Index System of Ecological Planning of Urban Greenspace in Northeast China

Yutang Lin* and Yu Tang**

1 Northeast Yucai Foreign Language School, in Shenyang, Liaoning, 110179
2 Institute of Architecture and Planning of Shenyang Architecture University, in Shenyang, Liaoning, 110168
Email: tangyu1@126.com; linyutang2002@qq.com

Abstract. Nowadays, scientists generally apply routine index of greenspace system planning in urban greenspace planning and design. Along with its development, the ecological planning plays a more and more important role in urban planning of greenspace. This article attempts to establish a primary ecological index system of urban greenspace in northeast China by extracting some ecological index from the usual quantitative indicators, the ecological planning of greenspace heterogeneity, and diversity of the system and structure of urban greenspace system etc.

Keywords. Index System, Ecological Planning, Urban Greenspace System.

1. Introduction
Ecological planning of urban greenspace improves the urban ecological environment and enhances the urban sustainable development, so in the urban planning, greenspace ecological planning is of great importance. In an ecological planning of urban greening system, you will need to establish a set of programming according to the content of planning.

Planning index has been the problem of urban greenspace system planning in practical work, the key point of greenspace ecological planning. China is currently covered by the provisions of the ministry of construction for greenspace index per capita green area index and the percentage of the greenspace of urban land, divided into the greenbelt area per capita, per capita public green area, the rate, green coverage rate. These are regular urban greenspace system planning.

2. Basic Principles to Construct Index System
To analyze urban ecological greenspace system is a very complex issue, which is related to multiple levels and goals. Because of the differences in regions, climate, culture etc., every city requires diverse values of index systems. In the experiment of Ecological planning of urban greenspace, we follow these succeeding principles to construct the index system:

(1) Systematic principle: To analyze the comment program in the system, we remarked the thorough condition of the program, ensuring the credibility and comprehensiveness of the comment program.

(2) Stratified principle: the system of program should be clearly stratified and logical, which helps to grip main factors and submain factors, ensuring the validity of comment.

(3) Qualitative and quantitative principle: the program includes not only qualitative description but also quantitative analysis. We should quantify problems for applying mathematical models in order to ensure the objectiveness of comment.
3. Index System
The index system of urban greenspace is divided into three levels: the first level is overall controlled index; the second level is regional controlled index; the third level is quantitative index. Combining qualitative and quantification raises comment index system (figure 1).

3.1. The Diversity and Heterogeneity of Urban Greenspace System

3.1.1. The Diversity of Greenspace Landscape (Landscape Size and Landscape Comparison).
(1) Spatial size. Spatial size in landscape ecology refers to length, area or volume, represented by the smallest unit in the space. The landscape size of greenspace system can be measured by the average diagram of all existing patch [1-4]. In general, we differentiate rough-stuff landscapes with thin-stuff landscapes. The rough ones with thin regions are the most beneficial ones to gain ecological rewards of big patches and for species, including human, to survive, offering environmental resources and conditions [4].

(2) Landscape comparison. This refers to the extent how diverse adjacent landscape units are. If neighboring units are obviously different with a clear and narrow transition, it will be deemed as a high landscape comparison, and vice versa. Landscape comparison is only an index to depict the characteristic of a landscape, and its number is neutral. The delta landscape, where some animals live, is an example of high landscape comparison. When Tidal flats bare land, fresh grass, alkaline, willow reeds and rushes choose habitats; they always have some preference with the landscape comparison. Therefore, we are not supposed to alter the landscape comparison when we design ecological planning of greenspace system.

Index to measure landscape comparison include inverse different moment and contrast.

3.1.2. Heterogeneity of Greenspace Landscape. We study the heterogeneity of greenspace landscape initially with patches, statistically analyzing every patch and the whole of greenspace system. Mainly applying some landscape ecology index, we describe the heterogeneity from different aspects: isolation, accessibility, interaction, dispersion [1]; heterogeneity, diversity, fractal, contagion, fragmentation, and affinity [5] etc.

3.2. Structural Network and Integration of Urban Greenspace System

3.2.1. Patch. Number of patches: congeneric patches’ sizes and areas in landscape always decide the motions and distribution of species among the landscape. According to the research, a single large patch includes more species than some patches whose combined area equals the big patch’s one [6], but if the scattered range of the latter is wide, we will discover more:

(1) Species in those small patches. This is because all patches contain similar margin species, while large ones also contain sensitive internal species. Widespread patches scatter in different flora or fauna regions. Forman etc. [7] deemed that to reach the maximum of species variety in landscape, it required at least 3 large patches nearby. The number of patches in landscape is deduced by these following standards separately: every community’s number of patches, the origin and genesis of patch, the size of patch, and the shape index.

(2) Patch area: we usually measure it in squared meters or hectares. The smallest and the most suitable patch area are always of great importance in a planning. In general, material and energy of a patch is positively related to its area, which is species double while the area times ten, and the species quadruple while the area times 100. In other words, when area times ten, the including species power two, where two is the average number, and its index is among 1.4 to 3.

(3) Shape index: shape index (S) has a great influence on community size and species abundance. S can be represented with the ratio of margin length to length of circle with the same area. The shape is increasingly complex with increasing S value.
In the research of landscape ecology, shape index is one of the common quantitative ones. Besides, there are still other index to depict the shape index, such as elongation, circularity, and compactness etc. [4]. The shape and orientation of a patch have a great impact on spreading or foraging of flora and fauna which crosses the landscape [8]. For example, forest patch and gap shape play important roles in wildlife’s habitat and emigration [9], while animal habitats are basically different in shape, such like oval, penannular, and strip [10].

(4) Inner-outer ratio: which refers to the ratio of inner marginal strip area to outer one. Its ecological significance is that the inner part of patch differs in living condition (such as light, temperature, food, predators etc.) with the marginal part, leading to difference in species composition. In general, a high inner-outer ratio promotes some ecological process, while a low ratio encourages other process.

3.2.2. Corridor. (1) Corridor width: according to some researches [11], when the corridor width is 12 meters between tree corridor and species variety, an obvious threshold exists. When the value is 3-12 meters, the relation between corridor width and species variety does not exist; however, for those with a width more than 12 meters, the herb species variety is for two times the ones with narrow width. Marginal species have nothing to do with corridor width. It is reasonable that corridor whose width is less than 12 meters is named linear corridor, and whose width is over 12 meters is named strip corridor.

(2) Curvature: it is the extent how curve a corridor is, and it is vital to the stuff in landscape. We can use fractal dimension to express curvature [12].

(3) Intervals: consecutive corridors always contain some intervals, which play important roles in the flow of species that live along or through the corridors. Its measurement can be denoted with the number of intervals of a unit corridor’s length, and the unit is upon dimension of the object.

3.2.3. Network. (1) Network node: the intersects or ends in a greenspace system network are also named as nodes, serving as relay stations instead of destination. Because of the climate change on network node, such as decreasing wind speed, lots of shade, increasing air or soil moisture, highly organic soil, or little temperature alteration, nodes are locations where animals have a rest during migration and which offer them food.

2 Grain size: the landscape factors in a greenspace system network, together with size, shape, condition, species abundance and human activities, have a great impact on the network. Because animals are sensitive to the average distance or area of network lines when they are foraging, protecting nests, or breeding, grain size turns out to be a vital characteristic of the network. Grain size is measured by the average distance of network lines or its inner area.

(1) Network connectivity: the extent of how well connected between green corridors and the nodes is called network connectivity, which is the standard to test whether the network is complex or simple. There are two common approach to calculate: γ index approach and α index approach.

(2) α index of network connectivity: the extent of node loop’s existence. Loop refers to the circular line which offers alternative ways to resources. The α index is the ratio of actual number of loops to the maximum possible number of loops.

3.3. Planning Quantitative Index

This kind of index confirms quantitative index, for the convenience to control and operate. Greenspace area, area per capita, public area, and greenspace rate are index t analyzed and calculated within urban greenspace of two-dimension; multilayer greenspace quantity, multilayer greenspace quantity per capita, greenspace of three-dimension, and greenspace of three-dimension per capita are all analyzed and calculated within urban greenspace of three- dimension.

(1) Greenspace area: it is the sum of all the urban greenspace area, including park greenspace area, production greenspace area, protection greenspace area, and adjacent greenspace area etc.

Public greenspace area: it contains public artificial greenspace, natural greenspace, and greenspace which belongs to organizations and corporations.
Public greenspace area per capita: it refers to the quantity of every citizen’s possession of urban public greenspace area, represented in squared-meters per individual, and the ecological standard should be equal to or greater than 11 squared-meters per individual.

(2) Public greenspace area per capita = public greenspace area / urban nonagricultural population

Greenspace rate: the ratio of urban greenspace area to urban occupied area.

Multilayer greenspace quantity: it means the sum of greenspace area from all layers (arbor, shrub, grass), an index which reflects the total covered area of leaves. Its unit is squared-meter. Furthermore, it emphasizes the ecological function and effect of greenspace, and make up for the flaw of present flat greenspace index. It aims at the functional difference of varied flora species and varied greenspace structure. Making the total covered space of all greenspace layers the standard, multilayer greenspace quantity reflects the extent of ecological functions.

Multilayer greenspace quantity per capita: the ratio of multilayer greenspace quantity to urban nonagricultural population.

(3) Greenspace of three-dimension: it refers to the space stem-plants occupied, which unit is cubic meters. In 1998, Shanghai government came out with this concept when they were investigating urban park greenspace and analyzing the environment with remote sensing technology. Compared with index of two-dimension, index of three-dimension better reflected the difference of urban greenspace’s impact on spatial structure, so it comprehensively and accurately analyzes the environmental benefits and the total needed urban greenspace.

(4) Green structural index: index, including arbor quantity, shrub quantity, evergreen trees quantity, covered ground area, deciduous trees area etc., mirrors the quantity and characteristics of urban greenspace structure and plant materials which construct the greenspace.

4. Conclusion
Ecological planning of urban greenspace system is a successive planning of ecological landscape. The ecological function of a habitat cannot finish its perfection and balance in a short period, and the time scale of ecological landscape’s growth is longer than that of urban development. Therefore, in contrast to the divided time of overall urban planning, as the time scale to layout index, the ecological planning should be long-term. Given that it also considers the overall urban planning, that of urban greenspace system also takes its own structure into consideration. For the specific program, which arrange greenspace model reasonably and harmoniously, we still need more analysis and experiment, combining the research of cities.
Figure 1. Urban Greenspace Ecological Planning Index System.
References

[1] Forman, R T T, and M Godron, 1986, Landscape ecology. Wiley and Sons, New York, New York, USA.

[2] Angelstam P 1992. Conservation of communities—the importance of edges, surroundings and landscape mosaic structure. Pages 9–70 in L Hansson, editor. Ecological principles of nature conservation. Applications in temperate and boreal environments. Elsevier Applied Science, London.

[3] Wiens, J A Stenseth, N C, Horne B V, et al. Ecological mechanisms and landscape ecology. Oikos, 1993, 66:369 - 380.

[4] Forman, R T T. Landscape Mosaics: The Ecology of Landscapes and Regions. Cambridge University Press, Cambridge. 1995

[5] He H S, DeZonia B and Mladenoff D J. 2000. An aggregation index (AI) to quantify spatial patterns of landscapes. Landscapes Ecology, 15(7): 591-601.

[6] Higgs A J and Usher B. 1980. Should nature reserves be large or small? Nature, 285:568-569.

[7] Forman R T T, Galli A E and Leek C F. 1976. Forest size and avian diversity in New Jersey woodlots with some land use implications. Oecologia 26: 1-8.

[8] Emlen J T, 1978. Density anomalies and regulatory mechanisms in land bird populations on the Florida peninsula. Amer. Nature. 112: 265-286

[9] Marcot B G, Meretsky V J. 1983. Shaping stands to enhance habitat diversity. J For, 81: 527~528

[10] Smith W P. 1983. A bivariate normal test for elliptical home-range models: biological implications and recommendation. Journal of wildlife management, 47:613-619.

[11] Baudry J. 1984. Effects of landscape structure on biological communities: The case of hedgerow network landscapes. In Methodology in Landscape Ecological Research and Planning. Vol.1. pp. 55-65, Edited by I. Brandt and P. Agger. Roskilde University Centre. Denmark.

[12] Milne B T.1990.Lessons from applying fractal models to landscape patterns. In: Tumer M. G. and Gardner R. H.(eds.), Quantitative methods in landscape ecology. New York: Springer-Verlag. 199-235.