Forest fires and forestry firefighting organization

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Abstract. The article discusses the situation with forest fires in the Samara region and suggests measures to combat them. The purpose of the work is to analyze the occurrence of fires in the Samara region, including in the Kinel-Cherkasy forestry. The study intends to solve the following problems: - to study the dynamics and causes of forest fires in the Samara region and the Kinel-Cherkasy forestry; - determine the extent of damage caused to the region forests by fires; - to analyze measures to improve the fire situation. Research methods: the abstract-logical method was used to assess the general situation with forest fires in the forestry of the Samara region; situational and system analyzes, econometric methods and the method of expert evaluations - to determine measures to improve the fire situation. Forest fires have a significant impact on the situation with the forests in the region. If in 2017 the share of forests killed by fires was less than 10%, then in 2010 and 2018 - more than 94%. In absolute terms, the minimum in 2018 was 68.8 ha, the maximum was 1687 ha (2010), which amounted to 0.25% of the region total forest area. It is necessary to carry out fire and preventive measures, taking into account the fire hazard situation in the area and the anthropogenic load on forests and adjacent territories. Based on the analyzed data, it is necessary to ensure the conservation of adult forest plantations and unclosed forest crops, taking into account the use of neighboring territories by farms and enterprises.

1. Introduction
The existence of the biological diversity a large part on Earth is associated with forests. The forest plays an economic, protective, resource, environment-forming, social role in human life, therefore, the preservation of the forest plantations area and species diversity is the most important task in the forests protection. One of the forest conservation main problems is forest fires. Forest fire - a spontaneous, uncontrolled spread of fire in the forest plantations area [1]. When they occur, forestry suffers huge economic damage as a result of wood stocks injury or destruction, the environmental situation worsens, animals and plants rare species die, the atmosphere is polluted, there is a threat to the population, air and ground transportation, industrial facilities [2-3].
Forest fires pose a danger not only to the forest, but also to settlements located near forests, the fire transferring from them to the people’s living territory leads to additional economic, psychological negative consequences [4].

One of the negative consequences is the valuable and relict forests destruction, the replacement of valuable trees with low-value species that are economically disadvantageous for the forestry [5].

Wildfire affects the soil and changes its physical, chemical and biological properties [6-9], as well as the abundance, biomass, activity and diversity of microorganisms [10-11].

In addition to the negative role of forest fires, the positive aspects of the fire use in forestry were also identified, thus methods such as: - preventive controlled fire burning aimed at destroying old forest litter, stubble near forest areas [12-13]; - management of controlled fires, in which combustible materials are burned in the path of the forest fire main wall, which helps to increase the width of obstacles to fire, this method is effective in forest areas inaccessible to firefighting equipment [14]; - suppression by a shock wave, that is, organized explosions, thereby undermining the main front of a forest fire, stopping its spread; reduction of forest pests in the short term [15].

2. Materials and methods
Forest fires and measures to combat them are one of the most important factors in the conservation of forest plantations in the Samara region.

The purpose of the work is to analyze the occurrence of fires in the Samara region, including in the Kinel-Cherkasy forestry.

The study intends to solve the following problems: - to study the dynamics and causes of forest fires in the Samara region and the Kinel-Cherkasy forestry; - determine the damage extent caused to the region forests by fires; - to analyze measures to improve the fire situation.

Research methods: the abstract-logical method was used to assess the general situation with forest fires in the Samara region forestry; situational and system analyzes, econometric methods and the expert evaluations method - to determine measures to improve the fire situation [16].

The results of the research are presented in tabular and graphical forms.

3. Results

![Forest resources of the Samara region on January 1](image)

**Figure 1.** Forest resources of the Samara region on January 1.

According to statistical data, at the beginning of 2019, the Samara region total forest area is 766.2 thousand ha, forest cover is 12.8%, i.e. the area is sparsely forested. Forests are located extremely unevenly - in the south 2% of the total area is occupied, in the north this indicator reaches 25% (figure
1). All forests, for their intended purpose, belong to protective forests, which are subject to development for the purposes of environmentally-forming, water-protective, protective, sanitary-hygienic, health-improving and other useful functions of forests. The predominant species: oak (25% of the area), pine - 14%, linden - 19%, aspen - 15%, birch - 9%, other species - 18%.

The age structure of forests is as follows: young growth - 10%, middle-aged - 37%, ripening - 17%, ripe - 28%, overripe - 8%. The total stock of wood of the main species is 85.1 million m$^3$, ripe and overripe - 33.0 million m$^3$. The total average increase is 1.64 million m$^3$.

Forest fires have a significant impact on the situation with forests in the region. According to figure 2, it can be seen that over the years, the damage from forest fires varies greatly in both absolute and relative terms. If in 2017 the share of forests killed by fires was less than 10%, then in 2010 and 2018 - more than 94%. In absolute terms, the minimum in 2018 was 68.8 ha, the maximum was 1687 ha (2010), which amounted to 0.25% of the region total forest area.

![Figure 2. The area of dead forest plantations in the Samara region, ha.](image)

4. Discussion
We will consider the specifics of the situation regarding the protection of the region’s forests from fires based on the Kinel-Cherkassky forestry. On its territory are located both individual forests, and partially the territory of the National Park "Buzuluksky Bor". Every year, a forestry plan is drawn up in forestry, the indicators of which for 2018 are shown in table 1.

| Table 1. Annual measures plan to protect forests from fires. |
|-------------------------------------------------------------|
| Events                                                      | Total |
| Installation and arrangement of recreation areas, pcs        | 1     |
| Maintenance and care of recreation areas, pcs                | 7     |
| Installation and operation of barriers on forest roads, pcs  | 17    |
| Creating a voluntary fire brigade, pcs                      | 1/5   |
| The fire mineralized strips creating, km                     | 22.8  |
| The fire mineralized strips cleaning and updating, km        | 359.2 |
| Conducting preventive controlled burning of brushwood, forest litter, dry grass and other forest combustible materials, ha | 605   |
| Reconstruction of forest roads designed to protect from fires, km | 1     |
| Operation of forest roads designed to protect from fires, km | 1     |
| Fireproof breaks clearing, km                                | 0     |
| Organization of firefighting equipment concentration points, pcs | 1     |
| Maintenance of stands and other signs containing information| 4     |
The budget is formed at the beginning of the year for 3 years in advance. The state assignment spells out all types of work, their volume, financing from the regional and federal budgets, as shown in Table 2.

Table 2. Budgeting for firefighting activities for 2018.

| Events                                                                 | Cost per 1 unit work, rub.       |
|------------------------------------------------------------------------|----------------------------------|
|                                                                        | total   | regional budget funds | federal budget funds |
| Maintenance and operation of forest roads designed to protect from fires, km | 30 142.8 | 0.0 | 30 142.8 |
| Fireproof breaks laying, km                                            | 2 665.0 | 426.4 | 2 238.6 |
| Fireproof breaks clearing, km                                          | 1 239.1 | 247.8 | 991.2 |
| Fire mineralized strips creating, km                                   | 559.8 | 2.1 | 557.7 |
| Fire mineralized strips cleaning and updating, km                       | 582.2 | 33.1 | 549.1 |
| Conducting preventive controlled burning of brushwood, forest litter, dry grass and other forest combustible materials, ha | 735.6 | 147.1 | 588.5 |
| Extinguishing fires in forests. Elimination of forest fire by ground fire forces, ha | 39356.8 | 0 | 39356.8 |
| Cleaning of forest plantations from clutter, ha                        | 2 019.9 | 21.6 | 1 998.3 |
| Installation of barriers, installation of barriers to limit the stay of citizens in the forests in order to ensure fire safety, pcs | 7 131.2 | 7 131.2 | 0 |
| Fire fighting, extinguishing forest and other natural fires, including with the involvement of specialized organizations, ha | 7 083.4 | 7 083.4 | 0 |
| Organization of new recreation areas, pcs                              | 41 976.3 | 41 976.3 | 0 |
| Maintenance of existing recreation areas, pcs                          | 23 182.0 | 23 182.0 | 0 |
| Mowing of fireproof breaks, mineralized strips and land plots bordering the forests, ha | 1 840.1 | 1 840.1 | 0 |

Fire propagation depends on climatic conditions, topography and forest type, degree of cluttering, and stands density [17-21]. The lower the moisture content of forest combustible materials, the weaker the flame source that can cause a fire: - with a moisture content of forest litter 26-33%, only a bonfire can cause a fire; - at a humidity of 19-25% - a bonfire, a burning match; - at a moisture content of 12-18% - the same and ashes hot from the tube; - at a humidity of 7-11% - the same and smoldering cigarette butt; - at a moisture content of 5-6% - the same and even sparks from internal combustion engines.

In open spaces, it is more difficult to stop the fire, as the influence of the wind strengthens; the grass cover becomes more powerful, the fire front increases, which complicates the fire localization. The fire shape and its area is determined by the length of the forest fire edge [22].

During inflammation detection, fire elements are identified that are necessary to predict the fire spread and extinguish [23].

There are several methods of forest protection: ground method (patrolling and extinguishing fires is done by ground means); air method (fire hazard and forest extinguishing is carried out by the aviation forest protection and space monitoring), and use of specially developed smartphone apps [24-28].

Quite often, repeated fires are observed in the former burned areas. Setting fire to the grass, they are thrown onto a deadwood, early damaged and not fully restored trees. Thus, the weakened forest area is dealt new damage, which can lead to the complete destruction of the forest, or to the emergence of the
pests and diseases focus on the burn. Repeated fire is represented by ground fire.

The total damage from a forest fire is calculated based on several indicators: - damage to young growths of natural and artificial origin; - the cost of extinguishing forest fires; - wood loss; - the cost of burnt products and objects in the forest; - expenses for clearing the consequences of the fire; - damage to the ground cover, protective properties of the forest area; - air pollution; - death of rare species of plants and animals.

The forest fires prevalence is determined primarily by the region climatic characteristics. As statistics show, with high climate humidity, the number of fires is much less than in regions with a humidity low degree. It also depends on the conifers presence in the big stand, a large amount of debris, cluttering with deadwood, trees and shrubs that died as a result of natural processes.

In most cases, the forest fires main cause is an anthropogenic factor, which manifests itself as a result of ill-considered actions, negligence, careless handling of fire, violations of sanitary and fire safety rules in forests, the use of combustible and flammable substances and objects in the immediate vicinity of forest trees litter, bonfire in the wrong places, was used by hunters during the fire hazard period.

As a rule, the fires peak occurs on the weekend, when the anthropogenic load on forests located near beaches, settlements, and at mushroom and berry gathering sites increases. Many citizens intentionally ignore the rules of conduct in the forest, fire and sanitary safety in the forests, which leads to adverse consequences. Finding the culprit and proving his guilt is sometimes quite difficult. Many fires arise from highways and railways, from abandoned cigarette butts.

Deliberate arson cases of the forest have also been reported. Of particular danger are deliberate arson attacks in several places, as this worsens the possibility of localizing a fire and quickly eliminating fires.

Based on the normative documentation of the Kinel-Cherkassky forestry, data on the fire situation, fire-fighting measures carried out in the forest, their cost, the correctness of the work, and safety precautions were analyzed.

The distribution of the Kinel-Cherkassky forestry land area by the natural fire hazard classes is shown in table 3. The average fire hazard class is 3.6 - the natural fire hazard is low.

| The local forestry                  | Total area, ha | Middle class of fire hazard | Note           |
|------------------------------------|----------------|-----------------------------|----------------|
| Forestry lands                     |                |                             |                |
| Kinel-Cherkassky                   | 22697          | 3.6                         | low burnability|
| Total                              | 22697          | 3.6                         |                |
| Forestry land previously owned by agricultural organizations | |                             |                |
| Kinel-Cherkassky                   | 1607.3         | 3.4                         | low burnability|
| Total                              | 1607.3         | 3.4                         |                |
| Total forestry                     | 24304.3        | 3.6                         |                |

The main economic sector of the Kinel-Cherkassky district is agriculture. Every year, with the melting of snow, many farms clear the stubble fields with the fire method, which is the cheapest way of cleaning. This period is the most dangerous, as last year’s dry litter burns unobstructed, but many organizations ignore fire safety rules in areas adjacent to the forest wall. Uncontrolled agricultural burns are dangerous not only for forest plantations, but also for settlements.

In 2012-2018, there were repeated cases of agricultural felling by farms. The largest fire in the territory of the Kinel-Cherkassk forestry was the fire of 2012. The cost of extinguishing it amounted to 14,750.0 rubles. The costs of extinguishing fires in the territories adjacent to the forest stands of the Kinel-Cherkasy forestry in 2018 amounted to 23,836.88 rubles. The damage to the forestry did not cause. It was not possible to establish the person whose fault caused the fire. The fire area at the time of detection was 1.5 ha. The fire occurred near the village of Vinno-Bannovo, Kinel-Cherkassky district. Even if there is no damage to the forestry, the resources spent on stopping the fire in the adjacent
territories bring losses to the organizations responsible for extinguishing fires.

After analyzing the statistic data, it can be concluded that the main cause of fires in the forestry area is uncontrolled dry grass burning in areas adjacent to forest stands and their further transfer to the forestry.

![Figure 3. Fire in the territory of Kinel-Cherkassky forestry.](image)

A large anthropogenic load on the forests of the Kinel-Cherkassky district and the development of agriculture and transport routes, the oil industry of the district requires large expenditures, both economic resources and labor.

Based on statistics for the period 2011-2017 an econometric forecasting function was constructed that characterizes the degree of forestry activities success. With a confidence of 85.6%, a significant reduction in all types of fires in the forestry area is visible. In accordance with the data in figure 3 in the near future (1-2 years) while maintaining the existing fire protection system, a further decrease in the number of fires is forecasted.

Untimely implementation of firefighting measures and insufficient work on the forest conservation promotion among citizens, heads of administrations, managers of other organizations using forests or territories adjacent to forests, leads to damage to forest stands and increases the risk of emergencies not only for the forestry, but also for settlements located near them.

In order to ensure fire safety, the entire population in everyday life must comply with certain preventive fire regulations. It is forbidden to clog the forest with household, construction, industrial and other waste and garbage. The burning of garbage exported from settlements may be carried out near the forest only in specially designated places, provided that:

- places for burning garbage (pits or sites) are located at a distance of not less than:
  - 100 m from the coniferous forest or separately growing conifers and young trees;
  - 50 m from deciduous forest or separately growing deciduous trees;
- the area around the places for burning garbage (pits or sites) should be cleaned within a radius of 25-30 m from dead trees, felling residues, other combustible materials and bordered by two mineralized strips, at least 1.4 m wide each; and near coniferous forest on dry soils - two mineralized strips, at least 2.6 m wide each, with a distance between them of 5 m.

During the fire hazard season, garbage burning is allowed only in the absence of a fire hazard in the forest due to weather conditions and under the control of responsible persons.

Propaganda of careful attitude to the forest among the population is a prerequisite for prophylactic

| Year | Total fires | Fires in the forestry | Fires in adjacent territories | Fires on lands of other categories |
|------|-------------|-----------------------|-------------------------------|-----------------------------------|
| 2011 | 44          | 4                     | 1                             | 5                                |
| 2012 | 40          | 2                     | 1                             | 7                                |
| 2013 | 57          | 5                     | 1                             | 11                               |
| 2014 | 54          | 2                     | 1                             | 13                               |
| 2015 | 43          | 2                     | 1                             | 13                               |
| 2016 | 38          | 2                     | 1                             | 13                               |
| 2017 | 36          | 2                     | 1                             | 13                               |

\[ y = -6.9286x + 61.571 \]

\[ R^2 = 0.8557 \]
fire prevention works. It is necessary to build awareness among citizens in compliance with fire and sanitary safety rules in forests, as well as a careful attitude to it. Conversations and lectures are held among students, citizens, who draw up contracts for the purchase and sale of forest stands for their own needs and organizations implementing the state task for the protection, reproduction and use of forests, with the heads of farms whose lands are located near the forestry and settlements that contribute to reducing the number of forest legislation violations cases regarding non-compliance with the fire and sanitary safety rules in forests.

Particular attention is paid to explaining the causes of forest fires and how to prevent them. Citizens are provided with contacts of specialized services in the fire detection cases.

In order to control the occurring fires and suppress violations of forest legislation in the fire and sanitary safety in forests, forestry has organized ground patrolling of the forests along specific patrol routes. All routes collectively cover all forest areas located in the forestry. Particular attention is paid to forest areas near settlements, places of citizens’ recreation, natural monuments, in places of plots development, along road and railways. The numbers of routes, their description, coordinates and patrol cars are prescribed in the plan of extinguishing forest fires annually.

The frequency of patrolling depends on the period and weather conditions prevailing in the forestry area, on the fire hazard class in the area calculated on the meteorological data basis. The increase in the number of patrols and the volume of forests firefighting arrangement, the interaction between organizations involved in extinguishing fires and voluntary squads contributes to a reduction in the ignitions number and loss due to forest fires and fires in adjacent territories.

An increase in the frequency of patrolling the forests during a special fire regime, as well as depending on the worsening weather conditions, makes it possible to increase the administrative violations detection of forest legislation (figure 4), to prevent fire or mass spread of an outbreak that has already arisen.

At least two people take part in patrolling. The forces of the Ministry of Emergencies and the Ministry of Internal Affairs are involved. During patrolling, violations of forest legislation are detected, the implementation of fire and sanitary safety rules at the timber harvesting places by citizens is monitored, conversations are held with citizens visiting the forest at the right time.

To ensure enhanced monitoring of forest fires, the information system for remote monitoring of forest fires of the Federal Forestry Agency (ISDM-Rosleskhoz) is used.

When planning fire events, it is important to take into account the proximity of forest areas to settlements, to places of frequent visits to places of recreation by citizens, forecasting weather conditions
for the next year, development of road networks, expanding the boundaries of settlements and territories of various enterprises, as well as the presence of forest fire units and their equipment and equipment for extinguishing forest fires.

The correct planning and implementation of fire prevention measures in forestry on the basis of technical guidelines for the organization of forest protection, forestry regulations and the analysis of the forestry burnability has a positive effect on improving the fire situation in the forestry.

Monitoring the sanitary condition of forests is important, as foci of diseases or pests can increase cluttering in forests and drying out of trees, which contributes to an increase in fire hazard. The most dangerous are drying trees, new and old rotted timber slash, windfall timber, snow breakage.

5. Conclusion
In the period from 2011 to 2017, 237 fires occurred on forest and non-forest lands of the municipal district. Of these, there were 21 fires in the adjacent territories. The reason for the majority of fires was the uncontrolled fall of dry crop residues on farm lands adjacent to the forests.

Therefore, it is necessary to carry out fire and preventive measures, taking into account the fire hazard situation of the district and the anthropogenic load on forests and adjacent territories. Based on the analyzed data, it is necessary to ensure the conservation of adult forest plantations and unclosed forest areas, taking into account the use of neighboring territories by farms and enterprises.

During the summer period, ground patrolling routes should be changed taking into account the needs for the protection of forest areas. It is necessary to increase the number of patrols and the number of fire prevention conversations about compliance with sanitary and fire safety rules in forests and adjacent territories, especially when establishing a special fire regime and high fire hazard classes.

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