

RESEARCH PAPER

The climatic and anthropological characteristics of fires in Zagros ecosystem (A case study: forests and rangelands of Gilan-e Gharb region of Iran)

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Highlights

- Fires are the most common threat to forests, which is one of the most important issues and concerns of people not only from an ecological point of view, but also from an economic, social and other point of view.
- To protect natural resources and increase production, it is necessary to use the information obtained for effective management and prevention of fires in forests and pastures.
- This study examined the causes of fires in forest ecosystems and pastures.

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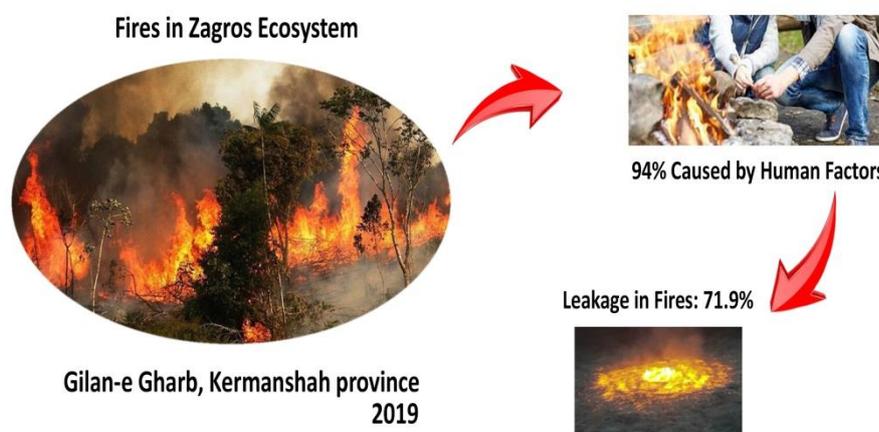
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Graphical Abstract



Abstract

Forest and rangeland fires are uncontrollable fires that occur naturally in areas with flammable plants. The study area is Gilan-e Gharb, which is located in Kermanshah province. For this study, all fires that occurred during a fire season in 2019 in Gilan-e Gharb city were recorded in national sources. The data collected in this study include the name of the place, type of national resources (forest, pasture, etc.), fire date, time of fire start and end, fire area, fire duration, location of the area as UTM, and... The results show that 94 and 6% of natural resource fires are caused by human factors and natural causes, respectively. Among the human causes of fires, the most common cause of fire is water spillage (71.9%). Among human causes of fires, the most common cause of fires in national resources (71.9%) is recreation. Most fires occurred in the affected areas in Piakoleh and Miandar (Nawdar), Milliane, national resources near Kolah-e-Daraz Olya village and Ghasem-Abad stack. About 633 hectares of national resources in the region were affected by the fire, most of them in Shiakuh, Sarkesh and Paikoleh with about 150, 95, and 78 hectares respectively. Most of the fires affected rangelands, which is about 48.4% of the fires. Fires occur in the study area for six months and on average every three days. In addition, it takes an average of 46 minutes for each fire to be under control. Among the different fire durations, the 30-minute fire duration is the most common (29.7%). The highest percentage of fires in the fifth month (October) is 29.7%. To effectively protect natural resources, the information obtained should be used to efficiently manage, prevent, and extinguish fires in the study area and in the Zagros ecosystem in general.

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1. Introduction

According to the statistics of the Forests, Range, and Watershed Management Organization, hundreds of fires occur annually in different parts of Iran (Sepahvand et al., 2021). According to Food and Agriculture Organization of the United Nations (FAO) reports in 2005, about 0.06% of Iran's forests are destroyed by fire every year (Finney, 2001; Mohammadzadeh, 2016). Forest and rangeland fires are a type of fire that occurs in areas with flammable plants in rural areas or nature (Karimi et al., 2017; Zeidali et al., 2021). Forest fires differ from other types of fires in terms of extent, speed of spread from the source, potential for the sudden change of direction, and ability to jump through empty spaces such as roads, rivers, and other non-flammable points. Forest fire in terms of the cause of the fire, its physical characteristics such as dispersion rate, the presence of flammable materials, and the effect of water and air on fire are described (Jamshidi Bakhtar et al., 2013; Karimi and Pourbabaee, 2017).

Inadvertent activities and improper use of fire in agriculture by humans, especially the presence of livestock and shepherds, as well as differences between exploiters cause forest fires and reduced production. The proximity of forest areas to residential areas due to increased human activities and on the other hand, roads in the forest also increase human access to the forest and increase the likelihood of fire. The Foehn Wind phenomenon has an important role in creating and spreading fires in forests (Ebrahimi et al., 2017). Periods of drought, which are accompanied by hot and dry winds during the day inside the arid continents, increase the heat and dryness and destroy the plants. These cases also strengthen the atmospheric conditions of lightning storms, which are a major source of fire (Janbaz Ghobadi, 2019).

Findings of Pourreza et al., (2014) in Iranian oak (*Quercus persica*) branch forests showed that in weak fire neither the total number of soil macrofauna nor the studied soil properties were significantly changed, but in severe burns, there was a significant decrease in Soil Macrofauna and soil properties were significantly changed (Pourreza et al., 2014). The results of the study of Moradi et al., (2016) in Sarvabad, Kurdistan province showed that after the fire and 10 years later, the share of oak trees decreased and the share of Hawthorns and almonds increased (Moradi et al., 2016). There is no difference in the type of mastic. Almonds and Terebinth showed more resistance to fire than Persian oak (*Quercus persica*). The results of other study in semi-arid rangelands showed that the amount of diversity in the control and 83 habitats was significantly different at the level of 5% and no significant difference was seen in the 87 and compared to the control and 83 habitats (Viegas et al., 1992). The results of Karimi et al., (2017) study on the effect of fire on relative importance index (SIV) and models of the abundant distribution of plant species in the Zagros forests showed that in both regions, the model of species abundance for tree layers and regeneration in geometric distribution and the shrub layer is geometrically distributed in the burned area and broken wands in the control area (Karimi et al., 2017).

For the grass layer, logarithmic distribution of species was obtained in both regions. In the tree layer and regeneration, the highest amount of SIV belongs to Broodar species and in the shrub layer belongs to Hawthorns and Ranas species in the area of fire and control, respectively, and in the grass layers of *Avena* *Factua* species in both regions, the highest relative importance Other species are assigned to it.

The results of Janbaz Ghobadi, (2019) research in the forests of Golestan province showed that most of the fires occurred in forest areas with dense canopy and cover, as well as in forest areas with moderate canopy and cover, and in the next stage in forest areas and bushes (Janbaz Ghobadi, 2019). In the study of calculating the density of fires in the highlands, the results showed that approximately 90% of fires occurred in the average highlands between 700 and 1500 meters. Overall, the research findings showed that 90% of continuous fires occurred in high-risk areas, 30% in hazardous areas, and 60% in high-risk areas so Galikesh, Minudasht, Azadshahr areas have a high risk of fire. In the field of investigating fires in national sources in terms of frequency, frequency, duration of firefighting, causes, their impact on the destruction of nature, and reducing the production of information gap, the present study tries to cover the existing information gap. Therefore, the purpose of this study is to investigate the fires created in the Zagros forest ecosystem in the protected area of the Gilan-e Gharb region located in Kermanshah province.

2. Materials and methods

2.1. Area of study

The study area is Gilan-e Gharb township, which is located in Kermanshah province. Gilan-e Gharb is one of the cities located in the west and south of Kermanshah province with a longitude of 45 degrees and 55 minutes and latitude of 34° 7'. From the north to Sarpol Zahab and Dalahu, from the northeast, east, and southeast to Eslamabadegharb, Qalajeh Pass, Sarableh, Eyvangharb, and Ilam Province and from the south and southwest to Soomar and Mandali (Iraq) and into the west are Naft Shahr and Qasr-e Shirin. Gilan-e Gharb is located at an altitude of 804 meters above sea level and the center of the township is one of the tropical regions of Kermanshah province. The further east and north of the township, the higher the altitude and the colder the air, and the further south and west and the Iraqi border, the warmer the air and the lower the altitude. For example, from the center of the city to Islamabadegharb or Kermanshah, after 15 km from the height of 800 meters, the city reaches 1100 meters in the surrounding villages in the Cheleh Rural District, and after 68 km, in the Govar section, it reaches 1500 meters. Conversely, as you move toward Iraq or Qasr-e Shirin, it gradually reaches an altitude of 500 meters and even 290 meters at the Soomar border. In terms of forest cover, Persian oak is the main tree in the forests of Gilan-e Gharb city. Other important tree species and shrubs of this region are Terebinth, Pistacia khinjuk, Fig, Acer monspessulanum, Almond, Prunus scoparia, Amygdalus lycioides, Amygdalus scoparia, Barberries, Ranas, Judas-tree, Hawthorns, European ash, Oleander and ...

Dominant rangeland plants in this area include Acantholimon, Acanthophyllum, Sainfoin, Alopecurus, Thymes, Clover, Liquorice and grasses.

2.2. Research method

In order to conduct this research, all cases of fire that occurred in national sources in the protected area of Gilan-e Gharb region during the fire season and in 2009 were recorded. The reason for choosing this area is the existence of suitable forest and rangeland cover (75,000 hectares of forest and 130,000 hectares of rangeland) as well as the prevailing climatic diversity in this area, so that tropical, temperate and cold climates are considerable in the area and allow an analysis of fires Provides different conditions. The frequency of fires is another reason for choosing this area, for example, in the data collection chapter of the present study, 64 fires have been recorded. The data related to the present study were collected in the field, directly and together with the forces participating in the firefighting operation, so that immediately after being informed of the fire, national sources were present at the scene and the data were recorded. The data collected in this study include the name of the region, type of national resources affected by fire (forest, pasture, etc.), date of the fire, start and end time of the fire, area of fire-affected, duration of the fire, time of the fire in 24 hours a day, the location of the area is UTM and The cause of the fire is also from other information taken. In general, fire is a natural or human fire that the most important human factors in this study include the spread of fire waste, military training, recreation, disputes over ownership of customary systems, and so on.

To calculate the area of the burned area, manual GPS was used and a special option was used to calculate the area as well as walking on the borders of the burned area with the non-burned area. The location of the area was also recorded using Garmin GPSmap 62 s model.

3. Results and Discussion

In general, the causes of forest fires can be divided into natural and abnormal (Graham et al., 2004). The results showed that 94% of natural resource fires have human causes and 6% of them are related to natural factors, among which lightning and hot winds are important in dry seasons (Fig. 1). Additionally, all fires, both natural and human, are superficial fires.

Many forest fires are caused by natural factors (fermentation and chemical interactions of organic matter, lightning, volcanic eruptions, sunlight shining on bottles and glass that act like lenses) that put trees in a state of fire, start (Merino-de-Miguel et al., 2010). However, rain extinguishes such fires without causing much damage. High atmospheric temperatures and dryness (low humidity) provide suitable conditions for starting a fire. When a source of fire such as a flame is released, a cigarette, an electric spark, or any other source of fire that comes in contact with flammable materials, fire is created that constitutes man-made (abnormal) causes of fire. The results showed that among human factors, recreation has the highest frequency (71.9%) in fires.

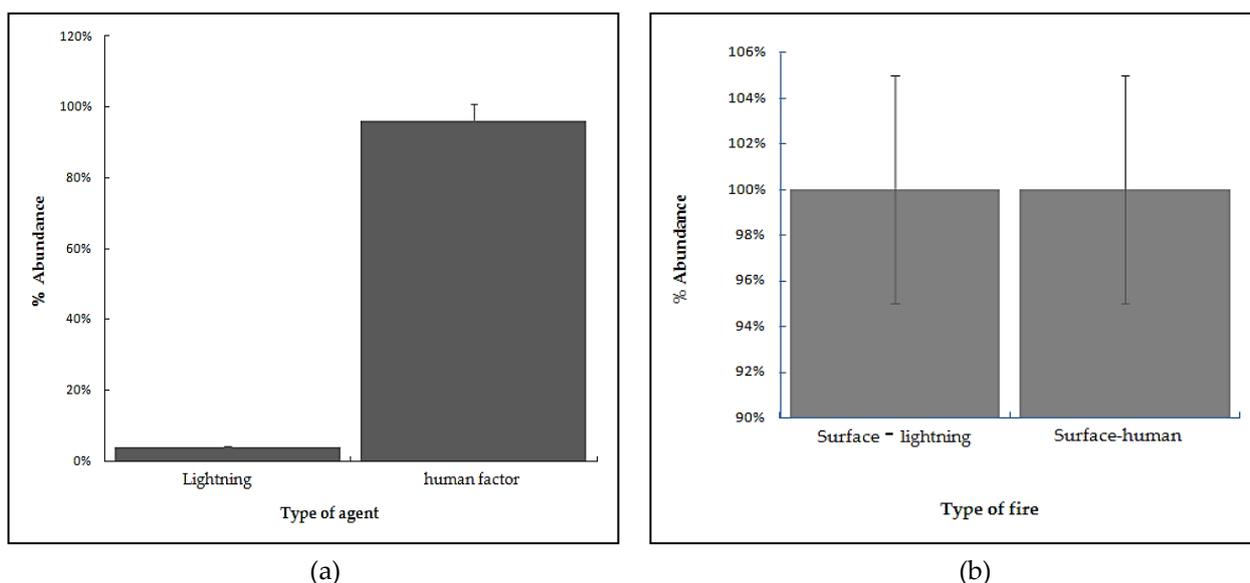


Fig. 1. Frequency of type (a) and cause of fire in terms of humanity and naturalness (b).

The results showed that among human factors, the recreation factor has the highest frequency (71.9%) in fires caused in the national resources of the region (Fig. 2). Factors of conflict and conflict between local communities, rehearsals, transmission caused by Straw farms, unknown human factors and transmission due to incineration of municipal waste have 9.4, 7.8, 4.7, 4.7, and 1/5% respectively.

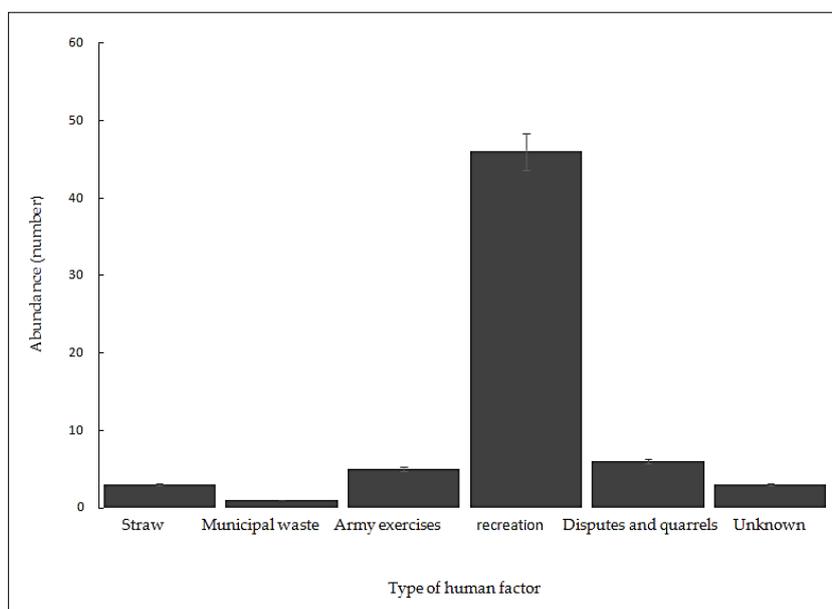


Fig. 2. Frequency of the human factor of fire.

Human fires are divided into two categories: intentional and unintentional. Deliberate fires are caused by rising agricultural land, psychological complexes and personal animosities, coal production, sectarian and tribal disputes, some customs, and so on. Inadvertent fires are caused by tourists, shepherds, hunters, burning crop residues in fields adjacent to forests and pastures, jumping sparks or throwing cigarette filters from locomotives or vehicles traveling on rails and roads in the forest. Certainly, many factors are effective in firefighting, and one of the most important factors that provide the background for forest fires is the decrease in relative humidity, which occurs with increasing temperature and drought. Therefore, the accumulation of fuel in the forest increases the risk of fire. On the other hand, the carelessness of forest dwellers or travelers, the type of forest, whether it is pure or mixed, the mountainous or plain nature of the forest ecosystem, the application of forestry

methods, forest health, access to burned areas, ecotourism and fire management are secondary factors that determine the intensity and extent of the fire.

The highest frequency of fires in the affected areas is related to the areas (Piakoleh and Miandar) Nawdar, each with six fires. Melihani, the national resources adjacent to the village of Kolah Deraz Olya and the Qasemabad stack, have also been set on fire four times each (Fig. 3).

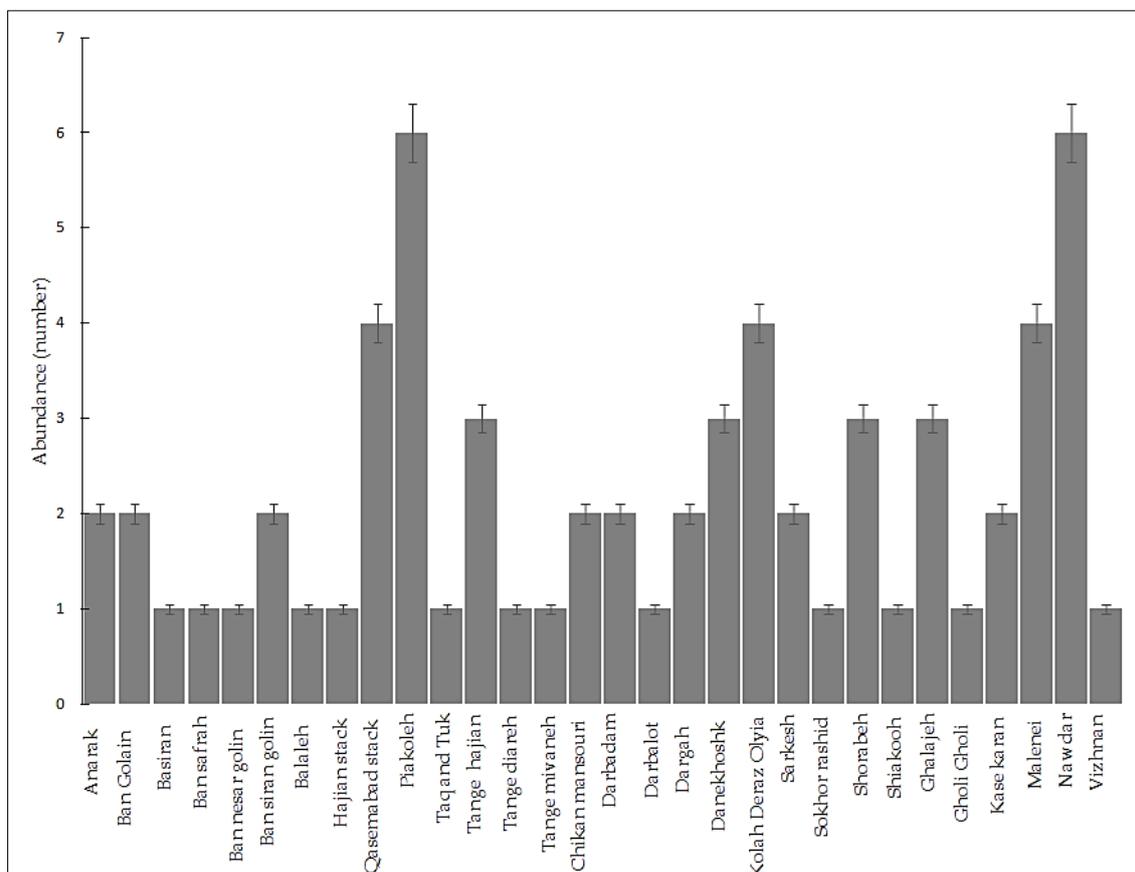


Fig. 3. Frequency of fire in different areas of the study area.

The level of national burn sources is presented in Table 1. In total, about 633 acres of national resources in the region, including forests and pastures, have been burned. As the table shows, the highest burn rate is Shiakuh with about 150 levels, Sarkesh with about 95 levels and 78 levels.

Table 1. The name of the place and area of the area affected by the fire.

Place name	Area (HA)	Place name	Area (HA)	Place name	Area (HA)	Place name	Area (HA)	Place name	Area (HA)
Anarak	2	Possteh	27.5	Tange mivaneh	40	Kolah Deraz Olyia	5.5	Gholi Gholi	0.5
Ban Golin	6	Piakoleh	78	Chikan mansouri	45	Sarkesh	95	Kase karan	4
Ban siran golin	12	Taq and Tuk	0.5	Darbadam	30	Sokhor rashid	1	Malenei	34.5
Ban safréh	5	Tange hajian	21.5	Darbalot	3	Shorabeh	7.5	Miandar	4.5
Ban nesar golin	5	Tong diareh	5	Dargah	8	Shiakoooh	150	Vizhnan	1
Balaleh	8			Danekhoshk	15	Ghalajeh	18		
Total	38		132.5		141		277		44.5

The results of the present study showed that the highest frequency and occurrence of fires in fire-affected areas are related to Piakoleh and Miandar (Nawdar) areas; (12 fires in total) Nationalism, national resources adjacent to the village of Kolah Deraz Olya and the Qasemabad stack (12 fires in total) have been burned. Repeated fires in an area indicate the intentionality of the fire in that particular area, one of the most important reasons for its occurrence is the differences between local communities in the use of pastures and forests, tribal disputes, and so on. In creating these fires, it is always tried to apply the principle of surprise and the pastures catch fire at a time (such as midnight) when the other party has the least opportunity to extinguish the fire or when the fire is reported. It's been a long time since it started. Out of 64 fires, the highest rate of fire is related to the pasture, which has suffered 31 burns (48.4%). Wooded pastures, forests and forest reserves have been burned (42.2%), 6 (9.4%) and 1 (1.5%), respectively (Fig. 4).

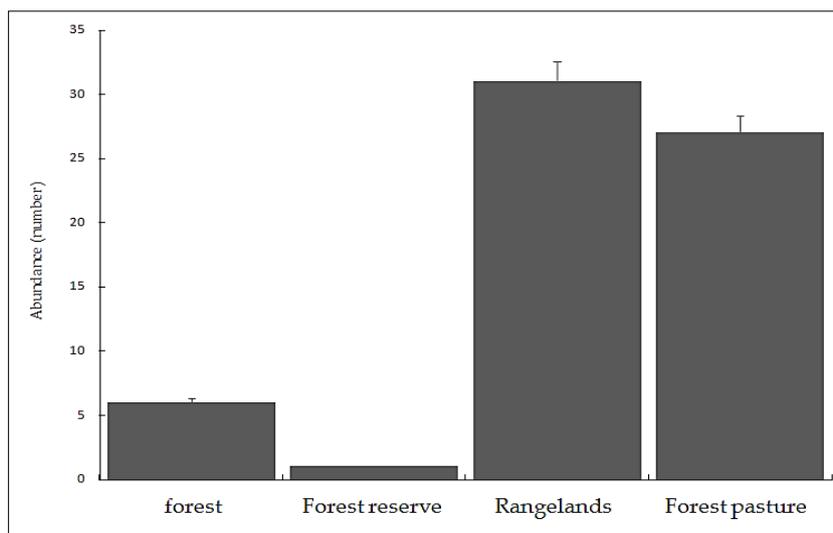


Fig. 4. Type and frequency of national source fire.

The results showed that the highest area of burns in terms of frequency is related to the levels of 1 hectare and 5 hectares, which occurred 8 times in each case (25% in total). The 2 hectare and 3 hectare areas have been affected by fires 7 times each, which includes 21.9% of the frequency of fires that have occurred. 0.5 hectare area has been burned 5 times (7.8%) (Fig. 5).

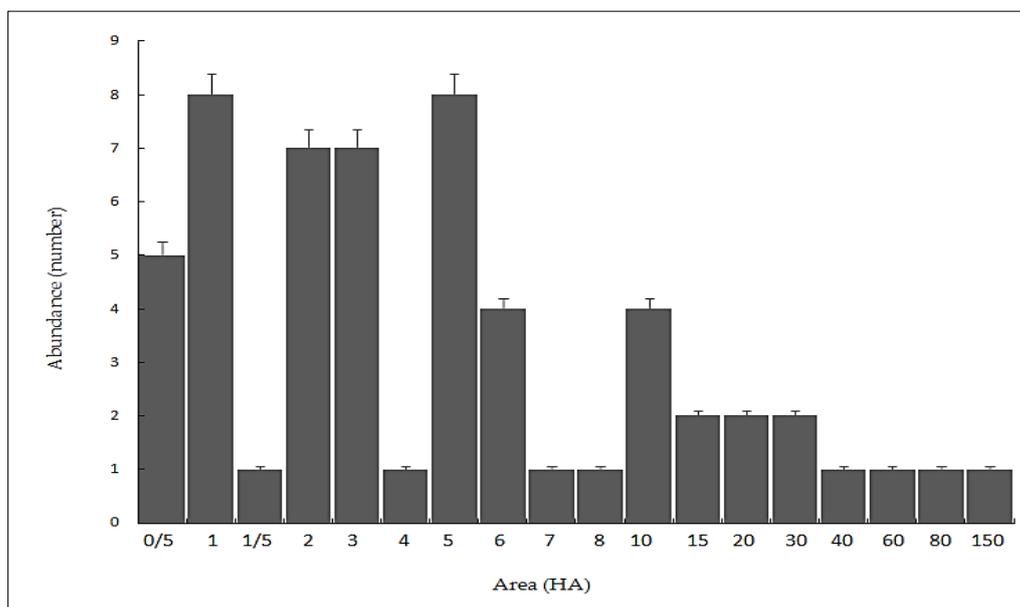


Fig. 5. Frequency and number of repetitions of fires on fire-affected surfaces.

The time of fire occurrence 24 hours a day is shown in Fig. 6. The highest frequency of fires is related to noon and evening, which occurred 12 times in each case (37.5% in total). There were 9 fires during the night, which is 14% of the frequency of fires. There were 6, 5, and 4 fires at midnight, evening, evening, and afternoon, respectively (Fig. 6).

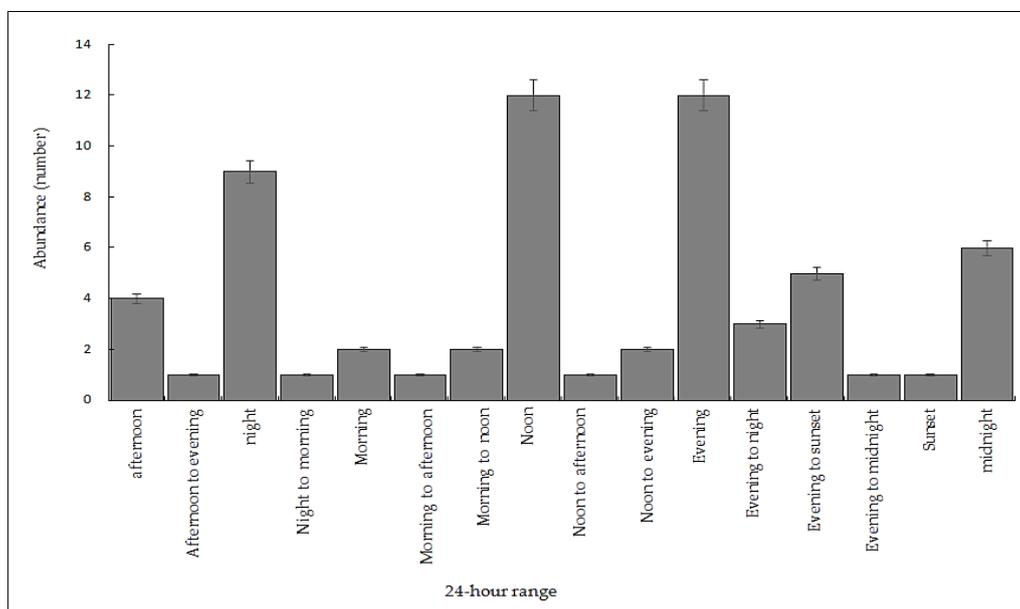


Fig. 6. Frequency of fire at different hours of the day.

The results show that each fire takes an average of about 46 minutes to extinguish. The duration of 30 minutes of fire has the highest frequency (19 cases equal to 29.7%) among the existing fire times. Durations of 60 minutes and 120 minutes are also among the most frequent causes of fire, in each of which 12 fires occurred (37.5% in total) (Fig. 7).

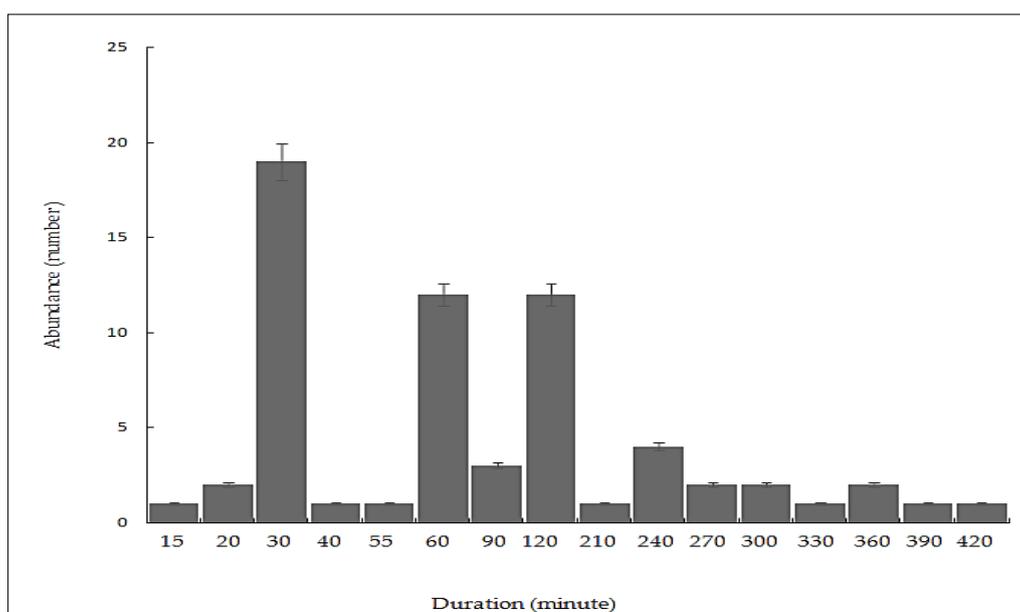


Fig. 7. Frequency of fires in terms of duration of fires.

The duration, severity, extent and extent of the fire vary in size. These parameters are mainly controlled by climate, leaf accumulation, flammability of fuels, soil moisture, wet and dry years, and the topography of the area. For example, in the dry forests of western Panderosa, the distance between two fires is between 2-18 years.

Moreover, the intervals between fires increase with increasing altitude; At higher altitudes in arid regions, the average of these intervals is about 35 years. In the northern mountains and wetlands, these intervals increase and, for example, in the redwood forests, they reach 600-500 years. While in the southern and arid regions, these intervals are reduced to 5-23 years. However, fires in local ecosystems and areas are affected by climate, physiography, vegetation, and human activities. The results also showed that the highest frequency of fires is related to noon and evening (37.5% in total). The reason for this can be attributed to the optimal conditions for fire in these situations because heat, oxygen and combustible material due to the maximum temperature and wind speed. Climatic compounds, if combined with several physiological conditions of the fuel, are a factor that fundamentally affects fire behavior. Drought is strongly associated with flammability and combustibility of combustible material, and wind plays an important role in flame diffusion. In many cases, climatic conditions prevail over other elements.

In describing the most important meteorological factors related to fire spread, the classification proposed by Velez is valid. Meteorological variables can be classified into two groups: variables that affect the possibility of fire combustion because they have the greatest effect on the humidity of the fuel; Thus, these variables have an effective effect on the spread of the accident, and they have a significant effect on the possibility that a fire can be more or less ignited. These variables include sunlight, rainfall, humidity, relative humidity and lightning. Variables affect the expansion ratio, because they affect the current required for combustion and heat transfer processes; Therefore, the dominant effect of these variables is on fire behavior. Among these variables are wind and atmospheric reliability. The first major fire is related to the May (2019/05/17), and the last is related to the end of November (2019/11/24). Furthermore, the maximum number of fires in one day was 4, which is related to the date of 2019/10/13. Three fires per day also occurred on 2019/08/13 and 2019/09/19 (Fig. 8).

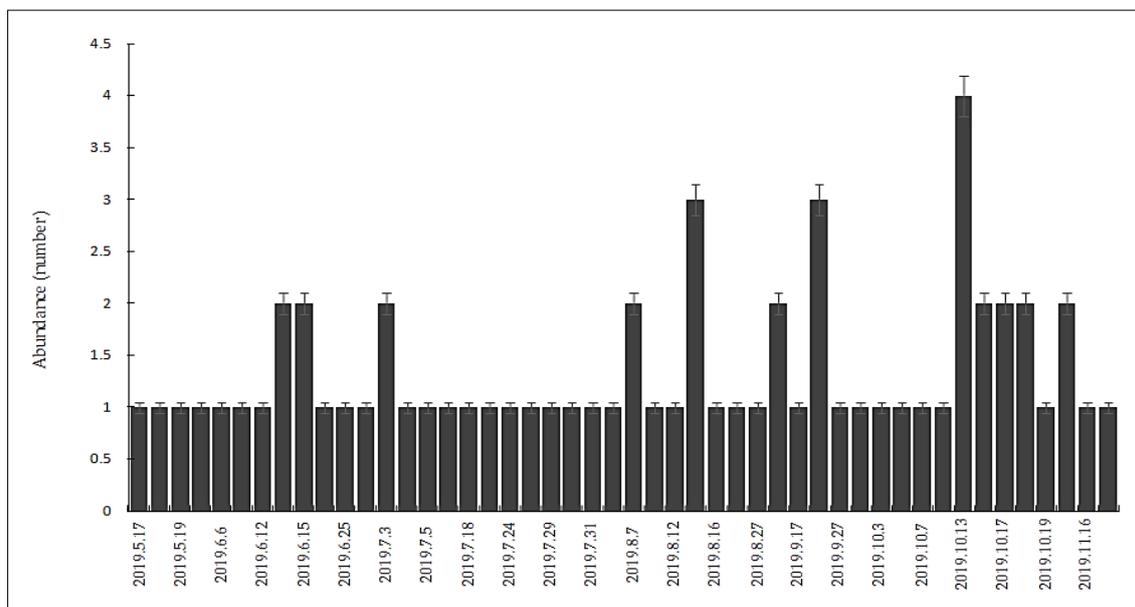


Fig. 8. Frequency of fire in the days of the fire season.

The duration of fire suppression depends on many parameters, the most important of which are the availability of appropriate facilities and a modern firefighting system, the timely reporting of fires and the promptness of action by natural resource management personnel, the presence of appropriate communication networks in the area, the participation of nature lovers and locals, to name a few. In general, the frequency chart of fires shows that the trend is upward over time (Rothermel, 1991). In general, one of the reasons for the increase in fires during the dry season in the region can be the increase in recreation and nature tourism along with reducing the length of days and cooling the air because at this time of year conditions for mountaineering, nature tourism and collecting by-products of Zagros forests and the rate of fire increases due to negligence.

Although there is a lot of recreation and nature in spring, due to the lack of dry vegetation, the incidence of fires is lower than in late summer, especially in early autumn. The results show that in the first month of the fire season, most cases related to lightning and recreation, in the second month, the main factors including differences between local communities and Straw-induced transmission, in the third month, recreation and differences between locals, in the fourth month, disputes over Ownership and exploitation, in the fifth month is leisure and disputes over ownership and exploitation, and in the sixth month is leisure and disputes over ownership and exploitation. The causes of fire in different months of the fire season are interesting points. In the early months, in areas that are warmer and farmers have irrigated land, they always destroy their straw to prepare the land for a second crop. The most common method of destroying straw is to set it on fire (Rothermel, 1972). In some cases, the negligence of farmers causes fire to spread to nearby pastures and forests and causes fires in national resources. In the middle months of the fire season, the predominant cause of disputes is personal, tribal and ethnic problems between local communities, who consider the best time to be when the total conditions for the destruction of the opposite side's pastures are in the best conditions, and this time coincides with August and part of It is September. In the last months of the fire season and early autumn, recreation and nature tourism are the main causes of fires, the reasons for which were discussed in the previous lines.

4. Conclusions

One of the most common hazards in forests is fire. Forest fires, which are as old as the forest itself, pose a threat not only to the health of the forest but to its entire flora and fauna, which seriously disrupts the biodiversity, ecology and environment of an area. Forest fires are one of the main issues and concerns not only from an environmental point of view but also from an economic, social and security point of view in many parts of the world.

In order to effectively protect natural resources and increase production, it is necessary to use the information obtained for effective management, prevention and fire extinguishing in the study area and the Zagros ecosystem in general. In addition to equipping natural resource offices with up-to-date fire extinguishing facilities, legal precautions can be taken for farmers who set fire to their fields, so that they can be held accountable if they neglect and cause a fire in national resources. Furthermore, serious measures should be taken to educate local communities and create a culture in using the gifts of nature and increasing production.

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