A Review on Spatio-temporal Pattern Evolution of Shrub Fire Caused by Human Disturbance in Yunnan Province

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Abstract. Artificial fire is the main cause of forest fires, and human intervention can reduce the occurrence of forest fires. Yunnan province is a province with a high incidence of forest fires. A large number of flammable shrubbery are distributed in many regions. The study on the time scale and space scale of shrubbery fires caused by human disturbance is conducive to the study on the evolution of the space-time pattern of shrubbery fires and the reduction of forest fires. Based on Yunnan province from 1990 to 2018 shrubbery fire data, combined with ArcGIS geographic information system, BP neural network analysis of the impact of human interference on Yunnan shrubbery fire and shrubbery fire time and space changes. The research results can provide some theoretical support for forest fire management departments.

1 Introduction

Chinese forest fires happen frequently and cause serious casualties and economic losses every year. Among the many factors causing forest fires, man-made fire occupies the majority. Yunnan Province is a mountainous plateau region, has always been known for the complex and diverse natural geographical environment, rich and colorful plant species, wide forest coverage rate, high forest density. Shrubbery is widely distributed and of various types, because shrubbery has clumpy structure, shrub or jungle appearance, unique cause, ecological environment and specific plant species composition, once on fire, uncontrollability. Brush fires occupy a large proportion of forest fires in Yunnan province, which causes great losses and is very unfavorable to the protection of forest resources. The climatic conditions of hot and dry for as long as half a year in Yunnan forest, the overload of forest fuels, the high density of fire sources and the threat of foreign fire sources are all potential dangers of heavy and very large forest fires. The complex terrain conditions of high mountains and deep valleys make it impossible for the rescue team to arrive at the fire site in the first time and delay the best time to put out the fire.

It is of great significance to study the prevention and control of shrub fire, forecast and prediction, fire spread and fire potential behavior to reduce the fire frequency and fire loss in Yunnan forest area.

2 Research status

At present, the study on spatial and temporal distribution of forest fires in foreign countries mainly uses statistical analysis method and geographic information system spatial analysis method to study the spatial distribution characteristics of forest fires in different regions and at different levels. In 2009, A Parajuli et al. used Moderate Resolution Imaging Spectroradiometer (MODIS) active data to show forest fire activity in Nepal and to assess fire size, distribution, seasonality, and risk zones in different geographic areas. In 1971, Hanes made a study on the heavy fire disaster areas in California, the United States, and showed that the shrubs had strong adaptability to fire. After fire, the seed germination made the rapid regeneration of the bushes and completed the automatic succession of the population, and fire was the regulator of this succession. The occurrence of forest fire is a complicated system science problem, which is related to many factors, and the human factors have the most serious impact on forest fire. Domestic scholars, experts and forest management departments pay much attention to the temporal and spatial distribution characteristics of forest fires and the effects of human disturbance, and use different theoretical methods and software to support the study of the effects of different degrees of human disturbance on forest fires. In 2018, Li Shangyi et al use Bivariate method to analyze correlation between sample biomass, tree species diversity index and soil nutrient content. According to the bivariate method, different degrees of human interference affect the biomass and its spatial distribution pattern of subtropical forest. In 2018, You Yujie et al. used Nemerow index and correlation coefficient method to carry out protective disturbance and moderate human disturbance respectively with intensity human disturbance as the contrast, and concluded that moderate human disturbance had better effects on soil water storage, water retention, fertility and carbon sequestration. In 2016, Zhang Chen et al. used correlation analysis and Bootstrap significance test to study the relationship between forest fire area and landscape index in Yunnan Province, and concluded that the increase of

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the average patch area of coniferous forest, broad-leaved forest, grassland and shrub would promote the spread of forest fire. In 2010, Wang Bin et al. used geographic information software to analyze the second-class survey data of forest resources and concluded that high-intensity external disturbances in Huoditang forest area increased the landscape diversity and richness of the region. The change of landscape pattern in Huoditang forest area fully reflected the influence of external disturbances on forest landscape pattern and the dynamic process of forest autonomous restoration. In 2009, Yang Guangbin et al. analyzed the statistical data of forest fires in Beijing from 1986 to 2006 by using statistical analysis methods and geographic information system spatial analysis methods, and concluded that the fire sources of grassland, dry land, rural residential land and other land around forest land may spread to form forest fires. In 2007, Tian Xiaorui et al. analyzed the temporal and spatial patterns of forest fires according to the statistics of forest fires in the Tibetan Autonomous Region from 1992 to 2005, and concluded that the fires mainly occurred in southeast Tibet, especially in Mangkang, Zayu, Nyingchi, Milin and other counties, and that the fires were mainly for production and domestic use. In 2007, Tang Lihua et al. analyzed and evaluated the risk degree of anthropogenic fire sources and the influence of positive anthropogenic interference through GIS spatial analysis method, and determined that the indicators of negative anthropogenic interference fire risk were agricultural land burning, agricultural mountain making and afforestation, grave visiting, tourism and basic activities, and the indicators of positive anthropogenic interference fire risk were input manpower and capital.

3 Research method

3.1 Study area profile and data sources

Yunnan is located in the southwest border of China and is called "Dian" for short. The whole province is located in a low latitude region south of 300° north latitude. According to the data of the fourth forest resources survey of Yunnan Province, the forest land area of the whole province is 26.07 million hectares, accounting for 68.0% of the total land area. Shrub land covers about 15% of the country.

In this paper, the data of brush fires in Yunnan Province from 1990 to 2018 were collected through forest fire prevention Office, yearbook and news reports.

3.2 Research procedure

This paper mainly uses BP neural network model in MATLAB and ArcGIS GIS for data collation and analysis.

The principle of BP neural network model construction is that the learning process consists of two processes: the forward propagation of signals and the reverse propagation of errors. BP network is a multilayer network composed of input layer, output layer and one or more hidden layer nodes interconnection. This structure enables the multilayer feedforward network to establish a suitable linear or nonlinear relationship between input and output, but does not cause the network output to be limited between -1 and 1. See Figure 1 for details.

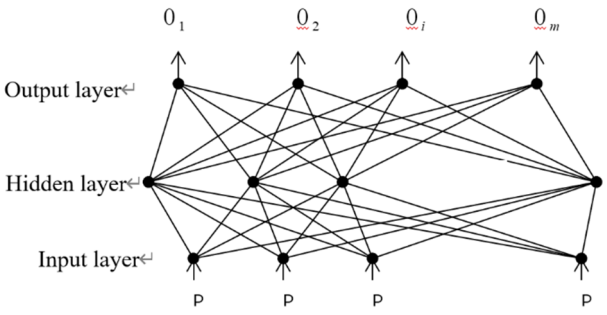

Fig. 1. BP network model.

The BP algorithm "trains" this event to get this input, and the output will get a suitable linear or nonlinear relationship.

4 Conclusion analysis

4.1 Analysis of bush fire time variation

The data of brush fires in Yunnan Province from 1990 to 2018 were collected. The number of brush fires and the number of fires in each month were different, and the fire peak was mainly concentrated in March and April.

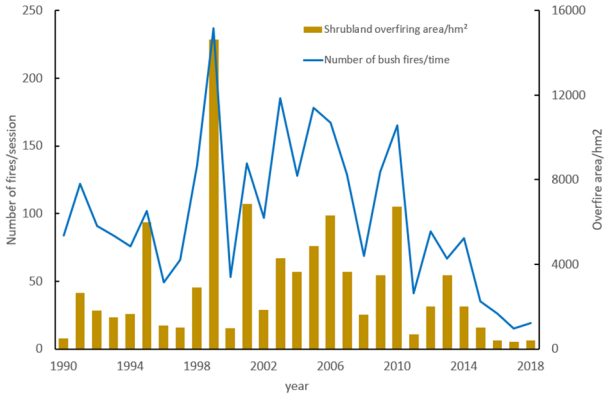

Fig. 2. Comparison of shrub fire occurrence and burning area.

Figure 2 is a comparison chart of the number of brush fires and the burned area in Yunnan Province from 1990 to 2018. It can be seen that the number of brush fires in Yunnan Province fluctuates greatly with the passage of years, but it has been on the decline since 2010. Especially, the number of brush fires has become less and less since 2016, and 2017 is the year with the least number of brush fires. The main reason may be that the government has increased the economic investment in forest fire prevention and the improvement of population quality in recent years. It can also be seen from the figure that the number of bush fires and the fire area on the whole is proportional to the number of bush fires, the fire area increases along with the number of bush fires, there are also some years of fire more times but the fire area is not large, the reason may be different areas, some years of the area where the bush fire may be more distributed.

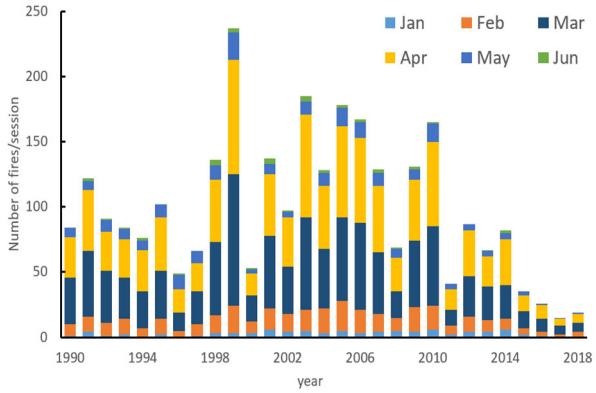

Fig. 3. Bush fires have monthly variations.

As can be seen from Figure 3, there were more brush fires in 1990 ~ 2010, but on the whole, the fires occurred in March and April, which were the most frequent. The forest fire prevention period in Yunnan Province was from December to June of each year, and the forest fire martial law period was from March to April. Brush fires in Yunnan province occur in months coinciding with fire prevention periods, with frequent occurrences in March and April.

4.2 Change of shrub fire area under human disturbance

Most forest fires in Yunnan Province are caused by man-made fire, so are brush fires. Man-made fire is a part of human disturbance, which can be divided into negative human disturbance and positive human disturbance. The index of positive human disturbance is mainly economic input. That is, when economic input is high, the number of bush fires will decrease correspondingly. Before 2005, the government's investment in shrubland was relatively small, so the number of shrubland fires was relatively high. From 2006, the trend of decline began, and the economic investment was higher than that of previous years. However, from 2008 to 2010, the shrubland fires briefly increased, mainly because Yunnan was in a period of drought at that time, and the number of fires was also relatively increased. However, the overall trend of shrub fire is decreasing, especially in recent years, the shrub fire has reached the lowest, which indicates that the economic investment of the government and the improvement of population quality in recent years play a role in the prevention and control of shrub fire.

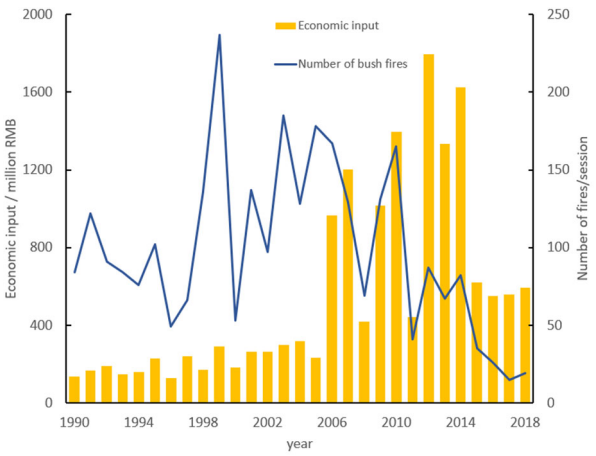

Fig. 4. Comparison of fire frequency and economic input.

Figure 5 reflects the relationship between the shrub fire area and economic input in Yunnan Province from 1990 to 2018. It can be seen from the figure that the economic input and the shrub fire area show a negative correlation. When the economic input is high, the fire area will decrease to some extent, which is mainly reflected in the increase of the government's economic input after 2005, especially in 2012. Economic input reached the highest, the fire area is relatively reduced.

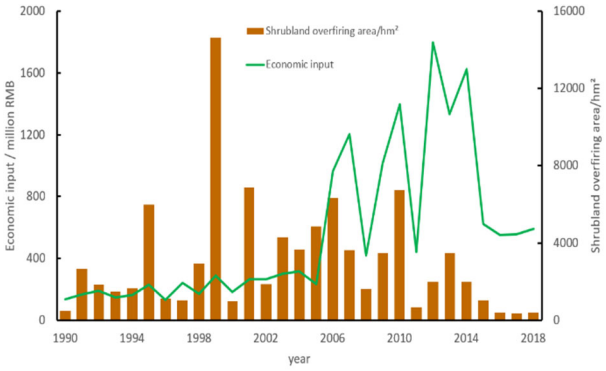

Fig. 5. Comparison of fire area and economic input

4.3 Spatial variation of shrub fire under human disturbance in Yunnan Province

The shrub is widely distributed in Yunnan Province. Among the 16 cities and towns, Dali, Lijiang and Kunming occupy a large area of shrub. From the brush fire data in the past 30 years, it can be seen that the number of fires in these areas is relatively high. Human ignition source is the leading factor of shrub fire. Man-made fire sources can be divided into two categories: productive fire source and non-productive fire source. Productive fire source mainly refers to burning land and charcoal, making mountains and afforestation and burning pasture. Non-productive fire sources mainly refer to the field smoking, heating and cooking, burning paper, burning mountains to drive animals, children playing with fire, dementia and fire and wire caused by these factors lead to the frequent occurrence of bush fires.

4.3.1 Analysis of productive fire source

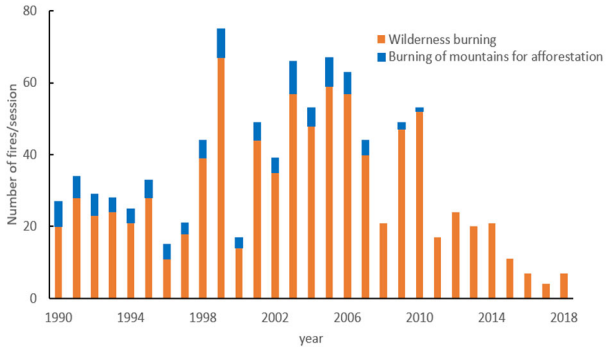

Fig. 6. Analysis of productive fire source of bush fire

As can be seen from Figure 6, the main productive fire sources of shrubland fires in Yunnan Province are wilderness burning and hill-making and afforestation, of which wilderness burning accounts for most, reaching 90%. Wildland burning is the main means of farmers' cultivation. The frequent occurrence of forest fires indicates that farmers' awareness of forest fire prevention has not been improved. However, the number of wildland fires caused by wildland burning has decreased significantly in recent years, so the government may strengthen management.

4.3.2 Analysis of non-productive fire sources

It can be seen from Figure 7 that the largest proportion of non-productive fires in the shrub fires in Yunnan province is outdoor smoking, which is the non-productive fire source and plays a leading role. Children playing with fire, heating and cooking, burning paper in the grave, dementia fire, electric wire caused by a certain proportion, but is less dominant than outdoor smoking, it can be seen that non-productive fire sources of outdoor smoking has the greatest impact on the brush fire in Yunnan province, but since 2010, all kinds of fire sources have been gradually reduced, the main reason is that the quality of the population is improved, the government to strengthen fire source management, In addition, with the progress of science and technology, people change the way of farming and the control of wildland burning, which has brought the fire source under control in recent years.

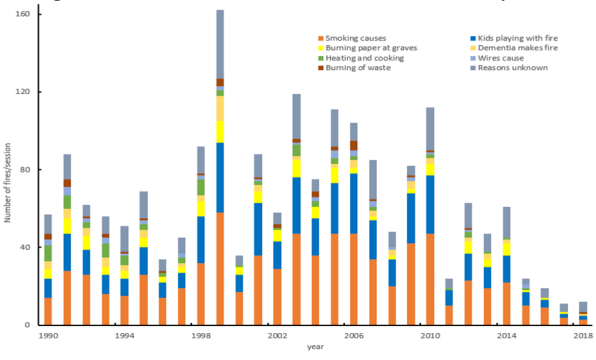

Fig. 7. Analysis of unproductive fire source of bush fire.

4.4 Spatial distribution characteristics of shrub fires in Yunnan Province

The distribution of shrubland in 16 prefectures and cities of Yunnan Province is different, and the number of shrubland fires in each city is also different. FIG. 8 is the comparison of the number of brush fires and the burned area in each city of Yunnan Province from 1990 to 2018. It can be seen that the number of brush fires in Kunming, Dali and Lijiang is the highest, Qujing, Dehong, Lincang and Wenshan is the least, Kunming has the largest burning area, Dali has more fires than Kunming, but the burned area is smaller than Kunming. The hazard degree of shrub fire in Kunming is higher than that in Dali.

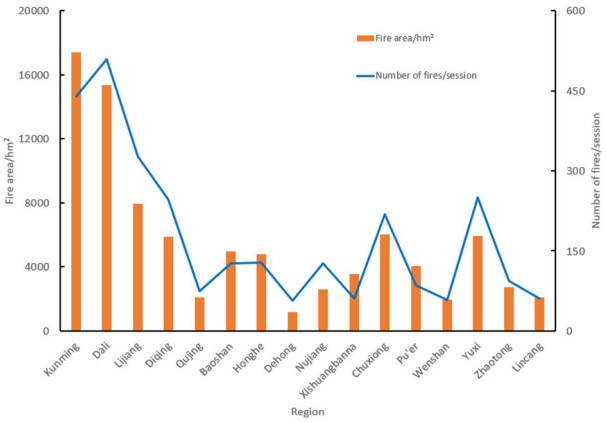

Fig. 8. Comparison of fire frequency and fire area in each city of Yunnan Province

4.5 Brush fire modeling in Yunnan province based on BP neural network

The number of brush fires in Yunnan Province tends to be stable in recent years. The simulation and model construction based on BP neural network are as follows: Data are selected as the training data, test data and prediction data of BP neural network. The error learning target of BP neural network is set as 1e-2, the maximum number of iterations is 50,000, the display step size is 50, the learning speed is 0.01, and the hidden layer is set as 100 neurons. BP neural network model is constructed by using neural network function provided by MATLAB.

The model diagram is as follows:

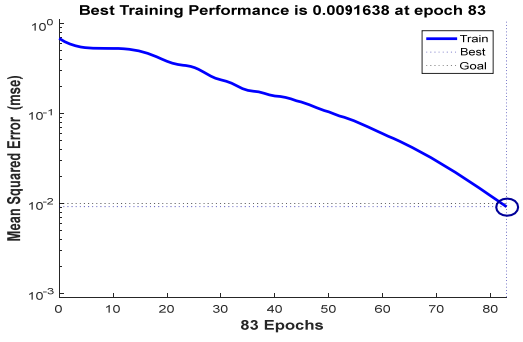

Fig. 9. Neural network error adjustment diagram

Fig. 10. Neural network goodness of fit graph

Figure 9 shows that the error of setting the target is 0.01, and the error of each iteration will be reduced. After 83 iterations of training, the target error is reached, so the iteration is stopped. Figure 10 shows the goodness of fit graph, in which each data point fluctuates little above and below the matching line, indicating that the model has well learned the data and has a high goodness of fit.

5 Conclusion

Based on the brush fire data of Yunnan Province from 1990 to 2018, the following conclusions can be drawn by ArcGIS and BP neural network prediction:

The brush fires in Yunnan Province showed a decreasing trend on the whole, with a substantial decrease in the past three years. The main reason is the increase in government investment.

The analysis of fire source indicates that the main factors causing shrub fires in Yunnan Province are burning land, burning charcoal and smoking in the field.

Shrub fires in Yunnan Province showed a decreasing trend, mainly in March and April. In terms of spatial scale, it is mainly concentrated in Kunming and Dali, which have the largest area of fire.

Acknowledgements

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