Black promenade

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Abstract

This study assesses the ecological value of urban tree lines in Karlovac (Croatia), focusing on the **"**Black Promenade" alley located along the eastern edge of the historic "Karlovac Star" fortification.

In spring 2025, detailed biometric measurements were conducted for **all 178 trees** following **GLOBE protocols**, including species identification, circumference of the tree, height of the tree, an location. Tree age was estimated using species-specific age factors. Based on these field data, diameter at breast height (DBH) was derived and used to estimate dry biomass, stored carbon, and lifetime CO_2 uptake.

The results indicate a mean tree age of approximately **99 years**, with an estimated total of about **99 t of stored carbon** and roughly **364 t of CO_2 absorbed** over the lifetime of the avenue trees. Size-class analysis highlights that medium-to-large diameter trees account for a disproportionately high share of total carbon storage, underscoring the importance of conserving mature, large trees as a key component of the urban "carbon bank." In addition, a comparison between field measurements and satellite-based platforms (GEDI/Landsat, Earth Engine) reveals limitations of satellite data in dense urban settings (data gaps and pixel-level averaging), reinforcing the need for systematic ground-based research.

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Introduction

- The city of Karlovac was built in 1579 in the shape of a six-pointed star (the Karlovac Star)

- The Karlovac Star is surrounded by tree-lined avenues

The research project with students was carried out in an alley called "Black Promenade", which was created 150 years ago and is located on the eastern side of Karlovac's Star. It is poorly lit and dark due to the large number of trees, which is why it was named "Black Promenade".

Black promenade contains 178 trees

- ➢ 80 linden trees *(Tilia* sp.*)*

- ➢ *45 wild chestnut trees (Aesculus hippocastanum* L.*)*

- ➢ 31 acacia trees *(Robinia pseudoacacia* L.)

- ➢ 15 maple trees *(Acer sp.)*

- ➢ 8 spruce trees (*Picea sp.*)

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Research questions

1 Age of trees

How old are the trees growing on the Black Promenade?

2 Carbon storage and absorbed CO_2

What is the mass of stored carbon and absorbed CO_2 in trees?

3 Comparison of field measurements with satellite images

Data analysis on satellite platforms: https://glad.earthengine.app/view/forest-height-2000-2020

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Research Methods

In the spring of 2025, detailed biometric measurements were conducted on all 178 trees on the Black Promenade according to GLOBE protocols - Biometry

01

Measuring tree circumference

Measuring according to GLOBE protocol

02

Measuring tree height and location

Using the application GLOBE Observer

03

Species identification

The types of trees were determined with the help of the Pl@ntNet application

04

Calculating the age of trees

Calculating age according to the age factor of a particular species

Calculating the age of trees

The age of each tree was calculated using specific age factors for each species, applying a standard estimation formula

(Beiser G. Baum & Mensch: Umfang und Alter der Bäume)

🗒 Formula

Tree age = tree circumference (cm) × age factor

Linden tree

0,8

Age factor

Wild chestnut tree

0,5

Age factor

Acacia tree

0,7

Age factor

Maple tree

0,5

Age factor

Spruce tree

0,6

Age factor

Methods for calculating stored carbon and absorbed CO_2

After field data collection, calculations were carried out in the classroom to determine the ecological values of trees.

Tree diameter at breast height (DBH)

Tree circumference divided by ∏

GW – green weight)

$GW = 0.0346 \cdot d^2 \cdot h$ (if the $d > 28\ cm$) or
$GW = 0.0577 \cdot d^2 \cdot h$ (if the $d < 28\ cm$)

DW – dry weight)

DW = GW/2

CC – carbon storage

CC = DW/2

Absorbed CO_2

Carbon storage $\cdot$ 3.67 jer je $\dfrac{Mr(CO_2)}{Ar(C)} = 3.67$

Results

Analysis of stored carbon and absorbed CO_2 by tree species of the Black Promenade

Tree species	Number of trees	Age of tree - average (years)	Carbon storage (kg)	Absorbed CO_2 (kg)
Linden tree	80	116	40020	146874
Wild chestnut tree	44	90	25269	92737
Acacia tree	31	138	24211	88852
Maple tree	15	59	5990	21983
Spruce tree	8	92	3576	13125
Total	**178**	**99**	**99066**	**363571**

99	99	364
Average age	Tons of carbon	Tons of CO_2

Classification of trees according to diameter intervals

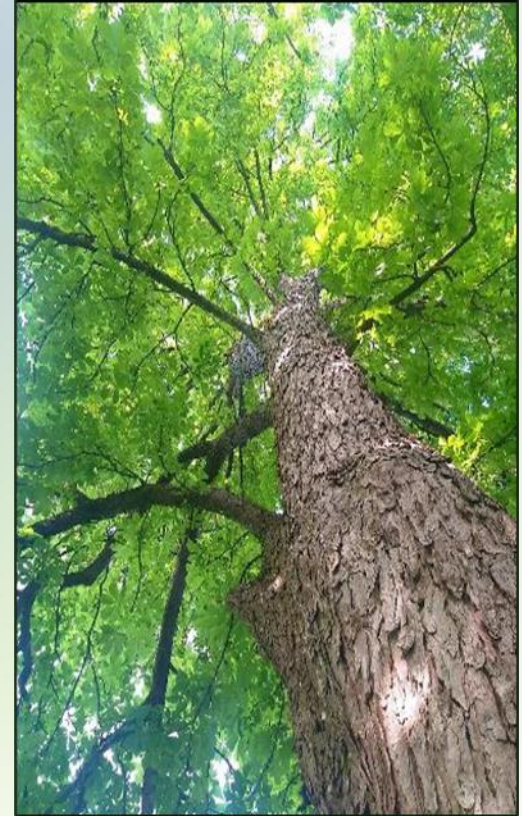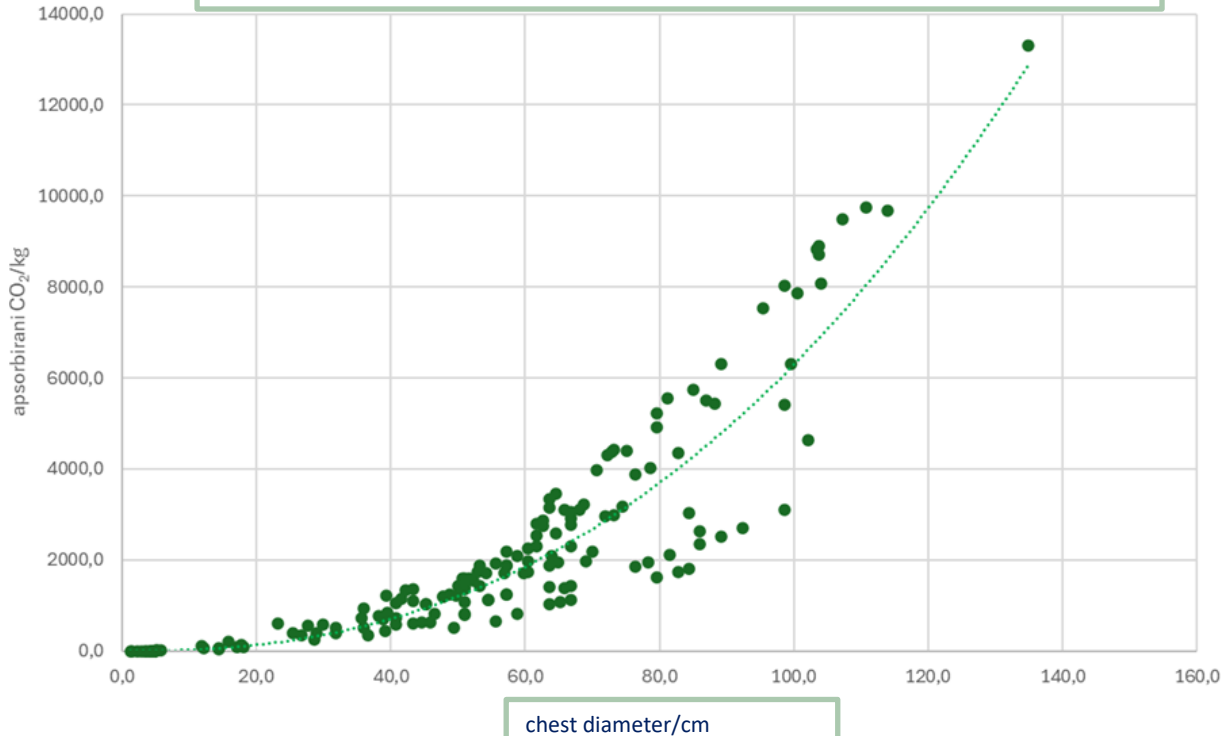Legend: ■ Carbon storage (kg) ■ Absorbed CO_2 (kg)
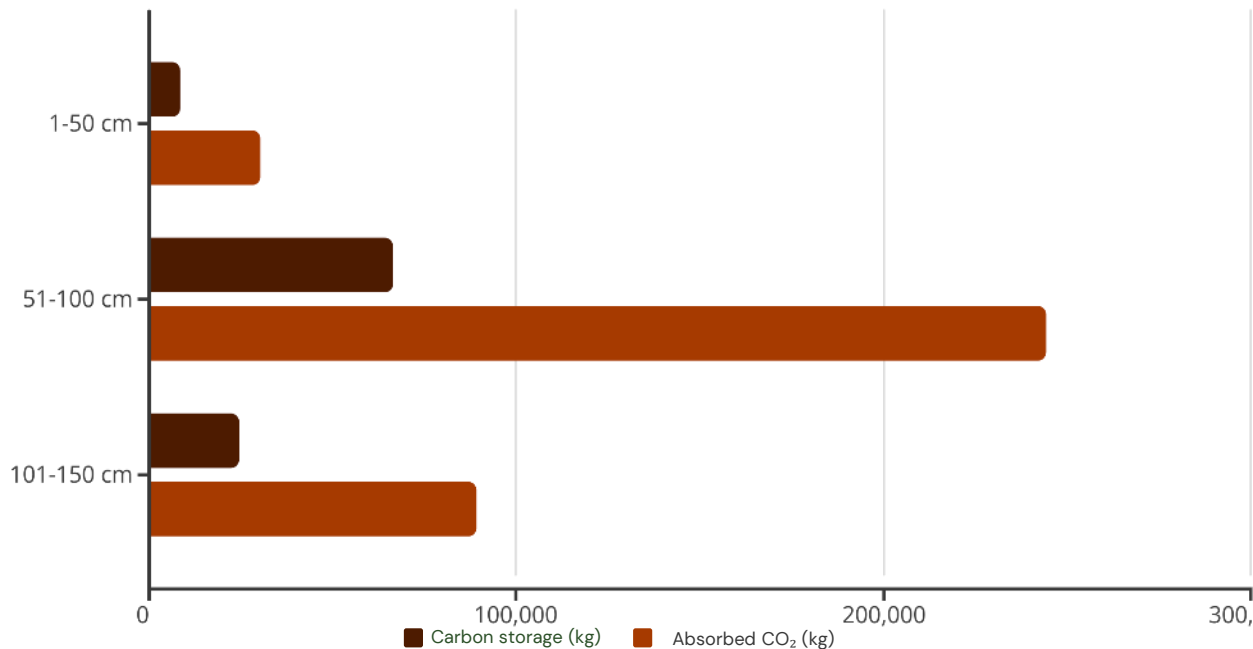
90 trees with a diameter of 51-100 cm store the most carbon – a total of 66490 kg

Just the 10 thickest trees (>100 cm) store more carbon than the 78 smallest trees combined
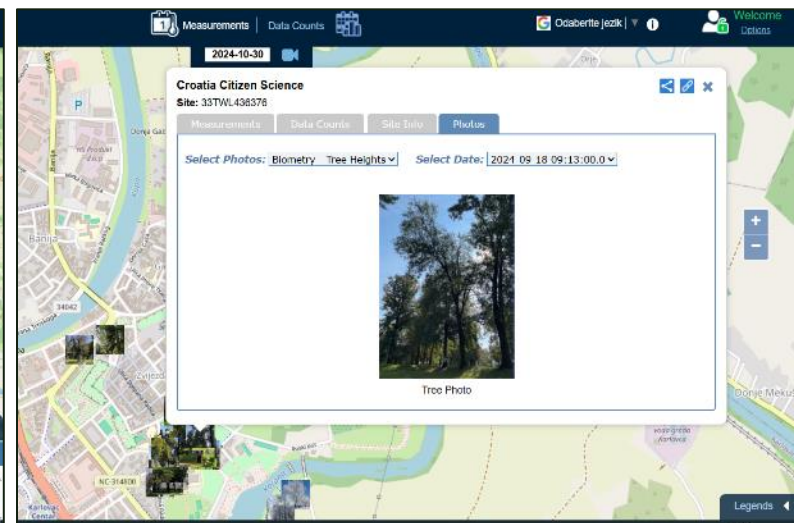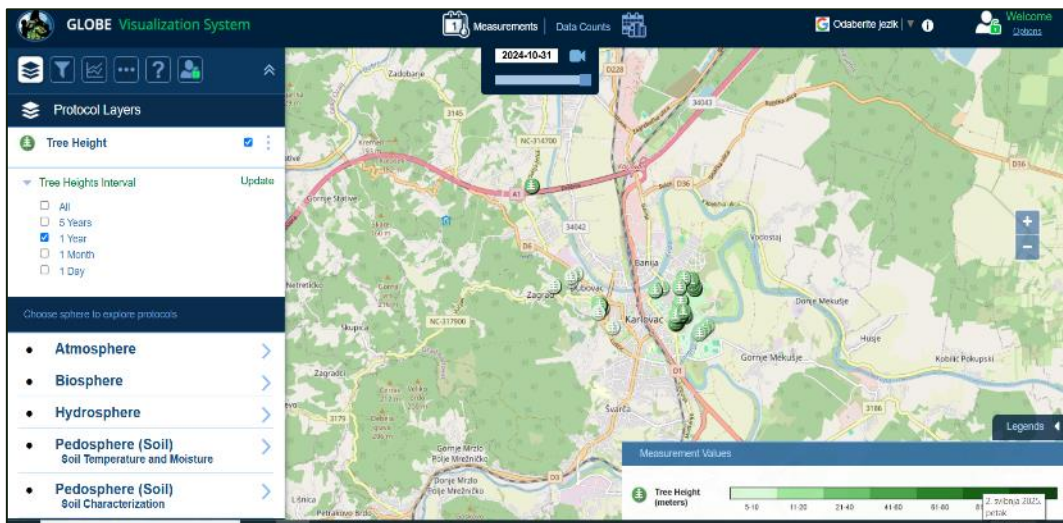
Protecting older and larger trees is key to preserving urban greenery

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Dependence of absorbed CO_2 on chest diameter

Older trees have a larger diameter at breast height, so they have absorbed more CO_2 from the atmosphere during their existence.
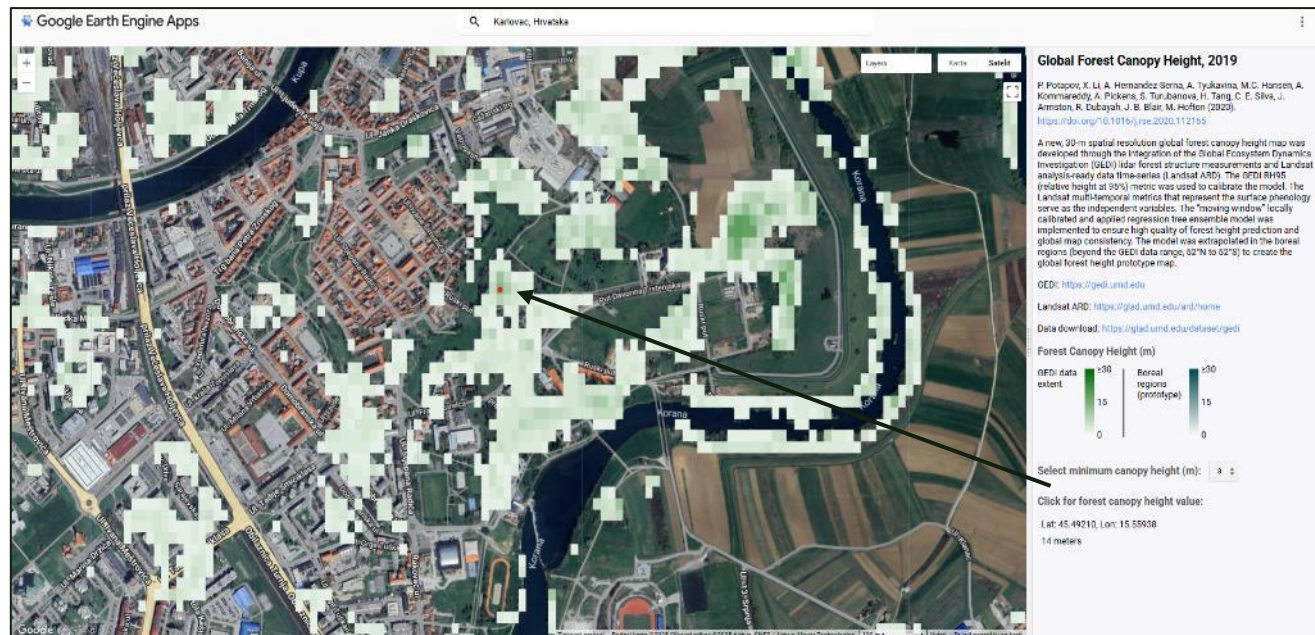
The measured values of tree height and girth can be read in the GLOBE database

Data search on satellite platforms: Earth Engine apps
(GEDI satellite - Global Ecosystem Dynamics Investigation, measures canopy height)


Different green colors show the cover heights but for some parts of the alley there is no data (we don't see the pixels)

By selecting and marking a pixel, only the average height of the entire pixel is obtained, not that of specific tree

Interactive map:https://glad.earthengine.app/view/global-forest-canopy-height-2019

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Analysis of land cover changes from 2000 to 2020 (Earth Engine app)

The integration of GEDI data with time series of Landsat satellite images enabled the analysis of forest cover changes in the period from 2000 to 2020
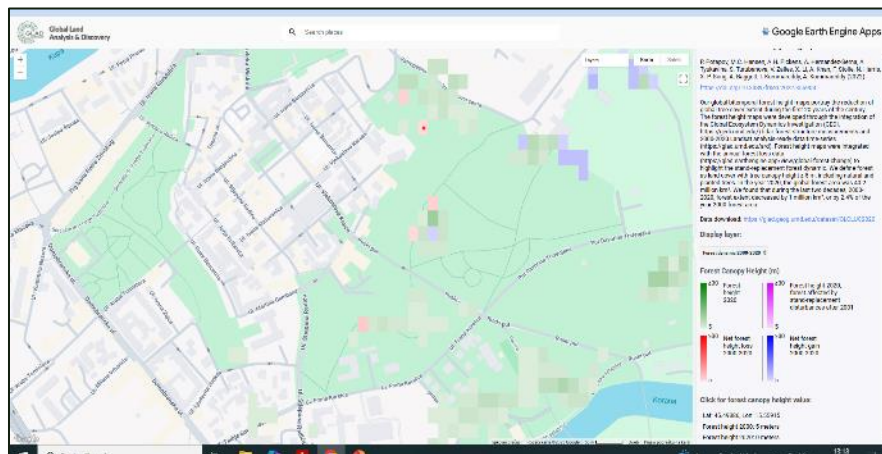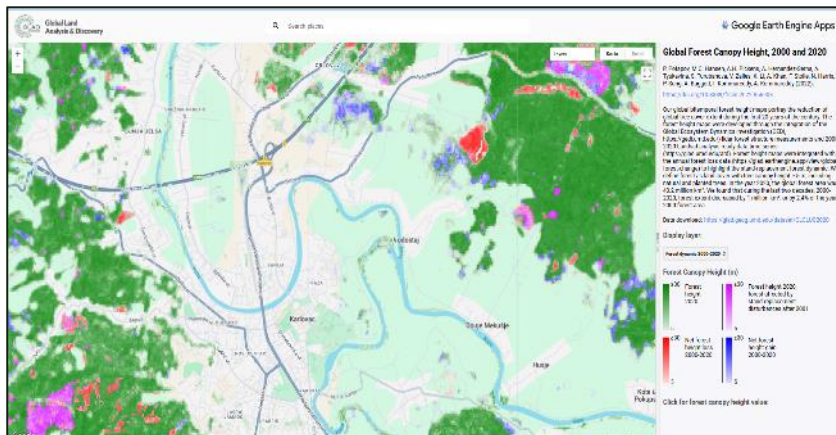
In urban areas, data on changes is missing (no visible pixels)

Only part of the area has change data. Although the area is marked in red as lost, pixels with newly planted trees are also shown.

Interactive map: https://glad.earthengine.app/view/forest-height-2000-2020

Discussion

The research results show an approximate value of the total mass of stored carbon in the trees of the Black Promenade and an approximate value of the total mass of absorbed CO_2 during the life of all the trees.

The obtained values show that the trees on the Black Promenade have absorbed more than 360 tons of CO_2 during their existence and contain more than 99 tons of stored carbon.

Results suggest that it is essential to take care of all tree rows, especially mature trees, because large trees contain large amounts of stored carbon. Trees with a larger chest diameter are older and contain more stored carbon, and have absorbed more CO_2 during their lives.
Old trees are valuable carbon sinks, but if they are cut down and rot or burned, the CO_2 will be released back into the atmosphere.

Calculating the age of a tree is an approximation because many variables can affect tree growth, such as soil composition and moisture, climate, root stress, competition for light in the ecosystem, and overall plant vigor.

In general, trees in urban areas grow more slowly than trees in forested areas. Trees in parks are often under greater stress and grow more slowly than forest trees.

Conclusion

The project was presented to the local community

- by introducing the importance of trees in the carbon cycle

- by introducing the species that grow on the Black Promenade

The City of Karlovac takes care of the Black Promenade, so old and diseased trees are removed, and new trees are planted.

The dynamics of the cover over 20 years on Earth Engine app show losses in the height of the cover, but also new areas with planted trees.

An accurate analysis over 20 years cannot be carried out because there is no complete data on satellite platforms, which is why it is important to conduct field research and create database for alleys in cities.

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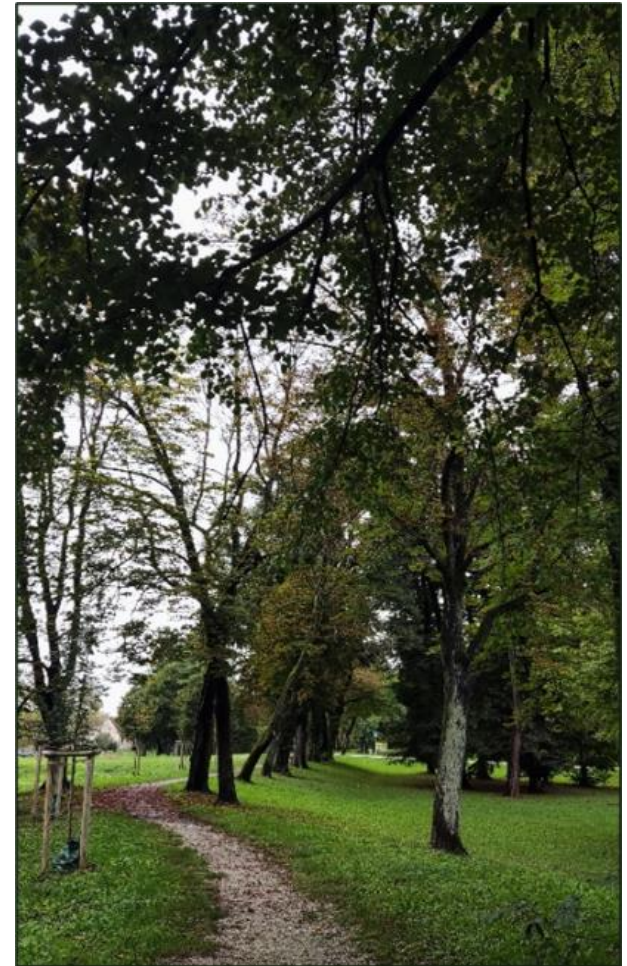
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