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LAND-COVER SURVEY IN NORTHEAST CHINA USING REMOTE SENSING AND GIS

Huang Tieqing(黄铁青)　　Liu Zhaoli(刘兆礼)
Pan Yuchun(潘瑜春)　Zhang Yangzhen(张养贞)
Changchun Institute of Geography, the Chinese Academy of Sciences, Changchun 130021, *P. R. China*

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ABSTRACT: In order to the quickly update land-cover information and improve the survey accuracy, the land-covers of northeast China were manually interpreted and mapped by using over 60 Land sat Thematic Mapped (TM) images and other information sources, then the interpreted land-cover maps were digitally entered into computers to form GIS. Under the GIS circumstances, the data were processed and calculated to draw out the area. Meanwhile, area proportion of small objects were estimated by means of sampling, this improved the survey accuracy.

KEY WORDS: remote sensing, GIS, land-cover, northeast China

I. INTRODUCTION

With the rapid development of national economy and the growth of the population since the 1990s, there comes new demands for exploiting and utilizing resources and environment. In order to assure the sustainable development of resources and environment and the scientific policy-making of exploitation and utilization of resources and environment, it is necessary to grasp the situation and dynamical change of national resources and environment timely and accurately, among which the land resources (especially the cultivated land) are particularly important.

Several land-cover surveys were carried out, which covered the whole northeast China or part of it in the last 40 years. However, these surveys were accomplished mainly by conventional survey methods, so it took much manpower, money and time. This survey of the land-cover of northeast China was done by using aerial RS(remote sensing), GIS(geographical information system) and other advanced techniques, which is different from conventional methods.

One of the characteristics of this survey is high-speed and new. We can complete macro-surveying of resources and environment of the whole region every two years. We use the latest 1990s' satellite information which make the land-cover map and data match the time. And we

use the means of proportion sampling to solve the losses of small objects in the procedure of interpretation.

The land-cover survey in Northeast China is part of the Macro-Surveying Resources and Environment of China (MSREC). In this article, we only studied the utilization of RS and GIS in the process and the result.

II. SURVEY AREA AND FEATURES OF RS IMAGES

The survey area lies in northeast China, approximately between 39°N and 53°N, 119°E and 135°E, including Heilongjiang, Jilin and Liaoning provinces, with more than 790 000 km^2. This area is abundant in natural resources, and is one of the relatively developed areas. There are complex geographical units, the following are the main parts: 1) the north part of the Da Hinggan Mountains in the northwest, covered mainly by deciduous coniferous forest, 2) Xiao Hinggan Mountains in the north and the Changbai Mountains in the south, covered mainly with mixed evergreen coniferous and deciduous broadleaf forest, 3) Sanjiang Plain in the northeast, covered mainly with grassland and cultivated land, 4) Songnen Plain in the central and west, covered mainly with cultivated land and grassland, and 5) the Liaohe Plain in the south, covered mainly with cultivated land, and reed swamps which distribute in the southern Liaohe River mouth.

The features of RS images changed with farming season and phenophase of the area. The land is covered with thick snow in winter, which make land-cover unable to be interpreted, for this area is in the mid-altitude. The land in the southern area is not covered with snow, due to their similiar tones, objects can not be interpreted on the image. In summer, crops and natural vegetation are growing luxuriantly, so their tones are similar and the objects have little difference, this makes it difficult to be interpreted. Only in spring and autumn seasons, the times of planting, emerging, and ripening of different crops are not in the same step. Meanwhile, withering and loom of natural vegetation's are staggered early or late. All these make images easier to be interpreted. From May to June, the green forest and bush, irrigated paddy field, planted dry lands, and the shelter-forest net work appears red tone on TM images, all these are striking. Between the end of August and the beginning of October, crops are ripe, gathered in, while natural vegetation is withering and turns yellow from north to south gradually. So the images of land-cover are different not only in tones but also in geometric shapes. Residential area is characterized by broken line border, which reflects artificial building traces, furthermore, the tone of building materials appear green and gray, which is distinct from the dry land in dark red tone. Grassland and woodland have irregular border, and different tones. Forest land appears red and looks like fine hair, while brush and shrub appear red and distribute in low mountains, river valley, other forest land appear dark red. High-density and medium-density grassland appear yellow and red, yellow and green, light yellow and green respectively. Grassland in valley looks like trees. Saline-alkali land appears white, like concentric rings around

lakes and pools. On the background of black water, marshland appears red spots, which are the vegetation in the marshland. In a word, the features of RS images are the instantaneous records of object's spectrum reflection. If we well know the farming calendar and the growing law of major vegetation, and select suitable time as the basis for interpretation, we can obtain reliable result.

III. DATA SOURCES

1. Main Data

Over 60 Landsat Thematic mapped images, covering the whole northeast China, were selected to be the main data in this survey, for TM images have higher spatial resolution and were obtained from ground satellite station. According to the farming calendar, the best time of images for interpretation is between May and June or in September, furthermore, the weather is clear and cloudless. The best data for land-cover classification is using TM bands 2 (0.53–0.61 μm), 3(0.62 – 0.69 μm) and 4 (0.78– 0.90 μm) to make conventional false color composite images.

2. Other RS Data

Other higher resolution data are used for interpretation or for auxiliary data in the area where there are no TM images or we cannot collect the TM images, such as MSS, Land-Satellite Data. Meanwhile, we correct aerial photographs to estimate the area proportion of small objects (smaller than 2 mm^2 on 1:250 000 TM images).

All these data were radiometrically and geometrically corrected, and transformed into the Gause-klüger projection by CSGS. Gray levels were normally extended and photographic images were output at scale 1:250 000.

3. Topographical Maps

Most recent available 1:250 000 topographical maps, covering the whole area, were collected and used to produce blue mylar base maps at the same scale, then we used them to position, interpretimages and compile land-cover classification maps.

4. Auxiliary Data

Auxiliary data include existing thematic maps of land use, soil or vegetation, statistical data, and so on, we used them to help identify land-cover classification.

IV. METHODS FOR INTERPRETING RS IMAGES AND GIS TECHNIQUE

1. Interpretation and Mapping

A transparent mylar, on which place name had been written and map border had been drawn, was positioned and fixed on the corresponding satellite image with the aid of the corresponding blue base map. Based on the color, shape, size, texture, pattern, position and other features on the images, an experienced interpreter identified land-cover categories on the image, then drew the boundaries and wrote their codes with a pencil onto the transparent mylar overlay to generate a draft polygon map. Using the same way, we generated draft arc maps which show the important linear objects.

Auxiliary data were used to help identify objects where any object could not identify for sure. Sometimes, field investigations were conducted in order to identify objects certainly.

Any draft map was checked and corrected by an expert, then input to computer for processing by GIS.

2. Small Objects Areas Proportions Estimation.

Because the spatial resolution of the TM images was 30 m by 30 m, small objects (smaller than 2 mm^2 on map) were omitted while interpreting. So the area proportions of small objects to any dominant class were estimated for improving the survey accuracy by means of sampling. Some areas with different characters, which represented different typical regions respectively, were sampled. Any area proportion of each surrounded class to each dominant class was measured and calculated based on higher resolution satellite images or aerial photographs. The calculation formula was:

$$P_{ij} = A_j / A_i$$

where A_i = the total area of the dominant class i on a map,

A_j = the total area of the small object class j encompassed in the dominant class i on the map,

P_{ij} = the area proportion of the small object class j to class i.

Any map sampled had a matrix of P_{ij} which represent the all area proportion's of those areas similar to the sampled typical area in land-cover pattern(Liu, 1995).

3. Data Input and Processing

The hardware that employed for the work mainly includes one AST 486, one DEC486 microcomputer, one scanner, and two digitizers. The main software was PC ARC/INFO(3.4D). PC ARC/INFO(3.4D) provides relatively completed graphics handling and auxiliary data managing functions for area's calculation and data output.

All interpreted land-cover maps and data of provincial and county boundaries were digitally entered into a database. The arcs of complex maps were scanned to produce raster data, then the raster data were vectored to generate vector data. The vector polygon data of one map and the corresponding category codes, entered with a digitizer, forming a coverage in the database. Any simple map was digitized with a digitizer and formed a coverage. Further processing was made in the GIS.

The area proportions of mall objects to dominant classes were keyboarded into the database.

4. Area Calculation

The total area of any land-cover category in any region could be easily calculated by map joining, map overlaying, area rectifying based on corresponding area proportions of small objects, area summing, etc. in the GIS. In order to improve the automatic degree of the calculation, many programs were written in SML or C.

V. REGIONAL LAND RESOURCES AND ENVIRONMENT FEATURE

1. Regional Land Resources

The total area of northeast China is 791 073 km^2, accounting for 8.3 percent of the total area of our country, and Liaoning, Jilin, Heilongjiang provinces account for 18.67, 24.11, 57.22 percent of this area respectively. According to classification system, among the first level classes (according land resources and land use properties), the proportion of cultivated land and woodland are the highest, while water body and unused land are the lowest (Table 1).

Table 1 The area of each land-cover in northeastern China(km^2)

Province	Total	Cultivated land	Woodland	Grassland	Water body	Building land	Unused land
Liaoning	147668	54262	57595	4617	7621	19708	2065
Jilin	190743	60204	91140	14786	6889	7275	10449
Heilongjiang	452662	135217	213668	47879	7906	19501	28491
Total	791073	249683	362403	69082	22416	46484	41005

Statistic data show that Heilongjiang Province has the biggest area of cultivated land, woodland and grassland, and they account for 54.16%, 58.96%, 69.31% of each type of land-cover area of the northeast China respectively. Then the second is Jilin Province, which amounts for 24.11 percent, 25.15 percent, 21.40 percent. Liaoning amounts for the rest.

The main type of cultivated land is dry land in this area. Among woodland, the area of

forest that canopy density is more than 30 percent is the biggest. Most of the grassland is high-cover grassland (cover degree is more than 50 percent) (Table 2, Table 3, Table 4).

Table 2 Cultivated land area and its components

Province	Cultivated land		Paddy field		Dry farm land	
	Area(km^2)	%	Area(km^2)	%	Area(km^2)	%
Liaoning	54262	100.00	11880	21.89	42381	78.11
Jilin	60204	100.00	7370	12.24	52834	87.76
Heilongjiang	135217	100.00	937.5	6.93	125842	93.07
Total	249682	100.00	28625	11.46	221057	88.54

Table 3 Woodland area and its components

Province	Woodland		Forest		Shrub		Others	
	Area(km^2)	%	Area(km^2)	%	Area(km^2)	%	Area(km^2)	%
Liaoning	57595	100.00	49366	85.71	1668	2.91	6561	11.93
Jilin	91140	100.00	73757	80.93	7545	8.28	9838	10.79
Heilongjiang	213668	100.00	175059	81.93	9461	4.43	29148	13.64
Total	362403	100.00	298182	82.28	18574	5.15	45547	12.57

Table 4 Grassland area and its components

Province	Grass Land		High-density		Medium-density		Low-density	
	Area(km^2)	%	Area(km^2)	%	Area(km^2)	%	Area(km^2)	%
Liaoning	6417	100.00	2085	32.50	4010	62.49	322	5.02
Jilin	14786	100.00	9582	64.80	3935	26.62	1269	8.58
Heilongjiang	47879	100.00	40949	85.53	4906	10.25	2024	4.23
Total	69082	100.00	52616	76.16	12851	18.60	3615	5.23

The cultivated land in Liaoning Province has higher proportion to its total area. Its building land proportion is higher than that of Jilin and Heilongjiang provinces. These show that Liaoning Province has a longer exploitation history, and has been effected more intensively by human activities. In Jilin and HeilongJiang provinces, woodland has higher proportion to their total area, which is the resources superiority attributed by superior regional features and favorable natural conditions. Grassland accounts for the highest proportion both in Heilongjiang and Jilin provinces.

2. Environment Features of Land Resources

Land-resources have distinctive regional difference, effected greatly by natural, social and

economic conditions. Each kind of land resources has its own features.

Cultivated land is distributed mainly in the plain, tableland and hilly land, with an area of 222 403 km^2, which accounts for 89 percent of the cultivated land of this area. Most cultivated land is characterized by flat terrain, fertile soil, (especially black earth and chernozen earth with high organic matter contents). A small amount of cultivated land scatters in mountains, valley, sloping fields, with an area of 27 280 km^2. It is suitable for annual crops, for this area lies in temperate, warm, moist and semi-moist climate zone.

Woodland is distributed intensively in medium-undulating, low-undulating mountains, hilly land and part of tableland, accounting for 91.7 percent of the woodland area. In plain area, the main woodland is the shelter forest and other artificial forest, and its area is about 30 000 km^2. Northeastern China is rich in forest resource, the biggest wood product area. From north to south, there distribute bright coniferous forest, dark coniferous forest, coniferous broadleaf mixed forest, deciduous broadleaf forest.

Grassland is distributed mainly in the plains in the central and western parts and the Sanjiang Plain covering an area of 53 110 km^2. About 11 453 km^2 grassland scatters over mountains. Because of the different regional conditions, there are some differences in distribution. The grassland area of Heilongjiang and Jilin provinces accounts for more than 90 percent of the total grassland of northeast China.

Building land includes mainly residential area, industrial and mineral land, which spread along the railways, roads and plains. The land for settlement has increased greatly in the past few years.

VI. CONCLUSION

Land-cover survey in a large area using RS and GIS technique needs less manpower, money and time than using conventional methods. Manual interpretation of TM image takes more manpower and time than computer classification, but it is more accurate than computer classification. The survey accuracy was improved greatly by estimating and using the area proportions of small objects. The accuracy of classification was over 95 percent. The land resources data stored in the GIS provides a base for further researching the dynamics of the land-cover change in northeast China.

REFERENCES

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