Jour. Korean For. Soc. Vol. 95, No. 5, pp. 591~594 (2006)

JOURNAL OF KOREAN FOREST SOCIETY

Urban Forest Monitoring in Korea since 1991: Case Study on Daegu Metropolitan City

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Abstract : To have better urban forests in future we are focusing on two major issues like other countries. How we could have more urban forest-*quantitative approach*-against the expanding of urbanization, and how we could produce better urban forest-*qualitative approach*-to give a chance in contact with better nature for urban people. Prime surveys on urban forests have been carried out in 6 major cities since 1991, and the city of Daegu which is located on the east southern area of Korea have been case studied for qualitative approaches during last 3 years. Major species of the remnant forests were *Pinus densiflora, Pinus rigida, Pinus thunbergii* and *Robinia pseudoacacia*. Approximately 20% of the surveyed forests were lost their structure as forests caused by illegal farming, facilities and as the bare ground by excessive visitors. Generally speaking the condition of forests for biotope was very poor in overall. From two years data of monitoring of birds, we found that wooded parkways and woodland squares had more species than street tree areas. Nests were found mainly on the branch of *Zelkova serrata*, *Pinus densiflora* and *Quercus myrsinaefolia*. The size of urban forests mainly determined the species richness of birds. According to the oxygen output and carbon input by photosynthesis measurement, the capability was in order of *Platanus occidentalis, Zelkova serrata* and *Ginko biloba*. Air conditioning effects of trees through transpiration measurement was found and the quality of forests also related to the reducing of urban heat-island.

Key words **:** *urban forest, monitoring, forest quality, biotope, urban environment*

Introduction

Alteration of Korean urban forest in size and forest structure was unpredictable during last decade. Generally speaking, it was caused by simultaneous urbanization and the demand of people's visiting on urban green-space exceeds their capacity. Because of these, the condition of urban forests in Korea has been altered more than planner expected in many ways for last decade. The prime character in the definition of Korean natural environment and landscape is the portion of mountains in land(Kwon *et al.*, 2002; Kwon *et al.*, 2003).

Forested mountains account for approximately 65% of total Korean land. This means that most of Korean cities are facing the lack of flat lands for living, such as roads, houses, factories etc. As a necessary consequence, urban green-space include urban forests could be the second option because of the rapid expanding of urban areas within the limited flat land (Kim and Kwon, 2003).

Many attempts in research related to urban forests and general public's life have been tried. However, to improve urban environment in everyday life, we believe that having better urban forests might be a key issue, therefore we are focusing on two major issues. '*How could we have more urban forests against the expanding of urbanization?*'-quantitative approaches, and '*how could we produce and generate better urban forests in overall to give a chance in contact with better nature for urban people?*'-qualitative approaches. The authors believe that the first issue could be considered by administrative branches, such as the Korea Forest Service and local governments, while the second issue might be related to academical branches, such as the Korea Forest Research Institute. To have and to conserve better natural environment in urban areas we believe that monitoring on the Korean urban forests, such as vegetation and wildlife habitat, etc. is the essential approach as Ferris-Kaan and Patterson (1992) said "Monitoring should be an integral part of conservation management in for-

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ests." With these limited conditions, focusing on the improvement of the quality of urban forest could be helpful. This research has been carrying out to make balance between the quantitative approaches to have more nature in cities, and the qualitative approaches for the improvement of urban natural environment in the Korean cities.

To produce better concept for networking from outside forested mountains to inner island forests, the roles and functions of each urban forests were surveyed. According to the results, we produced several practical skills and guidelines: *How the assessment could be done for Korean urban forests;* what *kinds of natural features and elements we could have in cities*, and *To do that what we should consider at first,* etc. Based on these results, we are planning further studies on the 5 Korean major cities to generate a better guideline which is fit for local natural characteristics.

Materials and Methods

Since 1991, prime surveys on urban forest vegetations have been tested in 6 major cities, *Busan, Daegu, Daejeon, Kwangju, Incheon* and *Ulsan*, and have produced the detailed vegetation maps on 6 urban mountainous parks, *Hwangryungsan, Apsan, Bomunsan, Mudeungsan, Cheolmasan* and *Yumposan*. From 2002 to 2004, the city of Daegu which is located on the east southern area of the Korean peninsula have been casestudied for qualitative approaches in 16 sites include 5 urban forest parks (Figure 1). In Daegu metropolitan city, more than 8 millions trees have been planted since 1982, and the city is well known as one of the advanced city for urban green-space policies in Korea. The area of city were dramatically expanded from 115.65 km^2 (year 1938), 178.32 km^2 (1963), 454.95 km^2 (1981), to 885.7 km^2 (1995). Green-space account for approximately 10% of the gross area in Daegu (75,750 m^2; included not only urban forests but also other type of green-space), however most of large urban forests are locating outside of the city. In the most urbanized inner areas, urban forests are standing like an isolated island (Kwon *et al.*, 2005). Character of urban forests in Daegu can be categorized by two groups, remnants of half-natural plantation forests and tally synthetic woodlands as a part of manmade park. 16 sites on both characterized groups include street tree areas, urban forests and parks were surveyed. The focused issues were the structure of urban forests and quality as a urban biotope, roles for birds and insects, and the functions against air pollution and urban heat-island phenomenon etc.

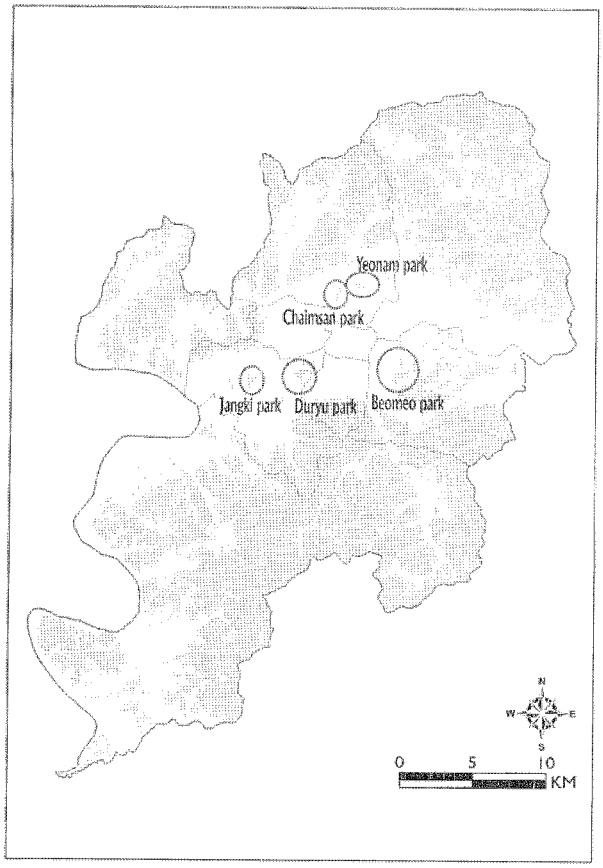

Figure 1. Locations of the studied five urban forests in Daegu.

To produce urban biotope maps as the base of urban forest monitoring, previous researches were reviewed. However, due to the two conflict characters of urban forests, we generated the modified method (Kwon *et al.*, 2005) from two previous research methods, Sukopp (1993)'s assessment method for urban greenspace and Grabher *et al.* (1997)'s approach for forests. The former could assess all kind of green-spaces in cities but it was not fit on the remnant forest which is derived from semi-natural plantation forests, while the latter was mainly suitable for forests. We produced assessment indices and methods which can be immediately applied for urban forests in other Korean cities.

To find out more effective tree species against harsh urban environment, the most popular trees planted in Korean cities were tested. For the capability in photosynthesis, CO^2 inputs and O^2 outputs were measured, and air conditioning effect by transpiration and temperature differences between forest structures were also tested.

Results and Discussion

Urban forests in Daegu were categorized into 2 characteristics. One is remnant forests survived from urbanization because of engineering difficulties in construction, and they have a similar forest structure compare to plan-

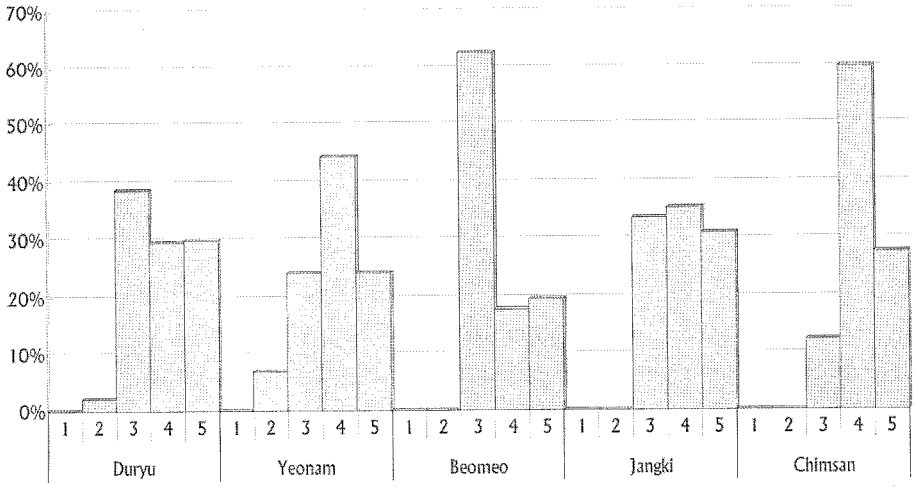

Figure 2. Quality of urban forests in structure (biotope function grade) of Daegu (grade 1 represent good quality while 5 means poor).

tation forests in rural areas. Another is tally synthetic woodlands as a part of manmade park. Lots of species include exotic species were selected and planted by the necessary of urban park designing.

Major species in the remnant forests of the surveyed urban parks were *Pinus densiflora, Pinus rigida, Pinus thunbergii* and *Robinia pseudoacacia*. Due to the various influences such as human activities, topographical character, etc. they were combined each other, therefore we subdivided the groups into second level and third level to have more detailed assessment.

Approximately 20% of tested remnant forests were lost their structure as forests caused by illegal farming, facilities and excessive visitors, and the forests became bare grounds. According to the results, the capability of the tested urban forests as a biotope was very poor in overall (Figure 2). Rarely there were small areas which are still maintaining the structure of beginning as semi-natural plantation forests. These relatively better forests were locating on very steep sloping areas which had no human interference at all. In less interfered areas, forest structure and species were relatively simple. However, it seems that this result is cause by another reason. According to the rapid expanding of urban areas, a rural forest was suddenly became an urban forest in terms of the change of an administrative district. Although the forest was no longer under the rural forest management programme, the structure was shown as a plantation forest likely in rural areas.

From two years monitoring data of birds in 16 surveyed areas, we found that wooded parkways and woodland squares have more species than street tree areas. Moreover, the nests were found mainly on the branch of *Zelkova serrata*, *Pinus densiflora* and *Quercus myrsinaefolia*. Species richness of birds was mainly determined by the size of urban forests (S=3.23 ln (A)=25.9, r^2=0.70, S; number of species, A: area in square meter). Number of hole and bush-nesters was low, while number of canopy nesters was high in sixteen urban forests. Therefore, it is needed to maintain the large size urban forest and conserve the bush-layer for bush nesters for inhabitation of birds. Furthermore, it is recommended to plant the bird-friendly species such as *Zelkova serrata*, *Pinus densiflora* and *Quercus myrsinaefolia* for nests of birds and enhance the connectivity among urban forests.

Insect fauna in urban forests of Daegu was monitored for 3 years at 3 categories based on the locations of urban forests, urban centre, urban edge, suburbs, to understand how they are linking from outside to inner city areas. '*Sweeping*' was carried out for shrub trees, and '*Beating*' for tall trees, '*Pitfall trap*' for ground-dwelling insects. It is assumable that species richness of insects is basically determined by the location of urban forests, and disturbance by human activities and management programme (Table 1). In synthetic woodlands, because they were planned and installed as a part of picturesque park, the after-management was stronger than other forests. Trees and surface vegetations and shrubs

Table 1. Insect Faunas in the parks of Daegu.

Parks	Beomeo	Yeonam	Gugchae	Duryu	Bongmu	Dalseong
No. of Species (No. of Family)	70(59)	154(122)	2(2)	57(47)	99(79)	6(4)

Table 2. Temperature Comparison between Computed Landsat (Landsat-7 ETM+ Band6 DN by NASA Model in 10th May 2003) and Field Measurement.

Locations	Field Measurement	Landsat	gap
A : Bare ground	19.7°C	22.0°C	2.3°C
B : *Robinia pseudoacacia*	18.8°C	19.1°C	0.3°C
C : *Pinus densiflora*	19.2°C	20.0°C	0.8°C

were kept in shape as was designed; therefore these areas were harsher place for insects. Moreover these urban forests are usually locating in the middle of city centre which means no possibility to link with more natural outside forests. It seems that the disturbance by human activities is the second factor for the species richness in the urban edge and suburb forests. Although the sizes of tested forests in urban edge are 23 times bigger than forests in suburbs, the species richness of insects was fallen off as approximately an half. In urban edge forests, there are lots of everyday human activities such as a walking, physical exercising, tracking or educational programme. Because the forests are linked with suburbs, it seems that there is immigration into urban edge forests continuously.

According to the oxygen output and carbon input by photosynthesis measurement, the capability was in order of *Platanus occidentalis, Zelkova serrata* and *Ginko biloba*. Although it is not thoroughly academicals, air conditioning effects of trees were converted into simple digital numbers to make easy general public's understanding, such as one tree (8 ± 1 m, DBH: 25 ± 3 cm) could replace 7 hours works of 5 air conditioners for a room of 49 m^2. In addition, the gaps between the computed (by the NASA Model; K = 1282.71/ln[(666.09/L)+1] L = [(12.65-3.2)(DN-1)/254]+3.2) temperatures by Satellite image and actual measurement were calculated based on the quality of forests and green-spaces. The gaps were 0.3°C at the forest of *Robinia pseudoacacia*, 0.8°C at the forest of *Pinus densiflora*, and 2.3°C at the bare grounds. Moreover, better structured forests are containing cooler air than poor structured forest (Table 2). It is probable that improving the quality and structure of urban forests can reduce the urban heat-island phenomenon.

Conclusion and Future Works

After 3 years research to understand the ecological quality of urban forests and their role for urban ecosystem, the produced assessment indices and methods can be applied to monitor urban forests in Korea. However, we believe that this approach can not totally acceptable for local character of forests in other cities. Therefore future monitoring is carrying out for other 5 major cities and Seoul from 2005 to 2009. Using advanced Digital technologies such as Remote Sensing and GIS skill could help to monitor nationwide change in urbanized areas, and the actual assessment in field also is needed.

There are urgent issues for the improvement of urban forest structure to enhance natural character into cities. Introducing more urban friendly tree species for both human activities and wildlife are recommended with a practical guideline which is derived from local natural character. To do that, we are focusing on the historical results related to forests and people. More than 500 remnant village groves in nationwide will give us a good clue to understand the relationship between human being and nature, and sustainable model as urban forests for Korean cities.

Acknowledgements

This article is an overall brief report of urban forest researches which have been carrying out by Korea Forest Research Institute. The detailed data mentioned in this are from the un-published KFRI annual report, and the data are/will be published separately based on issues. We would particularly like to thank to KFRI.

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(Received July 19, 2006; Accepted August 3, 2006)