The use of GIS technologies for the rapid detection of forest fires and monitoring the forest fire situation

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Abstract. The article describes the use of GIS technologies for the rapid detection of forest fires. Today there are changes in this situation due to the widespread and successful introduction and development of GIS technologies in this process. These changes have a positive connotation. It is important to note that this process today is much cheaper than before, which is reflected in the development of service architecture and the process of integrating various data and formats.

1 Introduction

The relevance of this article is because the natural, climatic, and economic conditions of the development of the Russian Federation determine an increased risk of emergency situations of various kinds for the country. Forest fires are one of them.

A fire is understood as uncontrolled burning outside a special focus, which can lead to mass injury and death of people, as well as environmental, material, and other damage.

Statistics say that since the beginning of the fire season in Yakutia, more than 500 forest fires have been registered. In the same period last year, 1,328 forest fires were registered on a total area of 4,359,442.77 hectares.

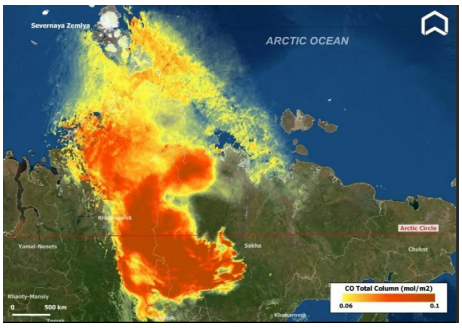

Fig. 1. Map of forest fires in Yakutia.

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Smoke from forest fires periodically covers the regional capital. In the air over Yakutsk, the maximum permissible concentration of chemical substances has now been exceeded.

On August 2, the situation with natural fires in the Srednekolymsky district of Yakutia worsened. The fire approached the settlements of Nalimsk, Khatyngnakh, Argakhtakh and Oyusardakh [1].

Figure 1 shows a map of forest fires in Yakutia [2].

2 Materials and methods

It is important to pay attention to the fact that there are currently three forest fire monitoring zones in Russia:

- Ground survey area. In this area, as a rule, the road network is widely developed. Therefore, getting there will not be difficult. This zone includes areas that are mostly populated: the European part, forest areas along the Trans-Siberian.
- Aviation surveillance zone.
- Satellite monitoring zone. This zone includes Siberia, the Far East, etc. In most cases, these areas are difficult to access, so there is no ground patrol. The reason for the lack of air patrols is that it is difficult and costly.

After ignition, that is, the occurrence of a fire, its spread occurs due to the transfer of heat released in the fire front by convection, conduction and transfer of burning particles to a fresh portion of the organic mass, resulting in its heating, drying and pyrolysis. After that, the combustion of pyrolysis products occurs, which contributes to the movement of the fire front with the release of ash. Then the same process is also repeated. And this happens until the entire stock of organic mass burns out.

3 Results

Currently in Russia there is a system aimed at fighting fire. This system provides a level that meets modern forest fire protection requirements. However, to organize and support a system for detecting and extinguishing forest fires throughout the forest fund of Russia, the resources that are available today are practically not enough. That is why we can observe that the level of efficiency, especially in those territories that have the status of specially protected areas, has been significantly reduced.

In this regard to prevent forest fires it is necessary to use high-quality and modern technologies. Today, these are various kinds of software products based on a geographic information system.

It is important to pay attention to the fact that GIS for the rapid detection of forest fires and monitoring the forest fire situation has been used since the end of the last century.

The tasks of a geographic information system include the following:

- spatial integration of operational data, analysis of the current fire situation,
- processing and provision of standard information products necessary for making decisions on the detection and extinguishing of forest fires,
- preparation of reporting cartographic information.

It should be noted that for the initiation and maintenance of combustion, the presence of the following components is necessary, among which the following are distinguished:

The main condition for the occurrence and maintenance of the combustion process is the presence of three components:

- combustible substance,
- oxidant,

– source of ignition.

This is the main condition for the combustion process, without which it is impossible to imagine its occurrence and, of course, its spread.

Interacting with each other, oxygen and a combustible substance form a combustible system. At the same time, the ignition source contributes to the development of a combustion reaction in the combustible system. If the mode is set, then this contributes to the fact that the reaction zone becomes the source of ignition.

It should be noted that in the Fundamentals of the State Policy of the Russian Federation in the field of protection of the population and territories from emergencies for the period up to 2030, the use of remote monitoring systems for emergencies, including using spacecraft [3].

Using satellite images, it is possible to assess the state of forests according to various vegetation indices, which are indicators calculated during the survey in different spectral ranges. Such indicators can provide information about the characteristics of the vegetation, about the state of the site after the fire, as well as about the process of its restoration [4].

The undoubted advantage is that the spectral characteristics of forests can be traced absolutely after any impact. So, for example, if needles have fallen or deforestation has occurred, then we can see this on a satellite image.

One cannot ignore the fact that geoportals, which are electronic geographic resources located on the World Wide Web, can also be used to monitor emergencies. One of the most important advantages of geoportals is that they can be used without any special software. In addition, absolutely anyone can use the geoportal, since, firstly, as a rule, they are in the public domain, and, secondly, special knowledge is not required to use them.

The use of geoportals provides an opportunity to work with data of various types. Of course, this is a great advantage of geoportals. Despite this advantage, it should be remembered that absolutely all information must go through a pre-processing stage before being placed on the geoportal.

It is important to note that the GIS includes the following subsystems [5] (Figure 2):

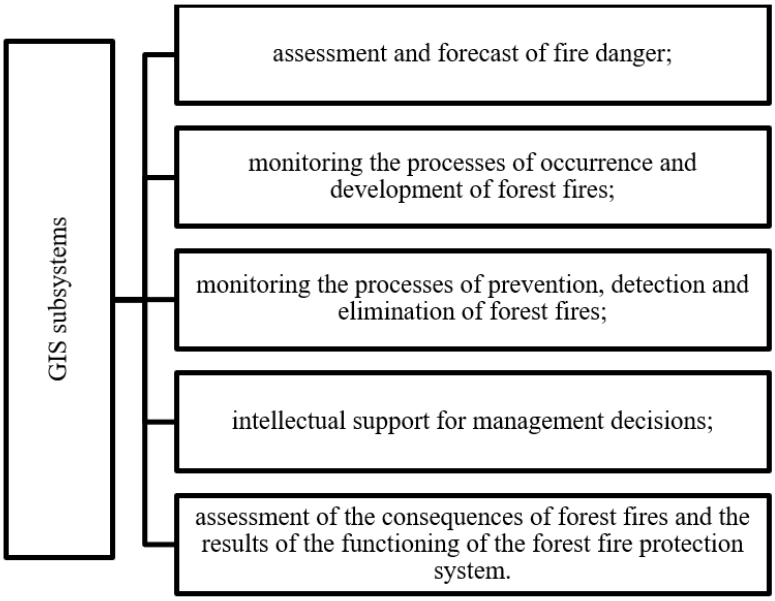

Fig. 2. GIS subsystems.

We shall note that the information in the GIS monitoring of forest fires in terms of periodicity can be classified as follows [6]:

- Conditionally permanent information – updated less than once a year.
- Seasonal information - updated 1-2 times a year.
- Operational information - updated at least once a day.

All information accumulated is stored in a data bank. However, it should be noted that its structure may be different, as it depends on which level of GIS is considered. All this contributes to the formation of a set of attributive data, as well as satellite images and digital maps.

When applying certain GIS technologies, it is necessary to use minimum time indicators. There is no doubt that this will help to avoid significant damage and, of course, the most important thing - victims.

Thus, one of the promising areas for detecting and eliminating forest fires in the initial period, which supplements ground and airborne detection, is the use of information obtained from modern satellite systems. To do this, it is necessary to create a forest fire monitoring system, which includes [7]:

- geoinformation hardware and communication complex;
- programs for processing digital satellite information;
- technology for the use of satellite information for the purpose of prompt detection of forest fires and monitoring of the forest fire situation throughout the forest fund.

4 Conclusion

In conclusion, we note that today the problem of fire safety remains the most urgent and serious of all possible. And despite the fact that humanity is taking all sorts of measures to reduce the number of fires and outbreaks, the results leave much to be desired. It should be noted that currently 1,146 people are involved in the firefighting, including 709 employees of the parachute fire service, 217 employees of the forest fire service, 68 employees of the State Fire Service and the Ministry of Emergency Situations, 152 volunteers from the local population, 110 pieces of equipment were involved.

Geoinformation applications, which allow solving issues related to the integration of operational data obtained from various sources, are one of the most effective means, the use of which is aimed at monitoring and assessing the consequences of an emergency.

It should be noted that this year the authorities reported on high readiness, funding from the federal center was increased by more than five times, and the state of emergency was predicted this year back in May. That is why the situation is much better. In 2021, millions of hectares of taiga were burning, this year hundreds of thousands are burning, this, you see, is a fundamental difference. But nevertheless, they let the fire go to the settlements. In this regard, the state of emergency in the forests of a regional nature continues to operate on the territory of the republic. Also, in Yakutia and the Khabarovsk Territory, an inter-regional emergency regime at the federal level has been introduced.

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