COVER ASSESSMENT, TREE BENEFITS REPORT AND LANDSCAPE EVALUATION FOR RECONSTRUCTION AND EXPANSION OF THE NORTHERN AND NORTHEASTERN VEGETATIVE BARRIER OF THE NATIONAL ETHNOGRAPHIC PARK 'ROMULUS VUIA

Păunița Iuliana Boancă[1], Alice Oprică[2]*, Sonia Bodea[1], Andrei Mărincean[3]
[1]University of Agricultural Sciences and Veterinary Medicine, Faculty of Horticulture and Rural Development Business, Horticulture and Landscape Architecture Department, Mănăştur St.3-5, 400372, Cluj-Napoca, Romania;
[2]Technical University of Cluj-Napoca, Faculty of Architecture and Urbanism, Department of Urbanism and Technical Sciences
[3]University of Agricultural Sciences and Veterinary Medicine, The Doctoral School of Agricultural Engineering Sciences
**corresponding author: alice.oprica@arch.utcluj.ro*

Abstract. This study was initiated in the context of the initiative for the restoration and expansion of the northern and northeastern vegetation barrier of the Romulus Vuia National Ethnographic Park. The aim of the study is to justify the need for the expansion and restoration of the vegetation barrier by investigating historical data regarding its structure, the current situation of existing trees, assessing the surrounding landscape, and analyzing the ecological, social, and economic benefits brought about by an increased presence of trees in a territory. To assess the current and potential scenarios of tree coverage and associated benefits, the online tool i-Tree Canopy is integrated, quantifying ecosystem functions, including economic and pollution sequestration perspectives. This tool is used in scientific research for evaluating vegetation coverage and other land cover classes, given its efficiency in facilitating assessments using aerial imagery. Two areas were considered: Zone 1 (Tetarom Industrial Park + National Ethnographic Museum Park) and Zone 2 (Tetarom Industrial Park) - analyzing 1000 points for Zone 1 and 500 points for Zone 2. The conclusions indicate that i-Tree Canopy plays a significant role in studies related to vegetation coverage and land use in urban environments. The use of i-Tree Canopy contributes significantly to the sustainable management of green spaces and provides relevant data regarding the environmental benefits brought by a potential development of the vegetation barrier in the studied area.

Keywords: I-Tree, assessment, landscape architecture, urban landscape

INTRODUCTION

The project for the "Restoration and Expansion of the Northern and Northeastern Vegetation Barrier of the Romulus Vuia National Ethnographic Park" stems from the concept for green space established in the 2020 Masterplan for Sustainable Development of the Hoia Natural Area (Fig. 1). The Hoia Masterplan underlies the initiatives undertaken by the Cluj County Council for the development of the Romulus Vuia National Ethnographic Park, providing an overview of the complex of thematic green spaces and natural objectives in Hoia.

The Hoia Hill is occupied by two divergent and incompatible categories of functions, organized in parallel on an east-west axis. Upstream, there are cultural, recreational, and agricultural functions, while downstream, economic functions with

an industrial character have developed. The two areas require a clear delineation, necessitating the development of a physical and visual green barrier with aesthetic and ecological values.

Currently, the separation through a vegetative curtain is only partially fulfilled by a row of poplars and lime trees, which is incomplete and in a precarious state. Considering the imminent urbanization to the west, both on the recreational and economic-industrial side, the restoration and extension of the tree alignment become imperative.

The primary role of the vegetation barrier will be to protect the rural ambiance within the Romulus Vuia National Ethnographic Park. This protection is necessary not only for the downward perspectives towards the immediate vicinity of the industrial zone but especially for the eye-level panoramas towards the densely developed residential area of Baciu over the past decade. Secondly, the vegetation barrier will play a positive role in stabilizing the slope and mitigating landslides.

To justify the need for the extension and restoration of the vegetation barrier, this study investigates historical data regarding the structure of the vegetation barrier, the current situation of the trees composing the barrier, assesses the landscape of the surroundings, and evaluates the environmental, social, and economic benefits delivered by the increased presence of trees in a territory.The current and the potential tree coverage scenarios and the related benefits are assessed by the integration of the i-Tree Canopy online tool (i-Tree i-Tree Canopy) to quantify the ecosystem functions, including an economic perspective and pollution sequestration, to support future policies for urban green areas expansion projects and investments. The concept and prototype of this program were developed by David J. Nowak, Jeffrey T. Walton and Eric J. Greenfield (USDA Forest Service). The current version of this program was developed and adapted to i-Tree by David Ellingsworth, Mike Binkley, and Scott Maco (The Davey Tree Expert Company). The i-Tree Canopy tool is fairly used within the scientific literature to assess not just tree canopy cover but also other cover classes, thanks to its efficiency in making land cover assessments relatively easy by using aerial imagery (Parmehr et al., 2016; Omodior et al., 2021; Puplampu et al., 2021; Cristiano et al., 2021; Endreny et al., 2017). Oliviera et al., 2022 uses the i-Tree Canopy Modeling Tool combined with the Life Cycle Assessment method to assess the potential benefits of increasing tree cover within the metropolitan city limits of Naples, southern Italy (Oliviera et al., 2022).

i-Tree Canopy represents a crucial tool in the field of studies on vegetation coverage and land use. This geographic information system (GIS) was designed to assess tree coverage in urban and suburban areas, providing essential data for the sustainable management of green spaces and natural resources. Scientific works exploring the use of i-Tree Canopy have made significant contributions in various domains, such as:

Urban Biodiversity Assessment: Studies have utilized i-Tree Canopy to evaluate the diversity of tree species and their impact on urban biodiversity. This research is essential for understanding how urban green spaces can support healthy ecosystems.

Air Quality Management: i-Tree Canopy provides data on the ability of trees to absorb air pollution and improve air quality in urban environments. Scientific

works have analyzed the effectiveness of this tool in identifying areas with air quality issues and developing improvement strategies.

Climate Change Adaptation: In the context of climate change, i-Tree Canopy has been used to assess how the growth and distribution of trees in urban areas can contribute to adapting to changing climatic conditions.

Sustainable Urban Planning: Research has highlighted the crucial role of i-Tree Canopy in sustainable urban planning processes, aiding in informed decision-making regarding the conservation of green spaces and balanced urban development.

Public Awareness and Community Participation: Studies incorporating i-Tree Canopy have also brought a dimension of public awareness, involving local communities in data collection and the monitoring process of green space health (Soares et al., 2011; Kirnbauer et al., 2013; Berland and Hopton, 2014; Hilde, 2014; Nyelele et al., 2019; Bautista et al., 2019; Nowak et al., 2019; Song et al., 2020; Tan et al., 2021; Alpaidze et al., 2023; Shetty, 2023). The use of i-Tree Canopy makes significant contributions to the understanding and promotion of sustainable management of urban green spaces, implicitly addressing the area that is the subject of the current study and provides relevant data regarding the environmental benefits brought by a potential development of the vegetation barrier in the studied area.

Figure 1. Extract from the Hoia Natural Area Master Plan. Concept for Green Spaces
Source: Alice Oprică

MATERIAL AND METHODS

1. Study Area. The location is situated within the urban area of Cluj-Napoca, in the Hoia Forest area. The study area is located on the northern slope of Hoia Hill, in the lower part. The general slope of the land is in the south-north direction. The altitude of the intervention area ranges between +353m and +385m above sea level.

The land is privately owned by the Cluj County Council. The land of the Romulus Vuia National Ethnographic Park encompasses ethnographic buildings from the 17th-19th centuries, constituting an immovable heritage of national and European importance. The length of the existing vegetation barrier is 786.00 meters

and runs on an east-west axis, parallel to the industrial area. The study area is adjacent to:

- North: Tetarom I Industrial Park and the expansion area of the industrial zone
- South: Romulus Vuia National Ethnographic Park and the expansion area of the park (Fig. 2).
-

Figure 2. The studied area
Source: Alice Oprică

From the perspective of the General Urban Plan of Cluj-Napoca, the studied area falls into the following reference zones (Fig. 3): ZCP_Vt: Protected built area. Thematic green area; UVa: Urbanization: Green area, squares, gardens, public parks; UEi: Urbanization: Area for economic activities with industrial character. The climate is of a moderately continental type, characteristic of the western and north-western regions of the country, and is subject to predominantly westerly circulation. Consequently, during winter, invasions of maritime polar or Arctic air from the northwest prevail, while in summer, warm air from the southwest, part of the north Mediterranean cyclonic activity, moves northward.

Precipitation in the county: varies between 600 and 800 mm:

- Calculated temperature for summer: +25°C; STAS 6472/2-83,
- Calculated temperature for winter: Te = -18°C; SR 10907/1-97,
- Calculated wind speed: qb = 0.5 kPa; STAS 10101/20-90,
- Snow loads: Sk = 1.5 kN/m2; STAS 10101/21-92.
-

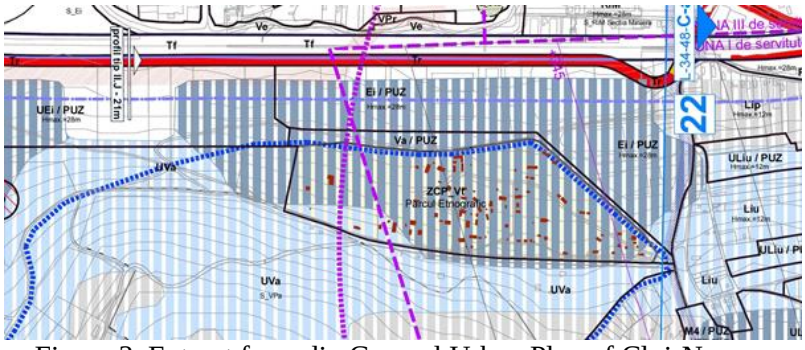


Figure 3. Extract from din General Urban Plan of Cluj-Napoca
Source: https://primariaclujnapoca.ro/strategii-urbane/plan-urbanistic-general/

2. ***Analysis of historical data regarding the peripheral alignments of the Romulus Vuia National Ethnographic Park***. Images and archival documents have been scrutinized to determine the original constituent plant elements.

3. The assessment of the landscape and existing vegetation included the evaluation of perspectives from and towards the study area. The condition of the existing vegetation, the composition of tree alignments, and the inventory of trees in the existing vegetation barrier were examined. The health and viability of the trees were analyzed, and an assessment was made of the landscape in the neighboring areas (Tetarom and Transilvania streets), the specific vegetation of the surroundings, the volume of existing vegetation, and the western expansion area of the protective visual barrier.

4. The evaluation of land cover classes involves analyzing different types of coverage, such as vegetation, buildings, roads, or other elements, in the study area. In the specific context of using i-Tree Canopy - assessing the percentages of tree canopy coverage, green spaces, or other types of land use. The report on the benefits of trees involves documenting and quantifying the advantages that trees bring to the area. These benefits include: improving air quality, reducing urban temperatures, contributing to biodiversity, retaining rainwater, as well as aesthetic and relaxation aspects.

The study was conducted using I-Tree Canopy, developed by USDA Forest Service, Davey Tree Expert Company, The Arbor Day Foundation, Society of Municipal Arborists, International Society of Arboriculture, Casey Trees, and SUNY College of Environmental Science and Forestry.

I-Tree Canopy utilizes aerial images from Google to generate statistical estimates of tree coverage and various land cover types, including grass, built structures, urban infrastructure, and impervious surfaces. Within the designated area of interest, random dots are strategically placed, and users identify the land cover class at the center of each dot, indicated by a yellow cross pointer. The user-defined cover classes contribute to the analysis. In a sample of 1000 random points, the standard error (SE) for the cover estimate was found to be less than 1.2 percent. For detailed information on calculating sampling error through photo-interpretation, readers can refer to Nowak (Nowak, 2021).

i-Tree was used to classify land and tree cover across the study area using random sampling of aerial imagery. We assess the tree canopy benefits in terms of carbon dioxide, air pollution, and stormwater impacts. Aceasta evaluare a stat la baza propunerii de refacere și extindere a barierei vegetale nordice și nord-estice a Parcului Național Etnografic ”Romulus Vuia”.

Two zones were taken into account: Zone 1 (Tetarom Industrial Park + National Ethnographic Museum Park); Zone 2 (Tetarom Industrial Park) – analyzing 1000 points for Zone 1 and 500 points for Zone 2. The tree cover classes/categories were estimated (trees, grass, buildings, roads, other impervious surfaces, soil).The initiation of the study involved the following steps:

- Definition of the research territory by drawing the shape of the studia area in the Google Earth map.
- Selection of land-cover categories/classes from the program menu, including:

- Grass/Herbaceous, Impervious buildings, Impervious roads , Impervious other, Soil/bare ground, Tree/shrub, Water (W).
- Creating a canopy database: the i-Tree Canopy program automatically randomly produces geographical points in the selected area, pinpointing those generated points on the Google Earth map. The user gives the corresponding surface category to each generated point until a sufficient geographical sample volume is reached.

The standard errors of the calculations regarding pollutant removal quantities and the monetary benefits are based on the standard errors of the sampled and classified points. Hydrological estimates rely on the following values: kl/ha/yr @ E/kl/yr, rounded.

For the assessment of the industrial area where the predominant vegetation belongs to the herbaceous class, two evaluations were conducted:

- The first assessment analyzes the situation according to the existing surfaces.
- The second assessment examines the situation in case the area covered by trees would increase. In this case - for the report - no interventions were made on the building, road, and impermeable surface cover classes; only modifications were applied to the herbaceous cover classes. Changes were made to the existing points classified as herbaceous to assess the situation where, following the proposed arrangement, trees with a high canopy cover would be planted.

RESULTS AND DISCUSSIONS

1. Historical data regarding the vegetation barrier around the "Romulus Vuia" National Ethnographic Park includes information about the evolution and changes over time regarding the composition, structure, and dimensions of this barrier.

The National Ethnographic Park "Romulus Vuia" was enclosed in the 1960s during the restructuring period led by ethnographer Valeriu Butură. The fencing project was presented to the Popular Council of the Cluj Region through Address 5569 dated May 13, 1964. The enclosure aimed to protect the area with folk architecture monuments, and initially, it was not accompanied by a vegetation barrier.

The vegetation barrier around the "Romulus Vuia" National Ethnographic Park was planted around the years 1965-1970, positioned at the downstream limit of the open-air museum on the north and northeast sides. During the same period, the Central Industrial Zone and the Western Industrial Zone developed in the same visual direction, making the alignment necessary at that time to protect the rural ambiance of the Ethnographic Park.

The vegetation barrier consists of a tall stand of poplar trees (*Populus sp.*) and a medium stand of lime trees (*Tilia sp.*). Most likely, the poplar species was chosen for its advantages as a green screen: it is resilient, grows rapidly, and reaches tall heights of 35-40m. *Tilia sp*. is a native species, providing a natural transition to the open-air ethnographic museum visiting area.

Figure 4. The foreground features the Moțului Văsar House from the open-air museum. © Ion Miclea in the Album: Cluj 1965. The photograph attests to the initial absence of poplar trees toward the industrial area, already planned during that period and approved within the 1969 Systematization Plan.

Figure 5. The alignment of poplar trees on the northeast side of the Ethnographic Park at an estimated age of 25 years. In the foreground is the Potter's House from the village of Josenii Bârgăului, Bistrița-Năsăud County. In the background, beyond the poplar alignment, the silhouette of the Central Industrial Zone (Cluj-Napoca Train Station area) is visible. © Minerva Archive. Photograph from the period 1987-1991

2. Results regarding the existing visual protection barrier on the north and northeast sides of the Ethnographic Park

a. The organization of the existing vegetation barrier. The open-air museum enclosure is outlined by a vegetal perimeter composed mainly of two primary height levels of tree vegetation, complemented by spontaneously developed low vegetation:

- **The tall tier** (35 m) is arranged at the northern and northeastern boundaries of the fence of the Ethnographic Park and consists of a row of poplars, *Populus sp*. This tier was planted between 1965-70, serving as a visual protection against the industrially developing area. On the northern segment

of the poplar row, some mature specimens are still preserved, while on the northeastern segment, almost all poplars have been cut. The cut trees were in an advanced state of degradation, exhibiting a crown drying rate of over 50%.

a b

Figure 6. a. The situation of affected trees in the year 2018
b. Deforested trees, the existing situation - August, 2020

- **The medium-tier** (20 m) is situated within the Ethnographic Park and is composed of linden trees (*Tilia sp.*), ash trees (Fraxinus sp.), and various species of deciduous trees of sizes I and II (*Carpinus sp., Fagus sp., Quercus sp., Robinia pseudacacia, Betula pendula, Acer platanoides*), creating a natural transition towards the rural atmosphere in the visiting area. Many of these specimens (except *Tilia sp.* and *Populus sp.)* have grown spontaneously, exhibiting high density in the field and a generally poor development specific to the species.

Figure 7. Spontaneous arboreal vegetation developed along the northeastern and northern perimeter, on the fencing line, August 2020

- A total of 75 tree specimens requiring replacement due to severe infection have been identified. The trees identified with a strong *Viscum sp.*

infestation belong to the following species: *Fraxinus sp., Tilia sp., Malus domestica, Prunus sp., Populus sp.*

Figure 8. *Populus sp.* Alignment – Viscum sp. infection, showing crown withering of at least 50%, August 2020

Figure 9. *Fraxinus, Tilia, Populus* - Affected by Viscum sp., showing a high percentage of crown withering - views from the museum area and from Tetarom towards the museum, August 2020

A third layer, in the N and NE area, is represented by the existing orchards with fruit trees. These are mainly composed of species such as *Malus domestica* and *Prunus domestica*, with the majority of specimens being mature.

Figure 10. Orchards, north side, August 2020

- The spontaneous tree and shrub present along the enclosure line provides effective screening towards and from the Tetarom Industrial Park. The spontaneous vegetation, which is not part of the initially planted alignments on the northern and northeastern sides, consists of dense species of trees and shrubs (*Carpinus sp., Fagus sp., Quercus sp., Robinia pseudacacia, Betula pendula, Acer platanoides, Prunus cerasifera, Crataegus monogyna*, etc.). The spontaneous vegetation along the enclosure line plays a crucial role in screening, and it is recommended to preserve and protect it, even if it is not part of the initial alignments.

Figure 11. Spontaneous vegetation on the northern and northeastern boundary

- Thus, at least until the proposed trees for planting, which will create the new vegetation barrier, mature, screening will be ensured with the help of the existing vegetation.
- A partially negative aspect is represented by a strip of land running along the entire length of the alignment (northern, northeastern perimeter) with a width ranging from 4 m to 15 m, where shrub and tree vegetation has developed. The vegetation in this area is dense and no longer fulfills aesthetic and practical functions agreed upon in the landscape. The spontaneous vegetation has formed a thicket that currently hinders the use of the area and encourages undesirable actions (such as waste dumping).

Figure 12. High density spontaneous vegetation - N, N-E perimeter

The area is impassable, except for small portions, and covers approximately 7,860 square meters (0.786 hectares). We estimate that if the area is cleared, the screening provided by the existing vegetation barrier will not be affected. Out of the total perimeter of the open-air museum of 1646.00 meters, the visual protection vegetation barrier measures a total of 786.00 meters and has the following composition:

Table 1

The composition and dimensions of the vegetation barrier

No. Crt.	*Segment*	*Segment description*	*Actual lenght*
1	North segment	1 incomplete row of *Populus sp.*, spaced at 10 m 1 incomplete row of *Tilia cordata,* spaced at 10 m	453.00 ml
2	Northeast segment	1 incomplete row of *Populus sp*. - deactivated 90% 1 incomplete row of *Tilia cordata* spaced at 10 m	333.00 ml
		Total length of the existing vegetal barrier	**786.00 ml**

b. Inventory of trees in the existing vegetal barrier

The primary species comprising the existing vegetal barrier are *Populus sp., Tilia cordata,* and *Fraxinus sp.*

Table 2

The primary species comprising the existing vegetal barrier

Populus sp.	number of specimens:53
Tilia cordata	number of specimens:44
Fraxinus excelsior	number of specimens:23

c. Health condition of the trees and viability

In 2020, the vegetative barrier of the Ethnographic Park reached approximately 50-55 years of age. Its overall health condition is poor. The alignment on the N-E side was almost entirely cut in the years 2018-2019 due to drying and mistletoe infection. Poplars are still maintained on the N alignment, but their health condition is deteriorated.

Following the analysis of the vegetative barrier's condition, it was found that along a total length of 860 m, the alignment is non-viable and requires replacement.

Table 3

Inventory of trees affected by mistletoe, exhibiting a crown drying percentage equal to or greater than 50%

Nr. Crt.	Species	Number of specimens showing a crown drying percentage of 50% or more
1	*Populus sp.*	53
2	*Tilia cordata*	8
3	*Fraxinus sp.*	9
4	*Malus domestica*	4
5	*Prunus domestica*	1

Figure 13. View - alignment, northern side

3. Results regarding landscape assessment in the Tetarom and Transilvania streets area. On Tetarom and Transilvania streets, there is a lack of alignments of large-sized trees. There is arboreal and shrub vegetation, but it primarily has ornamental characteristics and cannot substitute for the ecological functions provided by alignments of trees.

Figure 14. Landscape evaluation – street Tetarom and Transilvania

In the parking area, inappropriate species have been planted that lack ecological plasticity and show signs of stress (*Thuja occidentalis*, *Juniperus horizontalis*). These specimens are poorly developed, and compared to the existing vegetation on the northern boundary of the Romulus Vuia National Ethnographic Museum, they fail to stand out and contrast with the natural-looking vegetative barrier. Specifically, the species *Thuja occidentalis* is not tolerant of pollution and the environmental conditions typical of an urban industrial site. Another species of trees recently planted (in the last 2-3 years) is *Betula pendula*.

This species can withstand urban environmental conditions but requires light and a suitable planting area. The current situation indicates that these conditions are not met, and as a result, the existing specimens exhibit unnatural inclinations for the species, with the base area surrounded by sealed surfaces, etc.

Figure 15. Existing vegetation on the northern boundary of the Romulus Vuia National Ethnographic Museum

Figure 16. *Betula sp.* in parking area - sealed surfaces around trees

4. Results regarding the analysis of the western expansion area of the visual protection barrier. The expansion corridor to the west of the vegetative barrier has a length of 586.00 meters and a variable width between 20-40 meters. The expansion area of the barrier will include plantings in the following zones:

- Expansion of the National Ethnographic Park "Romulus Vuia" / ZCP – Vt,
- Tetarom Park – Uva,
- Western Expansion Tetarom Industrial Park I - UEi, with a minimum surface area of 20% allocated for green spaces in the barrier area.

Figure 17. The western extension area of the barrier with the role of visual protection
Source: Alice Oprică

The existing vegetation in the expansion area is generally herbaceous, typical of hillside meadows. Sporadically, spontaneous shrub vegetation has appeared in the Tetarom Park area. There are no tree alignments on Tetarom Street.

Figure 18. Herbaceous vegetation

5. Results regarding i-Tree assessment. The results highlight:

- Percentage of coverage by classes;
- Benefits related to air pollution mitigation;
- Benefits related to hydrology;

Monetary benefits regarding the value of trees for the environment. In the analyzed situation for zone 1, where a large area falls into the tree class due to Hoia Forest and the Ethnographic Museum Park, the environmental benefits of trees are extensive but can be improved, considering that a considerable area falls into the herbaceous class, impermeable buildings, impermeable roads, other impermeable surfaces, soil.

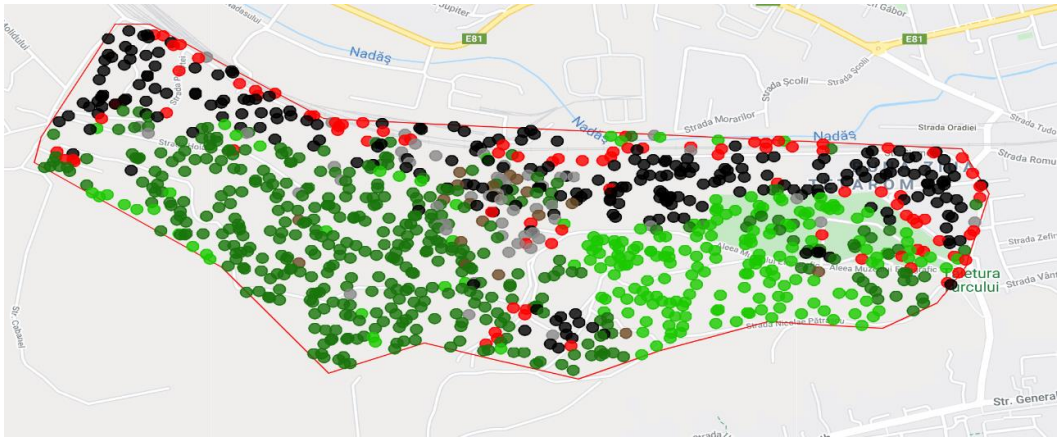


Figure 19. Zone 1 - Tetarom, Hoia, Ethnographic Museum Park - 1000 points analyzed. Estimated using random sampling statistics on 8/8/2020

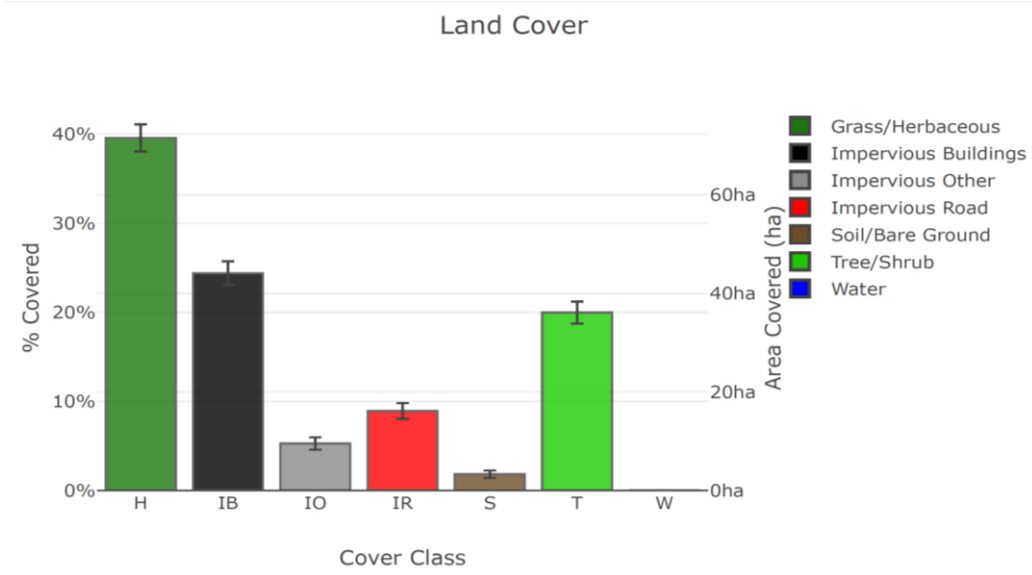


Figure 20. The percentage of coverage classes in Zone 1

Table 4

The percentage of coverage classes in Zone 1

Abbr.	Cover Class	Points	% Cover ± SE	Area (ha) ± SE
H	Grass/Herbaceous	412	39.58 ± 1.52	**71.56 ± 2.74**
IB	Impervious Buildings	254	24.40 ± 1.33	**44.12 ± 2.41**
IO	Impervious Other	55	5.28 ± 0.69	**9.55 ± 1.25**
IR	Impervious Road	93	8.93 ± 0.88	**16.15 ± 1.60**
S	Soil/Bare Ground	19	1.83 ± 0.41	**3.30 ± 0.75**

T	Tree/Shrub	208	19.98 ± 1.24	**36.13 ± 2.24**
W	Water	0	0.00 ± 0.00	**0.00 ± 0.00**
Total		**1041**	**100.00**	**180.82**

Table 5

Tree Benefit Estimates: Carbon (Metric units) in Zone 1

Description	Carbon (t)	±SE	CO_2 Equiv. (t)	±SE	Value (EUR)	±SE
Sequestered annually in trees	110.56	±6.86	405.37	±25.14	E17,631	**±1,094**
Stored in trees (Note: this benefit is not an annual rate)	**2,776.49**	**±172.21**	**10,180.45**	**±631.44**	**E442,774**	**±27,463**

Currency is in EUR and rounded. Standard errors of removal and benefit amounts are based on standard errors of sampled and classified points. Amount sequestered is based on 3.060 t of Carbon, or 11.220 t of CO_2, per ha/yr and rounded. Amount stored is based on 76.848 t of Carbon, or 281.776 t of CO_2, per ha and rounded. Value (EUR) is based on E159.47/t of Carbon, or E43.49/t of CO_2 and rounded. (Metric units: t = tonnes, metric tons, ha = hectares)

Table 6

Tree Benefit Estimates: Air Pollution (Metric units) in Zone 1

Abbr.	Description	Amount (kg)	±SE	Value (EUR)	±SE
CO	Carbon Monoxide removed annually	45.75	±2.84	E57	**±4**
NO2	Nitrogen Dioxide removed annually	252.74	±15.68	E103	**±6**
O3	Ozone removed annually	1,952.36	±121.10	E4,742	**±294**
SO2	Sulfur Dioxide removed annually	124.24	±7.71	E16	**±1**
PM10*	Particulate Matter greater than 2.5 microns and less than 10 microns removed annually	554.12	±34.37	E3,248	**±201**
PM2.5	Particulate Matter less than 2.5 microns removed annually	99.74	±6.19	E9,928	**±616**
Total		**3,028.96**	**±187.87**	**E18,095**	**±1,122**

Currency is in EUR and rounded. Standard errors of removal and benefit amounts are based on standard errors of sampled and classified points. Air Pollution Estimates are based on these values in kg/ha/yr @ E/kg/yr and rounded: CO 1.266 @ E1.25 | NO2 6.995 @ E0.41 | O3 54.038 @ E2.43 | SO2 3.439 @ E0.13 | PM10* 15.337 @ E5.86 | PM2.5 2.761 @ E99.54 (Metric units: kg = kilograms, ha = hectares)

Table 7

Tree Benefit Estimates: Hydrological (Metric units) in Zone 1

Abbr.	Benefit	Amount (kl)	±SE	Value (EUR)	±SE
AVRO	Avoided Runoff	2.80	±0.17	E6	**±0**
E	Evaporation	62.86	±3.90	N/A	**N/A**
I	Interception	63.27	±3.92	N/A	**N/A**
T	Transpiration	59.53	±3.69	N/A	**N/A**
PE	Potential Evaporation	404.29	±25.08	N/A	**N/A**
PET	**Potential Evapotranspiration**	**333.43**	**±20.68**	**N/A**	**N/A**

Currency is in EUR and rounded. Standard errors of removal and benefit amounts are based on standard errors of sampled and classified points. Hydrological Estimates are based on these values in kl/ha/yr @ E/kl/yr and rounded: AVRO 0.077 @ E2.00 | E 1.740 @ N/A | I 1.751 @ N/A | T 1.648 @ N/A | PE 11.190 @ N/A | PET 9.229 @ N/A (Metric units: kl = kiloliters, ha = hectares)

The analysis for Zone 2 shows significantly reduced benefits in the current situation. Additional analysis conducted for the scenario where the coverage level of the tree class is increased highlights much-improved values and significant differences between the two situations. The results clearly outline the urgent need for intervention in areas with a high degree of coverage with sealed surfaces (planting large trees with a high crown coverage).

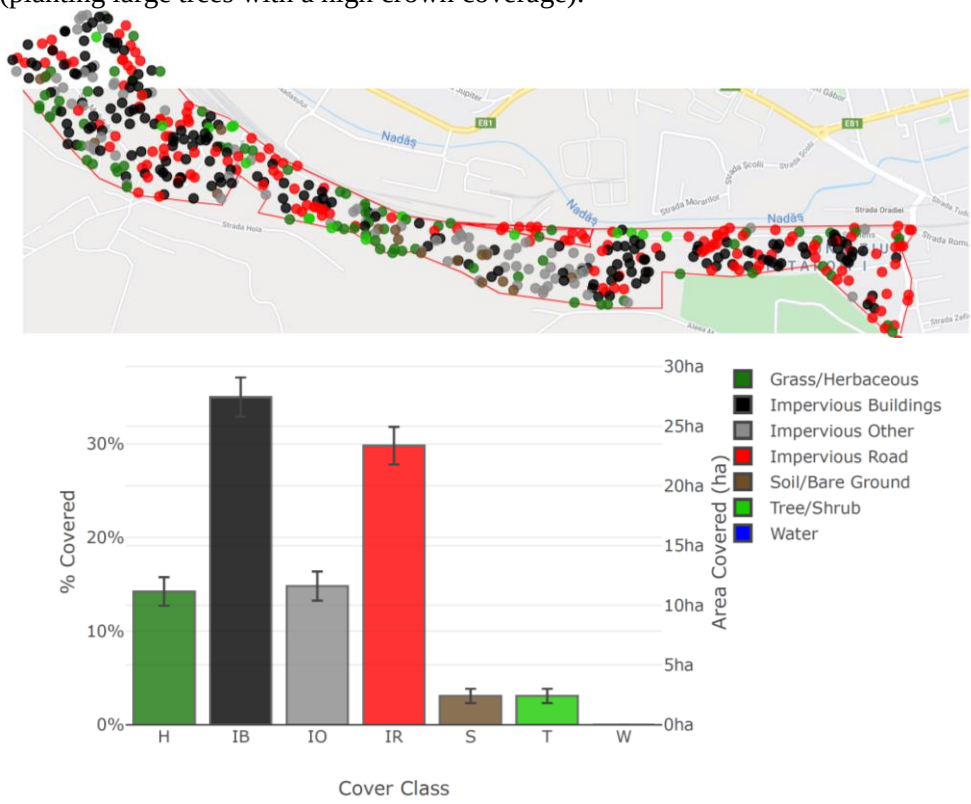


Figure 21.Tetarom – The analysis of 500 points for the current situation. Estimated using random sampling statistics on 8/8/2020

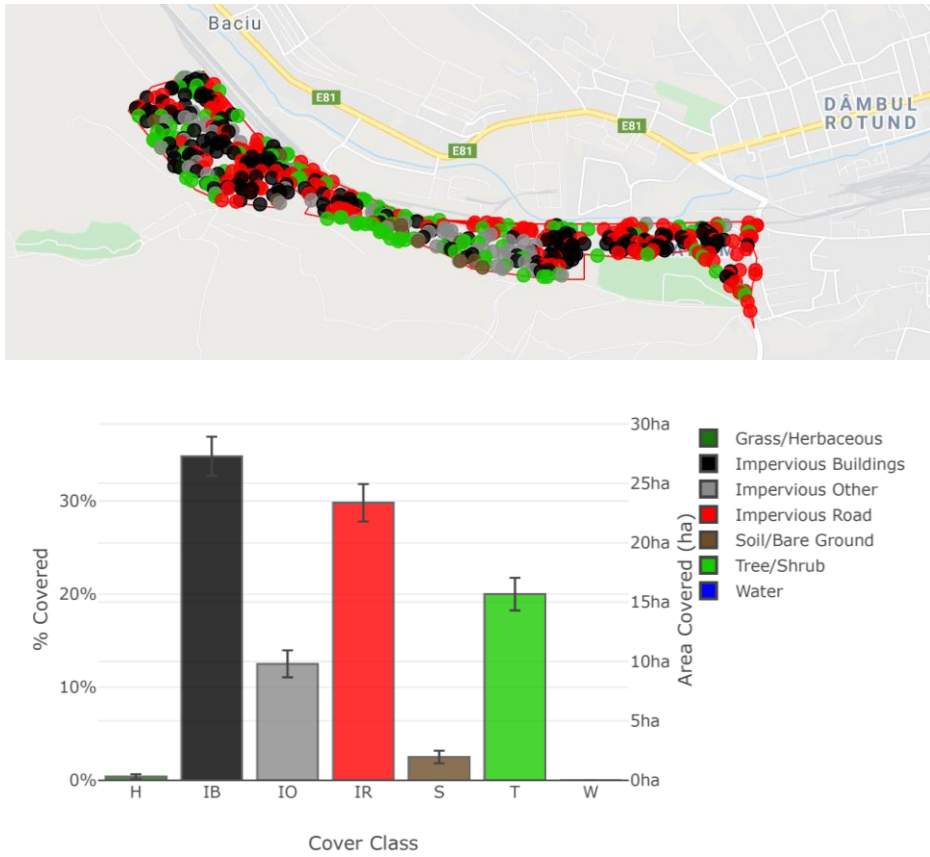


Figure 22. Tetarom – the analysis of 500 points for the improved situation

Table 8

The percentage of coverage classes in Zone 2 – existing situation

Abbr.	Cover Class	Points	% Cover ± SE	Area (ha) ± SE
H	Grass/Herbaceous	74	14.23 ± 1.53	**11.16 ± 1.20**
IB	Impervious Buildings	182	35.00 ± 2.09	**27.44 ± 1.64**
IO	Impervious Other	77	14.81 ± 1.56	**11.61 ± 1.22**
IR	Impervious Road	155	29.81 ± 2.01	**23.37 ± 1.57**
S	Soil/Bare Ground	16	3.08 ± 0.76	**2.41 ± 0.59**
T	Tree/Shrub	16	3.08 ± 0.76	**2.41 ± 0.59**
W	Water	0	0.00 ± 0.00	**0.00 ± 0.00**
Total		**520**	**100.00**	**78.39**

Table 9

The percentage of coverage classes in Zone 2 – proposed situation

Abbr.	Cover Class	Points	% Cover ± SE	Area (ha) ± SE
H	Grass/Herbaceous	2	0.38 ± 0.27	**0.30 ± 0.21**
IB	Impervious Buildings	181	34.81 ± 2.09	**27.29 ± 1.64**
IO	Impervious Other	65	12.50 ± 1.45	**9.80 ± 1.14**
IR	Impervious Road	155	29.81 ± 2.01	**23.37 ± 1.57**
S	Soil/Bare Ground	13	2.50 ± 0.68	**1.96 ± 0.54**

T	Tree/Shrub	104	20.00 ± 1.75	**15.68 ± 1.38**
W	Water	0	0.00 ± 0.00	**0.00 ± 0.00**
Total		**520**	**100.00**	**78.39**

Table 10

Tree Benefit Estimates: Carbon (Metric units)– existing situation

Description	Carbon (t)	±SE	CO_2 Equiv. (t)	±SE	Value (EUR)	±SE
Sequestered annually in trees	7.38	±1.82	27.06	±6.66	E1,177	**±290**
Stored in trees (Note: this benefit is not an annual rate)	**185.36**	**±45.62**	**679.66**	**±167.28**	**E29,560**	**±7,275**

Currency is in EUR and rounded. Standard errors of removal and benefit amounts are based on standard errors of sampled and classified points. Amount sequestered is based on 3.060 t of Carbon, or 11.220 t of CO_2, per ha/yr and rounded. Amount stored is based on 76.848 t of Carbon, or 281.776 t of CO_2, per ha and rounded. Value (EUR) is based on E159.47/t of Carbon, or E43.49/t of CO_2 and rounded. (Metric units: t = tonnes, metric tons, ha = hectares)

Table 11

Tree Benefit Estimates: Carbon (Metric units)– proposed situation

Description	Carbon (t)	±SE	CO_2 Equiv. (t)	±SE	Value (EUR)	±SE
Sequestered annually in trees	47.98	±4.21	175.91	±15.43	E7,651	**±671**
Stored in trees (Note: this benefit is not an annual rate)	**1,204.84**	**±105.67**	**4,417.76**	**±387.46**	**E192,140**	**±16,852**

Currency is in EUR and rounded. Standard errors of removal and benefit amounts are based on standard errors of sampled and classified points. Amount sequestered is based on 3.060 t of Carbon, or 11.220 t of CO_2, per ha/yr and rounded. Amount stored is based on 76.848 t of Carbon, or 281.776 t of CO_2, per ha and rounded. Value (EUR) is based on E159.47/t of Carbon, or E43.49/t of CO_2 and rounded. (Metric units: t = tonnes, metric tons, ha = hectares)

Table 12

Tree Benefit Estimates: Air Pollution (Metric units) in Zone 2 – existing situation

Abbr.	Description	Amount (kg)	±SE	Value (EUR)	±SE
CO	Carbon Monoxide removed annually	2.44	±0.60	E0	**±0**
NO2	Nitrogen Dioxide removed annually	13.29	±3.27	E0	**±0**
O3	Ozone removed annually	132.39	±32.58	E17	**±4**
SO2	Sulfur Dioxide removed annually	8.38	±2.06	E0	**±0**
PM10*	Particulate Matter greater	44.34	±10.91	E13	**±3**

	than 2.5 microns and less than 10 microns removed annually				
PM2.5	Particulate Matter less than 2.5 microns removed annually	6.43	±1.58	E36	**±9**
Total		**207.27**	**±51.01**	**E67**	**±16**

Currency is in EUR and rounded. Standard errors of removal and benefit amounts are based on standard errors of sampled and classified points. Air Pollution Estimates are based on these values in kg/ha/yr @ E/kg/yr and rounded: CO 1.011 @ E0.08 | NO2 5.511 @ E0.03 | O3 54.886 @ E0.13 | SO2 3.473 @ E0.01 | PM10* 18.385 @ E0.28 | PM2.5 2.667 @ E5.59 (Metric units: kg = kilograms, ha = hectares)

Table 13

Tree Benefit Estimates: Air Pollution (Metric units) in Zone 2 – proposed situation

Abbr.	Description	Amount (kg)	±SE	Value (EUR)	±SE
CO	Carbon Monoxide removed annually	15.85	±1.39	E1	**±0**
NO2	Nitrogen Dioxide removed annually	86.40	±7.58	E2	**±0**
O3	Ozone removed annually	860.52	±75.47	E113	**±10**
SO2	Sulfur Dioxide removed annually	54.45	±4.78	E0	**±0**
PM10*	Particulate Matter greater than 2.5 microns and less than 10 microns removed annually	288.24	±25.28	E82	**±7**
PM2.5	Particulate Matter less than 2.5 microns removed annually	41.81	±3.67	E234	**±20**
Total		**1,347.27**	**±118.16**	**E433**	**±38**

Currency is in EUR and rounded. Standard errors of removal and benefit amounts are based on standard errors of sampled and classified points. Air Pollution Estimates are based on these values in kg/ha/yr @ E/kg/yr and rounded: CO 1.011 @ E0.08 | NO2 5.511 @ E0.03 | O3 54.886 @ E0.13 | SO2 3.473 @ E0.01 | PM10* 18.385 @ E0.28 | PM2.5 2.667 @ E5.59 (Metric units: kg = kilograms, ha = hectares)

Table 14

Tree Benefit Estimates: Hydrological (Metric units) in Zone 2 – existing situation

Abbr.	Benefit	Amount (l)	±SE	Value (EUR)	±SE
AVRO	Avoided Runoff	11.67	±2.87	E0	**±0**
E	Evaporation	963.26	±237.08	N/A	**N/A**
I	Interception	968.65	±238.41	N/A	**N/A**
T	Transpiration	1,303.44	±320.81	N/A	**N/A**
PE	Potential Evaporation	7,299.05	±1,796.47	N/A	**N/A**
PET	**Potential Evapotranspiration**	**5,955.41**	**±1,465.77**	**N/A**	**N/A**

Currency is in EUR and rounded. Standard errors of removal and benefit amounts are based on standard errors of sampled and classified points. Hydrological Estimates are based on these values in

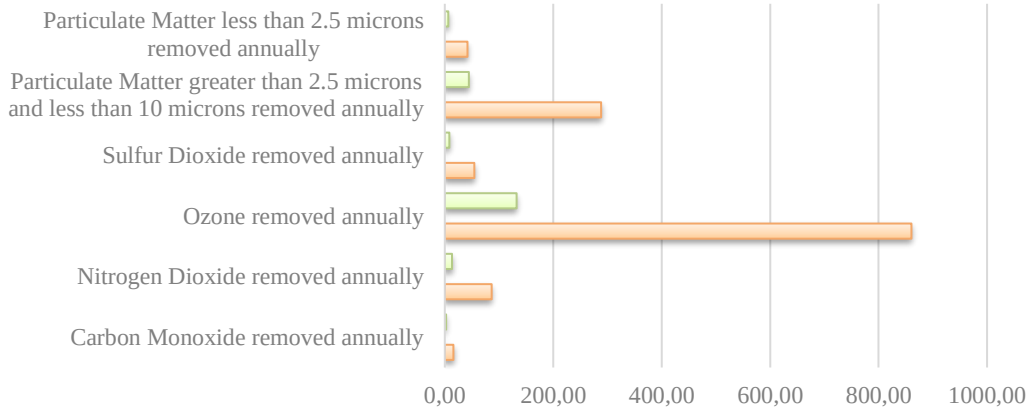
l/ha/yr @ E/l/yr and rounded:AVRO 4.837 @ E0.00 | E 399.355 @ N/A | I 401.590 @ N/A | T 540.389 @ N/A | PE 3,026.089 @ N/A | PET 2,469.035 @ N/A (Metric units: l = liters, ha = hectares)

Table 15

Tree Benefit Estimates: Hydrological (Metric units) in Zone 2 –proposed situation

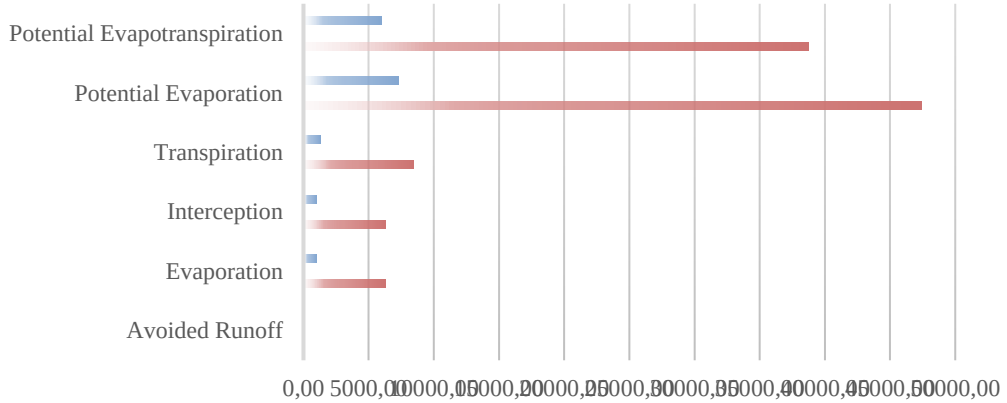
Abbr.	Benefit	Amount (l)	±SE	Value (EUR)	±SE
AVRO	Avoided Runoff	75.84	±6.65	E0	**±0**
E	Evaporation	6,261.19	±549.14	N/A	**N/A**
I	Interception	6,296.23	±552.22	N/A	**N/A**
T	Transpiration	8,472.36	±743.08	N/A	**N/A**
PE	Potential Evaporation	47,443.82	±4,161.10	N/A	**N/A**
PET	**Potential Evapotranspiration**	**38,710.19**	**±3,395.11**	**N/A**	**N/A**

Currency is in EUR and rounded. Standard errors of removal and benefit amounts are based on standard errors of sampled and classified points. Hydrological Estimates are based on these values in l/ha/yr @ E/l/yr and rounded: AVRO 4.837 @ E0.00 | E 399.355 @ N/A | I 401.590 @ N/A | T 540.389 @ N/A | PE 3,026.089 @ N/A | PET 2,469.035 @ N/A (Metric units: l = liters, ha = hectares)



Legend: Existing situation - green Improved situation - orange

Figure 23. Comparing zone 2 - Estimating tree benefits: Air pollution (metric units)



Legend: Existing situation - blue Improved situation - red

Figure 24. Comparing zone 2 - Estimating tree benefits: Hydrology (metric units)

The monetary benefits values show notable differences between the two situations.

CONCLUSIONS

Based on this study, the proposal for the arrangement regarding the restoration and extension of the northern and northeastern vegetative barrier of the "Romulus Vuia" National Ethnographic Park is more than justified, with the recommendation to consider the option of extensive planting of large trees in all areas that allow for such an initiative in the Tetarom industrial park area.

The local role of the vegetative barrier will be to improve the compatibility relationship between the open-air museum and Tetarom I Industrial Park and to stabilize the terrain. In relation to the entire Hoia slope, this investment represents the eastern segment of a vegetative strip that continues to the access area to Cheile Baciul, as outlined in the unified landscape concept from the Master Plan for Sustainable Development of the Hoia Natural Area (2020).

REFERENCES

1. Alpaidze, L.; Salukvadze, J. Green in the City: Estimating the Ecosystem Services Provided by Urban and Peri-Urban Forests of Tbilisi Municipality, Georgia. Forests 2023, 14, 121. https://doi.org/10.3390/f14010121
2. Bautista, D.; Peña-Guzmán, C. Simulating the hydrological impact of green roof use and an increase in green areas in an urban catchment with i-tree: A case study with the town of Fontibón in Bogotá, Colombia. *Resources* 2019, *8*, 68.
3. Berland, A.; Hopton, M.E. Comparing street tree assemblages and associated stormwater benefits among communities in metropolitan Cincinnati, Ohio, USA. *Urban For. Urban Green* 2014, *13*, 734–741.
4. Cristiano, S.; Ghisellini, P.; D'Ambrosio, G.; Xue, J.; Nesticò, A.; Gonella, F.; Ulgiati, S. Construction and Demolition Waste in the Metropolitan City of Naples, Italy: State of the Art, Circular Design, and Sustainable Planning Opportunities. *J. Clean. Prod.* 2021, *293*, 125856.
5. Endreny, T.; Santagata, R.; Perna, A.; de Stefano, C.; Rallo, R.F.; Ulgiati, S. Implementing and Managing Urban Forests: A Much Needed Conservation Strategy to Increase Ecosystem Services and Urban Wellbeing. *Ecol. Modell.* 2017, *360*, 328–335.
6. Hilde, T.; Paterson, R. Integrating ecosystem services analysis into scenario planning practice: Accounting for street tree benefits with i-Tree valuation in Central Texas. *J Environ Manage.* 2014, *146*, 524–534.
7. Hodges, JL and EL Lehmann. 1964. Basic Concepts of Probability and Statistics. Holden-Day, Inc. San Francisco.
8. Ion Miclea în Album: Cluj 1965
9. i-Tree i-Tree Canopy. https://canopy.itreetools.org/references (accessed on 15.11 2023).
10. Kirnbauer, M.C.; Baetz, B.W.; Kenney, W.A. Estimating the stormwater attenuation benefits derived from planting four monoculture species of deciduous trees on vacant and underutilized urban land parcels. *Urban For. Urban Green* 2013, *12*, 401–407.
11. Lindgren, BW and GW McElrath. 1969. Introduction to Probability and Statistics. Macmillan Co. London
12. Nowak, D. Understanding I-Tree: 2021 Summary of Programs and Methods. 2021. Available online: https://www.fs.usda.gov/nrs/pubs/gtr/gtr_nrs200-2021.pdf (accessed on10.12. 2023).

13. Nowak, D.J.; Bodine, A.R.; Hoehn Robert, E.I.; Ellis, A.; Hirabayashi, S.; Coville, R.; Auyeung, D.N.; Sonti, N.F.; Hallett, R.A.; Johnson, M.L.; et al. *The Urban Forest of New York City*; U.S. Department of Agriculture, Forest Service, Northern Research Station: Madison, WI, USA, 2018; 117, p. 82.
14. Nyelele, C.; Kroll, C.N.; Nowak, D.J. Present and future ecosystem services of trees in the Bronx, NY. *Urban For. Urban Green* 2019, *42*, 10–20.
15. Oliveira, M.; Santagata, R.; Kaiser, S.; Liu, Y.; Vassillo, C.; Ghisellini, P.; Liu, G.; Ulgiati, S. Socioeconomic and Environmental Benefits of Expanding Urban Green Areas: A Joint Application of i-Tree and LCA Approaches. *Land* 2022, *11*, 2106. https://doi.org/10.3390/land11122106
16. Omodior, O.; Eze, P.; Anderson, K.R. Using I-Tree Canopy Vegetation Cover Subtype Classification to Predict Peri-Domestic Tick Presence. Ticks Tick Borne Dis. 2021, 12, 101684.
17. Parmehr, E.G.; Amati, M.; Taylor, E.J.; Livesley, S.J. Estimation of Urban Tree Canopy Cover Using Random Point Sampling and Remote Sensing Methods. Urban For. Urban Green. 2016, 20, 160–171.
18. Puplampu, D.A.; Boafo, Y.A. Exploring the Impacts of Urban Expansion on Green Spaces Availability and Delivery of Ecosystem Services in the Accra Metropolis. Environ. Chall. 2021, *5*, 100283.
19. Shetty, N.H. Estimating Stormwater Infiltration and Canopy Interception for Street Tree Pits in Manhattan, New York. *Forests* 2023, *14*, 216. https://doi.org/10.3390/f14020216
20. Soares, A.L.; Rego, F.C.; McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Xiao, Q. Benefits and costs of street trees in Lisbon, Portugal. *Urban For. Urban Green.* 2011, *10*, 69–78.
21. Song, P.; Guo, J.; Xu, E.; Mayer, A.L.; Liu, C.; Huang, J.; Tian, G.; Kim, G. Hydrological effects of urban green space on stormwater runoff reduction in Luohe, China. *Sustainablity* 2020, *12*, 6599.
22. Tan, X.; Hirabayashi, S.; Shibata, S. Estimation of ecosystem services provided by street trees in Kyoto, Japan. *Forests* 2021, *12*, 311.
23. Thompson, S. K. 2002. Sampling, second edition. John Wiley and Sons, Inc., New York, New York.
24. Arhiva Minerva. Fotografie din perioada 1987-1991