JOURNAL OF ENVIRONMENTAL GEOGRAPHY
Journal of Environmental Geography 8 (3–4), 33–39.
DOI: 10.1515/jengeo-2015-0010
ISSN: 2060-467X

INVESTIGATION OF TREE STANDS OF PUBLIC SPACES IN SZEGED

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Research article, received 10 September 2015, accepted 1 November 2015

Abstract

In urban areas vegetation (especially woody vegetation) is of utmost importance, since it affects the ecological conditions of the city. Urban trees play an important role in improving urban climate both at the local (city, district) and the micro-level (e.g. in public squares). Establishing and maintaining advanced and detailed information systems necessary for the management of urban tree stands is an important task of environmental and climate-conscious city management. Despite that, few of the Hungarian municipalities have a regularly updated tree database. The city of Szeged started efficient green space management in autumn 2013, when we started the creation of a detailed and up-to-date tree register for the public areas, which has been continuously expanded ever since. The survey of the present study covers the period of the growing season, from late spring to early autumn of 2013. All the trees are included in the survey and quite a number of data are recorded for each individual (e.g. species, age, size parameters, exact location, health status, etc.). The recorded data are paper-based, however they are included in a GIS-based green space inventory software, Greenformatic, where coordinates are associated to each object, while information on the state of the tree, its location and handling can be found in the attribute table. The trees included are mostly concentrated in the inner city of Szeged, but the surveys will gradually cover ever larger areas of the city. The results highlight the fact that the structural attributes of the different species' populations are formed by the integrated effect of the species' urban tolerance and planting policies of the past decades. The current database already allows highly complex analysis, which contributes to the well-being of city residents.

Keywords: urban tree, green space management, tree database, Greenformatic

INTRODUCTION

Tree stands have many positive effects on the ecological status of a city, its population's health and well-being, making the urban built environment more liveable. One of the most noticeable direct effects is changing the microclimatic conditions (Andrade and Vieira, 2007; Bowler et al., 2010). During the active period of the growing season the daytime near-surface air temperature has been proved to be lower under the trees than above the free surface (Lin and Lin, 2010). This is primarily due to the canopy reducing the amount of radiation energy from the surface, as it reflects a part of it and absorbs another part - although the extent of this effect depends on the season and the time of day (Shashua-Bar et al., 2011; Konarska et al., 2013).

This directly causes a decrease in temperature, while on the other hand it has an even more significant impact on human comfort, because it results in further physiological (heat) stress reduction, which is well detectable using different human comfort indices (Égerházi et al., 2013). In areas planted with trees a much larger amount of water leaves to the air through evapotranspiration than either in grasslands or built-up areas. This increases humidity, which indirectly contributes to the development of lower temperatures under the trees and has a generally beneficial effect on human comfort, especially during heat waves (Zhang et al., 2013). Surface roughness increased by the presence of woody vegetation decreases the speed of near-surface air movement, which can have both positive and negative implications. In winter, it can lead to significant heating-related energy savings (Loehrlein, 2014).

An important element of improving air quality is the absorption of air pollutants (e.g. ozone, nitrogen, sulphur-dioxide, settling dust, etc.) - the actual quantity depending on the amount of leaf surface. During photosynthesis trees use a substantial amount of CO2 (extracting it from the air), one of the most important greenhouse gases (Nowak et al., 2006). Except for the latter, all those listed here have an indirect or direct impact on human health, either through human respiratory diseases or through otherwise affecting comfort.

A very important ecosystem service of urban tree stands is the massive interception of precipitation on the leaf surface, a part of which evaporates directly, while the rest is slowly conveyed towards the ground, making infiltration easier, and significantly reducing the size of flash floods following extreme precipitation events (to an extent depending on the size and state of the stand). The water trapped in this way does not burden the sewage system at the time, but seeps into the soil gradually and thus more efficiently. This in turn improves the quality of otherwise poor urban soils (Day and Dickinson, 2008).

Creating and maintaining a green surface property cadastre is a statutory obligation for municipalities in Hungary; woody vegetation represents a substantial part of this. However, the property value in this case is much more than just the value of wood. The pollutant and carbon sequestration, the reduction in runoff, the energy savings resulting from the shading of buildings are relatively easily expressible in monetary terms. Defining the monetary value of much more abstract concepts such as the reduction of thermal comfort, the aesthetic and / or cultural value, the mental and physical regeneration effect - the further benefits of well-maintained green areas and tree stands - is much more difficult, however without doubt these also should be given some consideration. It makes monetary evaluation particularly difficult that the idea of a property gaining value over time instead of losing it is quite foreign to traditional economic thinking (McPherson, 2003).

STUDY AREA

Szeged is situated in the south-eastern part of Hungary (46°N, 20°E; 78-85 m above sea level), in the Lower-Tisza-valley, at the confluence of the rivers Tisza and Maros. According to Péczely's climatic classification (Péczely, 1976) the Great Hungarian Plain is characterised with a dry-warm continental climate, therefore in summer heat is typical and drought susceptibility is high in the Szeged area. The annual sunshine duration is high and air humidity is typically low. Winter snow cover is rare and the amount of snow is also low. Szeged is the biggest city of the Southern Great Plain region with an area of 281 km^2 and a population of about 170 000 (Fig. 1).

Due to its size, the city of Szeged has easily detectable climatic effects on the local scale. The most apparent phenomenon is the formation of a so-called urban heat island as a result of artificial surfaces, which is most pronounced a few hours after sunset. In Szeged the added heat from the heat island is on average 2-3°C, but in calm, anticyclonic periods it may reach up to 6-8°C (Balázs et al., 2009). This (along with many other climatic effects) significantly affects the life chances of urban vegetation. It may therefore be useful if vegetation studies are supplemented with a climatological perspective, and vice versa, the climate-modifying effects of the vegetation are investigated.

METHODS

In order for a city to have an efficient green space management, which is also sustainable in the long term, a detailed, up-to-date database is necessary. To this end, in 2012 the Department of Climatology and Landscape Ecology of the University of Szeged (in collaboration with the Environmental Management Office of Szeged) started to set up such a detailed tree register which helps the performance of operational tasks and maintenance while also provides an opportunity for the scientific examination of the urban ecological role of trees (e.g. complex ecosystem services evaluation). The data-recording

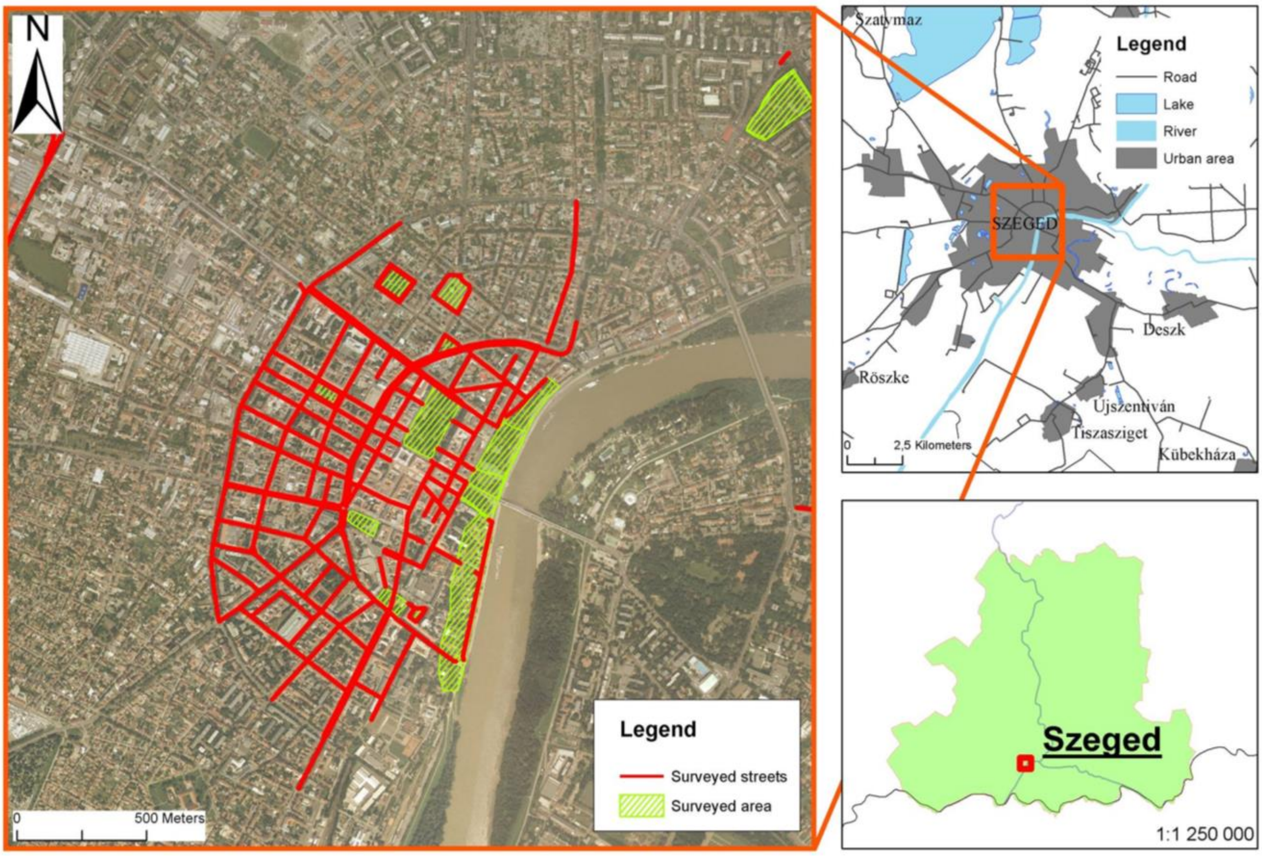


Fig. 1 Tree alleys and squares recorded by the end of November 2013

during the field surveys was paper-based, with a high demand on time and human resources; university students were heavily involved in the work.

The ideal period for the survey is from late spring to early autumn, namely the growing season, when the foliage has fully developed and autumn defoliation has not yet started. Some parameters, such as the exact extent of the canopy or the health status of individuals can only be established with reasonable accuracy in this period. All the trees or shrubs with a dbh (diameter at breast height) over 5 cm are included in the survey and quite a number of data are recorded for each individual (e.g. species, age, size parameters, exact location, health status, etc.). Photos are also taken of each tree and added to the database.

Additional data are related to the surroundings of the tree such as the size of the planting space, the nature of a protection measure or nearby damaging factors. Health data contain information on injury and lesions detected on the root system, the trunk or the canopy, as well as other anomalies included as comments. Based on the data recorded separately for the tree parts, an assessment of the whole tree's health status is provided on a 5-point scale. The person recording the experienced damage can also make management proposals and include them in the database.

In order to get more accurate scientific analysis some extra parameters are also recorded for each individual, which so far have not featured in such registers. These include for example the proportion of dried-out crown parts, the proportion of missing or truncated parts (as a percentage) and the degree of light availability. These enable more realistic calculations of tree volume and leaf area serving as input for pollutant absorption and carbon-sequestration calculations. Thus regulatory ecosystem services can be evaluated more precisely (Takács et al., 2014).

In order to record and store spatial data a GIS is necessary, since visualization and spatial analysis are part of the complex requirements of users (both managers and scientific experts). The Greenformatic - Geospatial Information Software, is a targeted GIS-based green space inventory software developed in Hungary. Coordinates are associated to each object, while information on the state of the tree, its location and handling can be found in the attribute table. This primarily serves to directly make users' everyday work easier.

The results shown in the present work were derived from the data of over 5000 tree individuals recorded until November 2013 (see the extent of the area on Fig. 1.). As shown on the map in Figure 1, the database assembled by that date mostly represents the densely built-up areas of the inner city, within the Great Boulevard (Nagykörút).

RESULTS

The tree population in the register recorded by November 2013 contains 5197 objects, the tree individuals belong to 110 species and 4 categories: stumps, empty planting spaces, former planting spaces and dried-out trees. The city is quite species-rich, however approximately 60% of the individuals belong to the 10 dominant species (Table 1). There are 48 species with less than 5 individuals in the database.

Almost half of the recorded individuals belong to species non-native in Hungary (Fig. 2.). Of these, *Sophora japonica, Celtis occidentalis* and *Koelreuteria paniculata* are present in highest numbers (over 200 individuals each). Of native species, different species of linden trees (*Tilia sp.*) are most frequent (1321 individuals).

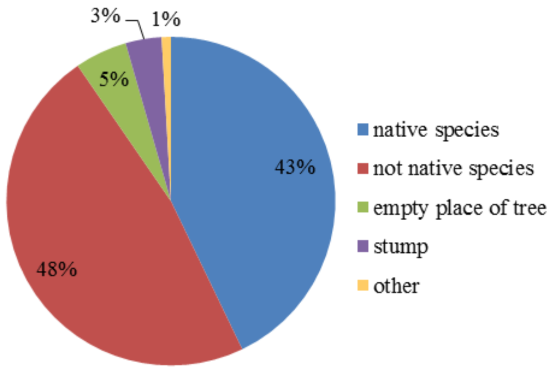


Fig. 2 The proportion of native and non-native species (miscellaneous: e.g. dried-out tree, removed planting space, unidentified species)

Table 1 The most common tree species in Szeged within the surveyed areas

Tree species		Number of individuals	%
Littleleaf linden	*Tilia cordata*	634	12.2%
Pagoda tree	*Sophora japonica*	542	10.4%
Common hackberry	*Celtis occidentalis*	472	9.1%
Silver linden	*Tilia tomentosa*	458	8.8%
Large-leaved Lime	*Tilia platyphyllos*	229	4.4%
Goldenrain	*Koelreuteria paniculata*	224	4.3%
Hore-chestnut	*Aesculus hippocastanum*	168	3.2 %
Manna or flowering ash	*Fraxinus ornus*	121	2.3%
Plane	*Platanus hispanica*	121	2.3%
Norway Maple	*Acer platanoides*	117	2.3%
dominant species	3086		59.38%
other species	1655		31.85%

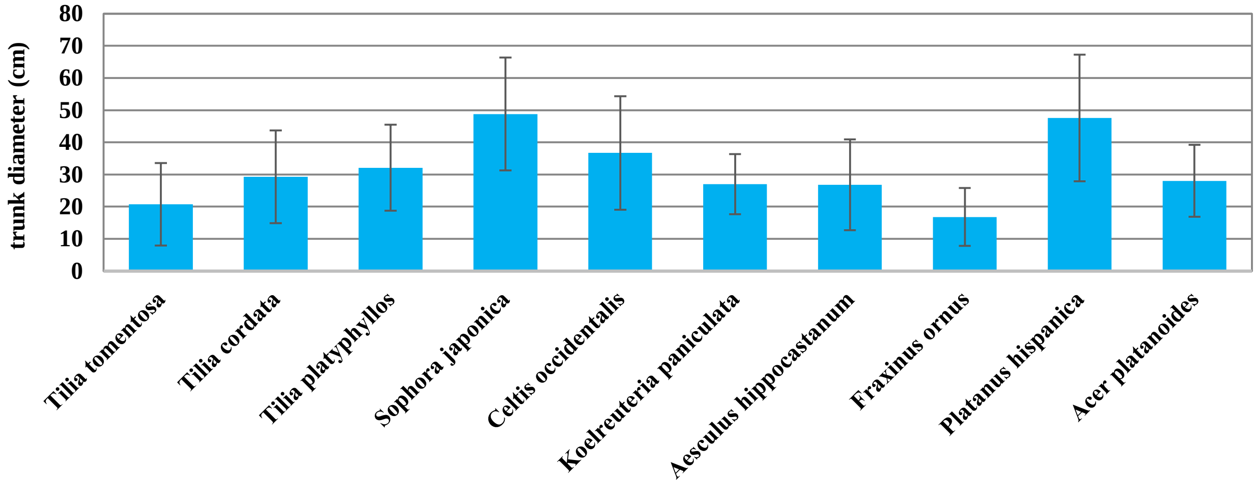


Fig. 3 The average dbh of the 10 most common tree species along with the standard deviation

It is noteworthy that empty planting spaces, tree stumps and other miscellaneous categories make up 8.6% of the whole database, which means 490 trees were waiting to be replanted. That number continued to increase in the winter of 2013, because in addition to the winter cuts a number of individuals had to be removed during the reconstruction of Kossuth Lajos Avenue. However, some trees were also planted in the autumn of 2013 and 2014. These changes are not included in the present analysis.

This also draws attention to the vital importance of an up-to-date database, which in addition to containing the existing trees, also includes the interventions, recorded in the shortest possible time. Only thus can the database facilitate effective green space management.

In addition to allowing the approximate estimation of tree volume value, the size parameters of the individuals serve as input to a number of other analyses. Although dbh depends on a number of parameters besides age, most importantly on species, light availability and other site conditions, the current distribution of stem diameter classes may be used to refer indirectly to the age of the stands. There is little information available in the literature concerning urban trees; there are more examples of such estimations from forest stands.

Sophora japonica and *Platanus hispanica* have the largest average dbh in the Szeged database, for both species it's close to 50 cm. True, these species also have the largest standard deviation, therefore their dbh range (and probably the age as well) is higher than that of the others. Similarly, there is a large standard deviation in the case of *Celtis occidentalis*, but the average dbh is lower. *Tilia tomentosa*, *Koelreuteria paniculata* and *Fraxinus ornus* have the lowest average dbh. In case of the latter two species standard deviation is also the lowest therefore they show the most homogeneous age distribution of all the species in the database (Fig. 3) and are probably the youngest stands as well.

Looking at the age distribution of the total recorded tree population, the average estimated age is 36 years, while the software estimates the age of the oldest specimens as 103 years. The age group 15-45 makes up 66% of the total population (Fig. 4). The age distribution suggests that the last great tree planting campaign in this area was at the end of the 1980's and the early 1990's, but significant planting actions took place between the two world wars and in the 1970's as well. (It should be noted that these results still only refer to areas of the city within Nagykörút. Since these events are intimately linked with the city's structural development, the extension of the database to the outer areas might significantly modify this picture). The number of the old trees (older than 90 years) is only 22. In the case of urban trees - with regard to the unfavourable ecological conditions and a fear of collapse damage – such high ages are very rare, especially in the light of Szeged having been destroyed by the great flood of 1879. As a result of the destruction, even the oldest trees can only be dated back to that time. Among the oldest trees are some of the planes in Széchenyi square, and a few old oak trees in Korányi Alley.

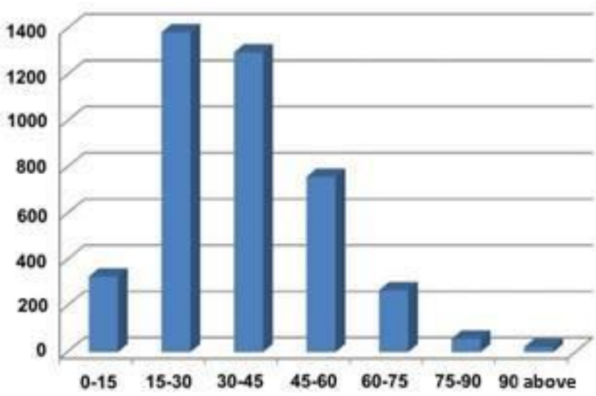


Fig. 4 Age distribution of the whole recorded tree population

Examining in detail the age distribution of the 10 most common species, the planting practices of the last hundred years are neatly outlined. It can be seen that Tilia plathyphyllos, Sophora japonica and Platanus hispanica have the most diverse age structure, which suggests that these species enjoyed an almost unbroken popularity over the last hundred years; they were favoured throughout the last century in plantations (Fig. 5).

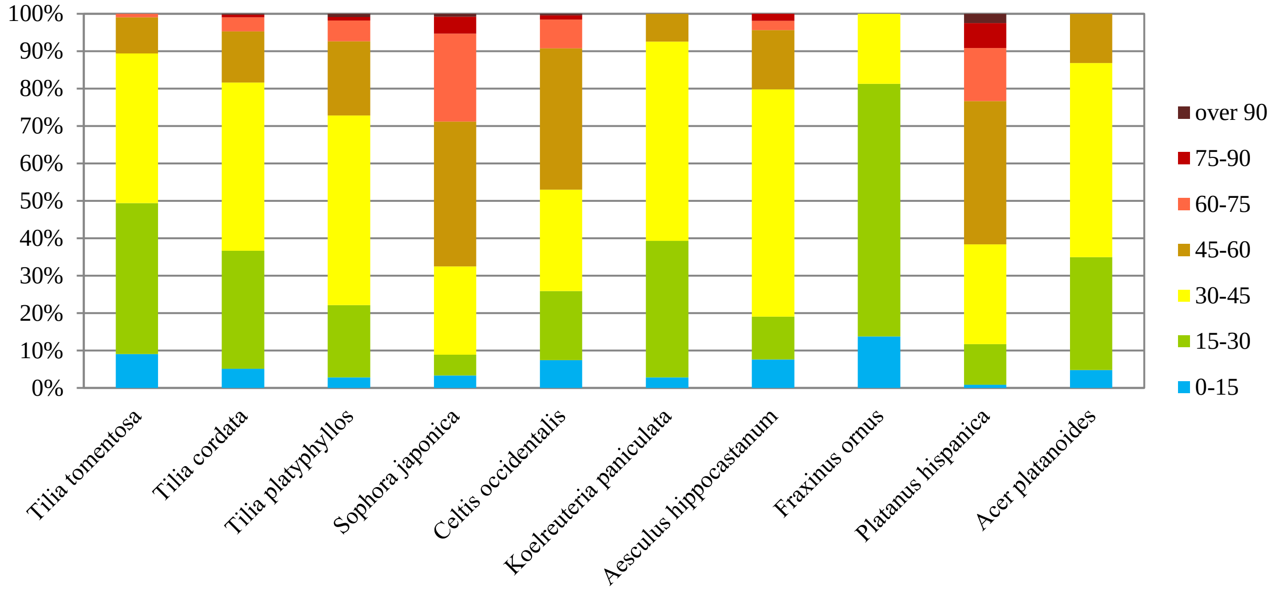


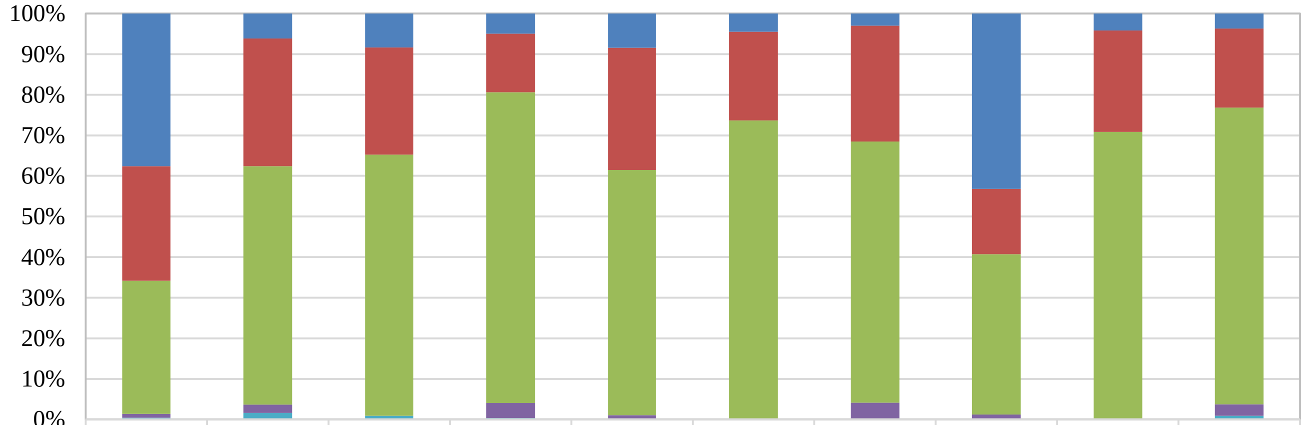
Fig. 5 Age distribution of the 10 most common species

Aesculus hippocastanum was clearly a favourite of the 1970's, the vast majority of today's white-flowered population belongs to the age group 30-45. The species is in many ways an ideal park tree; it has a very significant microclimate-improving effect since it allows only a small percentage of the direct radiation through the canopy, and it is also very decorative through almost the whole year. The species was very popular until the late 1980's (until the massive invasion of horse chestnut leaf miner - *Cameraria ohridella*) but by now the population is in a critical condition.

The proportion of older individuals is the highest in the case of *Sophora japonica* and *Platanus hispanica*. However, it seems that these species have lost some of their popularity over the last 20 years, since there are very few young individuals in the database.

Celtis occidentalis (with an average age of 42) shows the most uniform age distribution in the observed population. This is due to the fact it is one of most urban-tolerant species; much more tolerant to the unfavourable urban conditions (air and soil pollution, drought) than other species, so it was commonly used in the past as well as in today's urban tree planting.

In the last 20-30 years, however, the focus has clearly shifted towards *Tilia cordata* and *tomentosa*, *Fraxinus ornus* and *Koelreuteria paniculata*. The age distribution of lindens shows that from 1965 to the present day they are the fashion trees of the city of Szeged



	Tilia tomentosa	Tilia cordata	Tilia platyphyllos	Sophora japonica	Celtis occidentalis	Koelreuteria paniculata	Aesculus hippocastanum	Fraxinus ornus	Platanus hispanica	Acer platanoides
1	163	39	19	27	40	10	5	35	5	4
2	122	199	60	78	142	49	48	13	30	21
3	142	372	146	414	285	165	108	32	85	79
4	4	13	0	20	4	0	7	1	0	3
5	2	10	2	2	1	0	0	0	0	1

Fig. 6 Health status of the 10 most common species
(1: Optimal 2: Well-cared for, 3: Deficiencies, 4: Serious deficiencies 5: Neglected)

(Gaskó 2008), and in recent decades a rejuvenation process can be observed. However, *Tilia tomentosa* plays a more important role among younger individuals (about 50%). This is due to the fact that in recent years many perished *Tilia platyphyllos* trees were replaced with *Tilia tomentosa* individuals, more tolerant of the harsh urban environment.

In the inner, more built-up areas of the city, it is no wonder that in the last 20 years species with relatively smaller proportions have been favoured, which would not outgrow the confined space very fast – such as *Fraxinus ornus*.

The assessment of the health status of the population was carried out according to the standards presented in the methods section. In terms of the whole observed population it is pleasing that 40% of the trees are in a relatively good state, so only minor changes of the trunk and canopy are observed. The other end of the spectrum represents individuals with severe deficiencies, i.e. where serious trunk and/or foliage damage was observed, such as deep-penetrating trunk decay, rot of the root collar or the crown - which represents an imminent risk of an accident - or withering of the treetop, which warns of major root damage. These symptoms require immediate and significant intervention, and in some cases make it impossible to save the tree. The database contains 60 such individuals, which makes up only 3% of the total observed population, but since the most densely populated inner city areas are affected, they require increased attention.

The health status data of the 10 most common species draw attention to a number of interesting facts. The highest proportion of significant deficiencies (i.e. more than slight deterioration of health status), can be observed in the case of Sophora japonica (77%), *Platanus hispanica* (71%), *Koelreuteria paniculata* (74%) and Acer platanoides (73 %) (Fig. 6). The first two species can be characterized with higher average ages, including a relatively high proportion of older trees. Of course, this may explain the health status being worse than average.

The second place of *Koelreuteria paniculata* in these rankings is an interesting phenomenon since the age distribution suggests these trees to be relatively young, so poor health is not expected. It may be a reminder of the fact that the environmental circumstances in Szeged are probably not well tolerated by this species. The same applies to the case of Acer platanoides. The "serious deficiencies" or "neglected" category contain individuals with severe crown-base or root collar rot, or a strong deep-reaching parent branch decay.

These two categories appear in major proportions in the case of four species, *Tilia cordata, Sophora japonica, Celtis occidentalis* and *Aesculus hippocastanum*, which seem to be the most threatened of the observed tree population of Szeged. In Hungary the horse chestnut leaf miner (*Cameraria ohridella*) spread at a very fast rate in the early 1990's and that infection did not spare the trees in Szeged either. Even today, there are serious problems with the chestnut trees. In many cases, the individuals lose most of their foliage by the end of July, or the beginning of August and start flowering again in September – which in turn greatly weakens the tree's immune system.

Tilia tomentosa and *Fraxinus ornus* are in the best state of health among the recorded species. The proportion of individuals in the Optimal and Well-cared-for categories is way above 50%. A likely reason is that these species have the youngest stands, many of them having been planted relatively freshly.

DISCUSSION AND CONCLUSION

Urban woody vegetation plays an important ecological role in settlements, however they are not yet always appreciated accordingly in Hungary. There are very few municipalities who have an up-to-date usable tree register. In the current budget cycle (2014-2020) of the European Union there is particular emphasis on the development of green infrastructure. It is no coincidence, since the optimally chosen vegetation can locally mitigate the extremes of global change to a large extent and it can significantly improve the unfavourable living conditions in urban areas. However that requires an up-to-date green space database, which shows health status, location of the individual trees, and is also informative of the performed and to do tasks. Progress in Hungary in this respect has first appeared in some of the bigger cities. Szeged is at the forefront in this, since the city's tree register is constantly extended and updated. Such data are essential to the effective management of green areas, but keeping the data up-to-date is also the most labour-intensive part. During the everyday work trees are continuously replaced, there are rejuvenation actions, cuttings, so changes often occur, which need to be continuously monitored.

Most of the trees are not older than 45 years; and only 10 individuals in the current database belong to the age group of more than 100 years. This can be explained by the fact that tree planting affecting today's Szeged effectively began after the catastrophe of 1879, since trees planted before that time were destroyed by the flood. Wartime cuttings should also be taken into account, when the citizens of Szeged needed to acquire fuel for heating.

The oaks of Korányi Alley are among the oldest individuals that were demonstrably planted first, right following the flood. Therefore when the reconstruction of the river protection wall was carried out this was precisely the reason for the need to exercise caution during the construction works, as these old, healthy individuals represent a huge unique value. The age distribution of the tree population raises interesting questions. The question of how long it is "worth it" to keep an old tree is important for decision-makers and managers; i.e. what is the age when maintenance would become significantly more expensive (due to an increasing need for maintenance works, risk of accident, curled concrete, etc.) than the positive effects of the individual. Such aging populations usually have higher care needs, however due to their large canopy and consequently larger leaf surface can have a very significant air quality improving role;

furthermore such important aesthetic, historical, cultural values are connected to them, which are difficult to express in monetary terms.

The periods of increased tree planting are clearly visible in the age distribution data for each species, as is the fact that the constantly rejuvenated or freshly introduced species are in the best health. In some cases, however, contradictions arise, since *Koelreuteria paniculata* individuals despite the young population are in a poor state so their "profitable" maintenance is more difficult.

Concerning the health status of the Szeged tree population, in the case of certain species the proportion of the “deficiencies” category is relatively high. White-flowered *Aesculus hippocastanum* trees are especially in poor health. When the funding becomes available most probably the red-flowered variant of chestnut (Aesculus × carnea) will be used to replace these, which seems to be resistant to the pest destroying the other type. A noteworthy initiative to improve the health of the remaining population was the opening of the formerly asphalt-surrounded planting spaces in a substantial part of Szentháromság street. The open soil surface was covered with mulch and shrubs, which is supposed to greatly improve the state of the stand through allowing a better infiltration of rainwater. The poor health of the trees is probably related to the sometimes extremely parched urban soils. Unfortunately it is possible that the stand is already so heavily degraded that even this measure will not help.

The health status of species represented by older stands (*Tilia platyphyllos, Platanus hispanica and Sophora japonica*) is also worse than the average, the category of major deficiencies appears in their case. At present, *Tilia tomentosa* has the best health status, which may be the result of partly the young age of the stands, and partly of the fact that this sub-Mediterranean species tolerates urban conditions better than others. Therefore, it is an alternative to be considered when replacing other linden species.

Although the data presented in this study involve only a part of the total of Szeged’s street tree population, even the current database allows a highly complex analysis, of which here only species composition, age-, size- and health status distribution were examined.

The establishment of the appropriate species composition is very difficult. A lot of aspects should be taken into account by the maintainer; different public places have different needs and constraints thus different species can mean the ideal choice. In recent years *Fraxinus ornus* became fashionable; it is a popular species in fresh plantations. However planting a species with a relatively small leaf surface and high transmissivity in certain places (e.g. heavily used public squares) could contradict modern climate-conscious urban planning principles. The answers to these questions may become easier to find through in-depth data analysis and further research, which is the aim of our research group and also meets the needs of the municipality.

References

Andrade, H., Vieira, R. 2007. A climatic study of an urban green space: the Gulbenkian park in Lisbon (Portugal). *Finisterra* 17, 27–46.

Balázs, B., Unger, J., Gál, T., Sümeghy, Z., Geiger, J., Szegedi, S. 2009. Simulation of the mean urban heat island using 2D surface parameters: empirical modeling, verification and extension. *Meteorological Applications* 16, 275–287. DOI: 10.1002/met.116

Bowler, D.E., Buyung-Ali, L., Knight, T.M., Pullin, A.S. 2010. Urban greening to cool towns and cities: A systematic review of the empirical evidence. *Landscape and Urban Planning* 97, 147–155. DOI: 10.1016/j.landurbplan.2010.05.006

Day, S.D., Dickinson, S.B. 2008: Managing Stormwater for Urban Sustainability using Trees and Structural Soils. Virginia Polytechnic Institute and State University, Blacksburg, VA.

Égerházi, L.A., Kovács, A., Unger, J. 2013. Application of microclimate modelling and onsite survey in planning practice related to an urban micro environment. *Adv Meteorol,* 2013, Article ID 251586. DOI: 10.1155/2013/251586

Gaskó, B. 2008. Móra Ferenc Múzeum évkönyve. Természettudományi Tanulmányok. Studia naturalia 4. Csongrád Megyei Múzeumok Igazgatósága, Szeged.

Konarska, J., Lindberg, F., Larsson, A., Thorsson, S., Holmer, B. 2013. Transmissivity of solar radiation through crowns of single urban trees—application for outdoor thermal comfort modelling. *Theor Appl Climatol*. 117, 363–376. DOI: 10.1007/s00704-013-1000-3

Lin, B.S., Lin, Y.J. 2010. Cooling Effect of Shade Trees with Different Characteristics in a Subtropical Urban Park. *HortScience* 45, 83–86.

Loehrlein, M. 2014. Sustanable Landscaping. Principles and Practicles. Taylor & Francis Group, 978-1-4665-9321-3 (e-Book).

McPherson, E.G. 2003. A benefit-cost analysis of ten street tree species in Modesto, California, U.S. *Journal of Arboriculture* 29, 1–8. DOI: 10.1093/treephys/18.8-9.537

Nowak, D.J., Crane, D.E., Stevens, J.C. 2006. Air pollution removal by urban trees and shrubs in the United States. *Urban Forestry & Urban Greening* 4, 115–123. DOI: 10.1016/j.ufug.2006.01.007

Péczely, Gy. 1979. Éghajlattan. Tankönyvkiadó Budapest.

Shashua-Bar, L., Pearlmutter, D., Erell, E. 2011. The influence of trees and grass on outdoor thermal comfort in a hot-arid environment. *International Journal of Climatology* 31, 1498–1506. DOI: 10.1002/joc.2177

Takács, Á., Kiss, M., Gulyás, Á. 2014. Some aspects of indicator development for mapping microclimate regulation ecosystem service of urban tree stands. *Acta Climatologica et Chorologica* (47–48), 99–108.

Unger, J. 1997. Városklimatológia – Szeged városklímája. *Acta Climatologica et Chorologica Univ. Szegediensis* 31/B (Urban Climate Special Issue), 69.

Zhang, Z., Lv, Y., Pan, H. 2013. Cooling and humidifying effect of plant communities in subtropical urban parks. *Urban Forestry & Urban Greening*, 12, 323–329. DOI: 10.1016/j.ufug.2013.03.010