[Proceedings of the Fábos Conference on Landscape and Greenway Planning](https://scholarworks.umass.edu/fabos)

Volume 7
Issue 1 *Moving towards Health and Resilience in the public realm*

Article 20

August 2022

Importance of Parking Afforestation with its Impact on the Local Microclimate

András Rujp
Hungarian University of Agriculture and Life Sciences, rujp.a00@gmail.com

Krisztina Szabó
Hungarian University of Agriculture and Life Sciences, szabo.krisztina.dendro@uni-mate.hu

Vera Takácsné Zajacz
Hungarian University of Agriculture and Life Sciences, takacsne.zajacz.vera@uni-mate.hu

Antal Gergely
Hungarian University of Agriculture and Life Sciences, gergely.antal@uni-mate.hu

Recommended Citation

Rujp, András; Szabó, Krisztina; Takácsné Zajacz, Vera; and Gergely, Antal (2022) "Importance of Parking Afforestation with its Impact on the Local Microclimate," *Proceedings of the Fábos Conference on Landscape and Greenway Planning*: Vol. 7: Iss. 1, Article 20.
DOI: https://doi.org/10.7275/3d1m-0285
Available at: https://scholarworks.umass.edu/fabos/vol7/iss1/20

Importance of Parking Afforestation with its Impact on the Local Microclimate

Rujp, András[1], Szabó, Krisztina[2], Takácsné Zajacz, Vera[3], Gergely, Antal[4]

[1]master student, Hungarian University of Agriculture and Life Sciences, [2]associate professor, Hungarian University of Agriculture and Life Sciences, [3]PhD student and assistant lecturer, Hungarian University of Agriculture and Life Sciences, [4]master teacher, Hungarian University of Agriculture and Life Sciences

1. Abstract

In urban areas, trees are generally not in the best conditions. This is particularly true for car parks near shopping centres. Paving, traffic, small tree pits and chemical pollutants do not let the roots grow properly. Also, vehicles can cause harm to the tree's roots through compaction and the tree's trunk, therefore the most valuable part of trees – the crown – cannot reach its expected size (Jim 1993). In addition, weakness pests, pathogens can appear more easily. This is particularly true in parking lots especially in front of malls, where maintenance would be the responsibility of the company.
The solution is to pay regular attention and to ensure stricter compliance with the law, but without improving the conditions in which trees are located, we will not be able to make a significant difference. Of the innovative solutions available on the market, based on foreign experience and numerous publications the suspended pavement system is the best solution. Although it requires a large financial outlay, the results show that it is definitely worth the investment. Because in a loose medium with a healthy soil life, protected from the compaction and vibrations provided by the root cell, the tree will grow much faster, become larger and healthier without changing the structure of the car park, thus the ecosystem services of the parking lot and human wellbeing will be much better (Ulrich 1991). The difference between the current and potential condition of the trees in the car park was examined by making an environmental model. This showed that larger, healthier trees can reduce the predicted mean vote (human thermal comfort) by 20-24 °C in the summer.
In our study, we present further assessments and solutions that provide tangible evidence of the need to make our busy environment more liveable. A nice, well-maintained car park with shade and green vegetation provides a more pleasant environment for shoppers who prefer to spend time in or around the shop (Wolf 2003).
Key words: afforestation, parking lots, urban ecosystem, suspended pavements, root cell system

2. Introduction

Woody plants, tree stands in cities and other stressed areas are of enormous value (Dwyer et al. 1992; McPherson et al. 1997), making the urban environment more liveable (Tyrväinen et al. 2003). They bind dangerous gases and store CO^2 in their cells, from which they produce O^2, essential for life (Nowak 1996). They are able to bind up to 60% of particulate matter (including lead, nickel and other heavy metals), which does not damage human lungs and airways, thus reducing the risk of developing or aggravating various respiritory diseases (e.g. asthma) (INT-01). Sudden precipitation is a particularly high risk for large, continuous paved surfaces, but trees and other green surfaces can absorb some of the precipitation with their leaves and root systems, and infiltrate it, allowing it to be used locally and reducing the rate of run-off (Haughton and Hunter 1994; Lormand 1988; Xiao et al. 1998). Urban trees reduce stress and aggression and their presence has a calming effect (Ulrich 1991). According to a 2006 survey, one of the biggest determinants of property value is the proximity of green spaces and their maintenance (Studio Metropolitana 2006). Green spaces provide habitat for other organisms, thus increasing biodiversity (Johnson 1988). They cool their surroundings by shading, absorbing radiation and evaporating heat, reducing the heat island effect (Akbari et al. 1992). In this case tree canopy reduces wind speed, absorbs vibrations from various sources and reduces noise pollution (Heisler 1986).

3. Background and Literature Review

There are many factors that hinder the healthy growth of trees in urban environments. For example, poor quality urban soils reduce the life expectancy of trees (Craul 1992). Large paved surfaces in enclosures (which require compact soil to form) inhibit root growth (Grabosky et al. 2002). Small tree sites result in reduced root system size, which also negatively affects tree stability and crown size (Jim 1993). Due to small tree planting sites, most of the precipitation does not reach the soil, 85-90% of it runs off into stormwater drains (Lukács 2020). The deteriorating water balance and the lack of aeration lead to a deterioration of soil life, a reduction in organic matter content and even anaerobic processes, which can poison the soil with toxic substances (Láng 1981). Road salt and contamination from roads, as well as vibrations from vehicle traffic, damage capillary roots, reducing their absorption capacity (Farsang 2011), while acidic dog urine leads to root rot and tissue death. Parking and utility works can damage the main roots, leading to static problems and, in some cases, even drying out of the tree (Lukács 2020). Root collars and trunks are often damaged during maintenance work by lawn mowers, parked cars and bicycles, causing tissue damage, rot and static problems. In young trees, the lack of trunk protection is a particular danger, as it can lead to frost heaving. Poor conditions can prevent trees from growing vigorously, reduce their resistance and weaken them further through injury (Shigo 1990). All these symptoms are usually most noticeable in the crown, and a weak crown is more vulnerable to damage: its air pockets can become blocked (INT-01), its branches more fragile and more easily attacked by pests and pathogens. Overall, they are not able to provide ecosystem services and do not meet all the values described in the previous Paragraph.

Improving the living conditions of trees should not be delayed any longer. There are countless root and trunk protection solutions available on the market that can improve tree conditions and make them safer, while not reducing human living space. In our review, we looked at the following solutions:

- root barrier
- permeable cover
- tree trellis
- rainwater retention
- watering bag
- drainage pipe
- soil net
- mineral-based planting medium
- artificial topsoil ("Stockholm method")
- suspended pavement (root cell)
- stem protection with jute tape
- trunk protection roller
- trunk protection grid
- parking bollards, bollards

In Hungarian practice, the structural soil method is increasingly used, but foreign experience shows that in the long term it does not give as good result as the root cell system. As well, based on various

https://scholarworks.umass.edu/fabos/vol7/iss1/20
DOI: https://doi.org/10.7275/3d1m-0285

studies (Smiley et al. 2006; Ow et al. 2017; Page et al. 2015; INT-02; Bartens et al. 2010), the root cell system would be the most effective solution. Root-cell systems, which have been used for decades as suspended enclosures (INT-03), are simple structures, usually made of plastic elements. They are manufactured by several companies worldwide (e.g. GreenBlue Urban - RootSpace; GreenMax - TreeParker). Root cell systems provide an appropriate response to most of the root threats: their key feature - **the separation of the load-receiving and the load-bearing layers** - creates a habitat for the tree in an environment with a loose, healthy soil biota and improved water balance (Smiley et al. 2006). By dissipating vibrations, the roots of the hairs are not damaged and the soil is not compacted, and the looser medium can drain and retain more water (INT-04). The roots do not grow into the more compacted soil, so there is less risk of damage to utilities or pavement.

4. Methods and Data

To understand the problems in parking lots, we chose Budaörs, a small town in the agglomeration of Budapest, as the research site for our study. With its excellent transport links, a large shopping region has developed alongside the motorway over the last 25 years, but the large paved areas pose a major ecological problem and the poor condition of the trees prevents them from providing their assimilation services. The sample area under study is a parking lot in front of the Auchan supermarket in Budaörs, a French retail hypermarket chain. No official data were provided by the company, so we worked from our own surveys.

Visual tree survey for the parking lot survey, a multi-day site survey was conducted in July 2021, during which the existing floor plan was updated and tree locations and existing trees were inventoried. A visual tree survey and individual value calculation was performed for 300 specimens based on the guidelines and evaluation criteria of the Hungarian Tree Nursery Association (Puskás 2014). To calculate the value of the trees, the basic nursery price (updated for inflation (INT-05)) was multiplied by the values given for the following criteria: age of the tree, location and protection of the tree within the municipality, crown condition (based on EU assessment), health condition of the tree (based on EU assessment), and dendrological value of the species or variety.

Environmental model: We used the environmental modelling software ENVI-met to investigate the effects of the current tree population and the differences in thermal perception compared to an area with trees of ideal size. The program calculations were used to build a 3D model based on the tree inventory data. For the simulation of the current state, 5m tall trees with sparse or dense canopy and branches were used due to the limited capabilities of the program, while for the ideal state, trees with dense canopy and branches of uniform height of 15m were used (assuming that a similar stand would have developed over the last 20 years under appropriate conditions). In addition to temperature, we also investigated thermal comfort, which is quantified by an index called PMV (Predicted Mean Vote), which originally placed human indoor comfort on a 7-point scale: 0 being completely comfortable, -3 being cold and +3 being hot. Later, this scale was extended to measure outdoor thermal comfort, and was also mapped to temperature degrees (Gulyás 2009), so that a PMV of 0 corresponds to a thermal comfort of 18-23 ºC, while a PMV of 4 corresponds to a thermal comfort of 41-47 ºC.

Poll: An online poll was conducted instead of an on-site survey on the shopping habits, experiences and needs of Auchan car park users due to the COVID19 outbreak. In April 2021, 132 responses were received to a series of questions compiled in Google Forms and posted on social media platform (Facebook). The data was processed in an Excel spreadsheet.

5. Results

The Auchan site has 27% built-up area and 22% green area, with the remaining 51% (76 144 m^2) paved (Sin 2017). The car park area is almost entirely paved, with only a few areas broken up by green strips. It can be divided into 3 zones according to use along major roads for internal transport (Fig 1).

Zone 1: most exposed to traffic, 31 tree sites, 8 trees in need of replacement (26%)
Zone 2: average traffic, 197 tree sites, 69 trees in need of replacement (35%)
Zone 3: no traffic, 133 tree sites, 42 trees in need of replacement (31.6%)

Figure 1. Layout of the car park (Rujp 2021; source: Sin 2017)

The tree species typically used in the afforestation are *Fraxinus excelsior* and *Fraxinus angustifolia*, which make up more than 2/3 of the stand, but in some tree plantations the new planting consists of *Tilia tomentosa*. *Acer platanoides* and *Acer pseudoplatanus* are also found in more protected stands.
Our hypothesis assumption was that trees in the green belts, which provide better conditions, are healthier and larger than those in tree pits. However, the results of the visual tree survey show that there is also variation between zones (Table 1). The more stressed an area is, the smaller the trunk circumference of the trees in the green belts. The trees in the tree pit are equally small in all zones.

https://scholarworks.umass.edu/fabos/vol7/iss1/20
DOI: https://doi.org/10.7275/3d1m-0285

Table 1. Dimensions of trees in the car park by zone

	Trunkcircumference		Crown diameter	
	Tree pit	Green line	Tree pit	Green line
Zone 1	31-32 cm	**44 cm**	2,1 m	3,6 m
Zone 2		**49 cm**	2,1 m	3,9 m
Zone 3		**53 cm**	**2,5 m**	4 m

The data for trees in the tree canopy are striking in zone 3, where the crown diameter of trees is 20% larger than in the more loaded zones, while their trunk diameter is the same, i.e. the crown size of trees in the canopy also depends on the amount of traffic (Fig. 2).

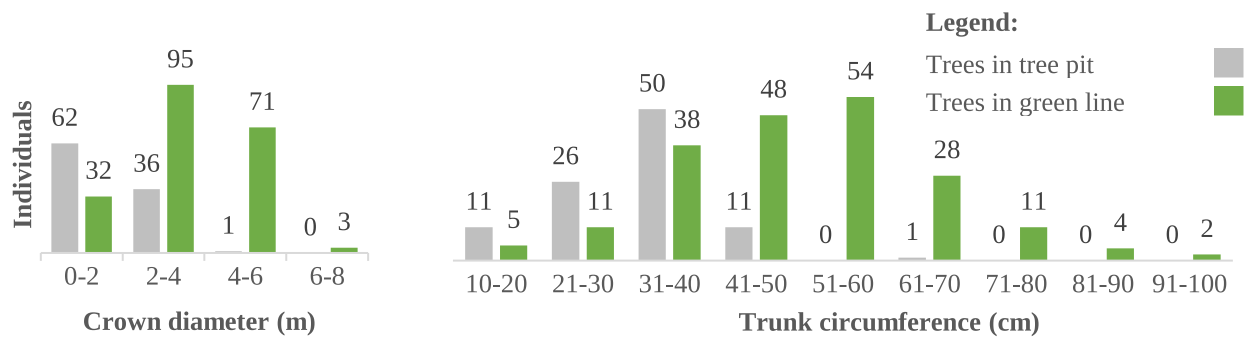

Figure 2. Dimensions of the trees in the car park depending on the conditions

So the first part of our hypothesis proved to be true: trees in better conditions - i.e. in green belts or less stressed environments - can grow larger. However, when looking at their health, the aggregated data show that it is similar regardless of the conditions (see Fig. 3).

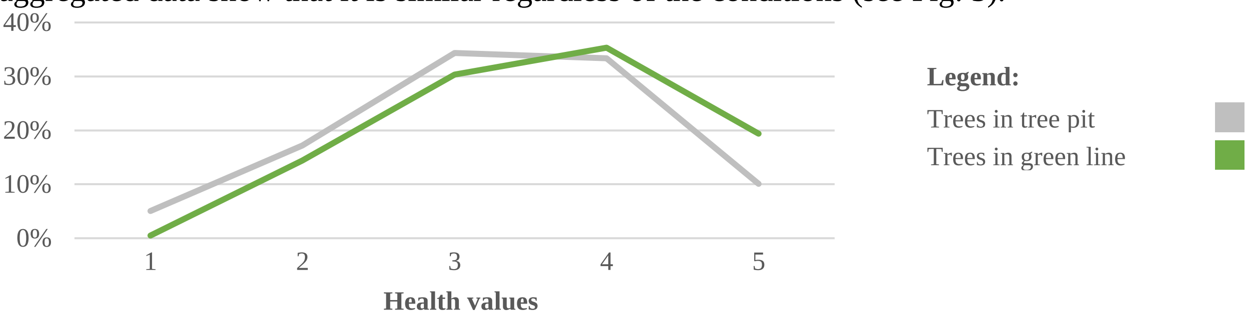

Figure 3. Health of the trees in the car park depending on the conditions

This part of our assumption was therefore not true, because although the green belts contain older and larger trees than the tree pits, their health is equally poor. However, given that trees in the green belts have been able to grow, the similarities in health are probably due to different damaging effects. The damaging effects detailed in Paragraph 2 are present in the area almost without exception. Poor growing conditions and continuous damage weaken trees (especially those in tree pit), making them less resistant to disease. Three main pathogens have been found in the area: *Aceria fraxinivora*, *Hylesinus* spp and *Hymenoscyphus fraxineus*. The latter unfortunately attacks the two most common *Fraxinus* species found in the car park (Maráczi 2013).
Trees also have a monetary value based on their ecosystem services. Based on the calculation described in Paragraph 4, the total value of the 300 live trees in the area is **19.03 million HUF**, i.e. the value of the nursery stock purchased would fully replace their current "service". However, with

regular care and attention and the right planting methods, these trees, planted 20 years ago, could now form a large, healthy stand, which would not only provide ecological services but also have a monetary value. Thus, a calculation was also made for the potential tree stock: the typical species *Fraxinus* excelsior was substituted in the empty tree sites, and all existing trees were taken as healthy 20-year-old trees. The value of the tree stock was thus more than **167.5 million HUF**.
This huge difference would also be reflected in their ecological services. We modelled the current and potential conditions in ENVI-met and ran it on a hot summer day, 15 July (with a westerly wind of 2.5 m/s), within the noon to 4 pm interval (Fig. 4).

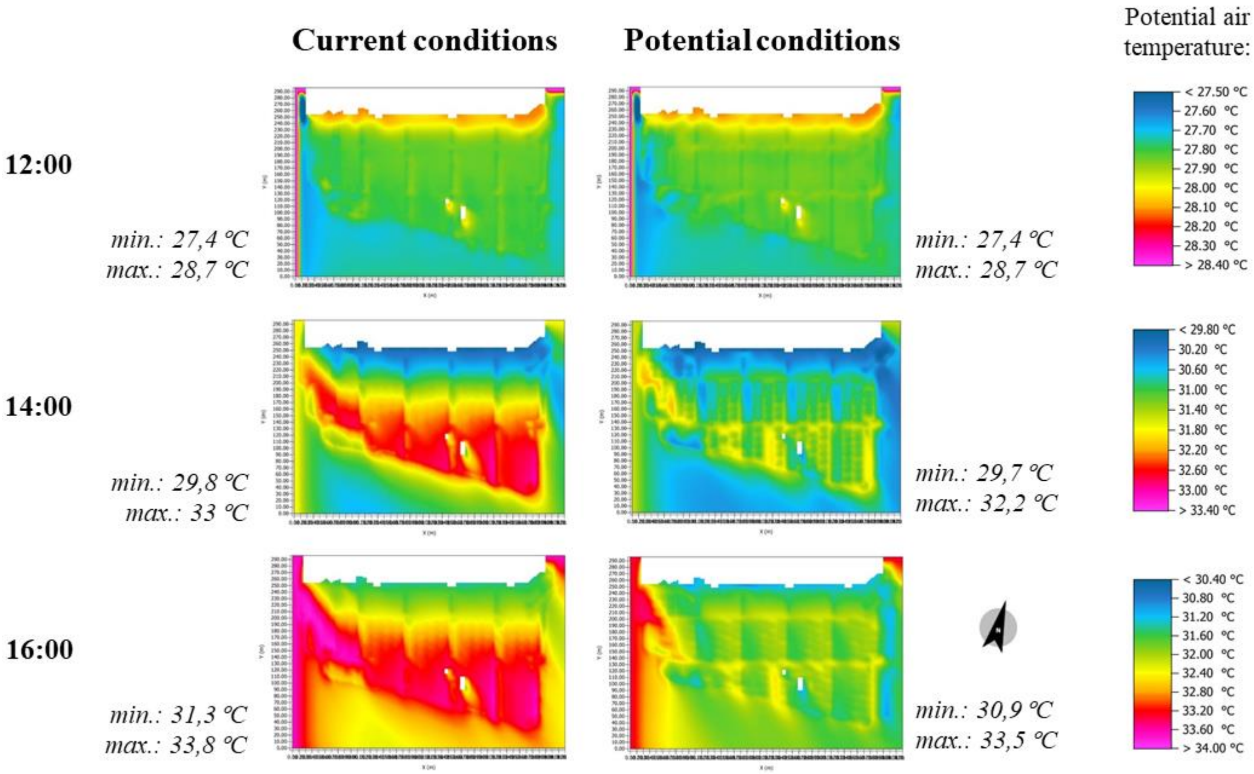

Figure 4. Temperature differences between current and potential forest cover

The difference is visibly large, with the biggest jump at 4pm, when the air inside the car park is on average 1ºC cooler due to the trees. Although this does not appear to be a significant decrease, the presence of larger trees (due to evaporation, shade and air movement) has a marked effect on thermal comfort, which is strongly influenced by the environment (e.g. quality of pavements, vegetation), and we therefore examined the differences in the degree of tree cover at the most critical time of 4 pm. The results are dramatic. The predicted mean vote (PMV) value of around 5 in the current condition is reduced to between 3.5 and 4 only around trees in the green strips. In ºC, this means a temperature of 47 ºC, which even in the immediate vicinity of the trees is only reduced to 41 ºC. In contrast, the healthy, large canopy trees of the potential condition can reduce the PMV of the asphalt surface by a very large proportion to almost 4.9: almost the entire car park would be around 0.5, i.e. the temperature could be as low as 23ºC. This represents a difference in thermal comfort of up to 18-24ºC compared to current data.
The vast asphalt surfaces of the shopping region, the nearby motorway and the heat emissions from Auchan and the surrounding stores combine to create a heat island that has a significant impact on

the life of the city, but also a particularly high impact on those living nearby. Figure 5 clearly shows the reduction in the height and extent of the warm air layers with improved tree cover, so it can be argued that it would not only improve the microclimate around the car park and the department store, but also the immediate surroundings, across site boundaries.

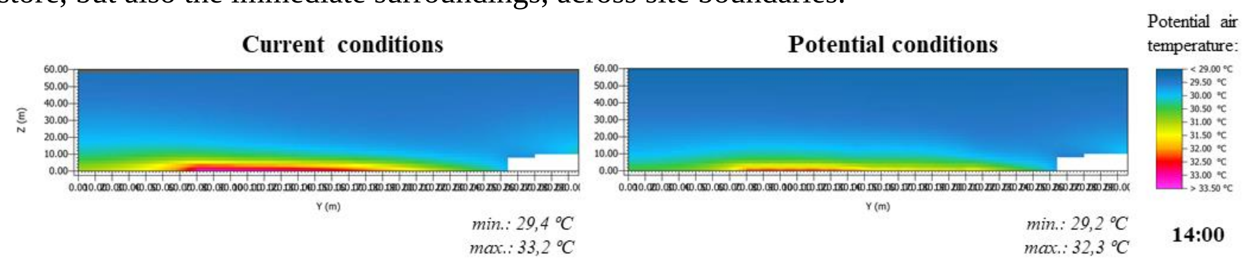

Figure 5. Impact of current and potential forest cover on the heat island effect

6. Discussion and Conclusion

Based on the results of the surveys, it is clear that the current state of green space in cities will need to be improved within a few years. To summarize, in order to improve the ecosystem services provided by the trees, the following should be considered. Even with more regular maintenance, the life of the current tree stock can be extended to a maximum of 10 years, but in the long term, the replacement of diseased and damaged trees is inevitable. When planting new trees, Auchan will have to decide whether the most economical solution is to plant a drought-tolerant taxon or to improve the living conditions of the trees for ecological benefits. This would require significantly larger tree sites, or one of the root protection options described (mineral potting media, artificial soil, root cells).

Although each of these represents a large investment, our calculations suggest that if trees had been planted 20 years ago in a root cell system, they would have almost fully recovered their value by now. However, even if the benefits, which cannot be quantified, are included, they far exceed the resources invested, which are repaid many times over: a more beautiful and relaxing environment attracts customers in shopping areas: they are more inclined to buy, spend more time in the shop or its surroundings and thus spend more money (Wolf, 2003). Our July 2021 survey confirmed this in part: although a greener environment is not a priority for Hungarian shoppers, it is something they would expect from any business. The suggestions received point in the same direction: a more humanised, liveable store environment would increase prestige and create stronger customer loyalty.

However, there are good examples in Hungary too. For example, in the car park in front of Auchan in Fót, where shrubs are planted in the tree pits, improving the living conditions of the trees and adding other additional functions (sports field, playground). Landscape architecture is about greening, making the urban environment more liveable and attractive. Our study helps planners and decision-makers to recognise the true value of trees. Further surveys should be conducted in other locations, providing an opportunity for psychological, sociological and economic research to fully understand customer needs and the true return on investment.

7. References

Akbari, Hashem, Susan Davis, Sofia Dorsano, Joe Huang and Steven Winnett. 1992. Cooling Our Communities - A Guidebook on Tree Planting and Light-colored Surfacing, Washington: U.S. Environmental Protection Agency

Bartens, Julia, P. Eric Wiseman and E. Thomas Smiley. 2010. “Stability of landscape trees in engineered and conventional urban soil mixes.” Urban Forestry & Urban Greening 9, no. 4: 333–338.

Craul, Philip J. 1992. Urban Soil in Landscape Design. John Wiley & Sons.

Dwyer, John F., E. Gregory McPherson, Herbert W. Schroeder and Rowan A. Rowntree. 1992. “Assessing the benefits and costs of the urban forest.” Journal of Arboriculture 18, no. 5: 227-234.

Farsang, Andrea. 2011. Talajvédelem, Pannon Egyetem - Környezetmérnöki intézet

Grabosky, Jason, Nina Bassuk and B.Z. Marranca. 2002. “Preliminary findings from measuring street tree shoot growth in two skeletal soil installations compared to tree lawn plantings.” Journal of Arboriculture 28, no. 2: 106–108.

Gulyás, Ágnes. 2009. Humán bioklimatológiai értékelések különböző léptékű megközelítésben. Szeged: SZTE TTIK Éghajlattani és Tájföldrajzi Tanszék

Haughton, Graham and Colin Hunter. 1994. Sustainable Cities - Regional Policy and Development, London: Routledge Press

Heisler, Gordon M. 1986. “Energy Savings with Trees.” Journal of Arboriculture 12, no. 5: 113-125.

Inkiläinen, Elina N. M., Melissa R. McHale, Gary B. Blank, April L. James and Eero Nikinmaa. 2013. “The role of the residential urban forest in regulating throughfall: a case study in Raleigh North Carolina, USA.” Landscape and Urban Planning 119, 91–103.

Jim, Chi Yung. 1993. “Soil compaction as a constraint to tree growth in tropical and subtropical urban habitats.” Environmental Conservation 20, no. 1: 35–49.

Johnson, Craig W. 1988. “Planning for Avian Wildlife in Urbanizing Areas in America Desert/Mountain Valley Environments.” Landscape and Urban Planning 16, no. 3: 245-252.

Láng, Edit. 1981. “A talaj.” *In Növényföldrajz, társulástan és ökológia*, edited by Hortobágyi Tibor and Simon Tibor, 380-415. Budapest: Tankönyvkiadó

Lormand, Jeffrey R. 1988. The Effects of Urban Vegetation on Stormwater Runoff in an Arid Environment. Master’s Thesis. School of Renewable National Resources, University of Arizona, Tucson, AZ.

Lukács, Zoltán. 2020. Faápolás. Budaörs: Garden Kft.

Maráczi, László. 2013. Díszfák, díszcserjék védelme. Szombathely: Nyugat-Dunántúli Díszfaiskolások Egyesülete

McPherson, E. Gregory, David Nowak, Gordon Heisler, Sue Grimmond, Catherine Souch, Rich Grant and Rowan Rowntree. 1997. “Quantifying urban forest structure, function, and value: the Chicago Urban Forest Climate Project.” Urban Ecosystems 1, no. 1: 49–61.

https://scholarworks.umass.edu/fabos/vol7/iss1/20
DOI: https://doi.org/10.7275/3d1m-0285

Nowak, David J., Rowan A. Rowntree, E. Gregory McPherson, Susan M. Sisinni, Esther R. Kerkmann and Jack C. Stevens. 1996. "Measuring and analyzing urban tree cover." Landscape and Urban Planning 36, no. 1: 49-57.

Ow, Lai F., Subhadip Ghosh. 2017. "Growth of street trees in urban ecosystems: structural cells and structural soil." Journal of Urban Ecology 3, no1: 1–7.

Page, Jonathan L., Ryan J. Winston and William F. Hunt III. 2015. "Soils beneath suspended pavements: An opportunity for stormwater control and treatment." Ecological Engineering 82, 40–48.

Puskás, Lajos, 2014. "A városi fák értéke." Erdészeti Lapok 149, no. 5: 162-163.

Shigo, Alex L. 1990. Die neue Baumbiologie Fachbegriffe von A bis Z. Braunschweig: Talacker Verlag,

Sin, Emília, 2017. Budaörs Város Kereskedelmi Parkjának TSZT és HÉSZ módosítására vonatkozó kérelmét alátámasztó telepítési tanulmányterv, Budapest: KASIB Mérnöki Manager Iroda Kft.

Smiley, E. Thomas, Lisa Calfee, Bruce R. Fraedrich, and Emma J. Smiley. 2006. "Comparison of structural and noncompacted soils for trees surrounded by pavement." Arboriculture & Urban Forestry 34, no 4: 164–169.

Studio Metropolitana. 2006. PRO VERDE; Budapest zöldfelületi rendszerének fejlesztési koncepciója és programja. Egyeztetett dokumentáció. Budapest: Studio Metropolitana Urbanisztikai Kutató Központ

Tyrväinen, Liisa, Harri Silvennoinen, and Osmo Kolehmainen. 2003. "Ecological and aesthetic values in urban forest management." Urban Forestry & Urban Greening 1, no. 3: 135–149.

Ulrich, Roger S., Robert F. Simons, Barbara D. Losito, Evelyn Fiorito, Mark A. Miles and Michael Zelson. 1991. "Stress recovery during exposure to natural and urban environments." Journal of Environmental Psychology 11, no. 3: 201–230.

Wolf, Kathleen L. 2003. "Freeway Roadside Management: The Urban Forest Beyond the White Line." Journal of Arboriculture 29, no. 3: 127-136.

Xiao, Qingfu, E. Gregory McPherson, James R. Simpson and Susan L. Ustin. 1998. "Rainfall interception by Sacramento's urban forest." Journal of Arboriculture 24, no. 4: 235–244.

INT-01 (2021. 03. 18.): https://ng.24.hu/tudomany/2020/12/11/tobb-tonnanyi-olmot-tartalmazo-szalloport-szurnek-ki-a-fak-levelei-a-levegobol/

INT-02 (2022. 02. 26.): https://greenblue.com/gb/resource-centre/soil-cells-vs-structural-soil-analyzing-soil-pavement/

INT-03 (2022. 02. 26.): https://www.smartcitiesdive.com/ex/sustainablecitiescollective/brief-history-trees-suspended-pavement/248906/

INT-04 (2022. 02. 26.): https://www.deeproot.com/blog/blog-entries/what-is-suspended-pavement/

INT-05 (2021. 10. 22.): https://www.ksh.hu/stadat_files/ara/hu/ara0002.html