Analysis of Topographic Features Based on Yunnan Fire

Duan Shangqi¹,a, Chen Haidong¹,b, Ge Xingke¹,c, Huang Shuangde¹,d, Wang Tao¹,e, Xu Debin¹,f, Xu Baoyu¹,g

¹Kunming Power Supply Bureau of Yunnan Power Grid Co. Ltd. Kunming, Yunnan 650011, Kunming, Yunnan, China

aemail: duanshangqi@km.yn.csg.cn, bemail: 494022669@qq.com,
cemail: 55748880@qq.com, demail: 52926524@qq.com, 
eemail: wfyle1314@163.com,
femail: xudebin@km.yn.csg.cn, gemail: 317542732@qq.com

Abstract: The Yunnan power grid has the characteristics of wide distribution and large geometric size, which makes the power grid vulnerable to natural disasters such as wildfires. The unique topography and climatic conditions of transmission lines crossing mountains, forests and other zones can easily lead to the outbreak of mountain fires, or even the tripping of transmission lines. In serious cases, transmission towers may be destroyed, thus causing major power accidents. The occurrence of mountain fire is closely related to topographic factors, and the change of each topographic factor (elevation, slope, slope direction, etc.) has a certain influence on fire. This paper mainly studies the relationship between three terrain factors and fire. Based on the statistical analysis of remote sensing data from 2005 to 2020, the terrain features and their influence of fire spots in Yunnan province were analyzed. The results show that most of the fires occur within the range of 1000-2000m above sea level, and the fires occur frequently. The frequency of fire occurring below 1000m and above 2000m is low. The occurrence frequency of fire is higher in the gentle slope range, among which, the number of fire point samples is the largest within the range of 5°-15°, followed by 0°-5° and less than 15°. In this paper, eight slopes are divided to make statistics of fire points, and the number of fires in different slopes also fluctuates, among which the south slope has the highest fire risk, accounting for 16.0%. The West Slope accounted for only 10.0%, with the lowest fire risk. Terrain factor is a fixed variable that has a fixed influence on the regional fire risk. Therefore, terrain analysis of fire is of great significance for the prevention of mountain fires in power grid.

1. Introduction
In recent years, with the continuous development of power grid scale, the probability of the line crossing the forest area increases. Under the influence of global warming and other factors, more and more mountain fires cause the line trip and power failure accidents, which threaten the normal operation of power companies and the normal production of national economy. If a large-scale wildfire affects multiple transmission lines, it will pose a severe challenge to the safe and stable operation of the power grid. Power grid fires will not only seriously threaten the animal and plant resources and their habitats in the ecosystem, and cause a series of environmental problems, but also are closely related to the safety of human life and property[1]. For example, on May 6, 1987, the great fire on the Sino-Russian border in the Greater Xing’an Mountains burned 212 people to death in China alone, burned 3 forestry bureaus (city filling), 9 forest farms, and 4 semi-woodyards (burned down). Lumber 850,000), 67 bridges, 9.2km railway, 284km transmission line, 64,000 square meters of houses, 3.25 million kg of grain, 2488 sets...
of various equipment\cite{2-3}. The losses were very heavy, with a direct economic loss of 420 million yuan\cite{2-3}. Therefore, doing a good job in forest fire prevention is not only related to the safety of life and property, but also related to the development of modern forestry, and it is also related to my country's ecological civilization and ecological security, which has very important practical significance.

Many scholars have carried out a lot of research on the time evolution, spatial distribution, fire spot monitoring and early warning of fires in various places based on historical documents. Jianhua Du et al. Based on the CRU grid point meteorological data of the fire yearbook data set, combined time series and Pearson correlation analysis set linear regression analysis and other methods to analyze the characteristics of forest fires and their climate driving factors during the period from 1950 to 2017 in China, and established a prediction model for the number of casualties caused by fire \cite{4}. Based on satellite infrared monitoring, Shengji Xu and others collected satellite infrared monitoring data of forest fires from 2004 to 2015, and analyzed the temporal pattern and distribution of forest fires in Yunnan Province\cite{5}. In recent years, with the development of remote sensing technology and big data, forest fire monitoring has developed rapidly. Various forest areas across the country have developed various fire risk weather forecasting methods based on local meteorological elements, historical fire conditions, and combustible moisture content. Such as the "multi-factor correlation probability fire forecast forecast" in the northeastern Yichun forest area, the "forest fire risk weather forecast" of the Liaoyuan Forestry Bureau of Jilin Province, the "forest fire risk weather forecast" of Fujian Province, and the Heilongjiang Forest Protection Research Institute "Forest Fire Forecast System", "Multi-factor Comprehensive Index Forest Fire Forecast" of Daxinganling Regional Meteorological Bureau and "Fire Risk Weather Grade System Forecast" of Ganzi, Sichuan Province\cite{6}.

Scholars and predecessors of researchers have obtained a lot of practical results. They have conducted in-depth studies on several important factors in the history of fires in my country, such as meteorological factors, vegetation factors, and human factors. Topographic factors are considered as the basic factors affecting the occurrence of fires. In order to better carry out forest fire monitoring business to prevent fires in power grid and reduce the occurrence of mountain fires in power grid, this paper analyzes the topographic characteristics of historical fires in Yunnan province by using multi-year fire point monitoring data.

2. Study Area

Yunnan Province is located in the southwestern border of the motherland, with numerous rivers, complex topography and geological conditions, and three-dimensional climate. 94% of the province’s land area is mountainous, with high mountain slopes and deep valleys. The terrain is complex and diverse, sloping from northwest Yunnan to southeast Yunnan. Yunnan Power Grid is an important part of the country’s “West-East Power Transmission”. Its overhead transmission lines have the characteristics of wide coverage and long line distances. According to statistics, more than 40% of the transmission lines of Yunnan Power Grid are directly affected by extreme meteorological disasters caused by wildfires.

3. Data and methods

3.1. Data source

Historical fire point data for the five years from 2015.1.1 to 2020.1.1 from the NASA official website-burning area MCD64A1. Download the digital elevation model DEM from the geospatial data cloud. For the reliability of data analysis and better prevention of fires in the power grid, this paper only selects the sample data of fire products whose confidence level is greater than 90 and the power grid has fired to extract and analyze relevant topographic factors. Among them, elevation (Elevation) is the most basic feature of terrain, and its elevation image is shown in Figure 1. Slope refers to the angle between the tangent plane of a point on the ground and the horizontal plane, which is used to indicate the degree of inclination of the ground at that point, as shown in Figure 2 below. Aspect refers to the angle between the projection of the normal vector of the tangent plane of a point on the ground on the horizontal plane
and the true north direction passing the point. The range of the angle is between 0° and 360°. The flat slope of the aspect is generally represented by -1, as shown in Figure 3.

Figure 1: Elevation

Figure 2: Slope
Aspect is a discrete factor, and its values have no significance between values, so it cannot be directly brought into the model, and dummy variables or dummy factors need to be set. This study uses one-hot encoding to process these discrete factors.

The aspect data is transformed by Elevation data in ArcGIS software. The value is 0-360°, indicating the angle with the true north direction. However, the value of the aspect data is not the meaning of the value itself, but indicates the direction. For example, in the azimuth representation, 0° and 360° both indicate the true north direction. If the aspect is brought into the model as a continuous factor for calculation, it will result in different results for 0° and 360° that also indicate the north direction. First, discretize the Aspect data according to the orientation indicated by the Aspect data, as shown in the figure below. This paper divides the aspect into 8 directions, centered on the 8 directions of north, northeast, east, southeast, south, southwest, west, and northwest, and then moves 22.5 to the left and right. For example, the north is declared with code 0, the range of the indicated aspect is the union of 337.5-360° and 0-22.5°; the northeast is declared with the code 1, the range of the indicated aspect is 22.5-67.5°, the other aspect codes The meaning is similar here. In addition, there are some pixels in the study area that are horizontal, that is, there is no aspect, but the number of such pixels is small, so they are classified as north and still declared with 0 code. As shown in Figure 4.

3.2. Statistical analysis

Elevation, slope and aspect are used to analyze the topographical factors of the fire point of the Yunnan power grid. Use python to analyze the data distribution, determine the characteristics of the terrain and landforms with a high frequency of fire; statistically analyze the correlation between the height and slope of the fire.
4. Results and analysis

4.1. Elevation distribution
The scatter plot of forest fires at each altitude of the fire samples is shown in Figure 5, and the data interval distribution is shown in Figure 6. It can be seen from the figure that there are 78 fire spot samples distributed in the interval with an elevation of less than 1000 meters, and 696 fire spots are distributed in the interval between 1000 and 2000 meters. However, there are very few fire spots in the third interval between 3000 and 4000 meters. Point samples show a cliff-like decrease overall at an elevation of 2000 meters. The distribution of the histogram is very consistent with the elevation characteristics of the regional distribution of fire points. Grassland fires mostly occur in the southeast of the study area, and the elevation of this area is relatively small.

4.2. Slope Distribution
The slope of the fire point sample is shown in Figure 7, and the distribution of the slope data interval is shown in Figure 8. It can be seen from the figure that there are 286 fire samples in the range of less than 5°. With the increase of the slope, the number of samples in the interval of 5-20° is 534, and the number of samples in the interval greater than 20° is 24. The number of samples does not increase as the slope increases. In summary, the slope distribution characteristics of fire spots are similar to the height distribution characteristics. Within a certain slope range, the distribution of fire spot samples gradually decreases with the increase in slope.

4.3. Aspect distribution
The interval distribution of the aspect data of the fire sample is shown in Figure (9). The impact of slope aspect on forest fires mainly lies in the duration of sunlight that affects vegetation. If you analyze the relationship with forest fires from a single slope aspect, it is difficult to find the regularity. However, from the overall analysis of the histogram of the aspect distribution, it is found that the number of fire spots in the south slope direction is the highest, accounting for 16.0% of the sample fire spots. The distribution of the fire spots in the four slope directions is different. Not big. The two directions west and
northwest are relatively small. In summary, the risk of wildfire in the study area is highest in the southern slope.

![Aspect Distribution](image)

**Figure 9** The aspect distribution

### 4.4. Correlation analysis of fire elevation and slope

The scatter plot distribution of the slope and elevation of the fire sample is shown in Figure 10. It can be seen from the figure that slope and elevation have their own characteristics, and the distribution characteristics of slope and elevation are roughly similar. Most of the fire points are distributed in a certain range of elevation and slope. Pearson analysis of the two shows that the correlation between elevation and slope is not strong. The correlation coefficient is only 0.050, and the p-value is only 0.146. Although the two are positively correlated, the correlation is extremely low.

![Scatter Distribution](image)

**Figure 10** Scattered distribution map of elevation and slope

### 5. Conclusion and discussion

Yunnan is a fire-prone area and one of the provinces seriously affected by fires. The analysis of the fire point data of the power grid from 2015 to 2020 shows that fires occur every year in Yunnan. Wildfires have an objective existence, and this objective existence is also quantitatively regular. Within a certain elevation range, the higher the elevation, the lower the risk of wildfire. With the gradual increase in elevation, when entering the vicinity of a watershed or snow line, precipitation will increase significantly,
and the risk of forest fires will be lower. The slope is also closely related to the spread of fire. For uphill wildfires, the upper combustibles will be directly baked by the rising hot air from the lower wildfires, causing a large amount of water loss in the combustibles, thereby increasing the spreading speed of the wildfires. With different slope directions, the intensity and duration of sunlight received by forests are different, which affects the temperature and humidity of forest soil and air, and vegetation conditions. Generally, the southern slope receives longer hours of sunlight, lower air humidity, lower moisture content of vegetation, higher risk of forest fires, and relatively faster fire spread.

From the perspective of the burning triangle, wildfires in power grids occur in the wild without being restricted by space. Openness is a difficult condition to restrict. Only combustibles and fire sources can be managed. Only in-depth study of these two factors can quickly resolve the issue. Effectively manage forest fires. The management of the fire source is currently the most invested and the most important key factor. According to the topographic distribution characteristics of power grid fire points, key management should be implemented to reduce the distribution of power grid or strengthen the prevention of power grid fire at the elevation where fire points frequently occur and the corresponding slope direction.

References

[1] TIAN Xiao-rui, DAI Xuan, WANG Ming-yu, et al. Forest fire risk assessment for China under different climate scenarios[J]. Chinese Journal of Applied Ecology,2016(3):769-776
[2] The state forestry administration of the People's Republic of China. China Forestry Statistical Yearbook (1998)[M]. China Forestry Publishing House,1990.
[3] Ministry of Forestry of the People's Republic of China. National Forestry Statistics Collection:1949-1987[M]. China Forestry Publishing House,1990.
[4] Xu Shengji, Hu Minrui, et al. Analysis of the Temporal Characteristics of Forest Fires in Yunnan Province Based on Satellite Monitoring[J]. FOREST FIRE PREVENTION,2016(4):35-38.
[5] Du Jianhua, GONG Yinting, JIANG Li wei. Study on the Characteristics of Forest Fires in China and Their Relationship with Major Climatic Factors[J].Forest Resources Management,2019(2):7-14
[6] Yu Chenglong. Study on forest fire danger forecasting based on GIS and RS. Northeast Forestry University.