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STREET TREE HEALTH ASSESSMENT SYSTEM: A TOOL FOR STUDY OF URBAN GREENERY

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ABSTRACT

This study deals with the recording of tree health and the evaluation of the greenery ratio, with a view to increase it, in three representative street trees in Thessaloniki city, North Greece. The three street trees are representative because of the species composition and the health of the trees on one hand and the flow of traffic on the other hand. The three street trees investigated in this study are located along three central roads of Thessaloniki city, namely Nikis Avenue, Egnatia Street and Karamanli Avenue. The study also includes the formulation of proposals in order to make some improvement in the choice of suitable species so as to increase the amount of greenery in the city. The results show that the most important problems related to tree health in the three streets are the leaves being attacked by insects and fungi as well as dry and broken branches of the crown. The majority of trees have moderate health. The greenery ratio in the three street trees is evaluated by the greenery's surface and volume indicators, which are calculated depending not only on the number of trees but also on the surface and volume of their crowns. Finally, a linear model for the greenery's volume indicator is estimated which depends on tree height, crown length and crown projection on the ground.

Keywords: crown surface, tree health, tree species, urban greenery.

1 INTRODUCTION

The 20th century was the century of urbanization. Nowadays, it is calculated that above half of the world population lives in urban regions while by 2030 the urban population is expected to be twice as large as the corresponding rural [1],[2],[3],[4]. The procedure of urbanization had important natural and spatial effects on the landscape because large parts of it were transformed into urban and thus the relationship between human society and natural environment changed dramatically [5],[6],[7]. Urban greenery is of fundamental importance for the quality of life on our ever increasingly urbanized societies [8],[9],[10]. Although trees have covered a large part of the human settlement all along the history, their great value for the citizens have only just been studied [11],[12],[13]. More specifically, the term 'urban greenery' refers to open green spaces that are located in the urban web and which include parks, street trees and other garden areas [14],[15],[16]. Urban greenery beyond the aesthetic and designing uses offers also social and psychological services which are very important for the well being of citizens. The large green areas in the urban and periurban web can reduce the stress of the residents and refresh them [17],[18],[19],[20].

Urban environment constitutes a difficult biotope for the trees. Environmental pressures decrease the vitality of many species and increase their sensitivity to diseases and parasitic attacks. Trees which develope in cities suffer from the effects of negative ecological factors, such as poor soil (compressed and with insufficient or low proportion of humidity and nutrients), polluted atmosphere and vandalism. These problems can only be prevented by choosing the proper species [21],[22],[23],[24],[25],[26].

The aim of this study is to record trees' health and to evaluate greenery ratio, with a view to increase it, in three representative street trees in Thessaloniki city, North Greece. The three street trees are representative because of the species composition and trees' health on one hand and the flow of traffic on the other hand. The three street trees of the study are along three central roads of Thessaloniki city, Nikis Avenue, Egnatia Street and Karamanli Avenue. The ultimate goal of the study is the formulation of proposals in order to make some improvement in the choice of the suitable species, for

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their survival in urban environment, so as to increase the greenery ratio in the city. For this reason a linear model was derived, which express the relation between the green volume indicator and three trees variables (tree height, crown's beginning height and crown projection).

2 MATERIALS AND METHODS

The research took place in the region of the Municipality of Thessaloniki, North Greece and included the study of the street trees along three central roads of Thessaloniki city, Nikis Avenue, Egnatia Street and Karamanli Avenue. The three roads were chosen not only because the traffic is dense but also for the species composition, the health and the characteristics of the street trees that are along them. The first street tree (in Nikis Avenue) is planted with *Platanus orientalis*, the second street tree (in Egnatia Street) is planted with *Celtis australis* and the third street tree (in Karamanli Avenue) is planted with *Albizia julibrissin, Liquidambar orientalis, Cupressus arizonica* and the clone *Populus X euramericana cv. 'I-45/51'.*

The total number of trees on the three roads was 913. Measurements were taken from all trees in Nikis Avenue and from 20% of the individuals in Egnatia and Karamanli streets (because of the big number of trees), that is to say; 248 trees, these being apportioned as 81 trees in Nikis Avenue, 70 trees in Egnatia Street and 97 trees in Karamanli Avenue (Table 1).

Table 1: Number of trees of each species, total number of trees and number of sample trees in the three studied roads

Road	Species	Total number of trees	Number of trees of each species	Number of sample trees
Nikis Avenue	*Platanus orientalis*	81	81	81
Egnatia Street	*Celtis australis*	347	347	70
Karamanli Avenue	*Albizia julibrissin*	326	185	65
	Populus X euramericana cv. 'I-45/51'		141	
Central division of Karamanli Avenue	*Liquidambar orientalis*	159	60	32
	Cupressus arizonica		99	
TOTAL		913	913	248

The trees in Egnatia and Karamanli streets were chosen by systematic sampling. According to this method, one tree from the first five trees of each street tree was selected randomly and afterwards the choice of our sample trees was done per five trees until our sample to be completed. Each sampled tree was measured for tree height, tree breast diameter, crown's beginning height and crown dimensions. The crown length, the projection of the crown on the ground and the crown volume were calculated. Regarding that tree crown is usually modeled as a cone, the crown projection (CP) is the surface of a circle with diameter d_i and so it was calculated by the formula $CP_i=\pi/4xd_i^2$. The crown diameter d_i was calculated by the formula $d_i= (d_1+d_2)/2$, where d_1, d_2 are the crown diameters measured from east to west and north to south correspondingly. The crown volume (CV) was calculated by the formula $CV= CPxL/3$, where L is the crown length which results if crown's beginning height is subtracted from the total tree height [27],[28]. The product: (crown projection of the average tree) x (number of trees in each road) was characterized as active greenery's surface while the product: (crown volume of the medium tree) x (number of trees in each road) was characterized as active greenery's volume [29],[30].

The recording of the damage was done according to a specific damage diagnosis catalogue and the tree species were grouped according to their health in 4 categories: Good health (trees without health problems), moderate health (trees with health problems that can be confronted), bad health (trees that must be replaced) and dead [14],[31].

Finally, for each road the greenery's surface indicator (the active greenery's surface divided by the length of the road) and the greenery's volume indicator (the active greenery's volume of the crowns divided by the length of the road) were calculated. The relationship between the volume indicator and three tree variables (tree height, crown's beginning height and crown projection) was derived by a linear model using the statistic program SPSS version 12.0 for Windows.

A presentation of the data statistic processing's results is given by using box and whisker plots. A box and whisker plot is a graph that presents information from a five-number summary (the smallest observation, lower quartile, median, upper quartile and largest observation). This plot is especially useful for indicating whether a distribution is skewed and whether there are potential unusual observations (outliers) in the data set. This type of graph is used to show the shape of the distribution, its central value and its variability. In a box and whisker plot: the ends of the box are the upper and lower quartiles, so the box spans the interquartile range. The median is marked by a vertical line inside the box. The whiskers are the two lines outside the box that extend to the highest and lowest observations. The position of the median in the plot defines whether a distribution is skewed or normal. If the median is in the middle of the box then the data distribution is normal. If the median is close to the lower end of the box then the data distribution has a positive skewness. On the other hand if the median is close to the upper end of the box then the data distribution is negatively skewed [32], [33].

3 RESULTS

Box and whisker plots of tree height values and tree breast diameter values in the three central roads and the central division (1.Nikis Avenue, 2. Egnatia Street, 3. Karamanli Avenue, 4. central division of Karamanli Avenue) are depicted in Figures 1 The figure indicates that the distribution of tree height data is normal in Egnatia Street while the distribution of breast diameter data is normal in Nikis Avenue and in the central division of Karamanli Avenue.

Box and whisker plots of tree height values and tree breast diameter values of the six tree species (1. *Platanus orientalis,* 2. *Celtis australis*, 3. *Albizia julibrissin*, 4. *Liquidambar orientalis,* 5. *Cupressus arizonica,* 6. *Populus X euramericana cv. 'I-45/51')* are depicted in Figure 2. The figure indicates that the distribution of height data is normal in the species *Celtis australis* (species 2) and *Populus X euramericana cv. 'I-45/51'* (species 6) while the distribution of breast diameter data is normal in the species *Platanus orientalis* (species 1), *Cupressus arizonica* (species 5) and *Populus X euramericana cv. 'I-45/51'* (species 6).

The health and the problems that the trees of each species had are presented in Figures 3,4,5,6,7,8. In each figure, each problem is depicted using the code number shown in Table 2.

The results of the research show that the most important problems the trees have in the three street trees are the followings:

- Insect and fungal damage (this problem is most evident in *Platanus orientalis* and the clone *Populus X euramericana cv. 'I-45/51'*)
- Dry and broken branches of the crown (this problem is most evident in the trees of the species *Celtis australis*, *Albizia julibrissin*, *Liquidambar orientalis*, *Cupressus arizonica* and the clone *Populus X euramericana cv. 'I-45/51'*)
- Bark damage (this problem is most evident in the trees of the species *Celtis australis* and *Albizia julibrissin*)
- Trees whose crown touches the crown of other trees (this is a big percentage in the species *Cupressus arizonica* and *Platanus orientalis*)

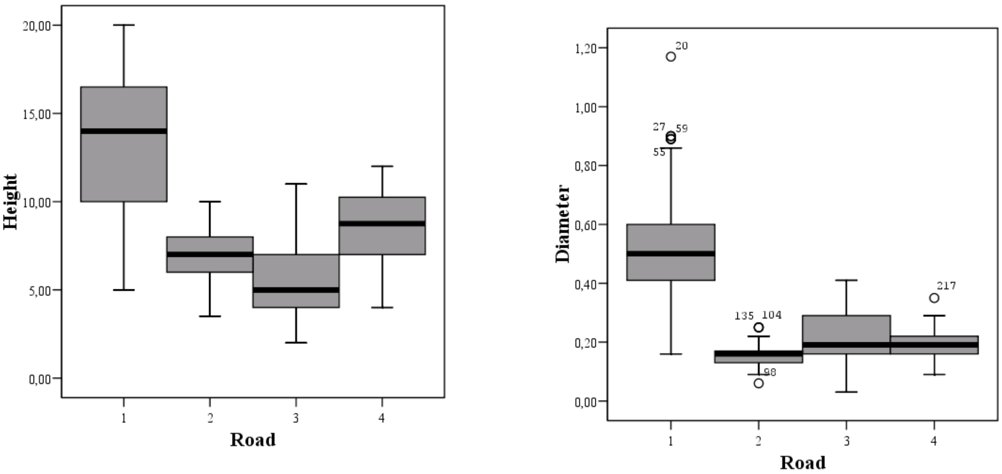

Figure 1: Box-and-whisker plots of height and breast diameter of the three central roads and the central division

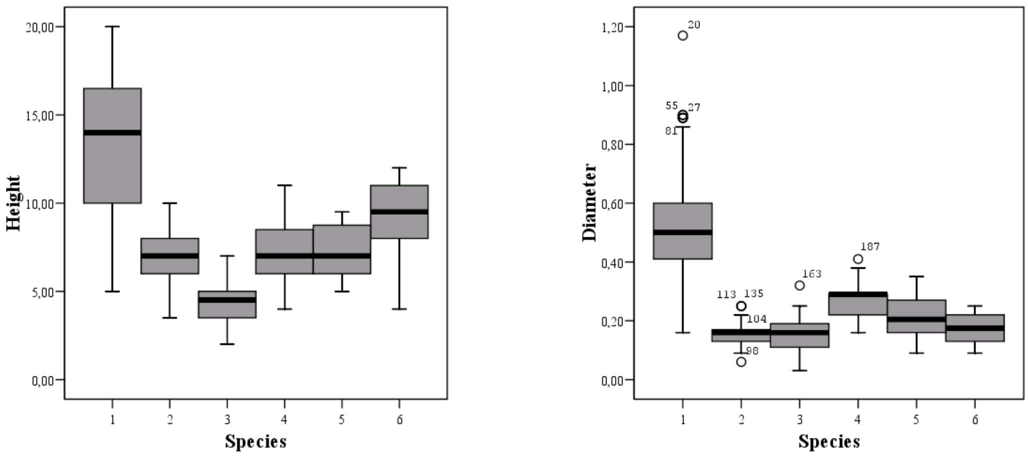

Figure 2: Box-and-whisker plots of height and breast diameter of the six silvicultural species

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Table 2: Diagnosis catalogue of tree health problems and damage

1: drying out of the crown	14: soil removal,
2: insect and fungal damage	15: root damage due to construction work
3: ivy on trunk	16: pavement damage due to roots
4: tree too close to road	17: root damage
5: long crown depth close to asphalt surface	18: fluid secretion on trunk
6: crown width over road	19: bark damage
7: tree too close to buildings	20: tree decay
8: crowns touching each other	21: narrow bi-furcation
9: crowns touching buildings	22: water retention in bi-furcation
10: damage from construction	23: dry and broken branches
11: trees too close to cables or light source	24: spreading branches
12: inadequate root space depth	25: branch tufts due to pruning
13: compaction of soil	26: intensive pruning

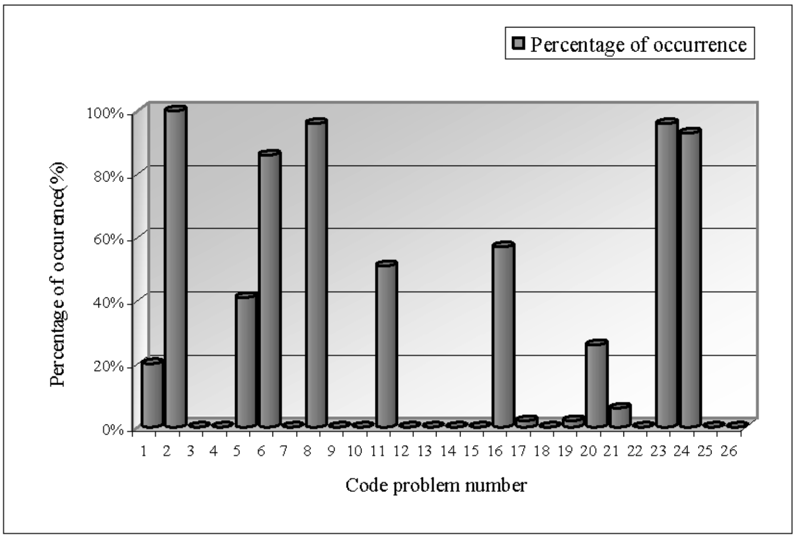

Figure 3: *Platanus orientalis* problems

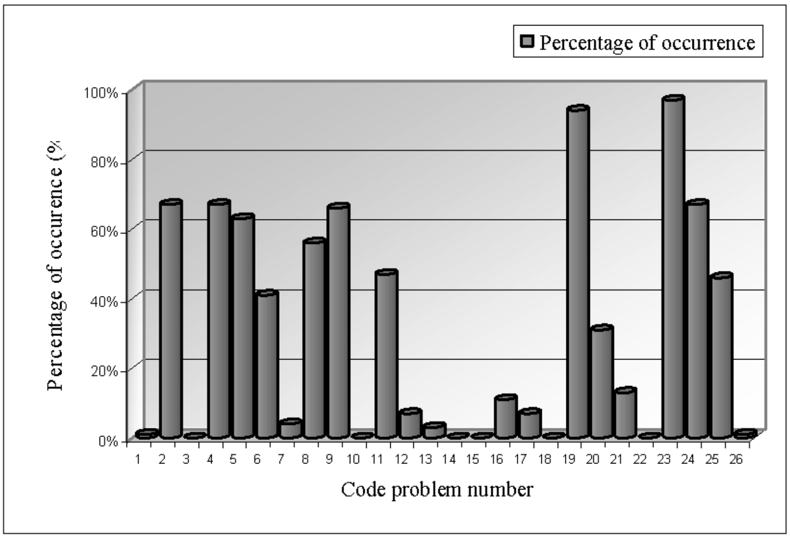

Figure 4: *Celtis australis* problems

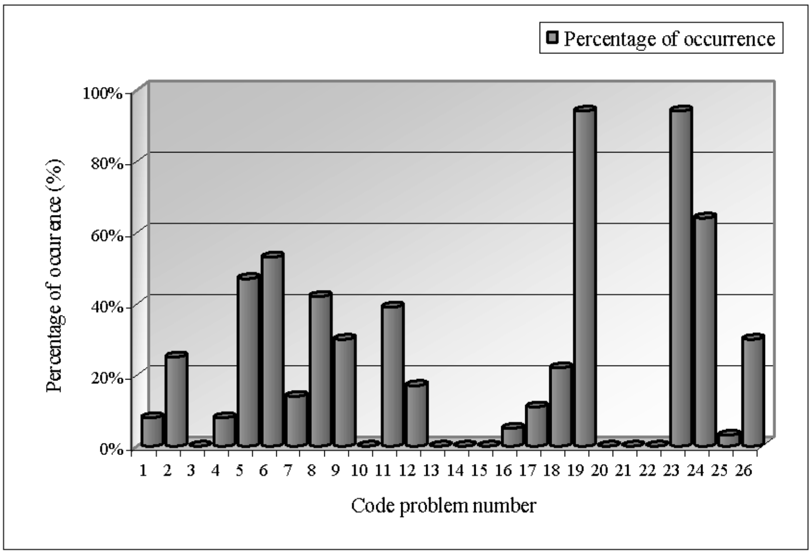

Figure 5: *Albizia julibrissin* problems

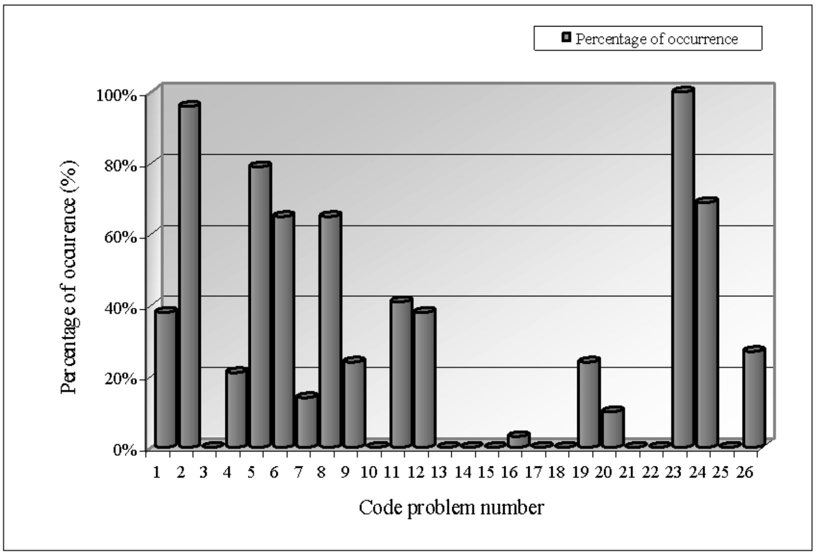

Figure 6: *Populus X euramericana cv. 'I-45/51'* problems

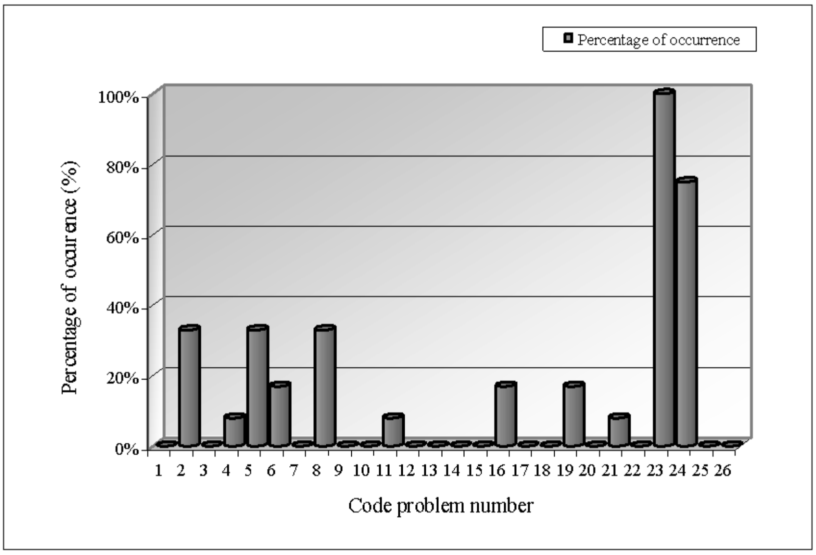

Figure 7: *Liquidambar orientalis* problems

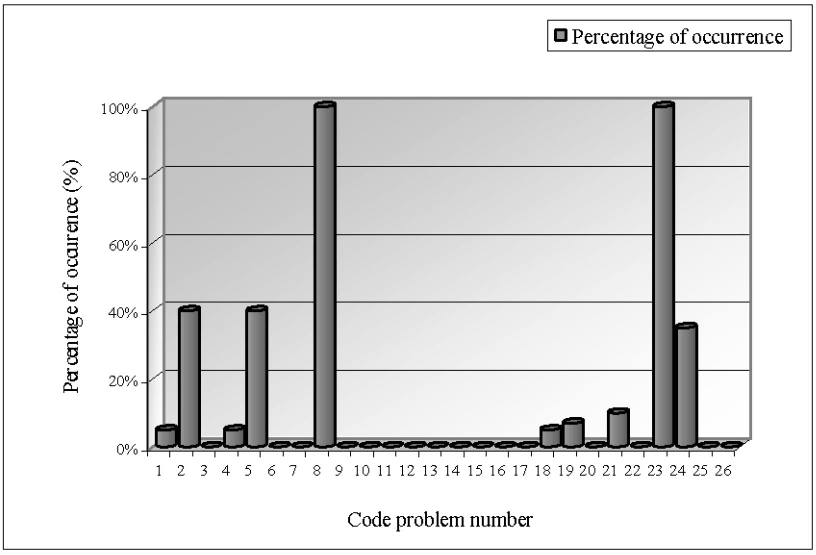

Figure 8: *Cupressus arizonica* problems

The health of the trees of the species *Platanus orientalis, Celtis australis* and *Cupressus arizonica* was characterized as moderate while the majority of the trees of the species *Albizia julibrissin, Liquidambar orientalis* and *Populus X euramericana cv. 'I-45/51'* have a good health.

The values of the greenery's surface indicator and greenery's volume indicator are highest in Nikis Avenue, which is consisted by *Platanus orientalis*.

Finally, using a multiple linear regression and using tree height, crown's beginning height and crown projection as independent variables, the following volume's indicator model was estimated: Y= -104,048+14,64X_1 (tree height)– 18,73X_2 (crown's beginning height) + 3,48X_3 (crown projection), with adjusted R^2= 93,5%. The standard errors and the significance of the model coefficients are presented in Table 2, while the analysis of variance is given in Table 4.

Table 3: Coefficients of the volume indicator model

Model	Unstandardized Coefficient		Standardized Coefficient	t	Sig.
	B	Standard error	Beta		
Constant	-104.048	10.179		-10.221	0.000
Height	14.640	1.058	0.350	13.836	0.000
Height of the start of the crown	-18.734	4.154	-0.079	-4.510	0.000
Crown projection	3.481	0.119	-0.701	29.197	0.000

Table 4: Analysis of variance of the volume indicator model

Model	Sum of squares	dF	Mean Square	F	Sig.
Regression	6911054	3	2303684.723	1183.283	0.000
Residual	475033,4	244	1946.858		
Total	7386088	247			

All model coefficients are significant at < 0.01 level of significance.

4 DISCUSSION AND CONCLUSIONS

Urban forestry was developed as a special branch of forestry in North America and was imported in Europe at the decade of 80's. However, today, the significance and values of urban forestry are not totally recognized while there is also a lack of comparative researches on this sector [4],[17].

With regard to the condition of street trees in other european cities, the followings are pointed out:

In Brussels, the number of trees in the streets of the town are 19.500 while 200-300 trees are being replaced every year. The total number of trees that are planted every year by the municipality is approximately 2.500 [34],[35].

In Munich, the most commonly used species in street trees are *Tilia cordata*, *Aesculus hippocastanum*, *Acer platanoides*, *Tilia xeuchlora*, *Robinia pseudoacacia* and *Fraxinus excelsior.* The most serius factors that influence the survival of trees planted in the majority of German cities are: 1) the ice-breaking salt which is very destructive for the trees and its use should be forbidden, 2) inadequate root space depth (code number 12), 3) compaction of soil (code number 13) that causes anaerobic soil conditions and 4) the cover of planting surface that leads to the insufficient airing of the ground and accelerates trees' desiccation [36],[35].

In Ireland, the Dutch elm disease (code number 2) caused serius damage to many trees in the majority of Irish cities. The fungi *Erwinia amylovora* and *Stereum purpureum* have atacked also many street trees. The most commonly used species in street trees in Dublin are *Acer platanoides*, *Platanus x hispanica*, *Betula spp.*, *Fagus spp.* and *Sorbus aucuparia*. Since 1970-1990 an average of 20.000 trees/year have been planted on the streets and on the open green spaces. Today 40.000 trees are planted annually and 60% of them take place along the streets [37],[35].

In Budapest, the number of street trees is 32.000 and the most serius problems that they have are: 1) ice-breaking salt 2) inadequate root space depth (code number 12) and 3) infected and damaged barks (code number 19) [38],[35].

In Swedish cities, trees's plantations is a procedure that takes place for many years. The most commonly used genera are Tilia (31.5%), Acer (13.8%) and Sorbus (16.9%). In North Sweeden dominates the genus Betula. The use of elms is rather limited because of the Dutch elm disease [39],[35].

In Finland, the choice of the species that will be used in the development of urban greenery is restricted by the harsh northern climate. For this reason, the choice of species aims at the enrichment of the native tree-flora with resilient species, origins and clones. The species composition that is used in the urban area of Finland is very common to that of West and Central Europe, even if poorer. The most commonly used species in street trees are: *Tilia vulgaris*, *Betula pendula*, *Acer platanoides*, *Sorbus aucuparia* and *Ulmus glabra*. It is also estimated that 100.000 trees are planted annually [40],[35].

In the Municipality of Thessaloniky, the number of trees in street trees is 30.000 and the most commonly used species are: *Sophora japonica* (16%), *Albizia julibrissin* (15%), *Robinia pseudoacacia* (14%), *Acer negundo/Acer pseudoplatanus* (12%), *Populus sp.* (11%), *Platanus orientalis* (5%), *Koelreuteria paniculata* (4%), *Celtis australis* (3%), *Citrus aurantium* (3%), *Liquidambar orientalis - Tilia tomentosa - Hybiscus syriacus - Ulmus campestris- Olea europea - Cercis siliquastrum* (2%) [26].

The analysis of the results of the study led to the following conclusions about the health and the damage that the species presented as well as to the formulation of proposals to avoid these problems:

The attacks on the leaves of *Platanus orientalis* by fungi and insects are secondary damage and it is mainly caused by the limited available growing space and the insufficient soil conditions. This species in Nikis Avenue's street trees forms a very large crown. In order to achieve the normal development of the crown (the crown must be aired and the interactions between crowns must be avoided) and the vertical position of the trunks, a bigger spacing, over than 10 m, should be applied among the trees. The dry and broken branches that the crown of many species *(Celtis australis Albizia julibrissin*, *Liquidambar orientalis*, *Cupressus arizonica* and the clone *Populus X euramericana cv. 'I-45/51'*) presents are due to the strong pruning (which means pruning almost all the branches of the crown in order only the trunk to be alive), which resulted in the development of tufts of branch shoots. These branch shoots had desiccation problems because of the self-thinning, which is a functional reaction of the tree to the excessive increase of branches. This problem is intensified by the insufficient soil conditions. In the case of *Cupressus arizonica,* the existence of dry and broken branches is due to the early ageing that this species presents because it grows fast. With regard to the pruning of species *Celtis australis*, *Albizia julibrissin* and *Liquidambar orientalis,* it is recommended the avoidance of it, but when this is necessary it should be done according to the pruning guidelines.

It may be remarked that the biggest density of greenery is presented in Nikis Avenue, which is consisted by *Platanus orientalis*, because the values of the greenery's surface indicator and greenery's volume indicator are the biggest in this avenue. This conclusion results from the fact that the trees of *Platanus orientalis* have the biggest average values of height, crown's beginning height, crown projection and breast diameter in relation to the trees of the other roads. Egnatia Street has a small greenery's volume because of its narrow pavements that prohibit the right growth of the trees. It is suggested that the trees should not be pruned unless it is necessary and the gaps of the street trees to be filled by the already using species which is *Celtis australis*, a very suitable species for the urban environment of Thessaloniki. Karamanli Avenue has also a small greenery's volume with unsuitable species. The poplar and cypress must be removed and substituted by a suitable urban–friendly species. The former, because it is susceptible to branch breakage by windfall, a dangerous outcome for citizens and cars. The latter, because its crown presents thinning in an urban environment caused by the pollution.

With regard to the linear model that concerns the greenery's volume indicator [$Y = -104{,}048 + 14{,}64X_1$ (tree height) – $18{,}73X_2$ (crown's beginning height) + $3{,}48X_3$ (crown projection)], it is noticed that the mathematical signs can be interpreted in real terms. The volume indicator increases with the increase of the height and with the increase of crown projection and decreases with the increase of the crown's beginning height because the crown length decreases. There is also a good adaptation of the model to our data, because tree variables were especially correlated with tree volume indicator explaining 93.5% of the model variance. Thus, this model may help to the estimation of the greenery volume in urban ecosystems.

References

[1] Girardet H., *The GAIA Atlas of Cities: New Directions for Sustainable Urban Living.* Anchor Books/Doubleday, New York, 1992.

[2] EEA, Europe's environment: the Dobris assessment. (eds. D. Stanners, Ph. Bourdeau), European Environment Agency, Copenhagen, 1995.

[3] Konijnendijk C.C., Urban forestry: overview and analysis of European forest policies. Part 1. Conceptual framework and European urban forestry history. EFI Working Paper 12. European Forest Institute, Joensuu, 1997.
[4] Konijnendijk C.C., Urban woodland conservation management and development in Europe - a comparative study. COST Action E12 "Urban forests and trees". Proceedings No 1. Luxemburg: Office for Official Publications of the European Communities. pp.328, 1998.
[5] EEA, State of the European environment. European Environment Agency, Copenhagen, 1998.
[6] Kuchelmeister G., Urban green for local needs-improving quality of life through multipurpose urban forestry in developing countries. *Proceedings of the First International Conference on Quality of Life in Cities*, March 4-6, Singapore, Vol. 1, pp. 181-191, 1998.
[7] Konijnendijk C.C., Adapting forestry to urban demands-role of communication in urban forestry. *Landscape and urban planning*, **52**, pp. 89-100, 2000.
[8] Grahn P., Man’s Needs for Urban Parks, Greenery and Recreation. Institute for Landscape Planning, Swedish Agricultural University, Alnarp, 1985.
[9] Hartig T., Mang M. and Evans G., Restorative effects of natural environments experiences. Environ. Behav. **23**, pp. 3–26, 1991.
[10] Godbey G., Grafe A., James W., The Benefits of Local Recreation and Park Services. A Nationwide Study of the Perceptions of the American Public. College of Health and Human development, Pennsylvania State University, Pennsylvania, 1992.
[11] Kuo F.E., Bacaioca M., Sullivan W.C., Transforming inner city landscapes: trees, sense of safety, and preferences. Environ. Behav. **1:**30, pp. 28–59, 1998.
[12] Chiesura A., The role of urban parks for the sustainable city. *Landscape and urban planning*, **68**, pp. 129-138, 2004.
[13] Tsitsoni Th., Samara Th., The existing situation and management of urban forests and trees in western Macedonia. *Proceedings of the 10th Panhellenic Forest Science Conference*, May 26-29, Tripoli, Greece, pp. 136-147 (in Greek), 2002.
[14] Grey G.W. and Deneke F.J., Urban Forestry. Second edition. Krieger Publishing Company. Malabar, Florida, pp. 299, 1986.
[15] Nilsson K. and Randrup T.B., Urban and periurban forestry. In: Proceeding of the XI World Forestry Congress, 13-22 October 1997, Antalya. Volume 1: Forest and tree resources. pp. 97-110, 1997.
[16] Randrup T.B., Konijnendijk C.C., Andersen F., Review of higher education on urban forestry in Europe. Report of COST Action E12 "Urban forests and trees". Luxemburg: Office for Official Publications of the European Communities, 2001. pp. 229, 2001.
[17] Randrup T.B., Konijnendijk C.C., Christophersen T., Nilsson K., COST Action E12 "Urban forests and trees". Proceedings No 1. Luxemburg: Office for Official Publications of the European Communities, 2002. pp.328, 2002.
[18] http://www.hellenic-landscapes.gr (accessed August 28, 2005)
[19] Ganatsas P., Tsitsoni Th., Zagas Th., Tsakaldimi M., Evaluation of the urban green space in Thessaloniki city. *Proceedings of the 10th Panhellenic Forest Science Conference*, May 26-29, Tripoli, Greece, pp. 627-637 (in Greek), 2002.
[20] Tsitsoni Th., Zagas Th., Estimation of adaptability of tree species on the basis of tree condition and human activities. *Proceedings of the Urban Greening and Landscape Arhitecture research symposium* (ed. Th. B. Rundrup), June 23-25, Copenhagen, Demark, Vol. 2, pp. 58-59, 1999.
[21] Beatty R.A., Heckman C., Survey of municipal tree systems in the United States. *Urban Ecology*, **5**, pp. 81-102, 1981.
[22] Kuchelmeister G., Urban and peri-urban multipurpose forestry in development cooperation - experience, deficits and recommendations. Funded by the Commission of the European Communities, Illertissen, Germany, (Unpubl. final report), 1991.
[23] Kuchelmeister G., Braatz S., Urban forestry revisited. *Urban and periurban forestry*, FAO, UNASYLVA, Vol. 44, No. 173, 1993.
[24] Samara Th., Tsitsoni Th., Tree quality control and care measures in urban environment. *Proceedings of the 11th Panhellenic Forest Science Conference*, October 1-3, Ancient Olymbia, Greece, pp. 705-721 (in Greek), 2003.

[25] Tsitsoni Th., Zagas Th., Silvicultural measures for improved adaptability of tree species to the urban environment. *Proceedings of International Conference on Ecological Protection of the Planet Earth* (eds. V. Tsihritzis and Ph. Tsalides), June 5-8, Xanthi, Greece, Vol. 2, pp. 415-422, 2001.

[26] Tsitsoni Th., Batala E., Zagas Th., Management of urban green and suggestions for its upgrade in the Municipality of Thessaloniki. *Proceedings of the 12th Panhellenic Forest Science Conferenc*e, October 2-4, Drama, Greece, pp. 231-242 (in Greek), 2005.

[27] U.S.D.A Forest Service, Forest inventory and analysis national core field. Guide Volume I: Field Data Collection Procedures For Phase 2 Plots. p. 80-89, 2007

[28] U.S.D.A. Forest Service. 2002. Phase 3 Field Guide - Crowns: Measurements and Sampling. Section 12. p.5-21

[29]http://www.dpi.vic.gov.au/DSE/nrenfor.nsf/FID/0AF90B034A49AE474A2567F50002146C?OpenDocument. Crown Cover. (accessed May16, 2006)

[30] http://sres-associated.anu.edu.au/mensuration/BrackandWood1998/CROWN.HTM#volume. Crown surface area and volume. (accessed May16, 2006)

[31] Dafis Sp., *Urban forestry*. Art of Text, Thessaloniki. Greece, p. 198 (in Greek) 2001.

[32] Tukey J., Exploratory Data Analysis. Addison-Wesley Publishing Company, 1977.

[33] Matis K., Forest Biometry I. Statistics. Pigassos Editions. Thessaloniki, Greece, p. 598 (in Greek), 2003.

[34] Basiaux Ph., Bodson M., Embo T., Gobeaux J.C., Hermy M., Van Herzele A., Van Slycken J., Report on the state of the art of Belgium. In: Research and Development in Urban Forestry in Europe. Report of COST Action E12 "Urban forests and trees" on the state of the art of urban forestry research and development in Europe. Forrest M., Konijnendijk C.C., Randrup T.B. (eds). European communities, Luxemburg, ISBN 92-828-7578-4, pp. 38-54, 1999.

[35] Forrest M., Konijnendijk C.C., Randrup T.B., Research and Development in Urban Forestry in Europe. Report of COST Action E12 "Urban forests and trees" on the state of the art of urban forestry research and development in Europe. European communities, Luxemburg, ISBN 92-828-7578-4, pp. 363, 1999.

[36] Duhme F., Dujesiefken D, Pauleit S., Report on the state of the art of Germany. In: Research and Development in Urban Forestry in Europe. Report of COST Action E12 "Urban forests and trees" on the state of the art of urban forestry research and development in Europe. Forrest M., Konijnendijk C.C., Randrup T.B. (eds). European communities, Luxemburg, ISBN 92-828-7578-4, pp. 121-141, 1999.

[37] Collins K.D., Forrest M., O'Sullivan R., Report on the state of the art of Ireland. In: Research and Development in Urban Forestry in Europe. Report of COST Action E12 "Urban forests and trees" on the state of the art of urban forestry research and development in Europe. Forrest M., Konijnendijk C.C., Randrup T.B. (eds). European communities, Luxemburg, ISBN 92-828-7578-4, pp. 178-192, 1999.

[38] Rach I., Schmidt G., Varga G., 1999. Report on the state of the art of Hungary. In: Research and Development in Urban Forestry in Europe. Report of COST Action E12 "Urban forests and trees" on the state of the art of urban forestry research and development in Europe. Forrest M., Konijnendijk C.C., Randrup T.B. (eds). European communities, Luxemburg, ISBN 92-828-7578-4, pp. 157-165, 1999.

[39] Gustavsson R., Axelsson-Lindgren C., Lindholm G., Lindqvist H., Rolf K., Report on the state of the art of Spain. In: Research and Development in Urban Forestry in Europe. Report of COST Action E12 "Urban forests and trees" on the state of the art of urban forestry research and development in Europe. Forrest M., Konijnendijk C.C., Randrup T.B. (eds). European communities, Luxemburg, ISBN 92-828-7578-4, pp. 273-293, 1999.

[40] Lindén L., Löfström I., Tyrväinen L., Report on the state of the art of Finland. In: Research and Development in Urban Forestry in Europe. Report of COST Action E12 "Urban forests and trees" on the state of the art of urban forestry research and development in Europe. Forrest M., Konijnendijk C.C., Randrup T.B. (eds). European communities, Luxemburg, ISBN 92-828-7578-4, pp. 76-107, 1999.