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Study on Potential Geographical Distribution of Diphtheria Aconitum in Xinjiang under the Scenario of Future Climate Change

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Abstract: *Aconitum diphtheria is a kind of poisonous grass widely distributed in Xinjiang and northwest Gansu of China. In recent years, the propagation of poisonous grass has led to a sharp reduction of fine forage, which has caused great harm to animal husbandry and ecological environment. However, little is known about the habitat of Aconitum diphtheriae and the key environmental factors affecting its expansion. In this study, the maximum entropy (MaxEnt) model was used to assess the potential impact of climate change in 2040 and 2080 on the distribution of Aconitum diphtheriae under the two scenarios (SSP126 and SSP585) predicted under BCC-CSM2-MR mode analyzed by IPCC6, and the key environmental factors affecting the distribution of Aconitum diphtheriae were analyzed. A total of 90 species distribution points and 4 selected variables were used for modeling. The ROC curve method was used to evaluate the established model, and the results showed that it showed good performance (AUC>0.9).The experimental results are as follows: (1) Aconitum diphtheria tends to grow in areas with relatively small changes in environmental factors. Aconitum diphtheria is mainly distributed in the south and north slopes of Tianshan Mountains and grows intensively. (2) The environmental factors affecting the distribution of Aconitum diphtheria are: the wettest monthly rainfall (Bio13), the driest monthly rainfall (Bio14), the average rainfall in the coldest season (Bio19), and the variance of temperature change (Bio4).*

Keywords: *Aconitum leucostomum Vorosch; MaxEnt Model; Climate Change; Geographical Distribution; Poisonous Grass*

1. Introduction

Climate change affects many global ecosystems and organisms, including the geographical distribution of many species [1]. Predicting the potential distribution of species based on niche models (ENMs) can predict the potential risks that climate change will pose a threat to biodiversity in the future[2], and help decision-makers put forward positive coping strategies to mitigate the impact of climate change on biodiversity[3].

ENMs is a verification toolfor simulating the spatial distribution of species, assessing the potential response of o rganisms to climate change and determining the niche of species based on environmental variables. Among various ENMs, the maximum entropy (MaxEnt) algorithm has relatively high prediction accuracy [4] while using a small amount of data to determine the occurrence of species according to environmental variables. Many scholars have used the maxent model to predict the species distribution, which proves that the MaxEnt model is superior to other species distribution models from another aspect.

For a long time, grassland degradation is one of the reasons that threaten the sustainable development of animal husbandry. The Aconitum diphtheria plant has strong reproductive capacity, rapid spread, and dense distribution. At present, it is breeding in large numbers in the Ili River Valley, Xinjiang, especially in the natural grassland of Nalati Grassland, occupying a large amount of space, inhibiting the growth of fine forage, reducing the quality of grassland, and seriously affecting the development of animal husbandry [5]. Therefore, the research on poisonous weeds is the top priority. In order to better control and protect the grasslands in Xinjiang, many scholars use their knowledge to apply what they have learned and make contributions to the protection of grasslands, ecological protection and sustainable development.

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2. Meterials and Methods

2.1 Overview of the study area

Xinjiang Uygur Autonomous Region is located in northwest China in the middle of Eurasia (Fig. 1), the grassland in Xinjiang covers a large area, accounting for one third of the total area of the country. The grassland plays an important role in the economic, social and ecological problems in central and western China [6]. As an important topic of protecting the grassland in Xinjiang, the problem of controlling poisonous weeds has many kinds and is growing and spreading. Therefore, it is very important to use geological knowledge to study the spatial distribution area of poisonous weeds.

Figure 1: (A) Schematic Diagram of Study Area (B) Aconitum diphtheria (C) Diphtheria Aconitum Leaf

2.2 Research objects

Aconitum leucostomum Vorosch is a herbaceous plant. Its leaf shape is very similar to that of Aconitum altissima. Its stem is about 1 m high, and there is about 1 basal leaf (Fig. 1). Its petiole is 20~30 cm long, and its raceme is 20~45 cm long. There are many dense flowers (Fig. 1). Aconitine, a large toxic ingredient, is contained in Aconitum diphtheriae. If it is eaten by livestock by mistake, it will cause certain harm to their health and even death [7].

2.3 Research data

2.3.1 Species distribution data

The geographical distribution data of Aconitum diphtheria is from the global biodiversity information network GBIF (https://www.gbif.org/) And China Digital Herbarium (https://www.cvh.ac.cn/), based on ArcGIS platform, the species distribution points of Aconitum diphtheriae within the scope of Xinjiang were selected according to the provincial boundary, and 90 points were finally selected for analysis without selecting duplicate sample points. The base map for geographical distribution analysis is from the Resource and Environmental Science and Data Center (https://www.resdc.cn/) Downloaded administrative division boundary data.

2.3.2 Climatic data

Historical climate data is from the World Climate Database (http://www.worldclim. org), which includes 19 environmental factors (Table 2-1). Future climate data comes from the Global and Regional Climate Data Reduction Data Portal of the Consultative Group on International Agricultural Research (CGIAR) Climate Change, Agriculture and Food Security Research Program (https://www.ccafs-climate.org/).

The historical climate data is the grid data of 19 environmental factors from 1970 to 2020, and the data resolution used is 2.5 minutes. The future climate data are the four main environmental factors affecting the distribution area of Aconitum diphtheriae under the two scenarios (SSP126, SSP585) predicted under BCC-CSM2-MR mode analyzed by IPCC6, with a spatial resolution of 2.5 minutes.

2.3.3 Introduction to BCC-CSM2-MR Mode and CMIP

The World Climate Research Program (WCRP for short) organized and implemented the sixth Coupled Model Intercomparison Project Phase 6 Overview (CMIP6 for short). According to the existing models and development trends, it wants to develop a new version of the model, a model with a wider range of project types, and through model research and development in recent years, Three latest models were launched to participate in the program, namely, the Earth System Model (BCC-ESM1.0), the Climate Model with Medium Distribution Rate (BCC-CSM2-MR) and the High Resolution Climate Model (BCC-CSM2-HR) of the aerosol chemistry module. The important components of the three models have both similarities and differences [8]. The test in CMIP6 plan was officially carried out in 2018.The BCC-CSM2-MR model is selected in this paper because it is widely used in the development of atmospheric, oceanic and terrestrial modules, including global carbon cycle and dynamic vegetation processes.

The IPCC AR6 to be released in 2021 will use the new climate model in CMIP6 to develop a set of latest emission scenarios driven by different socio-economic models - sharing economic paths (SSPs).In order to facilitate researchers to have more choices when making future climate predictions, CMIP6 upgraded CMIP5's RCP2.6, RCP4.5, RCP6.0 and RCP8.5 to SSP126, SSP245, SSP360 and SSP585.

SSP126 is an upgrade of RCP2.6 scenario based on the low forcing scenario (SSP1). It is a scenario with very low greenhouse gas concentration. Its radiative forcing will reach 2.6W/m^{2}in 2100. During this period, changes in the type of energy utilization worldwide will significantly reduce greenhouse gas emissions, making it the largest emission scenario for global crop area increase [9]. SSP585 is an upgrade of RCP8.5 scenario based on SSP5 (high forcing scenario), which is a scenario without climate change policy intervention. It is characterized by the continuous increase of greenhouse gas emissions and concentrations. Under this scenario, the consumption of fossil fuels increases with the significant growth of global population, slow growth of income, and changes in technology and energy efficiency, SSP5 is the only SSP scenariothat can make the radiation forcing reach 8.5 W/m^{2}in 2100.This paper selects a minimum forced scenario and a maximum forced scenario to predict, so as to see the changes more intuitively.

2.4 MaxEnt model

The basic principle of Maximum Entropy Models (MaxEnt) is that when predicting the distribution of some known values under certain limited conditions, there can be many or even infinite varieties. When one of the distributions has the maximum entropy, the distribution with the maximum entropy is selected as the distribution of the random variable probability distribution.It is the most uniform and the predicted risk is the smallest. When predicting the potential distribution of substances, the climatic and environmental factors and the geographical distribution space of species are taken as a system. When the system runs, when the parameters reach the maximum entropy, it proves that the predicted spatial geographical position of species is in a stable state, so as to determine the potential geographical distribution of species [10]. MaxEnt model software has JAVA language as the environment, and uses ROC (Receiver Operating Characteristic, ROC) curves to verify model accuracy. Based on MaxEnt model, more than 2500 studies have been conducted to predict the impact of global climate change on the potential geographical distribution of species and the planning of protected areas, and it has been proved that MaxEnt model is more accurate and more accurate than other species distribution models [11]. In this paper, MaxEnt software is used to take 19 environmental factors of current and future climate and longitude and latitude of actual geographical distribution of species as a system. In the process of model operation, other environmental variables are used to model, so as to determine the potential geographical distribution of Aconitum diphtheriae and predict the potential geographical distribution of Aconitum diphtheriae under future climate scenarios. The factors with high contribution rate will be considered as the main influencing factors of Aconitum diphtheriae.

3. Result analysis

3.1 Prediction of potential distribution area of Aconitum leucostomum Vorosch under historical climate conditions

In ArcGIS, the distribution of Aconitum leucostomum Vorosch is divided into four risk levels (RI) by using the reclassification tool, and they are divided into four levels, namely, non-suitable area ($0 \leq RI \leq 0.18$), low suitable area ($0.18<RI \leq 0.38$), suitable area ($0.38<RI \leq 0.63$) and high-risk area (0.63<RI

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≤ 0.89).

As shown in Figure 2, historical climate change is the current climate scenario. According to Table 1, the suitable area of Aconitum leucostomum Vorosch accounting for 4.9% of the whole study area;The area of low suitable area is accounting for 7% of the whole study area; The high-risk area accounting for 4.3% of the whole study area; The area where Aconitum leucostomum Vorosch grows accounts for 16.2% of the total study area, which is smaller than the whole study area, but larger than the grassland in Xinjiang; The area of unsuitable areas accounting for 83.8% of the total area of the study area. It can be seen that Aconitum diphtheria tends to grow in places with abundant rainfall and light, that is, Xinjiang grassland distribution areas. High risk area, suitable growth area and low suitable growth area are all grid areas, so it can be seen that the distribution of Aconitum leucostomum Vorosch is very concentrated, which makes it easier to control poisonous weeds.

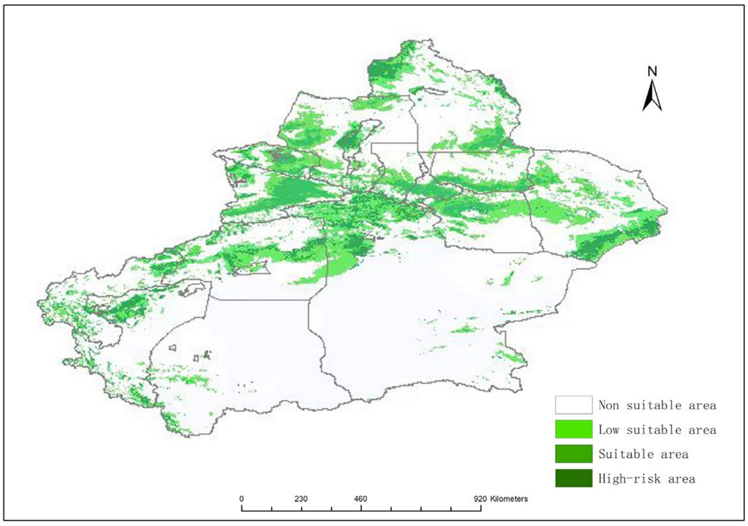

Figure 2: Potential Distribution of Aconitum leucostomum Vorosch under Current Climate Scenarios

3.2 Prediction of potential distribution area of Aconitum leucostomum Vorosch under future climate conditions

Fig.3 shows the spatial distribution of Aconitum leucostomum Vorosch under the SSP126 scenario in 2040, SSP126 scenario in 2080, SSP585 scenario in 2040 and SSP585 scenario in 2080. It can be seen from Fig.3 and Table 1 that the suitable habitat area of Aconitum diphtheria accounting for 3.2% of the whole study area, 1.7% less than that of the historical climate change scenario,; The area of low adaptive area is 11.8 square kilometers, accounting for 7.1%, which is 0.1% more than the historical climate change scenario. The area of high-risk area accounting for 2.6% in the whole study area, which is 1.7% less than the historical climate change scenario; The area of the unsuitable area accounting for 87% of the total area of the study area. Compared with the historical climate, the area has increased. On the whole, the change of increase or decrease is relatively small, and shows a decreasing trend.

According to the analysis under the SSP126 scenario in 2080, the suitable habitat area of Aconitum diphtheria accounting for 2.5% of the whole study area, which is 2.4% less than the historical climate change scenario; The high-risk area is 2.1 square kilometers, accounting for 1.3%, which is 3% less than the historical climate change scenario; The area of unsuitable area accounting for 90.5% of the whole study area; The area of low suitable areas accounting for 5.8%. Compared with the historical climate scenarios, the proportion of unsuitable areas has increased by 6.3%, which is very obvious. Climate change has a great impact on the spatial distribution of plants, and the spatial distribution of plants can also reflect climate change.

According to the analysis under the SSP585 scenario in 2040.The unsuitable area of Aconitum leucostomum Vorosch accounting for 90.5% of the whole study area; The area of low suitable area accounting for 5.3% of the whole study area; The suitable area accounting for 2.8% of the total study area,; The high-risk area accounting for 1.4% of the whole study area. It can be seen from the figure that Aconitum diphtheria is mainly distributed on the south and north slopes of Tianshan Mountains.

According to the analysis under the SSP585 scenario in 2080.The high-risk area of diphtheria

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aconitum accounting for 1.4% of the whole study area; The area of unsuitable area accounting for 90.5% of the whole study area; The area of low suitable area accounting for 5.3% of the whole study area; The suitable area accounting for 2.8% of the whole study area. According to the data comparison under historical climate scenarios, the proportion of suitable and low suitable areas decreased, the proportion of suitable areas decreased by 3.3%, and the proportion of unsuitable areas increased significantly, by 8.5%.It can be seen from the figure that low, suitable and high-risk areas are concentrated in northern Xinjiang. The growth area of Aconitum diphtheria decreased significantly.

Table 1 shows that the proportion of unsuitable areas of Aconitum leucostomum Vorosch in 2040 under SSP126 scenario is lower than that in SSP585 scenario, and in 2080 under SSP126 scenario is lower than that in SSP585 scenario. Under the same SSP126 scenario, the proportion of unsuitable areas in 2040 is lower than that in 2060-2080, and the trend of unsuitable areas shows a slow growth trend. The proportion of the low suitable area of Aconitum leucostomum Vorosch in the SSP126 scenario in 2040 is higher than that in the SSP585 scenario, and in the SSP126 scenario in 2080 is higher than that in the SSP585 scenario. In the same SSP126 scenario, the proportion of the low suitable area in 2040 is higher than that in 2080, and the trend of the low suitable area is slowly decreasing. The proportion of suitable growth areas of Aconitum leucostomum Vorosch in 2040 under SSP126 scenario is higher than that in SSP585 scenario, and in 2080 under SSP126 scenario is higher than that in SSP585 scenario. Under the same SSP126 scenario, the proportion in 2040 is higher than that in 2080, and the trend of low suitable growth areas is slowly decreasing. The high risk area of Aconitum diphtheria is the same as the low suitable area and the suitable area, showing a downward trend. Climate change has greatly changed the distribution area of Aconitum leucostomum Vorosch, which may lead to the transfer and reduction of the distribution range.

Table 1: Area and percentage of suitable growing area of Aconitum leucostomum Vorosch in different climatic conditions and scenarios

Climate scenario	Proportion (%)				Area (Square kilomater)			
	non suitable area	low suitable area	suitable area	high-risk area	non suitable area	low suitable area	suitable area	high-risk area
History	83.8%	7%	4.9%	4.3%	139.5	11.6	8.1	7.2
SSP126(2040)	87%	7.1%	3.2%	2.6%	144.8	11.8	5.3	4.3
SSP126(2080)	90.5%	5.7%	2.5%	1.3%	150.6	9.5	4.2	2.1
SSP585(2040)	90.5%	5.3%	2.8%	1.4%	150.6	8.8	4.7	2.3
SSP585(2080)	92.3%	4.8%	1.6%	1.3%	153.4	8.1	2.7	2.2

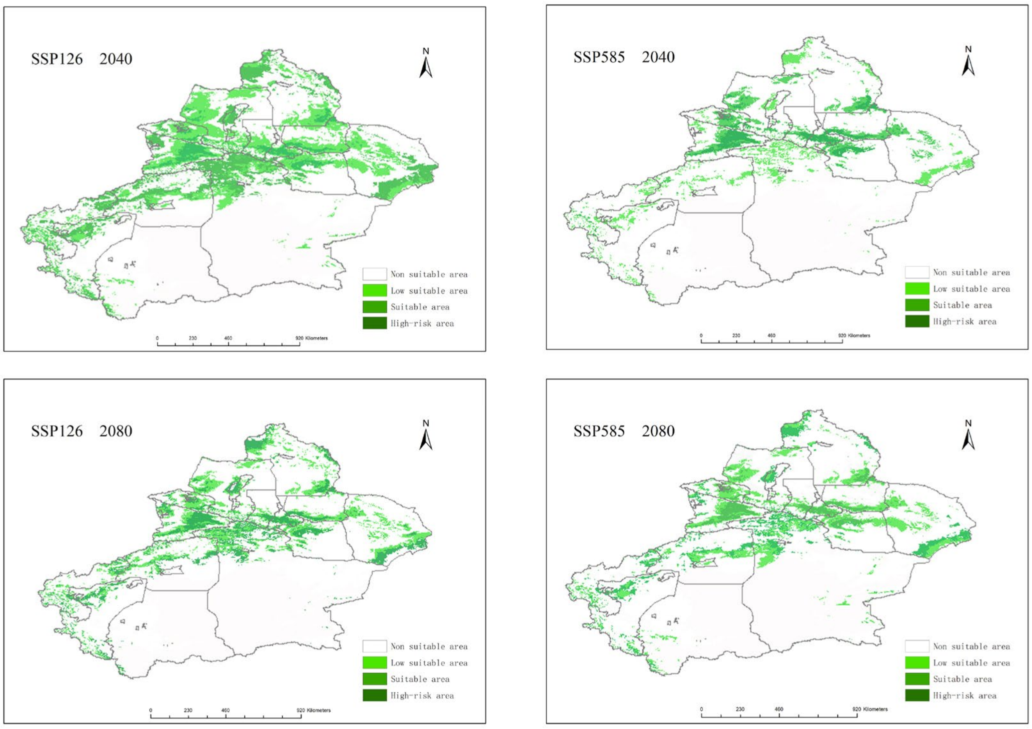

Figure 3: Occupied habitat maps of Aconitum leucostomum Vorosch under two climate scenarios

3.3 Dominant environmental factors in potential distribution area of Aconitum leucostomum Vorosch

Dominant environmental factors in potential distribution area of Aconitum diphtheriae

During the operation of the maximum entropy model, one environmental factor will not be considered in turn, and other environmental factors will be modeled to analyze the contribution value of this model. Then only one environmental factor will be considered, and its contribution value will be calculated. When the operation is completed, the output result data will intuitively see the contribution rate of each factor when modeling the distribution area of Aconitum diphtheriae, to indicate the importance of the impact. The results show that:

(1) The factors with high contribution rate to the distribution of Aconitum diphtheriae: the driest month (Bio14), the wettest month (Bio13), the average rainfall in the coldest season (Bio19) and the variance of temperature change (Bio4) have the highest contribution rate and the largest impact on the distribution of Aconitum diphtheriae, with the contribution rates of 19.1%, 18.1%, 14.1% and 12.1% respectively.

(2) Factors with low contribution rate to Aconitum diphtheriae: 9.2% of the average temperature in the coldest season (Bio11), 8.8% of the monthly mean value of day night temperature difference (Bio2), 7.8% of the average temperature in the driest season (Bio9), and 6.6% of the low temperature in the coldest month (Bio6). These four factors have low contribution rates to Aconitum diphtheriae relative to the variance of the average precipitation and temperature changes in the driest month, the coldest season, and the wettest month.

(3) The total contribution rate of these eight environmental factors to the potential distribution of Aconitum diphtheriae is 95.6%. These eight environmental factors can be regarded as indicators that affect the spatial distribution of species. However, if there are too many parameter indicators, it will lead to the uncertainty of establishing the model. Therefore, the factors with a contribution rate of more than 10% are selected, namely, the wettest monthly rainfall (Bio13), the driest monthly rainfall (Bio14), the average rainfall in the coldest season (Bio19) The variance of temperature change (Bio4) takes these four indicators as the environmental variables simulated by the model, as shown in Figure 4.

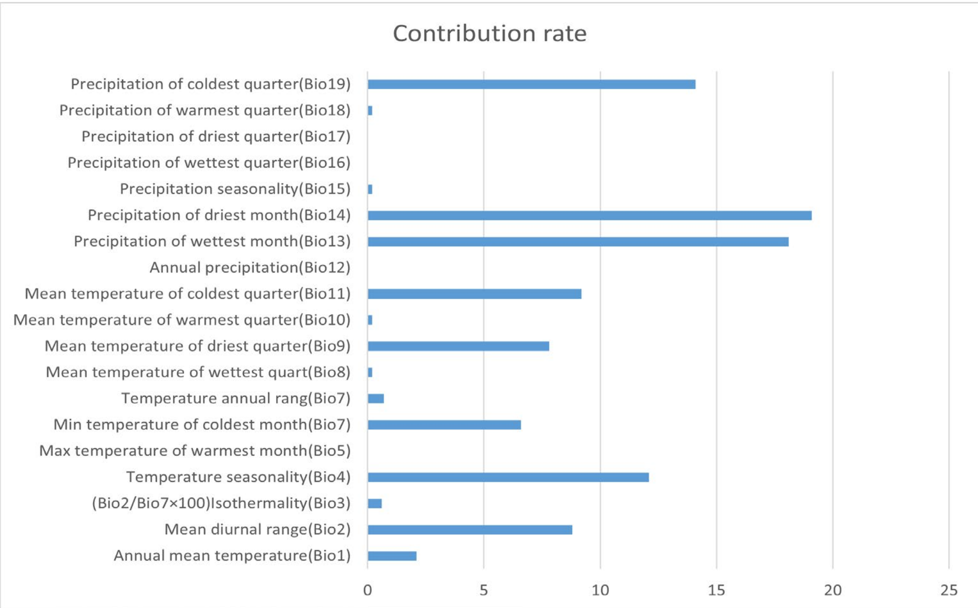

Figure 4: Contribution rate of each bioclimate variable

4. Conclusion

This paper studies the impact of climate change on a potential spatial distribution of Aconitum leucostomum Vorosch by using MaxEnt model and ArcGIS software. There is a large span in time and scene, which is intended to more obviously observe the growth of Aconitum leucostomum Vorosch under different scenarios at different time periods. The research results are:

Climate change is the main factor affecting the distribution pattern of Aconitum leucostomum

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Vorosch. The smaller the change in the distribution area of Aconitum leucostomum Vorosch, the greater the change in the distribution area if the climate change is obvious. Both the Aconitum leucostomum Vorosch tends to the areas with small climate change, and the high-risk areas are mostly distributed in northern Xinjiang, where the precipitation is abundant and concentrated, which indicates that the requirements for the growth area of Aconitum leucostomum Vorosch are narrow, this also facilitates centralized governance.

The distribution of Aconitum diphtheriae is mainly concentrated in the north of Tianshan Mountains, and a small part is distributed in the south of Tianshan Mountains.

The important environmental factors affecting the distribution of Aconitum diphtheriae are: the wettest monthly rainfall (Bio13), the driest monthly rainfall (Bio14), the variance of temperature change (Bio4), and the average rainfall in the coldest season (Bio19).

Under the carbon emission scenarios of SSP126 and SSP585 at different levels, the proportion of suitable growing areas of Aconitum diphtheriae decreased gradually, and the reduction was more obvious when the concentration of greenhouse gases was high.The proportion of suitable growing areas of Aconitum diphtheriae under the two scenarios of future climate (SSP126 and SSP585) shows a decreasing trend.

References

[1] Bosso L, Luchi N, Maresi G, et al. Predicting Current and Future Disease Outbreaks of Diplodia Sapinea Shoot Blight in Italy: Species Distribution Models as a Tool for Forest Management Planning[J]. Forest Ecology and Management, 2017, 400:655–664.
[2] Sillero N. What Does Ecological Modelling Model? A Proposed Classification of Ecological Niche Models Based on Their Underlying Methods[J]. Ecological Modelling, 2011, 222(8):1343–1346.
[3] Lawler J J, Shafer S L, White D, Et Al. Projected Climate-Induced Faunal Change in the Western Hemisphere [J]. ECOLOGY, 2009, 90(3):588–597.
[4] Pramanik M, Paudel U, Mondal B, et al. Predicting climate change impacts on the distribution of the threatened Garcinia indica in the Western Ghats, India[J]. Climate Risk Management, 2017: S2212096317300931.
[5] Yang Huifeng, Zheng Jianghua, Wu Xiulan, et al. Prediction of potential distribution area of Aconitum diphtheriae in China based on MaxEnt model and ArcGIS [J]. China Plant Protection Guide, 2015, 35 (5): 50-54, 85
[6] Lan Xiaoning, Chen Lili. Analysis of Xinjiang grassland eco economic development. Journal of Tarim University, 2005, (03): 110-114
[7] Wang Fang, Zhao Jun, Zhao Feicui, et al. Studies on the chemical constituents of Aconitum diphtheriae [J]. China Pharmacy, 2015 (9): 1233-1235
[8] Zhang Jie, Cao Lige, Li Xiucang, et al. The latest progress of research on new socio-economic scenarios (SSPs) in IPC AR5 [J]. Progress in climate change research, 2013, 9 (3): 225-228
[9] Wang Yanjun, Jing Cheng, Cao Lige, et al. China's provincial population pattern when global warming is controlled at 1. 5 ℃ and 2. 0 ℃ [J]. Progress in climate change research, 2017, 13 (4): 327-336
[10] Xu Zhonglin, Peng Huanhua, Peng Shouzhang. Development and evaluation method of species distribution model [J]. Journal of Ecology, 2015, 32 (5): 557-567
[11] Hu Xiu, Wu Fuchuan, Guo Wei. Prediction of potential planting areas of sandalwood in China based on MaxEnt ecological model [J]. Forestry Science, 2014, 50 (5): 27-33