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How much is a green area in town of Kecskemét worth?

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Abstract In our research, we try to prove the thesis that the value of ornamental plants can be expressed not only in their decorativeness. They have a number of measurable parameters that are far more important than aesthetics in many cases. The survey published in the work was carried out on an urban green area in Kecskemét established in the 1970s. Based on the previous data, it can be stated that the oldest individuals of the stock, which are mainly used for educational purposes, are already 40-45 years old. The collection is also an important part of the city's green infrastructure. The multi-level, dense vegetation has significant O_2-producing, CO_2-binding, evaporative, and dust-filtering properties. These are the ecological services that contribute to a more livable environment. During the survey, we measured 600 individuals and recorded their data. The environmental usefulness of this plant population, as determined by a comprehensive evaluation, is presented in our present study, which confirms the significance of the woody collection.

Key words

ecological services of woody plants, green value, ornamental trees and shrubs

The ecological role of urban green spaces consists of the following components, among others: climate, water management and water quality, influencing air quality, composition and speed, and soil protection [23]. The significance of these effects has greatly increased in recent decades due to global and regional plant eradication [24]. When determining the utility value, it should be taken into account that the significance of trees as living beings is determined by several subjective factors.

The definition of ecosystem services can help resolve certain contentious issues that arise from conflicts of economic and public welfare interests, such as in certain construction projects. Based on the opinion of Dezső Radó, this is based on the number of leaves in the plant; that is, the volume of foliage. The actual services and their data are as follows.

- improving the composition of the air (It produces 440 g of oxygen and processes 590 g of carbon dioxide per cubic meter of leaf area during a growing season) [25];
- shielding (absorbs 70% of incoming rays, reflects 10%);
- improving the climate (One cubic meter of leaf volume can evaporate 47 liters of water per year and thereby increases the relative humidity of the air by 5-6%);
- filtering out pollutants (10.6-13.7 g/m^2 foliage/year based on data from three U.S. cities [10], or per 1 cubic meter of foliage, it is able to filter out 4500 g of dust, heavy metals, soot, asbestos etc. per year based on Hungarian data) [25]. According to Nyelele, 2019, 1 hectare of Bronx green space can filter out 2000 tons of the really dangerous PM2.5 fraction;
- ozone-forming volatile organic compounds (VOC) [2] especially in the *Quercus*, *Populus*, *Platanus* and *Salix* genera [10];
- noise protection (32 dB for three-level plant strip; 8-20 dB reduction for tree line) [25];
- protection against vibrations (importance of roots between roads and buildings);
- soil protection (erosion, deflation);
- reduction of rainwater runoff [28];
- cloud-forming effect of pine forests;
- protection of built environment (buildings, roads);
- enhancing biodiversity (insects, birds);
- health-protecting monoterpene hydrocarbons, organic acids, alcohols, tanning substances;
- recreational effect [26];
- energy savings (20-25% per year) [3]. The cost of heating and cooling can be reduced by 10-40% annually with proper afforestation.

The aim of our research was to determine the ecological services of the collection garden, mainly in terms of the positive effects on the composition of the air.

Material and Method

The research was carried out in Kecskemét, on the campus of the Faculty of Horticulture and Rural Development of John von Neumann University (Mészöly Gyula square 1-3). The study area is 26600 m^2, of which the green areas are 11900 m^2 (45%). Higher education in the field of horticulture and agriculture has been taking place here since 1974 (Figure 1).

Note: buildings are marked with a stripe and green areas are marked with a dashed line and capital letters.

During the survey, we recorded 461 trees (or woody plants with trunks), as well as 174 shrub individuals and shrub groups and 17 patchy creeping shrubs. We used the work of Johnson and More (2007) and Tóth (2012) to identify taxa.

To determine the foliage volume of trees, canopy radius were measured (horizontal projection from the trunk to the edge of the crown) in 4 places. In the case of shrubs, the horizontal dimension of plants was measured in two places, perpendicular to each other (width and length). The vertical extent of plants (trees, some shrubs and creepers) taller than 5 meters was calculated using the method of similar triangles [27]. Multiplying the base area by the height (as well as subtracting the trunk height) we obtained the leaf volume, which was corrected by a crown shape multiplier given by Coder (2018) according to the taxon-specific habitus. Subsequently, the obtained value was used to calculate the O_2 production during the vegetation period, the CO_2 (kg) and dust (kg) filtering out of the air, and the rate of evaporation (l).

For measurements, a Hedue 5-meter telescopic leveling staff and 50-meter and 150-cm measuring tapes were used. When weather and light conditions allowed the horizontal distances required for altitude measurement, we recorded the Möller MR70664 laser rangefinder.

In the calculation of the value, we used the method of calculating the wood value recommended by the Association of Hungarian Tree Doctors. This method calculates the value of trees as follows:

Tree value = A×B×C×D×E×M, where the meaning of each multiplication factor is as follows:

A: the base price of a 12/14 trunk sized, earth ball tree transplanted at least 2 times plus VAT

B: age multiplier

C: the multiplier of the protection of the tree and its location in the settlement

D: the coefficient of the crown condition assigned to the EU cadastral survey

E: a multiplier for the overall health and viability of the tree

M: dendrological value of the tree [29].

To determine the prices of trees, we used the catalogs of Tahi Tree Nursery Ltd. and Alsótekeres Tree Nursery Ltd. The B values was determined from the trunk size data of the plants. In terms of protection, the total stock was evaluated with a coefficient of 1. The D and E values were determined using the bonitation values developed by Radó (1999). The dendrological value was given on the basis of a table prepared by Schmidt (2011) [29]. Where the given taxa was missing, the data of another member of the genus was assigned to the species. The valuation was carried out only for the trees.

Results and Discussions

Plants in the eastern, western and southern parts of the area (areas A to M)

There are 281 trees and 142 shrubs and creeping patches in this area. For trees, this is 61 for the total population; and 75% for shrubs. Trees have a foliage volume of 73,015 m^3, produce 47,46 kg of O_2, filter out 43,079 kg of CO_2 and 328,569 kg pollutants and evaporate 3431724 l of water. The 1084 m^3 foliage of shrubs produces 705 kg of O_2, filters out 640 kg of CO_2 and 4 880 kg of pollutants, and evaporates 50 965 l of water.

Plants in the northern part of the area (areas N to S)

Of the total stock surveyed, there are 180 trees, as well as 49 shrubs and creeping shrubs. There are 39% of trees and 25% of shrubs in this area. Trees with a foliage volume of 36,787 m^3 produce 23,911 kg of O_2, filter out 21,704 kg of CO_2 and 165,540 kg of pollutants, and evaporate 1,728,980 liters of water. The 261 m^3 foliage volume calculated for shrubs and creeping shrubs emits 170 kg of O_2 during a growing season, filters out 154 kg of CO_2 and 1176 kg of pollutants and evaporates 12 287 l of water.

Distribution of ecosystem services by taxa

Of the trees (or shrubs with trunks), 140 taxa are found in the study area. Within these, 99 species and 41 subspecies taxonomic categories (subspecies, variant and variety) can be observed. Of the evergreen plants, 87 individuals of 37 taxa are present. These specimens have a foliage volume of 5,687.64 m^3, which is 5.23% of the total volume.

The ecosystem services of the major taxa are illustrated in Figure 2. It can be read from this that the largest ecological services are 17 individuals of *Quercus robur*. The foliage of 14,801.99 m^3 provided by them represents 13.62% of the total stock of 461 pieces. *Tilia platyphyllos* has the largest number of species (28 individuals), but in terms of foliage volume, this species is only the second of the trees, with a total size of 10337.93 m^3. However, *Koelreuteria paniculata* with a capacity of 23 specimens is only 5th in terms of foliage and is preceded by the *Betula pendula* (8051.58 m^3) and the *Carpinus betulus* stock with a volume of 5080.16 m^3, of which 16 and 14 are located in the area. There are also 10-10 specimens of *Corylus colurna* and *Tilia cordata*, which have almost the same foliage volume (1328-1441 m^3). The *Cornus sanguinea* shown in Figure 2, although a shrub, is located among the trees due to its size and bald “trunk”.

Only one plant of 57 species or cultivars could be surveyed. Among these 'solitaire' individuals, *Ulmus minor* stands out in terms of environmental utility, which is located in the middle of the area 'O' (Figure 1). The foliage volume of this single tree is 1237.66 m^3 (1.14% of the total volume). However, this value is barely half the size of the largest individual from the species *Quercus robur* and has a data of 2689.21 m^3 (2.47% of the total value of 108710.5 m^3). This individual is located in the ‘C3’ area, next to the gym. Among the large trees, the two corpulent *Populus alba* specimen, on the border of the area areas 'E' and 'H', is also prominent. They have foliage volumes of 2557.69 and 2351.48 m^3 respectively. The largest evergreen 'tree' is a *Taxus baccata*, whose 535.44 m^3 green space continuously provides services that improve the atmosphere. The foliage of × *Cupressocyparis leylandii* (472.03 m^3) is also significant. Both plants are located above the gym in the ‘O’ area (Figure 1).

In terms of shrubs, 9 specimens and patches of *Pyracantha coccinea* stand out in terms of environmental utility (175.23 m^3). The largest number of pieces is the species *Ligustrum vulgare*, of which 12 patches have been measured in the area (95.69 m^3). In addition, more than 10 pieces can be observed in the case of *Lonicera tatarica*, which covers 55.36 m^3 of foliage (Figure 3). With a combined leaf volume of more than 50 m^3, there are still 8 specimens of *Sambucus nigra* (93.01 m^3).

There are 89 taxa among the 191 shrubs and patches. This value can be divided into 52 species and 37 varieties, respectively. The group of plants with the highest environmental utility (approximately 10 specimens) also comes from the species *Pyracantha coccinea*. This patch has a foliage volume of 35.04 m^3. *Campsis radicans* are the most significant of the creeping shrubs (22.33 m^3). The amount of green mass of leafy, scaly and needle leaf evergreens is 387.8 m^3, which is more than 1/3 (35.66%) of the total shrub stock (1087.48 m^3).

Valuation of the stock

The value of the plant stock in the eastern, western and southern parts of the area (areas A to M) is HUF 395784875 (approx. EUR 1070000), which is 62.4% of the total green wealth. *Quercus cerris* has the highest theoretical value in this part of the garden (HUF 20280000, approx. EUR 55000). This is followed by the *Celtis australis* and several specimens of *Quercus robur*, as well as the two *Carpinus betulus* specimens at the base of the building, which are also worth more than HUF 10 million. The category of HUF 5-10 million has already included an old *Populus alba*, some maple specimens as well as a *Koelreuteria paniculata* and *Gymnocladus dioica*. 81 plants have a value of between 1 and 5 million forints. *Platanus acerifolia* and *Tilia* are predominant in this range. The value of the other 181 plants is less than HUF 1000000. The theoretical value of the plant population located in the northern part of the area is HUF 238911955, which represents approximately 1/3 of the total surveyed area (37.6 %). Here, the three most valuable specimens all come from the species *Quercus robur*. Even a nearly 80-year-old *Ulmus minor* has a value of over HUF 10000000 (approx. EUR 27000). There are 5 trees in the 5 to 10 million category: in addition to the pedunculate oaks, there is also a *Koelreuteria paniculata* and an *Acer campestre*. The presence of *Koelreuteria paniculata* specimens is dominant in the range of HUF 1 to 5 million. The value of the other 123 trees is below HUF 1000000 or it was not possible to calculate it due to the missing data.

Conclusions

The environmental utility values of the entire woody stock in the area are as follows: 72 246.21 kg of O_2 emissions, 65 577.33 kg of CO_2 filtering, 500 166.08 kg of dust filtering and 5 222 956.77 liters of water evaporation during a growing season. Projecting these values per unit area (m^2), it can be calculated that the stock emits 6.1 kg of oxygen and filters out 5.5 kg of carbon dioxide; and 42 kg of dust and contaminants. In the United States, the carbon storage density of national urban forests is 2.51 kg of carbon per m^2, which is approximately in line with what we measure [11]. However, the value of the pollutant uptake is below the Bronx figure of 206.5 kg/m^2, which applies only to the fraction PM2.5. With regard to the evaporation of water, the green space in Mészöly Gyula Square contributes to making the environment more livable (not counting the longer growing season of evergreens) with a value of 438.9 liters/m^2. This figure is also in line with the 279.9-839.8 kg H_2O/m^2/vegetation period calculated from the southern transpiration rate of urban trees [7].

The value of the surveyed area is HUF 634696830 (approx. EUR 1700000). Per square meter of green space, this means HUF 53336 (approx. EUR 140). For an average public park, this value was HUF 9350/m^2 (approx. EUR 25/m^2) in 2011. This also shows how much higher value the collection gardens have compared to an average green area. The average value of one tree is HUF 1376783 (approx. EUR 3700). This is 162% of the average HUF 850000 reported in the literature [29]. And these are just data that can be quantified. In our research we did not detail the other ecological services, perhaps the extent of the green wealth represented by a collection garden in Kecskemét can be assessed in this way.

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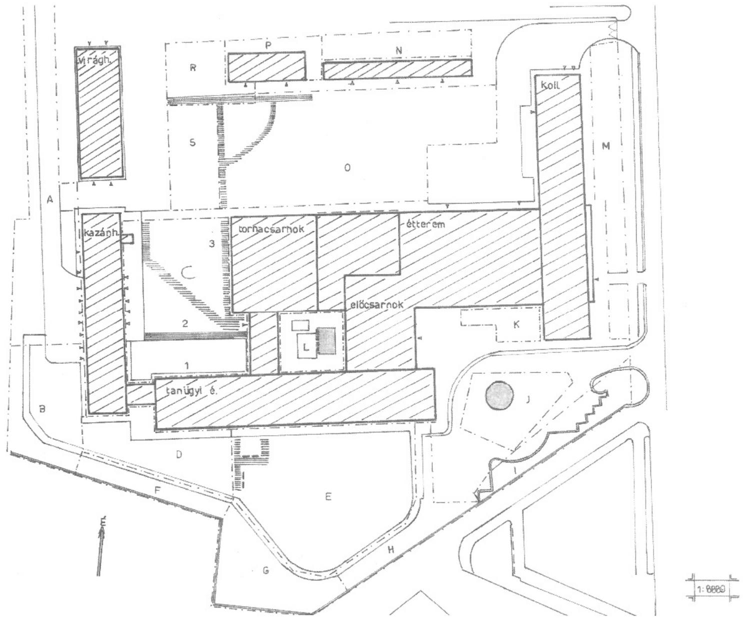

Figure 1. Overview map of the Faculty of Horticulture and Rural Development
of the John von Neumann University

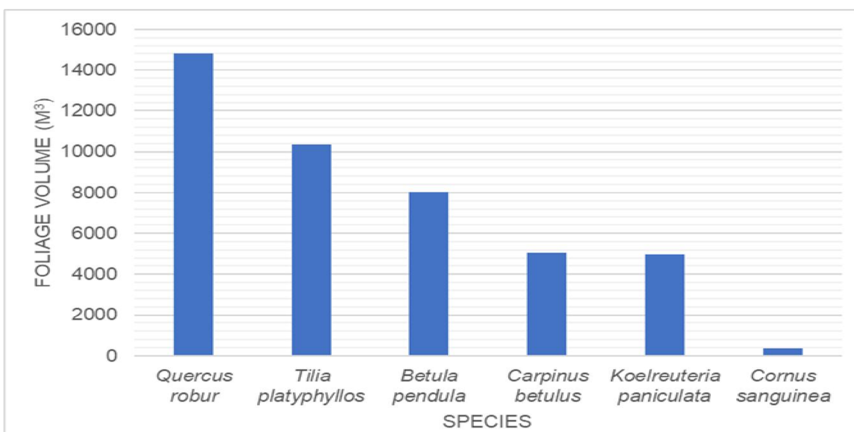

Figure 2. Foliage volume of the populations of trunk species with more than 10 species at the Faculty of Horticulture and Rural Development of John von Neumann University (2019, Kecskemét)

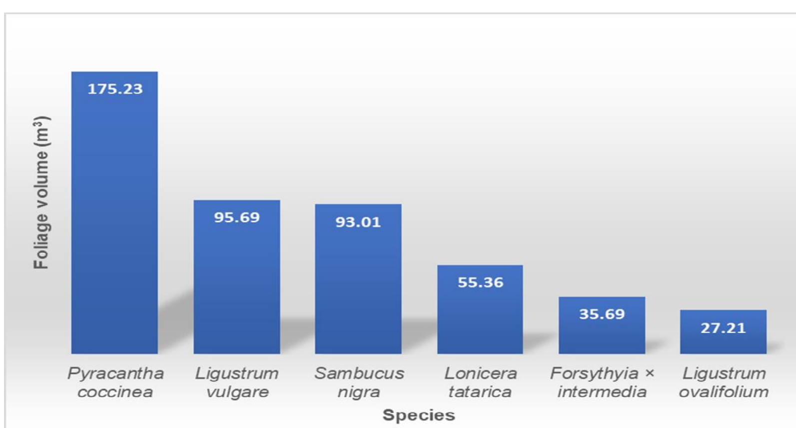

Figure 3. Foliage volume of shrub species with more than 6 species at the Faculty of Horticulture and Rural Development of John von Neumann University (2019, Kecskemét)