Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. XV, 2026
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

TREE COMMUNITY PATTERNS IN RELATION TO EDGE INFLUENCE IN A PERI-URBAN FOREST NEAR CLUJ-NAPOCA, ROMANIA

Ioana-Loredana GHIURCO[1], Carla-Maria APARASCHIVE[1], Adela-Maria NEAG[2], Iulia-Ecaterina MORA[1], Păunița BOANCĂ[1], Sonia BODEA[1], Denisa JUCAN[1], Catalina DAN[1], Adriana SESTRAS[1]

[1]University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca,
3-5 Calea Manastur Street, Cluj-Napoca, Romania
[2]Doctoral School of Technical University of Civil Engineering Bucharest,
122-124 Lacul Tei Blvd, District 2, Bucharest, Romania

Corresponding author email: carla-maria.aparaschive@usamvcluj.ro

Abstract

This study investigated the structure and diversity of tree communities in relation to edge influence in a sector of the Hoia-Baciu peri-urban forest located near Cluj-Napoca, Romania. A total of 20 circular sampling plots (500 m²) were systematically distributed along transects covering varying distances from the forest edge. Within each plot, tree species and the number of individuals were recorded to characterize community composition and structural parameters. Species richness, tree density, and diversity indices (Shannon and Simpson) were calculated, and differences in community composition were explored using non-metric multidimensional scaling (NMDS). The results indicate a simplified tree community strongly dominated by C. betulus. Species richness ranged between one and four species per plot, while Shannon diversity values varied from 0 to 1.22, reflecting moderate spatial heterogeneity among sampling plots. The NMDS ordination revealed a central cluster of plots characterized by the dominance of C. betulus, with a few plots showing greater compositional divergence. These findings highlight the relatively simplified structure but noticeable small-scale variability of tree communities in this peri-urban forest ecosystem.

Key words*: edge influence; peri-urban forest; Romania; species diversity; tree community.*

INTRODUCTION

Forests located in the immediate proximity of urban areas play an increasingly important role in maintaining ecological balance and supporting the quality of life of urban populations (Livesley et al., 2016; Sestras et al., 2018). In the context of continuous urban expansion and land-use transformation, peri-urban forests represent essential components of green infrastructure, providing multiple ecological, environmental, and social benefits (La Rosa et al., 2018). These ecosystems contribute to biodiversity conservation, climate regulation, carbon sequestration, and recreational opportunities, while also serving as transitional landscapes between urban environments and more natural forest ecosystems (Berglihn & Gómez-Baggethun, 2021; Mitchell et al., 2022).

The ecological importance of peri-urban forests has become particularly evident in recent decades, as cities have expanded into surrounding natural landscapes. Urban growth often leads to increased fragmentation of forest habitats, changes in environmental conditions at forest edges, and intensified anthropogenic pressure on vegetation communities (Harper et al., 2005; Seto et al., 2012; Dobbs et al., 2018). As a result, forest stands located near cities frequently exhibit structural and compositional characteristics that differ from those observed in more remote forest ecosystems. Understanding these differences is therefore essential for developing sustainable strategies for the management and conservation of urban and peri-urban green spaces (Zipperer & Guntenspergen, 2009; Salbitano et al., 2016).

One of the key aspects influencing vegetation structure in forest ecosystems situated near urban environments is the so-called edge effect. Forest edges represent zones where environmental conditions may differ from those found in the interior of forest stands (Hladnik et al., 2020). These gradients can influence species composition, vegetation structure, and

ecological processes within forest ecosystems (Murcia, 1995). Changes in light availability, temperature, wind exposure, and soil moisture may alter species composition and influence the regeneration dynamics of tree communities (Chen et al., 1995). In addition, edges located near urban infrastructure may be subject to direct human disturbances, including recreational activities, informal trails, or historical forest management practices (Hellenbrand et al., 2025).

Previous studies have shown that forest edges may exhibit both increased species diversity and simplified structural patterns depending on local environmental conditions and the intensity of human influence (Franklin et al., 2021). In some cases, edge environments may facilitate the establishment of opportunistic or light-demanding species, leading to higher local diversity. In other situations, repeated disturbances and anthropogenic pressure may favor the dominance of a limited number of species that are better adapted to altered environmental conditions. Consequently, the spatial distribution of tree species in peri-urban forests often reflects a complex interaction between ecological processes and human activities (Kodym et al., 2025).

In this context, analyzing tree community structure in relation to edge influence across forest stands can provide valuable insights into the functioning of peri-urban forest ecosystems (Hladnik et al., 2020; Baker et al., 2025). Such analyses enable the identification of patterns in species composition, diversity, and structural characteristics that may be associated with environmental gradients generated by forest edge effects (Murcia, 1995; Harper et al., 2005). Moreover, understanding these patterns is important for evaluating the ecological resilience of forest stands located near urban areas and for informing management practices aimed at maintaining biodiversity and ecosystem functions (Sousa-Silva et al., 2023).

Urban and peri-urban forests are frequently influenced by adjacent land-use systems that generate spatial gradients in environmental conditions and vegetation structure (Dobbs et al., 2018). The Hoia Hill area illustrates such a context, where two contrasting functional zones coexist along an east–west axis. Cultural, recreational, and agricultural activities dominate the upper part of the hill, while the lower sector has progressively developed industrial and economic functions (Boancă et al., 2023).

The Hoia-Baciu Forest, situated on the western outskirts of Cluj-Napoca in northwestern Romania, represents one of the most well-known forested areas within the peri-urban landscape (Deac et al., 2013). Due to its proximity to urban infrastructure and recreational areas, this forest sector is exposed to various forms of anthropogenic influence (Boancă et al., 2023). At the same time, it provides important ecological functions as part of the green landscape surrounding the rapidly expanding metropolitan area (Escobedo et al., 2011). Despite its ecological and social relevance, relatively limited information is available regarding the spatial variability of tree community structure within this peri-urban forest ecosystem.

Assessing tree species composition and diversity within such environments is important for understanding how vegetation communities respond to spatial gradients and environmental pressures associated with urban proximity (Alvey, 2006; McDonnell & Hahs, 2008). In particular, investigating variation in species distribution in relation to edge influence may reveal patterns related to forest structure, species dominance, and local heterogeneity in vegetation composition.

Therefore, the aim of the present study was to analyze tree community structure and diversity patterns in relation to edge influence in a sector of the Hoia-Baciu peri-urban forest. Using a systematic sampling design based on circular plots distributed along several transects covering varying distances from the forest edge, the study evaluates species composition, tree density, and diversity indices in order to identify spatial patterns within the forest stand. The results contribute to a better understanding of vegetation structure in forest ecosystems situated at the interface between natural landscapes and urban environments and provide useful information for the ecological assessment of peri-urban forests.

MATERIALS AND METHODS

Study area

The study was conducted in a sector of the Hoia-Baciu Forest located in the immediate vicinity of

the city of Cluj-Napoca, in northwestern Romania. This forest represents an important peri-urban green area situated at the interface between the urban environment and surrounding rural landscapes. Due to its proximity to the metropolitan area, the forest is frequently used for recreational activities and is influenced by nearby infrastructure and urban expansion.

The analyzed forest stand is characterized by mixed deciduous vegetation typical of temperate forest ecosystems. However, as in many peri-urban forests, the vegetation structure reflects the cumulative effects of past management practices and ongoing anthropogenic influences (Sousa-Silva et al., 2023). As a result, the tree community composition is relatively simplified and dominated by a limited number of species.

The study area forms part of the broader green landscape surrounding the city and plays an important role in maintaining ecological connectivity, biodiversity, and environmental quality in the peri-urban zone. The forest is dominated by hornbeam (*C. betulus*) stands typical for temperate deciduous forests of the Transylvanian region.

Sampling design

Field data were collected using a systematic sampling design based on circular plots arranged along transects across the forest, covering varying distances from the forest edge.

A total of 20 circular sampling plots were established in the analyzed sector of the Hoia-Baciu peri-urban forest. The distance between transects was approximately 70 m, while the distance between plots within each transect was about 40 m. This sampling design allowed the assessment of spatial variability in tree community structure along transects established across the forest. The spatial layout of the study area and the distribution of sampling plots are presented in Figure 1.

Data collection

Within each sampling plot, all tree individuals were recorded and identified at species level. For the purpose of the present study, the analysis focused on the species composition and abundance of trees within each plot.

The number of individuals belonging to each species was counted in order to determine the structure of the tree community. These data allowed the calculation of several basic structural and diversity parameters at the plot level, including: total number of trees; species richness; relative dominance of the main species.



Figure 1. Location of the study area and spatial distribution of sampling plots in the Hoia-Baciu peri-urban forest near Cluj-Napoca, Romania

Data analysis

The structure and diversity of the tree community were analyzed at the level of individual sampling plots. Several ecological indicators were calculated based on species abundance data using standard indices widely applied in community ecology (Shannon, 1948; Simpson, 1949; Pielou, 1966).

Species richness (S) representing the number of tree species recorded in each sampling plot.

Tree density expressed as the number of trees per hectare, calculated by extrapolating the number of individuals recorded within the 500 m² plots.

Shannon diversity index (H′) which reflects both species richness and the relative abundance of species within the community:

$$H' = -\sum(p_i \ln p_i)$$

where p_i represents the proportion of individuals belonging to species i.

Simpson diversity index (1–D) which measures the probability that two randomly selected individuals belong to different species:

$$1 - D = 1 - \sum p_i^2$$

Pielou evenness index (J) which expresses the degree to which individuals are evenly distributed among species:

$$J = \frac{H'}{lnS}$$

In addition, the relative dominance of the main species within each plot was calculated as the

percentage of individuals belonging to the most abundant species. To explore potential spatial patterns associated with variation in edge influence across the study area, species richness values were analyzed accordingly across the sampling plots. All diversity indices were calculated based on the abundance data recorded in the sampling plots.

Differences among transects for tree density, species richness, Shannon diversity index, and the relative dominance of *C. betulus* were further evaluated using the Kruskal-Wallis non-parametric test, considering the small sample size and the likely non-normal distribution of the analyzed variables. Statistical significance was assessed at $p < 0.05$.

RESULTS AND DISCUSSIONS

The tree community recorded within the sampling plots was relatively simplified and strongly dominated by *C. betulus*. This species occurred in the majority of plots and represented the highest proportion of individuals in most cases. Other species such as *Q. petraea*, *A. campestre*, *S. nigra* and *P. avium* were recorded locally and contributed to the variation in species composition among plots (Figure 2).

The relative dominance of *C. betulus* varied across the study area, exceeding 80% in several plots and reaching complete dominance in some cases. This pattern indicates a structurally simplified community typical of forest stands located in peri-urban environments. The spatial variation in the relative dominance of *C. betulus* among the sampling plots is illustrated in Figure 3.

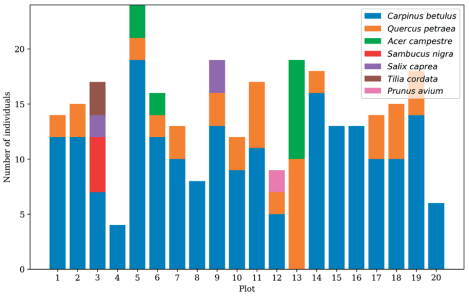


Figure 2. Tree species composition across sampling plots in the analyzed peri-urban forest stand. Bars represent the number of individuals belonging to each species in each sampling plot

Structural characteristics of the sampling plots

The number of trees recorded within the sampling plots varied considerably across the study area. The lowest number of individuals was recorded in Plot 4 (three trees), while the highest values were observed in Plot 5 (21 trees) and Plot 19 (16 trees). When extrapolated to hectare level, tree density ranged between approximately 60 and 420 trees ha^{-1}.

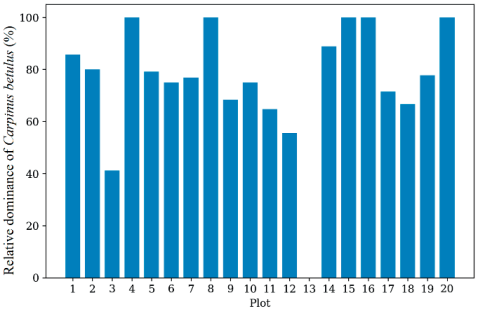


Figure 3. Relative dominance of *C. betulus* across the sampling plots in the analyzed peri-urban forest stand

Species richness showed relatively low values across the plots, ranging between one and four species per plot (Figure 4). Several plots, regardless of their position within the forest, contained only one species, indicating a high level of structural simplification. The structural characteristics of the sampling plots are summarized in Table 1.

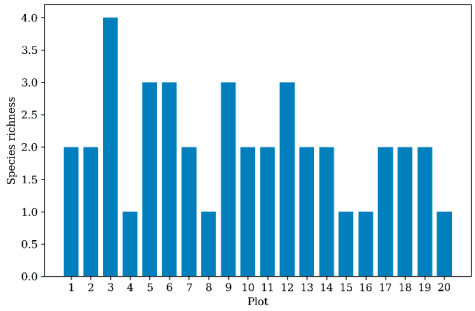


Figure 4. Species richness recorded in the sampling plots of the Hoia-Baciu peri-urban forest

Table 1. Structural characteristics of the sampling plots in the analyzed peri-urban forest stand

Plot	Total trees	Tree density (trees ha^{-1})	Species richness	Main species dominance (%)
1	12	240	2	91.7
2	12	240	2	83.3
3	10	200	4	50.0
4	3	60	1	100.0
5	21	420	3	85.7
6	13	260	3	84.6
7	11	220	2	81.8
8	7	140	1	100.0
9	16	320	3	75.0
10	10	200	2	80.0
11	15	300	2	66.7
12	6	120	3	66.7
13	17	340	2	52.9
14	6	120	2	50.0
15	12	240	1	100.0
16	12	240	1	100.0
17	12	240	2	75.0
18	13	260	2	69.2
19	16	320	2	81.2
20	5	100	1	100.0

Diversity patterns

Diversity indices calculated for each sampling plot indicate generally low to moderate levels of diversity across the analyzed forest sector. Shannon diversity index values ranged between 0 and 1.22 (Table 2). The highest diversity was observed in Plot 3, where four species were recorded and the distribution of individuals among species was relatively balanced.

Moderate diversity values were recorded in several plots, including Plot 9, Plot 11, Plot 12 and Plot 18. In contrast, plots dominated entirely by a single species showed Shannon index values equal to zero, reflecting the absence of species diversity. The spatial distribution of Shannon diversity values across the sampling plots is illustrated in Figure 5.

Table 2. Diversity indices calculated for the sampling plots

Plot	Shannon index (H')	Simpson index (1–D)	Pielou evenness (J)
1	0.29	0.15	0.41
2	0.45	0.28	0.65
3	1.22	0.66	0.88
4	0.00	0.00	0.00
5	0.50	0.25	0.46
6	0.54	0.27	0.49
7	0.47	0.30	0.68
8	0.00	0.00	0.00
9	0.74	0.41	0.67
10	0.50	0.32	0.72
11	0.64	0.44	0.92
12	0.87	0.50	0.79
13	0.69	0.50	1.00
14	0.69	0.50	1.00
15	0.00	0.00	0.00
16	0.00	0.00	0.00
17	0.56	0.38	0.81
18	0.62	0.43	0.89
19	0.48	0.30	0.70
20	0.00	0.00	0.00

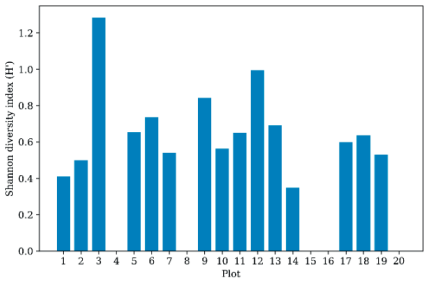


Figure 5. Shannon diversity index (H') calculated for the sampling plots

Spatial variation in relation to edge influence

The analysis of species richness in relation to the distance from the forest edge revealed moderate spatial variability across the study area (Figure 6). Variation in species richness among plots suggests differences in exposure to forest edges across the study area.

To further explore differences in community composition among sampling plots, a non-metric multidimensional scaling (NMDS) ordination based on Bray-Curtis dissimilarity was performed (Figure 7).

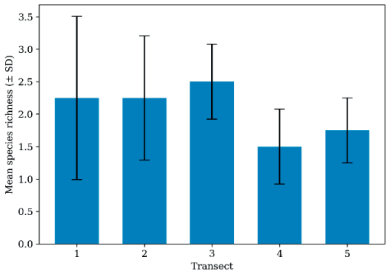


Figure 6. Mean species richness (± SD) across the five transects reflecting variation in edge influence in the Hoia-Baciu peri-urban forest

The NMDS ordination revealed a central cluster of plots dominated by *C. betulus*, while several plots showed greater compositional divergence, particularly Plot 13, which was characterized by the presence of *Q. petraea* and *A. campestre*.

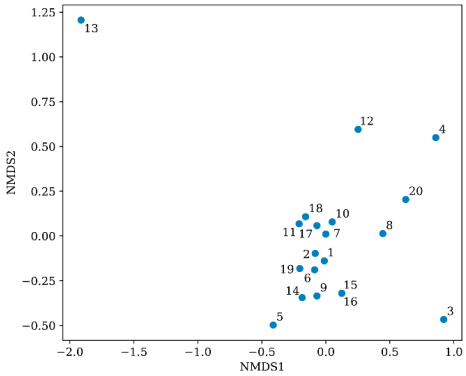


Figure 7. Non-metric multidimensional scaling (NMDS) ordination of tree community composition across sampling plots based on Bray-Curtis dissimilarity. Each point represents a sampling plot (1-20), and distances among points reflect differences in species composition

A summary of structural and diversity parameters at the transect level is presented in Table 3. Mean species richness ranged from 1.50 to 2.50 species per transect, while mean Shannon diversity values varied between 0.34 and 0.69. Mean tree density ranged from 185 to 260 trees ha^{-1}, and the relative dominance of *C. betulus* remained high across all transects, with values exceeding 70% in all cases.

Table 3. Summary of structural and diversity parameters across transects in relation to edge influence

Transect	Mean tree density (trees ha^{-1})	Mean species richness	Mean Shannon index
1	185	2.25	0.49
2	260	2.25	0.38
3	235	2.50	0.69
4	210	1.50	0.34
5	230	1.75	0.42

These results indicate moderate variability among transects, without a consistent spatial pattern related to edge influence.

Differences among transects were further explored using the Kruskal-Wallis test (Table 4). No statistically significant differences were detected among transects for tree density, species richness, Shannon diversity index, or the relative dominance of *C. betulus* ($p > 0.05$ in all cases). Nevertheless, moderate variability was observed at the plot level, indicating small-scale heterogeneity within the peri-urban forest stand.

Table 4. Kruskal-Wallis test results for structural and diversity parameters across transects

Variable	H statistic	p-value
Tree density	1.484	0.829 ^{ns}
Species richness	4.382	0.357 ^{ns}
Shannon diversity index	3.969	0.410 ^{ns}
Relative dominance of *C. betulus*	3.569	0.467 ^{ns}

ns - not statistically significant differences among transects

Simplified tree community structure in a peri-urban context

From a landscape perspective, the Hoia-Baciu forest sector represents an important component of the peri-urban green infrastructure surrounding the city of Cluj-Napoca (Boancă et al., 2023). Such peri-urban forests may contribute to environmental buffering functions, including microclimatic regulation, dust and noise attenuation, and the mitigation of urban environmental pressures (Leca et al., 2023).

The results of this study indicate that the analyzed forest sector is characterized by a relatively simplified tree community structure, with a strong dominance of *C. betulus*. In most sampling plots, this species represented the majority of recorded individuals and in several cases it occurred as the only tree species present. Such patterns are commonly observed in forest stands that have been subjected to long-term anthropogenic influence or historical management interventions (Leca et al., 2023).

The occurrence of additional species such as *Q. petraea*, *A. campestre*, *P. avium*, and *S. nigra* was limited to a smaller number of plots and generally involved low numbers of individuals. As a consequence, species richness values remained relatively low across the study area, ranging from one to four species per sampling plot. Similar patterns of reduced tree species diversity have been reported in peri-urban forests where historical management practices and human pressure may influence stand composition and regeneration processes (Stamin & Cosmulescu, 2025).

Spatial variability of diversity in relation to edge influence

Although overall species richness was relatively low, the study revealed noticeable spatial variability in diversity among the sampling plots. Shannon diversity index values ranged from zero in monospecific plots to over 1.2 in the most heterogeneous plot. These differences indicate that local variations in stand structure and environmental conditions may influence the distribution of tree species within the forest.

Plots exhibiting higher diversity generally contained a more balanced distribution of individuals among species, whereas plots dominated by *C. betulus* showed considerably lower diversity values. Such patterns may reflect differences in microsite conditions, light availability, or past disturbance events that affected tree establishment and survival. The presence of localized areas with higher diversity suggests that even within relatively simplified forest stands, small-scale heterogeneity may contribute to maintaining a certain level of biodiversity (Harper et al., 2005).

Influence of edge conditions and anthropogenic pressure

The spatial arrangement of the sampling plots allowed the assessment of variation in community structure in relation to edge influence across the forest patch. Although the results did not reveal a strong linear relationship between distance from the forest edge and species richness, variability in community composition among plots suggests that edge-related processes operate in a spatially heterogeneous manner rather than along a single directional gradient (Murcia, 1995; Godefroid & Koedam, 2003; Harper et al., 2005).

Edge environments in peri-urban forests are often subject to multiple external influences, including changes in microclimatic conditions, increased light availability, and disturbances associated with nearby infrastructure or human activities (Franklin et al., 2021; Hellenbrand et al., 2025). These factors may create heterogeneous environmental conditions that facilitate the establishment of different species (Morgan et al., 2025). In contrast, plots less influenced by edge conditions tended to display more uniform species composition and stronger dominance of the main species (Hladnik et al., 2020).

Given the proximity of the studied forest sector to urban infrastructure and recreational areas, it is likely that anthropogenic factors have contributed to shaping the observed community structure (Hellenbrand et al., 2025). However, further studies integrating structural and microclimatic parameters would be required to better understand the mechanisms underlying these patterns (Morgan et al., 2025).

Implications for peri-urban forest ecosystems

Peri-urban forests represent important components of green infrastructure surrounding cities, providing ecological, environmental, and social benefits for urban populations (Mitchell et al., 2022; Kodym et al., 2025). The simplified tree community structure observed in the present study highlights the potential vulnerability of such ecosystems to disturbances and long-term anthropogenic pressure (Morgan et al., 2025).

Despite the relatively low species richness recorded in the analyzed plots, the presence of several accompanying species and the spatial heterogeneity observed across the study area suggest that these forest stands still retain ecological value. Maintaining and enhancing structural and compositional diversity in peri-urban forests may therefore represent an important objective for sustainable landscape management and biodiversity conservation in urbanized regions (Mitchell et al., 2022; Kodym et al., 2025; Morgan et al., 2025).

In the case of the Hoia-Baciu Forest located near Cluj-Napoca, the results underline the importance of monitoring vegetation structure and species composition in order to better understand how urban expansion and human activities influence forest ecosystems situated at the interface between natural and urban landscapes (Mitchell et al., 2022).

Although this study provides useful insights into tree community patterns along a peri-urban forest edge, a few methodological limitations should be acknowledged. The results may not be as applicable to other forest ecosystems because the study was carried out in a single peri-urban forest using a systematic sampling design. Furthermore, even though the study focused on tree community patterns and the forest edge, other environmental factors such as soil characteristics, light availability, and previous

management history, were not specifically evaluated and may also have influenced the observed patterns. Future research should include multiple peri-urban forests with contrasting edge characteristics, integrate additional environmental variables, and incorporate long-term monitoring to improve the understanding of edge effects on forest communities.

CONCLUSIONS

The present study analyzed the structure and diversity of tree communities in a peri-urban sector of the Hoia-Baciu Forest located near Cluj-Napoca, Romania. The results indicate that the analyzed forest stand is characterized by a relatively simplified tree community structure, strongly dominated by *C. betulus*, while other species such as *Q. petraea*, *A. campestre*, *P. avium*, and *S. nigra* occur locally in lower proportions.

Species richness across the sampling plots was generally low, ranging between one and four species per plot, while diversity indices showed moderate spatial variability within the study area. The analysis of plots distributed across the forest revealed small-scale heterogeneity in community composition, although no strong linear trend in species richness with increasing distance from the forest edge was observed. The absence of statistically significant differences among transects suggests that, although moderate local variability exists, the edge influence does not generate a strong and consistent differentiation of the analyzed structural and diversity parameters at the spatial scale considered in this study.

These results suggest that local environmental conditions and anthropogenic influences may contribute to shaping the structure of tree communities in peri-urban forest ecosystems. Despite the relatively simplified species composition, the Hoia-Baciu Forest continues to represent an important component of the green landscape surrounding the city of Cluj-Napoca. Monitoring vegetation structure and diversity in such peri-urban forests is therefore essential for supporting sustainable landscape management and maintaining ecological functions in urbanizing regions.

ACKNOWLEDGEMENTS

The research was carried out with the partial support of the Doctoral School of the University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca (USAMVCN) for I.-L.G.

REFERENCES

Alvey, A. A. (2006). Promoting and preserving biodiversity in the urban forest. *Urban Forestry & Urban Greening, 5*(4), 195–201. https://doi.org/10.1016/j.ufug.2006.09.003

Baker, M., Yesilonis, I., Templeton, L., Shobe, B., Bos, J., Sonti, N.F., & Lautar, K. (2025). Distributed urban forest patch sampling detects edge effects in urban woodlands. *Ecosphere, 16*, e70236. https://doi.org/10.1002/ecs2.70236

Berglihn, E. C., & Gómez-Baggethun, E. (2021). Ecosystem services from urban forests: The case of Oslomarka, Norway. *Ecosystem Services*, 51, 101358. https://doi.org/10.1016/j.ecoser.2021.101358

Boancă, P. I., Oprică, A., Bodea, S., & Mărincean, A. (2023). 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". *Agricultura*, 129–130(3–4). https://doi.org/10.15835/agr.v129i3-4.14751

Chen, J., Franklin, J. F., & Spies, T. A. (1995). Growing-season microclimatic gradients from clearcut edges into old-growth Douglas-fir forests. *Ecological Applications*, 5(1), 74–86. https://doi.org/10.2307/1942053

Deac, S. O., Irimuș, I. A., & Păcurar, B. N. (2013). The landscape morphology of Cluj-Napoca residential neighbourhoods. *Studia Universitatis Babeș-Bolyai, Geographia*, 58(2), 73–84.

Dobbs, C., Eleuterio, A. A., Amaya, J. D., Montoya, J., & Kendal, D. (2018). The benefits of urban and peri-urban forestry. *Unasylva*, 69(250), 22-29.

Escobedo, F. J., Kroeger, T., & Wagner, J. E. (2011). Urban forests and pollution mitigation: Analyzing ecosystem services and disservices. *Environmental Pollution, 159*(8–9), 2078–2087. https://doi.org/10.1016/j.envpol.2011.01.010

Franklin, C. M., Harper, K. A., & Clarke, M. J. (2021). Trends in studies of edge influence on vegetation at human-created and natural forest edges across time and space. *Canadian Journal of Forest Research*, 51(2), 274-282. https://doi.org/10.1139/cjfr-2020-0308

Godefroid, S., & Koedam, N. (2003). Distribution pattern of the flora in a peri-urban forest: An effect of the forest edge? *Landscape and Urban Planning*, 65(4), 169–185. https://doi.org/10.1016/S0169-2046(03)00013-6

Harper, K. A., Macdonald, S. E., Burton, P. J., Chen, J., Brosofske, K. D., Saunders, S. C., Euskirchen, E. S., Roberts, D., Jaiteh, M. S., & Esseen, P. A. (2005). Edge influence on forest structure and composition in

fragmented landscapes. *Conservation Biology*, 19(3), 768–782. https://doi.org/10.1111/j.1523-1739.2005.00045.x

Hellenbrand, J. P., Kelly-Voicu, P., Bowers, J. T., & Reinmann, A. B. (2025). Edge and the city: Evaluating the role of edge effects on urban forest structure and tree species composition. *Urban Forestry & Urban Greening*, 107, 128745. https://doi.org/10.1016/j.ufug.2025.128745

Hladnik, D., Kobler, A., & Pirnat, J. (2020). Evaluation of Forest Edge Structure and Stability in Peri-Urban Forests. *Forests*, 11(3), 338. https://doi.org/10.3390/f11030338

Kodym, A., Lapin, K., Sanyal, D. (2025). *Ecological Connectivity in Urban and Semi-Urban Forests.* In: Lapin, K., Oettel, J., Braun, M., Konrad, H. (eds) Ecological Connectivity of Forest Ecosystems. Springer, Cham. https://doi.org/10.1007/978-3-031-82206-3_18

La Rosa, D., Geneletti, D., Spyra, M., Albert, C., Fürst, C. (2018). *Sustainable Planning for Peri-urban Landscapes*. In: Perera, A., Peterson, U., Pastur, G., Iverson, L. (eds) Ecosystem Services from Forest Landscapes. Springer, Cham. https://doi.org/10.1007/978-3-319-74515-2_5

Leca, Ș., Popa, I., Chivulescu, Ș., Popa, A., Pitar, D., Dobre, A.-C., Pascu, I.-S., Apostol, B., & Badea, O. (2023). Structure and diversity in a periurban forest of Bucharest, Romania. *Annals of Forest Research*, 66(1), 139–153. https://doi.org/10.15287/afr.2023.3011

Livesley, S. J., McPherson, E. G., & Calfapietra, C. (2016). The urban forest and ecosystem services: Impacts on urban water, heat, and pollution cycles at the tree, street, and city scale. *Journal of Environmental Quality*, 45(1), 119–124. https://doi.org/10.2134/jeq2015.11.0567

McDonnell, M. J., & Hahs, A. K. (2008). The use of gradient analysis studies in advancing our understanding of the ecology of urbanizing landscapes: Current status and future directions. *Landscape Ecology, 23*(10), 1143–1155. https://doi.org/10.1007/s10980-008-9253-4

Mitchell, M. G. E., Devisscher, T., Olivero-Lora, S., et al. (2022). Strong relationships between urbanization, landscape structure, and ecosystem service multifunctionality in urban forest fragments. *Landscape and Urban Planning*, 228, 104548. https://doi.org/10.1016/j.landurbplan.2022.104548

Morgan, R. B., & Tommaso, J. (2025). A unifying framework for understanding how edge effects reshape the structure, composition and function of forests. *New Phytologist*, 248(2), 529–541. https://doi.org/10.1111/nph.70457

Murcia, C. (1995). Edge effects in fragmented forests: Implications for conservation. *Trends in Ecology & Evolution*, 10(2), 58–62. https://doi.org/10.1016/S0169-5347(00)88977-6

Pielou, E. C. (1966). The measurement of diversity in different types of biological collections. *Journal of Theoretical Biology*, 13, 131–144. https://doi.org/10.1016/0022-5193(66)90013-0

Salbitano, F., Borelli, S., Conigliaro, M. & Chen, Y. (2016). *Guidelines on urban and peri-urban forestry. FAO Forestry Paper No. 178*. Rome, Food and Agriculture Organization of the United Nations.

Sestras, P., Bondrea, M. V., Cetean, H., Sălăgean, T., Bilaşco, Ș., Naș, S., Spalevic, V., Fountas, S., & Cîmpeanu, S. M. (2018). Ameliorative, Ecological and Landscape Roles of Făget Forest, Cluj-Napoca, Romania, and Possibilities of Avoiding Risks Based on GIS Landslide Susceptibility Map. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca,* 46(1), 292–300. https://doi.org/10.15835/nbha46110866

Seto, K. C., Güneralp, B., & Hutyra, L. R. (2012). Global forecasts of urban expansion to 2030 and direct impacts on biodiversity and carbon pools. *Proceedings of the National Academy of Sciences*, 109(40), 16083–16088. https://doi.org/10.1073/pnas.1211658109

Shannon, C. E. (1948). A mathematical theory of communication. Bell System Technical Journal, 27(3,4), 379–423, 623–656. https://doi.org/10.1002/j.1538-7305.1948.tb01338.x

Simpson, E. H. (1949). Measurement of diversity. Nature, 163, 688. https://doi.org/10.1038/163688a0

Sousa-Silva, R., Lambry, T., Cameron, E., Belluau, M., & Paquette, A. (2023). Urban forests – Different ownership translates to greater diversity of trees. Urban Forestry & Urban Greening, 88, 128084. https://doi.org/10.1016/j.ufug.2023.128084

Stamin, F., & Cosmulescu, S. (2025). Comparative Assessment of Biodiversity and Ecological Indicators in Three Forest Ecosystems of Southern Romania. Diversity, 17, 277. https://doi.org/10.3390/d17040277

Zipperer, W. C., & Guntenspergen, G. R. (2009). Vegetation composition and structure of forest patches along urban–rural gradients. In: Ecology of Cities and Towns. Cambridge University Press. https://doi.org/10.1017/cbo9780511609763.018