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# Analysis of innovative ways to eliminate forest fires in order to minimize environmental damage

A M Gazizov<sup>1,2,3</sup>, E V Popova<sup>1</sup> and R R Yangirova<sup>1,3</sup>

<sup>1</sup>Ufa State Petroleum Technological University, 1 Kosmonavtov str., Ufa, Republic of Bashkortostan, 450064, Russia

<sup>2</sup>Ural State Forest Engineering University, 37 Sibirsky Trakt, Yekaterinburg, 620100, Russia

<sup>3</sup>E-mail: ashatgaz@mail.ru; regina-moda@mail.ru

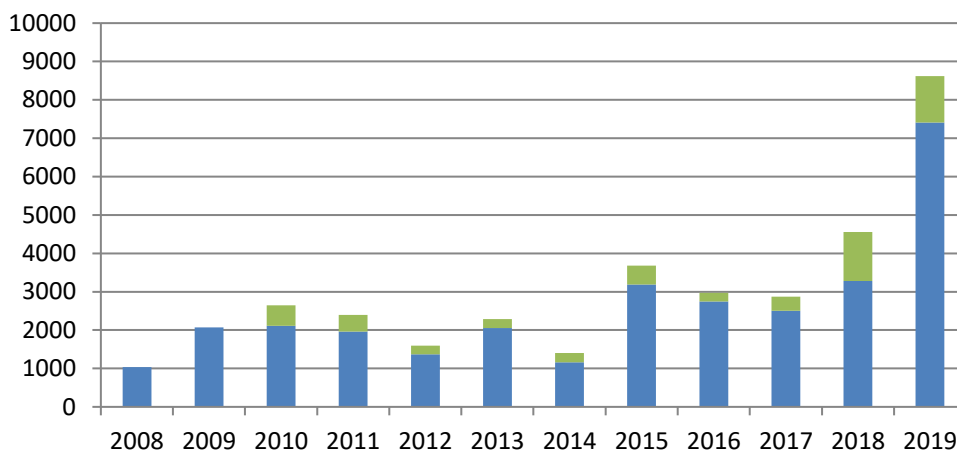
**Abstract.** Despite the accelerated development of science and technology in the world there are many different kinds of accidents, disasters associated with the death of people, the occurrence of serious environmental violations, etc. Natural emergencies are becoming more relevant today. Since forest areas occupy almost 50% of the entire area of Russia, research on ways to eliminate emerging fires in these areas is necessary. The purpose of the work is to recognize the types of forest fires, the causes of their occurrence, study the main methods of combating forest fires and consider the most effective measures to prevent forest fires and organize monitoring systems that will minimize economic, environmental and human damage. In addition, to study what novelties in the field of extinguishing forest fires await us in the near future, therefore, this article considers the existing and applied methods of fighting fires in our country, modern technologies in extinguishing forest fires, as well as the features of new equipment.

## 1. Introduction

Wildfires - Dangerous and dynamic processes that occur, as a rule, accidentally in time and space, often in inaccessible places, are a very inconvenient object to study and affect. From the point of view of control theory, these are objects with distributed parameters of the type of moving wave in a non-stationary and anisotropic medium on the surface of the Earth. The management of such objects is also spatially distributed [1].

Natural forest fire emergencies and the rapid management and detection of forest fires are relevant. The purpose of this work is to identify the types of forest fires, the causes of their occurrence and to study methods of combating forest fires that will minimize economic, environmental and human damage. Every year, a large number of forest fires are recorded in Russia, which cause great harm to the ecology, population and economy of the country [2]. Fire refers to the uncontrolled spread of fire, which covers large areas of land. These include forest, steppe, peat and other species [3]. Forest is the most common. The following figure 1 shows statistics on the areas of land that were subjected to fires in Russia.





**Figure 1.** Area covered by fires in the Russian Federation, thousand hectares.

This, from the above diagram (Fig. 1), where the area of non-forest land covered by fires and the area of forest fires covered by fires is marked with green color, it can be seen that the area of forest land covered by fires increases significantly every year. And if in 2008 this area was 1036.1 thousand hectares, then in 2019 this figure is 7408.4 thousand hectares.

What is required for effective disaster management, such as fire? The article attempts to identify put and solutions to this problem. Of course, to eliminate the fire, you must first stop the combustion process. Limiting oxygen access is the most effective way to stop the burning of forest combustible materials. Most often, this is carried out using chemical powders and solutions, explosives, a device for protective mineralized strips and various other structures [4].

**2. Materials and methods**

In order for nature to function effectively and help maintain people's well-being, other ways are required to help prevent forest fires in inaccessible places, reduce the cost of extinguishing fires and minimize the harm caused by nature that occurs when extinguishing fires. There are different methods of extinguishing fires: direct and indirect [5]. The first method is used when you can immediately start extinguishing a fire or create a barrier strip near it, and the indirect method is used when you select a fire stopping line at a certain distance from the edge of the fire. This method is used if it is necessary to take firefighters to a suitable place to create a support strip, reduce the strip and reduce the time to create it [6].

Effective control requires high-quality monitoring and forecasting at different levels: satellite monitoring, due to its low level of detail, is useful for the overall picture, while on-site monitoring (for example, through aviation) is useful for operational monitoring [7]. Table 1 presents the classification of forest fire monitoring types and methods.

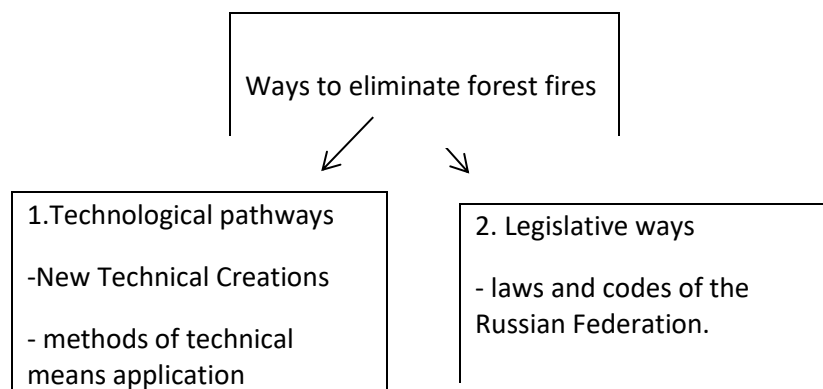
**Table 1.** Types and methods of forest fire monitoring.

Ground monitoring	Aviation monitoring
- Visual Method	-Unmanned aerial vehicles
- Observation Fire Towers	-Visual method
-	-Video surveillance
-	-Thermal imaging
-	-Space monitoring

Considering Table 1, visual inspection is a special tower that is equipped with communication and is located in which the forest is not located and is needed to determine the direction of the fire.

Satellite research is a method when using a scanner to take images in the infrared spectrum that indicate where exactly the source of ignition and the temperature difference. Ground monitoring to determine the place of fire is video surveillance, information from these devices is transmitted through Internet, GSM or radio communication.

The ways of elimination of forest fires can be divided into groups (figure 2).



**Figure 2.** Ways to eliminate forest fires.

Technological ways include new technical developments, methods of using technical means and improvement of previously used ones. Other ways are preparation of observation, extinguishing and prevention of fire in the forest [8].

Technological innovations, rapidly entering the processes of extinguishing fires, are technologies for the rapid creation of fire barriers. They are necessary to limit large forest fires and natural fires in the steppes. Previously, forestry tractors were used to extinguish fires, which were with special plows that create mineralized fire bands and prevent the spread of fire. But such a technique also had disadvantages with howls [9]. In addition to the cost of laying such a mineralized strip, it was necessary to take into account the time for delivering the machine to the extinguishing site and the possibility of using the equipment in conditions of inaccessibility.

Therefore, previously in such situations, manual labor was always used. Parachutists-firefighters threw a helicopter into the fire area and created mineralized stripes with their own hands and hands using a chancel tool. To prevent fire, ranching fire extinguishers with water were used. This method, of course, also exists today, but to facilitate the work of firefighters, many new technologies are invented and introduced. Various methods of creating fire-retardant support strips using effective fire extinguishing compositions are being implemented.

**3. Methods and results of research**

Thus, the cost of the mineralized strip is shown in Table 2 below, and the method is shown in figure 3.



**Figure 3.** Creation of mineralized strip by mechanized method.

**Table 2.** Worthiness of mineralized strip creation works.

Method name	Cost of works per 1 km
Mechanized method	4700 rub/km
Method using fast-solidifying non-combustible mineral foam	2291 rub/km

Thus, it can be seen from Table 2 that it is advantageous to use non-combustible fast hardening mineral foam. This method of extinguishing is shown in figure 4.



**Figure 4.** Fire extinguishing method using fast-solidifying non-combustible mineral foam.

This method is 51% cheaper than using mechanized method. Also, the main advantage of this method is the cost savings and the ability to use fire hazardous places where it is impossible to deliver equipment.

Together with the above methods, a method of creating support strips from fast-hardening foam by aviation is also being developed. Ultimately, tests of helicopter drain devices for the use of fast-hardening foam with a dosage of up to 0.5 l/m<sup>2</sup>, the length of the foam strip per drain was from 500 to 700 meters.

Thus, it is advisable to use such foam in open areas and on rare plantings, where it will help create a long-term non-combustible fire obstacle [10].

Also, to extinguish fires in forests in the absence of equipment, professionals of the FBU Avialesukhda developed a ranching fire extinguisher ORM-4/25. It is used to extinguish steppe fires with a sprayed jet of fire extinguishing composition under pressure and about masonry of the main strips of foam, as well as for spraying forest from pests. The efficiency of this fire extinguisher is 3.7 l/min at a jet pressure of 25 atmospheres. The fact that it significantly increases the productivity of work on fire

extinguishing, reduces costs and is convenient when transporting carts in a stuffy way to forest extinguishing places is its huge plus [11].

The ground-blower, called GR M-0,25/5, was also invented. It is convenient for laying mineralized fire-fighting strips, especially in anhydrous forests and extinguishing the edge with soil in plantations with a litter thickness of up to 10-15 s. The device is detachable, divided into parts, which allows reducing dimensions during transportation to hard-to-reach areas [12].

Unmanned aerial vehicles are used to observe fires with the ability to deliver goods to destroy fire. They are able to fly in different directions and without changing speed, move in different climates, in increased turbulence and in any direction of the wind, both at night and during the day.

"The Siberian Scientific Research Institute of Aviation named after SA Chaplygin" proposed a promising modernization project for the An-2 aircraft to increase economic efficiency and reduce costs during fire monitoring and throwing firefighters near fire in hard-to-reach areas [13].

They also return to the early methods used. The creation of artificial sediments is one of these methods. This method was introduced into the Forest Code by the Federal Law of 2306 2016 N 218-FZ at the FBU Avialesukhda, as part of a state task, carries out measures to artificially cause precipitation in order to extinguish forest fires. It is necessary to use this method in the near future using previously created equipment, while the new one is still being developed. But even now it has shown its effectiveness. So, in 2016, an experiment was conducted in the Baikal region, where we managed to cause three daytime rains in the area of foci of complex forest fires.

Also, for the fight against forest fires, aerial photography of the fire is of significant importance. This survey service consists in automatic detection of data, where all data on forests, areas of floors and other objects are included. Fire detection is carried out by estimating the degree of infrared radiation and the difference in spectral ranges. Infrared channels allow you to evaluate the entire burning area, show the dynamics of fire development at a certain time, the force of fire in the areas and the area of the already burned area.

Such a survey is carried out using such devices as multicopters (figure 5), equipped with a special mobile complex for aerial photography conducted in the IR spectrum.



**Figure 5.** Aerial shooting using multicopter in case of fire.

Fire data can be completely different, based on the images received during the fire. Some can only show horse fires, while others with high-precision camera resolutions allow even minor peat fires to be analyzed. You can also estimate the area of the hearth.

#### **4. Conclusion**

The main content of the study is based on the experience of extinguishing forest fires in inaccessible places. The main study focuses on the problem of extinguishing and finding new innovative ways to prevent and extinguish forest fires. It is also determined that conducting observations using aerial

shooting will significantly reduce the likelihood of fires, prevent possible centers of their occurrence, which makes aerial and space shooting an important tool for the work of fire brigades.

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