Type, quantity and layout of urban peripheral green space

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Abstract: Urban peripheral green space (UPGS) plays more and more important role in sustaining urban physical and ecological environments. In this paper, a preliminary classification of UPGS was presented for seven types and quantity index of UPGS was discussed tentatively. The quantity and layout problems in urban peripheral green space, and the several principles were mainly discussed in urban ventilation and sanitation, recreational opportunity and landscape ecological structure.

Key words: Peripheral; Green space; Quantity; Layout
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Introduction

Urbanization and environment degradation

Cities all over the world have shown a very rapid developing trend in the 20th century. There were only 16 cities with population of more than one million in 1900; however, there had been 235 cities in 1980 with incredible increase. It is estimated that half of the world population will dwell in urban areas by 2000, and 62.5% of world total population in urban areas by 2025, when there will be 135 cities with over 4 million population, which include some metropolises with 20-30 million dwellers. As the corollary of economical and technical advance and the inexorable trend of human society development, however, the urbanization has great impacts on human survival and living conditions. Standing at a perspective from urban region, a negative environmental effect at urban region scale is caused by the high aggregation in urban space and population, which is beyond the self-recovery capacity of natural systems, and so the natural landscape types such as wetland, lake, forest and natural river courses in urban areas will disappear; the functions of natural communities and ecosystems retard, bio-species quickly reduce; landscape diversity apparently decrease. It is necessary to properly use natural patches in urban peripheral area as supporting system to ameliorate and sustain urban ecological environment (Dong 1991).

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Urban peripheral green space

Urban Peripheral Green Space (UPGS), which has greater impacts on and ecological linkage with the urban inner environment, is a rough green ring with a certain distance outside the urban built area. These green matrixes, with the characteristic of photosynthetic regeneration and keeping bio-diversity, can purify the pollutant from city and have the abilities to sustain urban total physical and ecological environments. UPGS is spatially located at the urban or rural fringe. An ecotone with very unstable characteristics varied in space and time, which caused by the factors of population structure, economical pattern, energy and materials exchange, and living standards (Wang 1990). So, compared with urban inner green space, UPGS is more difficult to be controlled and coordinated because of its complex and changeful land-use, and its planning is partial to protection and conservation.

The significance of UPGS planning

The city developing and sprawling is mainly realized by encroaching the neighbor farmland, forestland or derelict lands in urban fringe, except for regulating and optimizing itself land-use structure in inner city. Therefore, through UPGS planning, we can in advance protect or conserve some green spaces with a strategic significance in urban fringe area and properly allocate natural recreational spaces that make an organic combination between inner and outlying green spaces and shape a complete urban green spaces system. This pre-planning activity has a great strategic significance for ever-developing cities to form a healthy green space with a sound ecological basis. On the other hand, UPGS planning can also provide a professional planning expertise for city master and development planning, to help planner properly and scientifically

consider the layout of urban green spaces, avoiding of aimless construction, setting up a good relationship between urban and rural development. In planning practices, traditional green space planning often mainly took consideration of scenic areas in outskirts and considered little investigation and research on the environmental green spaces in outlying belt. Study on the planning methodology of UPGS will also be significant to planning practice.

Types of UPGS

According to land-use characters, UPGS can be divided into the following types:

(1) Productive green spaces are mainly agricultural lands, including farm, forest, ranch, orchard, vegetable and fishing sites, which are encroached easily to become urban-use lands without green character.

(2) Recreational green spaces are similar to urban inner open spaces in character and function with higher scenic and recreational values, mainly including regional or suburban parks, suburban scenic areas, forest parks and large recreational water reservoir.

(3) Environmental and sanitary green spaces are used as environmental protection in need of city sanitary protection, which are sanitary protection belt, urban ventilator corridors, separated protective belt of industry, etc..

(4) Natural and ecological protection green lands, often protected by related government agency and regulation, are designated for biological and landscape diversity or for scientific research and education in urban region, which includes wildlife habitats, wetlands, unusual geological landscape, etc..

(5) Derelict lands include uncultivated land, barren slope, wilderness, and wasteland, etc..

(6) Unsuitably developed Lands are those with unstable geological formation, liable to be impacted by various disasters or too difficult to construction, such as the steep hill-land, belt, flood plain, slide land, etc..

(7) Lands for city public facilities in outskirts are the groundwater protection area for living and drinking, the sanitary landfill ground for city garbage and the corridors for transmission and power lines. These lands are often prohibited by facility usage regulation.

Some types of green spaces such as ones of recreation or natural ecological protection in urban region are much steadier in character, and have less effect from urban sprawling. So the type of lands unsuitable for city development can be used for agriculture, environmental and sanitary protection or outdoor recreation. In contrast, the land-use characteristics of productive green space with great amount and wide dispersal out the building area will change greatly during the city expansion, which is always realized by encroaching neighbor lands.

Quantity and allocation of UPGS

Quantity index of UPGS

Calculation of inner city green spaces

With the expansion of urban built area, the peripheral green spaces will turn into urban internal lands with clear and specific land use. The indices of average public green space per person and greenery ratio will increase with the rise of land use index. The increased part comes from UPGS, and the amount can be calculated with the following methods:

Ratio of green areas:

$$S_1=a_0\,(n_1\%-n_0\%)+n_1\% \tag{1}$$

Where:

n_0%, n_1%--urban present and planned greenery ratio respectively;

a_0, a_1--area of the built and planned region (hm^2).

Average public green areas:

$$S_9=M_1\times P_1-M_0\times P_0 \tag{2}$$

Where:

P_0, P_1 --present and planned population (ten thousand persons);

M_0, M_1 --the present and planned area of public green spaces per person (m^2/one person);

S_1, S_9-- the minimum area indexes of UPGS (hm^2).

According to the property of UPGS, three green space types, such as recreation green space, natural and ecological protection and unsuitability for urban development, may be totally remained and often firstly turned into the public green areas.

Calculation of environmental function

How many peripheral green spaces should we need to sustain the essential ecological environment in urbanization region? Oxygen and water balances are most related to the green spaces. However, it is not to say that the other problems are not important. For example, which level of diversity of bio-species can be an essential threshold for a city in maintaining a better ecological environment? It is may be an important question, but it is too difficult to discuss right now. An urban ecosystem study on the west Berlin by Germany researchers had shown that the underground water was a factor that should be consider in urban future land-use planning, and a degree of

vegetated area should be kept in city for groundwater recharge (Shi *et al.* 1996). Professor Dong also gave a suggestion to determine ecological equilibrium belt from the average water use amount (Dong 1991). This paper mainly discussed the urban oxygen balance. The Oxygen consumed in urban area can be replenished by air flowing and mixing. Green landscape is composed of forest, shrub, grassland, cultivated land and water body in peripheral belt can certainly become an oxygen-making spaces. How many areas of the open spaces can compensate the consumed amount of oxygen by a city? A ton dry weight of net biomass produced by green space often consumes 1.50-1.80 t carbon dioxide and releases 1.10-1.30 t oxygen in general. Ecosystem with different components often has different net primary productivity. Based on an analysis of type and composition of peripheral green space, the primary average net productivity (W) can be calculated by:

$$W = \frac{\sum F_i \times P_i}{F} \quad (3)$$

Where:

P_i—annual net primary productivity of landscape item i (t/hm^2 ·a^{-1}). A list of P_i of different ecosystems can be referred to Forest Ecology , (Li 1981);

F_i—area of landscape item i (hm^2);

F—total area of green landscape (hm^2).

If city annual consumed oxygen amount is V_0. The needed area of green balancing space (S) can be estimated by following equation:

$$S = C \times \frac{V_0 \times F}{K \times \sum F_i \times P_i} \quad (4)$$

Where:

S--the needed area of green balancing space (hm^2);

k—oxygen releasing coefficient in forming a ton dry net biomass, the value is about 1.10-1.30;

C—coefficient of local wind velocity;

V_0—amount of annual urban consuming oxygen (t), the calculation can be referred to the method in Urban Ecology , (Men 1986).

General principles of UPGS layout

Based on an evaluation of outlying land-use and the relationship between urban green space layout and city development at urban region scale, a good city green form or structure could be shaped, and aimlessly occupying peripheral open space only for economic benefits or partial interests could be avoided. F.S Chapin and E.J. Kaiser (1979) advocated that the land use design process should begin with the allocation of open space. Because: 1) the normal market-oriented urban growth process does not provide enough open spaces in the right locations to perform critical functions for the environmental and human-activity systems; 2) It is recognized that the environmental problems to be solved before layout are costly and often inefficient; 3) Open space allocation is easier than allocation of other land use. Many location requirements of open space can be expressed in terms of physical characteristics that already exist and need to be conserved (Chapin *et al.* 1979). This is in contrast to location requirements of industry, housing, commerce and so on, which are highly interdependent and need to synthesize with various determinants. From an ideal view, the more the amount of peripheral green lands is, the wider they distribute, and the better the urban ecological environment is. However, city needs spaces to develop, and will naturally take up suburban farmland, and woodland. It is necessary to provide an optimal allocation structure of UPGS, which has greatest potential for urban sustainable development and is most feasible in operation. This is the question about best layout. With the city expansion, open spaces in near-suburb will enter into the built area, and their function will be taken place by the ones in far-suburb. It is also necessary to deal well with these dynamic relationships among the open spaces in inner city, near-and-far suburb with a holistic view.

Amelioration of city sanitation and local climate condition

UPGS allocation should permit fresh and moisture air from green space to enter into inner city. Allocating green space along the annual most frequent wind direction is good for city air exchange and purification. On the other hand, the most unfavorable climate condition also needs to be considered. City has characteristic with the "heat" and "dry" islands, and the effect can be more apparent in the larger city. Layout or preservation of large scale open spaces, especially the large water bodies at the up-wind location along the summer main wind direction can help the cool and moisture airflow enter into the inner city during the hot and dry summer. In seasonal wind climate, the serious air pollution often takes place during the late autumn and the next early winter. In same air pollution intense, when there is a dominated urban weak wind, frequency intense of influential air pollution is decided by average velocity and direction frequency of weak wind. Raw wind records could be re-classified by 16 wind directions in 1-7 m/s wind velocity (Wang 1992).

Reasonable and even dispersal of recreation space

Green spaces were not evenly located in most cities, but layout of large scaled green spaces could be adjusted by the UPGS planning. Basic adjusting principle is to make green spaces dispersed evenly in general. With the urban expansion, the green space system in old city can be adjusted to a more proper, whereas the new city may do better further. Green space system with enough quantity and proper dispersal can offer much more chance for citizens contacting with and enjoying in nature settings. Therefore, the UPGS near the inner city district without enough green areas should be considered firstly and conserved and controlled well. This is a principle of partial compensation based on a general even distribution of green space.

Better landscape ecological pattern in function and structure

UPGS planning is a type of macro-controlling planning at urban region scale, dealing with green landscape elements, which are essential in urban ecological environment function. Green matrix and patches, as main primary producers and wildlife habitats, are significant to urban human-system. Large natural vegetation patches have many important ecological functions, for examples, conserving aquifers and inter-connected stream networks, sustaining viable populations of most interior species, providing core inhabitancy and refuge for most large-home-range vertebrates. Smaller natural vegetation patches could be taken as the "refuge" for some species to be preyed and as the "stepping stones" for species dispersal or recolonization. The optimal patch shape in ecology is a large core area with curvilinear edges and narrow lobes, because the compact or circular patch is better in protecting internal species, and curvilinear edges give much more survival opportunities for multiple-habitat species to escape from predators. Corridor, as linear landscape element, can connect isolated patches and divided landscape. Setting up a corridor system with different width can accelerate the recolonization and reduce the local distinct rate. Except of considering sanitary and ventilation conditions or providing much more convenient recreational spaces, we also need to apply landscape ecological principles to guide UPGS planning with a reasonable ecological objective which based on an analysis of present green spaces in urban region. For example, we can provide new corridors to complete green networks, and add "stepping stones" in more difficultly connected green spaces, which can provide opportunity for species dispersal and re-colonization. In doing so, we can make the green space layout with better ecological structure and finally upgrade the levels of bio-diversity and the quality of ecological environment in urbanization area.

Conclusions

Urbanization is an irresistible trend of social development. However, the companying problems are also startling. During city evolution process, it is a significant issue, that in which dire action the city will develop, and which method will be better for shaping a healthy and reasonable ecological environment. This paper presents a preliminary discussion on this related urban peripheral green space. At first, as far as the land use is concerned, UPGS is classified into seven categories: (1) Productive green space; (2) Recreational green space; (3) Environmental and sanitary green Space; (4) Natural and Ecological Protection Green lands; (5) Derelict lands; (6) Lands unsuitable for development; (7) Lands for city public facilities. Then, a calculating method according to inner city green paces and environmental function has been formulated to calculate quantify UPGS. And finally, it takes an incisive view on the planning principles of UPGS from the following three aspects: (1) Amelioration of city sanitation and local climate condition; (2) Reasonable and even dispersal of recreation space; (3) Better landscape ecological pattern in function and structure.

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