A RESEARCH ON THE DYNAMIC MONITORING SYSTEM FOR FORAGE-LIVESTOCK BALANCE IN THE TEMPERATURE GRASSLAND OF CHINA

Li Bo (Porf. GRI, Chinese Academy of Agricultural Sciences, China)
Shi Pei-Jun (Ass. Prof. Beijing Normal University, China)
Lin Xiao-Quan(Ass. Prof. GRI,Chinese Academy of Agricultural Sciences,China)

ABSTRACT

In this paper, some principles and methods for the dynamic monitoring of forage-livestock balance in the grazing system on the temperature grassland of china were discussed, some related models for dyamic monitoring and production estimate by remote sensing, the database and the technical system for dynamic monitoring were designed. In this way, set up a operational system of the dynamic monitoring for the grassland resources in large area, and provide a basis for the rangeland management and the strategic decision.

Keywords: Temperature grassland, Forage-livestock Balance, Productivity Estimate by Remote Sensing, Grassland Dynamic Monitoring System

PREFACE

The temperature rangeland area in China is about 3.5 million KM^2 and is the important basis for the grazing husbandry. In this area, the grassland seasons dynamic obviously. The herbages grow in a manner of " one peak ". The Winter last longer, and the withered period last for more than 6 monthes. As the precipatation variability among years is higher, it makes the grassland primary productivity fluctuation up and down, and the fluctuation range reached more than 15%, or even reached 200% or more in the extremely drought year. With the development of the grassland husbandry, the grazing presure increased more and more. In recent 30 years, the grassland deteriorated in large area, the productivity decreased, and the forage-livestock contradiction get more seriously. While in the year with drought or other disasters, a great number of the livestocks died of lack forage in the Spring and Winter. Therefore, the monitoring of balance status between the forage and livestock in grazing ecosystem is very important to regulate and manage the grassland husbandry on a large scale. With the accumulation of the ground observation data and the development of the remote sensing technique make it possible to realize the monitoring of the rangeland condition in large area. For this reason, under the support of the National Commission of the Science and Technology and the Ministry of Agriculture of P. R. China, we carried out a research on dynamic monitoring of the forage-livestock balance for temperature grassland in northern China, and expect to set up the operational system of the dynamic monitoring of the grassland resources through this research.

I. PRINCIPLE AND METHODS

To prepare the dynamic monitoring system of the forage-livestock balance of grazing rangeland system, the following theoretical bases will be observed in this work.

1. The principle of ecosystem: the rangeland grazing system is a completed ecosystem which was consisted of environment-grass-livestock. The exchange of energe and material each other determined its opening character, that is, it is a kind of dissipation structure; and the exchange of the energe and material among various subsystem determined its self-composition characters. So, it could reserve the substable structure under the status of away from the equilibrium. Various subsystem affected one another and closely related. Therefore, to monitor the whole entirety may be begin from its parts, and in turn,the monitoring for one part may reflect the whole entirety. On the whole, this monitoring system was finished on the basis of a through investigation of the relationship among the environment , plant production and the animal production.

2. The zonal principle: The rangeland ecosystem, influenced by the factors of moisture, thermal and topograph etc.,shows obviously the regularity of zonality,which decides the limitation in the space, popularity within a definite area and the difference of the local parameter for the dynamic monitoring model. In addition to, the rangeland ecosystem also were influenced by the land surface materials, non-zonal factors such as ground water etc.,and the human disturbance, which increse the limitation of the monitoring model and the inevitability in setting up the regional parameter model.

3. The principle of bioperiodiosm and the fluctuation: The grassland environment and the primary productivity posesses obviously the seasonal change regularity. As the yearly fluctuation of the productivity resulted from the climatic fluctuation shows the uniformity in a given area, the continuity with a given time span and the amplified feature of the chained structure of the ecological effect resulted from the fluctuation , which make it possible to set up the dynamic model and to refer to and compare the analytical results. In addition, as the character of non-defined of the status resulted from the mutation and the divergence of the rangeland ecosystem also make the dynamic model posess the limitation in time and the possibility in analysis.

4. The scale effect and hierarchical theory: To monitoring the rangeland ecosystem, an important link is to select the scale. The hierarchical composition is the very scientific concepts of the scale,and the biosphere itself is a ranked entirety with multiple levels, and any one level among various levels may be the attached or independent part to its upper level and may be the entirety to its lower level. So, any local impact to any level can certainly influence the whole. Our monitoring to the rangeland ecosystem is on the macroscopic scale, that is, on the higher grade hierarchical level, but begin from the middle level,adapted the county or banner as the administration unit area and the subecoregion as the natural unit area.

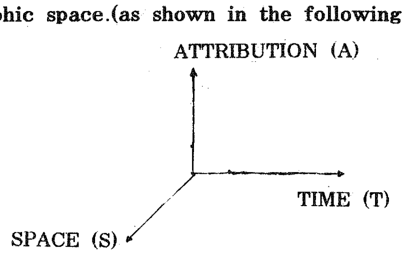
5. Equivalent and complementarity among different factors: In ecology, the surplus of certain factor may remedy the insufficent of another factor, and the

different things may posses the equivalance. In the rangeland monitoring, the amount of the biomass may be expressed by the spectrum value, and as the fog overcasting, any part of surface where lack of spectrum value may be replaced with the geographical model, so, a set of completed data for the same time span in a large area also may be derived.
Under the directions of the above principles, we adapted the technical thread by combining the ground investigation, statistical data and the remote sensing data, combining the geographical model, remote sensing model and the biological moel, and combining the digital output and the image output, and adapted the methods of entirety designing and preparing respectively.

II. THE MONITORING INFORMATION AND THE DATA BASE

1. The information types: This monitoring system is a kind of GIS. Its monitoring information includes three categories: attribute information(statistics information),thematic information and the remote sensing information.
(1). Attribute information: includes climatic data, disaster statistics, livestock husbandry statistical data, ground investigation and the observed data, population and the social and economy statistics data etc.
(2). Thematic information: The thematic information may express the spacial pattern, including the information maps of natural unit and the administration unit, such as landform map, administration regional map, land use map, rangeland-types map, ecological regionalization map etc..
(3). Remote sensing information: The main information sources are the information from NOAA-AVHRR, GMS, FengYun-1 satellite and the Landsat.

2. The Data Structure:The above-information can be divided into historic and real-time information according to the time axle, and these information can be sum up a kind of three-dimision information space by complex the above-information with the geographic space.(as shown in the following FIG.1).



The above information space can be defined as follows:

Time:

$$T = \begin{cases} t+\Delta t \text{ (future)} \\ t \text{ (real time)} \\ t-\Delta t \text{ (historic)} \end{cases}$$

The geographic position: $S = <\lambda, \phi, h>$

λ: logitude

ϕ: latitude

h: altitude

Attribution:

$$A = \prod_{k=1}^{p} <\text{attribution } K, \text{ value types } K>$$

The database structure can be defined as:

$$D = \prod_{i}^{n} \prod_{j}^{m} \prod_{K}^{p} <Ti, <Sj^{(i)}, <\text{attribution}_K^{(i)(j)}, \text{value types}_K^{(i)(j)}>>>$$

The data record can be defined as:

$$R = \prod_{i}^{n} \prod_{j}^{m} \prod_{K}^{p} <\text{value } i, \text{ value}^{(i)} j, \text{ value}^{(i)(j)} k>>>$$

III. THE DYNAMIC MONITORING MODEL

In setting up the dynamic monitoring system of the forage-livestock balance, the model play a very important role. Because the model is the tools for information analysis, and also the basis for setting up operational monitoring system. In this monitoring system, several types of the model are to be used as the following:

1. The geographical model for grassland productivity estimate(climatic model):

$$W = f(P, T, L, H)$$
$$P = f(\lambda, \phi, h)$$
$$Tj = f(\lambda, \phi, h)$$
$$Tp = f(\lambda, \phi, h)$$

Where, W : above-ground biomass
P : rainfull during the growing seasons
Tj: accumulation temperature ($\geq 10^\circ C$) during the growing seasons
Tp: the sum of month mean temperature during the growing seasons
λ: latitude
ϕ: logitude
h: altitude
L: soil status
H: man management level

When given the soil status (L) and the man management levels (H), then:

$$Wj = f(P, Tj)$$
$$Wp = f(P, Tp)$$

2. The optical model for grassland productivity estimate (remote sensing model)

Ground determination:

$$gi = fi(ch1, ch2)$$
$$Wg = fi(gi)$$

Where: i=1,2, two kinds of calculating model.
ch1: the channel 1 of the ground determinating optical spectrum
ch2: the channel 2 of the ground determinating optical spectrum
gi: vegetation index of the optical spectrum of the ground determinated according to the ith calculating model.
Wg: ground investigation grassland production

The corresponding model of the remote sensing optical spectrum:

$$Gi = f(gi)$$

Where, Gi: vegetation index of satellite remote sensing according to the ith calculating model

The production-estimate model of remote sensing:

$$Ws = fi(Gi)$$

Where: Ws is the grassland production by remote sensing according to the ith calculating model.

The model test: using the statistical-test methods, $P<0.05$.

3. The comprehensive model of the grassland production estimate

The geographical model, as a reflection of mean status of the grassland productivity, could not sufficiently express the influences of non-zonal factors, and the remote sensing model is easy to be influenecd by the meteological factor, plant life-form and the vegetation coverage etc. While combine these two aspects, the precision of production estimate can be lifted, and conform to the demand for setting up the operational dynamic monitoring system. The comprehensive assessing model can be expressed in the following concept equation:

$$P = a\,Wg + a\,Ws$$

Where: a and a are weighted coefficient.

4. The grassland utilization model

In order to calculate the balance between forage and livestock, it needs to reckon the available part of the grassland biomass, which were different in terms of livestock types, grassland types and the utilization seasons. The model concepts can be expressed in equation:

$$U = f(Si, Ai, Wi, U\,(max))$$

Where U: The utilization ratio by j animal to i type of grassland in the given time.

gi: area of i type of grassland.

Aj: number of j animal.

t: season or time .

Wi: aboe-ground biomass of i grassland in the given time.

U (max): maxmum utilization ratio of j animal to i type grassland.

5. Model of balance between forage and livestock

$$B = f\,(\,W, R, t\,) - (\,U, A, t\,)$$

Where, B: balance between forage and livestock

W: grass production

R: regrowth intensity of the herbages

U: utilization amount of the herbage by herbivore

A: number of the herbivores

t: time

6. the complex calculating model of the multiple information

The model-chains mould in the processing of the multiple information

7. System management and the control pattern

(1) operation commands system
(2) system dynamic monitoring
(3) system modelling
(4) the correction of the variables and the parameter

8. System intelligent model

(1) auto-distinguishing expert system
(2) the grassland environment quality and suitability evaluating expert system
(3) the grassland water and soil conservation expert system

IV. THE TECHNICAL SYSTEM OF THE DYNAMIC MONITORING

The structure of the monitoring system of forage-livestock balance for the temperature grassand is as Fig. 2.

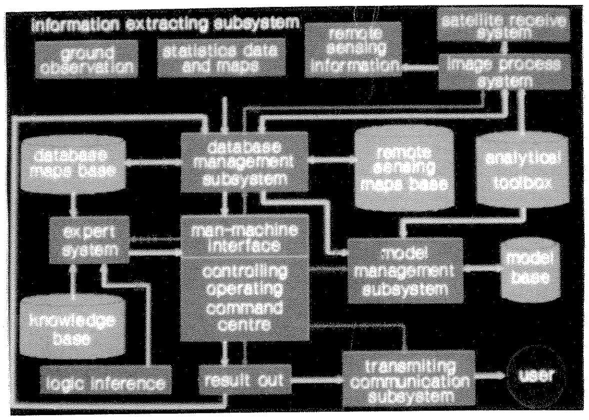


Fig.2 The technical system of the dynamic monitoring

In this structure diagram, the fat fold line represents the command flow, the thin line represents the data flow. The square fram represents the functioning models and the buffer-shaped represets the database or analytical tool box.

1. The command control center

The system operation was controled and operated by the command center. it determined the commands flow for the goal analysis according to the received tasks, and realize the operation and control for various subsystem, and in the same time, undertake the task of monitoring, recording and revising for the system operation status. It was realized by adapting the man-machine dialogue medium with sensitively and conveniently and the computer network system.

2. The information extracting subsystem: In terms of sources, forms and extracting method, the information can be divided into three parts:

(1). The information of ground monitoring: The ground monitoring include meteological observation, phenological observation, productivity assessment, ecological environment monitoring (land sandification, deterioration, water and soil erosion, moisture change etc.), resources utilization status monitoring, disasters monitoring etc..

(2). Statistical data and the thematic map: The thematic map mainly includes: administration regionalization map, grassland types map, ecological regionalization map, landuse map, landform map etc.

The statistical data mainly includes: agriculture statistical data (production facilities, livestock structure and numbers), the social and economy statistical data, disasters statistical data etc..

(3) Remote sensing information

Including the meteriological satellite receiving system and the Image processing system. The image processing system receive the original spectrum information from the satellite receiving system according to the operation commands and demands from the command center, and extracting the necessary analysis method from the analytical tool box, and if necessary, check the required attribute information by the database management subsystem, and process and calculate the original spectrum information, sort out the corresponding remote sensing information and pass them to the database managemant subsystem.

3. Information management subsystem

The main task of the information management subsystem is to pack the information into the database fram which have been designed according to given data mould structure, and form the database with uniformity record format. On the other hand, to pack the remote sensing information into the remote sensing mapbox in the form of phaseposition, and attribute, as the style of documents. In addition, the information management subsystem can provide the operation of look, check, delete, edit, update and usual calculation etc. for the records and map with multiple forms (including logistic form), and can sensitively alternate the calculation for the attribute and image.

4. The information processing subsystem: its task is to pocess the information by the machanical operation model or the intelligent model according to the management aims, and get the results used for the management departments or other users, and pass the information to the information transmission subsystem after sorting, in the same time, save to the database. In this process, the aims was given by users. Untill now, the system can provide three analytical aims:(1) The grassland productivity estimate, (2) The evaluation on the forage-livestock balance of the grazing rangeland system.(3) The grassland disasters estimation.

The information processing can be divided into two methods:

(1). The mechanical model processing method:

According to the analytical goals, the model management subsystem transfer concerned analytical model from the database adopted by the model management subsystem and by the concerned analytical tools. In addition to setting up the models, the model management subsystem carry out the managements according to the proviously types and diffinations of the models and provide the operations of check, look, delete,edit,update etc. for the models. The model box can not only provide analysis models for the digital calculation, but also provide the logistic modelling models of the non-digital calculation for the changing borders and changing parameters.

(2). The intelligent analytical processing methods: These mainly composed of various expert systems, e.g. the self-distinguishing expert system of the grassland types, the estimating expert system for the grassland environment quality suitability, the grassland water and soil conservation expert system etc. The intelligent model assists the analysis in order to solve some problems which concerned multiple factors, complex relationships and which is with sophisticated entirety or comprehension and of which it is difficult to process better with other analytical means.

5. The information communication and transmission

After sorting, the goal analytical results were transmissioned to management or strategic departments or other users according to given formats (maps, texts, tables etc.) by means of micro-weave communication facilities (fax, telegram etc.) or the satellite communication technology.

V. SUMMARY

The above technical system and the models, after testing on the typical area of Inner Mongolia rangeland, proved to be feasible. Using the NOAA-AVHRR data, the precision for the grassland production estimate can reached more than 95%. So, setting up the dynamic monitoring system of the rangeland resources for large area, can fully satisfied the demand of the grassland macroscopic management.

REFERENCES

Li Bo et al.1990.The Steppe of China, Science Press

T. F. Allen and Starr T. B. 1982. Hierarchy: Perspectives for Ecological Complexity. Univ. of Chicago Press, pp. 310

Chen Shu-Peng, 1990. Remote Sensing Monitoring and Forecasting of The Natural Environment Vicissitudes. Remote Sensing Utilization. The Exploration of The Geography, Vol. 3. pp. 124-129. Science Press

Xu Guan-Hua et al. 1988. The Expert System for Distinguishing Remote Sensing Image, Remote Sensing Research on the Regrowth Resources, Science Press, pp. 38-47.