Spatial Analysis of the Extraction and Severity of Forest Fire in the Northern Forest Area of Genhe

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Abstract

A large number of forest fires occur in Greater Khingan Range every year, and the burned area is an important information to describe the forest fire, which is of great significance to the study of the burned area. This study used fire trace to divide common NDVI, NDSWIR, NBR, dNBR and MNDWI to construct decision tree to identify fire trace. Fire severity is divided based on the dNBR index, and the proportion of moderate fire area is the largest, reaching 4432 hectares and 48.44% of the total area. Combined with the elevation, slope and slope direction of the terrain, the fire severity is mainly concentrated at 1000-1500 m, reaching 6839 hectares; The area of burned area is the largest in the slope of 6°-15°, accounting for 48.84% of the total area, and the range of burned area decreases to flat land and steep slope; On the slope, the burned area is concentrated on the west side and gradually decreases to the southeast side. The overall trend of Greater Khingan Range is that the northwest side is slower and the southeast side is steeper, which is also corresponding to the large area of the slow slope burned in the burned area and the large area of the west side burned area. The decision tree division based on multi-remote sensing index has practical reference value for accurate identification of burned land.

Keywords

Landsat 8; Burned Areas; Decision Tree Classification; Fire Severity; Topography.

1. Introduction

Forest fire is not only closely related to forest vegetation, but also constitutes the structure and function of ecosystem, which is a of ecological factors with double sides[1]. On the other hand, a certain degree of forest fire can also reduce the accumulation of surface combustible materials. At the same time, it improves some poor ecological environment, makes the ecological environment into a virtuous circle, attaches importance to the ecological impact of forest fire, and makes rational use of forest fire. Fire is one of the most serious ecological disasters. Every year, forest fire affects about 0.1% of the total forest area[2]. Environmental, economic and social impacts of forest burning are also further highlighted, and should be highly valued by national and local governments, and rational response to forest fire[3]. burned area is one of the most important information to describe forest burning. It can effectively provide important information such as the time, location, area and spatial distribution of forest fire, and find forest fire more quickly and accurately[4]. and it is an indispensable research object of fire formation mechanism[5].

The traditional method of burned area monitoring mainly depends on a large number of field investigations, Classification and of fire effects using manual mapping[6], At the same time, It is difficult to accurately analyze the large range and difficult to enter the deep mountains. With the development of remote sensing technology, The continuous progress of space information technology, Remote sensing monitoring technology plays an important role in forest fire[7]. Peterson introduced a new fire monitoring algorithm based on MODIS data, Practice in California forest fires, Help to improve the of discriminant accuracy. There are also studies on vegetation restoration monitoring after fire using multi-source remote sensing data[8], Combined airborne radar like Meng, High resolution satellite studied the short-term recovery rate of vegetation in different burned area. At present[9], the main research is to use the huge changes of surface radiation energy to realize fire point monitoring, or use the change of vegetation index before and after the fire to determine the fire degree and distribution[10], Or using hyperspectral data to monitor fire[11], or using atmospheric monitoring satellites to study the characteristic of smoke from forest fires[12], Or use synthetic aperture radar data after fire monitoring[13]. However, it is affected by the temporal resolution, spatial resolution and data quality, It is difficult to monitor small forest fire spots.

To sum up, The division of burned area is basically limited to the traditional division method. cremation trace extraction based on knowledge mode[14], threshold method based on multiple spectral indices[15-17]. The decision tree model proposed by Zu Xiaofeng and others is relatively accurate, However, due to the high score No .1 data band is less and there are some limitations[18]. This study mainly analyzes the multi-view landsat8 images and uses DEM data to assist, Depending on the fire coordinates provided by the Genhe Forestry Bureau, With the help of multiple remote sensing factors such as NDVI, MNDWI, NDSWIR, NBR and dNBR this differential remote sensing factor, The two forest areas in the northern part of the Genhe were identified by two different fires in 2017 and 2018, Classified extraction, and the area data in the root river fire data are used to verify. Exponential threshold method for dNBR this remote sensing factor, Divide the fire into four levels. The order is Unburned, Low severity, Moderate severity, High severity, The relationship between fire severity and topographic factors (slope, slope direction, altitude) was analyzed. In this study, the forest cover rate of the root river is 91.7%, County-level cities with the highest forest cover, Also is the lightning strike fire occurrence more concentrated area. Two fire fires were selected in 2017 from the highland forest farm of Mangui Forestry Bureau and 2018 from Hanma Nature Reserve. Using the NDVI, MNDWI, NDSWIR, NBR of the study area and dNBR 5 remote sensing index to construct the decision tree, To verify the applicability of the decision tree model in the identification of fire tracks, Multiple remote sensing indices can be better used to extract fire, And combined with the topography of the fire zone in the space of scientific and effective analysis, It provides scientific and effective theoretical basis for forest fire control and forest fire prevention in Genhe and Hanma Nature Reserve.

2. Survey and Data Sources

2.1 Overview of the Study Area

The city of Genhe is located in the north of China and is also located in the north of Daxing'anling. The geographical coordinates are 120°12′-122°55′ east, 50°20-52°30′north latitude. Not only border with Heilongjiang Province, close to Huzhong area, in the Genhe also has such a national nature reserve. The annual average temperature is below 0°Cand the lowest temperature reaches -58°C, which also makes the freezing period of the Genhe River longer, accounting for 2/3 of the whole year. Because the lowest temperature, is also the coldest city, has the "China cold pole" the name.

2.2 Source of data

2.2.1 landsat8

The images obtained in this paper are Landsat 8OLI_TIRS images of the U.S. Address Exploration Agency website (USGS), Landsat8 satellite contains two sensors, the Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS), OLI includes all the ETM bands, 30 m. spatial resolution The images before and after the fire were April 22,2017 and September 24,2018, The images are all images with less clouds and similar to the time of fire.

Table 1. Landsat8 Data Information

date	state	Path	Row	satellite
2017.4.22	before the fire	122	024	Landsat8
2018.9.24	after the fire	122	024	Landsat8

2.2.2 Fire site information

In this study, the fire data of Genhe Forestry Bureau of Daxing'anling Forestry Administration in Inner Mongolia were used, including the fire time, longitude and latitude, fire cause and rescue number. In this study, the lightning strike of 80 forest classes in Highland Forest Farm of the Forestry Bureau in July 2017 and the Khan Ma in June 2018 were selected Lightning fires in nature reserves.

2.2.3 Auxiliary data

ASTER GDEM V3 data were obtained through the National Aeronautics and Space Administration of the United States, and NASA and METI jointly released the ASTER GDEM V3 version, which added 360,000 optical stereo pair data on the basis of V2. The purpose is to reduce the previous existence of elevation blank areas and water numerical anomalies similar. From the DEM image can generate slope, slope and elevation and other topographic image factors.

3. Research methodology

3.1 Remote sensing image preprocessing

Lansat8 image is OLI_TIRS image, OLI image contains nine bands: four visible bands, Three infrared bands, 1 panchromatic band and 1 cirrus cloud band. this study uses six bands: blue band (band2), green band (band3), red band (band4), near infrared band (band5), mid-infrared band 1 (band6), mid-infrared band 2 (band7), etc. Downloaded images for L1 grade products, and has been radiated corrected. Radiometric calibration of the original image using ENVI5.2, Atmospheric correction and cutting, Get the image of the northern part of the root river covered with fire. Avoid fusion to affect image reflectivity, So only one image covering two fires was used to study, The column number is 122/24.

3.2 Spectral features and feature extraction

By visual interpretation, the OLI images are divided into four types: vegetation, barren, water and burned area. And the area of interest is established for each kind of typical ground objects. Each type selects 30 samples and 70% for ground object classification, and the other 30% for later accuracy verification. By using the ENVI5.2 to calculate the mean and standard deviation statistics of various ground objects in different bands through the samples of the region of interest. The spectral characteristics of all kinds of ground objects can be obtained.

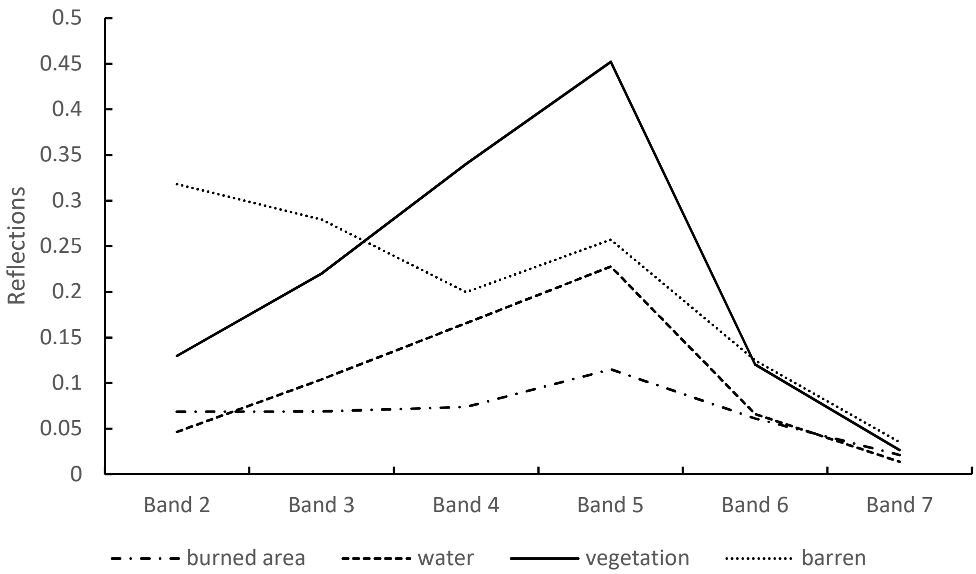

Fig. 2. Spectral characteristics

Remote sensing indices allow better extraction of ground information, facilitate accurate classification. Here are several indices: normalized difference Vegetation Index (NDVI)[19-20], normalized shortwave infrared index (NDSWIR), Normalized burn index (NBR)[21], The difference normalized burn index (dNBR) and normalized water difference index (MNDWI)[22]. DNVI commonly used in vegetation cover surveys, Is a better vegetation cover factor, It can distinguish vegetation from burning land. NDWSIR are NDVI improvements, The red wave segment (band4) in the NDVI is replaced by the mid-infrared band 1(band6), The index can better separate bare land from burning land. NBR calculated by NIR and NIR 2, Both bands are fire sensitive, Through the operation between the bands to enhance the burned area judgment. dNBR is an improvement on NBR, By reducing the combustion index of the two images before and after the fire, You know more clearly the extent of the fire zone, Better than NBR. accuracy And MNDWI can do a good separation, For water extraction, You can also distinguish between water and fire, MNDWI can reveal the fine features of water bodies more than NDWI, such as the distribution of suspended sediments, changes in water quality. And the distinction between water and shadow MNDWI can be better resolved, The problem of shadow in the process of water extraction has also been solved.

Table 2. Formula of remote sensing index

Remote sensing index	Formula	Meaning
NDVI	$(\rho_{nir}-\rho_r)/(\rho_{nir}+\rho_r)$	P_{nir} is Near infrared band ρ_r is Red band
NDSWIR	$(\rho_{nir}-\rho_{mir})/(\rho_{nir}+\rho_{mir})$	P_{nir} is Near infrared band P_{mir} is Medium infrared band1
NBR	$(\rho_{nir}-\rho_{swir})/(\rho_{nir}+\rho_{swir})$	ρ_{nir} is Near infrared band ρ_{swir} is Medium infrared band2
dNBR	$NBR_{pre-fire}-NBR_{post-fire}$	$NBR_{pre-fire}$ is NBR of pre-fire images $NBR_{post-fire}$ is NBR of post-fire images
MNDWI	$(\rho_{green}-\rho_{mir})/(\rho_{green}+\rho_{mir})$	P_{green} is Green Light Band ρ_{mir} is Medium infrared band1

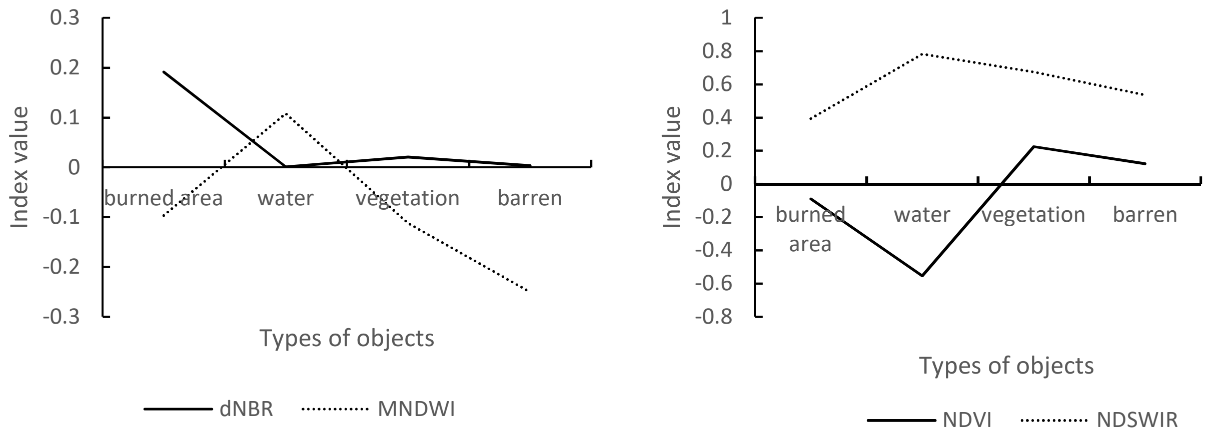

Fig. 3. Distribution of indices in different land types

3.3 Decision tree

The heterogeneity of each split node in the decision tree model is the criterion of whether the node is generated, The lower the node heterogeneity, The less impurity, higher accuracy of classification. Add spectral feature information to the decision tree model, Selecting the optimal combination in a large number of exponential data to form a classification model, The increase of the characteristic variables of the data will lead to the change of the decision rule, In this paper, according to the preliminary classification results and classification accuracy, the following classification steps are adopted, ENVI5.2 statistics and remote sensing index are used to obtain the critical values of various ground objects. First, burned area maximum of 1.51 in the band5 band, water at band5 maximum of 1.27, And the minimum vegetation band5 1.55, barren at a band5 minimum of 3.4, So choose 1.53 as critical value. More than 1.53 vegetation and barren, Less than is the burned area and water. And then compare the NDVI between vegetation and barren, A minimum NDVI vegetation of 0.14, And the maximum vegetation is 0.12, Select 0.13 as the critical value, It can distinguish vegetation from barren. Burned area and water can be distinguished by dNBR, A minimum dNBR value of 0.071, And the dNBR value of water is 0.061, Select 0.07 as the critical value, More than 0.07 is the burned area. MNDWI can distinguish water from other objects, More than 0 is water, Less than is another class.

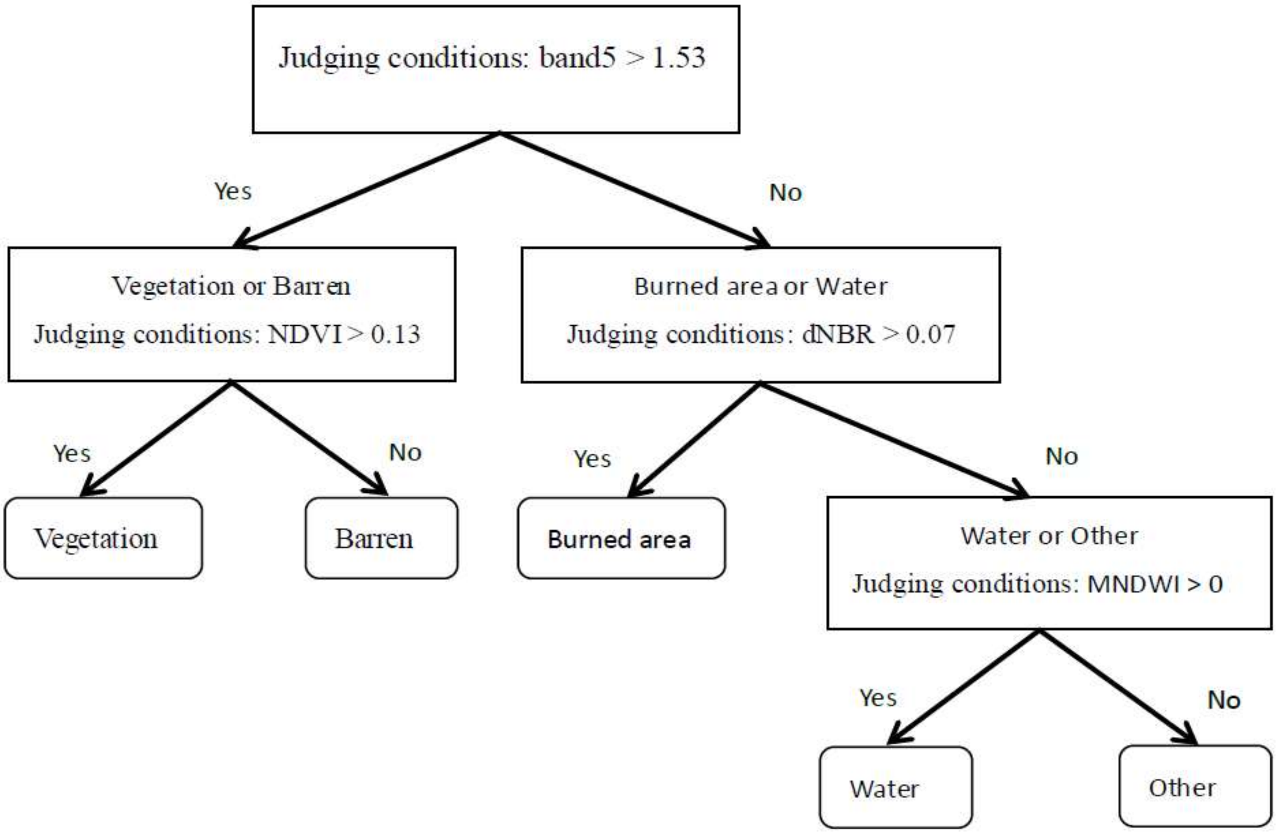

Fig. 4. Decision tree classification process

3.4 Fire severity and spatial classification

Forest fires generally occur deep in the mountains, and the terrain is very different. Different elevations, slopes and slopes are reflected in the burned area. A forest fire often has different fire severity range, which affects vegetation restoration and tree species reconstruction in different fire severity range. The difference of fire severity and the influence of topography, the species of plants in the same area of fire site will also be different, which contributes to the spatial heterogeneity of burned area.

This paper uses the difference between the NBR before and after the fire, that is, the dNBR of the burned area to divide the forest fire severity. The threshold division of fire severity needs to use interest zone to draw under the dNBR fixed threshold rule, and 30 sample points are selected for each class[23]. The severity of fire was divided into four grades: Unburned, Low severity, Moderate severity, High severity. Count the dNBR values of each type of fire severity.

Table 3. Statistical table of classified sample points

Degree of fire	Min	Max	Mean	StdDev	Number of pixels
Unburned	-0.017451	0.009295	0.002371	0.009022	30
Low severity	0.012382	0.060809	0.042462	0.024075	30
Moderate severity	0.091999	0.137397	0.118747	0.012091	30
High severity	0.139039	0.255537	0.191204	0.025424	30

Based on the statistical results, the confusion matrix is established to select the threshold of the classification grade, and the fire severity classification rules of the two burned area in this paper are obtained. According to the rules, the fire severity of the decision tree is divided, and the range of different fire severity is obtained and the area is counted.

Table 4. Classification rules of fire degree

Degree of fire	DNBR value
Unburned	< 0.01
Low severity	0.01 - 0.065
Moderate severity	0.062 - 0.13
High severity	>0.13

After the fire severity distribution map was obtained according to the fire degree threshold, the elevation, slope and slope direction data were extracted by adding DEM data. Fire severity is superimposed with topography (altitude, slope and slope direction) to study spatial heterogeneity.

4. Results and analysis

4.1 Decision tree classification results

The reflectance of different ground objects in the 2-7 band was extracted according to the OLI full band reflectivity of the landsat8 image, and four remote sensing indexes were calculated difference value. The decision tree model is constructed to identify the burned area, and the results of the decision tree are clustered and filtered to obtain the range and area of the burned area. And compared with parallel hexahedron classification. Kappa coefficient of parallel hexahedron 91.55. The decision tree reached 96.84. The accuracy of decision tree is improved in the recognition of burned area, and the division of burned area is more accurate.

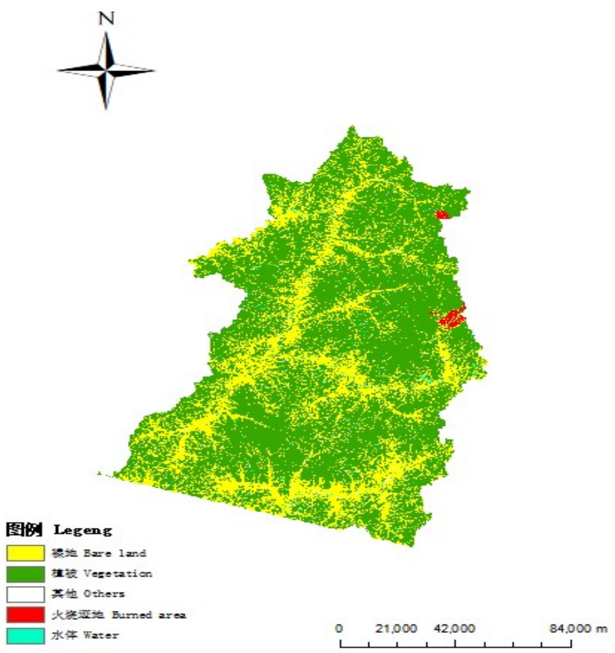

Fig. 5 Decision tree classification

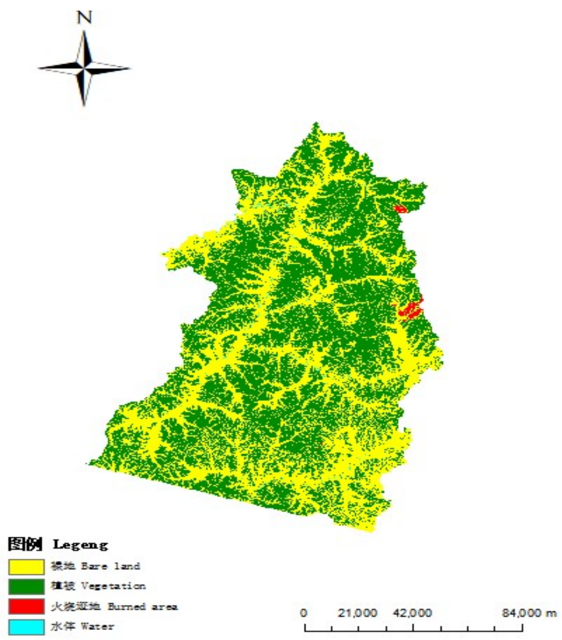

Fig. 6 Classification of parallel hexagons

4.2 Fire severity analysis

According to the field correction of the threshold of fire severity, the fire severity classification in the northern forest area of Genhe is divided into the following four grades: unburned, low severity, moderate severity and high severity.

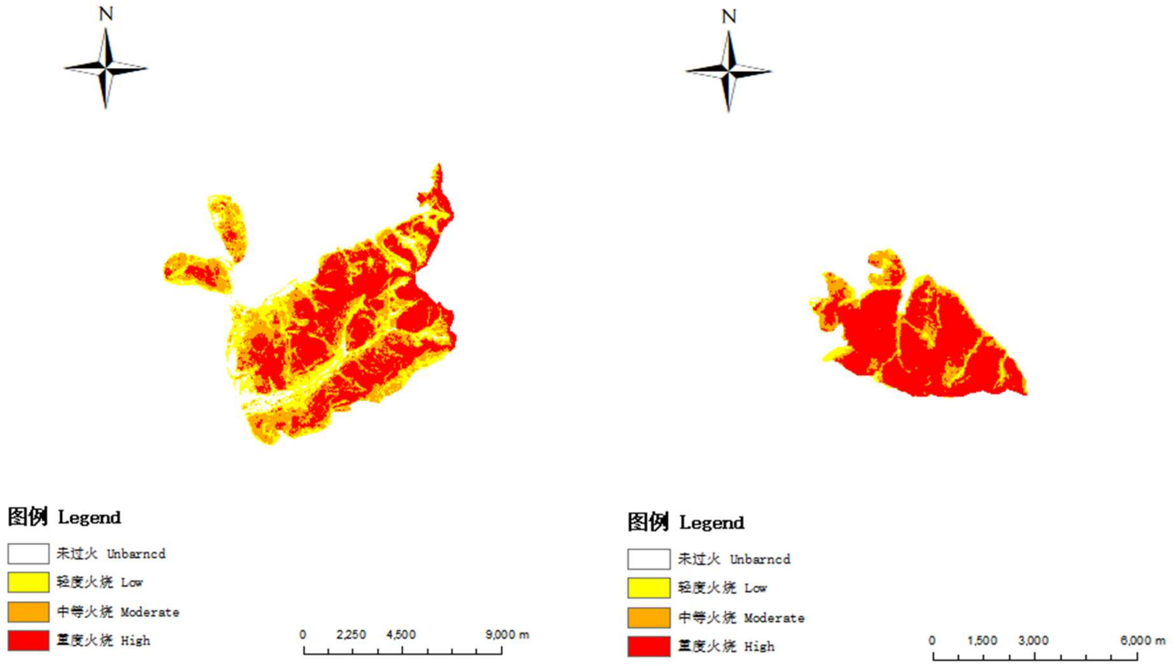

Fig. 7. Fire severity grade distribution

According to the four grades of fire severity, the area of land occupied by each grade can be calculated. The area occupied by high severity was the largest, reaching 48.44, almost occupying the general total area, followed by moderate severity area, accounting for 29.02. The area of unburned is part of the forest land in the middle of the burned area, which also accounts for 0.02%, which is also the most likely part of the area statistics after the forest fire.

Table 5. Area occupied by different fire severity

Severity level	Area/hm^2
High severity	4432
Moderate severity	2655
Low severity	1899
Unburned	163
Total	9149

4.3 Thermal severity spatial analysis

4.3.1. Fire severity and altitude

The altitude is divided into 0-500m,500-1000m and 1000-1500m three grades. The study area is extracted according to DEM altitude, concentrated in 500-1500m, 0-500m is no burned area. So the altitude is divided into 500-1000 m and 1000-1500m two grades. The fire severity distribution map and altitude were superimposed and analyzed. The forest fire was mainly concentrated in the range of 1000-1500m, and the proportion reached 74.75hm^2, far exceeding the range 500-1000m fire. The range of mild fire is relatively close at different altitude.

Table 6. Area of fire severity at different altitudes /hm2

Altitude	Unburned	Low severity	Moderate severity	High severity	Total
500-1000	78	873	820	539	2310
1000-1500	85	1026	1835	3893	6839
Total	163	1899	2655	4432	9149

4.3.2. Fire severity and slope

Classification of slopes according to the classification of slopes in the Technical Regulations of the Third National Land Survey, Divided into five grades. The order is I (≤2°), II(2°—6°), III(6°—15°), IV (15°-25°) and V (≥25°). Superposition analysis of fire severity grade and slope, The fire severity distribution of each grade in different slope ranges is shown in Table 7. In slope III, the area of the burning site is the largest, 48.84% of the total, The others are II, IV, I and V. The fire was concentrated on a slope of 6-15°, And if the slope is too large or too small, That is, to a certain extent to suppress the fire.

Table 7 Area of different slope in fire severity /hm^2

Severity level	I (≤2°)	II (2°— 6°)	III (6°—15°)	IV (15°—25°)	V (≥25°)	Total
Unburned	23	66	42	14	18	163
Low severity	138	683	747	239	92	1899
Moderate severity	123	747	1305	403	77	2655
High severity	112	873	2374	909	164	4432
Total	396	2369	4468	1565	351	9149

4.3.3. Fire severity and aspect

Superposition analysis of fire severity and aspect, Classified according to the value of ENVI5.2 aspect, The aspect is divided into 9 categories. followed by non-aspect (-1), north (0-22.5°, 337.5°-360°), Northeast (22.5°-67.5°), East (67.5°-112.5°), South-East (112.5°-157.5), South (157.5°-202.5), South-West (202.5°-247.5), West (247.5°-292.5 NW (292.5)5°-337.5°). The area occupied by different aspects from large to small is west > northwest > north > southwest > east, south, southeast > northeast > no aspect. The fire is mainly concentrated in the northwest aspect, The area to the southeast aspect is decreasing.

Table 8. Area of different slope directions in different fire severity /hm^2

Severity level	Unburned	Low severity	Moderate severity	High severity	Total
North	23	250	379	613	1265
Northeast	7	154	247	455	863
East	5	179	316	488	988
Southeast	10	203	286	405	904
South	31	238	286	421	976
Southwest	26	266	293	548	1133
West	31	310	415	788	1544
Northwest	29	294	431	711	1465
No aspect	1	5	2	3	11
Total	163	1899	2655	4432	9149

5. Discussion and conclusions

This paper constructs the classification model of decision tree by landsat8 image, DEM data and fire data record table of Genhe Forestry Bureau of Daxing'anling Forest Administration Bureau of Mongolia and remote sensing index such as NDVI, NDSWIR, NBR, dNBR, MNDW. Compared with the traditional parallel hexahedron classification. After that, the fire burned area is divided into four fire severity grades according to the dNBR multi-temporal difference remote sensing index. After that, according to the fire severity and DEM data, the spatial analysis was carried out, and the superposition analysis was carried out from three aspects: altitude, slope and aspect. The following results were obtained:

this paper uses the decision tree to identify the burned area, the results are basically consistent with the field statistical area. At the convenience of accuracy, the Kappa coefficient of parallel hexahedron is 91.55% higher. It reached 96.84. The division of the fire trace area of the decision tree is close to the range obtained by visual interpretation. Using multi-remote sensing index to construct decision tree can better identify burned area, and decision tree can be used as a more accurate method to identify burned area.

The two fire sites accounted for the largest area, high severity reaching 48.44%. The second was moderate burned area, accounting for 29.02. The vegetation destruction in the severe fire burned area is serious, the area occupied is also relatively large, the natural renewal effect is poor, the selection range is large, the site condition is better, the proper afforestation is helpful to the vegetation restoration of the burned area.

correlation analysis was carried out between fire severity and elevation, slope and aspect in DEM data. As a result, in 1000-1500 m the range of burned area is larger, but also more prone to fire, higher altitude is not conducive to firefighters to carry out effective fire fighting, so that high altitude has a larger area of burned areas. On the aspect III (6°-15°), the specific gravity of the over fire area is the largest, reaching 48.84% of the total over fire area. It shows that the slope spreads faster and is more suitable for forest fire. Flat land and relatively steep slope are not suitable for fire spread to some extent. From the aspect, it is found that the burned area in the west side is the largest, reaching 1544 hm^2, accounting for 16.88% of the total area. It also shows that the southeast slope is steeper, the northwest slope is consistent with the gentle inclination, and the northwest side area of the burned area is larger and the gentle slope area is larger.

The OLI data in the landsat8 image used in this paper are identified by decision tree classification method, which is also superior to the traditional parallel hexahedron classification in precision. It also makes the image have a little cloud effect, but the cloud concentration in vegetation and barren has no effect on the division of burned area. The result of the division of burned area is also more accurate, and some unburned vegetation in the fire trace area is also distinguished. In the future research, we can select images with higher spatial resolution to identify the burned area, so that the area statistics of the burned area can be more accurate. The overall performance of Daxing'anling is that the southeast slope is steeper and the northwest slope is gentle and inclined. The results show that the forest fire is reflected in the data superposition that the slope is more moderate than the northwest slope. In the study, vegetation types were not distinguished, and the correlation between fire severity and vegetation types was analyzed. In the future, the vegetation types of burned area can be analyzed by field investigation and sampling, and the fire severity can be discussed more deeply in combination with vegetation restoration and surface combustible materials. It provides a more detailed and effective theoretical basis for the protection of forest ecology in Daxing'anling, how to give full play to the ecological benefits of forest and fire, and the management of forest areas by various forestry bureaus in Daxing' anling.

References

[1] Zhang Yuxing, Wang Zhuxiong, Wu Hong dare, etc. Application of remote sensing technology in forest resource inventory [M]; and China Forestry Press, 2007.

[2] Li Jian, Chen Xiaoling, Lu Jianzhong, et al. on the Application of Remote Sensing Monitoring Method for Forest Fire[J]. Journal of Central China Normal University, 2011, 45(3):485-496.

[3] SHAN T C, WANG C L, CHEN F, et al. A Burned Area Map-ping Algorithm for Chinese FengYun-3 MERSI Satellite Data[J]. Remote Sensing, 2017, 9:736-753.

[4] Ruiz J A M, Lázaro J R G, Cano I D, et al. Burned Area Map-ping in the North American Boreal Forest Using Terra-MODIS LT-DR (2001-2011): A Comparison with the MCD45A1, MCD64A1 and BA GEOLAND-2 Products[J]. Remote Sens. 2014, 6: 815-840.

[5] Chuvieco E,YUE C,Heil A,et al.A new global burned areaproduct for climate assessment of fire impacts[J]. Global Ecologyand Biogeography, 2016, 25(5): 619-629.

[6] Bertolette D, Spotskey D. Remotely sensed burn severity mapping Proceedings of the 11th Conference on Research and Resource Manage-ment in Parks and on Public Lands.Crossing boundaries on the ground with technologies[C]. TheGeorge Wright Society, 2001:44-51.

[7] Beauty R, Taylor A.Spatial and temporal variation of fire regimes in a mixed conifer forest landscape, southern Cascades,California, USA[J]. Journal of Biogeography, 2001,28(8):955-966.

[8] Paloscia S, Pettinato S, Santi E, Notarnicola C, Pasolli L and ReppucciA. Soil moisture mapping using Sentinel-1 images: algo-rithm and preliminary validation[J]. Remote Sensing of Environ-ment, 2013,134: 234-248.

[9] Meng R, Wu J, Zhao F, Cook B D, Hanavan R P and Serbin S P. Measuring short-term post-fire forest recovery across a burn se-verity gradient in a mixed pine-oak forest using multi-sensor re-mote sensing techniques[J]. Remote Sensing of Environment, 2018,210:282-296.

[10] Gong Dapeng, Li Bingyi, Liu Xiaodong. Comparative Analysis on the Applicability of the Burning Severity Combustion Index of Grassland Fire [J]. Journal of Ecology, 2018,38(7):2434-2441.

[11] Veraverbeke S, Dennison P, Gitas I, Hulley G, Kalashnikova O, Kata-gis T, Kuai L, Meng R, Roberts D and Stavros N. Hyper-spectral remote sensing of fire: state-of-the-art and future perspec-tives[J]. Remote Sensing of Environment, 2018,216:105-121.

[12] Yao J Y, Raffuse S M, Brauer M, Williamson G J, Bowman D M J S, Johnston F H and Henderson S B.Predicting the minimumheight of forest fire smoke within the atmosphere using machinelearning and data from the CALIPSO satellite[J]. Remote Sensing ofEnvironment, 2018, 206: 98-106.

[13] Fernandez-Carrillo A, McCaw L and Tanase M A. Estimatingprescribed fire impacts and post-fire tree survival in eucalyptusforests of Western Australia with L-band SAR data[J]. Remote Sens-ing of Environment, 2019, 224:133-144.

[14] Zhou Xiaocheng, Wang Xiaoqin, high school spirit. Knowledge-based Method for Rapid Extraction of Forest Flue from Multi-temporal TM Images [J] by Fire Disaster Science, 2005, 20(2): 22-26.

[15] Kontoes C, Poilve H, Florsch G. A comparative analysis of afixed thresholding vs.a classfication tree approach for operationalburn scar detection and mapping[J]. International Journal of Ap-plied Earth Observation and Geoinformation, 2009, 11(5):299-316.

[16] [16] Bastarrika A, Chuvieco E, Martin M P. Mapping burned areasfrom Landsat TM/ETM+ data with a tow-phase algorithm:Bal-ancing omission and commission errors[J]. Remote Sensing of En-vironment, 2011,115(4):1003-1012.

[17] Yang Wei, Zhang Shuwen, Jiang Xiaoli. Extraction of Fire Trace Ground from Heilongjiang River Basin Based on MODIS Time Series Data [J]; Acta Ecologica Sinica, 2015, 35(17):5866-5873.

[18] Zu Xiaofeng, Qin Xianlin, Yin Lingyu, et al. Decision Tree Method for Identification of Flaming Ground Based on Spectral Index of High Score No .1 Image [J]. Forest resources management, 2015(4):73-78.

[19] Zhang Xiaoyu, Li Fengri, Yan Zhen, et al. Landsat-8 remote sensing forest vegetation classification [J]. Journal of Northeast Forestry University, (6):53-57.

[20] Yuan Huili, Ma Ronghua, Li Jiying. A New Method for Extraction of Remote Sensing Information from Gardenland in Plain Area[J]. Journal of University of Chinese Academy of Sciences, 2015, 32(3):342-348.

[21] Sparks A M, Boschetti L, Smith A M S, et al. An accuracy as-sessment of the MTBS burned area product for shrub-steppe fires inthe northern Great Basin,United States[J]. International Journalof Wildland Fire, 2015, 24: 70-78.

[22] Chen Wenqian, Ding Jianli, Li Yanhua, et al. Method of Water Extraction Based on Domestic GF-1 Remote Sensing Image [J]. Resources Science, 2015, 37(6):1166-1172.

[23] Liu Shuchao, Chen Xiaozhong, Qin Xianlin, Sun Guifen, Li Xiaotong. Remote Sensing Evaluation of Forest Fire Victimization in Bilahe Forest Farm, Inner Mongolia [J]. Forestry Resource Management, 2018(01):90-95 140.