FOREST FIRE MANAGEMENT IN THE KHABAROVSK PROVINCE

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Abstract

Forest fires take heavy tall in the Khabarovsk province, notwithstanding the permanent improvement of forest protection service and increase of costs for forest fire control. This paper begins with a general survey of forest characteristics in the province. Then, the structure and resources of local forest protection service are described and a scope of forest fire problems and environmental loss inflicted by fires are discussed. Finally, a new approach to the forest fire policy adopted by the forest administration of the province is discribed.

Keywords: forest, fire, pollutants, loss, control, management

Introduction

Forests and fire seasons in the Khabarovsk province

The Khabarovsk province stretches along the Russian part of the Pacific coast for about 2,000 km, its area is 82.5 mill.hec and population 1.588 mill.pcs (on 01.03.95), of which townfolk is 80,7 %. Forest area is about 44 mill.hec; forests are of the boreal type and presented mainly (70 %) by coniferous species. The latter are larch in the northern, spruce and fir - in the central, and cedar-pine and spruce - in the southern part of the province. Forest cover composition is very diverse, and there are very valuable and/or particularly protected species such as ash, walnut, cork-tree, a.o. Timber reserve is 5.2 bill. cu.m, and yearly cut is as much as 15 mill.cu.m of commercial wood, the essential part of which is exported to the overseas timber markets. Yearly cut area is about 100-150 thousand hectares.

The terrain of the forest area is mainly mountainous, more than 70 % of the area is occupied by mountains of altitudes up to 2,000 km above sea level. Other part of the area is occupied by moors and swamps covered by wilty larch-trees and brushes; the soil cover is composed by grasses (on elevations) and moss laying on the peat bed up to 2 m thick. Approximately one third of the forest area is situated in the permafrost zone.

Climate of the province is the monsoon type: deficite of snow in winters, drought in spring and autumns, and rainy summers. Annual precipitation in proximity of Khabarovsk is about 600 mm, two thirds of which are summer (July-August) rains. This is a typical pattern, however fire seasons of other patterns occur rather often.
Fire season ranges from 160 (northern districts) to 210 (southern districts) days; half of this duration are fire days when fire seasons are of moderate severity. Typical fire season follows the vegetative cycle for grass and decidious trees, with bimodal peaks during the spring and fall in the southern (May and October), and one fire peak (July) in the northern districts of the province. However, once or twice in the decade fire peaks happen in summer both in southern and northern districts. Majority of fire number occurs in May. Fireline intensity varies depending on wind and severity of drought, and reaches as much as 10 MW/m for surface headfires and up to 100-150 MW/m for crown fires, the latter occurs at severe droughts in summer and autumn months in coniferous forests of all districts.
Basically, forest fuels are dry grasses and litter in the south, and in the northern forests such fuels are the substantial addition to lichens and moss. Also snags, peat, crowns of coniferous trees and other storeys burn at severe droughts. Fuel loading for surface fires varies from 0.3 to 1.5 kg/sq.m and, for crown fires from 2 to 3.5 kg/sq.m. Density of surface fuels varies within 0.3 - 2 kg/cu.m for crown fuels and standing grass and within 8-20 kg/cu.m for laying grass, lichens, moss and litter.
By fireline intensity of burning, fires are classified under three categories: moderate (flame height up to 0.5 m, direct suppression is admissible by hand equipment), high (flame height 0.5-1.0 m, direct suppression is admissible by backpack pumps, but indirect methods of suppression - fire containment and counterfiring are recommended) and extreme (flames higher than 1 m, methods of indirect suppression - making catlines and counterfiring or other equipment to contain fires should be used).
More than 75 % of fires originate from forest recreationists, forest workers, railroads and harvesting equipment, other fires are assumed to be lightning fires. Percentage of fires of unknown causes is about 15 %.
The set of most popular equipment for forest fire control includes shovels, hoes. rakes, backpack pumps, portable engine pumps, various vehicled machines such as bulldozers, crawler and wheeled tanker trucks, and explosive flexible cords. At favourable conditions, rainfalls are stimulated by chemical treatment of cumulus clouds by special rockets launched from aircrafts. There are three categories of firemen: smokejumpers, rappellers and forest rangers; at extreme situations residential workers are mobilized to suppress fires.

Ownership and responsibility

Before 1917, forests of Russia were the property of the Tzar, State, landlords, church, persons and village agricultural communes. Decree "Concerning Lands" of October 26, 1917 abrogated "forever" those kinds of ownership, and established the State ownership for all forest and other lands of the country. Management, holding and disposal of forest resources were commissioned on the specially established forest state enterprises ("leskhozes") conducting their activity for and on behalf of the State.
Forest Code of May 27, 1918, and later on the USSR Constitution of 1936 proclaimed State forests to be the public property, according to which provision any citizen was entitled to visit and stay in forests for recreation and amateur collection of berries, mushrooms, etc. Visiting forests for commercial utilisation of forest resources was to be regulated by paid forest permits.
Decree of March 25, 1920 "Concerning State Monopoly on Forest Products and Timber" prohibited any commercial activity in forest lands of any person and entity

except State forest enterprises. Those enterprises and their contractors were bound to protect forests allotted to them from the moment of obtaining permits for forest utilization of the forest. The special forest fire control service of the USSR was established in August 26, 1939 as the Department of Forest Protection in the Ministry of Agriculture.

The USSR Constitution of 1978 did not include the above provision on forests as the "public property" but instead asserted: "any citizen must protect forest, soil and minerals". New forest law of 1993 assigns forests to the property of districts, which administrations becomes entitled to dispose forest resources under coordination, supervision and approvement of both the Federal and provincial forest Services, and the relevant provincial administration. The law stipulates any forest usage to be paid, and forests sites to be leased for harvesting and all profit made from forest usage and leasing to be the income of the relevant district administration.

However, currently, the provision of the law asserting the forests as the property of districts, turns out to be not suitable for State forest management, so the new forest code is now being elaborated announcing forests as the federal property of Russia.

Economic and ecological loss from forest fires

Forest fire is the essential geographic factor which influences stand replacement, migration and spatial distribution of wild animals, hydro-climatic and soil resources of the Earth and, finally, socio-economic conditions of people. Forest fire impact on the environment is short-term but its consequences prolong for many years and, even, decades.

Scope of forest fire impact on the Khabarovsk forests can be illustrated by the following Table 1 of fire statistics covering the past 35 years, i.e. three Sun cycles (Sun activity maximums in 1961, 1971, 1981, 1991, and minimums in 1966, 1976 and 1986) which, as it can be seen from this Table 1, fire periodicity corresponds to.

TABLE 1. Forest fire statistics for the protected area (60 mill.hec.) of the Khabarovsk province for the period of three Sun cycles (1960-1994).

Years	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
Yearly fire number	389	472	561	638	460	500	999	715	1149	625	830	505
Yearly burned area,thous.hec.	29	102	95	94	133	42	42	12	165	25	88	23

Years	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Yearly fire number	514	943	853	1142	1250	646	696	693	1009	600	641	627
Yearly burned area,thous. hec.	43	35	32	108	1345	116	55	29	67	153	64	43

Years	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	Aver.
Yearly fire number	662	462	930	638	1139	983	778	287	374	741	278	707
Yearly burned area,thous.hec.	37	19	42	85	267	156	188	49	39	127	21	113

This Table illustrates the average yearly burned area is almost equal to that annually cut. It means that the loss of timber inflicted by fires is comparable to, if not equal the cut volume of commercial timber. But in cut areas saplings and young growth are, to some extent, saved undamaged in the course of cuts and thus garantee successful natural reforestation, while in the burnt areas that vegetation is the first-turn victim of fire and, in an overwhelming majority of cases, is fully eliminated.

Logging enterprises loose fully or partly their leased forest sites in result of fires and have to change their locations and lease another forest site. Many harvesting and road-building enterprises have to take part in fire suppression with their personnel and earth-digging machines, thus suffering losses because of reduced production.

Ecological loss is as much essential.

Large and mass forest fires exhaust smoke particles and gases into the atmosphere. Scope of organics burned by fire in forest is about 5-30 ton/hec /1/. This organic matter consumes the same weight of oxygen for burning and exhausts in the atmosphere, in addition to water vapor and oxides of carbon, nitrogen and sulphur, also about 80-600 kg/hec of smoke particles. Smoke of forest fires consists of soot (25 %), ash (20 %) and drops of resins (55 %), 90 % of which does not exceed 1 micrometre /2/. Those particles, at large and high-intensity fires, are discharged as high as up to 4.5 km height /2/, which is the altitude of the level of condensation /3/. Being so tiny and numerous they can not work as nucleii for condensation of vapor in that zone, thus prevent falling rain from the clouds /2/. More than that, being black bodies, those particles absorb solar radiation, become hot and thus heat the ambient air. Heated air becomes hygroscopic and absorbs moisture from clouds which are thus dissolved and disappear in the heated air. The sky become cloudless, and the local surface drought grows longer. The phenomenon influences essentially on weather and climate patterns in the currently and repeatedly smoked area, correspondingly.

Smoke particles reduce the dielectrical strength of air. Special tests showed that the electric spark distance between high-voltage electrodes increases as much as for 7-14 % in the air smoked by forest fuels as compared with the unsmoked air. That phenomenon is the key to the understanding of the cause of the marked increase of lightning fire incidence in smoked areas and under smoke columns ahead of high-intensity fire edges as compared with the surrounding unsmoked areas, and it is undoubtfully the factor causing alteration of the pattern of spatial distribution of lightning strikes over the earth surface.

Repeating large and mass fires in the forest zone sometimes burn out hundreds thousand hectares and smoke the area thrice as much. Large-scale discharges of pollutants into the atmosphere are accompanied by both short-term and long-term effects displayed in the marked changes of certain local weather and, even, climate patterns.

One example. For many decades before 1978, wide-scale prescribed burnings were conducted in spring (April, early May) by residents in southern districts of the Khabarovsk and Amur provinces to clean pastures and hayfields off old dry grass. Also foresters made their spring burnings in cut areas, roadsides, intensely visited forest

sites to reduce fire hazard in surrounding valuable forest stands and inhabitated settlements. Wide areas were smoked by those burnings, and springs there were dry and hot, which phenomenon was perceived as the characteristic feature of the climate of those regions and was not related to the repeating smokiness of the region.
But in the end of the spring those prescribed burnings sometimes spread too widely and entered in the adjacent forest stands, so in July 1977 the then Forest Service of the ex-USSR ("Gosleskhoz") issued the resolution prohibiting any fire works in forest lands during the whole snowless season. Spring agricultural and forest burnings were ceased, and forest areas became unsmoked in spring, which situation had been maintaining up to these days.
More than a decade later it became possible for us to perform a statistically well-founded appraisal of the resolution and make conclusions concerning effects of that prohibition.
The conducted analysis has revealed that the averaged April precipitations for 14 years after 1978 increased from 43 mm to 64 mm, i.e. springs became markedly more rainy, and the averaged annual spring fire number decreased as much as on 20-25 % as compared to that averaged for 14 years before 1978. Annual loss of spring precipitation of about 21 mm is a long-term consequence of spring wide-scale burnings in the Khabarovsk province.
Short-time effects are manifested as 5-8 days delay of rainfalls, lower dew-point at night, increased lightning activity in smoked areas as compared to the surrounding unsmoked territories.
The atmosphere over smoked areas becomes warm and saturated with water vapor. When fires are suppressed, the smoke coating sediments and disperses, and the air above that area becomes cooler and the accumulated water vapor condenses from the cooled air. Showers begin, and they are more intensive than those in the surrounding regions.
Ash produced by fires and remained in burnt areas is washed off by showers into depressions and springs, and the soluble ash components come further on into the larger water intakes - rivers and lakes, thus polluting reservoirs of drinking water. Being effective fertilisers, the ash components stimulate growth of aquatic plants and alter the fauna of lakes. For instance, in September 1986, when after intensive large summer fires in marshes of the Amur floodland the ash layer of almost one foot thick was washed off into the Amur (the important source of drinking water for Khabarovsk) the Amur water had higher cloudiness for at least two weeks of that September.
Burning out the grass cover results in destruction of birds nests, mice, snakes, eliminates food for predators and thus destroys the trophical chain and ecological balance of the area.

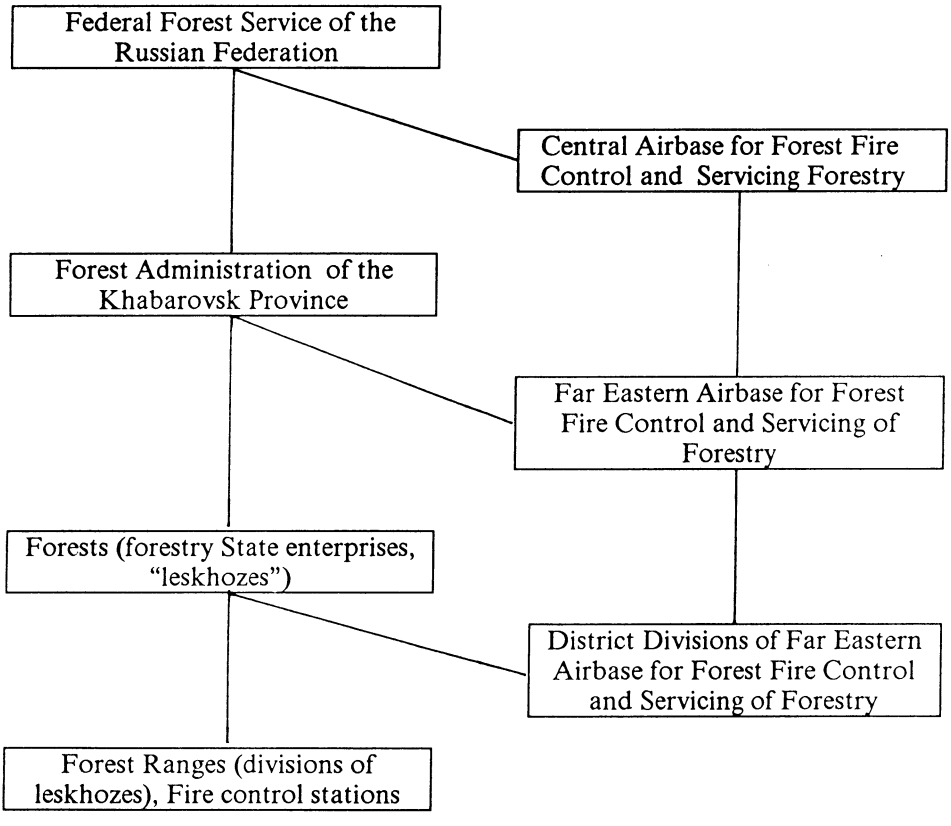
However it ought to be noted that there are some positive effects of fire in certain forests. Larch stands of boreal forests imbedded with thick moss can be reproduced by its natural way only after their moss cover is burnt by fire of moderate intensity since the moss prevents germination of tree seeds and rooting of sprouts. Moderate forest fires reduce fire hazard in all types of forests preventing accumulation of forest fuels. In addition, they contribute to the development of biological diversity in forest sites, improve forage for ungulates. Understanding of this important aspect of forest fires begins to make way through far-eastern foresters.

Forest fire control system in the Khabarovsk province

The implicit demand made on forest protection agencies of Russia is the compulsory suppression of any fire in the smallest burned area and within the shortest possible time.

The structure of organisation of forest management and protection in the Khabarovsk province as well as in any other province of Russia is illustrated by the following sheme:

POSITION OF THE KHABAROVSK FOREST PROTECTION SERVICE IN THE EXISTING ORGANISATION OF MANAGEMENT AND PROTECTION OF FORESTS IN RUSSIA



Responsibility for forest protection is laid on State forestry enterprises (leskhozes) reporting to the Province Forest Administration which, in its turn, reports to the Federal Forest Service of Russia. There are 48 leskhozes in the Khabarovsk province, and the protected forest area of one leskhoz varies from 200 thousand to 3 million hectares depending on the level of development of the territory. Leskhozes are entitled to register and give out forest permits for various kinds of forest utilisation, to supervise cuts, recreational and other forest use in forest areas under their protection.
As the Far East of Russia is a typical mountain and cross country, the leskhozes equipped only for conducting ground fire suppression can but little to do for fire control in their remote and vehicle-proof forests without assistance of aerial fire control service. That service was established in the Russian Far East in June 21, 1941, when one small biplane made the first patrol flight over the area of the southern part of the Primorsky province. Coincidentally, June 22, 1941 was the day of beginning of the Great Patriotic War (with Germany), so the newly born Far Eastern Forest Aerial Base proceeded with its activity again only in 1949 patrolling the area of 50 mill. hec. of Primorie and Khabarovsk provinces. Afterwards the area protected by the aerial forest service increased annually and now only in the Khabarovsk province it is 60 mill. hec.

The Khabarovsk provincial airbase ("Far Eastern Airbase") is funded by the provincial Forest administration from its budget allotted and formed by the Federal Forest Service. That funding is supplied based on the contract made annually between the airbase and the Forest administration of the province. However, the airbase reports to the Central Airbase of Russia.

By the conditions of forest fire detection and suppression, the forest area of the province is classified under three sections (zones) which borders are stipulated in the above mentioned contract: 1) zone of ground forest fire detection and suppression- 3 hours access for ground fire service or, 10 km from the nearest road, 2) zone of aerial forest fire detection and suppression - beyond the 3-hours-access-limit, and 3) zone of aerial fire detection and ground suppression (protected and other special forests, or forest areas specially stipulated in the contract). The zone under protection of the ground forest fire control service occupies about 5 % of the whole protected area of the province.

To suppress large forest fires (when the burned area of fire exceeds 300 hec.) which are scaled as natural disasters, additional resources should be supplied by harvesting enterprises (lessors of the State forest reserve), Committee on Natural Disasters and Emergency Situations, and neighbouring airbases if their fire situation is not so severe. Coordination and distribution of those resources is conducted by the Provincial Emergency Commitee for Forest Fire Suppression specially established annually for such events by resolution of the provincial administration.

The full-time airbase personnel is now about 400 men (200 smokejumpers and 200 rappellers). The airbase governs 28 aerial divisions located in all districts of the province. Each division disposes at least one aircraft - biplane AN-2 (it can carry up to 10 smokejumpers) or helicopter MI-8 (up to 25 pappellers) depending on the character of the terrain, and all necessary logistics to ensure their activity. Aircrafts are leased from the Khabarovsk Civil Aerial Transportation Division. The normative serviced area for each of said aircrafts is about 3 mill. hec. At moderate fire situations the airbase leases about 20 aircrafts which number can be increased when fire situation is going to be extreme. The extreme fire situation is identified by the critical fires number detected daily and fires number burning daily. Those maximum numbers ever registered are 32 and 40, correspondingly, and the average numbers are about one-third of that mentioned.

Activity of the airbase as well as any other forest protection agency is controlled based on the fire weather weather index system. This system is related to the probability of fire occurence and based on midday measurements of air temperature, dew point and precipitation, and calculations of fire weather index (FWI) on those data is made by the nearest contracted weather station using the following formula:

$$FWI = \sum_{i=1}^{i=n} t(t-\tau),$$

где Σ - accumulation suming;

t - air temerature of the current day at 12:00, °C;

τ - dew point for that temperature and humidity, °C;

n - number of days after the recent rain of at least 3 mm/day.

Example:

Date:	1.05	2.05	3.05	4.05	5.05	6.05
Rain on 12-00 of the current day, mm	5	-	-	2	-	3
Air temperarure on 12:00 of the current day, °C	10	12	15	9	11	8
Dew point on 12:00 of the current day, °C	1	0	-1	2	-3	3
Daily increment of FWI for the current day	90	144	240	63	154	40
Accumulated FWI	90	234	474	537	791	40

When FWI is calculated, the class of fire weather danger (FWC) is determined. For the Khabarovsk province, there is the local scale approved by the Federal Forest Service. This scale consists of five fire weather classes (Table 2).

TABLE 2. Scale for identification of FWC by FWI for the Khabarovsk province and regulation of fire control services' activity.

Regions and seasons	FWC 1 (0-5% of seasonal fire number). No patrol flights	FWC 2 (5-12 % of seasonal fire number).One patrol flight in two days	FWC 3 (12-17 % of seasonal fire number).One patrol flight a day.	FWC 4 (17-35% of seasonal fire number). Two patrol flights a day.	FWC 5 (to 100 % of seasonal fire number). Three patrol flights a day.
North of the province. (July, August)	0 - 200	201 - 650	651 - 1600	1601 - 3200	more than 3200
South and centre of the province. (April, May, September, October).	0 - 180	181 - 400	401 - 1200	1201 - 3200	more than 3200
South and centre of the province. (June, July, August).	0 -400	401 - 800	801 - 2400	2401 - 5000	more than 5000

Scientific achievements for forest fire control

Performance of forest fire control service depends substantially on the level of scientific elaboration of the problem. Such elaboration is conducted by regional research institutes of the Federal Service and some institutes of the Russia Academy of Science (RAS) which fire research projects are funded by federal budget. Results of their studies, in short, are: stimulation of rainfalls from clouds by chemicals, methods of fire suppression by explosive cord, munition for smokejumpers and rappellers, water buckets for helicopters, aircraft tankers of high carrying capacity, radio communication equipment, portable motor pumps, fire hoses, various tanker trucks and catline-making machines including those based on conversed military vehicles. As for the Khabarovsk province, forest fire studies are conducted from 1950-th in the Far Eastern Forestry Research Institute (DalNIILKh) in cooperation with other institutes, including those of Moscow. The Institute has its own engineering plant producing fire control devices developed by the institute. Among those devices most useful are: light synthetic high-pressure fire hoses and aluminium connections for them, improved backpack pump, fire torches for counterfiring and prescribed burning, all-terrain crowler tanker, etc. Spatial and time regularities of forest fire occurence and bevavior, and fire loss and various fire effects were also studied in the Institute.

In the recent years, forest fire studies are started also in the Institute for Computer Sciences (NIIKT) of the Khabarovsk State University of Technology. Main fire research projects under development are the mthematical and computer models of forest fire propagation and ecological effects of fires /3/.

research projects under development are the mthematical and computer models of forest fire propagation and ecological effects of fires /3/.

Conclusion: new approach to the forest fire problem

Experience accumulated for many years of fire prevention, suppression by the Khabarovsk forest fire control service and scientific studies of the problem has shown that the fire policy "to supress fires on minimum area for minimum time" is not always possible to realise, and not always reasonable economically. Forest fire control authorities have begone to understand that the policy leads to depletion of fire control resources far before the beginning of the forthcoming really dangerous fire situation, and when this situation happens the fire control service finds itself resourceless. Additional resources mobilized from residents and local enterprises are not so qualified and experienced as the full-time firemen and so are not enough effective though expensive.

So the new approach to the solving of forest fire problem has been developed and now it is in the process of its implementation /4/. It is not the suppression of all fires notwithstanding the price but also fire management taking into account fire economics. The plan in question stipulates the list of measures for fire prevention and detection based on forecasting of time and location of forthcoming fires, according concentration of fire suppression resources on most dangerous directions of fire propagation beforehand, maximum usage of natural and artificial fire barriers, and also (perhaps, it is most essential and radical change in the previous fire policy) conscious rejection from the requirement to suppress all fires remaining some of them (which are not so damaging and dangerous) non-suppressed but only under monitoring. This new policy is (or should be) based on perfect analises of fire situation and the computerised method of making decisions. Fire situation will be monitored based on the data of the net of weather stations, patrol flights, signals of lightning detectors of the already developed system "Ochag" ("Seat of fire"), forest inventory data on types and values of forest stands endangered, forest fire maps and the computer model of forest fire propagation.

Implementation of this Plan will ensure new, more effective and qualitative level of forest protection and optimal expenses for forest fire management. Also, essential reduction of burnt areas is expected.

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