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Articles

Analysis of the fire frequency of the southern taiga region of the Tomsk Oblast on the example of three forestries

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An analysis of the burning of forests in the Tomsk region is given, using the example of three forest districts: Asinovsky, Shegarsky and Timiryazevsky. On the territories of forestries, the areas for detecting fires, the areas for eliminating fires, the type of territories covered and the causes of occurrence are determined. The peaks of fire activity in the forest areas for a ten-year period were determined. In total, during the study period, 569 landscape fires were registered on the territory of three forestries, the total area of detection was 3369.36 ha, the total area of liquidation was 6793.74 ha. The areas most prone to fires are directly forested 84.49% and non-forested 11.48%. A comparison was made of the territories of the Timiryazevsky forest district, where fires took place over the period 2012–2021, as well as the territories where artificial reforestation was carried out over the same time period. The dependence of artificial reforestation measures on the frequency of fires in forestry areas was revealed.

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Keywords

Forest fires, forest restore, causes of fires, fire prevention

Introduction

From 4.5 to 27 thousand fires, which cover an area of 3.5 to 15 million hectares, occur annually in the forests of Siberia (Ponomarev and Shvetsov 2015). The problem of wildfires is urgent for the Tomsk Oblast where the forestry is one of the leading industries in the economic complex. The Oblast income mainly comes from the harvesting of coniferous wood, the use of forests for geological exploration of the subsoil resources, the development of mineral deposits for construction, reconstruction, and operation of linear facilities (Popova 2022). Studies prove that industrial logging, construction of roads and other infrastructure in the forest areas lead to an

increase in the number of fires (Ponomarev et al. 2016; Tokareva et al. 2021). However, weather conditions are one of the main factors in the occurrence of fires (Kopeykin et. al 2021; Bartalev et al. 2017).

The dynamics of long-term forest fire frequency of the southern taiga forest region of the Tomsk Oblast shows an uneven distribution of the number of fires (Fig. 1).

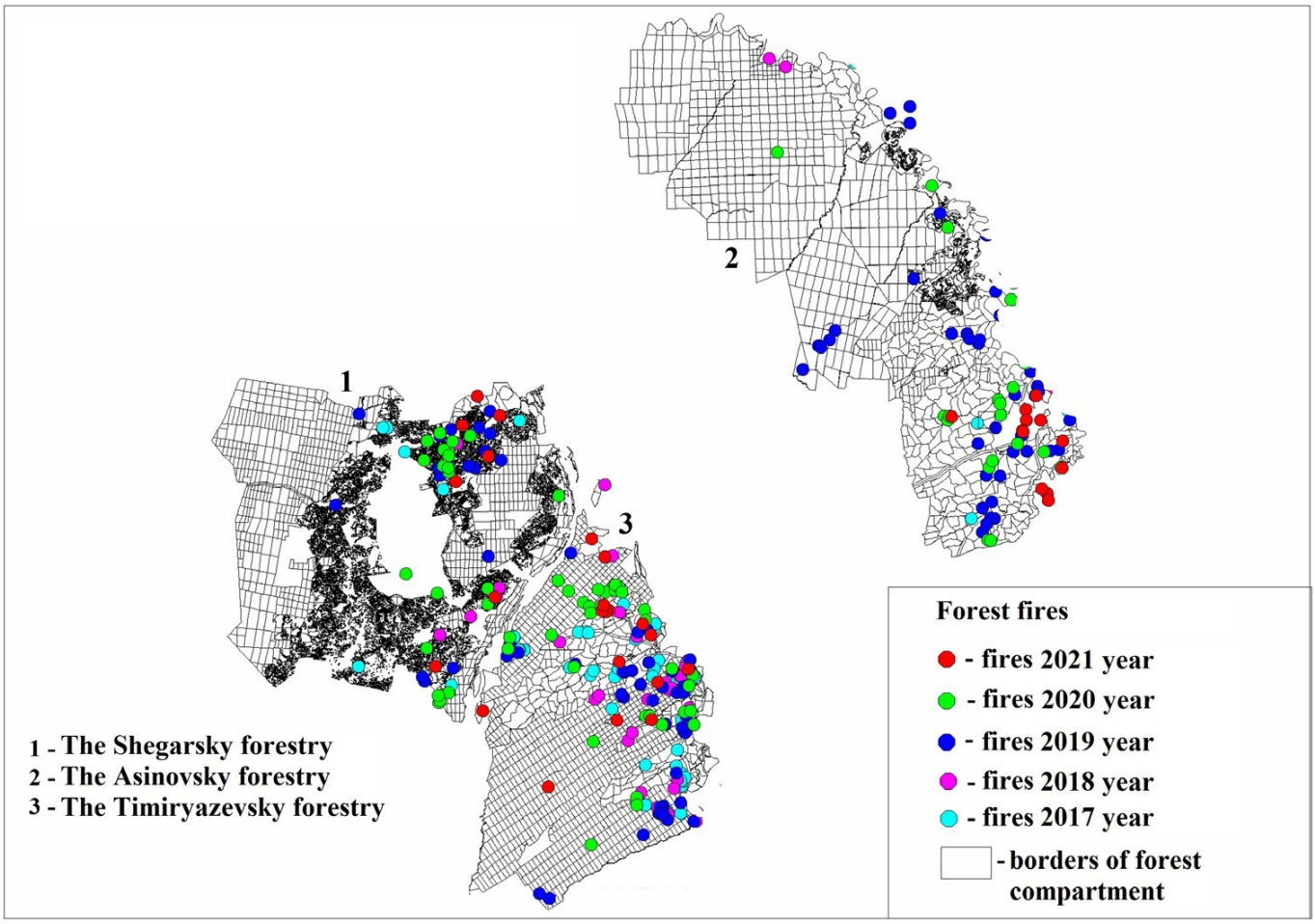

Figure 1. *Map of distribution fires of the forestries for the period from 2017 to 2021.*

This distribution is certainly associated with natural and climatic, and socio-economic features: excessive moisture of territories, heavily swampy terrain, which results in significant inaccessibility of most of the territories, and irregular road and railway networks. The population is heterogeneous, more than 70% of the oblast population is concentrated in cities along the rivers (the Ob, the Tom, the Ket, and the Chulym). All the factors below are decisive in carrying out evaluation of the effectiveness of forest protection from landscape fires. They are construction of forest roads to protect forests from fires, installation of fire-fighting mineralized strips and their maintenance, carrying out preventive controlled fire-fighting burning of brushwood, forest litter, dry grass and other forest combustible materials, cleaning of debris-strewn forest, regulation of the species composition of timber stands, and sanitary logging (Forest plan… c2018, State report… c2017). The works (Malenko et al. 2022; Fernandez-Pello 2017) describe the spread of forest fires which is affected by firebrands formed in the fire front. They ignite combustible plant material and, thus, create new fires.

The Asinovsky, Timiryazevsky and Shegarsky forestries are characterized by a low level of actual harvesting of wood (its rate per 1 hectare of forest land, including leased plots is less than 0.8), and the small size of the estimated cutting area (the indicator of permissible volumes of wood

withdrawal) (Zubareva and Perminov 2015). However, these territories are characterized by a large number of fires which endanger the local population and economic facilities.

An increased load on recreational areas of the forestries under study is predicted due to the immediate proximity to the Tomsk agglomeration, the growing interest in domestic tourist routes, and the relatively low level of the tourist infrastructure development. Uncontrolled tourists' presence and activities will certainly affect the fire-hazardous situation.

This study was aimed to provide a comprehensive analysis of the ten-year monitoring of forest fire frequency on the territory of the Asinovsky, Timiryazevsky, and Shegarsky forestries.

Materials and Methods

A comprehensive analysis of forest fire frequency of the forest resources of the Asinovsky, Timiryazevsky, and Shegarsky forestries for the period from 2012 to 2021 was carried out. The documents of the Forestry Department, including forestry regulations, and previously published research papers were used as the materials for the analysis (Moskalchenko et al. 2014; Moskalchenko 2021; Volokitina et al. 2004; Volokitina 2015; Vyshegurov et al. 2014; Forestry regulations… c2016). These forestries belong to the West Siberian southern taiga plain region, which is characterized by a more moderate and warm summer with an average July temperature of about 18-19°C. The frost-free period is from 105 to 120 days, the degree of waterlogging is lower in comparison with a typical taiga, and the growth class of coniferous forests is higher.

Forestry	District forestry	Area, ha
The Timiryazevsky forestry	The Moryakovsky forestry	39 686
	The Bogorodsky forestry	48 545
	The Temerchensky forestry	80 284
	The Kaltaisky forestry	96 770
The Asinovsky forestry	The Baturinsky forestry	157 598
	The Mitrofanovsky forestry	104 400
	The Malo-Yuksinsky forestry	100 307
	The Asinovsky forestry	77 857
The Shegarsky forestry	The Shegarsky forestry	125 559
	The Ilovsky forestry	185 178

Table 1. *The structure of forestries and their area, ha.*

The fire detection areas, fire elimination areas, the type of territories traversed by the fire, and the causes of occurrence were determined. The unidentified reasons comprised the loggers' activities, diesel locomotives, remains of bonfires, burning of oil spills, exhaust gases in the air, forestry facilities, impact of rocket stages, and expeditions with no recorded statistics. Some researchers believe that the causes from the "unidentified" category should be attributed to the local population. The (other causes) comprise thunderstorms, power lines, the transition of fire from other categories of land, and linear objects (Shcherbov et al. 2015).

Results

The fire season (according to the actual fire frequency) in the Asinovsky forestry territory comes as the snow melts and the ground cover dries out. Predominant species: *Pinus sibirica, Pinus sylvestris* L., *Picea obovata* L., *Abies sibirica* L., *Larix sibirica* L., *Salix alba* L., *Betula pendula* Roth, *Populus tremula* L. The average annual forest fire frequency is 110 days and it lasts from the beginning of May to the second decade of September (Fig. 2). During the study period, 96 forest fires were recorded; the fire covered the area of 1142.36 hectares. The peak of fire activity

occurred in 2019; however, the largest forest area (38.2%) was covered by fires in 2012 (Table 2). The earliest fire was recorded on April 19, 2020, the latest was on October 15, 2019.

Years	Total fires	Area, ha				
		detections	eliminations			
			total	covered with forest	non-forest area	uncovered with forest
2012	16	132	436	436	0	0
2013	1	2.5	2.5	2.5	0	0
2014	1	3.7	3.7	3.7	0	0
2015	7	34.7	49.6	49.6	0	0
2016	9	60.3	85.5	85.5	0	0
2017	2	17	26.5	26.5	0	0
2018	1	1	1	1	0	0
2019	33	126.7	259.01	232.01	0	27
2020	18	113.1	219.6	206.7	0	12.9
2021	8	38.4	58.95	35.95	23	0

Table 2. *Characteristics of the fire frequency of the Asinovsky forestry territory*

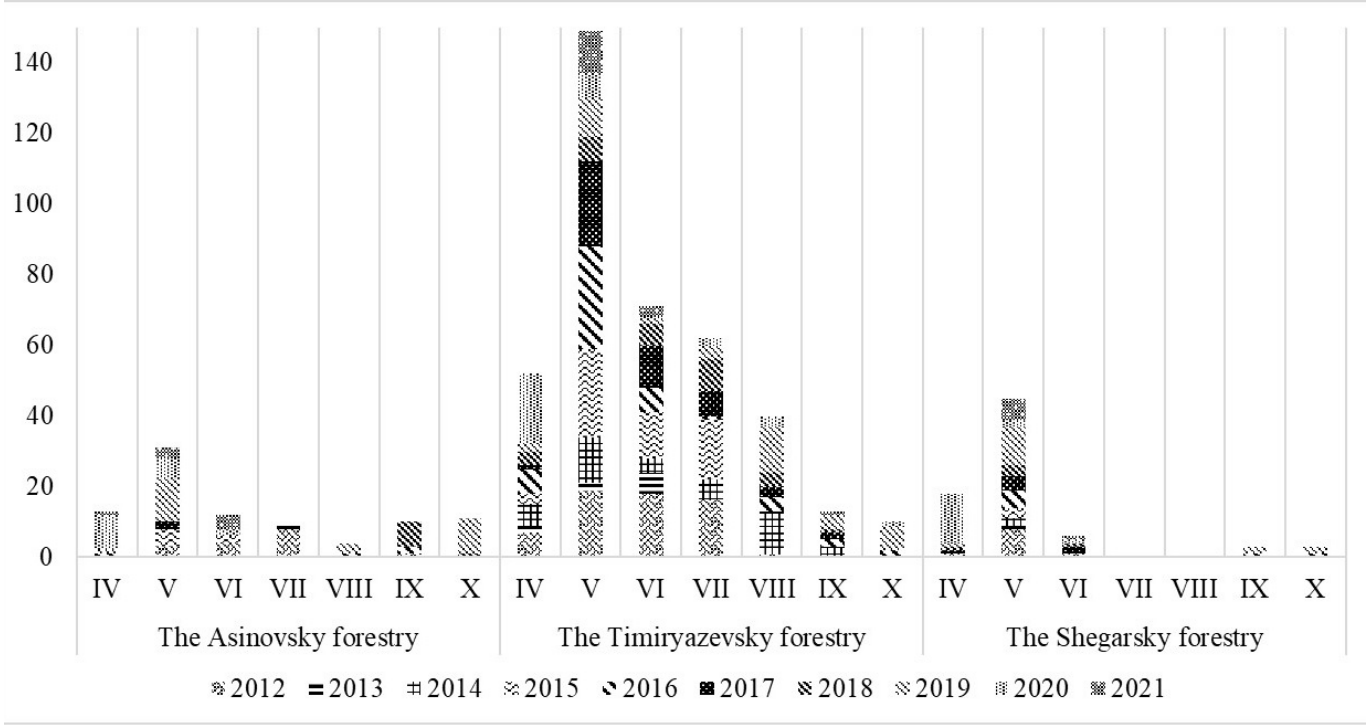

Figure 2. *The average annual fire frequency of the forestries for the period from 2012 to 2021.*

The Timiryazevsky forestry is characterized by the highest fire hazard values, which is associated with a high recreational load due to fishing, hunting, collecting wild plants, and transport accessibility (Melnik 2013). The fire season mainly begins in April and lasts until September or October. The total area covered by 397 recorded fires was 4775.28 hectares, where forest area was 80.7%, non-forest area was 13.54%, and the rest was uncovered with forest (Table 3). The fires of 2012, which affected 49.4% of the total burned area, are characterized by the greatest destructive force. On average, the fire season lasts 134 days with a sharp increase in the number of fires

recorded in May. The most difficult part of the fire period lasts until August inclusive (Fig. 2).

Years	Total fires	Area, ha				
		detections	eliminations			
			total	covered with forest	non-forest area	uncovered with forest
2012	61	540.03	2360.18	1625.48	610.2	124.5
2013	10	18.51	21.84	11.24	0	10.6
2014	44	226.03	490.58	464.04	23	3.54
2015	58	265.09	392.58	301.58	0	91
2016	52	181.92	272.53	272.31	0	0.2
2017	49	148.07	195.52	182.47	2.6	10.45
2018	31	143.27	173.11	160.11	10.9	2.1
2019	42	128.8	156.17	154.37	0	1.8
2020	34	481.23	551.56	523.56	0	28
2021	16	122.4	161.99	160.89	0	1.1

Table 3. *Characteristics of the fire frequency of the Timiryazevsky forestry territory*

The Shegarsky forestry territory is characterized by a large number of swamps and deciduous plantations (Table 4). The fire season (according to the actual fire frequency) in the forestry territory comes as the snow melts and the ground cover dries out. The average annual forest fire frequency is 110 days and it lasts from the beginning of May to the second decade of September. The fire danger is highest in spring, when almost the entire forest area is covered with last year's dry grass, as illustrated in (Fig. 2). During the study period, 76 fires were recorded; the fire covered the area of 584.6 hectares. The area uncovered with forest was not affected by fire 87.4% of the fire-sites were within the area covered with forest. When establishing the causes of fires in the forests of Siberia, similar values are given in (Drozdova and Sorokovikova 2021; Furyaev et al. 2017), which indicates the need to improve fire protection measures in forests and work with the local population.

Years	Total fires	Area, ha			
		detections	eliminations		
			total	covered with forest	non-forest area
2012	10	70.5	75.4	75.4	0
2013	1	3	9	9	0
2014	2	30	159	49	110
2015	3	26	35.2	35.2	0
2016	8	34.7	54.9	54.9	0
2017	7	39.3	55.1	55.1	0
2018	5	34.25	46.35	46.33	0.02
2019	16	151.45	188.45	188.45	0
2020	17	154.1	206.20	206.2	0
2021	7	38.3	46.50	46.5	0

Table 4. *Characteristics of the fire frequency of the Shegarsky forestry territory*

The analysis of the causes of fires in the study period is presented in Table 5 and illustrated in (Fig. 3). The main cause of fires for the studied forestries is the local population (more than 65%).

In the Shegarsky forestry, the number of fires resulted from burning of dry grass is increasing, which is linked with the developed agricultural activity, such as large agro-industrial and numerous farming enterprises.

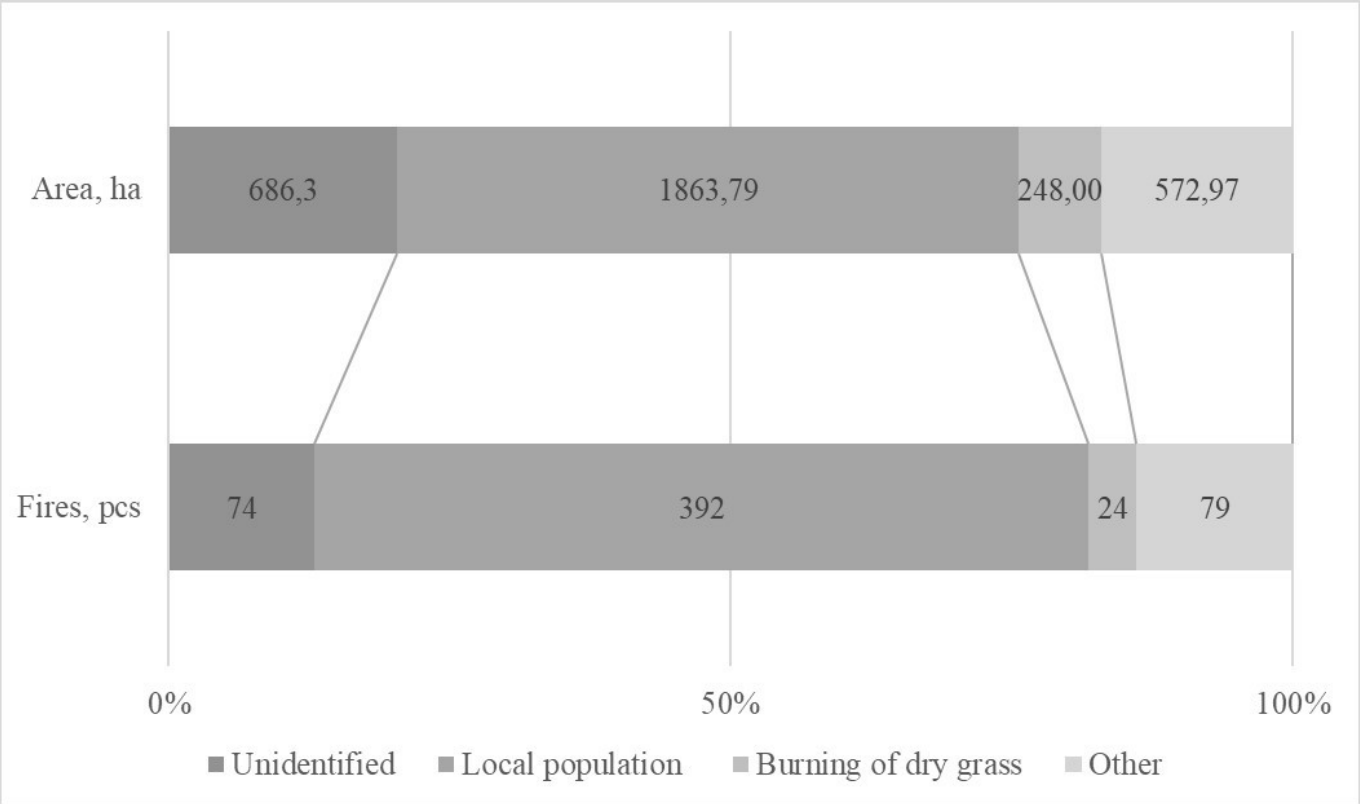

Figure 3. *Causes of fires in the Asinovsky, Timiryazevsky, and Shegarsky forestries for the period from 2012 to 2021.*

Forestry	Total fires detection area, ha	Cause of firesnumerator – quantity, %; denominator – detection area, %			
		unidentified	local population	burning of dry grass	other
the Shegarsky forestry	76/ 584.60	2.62/ 3.16	69.73/ 66.11	11.84/ 11.46	15.78/ 18.74
the Asinovsky forestry	96/ 529.41	10.41/ 22.15	60.41/ 49.92	2.08/ 1.22	27.08/ 26.63
the Timiryazevsky forestry	397/ 2260.35	15.38/ 24.40	68.48/ 53.78	3.22/ 7.73	10.17/ 14.29

Table 5. *Distribution of fires according to causes of their occurrence for the period from 2012 to 2021*

The organization of artificial reforestation is known to include tillage which is carried out by strip plowing, mineralization or loosening of the soil on bands or sites, digging furrows or trenches, formation of micro-elevations (ridges of furrow and mounds), and preparation of pits (Fig. 4). Such treatment of soil results in cleaning of forest combustible materials, which contributes to the formation of vast territories preventing the possible transition of wildfires and the spread of creeping fires.

In the course of analysis, it was hypothesised that forest fires occur less frequently in the territories that undergo artificial reforestation. The Timiryazevsky forestry was chosen as a model. From 2012 to 2021, the total of 397 fires were recorded in the Timiryazevsky forestry territory and 149 plantings were carried out; their distribution by district forestries is shown in (Table 5). The burnt territories and those with the implemented artificial reforestation measures were compared taking into account the quarter and the division of district forestries. During the period under study, 13 out of 397 fires in the Timiryazevsky forestry occurred in the territories where reforestation was carried out. The comparison showed that the territories with the implemented reforestation measures are less susceptible to fires.

Figure 4. *The restored forest area of the Timiryazevsky forestry of the Kaltaysky district forestry, the Kaltayskoye stow, compartment 186.*

Thus, the organization of fire protection measures in the forestries should take into account the specifics of the local population's activities in these territories, focus on cleaning of debris-strewn forest, installation of mineralized strips and water reservoirs near recreation areas and the forest sites intended for harvesting non-wood forest products.

Conclusions

Ten-year monitoring of the fire situation in the Tomsk Oblast forestries has shown that the Timiryazevsky forestry is still the most problematic in the fire season. The fire-hazardous situation is linked with transport accessibility, population density, and proximity to the populated areas. The local population was revealed to be the main cause of fires for the studied forestry. This fact confirms the link between the causes of fires and the nature and strength of the anthropogenic load in this territory.

Siberian pine, cedar and spruce are mainly used in the artificial reforestation. The largest amount of work on the artificial reforestation (about 50%) was carried out in the Asinovsky forestry territory, which belongs to the zone of intensive forest use. The Timiryazevsky and Shegarsky forestries amounted 20% and 30%, respectively. To formulate it differently, loggers are the main

performers of reforestation, which indicates insufficient budget funding.

The Timiryazevsky forestry territories where fires took place during the period from 2012 to 2021 were compared with the territories where artificial reforestation (planting of forest products) was carried out during the same time period. The revealed dependence of reduction in the frequency of fires in the territories with the implemented artificial reforestation measures suggests that the likelihood of forest fires can be reduced even by applying non-specialized fire protection measures. A further analysis is going to be conducted with account to the age and species of the planting material, and the territorial and climatic features of the studied sites.

Taking into consideration the above mentioned, the volume of artificial reforestation and the measures contributing to cleaning of territories from forest combustible materials should be increased in order to protect forests from fires.

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