STUDIES IN URBAN GREEN ECOLOGY AND ESTABLISHMENT OF INFORMATION SYSTEM

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Abstract

The Urban Green Ecology Information System (UGEIS) given in this article is one of the most essential system about some special topics and functions in the urban GIS . It consists of four parts, namely two-dimensional greening overlay rate library, three-dimentional green quantity information library, management information library of special greening areas and environmental information sub-library. The major means of setting up the system is the aerial remote sensing and computer technique and the major object is to research quantitatively the green ecology information and to analyse the relation between greening and environment. Specially the 3-D green biological quantity can be used to estimate the economic output of urban greening and to analyse the relation between the output and the social results. In short, from macroscope to microscope a basic means of researching the information of urban green ecology and the relation between the information and environment by aerial remote sensing was put forward in this article.

Keywords: Green ecology information system. Aerial remote sensing. 2-D greening overlay rate. 3-D green biological quantity. Economic output of greening. Relation between greening and environment.

With the daily increasing of urbanism degree and the mushrooming up of new cities, the urban population has become over concentrated, the land for construction has rapidly expanded and the industrialization has greatly deepened . The nearly all-man-made recycle system of production and living has replaced the previous natural ecological cycle system , making a large number of cities, particularly industrial cities face serious environmental problems. Take Shanghai as an excample. In the center of Shanghai city , approximately 1600 tons of floating dust and 1500 tons of sulfur dioxide are exhausted annually into one square kilometer of sky. The air pollutant content greatly exceeds the total volume which can be settled or absorbed by the atmosphere environment. This has not only affected the economic development and social progress, but also severely threatened the physical and mental health of the people . As you are all aware, green plants have many environmental functions such as solidating soil and reserving water, absorbing carbon and producing oxigen, adjusting atmospheric temperature, preventing pollution and settling down dust, sterlizing air, insolating noise, etc.. In order to help the urban residents to reproduce and live in urban development, it is a must to establish a man-made urban green ecology system to maintain the balanced recycle between people and environment.

However, the design and layout, living conditions and quantity of man-made urban greening are restricted by other environmental factors and the unbalacing of natural growth of plants and artificial trimming make the urban green ecological system complicated and variable so that we are not able to describe it by using a single simple fixed model. Therefore, the investigation and management of urban green ecological system are a very complicated system-engineening which combines scientific research with production,in the comtemporary urban planning and construction. The UGEIS is an multifunctional information system combining investigation with management, designed and established to solve the above mentioned problem.

In the course of establishing the UGCIS, we adopt the new technique of comprehensive investigation by aerial remote sensing and analysing by computer statistics, rather than the traditional method of measuring by measuring tape on the spot and carrying out statistics by manual charts. The new technique not only saves a lot of human and material resources, but also has such advantages as fast investigation, high quantitative accuracy, strong comparativeness among regions , convinient and quick data management and renewal. Helpful to the establishment of various types of statistical models to carry out modelization relative analysis, etc.. The following introduction is about the four parts of the UGCIS.

I. Preparation of Greening Present Situation Map and Establishment of Two-Dimensional Greening Data Library

The 2-D greening data library is a basic library with relatively complete functions, which is mainly used in the daily management & planning of municipal park department. The emphasis of this library is laid on the statistic, so the major form of the data is grid, and the minnor is polygon. The following is a brief introduction to the establishment method of this library and its fundamental functions.

1. information source and basic maps

The first step of establishing the library is to select the appropriate information source. The colour infrared aerial photoes can accurately reflect not only the profile of the tree crown and the scope of the spacious green land but also the different types of plants, growing conditions, mature extent , chlorophyll content and the relative relations with environmental factors, through the difference of colour, vein and shape of photo image. Before establishing the library, we accomplished the following basic works according to the colour infrared photoes and other remote sensing materials.

1) Greening present situation maps of 1:5000 and 1:20000 were translated , with the topographic maps of the same scale as control base and by single-projector transfer as a tool of uniformizing the scale and eleminating photo errors. The former is used as the basic map to accurately carry out the statistics of all kinds of greening area and overlay rate, and the latter is used as the basic map for the research of greening changes and for the comprehensive analysis of environment factors such as construction density,population density, heat field, dust, noise, toxic gases, etc..

2)On the basis of 1:5000 greening present situation map, distribution chart of sidewalk tree varieties were charted. After differentiating major tree varieties accoрding to the colour and shape of different tree varieties reflected on the aerial photoes and checking through on-the-spot investigation.

3) On the basis of 1:20000 greening present situation map, and with reference to the aerial photoes in 1964 and 1981, greenig change charts were interpreted and charted. These charts not only can reflect the regional feature of greening change and the increased or reduced area of various kinds of green land, but also can be used to analyse the change process and cause in comparison with the aerial photoes.

4) The regional population was investigated and intputted to carry out the statistics and analysis of the per person green land conditions.

2. Formation of greening data file

The image-spot showing the present situation of urban greening distribution are small and dispersive so the relatively economic and applicable method now available for the statistical quantization is the method of dot grid. We directly formed grid data of greening overlay rate (GOR) with the dot grid. In order to raise the the efficiency of the work, we also tried directly input the greening information on the photoes into the computer by using the colour scanning system to form the polygon data file.

As to the grid structure, a single grid is used as analysing and processing unit. Many codes of greening and environment information may be stored in one grid . As classification border line is automatically formed by code gathering,it is not only possible to save storage space, but also to carry out code overlapping analysis and statistics in the same unit. However the polygon structure has such advantages as high speed, correct border line, high precision of area quantization etc. in inputting and exportting complicated images and it is only such structure that can realize the input of greening pattern, so we use both the two structures in the library. Fig. 1 shows the working procedure of the establishment of the 2-D greening data library.

3. Monitoring of greening dynamic

We use the Shanghai present situation information library as a basic library, which may further form a greening dynamic data library in both positive and negative directions . The newest library may be formed through amendment and renewal of the duplicated basic diskettes by the aerial photo to be taken during recent months.The greening dynamic data library of negative direction is formed according to the past aerial photoes. An greening dynamic model may be made by using the dynamic data library. According to the information fed back by model, we may see the development of greening and even predict future. Fig. 2 is the negative change model exported from the library. This model reflects the dynamic change of greening in the area. We found out this linear area where the negative change of greening were most serious and analysed the reasons of change as well as provided technical basis of polity dicision for controlling continue lose of the kind of green land.

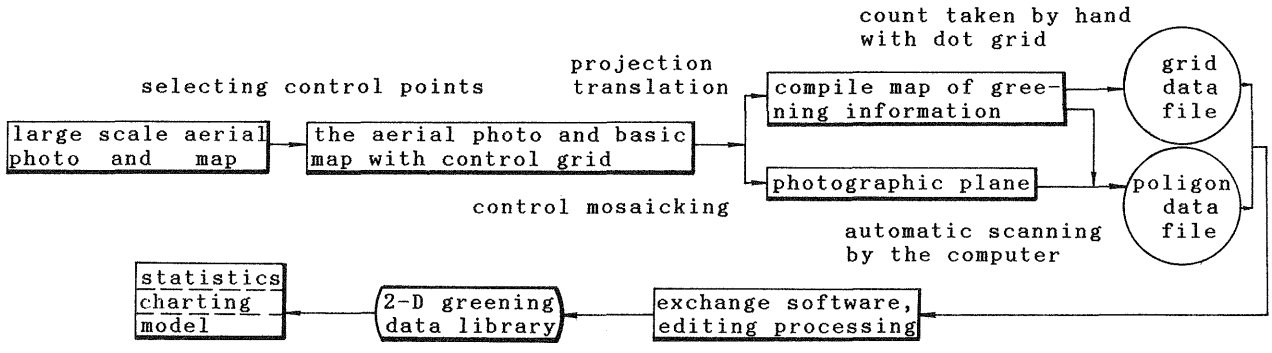


Fig. 1 Frame-diagram of the working procedure of establishing the 2-D greening data library

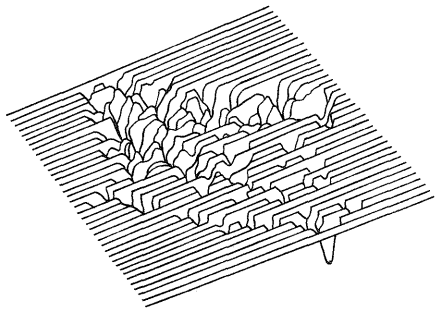


Fig.2 Negative change model of greeing in Yangpu Region of Shanghai

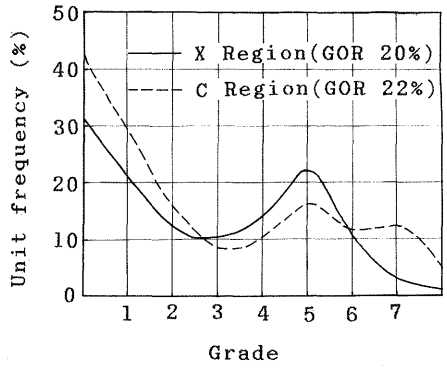


Fig.3 Greening overlay rate (GOR) Curve of typical regions

4.Output functions of 2-D greening information library and model studies

This library has many analysis & output functions, such as data autozoning, statistical overlapping, proportionality, diffrence, analytical histogram, plane figure, stereoscopic view, data renewal, etc.. By using these functions, it is possible to export the statistical amount, such as the land area of various neighborhoods, greening overlay area and the area of sidewalk trees, nurseries of young plants, public green land and special purpose green land, the green land area increased, decreased and greening change rate in the past 20 years and the green land area per person. It is also possible to directly export the geographic basic map of the whole city, including administrative border lines , major rivers and roads, greening function classification table,grid greening overlay rate chart and greening change rate chart, all kinds of statistical charts. It is worth mentioning particularly that by using these output functions of the library it is also possible to carry out a series of studies in greening models,for excample the hierarchical statistical histogram of GOR exported by the library is one of such models.The envelope line of this histogram is known as GOR frequency curve which may be used to design the optimization of greening quality in areas where the GOR is basically reached, for excample the laying proportion and distribution of various kinds of green land. We think that the GOR frequency curve is a relatively perfect model in assessing greening overlay quality. The proposal of this model makes the assessment of greening quality develope from the simple digital statistics (area, GOR) to the stage of model assessment and brings about a leap in assessment method of greening quality.Take the curves of two regions of Shanghai for excample (see Fig.3). In the traditional simple analysis that considers only the GOR,it is considered that the greening quality of the two regions is similar or the quality of C region is slightly better than that of X. However, in model analysis, it is considered that the curve indexs of X region, from grade four to six,are higher and the index of grade one is lower than those of C. This means that the greening quality norms of X such as greening popular rate, area of mature sidewalk trees etc. are higher. Namely, X has a better region greening quality.On the other hand, in C, there are several large pieces of green land, such as the airport, zoo, etc. (as is shown at the suddenly narrowed end of the curve)and C has a relatively higher GOR so as to offset the disadvantage in greening popular rate.

II. Survey of Urban Green Three-Dimentional Quantity and Establishment of Information Library

Generally 2-D statistical quantity of greening is used in the statistics of urban greening quantity and assessment of greening quality, i.e.the greening overlay rate and the greening area. However, the 2-D statistical quantity cannot accurately and completely reflect the greening function and level. For excample, by using the 2-D statistical quantity, it is impossible to express the stratified distribution of arbor, bush, flower and grass, greening conditions of wall vertical greening, the mature conditions of arbor and bush , the hight and crown closure of trees etc.. Therefore,analysis of greening environment and ecological effect only by 2-D greening statistical quantity is not accurate and complete enough. In particular in the past years the garden and greening department have accumulated a great deal of experimental data for greening micro environment and economic output. For excample, the per day amount of oxygen, removing dust,absorbing toxic gas of certain tree variety with certain diameter and hight, but these experimental value can hardly match the large scale 2-D surveying data of GOR. Therefore, these experimental value can only used for the analsis of small scale ecological effect in some areas. However as the ecological environment effect produced by greening is a complicated and comprehensive process in which the outside environment and internal conditions are constantly exchanged and the transmision toward outside environment is gradually

taking place. That is why the mere estimation of the greening ecological environment effect of a certain area unavoidable has limination and one-sideness. In order to make the quantization assessment and analysis of greening quality more complete and to enable the above mentioned experimental value of micro greening ecology effect to be used on a large scale so as to make the estimation of greening ecology effect and economic output be available for the whole city. We,on the basis of the 2-D greening statistical quantity, carry out the investigation of the three dimentional quantity , i.e. green biological quantity (GBQ), and establish the 3-D GBQ information library . It will provide reliable basis for further rational preparation of greening plan,correct analysis of the relative relation between urban greening and ecology environment and quantization assessment of economic output and environment effect of greening.

1. Collection of tree variety sample and establishment of GBQ model

In order to establish the interpretation mark of tree variety and explore the relative relation between the the crown diameter, hight and volume, we actually collect the sample value of 50 types of arbor and bush.In each type,we collect 40-50 samples from different areas of the city. The sample value of each sample includes hight and diameter of stock and crown, etc.. Regression analysis is done by the computer according to these sample value. In analysis, we find that in the caculation equation of the crown volume, the crown-hight and crown-diameter are two dependent parameter. That is, when the variety is determined, crown-diameter and crown-hight have certain relative relation, As long as one is known, the other can be caculated by this equation. This makes it possible for us to simplify the measurement of 3-D quantity so that it may be done on the 2-D plane. According to this idea, we continue the regression caculation to get the relative relations of crown-diameter to volume of many types of arbor and bush.In this way, after interpreting the tree variety and number of plants on the photo, we may caculated the GBQ.For excample the following is the relative equation of crown-diameter (D) to crown-volume (V) of cinnamon caphora in Shanghai, which is established on the basis of the regression of sample value of 50 samples.

$$V = 103.01\ D - 555.17$$

According to the analysing result of actual samples, with the principle of not only making tree variety have universal nature, but also making it easy to interpret the aerial photo and to code, we divide the greening plant varieties into 14 catagories. Then we combine the equations of these 14 categories and the inquiry program with the three codes of the number of trees, crown-diameter and tree variety as the indix, that is, establish the so-called function block of GBQ statistical model. The function block is the core of the GBQ information library, the quality of the block is vital to the accuracy of GBQ statistics.

2. Establishment of GBQ information library and output function

The basic form of the GBQ information library is still mainly grid type . The basic map to establish the library is subregional 1:5000 greening present situation map. On this map, the grid of lcmxlcm (actually 50mx50m) is drawn out as the basic unit to collect data. The coding method, file form and structure of this library are exactly the same as those of the 2-D GOR data library. This will ficialitate the interchangeable visit between the two libraries, relative analysis and image overlapping. It can also avoid certain unnecessary repeat work.

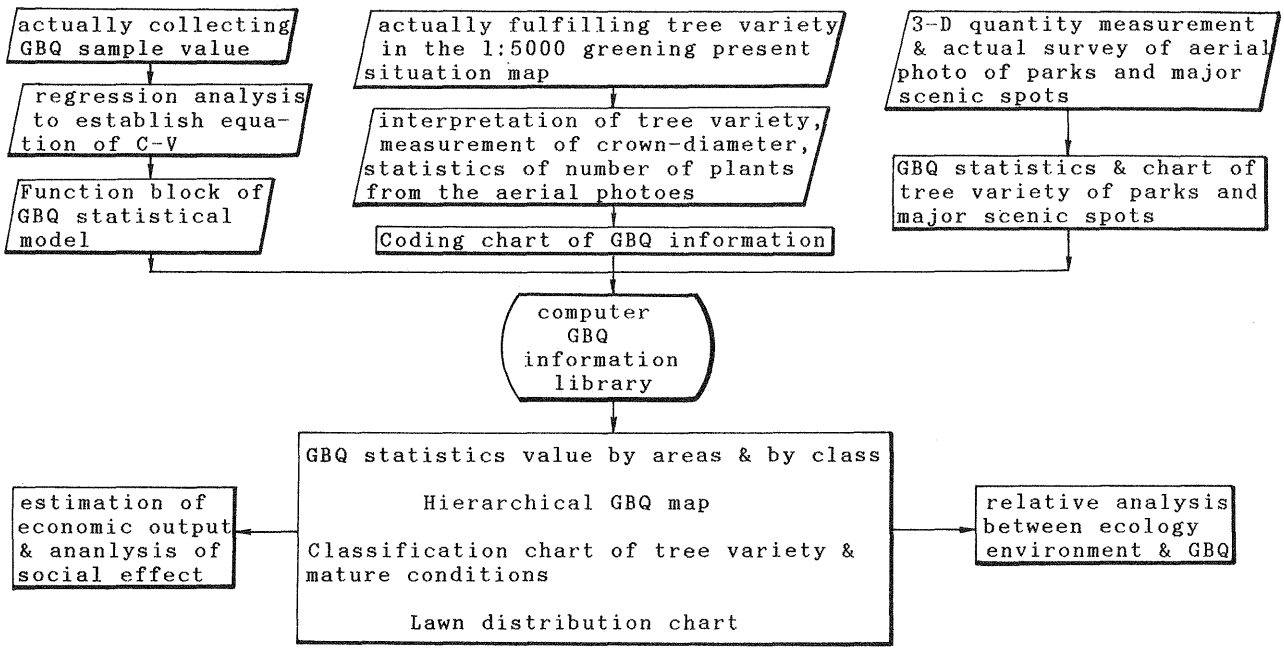
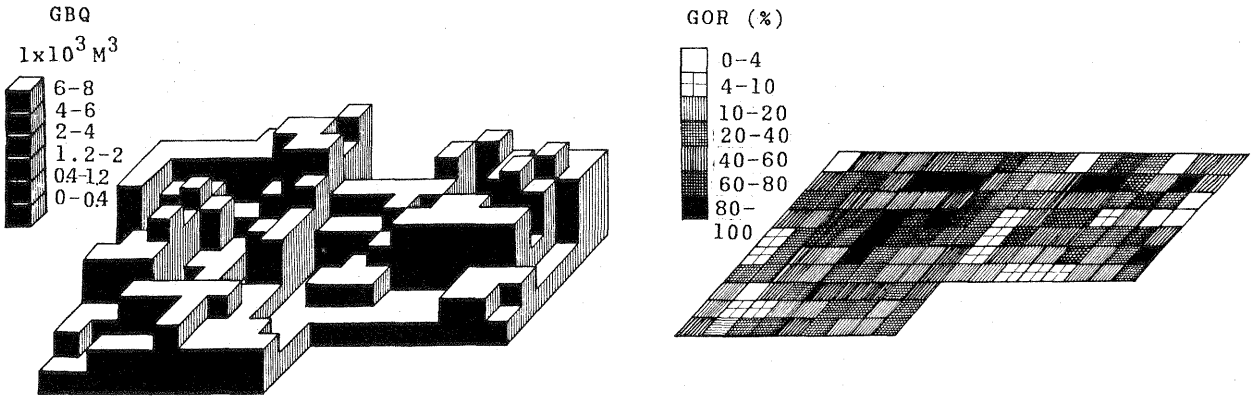


Fig. 4 Frame-diagram of the working procedure of establishing the 3-D GBQ information library



(a) GBQ chart (b) GOR chart

Fig. 5 Greening overlay rate (GOR) and green biological quantity (GBQ) chart of a small experimental zone in the southwest of Shanghai

On the aerial photo, we provid a lcmxlcm grid which is in conformity with that on the map.After interpretation of the aerial photo, four codes are programmed in each unit, namely the number of plants, average crown-diameter, tree variety code and lawn area and these codes are directly marked on the related grid to make up the so-called "GBQ information coding chart".

Fig.5 is a comparison between the greening overlay rate and GBQ of a small experimental zone . It shows that although the GBQ and greening overlay rate are closely related, the dimension-grade of the GBQ is greatly variable in the lawns, bushes and woods, where the greening overlay rate are identical. This variation must be relative with the difference in environment effects between these types of green land. That is to say, the analysis of the greening ecological environment effect and the estimation of the economic output by GBQ information have better relativeness and higher accuracy than by greening overlay rate.

Chart 4 shows the working procedure of the establishment of GBQ information library.This library has the major output functions of carrying out statistics of GBQ by region and by class and charting GBQ map. If statistics are done only for the GBQ of evergreen plants, the winter GBQ of the city may be given so as to compare the environmental difference of the city between winter and summer.If the experimental valuen of the greening micro enviromental effect of certain area is inputted, analysis of the greening environmental ecology effect of the regions or the whole city and quantitive estimation of the greening economic output of the whole city may be carried out.

III. Establishment of Management Information Library of Special Greening Areas

Both the above mentioned 2-D GOR data library and 3-D GBQ information library belong to macro library with medium scale (unit size: 50mx50m). They are mainly used in the macro planning management of urban greening and analysis of greening ecological environment of large areas. However, this kind of information library appears to be too rough for some of the special greening areas where the plant varieties are rather complicated such as parks, some of the street gardens and major scenic spots.In view of this,we carry out experiment for the establishment of the management information library with large scale of such special greening area. Compared with the above mentioned two libraries, this type of management library with large scale lays more emphasis on the micro garden view planning and horticultural technology management, for excample it stores such information related with the garden landscape and horticultural technology,as name of a certain plant,coordinate of tree stock, standing conditions, time of planting (tree age), crown diameter, crown shape,stock diameter,blossom period, fruitbearing period etc.. One may inquire and take out the related greening information of the greening areas managed by means of dialogue on the computer screen and may see the landscape effect of plant group from different angles to take screen-type garden landscape designing and planning and may see the entire planning effect of the district greening.

1. Preparation of plant distribution map and collection of plant information

The experiment of the establishment of large scale management information library of special greening areas is started from Shanghai Botanical Garden and Great View Garden. The library of Shanghai Botanical Garden emphasizes horticultural technology management. The information includes types of plant, standing conditions, time of planting and growth situation and so on. The library of Great View Garden emphasizes garden landscape planning. The information stored and output functions include layout and structure of whole garden,

selection of best view angle, drawing of three dimensional landscape view, etc.. In the following, we will cite the management information library of Shanghai Botanical Garden as an excample to introduce the method of establishing the management information library of special greening areas.

Shanghai Botanical Garden is the largest urban botanical garden in our country. It occupies an area of 800,000 square meters and has nearly 200 varieties of plants, including almost all the typical plant varieties in the southern cities of our country. It is a comprehensive garden that combines horticultural research, planting and sales and sight seeing. That is the reason why the management work is rather complicated.

In order to meet the accuracy requirement for the screen designing and mapping, the center of the tree stock has to have a correct coordinate in the library. Thus we place the control network and prepare the plant distribution map according to the measurement accuracy requirement for the 1:500 scale map.

First we place the city grade 3 traverse and spur traverse on the main roads of the garden. The all distance on the garden is measured by steel rule. Then we punctuate the control points on the aerial photoes and map board and at the same time, actually investegate outstanding trees, independent trees, rare trees and ancient trees and mark them on the aerial photoes. We correct the photo errors by these control points and translate the investigation result to the map board. At the same time we draw out the overlay scope of arbor and bush crowns, water, roads and buildings to make a plant distribution map. According to the aerial photo interpretation, actual investigation and garden archives, we further divide smaller and more simple arbor and bush groups in the overlay scope of arbor and bush crowns, and then investigate and record the name, standing conditions, time of planting, stock diameter, crown shape of outstanding trees and arbor and bush groups. At the same time, we draw out kilometer grid according to the control points. Then we further sub-divide them to 10mx10m grid to measure and mark the GOR and GBQ etc. in each grid, before charting the so-called " plant information chart", which is the main basis for establishing the library. In those areas where accurate garden designing is necessary, the method of actually placed building square grid may be used to actually measure the data to be directly inputted into the computer.

2. The establishment of management information library of special greening areas and output functions

Based on the plant information chart, the two input forms namely grid and poligon are used. For the grid-type GOR and GBQ data the grid-type input form is used. As to other point-and-line-form objects and square image, poligon-type input form is used. When certain software for inquiry, display, amendment, drawing is provided on the basis of geographical information package , the greening management information library for this special area is preliminarily completed. The working procedure of establishing the library is shown in Fig.6.

Through connecting the control network between the garden's and the whole city's, we make the plane coordinate of the management information library of various special greening areas be the same as the coordinate of the greening information library of the whole city, and adopt the the uniform codes. In this way each management information library may be inlaid in the 2-D GOR data library or 3-D GBQ information library at any time.

In the subsystem of horticultural technology management, a number of charts of the standing conditions, GOR, GBQ, growth case of the said special areas may be charted by means of some drawing software. And in the subsystem of garden landscape designing, the techniques such as amplification of sub-region, screen wandering may be used to display the landscape or image. Use may also be made of visual enlightening technique to imitate the situation in

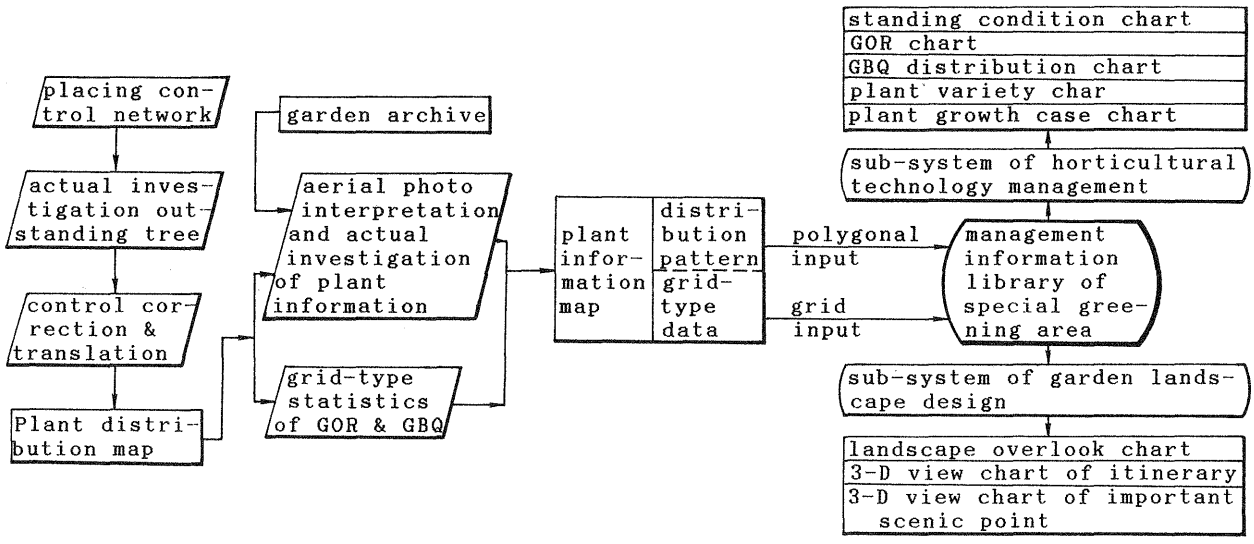


Fig. 6 Frame-diagram of the working procedure of establishing the management information library of special greening areas

which an inquirer is passing through the garden.We are considering further adopting experet system to select,revise and reject various designing proposal provided by the computer through screen dialogue, and to feed back the revision into the knowledge base so as to further improve the landscape designing function of the expert system.

IV. Reseach on the Relativeness between Urban Greening and Ecological Environment

To further study the relativeness between greening and ecology environment, we input some environment quantization information that is related to greening into the computer as the environment sub-library of greening data / information library. These environment quantization information includes such sample values as population of the area,construction volume rate, type of surface touching with atmospher, heat radiation temperture, noise, toxic gases, chlorophyll content,etc.. The following are two analysis excamples. excample 1 analyses the influence of greening on urban heat field. Excample 2 analyses the counter-action of urban environment on greening.

Excample 1. Reseach on the relativeness between urban greening and heat radiation field

As the surface touching with atmospher of the city has different physical structures, the heat radiation features are different. We match the heat scanning data of the TM heat image with the typical information of the surface touching with atmospher and then carry out relative analysis of the radiation temperature of various types of the surface touching with atmospher to get the following regression equation:

$$Y = 28.26671 + 4.7966\,b - 6.1044\,w + 0.6549\,g + 7.0997\,c + 4.2719\,t$$

In this equation,

Y -- macro radiation temperature
b -- building volume rate
w -- water area rate
g -- greening overlay rate
c -- area rate of cement surface
t -- area rate of roof tile

It can be see from the equation that in all kinds of earth surface structures, the coefficient of "g" is the lowest and is lower than those of other items by one order of magnitude. This means that if the urban greening overlay rate is increased (g value is increased), proportion of all kinds of earth suface structures will be smaller correspondingly, that is if b, c, t become smaller correspondingly, the Y value will be smaller too. i.e. the macro radiation temperature value will be smaller.This shows both the evaporation effect of green plant which will consume radiation energy and anti-greenhouse-effect of green plant which is caused when green plants absorb much carbon dioxide.Both the two effects have the physical function of adjusting the temperature near the earth. This kind of physical function is also proved in Fig. 7. Fig. 7 is a GOR chart of Shanghai and an overlapping isotherm chart which is obtained from the TM heat image. It can be seen from the figure that the radiation temperature of Shanghai heat radiation field is in negative relation to the GOR. The low isotherm areas of the heat radiation field all lie in high GOR areas,which are the areas of old-style garden residences and consulate areas. In the meanwhile , they belong to low

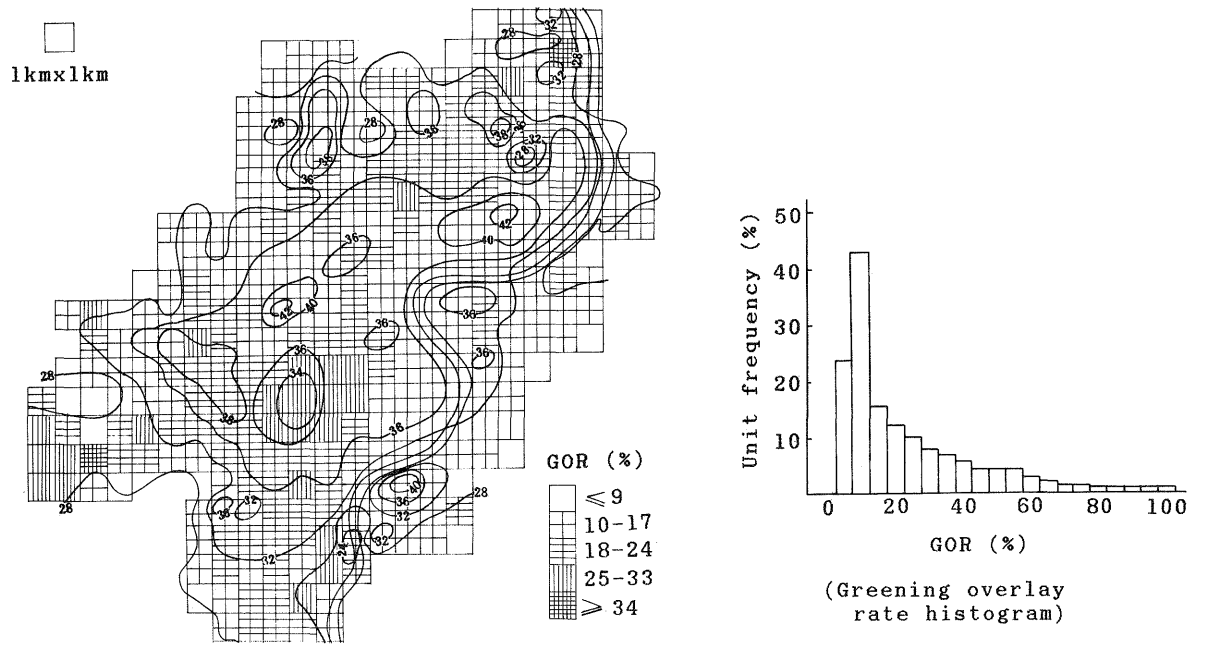


Fig. 7 Overlapping chart of greening information and radiation heat field of Shanghai

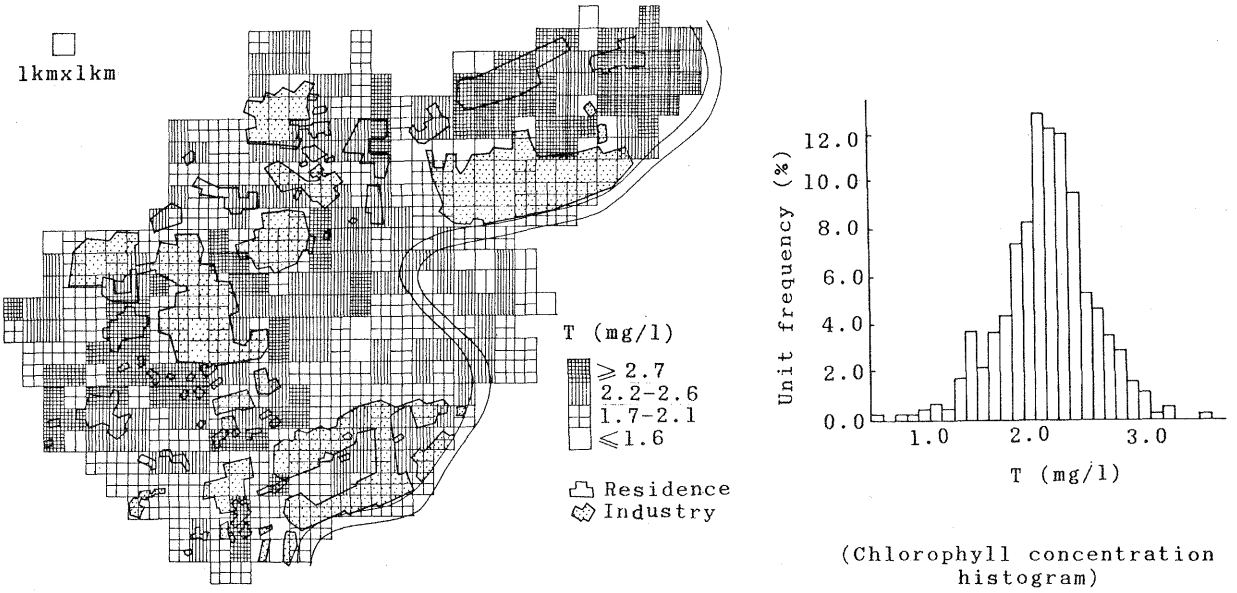


Fig. 8 Overlapping chart of chlorophyll T value and residental and industrial areas distribution

construction volume rate areas. The high temperature equal value line areas of the heat radiation field all lie in low greening overlay areas.These areas are located in the three high temperature inustrial societies and the high construction volume rate areas of Shanghai.

Excample 2. Research on the relativness between plant growth and environment quality

The urban environment pollution , particularly the atmosphere pollution, exerts great influnce on the growth of plants. However except in accidental events, the atmosphere pollution exerts influnce on various kinds of plants in a slow, prolonged way, and the common tree varieties in urban greening generally have strong resistance, so that the appearce can not show the influnce of the atmosphere pollution. In order to evaluate the influnce of atmosphere pollution on the greening plants in Shanghai in an all-round way, we select the backbone tree variety, platamis orientalis, from the sidewalk trees in central area of Shanghai as the major research object and select from the many growth norms of plants the norm of chlorophyll which can better reflect the growth conditions of plants to carry out the measurement and analysis.

Through the measurement of 758 effective samples which are distributed in the whole city, we obtain the chlorophyll concentration value T , and input the T value together with the coordinate of sampling points into the computer to establish the primary data library. Fig. 8 is a distribution chart of grid-type chlorophyll T value exported by the computer, and an overlapping distribution chart of Shanghai urban residental and industrial areas. It can be seen from this chart that the high value area of T value lies in residental areas. This means the exchange action of human breath and plants' metabolism is good ecology recycle which is beneficial to plant growth. On the contrary, the low T value area lies in the industrial area. This reflects bad influnce of industrial pollution on plant growth.

Concluding Remarks

Since the urban green ecology system is an important part of the entire urban ecology system and the urban green ecology quality is the result of the comprehensive influnce by many factors in the entire urban ecology system, reseach on district green ecology quality of the city enables us to indirectly evalute the environment quality of various districts of a city. Therefore the establishment of urban green ecology informatin system not only is useful to the investigation and management of green ecology information itself, but also may be used to monitor and evaluate the general environment quality of various districts of the city.