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A STUDY ON WETLAND CLASSIFICATION MODEL OF REMOTE SENSING IN THE SANGJIANG PLAIN

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ABSTRACT: The Sanjiang Plain, where nearly 20 kinds of wetlands exist now, is one of the largest wetlands distributed area of wetlands in China. To identify each of them and pick up them separately by means of automatic interpretation of remote sensing from TM Landsat images is extremely important. However, most of the types of wetlands can not be divided each other due to the similarity and the illegibility of the wetland spectrum shown in TM images. Special disposals to remote sensing images include the spectrum enhancement of wetland information, the pseudo color composite of TM images of different bands and the algebra enhancement of TM images. By this way some kinds of wetlands such as *Sparganium stoloniferum* and *Bolboschoenus maritimus* can be identified. But in many cases, these methods are still insufficient because of the noise brought from the atmosphere transportation and so on. The physical features of wetlands reflecting the diversification of spectrum information of wetlands, which include the spatial-temporal characteristics of the wetlands distribution, the landscape differences of wetlands from season to season, the growing environment and the vertical structure of wetlands vegetation and so on, must be taken into consideration. Besides these, the artificial alteration to spatial structure of wetlands such as the exploitation of some types of them can be also used as important symbols of wetlands identification from remote sensing images. On the basis of the above geographics analysis, a set of wetlands classification models of remote sensing could be established, and many types of wetlands such as paddy-field, reed swamp, peat mire, meadow, *CAREX* marsh and paludification meadow and so on, will be distinguished consequently. All the ways of geographical analysis and model establishment will be given in detail in this article.

KEY WORDS: wetlands in the Sanjiang Plain; wetland classification model; remote sensing classification; image disposal

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1 INTODUCTION

Wetland can perform enormous functions in resource and environment adjustment, and it is one of the important ecological environments that human beings rely on. International communities have already paid great attention to the wetland research, and some foreigners have done a lot of work in wetland research recently by using techniques of remote sensing and geographical information system (GIS). For example, Canada has investigated its wetland through TM remote sensing data.

In China, the study on the wetland conservation begins relatively late, so the irrational exploitation and the destruction of wetlands are very serious (ZHANG, 1997). The Sanjiang Plain, once "The Great Northern Wilderness" with many wetlands, will vanish within 20 years at the present reclamation. Therefore, China urgently needs to work out suitable measures of exploitation and conservation for

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the sustainable development of wetlands. For this reason, wetland research methods should be improved and the pace of new techniques' application to wetland study should be speeded up with the aim of knowing the exact distribution of the wetlands.

The advantage of studying wetlands through remote sensing is obvious. It can renew information quickly, with little human disturbance and reduce manpower and material resources. Generally speaking, because there is obvious difference between the spectrum of wetlands and that of other lands, wetlands can be recognized from the remote sensing images easily. But the spectrum characteristics of different wetlands are similar and it is impossible to distinguish some of them directly on the images. Therefore, to establish wetland classification model of remote sensing according to the environmental characteristics of different wetlands and considering their spectrum features is a feasible method for wetland classification of remote sensing. This paper will introduce these method in detail by taking the Sanjiang Plain as an example.

2 THE ENVIRONMENT AND DISTRIBUTION FEATURES OF THE SANJIANG PLAIN WETLANDS

The Sanjiang Plain is formed by the alluviation of the Heilong, Songhua and Wusuli rivers. The wetlands in the Sanjiang Plain formed on the lower alluvial plain, their distributions are mainly controlled by not only the geomorphologic conditions but also the shapes and kinds of surface materials. In this region, there is a geomorphologic difference between the eastern part and the western part. The westem part is high and the surface materials are coarse, so there are fewer wetlands, which are distributed mainly over flood land and old river courses in which the underground water is far below the surface. The eastern part is low and the surface materials are fine, so wetlands there are distributed enormously and widely not only in river floods and old river courses but also in lower lands on terraces. From the flood land to the terraces, the higher the terrain is, the less the wetlands distributed, and the wetland shapes change from strips or belts to stains gradually. On flood land (ZENG, 1998) and old river courses, Carex pseudocuraica marsh *Carex lasiocarpa* marsh appear sequently from the front edge to the back edge. From the centre to the margin of the lower land on the terraces, *Carex lasiocarpa* marsh, *Carex meyeriana* marsh and *Calamgrostis angustifolia* marsh are distributed in turn(CGSR, 1998).

3 WETLAND CLASSIFICATION MODELS BY REMOTE SENSING

3.1 Wetland Classification Model by Considering only the Spectrum Features of Remote Sensing

The spectrum information of wetlands from the original images can not show the differences between different kinds of wetlands. But if the images are processed, the dividing lines between some kinds of wetlands are bold. The followings are some images processing methods that can identify some wetlands efficiently.

3.1.1 The enhancement of TM wetland information

Although it is very difficult to see the differences of Landsat TM spectrum between some wetlands with naked eyes, the differences really exist. The spectrum curves of wetlands measured on the spot are shown in Fig. 1. As shown in Fig. 1, the spectrum curves of *Sparganium stoloniferum* and *Scirpus triqueter* are almost the same within the visible light and the near infrared, but they are different with the middle infrared. We can choose TM 5 (1.55–1.75 μm, a band of middle infrared) and stretch it. After magnifying the spectrum differences between both of them, we can distinguish the wetlands on the images easily.

3.1.2 Model through pseudo color composite of TM wetland information and extracting wetlands progressively

TM5 and TM7, two middle infrared bands, can

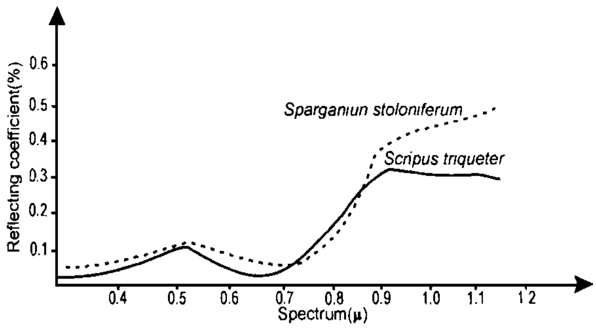

Fig. 1 Spectrum curves of *Sparganium stoloniferum* and *Scripus triqueter*

reflect the water condition of leaf surface and soil perfectly. TM5 has the most plentiful spectrum information among all the seven bands of TM, and the contrast between soils within this band is notable, so TM5 is the ideal band for composite. Through analysis, we can reach the conclusion that the pseudo color composite image of TM3, TM4 and TM5 is the best band for landuse classification and that of TM5, TM6 and TM7 has abundant vegetation information. From the pseudo color composite image of TM5, TM6 and TM7 we can see clearly the outlines between different kinds of vegetation. Therefore, we can use the following steps to extract different kinds of wetlands: First reject all other land types except wetlands through the pseudo color composite image of TM3, TM4 and TM5. Then combine with the pseudo color composite image of TM5, TM6 and TM7, and find out the outlines of wetlands. We have efficiently collected 36 types of land and 18 kinds of wetland through this method.

3.1.3 Wetland classification model on the basis of algebra enhancement of TM images

The TM spectrum information of wetlands is often a comprehensive reflection of spectrum features of wetland vegetation, water and soil. The "contributive degree" of vegetation, water and soil of different kinds of wetland to the spectrum of remote sensing varies with seasons. The soil's spectrum curve is straight and even, but its reflectance to long wave is slightly higher than that to short wave, and its reflectance varies with its color and luster. The radiation of water is usually low. Water's radiation level of long wave is lower than that of short wave. Consequently, some wetlands can be classified by dividing or multiplying or subtracting channel 3, 4, 5 with each other. TM4/TM3 can be regarded as green index of plants. For example, the reed swamp on the image of TM4/TM3 is clearer and its boundary is more distinct. The image of TM4 multiplying TM3 will overstate the difference of soil and water (humidity) between different wetlands.

3.2 Wetland Classification Model by Considering the Landscape Difference of Swamp in Different Seasons

One of the difficulties in the remote sensing classification is that the same things may have different spectrum. This difficulty also exists in the remote sensing classification of wetlands. Particularly during the summer season, most land is covered by green vegetation and the boundary between wetland vegetation and other vegetation is vague. Because different vegetation has similar spectrum features, the boundary between different kinds of wetland is more vague. Therefore, sometimes it is not sufficient to consider only the wetland's spectrum features. Practice shows that the combination of images of different seasons is the efficient method to extract different wetland types.

The seasonal difference of landscape refers to that the phenological order of wetland vegetation is not similar to that of other natural vegetation or artificial vegetation. This difference makes wetlands which are difficult to be distinguished in summer have utterly different characteristics of spectrum in spring and fall.

Fig. 2 is the growth curves of the main wetland plants in the Sanjiang Plain (ZHANG, 1999). In Fig. 2, the abscissa refers to months and ordinate is the coefficient of green degree of vegetation, which is a scalar quantity in which the cover rate of vegetation and the degree of green of it are the key factors. Also in Fig. 2, the intersect point of the abscissa and the ordinate indicates the soil and the part under the abscissa expresses the water. We can combine the remote sensing images of different time on the base of Fig. 2 to classify the wetlands.

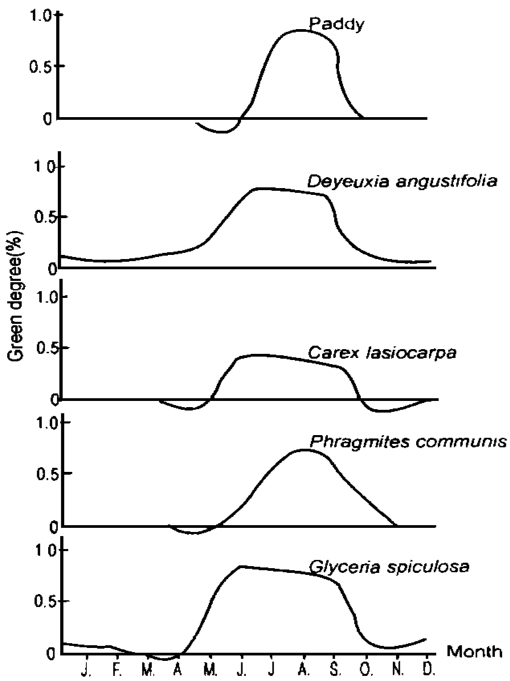

Fig. 2 Growing curves of main wetland plants in the Sanjiang Plain

(1) Paddy-field: The paddyfield in the Sanjiang Plain is irrigated in the last ten-day period of May and the paddy covers all field in the first ten-day period of July. Therefore, from the last ten-day period of May to that of July the spectrum of the paddy-field is similar to that of the dry farm land and similar to lake's in June. By combining the TM image of June with that of August and setting them with different colors, we may differentiate the paddy-field from dry farm land and lake.

(2) Reed swamp: In the late June and the early July, reed is in their tassel stage and its coverage is high. Meanwhile, spring wheat is not mature and the crops of the late autumn, such as soybean, doesn't cover the field entirely. At this time, it is difficult to distinguish the reed from the spring wheat, but there are clear boundaries between the reed and the late autumn crops. After August, reed grows up and the late autumn crops cover all the fields, so it is difficult to distinguish the reed from the late autumn crops during that time. But the TM image of the spring wheat, which have been harvested, is obviously different from that of the reed. Therefore, we can distinguish the reed from all other crops by combining the TM images of above two seasons and setting with different colors.

(3) Peat mire: Because peat is under the earth's surface, its information will be concealed when vegetation covers the ground. But we can make use of the images of the last ten days of April when there is no vegetation to extract peat mire. Due to the heavier moisture, peat mire has clear outlines on the near infrared band of TM images during the middle or last ten days of April — the thawing time of the Sanjiang region.

(4) Meadow: On the remote sensing image of the flood stage, when the mire and paludification meadow all are inundated, we can get rid of water, mire and paludification meadow (LI, 1998). We can also reject the cultivated land and the forestland by combining the images of the middle and the last ten days of May or the first and middle ten days of June with that of August or September.

(5) *Carex* marsh and paludification meadow: The temporal and spatial distribution features of the marsh hydrology control to a great extent the spatial distributive pattern of mire. According to the waterlogged time, the whole Sangjiang Plain can be divided into perennial waterlogged region, seasonal waterlogged region and region of the soil saturated by water. The perennial waterlogged region mainly appears in the marsh supplied with groundwater, low flood land marsh or mire of deep dish-shaped depression, where *Carex Lasiocarpa*, *Carex pesudo-curaica*, *Carex appendiculata* grow and the depth of the water is 5– 50 cm. The seasonal waterlogged region is often distributed over the high flood land and the edge of the depression on the terraces and the water is mainly supplied with flood, surface runoff and precipitation, so the soil of this region is over wet, *Carex* grows in this region. The region of seasonal overdamp soil under the influence of the flood is mainly

distributed over the high flood land and the highest terraces, in this region *Deyeuxia angustifolia*, *Carex*, *Alnus sibirica*, *Salix brachypoda and so on* form the paludification meadows. In short, we can get Carex marsh after rejecting the rivers and the lakes from the waterlogged regions on the image of the normal water level period. We will get paludification meadow after refjecting *Carex* mire, the cultivated land being inundated and the reed swamp from the inundated region on the images of the flood period.

3.3 Wetland Classification Model of Remote Sensing by Considering the Difference of the Spatial Structure of Wetlands

The shape of the spatial distribution of wetlands and the vertical distribution feature of wetland vegetation can be taken as the indexes of the wetland classification of remote sensing.

(1) Reed swamp and *Carex lasiocarpa*, *Deyeuxia angustifolia* marsh: The reed is often over 2 m high, and the height of *Carex lasiocarpa* and *Deyeuxia angustifolia* are usually less than 1 m. Therefore, we can make the image of the reed clearly different from other objects by combining the near infrared TM image of the flood period when other objects are inundated with that of June or July and setting them with various colors.

(2) Paddy-field and man-made lake: In summer, the differences of spectrum value among the paddy-field and man-made lakes and other wetlands are small, but unlike other's the outlines of the paddy-field and part boundaries of larger man-made lake, are either straight or broken. From this distributive difference of spatial structure, both of them can be extracted.

3.4 Wetland Classification Model of Remote Sensing by Considering the Habitat Differences Between Wetland Vegetation

The spectrum features of some wetland vegetation are similar, but their growth conditions are different. According to these differences, some wetland types can be easily distinguished. *Carex pseudo-curaica* and *Carex lasiocarpa* are almost similar in their growth stage, so it is difficult to distinguish them only by their spectrum features, but we can identify them by their habitable differences. *Carex lasiocarpa* grows in the low flood lands and the dish-shape depressions, where water is accumulated throughout the year due to the sufficient groundwater supply. The roots of *Carex lasiocarpa* grow in the soil and its height ranges from 20 cm to 30 cm, consequently it is often inundated in flood season and its leaves appear above the water surface after flood. *Carex pseudo-curaica* floats on the water like a straw raft and grows in the rivers flowing sluggishly, its leaves can be above the water surface at the height of about 1m in flood. Therefore, *Carex lasiocarpa* and *Carex pseudocuraica* can be distinguished by combining the remote sensing images of flood season and non-flood season.

3.5 Wetland Classification Model of Remote Sensing by Considering Reclaimed Wetlands

Some wetlands can be reclaimed, but some cannot. Some wetlands can only be reclaimed into paddy-field, while some wetlands can be reclaimed into paddy-field or dry farmland. These rules of the wetland reclamation can be used as the basis to identify the wetlands around the reclaimed areas.

Generally speaking, reed and *Carex pseudo-curaica* grow in deep water, so they are not suitable for reclamation and cannot be reclaimed into dry farmland. According to this, we can make it certain that the wetlands around the newly reclaimed dry farmland cannot be reed swamp or *Carex pseudocuraica* marsh. Meadow is on high places, meadow layer contains water, so it can not be reclaimed into dry farm land. The paludification meadow is distributed over wet area and the meadow layer contains much water. The newly reclaimed dry farm land from paludification meadow is very humid in spring, so its image on near infrared band appears in dark color. On the basis of the above characteristics, we can conclude thet what type of wetland around the newly reclaimed wetlands belongs to.

4 CONCLUSION

The differences of the seasonal landscape of wetlands and the differences of the growing habitat of wetland vegetation may result in the spectrum dissimilarity of wetlands on the images of remote sensing. This distinction can be extracted by combining the images of remote sensing of different time and different spectrum bands. The establishment of wetland classification model of remote sensing is a successful attempt of the above theory. We think to build expert knowledge storehouse and to realize the aim of classifying automatically wetlands on remote sensing image are the thrend of this field along with the understanding of wetlands and the development of wetland remote sensing.

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