INVENTORY OF WOODY SPECIES IN ROMANIAN HISTORICAL GARDENS FOR ESTIMATING THE IRRIGATION WATER NEEDS

MORAR Teodora[1)], Adela HOBLE[1)], Alina MORNEA PETRACHE[1)], Diana CULESCU[2)]*, Emil LUCA[1)]

[1)]*University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, 3-5 Calea Manastur St., Cluj-Napoca, Romania*

[2)]*RPR-Birou de studii contemporane, Bucharest, Romania*

*Corresponding author: dianaculescu@gmail.com

Abstract. Climate change effects can be seen in most urban areas around the globe, thus local public administrations take into consideration establishing irrigation systems when managing green areas. In Romania, more and more green areas with mature woody plants are irrigated, even historical gardens, but most projects lack the motivation behind implementing the watering systems. To establish if and when irrigation is needed in historical gardens, it is proposed to begin with a detailed study regarding the vegetation composition. This article presents the woody species data collected from three historical gardens around Romania (Cluj-Napoca City, Gornești - Mureș County, and Bucharest City). Furthermore, this information will be used to develop a methodology for estimating the irrigation water needs of woody species recorded in historical green spaces around Romania. Moreover, the inventory data and the irrigation recommendations could be also used by the local administrations for better decision making regarding planning and management in historical gardens.

Keywords: green space management, historical garden, woody species, green registry, irrigation.

INTRODUCTION

All over the world, woody plants inventories are undertaken to improve management efficiency of urban green spaces for enhancing environmental sustainability, biodiversity, and even green infrastructure (Thaiutsa *et al.*, 2008; Muthulingam & Thangavel, 2012; Threlfall *et al.*, 2016).

Woody species inventories are of major importance for assessing landscape water needs in specific climatic conditions because a plant's irrigation requirement is conditioned by the biological characteristics of plants (Beeson, 2005) in correlation with soil properties and topography of the field. These studies should be carried out every three years (Hilaire *et al.*, 2008).

In Romania, vegetation inventories should be part of the local green registries as the Romanian *Law 24/2007 regarding the regulation and administration of green spaces* stipulates. However, most of the Romanian local administrations do not have updated green registries, thus green space planning and management is very poorly done, and the ecological and aesthetical values of green spaces are declining.

Moreover, global urban water use increased in the past 100 years, thus most probably 55% of the world's population would face water crisis by 2050 (Gober, 2010). The European Commission recognised as well the challenge represented by water scarcity and droughts (Ortuño, 2010). Additionally, due to climate change, there is an increased need for watering landscapes (Hilaire *et al.*, 2008).

In this changing environment, affected by climate change and water scarcity, efficient landscape water management should be promoted for water conservation while keeping the environmental and aesthetical values of landscapes. Thus, green space management should include policies and standards for efficient irrigation (Kjelgren *et al.*, 2016; Hilaire *et al.*, 2008). New trends are also promoting deficit irrigation approaches, therefore a "plant approach" is mandatory (Ferreira *et al.*, 2008).

Regarding historical gardens, most studies focus on the conservation, restoration, management, design, philosophies, historical background and their biological diversity (Hamdy, 2007; Kümmerling & Müller, 2012; Athanasiadou, 2019; Gullino *et al.,* 2020), little research has posed the question of if and when irrigation is needed in historical gardens with mature woody plants.

The Florence Charter (ICOMOS/IFLA, 1981) defines the historic garden as an architectural composition whose constituents are primarily vegetal. It is also prohibited to employ any alteration to the physical environment which will endanger the ecological equilibrium. Thus, in the PhD research project is proposed a methodology for planning, design, and management of irrigation systems in historical gardens, applying the following steps: (a) firstly, a vegetation inventory should be conducted, then (b) the water needs of the plants should be estimated in interdependence with (c) climate data, soil characteristics and topography of the field, (d) to provide a set of rules of *when, where,* and *how* irrigation should be done in compliance with the international guidelines set by the Florence Charter regarding the preservation of historic gardens. In this paper, the results of the first step are presented, respectively the woody species inventory.

In the List of historical monuments in Romania, elaborated by the Ministry of Culture in 2015, 158 heritage parks and gardens were nominated (Mexi, 2020). However, even if historical gardens and parks are part of the list there is still a lack in research in landscape architecture heritage (Mexi *et al.*, 2018), and thus absence of proper management on historical gardens and parks.

The three historical gardens analyzed in this paper can be considered references in Romania, being among the first landscaping projects carried out, namely the Teleki Castle Garden in Gornești – Mureș (1789-1792) at the end of the 18th century, and the Central Park of Cluj-Napoca (1897) and the Cișmigiu Garden in Bucharest (1854) in the 19th century. It is also worth mentioning that two of them were designed for public use when the cities were modernized, namely Central Park and Cișmigiu Garden, and Teleki Castle Garden is private (Marcus, 1958; Iliescu, 2014; Mexi *et al.*, 2018).

MATERIALS AND METHODS

Detailed surveys of the existing woody species composition (Fig. 2.) were made in all the three historical gardens located as presented in Figure 1.

Central Park of Cluj-Napoca

The field data was collected for the Cluj-Napoca Green Register. The data was made available for research purposes by the Green Spaces Service - Directorate of Urban Ecology and Green Spaces within The City Hall of Cluj-Napoca. The primary data has been entered into the TreePlotter software in the summer of 2020.

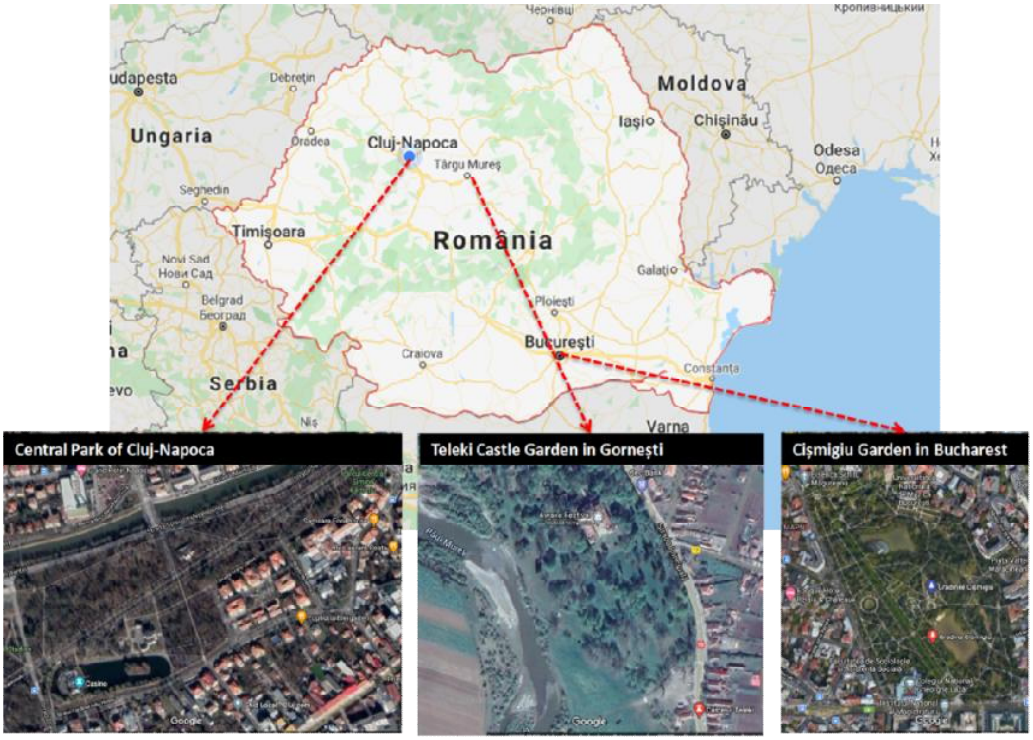
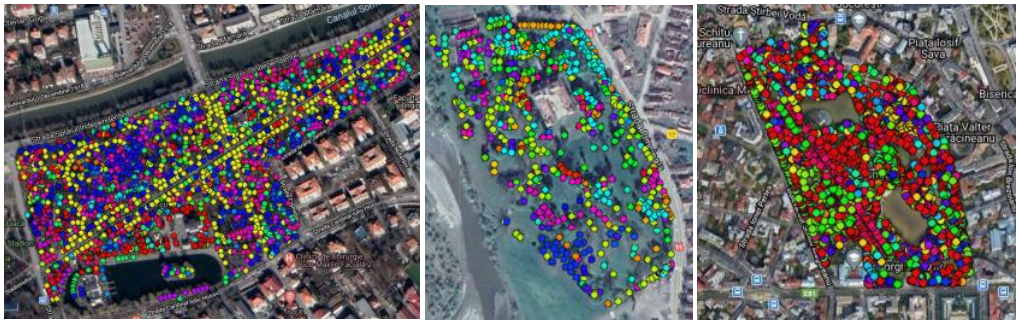


Fig. 1. Location of the historical gardens (adapted from https://www.google.ro/maps)



(a) (b) (c)

Fig. 2. TreePlotter maps of woody species composition: (a) Central Park of Cluj-Napoca; (b) Teleki Castle Garden in Gornești; (c) Cișmigiu Garden in Bucharest

Teleki Castle Garden in Gornești

The tree data was collected using the TreePlotter (Morar *et al.*, 2019) software, in the summer of 2019 by a team of 7 professionals and students from the fields of landscape architecture, arboriculture, architecture and history.

Cișmigiu Garden in Bucharest

The field data was collected using the TreePlotter software, in August and September 2019 by a team of over 60 volunteers, led by 5 professionals in the fields of landscape architecture.

All woody plants found on site were analyzed by adding in the Tree Plotter software the following data: georeferenced location, specie, and trunk diameter at a

height of 1.00 m according to nursery standards (DBH). The trunk diameter was measured at 1.00 m above ground because landscape trees characteristics are different from forestry trees due to the ecological conditions in which plants develop. All data was then exported to Microsoft Excel spreadsheets for data-file construction and analysis.

RESULTS AND DISCUSSIONS

A total of 7,238 woody plants were recorded across the three historical gardens taken into account, representing 161 plant species in 79 genera (Table1).

Table 1

Synthetic results regarding vegetation composition

Total trees and shrubs	Central Park of Cluj-Napoca	Cișmigiu Garden in Bucharest	Teleki Castle Garden in Gornești
Total Count	2914	3742	582
Total Species	97	119	42
Total Genera	57	62	28

Table 2

Most common genus - Central Park of Cluj-Napoca

Genus	Frequency of counted cases	Percent of total cases (%)
Aesculus	530	18.19
Acer	499	17.12
Tilia	298	10.23
Fraxinus	207	7.10
Robinia	114	3.91
Prunus	112	3.84
Thuja	112	3.84
Picea	101	3.47
Pinus	86	2.95
Berberis	83	2.85

Table 3

Most common species - Central Park of Cluj-Napoca

Species	Frequency of counted cases	Percent of total cases (%)
Aesculus hippocastanum L.	530	18.19
Acer platanoides L.	236	8.10
Acer pseudoplatanus L.	187	6.42
Fraxinus excelsior L.	156	5.35
Tilia cordata Mill.	136	4.67
Tilia tomentosa Moench	116	3.98
Robinia pseudacacia L.	114	3.91
Picea abies (L.) H. Karst	88	3.02
Thuja sp.	68	2.33
Acer negundo L.	57	1.96

The study conducted in the Central Park of Cluj-Napoca historical garden reveals that this green space has around 2,914 individual from 97 species in 57 genera (Table 1).

The most common genera (Table 2) representing around 50% of the total count: *Aesculus* (18.19%), followed by *Acer* (17.12%), *Tilia* (10.23%) *and Fraxinus* (7.10%).

The most common species (Table 3) representing around 50% of the total count are deciduous species: *Aesculus hippocastanum* L., *Acer platanoides* L., *Acer pseudoplatanus* L., *Fraxinus excelsior* L., *Tilia cordata* Mill., *Tilia tomentosa* Moench and *Robinia pseudacacia* L.

The inventory conducted in the summer of 2019 on the woody species recorded in the Teleki Castle's historical garden reveals that this green space has around 618 individuals from 42 species in 28 genera (Table 1). Almost 60% of the total species found pertain to only 3 genera (Table 4): *Acer (25.26%)*, *Fraxinus (22.85)*, *Tilia (10.31).* More than 50% of the most common species (Table 5) are deciduous and native to Romania*: Fraxinus excelsior* L., *Acer platanoides* L., *Tilia cordata* Mill.

Table 4

Most common genus - Teleki Castle Garden in Gornești

Genus	Frequency of counted cases	Percent of total cases (%)
Acer	147	25.26
Fraxinus	133	22.85
Tilia	60	10.31
Picea	48	8.25
Populus	37	6.36
Juglans	28	4.81
Aesculus	23	3.95
Robinia	22	3.78
Salix	19	3.26
Juniperus	11	1.89

Table 5

Most common species - Teleki Castle Garden in Gornești

Species	Frequency of counted cases	Percent of total cases (%)
Fraxinus excelsior L.	133	22.85
Acer platanoides L.	118	20.27
Tilia cordata Mill.	60	10.31
Picea abies (L.) H. Karst	47	8.08
Populus alba L.	28	4.81
Acer campestre L.	25	4.30
Aesculus hippocastanum L.	23	3.95
Robinia pseudacacia L.	22	3.78
Juglans regia L.	21	3.61
Salix alba L.	14	2.41

The survey conducted in Cișmigiu Garden in Bucharest reveals that this historical garden has around 3,742 individuals from 119 species in 62 genera (Table 1). The most common genera (Table 6) representing around 50% of the total count are:

Fraxinus, Thuja, Tilia, Buxus, Acer and *Prunus*. The most common species (Table 7) representing around 50% of the total count are both deciduous and evergreen species: *Thuja orientalis* L., *Fraxinus excelsior* L., *Buxus sempervirens* L., *Taxus baccata* L., *Celtis australis* L., *Tilia platyphyllos* Scop., *Cornus mas* L., *Prunus cerasifera* var. Pissardii, *Gleditsia triacanthos* L., *Tilia tomentosa* Moench.

Table 6

Most common genus – Cișmigiu Garden in Bucharest

Genus	Frequency of counted cases	Percent of total cases (%)
Fraxinus	389	10.40
Thuja	368	9.83
Tilia	346	9.25
Buxus	270	7.22
Acer	238	6.36
Prunus	231	6.17
Celtis	205	5.48
Taxus	194	5.18
Cornus	169	4.52
Ulmus	117	3.13

Table 7

Most common species – Cișmigiu Garden in Bucharest

Species	Frequency of counted cases	Percent of total cases (%)
Thuja orientalis L.	303	8.10
Fraxinus excelsior L.	294	7.86
Buxus sempervirens L.	270	7.22
Taxus baccata L.	187	5.00
Celtis australis L.	186	4.97
Tilia platyphyllos Scop.	181	4.84
Cornus mas L.	106	2.83
Prunus cerasifera var. pissard ii	105	2.81
Gleditsia triacanthos L.	104	2.78
Tilia tomentosa Moench	98	2.62

CONCLUSIONS

The woody species inventory in the three historical gardens reveals that the most common genera is represented by *Acer, Fraxinus, Tilia, Aesculus, Thuja, Prunus*, while the most common species are: *Aesculus hippocastanum* L., *Fraxinus excelsior* L., *Acer platanoides* L., *Thuja orientalis* L., *Buxus sempervirens* L., *Tilia cordata* Mill., *Tilia platyphyllos* Scop., *Taxus baccata* L., *Celtis australis* L., *Tilia tomentosa* Moench.

To provide a set of rules of *when, where and how* irrigation should be done - in compliance with the international guidelines set by the Florence Charter regarding the

preservation of historic gardens and the global climate change, and water conservation policies - the woody species inventory will be used to estimate the water needs in interdependence with climate data, soil characteristics and topography of the field for each of the three historical gardens studied.

The inventory data and the irrigation recommendations could be also used by the local administrations for better decision making regarding planning, conservation, restoration, management and maintenance of historical gardens.

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