# LAND COVER CLASSIFICATION RESEARCH AT SCALE OF 1:50000 IN SANJIANGYUAN STUDY AREA BASED ON SPOT-5 IMAGES

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**ABSTRACT:**

1:50000 land cover classification and mapping program is an important part of the mapping project in western China, which is organized by *Chinese State Bureau of Surveying and Mapping Organization* and will finish 5032 maps at scale of 1:50000 until 2010. With an average altitude of 4400 m, Sanjiangyuan mapping district is located at the center of the Qinghai-Tibet Plateau. Because of complicated terrain and inconvenient traffic, field reconnaissance is difficult. Obviously, land mapping in Sanjiangyuan district is suitable for high-resolution remote sensing image and field survey. Therefore, it is essential to choose typical area and carry out the 1:50000 land cover classification study. At first, the original SPOT-5 images are corrected as high-precision ortho-rectification images, which are fused as 2.5 m resolution multispectral image; Secondly, the fused image is interpreted and the draft of 1:50000 land cover classification map is mapped by using computer software; Then, field surveys are carried out according to the draft; Finally, 1:50000 land cover thematic map is mapped over the repeated examination and revision, which are based on the field surveys combining with other related data in study area. The objective of the 1:50000 land cover classification experiment in the Sanjiangyuan study area is to establish typical interpretation sample image sets and provide necessary remote sensing classification guidance and technical support for a large area of Sanjiangyuan mapping district. Based on the sample images and field surveys conducted by the sample images, the identified sampling image sets are promoted to the entire Sanjiangyuan mapping district. According to *Western Land Cover Classification System*, the experiment establishes 106 representative sample images of 23 typical land cover types and interprets 266 plots based on SPOT-5 image in the area of a 1:50000 map. Especially, the smallest plot in the map is 1 mm$^2$; the corresponding plot on the reality ground is 10000 m$^2$, as much as the size of a football field. Through several experiments in Sanjiangyuan mapping district, the results show that the land cover classification map can achieve 80% overall classification accuracy. This has greatly narrowed the field survey time and workload, which is especially important to western mapping project in the extreme hard conditions. By experimenting in the typical Sanjiangyuan study areas, the results show it is feasible that using SPOT-5 remote sensing images and a spot of field surveys to implement 1:50000 land cover classification and mapping.

## 1. INTRODUCTION

Because of the constraints of historical surveying technology and bad weather, complicated terrain in Western of China, there is 2000 000 km$^2$ land without topographic map at scale of 1:50000 (Wang, 2004). On April 27, 2006, the western mapping project is launched by Chinese State Bureau of Surveying and Mapping Organization. In order to meet the needs of sustainable development in Western China, the western mapping project will finish not only topographic map but also the land cover map. Therefore, 1:50000 land cover classification and mapping project is a significant work in the western mapping project, which will finish 5032 maps at scale of 1:50000 until 2010. Land cover is a synthesis of various factors covered by natural substances and artificial structures on the surface of earth, including vegetation, glacier, water and all kinds of buildings (Turner et al., 1995; Zuo et al., 1990; Li et al., 1996). Aimed to reflect the features and actuality of land cover in district, land cover classification and mapping will show important research value for the study of the natural resources distribution, vegetation and climate change, land-use variance.

Moreover, it also helps to provide scientific data for global change, biodiversity and rational development of the western resources (Anderson et al., 1976; IGBP, 2001; Bartholome et al., 2002). Therefore, it is essential to choose typical area and carry out the 1:50000 land cover classification research.

## 2. STUDY AREA

### 2.1 Location Overview

With an average altitude of 4400 m and 120,000 km2 total area, Sanjiangyuan mapping district is located between east longitude 92°45′ and 93°, and between the north latitude 34°50′ and 35°. In the north and west of the district, lying flat, longer glacial period and impeded drainage cause large area of marsh and bottomland. In the Southeastern, it is mainly made up of alpine and valley resulting from the steep terrain, more than 1000 m relative elevation difference and most 30 degree gradient. High elevation, strong solar radiation, low air pressure, high cold and lack of oxygen bring about the unique ecosystem and landscape

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features in the Sanjiangyuan mapping district with plenty of natural landscape, such as mountains, valleys, basins, desert, jokul, glaciers, rivers, lakes, marshes, steppe and meadow.

In this paper, Sanjiangyuan study area is chosen at the center of Sanjiangyuan mapping district, just with the size of a 1:50000 map. Its location is between east longitude 92°45′ and 93°, and between north latitude 34°50′ and 35°, which has the typical

land cover characteristics of Sanjiangyuan mapping district. The ETM images of Sanjiangyuan mapping district in September 2003 are showed as follows (the left is the Sanjiangyuan mapping district and the right is the Sanjiangyuan study area, both of which are combined from the fourth, the third and the second band of ETM):
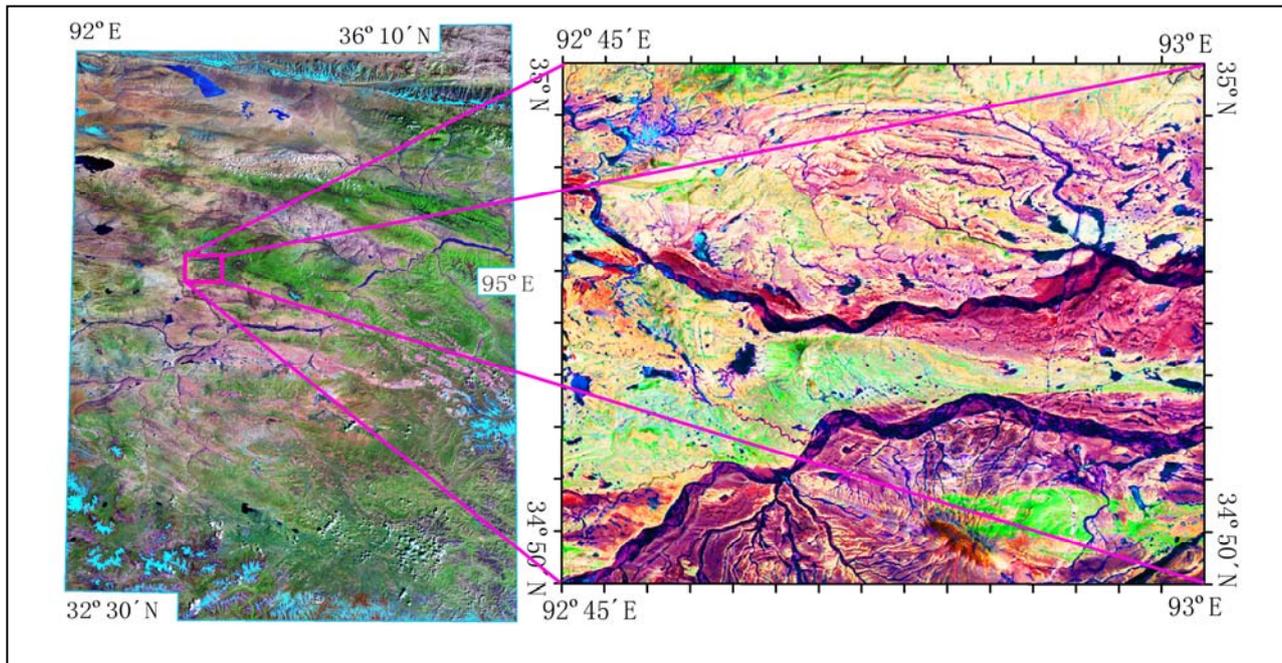


Figure1. The location sketch of Sanjiangyuan study area in Sanjiangyuan mapping district

## 2.2 Ecological Environment

Sanjiangyuan mapping district belongs to the plateau continental climate zone, which is a typical alpine ecosystem with high altitude, strong solar radiation, low air pressure, high cold and lack of oxygen. In recent decades, due to the combined effects of the irrational human activities and drought climate, the Sanjiangyuan region has shown many ecological and environmental problems, such as deglaciation, rivers and lake drying up, wetland area reduction, environmental degradation of the permafrost and surface vegetation, soil erosion and land desertification and so on. According to statistics from meteorological department, the average temperature in Sanjiangyuan region increases by 0.25 ℃ in every 10 years, the annual rainfall reduces by 2.81 mm and the evaporation rises by 5.8 mm per 10 years (Fan et al., 2004; Wang et al., 2001; Wang et al., 2004; Wang et al., 2006). As a result, the deterioration of ecological environment has direct impact on regional economic and social sustainable development, which also has brought a variety of adverse effects on ecological environment of the middle and lower reaches of the Yangtze River, Yellow River and Lancang River. Therefore, as a hot issue, the climate change in Sanjiangyuan region and its impacts on ecological environment have attracted world's attention (Li et al., 2006; Huang et al., 2006; Wang et al., 2006; Xu et al., 2007; Zheng et al., 2005). The researches from many scholars show that 90% grassland in Sanjiangyuan region has varying degrees of degradation, which has 1.246 7×107 hm² moderately degraded

grassland area, accounting for 64.7% total available grassland area (Zhang, 2008; Liu et al., 2005). Further statistics show that the growth height of alpine meadow in the 1990s depressed by 30% to 50% and the average yield declined by 20% to 60% than the 1980s' only in Qinghai province (Qin, 2003). Many studies show that the ecological environment in Sanjiangyuan region is friable, so it is critical to consider the ecological functions for land cover classification and mapping (European Commission, 2000; Mander et al., 2007).

## 3. CLASSIFICATION METHODS

### 3.1 Data Source

The research chooses SPOT-5 images as the main source of data and merged the red (Red), near infrared (NIR) and short wave infrared (SWIR) band image with panchromatic image into fusion image. Because these bands are more sensitivity to water, snow, vegetation and land, so this combination has more superiority in the researches of land use and land cover. The spectral reflectances of different SPOT-5 image bands for snow, vegetation, sand and water are shown in the following figure:
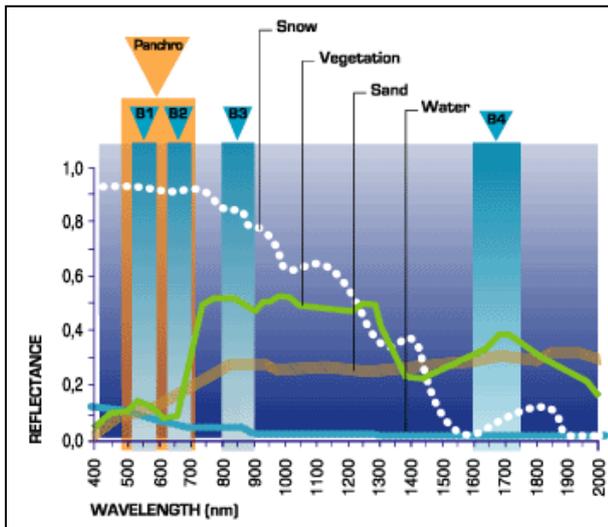
Figure 2. Different bands reflectance of SPOT-5

Generally, when the area of minimal element is less than 2.54 $mm^2$, it can not be displayed by category map in land cover classification (György et al., 2004). According to the mapping requirements at scale of 1:50000 and Land Cover Classification System in the mapping project of western China, 4 $mm^2$ is the minimal mapping precision for water, and $16mm^2$ for other land cover features. In other words, the ground area resolutions are respectively 40000 $m^2$ and 10000 $m^2$ at scale of 1:50000 land cover map. Actually, the SPOT-5 image adjusted by high precision control points can achieve 15 m for plane accuracy and 10 m for elevation accuracy (Beijing SPOT Image limited Company, 2008). Consequently, the SPOT-5 images are suitable for the production of 1:50 000 scale land cover map.

| Band | Spectral Range (μm) | Resolution (m) |
|------|---------------------|----------------|
| Pan | 0.48-0.71 | 2.5 or 5 |
| Green | 0.50-0.59 | 10 |
| Red | 0.61-0.68 | 10 |
| NIR | 0.78-0.89 | 10 |
| SWIR | 1.58-1.75 | 20 |

Table 1. Parameters list of different SPOT-5 bands

### 3.2 Data Processing

The research merges the 2.5m panchromatic image with 10 m multi-spectral images into 2.5 m fusion images, which choose the green, red and near red infrared bands to combine false images. Because every color space has 256 gray levels, the false

image assembled from blue, green and red tricolor has several millions of different color. Each color in the false images will correspond to one or more limited type of land cover features on the ground. This is useful for different season to use different gray level to reflect some of the heterogeneity of land cover. For example, the water is blue or blue-green, and the meadow is red or dark red in the false colour images.

Based on SPOT-5 images and multi-information, the main steps of land cover classification include data preparation, image interpretation, data inspection and mapping. The entire flow chart is shown as follows.
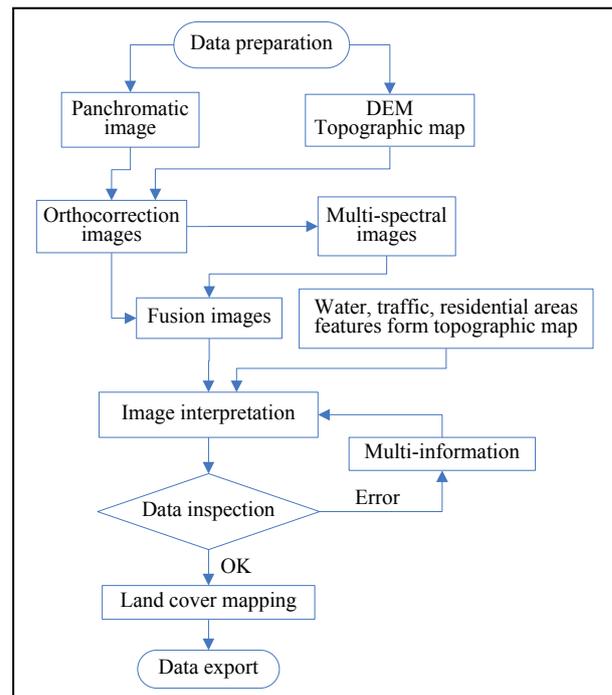


Figure 3. Land cover classifying flow chart

### 3.3 Classification Data

In addition to the SPOT-5 images, Beijing-1 and ETM images are useful for the feature inspection based on multi-images. When land cover type is changeable as the season, more referenced data is greatly important to land cover classification. Usually, topographic map, land use, vegetation data and grassland resources map in recent period are served as the auxiliary data. Furthermore, climate data is significant for the classification of forests and grassland, such as temperature and rainfall. The SPOT-5 false color image merged by panchromatic and multi-spectral images in Sanjiangyuan study area is illuminated as follows:
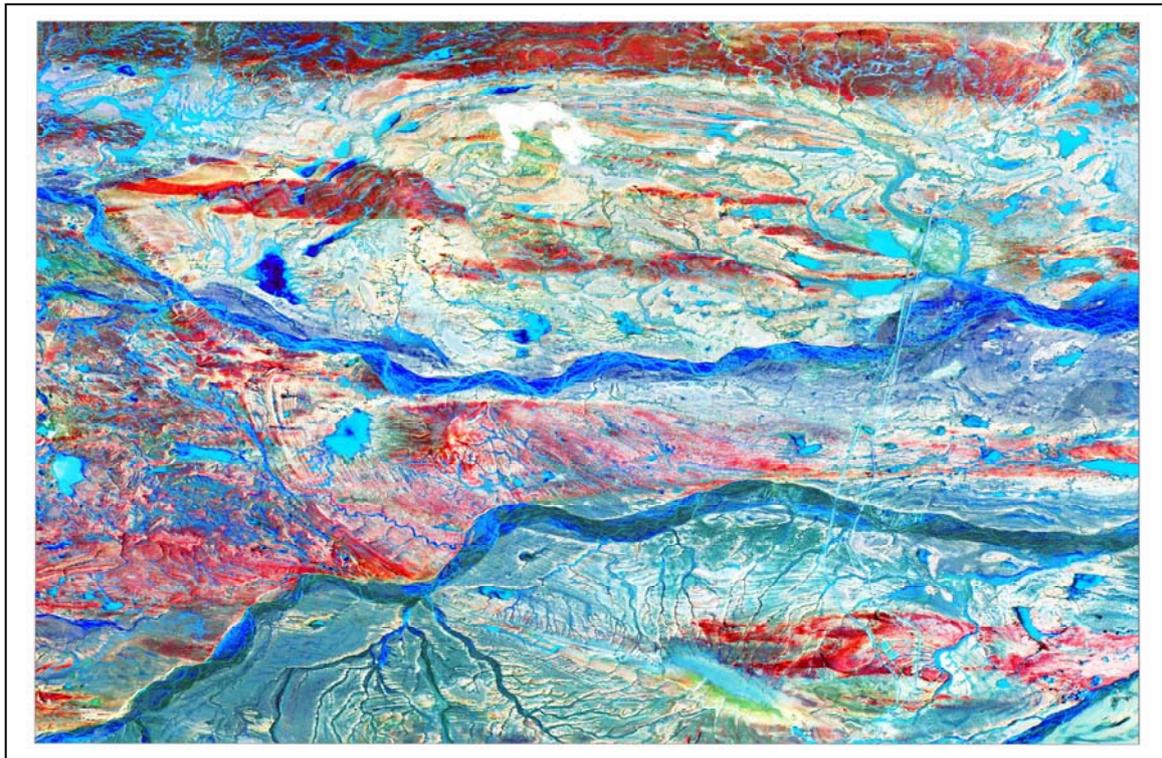
Figure 4. SPOT-5 false color image in Sanjiangyuan study area

## 3.4 Classification Results

According to the method described above and land cover classification system requirements in the mapping project of western China, Sanjiangyuan study area is classified and mapped for 1:50 000 land cover classification as follows:
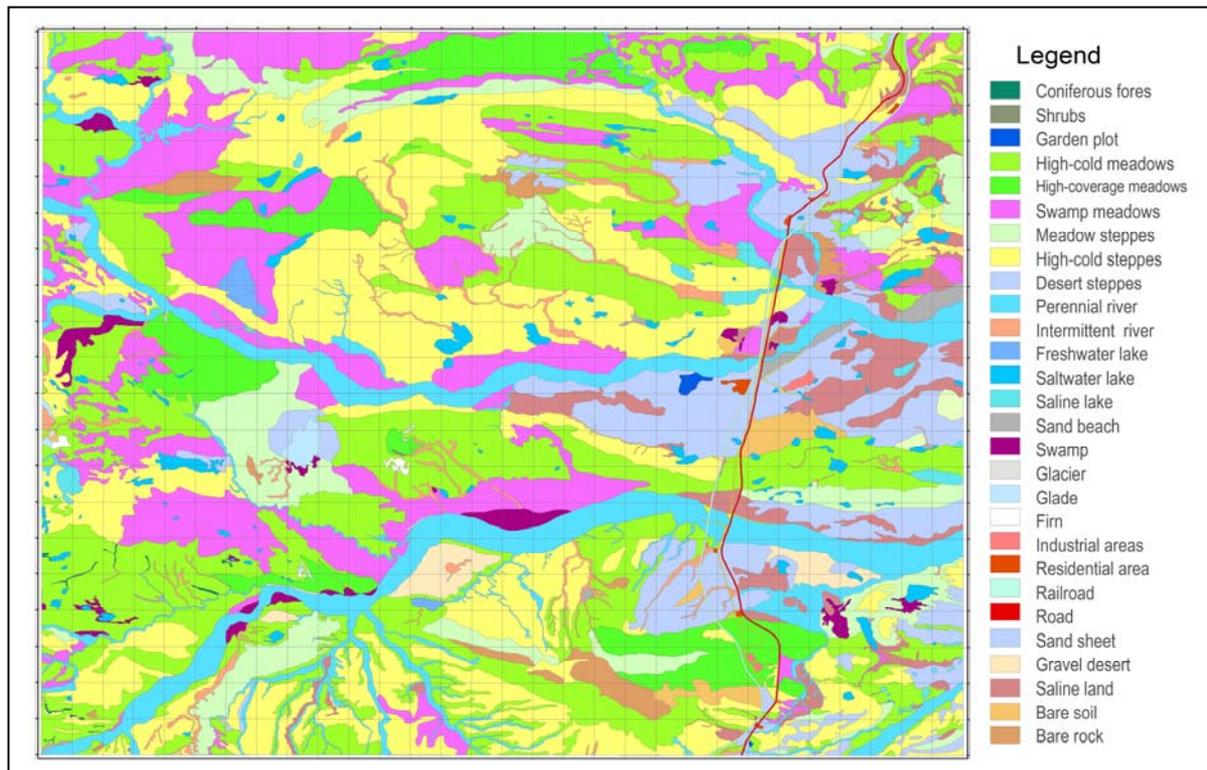


Figure 5. Land cover classification map in Sanjiangyuan study area

### 3.5 Accuracy Evaluation

When we discuss classification accuracy of land cover classification data in Sanjiangyuan study area, we adopt a test method which has been used in land classification (Zhang, 2006). Firstly, we assume that the Classification accuracy is divided into grades 1 to 6, which denotes the area ratio between the land cover scope in the map and the actual range of the check plot. In other words, the grades 0 predicates that some land cover types are totally wrong; the grades 1 to 4 explain that the area validity is respectively 20% to 80%; and the grade 5 shows that the land cover classification area is absolutely correct. For example, one plot in the map is classified as pasture,

but there is 20% forest on the interior the pasture. In this case, we can consider the plot accuracy of grassland is 80%.

Generally, we can select 15 to 40 check plots in a 1:50 000 land cover map. In this paper, in order to ensure the classification accuracy and requirements of remote sensing interpretation, we randomly choose 266 points for spot check, all of which are evenly distributed in the land cover map of Sanjiangyuan study area. Meanwhile, the reference data corresponding to the check points are chosen from field surveys, aerial images and other high resolution data in the recent period. According to the check method described above, the classification accuracy by spot check in the Sanjiangyuan study area is analyzed as the below table:

| Land Cover Classification | Check Number | Plot Number of Different Grades | | | | | | Accuracy (%) |
|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | |
| Coniferous Forest | 3 | — | 1 | — | — | — | 2 | 73.3 |
| Shrubs | 9 | 1 | — | — | 1 | 1 | 6 | 82.2 |
| Garden Plot | 5 | — | — | 1 | — | 1 | 3 | 84.0 |
| High-cold Meadows | 36 | — | 1 | 2 | 3 | 5 | 25 | 88.3 |
| High-cold Steppes | 27 | 1 | 1 | 1 | 2 | 5 | 17 | 84.4 |
| Swamp Meadows | 16 | — | — | 1 | 1 | 6 | 8 | 86.3 |
| Meadow Steppes | 7 | — | — | 1 | 1 | 2 | 3 | 80.0 |
| Desert Steppes | 15 | 1 | — | 1 | 1 | 2 | 10 | 84.0 |
| Intermittent River | 8 | — | — | 1 | 2 | 2 | 3 | 77.5 |
| Perennial River | 12 | — | — | — | — | 2 | 10 | 96.7 |
| Freshwater Lake | 13 | — | 1 | 1 | 2 | 3 | 6 | 78.5 |
| Saltwater Lake | 25 | 1 | 1 | 2 | 3 | 5 | 13 | 79.2 |
| Saline Lake | 5 | — | — | 0 | 1 | 2 | 2 | 84.0 |
| Sand Beach | 5 | — | — | — | 1 | 1 | 3 | 88.0 |
| Swamp | 4 | — | — | — | 1 | 3 | 0 | 75.0 |
| Glacier | 3 | — | — | — | — | 1 | 2 | 93.3 |
| Glade | 2 | — | — | — | — | 2 | — | 80.0 |
| Firn | 6 | — | — | — | — | 2 | 4 | 93.3 |
| Industrial Estate | 7 | — | — | — | 1 | 1 | 5 | 91.4 |
| Residential Areas | 9 | — | — | — | — | 2 | 7 | 95.6 |
| Railroad | 5 | — | — | — | — | 2 | 3 | 92.0 |
| Road | 12 | — | — | — | — | 4 | 8 | 93.3 |
| Sand Sheet | 3 | — | — | — | — | 2 | 1 | 86.7 |
| Gravel Desert | 2 | — | — | — | — | 2 | — | 80.0 |
| Saline Land | 6 | — | — | — | 1 | 2 | 3 | 86.7 |
| Bare Soil | 12 | — | — | 1 | 1 | 3 | 7 | 86.7 |
| Bare Rock | 9 | — | 1 | 1 | 1 | 1 | 5 | 77.8 |
| Total | 266 | 4 | 6 | 13 | 23 | 64 | 156 | 85.1% |

Table 2. Classification accuracy analysis in Sanjiangyuan study area

From the table it can be seen that the total classification accuracy in Sanjiangyuan study area can reach 85.1%. On the whole, sand, water and road all achieve high classification accuracy, but the forest, bottomland and bare land indicate relatively low precision. After repeated inspections, the reasons for the errors include: (1) the lack of multi-phase images results in the interpretation errors of seasonal vegetation, such as forest and grassland; (2) because large-scale topographic maps, DEM and high-precision control points are absent, the deformation of

image in geometric correction and ortho-rectification still exists. As a result, the image registration accuracy of fusion image is less than the requirements of interpretation, and the depressed stereoscopic images of ground features confuse the classification of forest, such as bush, coniferous forest and broad-leaved forest; (3) generally, it is easy to judge dry bare land from spectral information of images. But for the wettest bare land, such as swamp, bottomland and watery sand, it is

better to use comprehensive analysis based on auxiliary data to interpret the land cover classification.

## 4. CONCLUSIONS

The paper analyzes land cover classification in Sanjiangyuan study area based on multi-auxiliary information. According to the statistics and analysis of research, we find that not only grassland desertification is significant but also the area of lake and grassland is reduced obviously. The statistical result shows that high-cold meadows and high-cold steppes still occupy the absolute superiority in Sanjiangyuan mapping district. Though frequent human activities have caused serious grassland desertification, the land cover far from roads and residential areas is not greatly affected.

Compared with the land use data in 1990, 1995 and 2000, we can draw a conclusion that the most serious grassland desertification has happened from 1985 to 2000. Due to the combined effect of the exorbitant exploitation，temperatures rising and drought climate, the ecological environment tends to be deteriorated. In the arid high-cold ecological environment, because ecosystem structure and function is simple, the ecological environment is extremely friable. Once ecological damage happens, it is difficult to recover. What is more worrying is that the ecological environment will lose control and lead to rapid deterioration. The solution is to monitor land cover change, design more scientific land use policy and implement sustainable development of land resources.

## ACKNOWLEDGMENTS

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