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Habitat Suitability Evaluation of Different Forest Species in Lvliang Mountain by Combining Prior Knowledge and MaxEnt Model

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Abstract: The accurate habitat suitability evaluation of forest species is vital for forest resource management and conservation. Therefore, the previously published thresholds of soil organic carbon (SOC) contents for the six main forest species were used to screen sample points in this study; the maximum entropy modeling (MaxEnt) was applied to predict the potential distribution of those species in Lvliang Mountain, Shanxi Province, China. The following results were derived: (1) the area under the curve (AUC) value of the MaxEnt model was 0.905, indicating the model results had high accuracy; (2) the main environmental factors affecting the woodlands were mean diurnal temperature range, solar radiation, population density and slope; (3) the model accurately depicted the most suitable areas for those species, namely *Populus davidiana* Dode (Malpighiales: Salicaceae), *Betula platyphylla* Sukaczev (Fagales: Betulaceae), *Quercus wutaishanica* Mayr (Fagales: Fagaceae), *Platycladus orientalis* (L.) Franco (Pinales: Cupressaceae), *Larix gmelinii* (Rupr.) Kuzen. (Pinales: Pinaceae) and *Pinus tabuliformis* Carrière (Pinales: Pinaceae). This study has improved the representativeness of the samples based on prior knowledge to enhance the biological meaning and accuracy of the prediction results. Its findings provide a theoretical basis for the forest resource protection, management measures alongside the reconstruction of low-yield and low-efficiency forests.

Keywords: MaxEnt model; habitat suitability; soil organic carbon; Grain-for-Green Program; Lvliang Mountain

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1. Introduction

Forest ecosystems are the mainstay of terrestrial ecosystems, covering approximately 4.1×10^7 km^2 of the global land area [1], having the largest land carbon reservoir, accounting for approximately 2/3 of the total carbon sequestered in terrestrial ecosystems [2]. Thus, forest ecosystems play an important role in regulating the ecosystem carbon cycle, regulating the global climate and slowing down the increases in atmospheric CO_2 and other concentrations [3,4]. Since the 1970s, global problems such as forest fires, the conversion of natural vegetation to arable land and continued environmental degradation caused by overgrazing have emerged as human population has increased [5]. Thereafter, people have gradually realized the significance of forests in relation to sustainable development. The increase in forest cover area is conducive to the accumulation of biomass and soil carbon [6], and forest ecological restoration is necessary [7]. For this reason, the Grain-for-Green Program (GGP) was launched in China in 1999 to increase the land area covered by forests [8]. After long-term management, the program has achieved remarkable results, but it still confronts many difficulties. The key problem is that the survival rates and the preservation rates of forest trees are low, causing poor vegetation stability, and weak ability to withstand disasters [9]; in this way, many low-yield forests and low-efficiency forests have formed [10]. How to improve the survival rate and preservation rate of forest trees is a new concern related to afforestation. By analyzing the relationship between forestland and the ecological environment, the habitat suitability of forestland and its spatial distribution pattern can be judged, which is of great practical significance to the sustainable development of human society and construction of forest ecological civilization. Therefore, research on the habitat suitability of forest species is essential to improve low-yield forest and low-efficiency forest.

Previous studies have often used empirical models [11,12], regression models [13] and machine learning [14] to carry out research on species habitat suitability. Among them, the empirical models identify key environmental variables for modeling predictions based on field observations of species or expert experience, but there is a strong subjectivity in the ranking and weighting of habitat factors [15]. Regression models, such as generalized linear models and generalized additive models [16–18], are sometimes difficult to use to analyze habitat suitability since nonexistence species point data (that is, species are not distributed at the point) are hard to obtain [19]. However, machine learning models, such as artificial neural networks, genetic algorithm for rule-set prediction and maximum entropy modeling (MaxEnt), are more flexible when the relationships between the species distribution and relevant environmental conditions are complex [20–22]. The MaxEnt uses species distribution information and environmental variables to analyze and predict the potential suitability distribution of species. It requires only a small number of presence points, and has stability and expansibility [23]. Since the model can use both continuous and discrete data to make the evaluation factors of tree species suitability analysis more diverse, it can be applied to this study to obtain better results [14,24]. The Jackknife method in the MaxEnt can reflect the importance of each environmental variable in the model more truthfully [25]. In this paper, it can help us to accurately understand the environmental characteristics of different forest species, which can provide support for researchers and decision makers to propose decisions that are beneficial to tree species conservation and rational siting of forest species. Apart from this, the model can generate receiver operating characteristic (ROC) curves to verify the prediction results of the model. However, most previous studies on ecological niche models have focused on the process of sample collection and model calibration [26,27], and few studies have considered improving the representativeness of the samples to enhance the biological meaning and accuracy of the prediction results [28,29]. For the reasons mentioned, this paper presents a new framework to explore how to improve the accuracy of habitat suitability evaluation method for different forest species by combing the Prior knowledge (e.g., soil properties) in forests into the ecological niche models. As an important index of soil quality, soil organic carbon (SOC) is of great significance in the healthy growth of forest trees. Therefore, combining the representative samples obtained by using forest SOC content with the MaxEnt model may be an effective method to identify habitat suitability accurately.

The objective of this study was to test the feasibility of adopting SOC contents in forests as a prior knowledge and integrating this information into the MaxEnt modeling process. It is expected that it will effectively predict the suitable habitat area of different forest species and may provide a more biologically meaningful decision-making reference for the reconstruction of low-yield and low-efficiency forests and forest scientific management.

2. Materials and Methods

2.1. Study Area

Lvliang Mountain is located at 35°67′–40°30′ N, 110°38′–113°48′ E (Figure 1) in the western part of Shanxi Province on the east bank of the Yellow River, and it extends approximately 500 km from north to south and 230 km from east to west. The region has a warm temperate and semiarid continental monsoon climate, with a large diurnal temperature range of 10–25 °C, an annual average temperature of 5–13 °C and an annual precipitation of 330–500 mm [30]. The terrain is mainly mountainous and hilly, with undulating topography and altitudes ranging from 543 to 2763 m. The main dominant species of forest vegetation are *Betula platyphylla* Sukaczev (Fagales: Betulaceae), *Quercus wutaishanica* Mayr (Fagales: Fagaceae), *Platycladus orientalis* (L.) Franco (Pinales: Cupressaceae), *Populus davidiana* Dode (Malpighiales: Salicaceae), *Larix gmelinii* (Rupr.) Kuzen. (Pinales: Pinaceae), *Pinus tabuliformis* Carrière (Pinales: Pinaceae). Among them, *P. tabuliformis* and *L. gmelinii* are suitable for light, and have high cold resistance and strong wind resistance, which are often used as the main afforestation species in northern areas; B. platyphylla is suitable for moist soil and slopes facing south, with high economic value; Q. wutaishanica is suitable for a warm and humid climate, and is an excellent tree species for water conservation and fire protection forest; P. orientalis is a pioneer tree for afforestation, with a wide range of adaptability to soil PH; P. davidiana is a highly adaptable species that requires full sunlight and can survive in dry and infertile soils [31,32]. These tree species are important for preventing soil erosion and improving the ecological environment of Lvliang Mountains.

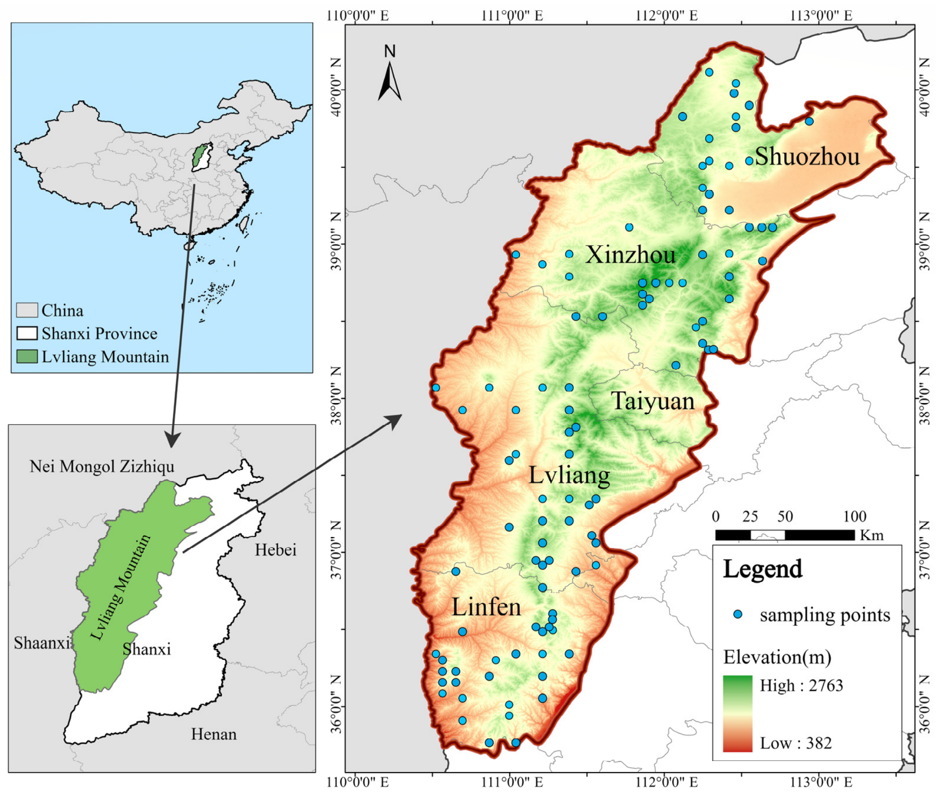

Figure 1. Study area and distribution of sample sites adopted in the Maxent modeling.

2.2. Data Collection and Preprocessing

According to the principle of representativeness, soil samples were collected in the woodland representing the vegetation, topography and soil characteristics of the study area from 2007 to 2008, and the geographical coordinates of the sample sites were recorded via Global Positioning System (GPS). After removing the litter from the surface, a soil drill was used to extract the soil samples at a depth of 0–40 cm, and the plant roots and gravel were removed. The content of soil organic matter was measured by the dry combustion method with a TOC analyzer, and the value was then multiplied by the Bemmelen conversion coefficient (0.58) to obtain the SOC content [33].

As previous research results have found [34], the minimum SOC content of different forest species (*P. davidiana, B. platyphylla, Q. wutaishanica, P. orientalis, L. gmelinii and P. tabuliformis*) in different soil layers (0–10 cm, 10–20 cm, 20–30 cm and 30–50 cm) was obtained as prior knowledge [35]. The minimum SOC content at 0–50 cm in the different forest species was obtained by the weighted average method based on prior knowledge (Table 1). Woodland sample sites with SOC contents higher than 4.99 g/kg were considered as the points-of-existence (POE) that were suitable for forest planting. A total of 65 POE was screened out to construct the woodland suitability model (Figure 1). The output results of the MaxEnt model represent the probability of woodland existence or occurrence, and the greater the probability is, the higher the suitability of woodland habitat is. Because the POE of a single forest species was screened only by its corresponding SOC content range, when the MaxEnt model was established for the different forest species, the actual planted forest species at these points could not be determined; therefore, in this study, the MaxEnt model results of a single forest species represented the marginal probability that an area was suitable for planting this forest species.

Table 1. Minimum SOC contents in different forest species based on a prior knowledge.

Soil Layer	Weight	Organic Carbon Content of Different Forest Species (g/kg)					
		Populus davidiana	*Betula platyphylla*	*Quercus wutaishanica*	*Platycladus orientalis*	*Larix gmelinii*	*Pinus tabuliformis*
①: 0–10 cm	0.2	18.34	35.09	12.09	14.07	31.02	14.86
②: 10–20 cm	0.2	5.13	16.81	5.95	2.54	11.13	7.93
③: 20–30 cm	0.2	3.28	11.8	3.22	1.34	5.02	4.35
④: 30–50 cm	0.4	2.94	7.82	1.85	4.08	5.68	5.18
0–50 cm	0.2 × ① + 0.2 × ② + 0.2 × ③ + 0.4 × ④	6.53	15.87	4.99	5.22	11.71	7.50

2.3. Environmental Variables

In this paper, a total of 27 environmental variables were selected from the aspects of climatic, topographic and social as auxiliary variables to construct the model. Climate variables include water vapor pressure, solar radiation and 19 commonly used bioclimatic factors in WorldClim dataset (version 2.1), namely Bio1 to Bio19 (https://www.worldclim.org, accessed on 16 August 2022) [36]. The aspect, slope and topographic wetland index values were extracted from ASTER GDEM 30 m resolution digital elevation data (https://www.nasa.gov, accessed on 16 August 2022). Social data included population density from WorldPop (http://www.worldpop.org.uk/, accessed on 17 August 2022) [37] and Per Capita Gross Domestic Product (GDP) data collected from the local statistics bureau [38] (Table 2).

Table 2. Environmental variables.

Variable	Description	Type
BIO1	Annual mean air temperature/°C	Climatic
BIO2	Mean diurnal temperature range/°C	Climatic
BIO3	Isothermality/°C	Climatic
BIO4	Temperature seasonality	Climatic
BIO5	Maximum temperature of warmest month	Climatic
BIO6	Min Temperature of Coldest Month/°C	Climatic
BIO7	Temperature annual range/°C	Climatic
BIO8	Mean temperature of wettest quarter/°C	Climatic
BIO9	Mean temperature of driest quarter/°C	Climatic
BIO10	Mean temperature of warmest quarter/°C	Climatic
BIO11	Mean temperature of coldest quarter/°C	Climatic
BIO12	Annual precipitation/mm	Climatic
BIO13	Precipitation of wettest month/mm	Climatic
BIO14	Precipitation of driest month/mm	Climatic
BIO15	Precipitation seasonality	Climatic
BIO16	Precipitation of wettest quarter/mm	Climatic
BIO17	Precipitation of driest quarter/mm	Climatic
BIO18	Precipitation of Warmest Quarter/mm	Climatic
BIO19	Precipitation of coldest quarter/mm	Climatic
VAPOR	water vapor pressure/Pa	Climatic
SRAD	Solar radiation/(W/m^2)	Climatic
DEM	Elevation/m	Topographic
ASPECT	Aspect	Topographic
SLOPE	Slope/°	Topographic
PD	Population density	Social
TWI	Topographic wetness index	Topographic
GDP	Per Capita GDP/(yuan/person)	Social

To avoid model over-fitting caused by high spatial collinearity between variables [39], ENMTools were used to analyze the correlations among the 27 environmental variables [40]. Meanwhile, the jackknife tool was used to analyze the contribution of environmental factors in the prediction of the model, and the environmental variables with lower contribution and correlation coefficients $|r| \geq 0.8$ were removed (Figure 2). Finally, ten environmental variables that had an important influence on the distribution of woodland suitability were selected: mean diurnal temperature range (BIO2), slope (SLOPE), elevation (DEM), solar radiation (SRAD), isothermality (BIO3), population density (PD), min temperature of coldest month (BIO6), topographic wetness index (TWI), precipitation of warmest quarter (BIO18) and Per Capita GDP (GDP). The above data were all resampled to a spatial resolution of 30 m × 30 m, and converted to ASCII files, which were used to construct the woodland suitability model.

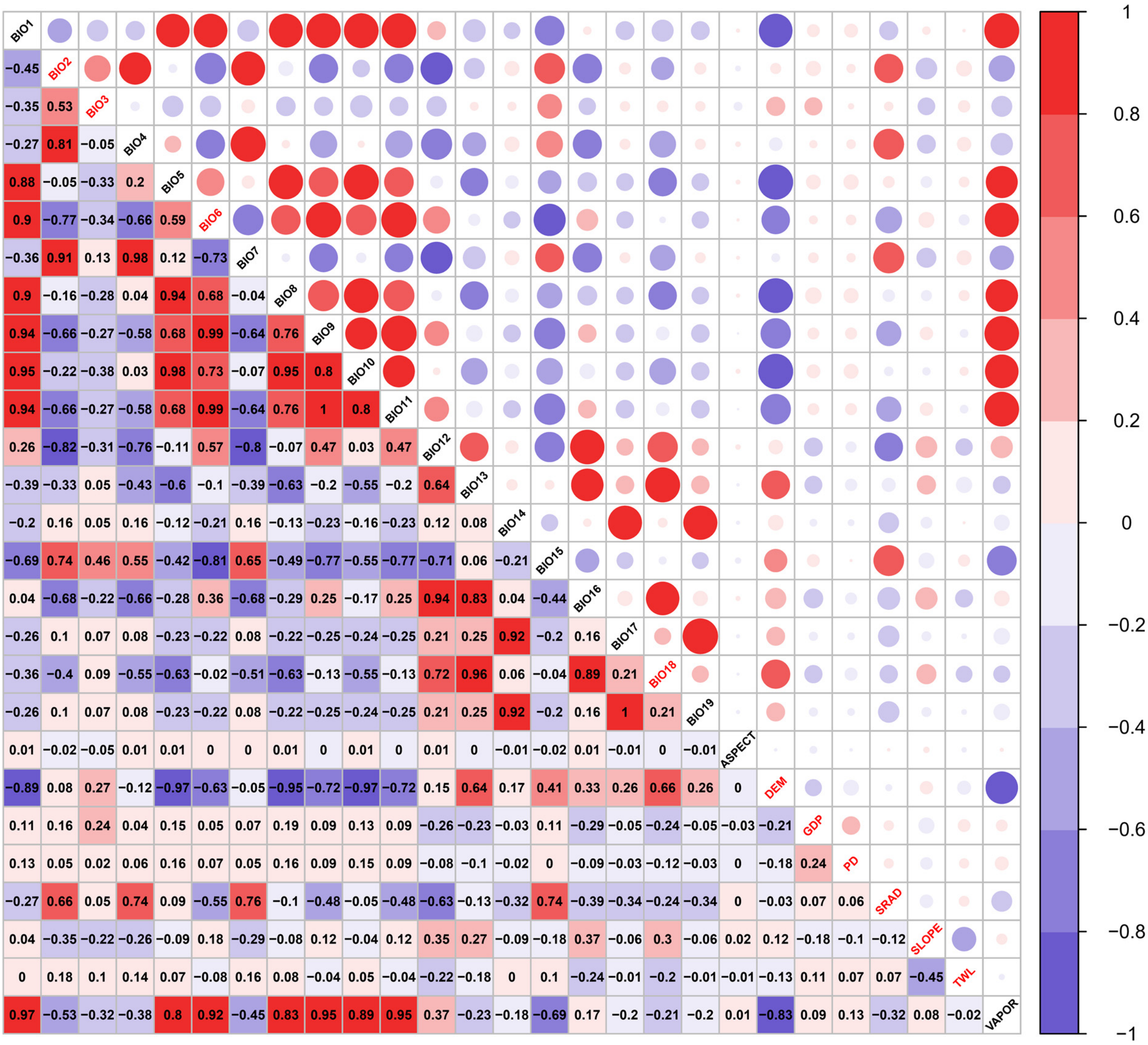

Figure 2. Correlations among 27 variables in Table 2. The red color stands for positive correlations and the blue color stands for negative correlations. The stronger the correlation between variables, the darker the color and the higher the saturation and the larger the size of the circle, the greater the correlation between variables. The red fonts represent the selected variables.

2.4. Model Construction and Evaluation

MaxEnt is one of the most accurate distribution models for simulated results [41]. A successful prediction of the MaxEnt distribution requires the selection of accurate and appropriate sample distribution data, environmental factor data that accurately reflect the ecological characteristics of species, and optimal model parameters [23]. The POE data and the ASCII files of the ten selected environmental variables were inputted into the MaxEnt software. Among these, 75% of the POE data were randomly selected as the model training set, and the 25% remained were used as the test set. The optimal feature parameters and regularization multiplier (0.5) were selected by ENMTools, and the 100-times bootstrap method was used to evaluate the habitat suitability [42–44]. The model performance was evaluated by the AUC (area under the curve) bounded by the ROC (receiver operating characteristic) curve and the horizontal and vertical coordinate axes [45]. An AUC range of 0.5–0.6 indicates a very poor performance; a range of 0.6–0.7 indicates a poor performance; a range of 0.7–0.8 indicates a general performance; a range of 0.8–0.9 indicates a good performance, and a range of 0.9–1 indicates an excellent performance [46].

3. Results

3.1. Model Accuracy

According to the evaluation results of the ROC curve (Figure 3), the average AUC of the model was 0.905, indicating that the model had excellent prediction results and high reliability and can be used to evaluate the habitat suitability of the forest in Lvliang Mountain.

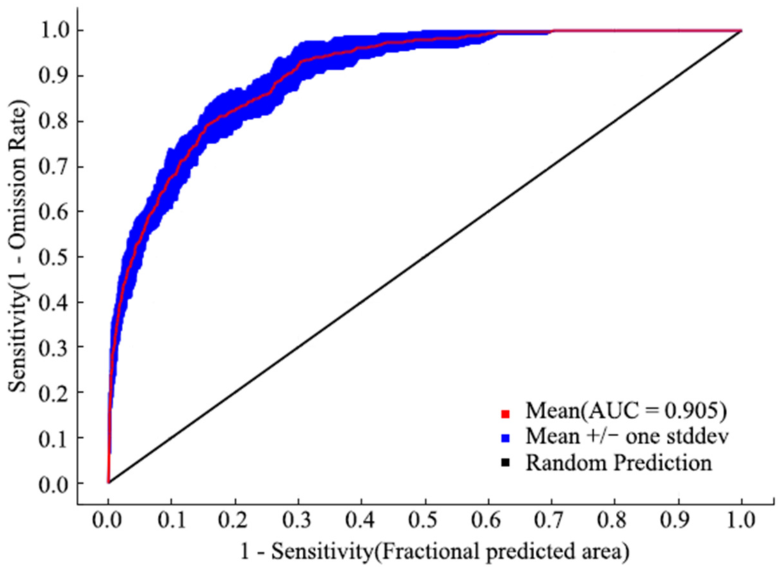

Figure 3. ROC curves and AUC values of the MaxEnt model.

3.2. Identified Main Environmental Factors

The environmental variable contributions (Table 3) and the results of jackknife gain test (Figure 4) showed that [47] the cumulative contributions of the classified environmental variables affecting the suitability of woodland habitat were ranked in the order of climatic (55%) > topographic (25.5%) > social (19.5%). The environmental variables with the contributions larger than 10.0% were the average temperature range of day and night (18.4%) > solar radiation (16.2%) > population density (14.8%) > slope (14.3%). The cumulative contributions of the above four environmental variables were 63.7% and could be identified as the main environmental factors in this study. Thus, it could be concluded that the climate factors were the most important environmental factors, among which the average diurnal temperature range had the greatest influence on the suitability of woodland habitat.

Table 3. Environmental variables adopted in the model.

Variable	Description	Type	Contribution
BIO2	Mean diurnal temperature range	Climatic	18.4%
SRAD	Solar radiation	Climatic	16.2%
PD	Population density	Social	14.8%
SLOPE	Slope	Topographic	14.3%
BIO18	Aspect	Climatic	9.4%
DEM	Elevation	Topographic	7.3%
BIO3	Isothermality	Climatic	6.9%
GDP	Per Capita GDP	Social	4.7%
BIO6	Precipitation of wettest quarter	Climatic	4.1%
TWI	Topographic wetness index	Topographic	3.9%

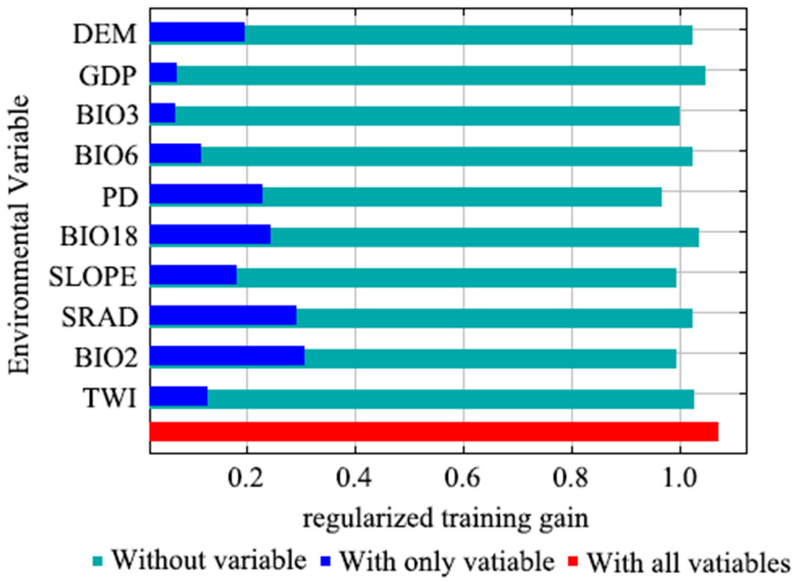

Figure 4. Jackknife test of the importance of environmental variables in MaxEnt model. The environmental variables in figure are mean diurnal temperature range (BIO2), slope (SLOPE), elevation (DEM), solar radiation (SRAD), isothermality (BIO3), population density (PD), min temperature of coldest month (BIO6), topographic wetness index (TWI), precipitation of warmest quarter (BIO18) and Per Capita GDP (GDP).

Figure 5 shows the response curves of the main environmental factors to the habitat suitability of woodland. The average diurnal temperature range had the most significant effect on the habitat suitability of woodland. The habitat suitability of woodland showed an increasing trend with an increase in the average diurnal temperature range. It reached maximum when the average diurnal temperature range value was 10.2 °C and then decreased gradually with further increases in the average diurnal temperature range value. When the solar radiation increased, the woodland habitat suitability increased rapidly, reached maximum when the solar radiation was 15,425 W/m^2, and then decreased gradually. Forest species preferred to grow in less populated areas and decreased gradually with increasing population density. The habitat suitability of woodland increased rapidly with increasing slope, increased slowly between 10° and 27°, and then decreased gradually. To summarize, the ranges of the main environmental factors for woodland with very high suitability were as follows: mean diurnal temperature range (10.2 °C–12.3 °C), solar radiation range (15,367–15,912 W/m^2) and slope range (10°–29°).

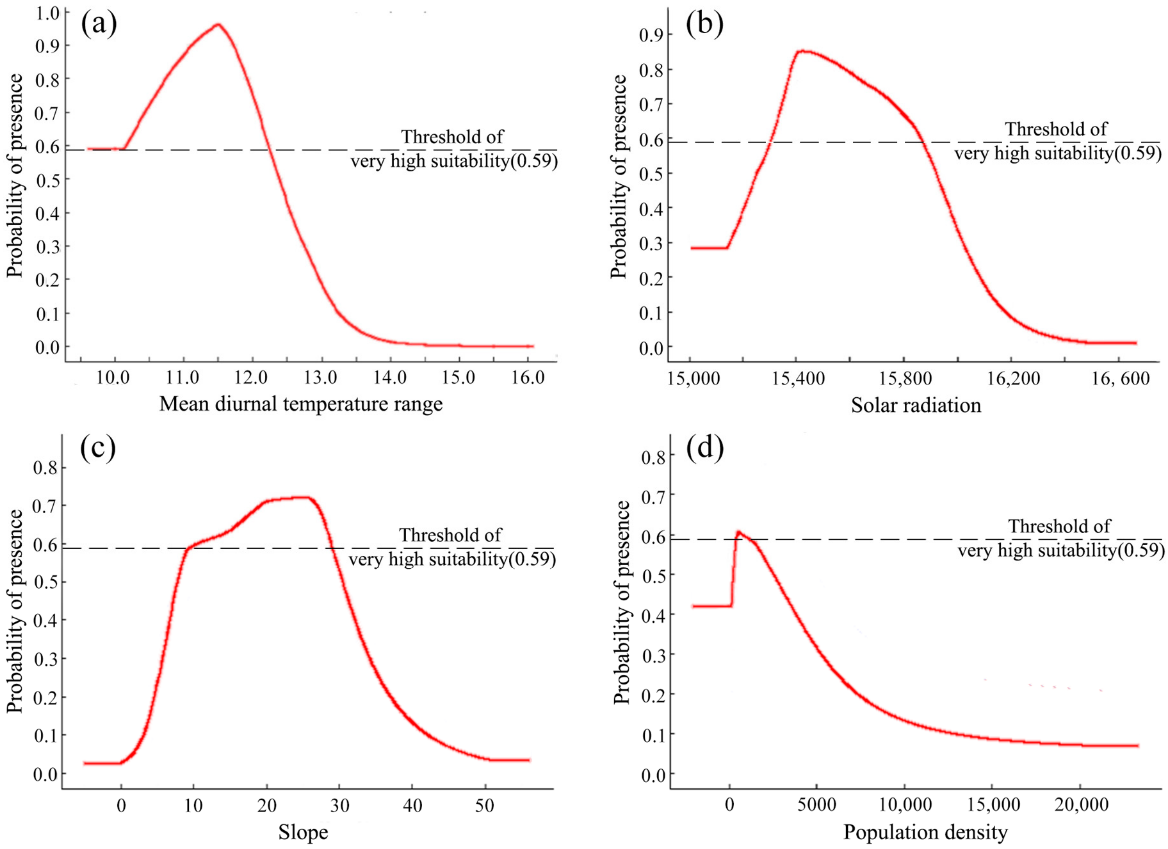

Figure 5. Jackknife test of the importance of environmental variables in MaxEnt model. (**a**) Mean diurnal temperature range (BIO2); (**b**) Solar radiation (SRAD); (**c**) Slope (SLOPE); (**d**) Population density (PD).

3.3. Suitable Habitats for Forest in Lvliang Mountain

The Natural Breaks (Jenks) have been used in many previous studies. The method is based on the natural clustering of the logical output value of the model, which can provide information on the habitat suitability ranking of species, compared to other methods. Therefore, this study could obtain a more reasonable and ecologically significant estimate by applying this method [48,49]. As shown in Figure 6, the geographical distribution of the habitat suitability of woodland considering SOC contents was divided into five levels based on natural break point method (Jenks): very low (0%–14%), low (15%–27%), medium (27%–42%), high (44%–59%) and very high (59%–100%). The area of very high suitability was 4771 km^2, which accounted for only 6.65% of the total area of Lvliang Mountain, and the area of high suitability, medium suitability, low suitability and very low suitability was 7014 km^2, 9089 km^2, 13,071 km^2, 37,729 km^2, respectively. The suitable woodland areas were mainly distributed in the soil-rock mountain areas in the middle and south of the study area. The very highly suitable areas were mainly concentrated in Zhongyang and Jiaokou County, Lvliang City, Shanxi Province and Pu, Xi and Ji County, Linfen City, Shanxi Province. The very low suitability areas were mainly in the loess hilly regions in the western Lvliang Mountain, which are Pianguan, Hequ, Houde and Wuzhai County in northwestern Xinzhou city; Xingxian, Linxian, Liulin and Shilou County in western Lvliang city; Yonghe County in western Linfen city; and Huairen, Ying and Shanyin County in northeastern Shuozhou city.

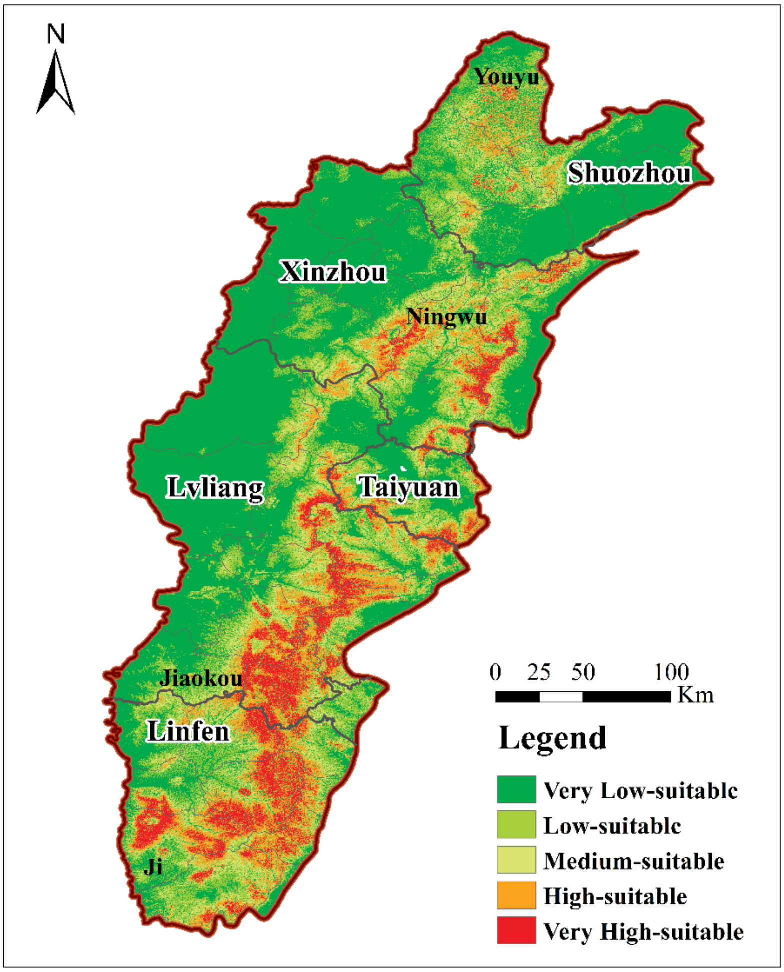

Figure 6. Map of habitat suitability of forests in Lvliang Mountain.

3.4. Suitable Habitats for Different Forest Species in Lvliang Mountain

The Lvliang Mountain area has rich forest resources and diverse vegetation types. According to the SOC contents of the different dominant forest species (Table 1), the POE data were screened into six representative POEs of the different forest species (*P. davidiana, B. platyphylla, Q. wutaishanica, P. orientalis, L. gmelinii and P. tabuliformis*). The marginal habitat suitability of the different forest species is shown in Figure 7, and the same classification method for habitat suitability as that in Figure 6 was used. The classified very highly suitable area of *B. platyphylla* was concentrated in the middle area of Lvliang Mountain with an altitude greater than 2000 m, i.e., in Ningwu County, Xinzhou city and the junction of Taiyuan city and Lvliang city. The average temperature difference between the day and night in these areas is small, the solar radiation is low and the precipitation is high. The most suitable areas for *Q. wutaishanica* and *P. orientalis* were concentrated in the southern part of the Lvliang Mountains. The lowest solar radiation was approximately 15,000 W/m^2 in the southernmost Linfen city, which was the area with the lowest mean diurnal temperature range value of only 10 °C. In this study, the most suitable area for *Q. wutaishanica*, the landmark plant in the Lvliang Mountain Nature Reserve, was the largest. Both the range of the SOC content of *P. davidiana*, *L. gmelinii* and *P. tabuliformis* and their suitability distributions were similar, but there were still some differences. The most suitable areas for *P. davidiana* and *P. tabuliformis* were in Youyu County, Shuozhou city, in the northernmost part of Lvliang Mountain, and the average temperature difference between the day and night in the study area was the largest, which comes up to more than 15 °C.

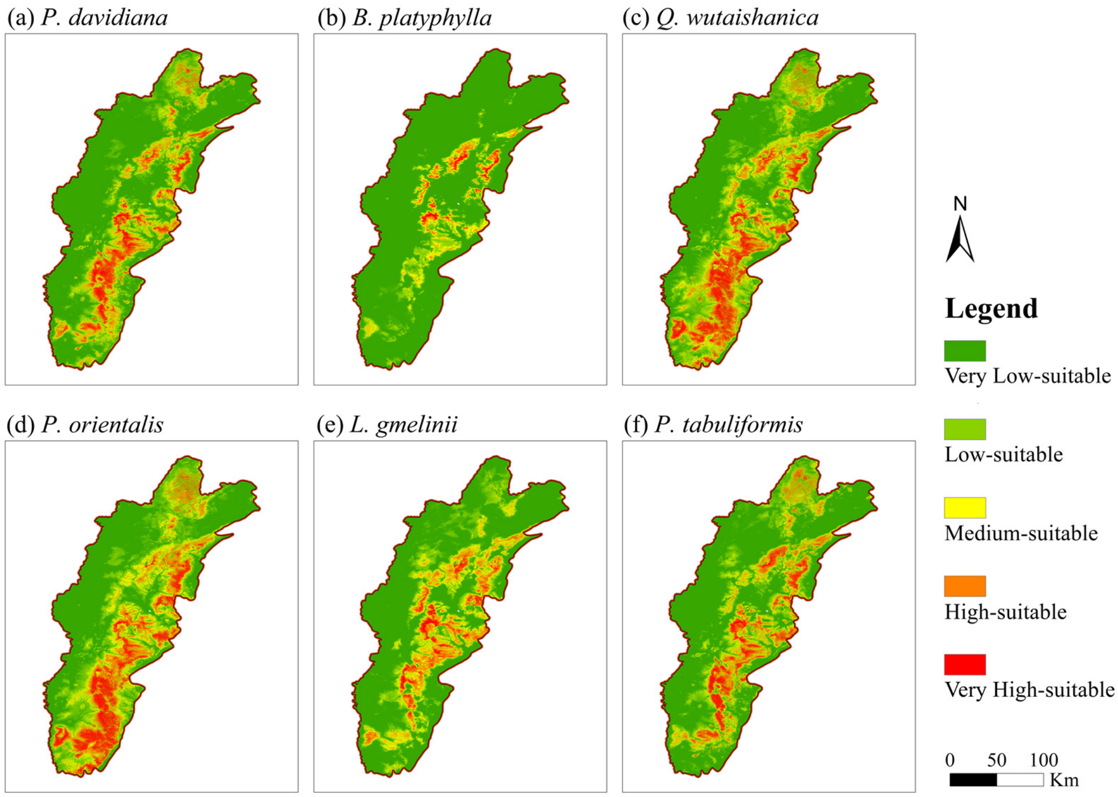

Figure 7. Marginal probability of different forest species that meet the SOC content requirements. (**a**) *P. davidiana*, (**b**) *B. platyphylla*, (**c**) *Q. wutaishanica*, (**d**) *P. orientalis*, (**e**) *L. gmelinii*, (**f**) *P. tabuliformis*.

4. Discussion

Based on climatic, topographic and social factors, MaxEnt model was used in this study to simulate and analyze the potential suitability of forest plantations in Lvliang Mountain that met the conditions of SOC content. The results showed that the mean diurnal temperature range was the most important environmental variable affecting the distribution of habitat suitability, indicating that the forest was highly sensitive to the temperature variation. In fact, the loess accumulation on the west slope of Lvliang Mountain, the steep mountain slope on the east side, the overall crisscrossed nature of ravines and gullies, the unique landform features and the obvious elevation changes lead to the temperature variation characteristics in Lvliang Mountain. Although the temperature difference between the day and night can regulate the production and accumulation of organic matters in plants, an excessive temperature difference will lead to burns or frost cracks in plant branches. Therefore, the mean diurnal temperature range in the suitable woodland area of Lvliang Mountain was 10.2 °C–12.3 °C. The results of this study were consistent with those of previous studies on the prediction of suitable areas for different plants, such as *Corylus mandshurica* Maxim. (Fagales: Betulaceae) and *Quercus fabrei* Hance (Fagales: Fagaceae) in which the mean diurnal temperature range was a key environmental factor [50–52]. However, the relevant study areas were mostly located in southern China [53], and there have been few studies on the relationship between forest trees, organic carbon and mean diurnal temperature range in northern China. Secondly, woodland is highly sensitive to solar radiation, which reflects the intensity of solar heating on the land surface and significantly affects vegetation growth. For different slopes receiving different amounts of solar radiation, the high solar radiation on sunny slopes can promote the decomposition of microorganisms and reduce the content of organic carbon, while the low solar radiation on shady slopes benefits the accumulation of organic carbon [54]. It was found that the content of SOC in mountain forest decreased when solar radiation increased [55], and it was thereby concluded that the growth of forest vegetation was affected by both SOC and solar radiation, which verified the necessity to explore woodland suitability distributions based on SOC content. Thirdly, the slope reflects the intensity of topographic relief, which in turn affects the land use mode. The suitability of woodland in Lvliang Mountain firstly rose and then decreased with the increase of slope. It went up gently to the maximum within the slope range of 20° to 27° and then dropped down below the very high suitability threshold after 29°. In the standard for returning farmland to forest, sloping land with a slope larger than 25° is included [56]. Therefore, sloping land ranging from 25° to 29° can be selected to plant woodland to improve the survival rate of trees. Finally, human activities are important factors affecting forest distribution [57]; social activities are greater in populated areas than in other areas, and areas affected by humans have scarce vegetation and greater soil nutrient losses. Population density represents the intervention degree of human activities on forests; therefore, it is negatively correlated with soil carbon content and forest vegetation [58,59]. It is therefore inferred that the highly suitable areas of woodland are mainly concentrated in sparsely populated areas, and the adaptability of woodland is low in social urban areas with developed economies. In general, the effects of the main environment factors and the corresponding ranges for highly suitable woodland habitat, which were identified in this study, can provide a specific and useful reference for the rational implementation of scientific forestry policies.

Forest habitat suitability could be effectively and accurately predicted by screening woodland samples through prior organic carbon conditions. The very highly suitable areas of woodland considering SOC content were located mainly in the southern and the soil-rock mountain areas in the central mountainous areas of Lvliang Mountain, and a small amount of woodland was distributed in the northernmost high-altitude area. The optimum area for *P. orientalis* and *Q. wutaishanica* was the largest, *P. orientalis* was suitable in high-slope areas with a greater light intensity, and *Q. wutaishanica* was suitable for middle-altitude and middle-slope areas. The most suitable area of *P. tabuliformis* was located in the high-altitude area with a low slope and weak light, and both were distributed in Xinzhou city in the middle of Lvliang Mountain and east of Lvliang city. The distribution of *P. davidiana* shows a direction from northeast to southwest [60], which is more suitable for planting in high altitude areas compared with the other two forest species in the Lvliang Mountain in Figure 7. Higher altitudes have more abundant solar radiation, which is the main ecological factor for transpiration and photosynthesis in sagebrush forests [61]. Therefore, the habitat suitability of *P. davidiana* was more affected by solar radiation compared with *P. tabuliformis* and *L. gmelinii*, which was also verified by the model results. *Betula platyphylla* and *L. gmelinii* were suitable for high-altitude areas with large slopes and low temperatures, and the optimum planting area of *B. platyphylla* considering the SOC content was the smallest and was concentrated in Xinzhou city, Taiyuan city and Lvliang city. *L. gmelinii* is more affected by the precipitation of warmest quarter, which was consistent with the results of previous studies [62]. The precipitation of warmest quarter is lower in the north and south, and higher in the middle in Lvliang Mountain. The suitable probability of larch increased with the increasing precipitation of the warmest quarter. Therefore, the northernmost area of Lvliang Mountain is less suitable for *L. gmelinii*, which is different from *P. davidiana* and *P. tabuliformis*. The habitat analysis of suitable areas was similar to the results of Wang, who studied the suitable habitats of different forests in the southern section of Shanxi Province [63]. More importantly, the prediction results in this paper are rather close to those of the Eighth National Forest Resources Inventory (2009–2013) [64]. For example, some natural woodlands are located in Youyu County in northern Shuozhou city, along with a large variety of shrubs planted under the special provisions of the state; these results proved and supported the reliability and feasibility of this study, which therefore can support the implementation of the Grain-for-Green Program and afforestation projects across China.

Moreover, the identification of areas with low habitat suitability for woodland can provide a guidance for reducing the failure rate of good seed cultivation and reforming low-yield forests and low-efficiency forests. The very low-suitability areas were mainly distributed in Pianguan, Hequ, Houde and Wuzhai County in Xinzhou city; Xing, Linxian, Liulin and Shilou County in Lvliang city; and Yonghe County in Linfen city. These areas are located on the west of Lvliang Mountain and are on the east bank of the Yellow River basin. The area is approximately 300 km long from the Great Wall in the north to the Yumen Estuary in the south of the Loess Plateau, and these areas have the most serious soil and water erosion [65]. Huairen city, Ying County and Shanyin County in the northeast of Shuozhou city, which are located in the northernmost part of the Lvliang Mountains, are also low suitability areas. They are located in the loess hilly areas in the east of the Lvliang Mountains and the Fenhe River basin in the east, and these sites have a loose soil structure, scarce natural vegetation and serious soil and water erosion. They are the main source of sediment in the upper reaches of the Fenhe River [36,66]. In other words, measures other than afforestation may be taken in these places to prevent the wasting of resources in the process of afforestation and improve the efficiency of soil and water conservation.

5. Conclusions

In this study, the MaxEnt model was used to simulate the distribution of habitat suitability in the forest in Lvliang mountain, and the simulation results were highly accurate. The distribution and main ecological characteristics of the suitable habitat were also analyzed. It was found that within the range of woodland organic carbon content, the four main environmental factors affecting the habitat suitability of woodland planting were: solar radiation, average temperature difference between day and night, population density and slope. In addition, the marginal probabilities for different forest species that meet the SOC content requirements were predicted and analyzed, which can provide more accurate advice for forest planting and ecological protection in Lvliang Mountain.

The species distribution models can be accurately and reasonably constructed to predict the habitat suitability of species by using the results of previous studies as prior knowledge to assist in the screening of sample data. In the future, the suitability distribution of different forest species, such as broad-leaved forest, coniferous forest and shrub forest, can be studied in combination with different actual ecological characteristics, such as soil properties, to provide a theoretical basis for the development of detailed forest management and afforestation plans in Lvliang Mountain and many other areas in China. Moreover, with the development of ecology and other related disciplines, corresponding prior knowledge for many species (including small range distributed species and rare species) can be found incorporated into ecological niche models to obtain more biologically significant prediction results, which can help us acquire better understanding of the distribution law of species.

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