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Research and analysis of the ecological environment index of broad-leaved Korean Pine Forest in Changbai mountain

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Abstract. In order to better study and analyze the ecological environment index of the broad-leaved Korean pine forest in Changbai Mountain, 30 sets of data related to the ecological environment index of the broad-leaved Korean pine forest and six influencing factors were collected. The influencing factors, including slope, temperature, humidity, soil erosion, elevation, and pressure, were analyzed for their correlation with the ecological environment index of the broad-leaved Korean pine forest through polynomial fitting. The results indicate that the ecological environment index increases with the increase of slope, temperature, humidity, and pressure, while it decreases with the increase of soil erosion and elevation. Soil erosion has the greatest impact on the variation of the ecological environment index of the broad-leaved Korean pine forest. Additionally, other factors such as slope, temperature, humidity, elevation, and pressure also affect the ecological environment index, thus requiring comprehensive consideration for the formulation of comprehensive ecological protection strategies.

Keywords: Changbai Mountain, Broad-leaved Korean pine forest, Ecological environment index, Polynomial fitting analysis, Environmental influencing factors, Soil erosion

1. Introduction

The ecological environment is an important guarantee for human survival and development. With the accelerated transformation of nature by humans, a series of environmental problems have emerged, making ecological environment protection and green development hot topics [1]. The quality of the ecological environment refers to the health status and sustainable development capacity of ecosystems, which is a comprehensive concept including ecosystem structure and function, ecosystem productivity, ecosystem carrying capacity, and ecosystem resilience [2]. In the high mountainous areas of Changbai Mountain, the broad-leaved Korean pine forest, dominated by broad-leaved trees and Korean pine, has rich biodiversity. This type of forest not only provides habitats for many wild animals but also plays a key role in maintaining the ecological balance of the region. Polynomial fitting analysis is an effective method that can help understand the degree of influence of various factors on the ecological environment index of the broad-leaved Korean pine forest in Changbai Mountain.

2. Data Collection

By reading literature and using Python crawlers, 30 sets of data from the broad-leaved Korean pine forest area in Changbai Mountain were collected, as shown in Table 1.

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Table 1. Data for 30 sets from the broad-leaved Korean pine forest area in Changbai Mountain

ecological environment index (EEI)	Elevation(°)	Temp(℃)	humidity level	soil erosion"t/(km²·a)	altitude (e.g. above street level)(m)	Strains(Pa)
0.7441	18.7	21.7	80%	3347	347	101780
0.1114	20.7	26.6	73%	3619	365	113402
0.732	24.8	25.3	78%	3434	322	101982
0.3148	20.7	23.5	78%	4391	369	119670
0.651	23.6	26.9	76%	3523	334	110760
0.8926	22.7	25.1	86%	3620	352	112195
0.009	20.1	25.5	78%	3395	346	102564
0.0252	19.9	22.8	95%	4061	440	110217
0.4825	19.7	27.5	72%	3330	326	101896
0.9887	22	27.1	74%	4378	434	118065
0.1704	20.9	23.3	73%	3403	326	115751
0.1577	18.8	25.4	75%	3955	319	101337
0.8367	19.6	26.8	79%	4464	347	116816
0.1707	22	23.2	74%	3213	399	104472
0.5947	18.2	25.8	82%	3084	338	121968
0.3993	21.3	23.1	76%	3368	397	106526
0.0908	23.5	25	73%	4122	369	100702
0.0503	18.7	26.5	81%	3423	437	104178
0.8287	20.8	26.7	93%	3571	381	121440
0.3901	22.5	24.9	74%	3352	379	120090
0.4592	22	23.6	90%	3326	395	118585
0.2245	22.4	23.2	72%	4237	300	115683
0.3657	22.8	25.8	88%	3597	392	126547
0.1228	20.1	21.4	91%	3763	342	107919
0.6883	19.3	25.6	87%	4448	421	127304
0.9794	24.4	23	78%	3768	357	129361
0.8252	24.8	21.4	90%	3140	413	123216
0.1219	19.4	23.9	83%	3162	407	100950
0.1739	19.6	22.8	90%	3101	434	118362
0.8292	23.7	27.8	84%	3064	379	102289

3. Polynomial Fitting Analysis of the Ecological Environment Index and Various Influencing Factors

Polynomial function fitting is a common data fitting method that approximates a set of data points with a polynomial function. Usually, in the fitting process, a polynomial function is selected to make it closest to the actual data at the given data points. In practical applications, polynomial function fitting is often used in data analysis, curve fitting, trend prediction, and other fields. Polynomial fitting was performed on the ecological environment index and various influencing factors mentioned above. The results are shown in the following figures:

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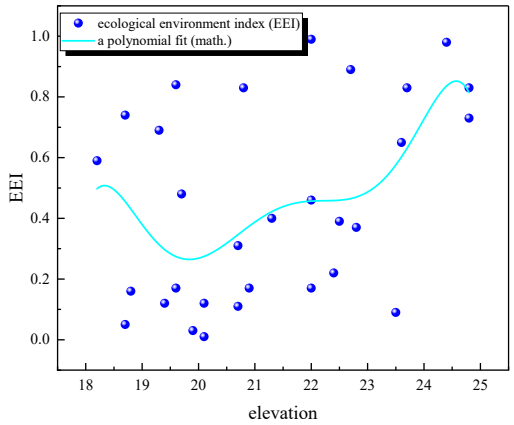

Figure 2. Polynomial fitting results of the ecological environment index and slope

(a) The fitting function of the ecological environment index and slope is as follows:

y=-118987+33729*x^1-3973.2*x^2+248.96*x^3-8.7*x^4+0.16*x^5-0.001*x^6

In the range of slopes from 18° to 25°, the ecological environment index of the broad-leaved Korean pine forest in Changbai Mountain generally shows a fluctuating upward trend, indicating that a moderate slope has a certain positive impact on the ecological environment. However, a low peak appears at a slope of about 20°, which may reflect the influence of some adverse factors on the ecological system of the broad-leaved Korean pine forest in Changbai Mountain at specific slopes, such as soil erosion, water and soil loss, or vegetation coverage issues. With further increase in slope, the ecological environment index gradually increases, possibly because larger slopes facilitate water drainage and soil retention, thereby improving the health status of the ecosystem [3].

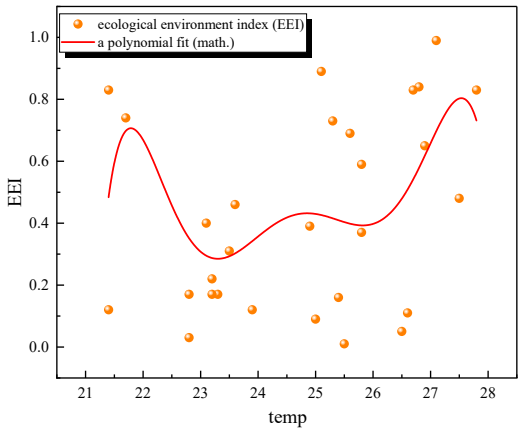

Figure 3. Polynomial fitting results of the ecological environment index and temperature

(b) The fitting function of the ecological environment index and temperature is as follows:

y=-1203020+318537*x^1-35861.7*x^2+2222.8*x^3-81.8*x^4+1.78*x^5-0.02*x^6+1*x^7

The impact of temperature on the ecological environment index shows a relatively small amplitude of change, which is particularly evident in the range of 21°C to 28°C. Two peaks appear around 22°C and 27.5°C, which may reflect the richness of activity and biodiversity of the ecological system of the broad-leaved Korean pine forest in Changbai Mountain at these two temperatures, conducive to maintaining the stability of the ecological environment. Between these temperatures, the ecological environment index shows fluctuating changes, which may be due to the influence of other environmental factors such as humidity and light. Overall, this trend indicates that the health status of the ecological system of the broad-leaved Korean pine forest in Changbai Mountain may be better maintained within a specific temperature range.

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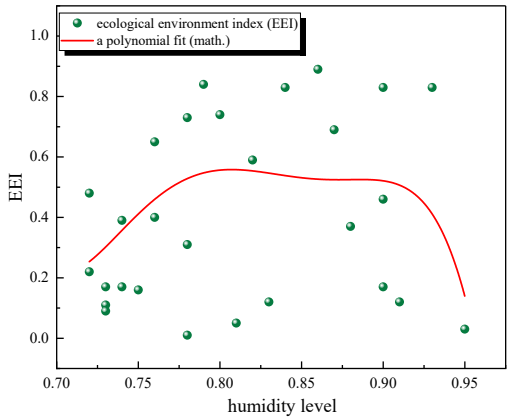

Figure 4. Polynomial fitting results of the ecological environment index and humidity

(c) The fitting function of the ecological environment index and humidity is as follows:

y=8320.5-51478*x^1+127002*x^2-156200*x^3+95788.7*x^4-23435.65*x^5

The impact of humidity on the ecological environment index of the broad-leaved Korean pine forest in Changbai Mountain shows a trend of increasing first and then decreasing, which is relatively stable. In the range of humidity from 70% to 95%, the ecological environment index first increases and then decreases, which may reflect the dual impact of humidity on the ecosystem. Between 80% and 90% humidity, the ecological environment index remains at a relatively high value, which may be because the humidity conditions in this range are conducive to the survival of many organisms and the stability of the ecosystem. In addition, both too low and too high humidity are unfavorable for the ecological environment, which is related to the adaptability of many organisms to humidity. Too low humidity may lead to drought and soil dryness, affecting the growth of vegetation and the stability of the ecosystem in the broad-leaved Korean pine forest, while too high humidity may lead to excessive moisture, causing problems such as waterlogging and insufficient oxygen [4].

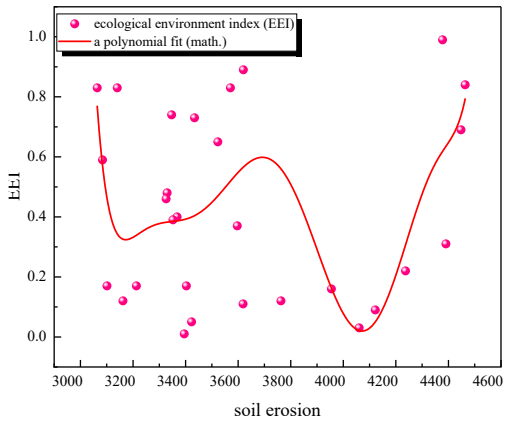

Figure 5. Polynomial fitting results of the ecological environment index and soil erosion

(d) The fitting function of the ecological environment index and soil erosion is as follows:

y=5708913.8-12318*x^1+11.6*x^2-0.006*x^3-2*x^4-4.45*x^5+6*x^6-4.5*x^7+1.5*x^8

The impact of soil erosion on the ecological environment index exhibits a "W" shaped trend, which is a noteworthy finding. When the soil erosion value is around 4100, the ecological environment index reaches a low peak, indicating poor ecological environment index of the broad-leaved Korean pine forest in Changbai Mountain at this point. This may be because soil erosion has reached a certain threshold, leading to ecosystem destruction and loss of biodiversity. When soil erosion is relatively low or high, the stability and functionality of the ecosystem are maintained or restored, thus increasing the ecological

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environment index. Overall, this "W" shaped trend reminds us of the negative impact of soil erosion on the ecological environment and emphasizes the importance of protecting soil and ecosystems.

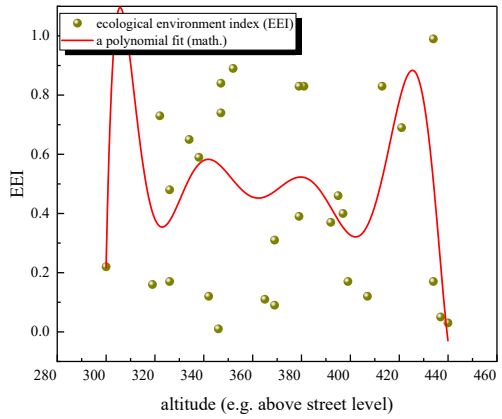

Figure 6. Polynomial fitting results of the ecological environment index and elevation

(e) The fitting function of the ecological environment index and elevation is as follows:

$$y=-1.09+2689367*x^1-29293*x^2+185.7*x^3-0.75*x^4+0.002*x^5-3.67*x^6+4.24*x^7-2.85*x^8+8.5*x^9$$

The ecological environment index exhibits an "M" shaped trend with changes in altitude, with two peaks appearing between altitudes of 280m to 460m, respectively around altitudes of 310m and 430m. This may reflect specific advantages or the highest point of biodiversity of the ecological system of the broad-leaved Korean pine forest in Changbai Mountain within these two height ranges. When the altitude is below 310m or above 430m, the ecological environment index rapidly decreases, possibly due to adverse factors affecting specific ecosystems within these height ranges. Within these ranges, the ecological environment index fluctuates, likely due to the complex interaction of factors such as Changbai Mountain's terrain, soil types, and climate. Overall, this trend indicates that both excessively high and low altitudes have significant impacts on the ecological environment.

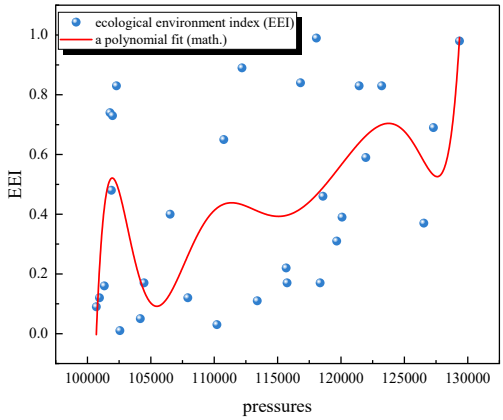

Figure 7. Polynomial fitting results of the ecological environment index and pressure

(f) The fitting function of the ecological environment index and pressure is as follows:

$$y=-1.62+126560*x^1-4*x^2+8.86*x^3-1*x^4+9.95*x^5-6*x^6+2*x^7-4*x^8+4.38*x^9$$

Between pressures of 100000pa and 130000pa, there is an upward trend in the ecological environment index, indicating that an increase in pressure within a certain range may contribute to the improvement of the ecological environment. A peak appears around 102500pa, which may be because the ecological system of the broad-leaved Korean pine forest in Changbai Mountain reaches its optimal state under this pressure. Then, the ecological environment index decreases rapidly, possibly because

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the pressure exceeds the tolerance of the ecological system of the broad-leaved Korean pine forest in Changbai Mountain, leading to environmental deterioration. The intermittent upward trend that follows may reflect the adaptive capacity of the ecosystem to pressure changes or the influence of other factors. Overall, this trend indicates that pressure has complex effects on the ecological environment.

4. Multiple Linear Regression Analysis of the Ecological Environment Index and Six Influencing Factors

Multiple linear regression is a statistical method used to analyze the relationship between multiple independent variables and one dependent variable. It establishes a linear model to predict the value of the dependent variable through the linear combination of multiple independent variables. Performing multiple linear regression analysis on the six factors mentioned above and the ecological environment index of the broad-leaved Korean pine forest in Changbai Mountain, the following function was obtained, where X1 to X6 represent the six influencing factors: slope, temperature, humidity, soil erosion, elevation, and pressure.

$$y=-3.75+0.058x1+0.055x2+0.95x3-8.1x4-0.001x5+1.18x6$$

1. Humidity and pressure have a significant impact on the ecological environment index of the broad-leaved Korean pine forest in Changbai Mountain: Humidity and pressure may be important influencing factors in the ecological environment index. With the increase of humidity and pressure, the ecological environment index also increases, which may reflect the positive effects of humidity and pressure on vegetation growth and soil moisture in the broad-leaved Korean pine forest in Changbai Mountain [5].

2. Soil erosion has the greatest impact on the ecological environment index, indicating that soil erosion may be a major threat to the health of the ecosystem of the broad-leaved Korean pine forest in Changbai Mountain. Soil erosion may lead to problems such as soil quality decline and vegetation destruction, thereby reducing the ecological environment index.

3. Within the scope of the study, the variation of elevation has a relatively small impact on the ecosystem of the broad-leaved Korean pine forest in Changbai Mountain. Elevation may be related to factors such as climate and vegetation distribution, affecting the stability of the ecological environment. This does not mean that elevation has no impact on the ecological environment, but rather that its impact is relatively small compared to other factors [6].

Figure 8 shows the error vibration test, which is relatively stable.

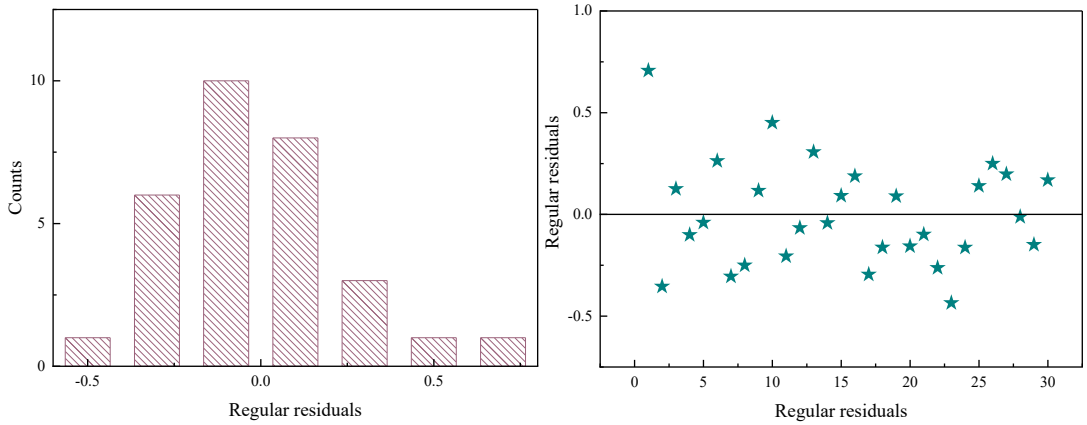

Figure 8. Error verification results

5. Conclusion

By analyzing the relationship between the ecological environment index of the broad-leaved Korean pine forest in Changbai Mountain and the six influencing factors of slope, temperature, humidity, soil erosion, elevation, and pressure through polynomial fitting, it is concluded that the relationship between the ecological environment index of the broad-leaved Korean pine forest in Changbai Mountain and the degree of soil erosion is most closely related. Soil erosion may lead to soil quality decline and water and

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soil loss, thereby indirectly affecting vegetation growth and coverage, and thus indirectly affecting the ecological environment index. Soil erosion may interact with other factors (such as slope, humidity, etc.), exacerbating its impact on the ecological environment index of the broad-leaved Korean pine forest in Changbai Mountain. The broad-leaved Korean pine forest in Changbai Mountain plays an important role in soil conservation, water conservation, climate regulation, and other aspects. Its vegetation cover is of great significance for soil protection and reduction of water and soil loss. The change of the ecological environment index of the broad-leaved Korean pine forest in Changbai Mountain is a complex process influenced by multiple factors, and it is necessary to comprehensively consider the influence of various factors to accurately assess its trend.

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