## Forest Fire Management

*Viktor N. Sergeenko*
Forest Protection Department, Ministry of Natural Resources of Russia

The current fire season is not over yet but it is already possible to state that the fire incidence this year has been much higher than the multiyear average of the last decade.

Compared to 2002, the number of forest fires in Russia reduced 1.2 times; however, the fire area increased 1.6 times while the area of forest lands covered by fires increased 1.9 times.

Difficult fire hazard conditions have been observed in Russian regions within the Ural, Siberian and Far East Federal Okrugs which account for 74% of 24,000 fires registered in Russian forests this year and for 99% of 1.9 million ha covered by such fires.

The Chita and Irkutsk Oblasts, Buryat Republic, Krasnoyarsk, Khabarovsk and Primorsky Krais where mass forest fires have occurred were characterized by an extremely high risk of forest fires.

The first mass outbreaks of forest fires were registered in the Chita Oblast in March-April. A high fire incidence level was primarily accounted for by extreme weather conditions: high daytime temperatures, lack of precipitation and strong winds. The situation was aggravated by the inflow of holiday-makers, fern and mushroom pickers, and by unauthorized burning of old grass in the fields, pastures and hayfields.

At the same time, it should be noted that compared to the same period in 2002 the fire-covered area in the Far East Federal Okrug reduced 1.4 times while the number of fires increased 1.3 times.

Nevertheless, efforts made to enhance fire prevention public awareness and detect the violators of fire safety rules and those who caused forest fires were inadequate, especially in view of the fact that the anthropogenic factor remained the principal reason of forest fires similar to the preceding years. The detection rate has decreased practically in all regions of the Okrug (except the Magadan Oblast). The growth of the mean area of an individual fire almost in all regions of the Okrug which indicates that fire extinguishing measures are not taken promptly enough. The mean area has decreased only in the Khabarovsk Krai and the Yakut Republic which reflects a responsible approach to the vital issue of forest protection.

It should be emphasized that federal and regional agencies responsible for land plots within the right-of-way of railways and highways, as well as power transmission, communication and gas transport lines, fail to conduct all necessary fire prevention and control activities in these areas. As a rule, they cut only those branches that come into direct contact with power transmission wires and conductors and leave them on site, which enhances the fire hazard in certain zones and plots. (For instance, there were three fires in the Amur Oblast that occurred within the right-of-way of railways.)

The MNR has submitted numerous requests to these agencies and we should tighten supervision of fire safety actions taken in such areas.

Unregulated agricultural burning conducted by MOA entities and enterprises is another source of forest fires. It accounts for 11-24% of total fires. However, only the Yakut Republic is making efforts to address the issue. The Republic has drafted a regional law on agricultural burning and a law on Administrative Liability for Environmental Delinquency. Copies of these draft laws were sent out to all offices early this year. Unfortunately, no specific steps have been made since then.

A large-scale unauthorized dumping of industrial and domestic wastes into forests that have been taking place over the last years cause damage to the environment, and subsequent burning of these wastes leads to the occurrence and spread of forest fires.

All these factors do not facilitate the reduction of forest fire incidence in the Okrug.

The regional forests are characterized by an increased fire hazard due to their climatic and site conditions. Complicated nature/climate conditions, an underdeveloped network of logging and forest fire roads, an intensive involvement of forest resources in the production process, the ever increasing forest visit rate – all these are major reasons for forest fire incidence. Therefore, the principle responsibility for forest protection against fire rests with aerial fire units (256.6 million ha out of 290 million ha of protected areas). However, the percent of fires extinguished only by smoke jumpers and helirappellers has been reduced drastically. In the early 1990s (1990-91) it was as high as 80% while at present it is about 40%. The “turnover” of fire control teams has gone down drastically. It takes them a long time to extinguish a single fire (usually a big one) while their basic task is to extinguish newly detected small fires as quickly as possible. Therefore, it was decided to strengthen the aerial fire fighting capacities. Under the current conditions, the MNR decided to establish the Far East Forest Fire Coordination Center to formulate and pursue an integrated fire prevention and control policy in respect to fires threatening forests, peat bogs and forest-tundra ecosystems, to ensure decision-making by and coordinate the operation of forest fire services, and implement the resolution of the Khabarovsk meeting of 17 April 2003. You will hear a more detailed account of its tasks and activities from the Head of the Far East Aerial Fire Center (Airbase), Mr. Alexandr Pavlovich Lyubiakin.

In addition, based on the analysis and assessment of forest fire prevention and control activities in 2002, the Ministry has done a lot to ensure the reliability of forest protection against fire. It has drafted a Concept of Forest Protection against Fire in Russia; taking into account your comments, the Ministry has prepared a new version of the Fire Fighters Safety Rules for Russian forests. We also started developing forest fire prevention schemes for Federal Okrugs of the Russian Federation, and improving the forest fire monitoring system at the federal and regional levels. The Ministry has signed Cooperation Agreements with the Federal Ministries for Emergencies, Agriculture and Defense to prevent and liquidate forest fire-related emergencies. The Agreements would make it possible to take joint coordinated actions in that sphere.

For the first time, a new provision (Article 226) has been included in the budget classification with a view to preparing for the fire season. It would allow targeted funding and strict enforcement of respective activities. At present, the Ministry for Natural Resources, together with the Ministry for Finances, is drafting an instruction on targeted allocation of funds, and we expect specific proposals from our regional offices.

The MNR is currently facing a number of priority tasks which should be implemented to provide technical support to forest fire services. The support includes, first and foremost, renewal of fire and auxiliary equipment, refurbishment of forest aircraft, and completion of the second stage of the Forest Fire Management Center. We are also trying to resolve the issue of air tanker use (in particular, amphibian aircraft Be-200P) for airborne forest fire suppression, which would ensure a high safety level and a timely elimination of forest fires.

Bearing in mind that the MNR does not have the required funds to implement its tasks, I find it expedient to discuss possible co-financing of these works by regional authorities interested in improving the performance of forest fire units and preventing emergencies in their respective region.

It is time for the MNR regional offices to start summing up their work in the current year, perform the analysis and commence the preparation for the 2004 fire season.

## Illegal Logging

Demand for hardwood species (especially ash) increased considerably in Pacific Asia over the last years, which lead to ash logging in excess of its share in the production forests. Comparison of data on industrial ash wood exports from the Krai with official wood sale data indicates there is a latent overlogging of the species.

Over 77% of logged ash is exported to China which is related to the fact that China put a long-term moratorium on logging in some parts of the country with a view to developing its own processing industry and creating new jobs.

In addition to China, Republic of Korea has also strengthened its position in the Russian wood market: in the past, wood export to Korea was insignificant but increased several times over the last years.

An especially difficult logging situation in respect of valuable wood species is observed in the Far East. Illegal logging in the region is performed by well organized mobile teams equipped with necessary logging and timber loading machinery and means of communication. Poachers do not stop at violence, even at murders of state forest protection officials who detected illegal loggers.

Wood logged in Siberia constitutes a large share of export wood transported via Far East regions.

Illegal logging in the Far East is growing.

In the first six months of 2003, the state forest protection officials uncovered 942 cases of illegal logging in the Far East. The amount of illegally logged wood was 36,200 cubic meters while damage to forestry totalled RUR 467.3 million. The Primorsky Krai, Khabarovsky Krai and Amur Oblast accounts for the bulk of illegal logging in the Far East: 340 cases and 11,900 cubic meters totalling RUR339.4 million; 147 cases and 7,500 cubic meters totalling RUR79.7 million; and 269 cases and 9,300 cubic meters totalling 34.4 million, respectively.

The officials of the state forest protection service – independently and together with the regional offices of federal executive authorities – take actions, within their terms of reference, to stabilize the situation as regards illegal logging.

Thus, in spite of a 8.5 times growth of illegal logging in the Jewish Autonomous Oblast relative to the similar preceding period, the delinquent detection efficiency of the state forest protection service was as high as 92%.

Similar work is also being done in other regions of the area.

At the same time, it should be emphasized that measures currently taken to stop illegal logging are inadequate. In spite of the efforts made by the state forest protection service of the Russian Federation, the stabilization of the situation relating to illegal logging requires the soonest possible resolution of a number of issues both at the federal and regional levels.

The imperfect regulatory legal framework of Russian regions relating to forest use, quantitative and qualitative assessment of forests, and supervision of wood logging, transportation, processing and sales (including export sales) also plays an important role.

Besides, changes should be made to the basic forest legislation, i.e. the Forest Code of the Russian Federation.

It is necessary to draft a number of regulatory legal acts at the federal level to regulate the issue under consideration.

Taking into account that the problem of illegal logging of valuable species involves a wide range of violations relating to illegal logging, transportation, processing and sales of wood in the domestic and foreign markets, as well as pricing and customs violations, there should be a clearly established interaction between federal executive authorities responsible for these issues, their regional offices and regional authorities.

To my mind, real-time decision making and coordination of the activities of federal executive authorities designed to control illegal logging and a shadow wood market at the governmental and federal levels might be possible within the framework of an Interministerial Commission. At the regional level, these functions might be performed through the establishment of similar commissions under regional authorities.

Therefore, we are currently drafting a Government resolution on the establishment of the Interministerial Commission to control illegal logging, transportation, processing and sales of illegally logged wood, and the Regulations on the Interministerial Commission and its members.

To ensure an open logging process with due regard for local conditions and a guaranteed compliance with legislative requirements to all stages of forest product movement (logging, transportation, storage, processing and final product shipment to users) the MNR, together with federal executive authorities concerned, has prepared an Action Plan to establish and maintain a forest certification system in the Russian Federation. At present, there is a National Voluntary Forest Certification Board which is drafting a national standard. Forest certification would be conducted in 12 regions and completed in 2005.

To improve the forest management system in Russia the MNR has developed and is implementing a set of measures, including:

The development of a regulatory framework for establishing an electronic forest exchange whose large-scale introduction would make it possible to resolve not only applied tasks relating to the organization of forest resources auctions, but also strategic issues of improving forest management.

The first working session of the electronic forest exchange took place on 30 June 2003 and showed a rather high efficiency of the arrangement.

At present, the Ministry is piloting a system of logged wood labelling that would use special labels put on the butt end of log which would establish a chain-of-custody to trace timber from the stump to the end user, including export timber.

On the whole, the issue should be resolved at the federal level through the adoption of a set of actions aimed at tightening public supervision of wood logging and sales in the domestic and foreign markets, enhancing the status and legal and social protection of forest protection service officials, and providing them with necessary equipment and devices.

Summing up the issue, I would like to say that it should be resolved at the federal level through the adoption of a set of actions aimed at tightening public supervision of wood logging and sales in the domestic and foreign markets, enhancing the status and legal and social protection of forest protection service officials, and providing them with necessary equipment and devices.

**Pest and Disease Management**

Forests in the Far East Federal Okrug are exposed to a number of unfavourable impacts which weaken and kill trees.

Forest fires have been a major reason for tree die-off in the Okrug over the last decade. Fires have destroyed 867,900 ha of forests over that period which is 97% of all perished stands. Forest death from unfavorable weather conditions places second: 20,600 ha (2.3%). The mean area of dead stands is 0.32% of the forested area in the Okrug. The largest area of perished forests was observed in the Kamchatka Oblast and Koryak Autonomous Okrug (2.51%), and a somewhat less area in the Sakhalin Oblast and Chukotka Autonomous Okrug (0.87% and 0.86%, respectively). The trend persisted in 2002. Besides, forest death was observed over large territories in the Sakha (Yakut) Republic. In 2002, forest stands in the Okrug died over the area of more than 157,500 ha which is 47% of all forests which perished in Russia that year. 98% of these deaths were caused by forest fires.

Damage from dendrophilous pests caused the die-off over 1,701 ha (1.1%) of stands. Unfavorable weather conditions killed trees over 805 ha (0.5%). Apart from these factors, forest health in the Okrug is adversely affected by the inadequate use of allowable cut which results in the accumulation of mature and overmature stands. Associations of forest pests and diseases become more active with the natural mortality of trees. The old growth accumulates combustion materials and reduces carbon deposition while the outbreaks of forest pests and diseases originating in the old growth threaten adjacent forests. As a result, the estimated value of the Okrug forests goes down, and general environmental conditions in the Okrug deteriorate. In 2002 taken alone, the Okrug forest value reduced by RUR 2,327.9 million due to timber quality deterioration. Forest health is being improved using a set of sanitary and rehabilitation activities. In 2002, these activities were implemented in 19.7% of the Okrug forests that needed such treatment.

Salvage operations conducted in 2002 enabled the Okrug to increase its forest revenues by RUR 179.8 million.

As of the end of 2002, forest pest and disease outbreaks in the Far East Okrug were observed over 4,764,500 ha which is more than 50 percent of all outbreaks in the country. Far East forests are invaded by a number of defoliating conifer pests, *Dendrolimus sibiricus* being the most harmful among them. Last year, the aggregate area of its outbreaks amounted to 4,583,700 ha. The outbreak of *Dendrolimus sibiricus* which has been observed in the Okrug during the last few years has had the strongest impact on forests in the Sakha (Yakut) Republic and the Khabarovsk Krai.

Air-based activities implemented in 2002 to control Dendrolimus sibiricus in the Khabarovsk Krai stands over 114,000 ha, together with natural factors, made it possible to reduce the area of its outbreaks almost 2 times. In 2003, eradicating measures have been taken in forests of the Sakha (Yakut) Republic and the Khabarovsk Krai over 86,600 ha. Allocations from the federal budget on the eradicating activities exceeded RUR 35.7 million.

The Okrug has organized and is conducting pest monitoring over the forest area in excess of 2.1 million ha.

The most unfavourable forest health situation is observed in the Sakha (Yakut) Republic and the Khabarovsk Krai. The Main Administration for Natural Resources of the Sakha (Yakut) Republic where mass outbreaks of *Dendrolimus sibiricus* covering 6 million ha have been taking place over the last few years does not have a single expert responsible for forest protection. Similarly, forest protection issues do not receive adequate attention in the Khabarovsk Krai which significantly increases the physical and financial costs due to the late detection of forest pest outbreaks.

FGU Roslesozaschita and its subsidiary for the Primorsky Krai monitor dangerous quarantine forest pest species (gipsy moth, pink moth and nun moth) within the framework of an agreement between the US Forest Service and Russian Quarantine Service. The activities allow a free flow of export products through the ports of Nakhodka and Vladivostok.

FGU Roslesozaschita and its subsidiary for the Primorsky Krai, acting under the FOREST Project, arrange for pest control in two leskhozes and organize landscape and environmental monitoring.

To ensure a successful implementation of its forest protection tasks the Okrug shall:

- Strengthen the forest protection units of the regional forestry authorities and consider, as soon as possible, the establishment of FGU Roslesozaschita subsidiaries in the Sakha (Yakut) Republic and the Khabarovsk Krai;
- Develop region-specific pest monitoring projects;
- Conduct field surveys of the Okrug forests with the most difficult forest health conditions.

**Reforestation**

In 2002, final clear cutting and sanitary clear cutting in the Okrug forests managed by the MNR covered 100,800 ha. Reforestation activities were conducted over 234,800 ha, including forest planting and seeding over 25,800 ha; the area of young growth classified as economically valuable stands amounted to 323,400 ha. Total expenditures on forest reproduction was RUR205.9 million, including RUR73.3 million allocated from the regional and local budgets. Most reforestation activities were financed through leskhozes (RUR132.1 million or 64 %).

Pursuant to the Reforestation Program of the Russian Federation for 2003-2010 designed to implement the Federal Targeted Program *Russian Environment and Natural Resources: 2002-2010*, the 2003 reforestation plan of the Far East Okrug covers 209,000 ha, including forest planting and seeding over 21,500 ha; thinning in young stands over 33,600 ha; and transfer of young growth into the category of economically valuable stands over 272,000 ha. The regional budgets have earmarked RUR 110.3 million for forest reproduction which is about 20% of the norm. The Khabarovsk Krai and Sakhalin Oblast budgets have earmarked only 6 percent.

As of 1 August 2003, reforestation activities were conducted over 71,400 ha, including forest planting and seeding over 21,300 ha, silvicultural treatment of forest plantations over 5,600 ha, and establishment of seeding plots in forest nurseries over 66 ha.

All regions in the Okrug met their forest planting targets in the spring-summer season, except the Kamchatka (70%) and Amur (93%) Oblasts, which should complete the silvicultural operations in the fall.

By the end of the first six months of 2003, expenditure on forest reproduction amounted to RUR 83.1 million while the actual allocations from the regional and local budgets amounted to RUR 42.9 million or 52 percent. No funds were allocated for these purposes from the Khabarovsk Krai budget.

Unfortunately I have to note that the Khabarovsk Krai and the Jewish Autonomous Oblast have no regional reforestation programs approved by the regional public authorities.

**Peculiarities of Reforestation in the Far East.**

Russia's vast forests differ by their climatic and soil conditions, intensity of forestry activities, and cutting and reforestation practices.

Reforestation tasks depend on natural and economic conditions in a specific region. Major reforestation principle is a mandatory restoration of cutting areas and regulated natural forest growing in other forest-free areas. In northern and middle taiga, the natural regeneration capacity of forests allows a successful use of natural regeneration in almost 70% of forest-free areas while 30% of the areas require the implementation of silvicultural activities; in southern taiga the ratio is about 50:50; in the mixed forest zone, silvicultural activities shall amount to 70% of total reforestation; and in the forest-steppe zone the figure increases to 100%.

The most common reforestation practice in the Far East is the facilitation of natural forest regeneration. Local site conditions are characterized by a high natural regeneration rate. Forest planning and inventory materials indicate that with good logging practices silvicultural activities shall be conducted only over 5-10% of the cutting area while in 40-45% of the area it is possible to take actions that facilitate natural forest regeneration; half of the cutting area may restore in a natural way.

In 2001-2002, reforestation area exceeded the area of final clear cutting and sanitary clear cutting 2.3 to 2.6 times. The balance of cutting and reforestation is maintained in all Far East regions.

According to the state forest accounting, the total forest-free area in the Far East increased between two accounts (1998-2003) by 2.7 million ha or 3.6 percent. As of 1 January 2003, the total area that required reforestation amounted 24.5 million ha. The majority of these lands are located in hardly accessible places. Areas that need forest seeding and facilitation of natural regeneration and are accessible for economic development amount to 0.6 million ha or 2.5 % of the total forest-free area.

Cedar (*Pinus sibirica*) forests play a special role in the Far East. A major cedar forest restoration method is to facilitate natural forest regeneration through an intensive removal of naturally regenerated cedar from under the deciduous species canopy. Silvicultural activities shall be implemented when cedar cannot be restored by facilitation measures. At present, cedar plantations are annually established over 6,000 to 8,000 ha. Efforts are made to improve the organization level of the cedar seed base and introduce the advanced methods of planting material cultivation and seed preparation.

Forest fires are a major factor determining forest conditions in the Far East. The area of burnt forests in the Far East is 10 times larger than the cutting area. Forest protection against fires is a key forest management issue for the territory.

# Important Forest Fire Issues in Russia

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In the late 20th – early 21st century, critically high fire rates turned forest fire into a problem of an unprecedented scale in the humankind history. There are many reasons for it ranging from the obvious climate change towards warming and aridity to extremely adverse consequences of many years of economic activities within forest areas resulting into grave structural transformations in the Forest Fund and stands, accumulation of forest fuels in great amounts, and impaired natural fire resistance of forests. Many forest regions of the world see the emergence of paradox outcomes of the earlier widely-used system of forest protection against fire lacking scientific justification: the more thoroughly and the longer fire impact on forest ecosystems was suppressed without a well-planned system of forest management activities to counteract the natural and unavoidable up-building of fire danger in forests, the more preconditions arose for the occurrence of catastrophic fires at a certain stage. Such a trend is most common for large forest areas in North America and Eurasia, but it has not passed by Australia, Southeast Asia, the Mediterranean and other regions, either.

The international community's concern over the high fire rates and perceptions of fire in the forest in a broader historical context were discussed at a number of major conferences on wildfire, including those supported by UN and the World Bank. Following-up such events, the MNR held an international seminar supported by the World Bank, in Khabarovsk on 9-12 September 2003.

The theme of the Seminar - "New Approaches to Forest Protection and Fire Management at the Ecoregional Level" - implicitly contains the notion of search for essentially new region-specific forest fire management strategies and technologies, really differing from the conventional ones. No doubt, the search for silviculturally, environmentally and economically efficient approaches and practices of forest protection against fire is of particular importance for Russia possessing over one billion ha of most diverse forests growing in various natural and economic conditions. For over eight decades, this vast area has been protected against fire according to a single stereotype established under the centrally planned, input-based inefficient economy. The system practically neglected recommendations of Russian and international forest pyrology.

Clearly, Russia must not mechanically transfer into its reality everything which is acceptable for other regions of the world – overdoing may be harmful in this sense. It is notably applicable to the concept of "fire management" which has been recently in vogue among certain circles. In this case, it should be born in mind that it is usually impossible "to manage a fire as a process of spontaneous spread of burning over a forest area" unless it is a prescribed burning for resource management purposes rather than a wildfire. Obviously, the term should be understood as the management of the pyrogenic factor through regulating the periodicity of fire impact on forest ecosystems with varying intensities of burning, and in some cases, complete elimination of this factor. The objective is to create such a regime of pyrogenic impact on forest ecosystems which would make it possible to preserve the whole range of dynamic plant communities and preclude the occurrence of destructive fires. Approaches to addressing this task should integrate prescribed burning as a tool for lowering the risk of abundant accumulation of surface fuels and fire regeneration under the canopy of commercially valuable coniferous stands.

A flexible approach to regulating the periodicity and extent of fire impact on forest ecosystems pre-determines various levels of forest protection against fire with each of them requiring certain financial inputs per protected area unit and appropriate technical and technological support. All these issues were touched up and more or less thoroughly discussed in the Seminar Proceedings. The publication reflects international experience and will be useful when addressing the complex and multi-faceted problem of forest fire.

# 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 *

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## 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 20$^{th}$ 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.

* Note: This paper has been pre-published in International Forest Fire News No. 29, 89-111. For completeness of the Special Issue on the Khabarovsk Conference the paper is reprinted in this volume.

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).

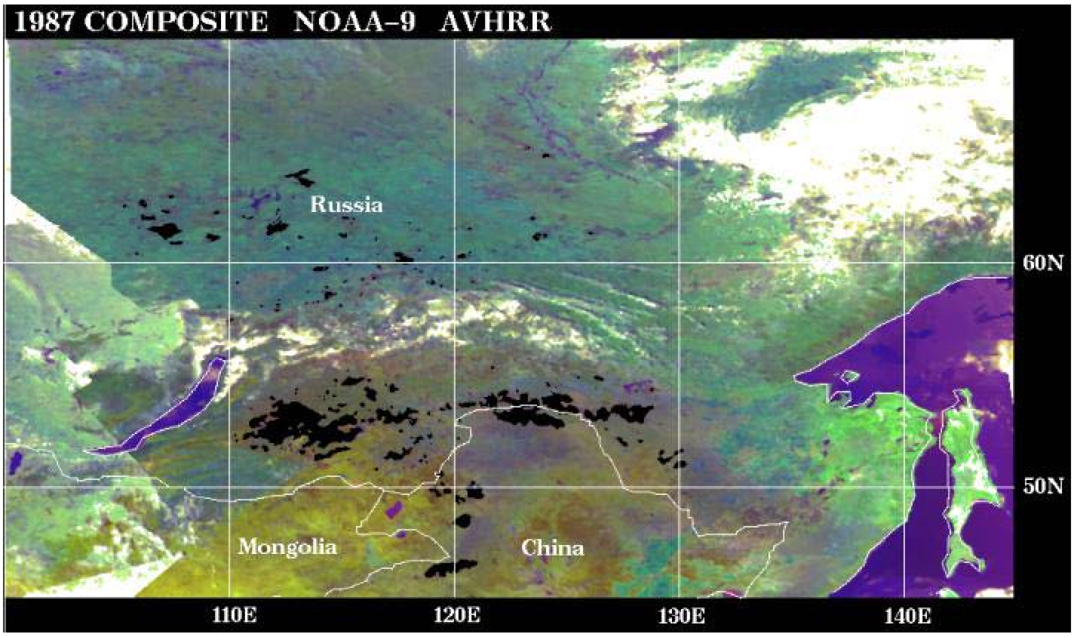



**Figure 1**. NOAA-AVHRR-derived burn scar map of the fire season of 1987 (Cahoon et al. 1994).

### 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.

Another recent study conducted by the authors of this paper investigated the fires of 2003 occurring in the region between 110.27°E to 131.00°E and 49.89°N to 55.27°N evaluating scenes of MODIS, MERIS and ASTER and compared with NOAA AVHRR. The study revealed that more than 20.2 million ha of forests and other lands had been affected by fire (Siegert et al., 2004).

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). The analysis of fires in Russia between 1996 and 2000 by NOAA AVHRR conducted by Soja et al. (2004) also support the discrepancy between officially reported fire sizes and satellite-derived data.

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.

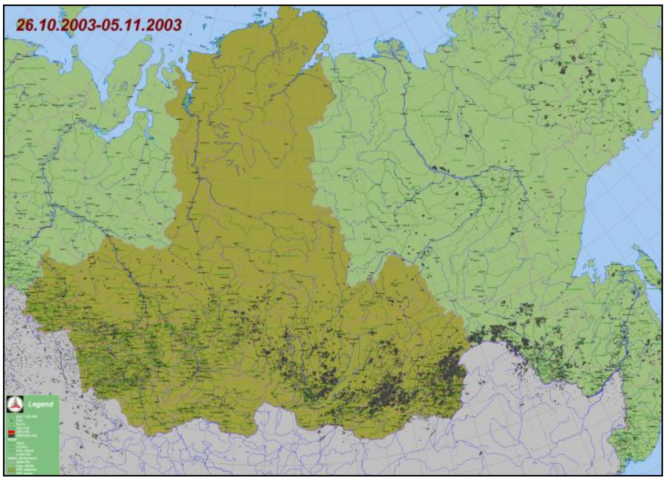



**Figure 2**. NOAA-AVHRR-derived burn scar map of the fire season of 2003. Source: Sukachev Institute for Forest.

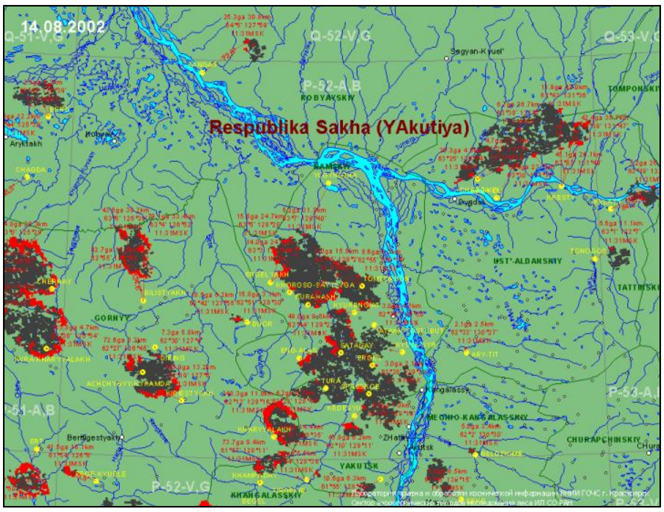



**Figure 3**. Example of a daily NOAA-AVHRR-derived burn scar map (Yakutia, 14 August 2002) generated by the Fire Laboratory of Sukachev Institute for Forest and displayed daily on the GFMC website.

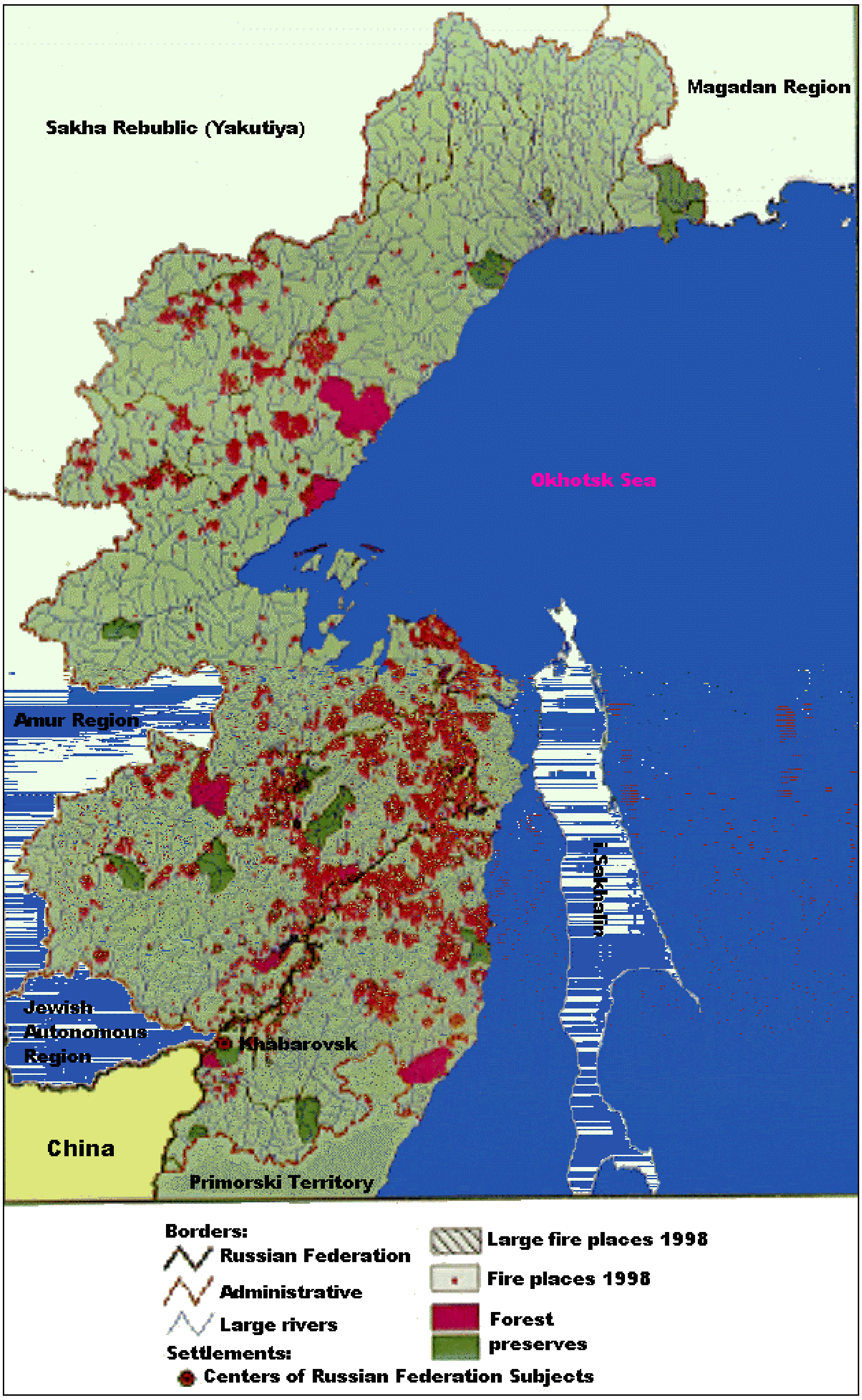



**Figure 4.** Forest fire map of Low Priamurya region at the end of the 1998 fire season. This fire map was digitised with the assistance of the Amur Design Office of the Russian Branch of the World Wide Fund for Nature (WWF). Source: Efremov and Sheshukov 2000.

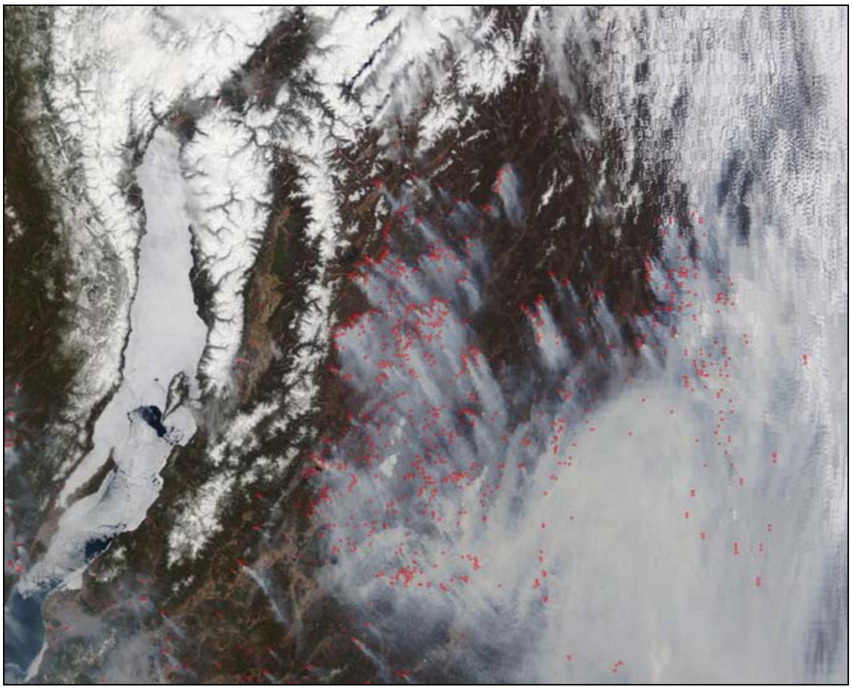


**Figure 5**. Fire activities on 8 May 2003 at 0400 UTC (11:00 local time) Southeast of Baikal Lake. Source: Moderate-Resolution Imaging Spectroradiometer (MODIS).

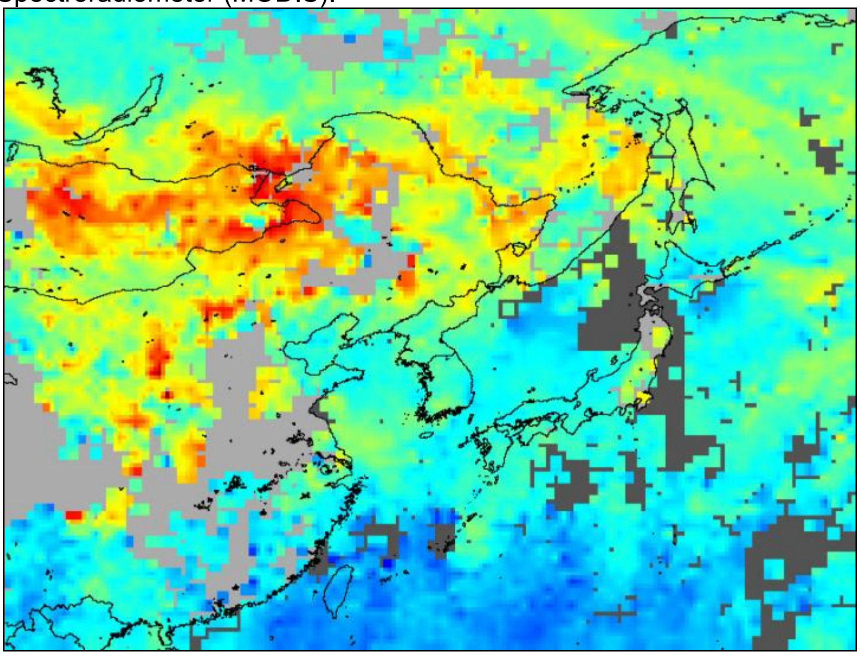
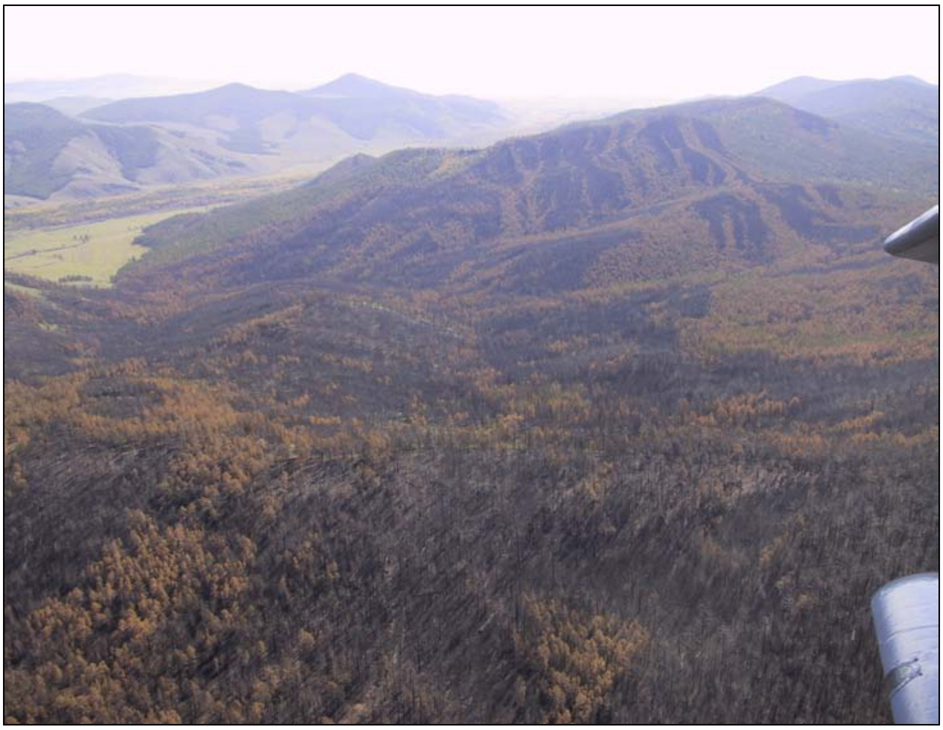


**Figure 6**. Accumulated carbon monoxide concentration for the period 3-8 May 2003 originated by smoke from wildland fires in the Transbaikal Region. The image shows measurements of carbon monoxide captured by the Measurements of Pollution in the Troposphere (MOPITT) sensor on the Terra satellite, with 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 9a-f in this report use Sukhinin's maps for the 5-year period 1998 to 2003 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

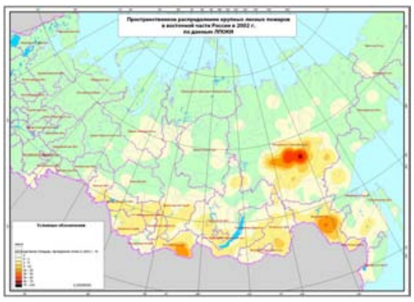


**Figure 9e**. Fire activity map of 2002

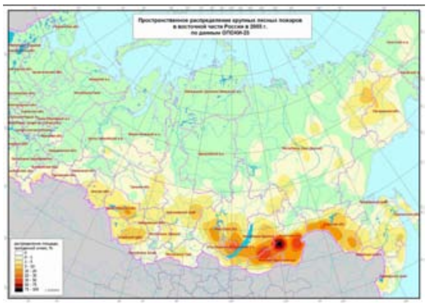


**Figure 9f**. Fire activity map of 2003

**Figure 9a-f.** Spatial distribution of areas burned by different degree in the Eastern part of Russia in the fire season of 1998-2003, 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.

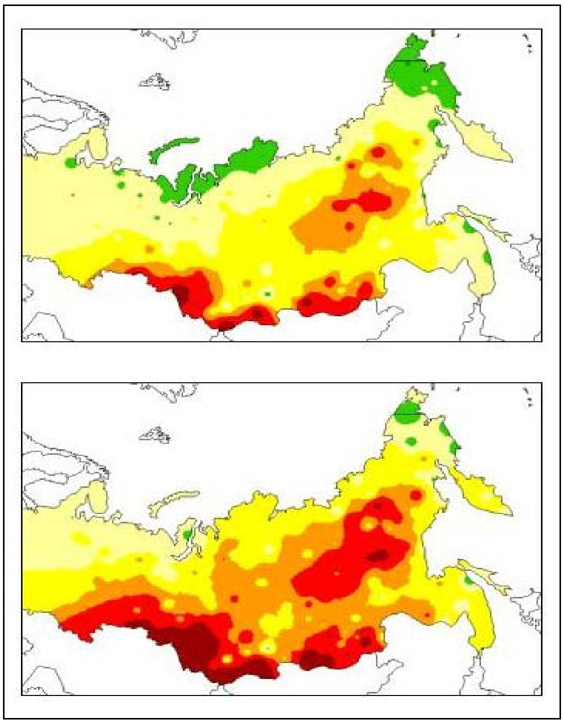


**Figure 10.** Seasonal fire severity rating across Russia under current climate conditions (upper) in comparison to a projected $2xCO_2$ climate (lower), based on the Global Circulation Model (GCM) of the Canadian Climate Center (CCC). Note the significant increase in the severity and geographical extent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

### 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 19$^{th}$ 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)[1]. 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 non-forested 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.

[1] 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.

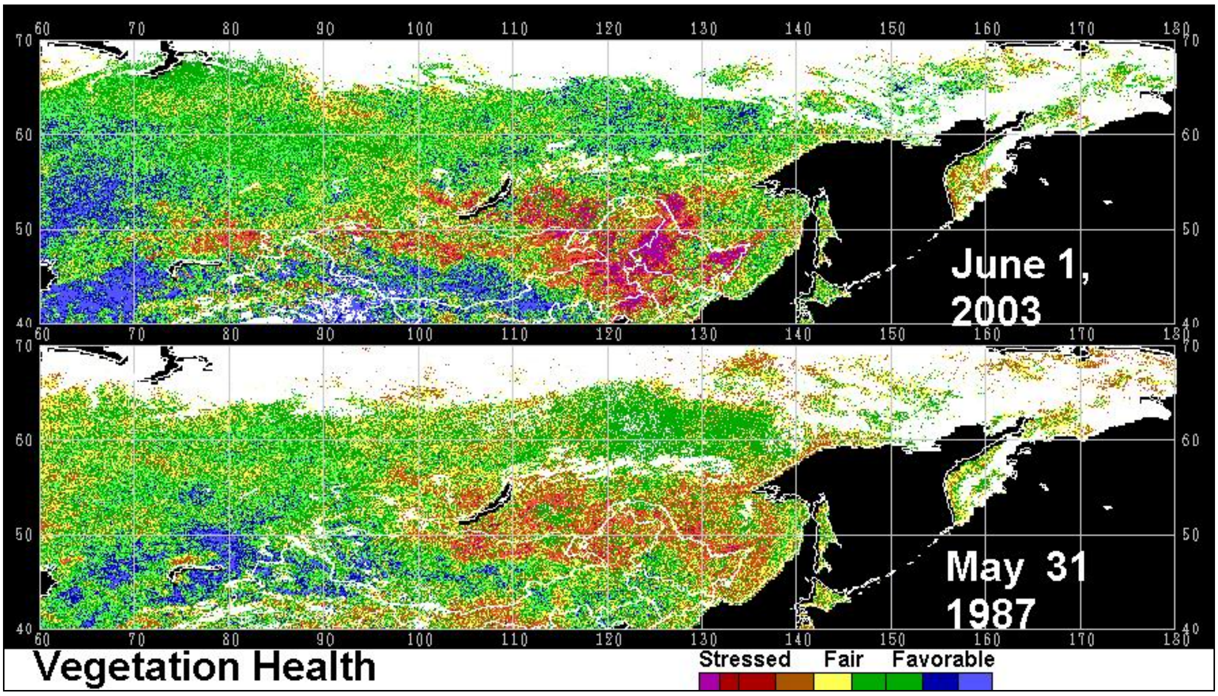



**Figure 11.** Vegetation health maps of Southern Siberia, Mongolia and Northern China on 1 June 2003 and 31 May 1987. The images is a colour-coded map of vegetation condition (health) estimated by the Vegetation and Temperature Condition Index (VT). The VT is a numerical index, which changes from 0 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.

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

(footnotes of Table 3 continued):
(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.

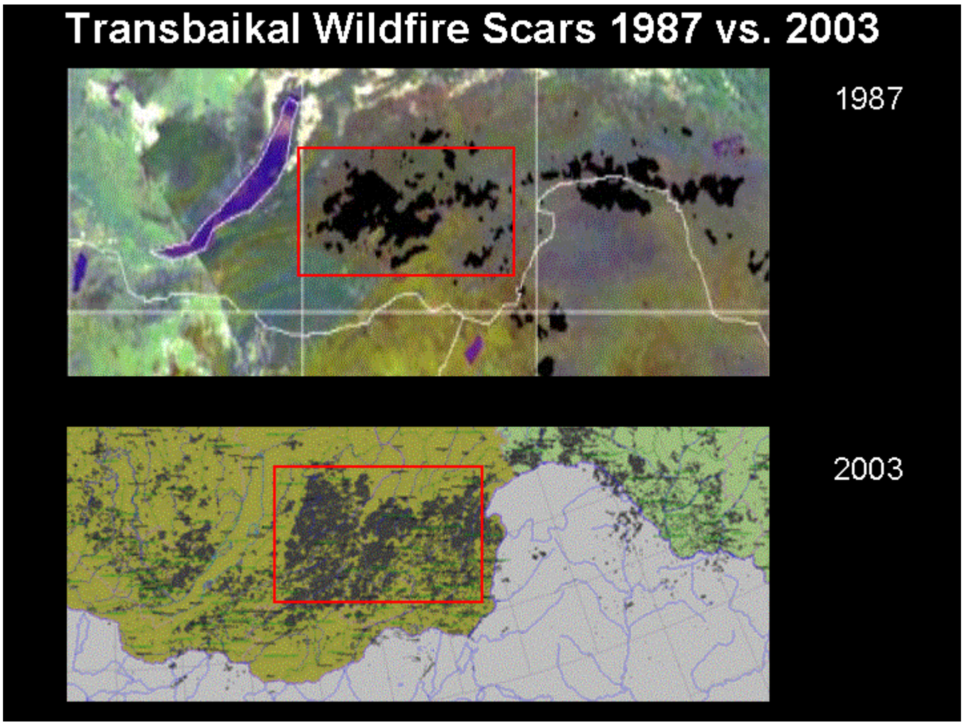



**Figure 12**. Comparison of the NOAA-AVHRR satellite-derived area burned in the region Southeast of Lake Baikal in 1987 (Cahoon et al. 1994) and 2003 (Sukhinin 2003). A major overlap of the area affected by fire during both episodes implies the necessity to revisit the datasets and the conclusions concerning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

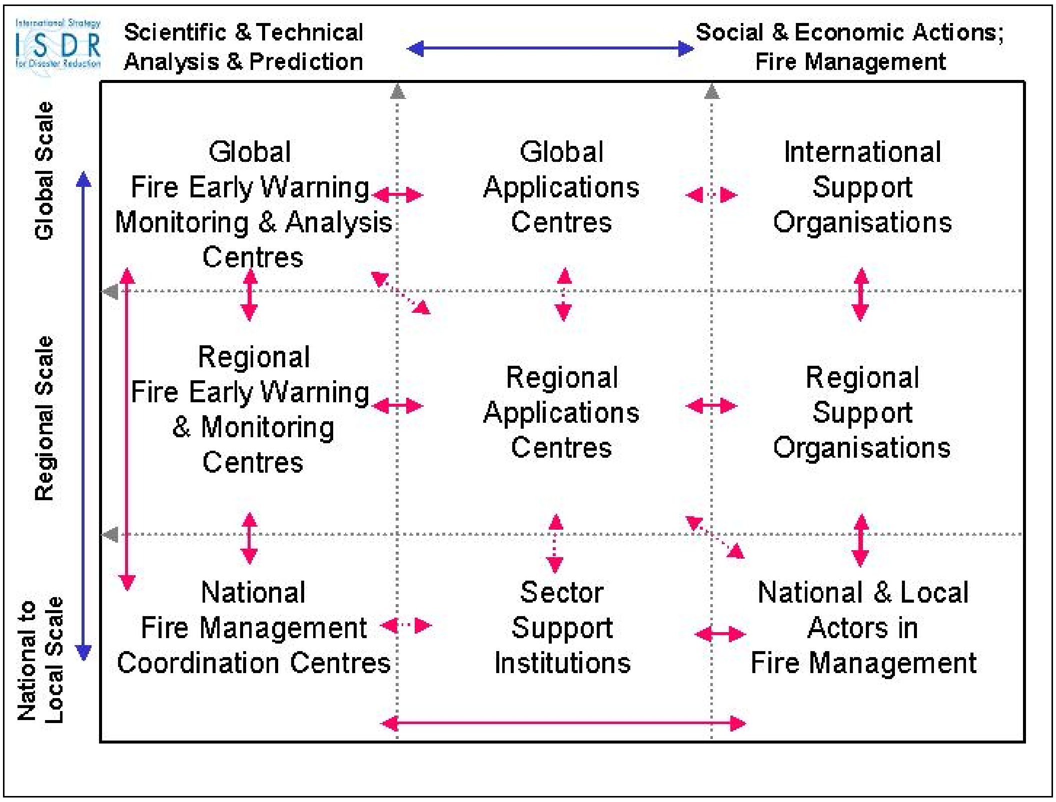



**Figure 13.** Schematic view of relationships and multi-directional flow of information, data, knowledge and advice in a global wildland fire network.

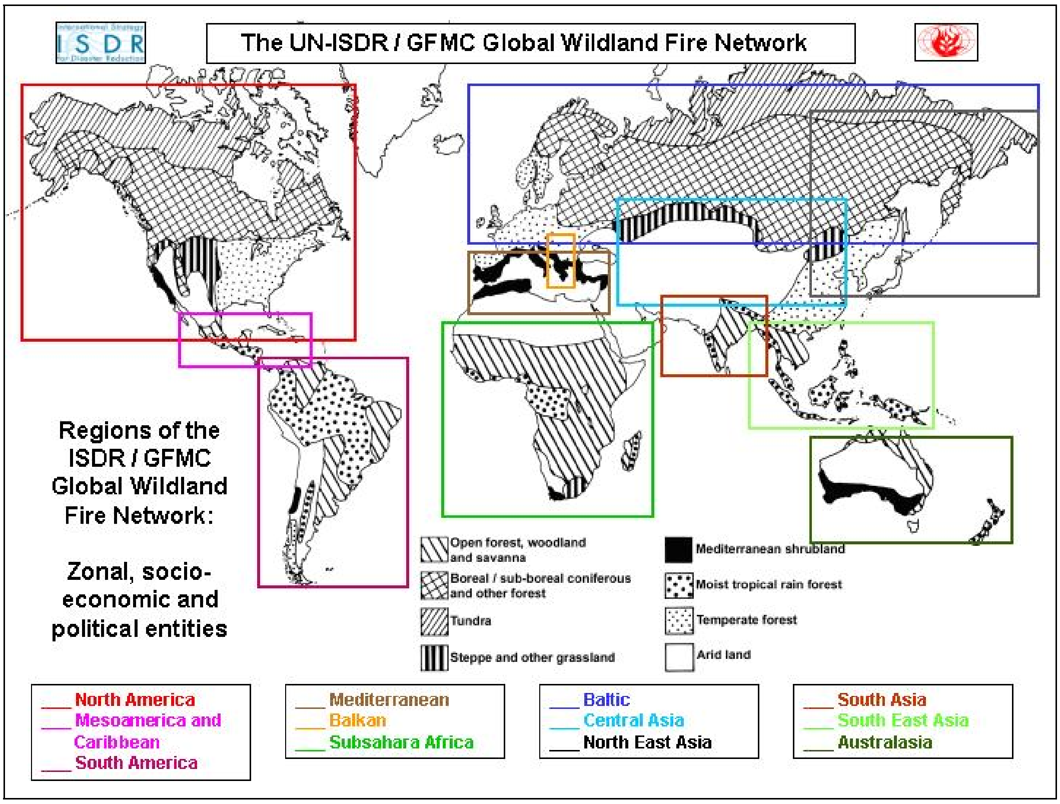



**Figure 14.** Delineation of regions within the Global Wildland Fire Network. Due to the size and inter-zonal extent of its territory the Russian Federation is encouraged to participate in three regional networks (Baltic, Central Asia, East Asia).

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[2]:

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

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

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

Meanwhile a “Framework for the Development of the International Wildland Fire Accord” has been jointly agreed between the GFMC/ISDR, FAO and GOFC-GOLD. The framework provides a roadmap between 2004 and 2005 towards development of a global agreement in wildland fire management (GFMC 2004).

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.

**Acknowledgements**

The authors gratefully acknowledge the in-depth discussion of this paper with Anatoly Shvidenko, International Institute for Applied Systems Analysis (IIASA). Don Cahoon discussed methodologies and relevance of his investigations of the wildfires burning in the area in 1987. The regional vegetation health maps for 1987 and 2003 were generated especially for this paper by Felix Kogan (NOAA NESDIS).

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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.[3]

**1. General Statement: The Role of Fire in the Global Environment**

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

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

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

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

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

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

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.

# Long-term Environmental Impact of Catastrophic Forest Fires in Russia's Far East and their Contribution to Global Processes

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When assessing the negative consequences of forest fires, researchers usually limit the consideration of the problem to the relatively short period of time that is presumably needed for restoration of the destroyed biotope. The impacts and consequences considered include direct fire-related loss of biological resources and commercial products, the rate and capacity of biological resources restoration, emissions of carbon and other pyrogenic products, specific features of the destruction of existing phytocenosis and formation of initial post fires, etc. It is commonly believed that post-fire rehabilitation leads to the formation of a new stand whose structure and composition would be very close to those of the pre-fire stand, and where the negative consequences of fire are extinguished and graded in a relatively short period of time. The philosophical background of this approach is recognizing the reversible nature of pyrogenic disturbances of forest ecosystems. However, recent studies have indicated that post-pyrogenic consequences of forest fires, in particular, of catastrophic forest fires, are cumulative in nature. Based on the fire's duration and severity, the level of the fire's concentration over territories, landscapes' and ecosystems' specifics, etc., the transformation of historically stabilized ecological processes is observed in all ramifications, including both biotic and abiotic spheres, in particular, synoptical processes.

In this respect, the major objectives of this paper are to:

- provide a brief characteristic of transformation and long-term environmental consequences of large forest fires and post-pyrogenic disturbances of forest;
- assess the global role of regional catastrophic forest fires;
- describe the trends and rates of "green desertification" (deforestation), as well as signs and criteria of pyrogenic impacts on forest ecosystems;
- consider specific features of fire emissions of greenhouse gases after catastrophic fires.

In this context, catastrophic forest fires mean fires covering an area of more than 10,000 ha, resulting in the total destruction of vegetation and organogenic horizons of soils, or the simultaneous occurrence of several fires of the same total area and intensity over a total area of 1,000 $km^2$ (Sheshukov, 1971). The term *catastrophic* is sometimes used in a different but close context. The classification of post fire catastrophic "traumatism" by Sapozhnikov (1984) includes the highest level of a fire's impacts following destruction of the soil cover, intensive soil erosion, and development of stone fields in mountains. The forests are destroyed completely, and are not restored before new soils are generated. For this class, the loss of potential productive forest land is estimated at more than 80% and lasts for a period of over 20 years (Sapozhnikov, 1984). Shvidenko and Nilsson (2003) used the term *catastrophic fire year* as a year for which the extent of fire is three-fold, more than the multi-year average and where the severity of fire is extremely high.

Long-term pyrogenic consequences are the irreversible transformation of the forest environment, which is obvious beyond the restoration period of an indigenous forest ecosystem, i.e. exceeds the length of the rotation period (i.e., ranging from 100-400 years for major forest forming species of the Russian Far East).

Russia's Far East has a clearly expressed geographical distribution of forests and specific nature of forest growing conditions that causes the high burning ability of forests. It makes this region an ideal model for studying the patterns and roles of forest fires in the evolution of forest vegetation and their input into global processes. This study is based on the long-term research of consequences caused by catastrophic forest fires in Khabarovsk Krai over a historically observable period of time.

In the context of the Far East, forest fires have always been the main factor determining forest-forming and forest-producing processes and specifics of succession regularities. To judge by the retrospective analysis of the vegetation cover structure and by the presence of charcoal in soil horizons and native bed rock depositions, catastrophic forest fires have occurred over the entire quaternary period. Peaks of the highest forest fire occurrence coincided with droughts and peaks of solar activity, as their frequency was between 40 to 80 years. In recent years, there has been a trend toward an increased magnitude and frequency of catastrophic fire occurrence. In particular, over the last 40 years, we observed peaks of catastrophic forest fire occurrence in 1976, 1988, and 1998, i.e. every 10 to 12 years (Fig. 1). There appears to be a clear link between the increased magnitude of catastrophic fires and enhanced anthropogenic impact on forests. The history of linear trends prior and after the 80s clearly shows an increased level of natural fire incidence, which might be viewed as an increase in the share of forest fire caused by anthropogenic factors. If we assume the indicators of burning given in Table 1 as the rate of natural forest fire regimes, we observe a dramatic prevalence in the rate of actual fire occurrence during recent decades over the rate of (mostly) natural fire occurrence of the previous periods, as well as an extensive destructive effect of forest fires regarding to the total forest fund area and, in particular, to local forest areas affected by repeated forest fires.

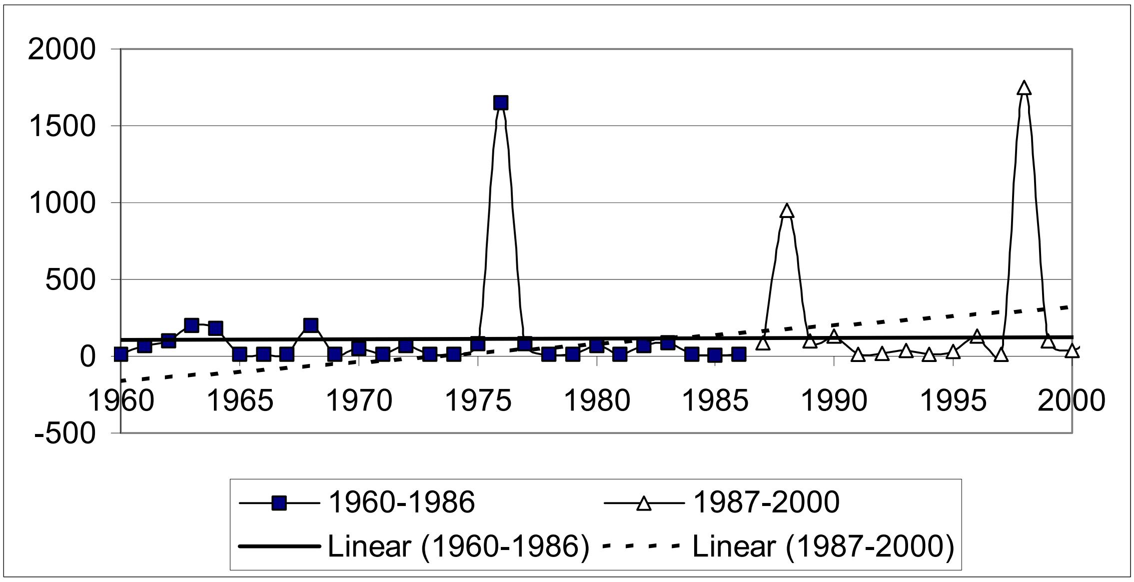


**Figure 1.** Area affected by fire in Khabarovsk Krai by periods (ha x 1000)

For example, in Khabarovsk Krai alone, 1,314 forest fires, which occurred there in 1998, affected 2.7 million ha or 3% of the total forest fund area. The fires were concentrated on an area of some 15 million ha. The severity of fire was extremely high and significant areas (estimated at 0.4 million ha) have lost organogenic horizons of soils almost completely (Kulikov, 1998). It is worth to mention that we use data of official forest fire statistics, which are very probably underestimated (Shvidenko and Goldammer, 2001). However, under any estimates, it is evident, that fires of that magnitude should be viewed as a pyrogenic disaster beyond a regional context, with century-long biotic, environmental, and socio-economic consequences.

Generally, the long-term environmental consequences of catastrophic forest fires became apparent in the following aspects:

1. A significant (up to several times) decrease of the biological productivity of forest lands due to the destruction of the indigenous ecotope and replacement of indigenous vegetation formations.
2. Irreversible changes in the cryogenic regime of soils and rocks.
3. Change of long-term amplitude of hydrothermal indicators beyond natural fluctuation.

4. Changes of multi-year average hydrothermal and bio-chemical indicators of aquatic and sediment runoff, as well as of hydrological regimes and channel processes of water streams.
5. Accumulative impacts on atmospheric processes resulting in global climate change.
6. Acceleration of large scale outbreaks of insects and disease.
7. Irreversible loss of biodiversity including rare and threatened flora and fauna species.
8. Transboundary water and air transfer of pyrogenic products.
9. Change of historical migration routes for migratory birds, ground and water animals.

**Table 1.** The ecologically permissible norm of fire occurrence rates for forest formations of Russia's Far East.

| Indicators | Rate (percent of total area of forest fund) |
|---|---|
| **Actual overall average annual fire occurrence rate** | 0.35 |
| Maximum | 4.0 |
| Minimum | 0.02 |
| **Hypothetically allowable rate for main forest formations** | |
| Dwarf pine forest | 0.01 |
| Spruce - fir forest | 0.1 |
| Cedar - broadleaf forest | 0.07 |
| Hardwood deciduous forest | 0.2 |
| Larch forest | 0.3 |
| Forests of river valley | 0.5 |
| Softwood deciduous forest | 0.3 |
| Grass-meadow communities | 0.6 |

Note: fire occurrence rate means a ratio (in %) of the total fire-affected forested area to total forest fund area or the area of individual forest formation.

Losing forest-producing lands is the most pronounced negative post-fire consequence of catastrophic forest fires. It leads to a dramatic degradation of the indigenous ecotope up to the irreversible and complete loss of forest-producing potential. There is a pronounced statistical link (Fig.2) between deforestation of lands and a forest fire occurrence rate. In particular, the correlation coefficient between the share of unforested areas and a forest fire occurrence rate is estimated to be 0.49 (0.05 level of statistical significance) (Sheingauz, 2001). At the level of a *Leskhoz*, a 1% increase in a forest fire occurrence rate will cause an 8.4% increase in the share of forested areas.

Over the last 50 years, forest fires increased the total area of deforested lands in the region by up to 8.0 million ha. Generally, single or repeated catastrophic forest fires transform about 30% of highly productive forest land (with a total stock of phytomass of up to 1000 Mg dry matter per ha) to barren land areas for which forest regeneration is postponed for an indefinitely long period of time. These lands include up to 70% of bogs, 15% of grass-small shrub and shrub lands, 10% of open woodlands, and up to 5% of stone fields and stone outcrops. Such lands can only be rehabilitated through targeted and labour-consuming meliorations. The natural restoration of forests requires hundreds of years in these areas.

The post-fire mechanism of indigenous ecotope transformation is closely linked to the changes of the multi-year average hydrothermal regime of soils. In particular, the average temperature of surface and near-surface subsoils of burned out forested areas is twice as high as the surface's temperature of soils under the forest canopy of areas that have not been affected by fire. Maximum soil temperatures could reach as high as 65°C resulting in a thawing of the near-surface layer of permafrost. The future succession trajectories depend on climatic peculiarities, properties of landscapes and severity of fire. As usual, given the lack of the forest stands' main drainage capability leads to changes in the water regime of habitats, irreversible swamping or meadow formation or, eventually, to the formation of post-fire stands with a lower productivity. On permafrost of continental territories with an insufficient amount of precipitation, it leads to the development process of northern steppization and replacement of forests by aridized steppe and shrub vegetation. Catastrophic fires eventually increase albedo and substantially impact all components of heat balance over large territories.

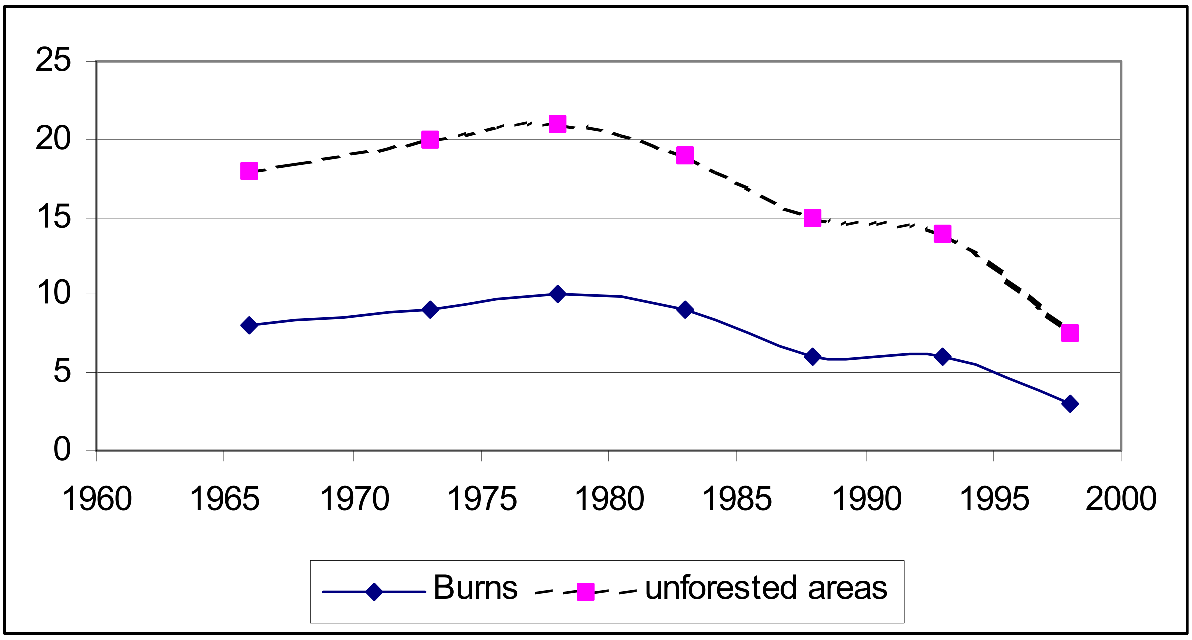


**Figure 2.** Percentage of burned out forest lands and unforested areas against forest fund areas

These changes have been the focus of many studies and are well quantified. Mechanisms and levels of the impacts of forest fire on the hydrological regime and water flow of rivers and, consequently, on spawning conditions for salmon and other valuable fish are less understood. The latter is of major importance for the Russian Far East, e.g., for the Amur River basin. A number of studies identified a linkage between the forest cover percentage in a watershed and annual runoff. Thus, a 10% change in the forest cover percentage in a watershed results in a 1.5-2% change in annual runoff. More importantly, deforestation of watersheds results in a dramatic fluctuation of water levels and flood performance. In addition, large fires impact temperature and contaminate water with ash and products of soil erosion that can lead to the mass mortality of fish.

There are specific features of the impacts of catastrophic fires on major biogeochemical cycles. The ratio between ground, peat (sod) and crown fires shifts to increasing crown and peat fires. The consumption of fuel is about 1.5 times higher compared to multi-year averages. The total amount of consumed carbon reaches 5 to 10-fold during catastrophic years. In 1998 the area of fire for entire Russia was estimated to be about 10 million hectares and consumed carbon – about 165 TgC (Kaji et al., 2002). The increase of peat and sod fires changed the gas composition of emissions increasing the share of methane (up to 2-3%) and carbon monoxide (up to 10-12%). It substantially increased the global warming potential of emissions. The post-fire mortality on areas affected by non-stand replacing fires is on average twice as big as under “normal” fire conditions. Eventually, large previously forested areas can be completely destroyed due to the post fire die-back accelerated by following windfalls. Taking into account the increasing probability of recurrent fires, this situation usually initiates degressive succession developments, which lead to the impoverishment and degradation of forest landscapes.

Much less attention was given to the study of forest fire impacts on large-scale atmospheric processes, because such impacts appear to be obvious if significant areas are enveloped by hot spots of high concentration. For example, the 1998 summer and autumn fires generated smoke that affected an area of over 500,000 km$^2$. In the southern part of Khabarovsk Krai, the smoke generated by the 1976 autumn forest fires spread over an area that was five to seven times larger than the burning area. The NOAA-5 weather satellite infrared images showed that the haze covered the north-east of China, the southern part of Khabarovsk Krai, the northern Japanese Sea including the Tatar Strait and Sakhalin. This is quite comparable with the scale of impacts of baric systems.

For nearly four months during the 1998 summer and autumn catastrophic forest fires, the solar-flux levels at a height of 2 m in the smoke affected area was between 10 to 20 percent under completely fair weather due to light-scattering effects. This reduced the maximum air temperature by 10 to 15°C and produced a pronounced "nuclear winter" phenomenon.

Observations of atmosphere patterns over the burning and smoking forests in Eastern Siberia and the Far East recognized (Sokolova and Teteryatnikova, 2002) the presence of anticyclones above huge chunks of Asian territory, from the Yenisei River to the Okhotsk Sea. These territories where enormous amounts of forest fuels is accumulated and which are characterized by a special atmospheric state, had a large-scale smoke blanket, the size of which is comparable to the extent of baric systems (i.e. over an area of 350-400,000 km$^2$) and which have a long period of high atmospheric pressure. It forces the cyclones to take a southern bypass (Fig. 3). The latter is the cause of intensified drought episodes over the fire-affected areas that extenuate the forest fire situation. The presence of anticyclones in temperate latitudes of Eastern Asia both in winter (this is common) and summer time (which is unusual) is due to the increased air density (through the cooling down of near-surface layers caused by the smoke aerosol), and summer anticyclones are duplicating the mechanism of winter ones. Alternatively, such a meteorological situation can generate long periods of rainfall and catastrophic floods like the basin of Yangtze River in summer of 1998.

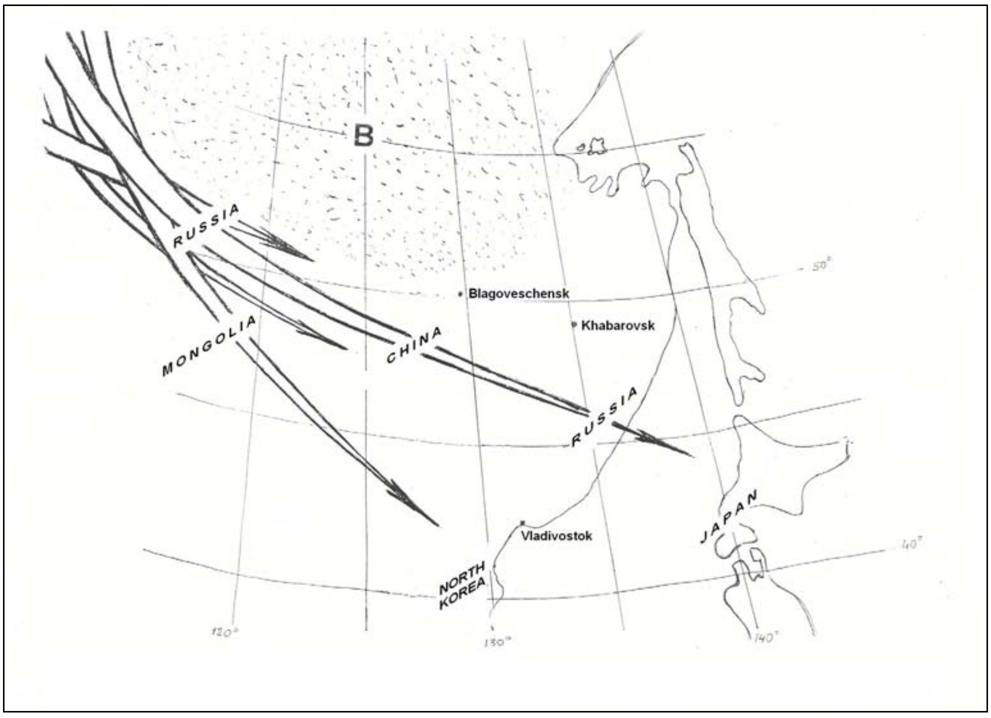


**Figure 3.** Trajectories of cyclones bypassing the anticyclones over burning and smoking forests of the Far East in the summer of 1998

Analysis of the meteorological processes based on pressure charts identified one specific feature. In all the years, when in early summer the usual tropospheric ridges at a baric height of AT-500 came into being in the smoke affected atmosphere, rather than in a clear one, the anticyclones (associated with a drought) persisted in this area over the entire summer (Fig. 4). This smoke-affected anticyclone is not destroyed over the entire warm period. Similar spatio-temporal sustainability for the continental ridges that are not affected by smoke aerosol does not exist in contrast to the smoke affected ones. During the summer, the continental tropospheric ridge is being supported by powerful heat fluxes from fire and hot smoke. Only the decreased solar radiation in late summer eliminates the influence of smoke atmospheric aerosol that leads to the gradual destruction of the continental tropospheric ridge.

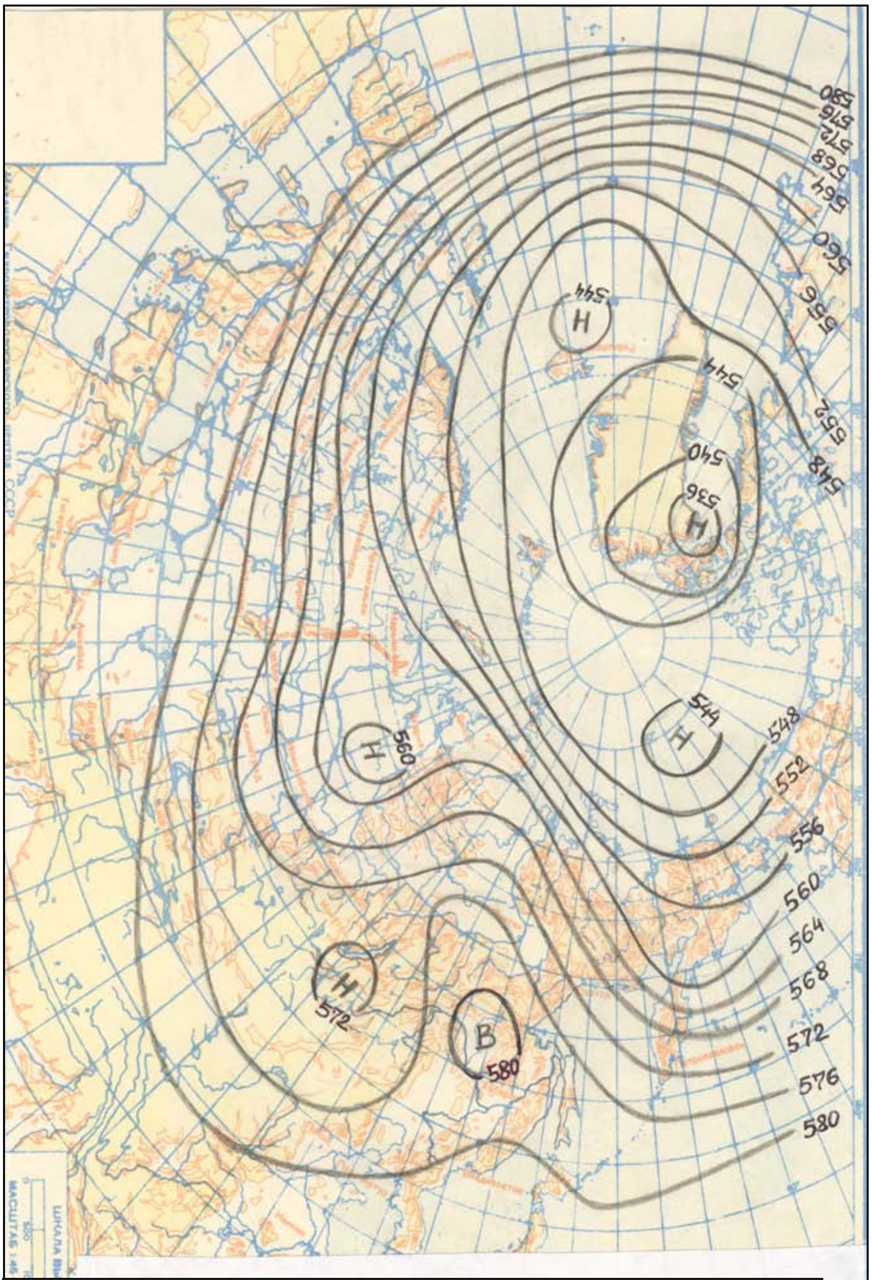


**Figure 4.** Constant Pressure Chart the Northern Hemisphere at a height of 5,000 m (surface 500 hPa) between 2 to 6 August 1998

During catastrophic forest fires, such meteorological conditions occurred in 1954, 1968, 1976, 1988, and 1998 in the Amur River Region, in 1979 and 1985 – in the Eastern Siberia (Krasnoyarsk Krai), in 1996 – in Amur Oblast and in the Republic of Sakha-Yakut, and in 2002 – in the Republic of Sakha-Yakut (Sokolova and Teteryatnikova, 2002). Despite an incomplete understanding of the mechanism of the above-mentioned regularities, we may safely assume that catastrophic forest fires have a substantial influence on the formation and alteration of surrounding parameters of the regional climate, with an apparent effect on global climate through a hierarchy of linkages.

Climate change is linked to the profound transformations of biotic processes. In particular, in recent years, for the first time in its history, Khabarovsk Krai faced an intensive outbreak of gypsy moss (*Limantria dispar*) on an area of some 8 million ha. There is evidence that this phenomenon is an aftereffect of the pyrogenic disaster of 1998. It is worth to note that the synergism of fire and biotic disturbances is typical for whole Northern Eurasia. Hence, the outbreak of Siberian eggar (*Dendrolimus superans sibiricus*) impacted from 8 to 10 million hectares in Yakutia in 2001-2002 under similar conditions.

Negative impacts of catastrophic fires on biodiversity is evident (Kulikov, 1998), in particular, at ecotones' boundaries and boundaries of natural habitats of animal and plants. They decrease the amount of fodder, lead to fragmentation of habitats and eventually substantially decrease populations of animals, reptiles and birds. Also migrating birds and ungulates now use routes that differ from their traditional ones.

In this work we are not in the position to quantitatively illustrate the effects of catastrophic forest fires on erosion processes and increased solid runoff, whose redistribution will change both the productivity of soils and aqueous runoff quality, transform river flows and bring about the irreversible loss of spawning sites. There could be other dramatic consequences as well. It is necessary to note, that all these are of a transboundary nature and their significance is beyond the regional context.

It is readily apparent that the international community should recognize the importance of catastrophic forest fires in the context of global climate change. It should identify criteria for the assessment of global threshold indicators regarding regional-level pyrogenic disasters and international responses for the management of catastrophic forest fires around the world.

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# Opportunities and Prospects of Mobilizing the Public Opinion in the Region for Promotion of Wild Fire Prevention Activities

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## Introduction

This is what one of the first foresters appointed in Priamurski Krai wrote in his "Correspondences from the Far East" (Forest Journal Number 1, 1890): *"Here, in Priamurski Krai, forest fires are raging, destroying vast forest areas. This evil is difficult, and sometimes impossible to fight even there, in Russia, where the population is relatively dense; what can we expect here, in Zabaikalie, where the population is extremely sparse…, in addition to this, the people have a habit of treating the forest carelessly, of seeing in it something that is not bad, but good to destroy; where trappers make burnings to destroy the deadfall to see the animals better – it is clear that these burnings burn out not only the deadfall, but also the forest; where former convicts are settled, who can enjoy destroying something, with some kind of dullness and just for the sake of satisfying the instinct of destroying; where lack of precautions is ruling everywhere; there this evil is a hundred times harder to fight than in Russia. However, the Governor-General and many others think that, with four foresters appointed here, the fires will be stopped or, at least, will significantly decrease. I fear, we will not be able to justify this hope."*

More than 100 years passed since that time, and forest fire statistics for the Russian Far East as a whole and for Khabarovski Krai and Sakhalinskaya Oblast specifically, show that the fears of the first forester were not groundless. The attitude of the people to forest has not changed much. As before, the overwhelming majority of fires appear due to the "lack of precautions that is ruling everywhere". Therefore, this is still a pressing problem today.

Forest fire statistics for Russia demonstrates that only a negligible number of fires can be attributed to natural reasons. This fact by itself allows us to speak with confidence about the effectiveness of forest fire prevention through changing people's behaviour in the forest. Of course, it is impossible to put an end to the problem of forest fires solely through public outreach, without any efforts in improving forest fire fighting. But it is also evident that there is a limit, beyond which equipping forest service units with fire-extinguishing means does not give the expected effect.

The FOREST Project, funded by the U.S. Agency of International Development, is working in Khabarovski and Primorski Krais, Sakhalinskaya and Irkutskaya Oblasts and in Krasnoyarski Krai three years already. Prevention of human-caused forest fires is one of the four major project components. Within this period the project has gained significant experience in community outreach and identified the problems that hinder in placing this work on a broad footing – and this is what we are going to share with you.

## FOREST Project Achievements

The FOREST Project is implementing an integrated approach to forest fire prevention awareness activities among the citizens. It incorporates three interdependent trends: 1) general awareness and targeted groups educational campaigns; 2) development of Fire Prevention Awareness Program for Pre-school and School aged Children; 3) strengthening foresters' communication skills/community participation.

With a view to obtain initial data necessary for development of the general awareness campaign that would cover broad sections of the population, a baseline public opinion polling/audience research was conducted in Khabarovski Krai and then in Krasnoyarski Krai and Sakhalinskaya Oblast. This research allowed to classify the goals and motives for visiting the forests, reveal the level of awareness and attitudes of the people to the problem of forest fires and discover habitual behavioural patterns of the citizens in the forest. This data made the basis of FOREST Project general awareness campaigns.

The follow-up focus-group research made an exact "portrait" of various community groups and identified the risk groups, i.e. those sections of the population through which forest fires are caused most frequently. This work made it possible to conduct targeted campaigns aimed at changing behaviours of selected groups of forest visitors. The first targeted campaigns were directed towards hunters and fishermen in Khabarovski Krai, wild plants collectors near Khabarovsk and picnickers in Krasnoyarski Krai. Since only the knowledge of the audience can bring about marked changes in the situation, special studies by experts and preliminary tests were conducted with the aim to develop the symbols and fire prevention materials for the general awareness campaigns – video and radio spots, tip sheets and posters.

Special fact sheets were published, where actual facts relating to the impact of forest fires on the economy, environment and health of the people in the Russian Far East and Siberia were gathered by forestry, economics, ecology and medicine experts and various aspects of this impact were popularized. All in all 26,000 fact sheets, 2.5 million tip sheets and 45,000 posters were distributed. Since these materials became highly popular, we think it advisable to continue these activities in the future.

Within the scope of this component also eight forest recreation areas were developed in all regions covered by the project. Today they are receiving their visitors. Seven two-sided billboards (18 $m^2$ each) were installed at interregional roads with highest traffic capacity. The project designed various types of souvenirs – badges, pendants, stickers and shawls with fire prevention symbols and is distributing them. Six sets of Tiger and Bear costumes were made for the conduct of community events.

Public participation is a decisive factor in implementing general awareness programs. Our experience shows that forest management bodies must bear the primary responsibility for this work and mobilize the community for the fulfilment of this task. 331 workers of Federal Forest Service from 232 leskhozes (Forests) attended trainings organized by the project staff. Knowledge, skills and fire prevention materials that they received helped them to improve general awareness activities in their communities.

The project developed "a network of partners", which comprises organizations and individuals interested in fire prevention, and keeps a permanent dialogue with them, sends out fact sheets and updates information on the project web-site. Fire prevention materials can be sent out to everybody who needs them for implementation of awareness programs, irrespective of how remote the location of the initiative group or organization is. The circle of partners today comprises about 2,000 people in all five project regions. Sixteen non-governmental organizations (NGOs) participate in the work.

Mass media is an important project partner. Local TV and radio companies are running six video and five audio public service announcements of the FOREST Project on donated air-time. The companies also prepare fire prevention reports and use fire danger level data supplied by the project and its partners in local weather forecasts and news programs.

School teachers who attended our training seminars are educating and encouraging their students in forest fire prevention behaviour and also involve the children in tip sheets distribution and community events. Each of these students brought his new knowledge into the family and shared his new skills with friends and neighbours. More than 700 educators attended FOREST fire prevention seminars on School Aged Children Program, where 5,000 copies of this Program were distributed. Over 7,500 schoolchildren were trained in fire prevention based on this Program. Regional departments of the Ministry of Education, institutes for advanced training and school teachers express their appreciation for the School Aged Children Fire Prevention Program. In response to their request an adapted version of this Program for kindergartens was issued and is distributed now.

Our experience shows that the wider the circle of partners is in the region or in a community, the more sustainable results can be achieved. The project is planning to transfer the contact base to specialized centers that will be established at Forest Service in each territory and to assist the centers in disseminating the information.

Of course, the results of this work cannot become apparent instantaneously. As we can see from the foreign experience, with regular general awareness activities conducted, change in behaviors and attitudes of people takes place in decades. Nevertheless, results of check polling in Khabarovski Krai showed that in one year about 90% of people became familiar and were able to remember some elements of the implemented campaigns and 18% declared that they have changed at least one aspect of their behaviour in the forest within this period.

Summing up the results of three-year activities, we would like to draw your attention to the following conclusions:

- The people are not fully aware of the consequences of forest fires and they do not know the behaviour rules in the forest. Therefore target work with various social, age and professional groups is necessary. Fire prevention work with children and young people is particularly promising and fruitful.
- The citizens did not reach that stage of civil society development, self-organization and well-being, where they could independently advocate their interests, including those in fire prevention.
- Many public organizations and public representatives today are ready for implementation of fire prevention awareness programs, provided that this work is coordinated and financially supported.
- However, only governmental structures are allowed to fulfil coordinating functions and provide financing for this work today.
- Implementation of regular fire prevention awareness activities among the citizens requires identification of structures and persons responsible for its implementation and coordination, as well as existence of a legal base, developed methodology and stable financing.

### Institutionalization of Fire Prevention Awareness Activities

As three-year experience of the FOREST Project shows, regular fire prevention awareness activities among the citizens cannot be implemented without respective laws and norms, stable finance and institutionalization. Furthermore, principles of financing and determination of structures responsible for the conduct of these activities must be fixed in normative acts - in Forestry Code in the first place. How does the acting Forestry Code treat these issues?

Clause 46 of 1997 Forestry Code attributes development, approval and implementation of federal forest protection programs to the authority of the Russian Federation.

Clause 47 attributes the same functions relating to territorial (regional) state programs to the authority of RF entities. The same clause attributes “organization of educational and awareness activities among the citizens in the sphere of forest management, protection and reforestation” to the authority of the subjects of the RF.

Clause 93 specifies that the Government of Russia, the federal forest management body and its territorial bodies shall provide fire fighting measures. The same clause says that forest fire protection, including fire prevention, shall be implemented by leskhozes, forest protection air bases and other structures of the federal forest management body.

Clause 96 specifies that volunteer forest brigades can be established for prevention and extinguishing of forest fires. Financing procedures for such brigades shall be established by the bodies of state power of the Subjects of the RF. Clause 102 says that citizens and organization can participate in forest protection.

Clause 100 treats in detail participation of the bodies of state power of the Subjects of the RF in organization of fire fighting. These bodies are also entrusted with planning of fire prevention measures, conduct of fire prevention awareness activities and collaboration with mass media.

However, clause 108 charges fire fighting expenses to the account of the federal budget.

This means that all powers and responsibilities of territorial forest management bodies in terms of forest fire prevention and extinguishing can be implemented solely through target financing by the federal budget. Neither the federal budget nor the budgets of RF entities allocate any money for fire prevention in general and awareness activities among the citizens in particular though.

Therefore, provisions of the Forestry Code relating to forest fire prevention awareness activities among citizens cannot be implemented today due to the following factors:

- Unclear wording of rights and responsibilities of the federal structures, their territorial bodies and bodies of state power in the Subjects of the RF in terms of fire prevention awareness activities;
- Lack of respective institutions;
- Lack or shortage of target financing.

The draft of the new Forest Code submitted by MNR (Ministry of Natural Resources) to the Russian Government on 19 August 2003 inspires no optimism with regard to above.

Clause 15 specifies that the RF does not develop and implement state forest protection programs now, but only exercises “federal control” over protection of the forest fund, which is the federal property (and this is virtually all forest fund, see clause 19) and establishes respective procedure.

The authority of RF entities and municipal structures comprises protection of forests which are the property of these entities and structures (in accordance with the new Code these are only city forests, moreover - not all of them).

Thus, if in the previous Code the responsibility for forest fire prevention was unclear, now it is not determined at all.

Clause 77 specifies that implementation of forest protection measures shall be provided by the Russian Government or duly authorized federal body or its territorial bodies, bodies of state power in the Subjects of the RF, bodies of local self-government, within their competence. With regard to the previous two clauses – by nobody.

Clause 78. Among the numerous rights and responsibilities of Federal Forest Service officials this clause does not provide forest fire prevention awareness activities among the citizens, neither does it provide prevention of other forest violations though.

Clause 83. Bodies of state power of the Subjects of the RF are entrusted with all fire prevention awareness activities and work with mass media – with threefold reduction of the income from forest taxes (clause 108).

Clause 97. Financing. Forest fire fighting (not fire prevention!) shall be financed, as before, from the federal budget.

Among the normative documents existing in RF entities regulating various aspects of forest fire prevention and community outreach we can mark out the Khabarovski Krai Forest Code and Concept of Fire Prevention Awareness Activities Among the Citizens of Khabarovski Krai.

The provisions of Khabarovski Krai Forest Code show the powers of the Krai government, regional administrations, citizens, duly authorized federal forest management bodies, as well as of public organizations to conduct fire prevention awareness activities among the citizens. Thus, clause 55 stipulates “organization of educational and awareness activities among the citizens in the sphere of forest management, protection and reforestation"; "provision of forest management, protection and reforestation information to the citizens" within the authority of Krai Administration.

Clause 56 of Khabarovski Krai Forest Code also specifies "organization of educational and awareness activities in the sphere of forest management, protection and reforestation" within the powers of regional authorities.

The rights of the citizens living in the Krai were not forgotten, and clause 89 specifies that "Citizens, who enter into forest legal relations, are obliged: … to promote forest ecological education of the young generation."

Clause 90 specifies the powers of public organizations in forest preservation, specifically, they are granted the rights "to develop, approve and promote their forest preservation programs, to advocate the rights and interests of citizens and communities in terms of forest preservation…"

Clause 104 that stipulates participation of Krai Administration and bodies of local self-government in organization of forest fire fighting also says: "…Krai Administration together with the bodies of local self-government shall organize fire prevention awareness activities, regular highlighting of forest preservation issues in the mass media, as well as of the issues of adherence to fire safety and sanitary rules in the forests."

The Krai Forest Code makes it possible to team the efforts of local authorities, public organizations and citizens in planning forest fire and emergency prevention measures in the Krai. However, there is no actual interaction between them due to lack of coordination between the governing entities, passivity of the citizens and low efficiency of activities implemented by public organizations.

When planning the annual Krai budgets, the Krai Duma that approved the Krai Forest Code does not allocate financial resources for forest protection and reforestation measures. The members of the parliament ignore these provisions of the Code and think that, under the Forest Code of RF, Federal forest management bodies shall be responsible for the problem of forest fires.

Concept of Fire Prevention Awareness Activities Among the Citizens in Khabarovski Krai developed by Krai Forest Management Department in 1997, is an auxiliary document, which was formally terminated in 2001, however did not loose its urgency in terms of public outreach and forest fire prevention.

This document provided a differentiated approach to various community groups with application of specific types of influence over the audience. The Concept specified the scope of public consciousness formation work, coordinating bodies and their functions, sources of finance and logistics, priming of participants and priority measures. The Concept, though developed six years ago, is still urgent and, after finalizing and application of FOREST Project experience, could serve as a basis for the new document that would consolidate managing entities on all levels and the community for the conduct of forest fire prevention measures.

Thus, the forest fire prevention system in RF entities today is not provided with a clear legal, institutional and financial base. Some experts believe that shift of the center of gravity into RF entities and their empowerment and allocation of financial resources would be the best way to solve this task. Forest taxes shall become the source of such resources. This will increase the responsibility of RF entities for the condition of the forests and raise their interest in the amount of forest income.

The FOREST Project is ready and is planning to team the efforts of federal, krai and regional authorities and mobilize public organizations, citizens and experts to develop the new Concept and introduce it into the forest management practices. We suggest discussing specific steps that can be made in this direction at a section meeting during this workshop.

# Landscape Framework for Regional Forest Fire Monitoring

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## Introduction

Sufficiently rapid and detailed assessments of the natural environment and the current fire hazard are key to coping with forest fires. Another important element is environment impact assessments of forest fires, including carbon emissions. Actual forest fire rates of specific areas reflect the pyrogenic factor role in the transformation of forest landscapes and the need for their protection.

Landscape science offers a broad range of approaches to forest fire monitoring and information support for forest fire management decision-making. Landscape science has identification and mapping techniques for and a hierarchy of geographical landscapes (GLs) and their conditions. GLs are viewed as relatively homogeneous pieces of the environment within which its parameters vary but insignificantly compared to variations among GLs. GLs are homogeneous in terms of their terrain, geological foundation, water and climate conditions, vegetation and soils. Diurnal variations of GLs are assumed to be spacious/temporal units with relatively permanent environmental parameters changing over a year. These parameters include, among other things, burning conditions, and therefore, also fire patterns as developing under the latter.

Nowadays, current fire hazard is assessed through identifying the fire hazard classes of the weather based on Nesterov's cumulative hydrothermal index or its improved alternatives and special scales. Fire hazard classes of the weather define the ignition potential of the specified forest types. They are derived from data of base meteorological stations to be used by aerial forest fire teams and to regulate activities of forest protection services. However, such assessments do not include parameters of potential fires; they consider neither intra-seasonal, and sometimes nor seasonal differences with their variation from year to year. To track and record changes occurring in the natural environment in the course of a year, three scales are used (for spring, summer, and fall) with the dates of each season coinciding with the respective calendar dates. In addition, the scales designed for large areas (e.g., in the Primorsky Kray, for its southern, western, and eastern areas) do not allow to take into all their local specifics; whereas the classes are defined for the areas which are protected by the aerial fire teams, and occupy rather vast (about 10,000 $km^2$) and diverse territories with widely varying forest site and hydrothermal conditions (Marchenko 1991b, Korobeynikov et al. 1992). In montane and poorly-developed areas, the work is complicated primarily with the sparseness of the weather stations network which necessitates data extrapolation.

The above constraints and difficulties may be overcome through using the landscape and its variations as operational units, and a landscape map as a basis for mapping the fire hazards and active fires, to interpret remote sensing data. Analyzed pyrological specifics of the Southern and Middle Sikhote-Alin landscapes and their diurnal variations revealed their close relationship with forest fires and allowed to design a method for assessing the current fire hazards based on potential fire parameters.

## Landscapes

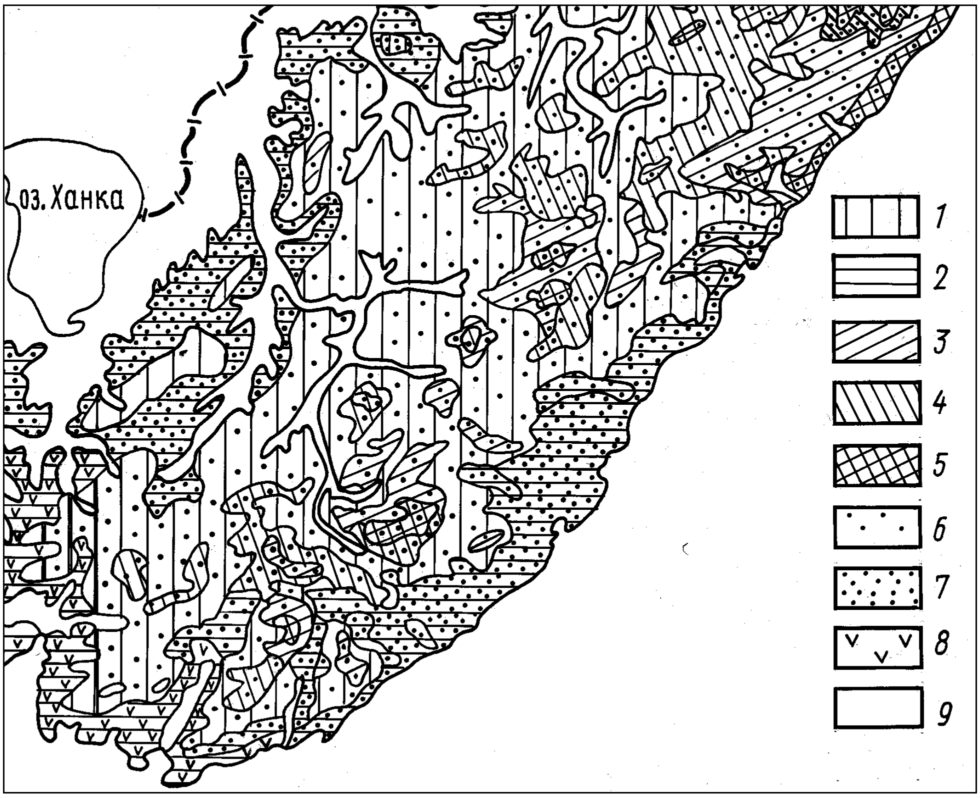
Landscape maps were drawn for the Southern and Middle Sikhote-Alin in the scale of 1 : 500,000, and 1 : 2,500,000 as based on the generalization of the first one. For these purposes, the following published maps of the Primorsky Kray were used: Geomorphology, Plant Ecology, and Soils in the scales of 1 : 500,000; as well as literature sources, and the author's own field research related to the GL patterns with such outputs as detailed descriptions of the facies, and a landscape map of the Livadiysky Ridge in the scale of 1 : 100,000 (as a key site typical of foothills/hills and low mountain landscapes in the southern part of Primorye and middle mountain landscapes which are widely spread throughout the territory under consideration). The Landscape Map of the Southern and Middle Sikhote-Alin (1 : 500,000) identifies the landscape types based on their hydrothermal conditions, zonal properties, and the altitudinal (vertical) tiers in the mountains. And within each type, it further shows the genera of the landscapes with their various terrain and vegetation. In order to identify landscape types as based on hydrothermal conditions at altitudes below 500 meters, we relied on the agro-climatic zoning of the Primorsky Kray after V.K. Khramtsova, and in the case of altitudes above 500 m, we were guided by certain vertical gradients of meteorological elements (see below), vegetation, and the altitudinal tiers in the mountains.

The legend to the landscape map is presented in both text and table forms. The table vertical lists the relief types and the terrain types: volcanic, denudational, denudational/erosional, erosional/denudational, and erosional/accumulative. The relief types identify altitudinal tiers and include: plain landscapes (No. 1 in the indices of the landscape genera), foothills/hills (below 300 m) (No. 2 in the indices of the landscape genera), low-altitudes (elevations of about 300-500 m – No. 3); middle-altitudes which are further classified into lower-altitudes (i.e. the lower tier of the middle-altitudes of 500-700 m – No. 4), middle-altitudes per se (700-900 m – No. 5) and high-altitudes with their alpine-tundra (*goltsy*) belt (above 900 m – No. 6). The table horizontal line shows plant communities: Manchurian broad-leaved forests with the hornbeam (C is the letter in the landscape genera indices), Manchurian broad-leaved forests (P), broad-leaved/Siberian pine forests with the hornbeam and needle fir (*Abies holophylla*) (X), oak forests (Q), broad-leaved /Siberian pine forests (FP), Siberian pine and broad-leaved/Siberian pine forests (PF), broad-leaved/dark coniferous forests (FT), dark conifers with broad-leaved trees (TF), fir/spruce forests (T); a combination of fir/spruce, larch, spruce/larch and small-leaved forests (R), birch/fir/spruce forests (B), elfin stone birch woodlands (BE), tundras and dwarf-tree elfin woods (E), fresh and wet reedgrass meadows, sedge and peat bogs (G). All in all, 51 landscape genera were identified within the surveyed territory. The short indexes of landscape genera are written by number (for relief) and letter/letters (for vegetation). For example, the index “2 Q” – means “foothill landscapes with oak forests” and “5TF” – means “middle-altitudes landscapes with dark conifer forests with broad-leaved trees”. Actual fire occurrence map of the Southern and Middle Sikhote-Alin (see Figure1) has been created on the landscape base. The landscape indexes are used in Figure 2, where probability of forest fires in different landscapes are shown for various conditions.

## Pyrological Specifics of the Landscapes

Pyrological specifics of the Southern and Middle Sikhote-Alin landscapes were defined, and their fire danger predicted through analysing the available forest fire data (about 1,000 fires) over the period of 1971-1977. The data were derived from the fire registers of the Primorye Aerial Forest Fire Centre (‘Airbase’) and used to compile a data bank with the description of each fire complemented with its attendant landscape and weather conditions, diurnal changes in the landscapes (see below), wind regimes, and average rates of fire perimeter enlargement (spreading speed) in km/day defined. The produced Actual Fire Incidence Map (1 : 2,500,000; Figure 1) shows two indicators of the landscape fire incidence: the relative fire area over a season per 100,000 ha, and fire frequency, i.e. the number of fires per 100,000 ha over a season (Marchenko, 1993a). The defined average and relative areas and frequencies of fires and the produced map allowed to reflect the actual fire rates in the landscapes of the Southern and Middle Sikhote-Alin at the current level of forest development and fire management which demonstrated the role of the pyrogenic factor in the dynamics of these forest landscapes and the need for their protection.

Within the surveyed territory, most of the fires (from 65 % to 90 %) were extra-small (0.2-1.0 ha) and small (1.0-10.0 ha), with extra-small fires prevailing among them; the shares of ignitions (<0.2 ha) and medium (10-50 ha) fires amounted to 10 % each, and significant (50 - 200 ha) and large fires (200-1000 ha) were substantially fewer (2%). Fires above 1000 ha occur very rarely. The absence of major and larger fires is typical of foothills and low montane landscapes. The differences in actual fire rates are accounted for by anthropogenic and natural factors. The below described trends are preconditioned by the facts that fires are mainly caused by human activities, and that the areas burned are largely dependant on fire fighting management. The most developed foothills/hills as well as low montane landscapes with oak forests contain maximum amounts of fire sources, and in general, have higher and high fire rates as measured by fire frequencies, and moderate rates in terms of their relative areas. The absence of major and larger fires is typical of foothills and low montane landscapes. Remote middle- and high mountain landscapes are located far from populated areas, so fires are detected late there and most of them are not suppressed; these landscapes have moderate forest fire rates as measured by their fire frequencies and very high rates in terms of relative areas. The largest relative area of fires is found in the high mountain landscapes with birch/fir/spruce forests where it reaches 863 ha per 1,000 ha a year or about 0.9 % of the total area. This indicator of actual fire incidence is also very high in foothills/hills landscapes with Siberian pine and oak forests located along the northern poorly-developed coast of the Japanese Sea, and high fire rates are typical of middle mountain landscapes with fir/spruce forests. Low and lower montane landscapes have moderate fire rates in terms of their fire frequency, and low rates in terms of relative areas. The differences in fires rates among areas with similar levels of development and protection, as well as fire rate variations as a function of diurnal variations of the landscapes, and no correlation between the probability of fire observation and burning of 1 ha of a forest area, on the one hand, and the diurnal changes for most of the landscapes, on the other – all these are explained by differing characteristics of fires, and in particular, by their different spreading speeds.




**Legend:**
Fire occurrence as measured in relative fire areas per season, ha/100,000 ha:
1 – low (< 10); 2 – moderate (10 - 30); 3 – increased (30 - 100);
4 – high (100 - 300); 5 – very high (> 300)
Fire rates as measured in fire frequency, # of fires/ 100,000 ha per season:
6 – moderate (0.5 - 2.0); 7 – increased (2.0 - 7.0); 8 – high (7.0 - 20.0)
9 – unexamined area (agricultural territory)

**Figure 1.** Actual fire occurrence map of the Southern and Middle Sikhote-Alin

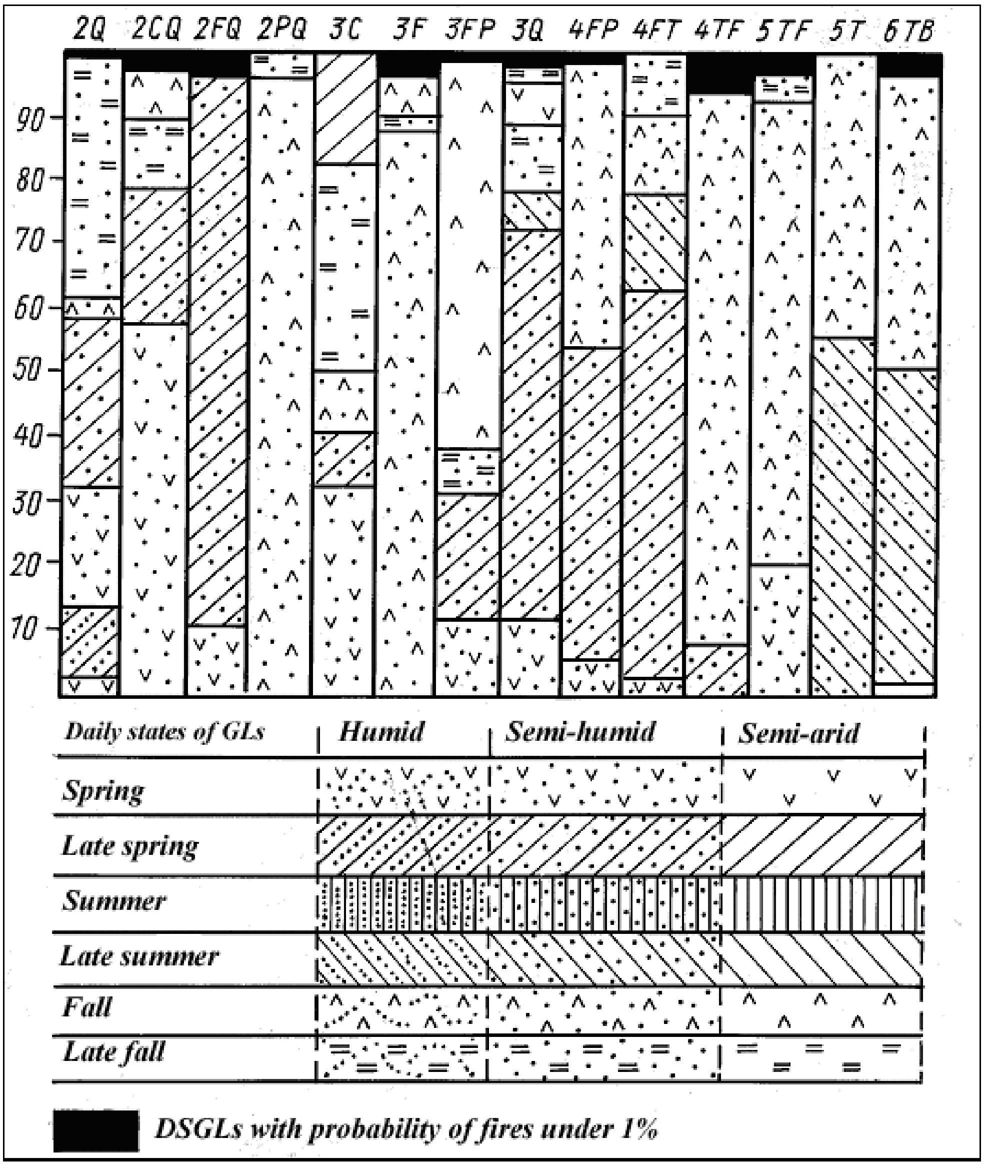
### Daily States of Geographical Landscapes and Forest Fires

Assuming that the landscape is a relatively homogeneous piece of the natural environment, the Daily states of geographical landscapes (DSGL) may be regarded as spatial/temporal units with relatively permanent environmental parameters changing in the course of a year. They are classified into winter (with stable or unstable snow covers), early spring (before plant vegetation), spring (when grassy plants start vegetating), late spring (when tree and shrub plants start vegetating), summer (peaks of the vegetation processes), late summer (yellow leaves), fall (fall of the leaves), late fall (after the leaf-fall, plant vegetation termination), and pluvial (with raining) DSGL. According to the reviewed literature, temperature thresholds (5, 10, and 15) are well applicable to the identification of DSGL in the Southern and Middle Sikhote-Alin. When DSGL are classified by humidity level (humid, semi-humid, and semi-arid), the factors considered include: soil horizon moisture levels, the hydrothermal coefficient equal to the ratio of the actual total precipitation over a decade to the average decade temperature. The applied indices may also be used to estimate fire hazards. DSGL of specific landscapes cannot be identified without data on their hydrothermal conditions. However, meteorological stations providing such information are in place not in each landscape. Currently, in the Primorsky Kray, there are 48 functioning weather stations which are located primarily in valleys and along the Japanese Sea coast. Therefore, the data from these stations have to be extrapolated. To this end, vertical gradients of temperature and air moisture deficit were determined for 36 pairs of weather stations using data for the period from 1952-1965 when the network of weather stations was much denser, with several "upland" weather stations in operation) (Marchenko 1989). The data obtained show that the vertical gradients have explicit patterns corresponding to the year's course, and depend upon the position relative to the sea, and the absolute elevation: thus, the territory is divided into foothills, low mountains, and middle mountains. And in the lower tier of the mountains, it is also divided into maritime and continental (the western slope of the Sikhote-Alin) areas. The maritime areas have the year's pattern of temperature gradients with a negative winter minimum and a positive or slightly negative maximum. The continental areas have the reverse pattern of the year's temperatures. In the middle mountains, the year's pattern is smoother and identical for eastern and western slopes of the Sikhote-Alin. Annual variations of the moisture deficit gradients are less expressed. Computed vertical gradients are used to define the landscape-specific hydrothermal conditions through adjusting the data from weather stations.

Data from the weather stations in the Primorsky Kray, and the computed vertical gradients of weather elements were used to trace the dynamics of dominating landscapes in the Southern and Middle Sikhote-Alin over the period of March to November 1971-1977, and to draw curves of their natural regimes with the abscissa depicting the months and decades, and the ordinate signifying the frequency of a given state in %. A review of the curves revealed substantial particulars in the seasonal dynamics of the dominating landscapes, average commencement dates and durations of various conditions, and the most likely transitions.

From the pyrological perspective, the most important characteristics include the frequency of semi-arid and semi-humid DSGLs; termination of winter DSGLs (snow cover disappearance); as well as the succession of the spring and fall DSGLs accompanying the vegetation processes which are known to be of great importance for forest pyrology. Throughout the reviewed period, humid DSGLs prevailed, the share of semi-arid DSGLs did not exceed 20 % in any of the landscapes and decades, and in the middle mountain landscapes, they were completely absent. In low montane landscapes with broad-leaved/Siberian pine forests, they were early spring, fall and late fall DSGLs; in those with Manchurian broad-leaved forests, these were fall and late fall ones; in those with broad-leaved forests with the hornbeam, they were late fall DSGLs; and in landscapes with oak forests, they were spring and late fall semi-arid ones. In foothills/hills landscapes with broad-leaved forests with the hornbeam, and with oak forests, late spring, fall, and late fall DSGLs are possible, whereas in these landscapes with broad-leaved forests, spring and late fall semi-arid ones are found. Semi-humid DSGLs may occur almost throughout the warm period in all landscapes. But they are more likely to occur in summer than in spring (30-50 % and 10-30 %, respectively).

Each landscape has recorded periods of only humid states, and such periods vary by landscape. On Figure 2, one can see the results of forest fire data bank data processing - Relative Probability of Burning 1 ha of a forest area under different Daily state of geographical landscapes (DSGL). Different types of hatching marks different Daily States: degrees of humidification are shown on horizontal axis, seasonal variation are shown on vertical axis ( see underneath picture as legend for upper picture). The forest fire data bank analysis shows that 61 % of all fires occur during the periods of semi-humid spring, late spring, fall and late fall DSGLs. Fires are the fewest during the periods of semi-arid DSGLs (3.1 %), since these ones are exclusively rare, as well as during summer humid DSGLs with already rich plant cover when the spread of fires is limited owning to higher humidity levels. Fires are rather frequent at the time of semi-humid summer and late summer DSGLs (10.2 %) as well as humid early spring, spring, fall and late fall ones (18.8 %). The relative areas of fires reflect the role of the pyrogenic factor in the dynamics of forest landscapes. This indicator reaches its highest level in foothills/hills landscapes with Siberian pine and oak forests, middle mountain landscapes with fir/spruce forests, and high-altitude landscapes where the annual relative burned area averages 0.3 - 0.93 % of the total forest area, with the greatest contribution resting with late summer and fall semi-humid DSGLs. Significant pyrogenic transformations occur in low and middle mountain landscapes with dark-conifer forests and inclusions of broad-leaved species as well (0.06 - 0.09%), primarily under late fall semi-humid DSGLs. In foothills/hills and low montane landscapes with oak forests, historic large and periodically returning fires had contributed into their plant cover evolution. Later, improved protection against fire reduced the pressure of the pyrogenic factor, but due to more frequent fires, this pressure remains substantial. Late spring semi-humid DSGLs are critical here. In the other landscapes within the surveyed territory (those of low mountains with broad-leaved/Siberian pine forests, and of lower mountains with broad-leaved/Siberian pine forests and broad-leaved/dark-conifer forests), forest fires do not cause significant modifications of the vegetation structure. The differences in actual fire rates are accounted for by anthropogenic and natural factors.




**Note:** The ordinate shows the probability in %, and the abscissa enumerates the landscapes; landscape indices are to be found in the text.

**Figure 2.** Relative probability of burning 1 ha of a forest area under different Daily State of Geographical Landscapes (DSGL) of the Southern and Middle Sikhote-Alin

The below described trends are preconditioned by the facts that fires are mainly caused by human activities, and that the areas burned are largely dependant on fire fighting management. The most developed foothills/hills as well as low montane landscapes with oak forests contain maximum amounts of fire sources, and in general, have higher and high fire rates as measured by fire frequency, and moderate rates in terms of relative areas. Remote middle- and high-altitude landscapes are located far from populated areas, so fires are detected late there and most of them are not suppressed; these landscapes have moderate forest fire rates as measured by their fire frequency and very high rates in terms of relative areas. Montane landscapes of the low and lower altitudes have moderate fire rates in terms of their fire frequency, and low rates in terms of relative areas. The differences in fires rates among areas with similar levels of development and protection, as well as among different DSGLs, and no by- DSGLs correlation with the probability of fire observation and burning on 1 ha of a forest area for most of the landscapes – all these are explained by differing characteristics of fires, in particular, by different spreading speeds.

The speed of fire spreading is equivalent to the perimeter growth rate, in km/day. In the examined landscapes, it varies from 0.0 (early spring humid DSGLs) to 6.9 (late summer semi-humid ones). Speed distribution is close to the log normal one with the most common spead at 0.17 km/day. The speed of fire spreading depends only on natural factors with the lead belonging to the wind regime followed by moistening conditions and the annual cycle phase. But the relationships are not always linear for the territory as a whole. Based on the speed of fire spread, fires were classified into 5 types.

Fires spread at less than 0.1 km/day (type 1) only with weak wind, and only under the conditions of humid and semi-humid DSGLs. They spread at 0.1-0.5 km/day (type 2) under the conditions of weak and moderate wind and all DSGLs in all landscapes; with strong wind – only under humid and semi-humid spring, late spring, summer, and fall DSGLs in landscapes with broad-leaved forests with the hornbeam, and those with oak forests, broad-leaved/Siberian pine, fir/spruce, and birch/fir/spruce forests. Spreading at 0.5 - 1.0 km/day (fire type 3) is associated with strong winds, but such speeds coupled with moderate winds are typical only of semi-humid and semi-arid DSGLs. There may be two patterns of fire spread at a high speed (over 1.0 km/day): (1) Crown fires which may occur only in closed stands with dominating confers and their abundant undergrowth and second story. Such fires occur in middle mountain landscapes with fir/spruce forests and high-altitude landscapes in late summer semi-humid DSGLs with strong winds which accounts for very high fire rates in terms of relative fire areas in these landscapes where they may spread faster than at 5.0 km/day. 2) Ground running fires may burn in sparse tree stands when the wind penetrates under the crowns both in foothills/hills landscapes with broad-leaved forests with the hornbeam, and with oak forests, as well as broad-leaved and oak forests. They spread but slightly faster than at 1.0 km/day. In foothills/hills landscapes with Siberian pine and oak forests, both patterns may be observed. The fastest fire spread is typical of middle- and high-altitude landscapes as well as of foothills/hills with Siberian pine and oak forests. The slowest fire spread is a feature of landscapes of low-altitudes and foothills/hills. Semi-arid DSGLs occur only in landscapes of foothills/hills and low mountains with deciduous forests, and are not prone to rapidly spreading fires, with the highest fire speeds inherent to semi-humid DSGLs. As regards the annual cycle phases, the slowest fire spread is typical of summer DSGLs which are more humid and coincide with the period of abundant growth of mesophytic grasses and shrubs, when even with strong winds, fires spread hardly faster than at 0.5 km/day. The fastest fire spread is observed in late summer and fall DSGLs.

### Current Fire Hazard Assessment

The revealed diurnal variations of landscapes offer a new method of the current fire hazard assessment with possible fire spread rates under given conditions to be used as its criterion (Marchenko 1993b). Fires are affected by factors of qualitative nature, and these factors have non-linear relationships with their spreading speed. Some combinations of landscapes, DSGLs and wind regimes are not realistic while others are associated with quite definite types of fires as determined by their spread speed. For practical purposes, it would be quite sufficient to know the fire spread speed within the accepted gradations. In view of the aforesaid, it would be expedient to define the fire speed using the established data bank which contains such speed values, fire types, and the likelihood to deal with fires referred to the indicated types, for different DSGLs of the explored landscapes.

In contrast with the current practices, the proposed method would define not only the risk of ignition, but also characteristics of the fire and its further behaviour. Fire hazard estimation by landscape rather than by administrative parcel can provide a more specific and detailed description of the current situation based on the actual spatial/temporal differentiation of the natural environment which is of particular importance under mountainous conditions. Thereby, a very important thing is the extrapolation of data from weather stations, using certain vertical gradients of meteorological elements.

When fire hazard estimates are based on the speeds of fires which may occur under given landscape conditions, it is possible, at a certain taxonomic level, to take into account the natural conditions affecting a fire and their intra-seasonal dynamics, to project the parameters of potential fires; to obtain a sufficiently detailed description of the protected area; and, to a substantial extent, to get rid of the limitations inherent to the currently applied methods. The designed method was implemented in a GIS (Marchenko 1989), which enables to draw fire hazard maps based on data from 15 base weather stations (6 parameters). These maps depict fire hazards, with potential fire perimeter proliferation rates indicated. Verification of the method and the GIS included daily mapping of the landscape variations and current fire hazards with subsequent mapping of active fires thereon. This process demonstrated sufficiently precise simulation of the processes taking place in the surveyed landscapes: parameters of 75 out of 77 recorded fires corresponded to the projections.

Current fire hazard maps of a protected area significantly facilitate the process and save the time of decision-making with respect to aerial patrolling and fire-fighting resource manoeuvring, and hence, help to reduce the areas of destroyed forests. The precision of fire hazard estimates may be raised through using additional meteorological information (from more weather stations and sub-stations), and processing the fire data for the previous years. Detailed knowledge of landscape/geophysical characteristics of an area would allow to compute the speed of fire spread at the thermal/physical level in meters per second for all aspects, and to simulate the dynamics of fire contours. Follow-up studies could be also focused on defining fire hazards, and fire parameters for other landscapes conditions in Russia and in the world; and on designing a system for routing monitoring for the entire Forest Fund. Great opportunities are offered by the use of remote sensing data.

Thus, a landscape map reflects the natural differentiation of the environment, and may become a good basis for a system of monitoring and information support for decision-making in the area of forest protection both to prevent fires through forest management planning and limiting the access to fire-prone areas, and to detect and fight fires through manoeuvring the fire fighting resources, planning the aerial patrolling routes, and managing the fire fighting operations. Landscapes as relatively homogeneous areas allow to develop and extrapolate data of pointed observations (field and laboratory phytomass analyses, assessments of amounts and characteristics of forest fuels), and to evaluate the consequences of fires and losses inflicted by them.

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# Basics of Fire Management in Eurasia

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Wildland fires represent an important natural factor affecting the global environment due to the influence on the distribution of carbon throughout the geosphere and the atmosphere. Forest fire evokes strong emotions because it is often associated with great destructive power. However, it is clear fire has long been a natural component of the forest and is in fact responsible for shaping many of the forests that we are enjoying and utilizing today.

In many cases wildfires define the occurrence of flora and forest ecosystem dynamics. Each forest formation has its own fire regime characterized by a definite type of fire, intensity, size, fire frequency and post-fire reforestation dynamics.

Historically fire regimes in forest landscape ecosystems have been defined by natural conditions. Two fire regimes can be allocated in Siberian forests. Rare fire returns define fire regimes of bogged dark coniferous forests of Western Siberia. In contrary big burned areas and high fire frequency are characteristic for lowland light coniferous forests of Eastern Siberia.

Burned areas of Siberia are defined by big fires having 95% annual damage. Their arising in Siberia is defined by high frequency of droughts and prevailing light coniferous forests.

In Eastern Siberia and Far East there catastrophic big fire outbreaks are repeated 2-3 years in one region after 3-4 years. In some cases wildfires have positive effects on forestry. They consume fuel load decreasing fire hazard in forest, destroy insects habitat and stimulate natural restoration in light coniferous forests. At the same time wildfires having long drought on the background often are destructive especially in dark coniferous forests. Fire kills all stands and forest restoration moves through stand replacement and is delayed for long time. Up to 60% fires have place in southern taiga forests around the Trans-Siberian Railway. These forests highly are subjected by man's impact. Long years coniferous forests cuttings, wildfires, insects like Siberian Moth outbreaks decreased coniferous forested areas and they were replaced by non valuable deciduous stands.

In a huge territories of Siberia it is impossible to fight fires in all forest-plant zones. Economy of the country will not stand to such kind of expenses. Moreover, full exclusion of wildfires in boreal forests leads to extra fuel loads. Catastrophic fires arising in extreme fire seasons spread on huge areas destroying dark coniferous and damaging light coniferous forests.

Many countries of Northern Hemisphere changed their fire control policy to fire management in 1980s. Fire management in forests is a balance between the practical considerations of fire protection and the need to allow fire to play its natural role.

Fire management system is less expensive and more effective due to the varied approach to the fire control providing from full suppression and their control in definite boundaries, where they will not have ecological and economical damages. And in some cases wildfires are allowed to burn within the specific landscapes.

Fire management programs also include planned prescribed burning to solve forest restoration problems and preserve forests.

For achievement of forest fire protection effectiveness, forest resources saving and biodiversity the resolving of following organizing and scientific measures are necessary:

- Not use the Policy of all fires suppression and admit that some forest fires have positive effects on boreal forest ecosystems.
- Inventory post-fire state of forests and evaluate post-fire ecosystem succession in case, when forest fires are not suppressed. These will allow revealing conditions, under which forest fire plays positive role.
- The forest fire management area districting has to be based on ecological-economical evaluation of fire effects accounting post-fire forest succession.
- Legal on Federal level the prescribed burnings on forest areas to decrease high intensity fire hazard near settlements, valuable forests and so on.
- Design and apply the system of forest fire management passports of forest areas. The main goal is fire management development providing forest resources saving and shifting of forest succession direction.
- Organize the forest fire protection system on four levels:
    - High level protection. It should be applied on areas with valuable economical objects of civil and defence structures, and where high losses are possible.
    - Continuous protection. It should be applied on areas with intensive forest management and history valuable areas (reservations, parks etc.).
    - Limited protection. It is appropriate for reserve forest fund with regions of high fire protection of valuable natural resources (oil or gas rigs etc.).
    - Episodic protection. It should be applied during extreme fire seasons.

All of above mentioned levels have to be different in level of financing, technical facilities, amount and qualification of stuff and other features. The system allows to minimize the forest fire protection expenses and to maintain the natural role of fires in biological resources formation. In the scientific sphere the following tasks should be done:

- Investigate wildfires effects on large ecosystems;
- Determine border conditions of fire effects on forest ecosystems and biodiversity.
- Develop scientific database for long term forecasting of fire effects on forest recourses and basics for economic evaluation of positive and negative effects on large ecosystems and whole biosphere.

All these allow to quantify and estimate time-space economical and ecological fire effects on forest ecosystems. The same database will be highly valuable for forest fire administration and fire protection services as well as for international programs and organizations concerning global forest fire effects modelling.

Forest fires are the problem in our country as well as in other countries of Northern Hemisphere. And the solving of this is the main key point in protection and saving of natural resources, the ecology state and surviving under global natural and technogenic catastrophes.

# Forest Fire Management Technologies

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### Fire management in forests damaged by the Siberian Moth

Dark coniferous forests damaged by Siberian Moth (*Dendrolimus superans sibiricus* Tschetw. [Lepidoptera: Lasiocampidae]) occupy huge territories from Ural Mountains to Far East. Patches of fully or partially dead stands vary from ten to one hundred thousand hectares. Total damaged areas have been estimated to be equal to several million hectares.

Forest fire potential increases significantly for number of years after stand mortality. Surface fuels consist of both downed and dead roundwood material on the ground covered by low herbaceous and fir (*Abies sibirica*) vegetation that becomes highly flammable after curing and drying in spring (Shabalina et al., 2001). After 4-5 years enough dead and downed surface fuels accumulates through fir decomposition to offset dampening effect of understory vegetation and summer fires will spread through the fuel complex.

Crown breakage and wind throw, with resulting rearrangement of the fuel complex and corresponding high surface fuel loads lead to severe wildfires. Standing dead trees ("snags") after first high intensity fire don't burn completely. The lower part of tree trunk usually has a high moisture content (>100%) and is often only partially charred.

Destruction of the stand after their mortality under frequent wildfires continues many years. Full restoration of dark coniferous stand moves through deciduous trees stage and take more than 150-200 years (Kulikov, 1965). Tree trunks downed by wind quickly loose moisture content and they fully burn out in wildfires. Therefore for high fuel consumption standing dead trees must be fallen down.

The preparation of the restoration of forest completely killed by the Siberian Moth includes three stages. The first stage involves felling of dead trees using a special forest fire unit based on a converted military tank T-55. Shuttle passes have been made by the unit after 10-15 m. Thereby to fall down trees increase dry fuel load and increase wind to continue fall down dead trees. The weight of the forest fire unit is 40 tons. So falling down dead trees was made in the spring when soils were frozen and soil damage by unit was minimal. Also due to the frozen soil the unit was able to move through bogged part of the site. Strong winds blowing perpendicular to the strip passes also add falling down trees and fuel load before prescribed burning exceeds 200 tons per hectare. Second stage consist construction of firelines around the site to contain prescribed fire within area surrounded by firelines. After two passes by the unit mineralized fireline 3-4 m wide effectively prevents surface fire spread. Then additional work must be done for falling down dead trees standing near firelines to prevent their spotting. Third stage consist prescribed burning of the site. All surface fuels unless to green grasses and some brush contribute to fire spread. Burning after the ignition immediately turns into crowning. Fir and birch tops totally involve in burning. The intensity of burning in the prepared by unit site damaged by the Siberian Moth is comparable with the high intensity crown fire. Dead fir boles and tops having cured while standing for a number of years had moisture content values low enough to make virtually the whole tree readily available for combustion. Intensive burning of fallen trees helps to burn out also dead standing trees. Dead fir bark peels readily after mortality and this burning fuel was transported in large amounts along with burning fine twigs and branches in the convection column starting downwind spot fires with resulting control problems.

Approximately, 20-30% of downed dead charred trunks were left after burning. Temperature of the soil doesn't exceed critical temperatures for microflora. Some humus layer left on the soil will contribute to the planting of the site without additional mechanical preparation of the soil. This procedure gives us the possibility not wait for hundred years natural restoration of forest damaged by the Siberian Moth. Forest restoration will be started immediately after its drying and prescribed burning using this technology.

**Fire management on logged sites**

Dark coniferous forests of the West Sayan Mountains represents the Siberian ecosystem characterized the highest biodiversity. Besides their commercial value these forests effectively perform a water protection function because they regulate the flow of big Yenisey river tributaries in its middle segment.

However, the area of dark conifers, especially in easily accessible low-mountain regions, has been significantly reduced by wildfires and timber harvesting activities.

Wide-scale commercial forest use started here as far back as in the 1930s and continues nowadays. Two factors accounted for intensive development of wood industry in this region: (1) close location of wood processing enterprises to the exploitable forests, and (2) inexpensive delivery of extracted wood by floating it on Mana river to Krasnoyarsk.

Logged forest site restoration is extremely slow and usually occurs through stand replacement. Most wildfires occur during spring and summer in this region and they always start from logging sites. This is due to abundant cured *Calamagrostis* spp. covering some 90% of any cut site. Huge amounts of logging slash contribute much to high-intensity fire development (Ivanova and Perevoznikova, 1994).

The wildfires that occurred in May and June 1999 are clearly discernable in the NOAA satellite image received at the Institute of Forest, Krasnoyarsk

One of these fires that burned in Mana region was more than 30 hectares in size. Cut sites with high logging slash loading comprised about 60% of burned area. The fire killed hundreds hectares of plantations. It extended cut sites to adjacent forest stands and jumped to crowns on steep slopes. Trees became snags in a vast area, and since no seed source was intact, forest restoration will take many decades. Moreover, forest planting is also problematic on slopes that steep.

While wood harvesting has been reduced here by several orders of since 1990, logging slash fuels has significantly increased in cut sites to amount often to 150 tons per hectare. This high loading is primarily attributed to the fact that non-governmental forest use organizations usually manage to haul some 30-40% of the wood they have harvested.

That huge amounts of large downed woody elements left on logging site means also a high probability of fungi-induced diseases and heavy insect outbreaks often affecting surrounding healthy stands.

The first thing to be done after logging completed, is to construct a fireline at least 3 m wide along the cut site perimeter.

Second, remove logging slash from the site to reduce fire hazard and make it suitable for natural forest regeneration and planting.

Heavy machinery is useless on steep slopes, so the only effective tool left is controlled broadcast burning of logging slash. After briefing, fire safety operations begin to include removal of snags and large downed woody elements from the planned firing line.

Then it comes to ignition itself. For steep slopes, the fire should always move downslope from fireline made in the upper side of cut area.

People responsible for ignition ignite at the center of this upper fireline section and then walk at the same pace to the opposite sides looking for the ignited line to be more or less continuous.

In a case of a slowly spreading fire, the crew can use step firing to save the time required for firing and increase fire intensity through establishing one -more ignition line 15-20 m lower on the slope. If needed these additional ignition lines can be several.

When burning in summer, controlled fire intensity may be low because of abundant green grass and shrubs. In order to increase fire intensity to a desirable level, logging slash should be ignited at many places across the site simultaneously using multi-point firing technique.

Again, the fire perimeter should be patrolled permanently for potential spot fires beyond the control line.

Fire can get too intensive and jump beyond the cut site during daytime, when burning in spring remarkable for very high fire danger. Therefore, it makes sense to burn during night hours.

Controlled fire consumes all fuel elements up to 2.5 cm in diameter. Larger fuel elements are consumed by 25-30%. Controlled fire produces some 2-3 tons of ash per hectare. As the forest floor moisture content is high, the upper soil layer and, therefore, all microorganisms inhibiting it, remain intact in prescribed fire.

Successfully burned logging site are very good for either planting or seeding woody species without preliminary soil treatment. Seedlings perform very well on soil enriched with nutrients after fire.

Controlled burning promotes fireweed over *Calamagrostis* on logging sites. Fireweed is known not to compete with conifers and provides a good protecting canopy for developing self-seeded or planted trees. Fireweed loading is insufficient to carry a fire, therefore, fire danger remains low for several years on burned logging sites covered by fireweed.

**Forest fire management in wildland-urban interface**

Forest fires in wildland-urban interface have a great danger. People can be injured in fire and homes and properties could be destroyed not only in small populated areas but small cities. These kind of catastrophic forest fires occur not only in Eurasian boreal forests but in other forests of our planet. For example, 1994 catastrophic fires in Sidney (Australia) killed 3 men and burned out more than 100 homes. In another side of Globe Malibu (California) catastrophic fires burned three people and 380 homes were converted to ash. Two weeks fires more than 1000 homes were destroyed and 200 thousand acres land have been passed by fires.

Is this kind of problem exists in Russia? Of course, yes, but here it is very little data. Many people believe that if there are no data there would be no problem. However, there are some historical data. In 1921 massive catastrophic fires in Mari Republic (Russia) 60 small villages were destroyed, 35 people and 1000 cows were killed. 1972 catastrophic forest fires in five regions of European part of Russia destroyed 19 small villages.

According to data from NOAA satellites received by the Institute of Forest 2.4 million hectares were passed by forest fires in Khabarovsk Region and Sakhalin Island in 1998. In Sakhalin small village Gorki was burned out. 680 people lost their homes, three people died and dozens of houses were burned in several populated areas.

Why these kinds of catastrophes arise? Like in America people in Russia also want to live near the forest or in the forest not knowing that life in paradise can cost. Residents doesn’t suspect of danger concealed in their lovely pine stand. Catastrophic fire arising in stand can take their homes and even their lives. These fires actively were protected from fires many decades. And fuel load in them exceeds 30 tons per hectare. These great fuel loads lead to high intensity surface forest fires. Regrowth of first and second age class, small height of crowns lower part are the steps to crowning. Ahead of crown fire there are hundreds of flying burning particles capable to burn out wooden properties. Due to our studies burning coals and smouldering bark and wood pieces are blown by wind to the distance more than 500 m. Therefore, glades and fuel breaks do not prevent forest fires. Fuel breaks only increase wind velocity near surface and complicate fire suppression due to dense smoke near the ground.

What kind of measures must be undertaken to prevent this kind of catastrophes?

Organizational measures: First, it is needed to develop cooperation system for Forest Service, EMERCOM, City fire protection system. Second, to develop responsibility zones for each service. Third, to define danger zones where all three services unite and act under one supervisor. Forth, to determine intensive fire protection zones in wildland-urban interface. The width of this zone must be more than 500 m.

Forestry measures: To form one storied forest stand structure and transform it into park like forest without regeneration and understory with minimal surface fuel load. Mechanical facilities can be used for that along with prescribed fire technologies. We strongly believe that last one is more effective and economical.

It is developed a prescribed fire technology allowing under definite weather conditions, combustion regimes to decrease forest fuel load up to prescribed level and remove regrowth with definite DBH not destroying main stand.

The creation of park like stand without regrowth and understory with minimal surface fuel load will exclude catastrophic forest fires.

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## Fire Regimes in Siberian Forests

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### Introduction

Current forests in Central Siberia manifest clear signs of long-term fire effects that contributed heavily to the way they look today. There is no forest stand now that has not experienced a fire at least once. The number of forest fires has increased considerably in the last centuries due to global climatic changes.

### Fire Regimes

Every forest formation has its specific fire regime. A fire regime is a historically evolved factor that determines conditions of fire occurrence, behaviour, and long-term effects. Forest fire regimes are characterized by:

- forest fire frequency and average fire return interval
- fire season development conditions

- drought frequency and extreme fire season occurrence conditions
- lightning forest fire danger rate
- native forest fire danger rate
- type, structure and stock of forest fuels
- type and behaviour of forest fires inherent to a particular area
- possible ecological consequences of forest fires

Central Siberia is a vast region crossed by several climatic and vegetation zones. This accounts for diverse climatic and site conditions that contribute to annual fire occurrence in different parts of the region. Most fires occur in light-coniferous stands. Surface fires of different intensity prevail (90 percent and more of the total number of forest fires). According to statistics, big fires account for up to 1 percent of the total number of forest fires and up to 90 percent of areas burned. Crown fires account for up to 10 percent of areas affected by big forest fires (Valendik, 1996).

### Geography of Fire Regimes

The occurrence of forest fires in Central Siberia depends on location: forest fires may occur in April and in the beginning of May in southern areas (50-55°N), in May and June in latitudes 55-60°N, and in June from the latitude 60°N and up. The peak occurs in July.

High fire activity in summer is due to long dry periods, whose total duration sometimes amounts to 115 in some parts of the region, with average duration of one such period of up to 45 days. These droughts make all vegetation highly flammable, natural fire breaks disappear and fires spread freely.

The occurrence of extreme fire seasons characterized by long dry periods and big forest fires accompanied by mass small fires varies in time and space. Extreme fire season periodicity in Central Siberian forests depends on drought frequency and latitude (Kurbatskii, 1975).

Droughts promoting extreme fire events may cover the entire region or part of it. Usually, they are induced by dry and warm air masses coming from Central Asia, Mongolia and the central part of Eastern Siberia. In terms of drought frequency, especially notable are southern areas where they occur seven times a decade, and the eastern part of the region (56-62°N) with five to six droughts a decade.

Fire frequency and return interval depends on the alternation of dry and wet years, weather dynamics, the type of forest, location of forest, and human activities. To a large extent it also depends on landscape characteristics. Fire frequency is higher in areas bordering on each other than on isolated sites such as islands surrounded by bogs or mountains. In the Yenisei plain, the average fire return interval in pine forests in non-isolated areas is smaller (average duration of fire return interval being 20-40 years) than in isolated areas (average duration of fire return interval being 80-90 years), where the only source of fire is lightning, and the fire return interval depends on the accumulation of forest fuel to the critical level.

The average fire return interval in Siberia's pine forests depends on latitude and decreases from north to south:

- 45-53 years in the northern taiga subzone
- 20-40 years in the central taiga subzone
- 24-38 years (northern border) and 12-21 years (southern border) in the southern taiga subzone
- 6-10 years in pine forests of the subtaiga subzone
- 8-12 years in forest-steppe pine stands
- 13-27 years in mountain pine forests

The mean fire return interval in Angara pine forests has decreased almost two-fold in the last decades due to human activities. At the same time, the average fire return interval in deciduous and dark-needle stands is 90 years and more.

### Lightning – an Important Source of Fire

Lightning forest fires in Central Siberia account for 34 percent of the total number of forest fires and up to 90 percent in northern regions. The areas affected by lightning fires are very big due to late detection and remoteness. The average duration of thunderstorms in Central Siberia increases from north to south (from 9 to 84 hours), including 21 hours in Turukhansk, 43 hours in Yartsevo, 54 hours in Pirovskoye, and 84 hours in Nizhne-Usinskoye. The number of cloud-to-ground lightning strikes increases from south to north.

Factors determining the occurrence and consequences of lightning fires:

- latitude
- average duration of thunderstorms
- number of days with thunderstorms
- coincidence of fire period with thunderstorm activity period
- territorial homogeneity
- share of wooded areas
- average class of native fire hazard

### Conclusions

The climatic sensitivity of fire regimes changed approximately at the end of the 19th century. Prior to that, fires occurred more simultaneously and were connected with the periodicity of dry periods. Later human activity grew to become a stronger factor controlling fire regimes as compared with climate due to the construction of the Trans-Siberian Railway and the subsequent development of settlements in remote areas.

It has been determined that previous fire regimes were characterized by intensive crown forest fires against the background of mass ground fires. The frequency of surface fires largely depended on weather conditions and landscape. High-intensity fires resulted in forming of uneven-age forest stands.

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# Presentation by the Regional Center of the Far Eastern Federal District for Prevention and Control of Forest Fires

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Pursuant to the resolution of the joint meeting of the Ministry of Natural Resources of Russia, the Ministry for Emergency Situations of Russia, the executive staff of the Authorized Representative of the President of the Russian Federation in the Far Eastern Federal District and the executive authorities of the constituent entities of the Russian Federation, by Ordinance No. 263-R of the RF Ministry of Natural Resources dated 19 June 2003 the Far Eastern base for aerial forest protection has been charged with the responsibility for day-to-day gathering and processing of information on forest fires and inventory of forest fire control resources. In connection with the above resolution a Regional Center of the Far Eastern Federal District for the Prevention and Control of Forest Fires (hereinafter, the "Center") was set up at the airbase.

Aerial protection of forests in the Far Eastern Federal District is effected over an area of 256.56 million hectares (ha) by the means and facilities of seven regional airbases (Yakutia, Amur, Far Eastern, North Eastern, Primorje, Kamchatka, Chukotka) and the Sakhalin aviation unit. Around 2500 forest fires break out on average in this region every year, affecting an area of some 800,000 ha. An average of 10.4 fires occur per 1.0 million ha of protected timberland.

The need for establishment of a center for coordination of response and mobilization of fire control resources has long been felt and it is a must under the existing economic conditions. Certain difficulties for movement of the means and resources by air are due to the time difference with Moscow (Pushkino base), necessitating routine decision-making before the central airbase starts functioning. The resources at the disposal of the federation constituent entities of the Far Eastern Federal District are sufficient only in the event of small-scale fire intensity, while additional forces have to be employed at short notice in the event of medium- and emergency-scale fire intensity. In 2003 the number of those employed in the Airborne and Landing Fire Service (ALFS) was 986, of which 318 were employed on a contractual basis. These are the forces which can at present be realistically manoeuvred within the district. In accordance with standard requirements, the ALFS force shall be 860 strong in the event of small-scale fire situations, 2650 strong in the event of medium-scale fire situations and 5560 strong in the event of large-scale fire situations. The employees of the forest protection service are also involved in controlling forest fires only in the areas of responsibility of the respective forestries. For better fire protection of the forests, it is planned to increase within the framework of the center to be established the ALFS strength, to create a mechanized unit and an air squadron to provide for prompt delivery of human resources and equipment to the forest fire fighting areas in the territory of the Far Eastern Federal District.

The center will provide for satellite monitoring and forecasting of forest fire situation in the territory of the district, as well as coordination of the activities of forest fire services of the Far Eastern Federal District for prevention and suppression of forest, forest and peat and tundra fires.

The present staff of the center is as follows:

- Chief, operations and control (O&C)
- Two shift supervisors
- Two electronic engineers
- One photo and video operator (mass media liaison)

In addition, it is intended to employ two controllers (during the fire-hazardous period the center will function on a round-the-clock basis) and one specialist for assessment of meteorological information and forecasting of forest fire situation.

Information on forest fires will be submitted in accordance with the established format on a daily basis to the executive staff of the Authorized Representative of the RF President, the Department of State

Supervision and long-term development in the sphere of use of natural resources and environmental protection for the Far Eastern Federal District (at three addresses), the Far Eastern Regional Center for Civil Defense and Emergency Situations, the Central Department of the Interior for the Far Eastern Federal District.

The Far Eastern Airbase has worked out a program for inventory of human resources of the airbases in the district, technical means and aircraft. A process of gathering information on the availability of the means and resources of land mobile forest protection forces has been initiated. The center will provide for communication over the Internet via a radio channel (at the transmission speed of 256 Kb/s). Use will be made of a single global IP address, with a modem link used as a standby communication channel.

For day-to-day weather analysis and forecasting of forest fire situation, the center will receive all necessary meteorological information from the Hydrometeorological Service agencies. Provisions will be made for equipping the center with a "Synoptic GIS METEO" unitized workstation which will make it possible to obtain weather data in real time at 3-hour intervals, as well as such parameters as the amount of precipitation, maximum and minimum air temperatures for all sites within the district. The weather maps received will be used in the routine operation of the center and will be transferred to the regional control stations of the bases for aerial forest protection.

As a result of interaction with the Far Eastern Center for reception and processing of satellite data the center will be provided with satellite images which will also be used for assessment of the meteorological situation in the district and monitoring of existing forest fires. The center will receive a large block of meteorological information from the Hydrometeorological Service agencies of the Khabarovsk Krai, including weather forecasts, storm warnings, information on the forest fire hazard, etc. The center will also make use of the meteorological information received by the central airbase from the Hydrometeorological Center of the RF (regional weather forecasts, synoptic materials). Use will also be made of the information on the detected seats of forest fires received from the crews of aircraft of the State Civil Aviation Service which perform scheduled flights.

The center's communication arrangements provide for use of satellite radio communication facilities of the Russian space segment of the Globalstar system. Based on the number of allocated terminals (satellite telephone sets) the central airbase is a corporate client eligible for receiving information free of charge. The cost of information transmission by using both the telephone and electronic communication facilities is US$0.99 per minute but it is necessary to bear in mind that transmission of digitized information is much shorter. Due to this, it should become the main mode in which the space segment will be used. In this connection, it is planned to implement in the nearest future a packet communication system at all airbases in the region.

Communication of the center with the superior authorities concerned is also effected by means of electronic mail, facsimile and telephone facilities. Every day the center receives by electronic mail satellite images from the server of the Aerial Forest Protection Service in Irkutsk and the Far Eastern Regional Center (FERC) for reception and processing of satellite data. The data on the flash coordinates and the cloud pattern are transmitted to the center from the FERC by telex. Reliable communication is maintained with all airbases in the district by means of electronic mail, telex and telephone facilities. Information has been gathered from the airbases in the Far Eastern Federal District on the availability of facilities for communication with the aviation units, forestries and timberland areas situated in the territory of responsibility of the airbases in the Far Eastern Federal District. A system for communication (facsimile, internet, telex) with the Central Department of Natural Resources, the Department of Natural Resources in the Far Eastern Federal District has been established.

To narrow the shortage of fire-fighting forces, a 100-strong mobile unit is being established at the center along with a mechanized brigade with a complement of 91. Based on the effective contracts and the plan of distribution of forest aviation aircraft for the Far Eastern Federal District, 98 aircraft could be used in 2003 for aerial forest protection applications, including 21 forest aviation aircraft. Given that the standard requirement for medium-scale fire intensity stands at 198 aircraft, these facilities are obviously insufficient. Considering this, it is planned to organize an air squadron at the regional center comprising 5 aircraft, including 2 AN-3 planes, 1 AN-2? plane and 2 MI-8 helicopters whose mission will be to carry out routine airlifting of fire control means and resources. It is intended to base these aircraft at the airports in Khabarovsk, including the Vostok airport (AN-3 planes and MI-8 helicopters) and the new Khabarovsk airport (AN-26 plane).

The Far Eastern airbase also has a federal reserve storage for the fire-fighting facilities the quantity and the nomenclature whereof are determined by the RF Ministry of Natural Resources. These are allowed to be used only with the consent of the Head of the Forest Service or the deputies thereof. When the center is established, a reserve storage for the fire-fighting facilities of the Far Eastern Federal District will be set up alongside the existing storage facility.

## Modern Information Technologies and Prospects for Establishment of Regional Situation Centers for Monitoring and Control of Forest Fire (Regional Forest Fire Coordination Centers)

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and

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Developed by the Federal State Unitary Enterprise Experimental Construction Bureau (KBOR FGUP), a Regional Forest Fire Coordination Center (RFFC) is a set of specially organized work places to carry out analytical work on an individual and team basis. The main objective of RFFC is to support strategic decision making through visualization and in-depth analysis of day-to-day information. Presenting situation in visualized images compresses information providing an overall insight into the developments. Acting on instructions from the State Forest Service of Russia's Ministry of Natural Resources, KBOR FGUP and *Avialesookhrana* FGU applied modern information technologies to develop a hierarchical structure for monitoring and management of resources and units to monitor, prevent and fight forest fires in Russia.

Figure 1 demonstrates the hierarchical structure for monitoring and management of resources and units.

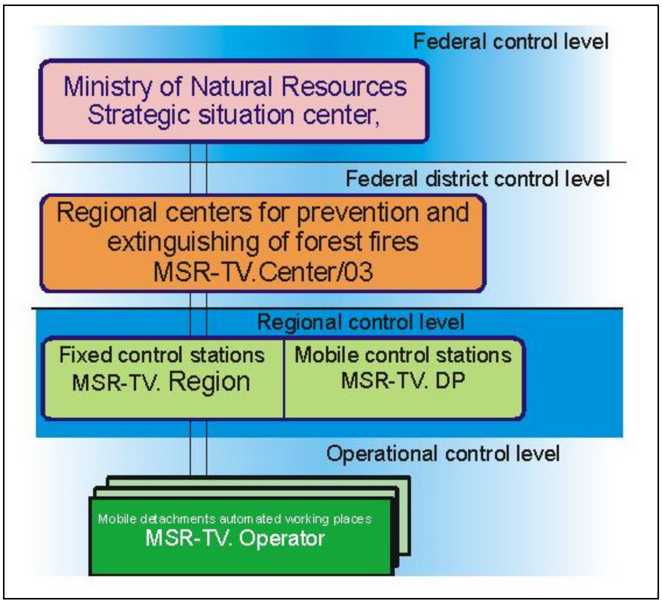


**Figure 1.** Hierarchical structure of monitoring and manpower and equipment control

The organizational arrangements of information coordination between the Khabarovsk Regional Forest Fire Center (RFFC) are based on the Main Functions and Decision Making Levels of government authorities, members of the Steering Committee.

The Far Eastern RFFC will directly manage a mobile fire fighting unit, provided with all the required resources and facilities.

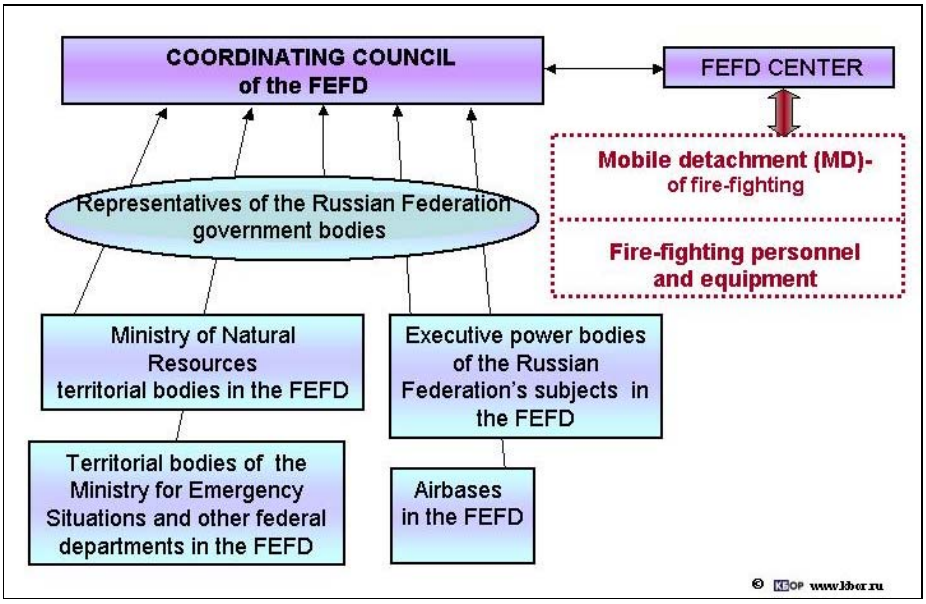


**Figure 2.** Information on the interaction structure of the Khabarovsk Regional Forest Fire Center (RFFC) with basic functions and different levels (regional, federal) of decision making in responding to fire incidents.

In the Far Eastern Federal Okrug (FEFO), the RFFC will control 6,215,900 km$^2$ (36.4% of Russia's territory). Figure 3 presents targets of monitoring, interaction and management, as well as basic information about the Far Eastern Federal Okrug.

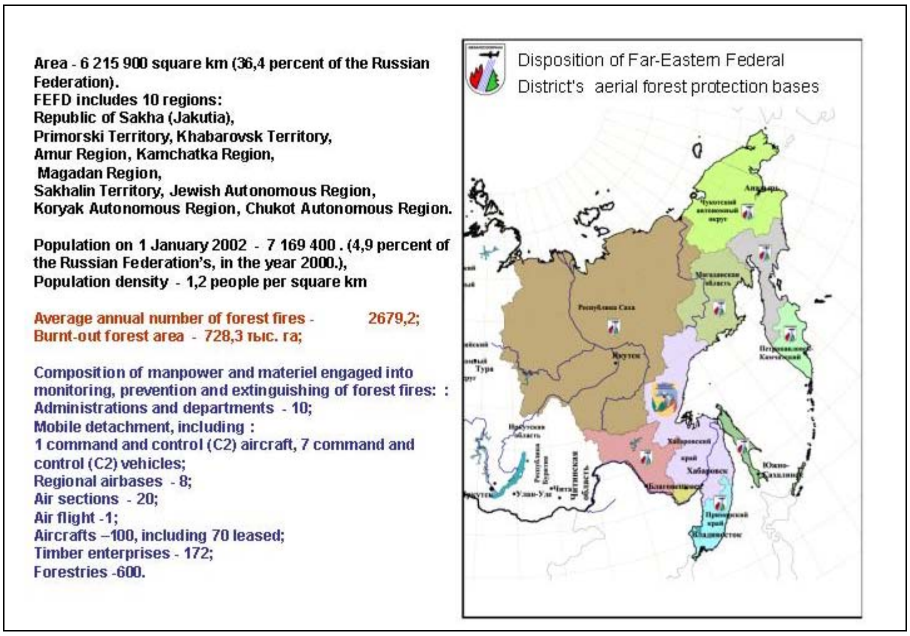


**Figure 3.** Area of responsibility and basic data of institutions involved in forest fire management in the Far-Eastern Federal District (FEFD).

The Center structure will ensure ongoing interaction with 17 federal objects, management coordination with 27 objects and control over 872 lower level objects. Figure 4 presents the information coordination arrangements of a regional forest fire coordination center.

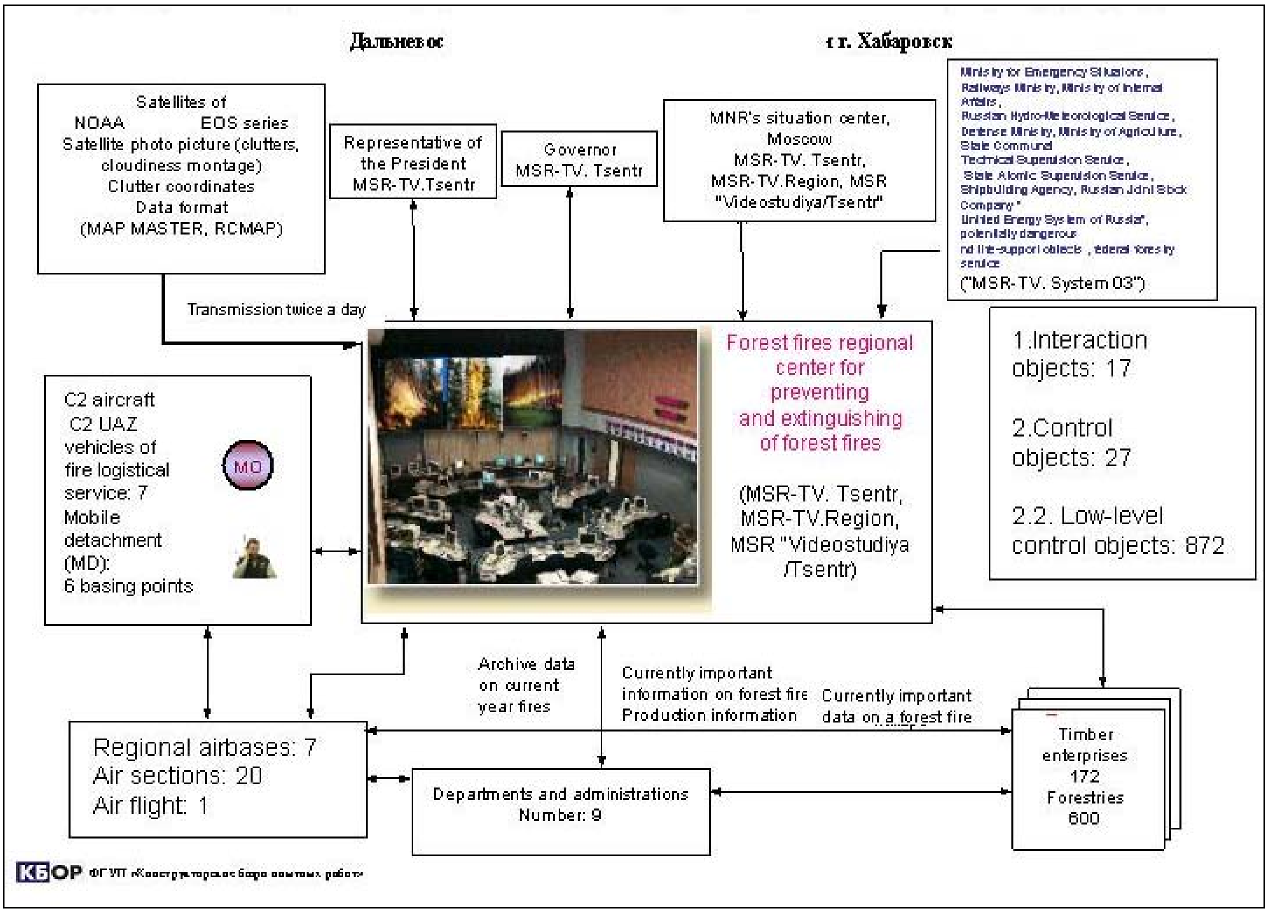


**Figure 4.** Interaction and control structure of the forest fires regional center for preventing and extinguishing of forest fires of the Far-Eastern Federal District of the Ministry of Natural Resources (MNR) of Russia, Khabarovsk.

Day-to-day situation is currently monitored at the Khabarovsk RFFC through the NOAA and EOS-TA Terra satellites. The advantage of the EOS TA is a MODIS device with 2 channels. It has a resolution of 250m and allows the identification of a fire source with an area of 100 $m^2$ with T=1000K, and a smouldering area of up to 900 $m^2$ with T-600K.

Fire forecasting allows for the establishment of fire hazards by five classes (FEFO fire forecast for July-August, September).

The Ministry of Natural Resources system of remote sounding from space allows the identification of probable forest fire sources.

In the Okrug, day-to-day collection and processing of information on the available fire sources is carried out by the MSR-TV.M/DC (Multiple-Function Registration System -TV Mobile Dispatch Center), aircraft and command vehicles (MSR-TV.M/DC).

Flying over a fire and using MCP-TB. M/DC, a pilot-observer fixes the GPS-based coordinates of the fire line, documents fire hazardous areas, builds for the operator colour photo plans linked to the date and coordinates, and submits them to RFFC as a Forest Fire Report.

In the fire area, the MCP-TB.M/DC Operator, who is a member of the mobile unit, collects and processes the information about the current fire behaviour and activities of the fire fighting team by photo and video filming. He then sends it on real-time radio channels to either the aircraft or directly to RFFC.

Using the computer-based MCP-TB/DC regional system, RFFC processes the “coordinates + photo plan + IK-photo + video + text + voice” information clusters integrating them into the existing “GIS Forest Fires” regional level management system. This is followed by analysis and decision making.

The proposed superimposed lower-bit rate digital network for a 9.6 kbit/s data transfer will receive and transfer an MCP-Cluster (text + photo plan + e-map) with a resolution of 600x800 dpi and a size of 50 KByte within 60 seconds from any point in this country.

Frame by frame video monitoring (1 CIF) is implemented through a modem at a rate of over 12 kbit/s.

MCP-TB.Com (4 CIF) videoconference operation requires 256 kbit channel.

Figure 5 presents the telecommunications arrangements a large fire situation.

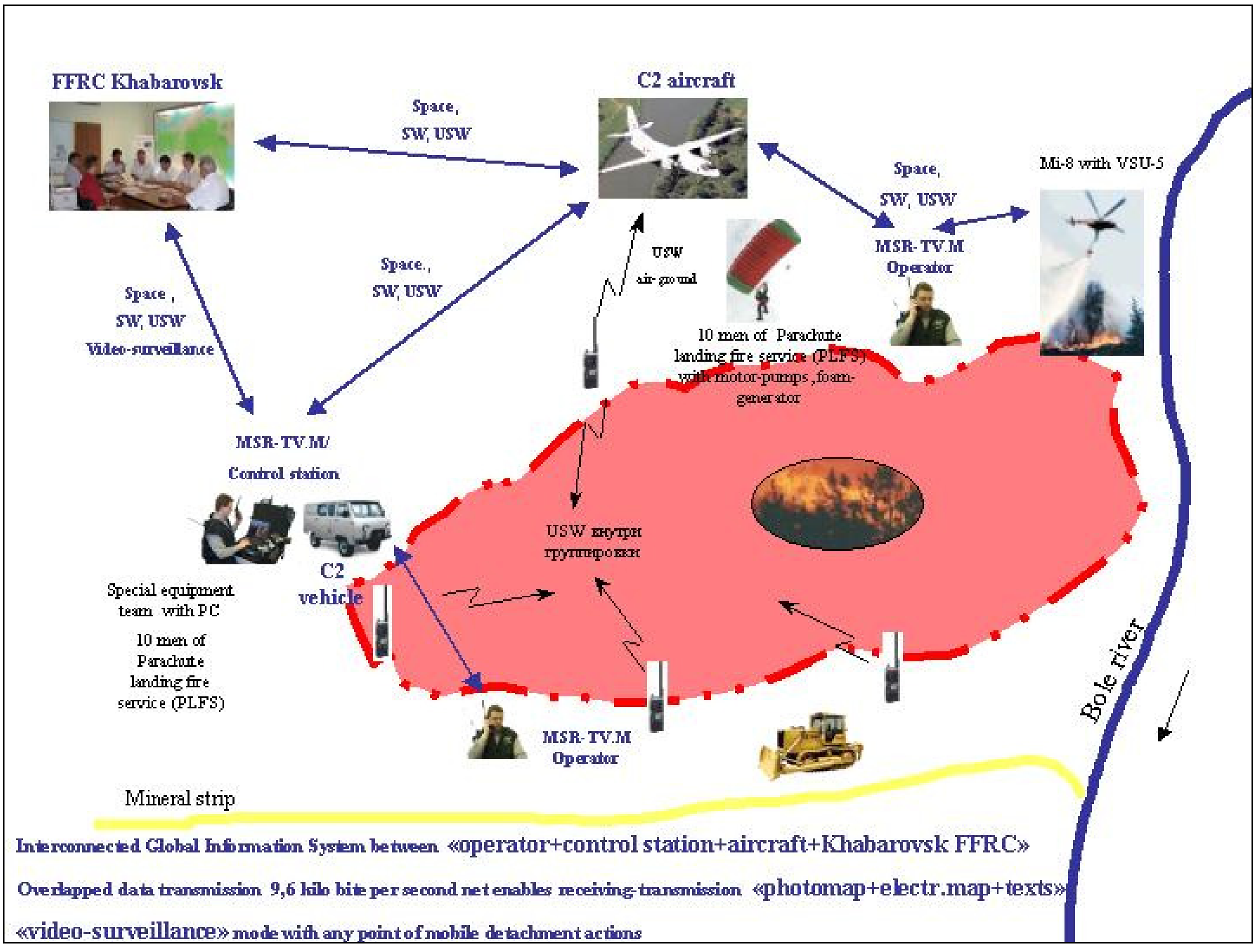


**Figure 5.** Communications system structure during extinguishing of a large forest fire

Hands-on cooperation of ground and aviation resources is based on prompt deployment (3-4 min.) of mobile units. These could operate under high humidity and in the context of high dust content. RFFC controls and assesses the results of fire fighting by using aviation- and ground-based methods, including artificial rains.

The system allows for operational manoeuvring of the mobile units to fight fires within the region. Establishment of such centers in the Siberian, Urals, Central and North Western Federal Okrugs will allow manoeuvring of the mobile resources and units across the country depending on the fire situation. The system provides automatic submission to the authorities and the public of end-to-end information concerning forest fire management.

The Center will implementation of the Steering Committee decisions, contract specialists from various organizations for analytical, expert and other works, including the application of IK facilities.

**Basic Operating Principles of MCP-TB System**

- Modelling of processes is based on visual adjustment of linkages between the elements
- The User can build a configuration of his processes on the bases of the newly established reference materials, documents and other elements that are linked between each other
- The User can draft any documents, associated with the activity of the Ministry;
- The data can be both imported from other programs and manually entered into the system ensuring a totality of the information
- The User is not involved in programming of the software functions but is capable of configuring them without applying to programming skills
- Any documents are drafted and printed in MS Excel or MS Word format, with the relevant information entering the database of the system and changing the database
- Full integration with MS Word
- Simple solution of complex problems where possible

The Situation Center is a management information system based on many provisions of the ISO 9000 and CALS technologies and will be able to:

- integrate any data (of different nature and even from different programs);
- see a real-time development in a user-friendly qualitative and quantitative context;
- identify areas requiring urgent response.

## Use of Experimental Prescribed Fires in Building Future Knowledge Bases for Fire Management Decision-Making

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### Introduction

The use of prescribed fire has had a long history in many parts of the world. Prescribed fire by definition is any fire that is deliberately used for prescribed burning, which is the knowledgeable application of fire to a specific land area to accomplish predetermined forest management or other land use objectives (Merrill and Alexander 1987). Prescribed burning is conducted for a variety of purposes including the removal of harvesting debris and site preparation for regeneration objectives (e.g., McRae et al. 2001, Walstad et al. 1990), for fuel management (e.g., Omi 2002), and for restoring fire back into natural fire-dependent ecosystems (e.g., McRae et al. 1994). In Canada, areas up to 2000 ha have been burned in a single 4-5-hour burning period, usually in the afternoon or evening, when burning conditions are best. The operational use of prescribed fire in Russia has been examined recently by Valendik et al. (2000, 2001) through a series of trials located in central Siberia. However, there is another important use of prescribed fire that may not be as familiar, which is the use of experimental prescribed fires or simply experimental fires.

Experimental prescribed fires are purposely ignited for a reason; hence, they are by definition prescribed fires. Forest fire researchers intentionally set these fires to study wildfire behavior, fire suppression strategies, ecological fire effects (forest health), emissions, and issues pertaining to climate change under controlled conditions. In most cases, these fires occur in standing forest fuel types to document what may occur in a naturally occurring wildfire. These empirical fires help researchers to better understand what can happen under the full interaction of all environmental factors (e.g., fuel beds, weather and atmospheric conditions, large fire physics, etc.). This approach has been extensively used in both Canada (e.g., Stocks 1987; Stocks et al. 1999) and Australia (e.g., CSIRO Forestry and Forest Products. 2003) in studying wildfires. For modelling purposes, a replicated plot design is used so that for a given fuel type a full range of burning conditions can be monitored and documented. This approach recognizes, and rightly so, that fires burning in a similar fuel type can be vastly different given the actual burning conditions (i.e., fire danger). This variation, of course, affects the fire severity that is experienced (e.g., tree mortality).

Experimental fires are usually small in size (<4 ha). The reason for the small size is that it assists in the control and suppression of the fire especially if a crown fire were to develop, which can be extremely hard to control without fuel breaks. In many cases, wide bulldozed firelines are used in places such as Canada to effectively contain these fires. More important, the small plot sizes assists in the full documentation of fuels (i.e., consumption) and ecological conditions both before and after the fire. Sampling is often established on a gridded system so that measurements are taken in a similar systematic way across the plot for all science disciplines. In all cases, quantitative (i.e., actual) rather than qualitative (i.e., descriptive) values are gathered so that predictive models can be produced. For a modern fire management organization, it is no longer suitable to descriptively describe a fire using qualitative terms (i.e., light- versus high-intensity fires). Fire behaviour characteristics, such as rate of spread and fireline intensity, are gathered during the actual fire event based on the grid system. Experimental plots are the only means of acquiring this type of quantifiable documentation, as it is impossible to do so during a wildfire because of the time needed to do the pre-fire sampling, especially in front of a rapidly approaching wildfire front that could adversely affect research personnel safety.

A complete fire weather station must be established and maintained at the experimental site for the season. Daily observations of dry-bulb temperature, relative humidity, 10-m open wind speed, wind direction, and precipitation are taken to assist in calculating different fire behaviour danger rating systems. Fire modelling often uses the fuel moisture codes and fire behaviour indices from these systems to predict what may occur during a fire (e.g., rate of spread, fireline intensity, fuel consumption, emission amounts, tree mortality, etc.). It is from these predictive models, using fire behaviour danger rating system values obtained from different districts, that fire managers at regional coordination fire management centers can better anticipate burning conditions for appropriate allocation and pre-positioning of suppression resources. These models can be used to predict anticipated fire behaviour and fire occurrence. Models play an important role when conducting prescribed burns operationally to understand the expected fire behaviour characteristics, the anticipated control problems, and ecological effects. More important, these models indicate when it is safe to burn so that the prescribed fires can accomplish the objectives for the burn without escaping control.

### Experimental Fires in Russia

A recent attempt to use experimental fires in Russia occurred in 1993 during the Bor Forest Island Fire Experiment in central Siberia (Firescan Science Team 1996). The primary objective of Bor Forest Island Experiment was to assess whether an international collaborative research team could successfully conduct and monitor an experimental prescribed burn in Russia. While this fire did show that such fires could be conducted safely, the Bor Island experiment was only a single burn conducted in one fuel type under one particular burning condition.

A replicated fire experiment in central Siberia was begun in 2000. The Russian FIRE BEAR (Fire Effects in the Boreal Eurasia Region) Project is a long-term forest fire research study developed to provide answers to basic questions on the management of fuels, fire behaviour, and fire regimes to enhance carbon storage, and forest sustainability in ways that minimize negative impacts of fire on global environment, wood production, and ecosystem health (McRae et al. 2004). Stands in the research area are representative of the central taiga pine forest (Parmuzin 1985) containing Scotch pine (*Pinus sylvestris)*, lichen (*Cladonia* sp.), and feather moss (*Pleurozeum schreberi*). To date, a total of fifteen 4-ha plots have been burned.

Fires were carried out in June and July, which corresponds to the main fire season for this region of Siberia. Plots were burned under a wide range of fuel moisture and weather conditions to observe effects on fire behaviour, fire severity, emissions, and other ecological factors. All experimental plots were burned using line ignition along the windward side to quickly create equilibrium fire behaviour that mimics wildfires under similar burning conditions (Johansen 1987, Weber 1998).

A complete inventory of the fuels was made both before and after the fire to understand fuel consumption. Ground fuels consisting of the organic forest floor (litter, fermentation, and humus layer), surface fuels representing dead and down woody fuels, and crown fuels were sampled. The vegetation and tree seedling regeneration (<5 years old) on the experimental plots was described based on standard Russian inventory methods (Sukachev et al. 1957, Pobedinsky 1966, Alexeyev's 1989). Stand structure of trees greater than 10 cm diameter at breast height (DBH) was measured using the point-centered quarter (PCQ) method (Cottam and Curtis 1956). Each tree was characterized by basic mensurational parameters (e.g., height, DBH, and height to live crown) as well as by measures of char height after the fire. Stand density and tree basal area were also determined from the PCQ data. In addition, other studies looked at changes in soil nutrients, soil microfauna, soil and tree respiration, wildlife, disease, and insect populations.

To enable accurate measurement of fire spread, electronic timers similar to those of Blank and Simard (1983) were used. In addition, an infrared camera was flown overhead to record digital images of the fire's progress, as infrared wavelengths are not obscured by smoke (McRae and Jin 2003). The digital images when geo-referenced and analysed provided reliable estimates of rate of spread for any area of the fire. Rate of spread is used to calculate the fireline intensity developed during each test fire (Byram 1959). Fireline intensity is an important indicator of the type of fire and the suppression resources needed to extinguish a fire. A number of depth-of-burn pins (McRae et al. 1979) were placed on the site to record the depth of ground fuel consumption. Trace gases and aerosol particles were sampled at ground level and aerially using a Russian MI-8 helicopter to characterize emissions. Aerial sampling provided a better collection of emissions released into the atmosphere after scrubbing by the tree canopy.

### The Need for Knowledge in Fire Management

Initial reactions for improving fire suppression efforts, especially when new funding becomes available, can be solely directed towards procuring more fire fighting equipment (e.g., hand tools, mist blowers, chainsaws, pumping units, vehicles, etc.), aircraft, and facilities (e.g., buildings, air strips, etc.), and increasing available manpower. However, a modern fire management approach cannot rely solely on its physical assets for controlling fire. The annual current fire loads of many countries, including Russia, are being overwhelmed by the sheer number and sizes of wildfire. For Russia, wildfires affect as much as 12-14 million ha annually (Cahoon et al. 1994, Conard and Ivanova 1997, Conard et al. 2002, Dixon and Krankina 1993, Kasischke, et al. 1999). In 2003, it has been estimated that approximately 22.6 million ha has been burned (Global Fire Monitoring Center 2003).

The recent implementation in the Far East of Russia of a coordinated fire management center system indicates how Russia is changing and modernizing its fire management systems to increase efficiency. However, this modernization must be coordinated with better predictions of expected fire occurrence, fire behaviour, and fire effects. Given the current and predicted increases of fire loads (i.e., too many fires to adequately action all at the same time given limited suppression resources), deployment of suppression resources will have to be determined by decisions based partially on the best available information from computer-based models. This will require an improved knowledge base to run these predictive models. Knowledge comes from dedicated wildfire research and any funding proposals for the improvement of fire suppression capabilities should consider what is required and be prepared to fund it appropriately. Ignorance of this simple fact will only hinder the overall modernization of any fire management program.

**Wildland Fire Research Needs**

The FIRE BEAR Project is presently documenting and modelling fire in the Scotch pine forest fuel type of central Siberia. There is a need to expand this vital research to other important fuel types found across Russia that could include:

- Larch
- Far East mixedwood
- Siberian mixedwood
- Far East Korean pine (*Pinus koraiensis*)
- Dark conifer
- Peat
- Forest steppe
- Steppe

A number of other fire research areas not addressed by FIRE BEAR would be appropriate for consideration for funding. Given the need to prioritise fires to be actioned, fire occurrence (i.e., ignition source, fuel type, and seasonality of fires) and fire growth models might be appropriate areas of increased concentration. The importance of periodic fire in reducing fuel buildup and fire intensity (fire severity) in fire-dependent ecosystems has been well documented in the United States. The increasing occurrence of catastrophic fires in the wake of a total suppression policy has initiated the use of prescribed fires to reduce natural fuel buildups in a controlled manner. Fire research in Russia should be undertaken to study the use of prescribed fire in Russia for assisting suppression efforts in reducing the number and intensities of fires by burning out wildland fuel buildups periodically.

The Nesterov Index (Nesterov 1949) and Moisture Index (Vonsky 1975) are simple one-code rating systems used to assess forest fire danger in Russia. Although providing an adequate means of estimating the general fire danger, they do not necessarily lend themselves well as fire behaviour indexes. As an example, the Canadian Forest Fire Weather Index (FWI) System (Canadian Forest Service 1987), derived for the boreal forests of Canada, has 3 fuel moisture codes representing ground fuel dryness for 3 different zone depths and 3 fire behaviour indices indicating potential fuel consumption, rates of spread, and fireline intensities (Van Wagner 1987). The FWI system helps a modern fire organization by allowing for the understanding of drought conditions present and being able to assist in understanding the potential fire behaviour characteristics of any fires that should develop in a particular fuel type. The Canadian Forest Fire Prediction System (Forestry Canada Fire Danger Group 1992) and BehavePlus fire modelling system (Andrews 2003) are examples of current modelling systems. Resource allocation, routing of detection flights, and prioritising of fires to be suppressed can be readily assessed using the FWI System. The codes and indices of the FWI System are used in developing a prescribed burn prescription in understanding when to best burn to achieve the burn objectives safely. In a modernization effort, a more complete fire weather index system should be developed for adoption in Russia.

A better record of the actual area that is annually burned is required for Russia. This is a large challenge because of Russia's vastness and many remote areas. The use of remote sensing, using satellite images to verify the annual burn area, is required. While products for recognizing burn scars (areas) are becoming better, there is an essential need to be able to recognize the fire severity better (e.g., crown fire with total tree mortality, high-intensity surface fire with total tree mortality, surface fire with partial tree mortality, low-intensity surface fire with no tree mortality, etc.) observed on these scars. The determination of fire severity remotely would assist to understand not only timber (economic) losses, but would be important to give more reliable estimates of carbon releases from fires for carbon cycling models. Some of this remote-sensing research would have to rely on other disciplinary research, such as FIRE BEAR, to be able to ground truth and verify the fire severity results observed.

Because of inherent differences between wildland fires across Russia and suppression equipment available on the market, technical and development research on the effectiveness and improvement of suppression equipment for Russian conditions would be worthwhile. The field of operational research and its role in resource placement could help in better pre-positioning limited resources (i.e., fire bases, positioning of manpower and location of aircraft bases, etc.), where they would be most efficient in fighting fire across a region (Hirsch and Martell 1996, MacLellan and Martell 1996,Islam and Martell 1998, Martell et al. 1998) rather than relying on subjective or personal biased placement.

International and interdisciplinary research approaches are required to make information available. Wildland fire is not unique to Russia, and researchers of all countries can help in understanding and dealing with this global problem. Sampling techniques and observation, accepted by the global fire science community, can be shared and used. Since research can be long-term and expensive, especially related to the use of experimental plots, it just makes good sense to have as many science disciplines involved in the research work as possible. Many of the disciplines piggy-back on to results obtained by other disciplines. For example, the prediction of many fire effects will require information from the fire behaviourist on the actual fire characteristics that existed.

## Conclusion

Modernization of the Russian fire management system, while needing to rely on more or better physical assets, must be done in concert with acquiring essential information or knowledge in various aspects of fire occurrence, fire behaviour, ecological effects, fuel management, and the use of prescribed fire. This information can only be obtained through properly funded wildland fire research. Without it, decision-making in fire management will not have the proper support data needed to make the best choices. The neglect of this basic need can have large consequences given the economical and human losses that can occur during a wildland fire. Given that the prediction is for increasing fire danger and fire load across Russia due to forecasted climate changes (Stocks et al. 1998), it would be prudent to expand on this fire research in Russia now.

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# Contribution of GOFC/GOLD-Fire to Fire Monitoring in the Russian Federation

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## Introduction

The Global Observation of Forest Cover/Global Observation of Landcover Dynamics (GOFC/GOLD) program is providing international coordination to put in place the long-term observing systems needed for global environmental monitoring (http://www.fao.org/gtos/gofc-gold/index.html). Environmental monitoring requirements include satellite and ground observations for global change scientific research, as well as for natural resource management and the associated policy and decision support systems. The obstacles to improved use of satellite data for fire monitoring are common to many countries. It is recognized that the range of global observations necessary to understand and monitor earth processes, to assess human impacts and support natural resource management, exceeds the capability of any one country and therefore necessitates an international program (Ahern et al. 2001).

GOFC/GOLD was formed under the Committee on Earth Observation Satellites (CEOS) to bring together data providers and information users to improve access to and use of satellite and ground based observations on forests and fire. GOFC/GOLD is part of the Global Terrestrial Observing System (GTOS), which is sponsored by the International Global Observing System (IGOS) Partners, including the United Nations Environment Program (UNEP), the United Nations (UN) Food and Agriculture Organization (FAO) and the World Meteorological Organization (WMO) (Figure 1). GOFC/GOLD is currently helping GTOS secure the global observation needed for carbon, biodiversity monitoring and natural resource management. The secretariat for GTOS is hosted by the UN/FAO, the secretariat for GOFC/GOLD is hosted by the Canadian Forest Service. GOFC/GOLD has a special relationship with the international space agencies through the Committee on Earth Observation Satellites (CEOS).

Through a series of international workshops, the GOFC/GOLD-Fire Implementation Team (http://gofc-fire.umd.edu/) has developed a set of program goals that cover the broad range of perceived observation needs of the fire community (Justice et al., in press):

1) To increase user awareness by providing an improved understanding of the utility of satellite fire products for resource management and policy within the United Nations system, at international national and local levels.

2) To encourage the development and implementation of standard methods for Fire Danger Rating suited to different ecosystems and to enhance current fire early warning systems. To facilitate the use of remote sensing data and the development of a global fire danger monitoring system that can be used to supplement existing national and regional systems.

3) To establish an operational network of fire product validation sites and protocols, providing accuracy assessment for operational fire products and a test-bed for new or enhanced products, leading to standard fire products of known accuracy.

4) To enhance fire data product use and access, for example by developing operational multi-source fire data and combined with GIS data and making these available over the Internet.

5) To develop an operational global geostationary fire network providing observations of active fires in near real time.

6) To establish operational polar orbiters with fire monitoring capability. Providing i) operational moderate resolution long-term global fire data and products to meet user requirements and distributed ground stations providing enhanced regional products. These products should include fire danger, fuel moisture content, active fire, burned area and fire emissions, ii) operational systematic high resolution data (c. 30m) acquisition allowing fire monitoring and post-fire mapping and assessments. Thereby continuing the long-term records from Landsat and SPOT.
.
7) To create emissions product suites, developed and implemented to provide annual and near real-time emissions estimates including the associated input data sets.

To achieve its goals, GOFC/GOLD-Fire has developed strategic partnerships with a number of international programs, including the CEOS Working Group on Land Product Validation (WG/LPV), the CEOS Disaster Management Support Group (DMSG), the International Geosphere-Biosphere Program's (IGBP) International Global Atmospheric Chemistry (IGAC) Biomass Burning Experiments (BIBEX) program, the European Association of Remote Sensing Laboratories (EARSeL) Special Interest Group (SIG) on Forest Fires and the UN International Strategy for Disaster Reduction (ISDR) Working Group 4 (WG4) on Wildland Fire. The latter is helping to increase the awareness of fire issues, strengthen fire monitoring within the UN System, to improve national collation of fire information and the standardization of national reporting and articulation of the information needs of policy makers with respect to fire information.

## The Northern Eurasian Regional GOFC/GOLD Fire Network

A major role of GOFC/GOLD is to provide a coordinating mechanism for national and regional activities by developing a number of regional networks of data providers, data brokers and data users. Strong networks of resource managers and scientists provide the key to sustained capability for improving the observing systems and ensuring that the data are being used effectively. Wherever possible these networks are building on existing regional structures and activities. A series of workshops are being held to provide a strong voice for regional needs and foster lateral transfer of technology and methods within and between regions. The networks are enhanced and strengthened through a partnership with UN/ISDR/WG4, involving policy makers and fire managers associated with the UN System and building on the existing organizational structures to develop and implement the regional fire agendas. This UN program, facilitated by the Global Fire Monitoring Center (GFMC; http://www.fire.uni-freiburg.de/ ), is bringing together fire managers to help develop and implement the regional fire policies.

One of the GOFC/GOLD networks are currently being developed is the Northern Eurasian Regional Information Network (NERIN). This network is recognized as one of the major data providers for the emerging Northern Eurasian Earth Science Partnership Initiative (NEESPI). Current members of the network include the Center for Forest Ecology and Productivity (CFEP) and the Space Research Institute (SRI) (both in Moscow), the Institute of Atmospheric Optics (IAO; Tomsk), the Sukachev Forest Institute (SFI; Krasnoyarsk) and the Institute of Solar and Terrestrial Physics (ISTP; Irkutsk). These institutes have been generating satellite-based products of active fires and burned areas from the Advanced Very High Resolution Radiometer (AVHRR) and from the Moderate Resolution Infrared Spectroradiometer (MODIS) aboard the polar orbiting NOAA and NASA Earth Observing System Terra and Aqua satellites, respectively. Network members have also been working towards other GOFC/GOLD-Fire goals, such as the development of fire danger rating systems or the use of new technology for fire monitoring. Through partnerships at local, regional and national level, the network of satellite data providers collaborates closely with the Arial Forest Protection Service Avialesookhrana (AFPS). The immediate goal of is the intercomparison and validation of fire information from various sources within the framework of an integrated data system.

Members of the network have a history of collaboration with international partners, particularly in the United States, Canada, Europe and Japan. One of the major partners in the US is the University of Maryland, whose contribution to the activities includes two major areas. First, the MODIS science team has been assisting in acquiring raw MODIS data and MODIS fire products for near-real time dissemination and use by fire management agencies within Russia. Second, a rigorous a-posteriori analysis of satellite-derived fire products is being carried out to ensure proper quality assessment of the data for emission estimates and other scientific analysis.

The Workshop was an ideal forum for further discussions among the network participants and for steps towards the inclusion of institutions and researchers located in the Russian Far East to formally participate in the network activities.

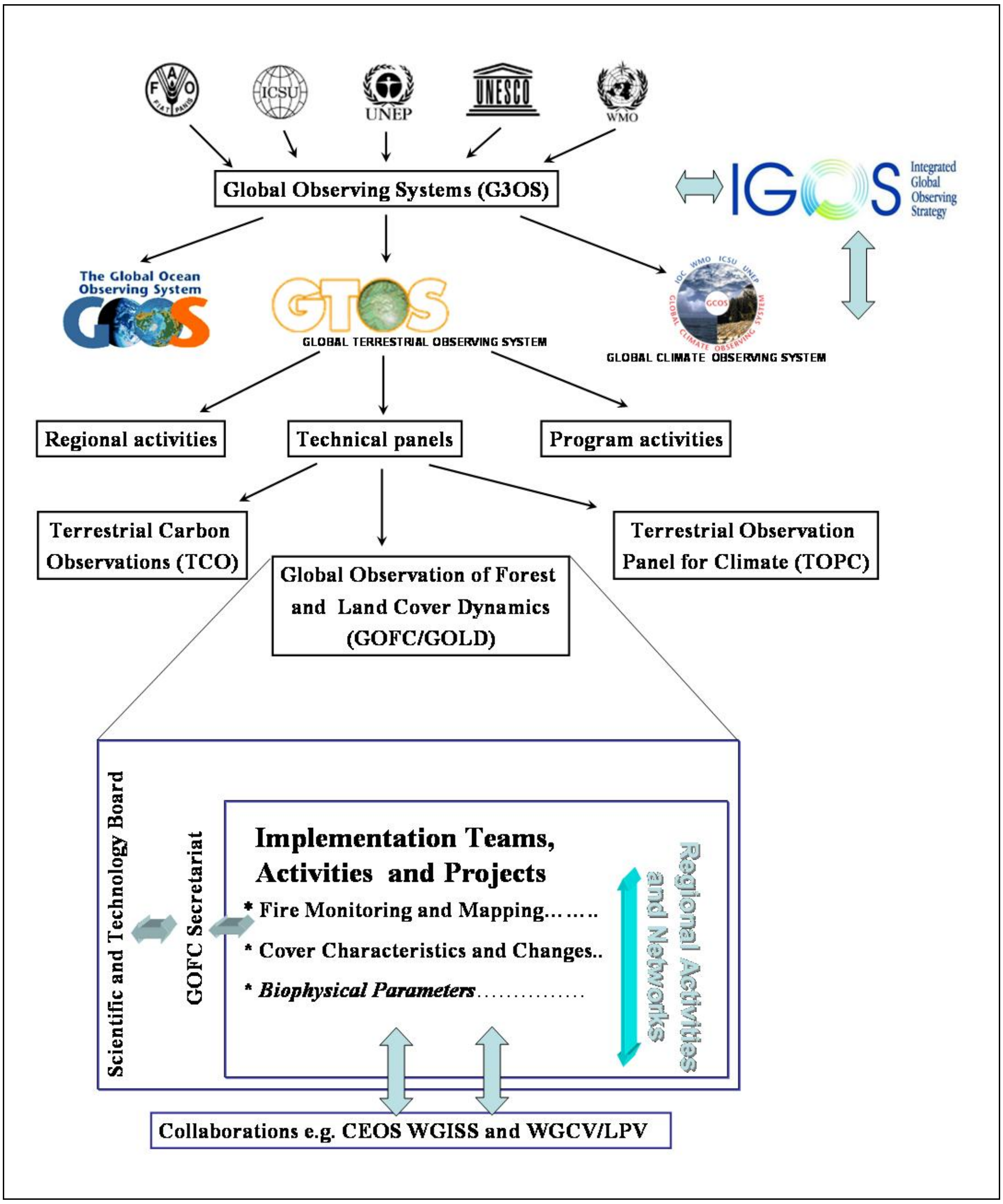



**Figure 1.** Organizational status of GOFC/GOLD

**Product comparison and validation**

For data products to be used in numerical models or in a decision-making framework, it is critical for users to understand their reliability and accuracy. Up until recently, satellite fire products and national fire statistics have been generated with little or no indication of accuracy. National fire statistics are compiled and reported using different methods and approaches making a quantitative comparative assessments and identification of trends extremely difficult. The CEOS WG/LPV and GOFC/GOLD are promoting the development of quantitative methods for quality assessment and to determine the accuracy (validation) of global, regional and national satellite fire products and maps (Roy et al. 2002; Morisette et al. 2002). This involves comparison with other airborne or satellite products and analysis of independent ground observations of known accuracy. Validation of global products is a labor intensive and costly activity and there are real advantages in international cooperation, sharing costs and resource between national and regional programs. A number of test sites are being established around the world as a focus for fire product validation (Justice et al. 2000). The primary challenge for GOFC/GOLD in this area will be to promote standardized national data collection and reporting and encourage satellite data providers to assess the accuracy of the products that they are delivering. Involvement of the user community in design of the information products and the accuracy assessment process is highly desirable. It is important for satellite data providers to recognize that quantitative product validation is not an option but an integral part of the data and information delivery system and must be included as part of the overall mission costs.

Both of the two major sources of fire data in Russia, AFPS and the satellite-based fire products, have their strengths and limitations. AFPS can provide accurate, high resolution data at all weather conditions, but only over a limited coverage area, and according to its mandate, only over forests. Satellites can provide observations over a wider area regardless of the land cover type, but cloudiness hampers detection of active fires. This is less a problem when burned areas are detected, when only a few clear scenes are needed for a successful mapping. However, issues related to sensor limitations and algorithm imperfections remain.

There have been attempts to directly compare total burned area estimates from AFPS and satellites and large discrepancies have been found (Conard et al. 2002). Here we present our analysis of data from 2001 over the Irkutsk airbase coverage area, using the fire product generated at SFI (Sukhinin 1999). This product includes cumulative active fires as well as directly mapped burned areas. Figure 2 shows the comparison of size distributions of burned scars. Total areas from AVHRR and AFPS are also shown. It is clearly visible that most fires in the AFPS database are smaller than 100 hectares. AVHRR data, on the other hand, have no burn scars smaller than the nominal resolution of the AVHRR pixel (~1 $km^2$). Note, however, that this does not indicate that satellites cannot detect fires smaller than that threshold; many of those fires are included in the 100-500 ha bin. Multiple individual small fires within one AVHRR pixel are represented as one single fire. The tendency of the AVHRR product to merge multiple fires into single clusters is also illustrated by several large fires which were not reported by AFPS.

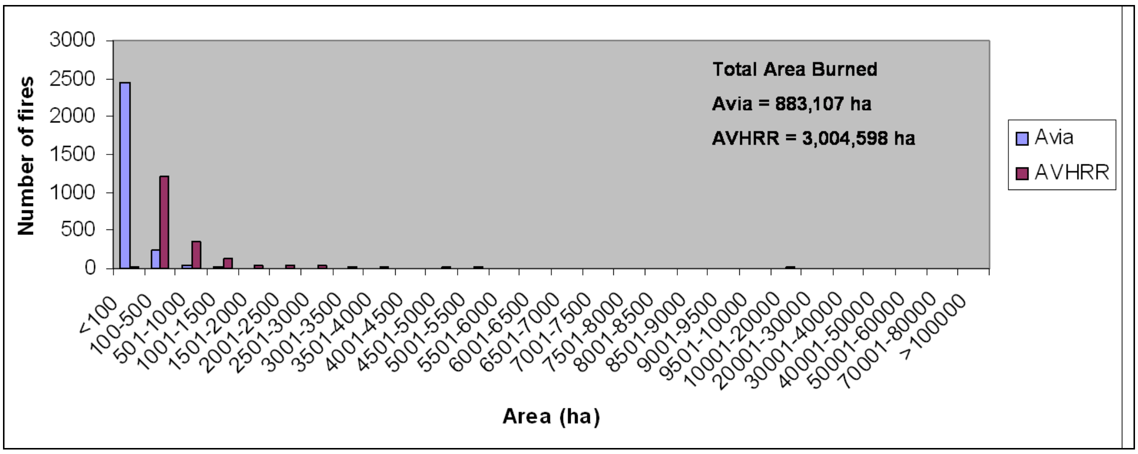



**Figure 2.** Size distribution of burned areas as reported by AFPS and AVHRR

The AVHRR data presented in Figure 2 include all fires within the coverage area, including fires over non-forested land surface. We used the 1-km AVHRR land cover classification dataset (Hansen et al. 2000) to determine the extent of burning over various land cover types. As it can be seen in Figure 3, the majority of the fires occurred over woodland and wooded grassland. In fact, if we calculate the sum of the burned areas over only the four "forest" land cover types (evergreen needleleaf, deciduous, deciduous broadleaf and mixed), the result (692,580 ha) is close to that reported by AFPS.

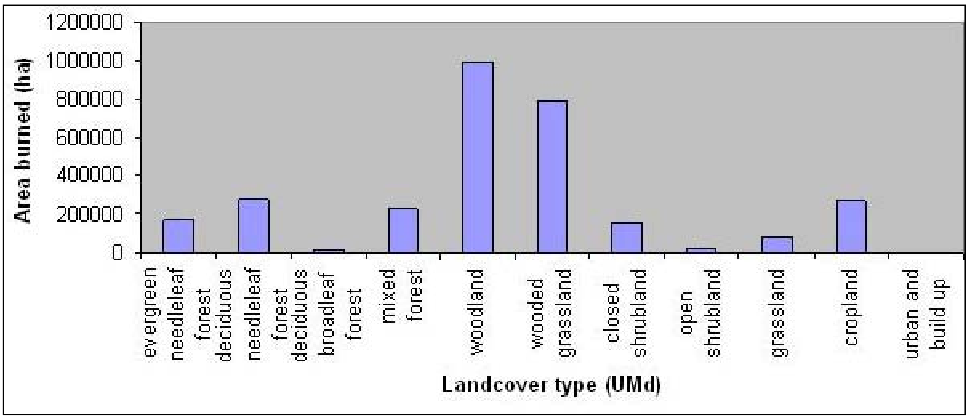



**Figure 3.** Distribution of burned areas derived from AVHRR over land cover types

Of course, definitions of "forest" used by AFPS and the satellite-based classification schemes are not compatible. We also computed total burned areas from AVHRR as a function of tree cover percentage from the University of Maryland continuous vegetation cover product (DeFries et al. 2000). From Figure 4 it can be seen that the best match between the two datasets is when we consider AVHRR burned areas over pixels with more than ~ 55% fractional tree cover.

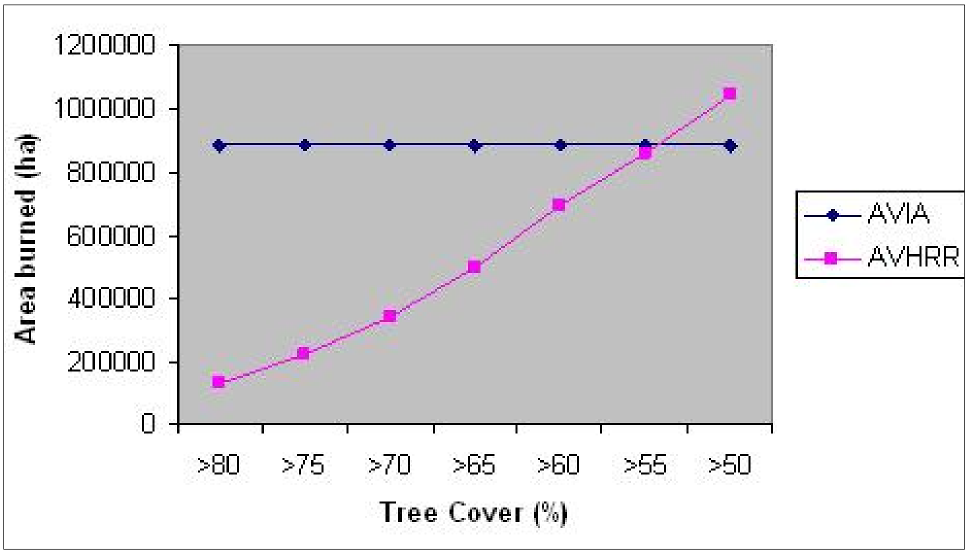
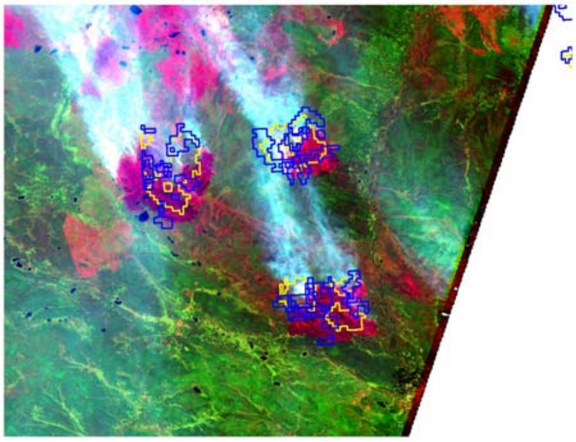



**Figure. 4.** Total burned area from the AVHRR product as a function of tree cover percentage. The blue horizontal line represents the total area reported by AFPS.

With the help of high resolution satellite imagery, such as Landsat/ETM+ (Enhanced Thematic Mapper) data, such total statistics can be compared to independent, more accurate estimates. High resolution imagery is also useful for the geospatial validation of the data. Figure 5 shows examples of comparisons between fire products from CFEP/SRI (Bartalev et al. 2001), SFI and Landsat/ETM+. Direct comparison of AFPS and satellite data has proven to be difficult because AFPS data are available only as center locations and areas (i.e. no perimeters) and because of the often large inconsistencies in the locations of fires reported by AFPS and mapped by satellites.



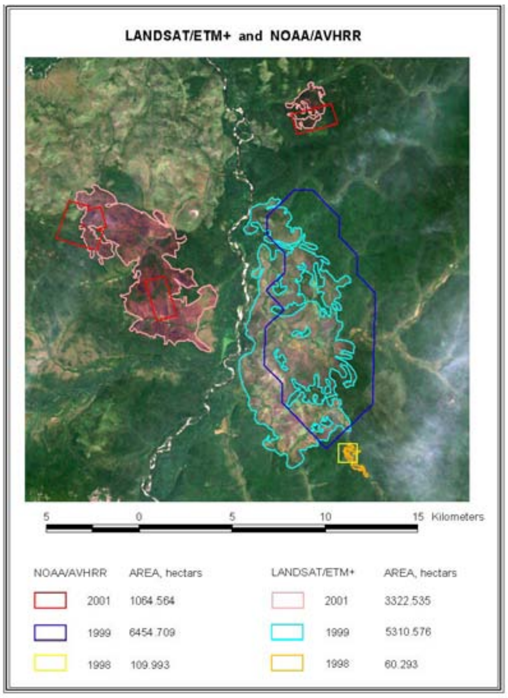



**Figure 5.** Landsat/ETM+ imagery with active fires and burned areas from AVHRR products generated at CFEP/SRI (left; 07/23/02, WRS 125_016) and SFI (right; 06/20/01, WRS 139_22).

## Conclusions

Various data sources of biomass burning in Russia are often incompatible due to differences in reporting and coverage, often as a consequence of the inherent differences in observing systems. Similarly, many of the requirements of the fire management and the scientific communities are also different, such as timeliness and form of delivery of the information. However, proper quality assessment is essential for both optimizing resource usage in the everyday fire management practice and for improving our scientific knowledge related to atmospheric emissions, land cover change, or other aspects of the Earth System. This indicates the interdependence between the various data user and data provider communities. Local and regional fire management agencies can provide invaluable source of fire data for the validation and calibration of satellite-based products developed by the science community. High-quality, more reliable satellite products, in turn, can assist the managers in making strategic planning decisions. These arguments prompt the convergence of the various products into one integrated system where the best use of each can be made in a complementary fashion.

## Acknowledgements

Thanks go to Drs. A. Sukhinin (SFI), E. Lupyan (SRI), D. Ershov (CFEP) and their colleagues for making their satellite-based products available. Part of the work presented in this paper was supported by the NASA New Investigator in Earth Sciences program.

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## Forest Management Data Summary for the Far Eastern Federal Okrug

*Ministry of Natural Resources of the Russian Federation*

### The Fire Situation in 2003

The natural fire danger and occurrence in the forests of the Far Eastern Federal Okrug are among the highest in the Russian Federation. Over 80% of its territory is classified as high fire risk territories.

By 1 September 2003, since the start of the fire season, the Far Eastern Federal Okrug has seen 3,300 forest fires affecting 806,200 hectares (ha) including 477,400 ha of forested land.

In the Far Eastern Federal Okrug, the subjects of the Russian Federation accounted for 7.2% of all forest fires (24,000) registered in the forests of the Russian Federation, while in terms of the forested area it accounts for 25% or 1.9 million ha.

As compared to 2002, there is a 1.3 times growth of forest fires, with a 1.3 times decrease in burned areas, including a 1.5 times decrease in burned forested land.

There is also a 120.7 ha decrease in the average area burned by one fire. An adequate response eliminated most of forest fires on the day of their occurrence and on smaller areas.

The above indicates increased effectiveness of Forest Fire Services of the said region. Fire management has been carried out in close cooperation with the governments of the subjects of the Russian Federation along with the mobilization of additional human and technical resources.

To render timely assistance in attacking forest fires, fire fighting service moved to the area 13 airborne fighting teams numbering 280 staff, with additional fire fighting means mobilized in other territorial units of the MNR.

The Forest Fire Service carried out a number of forest fire prevention activities. In the first six months of 2003, these included the construction of 4,600 km fire breaks (breaks, mineralized strips, forest edges, ditches, etc.), tendering of 10,000 km of fire breaks and mineral strips, construction of 200 km and repair of 654 km of fire prevention roads.

All the leskhozes, except the Jewish Autonomous Oblast leskhozes, met the targets for the construction and tendering of fire breaks.

Enforcement of fire fighting and prevention requirements and identification of those responsible for fires is characterized by the following figures. The first six months of this year caught 29 persons who were responsible for forest fires and 1,000 of those who violated fire safety rules in the forests. These indicators are lower as compared to the same period of last year. The amount of fines collected was 363,900 Rubles.

### Forest Insect and Disease Control

A number of adverse factors influence the forests of the Far Eastern Federal Okrug leading to the weakening and destruction of forest stands.

The last decade analysis of the drying up of forest in the Okrug shows that forest fires contribute most to the weakening and destruction of forest stands. Over this period, forest fires destroyed 867,900 ha of forested land (97 percent of the entire dry forest stands). Adverse weather conditions are the second leading factors of forest destruction (20,600 ha or 2.3 percent). The average acreage of dead forest stands in the Okrug comprise 0.32% of the forested land. Over this period, the highest intensity of forest destruction was found in Kamchanka Oblast and the Koriaksky Autonomous Okrug, followed by Sakhalin Oblast and Chukotka Autonomous Okrug (0.87 and 0.86 percent correspondingly).

The health and pathology situation in the Far Eastern Federal Okrug forests is characterized by a high level of forest stand drying, which in 2002 accounted for 157,500 ha or 47% of the entire forest lost in Russia. Forest fires are the main cause of forest stand destruction, having devastated 154,485 ha of forest stock (98%). Dendrophilous insects contributed to the drying of 1,705 ha (1.1%) of forests, while adverse weather conditions caused the drying of 805 ha (0.5%) of forest stand. In the Okrug, the dead forest area accounts for 0.57% of the forested land topping the average national indicator of 0.47%. Insufficient application of allowable cut leads to accumulation of matured and old trees in the structure of the forest stock and its subsequent deterioration as the process of natural dying of trees brings to life insects and diseases. The mature forest stand accumulates forest fuel reducing the carbon deposition, while the pets and disease hotspots, which it generates, tend to splash over to the adjacent forest areas.

In 2003 drought stress in forests was most intensive in Kamchatka Oblast, Koriaksky Autonomous Okrug, and the Republic of Sakha. The destruction of forest stands in these administrative units was caused by forest fires.

The current drying process and full destruction of forest stands result in environmental deterioration and reduced value of forests. When valuating stumpage alone, the drying and destruction of forests reduced the value of forest by 2,327.9 million Rubles in 2002 due to the deteriorated timber quality. The program of forest sanitation is being carried out to normalize the sanitary and pathological situation in the forests. In 2002, these activities covered 19.7% of the forested land in the Okrug, which are in need of improvements. In the Jewish Autonomous Oblast, the improvement activities amounted to 56.9% of the demand, in Khabarovsk Krai – 35.7%, in Primorsky Krai – 22.0%, in Sakhalin Oblast – 26.4%, while in other regions of Russia there is a considerable underperformance in this respect. For example, in Magadan Oblast this indicator is 9.5%, in Kamchatka Oblast and Koriaksky Autonomous Oblast it is 0.5%, while in the Republic of Sakha it is as low as 0.05%. Information on forest sanitation programs in Chukotka Autonomous Oblast is not available.

In 2002, forest sanitation increased forest income in the Okrug by 179.8 million Rubles.

By the end of 2002, the hotspots of insects and diseases in the Far Eastern Okrug were found on the total area of 4,764,500 ha or 59% of all the hotspots in this country. Siberian Silkworm is the major insect for the Far Eastern forests. In 2002, the hotspots of this insect were found on the total area of 4,583,700 ha. Most affected from the outbreak were the Republic of Sakha and Khabarovsk Krai.

In 2002, aviation-based response, carried out on 114,000 ha to control this insect in Khabarovsk Krai and natural factors reduced the area of mass breeding of Siberian Silkworm by 2,179 ha. The year of 2003 saw the insect control response in the Republic of Sakha and Khabarovsk Krai covering the total area of 86.6 thousand ha.

Over the last decade, the average cumulative area of hotspots in the Okrug amounted to 1,896,700 ha, ranging from 1,100 ha in 1993 to 6,893,700 ha in 2001. The Siberian Silkworm hotspots occupied most of the insect populated area (1,744,100 ha or 91.9%) followed by 7.9% of hotspots of leaf-eating insects. Over this period, the Okrug forests experienced aviation response to dendrophilous insects in Primorsky and Khabarovsk Krais, as well as in the Republic of Sakha.

The Okrug has organized and is carrying out a pathological monitoring of the forests on the total area of over 2.1 million ha.

The Roslesozashita State Agency is conducting monitoring of Rosy Silkworm, which is quarantine specie. This allows for a free export of forest products through the ports of Nakhodka and Vladivostok.

In the Okrug, forest protection is the responsibility of the State Forest Service officials and specialized forest protection organizations. Primorsky Krai is covered by the Center for Protection of Primorsky Krai Forests (a branch of Rosleszashita), while Khabarovsk Krai and Amur Oblast are covered by Insects and Disease Control Stations

### Illegal Logging

In recent years, the Asia Pacific markets have been witnessing an increased demand for hardwood, in particular *Fraxinus mandshurica*, driving its harvesting beyond the share of the species in the commercial stock. Analysis of the industrial export of this wood species and the official license data shows that illegal felling has been taking place.

The China market consumes over 77% of the harvested wood. This is due to the fact that the Chinese Government adopted the plan for the development of its processing sector and creation of new jobs while stopping forest harvesting in certain territories for a long-term period.

Along with China, the Republic of Korea has also increased its presence at Russia's wood market. Wood exports into that country used to be low, while recently it increased significantly.

Of particular concern is the harvesting situation with valuable wood trees in the Far Eastern Federal Okrug. Here, illegal felling is carried out by well organized mobile teams furnished with harvesting and wood loading machines, as well as communication means. Those involved in illegal felling use violence including murder of state forest service officers, who would identify illegal harvesters.

Wood harvested in Siberia constitutes a considerable share of wood exports through the Far Eastern Federal Okrug subjects of the Federation.

The pattern of illegal felling in the Far Eastern Federal Okrug indicates that it is on the increase. In the first six months of 2003, state forest service officers found 942 cases of illegal felling in the Far Eastern Federal Okrug totalling 36,200 $m^3$ worth 467.3 million Rubles. Most of illegal felling takes place in Primorsky Krai (340 cases, 11,900 $m^3$, 339.4 million Rubles), Khabarovsk Krai (147 cases, 7,500 $m^3$, 79.7 million Rubles), and Amur Oblast (269 cases, 9,300 $m^3$, 34.4 million Rubles).

The State Forest Service, on its own and in cooperation with the territorial units of the federal authorities, has been taking action to improve the situation concerning illegal felling.

At the same time, the current illegal felling response is far from being adequate. Despite the action taken by the State Forest Service of the Russian Federation, stabilizing the situation with illegal felling requires that certain federal and regional level issues are addressed as soon as possible.

For example, one of the factors influencing the operation of the State Forest Service is poor logistical provision of the State Forest Service caused by inadequate budget funding of the State Forest Service.

Another big concern is inadequate regulatory and legislation framework at the level of subjects of the Russian Federation concerning forest use management, quantitative and qualitative assessment of forest resources, and control over harvesting, transportation, processing and sales (including exports) of wood.

There is also a need to change the basic forest instrument, the Forest Code of the Russian Federation, and to develop a number of federal-level legal and regulatory instruments concerning illegal felling.

Taking into consideration that illegal felling of valuable wood trees comprises a number of various violations related to illegal felling, transportation, processing and sale of illegal products at the internal and foreign markets, including price and customs violations, there is a need in clear-cut cooperation of various federal authorities, which are responsible for this aspect, including their territorial units and authorities of the subjects of the Russian Federation.

The MNR is of the opinion that at the level of the Federal Government, prompt decision taking and coordination of the competent federal authorities, which are responsible for the control over illegal felling and informal wood market, could be managed through an Interagency Committee. At the regional level, these functions could be carried out by establishing similar committees under the relevant authorities of the subjects of the Russian Federation.

In view of this, MNR is working on the preparation of draft resolutions of the Government of the Russian Federation on the establishment of an Interagency Committee to combat illegal felling, transportation, processing and sale of wood, as well as the Interagency Charter and its composition.

Generally, this issue should be addressed at the federal level through a set of policies for stronger state control over the harvesting and sale of wood at the internal and foreign markets, as well as through a higher status, improved legal and social protection of officers of the State Forest Service of the Russian Federation, and improved firearms and hardware provision.

### Forest Management Roads

The level of forest management and compliance with the forest legislation concerning the implementation of prescribed forestry activities and programs is largely determined by forestry road network.

Increasing the productivity and improving the sound use of forest resources requires developed forest transport infrastructure. Under Article 91 of the Forest Code of the Russian Federation, construction of forestry roads, as an element of this infrastructure, is a direct responsibility of leskhozes of Russia's Ministry of Natural Resources (MRN).

It should be noted that the forestry road network in the forests of the Far Eastern Federal Okrug is clearly underdeveloped featuring the lowest indicators as compared to other regions and subjects of the Russian Federation, apart from Primorsky Krai and Sakhalin Oblast.

**Table 1.** Forestry road network in the Far eastern Federal Okrug (FEFO)

| MNR Territorial Bodies | Administered Forests (x 1000 ha) | Forested Land (x 1000 ha) | Availability of Forest Roads | | | Development Indicator (km/1000 ha) |
|---|---|---|---|---|---|---|
| | | | Total km | Logging Roads | Forestry Roads | |
| Primorsky Krai GUPR | 12,870.7 | 12,302.2 | 39,242 | 20,699 | 12,172 | 0.99 |
| Khabarovsk Krai GUPR | 75,308.6 | 53,666.4 | 65,451 | 32,850 | 15,880 | 0.29 |
| Jewish Autonomous Oblast GUPR | 2280.8 | 1628.4 | 3896 | 2908 | 55 | 0.03 |
| Amur Oblast GUPR | 31,644.4 | 23,129.7 | 30,269 | 17,654 | 4814 | 0.20 |
| Kamchatka Oblast UPR | 16,328.4 | 9650.2 | 9091 | 1411 | 4980 | 0.51 |
| Koriaksky Autonomous Oblast UPR | 28,919.3 | 10,236.9 | 950 | 395 | 32 | 0.003 |
| Magadan Oblast UPR | 45,728.1 | 17,733.3 | 5795 | 1272 | 1448 | 0.08 |
| Chukotka AO UPR | 27,698.4 | 5133.2 | 1402 | 0 | 0 | 0 |
| Republic of Sakha GUPR | 255,610.8 | 143,969.1 | 30,684 | 5830 | 1212 | 0.008 |
| Sakhalin Oblast UPR | 7,077.5 | 5561.2 | 16,024 | 5123 | 6567 | 1.18 |
| **Subtotal for FEFO** | **503,467** | **283,011** | **202,804** | **88,142** | **47,160** | **0.16** |
| **Total for MNR** | **1,172,322.3** | **769,785** | **1,472,017** | **405,058** | **592,348** | **0.61** |

Development of forestry road networks in the forests of all the subjects of the Far Eastern Federal Okrug is a common responsibility of the authorities of all levels. Addressing this challenge will improve forest management, fire management, organization and implementation of forest use, with a positive impact on the social development of the region.

It is necessary, through joint effort, to change the current down trend of forestry road construction volumes.

There are good reasons to believe that this objective is attainable. The Forests Sub-Programme under the Earmarked Federal Program "Ecology and Natural Resources", approved by Resolution 860 of the

Government of the Russian Federation, dated 7 December 2001, sets forth the target of 5,417 km of forestry roads to be constructed in 2002-2010 and provides for financing of this Subprogram. In 2002, leskhozes of Russia's MNR built and repaired 138.5 km of forestry roads. Under the Program, the year of 2003 will see the construction of 34 km of forestry roads in Primorsky Krai, Amur and Sakhalin Oblasts worth of 3 million Rubles.

**Table 2.** Construction of Forestry Roads 2002-2003.

| MNR Territorial Bodies | Targets | Actual Status | Expenses | Targets | Expenses |
|---|---|---|---|---|---|
| | 2002 | 2002 | 2002 | 2003 | 2003 |
| | km | km | Rubles (x 1000) | km | Rubles (x 1000) |
| Khabarovsk Krai GUPR | | 3 | 270 | 3 | 1212 |
| Amur Oblast GUPR | 6 | 6 | | 6 | 1366 |
| Kamchatka Oblast UPR | | 103.5 | 10 | 14 | 357 |
| Magadan Oblast UPR | | | | | |
| Sakhalin Oblast UPR | 11 | 10 | 366.1 | 6 | 387 |
| Republic of Sakha GUPR | | | | | |
| Primorsky Krai GUPR | 5 | 19 | 14.9 | 5 | 51.2 |
| **Subtotal for FEFO** | **22** | **138.5** | **660.9** | **34** | **3051.2** |
| **Total for MNR** | **400** | **448.7** | **8240.7** | **400** | **90,700** |

This is surely not sufficient. Given the fact, that along with forestry objectives forestry roads promote social development at the regional and local levels, one should recognize that budget financing should be complemented by investments from local governments, forest users and tenants.

### Reforestation

The current volumes of reforestation operations in the Far Eastern Federal Okrug provide for the timely reforestation of the harvested area. In 2002, final harvesting and environmental harvesting operations consumed 100,800 hectares (ha) of the Okrug forested land, administered by Russia's MRN. Reforestation operations were carried out on 234,800 ha including planting and seeding of 25,800 ha. Some 323,400 ha of saplings were classified as commercial stock. The reforestation operations expenses were 204.9 million Rubles, out of which the regional and local budgets contributed 73.3 million Rubles. Most of the reforestation expenses were born by the leskhozes (132.1 million Rubles or 64%).

In accordance with the Program for Reforestation of Russia's Forests in 2003-2010 developed as a follow up of the Ecology and Natural Resources of Russia Earmarked Federal Program (2002-2010) and approved by the Government of the Russian Federation, the Far Eastern Region will carry out in 2003 reforestation on 209,000 hectares including planting and seeding of 21,500 ha, sapling thinning on 22,600 ha, and commercialization of 272,000 ha of saplings. The subjects of the Russian Federation assigned 110.3 million Rubles for reforestation, which is only 20% of the requirement. Khabarovsk Krai and Sakhalin Oblast allocations will only be 6% of the requirement.

As of 1 August 2003, reforestation operations were carried out on 71,400 ha including plating and seeding of 21,300 ha, tending of 5,600 ha of plantations, and establishment of seeding blocks in the nurseries. In the first six months of 2003, reforestation expenses were 83.1 million Rubles, with the subjects of the Russian Federation and local governments having allocated 42.9 million Rubles or 52%. Khabarovsk Krai made no budget allocations for this expenditure.

Khabarovsk Krai and Jewish Autonomous Oblast have no regional reforestation programs, which are subject to approval by the authorities of these subjects of the Russian Federation.

# Minutes of Thematic Sessions at the International Workshop:
## *New Approaches to Forest Protection and Fire Management at an Ecosystem Level*
## 9-12 September 2003, Khabarovsk, Russian Federation

### Thematic Session # 1
### *Forest Fire Information and Data Processing*
Chair: E.A. Lupyan

This thematic session was attended by 17 participants, including representatives from the MNR's Central Office and Territorial Bodies, research and civil society organisations.

Presentations covered a variety of issues related to information management/support, satellite monitoring data processing and appropriate use for purposes of early detection of forest fires and inventory of burned areas; forest fire simulation based on the example of the software designed for the Gassinsky Model Forest; the availability of up-to-date GIS-based forest inventory and planning documents in the Far East Federal District. The session also reviewed the GEF Project of Fire Management in High Biodiversity Value Forests in the Amur-Sikhote-Alin Ecoregion.

Recommendations:

1. Define the legal status of the information obtained from satellites, and have regulations on its use under the forest fire early detection system;
2. Finalise the forest fire classification to include the term *catastrophic* therein;
3. Incorporate into the GEF Project of Fire Management in High Biodiversity Value Forests in the Amur-Sikhote-Alin Ecoregion another information management/support element (sub-element) to be called *Forest Fire Information and Data Processing*, including the following aspects:
   - setting up a specialised IS for the Project;
   - emphasising the information accessibility and openness;
   - providing the Project with data from Russian and international systems of forest fire monitoring;
   - preparing additional mapped data for the areas under 1st group forests and test areas with their composition to be defined based on an analysis of test regions information. Recommend that the Gassingsky Model Forest be used as a test area;
   - developing operational methods of estimating the potential impact of recorded fires based on monitoring data and simulated fire behaviour;
   - arranging for collection and processing of satellite high and medium resolution data for assessing the burned areas, including their retrospective assessment based on remote sensing data for 15 to 20 years;
   - producing methods for assessing the degree of forest disturbance using satellite data of various resolutions and forest inventory documents for assessing the impact and prescribing interventions to restore particularly valuable forests in the ecoregion;
   - designing information products through satellite data processing for assessing the areas or volumes of forest use (including illegal logging) in 1st group forests;
   - review the proposals on the status and arrangements of information sharing among forest users.

## Thematic Session # 2
### *New Forest Fire Management Technologies*
Chair: V.V. Furyaev

The thematic session was attended by 15 participants, including representatives from the MNR's Central Office and Territorial Bodies, research and civil society organisations as well as from the US Forest Service.

The session included presentations and discussions focused on the following aspects:

1. Fuel management and prescribed burning (Moderator: E. Valendik)
2. Fire Use (Moderator: J.G. Goldammer)
3. Applications of Forest Fire Research Outputs (I. Ivanova, D. McRae)
4. Fire Fighting (Moderator: W. Bushnell)

Recommendations:

To the end of effective forest fire management, conservation of forest biological resources and their diversity, it is necessary to address the following policy issues of management and research.

To have cost-efficient fire management, it is necessary to:

1. Shift from the policy of fighting absolutely all fires towards the recognition of the positive role of fire in boreal forest ecosystems.
2. Make a post-fire forest inventory and assess the post-fire dynamics of ecosystems under 'no-fighting' regimes which would allow to identify the conditions where fire plays a positive role.
3. Build the zoning of forests upon fire environmental/economic impact assessments with due regard to the trends in the forest-formation processes.
4. Adopt a federal legal tool to allow burn-out of forest areas (prescribed burning) in order to reduce the threat of intensive fires (in the vicinity of settlements, high value forests, etc.).
5. Introduce identifiers for forests involved into management activities. Its objective is to optimise fire management so that it could ensure biological resource conservation and targeted reforestation processes.
6. Establish the following four regimes of forest protection against fire:

   a) Enhanced protection. It is meant for areas where forest fires present a potential threat for sites of national economy and those of defence designation, i.e. where fires can cause maximum losses. Apply a system approach to raise the fire resistance of the forests in protected areas.

   b) Permanent protection. It is intended for developed and intensively managed areas, including areas of historical and cultural value (national parks, nature reserves).

   c) Limited protection. It is to be used in reserved forests and means enhanced protection of certain parcels with natural resources of particular value (oil deposits, etc.).

   d) Episodic protection. It is to be applied to protect an area only during seasons of extreme fire danger.

   Assignment of specific areas to one of the protection regimes is to be approved by the federal body upon agreement with the public authority of the Subject of the Russian Federation.

The four regimes should have different levels of financing, equipment, staffing and skills, and other economic and technical parameters.

Such a system may reduce costs of fire fighting and preserve the natural role of fire in the biological resource development process.

<u>Research Priorities</u>:

1. Study the ecosystem impact of vegetation fires as a natural permanent agent affecting ecosystems;
2. Identify boundary conditions of fire natural impact on forest biological resources and their diversity;
3. Develop a scientific framework for long-term prediction of fire impact on forest biological resources and principles for economic assessment of natural positive and negative impact of fires on ecosystems and the biosphere as a whole.

## Thematic Session # 3

***Improved Forest Fire Management Arrangements in the Region and the Roles of Parties Involved***

Chair: E.P. Kuzmichev

The thematic session was attended by 32 participants, including representatives from the MNR, international and non-governmental organizations, research institutions, and public authorities of the Subjects of the Russian Federation.

It was noted that the problem of Russian forest protection against fire is of global importance since it affects the biosphere and the world economy of the forest sector.

The session reviewed the existing forest fire management scheme. This scheme is comprised of the following main elements: administrative, regulatory/legal, engineering, social, information, and education/public awareness.

The presented MNR's draft Forest Fire Management Concept, for the first time, includes the principles of the Government's forest fire policy incorporated on a system basis. The document describes the goals and objectives of the forest fire policy, principles, strategy, and mechanisms of this policy implementation.

Upon discussion of the draft Concept, the participants agreed that after its finalisation, this document may serve as a basis for an up-to-date organizational scheme of fire management allowing to consolidate efforts of managers of all levels and the public.

The MNR and the Workshop participants invite all stakeholders to take part in discussing and finalizing this document.

It is impossible to improve the scheme of forest fire management and straighten the roles of its participants unless a relevant regulatory and legal framework is developed, and first of all – the federal Forest Code. The session participants reviewed the draft Forest Code submitted to the Government of Russia, and expressed the opinion that it should reflect the following requirements:

- distinct division of powers in the area forest fire control among the Subjects of the Russian Federation and municipal entities;
- the Article setting forth obligations of the Forest Guard officials should include a provision about the need of public awareness activities – to assign the coordination and managerial powers in the area of fire control to the executive authorities of the Subjects of the Russian Federation and support them with adequate financial resources.

<u>Recommendations</u>:

1. The Forest Code should provide for the establishment of a State Forest Fire Service.
2. To revise the scheme of financing the costs of forest fire control activities, make it compliant with the distribution of powers by authority level, ensure adequate financing to secure fire safety. To preserve the system of *leskhozes* as basic management entities in charge of forest fire prevention and control.
3. To approve the establishment of Regional Forest Fire Centres.
4. To develop a system of fire management for specially protected natural areas.

5. To improve the system of interrelations among the public authorities and municipal entities in the area of forest fire management, including fire prevention, control, detection and punishment of those to be blamed for fire occurrence. To develop a mechanism of public involvement in management decision-making and the development of schemes of forest fire management in the region.
6. To draft special regulations to define the procedures for fire prevention information activities among general public, officials of the authorised bodies and other federal executive bodies.
7. To recommend that in 2004, the MNR should hold a special workshop to discuss this issue under the FOREST Project. The thematic session recommends developing a forest management strategy, including forest fire management in areas of traditional nature resource use. To provide for involvement of indigenous peoples of the North and the Far East in management decision-making.
8. To recommend introducing long-term forest lease arrangements as a basis for a responsible approach to forest fire prevention.

## Thematic Session # 4
### *New Technologies for Illegal Logging Control*
Chair: V.V. Dmitriev

The thematic session was attended by 12 participants, including representatives from the MNR's Central Office and Territorial Bodies, research and civil society organizations.

The session participants reviewed the following issues:

1. Illegal logging and its impact on biodiversity conservation and the threat of forest fire occurrence.
2. The MNR's proposals towards addressing the problem of illegal logging: the MNR's decisions and initiatives in the area of voluntary forest certification, illegal logging control, timber labelling and the establishment of a chain-of-custody system.
3. Voluntary forest certification and international requirements to the chain of timber supply from the stump to the end consumer.
4. The experience of the Khabarovsk and Primorsky Krays, Jewish Autonomous Oblast and the WWF in illegal logging prevention and timber flow control in the Far East.
5. Prospects for implementing a pilot project of timber labelling and tracing in the Khabarovsk and Primorsky Krays, and the Jewish Autonomous Oblast.

Recommendations:

1. It is agreed to support the MNR's initiative of illegal logging control, and introduction of timber labelling and voluntary forest certification.
2. It is proposed to pilot a system of labelling and chain-of-custody for valuable species timber under the GEF Project and the Sustainable Forestry Pilot Project in the Khabarovsk and Primorsky Krays, and the Jewish Autonomous Oblast.
3. In the course of the GEF Project preparation, to provide for consultant services contracts and contracts for goods and services needed to implement the proposed activities.
4. It is also recommended to include a set of measures required for timber labelling and chain-of-custody practices into the Sustainable Forestry Pilot Project in the Khabarovsk Kray.
5. To prepare the pilot with due regard to the regional specifics and prospects for the introduction of labelling and tracing the sources of timber in the Far East Region.
6. In order to implement the planned activities, it is necessary to streamline the system of the MNR's cooperation and interagency coordination with other authorized agencies, the distribution of powers among the federal authorities and the Subjects of the Russian Federation in the area of forest protection and forest resource use oversight, timber labelling and chain-of-custody control.
7. In order to implement the planned activities related to timber labelling and chain-of-custody, it is necessary to improve the forest and its related legislation.

# Concept of the Proposed Project on Fire Management in High Conservation Value Forests of the Amur-Sikhote-Alin Ecoregion (Russian Federation)

*Andrey V. Kushlin, Serguei A. Milenin*
World Bank[1]

## Strategic context and sector issues

Although fires are now commonly recognized as an important element of the natural ecosystem dynamics, they remain the single most important factor threatening Russia's forest resources and ecosystems, especially in Siberia and the Far East with their low population density and large distances, and need to be properly managed. The period of transition from centrally-planned to market-based economy in the 1990s and early 2000s has substantially weakened viability of the formerly strong and highly centralized system of forest management and conservation in Russia, including its fire management system that had been targeted at full fire suppression. The on-going economic and administrative reforms in the country aim to reorient public forest management functions towards a clearer separation of management and oversight activities, with transfer of a broader range of forest management responsibilities to long-term commercial users, including the private sector. This is being accompanied by an increased acceptance of market-driven voluntary compliance mechanisms, such as independent forest certification that requires improved controls over the legality of origin (chain-of-custody) of harvested wood and wood products and introduction of special management regimes in high conservation value forests (HCVF). The government agencies would instead focus on policy and regulatory development, oversight and enforcement, and apply a much stricter prioritization of public expenditures (using a more strategic land-use planning and forest resource use allocation). Redistribution of public forest management responsibilities between federal, regional and local levels of government – including in fire management – is another key element of the on-going reforms that is still being fine-tuned.

The Government of the Russian Federation has already realized the need to focus more strongly on fire prevention in its public financing priorities and, with a strong fiscal position over the last 3 years, it has started to allocate a separate and increasing budget line to fire prevention activities. It has also recognized the importance of ecological functions of natural fires and shifted from the previous policy of total fire suppression to a more modern policy of fire prioritization. All these changes were spelled out in the decisions a high-level international conference "New Approaches to Fire Management at an Ecoregional Level" jointly held by the Ministry of Natural Resources and the Bank in Khabarovsk in September 2003 and subsequently reflected in the new "Concept of Fire Management" that was adopted by the Federal Forestry Agency (FFA) in 2004.

These processes, however, have not yet been properly tailored to meet also the specific requirements of Russia's vast system of federally and locally protected areas that harbor globally important biodiversity and other conservation values. The system was substantially strengthened in 1997-2003 as a result of implementation of the GEF-financed Biodiversity Conservation Project and adoption of the National Biodiversity Conservation Strategy and Action Plan. However, the latest period of reorganizations in the government has left the system in a situation of instability and legal vacuum. As a result, special efforts are required to ensure that fire management in these non-commercial forests don't fall behind the improvements in mainstream fire management activities (which are already supported by a World Bank loan). Without such efforts, these forests will continue to be subject to increasingly severe threats of fires, which are predominantly of anthropogenic origin and spread without respect to administrative and land tenure boundaries. These issues have become particularly acute in the regions that are recognized as global biodiversity hotspots and feature a sizable concentration of protected areas, such as the Amur-Sikhote-Alin Ecoregion (ASAE) in the south of the Russian Far East.

[1] The project concept was developed by the World Bank on the basis of detailed technical reports prepared by the Khabarovsk-based expert teams led by Alexander Sheingauz, Boris Voronov and Vadim Zausayev and coordinated by Alexander Kulikov and Victor Kryukov.

Global significance of the Amur-Sikhote-Alin forest ecosystems: The Amur-Sikhote-Alin Ecoregion (including the Primorsky and Khabarovsk Krays and the Jewish Autonomous Oblast) is at a geographical crossroads. It covers an area of 567,000 $km^2$ (which is larger than any Western European country or Japan), extending 1,200 km from 42 to 54 degrees North. The region escaped glaciation during the last ice age. This feature, combined with the varied topography, with altitudes rising to 2000 meters and a monsoon rainfall pattern unusual for such a northerly area, has led to a uniquely varied pattern of vegetation. Boreal, temperate and sub-tropical populations of plants and animals thrive together, comprising an unusual assemblage of forest ecosystems.

**Table 1.** Protected Areas and Protection Forests in the Amur-Sikhote-Alin Ecoregion

| | **Total Land Area** | **Strict Reserves (Zapovedniks)** | | **Partial Reserves and Other PA's** | | **Areas of Traditional Land Use** | | **Planned Protected Areas** | | **Protection (1st Group) Forests** | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | (1000 ha) | (1000 ha) | % | (1000 ha) | % | (1000 ha) | % | (1000 ha) | % | (1000 ha) | % |
| Khabarovski Kray | 36,530.0 | 839.4 | 2.3 | 3,333.1 | 9.1 | 11,385.8 | 31.2 | 7,800.0 | 21.4 | 4,674.9 | 12.8 |
| Primorsky Kray | 16,590.0 | 684.3 | 4.1 | 1,397.8 | 8.4 | 407.0 | 2.5 | 2,900.0 | 17.5 | 3,115.2 | 18.8 |
| Jewish AO | 3,620.0 | 91.8 | 2.5 | 383.5 | 10.6 | 0.0 | 0.0 | 130.0 | 3.6 | 377.6 | 10.4 |
| Ecoregion Total | 56,740.0 | 1,615.5 | 2.8 | 5,114.4 | 9.0 | 11,792.8 | 20.8 | 10,830.0 | 19.1 | 8,167.7 | 14.4 |

The region has been classified by the World Wide Fund for Nature (WWF) as one of the “Global 200 Ecoregions”. It includes 23 different forest formations and subformations, 150 forest types, over 200 tree and shrub species, and overall – about 2,000 species of vascular plants and an unusually rich fauna with about 20 species of amphibians and reptiles, over 250 species of birds, about 70 species of mammals, including the ‘flagship’ endangered species – the Amur tiger. Flora and fauna elements of the East Siberian, Okhotsk-Kamchatka, Manchurian and Hindo-Malayan origins share the same habitat in the unique broadleaved-coniferous forests of this ecoregion. The region includes forest ecosystems that have been almost totally destroyed in the neighbouring countries of China, Korea and Japan.

Although wildfire has always been a constituent element of the ecosystem cycle in the ecoregion, this natural cycle has been altered by decades of extensive forest logging, mining and other economic activities. The appeared large tracts of secondary forests with accumulated post-harvest wood debris are much more prone to accidental wild or human-induced fires, and therefore become conduits of more frequent fires to the adjacent natural forests. The frequency, size and intensity of forest fires in the ecoregion, and their damage to natural habitats and biodiversity, have increased dramatically over the last decades. Now over 80% of fires have anthropogenic origin. Catastrophic (massive) fires of the increased magnitude and with shortened return intervals now may lead to losses of up to 3-5% of the total forest cover in one year. As a result, forest fires now represent the gravest threat to the natural status and dynamics of the forest ecosystems and biodiversity.

### Project development objective and key indicators

The objective of the proposed project is to strengthen conservation of critical, non-economically accessible forests of high conservation value in the Amur-Sikhote-Alin Ecoregion (ASAE) of the Russian Far East through the improved forest fire management, reducing frequency, size and intensity of catastrophic fires in the areas of the global conservation importance. The project would develop and implement policies and practices for the integrated management, monitoring and prevention of forest fires across boundaries within a landscape matrix of protected and non-protected forest areas of high conservation value (HCVF).

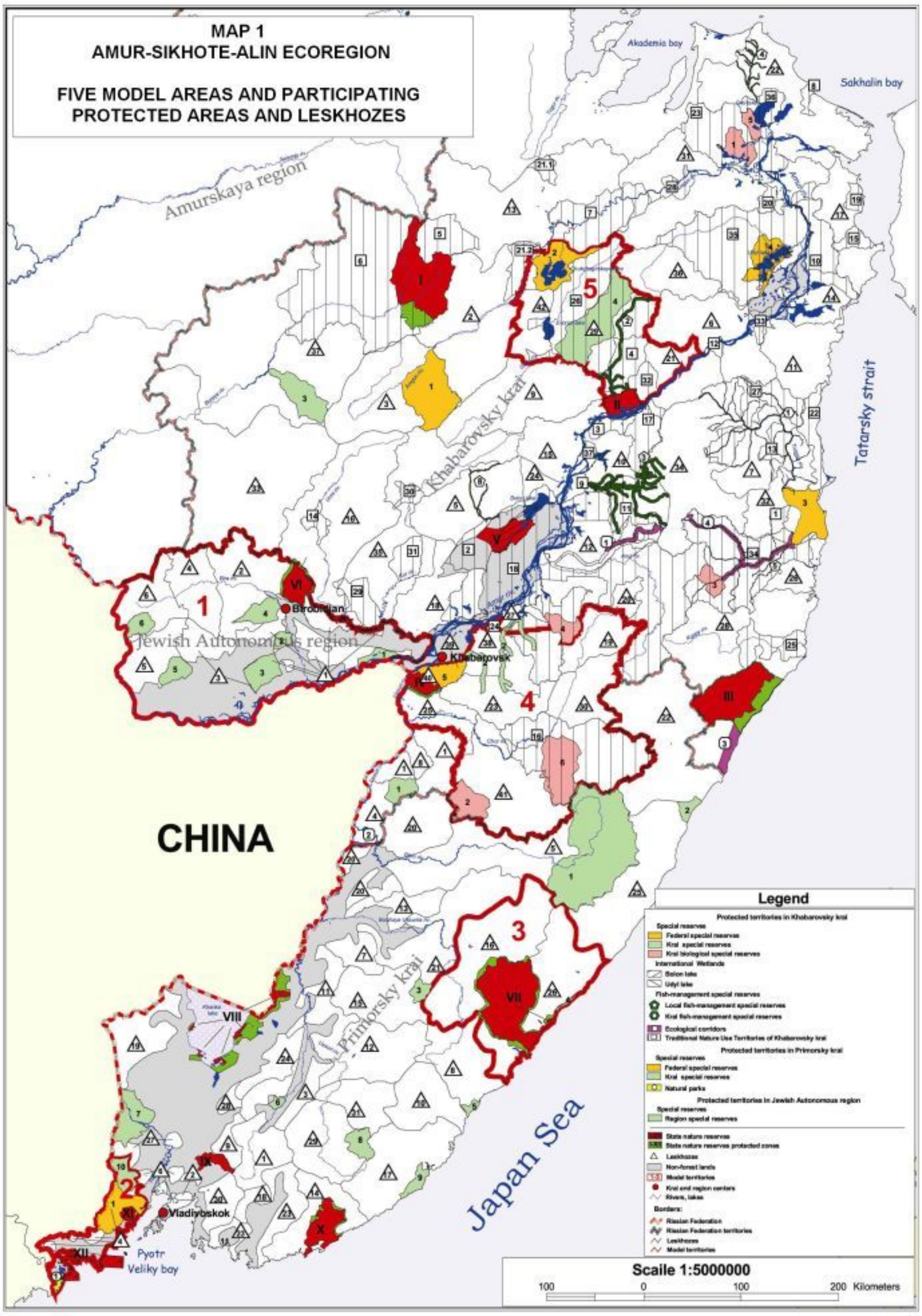


**Figure 1:** Map of the five model areas and participating protected areas and leskhozes in the Amur-Sikhote-Alin Ecoregion.

Achievement of this objective will be measured by:

(a) establishment of an ecoregion-wide integrated forest fire management system to include high conservation value forests (i.e. increase in the area of protection forests covered by the regional fire dispatch and monitoring system);

(b) increased effectiveness of fire management in high conservation value forests through strengthened regulatory framework and interdepartmental coordination, integrated ecosystem management, and increased capacities to address catastrophic fires and their consequences (i.e. reduction in average area burned per fire in model areas); and

(c) raised public awareness and support from the local population and communities to fire prevention and mitigation (i.e. increase in the number of equipped and trained volunteer fire groups and community participants in alternative land/ecosystem management programs).

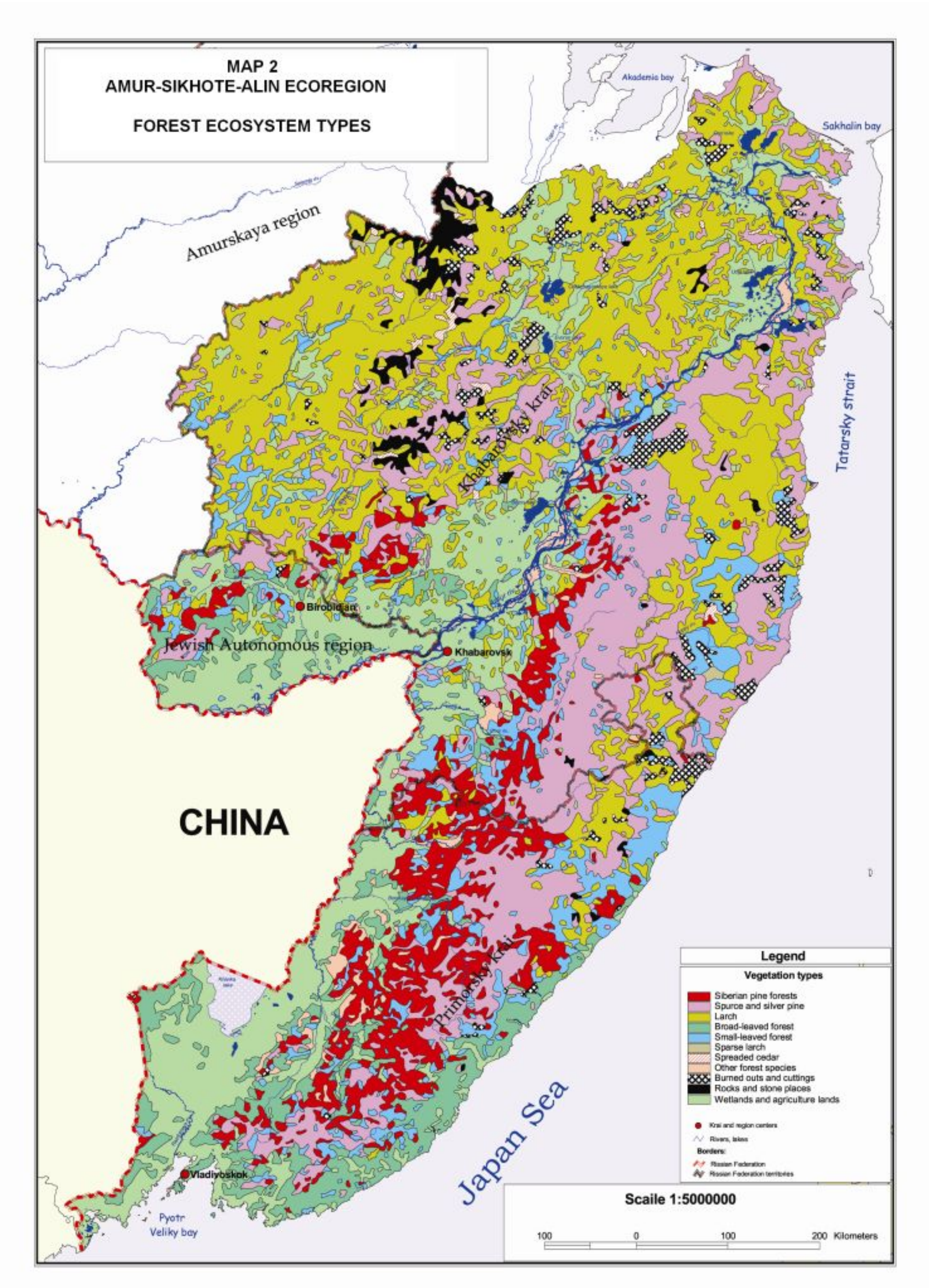


**Figure 2:** Map of the forest ecosystem types in the Amur-Sikhote-Alin Ecoregion.

**Project components**

The project will achieve its objectives by supporting improved fire management planning, training, community preparedness and emergency response activities in the selected high conservation value areas of the ASAE region in such a way that they could be subsequently replicated throughout the Russian Far East (36% of Russia's forests) and in other comparable ecoregions across the country. The project will support:

(i) fire risk analysis and zoning for the integrated system of command, control and communications in fire management aimed at preserving/restoring natural levels of biodiversity across the ecoregion;

(ii) support development and implementation of new interagency regulations and standards for regional fire management, emergency fire management operations, and incorporation of forest and fire management as tools for preserving biodiversity in model areas; and

(iii) increasing public, private sector and community understanding of, support for, and participation in fire and biodiversity management through a local initiatives program.

These activities will help reduce the adverse ecological and socio-economic impacts of catastrophic forest fires on the livelihoods of local communities, including indigenous populations. Furthermore, the project will help the Government fill important gaps in implementation of the on-going forest sector reform at federal and regional levels by developing and testing an adequate regulatory framework and monitoring system for management and protection of non-commercial forests of global significance, thereby assisting Russia in meeting its international obligations under the Convention on Biological Diversity (CBD). It will also strengthen Russia's capacity for participation in global wildfire management and emergency response systems.

**Table 1:** Project costs

| Component | Indicative Costs (US$ m) | % of Total | GEF financing (US$ m) | % of GEF Financing | Govt financing (US$ m) | % of Govt Financing |
|---|---|---|---|---|---|---|
| **A.** Integration of High Conservation Value Forests into an Ecoregional Fire Management System | 3.45 | 33.2 | 2.76 | 80.0 | 0.69 | 20.0 |
| **B.** Improving Effectiveness of Forest Fire Management in High Conservation Value Forests | 3.86 | 37.2 | 3.09 | 80.0 | 0.74 | 20.0 |
| **C.** Increasing Public Awareness and Community Participation in Ecoregional Fire Management | 1.76 | 17.0 | 1.71 | 97.1 | 0.05 | 2.9 |
| **D.** Project Management, Monitoring and Evaluation | 1.30 | 12.6 | 1.04 | 80.0 | 0.26 | 20.0 |
| **Total Project Costs** | **10.37** | **100.0** | **8.60** | **82.9** | **1.77** | **17.1** |

The project will be implemented at two levels: (i) region-wide activities – such as fire zoning and dispatch systems, regulations and standards; and (ii) activities in selected model areas – such as validation of fire models, inter-jurisdictional fire management planning and infrastructure, emergency operations and training. The latter will be focused on five areas, each containing a mosaic of protected and non-protected forest units of different jurisdictions and representing the variety of environmental/fire regimes and socioeconomic conditions of the ecoregion. Community participation activities (local initiatives) would be selected for project support from across the entire ecoregion, while ensuring that a critical mass of such activities is happening in and around the five model areas.

**Component A. Integration of High Conservation Value Forests into an Ecoregional Fire Management System**

The project will strengthen the capacity of the Khabarovsk-based Far Eastern Regional Fire Coordination Center (RFCC) and its branch in Vladivostok to: (i) assemble available data and baseline parameters of fire regimes of the high conservation value forests of the ASAE Region into an integrated database and GIS for fire risk zoning, modelling and prediction; (ii) develop and implement unified ecoregional fire management standards and long-term fire regime monitoring systems; (iii) carry out operational integration of Protected Areas (PA's) and other protection forests of various jurisdictions in the ASAE Region into a centralized ecoregional fire command and communication system; and (iv) translate incoming field and analytical data on baseline, historic and observed fire regimes into site-specific operational guidelines for local fire managers.

The first component will finance consulting services and information technology equipment covering the system-wide data integration needs for the ecoregion as a whole. It will include the following groups of activities.

*A.1. Fire Risk Baselines and Zoning* – the project will collate and analyze historical data and baseline parameters of HCVF fire regimes and aggregate them in a regional-level fire database and GIS base map at the 1:1,000,000 scale. Similar and hierarchically linked GIS's will be developed at a higher detail for the project's five model areas and specifically for the eleven PA's of the ecoregion (scale 1:50,000-1:100,000). This activity will further develop ands complement the HCVF map of the ecoregion recently completed by WWF-Russia. On its basis, a new regionally adapted methodology and map of forest fire risk zoning of the ecoregion will be developed for the RFCC and territorial Forestry Agencies;

*A.2. Fire Regime Monitoring, Modelling and Standards* – the project will assist the regional forest authorities and research organizations in developing, field-testing and implementation of a new system of targets, indicators and procedures for post-fire monitoring. The collected field data will be used to develop customized *models of fire impacts on the ecology and biodiversity* that would allow RFCC staff to develop new and update existing fire regime maps and databases in quicker and more cost-effective ways, i.e. covering large poorly accessible areas with least amount of resources. Lastly, the project will develop, publish and disseminate a set of new regional standards for forest fire management, protection and monitoring (which will support better implementation of fire management activities recently transferred from federal to regional responsibility.

*A.3. Fire Data Integration and Communications* – the project will provide necessary computing and communications equipment and software tools to the RFCC and its partners organizations across the ecoregion, including the forest districts and fire protection units, Protected Areas, municipal administrations, regional Hydrometeorological Service (the latter is being supported through the Bank's Hydromet Modernization Loan and the two projects will be establishing direct information exchange arrangements). The project will support the RFCC in developing fire forecast and behaviour models as a real-time decision-support tool for fire management operations, a single dispatch service of the ecoregion with a unified fire management procedures, as well as provide necessary training and study tours for RFCC dispatchers and line fire managers.;

*A.4. Regional Fire Coordination Capacity Building* – the project will support strengthening human resources capacity of the RFCC in its regular horizontal interaction with the territorial Forestry Agencies and fire protection units and Protected Areas across the ecoregion and ensure seamless coordination and planning of various project activities in multiple jurisdictions between the participating regions.

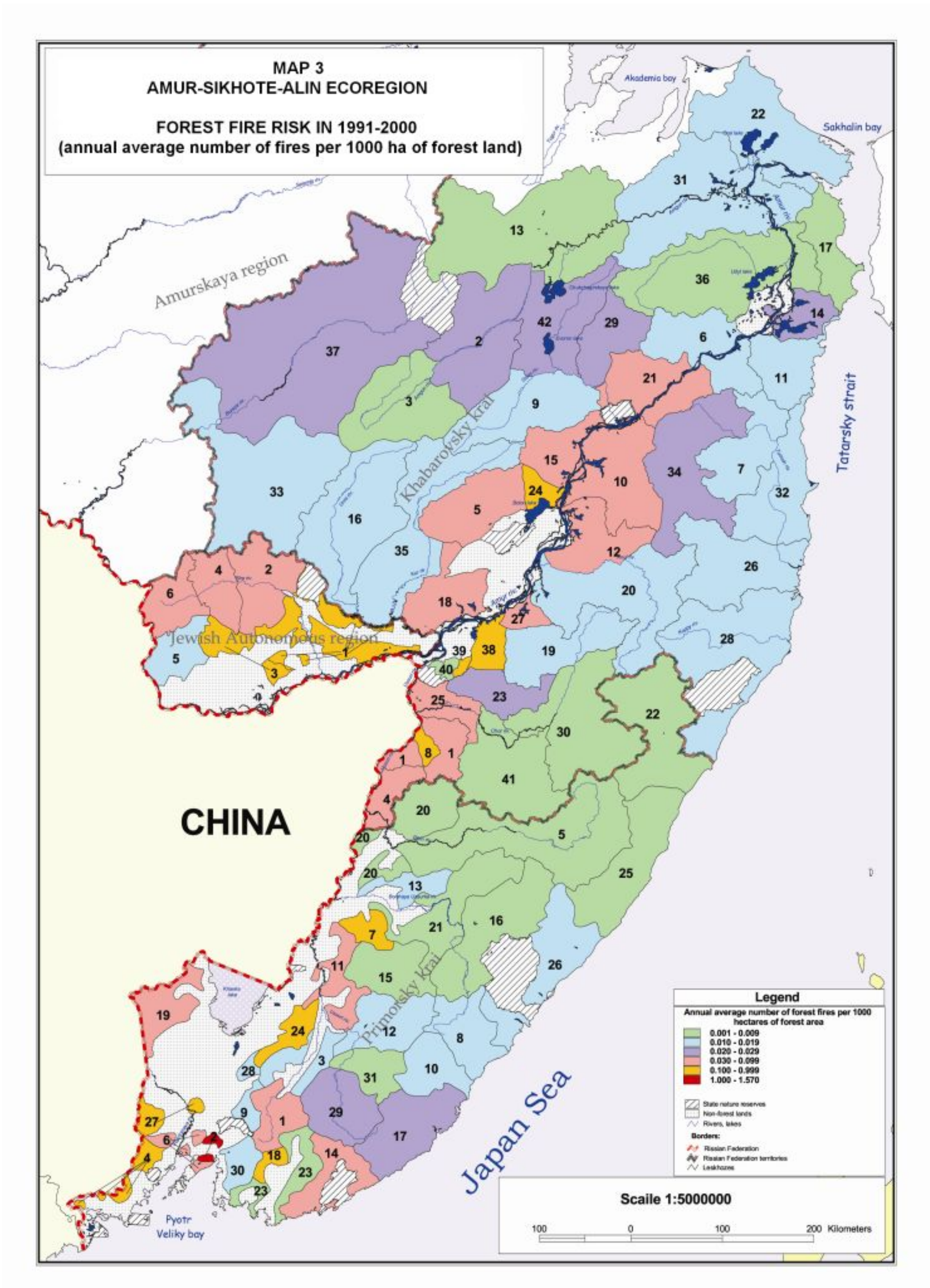


**Figure 3:** Forest fire risk map for the period 1999-2001 in the Amur-Sikhote-Alin Ecoregion.

**Component B. Improving Effectiveness of Forest Fire Management in High Conservation Value Forests of the Ecoregion**

This part of the project will be implemented in five pre-selected model areas (MAs)[2] that are: (a) representative of the variety of the ecoregion's conditions; (b) have a high concentration of HCVFs and

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2 The five model areas include: (MA1) mountain taiga of the Bureya watershed (Jewish Autonomous Oblast), (MA2) mixed forest-steppe of the Khasan-Khalka watershed (southwestern Primorsky Kray); (MA3) mixed mountain forests of the Central Sikhote-Alin watershed (north-central Primorsky Kray); (MA4) mixed forests of the Amur-Ussuri plain (southern Khabarovsk Kray), and (MA5) taiga of the Amur lowlands (central Khabarovsk Kray) – see Maps.

Protected Areas; and (c) have a multi-jurisdictional land tenure pattern within the forest landscape (i.e. with the combination of typical stakeholders). The test cases of these areas will be used to: (i) strengthen regional regulatory incentive framework to prevent and mitigate the wildfire damage; (ii) establish unified regulations and develop sample inter-stakeholder agreements for joint fire management and incident command systems at a local level (district, community); (iii) restore and strengthen technical capacity of staff of Protected Areas of different categories and jurisdictions to carry out effective forest fire management; and (iv) plan and carry out emergency fire management operations, including fuel loads management, fire prevention, suppression, and post-fire rehabilitation in critical HCVF areas.

Component B will finance emergency works, fire management equipment and consulting services under five sub-components:

B.1. Development, testing and submission for regional approval of *regulatory instruments for reconciliation, compensation, and mitigation* for legally enforceable damage to wildfire and biodiversity resources and the related legal training for PA and forest district managers. These, together with regional tax incentive to businesses for funds invested in fire prevention and management, will constitute the main new lever the regional governments will have to promote responsible private sector behaviour in the forest and their participation in fire management;

*B 2. Interagency Framework for Wildfire Management in Model Areas* – this will include producing the necessary new interagency standards and multi-stakeholder cooperative agreements for collaborative fire management in HCVFs in various model areas and involving a critical mass of interested community- and municipal-level stakeholders in the establishment of *professional (in-house, contracted, and volunteer) fire fighting teams*, addressing: (i) procedures for such teams establishment and deployment; (ii) level of professional skills; (iii) functional requirements to the staff and operational instructions; and (iv) regional and municipal standards (guidelines) for entities participating in fire management including volunteers.

*B.3. Wildfire Management - Emergency Operations in Model Areas* – This activity will help the line fire managers in the respective model areas plan in advance of fire emergencies. The existing fire management capacity in the MAs will be expanded with the 2 newly established heavy mobile units and 12 light mobile patrol units, and volunteer fire units equipped, trained, and certified, additionally focusing patrols in high conservation value forests. To reduce the threat of large fires in HCVF areas a network of fire breaks will be restored and expanded in the buffer zones of PAs where fire zoning would indicate minimum cultural and biological impacts. It will be complemented with 20 fire lookouts and about 40 strategically placed check points. Specific emergency activities will be carried out in the Southwest Primorsky Model Area to restore pine and hardwood forests – a key habitat for tiger and leopard – that had been lost to chronic fires set by local farmers. Finally, commercially viable forest management alternatives will be tested in selected MA sites as a method to reduce fuels, fire danger, and loss of biodiversity over the greater part of the permanent forest estate.

*B.4. Management to Reduce Fuels and Enhance Habitat at the Landscape Level* – Activities on-the-ground would (i) test 2 silvicultural (even- and uneven-age) and 2 logging systems for relative impacts on fuels, fire risk, and habitat compatibility; (ii) support re-creation of normative stand structure and composition by testing combinations of thinning and prescribed fire in 3 forest types and measuring effects on fuels and habitats; and (iii) support restoration of the selected fire-modified critical forest habitats of tiger and leopard.;

B 5. The above activities would be complemented by training of line forest managers from the model areas in *Landscape Level Reconstruction and Ecological Restoration*.

**Component C. Increasing Public Awareness and Community Participation in Ecoregional Fire Management**

As over 80% of forest fires now have anthropogenic origin, it becomes essential to increase public awareness on issues related to forest fire safety and support the informed participation of local population in fire management. The component would address (i) strengthening public education and awareness on issues related to fire management in high conservation value forests; (ii) implementing adaptive patterns of land and non-timber forest use to reduce occurrence of anthropogenic forest fires; and (iii) broadening public and community participation and volunteer on-the-ground support to forest fire management.

A program of small grants will be carried out with project support to assist mobilization of such local and community initiatives (expected between $2,000 and $50,000 each, and not more than 90% of sub-project cost). The governance arrangements for this component will include (i) a multi-stakeholder Steering Committee established in the region with balanced participation of regional and local authorities and civil society (including private sector) that determines specialized selection criteria for each thematic grant round, (ii) a evaluation panel of reputable national and regional experts, and (iii) a small grants administrator – a nongovernmental organization competitively selected on the basis of solid experience of grant-making in Russia. The Small Grants Procedures for this Component, satisfactory to the Bank, will be finalized at the beginning of the project – upon selection of, and with input from, the small grants administrator.

The Social Assessment and Stakeholder Participation Plan have identified the several thematic areas that should be considered as priority topics for support under the Small Grants Program.

**Component D. Project Management, Monitoring and Evaluation**

The overall project activities are proposed to be directed and monitored by the territorial branch of the Federal Forestry Agency in Khabarovsk Kray. The Khabarovsk Forestry Agency (KFA) has established a project unit comprised of three KFA staff that would monitor and coordinate project implementation with its territorial counterpart agencies, the RFCC and the Regional Governments of Khabarovsk Kray, Primorsky Kray and Jewish Autonomous Oblast. KFA will organize routine monitoring and evaluation of annual performance objectives and interim targets at the ecoregional, regional (Kray) and model area (municipal) levels, combined with midterm and final net impact assessments.

This component will finance the incremental operating costs incurred in relation to the project administration, including procurement, financial management, project reporting and audits. Overall impact of this component will be measured by the increased efficiency in project management and transfer of project planning and administration skills to the KFA.

**Lessons learned and reflected in the project design**

The project incorporated several important lessons from the World Bank's recent forestry and biodiversity portfolio, and specifically, the Russia Biodiversity Conservation Project.
One lesson is that strong commitment on the part of the sub-national and local governments is a key prerequisite to successful biodiversity conservation initiatives, as it allows to increase financial support to the project from various regional budgets. Therefore, this is structured as a regionally centered and regionally driven project, which is based on the original strong demand and continued support from the regional government in Khabarovsk and the Khabarovsk Regional Fire Coordination Center.

Another lesson is that biodiversity projects yield a much higher and more sustainable sector-wide developmental impact if they are implemented in tandem with other sectoral operations. This project is both thematically (fire management), geographically (Khabarovsk), and in its timing, well coordinated with the World Bank-financed loan for the Sustainable Forestry Pilot Project and is designed to build upon the mainstream policy and institutional capacity improvements at the Federal Forestry Agency supported by the loan.

The earlier project also showed that active involvement of NGO community at all stages of the project cycle is essential to ensure availability of critical professional expertise in specific subject areas, transparency of project governance, and effective utilization of existing public information and dissemination mechanisms. This lesson is reflected in the overall project implementation arrangements, in that a reputable local NGO has been selected as the PIU for the project, that a Public Council comprised of most active regional NGOs is included in the project governance structure increasing its transparency, and that the administration of the Small Grants Program will be also contracted to a competitively selected local NGO experienced with grant-making.

The need for support of horizontal interactions of protected areas of various jurisdictions is another lesson incorporated in the project design – by establishing model areas as focuses for intensive collaboration in joint fire management between neighbouring PA's.

The project design also takes into account key lessons of simplification of the project paper-flow procedures, especially in the context of rather remote regions and project locations. The project proposes to utilize wherever possible shopping and commercial practices procurement procedures for small items.

Although there is a strong commitment on the part of the protected areas' management to employ sound operational practices, the internal capacity to undertake adequate management planning in most protected areas is currently insufficient. A reasonable amount of external advisory support to end-beneficiaries (KFA, protected areas, municipalities, communities) is being planned on the administrative aspects of project implementation.

An important lesson from forestry projects in Croatia and Indonesia is that pure technical solutions in forest (incl. fire) management, if not positioned in the broad sectoral policy agenda, may risks institutional failure and a need for a project restructuring at mid-point. In this project, the technical and institutional aspects of fire management context are tightly integrated in a innovative and dynamic approach of ecoregional fire management that drives institutional change, while key tangible project support interventions are aimed at the lowest (regional and municipal) levels of institutions (usually least prone to all administrative changes).

**Partnership arrangements**

In addition to being in a strategic 'twin' partnership with the World Bank-financed Sustainable Forestry Pilot Project, the project will enjoy significant in-kind assistance and leverage of donor funds from the existing bilateral technical cooperation between the Federal Forestry Agency of Russia and the *US Forest Service* (development of fire prevention and management plans, fire modeling, ecological role of fires, fuel loads management and prescribed burning techniques, community fire brigades, regional fire coordination centers), as well as with the *Canadian Forest Service* (fire modeling, prescribed burning, model forests network).

The *USAID*-funded Forest Resources and Technologies (FOREST) Project that has been implemented in the Russian Far East provides a strong legacy of partners in fire education and public awareness in both Khabarovsk and Primorsky regions. The Far-Eastern Association of Indigenous Peoples of the North will also be a crucial counterpart in facilitating project implementation in the Territories of Traditional Use.

Another key partner to project implementation is *WWF*, the Bank's partner in the Global Forest Alliance. This partnership is crucial to the project success both because of the Alliance's coordinated approach towards development of HCVFs, and also at the operational dimension – with WWF's Russian Far East Office in Vladivostok being a major regional player leveraging significant donor funded activities within the target ecoregion, including the on-going mapping of the HCVFs of the ecoregion, the results of which will be directly used in the project. WWF will also play an important operational partner role in the field activities in Southwest Primorsky Model Area, where it will support reforestation of burned areas forests and carry out other forest habitat protection activities with the private sector and other NGOs. The Wildlife Conservation Society, Tigris Foundation, Phoenix Foundation, Sikhote-Alin Foundation, ISAR and other local and international NGOs active in the ecoregion will also play important roles in promoting public and community participation in fire management.

Important partnerships also include the *Global Fire Monitoring Center* (Freiburg, Germany) and the Fire Section of the *Global Observation of Forest Cover (GOFC)* International Program (co-chaired by University of Maryland at College Park, U.S.A.), which provide significant interface between the project and the global community of best practice in fire detection, modeling and mapping, as well as the Regional North East Asia Wildland Fire Network under the UN International Strategy for Disaster Reduction and the Pacific Forest Forum.

### Institutional and implementation arrangements

The expected duration of the project is 6 years. The project will be managed – upon authorization from the Ministry of Natural Resources of the Russian Federation and the Federal Forestry Agency – by the Khabarovsk Forestry Agency (KFA), which is already in charge of implementation of baseline forest and fire management investments in Khabarovsk Kray under the Sustainable Forestry Pilot Project (financed by a World Bank loan). KFA has established a Scientific-Technical Innovations Unit comprised of five KFA staff that would also oversee and coordinate GEF project implementation with its territorial counterpart agencies, the RFCC and the Regional Governments of Khabarovsk Kray, Primorsky Kray and Jewish Autonomous Oblast. The latter are co-chairing on a rotation basis the Project Supervisory Committee (PSC) that includes the above-mentioned regional government officials, representatives of the MNR and FFA, directors of the ecoregion's Protected Areas, the regional Indigenous Peoples Association and key regionally active NGOs. The PSC provides guidance on overall project implementation issues, approves annual work programs and budgets.

The bulk of the project activities will be implemented by regional and local (leskhoz) staff of the territorial Forestry Agencies in the three participating regions (Khabarovsk, Primorye, and Jewish Autonomous Oblast) and of the 11 Protected Areas (zapovedniks, zakazniks, wildlife reserves etc.). Specialists of the Regional Fire Coordination Center (located in Khabarovsk) and Aerial Fire Protection Bases (Khabarovsk and Vladivostok) will be also key participants in the project implementation, with assistance and inputs from various experts (national and international). Activities in each of the five model areas will be coordinated by a Local Coordination Team comprised of the relevant municipal (district) authorities, Forestry Agency and aerial fire protection officials, PA managers, indigenous community representatives (where applicable), with assistance of the relevant RFCC regional coordinator.

### Technical Issues

While it is generally accepted that fire is part of the ecological cycle, there are differing views on the right fire management approach for forests whose natural cycles have been altered over decades by human intervention. This is an issue more for the forests surrounding the high conservation value forests of the project area.

Landscape management is supported by landscape-level inventories of forest resources, with detailed planning for targeted sites, much like the planned use of pilot areas for this project. This is an approach applied in France, Sweden, and other countries.

The capacity to treat regional fire suppression issues at the landscape level resides with the Far Eastern Regional Forest Protection Air Base and its Forest Fire Coordination Center, the Primorsky Forest Protection Airbase, and the local federally funded MNR forest management authorities. The capacity to deal with the entire fire management cycle such as conducting fuels reduction, burned area rehabilitation and other tasks, would employ similar skills and resources, but would also require an additional mandate and resources to generally address fire management in the landscape. The landscape-level fire management approach is a thesis of this project and the additional human and material resources constitute much of this project. Fuel loads management, fire suppression, and burned area emergency rehabilitation constitute the full approach to fire management (i.e. they are required by the new U.S. National Fire Plan). The proposed investigations of forest practices conducive to both fuels reduction and biodiversity enhancement will command the skills of both local and foreign professionals as the approach is relatively new. Specific application of external experience with prescribed burning of accumulated fuel loads as a fire management tool (even if successful in Central Siberia) should be carefully compared to local vegetative response in the prevailing Amur-Sikhote-Alin forest ecosystems.

Another issue that requires careful analysis within the project is comparative efficiency and sustainability of fire breaks immediately around HCVFs versus comprehensive fuel management at a broader landscape level combined with restoration of previously logged landscapes. In the long run, the latter might have a farther reaching effect.

### Social Issues

The Social Assessment (SA) conducted during the project preparation period has determined that the key social issues are related to the significant damage caused by catastrophic forest fires to the livelihoods and health of local population, both in rural communities and larger towns.

Project stakeholders may be broken into the following major groups which can be potential sources of forest fires on the one hand, and provide various opportunities for involvement of the people in fire protection and environmental activities, on the other hand: entire population of individual local areas affected by hazardous discharge resulting from forest fires; indigenous peoples who heavily depend on forest resources and suffer greatly from forest fires; professionals whose job is directly related to forestry (including researchers); forest workers (timber harvesters, forest guards, road workers, hunters, forest managers, and others); students from universities, colleges and technical schools; schoolchildren; recreation visitors; gatherers of non-timber forest products; recreational fishermen; recreational hunters; managers of commercial companies; managers of not-for-profit organizations; office workers; rural businessmen; dacha owners; housewives; pensioners (a particularly impoverished part of the population); the unemployed.

The indigenous peoples (namely, the Nanay and Udege communities) will be specifically targeted through an Indigenous People Participation Plan that is a part of the overall Project Stakeholder Participation Plan developed during the Social Assessment (see Annex 10). The project's main objective of reduction of the risk of such catastrophic fires would be, in part, achieved through more active and participatory involvement of local population and businesses in fire prevention (public awareness campaigns) and fire monitoring and fighting (community fire patrols). Increased cooperation in collaborative fire management between various regional and local authorities, on one hand, and local population, academia and civil society, on the other hand, would also be an important social development outcome.

The Small Grants program (Component C) has been specifically designed to address fire-related social priorities and encourage a variety of suitable forms of stakeholder participation in implementation and monitoring, including community-based fire patrols and other types of local initiatives (see details in Annex 10). Key stakeholders will also participate in project implementation through the Project Supervisory Committee that is already established in the region and includes representatives of the regional and federal authorities, forest and protected area managers, Indigenous Peoples Association, local administrations and communities, research and non-governmental organizations.

Local NGOs (such as the Khabarovsk Wildlife Foundation) have been directly involved in the project preparation. The regional Indigenous Peoples Association and the other NGOs will continue to participate in the Project's Public Council and their representative will be sitting, on a self-selection rotation basis, in the Interregional Project Supervisory Committee. Public consultations on the project design have been held twice - at the startup and completion of project preparation activities. The project is coordinated with activities supported in the region by the World Wide Fund for Nature (WWF) and other international and national NGOs, including Ecodal and Wildlife Conservation Society (WCS).

### Environment Issues

The Environmental Assessment (EA) conducted during project preparation has confirmed that the project would generate substantial environmental benefits. No adverse environmental impacts will be caused by the project activities if implemented correctly. The EA report includes the Environmental Management Plan (EMP), which outlines relevant safeguard requirements and provides specific recommendations for various project activities. The project has budgeted appropriate funds to implement the EMP.

Most of the project activities entail no environmental risks and, therefore, require no preventive, mitigation, or compensatory measures. A few activities related to (i) establishment of the fire management infrastructure (firebreaks, lookout towers, helicopter pads, etc.), (ii) prescribed burnings, and (iii) fire management in the protected natural areas, will require implementation of the specific operational safeguards, which were developed by the EA and outlined in the EMP.

The EA has provided substantial input in improving project design to maximize positive environmental impacts of various activities. Those inputs include in particular the following: (i) criteria for defining high conservation value forests were further refined; (ii) additional specific recommendations were provided with respect to forest fire zoning of the ecoregion and model areas; and (iii) an activity was added to the project to facilitate transition of responsibilities for forest fire management on former agricultural lands to the forest authorities.

Based on the recommendation of the EA, a program to monitor project environmental impacts was added to the project.

**Project Results Framework**

| PDO | Outcome Indicators | Use of Outcome Information |
|---|---|---|
| Strengthen conservation of critical, non-economically accessible forests of high conservation value in the Amur-Sikhote-Alin Ecoregion | Improved forest fire management, reduced frequency, size and intensity of catastrophic fires in the areas of the global conservation importance | Yr.1-2: gauge effectiveness of project components in initial model areas<br>Yr.3: determine if components and/or model areas need to be changed<br>Yr.4-5: scale up results from model areas to the ecoregion, feed lessons learned into Government policy on regional fire management |
| **Intermediate Results One per Component** | **Results Indicators for Each Component** | **Use of Results Monitoring** |
| Component A:<br>Establishment of an ecoregion-wide integrated forest fire management system to include high conservation value forests | Component A:<br>Increase in the area of protection forests covered by the ecoregional fire dispatch and monitoring system<br><br>Increase in the number of fire dispatch decisions taken with the use of fire risk zoning maps reflecting biodiversity values | Component A:<br>Yr.3: Low area may flag unjustifiable complexity of monitoring parameters<br><br>Yr.4: Slow increase may indicate ineffective training of fire managers/dispatchers in comprehensive fire risk assessment |
| Component B:<br>Increased effectiveness of fire management in high conservation value forests through strengthened regulatory framework and interdepartmental coordination, integrated ecosystem management, and increased capacities to address catastrophic fires and their consequences | Component B:<br>Reduction in average area burned per fire in model areas<br><br>Increase in the number of effective interagency and municipal fire management agreements in model areas | Component B:<br>Yr.4: No decrease in burned area per fire may signal shortcomings in logistical/equipment arrangements and/or fire crew training quality<br><br>Yr.3: Low number may flag a disconnect between proclaimed regional policy and existing local capacity for implementation in a selected model area |
| Component C:<br>Raised public awareness and support from the local population and communities to fire prevention and mitigation | Component C:<br>Increase in the number of equipped and trained volunteer fire groups<br><br>Increase in the number of indigenous people/community participants in alternative land/ecosystem management programs | Component C:<br>Yr.4: Low number may indicate need to revise regional and local incentive structures for voluntary participation<br><br>Yr.3: Low number may signal ineffective, poorly targeted project communications |

# Concept of Forest Fire Protection in the Russian Federation

*Approved by the Federal Forestry Agency of Russia (2004)*

## 1. The State of Forest Fire Protection

According to the Concept of National Forestry Development for 2003-2010, approved by the order of the Government of the Russian Federation (# 69-r as of 18 January 2003), fire protection of forests should become the highest policy priority to ensure ecological security of this country and conservation of forest resources potential

By the scope and nature of its impact on forests, fire is the dominant factor driving the structure and patterns of the forest stock in the Russian Federation (the Forest Stock). Forest fires have a lethal impact on forest vegetation, fauna and upper soil. They destroy or damage the affected physical and cultural assets, disrupt the integrity and hydrological regime of landscapes, pollute the atmosphere and water bodies with fire products. Damaging and disrupting forest ecosystems causes deterioration of the environment protection and formation role of the ecosystems, and reduces biodiversity of forests. At the same time, fire as the natural element of forest ecosystems could be managed to support the natural processes in the forest, to control undesirable vegetation, to promote natural reforestation processes, to manage forest fuels and to address other economic issues.

The national forest fire protection policy aims to fight fires across the entire forested area which is accessible. Forest protection is based on the combination of the various approaches to fire prevention and activities to promptly detect and put out emerging fires with due consideration to local natural and economic conditions and intensity of forest management operations. Historically, the acceptable level of fire protection was based on the ongoing budget allocation increases for fire fighting activities and capacity building of forest fire services, which were quite successful in the periods of small and medium fire danger, but could not make it from time to time in catastrophic conditions.

What is specific about fire protection of forests is that here fire loads are unstable and overall outcome depends on the efficiency at peak fire loads. Some 3 to 4 regions of this country account for 75% to 95% of forested area affected by fire. These are regions with extreme weather conditions where fires would turn into natural disasters. Generally, an overall forested area with extreme fire occurrence is less than 15 to 20 percent of the protected forest stock. In this context, fire loads are hundredfold higher than in the context of average fire occurrence. This is clearly beyond the capacity of the fire services of these regions that are equipped and manned to fight fires in the context of average fire occurrence.

The current regulatory framework of forest fire management provides for uniform operations by the aerial and ground forest fire services across the entire protected areas irrespective of forest value and fire occurrence, levels of economic development of the area and the extent of fire related damage. As a rule, forest fire services suffer from the shortage of physical and financial resources – halved at what they really need to meet the established objectives. As such, this does not make it possible for the services to be really effective.

The current procedure for financing forest fire protection does not provide for the timely allocation of funds to address fires in the context of dramatic fire occurrence variations and scope of fire fighting activities. One big weakness of the current financing systems is that the limits of budget obligations as established for the respective financial year are based on an average fire fighting expenditures and very often ignore the real forest fire situation. This is particularly visible when regional and local authorities would issue an emergency resolution to mobilize all available resources to address the situation. This causes a one-off increase in financing, which, upon the completion of the forest fire season generates accounts payable situation causing social stress in the services, delays in payments to those who participated in the fire fighting, drain of qualified personnel, and failure to properly carry out preparation activities for next season.

In the context of dramatic variations in fire occurrence and fire seasons, manoeuvring with fire fighting means and resources to provide for effective response to fires involves, as a rule, aerial fire fighting activities. These are often inadequate and late. Local capacities in the forest rich areas with weak infrastructure are quite limited and their mobilization rate often lags behind the fire fighting needs.

## 2. Rationale for Development of Forest Fire Protection Concept and New Forest Fire Management Policy

- Failure of the current forest fire protection system to meet modern environmental and socio-economic standards; recognizing the fact that it is impossible and inadvisable to exclude fire from the forest life; considerable forest fire related damage and enormous financial burden of forest fire fighting;

- An opportunity to use fire as a forest management tool (regulating forest fuel stock, controlling undesirable vegetation, promoting natural reforestation, rejuvenation of pastures and hayfields, etc.);

- The need to maintain the role of fire as a natural element of sustainable forest ecosystems to improve their conditions, to support the natural processes in the protected areas in accordance with their goals and biodiversity conservation objectives.

## 3. Goals and Objective of Forest Fire Management Policy of the Russian Federation

The main goals of the Forest Fire Management Policy of the Russian Federation are:

- To protect human life, communities and business facilities;
- To reduce the destructive impact of fires on forests and the related environmental and socio-economic damage;
- To support sustainability and improve the state of forest ecosystems by managing fire in the natural contexts;
- To improve the use of financial and physical resources allocated for forest fire fighting.

These would be achieved by meeting the following objectives:

- Preventing the growth of forest fires caused by man-made sources through the development of fire prevention initiatives, strengthened state forest fire supervision and ground-based fire fighting developments in the respective service area;
- Increasing fire detection capacity of emerging fire spots through the development of an integrated system of forest fire monitoring based on modern ground, aerial and satellite means and modes of observation, telecommunication networks and GIS;
- Increasing response time to fighting forest fires by improving the institutional and operational structure of the forest fire services, strengthening their fire fighting capacity, providing them with modern fire fighting means, communications and transport;
- Improving efficiency of fire fighting with respect to major forest fires of a catastrophic magnitude by promptly mobilizing resources, improving fire fighting management, expanding the use of tankers and helicopter water dischargers to provide for aerial fire fighting;
- Carrying out prescribed fires in the forest ecosystems that are fire adapted and in the forested areas with extensive forest fuel stock;
- Integrating forest fire protection and targeted use of fire as a natural environmental element of forest ecosystems into one forest fire management policy;
- Strengthening the role of regional and local authorities in the implementation of the forest fire management policy;
- Making sure that the programs and plans for forest fire protection and forest fire management are scientifically and economically sound;
- Integrating and coordinating the effort in the area of forest fire protection and forest fire management at the international, national, interagency, regional and local levels;
- Ensuring the required development of forest fire fighters and management staff involved in forest fire protection and forest fire management;
- Zoning the forested area by types and levels of forest fire protection;

- Providing the aerial and ground forest fire services with human and material resources based on scientific standards and forest fire protection plans;
- Developing and improving the institutional and operational structures of the forest fire protection system and tools to allow adaptation to the ongoing changes in the forest fire situation;
- Ensuring sustainable and timely financing of forest fire protection in response to the nature and scope of forest fire activities and forest fire management;
- Increasing fire fighting advocacy and strengthening the state fire supervision in forests;
- Improving fire fighting response time of the forest fire services and manoeuvring the resources and means of fire fighting;
- Improving procedures fore resource mobilization in the context of extreme forest fire occurrence and fire fighting management regarding major forest fires;
- Regulating prescribed fires and providing legal and economic framework for regular prescribed fires;
- Improving planning and management of forest fire protection; incorporating fire fighting activities in the forest management and land management plans at the federal, regional and local levels;
- Restoring natural fire cycles in forest ecosystems by refusing in part of completely to put out individual natural forest fires under certain circumstances;
- Developing and implementing special fire management plans for state nature preserves and national parks through a differentiated approach to the issue of forest fire management based on a multifaceted analysis of the natural, economic and social context of a specific territory;
- Intensifying the state control over timely response to fire fighting and mitigation management, burned areas accounting and assessment of the related damage, adequacy of the decisions to carry out prescribed burning, refusal to partially or completely put out forest fires.

## 4. Main Directives for Development and Improvement of Forest Fire Protection System

### 4.1. Forest Zoning by Types and Levels of Fire Protection

The current division of the forested territory by aerial and ground fire protection will be further developed through its zoning by the level of fire protection based on the value of forest resources, fire occurrence and fire caused damage, as well as by the effective and expected budget allocations for forest fire protection.

The forest fire protection levels will be determined by a probability of a timely liquidation of forest fires in the context of average fire occurrence and will be differentiated by the types of protection. Frequency of aerial patrolling and adequacy of airborne fire fighting teams will be the main parameter to determine the level of aerial fire protection of forests. Correspondingly, the level of ground based fire protection of forests will be determined by the coverage of ground based observation points and fire chemical stations, as well as by the adequacy of fire fighting team composition.

Forest zoning by the level of protection involves:

- Developing a classifier of the aerial and ground fire protection levels and establishing the parameters and operational patters of forest fire services in response to each of these levels – low, middle and high;
- Assessing the current levels of the aerial and ground fire protection in each region (constituent entities of the Russian Federation) of this country that meet the actual parameters and operational patterns of the forest fire services;
- Assessing expected costs and damage caused by fires by the corresponding levels of forest fire protection by the regions (constituent entities of the Russian Federation);
- Differentiating the levels of the aerial and ground fire protection by the regions (constituent entities of the Russian Federation);
- Determining allocations, which correspond to the established levels of forest fire protection and identify the needs in human and physical resources.

Within the regions, the levels of forest fire protection will be differentiated during the development of general plans and draft forest fire protection arrangements focusing on the areas and facilities in need of enhanced protection.

### 4.2. Forest Fire Protection Arrangements

Forest fire protection arrangements will serve as the basis for the required set of fire fighting activities to prevent, detect, put out forest fires and to carry out prescribed burnings. The system of pre-project and project documents for forest fire protection arrangements includes (a) substantiation of the main directives for forest fire protection of major regions (federal *okrugs*) and the entire country; (b) general plans of forest fire protection arrangements by constituent entities of the Russian Federation; (c) projects of forest fire protection arrangements within *leskhozes* and other economic entities that operate in forests.

The General Plans of forest fire protection arrangements provide the pattern of consolidated characteristics of the aerial and ground forest fire protection for 10 to 15 years, while the forest fire protection arrangements plans include specific description and scope of fire fighting activities.

Forest fire protection arrangements plans are based on forest resources management targets, value of the assets subject to protection, expenditures to finance forest protection and fire management, amount of expected fire related damage and actual constrains to finance fire fighting activities.

Priorities of forest fire protection arrangements are (a) improved quality of the substantiation for the main directives for forest fire protection, general plans and projects; (b) updating of the current main directives for forest fire protection, general plans and projects; (c) planned coverage with fire protection arrangements of the entire forested area; (d) supervision over the activities under the forest fire protection arrangements.

The quality of the main directives for forest fire protection, general plans and projects will be improved through the enhancement of the regulatory framework and approaches to the substantiation of fire fighting activities by matching the expected cost of forest fire protection and expected fire related damage.

Updating of the current substantiations for main directives for forest fire protection, general plans and projects and ensuring gradual fire protection arrangements coverage of the entire forested area will involve incorporation of these activities into the overall system of forest management design, federal and regional program and plans for the development of forest management.

On the areas polluted with radionuclides, the system of forest fire protection arrangements will require tough requirements to the radiation safety of forest fire services and communities. The system intends to prevent forest fires and put out fire spots at as minimal area as possible.

As for forests with peatlands, the system of forest fire protection arrangements intends to radically reduce the natural fire capacity of the peatlands and probability of fire occurrence as well as to provide forest fire services with the relevant fire fighting hardware.

### 4.3. Development of Fire Prevention

Improved effectiveness of forest fire prevention will be based on a combination of traditional and innovative approaches to fire prevention awareness, intensification of fire and environmental education of the public at large. Advocacy of forest fire safety rules (requirements) through the use of outdoor means such as (billboards, photos, placards, leaflets, etc.) will be combined with a public awareness campaign in mass media such as regular forest fire related broadcasts and warning of the public on the forest fire situation.

As for intensification of fire prevention and environmental education, the focus will be on children and the youth as well as on nongovernmental organizations whose activities involve visits to forests. The environmental and ecological programs for the entire range of public educational establishments including the vocational ones will incorporate forest-related fire safety rules and prevention advice. The effort to intensify forest fire public awareness and education will be undertaken together with nongovernmental environmental organizations.

Establishing seasonal road check points in the areas with intensive traffic and movement of people along with the toughening of the state forest fire supervision is recognized as an important effort to reduce fires in the context of deteriorated fire situation.

Forest fuels that promote destructive fires are commonly reduced through mechanical or chemical treatment or prescribed burnings. This requires development of legal requirements and documents to regulate the procedures, timing and conditions of prescribed burning.

### 4.4 Improved Response to Forest Fire Detection and Fighting

Improved Response to Forest Fire Detection and Fighting is recognized as the highest priority in the development and improvement of the fire protection of forests.

Fire detection will be improved by developing an integrated monitoring system, as well as means and methods for the registration of lightning charges that are the main natural source of forest fires.

Fire response will be improved by expanding the network of the aerial and ground fire services, improving the preparedness and mobile capacity of the forest fire services, establishing task forces of rapid deployment to help the constituent entities of the Russian Federation in fighting fires in the context of high and extreme fire occurrence.

The priorities in the improvement of ground-based fire detection will include (a) gradually expansion of the network of observation points and ground patrols to attain full coverage of the respective areas; (b) aerial patrols over the areas that are not covered by the ground patrols and observation points. The priorities in the improvement of aerial fire detection will include (a) increased frequency of aerial patrols and optimization of flight schedules; (b) incorporation of modern satellite-based means and methods of observation into the system of forest fire monitoring; (c) expansion of the network of meteorological radars in the protected forested area to detect thunderstorms.

The priorities in the improvement of ground-based forest fire response will include (a) expansion of the fire and chemical stations (FCS) network to fully cover the territory of the respective zones; (b) completing the existing and new FCS with fire fighting teams, fire fighting hardware, telecommunications and transport in consistency with the current standards; (c) regular standby duties of fire fighting teams at the stations during middle, high and extreme forest fire situations depending on the weather conditions.

The priorities in the improvement of aerial forest fire response will include (a) increased number of aircraft and staff of the aerial fire teams in accordance with the standards; (b) providing the aerial fire service with tankers and helicopter water dischargers to provide for aerial fire fighting.

To ensure the timely detection and fighting of emerging fires, operational management responsibilities regarding the activities of the aerial and ground forest fire service will be delegated to the regional forest fire coordination centers to be established at the control points of the aerial forest fire service. These regional centers will be provided with the required meteorological information, satellite images and lightning detection data.

### 4.5. Improved Emergency Preparedness Associated with Forest Fires

The improved emergency preparedness of the forest fire protection will be by streamlining the operations of the forest fire services through the improvement of the current operational procedures to meet the required level of the forest fire protection, the current and forecasted fire danger with due regard to the weather conditions and actual fire situation, as well as by establishing task forces of rapid deployment (inter-regional forest fire centers with mobile fire teams).

Routine-preventive and operational manoeuvring with the resources of the forest fire services will be based on the fire forecasts and occurrence recognizing short-, mid- and long-term weather forecasts.

One of the operational regimes of the aerial and ground forest fire services may be established within one fire season (a) a daily operation; (b) a regime of increased preparedness; (c) an emergency regime.

In case of fire threat to the communities, located in the fire emergency zone, the respective emergency management authority will take over the operational management of fire protection as per the existing legislation of the Russian Federation.

The timely mobilization of the resources of the Emergency Management Services to assist in fighting fires in the context of high and extreme forest fire occurrence will be ensured through clear mobilization procedures, sound fire fighting management, guaranteed compensation of the individuals and legal entities involved in forest fire fighting. This will involve training and assessment of leaders that manage major forest fires, as well as safety instructions and fire fighting training of people who will be sent to fight fires.

The higher educational establishments will train engineers in the “Prevention and Fighting of Forest Fire” discipline, with the similar specialization to be taught at forest colleges.

### 4.6. Using Fire as a Natural Element of Forest Ecosystems

Using fire as a targeted tool of forest management will be based on the knowledge of the nature of forest fires, impact on forest vegetation and fauna, biodiversity and sustainability of forest ecosystems, global carbon cycle. The intrinsic relations between forest vegetation, fires, climate change and other natural (inspects, diseases) and human-made (logging) factors dictate a careful application of fire in the forest context.

Potentially, fire could be used (a) to reduce forest fuels; (b) to reintroduce low ground fires in the forest ecosystems that are adapted to them; (c) to restore historical fire cycles; (d) to promote natural reforestation; (e) to control forest pests and diseases; and (f) to improve the natural habitat of wild life.

One mandatory condition of successful integration of forest fire into forest management will be scientifically based recommendations for prescribed burning and reliable information on the current state of forest ecosystems. This integration will be an ongoing and long-term process to be matched with other goals such as human safety, air quality and other specific requirements. The targeted use of fire in forests should be preconditioned by the removal of legal barriers as a legacy of the historical policy to actively suppress any forest fires.

The targeted use of fires as a natural element of forest ecosystems will be under dedicated programs to maintain the long-term sustainability of forest resources and minimize detrimental consequences of fires. This will only be allowed within those territorial and economic units that developed and adopted approved fire management plans. In the absence of such plans, the policy of active suppression of all the emerging forest fires will be pursued.

Allocation of forest areas that require periodic prescribed burnings will be in accordance with the scientifically substantiated recommendations and criteria developed under the fire fighting arrangements of forests. Prior to the development of such criteria and allocation the territories that require prescribed burning, these will be planned and carried out as strip burnings to establish fire barriers, as well as continuous burning of vegetation in the areas with excess forest fuels that are located in the plains and are limited in size.

## 5. Implementation Tools of Forest Fire Policy

The main areas in the development and improvement of the legal framework for forest fire policy will be:

- Developing and adopting legal acts to determine the mandate of the constituent entities of the Russian Federation and municipalities, their responsibility in the area of forest fire protection and forest fire management and to identify the sources and procedures of financing;
- Developing and adopting legal and regulatory acts to regulate planning and the carrying out of prescribed burnings, as well as a targeted use of fires to maintain sustainability of forest ecosystems, to divide the responsibilities in the area of forest fire protection and forest fire management, to regulate the procedures and timing for the mobilization of resources and funds of the National Emergency Service with the aim of fighting fires if there is a threat of forest fire-related emergency situation, to establish a safety net for the personnel involved in forest fire fighting and to carry out prescribed burnings;
- Financing forest fire protection and forest fire management will be through the state budget and from other legal sources such as the budgets of the constituent entities of the Russian Federation and local authorities, various funds, own resources of forest users and other sources;
- Financial and material resources of the constituent entities of the Russian Federation and local authorities will be used to fight fires in case of an emergency risk;
- A special research program in the area of forest fires must serve as the basis to develop scientific principles of integrating fires into the nature management;
- Improving inter-agency and inter-regional coordination by establishing inter-agency coordination teams, local and federal level coordination teams;
- This inter-agency cooperation will be through multilateral and bilateral agreements that describe the goals and main areas of cooperation, mutual obligations of the parties, procedures for cooperation and dispute settlement;
- Interaction of the federal agencies with the constituent entities of the Russian Federation and municipalities will be through the joint development and implementation of regional programs and plans of forest fire protection and forest fire management. This will include joint effort to fight fires in the context of high and extreme forest fire occurrence;
- International cooperation in forest fire protection and forest fire management will be under international agreements of federal and regional level and detailed within the corresponding international inter-agency programs, agreements and projects/plans.

# Transport of Radioactive Materials by Wildland fires in the Chernobyl Accident Zone: How to Address the Problem

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## Abstract

As a result of failure on the Chernobyl nuclear power plant a total of six million hectares (ha) of forest lands were polluted by radionuclides. The most polluted forest area covers over 2 million ha in Gomel and Mogilev regions of Byelorussia (Belarus), in Kiev region of the Ukraine and in Bryansk region of the Russian Federation. The main contaminator is caesium-137 ($^{137}Cs$); in the core zones of contamination strontium-90 ($^{90}Sr$) and plutonium-239 ($^{239}Pu$) are found in high concentrations. Radioactive emissions from wildfires occurring in contaminated vegetation represent a high risk for firefighters. In addition populations are affected by radioactive smoke particles transported over long distances.

The most contaminated territories are located in the closed zone around Chernobyl in the Ukraine and the Polessky state radiation-ecological reserve in Gomel region of Byelorussia. Here the soils are concentrated with highest contamination by radionuclides. The total area of the reserve is 215,500 ha. Soils contaminated by concentrations ranging from 1517 to 2,960 GBq/km$^2$ cover 40% of the territory of the reserve. Here there are also sites contaminated by Sr-90 and Pu-239. The closed zone in the Ukraine covers the an area of over 100,000 ha contaminated by Cs-137, Sr-90, Pu-239. The considerable part of forest areas of adjoining districts in Gomel, Mogilev and Bryansk regions have also high level of radioactive contamination.

This region constitutes the largest area in the world with the highest contamination by radionuclides and is located in a fire-prone forest environment in the centre of Europe. Every year several hundred to several thousand of wildfires are occurring here affecting forests, peatlands, extended areas of contaminated and abandoned agricultural lands and former estates. The population of this area is 4.5 million people.

During fires on the abandoned lands and other open areas the surface fuels contaminated by radionuclides – the grass layer and the surface layer of peat fields - are burnt practically completely. Extended radioactive fires occurred in the closed zones in 1992: In the Ukrainian part 12,000 ha of forest were burnt, in the Byelorussian part – 1,200 ha. Outside the closed zone fires covered 870 ha of forest lands in Gomel and Mogilev regions. In Bryansk region the area of radio-active fires was less than 200 ha. As a result of the fires Cs-137 radionuclides were lifted and transported by the smoke to the territory of Russia, especially in May and August 1992.

In 1993-2001 a total of 770 wildfires in the closed zone of the Ukraine affected 2482 ha (4.4 % forest, > 95 % abandoned lands and agricultural estates. In the period 1993-2000 186 wildfires occurred in the closed zone of Byelorussia and affected an area of 3136 ha including 1458 ha of forest (46.5 %).

A number of measures are proposed to prevent the occurrence of fires in the contaminated areas, thus reducing the emission of radioactive particles and the contamination of fire service personnel and population by ionic radiation. Besides fire prevention measures practical actions include remote detection of forest fires, remote methods of fire suppression, and breathing protection of firefighters.

## Introduction

As a result of the failure on the Chernobyl nuclear power plant more than 6 million ha of forest lands were contaminated. The most contaminated forest lands are situated in the Gomel and Mogilev Regions of Belarus, the Kiev Region of Ukraine and the Bryansk Region of the Russian Federation. Their total area makes up more than 2 million ha. The main contaminant of all those territories is cesium 137 ($^{137}Cs$). There are also strontium-90 ($^{90}Sr$) and plutonium-239 ($^{239}Pu$) in alienation zones (Figure 1).

The alienation zone around the Chernobyl Atomic Power Plant and the Polessky State Radiation-Ecological Reserve in the Gomel Region of Belarus is of special importance. The most polluted by radionuclides lands are concentrated on these territories. The total area of the Polessky Reserve is 215,500 ha. The density of soil contamination by radionuclides of Cs-137 makes up from 555 to 2960 GBq/km$^2$ (from 15 to 800 Ci/km$^2$). The areas with the density of soil contamination from 1517 to 2960 GBq/km$^2$ (from 41 to 800 Ci/km$^2$) occupy 40% of the Polessky Reserve's territory. There are also territories contaminated by Sr-90 and Pu-239 in this area (Figure 2). The alienation zone in Ukraine covers the area more than 100,000 ha. The territory is contaminated by Cs-137, Sr-90 and Pu-239. The considerable part of forest areas of adjoining districts of the Gomel, Mogilev and Bryansk Regions has a high level of radioactive contamination as well.

**Contamination of Vegetation**

The largest in the world areas that are greatly contaminated by radionuclides, as well as fire-risk forests, are situated in the center of Europe. The population of this region is about 4,5 million people. Annually from hundreds to several thousands forest fires are recorded here. They burn out forests, peatlands, former farmsteads, etc. The stock of the most inflammable forest fuel materials (litter and dead trees) is increased considerably in the most contaminated by radionuclides forests, where thinning were stopped. Under such conditions both the intensity and severity of forest fires is growing. By 1995 a layer of dry grass mass 15 - 60 cm thick were accumulated on disused areas in the Ukrainian alienation zone of the Chernobyl Atomic Power Plant (Dusha-Gudym 1993, 1996, 1999).

The failure at the Chernobyl Atomic Power Plant took place in 1986. The natural dissociation of radionuclides, reduction of the contamination level of environment are observed first of all on the territories, contaminated by Cs-137 and Sr-90 which half-value period is 30 and 28 years correspondingly. It is less than the half-value period of supertransuranic elements (the half-value period of Pu-239 is more than 24,000 years). Their vertical migration takes places simultaneously with the dissociation of radionuclides. The most part of radionuclides moved to forest litter and upper soil layers. These layers are inflammable and burn practically during all types of forest fires. The contamination of underlying peat layers takes place on peatlands. On unused areas and farmsteads radionuclides are present in upper organic and mineral soil layers and in grass (Dusha-Gudym 1999).

Practically all grass mass contaminated by radionuclides and the most contaminated upper layer of peatlands burn during fires on unused areas and on other open places. The combustion products of dry grass mass go away to smoke emission. Investigations reveal that during the forest fire all radionuclides located in the area after the failure at the Chernobyl Atomic Power Plant appear in smoke columns and in aerosols.

**Radioactive fire emissions**

The radionuclide transfer with forest fire smoke to long-range distances and their fallout on large areas were realistically estimated after the forest fires in 1992. In 1992 a great number of radioactive forest fires took place in alienation zones. 12,000 ha of forest lands were burned out in the Ukrainian part of the alienation zone and 1200 ha in Belarus (Kaletnik 2002). Outside the alienation zone in the Gomel and Mogilev Regions of Belarus the forest area burnt by fires made up 870 ha. In the Bryansk Region the area of radioactive fires made up 200 ha. As a result of radionuclide transfer with fire smokes to hundreds of kilometers the content of Cs-137 in the atmosphere increased on the all territory of Russia contaminated by radionuclides. A very high increase took place in May and August during fire peaks (Dusha-Gudym 1996, 1999).

The results of investigations in the Bryansk Region have showed that peaks of fall-out of radioactive Cs on litter followed fire peaks. The fire peaks corresponded with the content of radioactive Cs in the atmosphere. The analyses of forest fire smokes have showed that the content of radionuclides in smokes exceeded the permissible rate for inhabited areas several times. Ash and not fully burnt materials remained after forest fires are open sources of the ionizing radiation. By the contamination level they correspond very often with radioactive waste. Therefore, the suppression of forest fires under the conditions of radioactive contamination should be carried out by remote methods. The suppression of burning fire edge by hand tools, especially putting out the fire with twigs is inadmissible.

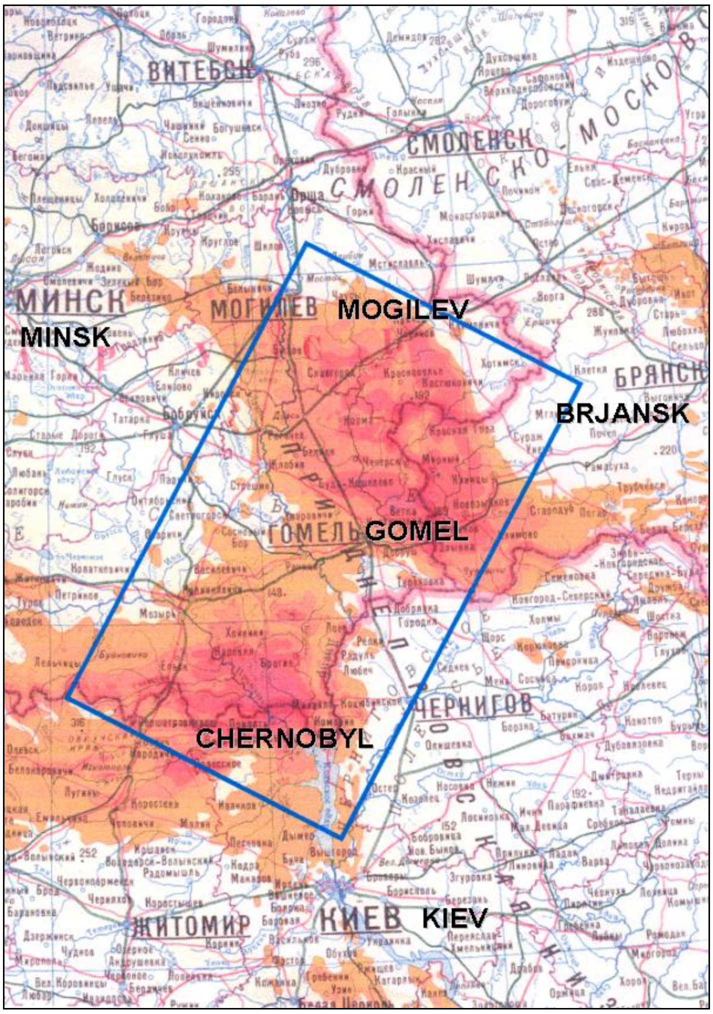


**Figure 1.** Map of Russia, Belarus and Ukraine most polluted by Cs-137. The area burned by radioactive forest fires in 1992 is 16 000 ha.

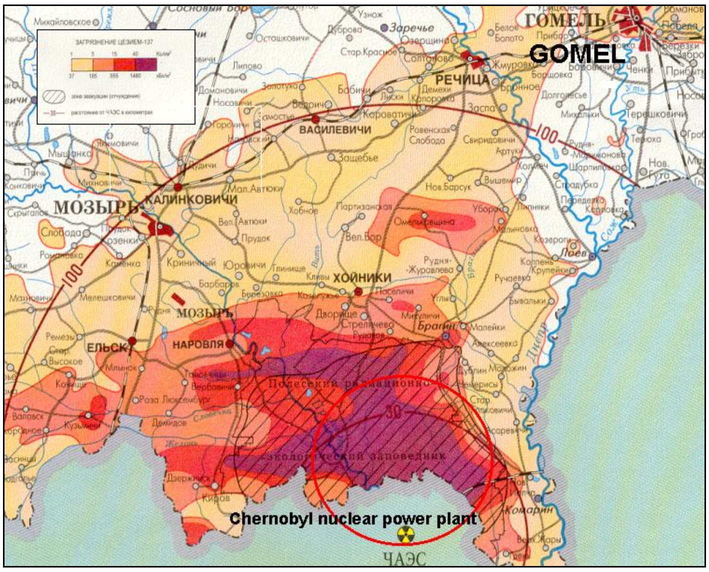


**Figure 2.** Map of the Polessky State Radiation-Ecological Reserve in the Gomel Region of Belarus.

The quantitative characteristics of forest fuel materials (FFM) contaminated by radionuclides and their combustion products in all zones of radioactive contamination have been received during the implementation of the first radiation and pyrological investigations in forests of the Russian Federation. The concentration levels of radionuclides in ash and in not fully burnt materials have been established as well. The results of these investigations allowed to develop a scientific basis for the fire protection system of forests contaminated by radionuclides. It could be used also for forests of Belarus and Ukraine. The affecting factors of forest fire, principles of protection and concrete practical measures for their implementation had been determined clearly. The determined dangerous factors of radioactive forest fires were included into the State Standard of Russia. The system of fire protection of forests contaminated by radionuclides is based on the position that the main dangerous factor of fires is solid and gaseous combustion products of FFM. The level of ash contamination in zones with the density of soil contamination by radioactive Cs (more than 15 $Ci/km^2$) corresponds with the level of contamination of radioactive waste (Dusha-Gudym 1993, 1996, 1999, 2002a).

The largest emission of radionuclides under other equal conditions is possible during general crown forest fires, when all layers of FFM are burnt out, including ground layers, and at the same time the upper mineral soil layer is destroyed. The smallest particles of upper soil layer contaminated by radionuclides accrue to radioactive ash, not fully burnt materials, smoke and aerosols generated from FFM. At the same time the emission of radioactive aerosols and radioactive ash during peat fires is considerably higher than during forest fires due to high peat ash content and large peat volumes on a unit of area. Burning peatlands are the most powerful and long-time acting sources of radioactive smokes. Therefore the prevention of peatland fires and forests fires on peatlands is one of the main measures on the reduction of emissions of radioactive smokes and radionuclide transfer (Dusha-Gudym 2002b).

The general regularities of the nature of forest fires, as well as new for pyrology aspects and physical characteristics of combustion products and processes reflecting the specificity of consequences of fires that generate greatly open sources of ionizing radiation, should serve as a scientific basis of forest fire protection on territories contaminated by radionuclides.

The general radiation characteristics of the territory and forest range, radiation features of burning objects (forest and non-forest lands of the Forest Fund), specific radioactivity of the main groups of FFM of predominant forest types under different density of contamination by radionuclides, general radioactivity of FFM stocks on the examined territory, output of solid and gaseous combustion products of FFM, characteristics of radioactive mass transfer with forest fire smokes, their vertical and horizontal migration on fire sites should be basic materials for quantitative and qualitative characteristics of FFM, solid and gaseous combustion products, features of air environment on fire sites and working places of firefighters, as well as for ground layer of the atmosphere.

In order to receive these and some other valid materials it is necessary to carry out the permanent monitoring of forest fire situations on the territories contaminated by radionuclides. There are three stages of forest fire situations in the radiation-pyrological monitoring: 1) pre-fire situation, 2) fire, and 3) post-fire situation.

After 1992 on the most territories contaminated by radionuclides the ratio of forest and non-forest lands burnt by fires changed appreciably. In 1993-2001 a total of 770 fires were recorded on the area of 2482 ha in the alienation zone of Ukraine: forest area made up 4.4%, unused areas and estates amounted to more than 95% (Kaletnik 2002). In 1993-2000 186 fires covered the area of 3136 ha, including forest area of 1458 ha (46,5%), in the alienation zone of Belarus (Figure 3).

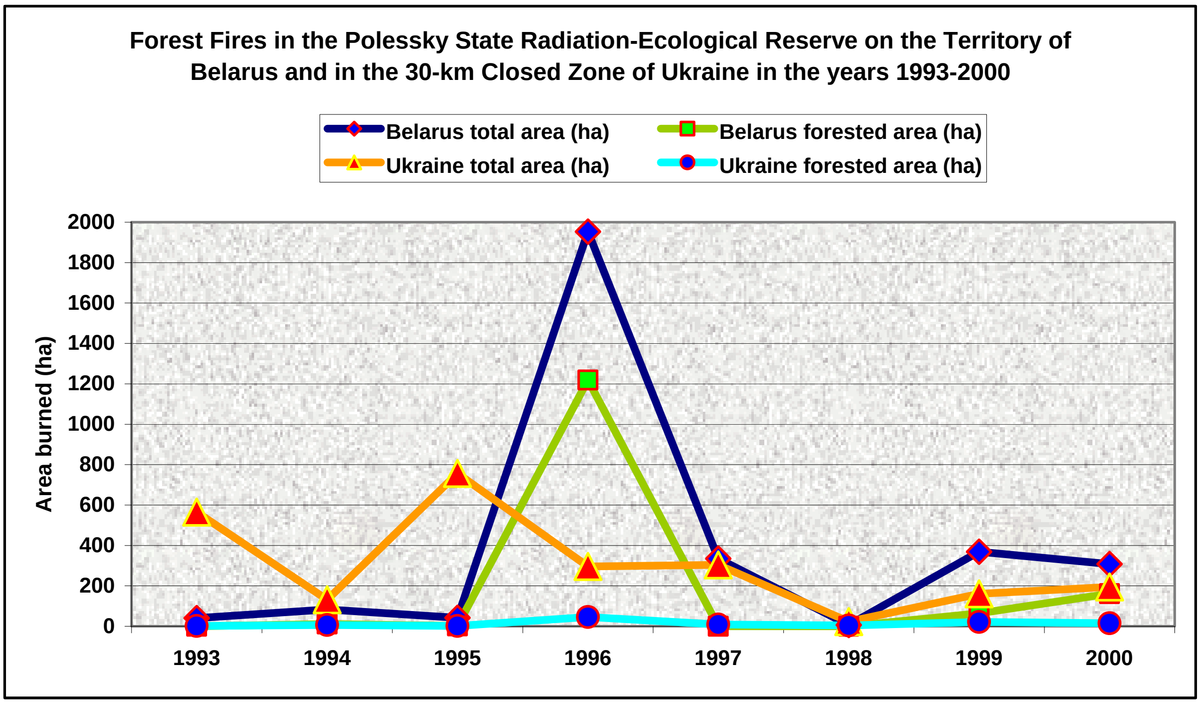


**Figure 3.** forest fires in the Polessky state radiation-ecological reserve on the territory of Belarus and in the 30-km Closed Zone of Ukraine in the years 1993-2000.

In 2002 a number of regions of the Russian Federation was characterized by a hard situation. In the last years 1015 fires were recorded in the Bryansk Region. The forest land area burnt by fires made up 1986 ha. After that large forest fires (over 25 ha) were prevented on the territory of the Bryansk Region contaminated by radionuclides. In the Zlinkovsky forest management unit Lleskhoz) 42 forest fires took place, the area burnt by fires made up 19.36 ha. 69 fires damaged 49.92 ha in the Klintsevsky Leskhoz. 28 fires were recorded in the Unechski Leskhoz, where the area burnt by fires made up 8.46 ha.

## Management of radioactive fires

The system of the protection of forests contaminated by radionuclides should be based on materials of radiation-pyrological monitoring of forests. The monitoring results serve as a database for the forest fire protection system, especially in the organization of protection and in prevention of extraordinary forest fire situations. A special attention should be paid to prediction and registration of preconditions for beginnings of extraordinary forest fire situations (EFFS). The radiation-pyrological models of forest (RPMF) worked out for the Bryansk Region and some other regions of Russia include a basis for predictions of forest fires (Dusha-Gudym et al. 2002). RPMF allow to predict type and category of the fire, volume of burnt biomass, output of combustion products, level of their contamination by radionuclides, volume and character of measures on fire suppression, probability of the secondary radioactive contamination of the territory. Using radiation-pyrological models it is possible to define territories and parcels of the Forest Fund, where radiation consequences of forest fires could be the most severe. At present measures for fire exclusion in such places and their immediate localization are being developed.

For prevention of radionuclide transfer and protection of fire service personnel and population the following *principles of protection* are developed (Dusha-Gudym 2002b):

1. Prevention of large fires – prevention of the destruction of forests that hold radionuclides, prevention of soil destruction; prevention of formation and distribution of contaminated combustion products and soil particles.

2. Exclusion of possible contacts of people with sources of ionizing radiation.

*Practical actions*:

1. Restricting measures. Protection regime
2. Remote detection of forest fires
3. Remote methods of forest fire suppression.
4. Protection of the respiratory tract of personnel

Reduction of fire number in forests contaminated by radionuclides can be achieved through the reduction of the number of potential fire sources mainly through the restriction and even stopping population access to such forests. These forests are under special protection regime because they relate to the category of high fire risk. The prevention of large forest fires (in Russia – 25 ha and over) is achieved through the detection of a fire on the minimal area and immediate delivery of sufficient forces and fire-extinguishing means. To detect a fire on the minimal area the number of aircraft patrol should be increased, as well as permanent control from forest fire towers provided with TV and remote control equipment should be carried out.

The suppression of forest fires should implemented both by indirect and remote methods. The control of forest fire spread on territories, where the density of soil contamination by Cs-137 makes up 100 $Ci/km^2$ (3700 $MBq/km^2$) and where Sr-90 and Pu-239 are present, should be carried out by helicopters with water dropping equipment or by air tankers (Dusha-Gudym 2002b).

The final localization and putting out of fires are carried out by modern fire tanks of high capacity combined with cross-country vehicles, all-terrain fire vehicles and high-pressure pumps. It is necessary to add fire retardants to water during forest fire suppression. The effectiveness of forest fire suppression by water with retardants is considerably higher than by pure water. The addition of retardants to water is especially important in suppression of peat fires.

**Protection of Firefighters**

The requirements for protection of forests contaminated by radionuclides are very strong. The State Standard of Russia has established criteria of the occurrence of extraordinary forest fire situation. They include forest fire covering 25 ha; forest fire on the territory contaminated by radionuclides that is not put out on the day of its occurrence; forest fire on the territory contaminated by radionuclides that generates a lot of smoke (Dusha-Gudym 2002b).

The cars and tractors used during suppression of forest fires should be equipped with the gas protection system. The current radiation dosimetric control is carried out during prevention and suppression of fires on working places of personnel. It consists in the determination of dose capacity and contamination level of working clothes, transport, machines and equipment.

The sanitary rules include the following requirements:

- the work should be carried out only in protective clothing. As overalls becomes contaminated it is to be passed to a special laundry;
- the transport used for the delivery of forest service personnel to working places is to be washed every day;
- drinking water and hot food are to be delivered to working places in closed vessels and vacuum bottles; home food should be extra packed in plastic sachets;
- after work completion overalls and footwear should be taken off, washed and packed in special bags. These bags are to be placed in an isolated compartment;
- hands, face, eyes, ears and nasopharynx are to be washed carefully. It is necessary to have some vessels with pure water thereto.

During forest fires on the territories contaminated by radionuclides their concentration in combustion products takes place. Therefore during suppression of fires, inspection of fire places, as well as in the process of fire localization and final putting out it there is need for the protection of the respiratory tract, skin and eyes from solid combustion products (ash, not fully burnt materials, smoke and dust). Hands and feet should be protected from high temperatures.

The models of protective clothes should have a minimal number of places for possible accumulation of radioactive dust. Head-dresses used for the protection of hair should be produced from materials that could be easy decontaminated.

For the protection of the respiratory tract from dust and smoke it is necessary to use disposable respirators. In case of heavy smoke generation or dust raising it is necessary to apply personal protective equipment with air forcing.

The closed protective spectacles are to be used for the protection of eyes from mechanical particles, dust and smoke.

Special foot-wear must be easy decontaminated and stable to impact of detergents. Under especially harmful conditions with a high level of radioactive contamination one should apply extra footwear that covers the main overalls.

**Acknowledgements**

The author is greatly indebted to Johann G. Goldammer, Fire Ecology Research Group, Max Planck Institute for Chemistry, and Global Fire Monitoring Center (GFMC), Freiburg, Germany, for his assistance in preparing and publishing earlier research results and for preparing this manuscript. This manuscript was also accepted as an invited paper to the 3rd International Wildland Fire Conference, Sydney, Australia, October 2003.

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# The 10th Anniversary of Avialesookhrana's Air Fleet
# Avialesookhrana Headquarters, Pushkino, 15 September 2004

*Nikolay A. Kovalev*
Director, Aerial Forest Protection Service *Avialesookhrana*

It seems that only very short time has passed since it was decided to transfer the bankrupt Seimchanski United Air Detachment "under the wing" of *Avialesookhrana*. This was a response to the proposal of the North-Eastern Airbase, supported by the authorities of the Central Airbase and by the Federal Forest Agency *Rosleshoz*. In 1994 the aviation subdivision within the North-Eastern Airbase was established. In 1995 the Ministry of Property of Russia turned the remaining property of the Vladimir State Aviation Enterprise over to the Central Airbase. Subsequently, on the basis of the turned-over property of the bankrupt aviation companies the detachments of forest aviation were reorganized into the Airbases North-West (Petrozavodsk), Krasnoyarsk (Yeniseisk) and Amursk (Svobodni) Airbases with in their subdivisions in Altai and Buryat Republics.

Today we celebrate the 10th anniversary of Avialesookhrana's way leading to the revival of forest aviation. Its establishment is dating back to 1931. If we take a look back to the history, the first air expedition for forest protection was organized on an area of 1.5 million ha in Nizhni Novgorod province and the first group of forest engineers was trained in the capacity of pilot observers (S.P. Rumyantsev, V.V. Stadnitsky, G.G. Samoilovich). The flight time with respect to forest fire protection activities during that year was 40 hours with 16 detected fires. From 1932 to 1935 research on the use of aviation for the solution of different questions in forestry had been conducted by the Leningrad Branch of the All-Union Research Institute of Agriculture and Forest Aviation.

Furthermore, in 1934 the same institute elaborated on the project on the use of parachutes in fighting forest fires. First tests were made on delivery of equipment and people to fire sites. In the Gorikovksi expedition in 1935 the parachute group, consisting of three persons under the guidance of G.A. Mokeev performed 50 parachute jumps for forest fire suppression from a U-2 plane using the parachute PT-1.

The year 2005 will be the 70th anniversary since the first use of parachute systems for forest firefighting!

In 1936 Leningrad Branch of the All-Union Research Institute of Agriculture and Forest Aviation was reorganized into the State All-Union Trust of Forest Aviation (VGTLA) in Leningrad city. P.A. Tsetlin was appointed Head of that organization. Since that time all activities on aerial forest fire protection have been planned for forest lands situated all over the USSR. The Department of air service was founded as well as the four air detachments of forest aviation – the Airbases in Leningrad (Head: M.D. Artamonov), Northern (V.S. Rekunov), Krasnoyarsk (A.T. Hramtsov), and Tyumen (S.Z. Beloborodin).These subdivisions were responsible for aerial forest fire protection, and also for serving wood floating, aerial photography of forest resources, providing transportation and communications and carrying out some other forest aviation functions. Within the air detachments forest aviation expeditions were organized. The protected areas and the amount of flight hours were growing swiftly. Within only eight years from 1931 to 1939 the protected areas increased by more than 45 times and reached 95 million ha, and the amount of flight time grew up to 7200 hours or 76 hours per one million ha – to this index we returned in 2003.

Besides the Trust of forest aviation in 1940 another aviation group (Head: L.D. Dolmatov) was established for forest protection in the zone of artificial reforestation. This group was formed by three detachments – Semenovsky (A.G. Timofeev ), Zagorsky (B.I. Bogolepov and Deputy I.A. Proshkin) and Solikamsky (V.F. Jakovlev).

By the beginning of the Second World War the area protected by aviation accounted for about 109 million ha. The number of involved U-2 aircraft was close to 110 out of which 60 belonged to the Forest Protection Service itself. In 1949 the aviation of the Ministry of Forestry of the USSR together with the plane-motor park and the engineering and technical personnel was turned over to the Central Board of the Civil Aviation Fleet of the USSR for the purpose of forestry service improvements and more effective use of aircraft in forest protection. In connection with that the special bases for air protection of forests and attending to forestry had been established for providing struggle with forest fires and aviation service of forestry by the aircraft being under the authority of the Central Board (CUGVF). In 1955 the All-union Enterprise for Aerial Forest Protection and Forest Service *Leskhozavia* was established. Starting in 1958 the Central Base of the Aerial Forest Fire Protection Service *Avialesookhrana* was entrusted with guidance over all the air bases. The first Head of the Central base was I.A. Proshkin, followed by V.V. Podolsky and N.A. Andreev.

PO-2 airplanes used in the 1930s until the end of the 1940s

PO-2 airplanes during air patrol

Chief pilot observer Evlalia P. Gruzdova (North airbase) is instructing a fresh pilot instructor (mid-1950s).

Smokejumpers boarding to PO-2 (1950s)

Before the 1990s the Airbases were leasing airplanes from the civil aviation enterprises, which had the required number of airplanes available. The number of aircraft, their flight hours for different types of missions, and the price of a flight hour for each type of aircraft was planned centrally by the state. During the period of "perestroika" – a period of stormy changes in the social, economic, and political development of our country – and during the transition from the centrally planned national economy to the market economy, the civil aviation agencies responsible for planning the use of aviation in the national industry and economy (PANH) lost their volume of work and financial support by the state as it had been oriented towards planned public economy itself. This led to ravage and left most of them bankrupt. The bases of aerial forest protection in the Far East and Siberia were the first to feel the shortage because the lack of aircraft for aerial forest operations. Under the conditions of an economy in transition, involving illegal operations and suffering an absence of control by the government, the air enterprises stopped the flight operations of the AN-2 air planes and increased the prices for leasing the helicopters MI-8.

For smokejumping the D-1 parachute was used from 1950 to 1970

MI-1 was used as patrolling helicopter in the 1950s and 1960s.

MI-4 unloading helirappellers to fire (early 1960s)

Ka-26 helicopter used for helirappelling in the 1970s


Antonov-2 used for aerial fire management since 1950s until today

Not much attention was paid to the interests of aerial protection of forests in many regions. This was the reason why the Heads of *Avialesookhrana* and *Rosleshoz* were obliged to keep on maintaining the more or less ruined aviation enterprises in Siberia, the Far East and on the European part of Russia.

At present the Federal State Enterprise (FGU) *Avilesookhrana* has 24 branches (subsidiaries). The Vladimir state aviation enterprise, whose property complex will be turned over to the FGU, will serve as the European subsidiary Airbase. Altogether there are now five airbases that are operating own aircraft (North-West, in Vladimir; North-East, in Krasnoyarsk; Amurskaya, in Blagoveshensk; and the small aviation detachments in Altai and Zabaikalie, Ulan-Ude). Before the end of the current year 2004 all of them will be consolidated under united single certificate of the FGU '*Avialesookhrana*. The park of aircrafts consists of 102 units, including 69 AN-2, 18 MI-8T, one MI-8MTV, three MI-2, two AN-24, four AN-26, and one IL-103.

## GFMC Address to the 10th Anniversary of Avialesookhrana's Air Fleet Avialesookhrana Headquarters, Pushkino, 15 September 2004

*Johann G. Goldammer*
The Global Fire Monitoring Center (GFMC)

Dear colleagues and friends!

Today is an important event to which the Global Fire Monitoring Center (GFMC) has been kindly invited. I would like to take the opportunity of the celebration of the 10th Anniversary of the establishment of *Avialesookhrana*'s own air fleet to reflect on the developments of the last decade. It is more than one decade ago when I first visited the your country in 1991. In this first official visit of Western wildland fire specialists after the end of the Cold War I travelled together with Professor Stephen J. Pyne, the most prominent fire historian of the world. We were hosted by *Avialesookhrana* and visited the most important fire regions of your country, starting in Leningrad Oblast and ending in the Far East. For the first time I was able to understand that the size of Russia's forest land, its magnificent beauty and its ecology are unique in the world. Russia's forest do not only have an economic potential for the country. The forests are home of biodiversity and people, and they store large amounts of terrestrial carbon. Natural fires have shaped the forests over millennia, and many species have fairly well adapted to natural fire regimes. However, forest fires have a potential of destruction. In the early 1990s it became clear that the combination of economic changes, social instability, and the effects of climate variability may lead to extreme fire situations. Climate change predictions also indicated that increase of temperatures, combined with prolonged and drier fire seasons, would lead to extreme fire behaviour and fire damages.

Andrey Eritsov translating the speech of J.G. Goldammer at the celebration of the 10th Anniversary of Avialesookhrana's Air Fleet.
Photo: *Avialesookhrana.*

Immediately after my first visit we prepared the first joint East-West conference "Fire in Ecosystems of Boreal Eurasia", conducted in partnership with the Sukachev Institute of Forest, Krasnoyarsk, and supported by *Avialesookhrana*. Together with Dr. Valentin V. Furyaev we organized this first joint meeting of forest fire scientists and the fire management communities that had been separated by the Cold War over decades. Supported by Nikolay Alexeevich Kovalev, former Head of the Aviabase Krasnoyarsk and now chief of *Avialesookhrana*, we conducted the first large international and interdisciplinary forest fire experiment near Bor, Krasnoyarsk Region. The conference and experiment gave to all of us new insights on the role and importance of forest fires in Russia and the global boreal zone.

This was also the time when *Avialesookhrana*, representing the Russian Federation, became an active member of the international community which started to work together to address forest fire problems worldwide. Eduard Pavlovich Davidenko was the first representative of the Russian Federation in the ECE/FAO Team of Specialists on Forest Fire. He also belongs to the United Nations Wildland Fire Advisory Group.

The Russian Federation in 1996 was host of an important international conference entitled “Forest, Fire and Global Change”. Supported by *Avialesookhrana*, specialists from throughout the world met in Shushenkoe to discuss programmatic issues. The questions to be answered included this: “How can the international community work together more efficiently to address the expected changes in the world that may lead to more destructive fires?” The Shushenkoe conference was a great milestone for improving international cooperation in wildland fire management.

However, these years in the middle of the 1990s brought not only enthusiasm but also many changes to Russia and to the rest of the world. At the time when *Avialesookhrana* started to build up its own airfleet for forest protection, the country suffered an economic crisis which went along with all the problems arising from the transition of the former policies and administrations to new concepts of managing natural resources, including forestry.

Russia was not alone. Many other countries in Western and Eastern Europe transformed old systems of forestry to new ones (decentralization and reduction of forest administrations, privatisation, change of forest management). As a general trend both in the West and the East of Europe the role of the State (either central government or regional governments) was reduced, with all the negative consequences on forest management and the capabilities of efficient forest protection.

Avialesookhrana went through a very critical time. During my regular visits I observed this crisis which had a tremendous negative impact on the ability of Avialesookhrana to fulfil its duties. Nonetheless, the professionalism and enthusiasm of Avialesookhrana’s staff did not only keep your service alive – you were also able to expand your visions and capabilities to build up your own airfleet of helicopters and fixed wing aircraft for fire observation, transport and fire suppression

Observing the forest sector of the Russian Federation from outside I have the impression that there is a process of stabilization. During yesterday’s briefing of the regional heads of the forest administrations the Chief of the Federal Forestry Agency, Mr. Valery P. Roshchupkin, indicated that the Agency and the Ministry of Natural Resources intend to strengthen the capabilities of forest fire protection. There is also a discussion of a new fire management strategy to be formally adopted by the government. A new strategy will look at both economy and ecology of fire protection – and this is what is really needed.

The international community is looking at Russia as a forest country which has a significant importance in the global system. The interest to protect Russia’s forest resources from destructive fire is a global interest. This is why we are looking at Russia with solidarity and also friendship. We are also aware that the magnitude of the fire protection problem requires specific and probably unique solutions.

But back to crisis management. From my point of view I have observed that the personnel of *Avialesookhrana* was successful to manage the most difficult times of the economic crisis. The crisis is not yet over. Staff members and families have been severely affected by the economic problems. However, *Avialesookhrana* staff has managed the crisis by acting responsible and in solidarity.

Solidarity is also a term which I would like to use when conveying the greetings and congratulations of the Global Fire Monitoring Center and the United Nations Wildland Fire Advisory Group. I wish all of you a safe hand in meeting the challenges of the future. As I said before, Russia is a unique country concerning the importance of forests. Russian forest have a unique importance for the functioning and sustainability of the of ecosystem Earth. This is why the country also needs unique solutions in protecting these forest resources.

Solidarity is also conveyed to the families of those who served in *Avialesookhrana* and who lost their lives in the fight against forest fires. At the occasion of the inauguration of the firefighter's memorial today I would like to express the recognition of the international community for those who gave their lives in firefighting missions.


Inauguration and blessing of the Firefighter's Memorial at headquarters of Avialesookhrana, Pushkino, Moscow Region, 15 September 2004.
Photo: *Avialesookhrana.*