EVOLUTION OF SOME WOODY PLANTS FROM THE CLASS OF GYMNOSPERMS ADAPTED TO THE SEASONAL CONDITIONS IN ARBORETUM SYLVA FROM GURAHONȚ, ROMÂNIA. STUDY CASE: LIBOCEDRUS DECURRENS

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RESEARCH ARTICLE

Abstract
This study aims to conduct a descriptive analysis of gymnosperm stands, specifically specimens of Libocedrus Decurrens. located in plot IV of Arboretum Sylva in Gurahonț, using modern assessment tools such as spatial analysis through Geographic Information Systems (GIS), the Mergin Maps application, and various methods and formulas for calculating growth and development indicators, as well as biomass estimation.
The intended purpose is to highlight the importance of conserving and studying gymnosperms, specifically Libocedrus decurrens as a case study, encompassing their biological characteristics and their ecological and economic significance.
Identifying resilient and aesthetically valuable specimens with potential landscape and silvicultural importance could provide a robust foundation for the propagation of highly adaptable species, supporting not only their ornamental and dendrological value but also their cultural, forestry, and economic contributions.

Keywords: Gymnosperm, Libocedrus decurrens, Arboretum Sylva, GIS, Mergin Maps
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INTRODUCTION

The Arboretum Sylva in Gurahonț plays a crucial role in the conservation and promotion of unique and rarely encountered tree species, contributing to the maintenance of ecological balance and the environmental education of the general public. This paper explores in detail the contribution of this arboretum to the conservation and promotion of gymnosperm species, which are not specific to the area - a group of plants that is particularly important from both ecological and economic standpoints. By specifically analyzing how these species are managed and protected within the Arboretum Sylva, I will highlight the importance of this dendrological park in the context of biodiversity conservation and will emphasize the methods and practices that can be replicated in other arboreta, nature reserves, and forestry cultures. (Monograph of the SYLVA arboretum - author Eng. Ștefan Eusebiu, since 1992)

Identifying resilient and valuable specimens from a landscape and silvicultural perspective could provide a solid foundation for replicating species with a high degree of adaptability and growth.

The Arboretum Sylva is located in a hilly area that provides ideal conditions for the growth and development of a diverse range of tree species, including rare and unique ones. The proximity to the Apuseni Natural Park also enhances the ecological and conservation significance of Arboretum Sylva (Bulboaca S., Sinaci D., Fragment from the "Historical dictionary of localities in Arad County", vol. III, 2020).

The Arboretum Sylva is located in the commune of Gurahonț, Arad County, Romania (Figure No. 1). The commune of Gurahonț is situated in Arad County, 108 km from the city of Arad, and is bordered to the north and northwest by the communes of Dezna and

Cărpinet in Bihor County, to the east by the communes of Vîrfurile, Pleşcuţa, and Vaţa de Jos in Hunedoara County, to the south and southeast by the communes of Bîrzava, Petriş, and Brazii, and to the west by the communes of Almaş and Dieci.

Historically, the Sylva Arboretum covered an area of 12.6 hectares, divided into 30 units (plots). At present, the arboretum occupies only 4.6 hectares on the left side of the Honţişor Valley, while the remaining 8 hectares, located on the right side of the same valley, were restituted to their rightful owners after the 1990s

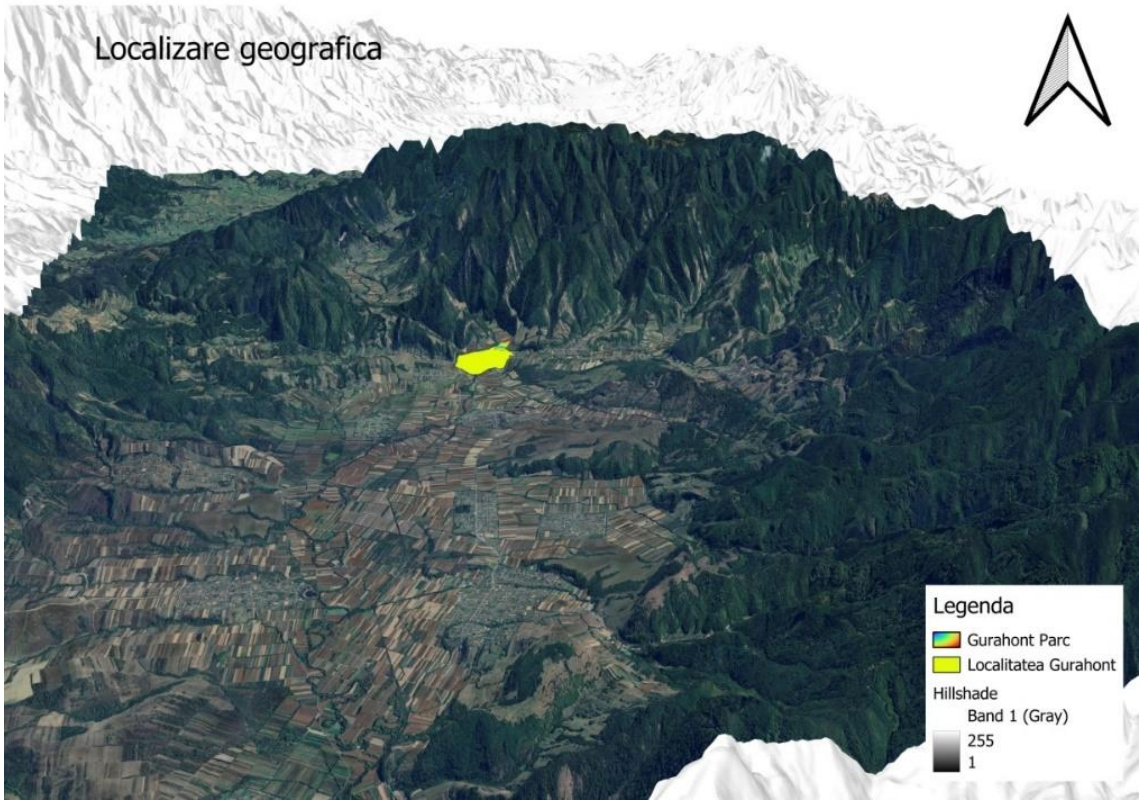

Figure 1 **Geographical location of Gurahonț village and arboretum SYLVA - 3D view performed in QGIS 3.34 PRIZEREN**

From a *pedological perspective*, the arboretum falls within the area of floodplain soils formed on Quaternary alluvium. Due to the repeated flooding of the Crişul Alb River and especially in the Honţişor Valley, alluvial soils belonging to this classification are often found in various stages of evolution. (Table No.1)

Table 1

Pedological characteristics of the soil in Arboretum SYLVA

Characteristics	Profile 1	Profile 2
Geomorphological unit	Low floodplain	High floodplain
Terrain configuration	Flat	Flat
Flora	Grasses	Grasses
Genetic soil type	Meadow brown	Forest brown
Depth	Shallow	Shallow
Physiological depth	30 cm	60 cm
Usable physiological volume	Very low	Very low

Analysis results indicate that the soil is of the sandy loam type, with a dominance of particle sizes ranging from 0.2 to 1.002 mm, making up 57.2%. The soil reaction is slightly acidic, as indicated by a low pH of 5.65.

The relatively high humus content of 2.76% is well-supplied with mobile phosphorus and moderately supplied with potassium. (Table No. 2)

Table . 2

Soil Parameters for the Arboretum SYLVA

pH / KC1-01-4/	5,65
Humus	2.76 %
P2 05 mg/100 g/sol	5.10
K2 mg/100 g/sol	10.0

With regard to the temperatures considered in the analysis in this study, they cover the entire period since the establishment of the meteorological observatory in Gurahonț village, specifically from January 1, 1963, until the end of 2023. (National Meteorological Administration, 2024 - electronic correspondence 01.07.2024).

To ensure the highest accuracy of the conclusions drawn, data spanning 60 years were compiled to obtain annual average values, annual minimum averages, annual maximum averages, absolute minimums, and absolute maximums, for maximum fidelity to the specific conditions of the area.

In general, for the climatic factor of temperature in this area and the analyzed period, the following conclusions can be drawn:

- The average annual temperature ranges from 8.8°C to 12.2°C, which is suitable for the healthy development of plantations. The same conclusions apply to the annual average minimum and maximum temperatures.

- Regarding the absolute maximum temperature, values exceeding 38°C were recorded in 2000 (38.8°C), 2007 (38.9°C), 2012 (38.5°C), 2017 (38.7°C), and 2019 (38.7°C), culminating in a value of 39.2°C in 2022. Up to the threshold of 37.4°C, the temperature can be considered satisfactory for the development of tree species in the Sylva arboretum. However, with recent years exceeding these values, this environmental factor may favor species adapted to these conditions at the expense of those that do not have a similar degree of adaptability.

Description of Libocedrus decurrens:

*Libocedrus decurrens Torrey 1853 (*Figure No.2) Calocedrus decurrens (Torrey)
Order: Cupressales - Family: Cupressaceae - Genus: Libocedrus.
Common Names: Incense cedar; white cedar, bastard cedar, or post cedar of California (D.C. Peattie 2013); cedro incienso*[Spanish] (Thieret John W. 1993).
Taxonomic Notes: Synonym: Libocedrus decurrens Torrey 1853 (Thieret John W. 1993).

Libocedrus decurrens is an aromatic, resinous tree reaching heights of 18 - 46 (57) m and a trunk *diameter* at breast height (DBH) of 90-150 (360) cm. The trunk is irregularly conical with angled edges and a narrow, columnar crown that becomes open and irregular with age. The *bark* is light brown to reddish, thick, fibrous, and deeply furrowed into crumbly ridges. *Branches* are highly ramified and flattened, with wedge-shaped joints that are longer than they are wide and composed of scaly leaves. *Leaves* are persistent, glossy, arranged oppositely in four rows, 3-14 mm long, with a decurrent base, rounded on the abaxial side, and have an acutely pointed (often abruptly) apex, usually mucronate. The lateral pair of leaves is keeled, punctuated, overlapping with the subsequent pair, and extends along the branch, releasing a fragrance when crushed. *Pollen cones* are reddish-brown to light brown. *Seed cones* are reddish-brown to golden brown, 14-25 mm long (including the wings), oblong-ovate when closed, and pendulous on a leafy peduncle; proximal scales often reflex when mature, and median scales spread widely to recurve. Each cone contains up to four seeds, paired, with two unequal wings. Chromosome number: 2n = 22 (Little E.L.J. 1980, Thieret John W. 1993).

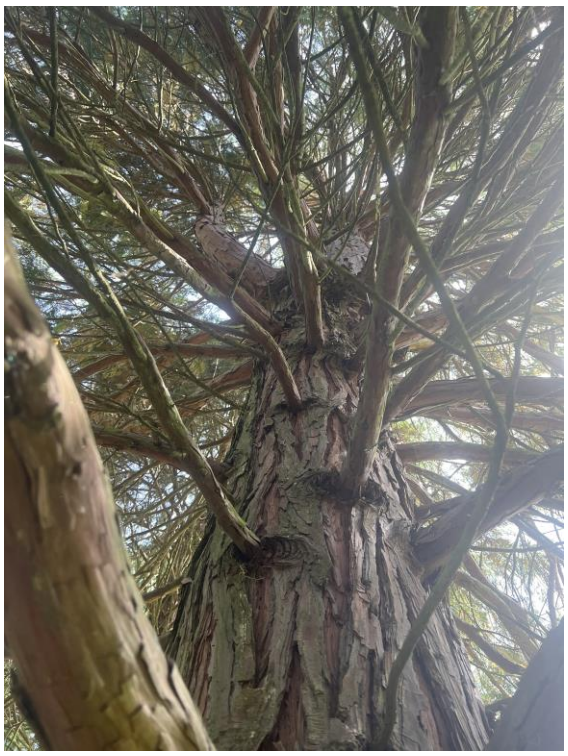

Figure 2 **Specimen of Libocedrus decurrens Torrey – photographed in Arboretum SYLVA**

Distribution and Ecology:

This species is found in the United States, specifically in western Oregon, Nevada (Lake Tahoe area), and California, and in Mexico in northern Baja California Norte, at elevations ranging from 50 to 2010 m in the northern parts of its range and 910 to 2960 m in the south. Its northernmost range extends to the southern slopes of Mount Hood, with its southern boundary in the Sierra San Pedro Mártir (R.F. Powers & W.W. Oliver 1990). Within its natural range, the climate is characterized by dry summers, usually with less than 25 mm of precipitation per month. Annual temperature extremes range from -34°C to 48°C. Annual precipitation varies from 380 to 2030 mm, with some falling as snow, and the driest conditions occur near the northern limits of the species in Oregon and northeastern California. The tree grows on an exceptionally wide variety of soils derived from silicate, serpentine, and carbonate parent materials, with textures from coarse sand to clay (R.F. Powers & W.W. Oliver 1990). It shows a remarkable tolerance for warm, dry sites with poor soils, growing in areas more typical for *Hesperocyparis* or *Juniperus*. However, the largest specimens tend to be found in sunny, well-watered locations, such as riparian zones in canyons or near subalpine lake shores. Rarely forming pure stands, it is found in mixed forests with other species (R.F. Powers & W.W. Oliver 1990).

Notable Trees:

The largest known specimen, the Devil's Canyon Colossus, has a diameter of 378 cm, a height of 50.3 m, and a stem volume of 223 m^3, located in Devil's Canyon near Sawyer's Bar, Marble Mountains Wilderness, California. Another notable tree, the Alex Hole Cedar, has a diameter of 456 cm and grows on the north side of Condrey Mountain in Rogue River National Forest, Oregon. The tallest known specimen, with a diameter of 175 cm and a height of 69.8 m, is located near Tiller in Umpqua National Forest, Oregon (Van Pelt 2021).

Oldest Known Specimen:

The age of the oldest known specimen is uncertain; a report mentions an individual estimated to be 933 years old, but further details are lacking (Carder A.C. 1995).

Ethnobotany:

The tree is widely cultivated as an attractive ornamental species. In the past, it was valued in manufacturing, particularly for pencil production, due to its softness and isotropy. Although timber harvesting has declined due to resource depletion, its wood, highly resistant to decay and very durable in outdoor conditions, remains useful in carpentry for cedar chests and cabinets (Little E.L.J. 1980, Thieret J.W. 1993).

Libocedrus decurrens is a versatile and valuable tree, ideal for various applications in landscaping and forestry. The tree in the Image No. 1, was planted in the Sylva Arboretum by Engineer Eusebiu Ștefan 57 years ago, in 1967, originating from Szarvas, Hungary and currently has a diameter of 63 cm.

The Libocedrus decurrens trees were identified in plot VI at positions 37/39/41/42.

MATERIAL AND METHOD

An inventory of gymnosperm trees and shrubs, specifically Libocedrus decurrens specimens, was conducted using Mergin Maps (https://merginmaps.com/accesat 2024.06.28) and GIS processing, with Libocedrus decurrens specimens identified within plot VI. Growth and development indicators for these trees were also calculated, as well as biomass

estimation for these specimens, using allometric calculation formulas.

QGIS is a free, open-source, cross-platform geographic information system (GIS) application that supports geospatial data visualization, editing, printing, and analysis. The Geographic Information System (GIS) facilitates the location, processing, and analysis of spatial data by combining traditional tools, such as standard maps, with advanced systems like remote sensing technologies, GPS systems, and aerial imagery. By utilizing this technology, the positioning of the SYLVA forest in Gurahonț, the surrounding areas, the topography of the region, and the distribution of gymnosperm stands, specifically the specimens of Libocedrus decurrens in plot VI, was accomplished. This highlights the importance of the distribution of forest species within the stand, aiming for a better understanding of their representation in the studied space, the adaptability of gymnosperms, and the identification of valuable specimens from both a landscape and silvicultural perspective.

The Mergin Maps application was used to individually register each tree (point on the map = tree) in the Mergin Maps map, synchronized with QGIS prior to the field visit. The information collected in the field included: the date of the field exploration, geographic coordinates, uploaded photographs, and details related to the registered tree (species, diameter, etc.).

Growth and development indicators in gymnosperms are essential for a wide range of practical and research applications. These data contribute to sustainable forest management, biodiversity conservation, climate change monitoring, and the enhancement of agricultural and forestry practices. Key growth and development indicators include:

- Tree height – an indicator of the tree's maximum growth potential and maturity.
- Trunk diameter – used to assess the biomass and timber volume of a tree.
- Annual growth rate– provides insights into the tree's growth pace and health over different periods.

These are just a few of the critical indicators to consider when aiming to conserve and promote rare wood species.

Biomass Estimation for Representative Specimens of *Libocedrus decurrens* Torr in the Sylva Arboretum

To estimate biomass, we selected four specimens of *Libocedrus decurrens* located in plot VI (positions 37, 39, 41, 42), with trunk diameters ranging from 54 cm to 63 cm. Although specific allometric formulas can vary, and coefficients are determined through empirical studies on this species across different regions, we applied species-specific coefficients for *Libocedrus decurrens* from the scientific literature, referencing the allometric formulas for North American conifers.

General Formula for Conifers:

$$M = \exp(\beta_0 + \beta_1 \ln(DBH))$$

where:

- M is the total biomass (in kg),
- DBH is the diameter at breast height (in cm),
- β_0 and β_1 are species- and region-specific coefficients.

General coefficients for conifers (from Jenkins et al. 2003):

For conifers (coefficients also used for Libocedrus decurrens), the coefficients used are:

$\beta_0 = -2.5356$

$\beta_1 = 2.4349$

For the most representative specimen with diameter = 63cm, the formula becomes:

$$M = \exp(-2.5356 + 2.4349 \ln(63))$$

$$\ln(63) = 4{,}1431$$

$$M = \exp(7{,}5524) = 1905.31 \text{ kg}$$

Calculation of the growth rate of specimens of Libocedrus Decurrens Torrdin plot VI Arboretum SYLVA

Specimen Libocedrus Decurrens Torr

- Location: $46^0 16'0"$ N $22^0 20'55"$ E
- Positioning: Pacela VI, position no. 37
- Year of planting: 1967

• Current year: 2024

• Tree height in 2024: 16 meters

• Tree diameter in 2024: 62 cm

The first step was to determine the age of the tree in 2024: Tree age = 2024−1967=57 years

Calculation of the rate of growth in height

The average annual height growth rate is calculated by dividing the total height of the tree by its age:

Height growth rate = (Total height)/Age=16/57=0.281 meters/year

Calculation of the growth rate in diameter

The average annual growth rate in diameter is calculated by dividing the total diameter of the tree by its age:

The average annual growth rate in diameter is calculated by dividing the total diameter of the tree by its age:

Growth rate in diameter = Total Diameter/Age=62/57=1.088cm/year

In summary we could find an annual growth rate in height of approximately 0.281m/year and an annual growth rate in diameter of approximately 1.088cm/year.

We performed a similar calculation for all 4 specimens of Libocedrus decurrens Torr, the results being recorded in Table No 3

Table 3

Geographic Distribution, Size, Age, and Annual Growth Rates of Libocedrus decurrens Torrey in the Arboretum SYLVA

Name	Coordinates	Position in the Arboretum	Diameter (cm)	Height (m)	Age (years)	Annual Growth Rate in Height (m/year)	Annual Growth Rate in Diameter (cm/year)
Libocedrus decurrens Torr	46º16'0"N 22º20'55"E	37	62	16	57	0,280702	1,087719
Libocedrus decurrens Torr	46º16'1"N 22º20'54" E	39	62	14	57	0,245614	1,087719
Libocedrus decurrens Torr	46º16'0"N 22º20'54"E	41	54	14	57	0,245614	0,947368
Libocedrus decurrens Torr	46º16'0"N 22º20'54"E	42	63	17	57	0,298246	1,105263

RESULTS AND DISCUSSIONS

The Libocedrus decurrens trees were identified individually by using Mergin Maps application in plot VI at positions:

- 37- coordinates $46^0$16'0"N $22^0$20'55"E,
- 39 -coordinates $46^0$16'1"N $22^0$20'54" E
- 41- coordinates $46^0$16'0"N $22^0$20'54"E
- 42 - coordinates $46^0$16'0"N $22^0$20'54"E

Libocedrus decurrens has a moderate growth rate, usually between 0.2 and 0.3 meters/year in good condition. The annual growth rate in height, calculated for the 4 specimens of Libocedrus Decurrens Torr is between approximately 0.246 – 0.298 meters / year and is in accordance with the typical growth for this species.

Regarding the growth in diameter, growth in diameter for Libocedrus decurrens is usually between 0.5 and 1 cm/year but can be greater under optimal conditions.

The rate calculated for the 4 specimens of Libocedrus decurrens on plot VI within the

Sylva arboretum is between 0.947 - 1.105 cm/year and is slightly above average, indicating favorable growth conditions. Compared to other similar trees, the data for Libocedrus decurrens is similar or slightly better.

The calculated growth rate for Libocedrus decurrens is in line with typical values for this species, indicating healthy growth and good environmental conditions. Compared to other similar species, growth in height is moderate and growth in diameter is slightly above average, suggesting favorable seasonal growth conditions.

Growth and development indicators in gymnosperms are essential for a wide range of practical and research applications. These data contribute to sustainable forest management, biodiversity conservation, climate change monitoring, and the improvement of agricultural and silvicultural practices.

The creation and development of a dendrological park, such as the Sylva arboretum, as well as the expansion of the planting of rare and non-native trees that are acclimatized, can bring multiple landscapes, silvicultural, and economic benefits.

The contribution of the Sylva arboretum in Gurahonț to the conservation and promotion of rare and unique woody species is evident and should serve as a model for good forestry practices. In addition to the landscape and ecological benefits, the contribution to increasing biodiversity through the introduction and acclimatization of rare and non-native species has had a positive impact on the local ecosystem.

CONCLUSIONS

The Sylva Arboretum in Gurahonț is an attraction that can be exploited both from a tourist point of view for nature lovers and educationally. This dendrological park can become, in this context, a real educational and research hub. The Sylva Arboretum is a laboratory for outdoor silvicultural research, and the survival rate of gymnosperm specimens under local environmental conditions and in the context of appropriate care may constitute a model of good practice that can be replicated.

In addition to aspects related to the adaptability, growth and development of Gymnosperm species, not specific to the local area, rare trees are at the same time a habitat for various species of animals and insects thus contributing to a healthier ecosystem.

An arboretum serves as a natural laboratory for studying the growth, adaptation and behavior of various tree species. This can be a center for silvicultural research, contributing to the knowledge and development of more effective management techniques. By acclimatizing and cultivating rare species, an arboretum can help preserve them and prevent their extinction.

The 4 specimens of Libocedrus decurrens on plot VI, within the Sylva arboretum have shown a good rate of growth and development, reaching considerable diameters in a relatively short time, which supports the possibility of testing and expanding similar models in other areas as well.

Libocedrus decurrens is a versatile and valuable tree, making it an ideal species for various applications in landscaping and forestry, providing both visual and recreational benefits as well as economic advantages.

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