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Comparison of vascular plants in herb layers of ecotones in urban and non-urban forests in Brzesko city (Polish Carpathian foreland)

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Abstract

Nowadays, human influence is more noticeable in urban and non-urban ecosystems, which, in turn, leads to the transformation of valuable natural resources. This article presents a study on the diversity of species composition of the vascular herb layer species of ecotones in selected urban forests of the city of Brzesko and in forests outside the city. All forests represented the association of oak–hornbeam plant. The results showed that there are inconsistent and consistent vascular plant species with the *Tilio-Carpinetum* habitat in urban and non-urban forests. Plant species were significantly (c^2 test, $p < 0.05$) found more frequently in the herb layer of non-urban forests than in urban forests. This proves, among other things, that the influence of anthropogenic activity is more on these objects than in forests outside the city.

Key words

vascular plant species, herb layer, ecotone, human impact, oak–hornbeam forest, urban forests

Introduction

Forests are very important elements in the ecological structure of cities and rural areas. They are reservoirs of flora and fauna biodiversity in the ecological system (Sanesi et al. 2017). Urbanisation is a process which causes many changes in the environment, such as habitat fragmentations, temperature increase and soil compaction (Patarkalashvili 2017; Wang et al. 2020). Anthropogenic activities mainly affect semi-natural and natural ecosystems (Faliński 1966; Kornaś 1968; Sokołowski 1972; Sudnik-Wójcikoska and Galera 2005). Plant cover is often altered by displacing and depleting native species and appearance of species incompatible with the natural habitat. This process is highly undesirable in natural habitats and often leads to irreversible changes in forest ecosystems as well (Lundholm and Marlin 2006; Gonzalez et al. 2010; Zhou et al. 2018; Fornal-Pieniak et al. 2019). Herbaceous plants are very dynamic with respect to habitat changes within a short period of time. Therefore, they are suitable indicators of changes in plant association (Hofmeister et al. 2013). It is impor-

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tant to identify consistent plant species, which are an important indicator of forest naturalness. The purpose of this study was to analyse the composition of vascular plant species in the herb layer of ecotone's selected urban forests and forests outside the city.

Material and methods

Field studies were carried out in the years 2019–2020, including two seasonal aspects, spring and summer, in eight forests located in Brzesko city and outside the city. Brzesko city has got a surface area of 11.83 km² and has 16,819 inhabitatns. (https://krakow.stat.gov.pl/vademecum/vademecum_malopolskie/portrety_gmin/powiat_brzeski/brzesko.pdf). A homogeneous habitat according to the phytosociological aspect was the primary criterion for the selection of research objects. It means that all forests are represented the oak–hornbeam community (*Tilio-Carpinetum* Scamoni et Pass. 1959 em. Traczyk 1962), growing on fresh, rich soil. Urban forests (four objects) were located nearby single-family houses with accompanying greenery, and the other forests (four objects) were adjacent to meadows and pastures with a small share of arable land outside the city (Fig. 1). The study included an inventory and identification of vascular plants in the herb layer on transect which represented the forest ecotone – 150 m from the edge of forests into the forests. According to Wuyts et al. (2009) and Goznalez et al. (2010), forest ecotone with was about 150–200 m.

It distinguished 15 study plots (phytosociological records were made according to the Braun-Blanquet method (Braun-Blanquet 1951)), with an area of 100 m^2 in each forest. In total, 60 phytosociological records were made in urban forests and 60 phytosociological records were made in forests outside the city (available from author(s) on request). The identified plant species were grouped according to the degree of compliance with the natural habitat. We distinguished consistent species represented by forest species, which including tree, shrub, herb and grass species, which are typical for *Tilio-Carpinetum* habitat. The second group of species was inconsistent species such as tree, shrub, grass, synanthropic and associated species, not typical for oak–hornbeam forest. Associated species means the species which occur in more than one habitat (Matuszkiewicz 2014).

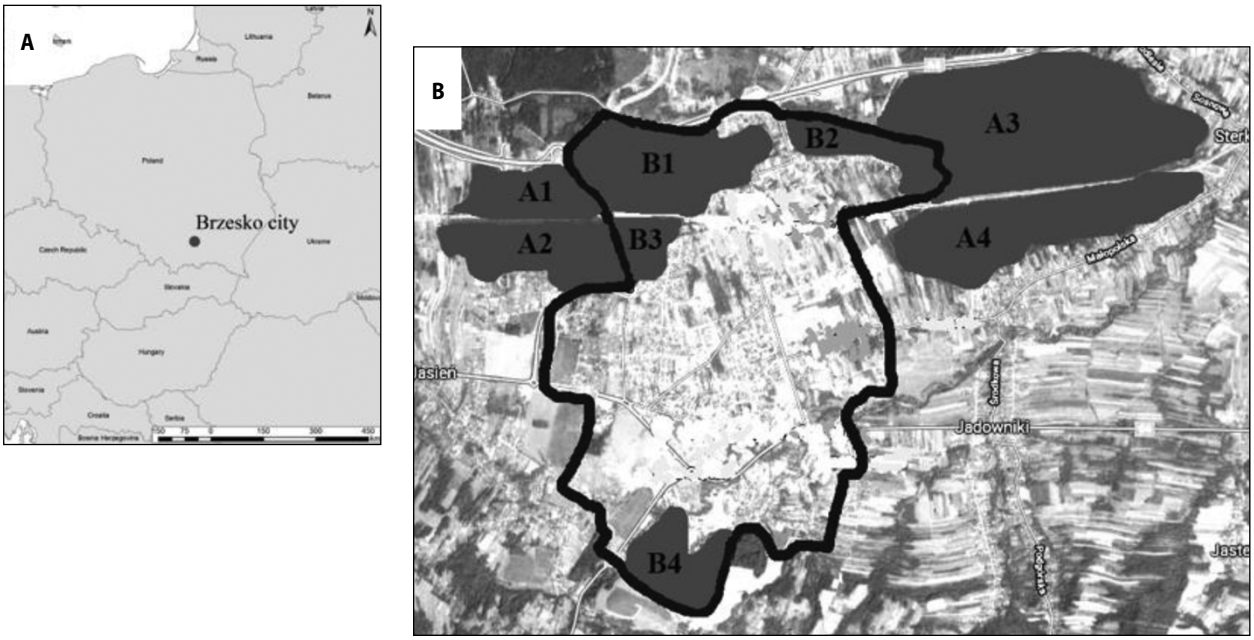

Figure 1. Map of the location of Brzesko city (a) and the studied forests (A1, A2, A3, A4 – non-urban forests; B1, B2, B3, B4 – urban forests) (b) in this city

To compare the occurrence of individual herbaceous species , its frequency in individual forests was determined as the share of research plots where the species was found within all plots in a given forest. The analyses were performed using the STATISTICA 13.0 package. A simple c^2 test was also used to distinguish forest herbaceous species characteristic/diagnostic of urban and non-urban forests.

Results

The mean number of vascular plant species (20) was higher ($p < 10^6$) in forests outside the city than in urban forests (17). There was also a variation in the number of species between the forests ($p = 0.013$), with the number of species in all urban forests being lower than in all forests outside the city. No significant differences were found between urban forests and forests outside the city ($p = 0.84$) or between individual forests ($p = 0.97$). A list of 10 vascular plant species occurring significantly ($p < 0.05$) more frequently in forests outside the city than in urban forests is presented in Table 1.

Table 1. The list of vascular plant species which occurred significantly (c^2 test, $p < 0.05$) more frequently in the herb layer of forests outside the city than in urban forests (arranged according to increasing value of species in urban forests)

Forest species	Urban forests	Non-urban forests
Anemone ranunculoides L.	65	78
Corydalis cava (L.) Schweigg. & Korte	51	72
Gagea lutea (L.) Ker. Gawler	51	77
Polygonatum multiflorum L.	51	70
Luzula pilosa (L.) Willd.	48	71
Stellaria holostea L.	42	78
Aegopodium podagraria L.	40	60
Polygonatum odoratum (Mill) Druce	29	52
Carex pilosa L.	0	61
Lathyrus vernus (L.) Bernh.	0	60

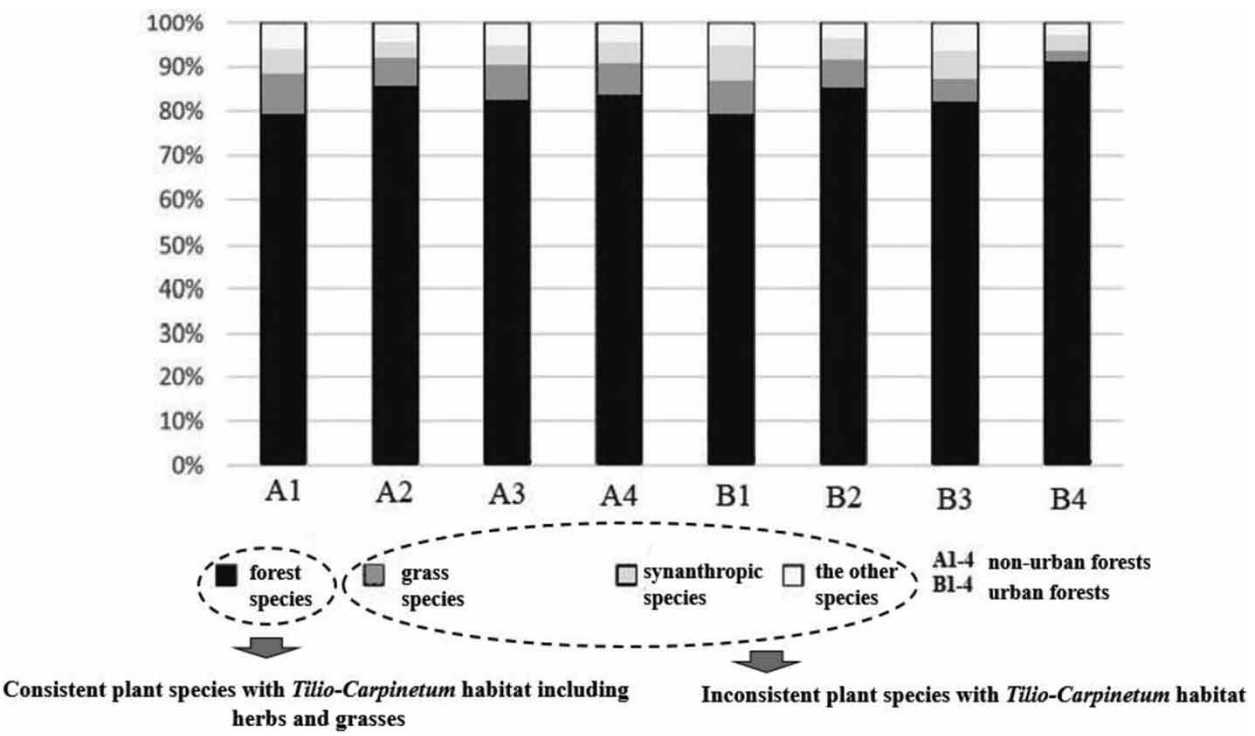

Figure 2. The share of forest, grass, synanthropic and the other plant species in the studied forests (own study)

The composition of vascular plant species in the herb layer was dominated by forest species, consistent with *Tilio-Carpinetum* habitat (from 80% to 90%), and grass species from 4% to 12%. Grass species means grass plants inconsistent with *Tilio-Carpinetum* community, typical for meadows and pastures. A greater proportion of grass species was found in forests outside the city than in the city. The share of synanthropic species ranged from 3% to 8%. A higher share of synanthropic and other species group, typical for areas with human impact, was observed in urban forests (Fig. 2). The analysis of the frequency of occurrence of individual species allowed to find those occurring only in forests outside the city. There were no species characteristic of urban forests. Some plant species as *Carex pilosa* L. and *Lathyrus vernus* (L.) Bernh. were found only in forests outside the city.

Discussion

Urbanisation has got many negative impacts on natural habitats in cities. It causes modifications in the environment as habitat fragmentations, increasing temperature and soil compaction (Patarkalashvili 2017; Wang et al. 2020). The fragmentation of natural habitats leads to transformations and, as a result, to changes in plant species compositions in forests (Dearborn and Kark, 2010). The total number of plants species was higher in forests outside the city than in urban forests. Similar results were obtained by Kowarik et al. (2019).

A higher proportion of grass species was found in forests outside Brzesko city. There were meadows and pastures adjacent to the forests, which could have influenced penetration of inconsistent species from the surrounding areas into the forests. A slightly higher share of synanthropic species typical for urbanised areas and a smaller share of grass species were found in the urban forests of Brzesko city. The number of forest species typical of natural habitat *Tilio-Carpinetum* (consistent) was similar in both types of studied forests. It means that forests still 'keep' their natural habitat despite human impacts. It should be noted that in the case of the investigated urban and non-urban forests, we observed preservation of native forest plant species, for example, *L. vernus* (L.) Bernh. and *C. pilosa* L., which were found only in the herbaceous layer of forests outside the city. According to Dzwonko (2015), these species are very sensitive to changes in habitat and occur only in natural or slightly transformed habitats. Similar research results were obtained by Fornal-Pieniak and Ollik (2013) and Fornal-Pieniak et al. (2019). Some authors, including Palmer et al. (2008) and Speziale and Ezcurra (2011), pointed to the fact that reduction of native flora enables the propagation of non-native species on the natural habitat.

Surrounding landscape structures have probably higher impact on the collection of plant species not typical for *Tilio-Carpinetum* habitat in urban forests. It was confirmed in the present study. The inconsistent species (mostly synanthropic plants) along the road and walking paths are the factors for their invasion into the natural habitats (Lee et al. 2012; Gonzalez et al. 2010). These plants are mostly characterised by an easy seed dispersal mostly by wind, which could possibly explain their occurrence in the forests (Rehm et al. 2019). The higher frequency of disturbance could also have an impact on the collection of synanthropic plants in urban forests than in forests outside the city.

Conclusions

1. Flora of urban forests is disturbed more by human influence than the flora outside the city, as evidenced by occurrence of more inconsistent species in the herb layer.
2. The different land uses shape vascular plant species composition in urban forests and outside the city.
3. Urban forests form valuable natural shelters for forest species typical of oak–hornbeam habitat.

References

Braun-Blanquet, J. 1951. Pflanzensoziologie. Grundzüge der Vegetationskunde. Springer-Verlag, Wien.

Dearborn, D., Kark, S. 2010. Motivations for conserving urban biodiversity. *Conservation Biology,* 24 (2), 432–440.

Dzwonko, Z. 2015. Rośliny runa wskaźnikami pochodzenia i przemian lasów. *Studia i Materiały CEPL w Rogowie*, 42 (1), 27–37.

Faliński J.B. 1966. Próba określenia zniekształceń fitocenozy. System faz degeneracyjnych zbiorowisk leśnych. Dysk. Fitos.(3). *Ekologia Polska*, 12 (1), 31–42.

Fornal-Pieniak, B., Ollik, M. 2013. Diversity of flora in the undergrowth of park afforestations, rural plantings and oak-hornbeam forests. *Folia Forestalia Polonica, Ser. A-Forestry*, 55 (3), 132–136.

Fornal-Pieniak, B., Ollik, M., Schwerk, A. 2019. Impact of different levels of anthropogenic pressure on the plant species composition in woodland sites. *Urban Forestry and Urban Greening*, 38, 295–304. DOI: 10.1016/j. ufug.2019.01.013

Hofmeister, J., Hošek, J., Brabec, M., Hédl, R., Modrý, M. 2013. Strong influence of long-distance edge effect on herb layer vegetation in forest fragmentations in and agricultural landscape. *Perspectives in Plant Ecology, Evolution and Systematics*, 15 (6), 293–303. DOI: 10.1016/j.ppees.2013.08.004

https://krakow.stat.gov.pl/vademecum/vademecum_malopolskie/portrety_gmin/powiat_brzeski/brzesko.pdf (access on 6 July 2021)

Gonzalez, P., Neilson, R.P., Lenihan, J.M., Drapek, R.J. 2010. Global patterns in the vulnerability of ecosystems to vegetation shifs due to climate change. *Global Ecology and Biogeography. A Journal of Macroecology*. DOI: 10.1111/j.1466-8238.2010.00558.x

Kornaś, J. 1968. Geograficzno-historyczna klasyfikacja roślin synantropijnych. *Materiały Zakładu Fitosocjologii Stosowanej UW*, 25, 33–41.

Kowarik, I. Hiller, A., Planchuelo, G., Seitz, B., von der Lippe, M., Buchholz, S. 2019. Emerging Urban Forests: Opportunities for Promoting the Wild Side of the Urban Green Infrastructure. *Sustainability*, 11, 6318. DOI:10.3390/su11226318

Lee, M.A., Davies, L., Power, S.A. 2012. Effects of roads on adjacent plant community composition and ecosystem function: An example from three calcareous ecosystems. *Environmental Pollution*, 163, 273–280. DOI: 10.1016/j.envpol.2011.12.038

Lundholm, J.T., Marlin, A. 2006. Habitat origins and microhabitat preferences of urban plant species. *Urban Ecosystems*, 9, 139–159.

Matuszkiewicz, W. 2014. Przewodnik do oznaczania zbiorowisk roślinnych Polski. PWN, Warszawa.

Palmer, G.C., Fitzsimons, J.A., Antos, M.J., White, J.G. 2008. Determinants of native avian richness in suburban remnant vegetation: Implications for conservation planning. *Biological Conservation,* 141, 2329–2341. DOI: 10.1016/j.biocon.2008.06.025

Patarkalashvili, T.K. 2017. Urban forests and green spaces of Tbilissi and ecological problems of the city. *Annals of Agrarian Science*, 15 (2). DOI: 10.1016/j.aasci.2017.03.003

Rehm, E.M., Thomas, M., Yelenik, S., Bouck, D., D'Antonio, C. 2019. Bryophyte abundance, composition and importance to woody plant recruitment in natural and restoration forest. *Forest Ecology and Management*, 444, 405–413.

Sanesi, G., Colangelo, G., Lafortezza, R., Calvo, E., Davies, C. 2017. Urban green infrastructure and urban forests: a case study of the Metropolitan Area of Milan. *Landscape Research*, 42, 164–175. DOI: 10.1080/01426397.2016.1173658

Speziale, K.L., Ezcurra, C. 2011. Patterns of alien plant invasions in northwestern Patagonia, Argentina. *Journal of Arid Environments,* 75 (10), 890–897. DOI: 10.1016/j.jaridenv.2011.04.014

Sokołowski, A.W. 1972. Gospodarcze użytkowanie lasu jako główny czynnik synantropizacji zbiorowisk leśnych. *Phytocoenosis*, 1 (3), 211–216.

Sudnik-Wójcikowska, B., Galera, H. 2005. Floristic differences in some anthropogenic habitats in Warsaw. *Annales Botanici Fennici,* 42, 185–193.

Wang, W., Wu, T., Li, Y., Xie, S., Han, B., Zheng, H., Ouyang, Z. 2020. Urbanization Impacts on Natural Habitat and Ecosystem Services in the Guangdong-Hong Kong-Macao "Megacity". *Sustainability*, 12, 6675, 1–7. DOI: 10.3390/su12166675

Zhou, Q., Zhu, Z., Shi, M., Cheng, L. 2018. Growth and physicochemical changes of *Carpinus betulus* L. influenced by salinity treatments. *Forests*, 9 (6), 354. DOI: 10.3390/f9060354

Wuyts, K., De Schrijver, A., Verheyen, K. 2009. The importance of forest type when incorporating forest edge deposition in the evaluation of critical load exceedance. *iForest—Biogeosciences and Forestry*, 2, 43–45.