Investigation of FF characteristics of Spatio-temporal distribution in NK

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ABSTRACT: The forest is called the lung of the earth. It is an important wealth and resource of human beings. It is conducive to promoting the green and circular development of social ecology and is of great significance to the development of human society. However, forests are affected by fires in growing period. In the event of a fire, forests are vulnerable to devastating blows. As the temperature continues to rise and extreme weather occurs frequently, the number of forest fire (FF) has also increased significantly. This paper used the MODIS fire product (acquired from Fire Information for Resource Management System) to provide statistical data on FFs in the North Korea (NK) from 2001 to 2015, and the Kernel density function in ArcGIS was used to analyze the characteristics of spatial and temporal distribution in NK. Furthermore, driving force of FF was investigated according to the land cover and DEM in study area. After comparing and researching the results, the following conclusions are drawn: 1) Most FF generally distributed along the eastern coast in NK. 2) The frequency of the FF in spring is lager than that in other seasons. 3) In terms of geography, FF in NK is mainly concentrated in a height of more than 300m and a slope of less than 30°.

1. Introduction

As an important resource, forests can promote the sustainable development of social ecology and serve as habitats. However, due to the rapid, sudden, destructive and difficult rescue of fires, forests can cause irreversible damage to forests. Impact (Dong, 2019;Deng, 2012) The occurrence of FFs will destroy the habitats and diversity of biological resources in the ecosystem, and cause some environmental problems, which seriously threaten the safety of human life and property (Yang, 2019;Naderpour, et. al., 2019). Timely monitoring is important for forestry management, vegetation restoration, and carbon emission estimation. Therefore, FF assessment is particularly important (Yang, Jiang, 2018).

Satellite remote sensing technology has the characteristics of wide observation range, rich collection information and strong repetitive observation ability. It can detect the location and change of fire points in time, and accurately assess the fire loss and impact, especially for FFs with wide distribution and unsuitable access to disaster areas. Satellite remote sensing has unique and important advantages, providing more powerful data support for FF monitoring and loss assessment(Liu, Jia, 2018).

Since the beginning of the 21st century in NK, extreme weather has led to frequent FFs, and local forests have been burnt down. In addition, in order to solve the food and fuel problems, the forest around the NK city is also being destroyed, resulting in the continuous deterioration of the entire Korean ecological environment. In addition, NK's FFs have affected the ecological balance of East Asia and even affected the global climate. China, one of the bordering countries

of the DPRK, has also been affected to a large extent. Once a FF occurs, it is very likely to affect the balance of life and property of the people in our border ecosystem. Strengthening the monitoring and evaluation of FFs in NK not only provides a scientific basis for the decision-making of FF prevention in NK, but also reduces the losses caused by FFs. It also has important practical significance for strengthening China's ecosystem balance and border stability.

2. *Materials and methods*

2.1. Study sit

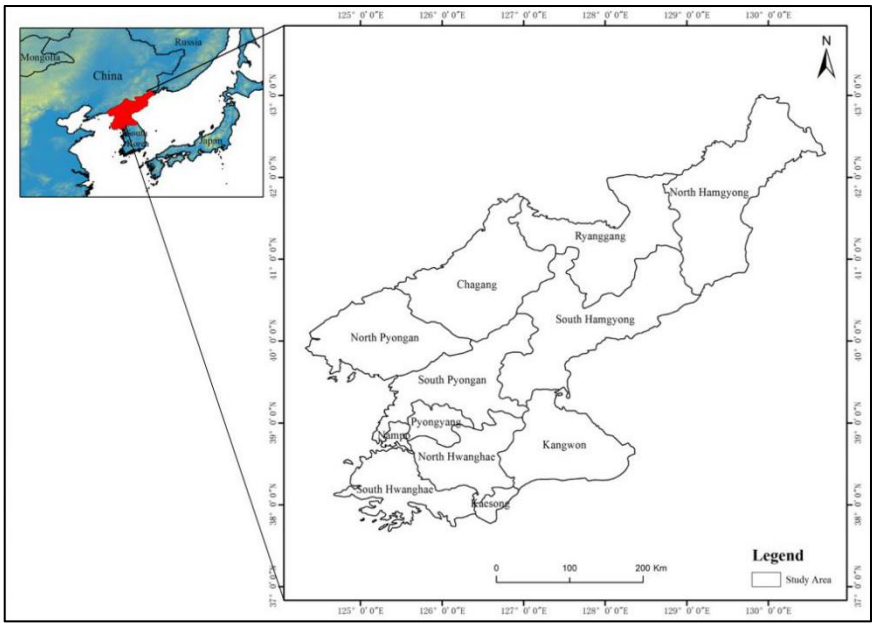

Fig. 1.Study area.

This paper selects the NK region (Fig. 1) as the research object. The terrain is high in the northeast and low in the southwest, and there are many mountainous areas in the territory. The forest resources are abundant. Once a FF occurs, such terrain factors cause the fire to be unsuccessful, which greatly increases the fire disaster degree and economy. cost. NK is dominated by temperate monsoon climates, with dry springs; autumn and winter precipitation is sparse and temperatures are low. The annual average temperature is about 8-12 ° C, the average annual precipitation is about 1000mm to 1200mm, and seasonal changes are strong, so NK is more prone to FFs.

2.2. Data used

The MODIS data is the FF data of various regions of the world measured by satellites in real time, and the statistics of FFs in the Korean Peninsula from 2001 to 2015 are extracted. The area where the atmospheric temperature is higher than 5°C to 10°C in the surrounding area and the area is more than 1km2 is set as the FF area, which is the hot spot. The red dot on the image is the hot spot, and the black spot is non-high heat area.

2.3. Methods

Kenel density

The motion detection method based on kernel density estimation is a method of estimating the probability density of the current frame pixel by using historical frame data to set the probability density threshold to obtain the motion foreground. It is assumed that there are M pixels in the video frame, and each pixel point There are N samples, each of which is considered to be an equal contribution in the density estimation, and the weighting coefficient is 1/N. That is, the j pixel value in the i frame at time t is xj, and the i background sample corresponding to the pixel The pixel value is xj, i (i = 1, 2, ..., N), Then the probability p(xj) of the j pixel in the video at time t can be estimated by the following formula:

$$\mathrm{p}(x_j) = \frac{1}{N}\sum_{i=1}^{N} K(x_j - x_{j,i}) \qquad (1)$$

Where: K is the kernel estimator. If K takes a normal distribution and the pixel takes a one-dimensional gray scale, then equation (1) becomes

$$\mathrm{p}(x_j) = \frac{1}{N}\sum_{i=1}^{N}\sum_{m=1}^{d} \frac{1}{\sqrt{2\pi\sigma jm}} \exp\left\{-\frac{\left[x_{(j,m)} - x_{(j,m,i)}\right]^2}{2\sigma_{(j,m)}}\right\} \qquad (2)$$

In equation (2): σj is the corresponding kernel width, d is the feature dimension. Set the probability threshold T, and the probability obtained by using equation (2) is selected by p (x j) <T. If p (x j) is satisfied <T, it is judged that the corresponding pixel is a moving foreground object; otherwise, it is judged as the background.

The greater the probability threshold is selected, the greater the probability of misjudging the foreground; if the selection is too small, the miss detection rate becomes larger. The T value is generally obtained from the experiment according to the specific situation, and the probability histogram obtained by the image is observed here. This study used ArcGIS10.1 to extract statistical data of FFs in NK from 2001 to 2015, and conducted Kenel density analysis. The annual and seasonal variations of FFs in NK during the past 15 years and the distribution of FFs in various administrative regions of NK(Zhang et.al., 2010).

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3. Results and discussion

3.1 Time distribution characteristics of FFs

In different years and different seasons, the climate, temperature conditions and precipitation are different, and there are obvious annual and seasonal changes in FFs. Therefore, the study of the temporal distribution of FFs is mainly based on its annual variation law and seasonal variation law (Chai et.al., 2009). According to the time distribution law, the division of fire prevention period is of great significance for the prediction of FFs.

From the inter-annual perspective, using the statistics of the number of FFs in Korea from 2001 to 2015, it can be concluded that the overall occurrence of fires is on the rise (Fig. 2). In the middle of 2001-2015, FFs occurred the most in 2014, followed by 2009; and FFs occurred

the least in 2002. Combined with the statistics, although the number of FFs in NK has been relatively small since 2010. However, during these 15 years, FFs shows upward pattern. This shows that NK's prevention and control of FFs needs to be strengthened.

From the seasonal changes, based on the statistics of the number of FFs in the 15 years of NK in 2001-2015, it can be concluded that FFs are closely related to the season. According to the chart (Fig. 3), it can be directly seen that FFs generally occur in spring and autumn, especially in spring. According to statistics, in NK, FFs accounted for 92.4% in spring and 5.2% in autumn, while 0.7% and 1.6% in summer and winter, respectively. The reason why FFs are concentrated in spring is because spring is the driest season on the Korean Peninsula. The average temperature in the whole season is around 10 °C, which increases the possibility of fires. At the same time, the wind is strong, which is conducive to the strengthening of the fire. In addition, spring is the most frequent season for agricultural activities in NK. It is planted in agriculture, and a large number of crops are burned and the source of fire is increased. This is the main reason for the FFs in spring. The number of fires in autumn is also relatively high, mainly due to the increase of litter in autumn and the increase of combustibles, which may easily lead to the spread of FF under certain conditions. The reason why FFs occur in summer is less than the rest of the season, because the Korean Peninsula is affected by the East Asian monsoon in summer and there is more precipitation. FFs generally do not occur unless there is a fire in a dry year. In winter, the temperature is declining, and there is a lot of snow in the mountains, so the occurrence of winter fires is relatively small.

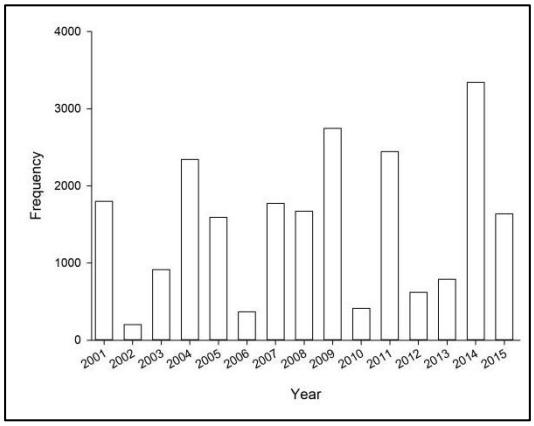

Fig. 2. The number of annual FF occurrence in study site from 2001 to 2015

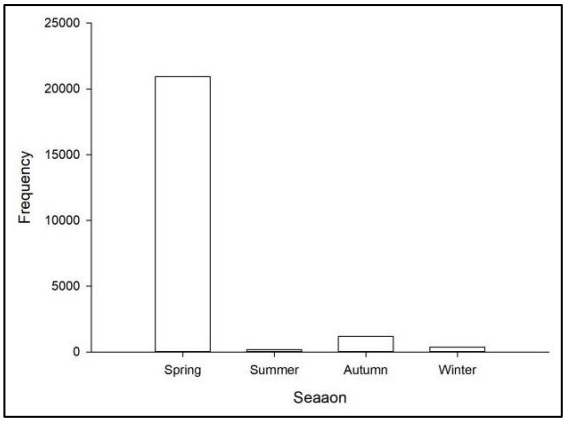

Fig. 3. The number of seasonal FF occurrence in study site from 2001 to 2015

3.2 Spatial distribution characteristics of FF

The characteristics of spatial distribution of FF is related to the natural distribution of FF and their distribution in different regions. And it has scientific guiding significance for the division of FF occurrence area and the rational allocation of fire prevention resources. Furthermore, it is also an important basis for implementing various programs for FF remediation.

In terms of topology, most of the Korean territory are mountainous and plateau. This type of terrain also brings great difficulty to the forest inspection work. It often causes the inspection to be in place, the surveillance is not comprehensive, and the FF cannot be discovered in time. Therefore, this is one of the reasons why there are more FF incidents every year in NK. Moreover, such a topography, once a FF occurs, greatly increases the difficulty and economic cost of on-site remediation, which is also an important reason for the large loss of FFs in NK. In addition, the NK economy is relatively backward and living conditions are very difficult. Therefore, in order to survive and develop, the Korean people have planted a large number of

them in the mountains and river valleys. The vegetation is seriously damaged, especially the forest. In addition, the local people's fire prevention awareness is also poor, often only for farming, a large number of burning plant dead branches and straw, resulting in widespread fire, resulting in FFs. From the natural distribution of FFs in NK, FFs are concentrated in the valleys with high elevation and steep slope like show in the obvious distribution characteristics on satellite images (Fig. 4).

Fig. 4. FF occurred area with Satellite imagery background in NK

In addition, through the analysis of nuclear density in the four seasons of NK, it is concluded from the analysis that the spring FFs in NK are mainly distributed along the Changbai Mountains on the east coast of Korea, and the distribution is relatively scattered. The FFs in Gangwon Province in the southmost part are more frequent (Fig. 5) In summer, it is the rainy season in NK, and the precipitation is high, so FFs rarely occur (Fig. 6). In autumn, due to the yellow and yellow leaves, in addition, this is also the season of harvest, and humans are also active in the mountains. FFs often occur, causing FFs to occur relatively in the fall (Fig. 7); in winter, there is more snow in the mountains of NK, which is a possible limitation of FFs. However, due to the cold weather, people in the outdoor area burn in the wild for heating, and the fire prevention awareness is poor. People are not separated from the fire, causing the fire to spread, resulting in FFs. In addition, because of the border with South Korea in southeastern Korea, in order to ensure the vision of the military demarcation line, artificially burning vegetation, the distribution of winter FFs is mainly concentrated on the east coast of Korea and Gangwon-do area (Fig. 8).

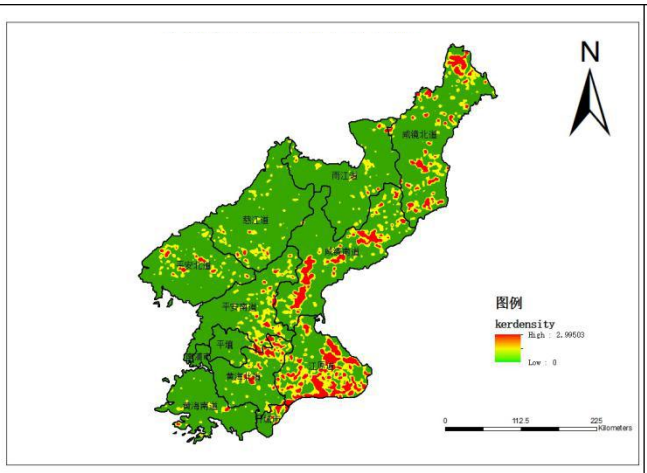

Fig. 5. Distribution of spring FFs in NK

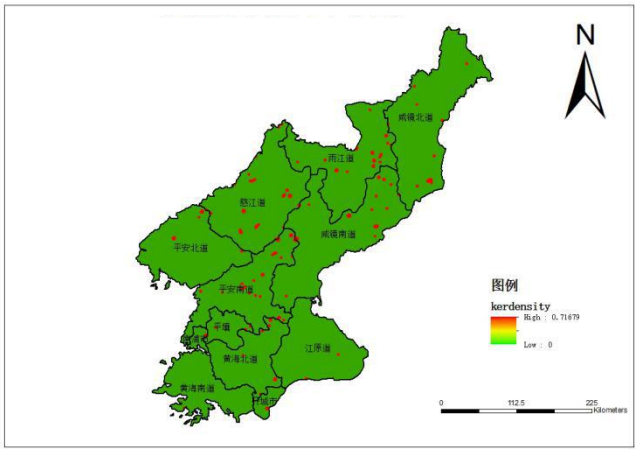

Fig. 6. Distribution of summer FF in NK

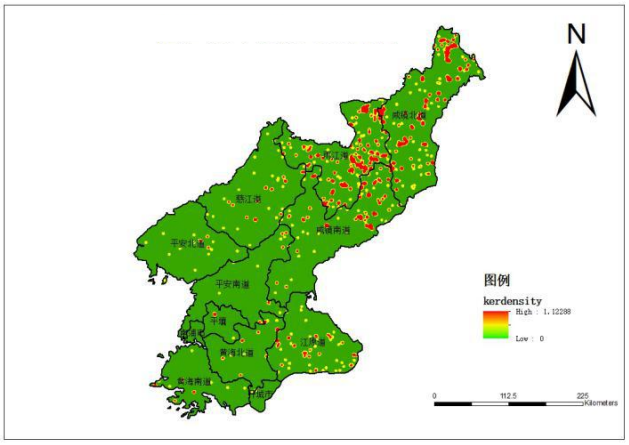

Fig. 7. Distribution of autumn FF in NK

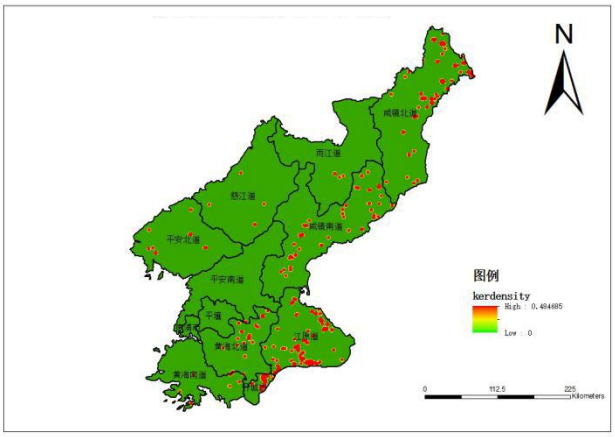

Fig. 8. Distribution of winter FF in NK

According to the statistics of (Table 1), it is known that in the four seasons, the FFs in NK mainly occurred in areas with a height of more than 300m, accounting for 71.4%, and the rest accounted for 28.6%. Combined with the slope and the common statistics of the four seasons (Table 2), in the whole year of the year, the FFs in NK are mainly concentrated in the area of 0° to 25°, accounting for 75.9%. The main reason for the occurrence of more FFs in winter in areas with slopes below 15° is that these areas are flat and more suitable for human settlement; in addition to cold winters, artificial fires often occur in order to keep warm. In general, FFs have distinct distribution differences in different types of topography. For this reason, only by mastering the relationship between FFs and terrain conditions can the key monitoring of fires be carried out, thus effectively reducing the possibility of FFs.

(Table 1) Frequency of occurrence of FFs of different heights in NK in each season Unit/%

	Spring	Summer	Autumn	Winter	Total
0-300m	29.2	18.2	11.0	53.0	28.6
300m-2736m	70.8	81.8	89.0	47.0	71.4

(Table 2) Frequency of occurrence of FFs in different slopes in NK in each season Unit/%

	Spring	Summer	Autumn	Winter	Total
0-15°	36.7	43.8	38.0	51.2	37.1
15° -20°	19.9	14.8	16.1	17.4	19.6
20° -25°	19.4	17.0	18.0	16.6	19.2
25° -30°	13.6	13.7	15.1	8.4	13.6
>30°	10.4	10.7	12.8	6.4	10.5

From the perspective of NK administrative units, due to the differences in the distribution and geographical location of forest resources and the development status of various regions, there are also obvious regional differences in FFs. The study on the distribution of FFs in different administrative regions is of great significance for the rational distribution of fire prevention resources and the strengthening of FF prevention and control. According to research, there are significant differences in Korean FFs in various administrative regions (Fig. 9). It can be seen from the bar chart that the three administrative districts with more frequent FFs are Gangwon Road, Hamgyong North Road and South Hamgyong Province. Combined with the topographical features of NK, these three regions are located on the east coast of NK and are a region with a wide distribution of mountains and plateaus in NK. This shows that the FFs in NK are mainly distributed in the east coast of NK. In addition, the image is processed in conjunction with ArcGIS spatial analysis. Administrative areas with relatively large FFs are generally located in areas of mountains and plateaus. Such as South Pyongan and North Yellow Sea. The areas with less forests are generally concentrated in the western part of NK, and are also the areas where the semi-plains and hills of NK are distributed. This indirectly indicates that the characteristics of the east and west of NK are quite different and the resources are unevenly distributed. Therefore, Gangwon-do and Hamgyong North Road and South Hamgyong Province are key areas for the prevention and control of FFs in NK. The area should increase the monitoring of FFs, as well as invest in fire prevention resources, and improve the corresponding laws and regulations. Maximize the prevention of FFs.

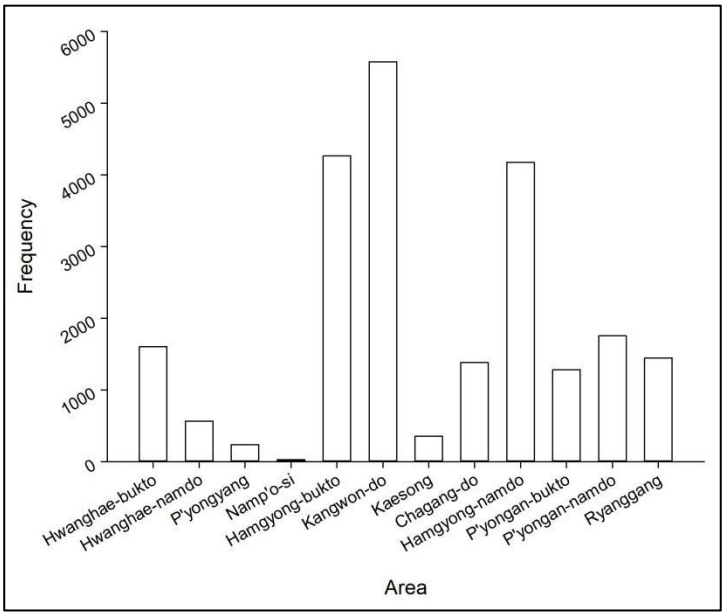

Fig. 9 Distribution of FFs in various administrative regions of NK

3.3 General characteristics of fires in Korean forests

The total number of FFs in NK from 2001 to 2015 was counted from different aspects such as year, season and terrain, and administrative district. According to the analysis of statistical results, Korean FFs have significant spatial and temporal distribution patterns. In the time of FFs, the occurrence of FFs is mostly concentrated in spring and autumn, and FFs are also long. There are geographical differences in space, and the possibility of FFs in different regions is completely different. On the whole, FFs in NK generally occur in mountainous and highland areas, especially in the east coast of the East Coast, where FFs are significantly more common than in other places (Fig. 10). Secondly, from the perspective of the topography of NK, there are more fires on the East Coast, especially in areas with more residents, that is, areas where human activities are more frequent.

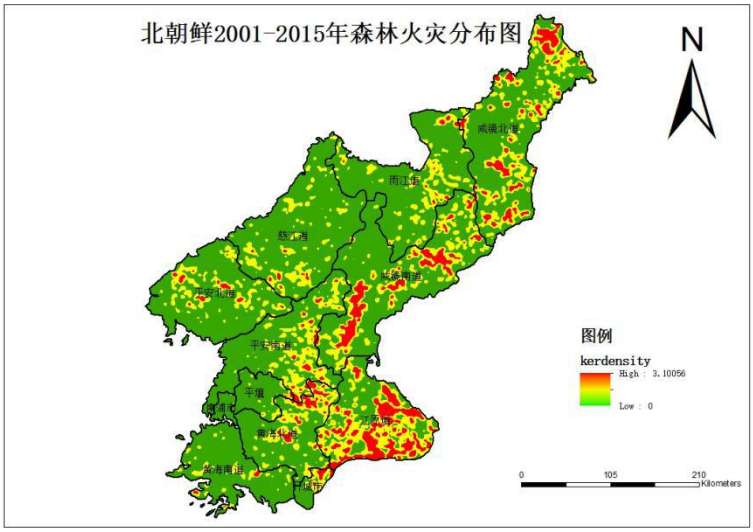

Fig. 10. The distribution of total FF from 2001 to 2015 in study site

4. Conclusion

FF is a major natural disaster in the world and a problem that must be faced by forest protection in mountainous area like NK. There are many driving factors for FF such as global warming. The damage to the global ecosystem is becoming more and more serious. Therefore, research on FFs become the global issue. Through the study of this paper, we figured out the distribution and characteristics of FFs in NK during the period of 2001-2015. During the research period, the spatio-temporal distribution of FF in NK mainly has the following characteristics: 1) Most of the FF in study site mainly occurred in mountainous area along the east coast of NK. 2) Most of FF in study site mainly occurred in spring season, there was a fewer FF in summer and winter. Furthermore, the rate of growth for FF gets bigger with the increase of time. 3) The distribution of Korean FFs in various administrative regions is quite different. In addition, the number of FFs in mountainous areas and plateaus is significantly higher than in plain areas, especially in areas where altitudes are above 300 m and slopes are between 0° and 25° . Therefore, the distribution characteristics of FFs vary greatly at different spatial scales.

References

[1] Chai,Z.P., Tian,C.L., Li,F.Z., Distribution of FFs in Heihe area.Forestry technology, 2009，34,38-41.
[2] Deng,O., Spatio-temporal model of FFs and fire danger zoning in Heilongjiang Province.Beijing Forestry University,2012.
[3] Dong,Z.H., The importance of FFs and seasonal impacts in FF prevention.Farmers' Friends of Riches,2019,15-197.
[4] Liu,M., Jia,D., Application of Satellite Remote Sensing Technology in FF Fighting.City and disaster reduction,2018,66-70.
[5] Naderpour M., Rizeei, Mojaddadi, H., Khakzad, N., Pradhan, B., FF induced Natech risk assessment: A survey of geospatial technologies , Reliability Engineering & System Safety , 2019,106558.
[6] Yang,J.R., FF Prediction Based on Linear Regression Algorithm.Communication world,2019,26,227-228.
[7] Yang,W., Jiang,X.L., Remote sensing information extraction and application of FFs.Forestry science,2018,54,135-142.
[8] Zhang,J., Chen,J.C., Huang,H.C., Probability density estimation and shadow suppression for moving target detection.Journal of Huaqiao University (Natural Science Edition,2010,31,20-22.