

Application of aerial remote sensing in the study on vegetation in Guangzhou, China

Chen Shijie, He Shigan, Yang Jieli, Wang Liangping

Department of Geography, Guangzhou Normal College, Guangzhou 510400, China

Abstract—This paper showed the study on the vegetation in an 820km² area in Guangzhou to make vegetation classification with aerial remote sensing images. Based on the synthetic reflection of the mutually dependent relationship between vegetation and environment in the images, the vegetation in Guangzhou can be divided into six types and seventeen communities. The composite images from a vegetation map for Guangzhou at a scale of 1:25000, which is further reduced to 1:50000. This paper made an ecological evaluation of vegetation in Guangzhou.

Keywords: aerial remote sensing; vegetation classification; vegetation map; ecological evaluation.

1 Introduction

The macroscopic properties of satellite remote sensing make it suitable for studying very large areas. The aerial remote sensing, however, is even suitable for studying smaller areas like a city and its suburban districts, especially, in composing the vegetation map on a large scale. This paper is a summary of the application of aerial remote sensing in the study on vegetation in Guangzhou.

The range of study is: east longitude 113°10'—113°34', north latitude 23°2'30"—33°14'; the area is 820km². The date of aeroplane photography is 1984 and 1985. The type of photograph and its scale is: colour infrared aerial photograph(1:20000); panchromatic aerial photograph(1:15000); natural colour aerial photograph(1:10000); the flight altitude is: colour infrared aerial photograph:3300m; panchromatic aerial photograph:2550m; natural colour aerial photograph:1750m.

2 The classification system for vegetation in Guangzhou and its interpretation key

Based on the images of aerial remote sensing, we can establish a sample region for the field differentiation, make a vegetation survey on the model section, and take vegetation landscape photographs of all vegetation types. Next, according to the scientific systematic distinguishable principles, we classify into three distinct classes, and under individual conditions, make four classifications. The vegetation in Guangzhou can be divided into six types and seventeen communi-

ties.

2.1 Natural vegetation

This is a vegetation which either grows naturally or is protected or cultivated artificially, but not managed frequently. Such vegetation is now established in a natural or semi-natural state.

Monsoon evergreen broadleaf forest (subtropical evergreen monsoon forest): this is an evergreen broadleaf forest which possesses south-subtropical zonal characteristics. They are distributed along Baiyun Mountain, where it is better protected by people, and alongside many villages, where it is called "Feng Shui Wood". In reality, they are few surviving communities of the monsoon evergreen broadleaf forest in suburban districts in Guangzhou.

Schima superba + *Syzygium rehderianum* community: this is a community composed of the common-edificator *schima superba*, *syzygium rehderianum* with other dominant, associated species. They are distributed at Huangpu Huakeng Village.

Engelhardtia chrysolepis community: this is a community composed of the edificator *engelhardtia chrysolepis* and other dominant, associated species. They are distributed at Luogang Shixi Village, Nangang Honggang Village.

Castanopsis chinensis + *Acronychia pedunculata* community: this community is made up of the common-edificator *castanopsis chinensis*, *acronychia pedunculata* with other dominant, addo-coated species, are distributed at Moxingling of Baiyun Mountain.

The image of the monsoon evergreen broadleaf forest appears as a small or middle sized pellet in an uniform mixture, a deep and light mixed greyish white; a deep red or bright red in the color infrared photographs.

Warm coniferous forest: this is a coniferous forest, made up of many coniferous trees growing under the subtropical warm damp conditions on low mountains, hill and plains.

Pinus massoniana community: this is a community, made up of the edificator *Pinus massoniana* and other dominant, associated species, which are distributed at Niuling, Wuleiling, Dadanling and Fenghuang Mountain, and formed mostly by the artificial forestation from direct seeding in the past fifty years. It is now established in a natural state. The great majority of *Pinus massoniana* forests are pure forests, and there are yet some mixed forests in partial district, containing broad-leaf trees *Eucalyptus citrodora*, *Eucalyptus tereticornis* and so on.

The image appears as a middle sized pellet evenly distributed, light grey; a red in the color infrared photographs.

Cunninghamia lanceolata community: this is a community made up of the edificator *cunninghamia lanceolata* and other dominant, associated species, which are distributed at some regions of the hills, like the western hillside of Pachili reservoir and Dongqifeng. It is a pure forest of *Cunninghamia lanceolata*, although artificially cultivated, the forests are now in a semi-natural state.

The image appears as a small pellet, evenly distributed, light black; a red brown in the color infrared photographs.

Shrub herbosa: this is a community, made up of xeric-mesophytism herbs, which occupy a dominant place, and some heliophilic shrubs, which are disseminated.

Rhodomyrtus tomentosa—*dicranopteris linearis* community: this is a community made up of

the dominant species *Rhodomyrtus tomentosa* and *Dicranopteris linearis*, and some other associated species. They are distributed at the northern hillside of Baiyun Mountain, where the coniferous forest and broadleaf forest were broken, but where the soil layer is still thick, and the humidity is still high. The *Dicranopteris linearis* occupies an absolutely predominant place, while the *Rhodomyrtus tomentosa* disseminate only among, the associated species usually are *Melastoma candidum*, *Breynia fruticosa*, *Pschotria rubia* and so on. A few coniferous trees are disseminated also at some sections.

The image appears as a fine hair-like, equally distributed, dark grey; a dull red in color infrared photographs.

Baeokea frutescens - *Eriachne pallescens* community: this is a community made up of the dominant species *Baeokea frutescens* and *Eriachne pallescens* and other associated species. Its distribution is in the southern hillside of Baiyun Mountain, where coniferous forest was broken, and the soil layer is slight, poor, dry, and where the soil erosion is serious. The *Eriachne pallescens* occupies an absolutely predominant place, the *Baeokea frutescens* are disseminated throughout the region. The associated species usually are *Ischaemum ciliare*, *Desmodium pulchellum*.

The image appears as a fine hair-like, equally distributed, grey; a deep brown in the color infrared photographs.

2.2 Artificial vegetation

This is a vegetation which chief purpose is production by artificial cultivation and frequent management.

Economic forest; this is a community made up of various plants of economic importance.

Orchard; type of garden which produces fresh fruit. Chief species include *Citrus reticulata*, *Litchi chinensis*, *Dimocarpus longan*, *Averrhoa carambola*, *Musa nana*, *Ananas comosus* and so on.

The image appears as a large, middle or small pellet, concentrated regular range or dispersed, dark grey to light black; a red in color infrared photographs.

The image and distribution of each community is as follows: *Citrus reticulata* community: the image appears as small pellet forms, uniform range, black; a bright red in color infrared photographs. Most of them are distributed at Kent field or Dong field where the slope is slight and by the gentle slope fields and foot hills.

Litchi chinensis and *Dimocarpus longan* communities: the image appears as middle sized round pellet forms, a deep red in color infrared photographs. These are distributed on hillsides field or dikes, or concentrated into forest form established along river banks.

Averrhoa carambola community: the image appears as velveting forms, light black; a red-brown in color infrared photographs. Most of them are distributed concentrically on plains.

Musa sapientum community: the image appears as velveting forms, dark grey, a dull red in color infrared photographs. These are distributed at gentle sloping field or flatlands.

Musa nana community: the image appears as velveting, dark grey; a bright red in color infrared photographs. Most of them are distributed on level sands of the delta region.

Ananas comosus community: the image appears as minute pellet forms, regular arrange-

ment, light black; a red in color infrared photographs. Most of them are distributed at newly cultivated, gentle or steep sloping fields.

Bamboo forest; this is a monodominant community made up of various bamboos. The chief species is *Bambusa textili*, and includes *Bambusa stenostachya*, *Lingnania chungii* and so on.

The image appears as a fine hair-like, equally distributed, light black; a light red in color infrared photographs.

Tea plantation; this monodominant community made up of *Camellia sinensis*, are distributed at Mingzhulou near hillsides of Baiyun Mountain.

The image appears as minute pellet forms, regular arrangement, dark grey; a dull red in color infrared photographs.

Crops; type of various agriculture communities, where the chief purpose is agriculture production.

Oryza sativa community; it was winter fallow. The image appears as small square form, greyish white to dark grey; a grey to blue in color infrared photographs, the watery fields appears as a dark blue and damp fields appears as a light blue.

Vegetable community: (1) Aquatic vegetation community; the image appears as a rectangle form, grey; a dull red to orange red in color infrared photographs. *Nasturtium officinale* community; are orange to red and square or rectangle forms. *Eleocharis tuberosa* community; dullred, square forms; *Nelumbo nucifera* community; orange, square forms. (2) Irrigated field vegetable community; A terrestrial vegetable communities, which usually have water to irrigate. Most distribution is in level fields or gentle sloping fields of the nearby siedlungew. The image appears as a rectangle form, grey; a red or light red, tone is mixed, in color infrared photographs.

Saccharum officinarum community; this is an artificial monodominant community made up of *Saccharum officinarum*. Most distribution is at level sandy fields and low hills where the water sources are sufficient.

The image appears as a fine hair-like, regular square or rectangle. Light grey; a light red to deep red in color infrared photographs.

Bloomtrees community; an artificial communities, which are cultivated in large areas for producing flowers and oranges. Most distribution is at Fangcun. The image appears as a minute pellet, equally distributed, grey to dull grey; a orange red or light red, tone is mixed in color infrared photographs.

Dry field cereal community; these are a cereal community which grow on hillside fields has no artificial irrigation equipment, relying on natural precipitation. Distribution is at near low hills fields of Xinhua, Lougang and so on. Chief cereal crops are *Arachis hypogaea*, *Ipomoea batatas*, *manihot esculenta*.

The image appears as irregular form, dark grey or grayish white; light yellow or light red, tone is mixed in color infrared photographs.

2.3 Greening vegetation

This is a community made up of various trees, shrubs, grasses plants, and receiving artificial cultivation or protection. Their purpose is to protect the environment of the city.

Garden, foursides greening vegetation; Garden, foursides greening vegetation (include; *Casuarina equisetifolia* forest, *Eucalytus spp.* forest, *Acacia confusa* forest).

The image appears as a large, middle or small pellet to fine hair-like, shade trees are regular rang, linear form, light to dark grey; a dull red, red, grey yellow and so on in color infrared photographs.

Geographical factors; Water bodies, building, Mining space, sandy beaches, roads.

3 The compilation of the vegetation map in Guangzhou at the scale of 1:50000 and area measurements

3.1 The compilation of the vegetation map

The interpretation and drawing of the aerial photographs.

After making an initial distinguishing, take a sample field, seek out the relationship between image characteristics and the ground truths of vegetation, and decide upon the mark for visual interpretation.

The identification and drawing of the model aerial photographs is made in the field, according to actual surface areas of $50 \times 50 \text{cm}^2$ as a minimum area to draw the boundary of the location of each vegetation type by classification standards. The drawing on other aerial photographs is done in the laboratory, following the same principle.

Interpretation of the image is based on the combination of both direct interpretation marks and indirect interpretation marks, using the direct interpretation marks as the chief foundation. The direct interpretation marks include the image texture, tone and color of the plant community and the shape, size of the plant individuality, the indirect interpretation marks include the location of landform, altitude, anthropogenic influences at the growth environment of plant. The difficult image is corrected by a sampling, investigation, filed verification. If differences exist yet, make a more exact analysis. The interpretation results of the image of vegetation in aerial photographs, must agree with ground truths at the time of aerial photography.

Transfer mapping; After the personal inspection, mutual correction, synthetic arrangement, according to the standards requirement, by the B8S and A10 accurate mapping instrument, make a projection transfer into an original map of single element at the scale of 1:25000.

According to the statistics in transfer of office work, the mean square error of the stereo model control point is:

$$m_{\text{plane}} = \sqrt{\frac{35.04}{1700}} = \pm 0.14 \text{m} \quad m_{\text{height}} = \sqrt{\frac{586.63}{1982}} = \pm 0.54 \text{m}$$

Transfer error: $\Delta < 0.2 \text{mm}$; $\Delta_{\text{max}} < 0.5 \text{mm}$.

The original map at the scale of 1:25000, is further reduced to a vegetation map of Guangzhou at the scale of 1:50000 (Fig. 1).

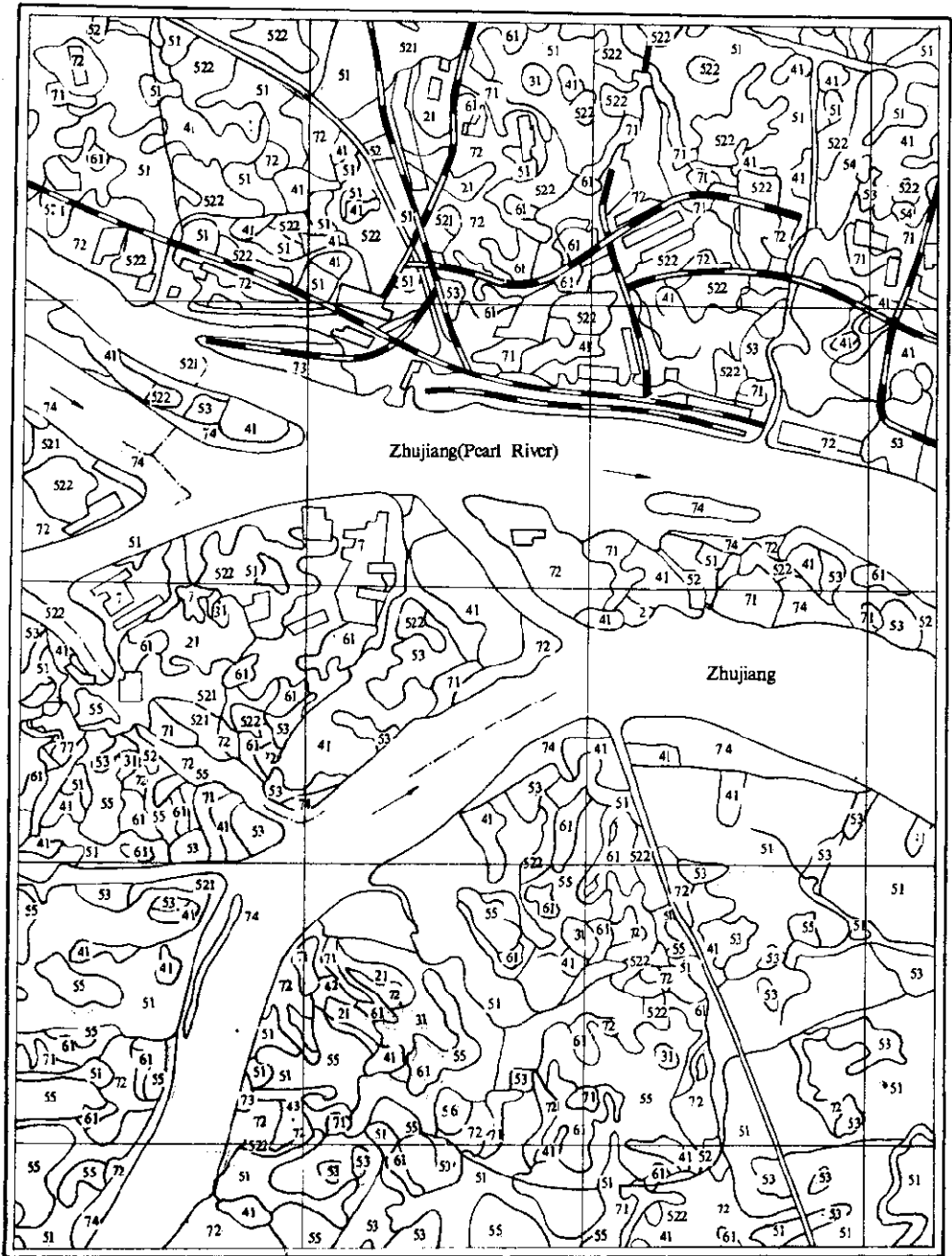


Fig. 1 The vegetation map in Guangzhou (1:50000)
The numbers are the classification of main body

3.2 The area measurement

The measurements of the area are made on the vegetation map (1:25000).

According to the statistics of eight district (Dongshan, Yuexiu, Liwan, Haizhu, Fangcun, Tianhe, Huangpu and Huangpu special district) each having comprehensive boundaries in the district, the cover rate of the vegetation reaches 50.31%. The great majority of the crops and the shrub - herbosa vegetation within the district would not be counted only the broadleaf forest, coniferous forest, economic forest, bloomtrees vegetation and greening vegetation were counted, and their cover rate is 21.83%.

4 The ecological evaluation of vegetation in Guangzhou and counter measures

4.1 The ecological evaluation

The vegetation of Guangzhou region is very seriously endangered by accepting anthropogenic influences. The original natural vegetation no longer exists in the region.

The monsoon evergreen broadleaf forest, which serves as a chief representative type of the south subtropical zone, has only a few secondary communities. Their cover rate at 0.1% is not enough. They are distributed in Baiyun Mountain and alongside many villages, where it is called "Feng Shui Wood". These "Feng Shui Wood" effect greatly wind prevention, rain water protection, and improvements of environmental life. They have formed a component part of a reasonable ecological structure beside a residential area of the village in the countryside of suburban districts around Guangzhou.

The subtropical warm coniferous forest, formed mostly by the artificial forestation from direct seeding in the past fifty years, is established in a natural state now. They are the chief component of the natural vegetation in suburban districts. Their cover rate is 3.8%. They effect greatly conserving the water - soil, foresting the wastelands, adjusting the weather, safeguarding the ecological balance.

The economic forest distribution area is larger, and the cover rate is 10.3%. They posses in one respect the ecological effects of a natural forest, and in another respect, possess a special community physionomy. For example, the litchi, longan, oranges, banana and pineapple show fully the characteristics of the vegetation landscape from a south subtropical zone.

The bloomtrees vegetation is a special type of vegetation in Guangzhou, and their cover rate is nearly 0.4%. They are important to beautify, to add fragrance to the city, and especially, to provide a large number of the flowers at the flower - market of the Spring Festival each year, to form the stereoscopic structure of the city greening, to improve the ecological environment of the residential areas of the city.

The cover rate of the Garden, four side greening vegetation is 7.3%. They are distributed in the city proper nearest the dense population and have directly affected the ecological environment, by the purification of air, by the absorption of dust, by the elimination of noise and so on.

In a word, the Guangzhou region possesses a warm and moist climate. The rain and heat

can arrive at the same time. The ecological condition are very favorable for the plants to grow luxuriantly, the leaves to keep evergreen in four seasons, and the flowers to fully bloom all the year round. Their appearance is fully a characteristic of a fine environment and fresh air in the subtropic city of southern China.

Because of many causes, the population density of the city in Guangzhou is getting bigger. The average density of population in the old city district (Dongshan, Yuexiu, Liwan, Haizhu) reaches 36000 person/km². And in recent years, the economic development speed very fast. Therefore, the quantity of wastes, which the city emits, is enormous. According to the statistics, the emissive quantity of SO₂ reached 70000 and more tons/a. The monthly average value of falling dust in quantities reached 12.66 tons/km² in Guangzhou in 1985.

The environment is seriously polluted. The existing vegetation in Guangzhou can not play its proper role effectively. The content of polluted material outstrips the bearing capacity for species of many plants under the normal condition of growth and development. Their life suffers in varying degrees from serious anthropogenic influences.

Based on the investigations, the fall dust quantity increases gradually from north to south in the city proper of Guangzhou. The growth of the *Casuarina equisetifolia* withers gradually too from north to south. Under the monthly average value of falling dust in quantities of more than 15-20 tons/km², the growth and survival *Casuarina equisetifolia* is with very great difficulty. The content of the CO₂ increases gradually from east to west, the growth vigor of *Cinnamomum camphora* weakens gradually too from east to west. Under the content of more than 0.035%, the *Cinnamomum camphora* cannot grow normally.

The existing vegetation as the most important components of the city ecological system in Guangzhou, raises many questions, which wait impatiently to be answered with solid stations.

4.2 The counter measures

The cover rate of the vegetation in Guangzhou is 21.83%, and according to the standard area of average greenland for every person, which a modern city must possess to measure, has an even larger disparity.

Guangzhou is located in the south subtropic zone, and the sun radiation very strongly in the summer, and has longer period of the dry season in the winter. Therefore, we must enlarge further the cover areas of vegetation, and further increase the cover quality of vegetation, to fully give play to the ecological effects of the vegetation. This is an essential condition to keep pace with the high speed increases continuing in the economy of the Guangzhou region. Therefore, we suggest the following counter measures: to protect evergreen broadleaf forest; to transform coniferous forest; to make full use of the waste and expose land of hillsides to forest and plain grasses, and to build natural reserves.

References

- Chang Hungta. *Acta Scientiarum Naturalium Universitatis Sunyatseni*, 1983, (1): 1
Chen Shijie. *Journal of Guangzhou Normal College*, 1990, (2): 67