BUILDING A NEW SYSTEM OF FOREST INWENTORY

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ABSTRACT

Satellite data has been used over 20 years. Chinese forestry scientists have taken great effort for application of satellite data. In order to establish a new system of forest inventory, the preparing of technology have been done. They are as following (1) Estimating stock volume of forest using quantitative value and qualitative factory of satellite data. (2) Estimating especially forestland, including fragments woodland and forest network index of area etc. (3) Estimating inventory factory of stand by remote sensing not satisfied the needs of the rule in forest inventory, should be approach another method, that is combine satellite data with else information recourse. (4) The method has been spread over 7 million-hectare in China.
All of work mentioned in this paper is special achievements of Chinese forestry experts.
The existing problem: the method should be bringing into forest inventory rules, and building a new forest inventory system in China as soon as possible.

1 Background

China is a less forest country. Its coverage is 13.94% and its forest stock volume is 100 hundred millions m^3, which is 120^{th} in the world. However forest quality is so bad that volume per hectare is only 75 m^3. And the useful resources are very limited. These don't match with Chinese economy developing trend and level of people living, so state has already begun to protect natural forests and stopped cutting current natural forests. Because of forest being reduced we must clear ourselves family property at any time, and find a quick and inexpensive surveying way. Forestry resources workers always seek it for many years.

As a great developing country, China has wide markets in space remote sensing techniques. The reason is that space remote sensing data's macroscopic and inexpensive are superior to other information sources.

Here we will mainly introduce application of space remote sensing in forestry, especially innovating on current survey system of forest resources, and Building a new system of forest.

2 Forest volume estimation

Forestry resources mainly include area and stock volume. Researching for ten years or so we have already realized the obvious advantage of space remote sensing data in estimating all kinds of land area, moreover many geologists are setting up the work. Forest stock volume estimation is a very difficult problem, but only forestry scientists have researched it for many years. Chinese forestry science and technology personnel realize it and set about researching the methods of space data estimating volume at the beginning of 1980s.

2.1 Method outline

Now we are ready to introduce the method that began to research and use since 1981, it's main progress using space (satellite also named in this paper) remote sensing data to estimate forest stock volume.

2.1.1 Conception. We build up a multivariate regression equation in order to estimate stock volume with satellite data, its independent variable is mixed matrix including quantitative and qualitative factors, the dependent variable is stock volume of certain area (plots). The equation is:

$$y=a+a_1x_1+a_2x_2+\ldots+a_nx_n \quad (1)$$

Quantitative factors are gray values of each waveband image relating to position of plot which is surveyed from satellite images. Qualitative factors include color and tree species groups, which are gained by satellite photo interpretation.

2.1.2 Precision test. Except characteristics mentioned above, people will certainly stress its precision. If the method hasn't enough precision, the characteristics will not be useful. Based on the experiment result to a certain county lying north of China in 1982, its precision of volume estimation is 85.93%.

2.1.3Characteristics of the method. The method is simple. It can enough use satellite data for stock volume estimation. Meanwhile it can also enhance dependence of stock volume estimation at part regions. It is able to decrease fieldwork and increase indoor work.

2.2 Applicability of the method

From 1982 to1995 people have researched the applicability in subtropical forest and tropical forest, the precision above is basically able to be get to. Following will list correlation coefficient **r** of multivariate regression equation to different area.

Experiment area	Temperate(Hebei)	Subtropics (Guangdong)	Tropic(Yunnan)
Re-correlation coefficient of volume multivariate estimation	r=0.73	r=0.83	r=0.60
Re-correlation coefficient of different watershed equation	r=0.84	don't	don't

Table 1. Repeated correlation coefficient r table

The results above indicate that the method can exactly express stock volume and have wide applicability at different forest regions.

2.3 Experiment on production

In order to test the method's applicability we carried out applied experiments for production at two forestry bureaus having about 0.6 million hectares of Inner Mongolia province forest regions in1995. The result is that forest bureaus' estimation precision get to 96% and forest farm is about 85%.

Chinese forest resources surveying is divided three kinds.
The first is helpful to master state forest resources increasing and decreasing. The second is helpful to draw up forest management plans. The third is helpful to assess productive commercial timber quantity of forestland cut. Results show that the method may enough up to the needs of the first investigation and basically up to the needs of the second investigation in forest bureau and forest farm.

2.4 Method efficiency assessment

If a method gains high precision with high cost or low precision with low cost, we will not want it. So we define the concept of efficiency, that is, comprehensive assessing a method by precision and cost. We did three stock volume estimation experiments with different remote sensing data in a certain county lying

Temperate Zone. They estimated stock volume by air-photo and plot, multivariate regression equation as well 2-stage sampling with satellite data and air-photo. Three methods mentioned above were same quantity of plot and operated at the same time, so they were comparable each other, for example ,if we use K to express efficiency parameter(K= precision / cost), efficiencies of three methods above are 10.51%□34.16% and 10.40% respectively . It indicates that satellite data estimating stock volume is an efficient method. In fact satellite data to survey forest resources can save cost from 1/3 (old air-photo) to 1/2(new air-photo).

3 BRIEF INTRODUCTION OF RESEARCHES ON RESOURCE FIELDS

3.1 Canopy density estimating of tropical forest

In tropical forest it is almost unable to classify tree species with satellite remote sensing data, and we mainly consider canopy density of forest stand in forest management. Investigation tradition of canopy density is low precision and tedious work. Chinese forestry scientific research personnel recommend a method of macroscopic estimating tropical forest canopy density with satellite data estimating stock volume as well the relationship between stock volume and canopy density. For example, tropical forest in Yunnan province has a relationship between canopy density and volume estimation.

It is

$$y = 0.608 - 0.614e^{-0.1x} \qquad (2)$$

Here **y** is canopy density estimation, and **x** is stock volume estimation with remote sensing.

3.2 Area estimation

As mentioned above, area estimation is an advantage of satellite remote sensing data, and geologists have already researched it for many times. For recent years forestry personnel have mainly researched estimation of special area in forestry field. They are such as double sampling estimation for forest net area in farmland, and unequal probability 2-stage sampling for area of tree around residential area, as well estimating for all kind area with non-mapping sampling and application of correction methods.

3.3 Forest dynamic mapping

Chinese forestry personnel early proponed the forest dynamic maps and made it. They expressed space variations of forest coverage with two periods satellite images, including forest land not destroyed□forest land increasing□forest land destroyed and brushwood.

Work above based on state key project “Comprehensive inventory of remote sensing in three north protection forest”, international cooperation project “ Tropical forest assessment in south China” and award project “Research in forest resources remote sensing surveying”.

4 PROSPECT AND PROBLEM

4.1 Prospect

Looking back the course of forestry remote sensing developing for 20 years in China, it is not only successful but also very difficult.

The advent of satellite data has brought promise and hope to remove the currently bewilder of resulting from backward technology or lack of funds in forest inventory.

(1) In this information age, the instant report of forest information is the demand of times and production. It is obvious that the long cycle of information acquiring based on aerial photograph or topographic map cannot meet the requirement any more. So building of a new system, which is based on space remote sensing information and makes full use of computer technology and mathematical models, is imperative. Space information source makes it unparalleled due to the temporal resolution of 16 days (or even shorter).

(2) Low cost is the effective impetus to generalizing application of satellite data, which makes it possible for the general application by public producing units. As is stated earlier, the cost of space data is only one tenth

of aerial photographs. Space data will come into full use in forest inventory with the overcoming of problems in technology and in norms. Some production units in China's northeast and southwest have applied it. The method has been spread over 7 million-hectare in China.

(3) The research in the application of space data in forestry in the past 10-plus years shows that wherever aerial photographs are used in forest management inventory, for example, division and sketching on-the-spot, searching ground objects, and map completing, they can be replaced by space data.

(4) As stated above, demand and feasibility are combining to set the basis for the general application of space data with its powerful vigor. The setting off of an industrialized revolution of forest inventory is only a matter of time.

4.2 Problem and Tasks

The application of remote sensing should divided into three levels:

(1) The aspects giving play to its advantages such as the area, forest transition interpret; mapping and Check on spot should be fully utilized. At the same time of strengthening research, the application of the satellite data should been brought into laws and regulations (at least the more matured part in practical use should be included). The laws and regulations is a mirror of the developing stages of various sciences and technologies, which should have the burning trace of age and comprise the new technology at that time.

(2) The part such as the estimation of stock need to be tested should be experimented according to the different region.

(3) The part that can't yet content with the demands of productivity such as the estimation about the inventory factors of the forest stand needs to search the complementary ways of the conventional methods. A kind of information resource can't content with the all kinds of need of the forest inventory, its necessary role in the inventory system should be played, meanwhile its inadequate noticed. So the interface problem of studying the matching use with other information system is the question that can't be looked down upon for constituting the practicable inventory system.

(4) The technical preparation for information sharing

The situations reflected according to the eleventh world forest conference (It was convened in ANTALYA Turkey 1997), the remote sensing technology has been served as the main way of obtaining the information source of forest resource inventory in most countries in the world. But the patterns of various countries have great difference and the criterions (such as classification system) are also not same, which will result in the information losing comparability and influencing information sharing. The international community has already noticed this. For example, the initiated Montreal proceeding, and Helsinki proceeding is the effort of

heading to this direction. We should notice the international tendency, place ourselves in the large environment of international, and often keep connection with the international community like FAO. During 1992 to 1997, the item titled establishing the national forest resource monitoring system executed by UNDP

was a very good trial of this respect, which was coordinated with international in the method of classification and system.

Only the progress was made in this aspect, the sharing information, the comparability of data, the convenience of statistics and application may come true.

(5) On the arriving of the new century, there is going to be more new information coming out. The assessment and application of the new information sources is the problem faced with us. But the more important work is to study the fusion technology of information. With the diversification of the information source, the people always hope to integrate the advantages of various information source, but not simple composition. This is undoubtedly a very significant work. The research on such thing has already been carried out by internal scholar through trial integration of the wavelet transformation coefficient and the theory of Markov random process, the noise interference was avoided effectively and the better result was reached.

Reviewing the progress of the forest remote sensing in China during last 20 years in 20th century, we think the development that is substantial. Although there are quite a few problems needed to solve, the developing perspective is full of hope. On getting into the gate of the 21st century we should know that there are too many work waiting for us to finish.

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