IMPROVEMENT OF A TECHNIQUE TO ASSESS ECOLOGICAL DAMAGE TO THE ATMOSPHERE FROM WILDFIRES*

MELHORIA DE UMA TÉCNICA PARA AVALIAÇÃO DOS DANOS ECOLÓGICOS PRODUZIDOS NA ATMOSFERA POR INCÊNDIOS FLORESTAIS

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ABSTRACT

Data on negative ecological consequences of forest and peat fires have been systematized. A specific woodland area of coniferous and deciduous trees in the Tomsk region has been studied. The ecological and economic damage caused by different types of fires in the 1 ha area has been calculated.

Keywords: Ecological and economic damage, wildfires, peat fires, damage assessment.

RESUMO

Dados sobre consequências ecológicas negativas dos incêndios florestais e turfa têm sido sistematizados. Reserva específica da madeira de coníferas e caducifólias raças de árvores na região de Tomsk foi investigada. Calculouse danos ecológicos e económicos, provocado por diferentes tipos de incêndios na área de 1 hectare.

Palavras-chave: Danos ecológicos e económicos, incêndios florestais, incêndios de turfa, avaliação de danosa.

Introduction

Taking into account the essential importance of the woods for the ecology and people's economic activity, a problem of rational use of forest resources and measures of its protection and reproduction becomes urgent for Russia, as well as for the whole world. Woodlands in Russia occupy about a half of the country area, therefore containing one fifth of all world reserves of the wood. Distribution and structure of the woods depends on climatic and anthropogenous factors. The greatest indicators of woodiness (over 80 %) have been noted in the middle taiga in Perm region, in Komi Republic and Central Siberia (Popova, 2015).

Annually tens and even hundred thousands of hectares of forest are destroyed by wildfires. It includes not only a loss of valuable business wood (loss of the wood can reach from 5 to 95 % depending on the kind and the fire intensity), but also an ecological damage which is shown up long in time and is capable to make impact on biocenoses in the local and regional levels).

Ecological damage to the surrounding environment is the actual ecological, economic or social losses which have resulted in the violation of the nature protection legislation, human beings' economic activity, natural ecological disasters and other accidents. The damage is shown in the form of losses of natural, labor, material,

financial resources in the national economy, and in the deterioration of social and hygienic conditions of accommodation for the population and high-quality changes (losses) of economic capacity of the country (RIA News, 2016) and (Department of forestry of the Tomsk region, 2016).

Wildfires are the sources of pollution of the surrounding environment. Despite of the extensive material damage, they deteriorate substantially the sanitary and hygienic situation; as in the result of the fire, the products of full and incomplete combustion get in the atmosphere, soil and water. The fire extinguishing substances and a large amount of water used for suppression of the fires are also capable to cause long-term ecological consequences which have not been investigated completely. While burning, various chemical transformations occur; some difficult toxic connections are formed. The quantitative and qualitative structure of products of burning depends on the properties of the forest combustible materials, an exit of flying combustible components and the time of their burning out.

Emitted substances of the peat fires are the most dangerous due to their toxicity. It is experimentally established that among products of peat burning there are saturated and unsaturated hydrocarbons, benzene, toluene and other toxic agents which exceed the value of the threshold limit in thousands of times according to their concentration (N. Kostyileva, *et al.*, 2010) and (K. Gongalsky, 2015). Taking into account that the peat fire can last for months, the volume of emissions of toxic agents increases in considerable scales.

The most dangerous negative factor of the underground fires is the pollution of the atmosphere ground layer. The forest and local fires, which are quite often the cause of the peat fires, create powerful ascending air streams which extend products of peat burning to tens of kilometers. In the absence of such streams, only the pollution of the atmosphere ground layer occurs. The smoke of such fires is extremely dangerous for people who have diseases of respiratory organs and the cardiovascular system and can cause death. Specialists of the US Department of Internal Affairs and Environment associated with the independent experts in the sphere of ecology claim that emissions of carbon from the fires in the USA and nearby countries will increase in 50 % by 2050 and will double by 2100 (S. Solovyov, 2006).

The composition of the flying and semi-flying organic substances emitted in the course of peat burning (I.J. George *et al.*, 2016) and (R.R. Black *et al.*, 2016) has been studied in the laboratory. The samples have been taken from two national parks in Northern Carolina in USA. The burning has been carried out in special installation with a possibility of the analysis

of volatile compounds within 7 hours. It has been established that the greatest fraction (60 %) represents flying organic aerosols (acetaldehyde, formaldehyde, benzene, toluene and chloromethane). As a part of firm particles, alkanoic and alkenoic organic acids and the polycyclic aromatic hydrocarbons (PAH) have been found. General concentration of polyaromatic hydrocarbons (over 12 mg/kg) has happened to be higher than similar indicators of biomass burning and, however, equal from the point of view of the level of the toxicity (J.D. Landsberg *et al.*, 2012) and (G.E. Machilis, 2002).

Now there is an insignificant quantity of the developed techniques on the assessment of ecological damage caused by the fire in industrial facilities and the woods. The methods of assessment of ecological and social consequences of the fires give results substantially differing from each other. Now damages caused by wildfires are assessed as the cost of the lost of the valuable wood. However, the ecological consequences of the fires have much more difficult and deep character.

Nevertheless, these days there is no common technique which allows calculating an actual ecological damage caused by the vegetation fires. As a rule, an ecological damage is a part of ecological and economic damage which is reflected in the cost loss of the wood. Respectively there is an urgent need of the development of a technique of assessment of ecological damage from the pollution in the atmosphere caused by natural wildfires.

Methods

According this technique (Methodic of calculation of concentration in atmospheric air of the harmful substances which are contained in emissions of the enterprises, 1986) the ecological and economic damage caused by wildfires has been designed for 1 hectare of forest vegetation on the sample of the boreal and deciduous woods. According to the technique, an ecological and economic damage consists of the wood losses (m^3) and losses of its cost (in Rubles). Losses of the wood are defined taking into an account the look and the intensity of the fire, breed of a tree and average diameter of its trunk. The purpose of this article is to develop a methodology for assessing the environmental damage to the atmosphere from forest wildfires.

The following basic data for calculations have been accepted:

- Specific reserve of the wood (153 m^3 for coniferous breeds and 145 m^3 for deciduous ones (per 1 hectare).

- Average intensity of the fires.

- Average diameter of trees trunks (25-32 cm).

The coefficients of the wood loss depending on the tree breed and the type of the fire are presented (TABLE I).

Results and discussion

Environmental damage from pollution of the natural environment is defined as the sum of the costs of reimbursement of damage caused by individual sources within a certain territory. However, there is no single methodology that allows efficient calculation of direct ecological damage from forest fires, not only in the territory of the Russian Federation, but also in the territory of a number of developed countries of the world. The developed methodology is designed to calculate in value form the amount of damage caused to the environment by forest natural fires.

Forest fires are accompanied by air emissions of a significant number of different small gas components including carbon oxides (CO, CO2), nitrogen oxides (NO, NO2), sulfur dioxide (SO2), as well as aerosols, fly ash and soot. Such emissions have a significant impact on the quality of the environment, produce negative effects on human health, affect climate and visibility conditions.

We are proposing to use the coefficient of loss of forest combustible materials, which should be taken in consideration of the composition of forest combustible materials, the peculiarities of certain types of fires as well as the specific density of a particular type of wood. These coefficients accurately reflect the strength and specificity of each specific type of fire and detail the calculations.

Losses of the wood in m³ are presented (TABLE II).

The cost of losses of the wood is calculated considering the correction coefficient in relation to the rate of forest taxes at removal distance which is 0,72 taking an average diameter of plantings equaled 24 cm. The current rate of forest taxes for the business wood of the average category of fines according to the second category of dachshunds equals 23 RUB for 1 m³. The damage from the wood losses is presented in TABLE III. If the sale of the wood remains possible after the fire, the size of the damage is subtracted from the cost of the wood which is suitable for sale.

TABLE I - Basic data for calculating the ecological and economic damage.

TABELA I - Os dados básicos de cálculo de dano ecológico e econômico.

Breed of the tree	Wood reserve (per 1 hectare)	Percentage (of the general stock) of the died-off wood and expected subsequent smasher			
		Local fluent fire	Local steady fire	Peat fire	Crown fire
Larch	145	5	25	70	15
Pine	153	10	35	75	90
Cedar	153	15	5	80	75
Fir-tree	153	20	60	95	95
Fir	153	30	85	100	95
Birch	145	20	55	95	55
Aspen	145	7	30	95	30

TABLE II - Loss of material for 1 hectare.

TABELA II - Perdas da madeira por 1 hectare.

Breed of the tree	Losses of the wood, m³			
	Local fluent fire	Local steady fire	Peat fire	Crown fire
Larch	7,25	36,25	101,5	21,75
Pine	15,3	53,55	114,75	137,7
Cedar	22,95	7,65	122,4	114,75
Fir-tree	30,6	91,8	145,35	145,35
Fir	45,9	130,05	153,0	145,35
Birch	29,0	79,75	137,75	79,75
Aspen	10,15	43,5	137,75	43,5
Total damage from the fire	161,15	442,55	912,5	688,15

TABLE III – Damage from timber loss for 1 hectare.

TABELA III – Dano de perdas da madeira por 1 hectare.

Breed of the tree	Correction coefficient	Tax, RUB.	Cost of losses of the wood, RUB.			
			Local fluent fire	Local steady fire	Peat fire	Crown fire
Larch	0,72	23,0	120,06	600,3	1680,84	360,18
Pine			253,368	886,788	1900,26	2280,312
Cedar			380,052	126,684	2026,944	1900,26
Fir-tree			506,736	1520,208	2406,996	2406,996
Fir			760,104	2153,628	2533,68	2406,996
Birch			480,24	1320,66	2281,14	1320,66
Aspen			168,084	720,36	2281,14	720,36
Total damage from the fire			2668,64	7328,62	15111,00	11395,76

Conclusion

According to the given results of calculations, it is possible to draw the following conclusions.

In general the ecological and economic damage from the fires to the boreal and deciduous woods can be characterized as considerable. Annually about 300 thousand hectares of forest plantings are destroyed by wildfires that results in economic damage estimated in 60 billion rubles.

The greatest ecological and economic damage is caused by the peat (underground) fires and the riding fires. Peat fires destroy trees completely leading to their death; burning out of the soil and its excessive fertilizing with the ashes leads to changing of the mode trees life, when most of trees are depressed and often die.

Riding fires are the most dangerous, spontaneous and powerful. They cover crowns and, due to their extremely quick speed, extend to huge territories. Because of the riding fires, as the tree burns out entirely, the valuable business wood is destroyed completely and therefore becomes out of sale.

Coniferous breeds of trees (pine, cedar) suffer from the fire most often. However, these breeds of trees are the most widespread in Siberia. This fact also influences the speed of the wildfires distribution and, as a result, increases an ecological and economic damage.

The situation with the wildfires has been worsened by the changes in forestry. Recently the number of works on monitoring and aerial surveillance of the woods has been reduced, the material and technical resources have been exhausted and the personnel list of forest firefighters in the services has been cut down. All this leads to the impossibility of timely and effective forecast, localization and suppression of the wildfires and it results in the increase of ecological and economic damage.

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