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Fire Management Working Papers

Global Forest Resources Assessment 2005 – Report on fires in the Central Asian Region and adjacent countries

by
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The purpose of these papers is to provide early information on on-going activities and programmes, and to stimulate discussion.

Comments and feedback are welcome.

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FOREWORD

Fires impact upon livelihoods, ecosystems and landscapes. Despite incomplete and inconsistent data, it is estimated that 350 million hectares burn each year; however, the nature of fires determines whether their social, cultural, environmental and economic impacts are negative or positive. Up to 90 percent of wildland fires are caused by human activities primarily through uncontrolled use of fire for clearing forest and woodland for agriculture, maintaining grasslands for livestock management, extraction of non-wood forest products, industrial development, resettlement, hunting and arson - thus any proactive fire management needs to adopt integrated, inter-sectoral, multi-stakeholder and holistic approaches. The situation varies markedly in different regions of the world.

As a supplement and complement to the Global Forest Resources Assessment, 2005, this working paper is one of a series of twelve prepared by regional and country contributing authors to provide a greater depth of data and information on fire incidence, impact, and management issues relating to the twelve UN-ISDR Regional Wildland Fire Networks around the world.

The working paper series assesses the fire situation in each wildland fire region, including the area extent, number and types of fires and their causes. The positive and negative social, economic and environmental impacts are outlined. Prediction, preparedness and prevention as key elements in reduction of the negative impacts of fire, rapid response to extinguish fire incidents and restoration following fires are addressed.

The working paper series also addresses institutional capacity and capability in wildland fire management, including the roles and responsibilities of different stakeholder groups for prevention and suppression, particularly the unique role of community-based fire management.

From these working papers, a FAO Forestry Paper on Fire Management will synthesize the highlights from each region, but also provide a global summary of important lessons that can be used in fire management in the future. These papers are a valuable resource in the process to prepare the Fire Management Code, the Global Strategy to Enhance International Cooperation in Implementing the Fire Management Code and associated capacity building.

ACKNOWLEDGEMENTS

This working paper is the product of a global team of dedicated people willingly giving of their time and specialist expertise within each of the twelve UN-ISDR Regional Wildland Fire Networks.

Johann G. Goldammer, as the author, obtained key information and data for this working paper from Afghanistan, Armenia, Azerbaijan, Belarus, China, Georgia, Iran, Iraq, Kazakhstan, Kyrgyzstan, Mongolia, Pakistan, Tajikistan, Turkmenistan, Ukraine, Uzbekistan and the Russian Federation; and we wish to than him for contributing materials.

We also wish to thank Michèle Millanès for the excellent editing and formatting undertaken.

To all persons who contributed to this working paper, we express our grateful thanks.

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1. Background

Following the release of the Global Forest Resources Assessment 2000 (FRA 2000) report in 2001, the global FRA process has entered its next reporting cycle. Recommendations from the Kotka IV Expert Consultation in July 2002 on directions of global FRA's were confirmed by FAO's Committee on Forestry (COFO) in 2003. It included to embark on an update of the global FRA for the year 2005 (FRA 2005) and to increasingly involve countries directly in the assessment and reporting, in particular to submit national reports on the status and trends of a range of forestry parameters. More information about FRA 2005 is available at www.fao.org/forestry/fra.

FRA 2005 also included thematic studies, including e.g. one on forest fire, forests and water, and mangroves. The thematic study on wildland and forest fire in 2005 is built on regional reviews on forest fire management in the UNISDR Global Wildland Fire Networks (GWFN) The current report is a contribution and makes a review of the UNISDR Central Asia Region and adjacent countries.

This Working Paper FM/16/E has been written by Mr Johann G. Goldammer and does not reflect any official position of FAO.

2. Introduction

The regional review is primarily covering countries of the Regional Central Asia Wildland Fire Network.[1] This network is still in its infancy stage of definition, formation and functioning. Most of geographic Central Asia is covered by countries that historically belonged to the former Soviet Union (FSU) – Armenia, Azerbaijan, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan and parts of the Russian Federation – and their neighbour states Mongolia and the Northern territories of China, Afghanistan, Iran and Iraq.

Due to its large extent the territory of the Russian Federation is part of geographic Central Asia and actively participating in the establishment of the Regional Central Asia Wildland Fire Network, the Regional Baltic Wildland Fire Network[2] and the Regional Northeast Asia Wildland Fire Network. Some of the neighbouring Regional Wildland Fire Networks are also still in a stage of organizing themselves by determining membership, boundaries and scope of cooperation. For instance, the former Regional Balkan Wildland Fire Network recently expanded its scope for cooperation and reorganized itself as a Regional Southeast European Wildland Fire Network. The southern part of mainland Asia, which is not belonging to the ASEAN region and its network, is currently investigating the formation of a Regional Southern Asia Wildland Fire Network with membership of Bhutan, India, Nepal, Pakistan and Sri Lanka.

In the recent years the Global Fire Monitoring Center (GFMC) has monitored the fire occurrence in some parts of Central Asia. Besides forest fire data provided by FRA 2005, the GFMC database does not provide any additional substantial information on forest fires in Armenia, Azerbaijan, Georgia, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan. The same refers to the northern parts of Pakistan, Afghanistan, Iran and Iraq.

Due to the limited availability of information, the GFMC has asked these countries to contribute to the Global Wildland Fire Assessment 2004.[3] This assessment was considered to complement information collected through the focal points and other contributors of FRA 2005 and to support the compilation of other regional reports. However, the period of transition from centrally-planned to market-based economies of the FSU countries in the 1990s and early 2000s has substantially weakened the formerly strong and highly centralized system of forest management and conservation, including their fire management system, and their ability to respond to these requests. Political instability, war or weak international communication did not yet allow duly information flow from Afghanistan, Iran and Iraq.

[1] http://www.fire.uni-freiburg.de/GlobalNetworks/CentralAsia/CentralAsia.html

[2] For the other regional networks, see GWFN website: http://www.fire.uni-freiburg.de/GlobalNetworks/globalNet.html

[3] http://www.fire.uni-freiburg.de/inventory/assessment.htm

Thus, this report is focussing on countries for which more detailed information is available: Mongolia, Kazakhstan, the Central Asian part of the Russian Federation and Northern China in the centre, and Belarus and Ukraine at the Western edge of the region. Most of the materials used in this report are taken from documentations, projects and country reports of government and non-government institutions and individuals in the region, and the regional activities of the GFMC, respectively.

3. Assessment of the Wildland Fire Situation in the Region

Over the past decade, some countries of Central Asia have witnessed a growing number and size of wildfires in forest and non-forest ecosystems, resulting in considerable ecological and economic damages. Some of these fires have transnational impacts, for example smoke pollution and its impacts on human health and safety, loss of biodiversity; or forest degradation at landscape level. The depletion of terrestrial carbon by fires burning under extreme conditions in some vegetation types, especially in temperate, hemiboreal and boreal peatlands, is an important factor in causing disturbance in the global carbon cycle. Increasing vulnerability of human populations living in or around forest environments has been noted throughout the region. Projected trends of climate change impacts on vegetation cover and fire regimes, as well as observed demographic and socio-economic trends suggest that wildland fire may continue to play a major role in the destruction of vegetation cover in Central Asia, resulting, among other, in accelerating steppization.

3.1 Extent of wildland fires

National statistical databases on the spatio-temporal extent of wildland fires – numbers and size of fires occurring in forests, other wooded lands and other lands – are important for fire management planning and environmental and economic impact assessments. In most countries of the Central Asian/Eurasian region, the data collected by agencies on the ground or by aerial monitoring are not reflecting the full extent of wildland fires. In most countries the forestry agencies or the aerial forest protection services are collecting data only for the protected forests and other protected vegetation under their respective jurisdiction. In none of the countries data of grassland, steppe and peat bog fires are entering the statistical databases, even if data on such fires are recorded by other services, e.g. civil protection or fire services. Unfortunately these different databases are not merged or published jointly. The fire statistical data provided by the countries within the FRA 2005 reports (Table 1a) are reflecting this general situation.

On the other side newly built institutional capabilities in remote sensing application – inside the region and internationally – have generated new datasets of wildland fire information based on various spaceborne sensors such as the NOAA AVHRR, MODIS, MERIS, ASTER and SPOT-Vegetation instruments. These datasets include all vegetation types affected by fire. Active fires and area burned recorded from space include both the ecologically benign fires burning in fire-dependent or adapted ecosystems, and the economically and environmentally detrimental fires burning in fire-sensitive systems. These satellite-derived data cannot be compared directly with the conventionally collected data of the forest services unless they are validated or embedded in a fire information system which includes GIS layers with ecosystem sensitivity and potential fire behaviour and fire effects.

In this regional analysis, data from various sources are used for comparative analysis. Tables 1a and 1b include the FRA 2005 forest fire data and data on file in the Global Fire Monitoring Center (GFMC). As a single reference to satellite-derived dataset country data of the Global Burnt Area 2000 (GBA-2000) product have been included in Table 1b.

In the following sections fire data from countries covered by this regional report are highlighted and their origin and reliability briefly explained. At the end of this chapter the discrepancies between the data of different origin are explained by comparison of the two fire seasons of 1987 and 2003.

Table 1a. Basic data on forest cover and wildland fires in Central Asian countries compiled from national FRA-2005 reports.

Country	FRA 2005 Total Forest Cover		FRA 2005 Other wooded land	FRA 2005 Other land	FRA 2005 Forest fire database (years, periods)	FAO FRA 2005 Average area annually burned in 5-yr-periods (ha)	
	(ha)	%	(ha)	(ha)		1990 (1988-92)	2000 (1998-02)
Azerbaijan	936 000	11	54 000	7 270 000	1988-2003	26	147
Kazakhstan	3 337 000	1.2	15 622 000	251 011 000	1990-2000	30 900	179 000
Kyrgyzstan	869 300	4.3	312 800	17 997 900	2000	--	60
Tajikistan	410 000	2.9	142 000	13 444 000	1987-2003	100	1 100
Turkmenistan	4 127 000	8.5	0	42 866 000	--	--	--
Uzbekistan	3 295 000	7.4	904 000	37 225 000	1991-2002	73	70
China	197 290 000	20.6	87 615 000	647 837 000	1988-2002	44 200	50 700
Mongolia	10 252 000	6.5	2 388 000	144 010 000	1980-2003	225 000	418 000
Russian Federation	808 790 000	47.4	74 185 200	805 874 800	1988-2002	681 100	1 267 500
Georgia	2 760 100	39.6	50 300	4 138 600	1998-2002	14	237
Armenia	283 000	9.5	45 000	2 492 000	1998-2003	--	103
Belarus	7 894 000	38.0	914 000	11 940 000	1998-2002	--	6 400
Ukraine	9 575 000	15.9	41 000	48 319 000	1988-2002	2 000	4 000
Iran	11 075 000	6.7	5 340 000	147 205 000	1988-2002	9 800	6 500
Iraq	822 000		927 000	41 988 000		--	--
Afghanistan	867 000	1.3	--	64 342 000		--	--
Pakistan	1 902 000		1 389 000	73 797 000	1990-2000	49 000	41 000

Table 1b. Wildland fire data contained in the database of the Global Fire Monitoring Center (GFMC) and the satellite-derived global assessment for the year 2000 "Global Burnt Area – 2000" (GBA2000) initiative.

Country	Fire information in GFMC database (years) [1]	GBA 2000 Total area affected by fire (ha) [2]	GBA area burned Coniferous/Mixed stands		GBA area burned Broadleaved Stands		GBA area burned Woodland/Shrubland		GBA area burned Grassland/Cropland		GFMC Average forested area annually burned in 5-yr-periods (ha) [3]	
			(ha)	%	(ha)	%	(ha)	%	(ha)	%	1990	2000
Azerbaijan	2000	53 100	4 400	1.4	4 500	1.9	33 700	0.6	10 900	0.4	--	--
Kazakhstan	1981-2003	8 162 200	8 900	1.0	800	1.0	7 409 800	4.6	683 500	0.8	2 679	16 981
Kyrgyzstan	2000	106 700	2 500	1.7	400	2.1	69 500	0.7	33 400	0.5	--	--
Tajikistan	2000	44 900	--	--	--	--	33 700	0.7	11 000	0.2	--	--
Turkmenistan	2000	23 300	--	--	--	--	17 800	0.4	6 300	0.0	--	--
Uzbekistan	2000	50 600	--	--	--	--	36 100	0.3	15 700	0.1	--	--
China	1950-2001	6 238 800	880 100	1.5	166 900	1.4	2 354 300	0.7	2 888 900	0.7	106 254	--
Mongolia	1981-2000	2 655 600	121 700	3.5	300	1.2	1 661 800	2.9	810 800	1.0	2 348 200	--
Russian Federation	1981-2005	22 380 000	2 984 600	0.8	116 200	1.0	10 111 800	4.0	9 023 700	0.9	1 835 220[3]	1 158 838[4] 5 334 800[5]
Georgia	2000	18 100	4 200	0.5	100	0.0	6 600	0.2	5 600	0.2	--	--
Armenia	2000	7 900	1 100	1.3	400	1.5	3 000	0.2	5 600	0.8	--	--
Belarus	1959-2003	43 500	400	0.0	--	--	30 600	0.2	15 100	0.2	5 784	6 497
Ukraine	1996-2002	2 193 800	10 200	0.9	5 900	2.6	294 000	3.2	1 880 900	4.1	--	1 760
Iran	1982-2000	104 200	21 100	2.3	7 400	2.4	32 000	0.1	39 500	0.2	1 273	--
Iraq	--	6 500	--	--	--	--	3 400	0.0	3 100	0.1	--	--
Afghanistan	--	--	600	1.5	--	--	34 400	0.3	33 600	0.1	--	--
Pakistan	2000	44 900	5 000	1.3	600	3.6	11 000	0.1	24 100	0.1	--	--

[1] Statistical information from various sources (sources cited within the database)
[2] GBA 2000: See introduction and links in: http://www-gvm.jrc.it/tem/Disturbance_by_fire/products/burnt_areas/global2000/global2000.htm
[3] Forest only for comparison with GBA coniferous / mixed / broadleaved stands
[4] Data provided by the Aerial Fire Protection Service *Avialesookhrana*
[5] Satellite-derived data (details see Table 2)

Russian Federation

Comprehensive reports about the fire situation in the Russian Federation have been published in the pages of UN-ECE/FAO International Forest Fire News (IFFN) since the early 1990s.[4] During this time period the resources available for fire detection, monitoring and suppression as well as for fire prevention decreased substantially as compared with the 1970s. At that time over 8 000 smokejumpers and rappellers had been employed in the Aerial Fire Protection Service *Avialesookhrana*. In the average they were able to suppress about 70% of the fires at initial stage. About 600 aircraft were rented from aviation enterprises. As a consequence of reduction of available aircraft, permissible flight hours and personnel (in 2005 the amount of smokejumpers and helirappellers was cut half as compared to the 1970s) the detection of fires was delayed. Consequently the average size of fires at detection and initial attack constantly increased over the past decade resulting in an increase of the number of large fires (= fires >200 ha) (Figures 1 and 2).

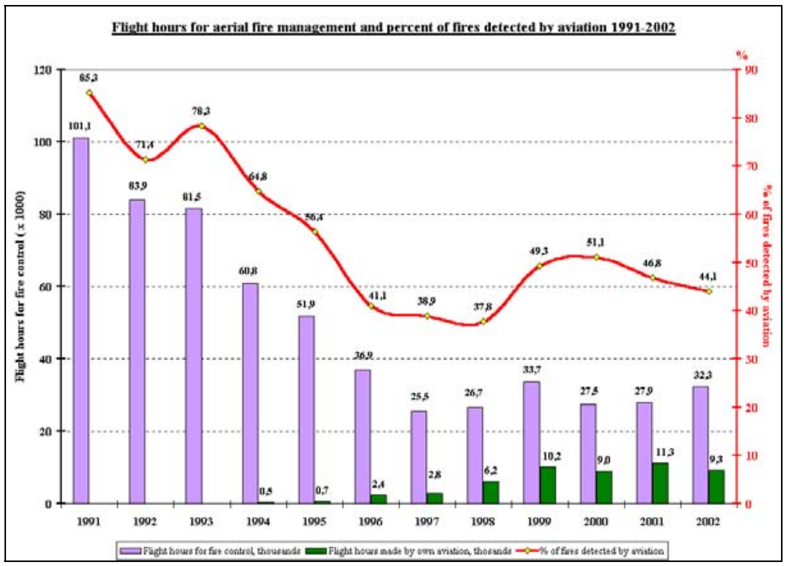

Figure 1. Flight hours for aerial fire management and percent of fires detected by aviation 1991-2002. Source: Davidenko and Eritsov (2003).

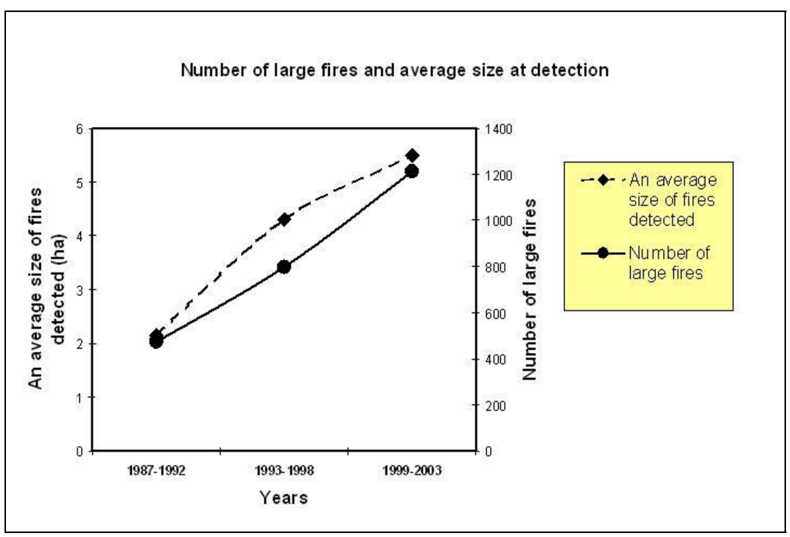

Figure 2. Starting in the 1990s the average size of fires at detection and the number of large fires increased in the Russian Federation as a consequence of shrinking fire management resources. Source: Davidenko and Kovalev (2004).

[4] http://www.fire.uni-freiburg.de/iffn/country/country.htm#RUSSIANFEDERATION

The data provided to FRA 2005 by the Ministry for Natural Resources (MNR) include the data from *Avialesookhrana* (mainly based on aerial monitoring and reporting) and other responsible units and agencies. The FRA 2005 data by MNR confirm the trend of increasing area affected by fire from the 5-year reporting period 1990 (average annual area burned between 1988 and 1992: 681 100 ha) to the 5-year reporting period 2000 (average annual area burned between 1998 and 2002: 1 267 500 ha) (Table 1a). This is almost a doubling of the area of forests affected by wildfires.

The GBA-2000 total forest area burned for the year 2000 is ca. 3.1 million ha. This area is about 2.5 times higher than the figures provided by FRA 2005 for the same year (1 240 440 ha).[5]

The comparison of data reported by *Avialesookhrana* and by an independent remote sensing institution of the Russian Academy of Sciences (Sukachev Institute for Forest, Krasnoyarsk) for the last ten years reveals similar discrepancies (Table 2). In the case of the year 2000, the size of burned forest area assessed by the Sukachev Institute is almost 6 million ha which must be compared to 0.9 million ha reported by *Avialesookhrana*. The discrepancies between reported burned areas on non-forest lands are even greater. Possible explanations of these discrepancies will be discussed at the end of this chapter 3.1.

Table 2. Comparative fire statistics for total vegetated area and forest area burned in the Russian Federation in the period 1996 to 2005, based on agency reports and remote sensing.

Year	Agency Reports based on Ground and Aerial Observations [1]			Satellite-Derived Data (NOAA AVHRR) Based on Fire Counts and Derived Area Burned [2]		
	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)
1996	22 623	2 209 654	1 789 583	7 103	6 046 000	3 840 000
1997	23 090	861 148	643 969	3 598	4 540 000	3 600 000
1998	15 931	3 000 569	2 365 017	6 255	11 490 000	6 684 000
1999	18 138	711 799	533 150	7 940	5 434 000	3 190 000
2000	13 447	1 117 799	898 911	8 399	9 706 000	5 990 000
2001	14 561	1 220 305	792 357	7 095	7 560 000	4 200 000
2002	19 066	1 856 730	1 204 757	10 355	11 766 795	6 610 000
2003	21 699	2 634 722	2 071 057	16 112	17 406 900	14 474 656
2004	16 729	532 184	424 404	9 477	5 832 000	3 130 000
2005	10 923	963 000	706 900	24 272	12 861 000	7 240 000

1 Agency data provided by *Avialesookhrana* of Russia for the forest land under the jurisdiction of the Federal Forest Agency (Federal Forest Fund). In the average these statistical data represent ca. 90% of fires recorded statistically. The remainder of ca. 10% are data collected within the responsibility and jurisdiction of other agencies, e.g. the National Park Service. The forest area burned is therefore less than the totals reported to FRA 2005.

2 Satellite data provided by the Sukachev Institute of Forest, Remote Sensing Laboratory, Russian Academy of Sciences, Siberian Branch, Krasnoyarsk, Russian Federation, courtesy A. Sukhinin. The Krasnoyarsk satellite receiving station is covering the Russian Federation between the Ural mountains in the West and Sakhalin Island in the East and recording fires and area burned independent of landownership.

Globally the Russian Federation is the country with the largest forested and non-forested territories in the world in which natural and human-caused wildfires are occurring at large scale. A satellite-generated map of the spatial and annual distribution of area burned between 1998 and 2005 (based on the data in Table 2) reveals the inter-annual changes of "hotspot" areas in which large fire situations occur (Figure 3).

[5] Note: The comparative analysis of agency reports and satellite-derived data of the other countries of the region is similar (see further below).

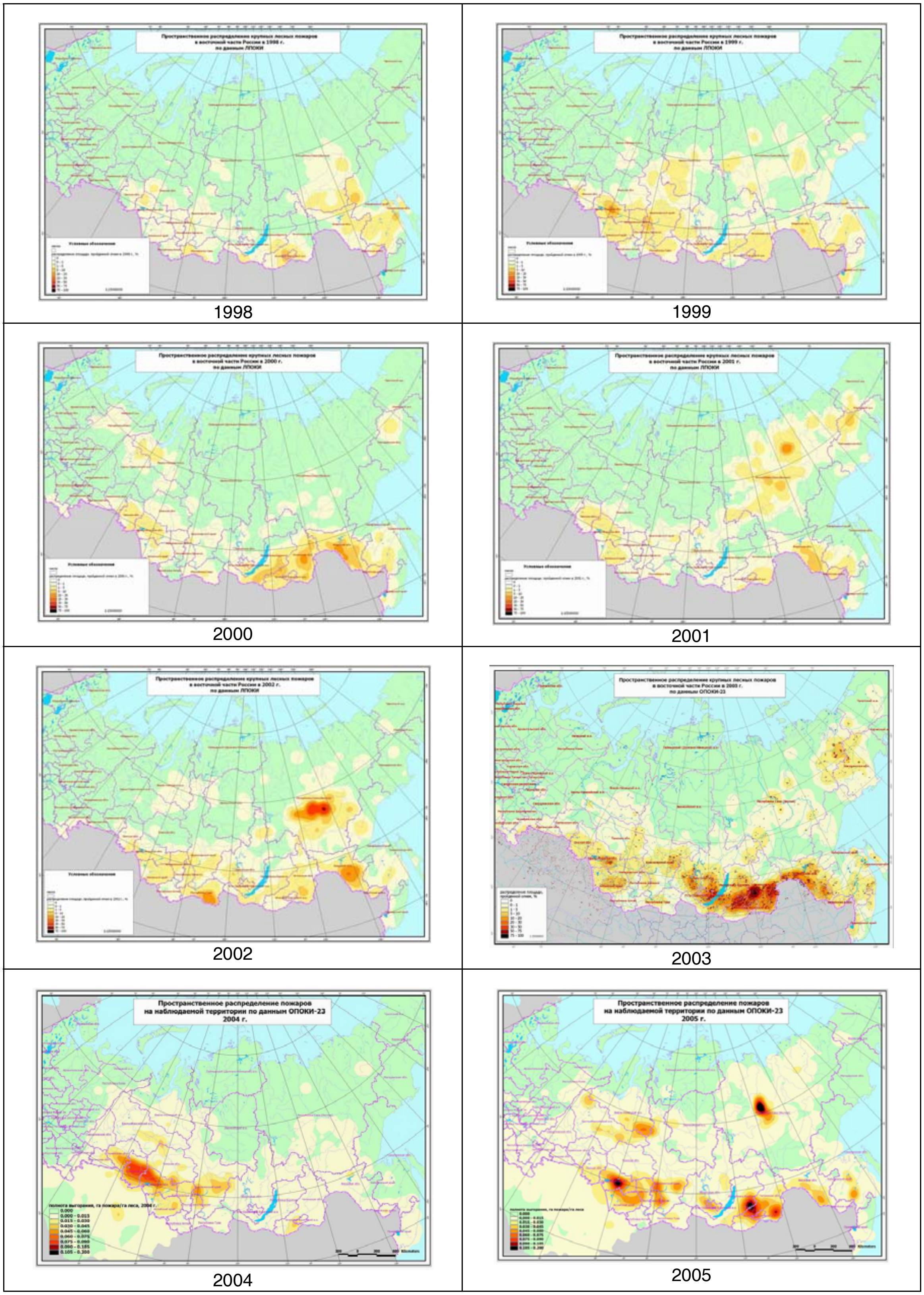

Figure 3. Spatial distribution of areas burned by different degree in the Central and Eastern Asian part of Russia in the fire seasons of 1998-2005, derived from interpolated NOAA AVHRR forest fire data. Zones are delineated by colours that represent the ratio of the burned area to the total area marked by the colour. Courtesy: A. Sukhinin, Remote Sensing Laboratory, Sukachev Institute for Forest, Krasnoyarsk, Russian Federation.

Kazakhstan

Following the post-soviet economic crisis and deficit of funds allocated for forest fire-prevention and maintenance activities, capacity of the forest fire service weakened significantly, areas of the forest fund protected by the Aerial Fire Protection Service (*Avialesookhrana* of Kazakhstan) have decreased, and statistics of discovering and extinguishing fires deteriorated sharply (Kushlin *et al.*, 2004; Ezhov, 2004). This led to a significant increase in the number of big fires not controlled by the forest protection system, and increased costs for extinguishing and fire damage control (Ezhov, 2004).

The FRA 2005 fire data of the second 5-year period provide an average of 179 000 ha of forests burned annually. This is neither confirmed by the GFMC database (based on official inputs from *Avialesookhrana* of Kazakhstan), nor by satellite remote sensing by GBA 2000 (Table 1) and the Sukachev Institute (Table 3). There is also an inconsistency of data on fires burning on other wooded lands. The GBA-2000 derived area of burned woodlands/shrublands of 7.4 million ha is almost 5 times higher than the Sukachev data for the same year.

Table 3. Comparative fire statistics for total vegetated area and forest area burned in Kazakhstan in the period 2000 to 2005, based on agency reports and remote sensing.

Year	Agency Reports based on Ground and Aerial Observations [1]			Satellite-Derived Data (NOAA AVHRR) Based on Fire Counts and Derived Area Burned [2]		
	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) /number
2000	957	27 205	12 933	1448	1 392 493	n.a.
2001	774	30 883	19 028	626	471 812	n.a.
2002	614	30 115	13 675	1836	1 738 000	n.a.
2003	1061	34 085	34 085	1760	1 025 300	56 032 / 78
2004	1315	59 565	45 185	1602	937 165	45 264 / 59
2005	757	19 659	12 909	2026	898 760	45 699 / 46

[1] Data provided by *Avialesookhrana* of Kazakhstan

[2] Data provided by the Sukachev Institute of Forest, Remote Sensing Laboratory, Russian Academy of Sciences, Siberian Branch, Krasnoyarsk, Russian Federation, courtesy A. Sukhinin.

Mongolia

A number of analyses published in ECE-FAO international Forest Fire News (IFFN) and in the FRA 2000 Global Forest Fire Assessment provide insight in the general wildland fire situation in Mongolia[6]. This general situation did not change in the past five years. The highest forest fire hazard is found in the submontane larch (*Larix sibirica*) and pine (*Pinus sylvestris*) stands growing on seasonally freezing soils. These stands are distributed on Khentey, East Khentey and Khubsugul foothills that are characterized by an extremely continental climate. Forest fire statistics of the 1990s reveal that the majority of fires burned within the central and eastern parts of the forested area. This can be attributed to the predominance of highly fire susceptible (highly flammable) pine and larch stands. Moreover, economic activity is much higher here as compared to other parts of the region. Extreme fire seasons are caused by long droughts. Fires burn from April to July under such conditions. The average fire season usually has two peaks. One peak is during spring (from March to mid June) and accounts for 80 per cent of all fires. The other fire peak falls within a short period in autumn (September to October) and accounts for 5 to 8 percent of all fires. In summer, fires occur very rarely (only 2 to 5 percent of the total) because of heavy rains.

Extremely large fires occurred in Mongolia in the following periods: 1968-1969, 1977-1978, 1985-1987, 1991-1992, 1996-1998, 2000-2002 (Enkhtur *et al.*, 2005). Figure 4 shows the fire statistics for forest and steppe area burned in Mongolia in the period 1994 to 2004. The FRA 2005 data for forests affected by fire are provided for the period 1980-2000. A comparison with other data is possible for the

[6] http://www.fire.uni-freiburg.de/iffn/country/country.htm#MONGOLIA

year 2000. GBA-2000 provides ca. 122 000 ha of forests burned, whereas the FRA report lists a forested area burned of 663 000 ha.

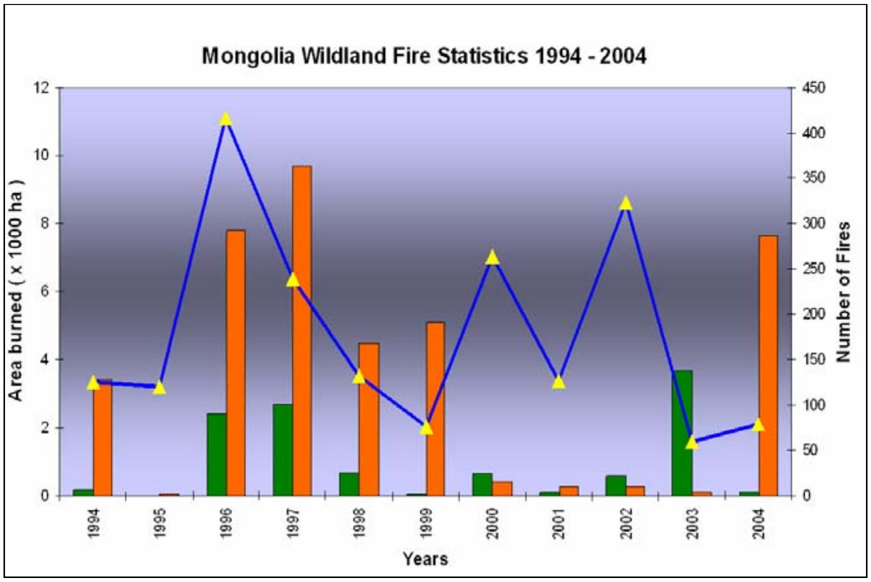

Figure 4. Fire statistics for forest (green) and steppe (orange) area burned in Mongolia in the period 1994 to 2004. Source: GFMC database and Enkthur *et al.* (2005).

Despite the inconsistency of data for forest and non-forest vegetation affected by wildfires the GFMC has recorded large-scale devastation of forests. The cumulative effects of illegal logging, the lack of sustainable forest management in large parts of the country, including the long-term effects of forest exploitation under the Soviet rule, and the consequences of increased ignition sources (cf. chapter 3.2) have resulted in an overall degradation of forests in the country. This trend could not be reverted in the second FRA 2005 reporting period.

China

The provinces most affected by wildfires are Heilongjiang, Inner Mongolia, Yunnan, Guangxi, Guizhou and Sichuan. The seasonality of forest fire occurrence in these provinces depends on the climate (Figure 5). The provinces with the highest number of fire incidents are situated in the South of China and include Yunnan, Guangxi, Fujian, Hunan, Zhejiang, Guizhou, Guangdong, Sichuan, and Jiangxi. In these provinces, which are characterized by tropical and subtropical climate, more than 80% of all fires are recorded. However, the average burned forest area in the South of the country is less than 30%. The provinces with largest burned area include Heilongjiang, Inner Mongolia, Yunnan and Guangxi. These four provinces, which are characterized by continental climate and hemi-boreal forests and steppe vegetation, account for 74% of all the burned forest area in China (Shu Lifu *et al.*, 2004).

Long-term fire statistics provided in Figure 6 are in line with the official FRA 2005 data. The comparison with GBA-2000 which provides 1.04 million ha coniferous and broadleaved forests burned in the year 2000 shows a discrepancy similar to other countries of the region.

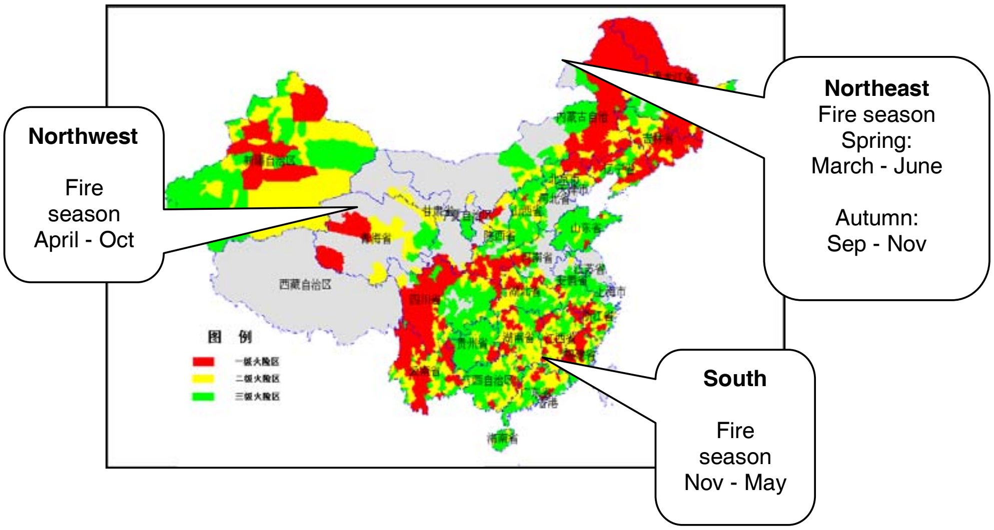

Figure 5. Fire seasons in China are determined by regional climate patterns. Source : Shu Lifu *et al.* (2004)

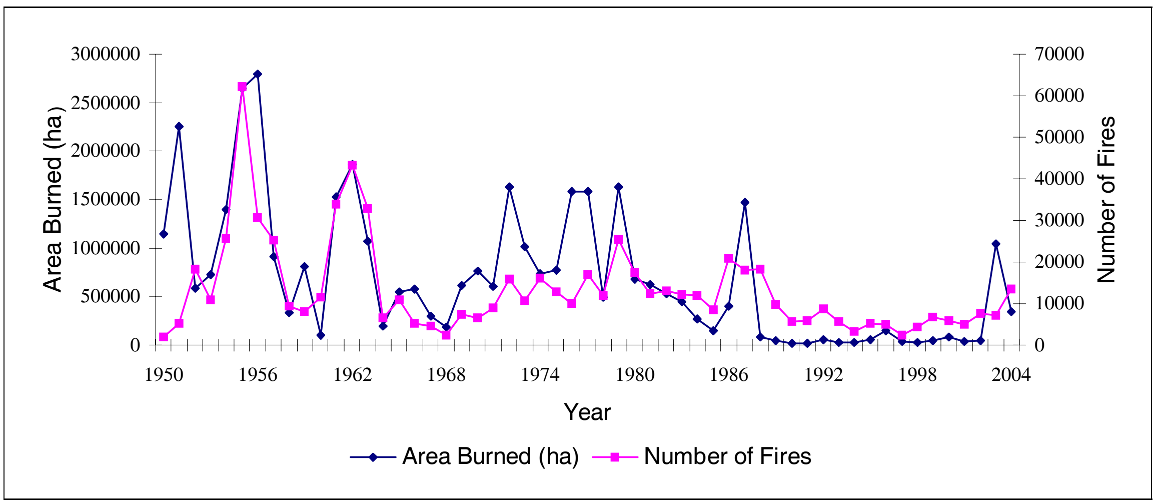

Figure 6. Number of wildfires and forest area burned in China in the period 1950 to 2004. Source: GFMC database and Shu Lifu *et al.* (2004)

Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan

Besides the fire data in the FRA 2005 reports, there is very scant information available from other sources. The GBA-2000 satellite products provide data on forest fires only for Kyrgyzstan, and for all countries fires in shrublands and grasslands (Central Asian steppes).

Afghanistan and Pakistan

Since the last fire emergency report from Afghanistan,[7] there is no updated forest fire information available from the country.

For Pakistan the national FRA 2005 report provides an average annual forest area burned for the two reporting periods of 49 000 and 41 000 ha, respectively. In this case the GBA-2000 satellite data for forests burned are remarkably lower (5 600 ha). However, the total GBA-2000 data of 44 900 ha may

[7] http://www.fire.uni-freiburg.de/current/archive/af/1999/06/af_220699.htm

reflect the fact that much of the burning activities in Pakistan include maintenance burnings of grassland in Rakhan land-use systems that are embedded in the forest environment. [8]

Armenia, Azerbaijan, Georgia, Iran and Iraq

Within this cluster of countries with forest lands located between the Caspian Sea and the Black Sea, the national forest cover and fire occurrence are quite different. In Armenia, Azerbaijan, Georgia, the average annual forest area burned as reported by FRA 2005 is in the range of 100 to 200 ha. GBA-2000 provides forested areas burned of 1 000 to 4 000 ha. In the case of Iran the official average fire data are 9 800 and 6 500 ha for the two reporting periods; GBA-2000 provides 28 500 ha forests burned in the year 2000, which must be compared with the official fire statistics for the same year (2 155 ha). Following the FRA 2000 fire report (Allard, 2001) in which forest fires were attributed mainly to the consequences of war (fires caused by mine explosions and artillery fire; arson, smuggling traffic), there is no updated report available. There are also no official data available for Iraq. GBA-2000 provides 5 100 ha burned shrublands and grasslands for Iraq.

Belarus and Ukraine

The two countries are situated at the western edge of the Central Asian/Eurasian belt and are facing similar problems – radioactive emissions from fires burning in forests and other land contaminated after the Chernobyl nuclear power plant failure (for details see section 3.3).

In 2001 Belarus provided a national fire report to the GFMC (Mysleiko and Shamal, 2001). There are some discrepancies in agency fire statistics and scientific analyses, e.g. by Usenya and Katkova (2004). Forest fire statistics covering the period 1959-2003 that are included in the GFMC database (Figure 7) shows some differences compared to the most recent statistical dataset provided by the Aerial Fire Protection Service *Bellesavia* for this report (Table 4).

Radioactive emissions are also released by fires occurring on contaminated non-forest lands. Thus, the GBA-2000 data, which indicate a total area burned of 45 700 ha for the year 2000 (Table 1b), are a valuable source of information.

Table 4. Forest fire statistics of Belarus for the period 1994-2005. Source: Aerial Fire Protection Service of Belarus *Bellesavia*

Year	Number of fires	Forest area burned (ha)
1994	2 776	1 504
1995	2 986	2 965
1996	3 843	5 539
1997	1 353	552
1998	827	471
1999	3 452	3 067
2000	2 178	1 398
2001	1 048	343
2002	4 471	6 896
2003	1 835	893
2004	1 017	505
2005	1 037	290

[8] Rakhan lands are too steep or too rocky for cultivation and are mainly used for grass production. They are managed by using fire to open the forest and to eliminate competing bushes and herb species. This technique favours the growth of desired grass species and keeps the cover with pine trees scattered (Aumeeruddy-Thomas *et al.,* 2004).

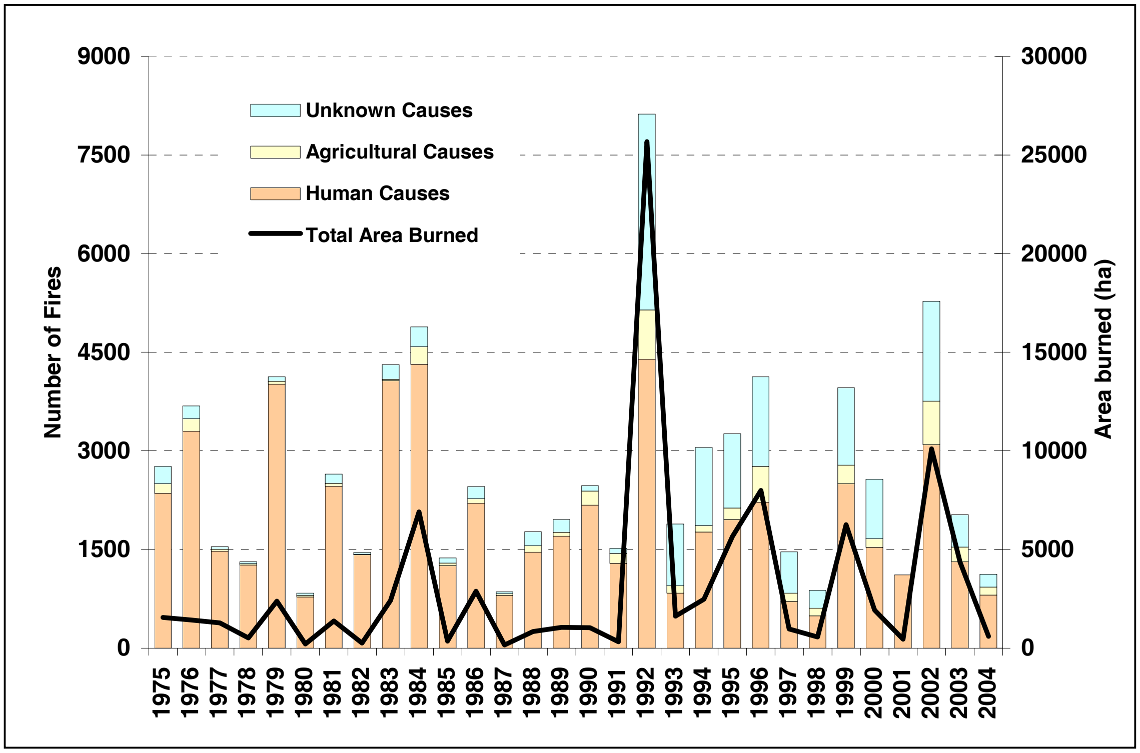

Figure 7. Fire statistics for forest area burned in Belarus in the period 1975 to 2003. For consistency with Table 4: see text. Source: Institute of Experimental Botany, Academy of Sciences, Republic of Belarus.

Fire statistical information for Ukraine is provided by the State Committee of Statistics of Ukraine which is issuing statistical forest fire bulletins. These data are included in the FRA 2005 tables. In addition remote monitoring of wildland fires in Ukraine is conducted by the Ukrainian Land and Resource Management Center. Kharechko (2004) reported a number of cases where the area burned in Polissya in 2002 – an area contaminated by radionuclides – exceeded an area of 98 000 ha; in the official forest fire statistics a total of 5 000 ha burned forest land is reported. For the year 2000 the official statistics report 1 600 ha forest lands burned, whereas GBA-2000 provides 16 100 ha forests affected by fire and more than 2 million ha of other wooded land, shrubland and grasslands (Table 1b).

Explanation of discrepancies between agency forest fire statistics and remote sensing products

As mentioned initially in most countries of the Central Asian/Eurasian region, the data collected by agencies on the ground or by aerial monitoring are not reflecting the full extent of wildland fires. The extremely large discrepancies between the reported sizes of area burned by ground or aerial observations versus the data derived from satellite sensors are most obvious in the Russian Federation where most remote sensing research projects and operational observations in the Central Asian region have been conducted.

On the one side conventional monitoring of an area of 690 million ha by *Avialesookhrana* relies on aircraft and ground reports. Daily updated statistics are filed in the organization. However, as mentioned above, the organization is facing severe financial constraints resulting in reduced capabilities to adequately monitor and map fires and fire effects from the air and on the ground.

On the other side, the Krasnoyarsk satellite receiving station at the Sukachev Institute for Forest, now capable of downloading and processing both AVHRR and MODIS data, is covering 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 satellites and the derived burned area, however, bears an uncertainty and must be adjusted. According to the Sukachev Fire Laboratory there is some overestimation of areas burned by small fire events due to the system-inherent low spatial resolution of the AVHRR sensor. 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.*, 2004; see also Soja *et al.*, 2004).

Intercomparison of data generated by various institutions, particularly involving different space instruments (multi-sensor analysis) 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 relatively similar levels of fire occurrence: The Krasnoyarsk Laboratory recorded 882 fire events affecting a total of 554 665 ha, whereas the Irkutsk Laboratory recorded 1 055 fires affecting a total of 625 800 ha (Goldammer *et al.*, 2004a).

A recent multi-sensor analysis investigated the fires of 2003 occurring in the region around and Southeast of Baikal lake between 110.27°E to 131.00°E and 49.89°N to 55.27°N by evaluating scenes of MODIS, MERIS and ASTER and comparing these with NOAA AVHRR (paper submitted for publication, on file at the GFMC). The study revealed that more than 20.2 million ha of forests and other lands had been affected by fire in 2003 – an area larger than the 17.4 million ha reported by the Sukachev Institute (Table 2).

There are some caveats concerning the interpretation and use of satellite-derived fire data. Without a clear reference to the ecosystem characteristics and fire regimes – particularly fire characteristics and impacts – satellite data should not be compared directly with agency reports. In most countries forestry agencies or aerial forest protection services are collecting data only for the protected forests and other protected vegetation under their respective jurisdiction. In the Russian Federation, for instance, fires on some protected reindeer pasture lands are included in the statistical database of *Avialesookhrana*. Otherwise Russia does not include any data on fires in grassland, steppe and peat bogs in the statistical databases.

According to on-site field research by the GFMC in Central Asia, fires are often reported only if protected forests have been damaged directly and visibly, e.g. by crown scorch, timber damage or foliage consumption with subsequent mortality. Thus, fires burning in so-called “grass forests” – open, park-like pine or larch stands with a grass cover which are regularly underburned – may not result in an immediately visible damage. However, these stands may be subjected to long-term degradation due to the increasing fire frequency of short-return interval fires.

A revisit of earlier investigations of the extent of area burned may be useful to identify possible misinterpretations of satellite imageries. For instance, a quick-look comparison of regional fire scar maps of the 1987 fire season with the fire season of 2003 (these seasons experienced similar droughts – see Figure 10) shows a strong overlap of the area burned Southeast of Lake Baikal (Figures 8 and 9). 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 (the low resolution of Figures 8 and 9 which provide a regional overview in no case allow a detailed analysis). It should be considered to reprocess the historical data with the same algorithms that have been used recently.

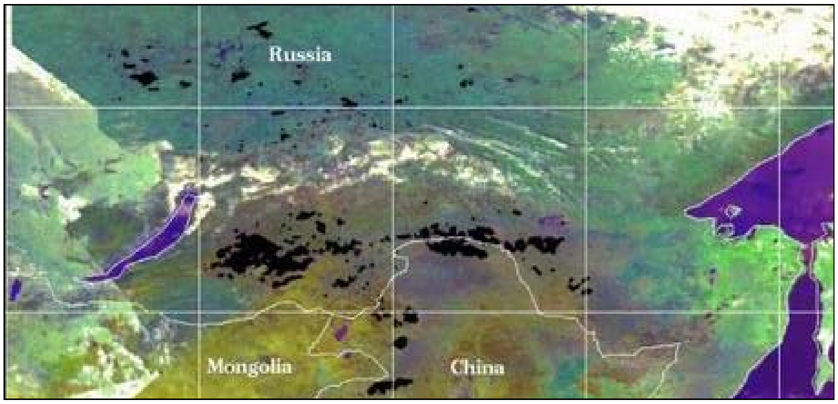

Figure 8

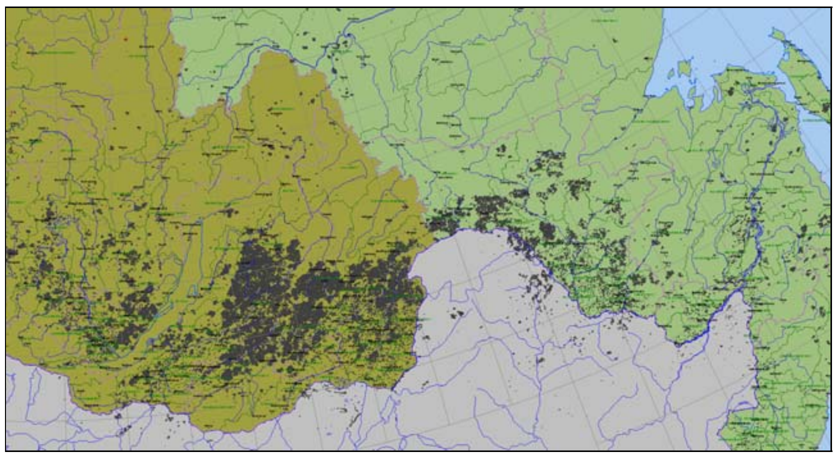

Figure 9

Figures 8 and 9. Comparison of the NOAA-AVHRR satellite-derived area burned in the region Southeast of Lake Baikal in 1987 (Figure 8; Cahoon *et al.* [1994]) and 2003 (Figure 9; 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. Source: Goldammer *et al.* (2004a).

3.2 Reasons

Numerous scientific investigations have revealed history, ecological importance and the cyclic nature of lightning-caused fires in Eurasian ecosystems (Goldammer and Furyaev, 1996). However, similarly to most populated regions of the world, the current fire regimes in Central Asian ecosystems are primarily determined by human-caused wildfires. On the other hand, successful suppression of natural (lightning-caused) fires in some territories, in which the complete fire protection policy of the former Soviet Union was practiced over many decades, may have resulted in changes of ecosystem properties. Fuel accumulation and changed composition and structure of fire-protected stands have increased the hazard of more intense and severe fires. Extreme droughts in Central Asia aggravate the risk of extremely large and severe wildfire episodes.

In the following the reasons of the current fire situation and the causes of wildfires – including the underlying causes – are summarized for those countries where information is available.

Russian Federation

The FRA 2005 report from Russia states that, over the past 10 years, up to 72% of the forest fires were caused by humans, about 7% result from agricultural burnings, 7% originate from lightning and 14% of fires are due to other causes. However, in some regions – especially in the Northern areas of European Russia, Siberia and Far East, particularly in sparsely inhabited territories where forest fires are not suppressed – the share of lightning-caused ignitions is considerably higher (up to 50-70 %) (Davidenko and Kovalev, 2004).

These statistical data, however, do not reflect the complex interaction of factors that may lead to extreme fire situations. The fire season of 2003 is in Russia 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
- economically motivated arson and carelessness

resulted in an extreme fire situation in the regions Northwest and Southeast of Lake Baikal. This region was mostly affected by extreme drought in 2002/2003 (Goldammer *et al.*, 2004a). 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). 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 10).

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 and its neighbouring countries. 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 timber dealers have encouraged or bribed local people to set fires to forests in order to increase the permissible salvage logging areas. Fire-damaged timber is presently allowed to be harvested for sanitary reasons at low stumpage prices, and can be a lucrative source of income. In addition extended illegal logging and timber export has been observed during two on-site inspection missions by the GFMC in Mongolia and the Russian Federation by the first author during 2003.[9]

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.

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[9] The view of the GFMC is supported by this article "Fiddling while Siberia burns: 'lungs of Europe' under threat from forest fires. Russia's pristine forests are the lungs of Europe. But vast swathes are being destroyed by global warming and loggers' greed - and ill-equipped firefighters are powerless to act", in which a number of scientists from Russia and the USA were interviewed, published by The Independent, 31 May 2005: http://www.fire.uni-freiburg.de/media/2005/news_20050601_ru.htm

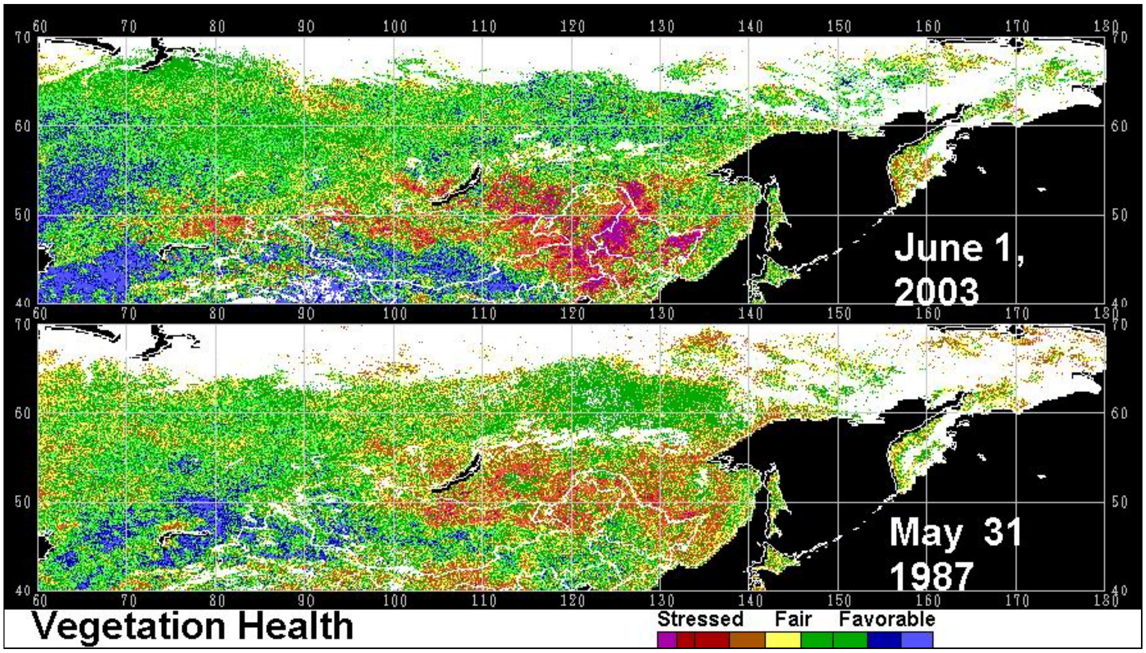

Figure 10. Vegetation health maps of Southern Siberia, Mongolia and Northern China on 1 June 2003 and 31 May 1987 reflect the impact of drought on vegetation in two years which experienced similar droughts and extended fire episodes. For technical details for the background of the tool see Kogan (1997). Map courtesy F. Kogan, NOAA.

Kazakhstan

The amount of lightning ignition in Kazakhstan is comparatively higher due to the continental climate and the regular occurrence of thunderstorms during the fire season (April – September). A recent analysis of fire data by the World Bank (Teusan, 2005) reveals that in some years up to 60% of fires are caused by lightning. However, today an increase of human-caused fires (approx. 50% of all causes) has been recorded, often associated with illegal activities in the forests. This increasing fire occurrence, however, is only partly due to the increased public access to forests. The main reason for a major increase in severity and extent of fire impact (i.e. area burned) is due to the lack of timely fire detection and control which deteriorated because of the lack of finances for the operations of the Aerial Forest Fire Service (Avialesookhrana of Kazakhstan) (Kushlin *et al.*, 2004; Ezhov, 2004). Also rural people on farm land adjacent to forests tend to burn off vegetation and such fires often accidentally spread to forests. Public budgets for fire management have declined. The need has been recognized to shift expenditures from suppression of fires to fire prevention and public awareness. In addition, and linked to budget, finance and governance issues, some fires may have been deliberately started to circumvent the 'no cutting' rule for healthy forests (Kushlin *et al.*, 2004). Fire-damaged timber is presently allowed to be harvested for sanitary reasons at low stumpage prices, and can be a lucrative source of income. Fires and pests are a major concern in the north and northeast, especially in the relic pine forests of the Irtysh River watershed where over 100 000 ha were severely damaged by fires in 1997 and are being increasingly damaged by pests and uncontrolled 'sanitary' cutting since then.

Mongolia

In one of the most sparsely populated countries in the world, it is difficult to get accurate information on fire causes. During the main fire seasons (spring and late fall), there are very few to none lighting fires. The recent increase in the number of fires is related to the opening of markets once highly controlled or restricted (Goldammer *et al.*, 2004b). The vast majority of fires are not deliberately set to clear land. Rather, it is a function of carelessness. One example is the collection of elk antlers for sale to European and Chinese markets. During the previous regime, a single, state-run enterprise managed this market under strict controls and guidelines. Today, it is open to virtually anyone. In this context fires start for three reasons: (1) antler collection starts in February when fire is a survival tool in the cold winter weather; (2) sparks from vehicle exhaust pipes in remote forests; and (3) tracer bullets that ignite forest fuels (the bullets were left by the Russian military and have entered the game hunting market).

The 2005 country report from Mongolia (Enkhtur *et al.*, 2005) summarizes the causes of forest fires in the period 2000-2004 as follows:

- Lightning – 12%
- Campfires – 16%
- Cigarettes and matches – 15%
- Sparks from vehicle exhaust pipes – 6%
- Border-crossing fires from neighbouring countries – 7%
- Other – 43%

China

According to the China wildland fire reports submitted to the GFMC (Shu Lifu *et al.*, 2004, 2005), more than 98% of the forest fires in the whole country are people-caused. However, in some regions of the North – the region belonging to geographic Central Asia – lightning is a significant source of wildfires. The typical lightning fire period is between May and July. Human-caused fires are linked to forestry operations and the careless use of fire, e.g., burning for cultivating in barren lands, straw residues, or burning for collecting of manure.

Pakistan and Iran

The remote Pakistani tribal region of South Waziristan (North of Baluchistan) at the border to Afghanistan has been repeatedly targeted by military efforts to locate al-Qaeda and Taleban fighters. In July 2004 air attacks (bombing) and artillery fire caused forest fires in the Bosh Ghar area.[10]

According to the FRA 2000 report, some of the fires occurring in Iran are transboundary, i.e. along borders with Iraq, and are difficult to access and to control. In fact, the situation in Iran is unusual in that conflicts at border areas and unmapped landmine fields exacerbate the fire control situation. Most fires are caused by arson and are mostly pasture fires, some are caused by landmines triggered by cattle and artillery fire and have to be seen as a side effect of smuggling of opium and oil through Iran and refugee activity (Allard, 2001). Currently no database is available on the causes of fire.

3.3 *Damages*

General damage assessments

The calculation of economic damages is quite problematic because there are no international standards for calculating the indirect losses and the environmental damages. However, some countries are compiling estimates of damages and recording direct losses, e.g. houses or livestock etc. lost by wildfires. Exemplary information from the Russian Federation and Mongolia is provided in the following.

Annual costs and losses are reported by the regional governments to the Federal Ministry for Natural Resources of the Russian Federation. The figures given in Table 5 include costs for equipment and salaries for fire suppression, costs for rehabilitation/reforestation. According to information provided by the Russia-US FOREST project, the economic losses by wildfires in Sakhalin between 1998 and 2004 exceeded US$ 833 million.

[10] http://www.pakistanidefence.com/news/MonthlyNewsArchive/2004/July2004.htm

Table 5. Fire damages in the Russian Federation reported by the Federal Ministry of Natural Resources for the period 1999-2003.

Year	Damage in Roubles (billion)	Equivalent in US$ (million)
1999	1.2	42
2000	2.4	84
2001	2.4	84
2002	4.7	164
2003	19.9	695

In Belarus, Usenya and Katkova (2004) conducted a damage assessment based on long-term statistics and concluded that average annual direct wildfire damages amount to an average of US$ 700 000, while indirect (ecological) wildfire damages amount to about US$ 340 000.

The 2005 Mongolia report (Enkhtur *et al.*, 2005) summarizes the damages that have occurred during the last five years (2000-2004), particularly in the autumn and spring seasons. A total of 853 wildfires affected 5.1 million ha of forest and 9 million ha of steppe vegetation. The environmental damages in the country amounted to 10.4 billion tugrik (US$ 8.5 million) and material base to 180 million tugrik (US$ 150 000). Cost of fire suppression amounted 740 million tugrik (US$ 0.6 million). 742 livestock, 55 houses (including the traditional *gers*), 5 vehicles and 24 sheds were destroyed by the fire. In the 79 steppe fires, which covered territories of 11 provinces (*aimags*), 738 firefighters and 3 490 local people were mobilized.

Impacts on ecosystem properties and biodiversity

As elaborated below,[11] fire research has revealed the historic and cyclic nature of wildland fires in ecosystems of Eurasia. Natural fire regimes are characterized by fires of various return intervals and severities. The consequences of large high-severity fires in Central Asia and its adjoining regions are quite diverse, depending on the specific site conditions and regional climate. The Far East of Russia is an example where fire regimes have changed dramatically over the last decades. Historic extreme fire years occurred in cycles of 40 to 80 years (Yefremov and Shvidenko, 2004). Over the last 40 years peaks of catastrophic forest fire occurrence were observed in 1976, 1988, and 1998, i.e. every 10-12 years. The consequences summarized by Yefremov and Shvidenko (2004) include:

- 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 (fires > 10 000 ha) transform highly productive forests to barren land areas on which forest regeneration is inhibited for long 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-intensive ameliorations. The natural restoration of forests requires hundreds of years in these areas.
- On continental low-precipitation permafrost territories, large fires lead to northern steppization and replacement of forests by arid steppe and shrub vegetation.
- 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.
- As a consequence of large fires, for the first time in its history, Khabarovsk Krai faced a mass outbreak of gypsy moth (*Lymantria dispar*) on an area of some 8 million ha. Under similar condition the outbreak of Siberian eggar (*Dendrolimus superans sibiricus*) impacted 8 to 10 million ha in Yakutia in 2001-2002.
- Negative impacts of catastrophic fires on biodiversity is evident (Kulikov, 1998), in particular, at boundaries of ecotones and at boundaries of natural habitats of animals 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

[11] See section: Long-range smoke transport and long-term impacts of smoke pollution on the atmosphere.

use routes that differ from their traditional ones. The Amur Tiger (*Panthera tigris altaica*) historically inhabited taiga and mixed deciduous and coniferous forests in mountain areas of Eastern Asia, northern China, Korea and Manchuria. The last viable population of Siberian Tigers, which is surviving along the Amur-Sikhote-Alin mountain range, is threatened by the consequences of large fires.

The Amur-Sikhote-Alin Ecoregion (including the Primorsky and Khabarovsk Krays and the Jewish Autonomous Oblast) covers an area of 567 000 km^2 which 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. The Amur-Sikhote-Alin ecoregion has been classified by the World Wide Fund for Nature (WWF) as one of the "Global 200 Ecoregions".[12] It includes 23 different forest formations and subformations, 150 forest types, over 200 tree and shrub species, and overall – about 2000 species of vascular plants and an unusually rich fauna with about 20 species of amphibia 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. However, in the Far East of the Russian Federation, the biodiversity and ecosystem functioning at landscape level is also threatened by the increasing occurrence of extremely large fires. The proposed Global Environment Facility (GEF) Russian Far East Project "Fire Management in High Conservation Value Forests of the Amur-Sikhote-Alin Ecoregion" is aiming at taking a lead in the 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). [13]

Peatland fires: Impacts of smoke pollution on human health and safety

A major source of extended wildland fire smoke pollution in the Russian Federation are fires burning in drained or desiccated peatlands. 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).

Peatlands in Western Russia have been drained and used for agricultural purposes since the early 19th Century. 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 fires in the last years in Moscow region many people continued to visit the forests around Moscow, even when the fire situation was quite obvious.

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 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 permissible values 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. Smoke from vegetation fires has a number of solid and gaseous constituents that are 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

[12] http://www.panda.org/about_wwf/where_we_work/ecoregions/russian_fareast_temperate_forests.cfm

[13] Source: The World Bank. For details see section "Recent major investments" in chapter 3.5 of this report.

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.

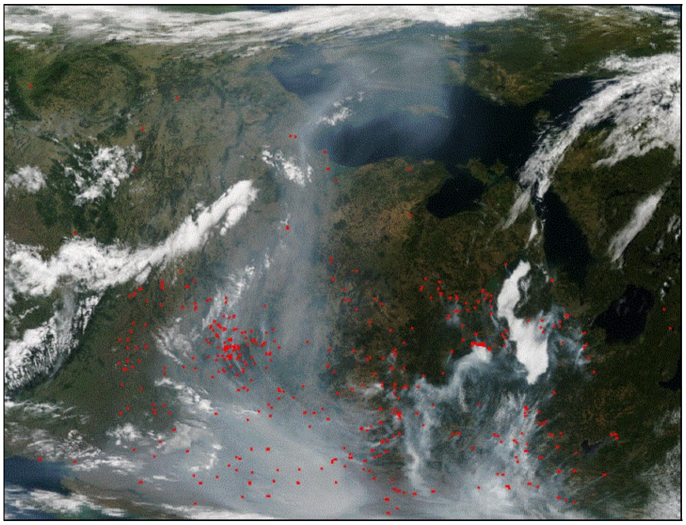

Figure 11

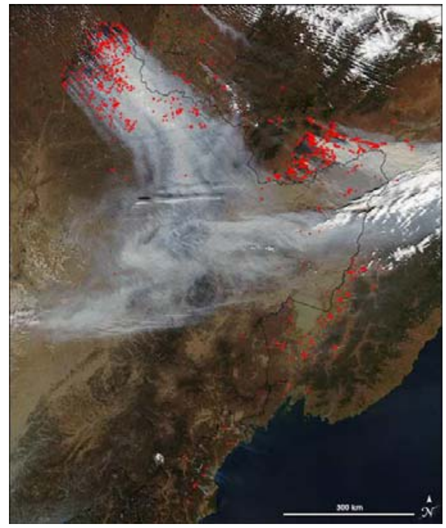

Figure 12

Figure 11 (left): Satellite scene of Western Russia on 4 September 2002. The heat signatures of the peat and forest fires are given in red colour. The smoke plumes (light blue haze) stretch from Western Russia to Belarus, Poland and the Baltic Sea. **Figure 12 (right):** Smoke transport from fires (marked in red) in northern China (top left) and south-eastern Russia (right) on 15 October 2004. Source: True colour image by Moderate-Resolution Imaging Spectroradiometer (MODIS), resolution 2 km.

Short- to long-distance transport of smoke has also been noted within Central and East Asia during the last years. The fire episodes of 1998 (Far East), 2003 (Transbaikal region) and 2004 (North-East China, Jewish Autonomous Region) caused severe smoke pollution in the Far East of Russia. The consequences of regional smoke pollution in 2004 were recorded in Khabarovsk and revealed that both aerosol and carbon monoxide concentrations exceeded the maximum permissible concentrations (Goldammer *et al.*, 2004b)[14].

Plans to restore peatlands by flooding have been discussed in the recent years. These plans have been pushed by the Ministry of Emergency Situations (EMERCOM) but in many places were opposed by peat extractors or owners of *datcha* properties that have been established on former peatlands. Bannikov *et al.* (2003) provide an 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.

Long-range smoke transport and long-term impacts of smoke pollution on the atmosphere

Long-distance inter-continental transport of smoke from fires burning in Central Asia has also been observed. In 2003 the extended wildfires in the Trans-Baikal region resulted in severe smoke pollution of Mongolia and China. Smoke plumes generated by fires burning in forests, grasslands and swamps in Irkutsk, Chita and Buryatia regions travelled as far as Sakhalin, Japan and North America. The northern hemispheric smoke pollution generated by these extended fires has been recorded by various sensors. Measurements of carbon monoxide from ground based stations in the Arctic and Europe by Yurganov *et al.* (2004) revealed increased CO concentrations in summer and autumn of 2002 and 2003 in comparison with the previous two years. The study concludes that it is most likely that the wildfires occurring in Northern Asia are responsible for the hemispheric CO build up.

[14] See also FAO Global Forest Resources Assessment 2005 – Thematic report on forest fires in North East Asian Region. Forest Fire Management Working Paper 6.

Spaceborne sensors confirm the long-range intercontinental northern hemispheric transport of carbon monoxide and the shorter living fine particles. Figures 13 to 15 provide an interesting overview of the hemispheric pollution caused of the wildland fires in Russia in spring 2003.

Numerous investigations in the past years have attempted to quantify the total annual or periodic emissions from vegetation fires occurring in the Russian Federation and in other parts of the boreal zone to the atmosphere (for syntheses and an extended list of references, see Kasischke and Stocks [2000]; Conard *et al.* [2002]). The general aim of many studies was to assess the area burned and the amount of organic matter combusted in order to calculate the release of radiatively active trace gases (greenhouse gases) and particles released to the atmosphere.

One of studies of 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 general 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 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 loads or available fuels, 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 roughly derive net transfer of carbon to the atmosphere. There are exemplary and preliminary model calculations. For instance, the calculation of net release of carbon by fires in Central Asia by Goldammer *et al.* (2004b) was an example of a first quick assessment which was revised several times. The methodology needs to be consolidated in the future as more concrete data on post-fire forest development and carbon sequestration will be available.

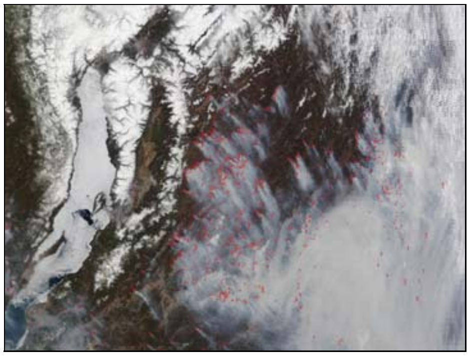

Figure 13

Figure 14

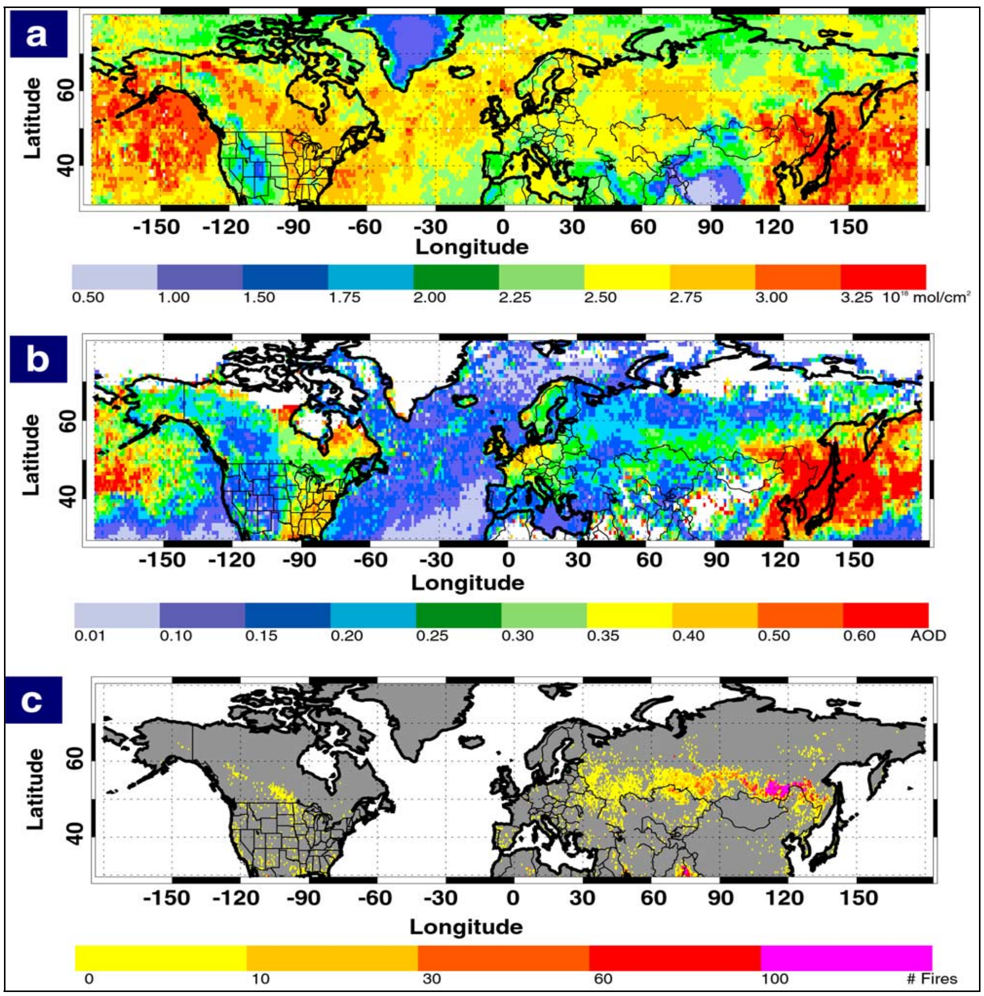

Figure 15

Figure 13: Fire activities on 8 May 2003 at 0400 UTC (11:00 local time) Southeast of Baikal Lake recorded by the Moderate-Resolution Imaging Spectroradiometer (MODIS). **Figure 14:** Smoke column stretching from fires in the Transbaikal Region to Sakhalin, Japan, and Alaska (8 May 2003). Source: MODIS. **Figure 15:** Multi-sensor characterization of fire emissions and fire activities on 10 May 2003. **(a)** Carbon monoxide (CO) concentration captured by the MOPITT (Measurements of Pollution in the Troposphere) instrument on the Terra satellite, with values ranging from zero (dark blue) to 360 parts per billion (red), depicting the long-range transport of the relatively long-living CO; (**b)** Terra/MODIS "fine mode aerosol optical depth (AOD) depicting fine shorter-living combustion-generated particles; **(c)** Terra/MODIS fire counts. Source of Figures 15 a-c: Edwards *et al.* (2004).

Impacts of fires burning in radioactively contaminated forests

As a result of failure on the Chernobyl nuclear power plant, a total of 6 million ha of forest lands were polluted by radionuclides. The most polluted forest area covers over 2 million ha in Gomel and Mogilev regions of Belarus, in Kiev region of 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. 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 hundreds of wildfires are occurring in the contaminated forests, peatlands and former agricultural sites. Between 1993 and 2001 a total of 770 wildfires in the closed zone of Ukraine affected 2 482 ha. In the period 1993-2000, 186 wildfires occurred in the closed zone of Belarus and affected an area of 3 136 ha including 1 458 ha of forest. The above cited report from Ukraine reveals that in 2002 alone a total area of 98 000 ha of wildland were burned in the contaminated region of Polissya.

Under average dry conditions the surface fuels contaminated by radionuclides – the grass layer and the surface layer of peatlands – are consumed by fire. Most critical is the situation in peat layers where the radionuclides are deposited. The long-range transport of radionuclides lifted in the smoke plumes of wildfires and their fallout on large areas were investigated in detail in 1992. Radioactive smoke plumes containing caesium-137 were monitored several hundred kilometers downwind from the sites where fires occurred in May and August 1992 (Dusha-Gudym, 2005).

This risk of radioactive contamination has not decreased substantially and is particularly threatening the population living in the immediate environment of the accident site (4.5 million people). Radioactive emissions are also a high risk for firefighters. In addition populations are affected by radioactive smoke particles transported over long distances (Dusha Gudym, 2005).

A number of measures have been proposed by Dusha-Gudym (2005) to prevent the occurrence of fires in the contaminated areas. Besides fire prevention the fire management options include remote detection of forest fires, remote methods of fire suppression (aerial fire fighting), and personal breathing protection of firefighters. Remote detection and monitoring of wildland fires in contaminated terrain in the Ukraine has been demonstrated by the Ukrainian Land and Resource Management Center (Kharechko, 2004).

A similar situation is found on the territory of Kazakhstan. At the Semipalatinsk Nuclear Weapons Test Site, more than 450 nuclear tests, including ca. 100 atmospheric tests, were conducted for a period of 40 years between 1949 and 1989.[15] Radioactive contamination is highest in Eastern Kazakhstan, including the fire-prone pine-strip forests along the Irtysh river at the border to the Russian Federation (Gorno-Altay). Since 2004 the World Bank is financing the Kazakhstan Forest Protection and Reforestation Project (P078301 and P087485 [GEF]) in which radioactive contamination and fire management are key project issues.

3.4 *Wildland fire prevention*

Public relations and education

Taking into account that the majority of wildfires in the Russian Federation and adjoining Central Asian countries are human-caused (cf. section 3.2) the prevention of forest fires is considered a priority in forest fire protection. A recent publication by Eritsov *et al.* (2005) pointed out that in the Russian Federation there are deficits in public education, as well as insufficient law enforcement. Therefore public education and awareness building are now considered one of the primary tasks of the aviation groups and the forest enterprises within their mandate and activities of forest protection. The activities include public lectures and reports, articles in the local, regional and national press, mass production and distribution of public relations (PR) materials.

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[15] http://www.bellona.no/en/international/russia/report_1-1994/7568.html#O10

Between 2001 and 2005 the USAID-sponsored Forest Resources and Technology (FOREST) Project was implemented in Russia. This five-year USAID initiative (budget: US$ 20 million) aimed at reducing the threat of global climate change and conserve biodiversity by promoting sustainable forest management and projects targeting fire prevention (Kuzmichev *et al.*, 2004). To address this, US$ 3 million were spent on public education in Russia's Far East and Siberia regions. Up to 2005 Public Awareness Campaign on forest fire prevention reached 3.5 million people. A total of 753 groups, including NGOs, mass media organizations, schools, educational institutions, state forestry units, participated in education and communication programmes in forest fire prevention.[16]

In Kazakhstan fire prevention measures consist of awareness campaigns, educating the population on ways to handle fire in a forest and on simple methods of extinguishing a fire (Kushlin *et al.*, 2004). Public awareness campaigns include lectures, radio announcements, newspaper articles, and television spots. Schools take over patronage of forests and organize "green patrols" in certain forests. "Forest Days" or "Forest Weeks" are held and interest groups like "Friends of Forest" are organized for young people. Fire prevention posters are set up in parking/rest areas.

In Mongolia fire prevention flyers are distributed to car drivers leaving the capital Ulaanbaatar. The production of this leaflet was supported by the Mongolian-German project "Conservation and Sustainable Management of Natural Resources" (supported by the German Agency for Technical Cooperation – GTZ).

In the Russian Federation the aviation groups control the observation of fire safety rules in forests. Together with the police (Ministry of Internal Affairs), they enforce restriction of public access to the forest and in other measures which allow to reduce forest fire risk.

3.5 *Wildland fire management*

Fire hazard reduction by forest management and other technical measures

Technical and silvicultural measures for the prevention of spreading of wildfires are implemented by forest enterprises and the mechanized subdivisions of the aviation groups. These measures include the creation of forest edges composed of less flammable and fire resistant species, fire breaks and fuel breaks, mineralized stripes along roads and removal of debris along roads.

The technical and silvicultural fire prevention measures in Kazakhstan are similar. Besides the maintenance and the creation of new mineralized fire breaks, the timber enterprises have to set up fire-safe recreation and smoking areas along all roads on the territory of the enterprises at intervals of 3-5 km. Fire guard posts are set up in locations frequently visited by people. Barriers for regulating access to particularly fire-prone forests are set up in the fire season.

In China one of the priorities in technical and silvicultural fire prevention measures is given to the construction of firebreaks. Firebreak construction includes mechanical means, use of herbicides and prescribed burning. The total length of firebreaks in China is 490 000 km (Shu Lifu *et al.*, 2004). Fuelbreaks on which fire-resistant trees, fruit trees, and other economic plants are grown are designed to slow down or halt the spread of a wildfire. These systems can produce economic benefits to the area, conserving the water and soil, and improving ecological conditions. The change of tree and other vegetation composition on fuelbreaks can prevent the spread of forest disease or insect pests. Economic, socio-economic, and ecological benefits all can be achieved through a network of fuelbreaks. The total length of greenbelt fuelbreaks in China at the end of the year 2000 is 172 100 km (Shu Lifu and Tian Xiaorui, 1999, 2002).

Use of prescribed fire for fuel reduction

In the Far East and Baikal regions of the Russian Federation, prescribed burning of the grass layer has been used extensively in spring time in order to reduce highly flammable surface fuels that

[16] http://www.usaid.ru/en/main/documents/index.shtml?lang=en&id=842
http://www.chemonics.com/projects/default.asp?content_id={35358636-B1F3-4247-9432-DB19A4050EE1}

contribute to the spread of wildfires into forests. However, as a consequence of reduced budgets the annual area treated by prescribed fire has been reduced considerably (Table 6).

Table 6. Forest and grassland area treated by prescribed fire in Chita, Buryatia and Amur regions. The numbers reveal a decline of prescribed burning activities. Source: GFMC database

Year	Area prescribed burned
1993-1996	1.0 - 4.0 million ha / yr
1997	4.2 million ha
1998	3.9 million ha
1999	1.4 million ha
2000	1.3 million ha
2001	50,000 ha
2002	40,000 ha
2003	60,000 ha

A paper highlighting future concepts of forest fire protection in Russia presented by Davidenko (2004) at the Regional Baltic Wildland Fire Network Meeting (Helsinki, Finland, May 2004) postulates the application of prescribed burning for fuel reduction and underscores the need for legalizing prescribed burning and developing regulation and budgets for regular application of prescribed burnings.

In China prescribed burning for fuel reduction has been investigated by forest fire research projects (Shu Lifu *et al.*, 2004). However, prescribed burning is not yet used in practice. There is no application of prescribed fire in any other Central Asian country.

Wildland fire detection and monitoring

In the Russian Federation, Kazakhstan and Belarus aerial patrolling is implemented on a regular basis for the detection of newly started fires and for reconnaissance/monitoring of ongoing forest fires. Aerial patrolling is conducted by specially trained crews which include a pilot-observer. Reports from the Russian Federation and Kazakhstan clearly indicate that the reduction of aerial patrolling due to lack of financial resources has resulted in a delay of early detection and initial attack.

Thunderstorms and cloud-to-ground lightning charges are localized and monitored by lightning detection systems. In the Russian Federation, 18 of these systems were set up in 2003 in Irkutsk, Chita, Tomsk, Archangelsk, Krasnoyarsk, Buryatia, Altai, Komi, and Khanti-Mansisk regions (Davidenko and Kovalev, 2004; Eritsov *et al.*, 2005). In China lightning detection systems are operated in Inner Mongolia and in the Daxing'anling mountains, Heilongjiang province. In addition more than 10 000 fire lookout towers are covering around 85% of the forest area of China (Shu Lifu *et al.*, 2004).

In Russia monitoring of clouds (precipitation) and active fires is using spaceborne data from Resurs, NOAA AVHRR, and the MODIS instruments on Terra and Aqua. The data are processed and displayed in the Avialesookhrana Information System Web-Servers (6 main servers, 2 auxiliary servers distributed in different locations within the Russian Federation). Apart from the monitoring data, the following information is added to the GIS database: meteorological information, data on all fires including their characteristics, information on response measures taken, reports on fire suppression operations (aerial and other resources) (Figure 16).

The Remote Sensing Laboratory of the Sukachev Institute for Forest, Russian Academy of Sciences, Krasnoyarsk, provides daily fire maps for the Russian territory between the Urals and the Far East. Selected maps are displayed on the website of the GFMC (Figure 17). These daily maps represent the most advanced state-of-the-art in processing NOAA AVHRR and MODIS information of active fires and area burned. Each active fire is displayed on a map with time of satellite overpass, geographic location, size of fire and distance to the nearest settlement. The GFMC is maintaining a portal to all fire monitoring institutions all over the world, including the monitoring services in Mongolia (Information and Computer Center - ICC) and Ukraine (Ukrainian Land and Resource Management Center - ULRMC) (Figures 18-19).

Most of the institutions producing and disseminating operational satellite-derived fire monitoring information are cooperating within the Northern Eurasian Regional Information Network (NERIN), the 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 (see section 4.1).

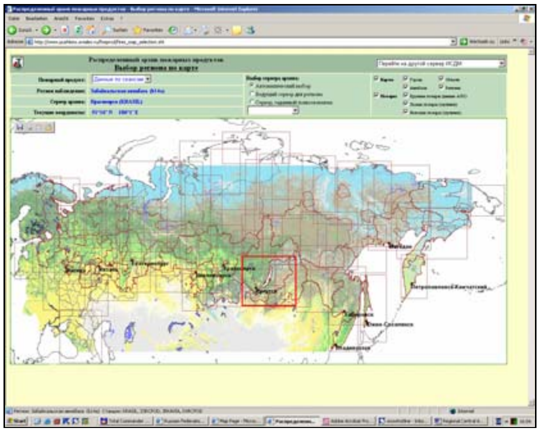

Figure 16

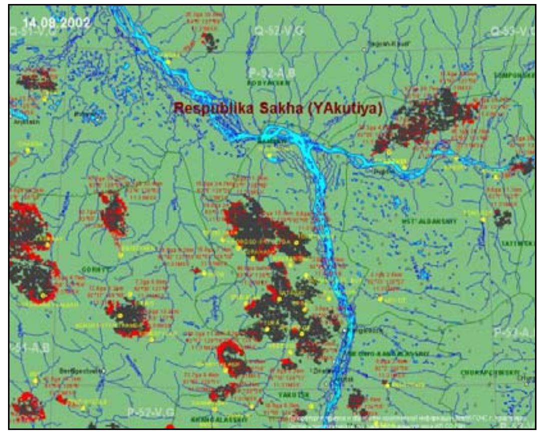

Figure 17

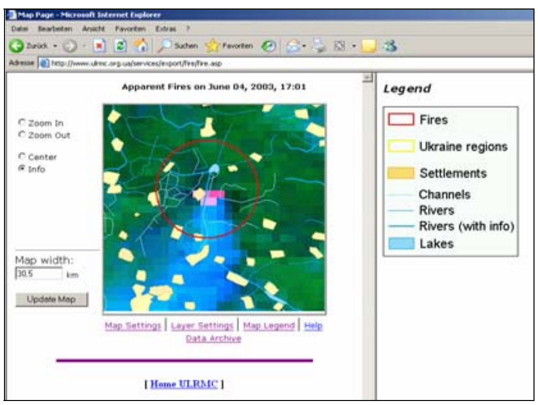

Figure 18

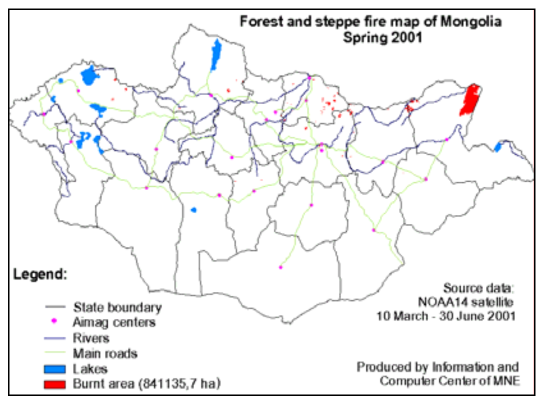

Figure 19

Figure 16: Screenshot of the Avialesookhrana Fire Monitoring and Information System which is serving the whole Russian Federation. Online users may zoom into 250m resolution maps with fire location information. **Figure 17:** Example of a daily fire map produced by the Sukachev Institute for Forest, Krasnoyarsk, and displayed on the website of the GFMC. **Figure 18:** Example of an enlarged (zoomed) real-time satellite and GIS product of an active fire which can be accessed on the website of the Ukrainian Land and Resource Management Center (ULRMC). **Figure 19:** Example of a satellite-derived fire season map of the Mongolian Information and Computer Center (ICC). Sources:

(17) http://www.nffc.aviales.ru/engl/main.sht
(18) http://www.fire.uni-freiburg.de/current/globalfire.htm
(19) http://www.ulrmc.org.ua/
(20) http://www.env.pmis.gov.mn/efire.php / http://www.fire.uni-freiburg.de/current/Mongolei.htm

Early warning of wildland fire danger

In the Commonwealth of Independent States (CIS) countries, fire danger rating has traditionally been used as a tool to provide early warning of the potential for serious wildfires. Fire danger rating systems (FDRS) utilize basic daily weather data to calculate wildfire potential. FDRS early warning information is often enhanced with satellite data such as early detected fires and spectral data on land cover and fuel conditions. In Russia the daily fire danger index is used to determine the preparedness of the fire management organization, including the number of daily patrol flights. However, there is a general lack of a reliable, complete network of ground-based precipitation stations that cover the whole territory of Russia. Russia's neighbouring countries of Central Asia in general do not have operational fire danger rating systems. Therefore a comprehensive monograph has been published recently in Russian language to provide the scientific and technical basis for fire danger rating in the Russian speaking countries (Sofronov *et al*., 2005). This book publication is an activity of the Regional Central Asia Wildland Fire Network.

The Central Asia region is also supported with Eurasian Experimental Fire Weather Information System. This system is using the Canadian Forest Fire Danger Rating System (CFFDRS) which was developed by the Canadian Forest Service. Weather data from more than 400 weather stations of large portions of northern Europe and the CIS are automatically gathered and processed daily to produce fire weather and fire behaviour potential maps and reports. These data, along with calculated Fire Weather Index (FWI) system values, are stored in a relational database at the Northern Forestry Centre in Edmonton, Canada. The GFMC displays the daily FWI map (Figure 21). The Canadian Forest Service and the Russian Ministry for Natural Resources agreed in 2005 to initiate a cooperative research programme for wildland fire danger rating in Russia (see section 4.3).

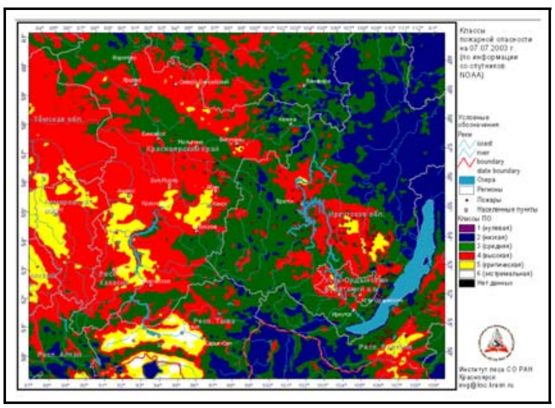

Figure 20

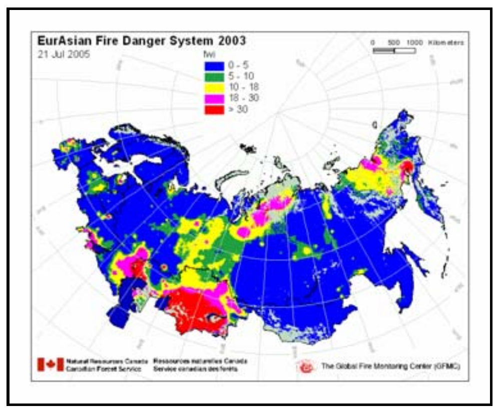

Figure 21

Figure 20: Example of a daily fire danger rating map of Krasnoyarsk region, provided by the Sukachev Institute for Forest, Krasnoyarsk for local use (also displayed on the GFMC website). **Figure 21:** Example of a daily fire danger map for Eurasia, produced by the Canadian Forest Service as a contribution to the GFMC global early warning capabilities.
Source: (20) http://www.fire.uni-freiburg.de/current/globalfire.htm
(21) http://www.fire.uni-freiburg.de/fwf/eurasia.htm

Wildland fire management training

Information on fire management training in Central Asia is available only for Russia (Eritsov *et al*., 2005). The initial training of the pilot-observers for the subdivisions of Avialesookhrana takes place in special courses at the All-Russian Institute for Improvement of Professional Skills of Leading Workers and Forestry Specialists (Pushkino, Moscow Region). In order to be admitted to the courses the candidate must have higher or secondary forestry education, qualification for flying work and work experience in forest protection for at least 1 to 2 years. During seven months of training the candidates study forest fire and aviation disciplines (forest fire protection, fire suppression technologies, radio communication, use of explosives, smokejumping and rappelling, air navigation, aviation meteorology, aerodynamics, aeronautics, psychology, and other). Theoretical training is followed by two months flying practice. After passing state examinations the students receive the qualification of Pilot Observer of Civil Aviation Class 3-d. With accumulation of practical experience and after successful participation in courses for improvement of qualification skill the Class 3-d holders can receive Class 2-d and Class 1. A Class 1 pilot observer is the most experienced specialist carrying out the main duties: Leading of aviation patrolling operations, landing of smoke-jumpers, work on helicopter MI-8 with landing of rappellers, operating the VSU helibucket, and work on air tankers.

Smokejumpers and rappellers are trained at regional aviation bases. Special attention is paid to physical state, safety techniques, strategy and tactics of fire suppression, practical work with chainsaws, motor pumps, explosives, hand tools, orientation in forests, performance techniques of parachute jumps on restricted areas, and landing from helicopters etc. Before every fire season smokejumpers and rappellers have tests on physical state, training jumps with parachute and rappelling systems, practical lessons in tactics and techniques of fire suppression. Once every two years they go through a full confirmation of their qualification (classes 3-d, 2-d and 1).

Wildland fire preparedness

Besides the annual checkup of the firefighters, regional and district conferences are held in Russia with participation of all leaders of forestry enterprises and organizations concerned with forest protection or other forestry operations. In such conferences, in which heads of regional and district administrations participate, an operational plan for the fire season is agreed upon, including the interaction of the different institutions. The work plans of the Regional and District Committees on Emergency Situations are also approved at the conference (Eritsov *et al.*, 2005).

In Kazakhstan orders on “Strengthening Forest Fire Protection and Preparation for the Fire Season” are issued annually by Oblast departments (Kushlin *et al.*, 2004). Extensive plans for forest fire suppression are elaborated by the Headquarters on Civil Defence, Department on Home Affairs, Emergency Office, and Rayon Home Affairs Departments, which stipulate participation of human resources, machinery and mechanisms from enterprises, organizations, farms and family farms adjacent to forests. Duty schedules listing responsible staff are prepared at all timber enterprises and oblast enterprises for the duration of the fire season. Forestry enterprises are required to organize voluntary fire brigades for the enterprises, family farms and other farms adjacent to the state forest fund.

Wildland fire suppression

In most of the CIS countries, the reduction of financial resources for government agencies as a consequence of the transition of national economies has substantially weakened the fire management capabilities. The organizations responsible for fire suppression are facing severe financial and logistical constraints resulting in reduced availability of modern equipment and flight hours to detect and monitor fires timely and to respond efficiently by aerial and ground means. The amount of firefighters employed also decreased sharply over the last years.

In the Russian Federation the Aerial Forest Protection Service *Avialesookhrana* is the main actor in forest fire suppression on a total area under protection of 690 million ha, including 12.9 million ha of reserved forests. The service is operating through 24 regional airbases across Russian Federation. A total of 270 subdivisions are responsible for detection, combat and monitoring wildland fires. *Avialesookhrana* is using a fleet of 102 own aircraft and 257 by leasing. About 4 000 smokejumpers and helirappellers and about 400 aerial forest observers are employed by *Avialesookhrana* (Davidenko and Kovalev, 2004).

Despite the overall budget constraints during the economic crisis, *Avialesookhrana* continued to enlarge its own aerial fire management resources. In 1994 Aerial Forest Protection bases were established in Magadan, Vladimir, Krasnoyarsk and in Karelia. The number of own aircraft in 2005 reached 106 units including 69 planes AN-2, one helicopter MI-8MTV, five AN-26, two AN-24, 18 MI-8T, six MI-2, and one IL-103. Regional aviation bases are owners of 38 airfields and landing places equipped with fuel supply capabilities. Plans for future acquisition of new types of aircraft include, among others, light planes for fire patrolling, development of air tanker technology for fire suppression and an airborne (AN-26 based) dispatch and coordination unit.

The new Russian multi-purpose land-amphibian (scooping) aircraft BE-200LP[17] is currently advertised for sale and leasing on international markets (Kanakis 2004) and has been tested in Italy in 2005. Domestically three prototype versions of this medium-sized scooping plane are operated by the Ministry of Emergency Situations (EMERCOM) and have been used only once in October 2005 in attempting to control peat bog fires in Moscow region. Insufficient experience of EMERCOM crews in aerial forest fire suppression has stirred the discussion about a transfer of these aerial assets to *Avialesookhrana*.

The water dropping system VSU-5A in conjunction with a foam injection system (SPS-1) has increased the fire-fighting capability of helicopters.

Other innovative developments included the use of drip torches for backfiring and the developments of new a smokejumper parachute (Lesnik-3).

Cloud seeding for generating precipitation for dousing wildfires is used in Russia, China and Mongolia. In 1996 snowfalls artificially-induced to extinguish fires raging across the steppes of Mongolia have killed at least 4 900 cattle by freezing or drowning along the southern slopes of the Khangai Mountains.[18]

In China and Belarus unique fire suppression equipment is used. Chinese firefighters are employing air jet extinguishers for fighting surface and grass fires (92 000 units are in use) (Shu Lifu *et al.*, 2005). China is also using fire extinguishing bombs (Shu Lifu *et al.*, 2004). In Belarus motorized sand blowers are used for fighting wildfires in the forest belt stocking on sandy soils. The fire service is employing motorcycles equipped with small amounts of fire extinguishing agents.

Typically, in the remote regions of Mongolia, firefighters are using traditional tools and means of transport. The 2002 fire report of Mongolia reveals that the wildfires were fought by 11 464 people using – among other transportation – 2 737 horses.

Recent major investments

Despite the technological developments for fire management, the majority of forestry enterprises of some of the CIS countries are not provided with adequate technical and financial means for fire management. In the Russian Federation many of the forestry enterprises (*lekhozes*) have only outdated, over-aged and in general insufficient equipment for fire suppression and do not have sufficient financial resources for silvicultural and technical fire prevention measures. The Russian Federation and Kazakhstan therefore have negotiated World Bank loans and grants from the Global Environment Facility (GEF) to improve sustainable forests and fire management.

The World Bank's Country Assistance Strategy (CAS) for the Russian Federation is providing a loan for the Sustainable Forestry Pilot Project (SFPP).[19] The project supports key areas of structural reform identified as critical to restoring economic growth and poverty reduction in Russia, including strengthening the institutional framework for enforcement of existing laws and regulations for environment and natural resources forests management. The components include the support to sustainable public sector forest management through policy reforms, improved forest land-use planning and information management, improved forest protection, and improved regeneration.

About 80% of the investments in the forestry sector that are supported by the World Bank loan (total US$ 33.65 million) and the national contribution of (total US$ 39 million) are provided for improving fire management capabilities in Archangelsk, Buryatia, Chita, Leningrad, Irkutsk, Khabarovsk and Krasnoyarsk regions. The equipment delivered by 2005 has already improved the fire management capabilities in the *leskhozes* and the aerial fire protection centers of Avialesookhrana.

[17] http://www.fire.uni-freiburg.de/emergency/BERIEV%20200.htm

[18] New York Times, 12 May 1996 (Reuters)
http://select.nytimes.com/gst/abstract.html?res=F60F10FD395D0C718DDDAC0894DE494D81&n=Top%2fNews%2fInternational%2fCountries%20and%20Territories%2fMongolia

[19] World Bank Loan 4552-RU

In 2005 a GEF project proposal "Fire Management in High Conservation Value Forests of the Amur-Sikhote-Alin Ecoregion" has been approved by the Ministry of Natural Resources.[20] The objective of the proposed project (total budget: US$ 10.37 million) is to strengthen conservation of the high conservation value forests of 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).

The World Bank and GEF are also supporting Kazakhstan with an upcoming "Forest Protection and Reforestation Project".[21] With a proposed loan of US$ 30 million and a US$ 5 million GEF grant, more than US$ 15 million will be invested for improving fire management capabilities on a forest area of 645 000 ha. Besides the infrastructural and technical equipment for fire prevention, detection and suppression, the programme aims at overcoming backlogs of 15 years of forest thinning and cleaning.

4. Stakeholder / Actors Situation

4.1 *Institutions, responsibilities and roles*

Despite the transition from centrally-planned to market-based economies of most of the Central Asian countries and the attempt in some countries to decentralize the formerly strong and highly centralized system of forest management the responsibilities in forest fire management are primarily centralized and predominantly under the prime responsibility of the forest services.

Russian Federation
According to the General Law on Decentralization, the responsibilities for fire management will be delegated to the regions starting 1 January 2007. At the federal level, the Federal Forestry Agency (Ministry of Natural Resources) will maintain responsibility for national policies. Regional Airbases are being established in Chukotka, Magadan, Kamchatka, Tyumen, Khantimansik, Nijni Novgorod and Khabarovsk.

It is assumed that forest protection responsibility by government authorities at federal and regional levels will be strengthened with the need of combating illegal logging and associated timber trade under the ENA-FLEG Ministerial Process. [22] Currently observed negotiations allow the conclusion that regional capabilities in aerial forest patrolling with aerial photogrammetry will be strengthened to meet the demands for a better control of the forest lands by the national and regional governments.

The responsibility for fire suppression is under the overall auspices of the Federal Forestry Agency. Repeated discussions have been held to transfer the overall forest fire suppression responsibility to the Ministry of Emergency Situations (EMERCOM).

Kazakhstan
Forest protection, including fire protection, remains under the control of the State Forestry Committee at national level, and under the control of provincial administrations, forest reserves and nature parks. The Aerial Forest Protection Agency *Avialesookhrana* of Kazakhstan is controlled by the State Forestry Committee.

Belarus
In Belarus the responsibility of aerial forest fire suppression wing *Bellesavia*, formerly operating under the State Forest Committee, was moved to the Ministry of Emergency Situations.

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[20] Project ID P068386. Source: PID Report No. AB1422; see also section 3.3 of this report (Impacts on ecosystem properties and biodiversity). At the time of writing this report (December 2005), the project proposal is reviewed by the government of the Russian Federation.

[21] Project ID P078301 (October 2005)

[22] Europe and North Asia Forest Law Enforcement and Governance (ENA-FLEG)

Mongolia
In Mongolia the National Disaster Management Agency and its subordinate bodies at provincial and local levels are responsible for forest fire suppression. According to Enkhtur *et al.* (2005), about 3 000 officers are involved in rescue and fire suppression service, supply units and research.

China
After the extreme fire year 1987, China has strongly enhanced institutional capabilities in prevention, fighting, and management of forest fires. In order to strengthen the leadership of forest fire management, Forest Fire Headquarters were set up successively in 30 provinces, autonomous regions, and municipalities (Shu Lifu *et al.*, 2004).

4.2 *Community involvement*

Russian Federation
In the Russian Federation the increasing attention which is paid on fire prevention (see chapter 3.4) is an indicator for the overall involvement of the general public in reducing human-caused wildfires. This is also reflected by the concept paper "Fire Protection of Forests in the Russian Federation" of the Ministry of Natural Resources of 2004 (see chapter 4.1). The proposed GEF Russian Far East Project "Fire Management in High Conservation Value Forests of the Amur-Sikhote-Alin Ecoregion" (chapter 3.5, section "Recent major investments") is aiming at integrating community participation 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.

Kazakhstan
According to the report by Kushlin *et al.* (2004) Civil Defence, Department of Home Affairs, Emergency Office, and the Rayon Home Affairs Departments stipulate participation of human resources and equipment for fire management not only from enterprises and agencies, but also from family farms located adjacent to forests.

Mongolia
Experience in Integrated Fire Management (IFM), also referred to as Community-Based Fire Management (CBFiM), in the Central Asian region has been gained in Mongolia (Goldammer, 2001, 2002; George and Mutch, 2001; Goldammer *et al*., 2002). Between 1997 and 2000 an Integrated Fire Management Project – supported by Germany (through GTZ) – was operational in Mongolia. The project region selected by the Integrated Fire Management Project was the Khan Khentii Strictly Protected Area and its buffer zones – one of the harder hit areas during the 1996 fires. A primary task was the establishment of a fire management plan compatible with the protected area goals and the responsibilities of the local communities. Fire Management Units in the local communities received professional training and basic hand tools suitable for the regional conditions. Information and Training Centres provided the necessary infrastructure for fire prevention activities, management information, training exercises, dispatch and field organization.

However, the project did not leave any institutional structures that could be regarded as substantial or sustainable. Lack of funding to maintain trained fire crews resulted in disappearance of formerly hired and trained unemployed local people after the termination of the project (Goldammer, 2001). Furthermore, the IFM project concept of "Integrated Fire Management" focussed on community integration in fire prevention and suppression only. The project did not include the development of an ecology-based fire and forest management component in which human-caused and natural wildfires and prescribed management fires as well as forest management are integrated. Forest and steppe ecosystems of the IFM project area show remarkable adaptations to fire that could be exploited for designing integrated fire and silvicultural treatments (use of prescribed burning and let burn natural and human-caused fires that have a beneficial effect on forest ecosystems; fuelbreak and bufferzone construction, silvicultural measures that ensure maintenance of see trees). Another option of integrated management of forests could be envisaged by developing alternative methods of biomass utilization. In remote areas there is limited utilization of non-merchantable (residual) forest slash, either after forest harvest or after forest fire. There are also large areas of birch (*Betula*) forests that are results of clearcuts or high-severity forest fires. It should be investigated if this biomass could be utilized for charcoal production and subsequent use as heating and cooking fuels. The advantages of this concept could include:

- Establishment of small businesses for charcoal production and delivery
- Reduction of transport costs for fuel supply to the end users (herder families widely scattered over the country)
- Fuel and fire-hazard reduction in post-harvest or fire-damaged stands

Pakistan
In Pakistan a community-based forest fire-fighting system is being established with the assistance of UNDP by providing fire-fighting training and equipment to communities living in the forest. [23]

4.3 *International collaboration*

The international dialogue between the majority of the countries of the region covered by this report has a long tradition. With the establishment of the FAO/UNECE Team of Specialists on Forest Fire in 1981, an activity of the former Joint FAO/ECE/ILO Committee on Forest Technology, Management and Training and today operating under the auspices of the UNECE Timber Committee and the FAO European Forestry Commission, a platform for exchange and dialogue in forest fire management was created in the ECE region.[24] With the transition of the former Soviet Union to the CIS the dialogue was disrupted partially because most of the new independent states were not in the position to send delegates to the regional conferences and consultations. Russia's commitments, however, continued to support the regional dialogue, especially through the strategic conference "Forest, Fire, and Global Change" held in Shushenkoe, Russian Federation, in 1996. The recommendations of this conference laid the foundation for a comprehensive strategic vision for international cooperation in fire management. [25]

The most recent developments brought the Team of Specialists and their home countries into the new Regional Wildland Fire Networks that joined, became recognized or were established under the UNISDR Global Wildland Fire Network. As mentioned in the introduction of this report (see chapter 2), there are overlaps of network definitions and boundaries – and this process is still dynamic.

Since the year 2000 a number of regional conferences and consultations have been held which brought some countries of the region together. Table 7 provides a brief overview of country participation in and the key outcomes of these regional events.

Other activities in the region included a meeting of the prime ministers of the six member countries of the Shanghai Cooperation Organization (SCO) (China, Kazakhstan, Kyrgyzstan, Russia, Tajikistan, Uzbekistan). The first SCO summit was held in September 2001 and concluded to work together in fields such as trade, transportation, energy, agriculture, environmental protection, finance, water resources and forest fire prevention. [26]

[23] http://www.un.org.pk/undp/energy/service-projects.htm
[24] For a record of activities see: http://www.fire.uni-freiburg.de/intro/team.html
[25] See IFFN No. 15 (September 1996): http://www.fire.uni-freiburg.de/iffn/org/ecefao/ece_3.htm
[26] http://english.people.com.cn/english/200109/15/eng20010915_80280.html

Table 7. Regional wildland fire management conferences and consultations in the Central Asia/Eurasia region 2000-2005. Source: GFMC

Year	Host Country	Participating Countries from Central Eurasia/Asia	Conference Theme	Purpose and/or Key Outcomes
2000	Finland (Kuopio)	Belarus Russian Federation	BALTEX FIRE 2000 (Baltic Exercise for Fire Information and Resources Exchange) [1]	Multinational Wildland Fire Exercise. **Recommendation:** To cooperate with UN International Search and Rescue Advisory Group (INSARAG) Europe-Africa Region and UN-OCHA
2004	Turkey (Antalya)	Kazakhstan Russian Federation Ukraine	Conference on Forest Fire Management and International Cooperation in Fire Emergencies in The Eastern Mediterranean, Balkans and Adjoining Regions of the Near East and Central Asia [2]	**Antalya Declaration on Cooperation in Wildland Fire Management in the Balkans, Eastern Mediterranean, Near East and Central Asia:** To develop arrangements to support collection and dissemination of wildland fire information, facilitation of regular regional dialogue and joint projects between the countries, and to technically support countries in need of aerial assets for wildland fire suppression
2004	Finland (Helsinki)	Russian Federation	Regional Baltic Wildland Fire Network Meeting [3]	**Helsinki Declaration on Cooperation in Wildland Fire Management in the Baltic Region:** Helsinki Plan of Action for Cooperation in Wildland Fire Management in the Baltic Region
2004	Kyrgyzstan (Bishkek)	Azerbaijan Kazakhstan Kyrgyzstan Russian Federation Tajikistan Turkmenistan Uzbekistan	Regional Forest Congress "Forest Policy: Problems and Solutions" [4]	**Resolution:** Countries to join the United Nations International Strategy for Disaster Reduction (UN-ISDR), Global Widland Fire Network, and support the development of an international accord on cooperation in wildland fire management
2005	Russian Federation (Irkutsk)	Mongolia Russian Federation China	Consultation of the Regional Central Asia Wildland Fire Network [5]	**Recommendation:** Countries of the region to unite their efforts and resources to combat the uncontrolled forest fires and prevent extreme damage.

[1] http://www.fire.uni-freiburg.de/iffn/org/ecefao/baltex2000.htm
[2] http://www.fire.uni-freiburg.de/GlobalNetworks/CentralAsia/CentralAsia_0.html
[3] http://www.fire.uni-freiburg.de/GlobalNetworks/BalticRegion/BalticRegion_7.html
[4] http://www.fire.uni-freiburg.de/GlobalNetworks/CentralAsia/CentralAsia_0.html
[5] http://www.fire.uni-freiburg.de/GlobalNetworks/CentralAsia/CentralAsia_2.html

Bilateral agreements

A number of bilateral agreements in forest fire management are in place. Those agreements available at the GFMC or listed in the FAO report "Legal Frameworks for Forest Fire Management: International Agreements and National Legislation" include bilateral agreements between:

- China – Mongolia
- China – Russia
- Russia – Mongolia
- Russia – Finland
- Iran – Russia

Some agreements are primarily implemented at regional levels, e.g. between Buryatia Republic and Mongolia. Other agreements are elements of larger political cooperation agreements such as the

Russia-China agreements of 2000 and 2005 [27] and the Russia-Iran cooperation which resulted in first mutual visits of forest fire protection delegations in both countries in 2005.

Multilateral wildland fire emergency exercises

Multilateral wildland fire exercises were held in Southeast Europe in 2002 ("Taming the Dragon - Dalmatia 2002") and 2004 (EASTEX FIRE 2004).[28] The field exercise "Taming the Dragon - Dalmatia 2002" was conducted in Croatia with participation and observers from 28 countries, as a Partnership Work Programme (PWP), Euro-Atlantic Disaster Response Coordination Centre (EADRCC) and Euro-Atlantic Disaster Response Unit (EADRU) activity. Kyrgyzstan participated in this exercise. In the above mentioned exercise EASTEX FIRE 2004 (Table 7) no organization of a Central Asian state was able to participate.

International cooperation in wildland fire science and related research

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 in Central Asia/Eurasia 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) (for a complete overview see Goldammer *et al.,* 2004a). The most recent initiatives include the establishment of the Northern Eurasian Regional Information Network (NERIN), the 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[29], the Siberia II project and the Northern Eurasian Earth Science Partnership Initiative (NEESPI) (Csiszar *et al.*, 2004). The Siberia II project contributed to the improvement of assessing emissions of radiatively active trace gases from fires in the Russian Federation.[30] NEESPI is a currently active, yet strategically evolving programme of internationally-supported Earth systems science research, which has as its foci issues in northern Eurasia that are relevant to regional and global scientific and decision-making communities. By establishing a large-scale, multidisciplinary programme of funded research, NEESPI is aimed at developing an enhanced understanding of the interactions between the ecosystem, atmosphere, and human dynamics in northern Eurasia. It is expected that forest fire research will continue to play an increasing role in the overall NEESPI programme. [31]

Wildland fire management research and development

Besides fundamental research which is primarily aimed at clarification of ecological and environmental impacts of wildland fires several other internationally supported projects have been conducted or are underway aimed at improving management capabilities.

Between 1998 and 2001 the EU-TACIS Programme (European Union Technical Assistance to the Commonwealth of Independent States) supported the Russian Federation with the project

[27] http://www.fire.uni-freiburg.de/media/news_10162000_ru_2.htm
http://www.fire.uni-freiburg.de/media/2005/news_20050816_ru.htm
[28] http://www.fire.uni-freiburg.de/emergency/International%20Wildland%20Fire%20Exercises.htm
[29] http://gofc-fire.umd.edu/RegNtwks/sibfareast/index.asp and
http://gofc-fire.umd.edu/RegNtwks/wrusfenn/index.asp
[30] http://www.siberia2.uni-jena.de/index.php
[31] http://NEESPI.org/

"Improvement in Forest Fire Response Systems - Forest Protection" (TACIS ENVRUS 9701).[32] This project was instrumental for the development of the satellite fire monitoring capabilities of Avialesookhrana of Russia.

The EU-TACIS Project Information System for Environment and Agriculture Monitoring (ISEAM) (TACIS FDREG 9701) supported Mongolia, Kazakhstan, and Uzbekistan between 1999 and 2001 to set up a multi-country network to assist government authorities to develop national information systems for improved agricultural and environmental monitoring, planning and management. It included the elaboration of a fire monitoring system for Mongolia and Kazakhstan.[33]

Under the Memorandum of Understanding (MoU) between the Canadian Forest Service (CFS) and the Russian Federal Forest Agency (RFFA), a Forest Fire Subcomponent ("Canadian/Russian Forest Fire Initiative in Russia") was developed in 2005. The work plan 2006-2007 includes the evaluation of the Canadian Forest Fire Danger Rating System (CFFDRS) for use in Russia (see also chapter 3.5 of this report, section "Early warning of wildland fire danger") and the reconstruction of post-1980 fire activity in Russia from archives of satellite imageries for climate change projections of future Russian fire regimes.

4.4 *Needs and limitations*

The needs and limitations for exhaustive fire management in the region are obvious. Institutional weaknesses and economic constraints, which in some countries are a consequence of economic transition, lack of awareness and adequate policies, and a lack of commitment and involvement of civil society in many countries of the region have substantially weakened formerly strong fire management capabilities, or are impediment to introduce systematic fire management where needed.

Similar to, and in agreement with the defined needs and limitations of the Northeast Asian regional report (FAO, 2005), the major needs for Central Asian countries to develop forest fire management capabilities include the following:

- institutional and technological capacities
- public awareness and responsibility of civil society in issues related to wildland fires
- training and educational programmes
- clear legal, institutional and financial basis for forest protection
- capacities of government institutions, research entities, business and NGOs with regard to planning and implementation of sustainable development programmes
- modern fire extinguishing equipment, use of satellite information and information technologies
- implementation of international cooperation, including compliance with Agenda 21 and the conventions related to fire issues in Central Asia – notably UNCBD, UNCCD, UNFCCC and Ramsar
- considering the obvious increase of intentionally set fires in conjunction with illegal logging or illegal practices to obtain salvage logging permits: link to and joint interaction with the Europe and North Asia Forest Law Enforcement and Governance (ENA-FLEG) process.

[32] http://www.fire.uni-freiburg.de/programmes/techcoop/tacis.htm
[33] http://gafweb.gaf.de/iseam/

5. Analysis and Recommendations

5.1 *A regional analysis and perspective*

In 2004 the Ministry of Natural Resources of the Russian Federation, supported by the Center of Ecology and Forest Productivity, Russian Academy of Sciences, developed a concept paper "Fire Protection of Forests in the Russian Federation" which may provide guidance towards development of a new fire management policy and the introduction of technical steps necessary for implementation (MNR, 2004). This concept includes considerations and strategic elements that reflect the most recent scientific insights and technical developments in fire management. The following elements of the concept paper represent visionary recommendations that were genuinely developed in the region. From the point of view of the regional rapporteur, these recommendations are relevant for other countries in the Central Asia region.

General

- Fire protection of forests should become the highest policy priority to ensure ecological security of the 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. Forest fires have a lethal impact on forest vegetation, fauna and upper soil. 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.
- 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.

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.

New objectives of a forest fire management policy

- Developing fire prevention initiatives for preventing fires caused by humans
- Strengthening the role of regional and local authorities in the implementation of the forest fire management policy
- Strengthening the state forest fire supervision and ground-based fire fighting developments in the respective service area
- 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
- Restoring natural fire cycles in forest ecosystems by refusing in part of completely to put out individual natural forest fires under certain circumstances

- Regulating prescribed fires and providing legal and economic framework for regular prescribed fires
- Making sure that the programmes 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
- 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
- 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.

Main directives for development and improvement of forest fire protection system

Forest zoning by types and levels of fire protection

- The current division of the forested territory by aerial and ground fire protection must be further developed through its zoning by 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 must be determined by a probability of a timely suppression 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 must 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.

Special forest fire protection arrangements

- On the areas polluted with radionuclides, the system of forest fire protection arrangements will face tough requirements to the radiation safety of forest fire service personnel 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.

Development of fire prevention

- Improved effectiveness of forest fire prevention must 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., must 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 must be on children and the youth as well as on non-governmental organizations whose activities involve visits to forests.
- 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.

Improved response to forest fire detection and fighting

- Fire response must 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 fighting fires in the context of high and extreme fire occurrence.

- The priorities in the improvement of ground-based fire detection must include (a) gradual 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 must 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.

<u>Improved emergency preparedness associated with forest fires</u>

- Improved emergency preparedness of the forest fire protection must streamline the operations of the forest fire services through improvement of the current operational procedures to meet the required level of the forest fire protection.
- Task forces of rapid deployment (inter-regional forest fire centers with mobile fire teams) must be established, as well as timely mobilization of the resources of the Emergency Management Services to assist in fighting fires in extreme situations
- Higher educational establishments must train engineers in the "Prevention and Fighting of Forest Fire" discipline, with the similar specialization to be taught at forest colleges.

<u>Using fire as a natural element of forest ecosystems</u>

- Using fire as a targeted tool of forest management must 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 man-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-intensity surface fires in those forest ecosystems that are adapted to fire; (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 wildlife.
- One mandatory condition of successful integration of forest fire into forest management must be scientifically-based recommendations for prescribed burning and reliable information on the current state of forest ecosystems. This integration must 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 must be implemented under dedicated programmes 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 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 must 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 to the territories that require prescribed burning, these must 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.

<u>Implementation tools of forest fire policy</u>

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

- Developing and adopting legal acts to determine the mandate of the constituent entities of the country 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.

- Launching a special research programme in the area of forest fires which must serve as the basis to develop scientific principles of integrating fires into the ecosystem 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.
- International cooperation in forest fire protection and forest fire management should be developed under international agreements of federal and regional level and detailed within the corresponding international inter-agency programmes, agreements and projects/plans.

5.2 *Analysis and recommendations from an international perspective*

Global repercussions of excessive wildland fires and forest destruction

In the above-cited concept paper, fire management policy reform is proposed and a list of priority actions is recommended. These recommendations are mainly targeting national to local needs. In the last paragraph, however, the necessity to develop international agreements is underscored.

With regard to existing international agreements, a statement of the Russian Academy of Sciences on the role of the Kyoto Protocol mechanisms in forestry and land use development in Russia (Korovin, 2005) is drawing the context between the Kyoto Protocol and the potential of reducing carbon emissions by fire management, by stating:

> *The urgent need to reduce fire-induced emissions of the greenhouse gases is dictated by both increased fire occurrence in the boreal forests and the projected increase in the number and scope of forest fires due to global warming.*

This report and other studies refer to the scenarios that the Eurasia's large terrestrial carbon pool – mainly carbon stored in forests, tundra and peatlands – may become threatened by the combined effects of climate change, human interventions and fire. With more than 300 billion tons, the territory of the Russian Federation is currently holding the largest terrestrial carbon pool (Dixon *et al.*, 2004) and one of the most important terrestrial carbon sinks, especially in the Siberian peatlands (Smith *et al.*, 2004).

Climate-change models (Global Circulation Models - GCMs) have been used since the early 1990s to predict drought severity and consequently fire severity of the boreal zone including Central Asia (Stocks *et al.*, 1998). Selected scenarios are provided in Figures 21 and 22. It is based on the GCM of the Canadian Climate Center (CCC) and compares average monthly fire severity rating across Eurasia and North America under the current climate conditions vs. a projected climate-change (2 x CO_2) scenario for the year 2030 (Stocks, 2004). Increased wildland fire occurrence and severity will be a consequence of increased occurrence of droughts in the extreme continental climate of Central Asia.

Stocks (2004) furthermore summarizes the trends associated with regional climate change:

> *In addition to increased fire activity and severity, climate warming of the magnitude projected can be expected to have major impacts on boreal forest ecosystem structure and function in northern circumpolar countries. Based on GCM projections large-scale shifting of forest vegetation northward is expected, at rates much faster than previously experienced during earlier climate fluctuations. Increased forest fire activity is expected to be an early and significant result of a trend toward warmer and drier conditions, resulting in shorter fire return intervals, a shift in age-class distribution towards younger forests, and a decrease in biospheric carbon storage. This would likely result in a positive feedback loop between fires in boreal ecosystems and climate change, with more carbon being released from boreal ecosystems*

than is being stored). It has been suggested that fire would be the likely agent for future vegetation shifting in response to climate change. [34]

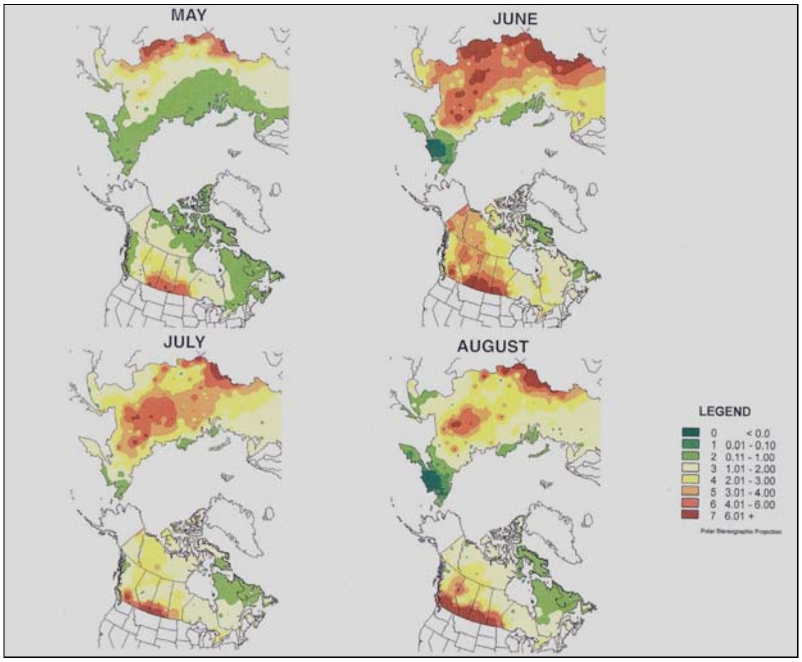

Figure 21. Average Monthly Severity Rating (MSR) maps for Canada and Russia, based on measured 1980-1989 daily weather. [35]

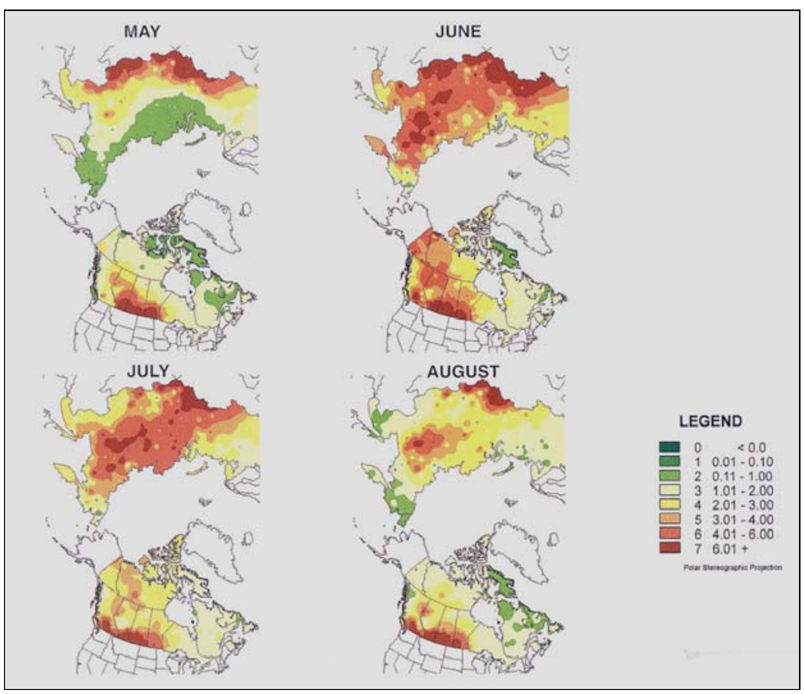

Figure 22. Average Monthly Severity Rating (MSR) maps for Canada and Russia under a $2xCO_2$ climate using the Canadian General Circulation Model (see footnote).

[34] For detailed references of cited trends, see Stocks (2004)

[35] Average Monthly Severity Rating (MSR): see Alexander and Stocks (1987) and additionally http://www.fire.uni-freiburg.de/programmes/un/idndr/idndr_ha.htm

From the point of view of the regional rapporteur, this scenario is already becoming reality. Spaceborne monitoring of wildland fires and drought as well as local records provide evidence of increasing regional aridity and severity of wildland fires (cf. chapter 3.2; Pilifosova *et al.*, 1996; Arkhipov *et al.*, 2000; Shvidenko and Goldammer, 2001). The trend of increasing fire occurrence, however, is being driven by humans; the underlying causes have been highlighted in this report.

Implications for concerted action

Given the high significance of Eurasia's/Central Asia's boreal forest in the functioning of the Earth system and the predicted risks of losing forest cover and terrestrial carbon storage potential, the increasing destruction of forests should be addressed vigorously at national and international levels.

Forest and fire management is in the responsibility and interest of countries. However, currently and in the near future some countries of Central Asia do not seem to be in the position to ensure sustainable forest fire management practices. Lack of institutional capabilities in fire management and law enforcement are limiting the ability to halt forest destruction by illegal logging and/or wildfires.

Thus, there should be a high interest of the international community in supporting the preservation of the multifunctional role of forests and other vegetation – including the wetlands – by efficient fire management in Central Asia. Besides the international conventions (e.g., UNFCCC, UNCCD, UNCBD) recent international minister-level meetings and other international negotiations confirmed the interest of the international community to cooperate in sustainable forest management and fire management, e.g.:

- FAO Ministerial Meeting on Forests (2005) which recommended the development of a strategy to enhance international cooperation in wildland fire management;
- FAO Committee on Forestry (COFO) (2005) which recommended the development of voluntary guidelines for wildland fire management;
- North Asia Forest Law Enforcement and Governance (ENA-FLEG) (2005) which recommended countries to cooperate in reducing illegal logging; and
- United Nations Forum on Forest which in its 6th session (2006) recommended to further develop an International Arrangement on Forests (IAF) and a multi-year programme of work in 2007 in which cooperative approaches in wildland fire management could be included

International cooperation and targeted projects and programmes in wildland fire management must rely on accurate and meaningful wildland fire data and information that allow an assessment of the current fire situation and trends of changes. Statistical wildland fire products from countries are often incomplete. They are also inconsistent and not inter-comparable due to different methodologies used and due to a lack of coverage. Satellite remote sensing products are not yet used systematically for assessing extent and impacts of wildland fire. There is no agreed system in place for economic and environmental fire damage assessment.

In conclusion the need is underscored that governments in the regional and the international community give highest priority to the improvement of fire management capability in the countries. International cooperation will be important for developing internationally or regionally accepted standards and protocols, and sharing knowledge, expertise and resources in joint projects and programmes in wildland fire management. The majority of territories with fire-prone forest and other vegetation in Central Asia is located in countries where Russian is the official or prevailing language. Investments in training materials, guidelines, terminologies etc., could easily be shared between countries.

The Regional Central Asia Wildland Fire Network, together with its neighbour networks (Baltic, Northeast Asia) may provide an arrangement suitable for developing cooperative efforts and synergies. The recommendations of governments represented at the Regional Forest Congress "Forest Policy: Problems and Solutions", held in Bishkek, Kyrgyzstan, November 2004[36], urging countries of Central Asia to join the Global Wildland Fire Network, reveal a positive atmosphere for enhancing cooperative efforts in the region.

[36] see Table 7 and http://www.fire.uni-freiburg.de/GlobalNetworks/CentralAsia/CentralAsia_0.html

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