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ANALYSIS OF DIAMETER AND HEIGHT GROWTH OF SCOTS PINE SAPLINGS PLANTED IN 2023 ON THE STERILE DUMPS OF RECEA ȘUNCUIUȘ QUARRY, BIHOR COUNTY

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Abstract

This study evaluates the success of Scots pine sapling plantings conducted in 2023 on the waste deposits at the Recea Șuncuiuș Quarry in Bihor County. Four experimental plots were established, divided into two slope categories. Half of the saplings received fertilizer, and for all saplings, survival rates were assessed, along with measurements of diameter and height growth. The findings indicate no significant differences in sapling growth between the slopes, and the application of fertilizer did not notably affect their development in the first year after planting. However, in the second year, significant changes were observed. The slope became a negative factor, while fertilization had a significant positive impact on growth in terms of diameter and height, particularly under the harsh conditions of the exceptionally dry and hot summer of 2024.

Key words*: diameter, height, pine, Pinus, survival rate.*

INTRODUCTION

Over the past century, the global population has increased from 2 billion to over 8 billion, placing significant strain on natural resources. Growing demand for products has intensified landscape impacts, particularly through the extraction of underground resources, leading to a considerable expansion of degraded lands in recent years. In this context, restoring ecosystems has become a key responsibility for foresters, with afforestation widely recognized as an essential component of this effort (Huang et al., 2024).

Afforestation offers a practical solution for the ecological restoration of degraded lands, providing a foundation for their sustainable use and development in the medium and long term (Constandache et al., 2020). Additionally, afforestation efforts are widely acknowledged as effective measures for combating climate change by sequestering carbon (Zhiyanski et al., 2016).

One of the most used worldwide tree species for afforestation is the Scots pine (*Pinus sylvestris* L.). It has the largest natural range of any pine species, extending across both Europe and Asia (Przybylski et al., 2015; Bonciu et al., 2023). Latitudinally, it ranges from northern Scandinavia (70°N) to the Sierra Nevada mountains in southern Spain (37°N) (Houston Durrant et al., 2016).

During the twentieth century, Scots pine forests saw significant expansion throughout Europe, currently accounting for over 20 percent of the EU's forest area. Although the initial focus of this expansion was to enhance timber production, recent decades have shifted towards a broader set of management goals (Mason & Alia, 2000). Scots pine exhibits significant morphological and genetic diversity due to its wide distribution (Stoica et al., 2022; Sheller et al., 2023), with several varieties, including *Pinus sylvestris* "Glauca", *Pinus sylvestris* var. *hamata* Stev, and *Pinus sylvestris* var. *mongolica* Litvin (Budău et al., 2024). Scots pine is a pioneer species with a wide range of uses, including in the wood and chemical industries, household applications, decoration, ecological restoration, as well as in medicinal and cosmetic products (Papp et al., 2022; Gurău, 2024; Szanto et al., 2025). Particularly, it is recognized for its resilience to frost and drought, as well as its capacity to grow in nutrient-poor soils, allowing it to inhabit a variety of ecologically diverse environments (Enescu, 2015). It forms a deep root system, allowing it to tap into water from deeper soil layers and stabilize land prone to erosion. Its rapid growth supports the restoration of vegetation in degraded areas. Scots pine can thrive in both lowland and mountainous regions due to its adaptability to diverse climatic conditions and its ability to grow in nutrient-poor soils, making it an important resource for ecosystem restoration and the fight against desertification (Kelly and Conolly, 2000; Doniță et al., 2004; Pietrzykowski et al., 2013). Through the decomposition of its needles, *P. sylvestris* contributes to the formation of raw humus (Traci et al., 1981), thereby enhancing biodiversity in the soil's upper layer (Xue et al., 2022).

In many European countries, Scots pine is one of the primary coniferous species used for afforestation and is often considered the dominant species for forest formation (Oszako et al., 2023; Okon et al., 2024). For example, Scots pine has been successfully planted in the Czech Republic, where it ranks as the second most important tree species for industrial wood production (Brichta et al., 2023), and has been established in various terrains, including post-mining sites (Zeidler et al., 2024). In Latvia, Scots pine has been successfully used for afforestation of abandoned peat extraction sites (Skrastiņa et al., 2021), while in Ukraine, it has been planted to establish forest plantations resilient to environmental factors in the northern steppe region (Gritsan et al., 2019). Positive results have also been reported in Russia (Belan et al., 2024) and Mongolia (Sukhbaatar et al., 2018).

In Romania, Scots pine has been planted in a variety of site conditions, including the sandy soils of the Oltenia region in southwestern Romania (Nuță, 2005), abandoned mining lands in the northwestern part of Transylvania (Buta et al., 2019), and degraded terrains in eastern part of the country (Vlad et al., 2019). In most cases, Scots pine exhibited a rapid growth rate, particularly during the initial years of vegetation (Batsaikhan et al., 2018; Colișar et al., 2024).

This study aimed to evaluate the growth in diameter and height of Scots pine saplings planted in 2023 on sterile dumps at the Recea Șuncuiuș Quarry in Bihor County.

MATERIALS AND METHODS

The experiments were conducted within the 2.89 km² Recea perimeter, situated in the Șuncuiuș refractory clay deposit in the northern part of the Pădurea Craiului Mountains, Bihor County (46°55'11"N, 22°30'34"E), where the first afforestation experiments were made in 2008-2009 (Bodea et al., 2023).

According to Ministerial Order no. 2533/2022 (MMAP, 2022), the landfill site in this case is classified as YD1B (Y - landfill; D - hill region; 1 - for raw waste dumps or terrigenous materials from mining and B - anthropogenic materials composed of small materials such as sand, gravel, loess, and clay). The planting materials were sourced locally, and 4 experimental plots, 50 m^2 each, noted with E, F, G and H, were established (Figure 1).

Figure 1. The 4 experimental plots

In the four experimental plots, 3-year-old Scots pine seedlings, averaging 30 cm in height, were planted using a 2x1 m spacing arrangement, with 25 seedlings in each plot. During the spring and autumn of 2023 and 2024, the following characteristics were measured:

- the survival rate after planting in the field, expressed as a percentage;

- the survival rate of seedlings, recorded at the end of the first vegetation period, expressed as a percentage;
- seedling height (cm), measured from ground level to the top of the main stem;
- seedling diameter at the root collar (mm) at the end of the first vegetation year in the field;
- the number of whorls;
- the number of branches per whorl.

The four experimental plots were labelled as follows:

- Variant E, code Pi.s. S_1P_1N: small slope P1≤10°, N - unfertilized substrate;
- Variant F, code Pi.s. S_2P_2N: large slope P2>10°, N - unfertilized substrate;
- Variant G, code Pi.s. S_3P_1F: small slope P1≤10°, F - fertilized substrate;
- Variant D, code Pi.s. S_4P_2F: large slope P2>10°, H - fertilized substrate.

The saplings' height was measured with a height measuring tape (Figure 2a), and the trunk diameter at the base was measured using a digital caliper (Figure 2b).

Figure 2. Measuring the height and the collar diameter of the saplings

Fertilization was applied in experimental plots G and H using a chemical fertilizer specifically formulated for softwood seedlings, containing 14% N, 7% P_2O_5, 17% K_2O, 2% MgO, 9% S, 0.02% B, and 0.01% Zn. The fertilizer was distributed around the seedlings at a rate of 15–20 grams per plant (Figure 3).
For most of the analyzed characteristics (degree of survival after planting, degree of survival after the first year, plant height, diameter at the root collar, number of whorls, and number of branches per whorl), the arithmetic mean was calculated using the standard formula: $x = \sum x/n$.

Figure 3. Applying fertilizers

For the number of branches per first whorl, as each sample contained groups of plants with varying numbers of branches (ranging from 0 to 6 branches per whorl per plant), the weighted arithmetic mean was used, calculated with the following formula:

$$X_{med.pond.} = \frac{\bar{x}_1 n_1 + \bar{x}_2 n_2 + \ldots + \bar{x}_k n_k}{N},$$

where:
$N = n_1 + n_2 + \ldots + n_k$;
$\bar{x}_1 \cdots \bar{x}_k$ = group averages.
To determine the degree of survival after planting in the field, the following formula was used:

$$Gp(\%) = \frac{Pveg}{Pplant} 100,$$

where:

- P_{veg} represents seedlings started in vegetation on April 20, 2023;
- P_{plant} accounts for planted seedlings.

To determine the degree of survival after planting in the field, the following formula was used:

$$Gm(\%) = \frac{Pviab}{Pveg} 100$$

where:

- Pviab represents viable seedlings at the time of determination;
- Pveg represents the number of seedlings that started growing on April 20, 2023.

The results from the biometric measurements were statistically analyzed using analysis of variance, appropriate for monofactorial experiments conducted in randomized blocks. The significance of differences between the two tested varieties was assessed using the DL test or the multiple comparisons test (DS5%). For certain characteristics, the Student's *t* test was also applied (Ardelean et al., 2005; Ardelean, 2011).

The coefficients of variability (s%) were calculated using data from the series of measurements taken on the 25 individuals in each variant, following the formula described by Ardelean (2011):

$$s\% = \frac{s}{\bar{x}}\ 100, \%$$

where:

- s represents the standard deviation;
- x is the average of the series.

Simple correlation coefficients were calculated using Microsoft Excel, with their significance assessed at the 5% and 1% levels.

RESULTS AND DISCUSSIONS

The data presented in Tables 1 and 2 confirm the uniformity of the planted material, indicating that at the time of planting, there were no significant differences in seedling height or diameter within the parcel.

Tables 3 and 4 present the mean diameters and heights of *P. sylvestris* measured in spring and autumn of 2023 and 2024 across the four experimental plots.

Table 1. Mean collar diameter (mm) in the 4 plots

Var	Initial diameter, mm	± d, cm	t	Significance of difference	s%
	$\bar{X} \pm s_x$				
E	12.66 ± 0.63	-	-	-	21.9
F	10.81 ± 0.44	-1.85	-0.84	n.s.	17.7
G	14.57 ± 0.53	1.91	0.79	n.s.	13.8
H	11.22 ± 0.34	-1.44	-0.70	n.s.	27.9
$t_{calc} < t_{P5\%} = 1.9$					

Table 2. Mean height (cm) in the 4 plots

Var	Initial height, cm	± d, cm	t	Significance of difference	s%
	$\bar{X} \pm s_x$				
E	28.90 ± 1.26	-	-	-	24.9
F	29.54 ± 1.04	0.64	0.07	n.s.	20.1
G	31.58 ± 0.87	2.68	0.30	n.s.	18.1
H	30.48 ± 1.70	1.58	0.10	n.s.	15.3
$t_{calc} < t_{P5\%} = 1.9$					

In terms of survival rate after planting, it was observed that losses were minimal, with only 1% in the first year and an additional 1% (one dried seedling in experimental plot H) in 2024.

Table 3. Mean diameters and heights measured in spring and autumn 2023 for *P. sylvestris* in the 4 experimental plots

Code	Variant	Collar diameter, mm		Diameter growth, mm	Height, cm		Height growth, cm
		03.2023	11.2023		03.2023	11.2023	
Pi.s. - S1P1N	E	12.66	12.95	0.28	28.90	45.60	16.70
Pi.s. - S2P2N	F	10.81	11.10	0.24	29.54	46.50	16.73
Pi.s. - S3P1F	G	14.57	14.99	0.42	31.58	45.70	14.12
Pi.s. - S4P2F	H	11.22	11.71	0.49	30.48	46.10	15.62

Table 4. Mean diameters and heights measured in spring and autumn 2024 for *P. sylvestris* in the 4 experimental plots

Code	Variant	Collar diameter, mm		Diameter growth, mm	Height, cm		Height growth, cm
		03.2024	11.2024		03.2024	11.2024	
Pi.s. - S1P1N	E	12.95	19.85	6.90	45.60	57.53	11.94
Pi.s. - S2P2N	F	11.10	17.34	6.24	46.50	59.94	13.44
Pi.s. - S3P1F	G	14.99	26.75	11.75	45.70	66.79	21.08
Pi.s. - S4P2F	H	11.71	20.36	8.65	46.10	63.94	17.84

An analysis of the 25 seedlings from the first variant (E; no slope, unfertilized) revealed that, at the end of the first year of growth, the seedlings' height ranged from 25 to 67.5 cm, with a variability coefficient of 23.8% (high variability).

The calculation and interpretation of results from the bifactorial experiments involve the following factors:

- Factor A: fertilization method, with two levels: N (unfertilized) and F (fertilized);
- Factor B: slope, with two levels: P1 (0-10°) and P2 (>10°).

The experiment was carried out using a randomized block design with 25 replications (n = b = 25). The total number of experimental variants (v = 4) was determined by the combination of the two factors at two levels each (2 × 2 = 4). Each experimental plot contained 25 seedlings, and the average height growth for each replication area was calculated as the mean of the measurements from all 25 seedlings within the plot. The analysis of variance for the bifactorial experiment (2 × 2), considering slope and fertilization method, is presented in Table 5.

Table 5. Analysis of variance for the bifactorial experiment (2 x 2) with slope and fertilization mode

Source of variation	Sum of squares (SS)	Degrees of freedom (DF)	Mean square (MS)	F-Statistic (F)			
Total	3892.70	99					
blocks	872.0596	24				5%	1%
fertilization	56.7009	1	56.70	1.39	<	3.98	7.01
slope	502.7481204	1	502.75	12.35	>	3.98	7.01
fertilization x slope	-469.80	1	-469.80	-11.54	>	3.98	7.01
Error	2930.99	72	40.708				

According to the data in Table 5, the calculated *F* values for the slope factor exceed the theoretical *F* values at the 5% significance level (P5%), indicating that slope has a significant influence on seedling height growth during the first year after planting.

The significance of differences between variants is assessed below. Given the potential for multiple types of comparisons, the analysis of variance method was used to calculate the standard deviation (sd) and least significant difference (LSD) values for each comparison.

a) In Table 6, the variants are compared to the control variant:

- sd = 1.80 cm
- $LSD_{5\%}$ = 3.59 cm
- $LSD_{1\%}$ = 4.78 cm
- $LSD_{0.1\%}$ = 6.19 cm

Table 6. Summary of the results

Var.	Variant name	hm, cm	h rel, %	±d, cm	Significance of difference
11	NP1 (Control variant)	16.70	100.0	-	-
12	NP2	16.73	100.2	0.0	-
21	FP1	14.12	84.6	-2.6	-
22	FP2	15.62	93.5	-1.1	-
	LSD 5%=	3.59			
	1%=	4.78			
	0.1%=	6.19			

b) The influence of fertilization on height growth was evaluated relative to the unfertilized variant, which served as the control. The error and least significant difference (LSD) values corresponding to the fertilization factor were as follows:

- sd (fertilization) = 11.51 cm;
- $LSD_{5\%}$ = 22.91 cm;
- $LSD_{1\%}$ = 30.51 cm;
- $LSD_{0.1\%}$ = 39.49 cm.

The results are given in Table 7.

Table 7. The influence of fertilization on hm

Variant name	hm, cm	h rel, %	±d, cm	Significance of difference
unfertilized (Mt)	16.4	100.0	-	-
fertilized	14.9	90.8	-1.8	-
LSD 5%=	22.9			
1%=	30.51			
0.1%=	39.49			

It can be observed that regardless of the slope, the applied fertilization does not result in significant growth in the seedlings.

c) The influence of slope on growth height is compared to the variant without slope as a control. The results are given in Table 8. Regardless of the fertilization applied, slope negatively influences seedling growth, but insignificantly.

d) Comparing all variants with each other using the Duncan test (multiple comparisons method). It is applied when the interaction of the 2 factors is significant.

d1) To compare the influence of fertilization on height growth, regardless of slope:

- sx = 0.90 cm
- Degrees of freedom for error = 72

The $DS_{5\%}$ values for different comparison limits between the mean effects of the fertilization factor were calculated as follows:

- Number of variants within the comparison limits: 2
- q5%, (for DF = 72) = 2.82
- sx = 0.90 cm
- $DS_{5\%}$ = 2.54 cm

The $DS_{5\%}$ values for the different comparison limits between variants are presented in Table 9.
d2) The same as variant d1) - All non-significant.

Table 8. The influence of slope on hm

Variant name	hm, cm	h rel, %	±d, cm	Significance of difference
P1 (Mt)	15.41	100	-	-
P2	15.836	102.7644	-0.86	-

LSD 5%= 22.91
1%= 30.51
0.1%= 39.49

Table 9. The $DS_{5\%}$ values for different comparison limits between variants

Variant	hm	1	4	3
2	16.73	0.03	1.11	2.61
1	16.7	-	1.08	2.58
4	15.62		-	1.5
3	14.12			-

All non-significant

d3) To compare the influence of fertilization on the same or different slopes, as well as the effect of slope under the same or different conditions on height growth: sx = 1.28 cm. The DS5% values for the different comparison limits between variants are presented in Table 10. Table 11 presents the seedling height growth (cm) one year after planting, under the influence of two slope categories and two fertilization methods. Differences between two variants followed by the same letter in the table are not statistically significant.
The same procedure was applied for the year 2024. The average increases in collar diameters in the first 2 years in all 4 experimental plots are given in Figure 4. The average increase in height in the first 2 years in all 4 experimental plots are given in Figure 5.

Table 10. The DS5% values for different comparison limits

The number of variants within the comparison limits.	2	3	4
q 5% for DF= 72	2.82	2.97	3.07
s_x in cm	1.28		
$DS_{5\%}$	3.60	3.79	3.92

Table 11. Seedling height growth (cm) one year after planting by slope category and fertilization method. Variants sharing the same letter do not differ significantly

Fertilization \ Slope	P1	P2	Fertilization average
N - Unfertilized	16.7 b	16.7 b	16.7 A
F - Fertilized	14.1 a	15.6 a	14.9 A
Average slope	15.4 M	16.2 M	

$DS_{5\%}$ to compare two averages fertilization =2.5
$DS_{5\%}$ to compare two averages slope =2.5
$DS_{5\%}$ to compare two averages: fertilization x slope =3.6-3.9

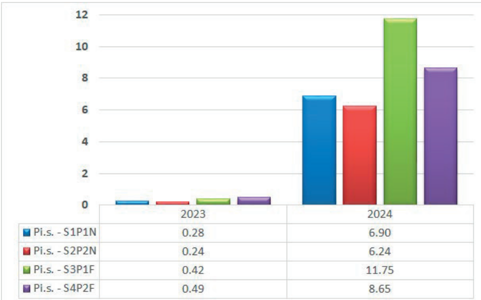

Figure 4. The average increase in collar diameters (mm) in the first 2 years in all 4 experimental plots

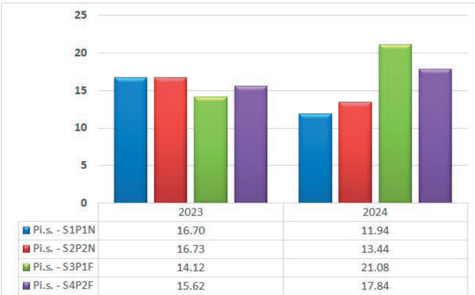

Figure 5. The average increase in height (cm) in the first 2 years in all 4 experimental plots

CONCLUSIONS

Scots pine seedlings of local origin (Șuncuiuș nursery, Bihor County), planted in 2023, demonstrated a high survival rate of 98% during the first two years after planting.
The 3-year-old seedlings, planted in large planting holes (40 × 40 × 40 cm), showed no significant differences in diameter and height growth during the first year, regardless of fertilization, due to prior nursery growth and initial site conditions. However, in the second year, seedlings in plot G, where fertilizers were

applied on a gradual slope, exhibited significantly higher growth, with height increases 70.2% greater than in the unfertilized plot E. On steeper slopes, diameter growth was 26.3% lower compared to flat or gently sloping areas.

In 2024, height growth was lower than in 2023 for unfertilized seedlings. In contrast, fertilized seedlings on gradual slopes achieved height increases 49.2% higher than in the first year and 76.5% higher than unfertilized seedlings on the same slope in the second year. Overall, fertilization significantly enhanced height and diameter growth in 2024 compared to 2023. However, due to exceptional climatic conditions in 2024, including three months of severe drought, growth increments were lower in unfertilized seedlings compared to the previous year.

During the first year after planting, slope had a clear and significant influence on height growth. Scots pine has proven to be a valuable species for afforesting degraded lands due to its exceptional adaptability to challenging conditions. It has demonstrated effectiveness in restoring areas impacted by vegetation removal and excavation, particularly in high clay content soils where other species struggle to establish. With its capacity to stabilize soil and support ecosystem recovery, Scots pine plays a critical role in ecological restoration projects, contributing to vegetation recovery, biodiversity enhancement, and long-term environmental protection.

REFERENCES

Ardelean, M., Sestraș, R., Cordea, M. (2005). *Horticultural experimental technique*. Cluj-Napoca, AcademicPres Publishing House.

Ardelean, M. (2011). *Metodologia elaborării tezelor de doctorat, Ediție revăzută şi completată*. Cluj-Napoca, AcademicPres Publishing House.

Batsaikhan, G., Tsogtbaatar, J., Gerelbaatar, S. (2018). The growth trend of planted trees (*Pinus sylvestris* L.) in the early stage of plantation establishment. *Proceedings of the Mongolian Academy of Sciences*, *58*(4), 48-56.

Belan, L., Bogdan, E., Suleymanov, R., Fedorov, N., Shirokikh, P., Suleymanov, A., Vildanov, I., Sayfullin, I., Tuktarova, I., Bakhtiyarova, R., Zaitsev, G., Fayruzov, I., Vitsenko, A. (2024). Carbon sequestration at different stages of succession during pine (*Pinus sylvestris*) Afforestation of abandoned lands. *Forests*, *15*, 2094.

Bodea, B., Budău, R., Timofte, A.I. (2023). Study on the Evolution of the Black Pine Stand (*Pinus nigra*) Artificially Installed on the Site of the Recea Șuncuiuș Quarry, Bihor County. *Analele Universităţii din Oradea, Fascicula Protecţia Mediului*, *XLI*, 63-70.

Bonciu, E., Olaru, A.L., Slusarczyk, J. (2023). The main characteristics of the genetic system in some forest tree species. *Scientific Papers. Series A. Agronomy*, *LXVI*(1), 655-664.

Budău, R., Bodea, B., Racz, K.A., Haiduc, I.N., Pantea, S.D., Stancea, M. (2024). The origin of the woody species of pines cultivated in the Sylva Arboretum in Gurahonț, Romania. *Annals of the University of Oradea, Fascicle: Environmental Protection*, 61-66.

Buta, M., Blaga, Gh., Paulette, L., Păcurar, I., Roșca, S., Borsai, O., Grecu, F., Sînziana, P.E., Negrușier, C. (2019). Soil reclamation of abandoned mine lands by revegetation in northwestern part of Transylvania: A 40-Year Retrospective Study. *Sustainability, 11*, 3393.

Brichta, J., Vacek, S., Vacek, Z., Cukor, J., Mikeska, M., Bilek, L., Simunek, V., Gallo, J., Brabec, P. (2023). Importance and potential of Scots pine (*Pinus sylvestris* L.) in 21st century. *Central European Forestry Journal, 69*, 3-20.

Colișar, A., Dîrja, M., Simonca, V., Sîngeorzan, S.M.M Sfeclă, V., Vlasin, H.D., Negrusier, C., Truța, A.M., Brebean, F.A., Ceuca, V. (2024). Sustainability of some forest species' associations established on degraded lands from the Transylvania Plain, in the context of climate change. *Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering*, *13*, 937-950.

Constandache, C., Dincă, L., Tudor, C. (2020). The bioproductive potential of fast-growing forest species on degraded lands. *Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering*, *9*, 87-93.

Doniță, N., Geambașu, T., Brad, R.R. (2004). *Dendrologie*, Vasile Goldiş University Press, Arad.

Enescu, C.M. (2015). Shrub and tree species used for improvement by afforestation of degraded lands in Romania. *Forestry Ideas*, *21*(1), 3-15.

Gritsan, Y.I., Sytnyk, S.A., Lovynska, V.M., Tkalich, I.I. (2019). Climatogenic reaction of *Robinia pseudoacacia* and *Pinus sylvestris* within Northern Steppe of Ukraine. *Biosystems Diversity*, *27*(1), 16-20.

Gurău, M. (2024). Plants from the spontaneous flora of Romania that have decorative value. *Scientific Study & Research. Biology*, *33*(1), 1-24.

Houston Durrant, T., de Rigo, D., Caudullo, G. (2016). *Pinus sylvestris* in Europe: distribution, habitat, usage and threats. In: San-Miguel-Ayanz, J., de Rigo, D., Caudullo, G., Houston Durrant, T., Mauri, A. (Eds.), European Atlas of Forest Tree Species. Publ. Off. EU, Luxembourg, pp. e016b94+.

Huang, K.C., Zhao, W., Li, J.N., Mumin, R., Song, C.G., Wang, H., Sun, Y.F., Cui, B.K. (2024). Afforestation-Induced Shifts in soil bacterial diversity and community structure in the Saihanba Region. *Microorganisms, 12*, 479.

Kelly, D.L., Connolly, A. (2000). A review of the plant communities associated with Scots pine (*Pinus sylvestris* L.) in Europe, and an evaluation of putative indicator/specialist species. *Invest. Agr.: Sist. Recur. For.: Fuera de Serie*, *1*, 15-39.

Mason, W.L., Alia, R. (2000). Current and future status of Scots pine (*Pinus sylvestris* L.) forests in Europe. *Invest. Agr. Sist. Recur. For. Fuera de Serie*, *1*, 317-335.

Ministerul Mediului, Apelor și Pădurilor (MMAP), (2022). Ordin nr. 2.533 din 28 septembrie 2022 pentru aprobarea Normelor tehnice privind compoziții, scheme și tehnologii de regenerare a pădurilor și de împădurire a terenurilor degradate și a Ghidului de bune practici privind compoziții, scheme și tehnologii de regenerare a pădurilor și de împădurire a terenurilor degradate.

Nuță, S. (2005). Structural and functional features of the protection forest belts in the south of the Oltenia. *Analele I.C.A.S., 48*, 3-11.

Okon, S., Wieruszewski, M., Dynowska, J., Ankudo-Jankowska, A., Adamowicz, K. (2024). Cost of Regeneration of Scots Pine (*Pinus sylvestris* L.) Crops in national forests. *Forests*, *15*, 1218.

Oszako, T., Kukina, O., Dyshko, V., Moser, W.K., Slusarski, S., Okorski, A., Borowik, P. (2023). Afforestation of land abandoned by farmers poses Threat to Forest Sustainability Due to *Heterobasidion* spp. *Forests*, *14*, 954.

Papp, N., Purger, D., Czigle, S., Czegenyi, D., Stranczinger, S., Toth, M., Denes, T., Kocsis, M., Takacsi-Nagy, A., Filep, R. (2022). The importance of Pine species in the ethnomedicine of Transylvania (Romania). *Plants*, *11*, 2331.

Pietrzykowski, M., Wos, B., Haus, N. (2013). Scots pine needles macronutrient (N, P, K, CA, MG, and S) supply at different reclaimed mine soil substrates – as an indicator of the stability of developed forest ecosystems. *Environ. Monit. Assess.*, *185*, 7445-7457.

Przybylski, P., Matras, J., Sulkowska, M. (2015). Genetic variability of Scots pine (*Pinus sylvestris* L.) in maternal regions of provenance. *Folia Forestalia Polonica, Series A*, *57*, 112–119.

Sheller, M., Toth, E.G., Ciocîrlan, E., Mikhaylov, P., Kulakov, S., Kulakova, N., Melnichenko, N., Ibe, A., Sukhikh, T., Curtu, A.L. (2023). Genetic Diversity and Population structure of Scots Pine (*Pinus sylvestris* L.) in Middle Siberia. *Forests*, *14*, 119.

Skrastiņa, E., Straupe, I., Lazdins, A. (2021). Afforestation of abandoned peat extractions sites with Scots pine (*Pinus sylvestris* L.) as a solution of climate change mitigation. *Forestry and Wood Processing*, *36*, 63-69.

Stoica, E., Alexandru, A.M., Mihai, G. (2022). Assessment of genetic variability in Scots pine (Pinus sylvestris L.) provenance trials in Romania. *Revista de Silvicultură și Cinegetică*, *51*, 21-29.

Sukhbaatar, G., Suran, B., Nachin, B., Chultem, D. (2018). Effects of Scots Pine (Pinus sylvestris L.) plantations on plant diversity in Northern Mongolia. *Mongolian J. of Biological Sciences*, *16*(1), 59-70.

Szanto, L.G., Marc, R.A., Mureșan, A.E., Mureșan, C.C., Pusacs, A., Ranga, F., Fetea, F., Moraru, P.I., Filiș, M., Muste, S. (2025). Biofortification of Acacia and Polyflower Honey with *Pine sylvestris* L. Bud Extracts: Exploring antioxidant variation across developmental stages for enhanced nutritional value. *Plant Food for Human Nutrition*, *80*, 47.

Traci, C., Gașpar, R., Munteanu, S.A. (1981). The effect of afforestation of degraded lands and torrent's control in Mușca site from Valea Arieșului. *Silvicultura și Exploatarea Pădurilor*, *2*, 83-87.

Vlad, R., Constandache, C., Dincă, L., Tudose, N.C., Sidor, C.Gh., Popovici, L., Ispravnic, A. (2019). Influence of climatic, site and stand characteristics on some structural parameters of Scots pine (*Pinus sylvestris*) forests situated on degraded lands from east Romania. *Range Management & Agroforestry*, *40*(1), 40-48.

Xue, H., Wang, Q., Mao, K., Liu, Y., Jiang, X., Murray, P.G., Zhang, L., Liu, W. (2022). Positive effects of reforestation on the diversity and abundance of soil fauna in a landscape degraded red soil area in subtropical China. *Forests*, *13*(10), 1596.

Zeidler, A., Boruvka, V., Tomczak, K., Vacek, Z., Cukor, J., Vacek, S., Tomczak, A. (2024). The Potential of non-native pines for timber production – A case study from afforested post-mining sites. *forests*, *15*, 1388.

Zhiyanski, M., Glushkova, M., Ferezliev, A., Menichetti, L., Leifeld, J. (2016). Carbon storage and soil property changes following afforestation in mountain ecosystems of the Western Rhodopes, Bulgaria. *iForest*, *9*, 626-634.