THE ROAD FROM THE CITY TO THE FOREST. OR HOW FAR IS THE URBAN MAN FROM A FUNCTIONAL FOREST?

Vilém Pechanec[1], Helena Kilianová[2], Ivo Machar[2]
[1] Dept. of Geoinformatics, Faculty of Science, Palacký University, Olomouc, 17. listopadu 50, 771 46 Olomouc, Czechia
[2] Dept. of Development and Environmental studies, Faculty of Science, Palacký University, Olomouc, 17. listopadu 12, 771 46 Olomouc, Czechia

https://doi.org/10.11118/978-80-7509-904-4-0326

Abstract
This paper presents results from an analysis of the frictional distance of urban development to the nearest functional forest. A functional forest is defined by natural forest habitats in the sense of the Catalogue of Habitats of the Czech Republic, which simultaneously meet the minimum area requirement. The distance to the forest is calculated using the modified distance to nature (D2N) method for all locations in the Czech Republic, described by a 10x10 m area. The direct distance is calculated using the Euclidean distance method without barriers, and the friction is given as a function of the naturalness of the intersecting habitats. Results - maximum and median distances are evaluated at county and state levels. The distances achieved are further compared to the direct distance to the functional forest and the distance to the nearest forest segment (regardless of quality and area).

Key words: administrative units, distance to nature, functional forest, GIS

Introduction

The forest performs several ecosystem functions (Pechanec et al., 2021, Machar et al., 2022) which are essential for humans. In addition to production and regulatory functions, it is also a recreational function (La Rosa et al., 2016). In many cases, it is recommended by many experts to "go to the forest" for its beneficial effect on human health (Došenović et al., 2017, Kilianová, 2020). How far do the inhabitants of towns and villages in different parts of the country have the forest? How do the maximum and average (or median) distances differ at the regional level? That is, at the level of administrative units where development planning for the respective region is actively taking place?
And which forest does one have at one's disposal? The average forest cover in the Czech Republic is 33.4%, and according to the annual reports of the Ministry of Agriculture (Ministry of Agriculture, 2021), the forest cover has been slightly increasing in recent years.
Is there any difference between the different types of forests (in terms of naturalness) and their distribution in the country?

Materials and methods

The area of interest for this study is the entire Czech Republic. The data of administrative division (state borders, regional borders and borders of municipalities with extended competence) are taken from the free available database ArcČR 3.3.
The category "natural forest" comprises segments of natural forest habitats defined in the Catalogue of Habits of the Czech Republic - code designation L1-L9.3 (Chytrý et al., 2010) and identified in the Detailed Combined Layer of habitats (DCL). DCL is a vector map layer processed at a scale of 1:10 000 in the extent of the Czech Republic. It describes vegetation cover at the level of habitats. It distinguishes 156 types of natural biotopes and 38 types of non-natural habitats. The whole territory is described by 3 397 852 segments. Several national and international datasets (mainly from the European Copernicus project) were used in its construction. The last update is from 2018. More information is described in Cudlín et al. (2020).
The "functional forest" category is a selection from the type "natural forest", provided that each segment meets (is greater than or equal to) the parameter of minimum area parameter of the respective habitat, indicating sufficient size for the full development of the habitat. Adjacent segments of function forests were merged, and the minimum area size was tested on the merged element. Minimum area values were taken from Seják, Dejmal et al. (2003). The categories of Contiguous and Discontiguous urban fabric (TAG 1.1.1 and 1.1.2) from Corine Land Cover Methodology define the urban environment. The data source was the 2018 vector version of the Corine Land Cover dataset, freely available from the repository http://land.copernicus.eu.

The frictional value was determined by the degree of naturalness of each habitat and normalized on a scale of 1-2. Distances to forest segments were calculated using the algorithm of the Euclidian and Cost distance without barriers in a raster representation with 10m/px resolution in ArcGIS Pro. The frictional value was included according to the D2N methodology (Rüdisser et al, 2012). Individual rasters of distance were disaggregation into administrative units and compared to each other using map algebra tools.

Results

The results show the variability of the proximity of forests to the urban environment in individual regions of the Czech Republic. The distance varies depending on the desired character of the forest environment. The results are presented in Table 1-3.

Tab. 1: Distances to the „forest“ category at the state and county level

Name	Direct distance (m)			Friction distance (m)		
	MAX	MEAN	MEDIAN	MAX	MEAN	MEDIAN
Czech rep.	1494.9	84.5	67.1	2942	168.5	132.8
Capital City of Prague	1015.1	215.4	176.9	1939.1	425.5	348
Central Bohemia Region	325.7	65	51	678.7	129.6	103.8
South Bohemia Region	527	79.2	67.1	955.4	157.9	136.6
Pilsen Region	336.2	76	60	667.9	151.7	121.3
Karlovy Vary Region	161.2	76.9	64	317.9	149.1	129
Ústí nad Labem Region	393.6	92.4	78.1	785.1	184.2	153.3
Liberec Region	351.7	60.3	53.9	731	117.7	104.7
Hradec Králové Region	433.8	73.6	67.1	901.1	146	130.1
Pardubice Region	386.3	80.2	70	788.4	159.3	133.1
Vysočina Region	331.2	85.1	76.2	649.1	170.8	149.6
South Moravian Region	1494.9	103.2	72.8	2942	207.8	151.4
Olomouc Region	608.3	85.8	70.7	1223.2	172.6	141.4
Zlín Region	413.4	83.9	76.2	831.7	168.3	150.8
Moravian-Silesian Region	575.7	63.3	50	1126	126.3	99.5

The analysis of the tabular results shows that for the territory of the Czech Republic, the category "forest" is at a maximum direct distance of 1,495 m with a median of 67 m, which means that any/average resident of the Czech Republic has a forest within 1,495 m of a town or village, with half of the distances within 67 m. When evaluating distance with friction, the distance category "forest" is 2942 m with a median of 133 m. This represents 50.8% of the maximum distance and 50.5% of the median value.

When evaluating the regions in terms of accessibility to the forest, the most favourable values for the maximum direct distance are the Karlovy Vary, Central Bohemia and Vysočina regions, with values of 161, 326 and 331 m, respectively. When considering the median of the maximum direct distance of the "forest" category from the urban area, the Moravian-Silesian (50 m), Central Bohemian (51 m), and Liberec (54 m) regions have the lowest values. In terms of the highest distances to the forest, the inhabitants of the South Moravian Region (1495 m), the Capital City of Prague (1015 m) and the Olomouc Region (608 m) have the furthest distances. However, the median distance is highest in the Capital City of Prague (177 m), the Ústí nad Labem Region (78 m) and the Vysočina Region and the Zlín Region (76 m).

The maximum distance to the "forest" influenced by friction is lowest in the Karlovy Vary Region (318 m), the Vysočina Region (649 m) and the Pilsen Region (668 m). In comparison, the highest values were reached by the South Moravian Region (2942 m), the Capital City of Prague (1939 m) and the Olomouc Region (1223 m). The results of the median calculation show that the lowest median values are in the South Moravian (100 m), Central Bohemia (104 m) and Liberec (105 m) regions, while the highest values are in the South Moravian (151 m), Ústí nad Labem (153 m) and Prague (348 m) regions.

The maximum distance reaches the lowest 48% of the distances with friction in the Central Bohemia Region and the highest at 55.2% in the South Bohemia Region. In comparison, the median rating

reaches the lowest value of 48% in the South Moravia Region and the highest of 52.6% in the Pardubice Region.

Tab. 2: Distances to the „natural forest“ category at the state and county level

Name	Direct distance (m)			Friction distance (m)		
	MAX	MEAN	MEDIAN	MAX	MEAN	MEDIAN
Czech rep.	4795.5	629.9	496.5	8400.1	1117.2	905.4
Capital City of Prague	1963.1	683	735	3579.9	1264.1	1348.5
Central Bohemia Region	3470.8	660.1	539.4	6031.6	1161.3	960.3
South Bohemia Region	2527.9	640.5	587.3	4285.7	1115.7	1024.9
Pilsen Region	1596.6	569.5	490	2674.2	998.5	889.2
Karlovy Vary Region	901.4	315.9	304.1	1588.6	552.2	530.3
Ústí nad Labem Region	2929.3	569.4	418.7	5067.6	1005.7	745.3
Liberec Region	841.7	302.4	260.8	1555.6	535.4	476.8
Hradec Králové Region	2125.6	541	449.1	3630.2	962	807.9
Pardubice Region	2218.9	571.7	460.3	3906.4	1014.4	868.6
Vysočina Region	2626.8	661.5	584.6	4236.7	1163.2	1088
South Moravian Region	4430.9	909.7	687.7	7657.2	1613.3	1237.9
Olomouc Region	4795.5	827.7	623.7	8400.1	1481.1	1133.4
Zlín Region	2319.3	575.1	440.5	4128.5	1030.5	792.5
Moravian-Silesian Region	2127.2	493.5	413.4	3558.6	879.8	728.3

For the "natural forest" category, the maximum direct distance from the urban area is 4,796 m with a median value of 497 m, for residents represent natural forest within 5 km of the urban area with half of the values within 497 m. The distance with friction is 8 400 m with a median of 905 m. The direct distance is 57.1% of the distance with friction; the median rating is 54.8%.

The "natural forest" category has the lowest values of maximum distance in the Liberec (842 m), Ústí nad Labem (901 m), and Pilsen (1597 m) regions, while the highest values are in the Olomouc (4795 m), South Moravian (4431 m) and Central Bohemia (3471 m) regions. When considering the median of the maximum direct distance of the category "natural forest" from the village/town, the lowest values are in the Liberec Region (261 m), the Karlovy Vary Region (304 m) and the Moravian-Silesian Region (413 m), while the highest values are in the Capital City of Prague (735 m), the South Moravian Region (688 m) and the Olomouc Region (624 m).

The maximum distance to the "natural forest", including friction, is lowest in the Liberec (1556 m), Karlovy Vary (1589) and Pilsen (2674 m) regions and highest in the Olomouc (8400 m), South Moravia (7667 m) and Central Bohemia (6032 m) regions. The results of the median calculation show that the lowest medians are in the Liberec (477 m), Karlovy Vary (530 m) and Moravian-Silesian (728 m) regions, while the highest values are in the Capital City of Prague (1348 m), the Olomouc Region (1133 m) and the Vysočina Region (1088 m).

The maximum distance reaches the lowest of the distances with friction in the Liberec region (54,1%) and the highest in the Vysočina region (62%), the median rating reaches the lowest value in the Pardubice region (53%) and the highest in the South Bohemia and Karlovy Vary regions (57.3%).

The category "functional forest" reaches a maximum distance from the urban area of 5,095 m with a median of 580 m. Distances with friction are 8,903 m and 1,031 m, respectively. The direct distance reaches 57.2% of the distances with friction; the median rating is 56.3%.

The analysis of the regions in the "functional forest" category shows the lowest values of the maximum distance in the Liberec, Karlovy Vary and Moravian-Silesian regions with values of 1011 m, 1528 m and 2133 m, while the highest values are in the South Moravian, Olomouc and Central Bohemia regions with values of 5095 m, 4795 m and 3652 m. The analysis of the median of the maximum distance of the category "functional forest" from the village/town shows that the lowest values are in the Liberec Region (303 m), Karlovy Vary Region (339 m) and Ústí nad Labem Region (445 m), while the highest values are in the Vysočina Region (850 m), the Capital City of Prague (835 m) and the South Moravian Region (812 m).

In terms of the maximum distance concerning friction, the lowest distances to the functional forest are in the Liberec Region (1655 m), the Karlovy Vary Region (2687 m) and the Moravian-Silesian Region (3561 m), while the highest distances are in the South Moravian Region (8903 m), the Olomouc Region (8400 m) and the Central Bohemian Region (6800 m). The results of the median calculation show that the lowest median values are in the Liberec (538 m), Karlovy Vary (585 m) and Ústí nad

Labem (814 m) regions, while the highest values are in the Capital City of Prague (1529 m), Vysočina (1508 m) and South Moravian (1437 m) regions.
The maximum distance reaches the lowest distances with friction in the Pardubice Region (55.5%) and the highest in the South Bohemia Region (66.3%). In comparison, the "median distance" reaches the lowest value in the Pardubice Region (53.9%) and the highest in the Karlovy Vary Region (58%).

Tab. 3: Distances to the „functional forest“ category at the state and county level

Name	Direct distance (m)			Friction distance (m)		
	MAX	MEAN	MEDIAN	MAX	MEAN	MEDIAN
Czech rep.	5094.8	732.8	580.1	8902.7	1286.8	1030.6
Capital City of Prague	2807.5	748.8	834.9	4904.7	1384.8	1529.1
Central Bohemia Region	3651.8	754	616.1	6500.3	1318.7	1081.6
South Bohemia Region	2843.5	754.3	680.1	4289.8	1297.5	1183.9
Pilsen Region	2471.8	709.8	612.2	4093.7	1226.3	1078.1
Karlovy Vary Region	1527.6	389.2	339.4	2687.3	666.7	585
Ústí nad Labem Region	2929.3	605.5	445.5	5067.6	1061.1	814.4
Liberec Region	1010.6	344.4	303.1	1654.5	601.2	537.5
Hradec Králové Region	2172.8	663.8	541	3778.4	1163.9	974.3
Pardubice Region	2218.9	683.3	529.5	4001.6	1194.3	983.2
Vysočina Region	3199	941	850	5407.4	1620.1	1508.3
South Moravian Region	5094.8	1030.3	811.5	8902.7	1818.2	1437.3
Olomouc Region	4795.5	931.7	692.3	8400.1	1659	1224.3
Zlín Region	2337.9	635.3	495	4192.9	1126.2	846.1
Moravian-Silesian Region	2133.2	555.2	466.9	3560.9	979.9	828.1

Discussion

In evaluating any analysis, the purpose should always be clearly defined. The research performed here is based on exact data but with a certain degree of subjectivity in the design of the entire analysis.
In this case, the maximum and median distance indicators were compared. Similarly, a more common average distance could have been used. The median was chosen because its value is not affected by the occurrence of outliers. The mean values were also calculated, and the results tables show them.
The critical point is the choice of the cost value for calculating the frictional distance. Here a naturalness value was used, with natural habitat having a resistance value of 1 and artificial habitat having a resistance value of 5 (Cudlín et al. 2020). This scale is based on assessing permeability to biological processes, which is significant in maintaining functional connectivity, the spread of diaspores in the landscape, etc. However, it is questionable to what extent today's typical person considers themselves a natural feature and would perceive the load in this way rather than an inverted scale where they would assume that they move more quickly through artificial habitats and least easily in real nature.
However, regarding the effect of recreation and relaxation, the preservation of nature and the degree of fulfilment of the ecosystem services involved are more important (Pechanec et al., 2021); therefore, the scale was used.

Conclusion

The paper shows the variability of the direct and frictional distance to the forest in individual regions of the Czech Republic and the value valid for the whole Czech Republic.
The distance is calculated from the urban area to the nearest forest segment, which is analysed at three functional levels - any forest, natural forest and functional forest. Distance is calculated by Euclidean (direct) distance and frictional distance, where the cost value is expressed by the degree of naturalness of the intersecting landscape segments.
According to the analysis results, the Liberec region performs best, having the shortest maximum distance to a functional forest at 1010 m, which is about five times closer than the value for the whole country. In the case of the distance of any forest, the Karlovy Vary region performs best at 161 m, compared to the national distance of 1494 m.

References
Cudlín, O., Pechanec, V., Purkyt, J., Chobot, K., Salvati, L., Cudlín, P. (2020). Are Valuable and Representative Natural Habitats Sufficiently Protected? Application of Marxan model in the Czech Republic. Sustainability. 2020, 12(1).
Došenović, L., Trkulja, T., Sekulić, M. (2017). Recreation function of forest complexes as an element of urban planning: A view from Republic of Srpska. Facta universitatis - series: Architecture and Civil Engineering, 2017.15 (1): 103-115
Chytrý M., Kučera, T., Kočí, M., Grulich, V., Lustyk, P. (eds.) (2010). Habitat Catalogue of the Czech Republic. Second edition. Catalogue of Habits of the Czech Republic. Praha, Agentura ochrany přírody a krajiny ČR, 2010, pp 447.
Kilianová H. (2020). Environmental trip destinations of university urban day camps in Olomouc surroundings. In Fialová J (ed). Public Recreation and Landscape Protection - With Sense Hand in Hand? Conference Proceedings 2020, pp. 127 - 131
La Rosa D., Spyra, M., Inostoza, L. (2026). Indicators of Cultural Ecosystem Services for urban planning: A review. Ecological Indicators, 2016, 61(1): 74-89
Machar, I., Šimek,P., Schlossárek,M., Pechanec,V., Petrovič, F., Brus, J., Špinlerová, Z., Seják, J. (2022). Comparison of bird diversity between temperate floodplain forests and urban parks, Urban Forestry & Urban Greening, 2022, 67, 127427.
Ministry of Agriculture. Zpráva o stavu lesa a lesního hospodářství České republiky v roce 2021 / Report on the state of forests and forestry in the Czech Republic in 2021/ Praha, Ministry of Agriculture, 2021, pp. 144
Pechanec, V.; Machar, I.; Kilianová, H.; Vyvlečka, P.; Seják, J.; Pokorný, J.; Štěrbová, L.; Prokopová, M.; Cudlín, P. (2021). Ranking the Key Forest Habitats in Ecosystem Function Provision: Case Study from Morava River Basin. Forests 2021, 12, 138.
Rüdisser, J., Tasser, T., Tappeiner, U. (2012). Distance to nature—A new biodiversity relevant environmental indicator set at the landscape level. Ecological Indicators, 2012, 15(1): 208-216.
Seják, J., Dejmal, I., Petříček, V., Cudlín, P., Míchal, I., Zapletal, J. (2003). Hodnocení a oceňování biotopů České republiky. / Assessment and valuation of biotopes of the Czech Republic./. Praha, Český ekologický ústav, 2003, pp 442.

Acknowledgement
This paper is supported by the grant “Biocultural Diversity – joining of cultural and natural heritage in historical urban areas” No. DH23P03OVV002, founded by Ministry of Culture of the Czech Republic in the frame of NAKI III (Programme for support of applying research on national and cultural identity in the period of 2023-2030).

Souhrn
Příspěvek představuje výsledky analýzy přímé a frikční vzdálenosti intravilánu k nejbližšímu lesa. Les je rozdělen do 3 kategorií veškeré les, přírodní les a funkční les). Funkční les je definován přírodními lesními biotopy ve smyslu Katalogu biotopů ČR, které současně splňují požadavek minimální rozlohy. Vzdálenost k lesu je vypočtena pomocí modifikované metody vzdálenosti k přírodě (D2N) pro všechny lokality v ČR, popsané plochou 10x10 m. Přímá vzdálenost je vypočtena pomocí metody euklidovské vzdálenosti bez bariér a tření je dáno funkcí přirozenosti protínajících se stanovišť.

Contact:
prof. RNDr. Vilém Pechanec, Ph.D.
E-mail: vilem.pechanec@upol.cz