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Hyperspectral Remote Sensing Estimation Models of Aboveground Biomass in Gannan Rangelands

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Abstract

Accurate estimates of grass biomass can provide valuable information about the productivity and functioning of rangelands and grassland ecological resource utilizing more reasonable. In order to improve the biomass quantitative analysis with hyperspectral remote sensing data, a field experiment was carried out in Gannan rangelands, Gansu province. To achieve this objective, fresh grass aboveground biomass and hyperspectral canopy reflectance were collected at four types pasture in august 2007. On the base of the analysis of spectral characteristic of four grasslands and correlation between original spectral, hyperspectral feature variables and aboveground biomass of four rest grazing grasslands, the experiment data were classified two groups. One group was used as the training sample to build the regression of models with the one-sample linear method, the nonlinear method and stepwise analysis method, another group was used to the testing sample to predict the precision of regression models. Results show that the regression of quadratic model using RVI provide a better univariate regression involving hyperspectral indices for grass aboveground fresh biomass estimation compared other models in Gannan rangelands, the estimation standard deviation was 0.178（kg/m^2）, In conclusion, the results of this paper indicate that the grassland biomass can be estimated at the canopy level using the hyperspectral reflectance .

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Key words: Gannan rangelands； aboveground biomass； hyperspectral index； Estimation models

1. Introduction

The grassland ecological system is the most important and distributed widely in Land ecosystems[1]. High-cold grassland in Gannan, in northeast of Tibetan Plateau, longitude 100°45′--104°45′E, latitude

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33°6′--35°34′N covers 260.25×104hm2, 75％ of the total area. This is one of the largest grassland ecosystems in the world. Recently, series protection measures were practiced because of rapid land degradation and desertification. Accurate quantitative estimates of biochemical properties of the grassland are important applications of remote sensing for terrestrial ecology [2-3].That Hyperspectral remote sensing. acquiring images in narrow (<10 nm) and continuous spectral bands provides a continuous spectrum for each pixel, Therefore, its data is considered more sensitive to specific variables[4-5].

The object of this study is to use hyperspectral reflectance data and offer the prime basis for the aboveground biomass monitoring and remote sensing estimating model.

2. Materials and experimental method

2.1. metetials

The mainly types in Gannan rangelands is in Tab.1

Tab.1 the spot and type for the grassland in Gannan

Tab.1 the	villages	type	Grass type
Luqu	Bukanggeri	Alpine Meadow	Elymus dahuricus
Luqu	Jiacang	Alpine Meadow	Stipa aliena + Poa sphondylodes
Maqu	Oula	Alpine Meadow	wormwood + Elymus dahuricus
Maqu	Oula	swamp meadow	Carex + Potentilla chinensis

2.2. Spectral and Aboveground Biomass Measurement method

The canopy and leaf spectral reflectance was measured using a portable ASD Field Spec Pro FR2500 spectroradiometer (Analytical Spectral Devices Inc., Boulder, CO, USA) with spectral range from 350 to 2500 nm (1 nm intervals). The spectral resolution was 3, and 10 nm for the ranges 350–1000 and 1000–2500 nm, respectively. The optical sensor of the spectroradiometer was mounted in the frame of a supplemental light source with a 50-mm distance from target leaf surface. The sight angle is 25°.A Spectralon white reference panel was used to optimize the instrument to 100% reflectance at all wavebands prior to canopy reflectance measurements.

The aboveground biomass is measured by an electronic balance after spectral measurement, and it is defined as the mass of all edible grass in the experiment site (kg/m^2).

2.3. hyperspectral Indices and calculationer

There’re three kinds of indices in this study, based on the position of hypespetral variables: Db、 λ b 、Dy、 λ y、Dr、 λ r、Rg、 λ g、Rr and λ o；based on the areas of hypespetral variables: ： SDb、SDy、SDr；and based of the hypespetral vegetation index:：NDVI，RVI，EVI，SAVI，DVI，PVI，NDWI.

Tab.2 the definitions of hyperspectral variables used in this study

Spectral variables	defination
Db	maximum of the first derivative reflectance in Blue edge(490～530nm)
λ b	The position of the Db（nm）

Dy	maximum of the first derivative reflectance in yellow edge (550～582nm)
λ y	The position of the Dy（nm）
Dr	maximum of the first derivative reflectance in red edge(80～780nm)
λ r	The position of the Dr（nm）
Rg	the maximum reference in 510～560nm
λ g	The band position of Rg（nm）
Rr	The minimum reference in 640~680nm
λ_o	he band position of Rr（nm）
SDb	the area of the first derivative reflectance surrounded the blue edge
SDy	the area of the first derivative reflectance surrounded the yellow edge
SDr	the area of the first derivative reflectance surrounded the red edge
NDVI	$NDVI = \frac{R_{nir} - R_{red}}{R_{nir} + R_{red}} = \frac{R850 - R650}{R850 + R650}$
RVI	$RVI = \frac{R_{nir}}{R_{red}} = \frac{R_{850}}{R_{650}}$
PVI	$PVI = \frac{R_{nir} - aR_{red} - b}{\sqrt{(1+a^2)}} = \frac{R_{850} - a \times R_{650} - b}{\sqrt{(1+a^2)}}$ (a=10.489,b=6.604)
SAVI	$SAVI = \frac{R_{nir} - R_{red}}{R_{nir} + R_{red} + L}(1+L)$，L=0.5
EVI	$EVI = 2.5 \times \frac{R_{nir} - R_{red}}{R_{nir} + 6 \times R_{red} - 7.5 \times R_{blue} + 1} = \frac{2.5 \times R_{850} - R_{650}}{R_{850} + 6 \times R_{650} - 7.5 \times R_{450} + 1}$
NDWI	$NDWI = \frac{R_{860} - R_{1240}}{R_{860} + R_{1240}}$
DVI	$DVI = R_{nir} - R_{red} = R_{850} - R_{650}$

3. Results and analysis

3.1. Relativity analysis of the aboveground biomass and hyperspectral indicesi in Gannan grassland

3.1.1. relativity of the original spectral data and aboveground biomass

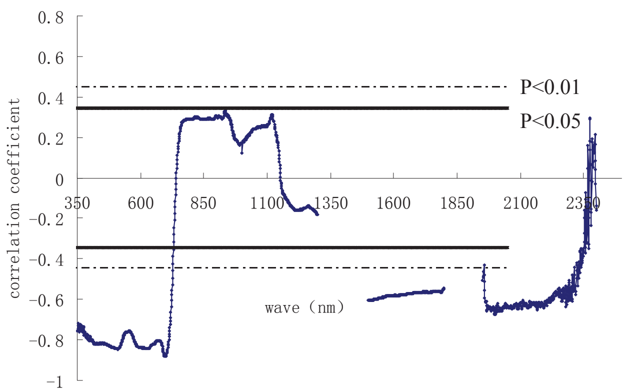

Fig.1 Correlogram of the grassland spectra and the above-ground biomass

From the Fig.1, The value of canopy spectral reflectance(CSR) and the biomass is negative correlation when the band is less than 741nm in visible area(VIS), and the correlation coefficient is extra marked in 350～738nm,and the correlation coefficient is maximum in 699nm (r=-0.882) .and the correlation coefficient is more than zero in 741nm～1155nm, and the correlation coefficient is negative in 1511nm～2340nm, and it pass the test of the extra marked level.

3.1.2. relativity of the hyperspectral Indices and aboveground biomass

From the Tab3, the Correlation coefficient(R) of the hyperspectral Indices and aboveground biomass is greater for Rr， λ_o， all passed the test of $P<0.01$.and the R passed the test of $P<0.05$ for Db，Rg，Dr，λr. in all the variables, the R of RVIand biomass is maximum(R=0.865). The R of the SDb，SDy，λb，λy，λg and the biomass are lesser and they didn't pass the significance test.

Tab3 Correlation coefficient about the above-ground biomass of grassland and hyperspectral variables

areas of hypespetral variables	Correlation coefficient(R)	Position of hypespetral variables	Correlation coefficient(R)
SDb	-0.276	Db	-0.447*
SDy	-0.312	λb	0.290
SDr	0.58**	Dy	-0.588**
hypespetral vegetation indices	Correlation coefficient(R)	λy	-0.025
NDVI	0.786**	Dr	0.454*
RVI	0.865**	λr	0.456*
PVI	0.828**	Rg	-0.459*
DVI	0.46*	λg	0.207
SAVI	0.573**	Rr	-0.636**
EVI	0.689**	λo	-0.621**
NDWI	0.556**		

3.2. Hyperspectral remote sensing estimation model of Gannan grassland aboveground biomass

Select six variables which the R is more than 0.6 and the $P<0.01$ from the tab 3: RVI，PVI，NDVI，EVI，Rr, λo, and build the regression equation of the Gannan grassland aboveground biomass by linear and non-linear regression analysis as following(tab 4):

Tab 4 Linear and non-linear regression equations and the coefficient of determination of estimated measurees between abobe-ground biomass of grassland in Gannan and the hyperspectral variables

Regression equation	fitting value(R^2) (n=18)	F value	Forecast R^2 （n=10）
Y=20.019(RVI)－57.826	0.741	45.798	0.7986
=263.1ln(RVI)－452.54	0.6868	35.06	0.7652
=0.6618(RVI)2+0.0848(RVI)+73.282	0.7567	23.32	0.8049
Y=7353.3(PVI)+4787.1	0.645	29.09	0.7297
=134566(PVI)2+15211(PVI)+57102.1	0.695	17.06	0.7647

Y=1769.5(NDVI)－1278.7	0.6087	24.03	0.7187
=1447Ln(NDVI)+463.66	0.583	22.35	0.7095
=13547(NDVI)2－20806(NDVI)+8082.6	0.707	18.10	0.7842
Y=1323.5(EVI)－357.63	0.447	12.92	0.7499
=557.59Ln(EVI)+688.51	0.432	12.17	0.7362
=3392.1(EVI)2－1643.7(EVI)+277.6	0.457	6.32	0.7603
Y=469.552－8923.671 Rr	0.405	17.024	0.5654
＝－243.42Ln（Rr）－663.17	0.426	18.53	0.6691
=273446 Rr2－24600 Rr+673.71	0.430	9.06	0.7502
Y=－53.55 λo +36289	0.4471	12.94	0.1634
=－36054Ln(λo)+235022	0.4472	12.94	0.1631

From the tab 4, the fitting R^2 of regression equation passed the test of P＝0.01 are RVI，PVI and NDVI, and the Rr is passed the test of P=0.05. The most feasible model is the linear regression equation for RVI as the variables (Fig.2)

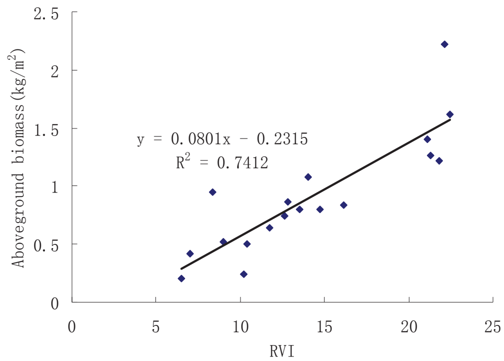

Fig.2 Estimated model of above-ground biomass using RVI

3.3. precision analysis of the Hyperspectral remote sensing estimation model of grassland aboveground biomass

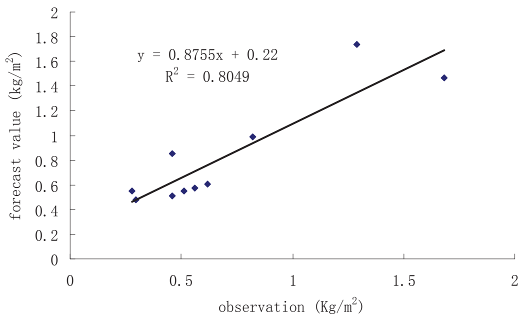

Fig.3 Results of estimation model using the RVI

For another group data, ten samples were used to test precision of the model. And the regression coefficient value for test value and the estimation value is in range 0.1631～0.8049(Tab 4), the average value is 0.6646, and the best estimation equation is best when RVI is as variable, the estimation standard error is 0.178（kg/m^2）.From the fig.3, the fitting results are better when the biomass is smaller, and which is worse when the biomass is bigger, this indicated that this model exists some unsteadiness, and it needs to improve in future.

4. discussion and conclusion

Based on the field experiment, the relationship between the hyperspectral spectral reflectance and aboveground biomass for four kinds of grass types in Gannan rangelands were analyzed, using the parameters of the canopy spectral reflectance absorbed character and the vegetation indices and the biomass analysis by single variable linear and non-linear regression analysis indicated that the biomass estimation model based on the spectral vegetation indices is better than the models b.ased on the spectral position variable, this is mainly caused by the samples time serial, the data in this study is mainly gained in august, this seems to indicate that the spectral vegetation index is suit for some spectral grown stage.

Comparing all the models, the linear regression equation for RVI as single variable, and this index also can be used in broad wave remote sensing .the estimation standard error is 0.178（kg/m^2）.because the covered degree in Gannan grassland is more than 90%, the NDVI is easy to satiation, it ‘s not sensible to the grown difference, this is different to the other conclusions in sparse grassland[6]. And RVI is more suitable in Gannan grassland with high cover degree in late grown stage.

Because of the time and the samples, more samples and long stage experiments is needed in future for more precision of the model.

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