The Production Estimation by Remote Sensing and the Productivity Spacial Patterns of Grassland in Xilingol League of Inner Mongolia, China.

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Abstract

This paper is a part of dynamic monitoring of the grassland resources in the rangeland of China, Made a discussion of the techniques and examples of the grassland production measurement with NOAA-AVHRR data and the concerned models for large area, analysed the Grassland spacial models of the productivity in Xilingol League of Inner Mongolia.

Keywords: Grassland of Inner Mongolia, Production Estimation by Remote sensing, Dynamic Monitoring of Grassland Productivity. Grassland Productivity Models.

Preface

The temperature grassland area is about 3. 5 million KM^2, it is an important livestock base for grazing. As the influence of climatic factors etc. , the grassland productivity shows great fluctuation among seasons and years. While in the drought year, great number of livestocks died lack of forage in Spring and Winter. So, to monitor the balance status between the forage and livestock of rangeland grazing system posses very important significant for macroscopic management and regulate the husbandry livestock.

Under the support from State Commission of Science and Technology and the Ministry of Agriculture of China, from 1991, we begin a research on the methods and technical system of the dynamic monitoring for the forage-livestock balance in the temperature grassland of China. In order to set up the dynamic monitoring system of the rangeland, it is necessary to solve the technical problems for production estimation by remote sensing in large area. We selected the Xilingol League of Inner Mongolia as the sitting area to carry out the experimental test of the production estimation by remote sensing. In this area, the land form is vast and flat, mainly vegetation types are tussock steppes, and it is the typical representatives of the steppe of China. The area of test region reached more than 210 thousands Km^2. The temperature gradually increased from east to west, and the rainfull gradually decreased in this direction. The grassland showed obviously the zonal differentiation, which benefited the comparably analysis of the various grassland types.

Ⅰ. THE INFORMATION SOURCE AND THE RESEARCH METHODS

The remote sensing information mainly use the NOAA-AVHRR data which were provided by the Meteorological Center of Inner Mongolia. The climate data all come from the 22 meteorological station of Xilingol League. The ground data was collected in two times field investigation in August of 1990 and September of 1991. In the investigation, altogather collected for 59 sample sits, the production measurement and the optical spectrum determination were carry out with same pace and same time. The data processing were finished with the IP-9000 Image Processing System and the Olivetti M300 PC.

Ⅱ. THE PRODUCTION ESTIMATION MODEL OF REMOTE SENSING

The AVHRR sensor of the NOAA have two channels. the CH1 (0. 58-0. 68um) and CH2 (0. 72-1. 10um), the former is the absorbing zone of the spectrum of the green vegetation, and the later is the reflecting zone of that. A certain ratio of the data (vegetation index) gained by these two channels can be used as the function of the vegetation coverage or the leaf area index. For the natural grassland. the leaf area index of the vegetation posses the direct ratio with the above-ground biomass. So, we can evaluate the above ground grassland production in terms of vegetation index.

The production-estimation model of remote sensing mainly including the following steps: one is the 1B data collection of which the information trousmmited from the AVHRR sensor of NOAA and were corrected by computer with the projected correction and the solar altitude correction etc. Then, the vegetation index gained by the 1B data collection were rectified of the atmosphere and various types of the mathmatical operation. Finally, the correlation model were set up by the vegetation index and the grassland production measured by the ground invetigation.

In order to avoid the complex calculation, we used a simple method to replace the atmosphere effect correction, that is, in the same time of measuring ground production, determine the ground optical spectrum, find out the quantative relations between the ground optical spectrum and the NOAA-AVHRR spectrum of the same wavelenth, furthermore, setting up the correlation model by corresponding the serveyed ground production with the spectrum data of the meteorological satellite.

1. The correlation model between determined ground spectrum (g_1, g_2) of grassland and the above ground grass production (w):

   $W = -124.876 + 144.165 g_1 \cdots (1)$

   $n = 24,\ r = 0.9858$

   $W = 29.0789 * 2.7183 \exp 4.574 g_2 \cdots (2)$

   $n = 38\ r = 0.9690$

2. The interrelated model between the ground determined spectrum (g_1, g_2) and the NOAA-AVHRR spectrum: (G_1, G_2).

   $G_1 = 3.0581 g_1 - 2.1927 \cdots (3)$ n=31, r=0.9317

   $G_2 = 13.1579 g_1 - 0.6447$ (4) n=18 r=0.9818

3. The interrelated model between the NOAA satellite spectrum (G_1 G_2) and the above ground grass production (W)

   $W = 8.04 + 4.715 G_1$ (g. m) ……………………………… (5)

   $W = 29.0789 * 2.7183 \exp 4.674 G_2$ (g * m) ……………… (6)

We made a calculation with above model (5), and (6), using the Meteorological satellite data on August 13, 1990, the results (the average value) is as the following:

367.382 * 10exp9 kg fresh weight

389.617 * 10exp9 kg fresh weight

On the creteria of the ground investigation, the errors of the results by the model (5) is 1.64%, and 5.21% by the model (6). Therefore, the results derived from the production-estimation model of remote sensing can satisfied the demand of the production assessment.

The production measurement model of remote sensing also exists the defect. One is that it is easy to be influenced by the metoerological factors, and another is that the vegetation index is difficult to be determined in the case the vegetation is sparsed. So in order to set up the operational system it is necessary to assistant with the geograghical model.

Ⅲ. THE GEOGRAPHICAL MODEL OF THE GRASSLAND PRODUCTION ESTIMATION

In view of the facts that the grassland productivity was mainly controled by the regional thermal, water condition, soil condition and its utilization status. So, the grassland production can be looked as the function of these factors.

$W=f(T,P,L,H)$ ······(1)

in the formula, T: temperature, P: pricipitation; L: soil condition H: human utilizational status. For the natural grassland, under the same condition of the climate, L have little changes, and the H can be ignored, so, the formula (1) could be expressed in:

$W=f(T,P)$ ······(2)

Within the testing area, T and P was mainly affected and controled by latitude(λ), longitude (φ) and the altitude(h), first, we calculate the P' (the rainfull in growing season), Tj ($\geqslant 10$℃ accumulated temperature in the growing season):

$P'=f(\lambda,\varphi,h)$ ······(3)

$Tj=f(\lambda,\varphi,h)$ ······(4)

$Tp=f(\lambda,\varphi,h)$ ······(5)

seperately, take the (3),(4),(5) formula into the formula(2), then:

$W=f(P')$ ···(6)

$W=f(P',Tj)$ ···(7)

$W=f(P',Tp)$ ···(8)

On the basis of observation data collected by the 22 meteorological station in the testing area, and selected the other λ φ, h values for 80 sites from the landform map scaled 1 : 500000, we set up the mean distribution model with the trend surface analysis method, the results are:

$P'=f(\lambda,\varphi,h)=-2926.02\lambda+20.58\varphi-11.08\lambda$

$n=38,\ r=0.9437$

$Tj=f(\lambda,\varphi,h)=22077.32-94.26-160.09\varphi-1.83h$

$n=38,\ r=0.9062$

$Tp=f(\lambda,\varphi,h)=346.80\lambda-1.438-\varphi 0.023h$

$n=38,\ r=0.8442$

With the models, we can reckon the P, Tj and Tp value in any point of the whole grassland using the interpolation method. We have sign and read 59 values of λ,φ,h for the field sampling fron thel : 500000 landform map scale, and calculated the values of P', Pj, Tp, then, take these into the formula (6),(7) and (8), the results are as follows:

$W=f(p)=-223.9+2.46p$ (9)

$W=f(P',Tj)=-544.5+2.055P'+0.146Tj$ (10)

$W=f(P,Tp)=443.4+0.738p-12.01Tp$ (11)

Finally, we carry out the works of model-testing and the production calculation, With the landform map scale 1 : 500000 as the base map, pointly draw the isopleth of P, Tj and Tp, and compile and draft the grading map of production, then, according to model (10),(11), and overlay these two types of map, determining the grading boder. In this way, calculate the values of lower, middle and upper of the grassland production for various grades seperately according available utilization area of grassland, and made a comparasion with the ground investigation data (table 1.)

Table 1. The grasland total production of the Xilingol League

(fresh weight, 1 * 10exp7 kg)

estimation model	lower limitation	middle	upper limitation
W=f(P,Tj,Tp)	339.754	449.715	508.096
ground investigation	262.99	370.31	477.64
relative errors (%)	29.2	21.4	6.3

The above geographical production-estimation model reflected the statistical relations between the grassland production and the environmental factors, and the model can be adapted in the condition of difficult to estimate the productionn by remote sensing, e. g., overcasting day or the oversparsed vegetation etc. and can check its results with that by remote sensing production estimation model.

Ⅳ. THE SPACIAL PATTERNS OF THE GRASSLAND PRODUCTIVITY IN THE XILINGOL LEAGUE

on the basis of above-ground biomass given by the production estimation model, we had a discussion on the distribution model, we had a discussion on the distribution pattern of the grassland productivity and ground investigation data in the testing area.

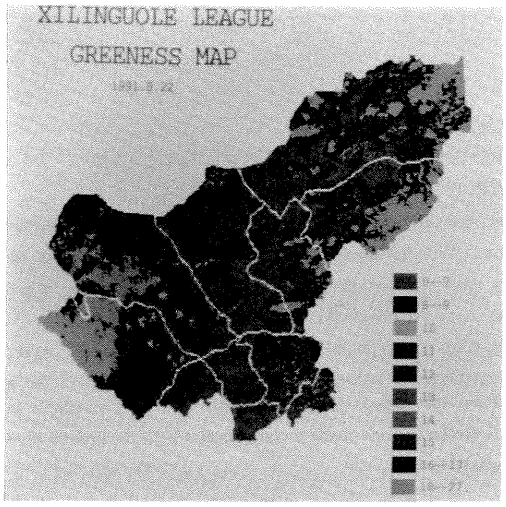

Fig. 2. The grassland greeness map (calculated according to production-estimation model by remote sensing)

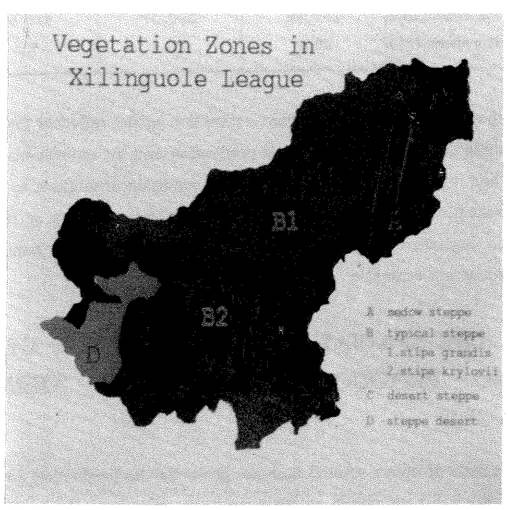

Fig. 3. The grassland vegetation zones map (Calculated according to the ground investigation data)

From Fig. 1 though Fig. 3., We can see that the productivity of grassland decreased from east to west, which response to the patterns of rainfall. The east past is the mountains hills of west-foot hills of DaxinanLing mountains with the precipatation of 350-400mm, the above-ground biomass reached 800 k. g. ha^2, In the west part ,the precipation decreased to 250mm more or less, and the biomass also decreased to 450 kg. ha^{-2}. In term of above alternation, The testing area can be decided into four productivity belts, and the belt pattems fitted with the differentiation of the natural zones.

V. CONCLUDING REMARKS

The production estimation by remote sensing is a basis for setting up the dynamic monitoring system of the grassland. According to the experimental research on the grassland of Xilingol league, it is proved that the above several production estimation models we have provided are feasible, and can reached about 95% of the precision of the production evaluation. In the present, on the base of above works, it is necessary to set up the parameter system for local production estimating in terms of grassland ecological region, enlarge the application area of the production estimation models, and in the same time, set up the utilization model of grassland, so that to calculate the balance status between the grass and livestock.

References

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