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ORIGINAL PAPER

Provision of periurban zones of small towns of Kyiv region by forests as a factor of eco-stability

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Abstract

Humanity has come to the conclusion about the need for eco-balanced planning of territorial land use at both regional and local levels. The object of research is the periurban areas around 20 small towns of the Kyiv region – the most common category of cities in Ukraine. The provision of periurban areas of small towns with forests is analyzed taking into account three indicators: population in cities, distance to the nearest forests and their size. It was found that forests are absent in the vicinity of most small towns in the region which are mostly surrounded by arable land. Small towns are grouped into four clusters according to the similarity of forest provision of periurban zones with indicators: average (55% of towns); improved (Vyshhorod, Bucha); with the best situation (Irpin); worse (Vyshneve, Myronivka, Uzyn, Skvyra, Tetiiv, Yahotyn). Each such cluster requires the development of certain strategies for the formation of periurban green infrastructure, which will include both protective green stands and recreational areas. Therefore, around the small towns of Kyiv region it is recommended to immediately form periurban recreational and protective zones with a predominance of forests. This will dramatically improve the environmental situation and contribute to the environmental and social sustainability of urban areas.

Key words: cluster analysis; ecological situation; forest cover; green infrastructure; recreational zone

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Introduction

Cities are the source of civilization and at the same time one of the main culprits of environmental degradation, and our future depends on the ability of mankind to turn cities from destroyer of environmental into centers of sustainable development (Grigoriev & Ogorodnikov 2001). The authors note that desurbanism contains the idea of a city of limited size, inscribed in the natural environment. However, the focus is still on green spaces within the city, although there is a growing tendency to anticipate a regional perspective (Liu 2008).

Urban forests are important because they provide recreation areas and environmental services (Zhao et al. 2020). Visiting forests has a beneficial psychological and physiological impact on human health (Tyrväinen et al. 2019). Urban forests provide many benefits to human health and well-being, the local urban environment and biodiversity. Nevertheless, in many periurban areas, urban forests are declining due to urban consolidation (Bolleter & Hooper 2021).

The expression "periurban area", despite its large use, does not have a clear and unambiguous definition (Murgante et al. 2008). Periurban green areas perform a compensatory function and ensure the environmental sustainability of the system "city – suburbs", i.e. perform at the same time regulatory, protective, recreational functions, but are formed mainly around large cities as periurban areas necessary for their functioning and development (Potaev 2009). To solve urban ecological problems, the natural framework must be formed in the form of an integral and continuous structure that permeates the entire space of the city and goes into the periurban environment – in the forests of the green zone (Grigoriev & Ogorodnikov 2001). Forest landscapes are the most resistant to anthropogenic loads (with a population density of up to 100 capita per hectare) due to their increased ability to self-regenerate (Vladimirov et al. 1986). According to its position and functions in the periurban area of the city, the stand is classified as a special purpose forest. The social role of periurban forests is diversifying, which means that periurban forests

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have been redesigned to meet and shape social demands (Sevianu et al. 2021). In contrast, recreational lands in Ukraine occupy only 0.2% of the land fund and in the Kyiv region they do not exceed 0.1% and their area continues to decline (Poltavets 2013). Only rational spatial management, based on high planning standards, can stimulate the spatial development of a certain area and at the same time properly protect valuable spatial elements (Budnicka-Kosior et al. 2019). Any national nature policy in cities will be implemented in different ways at the local level due to the political will and perceptions of local authorities about environmental priorities. Good ideas of urban green space should be inscribed in the local political context (Douglas 2014).

Urban development leads to the urbanization of the surrounding rural areas. Poland's 2030 National Urban Development Plan has introduced the concept of mandatory green belts around metropolitan and regional centers to prevent uncontrolled suburbanisation (Szczepanska & Senetra 2019).

Costa et al. (2008) believe that an appropriate strategy for the development and improvement of urban green systems is needed. Cities are different; each has an individual specific situation in terms of spatial conditions, potentials, opportunities, problems and requirements, social, cultural and historical circumstances. However, the authors do not consider it possible, useful or effective to develop such strategies for each city.

Types of interaction in the system "city-nature" depend on the size of the city and its population (Grigoriev & Ogorodnikov 2001). The small town was considered as a whole with its natural environment. To overcome, the negative impacts of urbanization and preserve sustainability in urban areas, governments are compelled to undertake measures, to increase the benefits derived from periurban and urban green spaces (Kalfas et al. 2020). The change in the planning and management of green periurban areas improves the multifunctionality of periurban spaces and promotes the city's sustainability (Fernández-Pablos et al. 2021).

The territory of Ukraine is characterized by an extremely high rate of agricultural development (70% of the country's territory), which significantly exceeds the environmentally sound borders and indicators of European countries (Analytical Report..., 2013). Despite the fact that the forest is the most effective ecological stabilizer, the forest cover of the territory of Ukraine according to different methods of determination is in the range of 15–17% with the optimal more than 20% (Pylypenko et al. 2004).

According to Ukrainian scientists, the area of arable land in Ukraine should be reduced by 1.5 times, and the area of forests – increased by at least 1.2–1.5 times (Pylypenko et al. 2004).

As in many countries, small towns are the most numerous categories in Ukraine and make up about 80% of the total number of cities. However, as all over the world, studies of urbanization and environmental processes have generally concerned large cities, and the socio-ecological situation in Ukrainian small towns has been virtually unexplored (Nazaruk & Zhuk 2014). Scientists believe that the predominant objects of integrated greening should be small towns as the most sustainable forms of settlements (Safroshkin 1991).

According to Klimenko et al. (2013), given the typical problems of small towns, their ecological status can be determined by the dynamics of a number of basic indicators, including the level of landscaping and the percentage of territory occupied by natural landscapes. Since in urban conditions the ability of plants to accumulate carbon dioxide is reduced by 5–7 times and it is usually not possible to increase the area of urban greenery by the same number of times, the importance of adjacent territories increases in providing cities with natural resources. These areas should be used as "eco-donors".

According to the chronicles, a dense forest stretched just outside the gates of ancient Kyiv in the 15th century.

Now the situation has changed dramatically. The comparison of territories with the help of Google Earth Pro highlights the cardinal difference between the suburbs of European cities drowning in forests and the "bare" defenseless territories of Ukrainian small towns, surrounded mainly by plowing. That is why the work is devoted to clarifying the provision of periurban areas of the most common and overlooked category – small towns – forests, the presence of which guarantees the ecologically balanced development of urban areas.

The purpose of the work is to assess the provision of small towns in the capital region with periurban forests, as well as to develop strategies for the formation of periurban green infrastructure of a small town as a basic factor of environmental sustainability of the urban area.

2. Materials and methods

The Kyiv region is located in the basin of the middle reaches of the Dnieper and without the city of Kyiv occupies 4.7% of the country's area. The population of Kyiv region amounts 4.1% of total population of Ukraine, 68.1% of which are urban population. The population density of the region is 62 inhabitants per km^2.

Objects of research are periurban areas of small towns within the Kyiv region, the peculiarity of the development of which is due to the proximity to the capital and its influence. Assessment of landscape resources of small towns was the first stage in the process of studying their ecological balance.

Kyiv region is one of the most developed industrial and agricultural regions of Ukraine. During the period 2008–2014, the area of agricultural, forest, open wetlands and lands under surface waters decreased in the region, and at the same time the area of buildings increased (Shevchenko 2015). In the total area, agricul-

tural lands make up 58.9%, built-up lands – 4.9%, forests and forested areas – 23.0%, inland waters – 6.2%. The degree of landscaping of the region is 19.4% and decreases in the direction from northwest to southeast: from 40–50% in forest areas to 2–4% in forest-steppe areas, while for Kyiv is 57.6% (Podorozhko 2006).

There are 20 small towns in the Kyiv region – that is, cities with a population of 10 to 50 thousand inhabitants (Fig. 1).

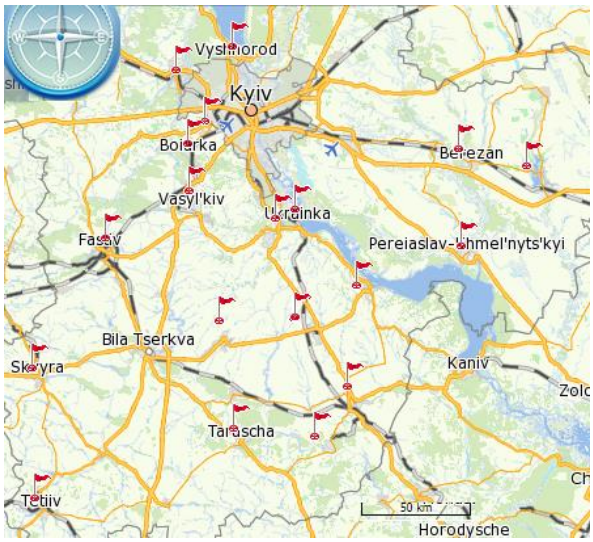


Fig. 1. Location of small towns relative to Kyiv city.

Small towns are home to 23.6% of the region's population. Several small towns closest to the capital are characterized by strong positive demographic dynamics, which may soon translate them into the category of medium (with a population of 50 to 250 thousand inhabitants). Small ties of Kyiv region are in the zone of influence of Kyiv, located at a distance of 2 km (Vyshneve town) to 144 km (Tetiiv town) (Table 1).

Table 1. Characteristics of small towns of Kyiv region.

Town	Distance from Kyiv [km]	Town area [ha]	Population density [persons per km^2]
Vyshneve	2	2 520	1 552
Boiarka	9	1 233	2 879
Irpin	15	3 705	2 310
Vyshhorod	20	874	3 180
Bucha	32	2 657	1 072
Vasyl'kiv	38	37 792	1 267
Ukrainka	38	591	2 622
Obukhov	45	2 419	1 397
Fastiv	64	4 300	1 081
Berezan	65	3 292	504
Rzyshchiv	76	3 557	208
Kaharlyk	77	2 131	648
Pereiaslav	78	3 200	850
Uzyn	86	6 700	181
Yahotyn	101	5 750	350
Myronivka	106	1 150	1 043
Tarashcha	115	3 696	295
Skvyra	121	6 328	258
Boguslav	124	1 590	1 050
Tetiiv	144	1 304	1 012

According to physical and geographical zoning, 15% of small towns in Kyiv region belong to the Polissya zone of mixed coniferous-deciduous forests. The rest towns are located in the forest-steppe zone. The duration of the frost-free period varies from 160 to more than 185 days, and the rainfall is from 500 to more than 650 mm/year. Agrocenosis on the site of oak forests are common in areas around 35% of small towns in Kyiv region; agrocenoses on the site of meadow steppes and steppe meadows – about 25% of towns. Floodplain vegetation is widespread around 15% of towns: meadows, swamps, bushes, forests. Sedge, sedge-hypnum, reed-sedge lowland bogs, sometimes in combination with forest alder bogs are characteristic of areas around 10% of small towns in the region; about 5% – agrocenosis on drained grass bogs and swampy meadows and about 5% of towns – forests of oak with an admixture of other deciduous species of woody plants, as well as agrocenoses in place of oak and hornbeam forests (Onishchak et al. 2009).

In previous papers, the structure of the land fund of small towns in Kyiv region was analyzed according to such indicators as the ratio of different types of land use, the level of urban landscaping and the provision of greenery (Yukhnovskyi & Zibtseva 2019; 2020).

According to various data (Analytical report..., 2013; Shevchenko 2015), the forest cover of the region is 20.4–23.0%, and forests have mainly protective value. Most of the forests are concentrated in the northern Polissya part of the region (closer to the former Chernobyl nuclear power plant, in the area of compulsory resettlement and controlled residence), where towns have a lower population density. Forests, especially in the forest-steppe part of the region (division into Polissya and Forest-steppe passes through the territory of Kyiv), are usually confined to river valleys and ravine-gully systems. As a rule, they are artificially created by reforestation or afforestation of lands unsuitable for agricultural use.

Determination of the provision of periurban areas with forests was carried out according to the method proposed by Kruglyak (2013), which provides for cartographic (satellite map) determination of the presence of forests. Automatic determination of distances and areas of forests was carried out using Internet resources.

Clustering of towns was carried out using the program STATISTICA 10 – StatSoft, which took into account their similarity in three characteristics: city size (population), distance to the nearest forests and their size (area), i.e. the availability of forests taking into account the population of the towns.

3. Results and discussion

The constant fragmentation of surfaces covered with forest in the periurban, requires that urban planning should benefit from the combination of conventional cartographic products and remote sensing imagery (Huzui et al. 2012).

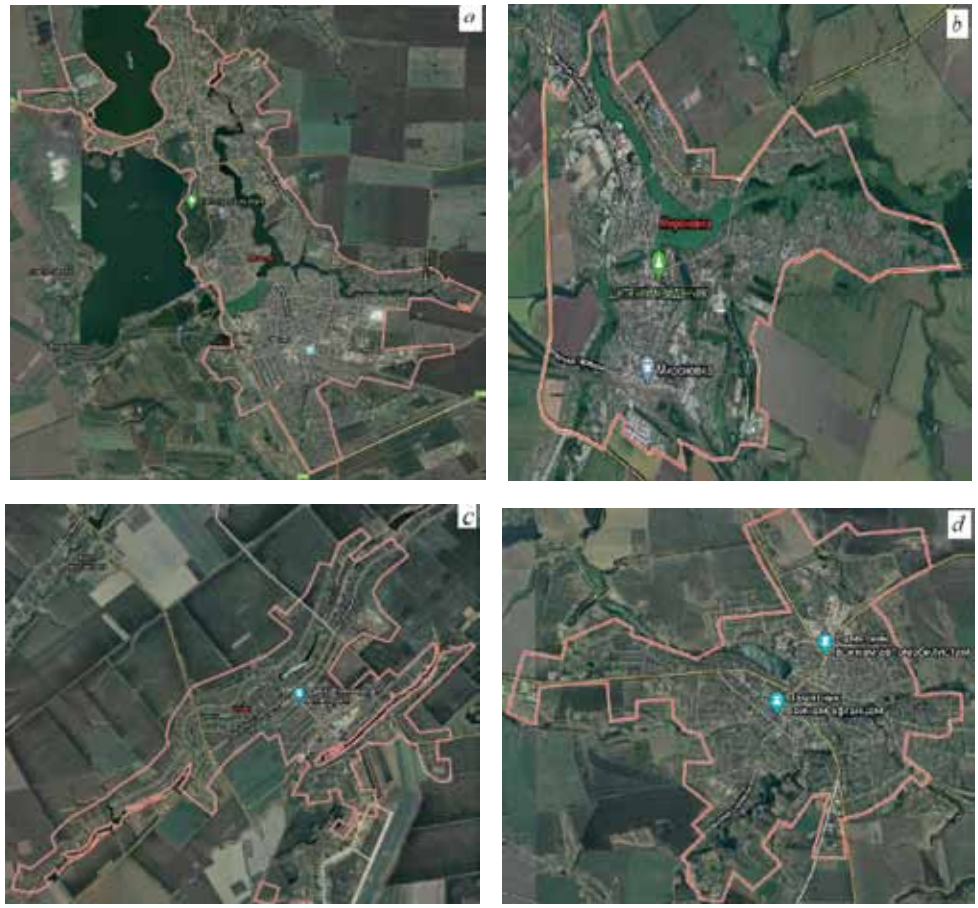


Fig. 2. General appearance and characteristics of landscaping systems of towns, the least provided with periurban forests: Yahotyn (*a*), Myronivka (*b*), Uzyn (*c*), Skvyra (*d*) (Data taken from Google Earth Pro 2020).

There is no periurban green zone in the form of a protective green ring with a predominance of forests around any small town in the region. As a rule, cities are surrounded by agricultural lands (Fig. 2; taken from https://www.google.com.ua/maps/place).

Fig. 2a shows the combined landscaping system of Yahotyn. There are green stripes in the north (confined to the river), lines and green spots. Agricultural fields adjoin the town from the east and south. The wide bed of the Supiy River stretches to the northwest.

There are only agricultural fields around the Myronivra (Fig. 2b). The large river Rosava flows from the north. From the west and east the build area is limited by the river Sukha Butenya and the pond, to which landscaping is timed. In general, the system of greenery inside the town can be considered as a scattered park environment.

Uzyn town stretches along the river Uzynka and a number of oblong ponds (Fig. 2c). In accordance with the planning structure of the city, the greening system is linear-strip. There are plain fields around the town and there are no forests.

Skvyra's landscaping system can be characterized as a system of green wedges due to the water-green diameter of the Skvyra River and watercourses to it from different parts of the town (Fig. 2d). There are only fields around the town.

Forests are located only near Boguslav (mostly from the north), Tarashcha (from the northwest and southeast), Berezan (in the southwest), south of Pereyaslav, in the east of Tetiev, northwest of Ukrainka, southwest of Fastiv and Boiarka, in the east and southwest of Irpin, southwest of Vyshhorod – that is, only near half of small towns. Larger forests stretch only near Irpin. However, the towns are currently being intensively built up. There are no forests near the towns of Kaharlyk, Uzyn and Skvyra within a radius of almost 10 km.

To identify the nature of the location of towns depending on forests, and, accordingly, the provision of periurban areas as a potential recreational and protective area, according to the method of Kruglyak (2013), indicators were taken into account: size of the city (population), distance from urban development to the nearest forests and the size of forests and areas (Table 2).

Table 2. Basic indicators of clustering of small towns by the provision of periurban zones by forests (Kruglyak 2013).

Town	The nearest forest tract		Town population [thousand inhabitans]
	Area [thousand hectares]	Distance from town [km]	
Vyshhorod	22.4	0.1	27.8
Vyshneve	1	6.7	39.1
Bucha	18	5.4	28.5
Boiarka	5.2	0.1	35.5
Irpin	18.2	0.1	85.6
Vasyl'kiv	8.2	1.3	37.5
Fastiv	3.1	0.1	46.5
Obukhiv	1	0.1	33.8
Ukrainka	0.5	0.2	15.5
Rzyshchiv	0.4	0.6	7.4
Kaharlyk	0.05	0.2	13.8
Myronivka	3	5.5	12
Boguslav	3	0.1	16.7
Uzyn	3.2	9	12.1
Tarashcha	6.9	1	10.9
Skvyra	0.4	13.3	16.3
Tetiiv	0.3	9	13.2
Pereiaslav	2	0.8	27.2
Berezan	3	0.8	16.6
Yahotyn	3.5	9	20.1

Cluster analysis of the size of cities and their position relative to forests and their size allowed to unite cities into four clusters (Fig. 3).

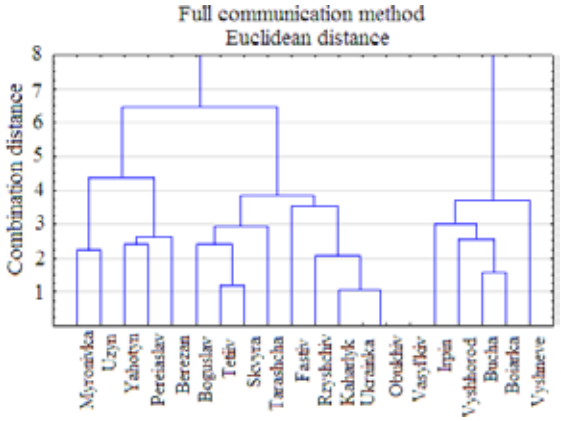


Fig. 3. Dendrogram of similarity of small towns of Kyiv region in terms of provision of periurban areas with forests.

The first cluster includes 11 (or 55%) small towns with average indicators: average population, mostly unevenly distributed small forests, often located on the border with the city: Boiarka, Vasyl'kiv, Fastiv, Obukhiv, Ukrainka, Rzhyshchiv, Kaharlyk, Boguslav, Tarashcha, Pereiaslav, Berezan. The second cluster includes two towns (10% of the research small towns) with an average population and relatively large forests at a short distance: Vyshhorod, Bucha. The third cluster forms one town (or 5% of towns) – Irpin, which is characterized by the largest population and large forest areas at a small distance (Fig. 4).

The fourth cluster includes the remaining six towns (or 30%), mostly with a smaller population, which are characterized by low rates of periurban landscaping (on average, the smallest forests occur at the longest distance, and on the border with the town they are usually absent):



Fig. 4. Clusters of small towns on the provision of forests of periurban areas, determined by the method of k-means.

Vyshneve, Myronivka, Uzyn, Skvyra, Tetiiv, Yahotyn towns. The options for the location of forests in relatively small towns are very different; the difference in all indicators is significant at a high level of significance (Tables 3 and 4). The obtained distribution corresponds to the situation described in the literature regarding the forest cover of the districts of Kyiv region.

The main principle that is put forward to the formation of the city's landscaping system is evenness. Namely this principle should be adhered to on a larger – regional scale and even on the scale of countries and continents. It is recognized that in order to guarantee sustainable land use, the forest cover of the region should be more than 30%. As you know, Europe is currently one of the most forested regions. In Ukraine, a significant proportion of whose territories are located in forest and forest-steppe zones, forest cover is less than 16%. Unlike European cities, Ukrainian cities are mostly surrounded not by forests but by agricultural lands. Low forest cover in Ukrainian territories can have a negative impact (in the form of dust storms, lower groundwater levels, drying and degradation of soils) even on a European scale.

Ukraine, despite favorable climatic conditions, is an extremely sparsely forested country. And despite the fact that small towns are traditionally considered the most comfortable urban environment, Ukrainian small towns are mostly completely unprotected from the outside. They do not have enough forests in the suburbs. And the periurban area itself is unformed and not enshrined in law. This affects both the sanitary and hygienic situation and the recreational potential of urban areas.

Currently, the lack of a reliable information base on quantitative and qualitative indicators of landscaping, including in periurban areas, is the main obstacle to successful urban planning.

The strategic concept of small town development should introduce the formation of an eco-oriented system of green areas (green infrastructure) and provide for the creation of periurban forest protection zones with the

Table 3. Analysis of variance in the similarity of small towns in the provision of periurban areas with forests.

Variables	Between – SS	cc	Within – SS	cc	F	–-value
Area, thousand hectares	16.83688	3	2.163116	16	41.51266	0.000000
Distance, km	16.00829	3	2.991714	16	28.53799	0.000001
Population, thousand people	12.17603	3	6.823970	16	9.51628	0.000762

Table 4. Descriptive statistics for clusters of towns on the availability of forests.

Variables	Average	Standard deviation	Dispersion
Cluster 1 – 11 towns			
Area	−0.323013	0.410880	0.168823
Distance	−0.647305	0.104860	0.010996
Population	−0.113674	0.717004	0.514095
Cluster 2 – 2 towns			
Area	2.273601	0.470566	0.221433
Distance	−0.101135	0.902425	0.814372
Population	0.130582	0.027563	0.000760
Cluster 3 – 1 town			
Area	1.971110	0.00	0.00
Distance	−0.739246	0.00	0.00
Population	3.329691	0.00	0.00
Cluster 4 – 6 towns			
Area	−0.494195	0.225148	0.050692
Distance	1.343646	0.643022	0.413477
Population	−0.390074	0.580045	0.336453

inclusion of recreational areas, primarily confined to river systems, protection of springs, preservation of urban forests and natural centers that provide the ecobalance development of urban areas.

Recreational periurban public areas should be oriented primarily to river systems and other water bodies – it is in these areas that urban development will continue to expand. Currently, in the absence or insufficiency of periurban forests, the organization of periurban recreational areas should begin with the creation of meadow- and hydroparks. The creation exclusively of new green areas for general use and special purpose should be timed to water bodies.

Integrating emerging periurban forests into urban green infrastructure is a promising pathway to sustainable cities and can complement traditional approaches to restoration or greening (Manes et al. 2016; Kowarik et al. 2019; Verdú-Vázquez et al. 2021).

General principles of building an eco-oriented system of urban landscaping have to include: maximum preservation of natural landscapes, formation of buffer (periurban) zones, continuity of landscaping, prevention of fragmentation of green space, taking into account development trends, demographic features of the city, natural and microclimatic conditions, maximum organic connection with natural features of the area.

Distance to the forest is an important factor, and walking time has clearly been identified as the singl most important precondition for use of urban green space in general (Van Herzele & Wiedermann 2003; Tyrväinen et al. 2005). According to England national woodland access standard, no person should live more than 500 m from at least one woodland area of 2 ha or more, while a woodland area of a least 20 ha should be situated within 4 km. According to this standards, only 10% of the English population had access to nearby small woodland areas (Konijnendijk 2008).

The proximity to greenery and its area are important determinants of housing prices in Prague (Melichar & Kaprová 2013). On average a one hundred meter increase in distance from the forest decreases land value by 3% (Zygmunt & Gluszak 2015).

Towns of the 1st cluster need systematic development of their periurban areas with the above mentioned nuances. Towns of the 2nd cluster (Vyshhorod, Irpin) need to form forest parks in the periurban area to meet primarily the recreational needs of the population. The Irpin town (cluster 3) is needed the cessation of thoughtless ten-year deforestation and build in the middle of the forests of multi-storey residential complexes. The forest-free periurban areas of the towns of the 4th cluster need urgent protective afforestation and priority creation of hydro parks (for example, Yahotyn) and meadow parks (other small towns) for recreation of citizens and tourists.

The concrete composition of the landscaping elements of every urban system should be determined by the demographic situation, landscape conditions, as well as the specifics of anthropogenic impact on the environment. Therefore it is necessary to develop informal landscaping programs for every small town.

It is ecologically expedient to preserve and, if possible, expand the area of urban forests as a more effective eco-stabilizing component.

Periurban recreational areas are primarily needed for small towns, where there are no town's parks and there is no possibility of their organization within the town (for example, Vyshhorod town). For most of small towns without of forests in the periurban area it is advisable in the short term to create meadow-parks and hydroparks.

Periurban zones of small towns of the 4th cluster (30% of small towns of the region) need immediate afforestation, namely: Vyshneve, Myronivka, Uzyn, Skvyra, Tetiiv, Yahotyn towns.

4. Conclusions

In the current conditions of global accelerated urbanization, the importance of forming complex eco-oriented landscaping systems of small towns, integrated with periurban areas, is growing.

There are currently no forests in the form of a protective and recreational ring around any small town in the region. According to the similarity of forest provision in periurban areas, clusters have been formed: with average indicators (55% of cities); with relatively better indicators (Vyshhorod, Bucha); with the best situation (Irpin); with the worst values of indicators (Vyshneve, Myronivka, Uzyn, Skvyra, Tetiiv, Yahotyn).

The research results indicate that the priority should be the formation of periurban recreational and protective zones with a predominance of forests around small towns of Kyiv region, which will dramatically improve the environmental situation and contribute to the ecological and social sustainability of urban areas.

The introduction of a comprehensive landscaping system of a small town (identical to the concept of green infrastructure) will allow to move to eco-balanced development planning, cessation of ill-considered urban expansion in the surrounding areas, which is currently taking place in towns nearby to the capital.

Promising green systems of small towns should provide for the creation of periurban protective forests around urban areas with the inclusion of recreational zones, which will have a positive effect on the towns' eco-balance and the well-being of population.

References

Analytical report of the National Institute for Strategic Studies. Ecological component of national security: main indicators and ways to achieve them. Kyiv, 2013.

Bolleter, J., Hooper, P., 2021: The importance of place-based narrative in suburban forest planning. Journal of Urban Design, 26:209–234.

Budnicka-Kosior, J., Janeczko, E., Kwasny, L., Woznicka, M., 2019: Protection of forests in the face of the progressive urbanization process – Jablonna commune case study. SYLWAN, 163:150–157.

Costa, C., Erjavec, I., Mathey, J., 2008: Green spaces – a key resources for urban sustainability The Green-Keys approach for developing green spaces. Urbani Izziv, 19:199–211.

Douglas, I., 2014: The political filter in the local implementation of initiatives relating to urban ecology. Landscape and Urban Planning, 125:312–319.

Grigoriev, V. A., Ogorodnikov, I. A., 2001: Problems of cities' ecologization in the world, Russia and Siberia: Analytical review: GPNTB SB RAS. Novosibirsk, Ecology, 63:152.

Huzui, A. E., Călin, I., Pătru-Stupariu, I., 2012: Spatial Pattern Analyses of Landscape using Multi-Temporal Data Sources. Procedia Environmental Sciences, 14:98–110.

Fernández-Pablos, E., Verdú-Vázquez, A., López-Zaldívar, Ó., Lozano-Diez, R. V., 2021: Periurban Areas in the Design of Supra-Municipal Strategies for Urban Green Infrastructures. Forests, 12:626.

Kalfas, D. G., Zagkas, D. T., Dragozi, E. I., Zagkas, T. D., 2020: Estimating value of the ecosystem services in the urban and peri-urban green of a town Florina-Greece, using the CVM. International Journal of Sustainable Development & World Ecology, 27:310–321.

Klimenko, M. O., Prischepa, A. M., Brezhitskaya, O. A., 2013: Selection of indicators of sustainable development to assess the ecological status of urban ecosystems. Proceedings of the II All-Ukrainian Congress of Ecologists with International Participation, November 17, p. 221–224.

Konijnendijk, C., 2008: The forest and the city: The cultural landscape of urban woodland. https://www.springer.com/gp/book/9781402083709

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.

Kruglyak, V. V., 2013: Adaptive greening systems for settlements in the central black earth region. [Thesis abstract]. GNU VNIALMI. (in Russian)

Liu, L., 2008: Status and prospects for urban green structure planning in China: Weihai city as a case study. (Research No. 41–2008; No. 302). Forest & Landscape University of Copenhagen.

Manes, F., Marando, F., Capotorti, G., Blasi, C., Salvatori, E., Fusaro, L. et al., 2016: Regulating Ecosystem Services of forests in ten Italian Metropolitan Cities: Air quality improvement by PM 10 and O 3 removal. Ecological Indicators, 67:425–440.

Melichar, J., Kaprová, K., 2013: Revealing preferences of Prague's homebuyers toward greenery amenities: The empirical evidence of distance-size effect. Landscape and Urban Planning, 109:56–66.

Murgante, B., Casas, G. L., Danese, M., 2008: The periurban city: Geo-statistical methods for its definition. Proceedings Paper Meeting Annual Symposium of the Urban-Data-Management-Society Stuttgart, Urban and regional data management. Germany, p. 473–483.

Nazaruk, M. M., Zhuk, Yu, I., 2014: Algorithm of socio-ecological research of small towns. Scientific notes of Ternopil National Pedagogical University named after V. Hnatyuka, 1:8–15.

Onishchak, O. V., Korol, O. Yu., Radchenko, O. V., Adamenko, T. I., Antoshchuk, M. L., Babichenko, V. M., et al., 2009: Comprehensive atlas of Kyiv region. DNVP Cartography.

Pylypenko, O. I., Yukhnovskyi, V. Yu., Urlyiuk, Yu. S. et al., 2004: Methodological bases and research methods in protective afforestation. Scientific Bulletin of National Agricultural University, 72:242–250.

Podorozhko, N. O., 2006: Assessment of the structure of the natural framework of the administrative region and the administrative center (On the example of Kyiv region and the city of Kyiv). Proceedings of the International Scientific Conference of Students and Postgraduates, dedicated to the 155th anniversary of the outstanding researcher of the Dnieper VO Domgera, 3:44–47.

Poltavets, A. M., 2013: Current issues of preserving the recreational potential of Kyiv region. Bulletin of Sumy National Agrarian University, 6:162–166.

Potayev, G. A., 2009: Environmental Renovation of Cities: Monograph. Minsk: BNTU, 173 p.

Safroshkin, Yu. V., 1991: Ecopolis is our future. Fundamentals of the concept of harmonious lower cells of the settlement of the noosphere (Report on exploratory research). Moscow-Ulyanovsk.

Sevianu, E., Maloș, C. V., Arghiuș, V., Brișan, N., Bădărău, A. S., Moga, M. C.et al., 2021: Mainstreaming Ecosystem Services and Biodiversity in Peri-Urban Forest Park Creation: Experience From Eastern Europe. Frontiers in Environmental Science, 9:618217.

Shevchenko, O. V., 2015: Ecological and economic condition of agricultural land use in Kyiv region. Economics and Ecology of Land Use, 2:90–100.

Szczepanska, A., Senetra, A., 2019: Forests as the Key Component of Green Belts Surrounding Urban Areas. Baltic Forestry, 25:141–151.

Tyrväinen, L., Pauleit, S., Seeland, K., de Vries, S., 2005: Benefits and Uses of Urban Forests and Trees. Urban Forests and Trees, Dordrecht, Springer, p. 81–114.

Tyrväinen, L., Ojala, A., Neuvonen, M., Borodulin, K., Lanki, T., 2019: Effets bénéfiques de la forêt sur la santé et le bien-être. L'expérience de la recherche finlandaise. Santé Publique, S1(HS), 249.

Van Herzele, A., Wiedemann, T., 2003: A monitoring tool for the provision of accessible and attractive urban green spaces. Landscape and Urban Planning, 63:109–126.

Verdú-Vázquez, A., Fernández-Pablos, E., Lozano-Diez, R. V., López-Zaldívar, Ó., 2021: Green space networks as natural infrastructures in PERI-URBAN areas. Urban Ecosystems, 24:187–204.

Vladimirov, V. V., Miuklina, E. M., Yargina, Z. N., 1986: City and landscape. Moscow, Mysl, 238 p.

Yukhnovskyi, V. Yu., Zibtseva, O. V., 2019: Normalization of green space as a component of ecological stability of a town. Journal of Forest Science, 65:428–437.

Yukhnovskyi, V. Yu., Zibtseva, O. V., 2020: Environmental indicators of the balance of the territories of small towns in Kyiv region. Forestry Ideas, 26.1:165–176.

Zhao, Q., Tang, H., Gao, C., Wei, Y., 2020: Evaluation of urban forest landscape health: A case study of the Nanguo Peach Garden, China. IForest – Biogeosciences and Forestry, 13:175–184.

Zibtseva, O. V., 2017: Dynamics of green areas in settlements of Ukraine. Scientific reports of the National University of Life and Environmental Sciences of Ukraine, 4(68).

Zibtseva, O. V., Yukhnovsky, V. Yu., 2019: Analytical assessment of modernized norms of urban landscaping. Bioresources and Nature Management, 11: 131–140.

Zygmunt, R., Gluszak, M., 2015: Forest proximity impact on undeveloped land values: A spatial hedonic study. Forest Policy and Economics, 50:82–89.