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Biomass Model of Typical Grassland Area Based on Vegetation Index

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Abstract: Grassland ecosystem is one of the most important and widely distributed ecosystem types in terrestrial ecosystems. Grassland biomass is an important indicator to characterize and evaluate grassland ecosystems. The purpose of this paper is to study a typical grassland biomass model based on vegetation index. Grassland A is used as the research area, the research object is grassland aboveground biomass, and the aboveground biomass data of field measured sampling points are used as modeling data. Based on the NDVI vegetation index, the correlation analysis between RVI and the measured value of above-ground biomass in grasslands, respectively, established a linear model, an exponential model and a quadratic polynomial model. Through SPSS statistical analysis, the accuracy of the model was tested, and the aboveground biomass of remote sensing grassland was inverted using the optimal model. The research results show that the aboveground grassland biomass simulated by the power function model with RVI-Y=102.45x1.35 is basically close to the measured aboveground biomass. The average error of the estimated error/measured value is 6.79%, and the fitting accuracy is 94.6%. Therefore, it is feasible to estimate grassland biomass using an exponential function model based on RVI-above-ground biomass.

1. Introduction

Grassland ecosystem has the functions of regulating climate, ventilation, wind and sand prevention, maintaining soil moisture and fertilizer, reducing soil erosion, and maintaining ecological balance [1]. However, grassland ecosystems are vulnerable to natural and anthropogenic factors and are fragile ecosystems. Therefore, whether to use grassland is the key science and understanding of environmental protection and sustainable development of animal husbandry. Grassland aboveground biomass is an important indicator of ecological concern and environmental assessment. At present, the typical grassland biomass model based on plant index has become a frontier subject of international grassland scientific research [2].

The study of aboveground biomass in grassland has always been one of the research hotspots of scholars at home and abroad. Facioni L uses time series to analyze changes in vascular plant species richness and composition during successional stages and productivity gradients (i.e. increases in carbon stocks). To test for potential differences in regeneration levels, species richness and carbon stock data were analyzed by ANOVA. Mixed model regression analysis was used to assess the effect of carbon stocks on changes in plant species richness and composition. Plant matter was found to vary with development, with newly cultivated grasslands and woodlands having the highest value. Although soil carbon did not differ significantly between succession levels, biomass and soil carbon increased with succession. Plant species richness does not depend on continuous changes in carbon pools (i.e. biomass and soil carbon), whereas plant species composition responds significantly to these changes [3]. Iravani M developed and implemented an innovative approach to regional regeneration and balance of annual ecosystem models. We measured temporal and spatial changes in organic carbon (SOC) stocks and aboveground plant biomass (AGB) production and examined their responses to recent climate changes in several grassland systems in western Alberta, Canada. Incorporating both SOC and AGB in calibration and analysis explained most of the spatial variability in SOC and AGB measurements and reduced model uncertainty for the nine grassland sites. These findings underscore the importance of systematic parameterization and standardization for reliable assessment of carbon-related ES across broad geographic regions with diverse ecological conditions. The simulation results show that the spatial distribution of SOC and AGB in grassland has changed significantly, with associated uncertainties [4]. Shirke V developed a biomass gasification thermodynamic equilibrium model to calculate syngas composition and gas heating value. Solve the model using the "Fsolve" function in MATLAB. Four types of biomass were studied in Punjab, India: wheat straw, hay, straw and rice husk. The total calorific value of the four biomasses at 1073K and oxygen/biomass=0.45 was in the range of 24.0-26.6 kcal/mol. For temperatures of steam/biomass = 0.6 and 1073 K, the GCVs of the four biomasses were in the range of 23.7-25.9 kcal/mol [5]. From this point of view, foreign scholars have a lot of valuable research results in grassland research, especially the use of vegetation index to invert grassland aboveground biomass.

In this paper, the representative grassland area was taken as the research object, the correlation between different vegetation indices and grassland biomass was analyzed, and the linear regression test was carried out on the vegetation index and grassland biomass. It provides a good foundation for the management of grassland resources. On the basis of field research, this paper first establishes an evaluation index system, then interprets the spatial distribution of forest damage through supervision and classification, and simulates the ideal biomass of subalpine grasslands through renewable energy emission analysis. Biomass production evaluation model and final land degradation impact analysis, aiming to provide scientific reference for local management departments to carry out rational land use and ecological protection.

2. Study on Vegetation Index and Biomass Model of Typical Steppe Regions

2.1. Overview of Vegetation Index

The calculation of the vegetation index is based on the visual characteristics of vegetation. The spectral characteristics of vegetation are often affected by a variety of physical factors. Due to different environmental factors such as terrain, soil, atmosphere, area and surface water content, the visual appearance of vegetation is often affected by factors such as vegetation type, vegetation area, chlorophyll content, plant water content, physical properties, and environment. At the same time, the changes of day, night and season also greatly affect the appearance characteristics of vegetation, and the spectral reflectance of vegetation will also change correspondingly with the changes of solar altitude angle, plant biological period and other factors [6-7].

2.2. Commonly Used Vegetation Indices

(1) Difference Vegetation Index DVI

DVI values range from 0 to 1, where 0 represents no vegetation coverage; 1 represents a high degree of vegetation coverage [8-9].

(2) Normalized vegetation index

NDVI is often used to detect vegetation growth status, vegetation area, and eliminate some radiation errors. It is a popular botanical index. The value ranges from -1 to 1, NIR and R are roughly equal, the value better represents vegetation coverage, and the larger the value, the higher the vegetation coverage [10-11].

(3) Ratio Vegetation Index RVI

RVI is an important parameter of green plant sensitivity index and one of the attractive vegetation indicators for plant biomass conversion [12-13].

(4) Soil Adjustment Vegetation Index SAVI

The soil adjustment index is based on the NDVI index, taking into account the soil background factors, therefore, increasing the soil adjustment coefficient L[14-15].

2.3. Establishment of Grassland Aboveground Biomass Model Based on Vegetation Index

(1) Univariate linear model

Use statistical software to generate a scatter plot from the data, add a linear trend line, and fit these scatter points to a straight line to ensure that the sum of the vertical distances from the scatter points to the straight line is the smallest [16-17]. In the establishment of a univariate linear model of grassland aboveground biomass, the measured grassland aboveground biomass is selected as the dependent variable, and the NDVI and RVI of the coordinate points corresponding to the measured value in the remote sensing image are selected as independent variables, and the univariate linear regression equation is:

$$y = kx + b \tag{1}$$

In the formula, y is the estimated value of aboveground biomass in the grassland, x is the NDVI or RVI value, and k and b are parameters.

(2) Exponential model

Exponential model is a kind of curve model and is often used as a model for monitoring grassland aboveground biomass. Similarly, the measured aboveground biomass value of grassland is used as the dependent variable, and the NDVI and RVI of the coordinate points corresponding to the measured value in the remote sensing image are used as independent variables, and the exponential regression equation is:

$$y = be^{kx} \tag{2}$$

In the formula, y is the estimated biomass of grassland above ground, x is the NDVI or RVI value, and k and b are parameters [18].

(3) Quadratic polynomial model

The quadratic polynomial model is also a kind of curve model. This study intends to establish a quadratic polynomial model (one-dimensional quadratic polynomial) to compare the one-variable linear model and the exponential model, in order to establish a higher prediction accuracy model. When constructing a one-variable quadratic regression model, the above-ground biomass of the grassland is regarded as the dependent variable, and the NDVI and RVI corresponding to the coordinate points of the measured values in the remote sensing image are regarded as the independent variables, and the one-variable quadratic equation is:

$$y = zx^2 + bx + c \quad (3)$$

In the formula, y is the estimated value of aboveground biomass of grassland, x is NDVI or RVI, and a, b, and c are parameters.

3. Biomass Model of Typical Grassland Area Based on Vegetation Index

3.1. Data Collection and Verification

Some of the data used in the construction of the biomass model are measured data, and some are based on the data in published journals and master's and doctoral dissertations. There are 160 standard data in total, of which 100 are measured standard data. There are 74 land data, a total of 340 standard wood data, of which the standard wood measured data are all used for the calculation of carbon measurement parameters, and the measured data and collected data are used for the construction of the plantation biomass model. The 60 data of 10 to 20 standard logs constructed by the model are used for the final model verification. In this study, outliers are defined as some data that are too large or too small in a batch of observed data compared with other data with basically the same conditions.

3.2. Modeling Method of Regression Model

Regression analysis is a statistical and technical method that uses the relationship between variables to predict the value, and to measure the accuracy of the prediction or control. Its purpose is to estimate and/or predict the mean (population) of the former based on known or determined values of the latter. This is a mass movement, also known as a mass movement. This paper mainly discusses the effects of different vegetation indices, PRE and TEM on AGB. The selection of vegetation indices, PRE and TEM as independent variables is the key to the establishment of multiple regression models. Mainly follow: (1) The selected independent variables are closely related to AGB; (2) The selected independent variables are independent variables. In this paper, SPSS software is used, and the stepwise regression method is used to establish the model of the MODIS remote sensing data from March to December and the annual meteorological data of 15 grassland types according to the method of multiple regression. The multiple regression models established by using remote sensing data and meteorological data were compared, and a model with better yield estimation effect was obtained.

3.3. Regression Model Accuracy

The root mean square error (RMSEP) of an experimental prediction is the square root of the ratio. RMSEP accurately reflects the amount of error in a set of observations, so it can demonstrate the accuracy of the measurement:

$$RMSEP = \sqrt{\frac{\sum_{i=1}^{n}(y-y')^2}{n}} \tag{4}$$

In the formula, y is the measured grass yield; y' is the grass yield predicted by the regression equation.

4. Analysis and Research of Biomass Model in Steppe Region

4.1. Correlation Analysis

The correlation coefficient indicates how closely the two are related and whether the general situation can be learned from the sample measurement data. The correlation analysis between each vegetation index and the biomass in the grassland area is carried out, and the results are shown in Table 1.

Table 1. Phase coefficients between vegetation indices and aboveground biomass

Vegetation Index	NDVI	RVI	DVI
Correlation coefficient	0.86	0.88	0.87
Vegetation Index	SAVI	MSAVI	PVI
Correlation coefficient	0.83	0.83	0.79

It can be seen from the table that there is a 95% confidence that aboveground biomass is significantly correlated with each vegetation index. Aboveground biomass had the highest correlation with RVI at 0.88, and the lowest correlation with MSAVI at 0.79. There was no significant difference between vegetation index and aboveground biomass.

4.2. Model Establishment

Table 2 lists linear and nonlinear regression models for various vegetation indices and biomass indices. From the linear regression model, the correlation between aboveground biomass and RVI (R2=0.7962) is better than other vegetation indices.

Table 2. Regression model of vegetation index and aboveground biomass

	DVI	GVI	MSAVI	NDVI	PVI	RVI	SAVI
Linear model	0.7472	0.7528	0.6161	0.7374	0.7146	0.7962	0.6842
Quadratic Polynomial Model	0.7698	0.7742	0.7393	0.7935	0.7163	0.7970	0.7544

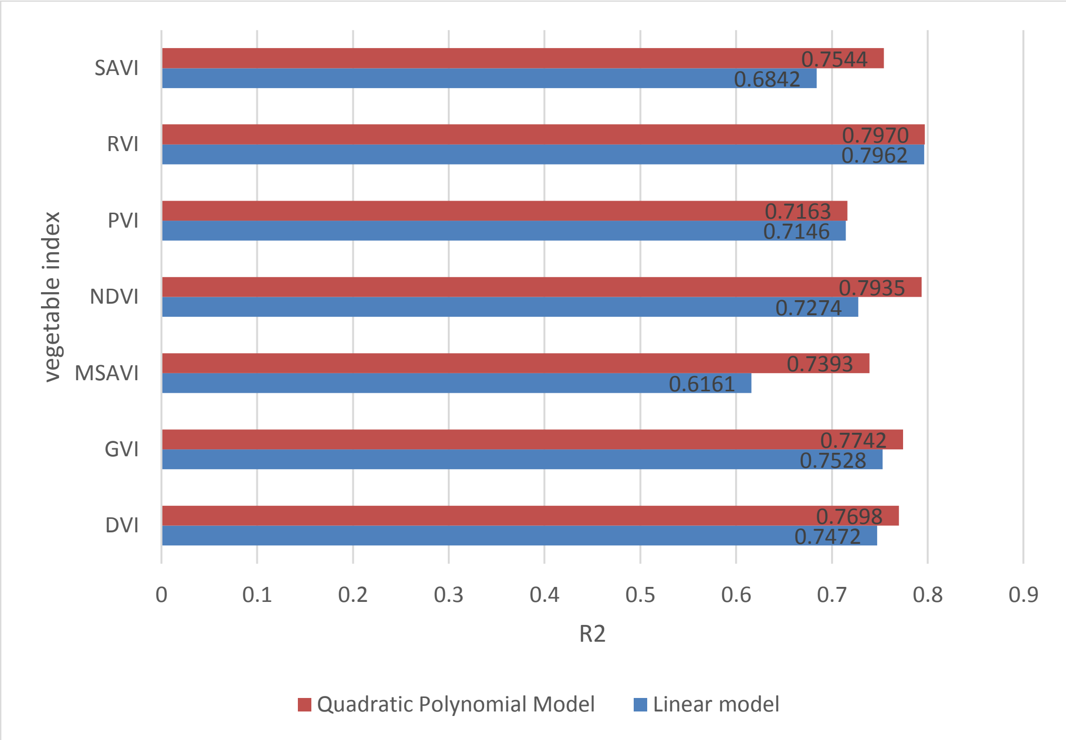

Figure 1. Regression model of vegetation index and aboveground biomass

As shown in Figure 1, overall, the modeling effects of RVI and aboveground biomass are better than the other 6 vegetation indices, the modeling effects of MSAVI, GVI, PVI and aboveground biomass are poor, and the modeling effects of other species are different Not obvious. Some vegetation indices are insensitive to vegetated areas, while RVI is sensitive to that vegetated area.

4.3. Model Validation

In order to evaluate the simulation results of the model, this paper selects the exponential function model of RVI for model verification. Use 10 quadrats not involved in the model to verify the accuracy, the results are shown in Table 3.

Table 3. Power function regression model test based on RVI

Numbering	Measured value(g/m^2)	Predictive value(g/m^2)	Error coefficient(%)
1	541.5	534.6	1.22
2	565.3	611.4	10.44
3	965.7	855.7	12.43
4	616.7	599.7	3.21
5	587.6	543.4	8.55
6	784.6	824.6	4.97
7	507.8	587.6	15.4
8	716.8	725.4	1.54
9	786.4	824.6	4.67
10	548.7	567.9	3.57

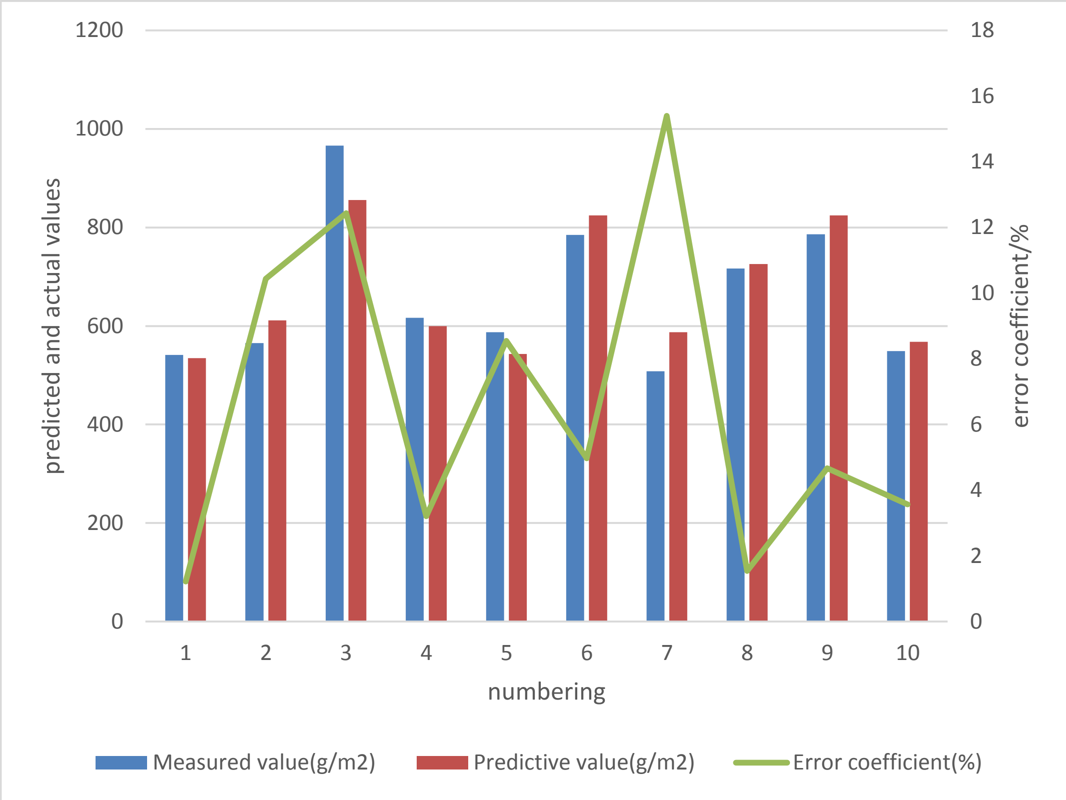

Figure 2. Power function regression model test

The experimental results (Fig. 2) show that the aboveground biomass of grasses simulated by the exponential function model RVI-Y = 102.45x1.35 is close to the measured aboveground biomass and the error coefficient between the predicted value and the actual value. The actual measurement is between 5%. The square of 5.1%~10% has 6 square data, and the square of more than 10.1% has 3 data. The mean error of estimate/standard error was 6.79%, and the accuracy was 94.6%. There is a slight difference between the estimated value and the measured value, which fully shows that the biomass-aerial RVI-based energy function model can be used to estimate the biomass of grassland A.

5. Conclusion

This paper takes 15 types of grassland as the research objects, and takes the geographical location and water and heat conditions of different grassland types as the environmental background. The relationship between thermal factors and data is the entry point. Focusing on the relationship between hydrothermal factors and the above-mentioned grassland biomass and the correlation between data and grassland biomass, we analyze the changing trend of grassland biomass and explain its relationship with the hydrothermal factors. relationship and specify how the data relate to aboveground biomass. Correlation between greenhouse warming factors and aboveground biomass. Relevant research results can not only provide important scientific data for detecting grassland degradation, but also provide scientific data for discussing aboveground biomass estimation of grasslands with similar landforms.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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