Assessment of forest fire in Bulgaria

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Abstract. Bulgaria is exposed to a number of natural hazards and risks negative consequences have a significant impact on the environment and the population, industry, infrastructure, cultural heritage, etc. Forest fires account for the largest number of these disasters.In the present work a statistical analysis of the forest fires in Bulgaria for the period 2000-2019 is made. The present paper also proposes an idea for an early warning system for fires. The idea is to work on early forecasting, which will help to timely notify municipalities and regional fire departments in order to quickly control the fire and its consequences.

1 Introduction

Forest fires have become a global disaster, causing enormous damage to forests and forestry around the world. These fires also have a significant impact on the ecological balance of the entire planet.

In general, forest fires have a negative impact on the economic, social and environmental condition of individual countries and entire geographical areas. The results of forest fires lead to the destruction of huge amounts of valuable wood, disruption and deterioration of forest plantations, deforestation of vast areas, deterioration of the protective functions of forests, reducing their water protection role, increasing soil erosion, especially in mountainous areas. At the same time, the conditions for agricultural production are deteriorating, animals and people, industrial buildings and dwellings, infrastructure and other sites directly or indirectly affected by the fire are being exposed to great danger.

According to forest fire statistics, 10 to 15 hectares of forest are burned each year worldwide, and in some years 20 million hectares [1]. In the European Union alone, an average of 480,000 hectares of forests have been burned each year over the last 30 years, 85% of which are in the Mediterranean region [1].

The data from our forest fire statistics show that for the last 20-25 years on average in our country about 10,000 ha of forests are burned. The forest territories burned for the same period occupy approximately 5% of the total forest territory of our country [1].

Statistics also show that as a result of forest fires and the fight against them, the number of dead and injured people is increasing in Australia, Russia, Greece, Italy, Portugal, Turkey and elsewhere. In countries such as the United States, Russia and Turkey, fighting forest fires is seen as an element of their national security [1].

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Significant human, financial, material and scientific resources are allocated to solve these problems related to the negative consequences of forest fires and their fight at the national, regional and international levels. Significant funds in this regard are also set aside in the European Union's fire protection programs for the Union's forests. The main objectives of the programs for resource provision of measures and measures for the protection of the Union's forests from fires are aimed at reducing the number of fires and reducing the size of the burned areas [2-4].

The aim of the current work is to make an assessment of risk of forest fires and to suggest a system for early fire warning.

2   Type of forest fire

There are three fuel layers in the forest: below the underground, surface and crown.

A forest fire can start in one or any combination of these layers. However, most fires occur and burn on the surface of the fuel. Sometimes surface fires burn intensely and spread to tree crowns. Here the fire will reach the tops of the trees with a high degree of distribution, but eventually it is possible to return to the surface layer of fuel. Under certain circumstances, fire can also be observed in the underground layer. There he can stand "asleep", burn slowly and wait for them to be rekindled in the surface fire, and from there "jump" up to become a rapidly evolving peak fire under favourable fuel and weather conditions.

The three main types of forest fires that occur are:

1) Underground fires
2) Surface (bottom) fires and
3) Crown fires

Underground fires burn the organic material below the surface and will spread slowly by itself (Fig. 1). The depth to which it burns will vary depending on the depth of the decomposed and partially decomposed vegetation and the drought conditions. It can form from a few centimeters to a depth of one meter. Underground fires can be a problem in controlling them due to the difficulty of finding and extinguishing the fire.

• weak - up to 25 cm burning of the peat layer;

• medium - up to 50 cm;

• strong with burning of the peat layer over 50 cm.

Surface ground fire is a fire that burns in the fuel on the surface of the earth. This category includes burning: logs, shrubs, grass and waste on the surface (twigs, dry leaves, needles and other materials) or something that can burn on the ground (Fig.2).

• low surface fires with flame height h_{fl} up to 0,5m and initial velocity V_1 up to 1m/min;

• medium with up h_{fl} to (0.5 ÷ 1.5 m) and V_1 up to (1 ÷ 3 m / min);

• - strong with $h_{fl} > 1,5m$ and $V_1 > 3m / \min$

Crown fire is developed from a surface fire, where the type, volume, and vertical arrangement of fuels will transfer fire and gases from the surface to the corona fuel layer (Fig. 3). Such an arrangement of fuels represents a "stepped" effect. Peak fire usually occurs in coniferous forests with continuous crown cover. Fires that burn in the corona layer are extremely difficult to control because they spread quickly enough.

• weak - with V_1 up to 3 m / min;

• medium – with V_1 up to (3 ÷ 100) m / min;
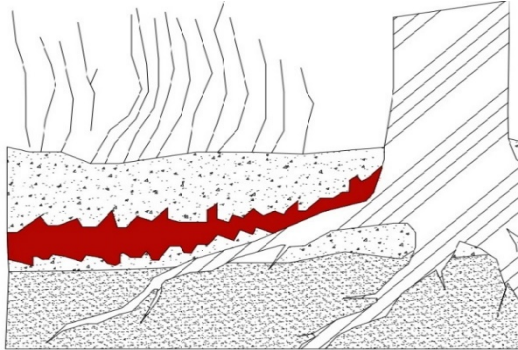
• strong - with V_1 over 100 m / min.).

Fig. 1-Scheme of ground fire.
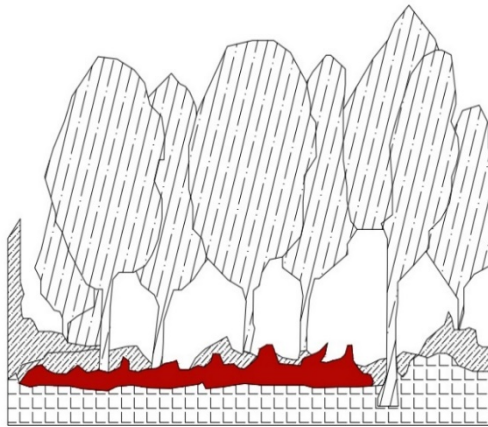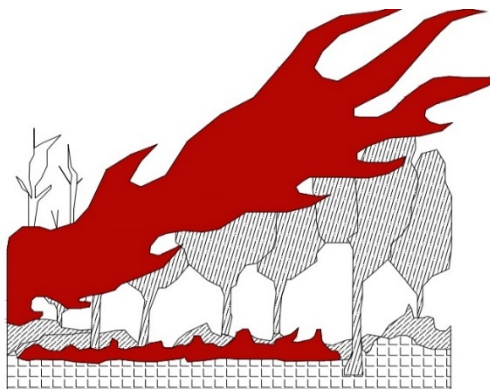

Fig. 2 Scheme of surface fire.

Fig. 3 Scheme of crown fire.

3   Forest fire in Bulgaria

Bulgaria has area of 111 thousand km², the agricultural and forest fund occupy 53 and 33.8% of the territory of our country, respectively. These areas are under constant threat of natural disasters and a large number of crises. At figure 4 is given the distribution of natural disasters in Bulgaria for 2020.It can be seen that fire is the biggest part form them.
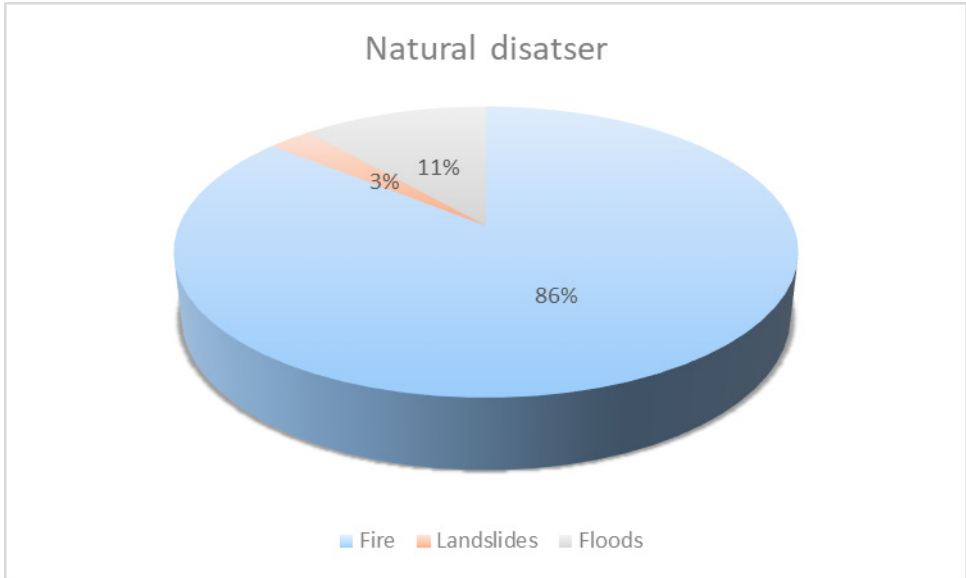

Fig. 4 Natural disasters in the Republic of Bulgaria in 2020.

The analysis of the fire activity in the forests in our country and the subsequent assessments include data for the period from 1980 to 2019 (39 years) [5].

For the period from 1980 to 2019, a total of 16,362 fires occurred in the country, or an average of 420 per year [1].

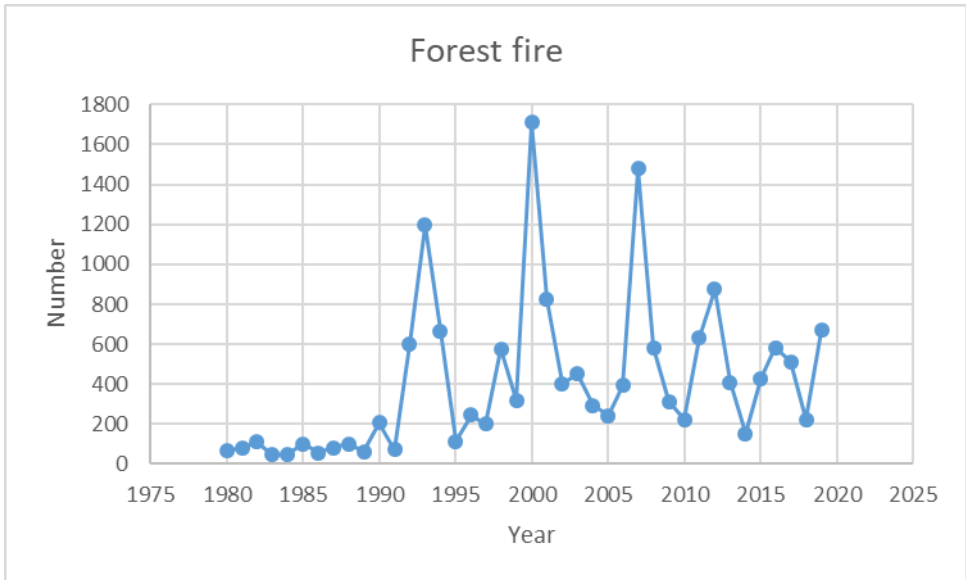At fig. 5 are presented the number of fires that occurred in the period 1980 - 2019.

Fig. 5 Number of fire in period 1980-2019.

It can be said that the number of fires by year is an extremely dynamic variable, characterized by great unevenness in different years. It can be said that there is some cyclicality of the peaks over the years. For the period 1980-1992 this peak is observed on average every two years. Then this peak begins to be observed on average at 7 years - 1993, 2000, 2007, 2012 and 2019. The number of fires that occurred during this period exceeds the national average number of fires is given in Table 1.

Table1. Deviation, in times, from the average annual for number of fire.

Year	Deviation, in times, from the average annual
1993	2,84
2000	4,07
2007	3,52
2012	2,08
2019	1,59

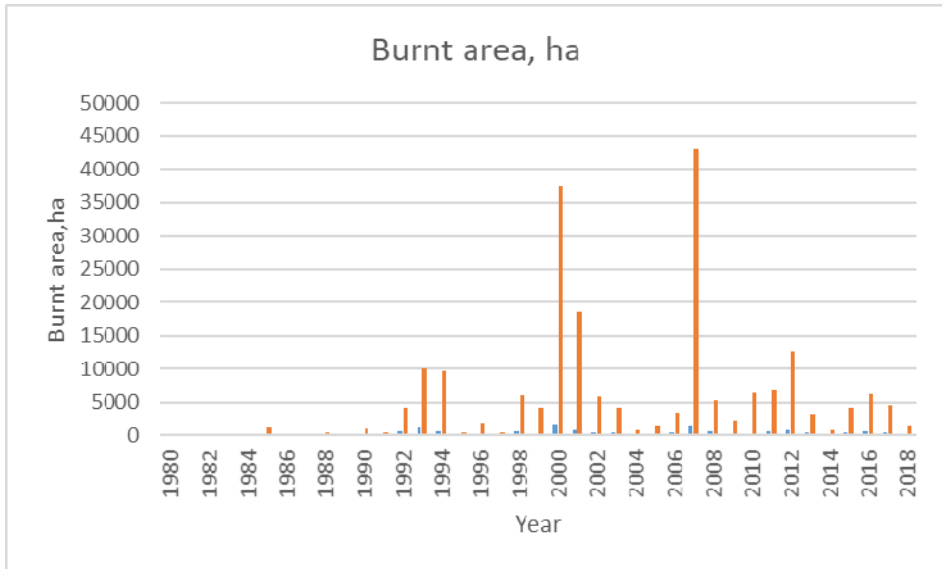Figure 6 shows the number of burned areas by year for the same period (1980 - 2019).

Fig. 6 Burnt area in Bulgaria for period 1980-2019.

The graph shown clearly shows the large unevenness and the direct relationship of this value with the data on the number of fires (Fig. 1). The deviation in times compared to the annual average for a country (5567 ha) in the period is given in Table 2 for the peak fire years - 1993, 2000, 2007, 2012 and 2019.

Table 2. Deviation, in times, from the average annual for burnt area.

Year	Deviation, in times, from the average annual
1993	1,8
2000	6,72
2007	7,72
2012	2,29
2019	1,1

4   System for forest early warning

Based on the data shown for forest fires and burned areas of forest fires in Bulgaria, it can be seen that this is a huge problem for the country. There is a great need for early warning of the population and the services for fires. The earlier a forest fire is detected, the smaller the consequences will be.

The modern development of high technologies makes it possible to significantly reduce the time for the transfer of information, as well as more mass and more effective notification of the population. The higher level of knowledge that people have thanks to modern means of communication and access to information of all kinds helps (especially in more technologically advanced countries) to use new early warning systems. The main guidelines in these advanced systems include the use of "smart sensors" capable of "alone" deciding when a disaster is dangerous (if, for example, it is strong enough, threatens more

people or dangerous objects, etc.) skip several of the stages typical of the old early warning systems - determination of the parameters of the phenomenon, assessment, decision-making by an operator or a commission for broadcasting the warning. Skipping these stages and using modern high-speed means for transmitting information and transmitting messages reduces time and significantly speeds up the efficiency of systems [6-9].

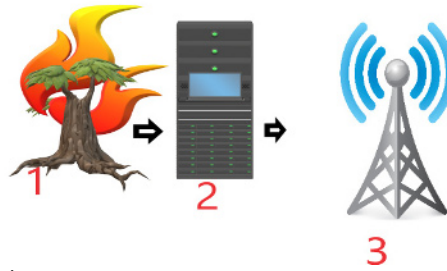A schematic of the system proposed in the present development is given in fig. 7.

Fig. 7 Schematic of early warning system.

Based on the above, the article offers an idea of a forest fire warning system. The early warning system will be located in places with a high risk of fire. The method of operation is as follows: The sensors (1) are located at a certain height on trees. These are temperature sensors, which when the temperature changes above 150^0C will signal to the control point (2) a signal that there is an increase in temperature in the area and most likely a fire will start to develop. The control point will immediately transmit the information to the mobile network and the disaster management services (3). This will help the services to react quickly and warn the population about the impending fire.

5   Conclusions

An analysis of forest fire in Bulgaria for period 1980-2019 is given. This can be very helpful for assessment of the risk of forest fire in Bulgaria. It is presented a new idea for early warning systems for forest fires, which are extremely necessary, and in order to protect forests and forest ecology. The proposed scheme of a fire warning system can help reduce damage to forests, as well as to warn the population located near places of forest fires.

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