Forest fire situation analysis over forest reserve land in Tomsk petroleum province

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Abstract. The paper delivers the analysis of space-time characteristics of forest fire ignition and spread in the North of Tomsk oblast, i.e. petroleum production area (Kargasok, Parabel and Teguldet districts). It also presents long-term and seasonal forest fire behavior including fire ignition and spread frequency (annual and seasonal), the fire season duration and their zonality. The main driving factors of forest fire ignition both human and natural ones are revealed.

1. Introduction
Experts estimate the total hydrocarbon resources of Tomsk petroleum province at 2.95 billions of tons, which makes the province one of the most prospective areas of Russian fuel and energy complex. The production and infrastructure development including transport accessibility contributes to the increasing number of forest fires on the one hand, but facilitates their discovery and suppression [1]. The fire destructs productive woodlands that could have been reclaimed and is of serious hazard to the oil and gas complex. The degree of fire danger is determined by oil and gas flammability. Among technogenic factors are oil spills, atmospheric gas pollution, failed electrical equipment [2], left wood, assarted trees and wastes [3]. Another aggravating factor is the fact that it is pine forests that are typical for the northern area of Tomsk oblast. These forests have the most fire risks potential (the geographic range of birch forests is limited up to the 57\textdegree{} of northern latitude).

The number of fires in European and North American countries has been reduced lately. It can be attributed to satellite monitoring, automatic remote sensing data processing and effective use of firefighting resources [4]. On the contrary, the number of fires in the European part of Russia has increased many-fold due to forest management reorganization, the abolition of federal fire management body and forest service staff reduction [5].

The aim of the work is to study space-time characteristics of forest fire ignition and spread in the North of Tomsk oblast, i.e. petroleum production area (Kargasok, Parabel and Teguldet regions).

The research object is the pattern of forest fire ignition and its spread over the forest reserve lands.

To achieve the aim the following tasks are to be solved:
1. to study fire behavior in the North of Tomsk oblast including fire ignition frequency (annual and seasonal), fire season duration and the zonality;
2. to forecast the rate of fire danger and compare it with factual data;
3. to distinguish natural and human factors facilitating fire ignition and spread.
2. Research object, tools and methods

The research object is forest reserve lands of Tomsk oblast that are exposed to forest fires. It is the area where the main oil and gas field facilities of the region are situated. Long-term data of Tomsk oblast forestry department were analyzed (1991-2013). To predict the fire danger in 2013 Nesterov’s method was applied with the obtained data being compared with factual ones according to the following formula:

\[ G = \sum_{1}^{n} (t - \omega) t, \]

where \( G \) is burning index of ground cover, °C; \( n \) – the number of dry days (days with precipitation less than 2.5 mm are considered to be dry); \( t \) – atmospheric temperature for 12 hours, °C; \( \omega \) – dew point, °C [6].

Statistical data processing was carried out by means of software STATISTICA.

3. Results and discussions

The research results prove that the number of forest fires varies by location and from year to year. Changes of forest fire danger in Tomsk oblast have a cyclical pattern (figure 1). The annual average number of forest fires over the period from 1990 to 2013 is 276. The fire frequencies are: about 6 years - for maxima (more than 400 fires per year) and about 4 years for minima (less than 200 fires). The intermediate fire activity peaks make a 4 to 6-year cycle. The first cycle stage, which is characterized by the increasing number of fires, lasts 1-2 years. The next is a peak followed by the second cycle stage (the decrease of fires to the minimum) which continues 1-3 years. Sharp contrasts of the graph curve and no stabilization period are particular features of the graph.

![Forest Fires, number of incidents](image)

**Figure 1.** Forest fires in Tomsk oblast over the period 1990-2013

In general, there are three peaks of seasonal fire activity in Tomsk oblast: spring, summer, with stable fires, and autumn. However, Aleksandrovskiy, Kargasokskiy and Parabelskiy districts are characterized only by stable summer fires, mostly in June (figure 2). The areas of these districts refer to the second and third danger classes of the fire danger rating, which means there is high probability of surface fire during a whole fire season. The fire frequency is quite low but the fire areas are significant, which is attributed to poor area development and difficulties in fire spot detection. The factual fire season lasts no more than 87 days.
Nesterov’s method was used to predict fire situation in 2013. The factual and predicted data show high degree of repeatability (figure 3). In northern part of Tomsk oblast the fire season of 2013 started on 10 May. 59 fires were registered over the fire season. The fire area covered 2,211 ha including 2,164.3 ha of forest area (figure 4). The figures show a decrease of 548 fires in comparison with the same period a year earlier as well as a 295,586-ha reduction of fire area.

**Figure 2.** Seasonal fire activity in Tomsk oblast (data for districts)

| District          | May | June | July |
|-------------------|-----|------|------|
| Aleksandrovsky    | 15  | 11   | 12   |
| Asinovskiy        | 8   | 5    | 7    |
| Bakcharsky        |     |      |      |
| Zarinskoy         | 39  |      |      |
| Zaprudenskoy      | 32  |      |      |
| Kolpashechenskoy | 12  |      |      |
| Krivoshenskoy     | 7   |      |      |
| Molchanovskoy     | 8   | 5    | 39   |
| Pervomayskoy      | 7   | 32   | 39   |
| Tegidetsky        | 32  | 39   | 39   |
| Tomsko            | 12  | 7    | 7    |
| Charnskoy         | 8   | 5    | 39   |
| Shtepenskoy       | 15  | 11   | 12   |

**Figure 3.** Accuracy of fire danger forecast in 2013 year in Tomsk oblast
The variables of Nesterov’s formula reflect natural factors of fire ignition and spread, which are typical of the North of Tomsk oblast. High moisture of forest fuel prevents the forest from burning most part of the fire season. However, if a long dry period occurs, moss-ground cover and debris layer become dry, which makes them the basic source of fire danger. As a result, 98.5% of all the wildfires in Tomsk oblast is surface fires, 1.4% is crown fires and 0.1% is ground fires. Another factor associated with fire ignition is coniferous (pine) forests that dominate in the region. Up to 70% of all the wildfires occur in grass pine forests. Other factors of seasonal fire activity peaks are dry periods at the end of spring or beginning of summer, hot temperatures in summer, low humidity, thunderbolts and winds bringing dry and warm air from Northern Asia, Mongolia and Eastern Siberia. Such climatic pattern facilitates all the forest areas having high level of fire readiness by the middle of summer.

The intervals between fires and their frequency determine the dynamics and state of forest cover and vice versa. Thus, their study should be the foundation for the fire management. Every forest cover has its fire pattern (type, intensity, size, frequency interval) and dynamics of after-fire forest reproduction. It is obvious, that fire modeling allows revealing the fire patterns that are typical for a particular area and forecasting development trends of forest ecosystems.

Human factors should be also regarded as the reason of forest fires in the North of Tomsk oblast. These are the following factors: in-situ burning of oil spills, exhaust of waste gas, falls of rocket stages, activities of exploration companies, local people’s activities and power line breakdown. It is not possible to classify these factors nowadays, as there are no factual data on this point.

The forest fires can threaten settlements, impede economical activities and destroy vast areas of wood resources, which lead to economic losses. On the other hand, wildland fires are a natural part of the forest ecosystem and important valuable tool of its self regulation, sustainable development and excessive fuel disposal. Fire danger forecasting, GIS and video monitoring of fire situation and its development, new technologies used for firefighting as well as land use works (control lines, lanes and water sources) allow reducing the number of fires and fire risks in Tomsk petroleum province. It should be noted that the stable decrease in fire incidents in Tomsk oblast is not registered. Thus, the Russian scientists’ idea of the Forest Service reorganization having negative impact has not been proved yet. New fire detecting and fighting technologies, which are effectively used in European and North American countries, have not improved the fire situation in Tomsk oblast either.

Figure 4. Changes in forest fire in Parabelskiy, Kargasokskiy and Aleksandrovskiy districts of Tomsk oblast from 2008 to 2013 years
4. Conclusion
1. Zone fire characteristics in the petroleum production areas of Tomsk oblast are conditioned by high natural fire danger of pine forests and climatic peculiarities of the region.
2. The seasonal and annual changes in number of fires in Tomsk oblast are of cyclical character.
3. Nesterov’s method of fire danger forecasting shows high repeatability with the development of real situation.

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