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Analysis on the Influence of Saihanba Forest Farm on Dust Storm in Beijing

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Abstract

In order to study the impact of Saihanba forest farm on Beijing sandstorm, this paper first establishes the ecological environment evaluation model of Saihanba forest farm, and compares the environmental conditions before and after the restoration of Saihanba forest farm. Secondly, the evaluation model of dust storm in Beijing is established to observe whether the phenomenon of dust storm in Beijing has been improved after the completion of Saihanba forest farm. Explore whether the establishment of Saihanba forest farm is related to the improvement of dust storms in Beijing.

Keywords

Saihanba Forest Farm; Beijing Sandstorm; Evaluation Model.

1. Introduction

Saihanba, 200 kilometers north of Beijing, is the largest forest in North China and the largest plantation in the world. China's national meteorological data [1] show that in the 1950s, the annual average number of sand and dust days in Beijing was 56.2 days; During the decade from 2002 to 2012, the number of dust days decreased to single digits, and the number of dust days in Beijing decreased by more than 80%.

This paper analyzes the impact of Saihanba forest on Beijing sandstorm by establishing Saihanba ecological environment evaluation and Beijing sandstorm evaluation models. This study is helpful to provide guidance for dust treatment.

2. Model Establishment and Solution

2.1 Development of Ecological Environment Assessment Model of Saihanba

2.1.1 Indicators Determination

Based on the comprehensive consideration of the environmental factors and the reliability and accessibility of data sources in the ecological reserve, 7 indexes were selected to evaluate the environmental quality of the forest farm before and after restoration. They are woodland area (FS), forest coverage (f), forest stock (V), wetland area (FW), water conservation (W), carbon dioxide absorption (QCO2), oxygen release (QO2).

According to the official website of Saihanba Mechanical Forest Farm [2], the data of FS before and after restoration are 240,000 mu and 1.151 million mu respectively. The data of f before and after restoration are 11.4% and 82% respectively. The data of V before and after restoration are 330,000 cubic meters and 10,368,000 cubic meters respectively. The FW was close to 0. The value of W is 103,000 mu after restoration.

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This paper gets the data of soil organic matter (SOM) in 1964 of Saihanba from China first general survey and soil organic carbon in 1972 from dataset of soil properties for land surface modeling over China [3-4].

The average conversion coefficient between soil organic carbon and soil organic matter is 1.724 [5].

$$SOM = SOC * 1.724 \tag{1}$$

By stock-difference method: according to the difference of soil organic carbon storage between 1964 and 1972 [6], the amount of carbon sequestration can be estimated.

$$\Delta C = (SOC_t - SOC_0) * A \tag{2}$$

ΔC is the amount of carbon sequestration. SOC0 is original soil organic carbon storage. SOCt is soil organic carbon storage at year t. A is soil area.

$$m_c = \frac{\Delta C}{t} \tag{3}$$

Where, mc is annual carbon sequestration.

According to molecular weight ratio, the conversion coefficient between carbon and carbon dioxide is 3.6667.

$$m_{CO_2} = \frac{44}{12} * m_c \tag{4}$$

Where, mco2 is annual carbon dioxide absorbing capacity.

The afforested area in 1962 is 240,000 mu. The average annual sun exposure days is 213.1 days [7]. According to the study of greening tree species photosynthetic characteristics and ecological benefits, based on the net photosynthetic rate and leaf area index, the daily oxygen absorbing capacity per hectare forest is 25.1 kg [8]. Therefore, the annual oxygen absorbing capacity could be estimated by:

$$m_{O_2} = 25.1 * A_a * D \tag{5}$$

Where, mo2 is annual oxygen absorbing capacity. Aa is afforested area. D is annual sun exposure days.

2.1.2 Weight Determination by AHP

This paper uses analytic hierarchy process to determine the weight. Reasonably using Delphi method, the paired comparison matrix is obtained as follows.

By test, the eigenvalue of the matrix B is:

$$\lambda = 7.268523$$
$$CI = 0.044754$$
$$CR = \frac{CI}{RI} = 0.032907 < 0.1 \tag{6}$$

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Therefore, the matrix passes the consistency test and can be used to obtain weights.
The weight of each index is the eigenvector of the comparison matrix B.

$$w = (0.028,0.055,0.083,0.169,0.169,0.248,0.248)^T \tag{7}$$

The weighted score of Saihanba Forest Farm before and after restoration was obtained by multiplying the weights of each index by the value.

Table 1. Paired Comparison Matrix B

	FS	***f***	*V*	***FW***	***W***	Q_{CO2}	Q_{O2}
FS	1	1/2	1/4	1/6	1/6	1/8	1/8
f	2	1	1/2	1/3	1/3	1/4	1/4
V	4	2	1	1/4	1/4	1/2	1/2
FW	6	3	4	1	1	1/2	1/2
W	6	3	4	1	1	1/2	1/2
Q_{CO2}	8	4	2	2	2	1	1
Q_{O2}	8	4	2	2	2	1	1

2.2 Establishment of Sand Storm Evaluation Model in Beijing

2.2.1 Indicators Determination

This paper used normalized difference vegetation index (NDVI), which quantifies vegetation by measuring the difference between near-infrared (which vegetation strongly reflects) and red light (which vegetation absorbs). NDVI increases with the increase of vegetation coverage. This paper gets the NDVI of 1998, 2003, 2008, 2013 and 2015 from China Annual Vegetation Index (NDVI) spatial distribution dataset [9].

As for Beijing's dusty weather conditions, according to the definition and classification of sandstorm, floating dust weather and sand blowing weather by the National Meteorological Bureau, it can be found that the classification of sand weather is based on visibility. Through the collected reports and data, people can easily find the average number of sandstorm days, sand blowing days and floating dust days before 2000 [10]. However, according to the records of weather conditions, only air quality index (AQI) and PM10 related data can be obtained. According to relevant papers [11], the correlation between air quality index, PM10 content and dust weather can be obtained, so as to establish standards to judge dust weather conditions from 2000 to 2020.

Table 2. Beijing Dust Statistics

Years	Floating dust days	Sand lifting days	Sandstorm days
2018	4	2	0
2013	3	3	0
2008	5	0	0
2003	0	0	1
1998	4	13	1

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Table 3. Forest Coverage Rate of Saihanba

Years	NDVI
2018	0.832
2013	0.816
2008	0.736
2003	0.728
1998	0.716

According to relevant papers [12], the influence weights of these five aspects on dust weather can be obtained, which are: average annual wind speed (0.5), sand source distance (0.5), floating and sinking days (0.23), sand blowing weather (0.35), number of sandstorm days (0.42).

2.3 Sandstorm Change in Beijing and Its Relationship with Saihanba Forest Farm (By Correlation Analysis)

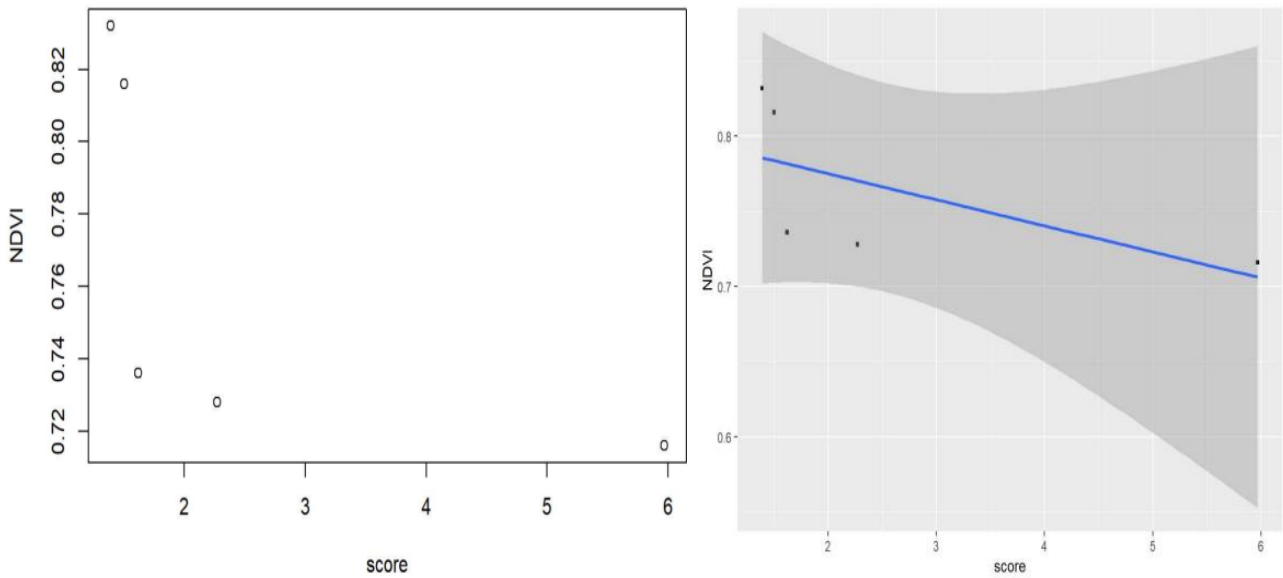

Fig. 1 Plots of Correlation

The correlation between the NDVI can be found and the resistant ability of sandstorm has a nearly strong negative correlation with a correlation coefficient of -0.6225, which means with the increase of the NDVI, the probability of sandstorm decreases to some degree.

3. Model Evaluation and Improvement

This paper innovatively puts forward some evaluations indexes and comprehensively analyzes the ecological protection areas.

The selection of indicators in this paper can be further strengthened, for example, more factors should be considered, and grading indicators should be selected for evaluation.

References

[1] http://data.cma.cn/site.

[2] SAIHANBA. Basic Situation of Saihanba Machinery Forest Farm - Green Pearl - Saihanba [EB/OL]. lycy.hebei.gov.cn. 2021-11-01/2021-11-28.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202208_8(8).0023

[3] National earth system science data center. Soil Science Data Center [EB/OL]. soil.geodata.cn. 2021/2021-11-27. http://soil.geodata.cn.

[4] Big Data Platform for Space-time Tripole Environment. China Soil Organic Matter Dataset - Spatiotemporal Tripole Environment Big Data Platform[EB/OL]. poles.tpdc.ac.cn. 2019.

[5] Chang R, Tang H. SENSITIVITY ANALYSIS ON METHODS OF ESTIMATING CARBON SEQUESTRATION IN GRASSLAND ECOSYSTEM OF INNER MONGOLIA, CHINA[J]. Journal of Plant Ecology (Chinese Version), 2008, 32(4): 810~814.

[6] Cheng JM, Cheng J, Yang XM. Study on Vegetation and Soil Carbon Sequestration in the Loess Plateau[J]. Journal of Natural Resources, 2011, 26: 401.

[7] Liu C. Preliminary study on soil soluble organic carbon of meadow steppe, Pinus sylvestris var. mongolica and Larix gmelini plantation in Saihanba, Hebei Province - and the effect of grassland afforestation on soil organic carbon[J]. Peking University, 2008.

[8] Liang S. Physiological characteristics of some urban greening tree species and their responses to air pollution[J]. Nanjing forestry university, 2008.

[9] Xu X. Spatial distribution dataset of annual vegetation index (NDVI) in China[EB/OL]. Resdc.cn. 2021/2021-11-27.

[10] Baidu. Dust Storm Weather in Beijing[EB/OL]. baike.baidu.com. 2021.

[11] Guo X, Zhou T. Investigation and Analysis of Dust Storm Weather in Beijing in 2000[M]. jz.docin.com, 2013.

[12] Wang YZ, Risk H Y. Assessment of Sandstorm Disaster in Xinjiang[J]. Chinese Desert, 2020, 40(6): 13–21.