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Recreation characteristics of the green zone forests of the Zhytomyr city

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Abstract. Recreation in forests is important for residents of cities, including Zhytomyr. The forests of the city's green zone require a comprehensive assessment to regulate the recreational use of state and municipal forests. In order to analyse the recreational indicators of the forests of the green zone of Zhytomyr, a comparative analysis of forest management data of landscape mensuration was carried out and compared with the results of our own field research. To analyse the recreational indicators, the forest management database, materials of previous field studies, as well as electronic mapping materials and a geographic information system were used. According to the forest management data, the spatial structure of the forest park area is far from optimal due to the small share of open and semi-open landscape types. The existing functional zoning in most areas does not correspond to the actual recreational use of the territory. There are areas with intensive visits that are not classified as forest parks and do not have landscape mensuration data, although they have a high level of improvement. In terms of walkability, sustainability, aesthetic and integrated assessment, the forest park areas demonstrate mostly mediocre results. The recreational digression of the vast majority of sites is insignificant. Some plots have the necessary indicators for a high additional assessment. The results of the field surveys confirmed the unreliability of some recreational indicators determined by forest management. The largest discrepancy was noted in the determination of walkability, additional and recreational values, which are significantly

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underestimated. In the most visited areas, the actual indicators of recreational digression and aesthetic assessment are lower than those in the forest management materials. Refinement of the data on recreational characteristics of the forest park zone areas allows updating the information on landscape mensuration and developing a comprehensive functional zoning of the territory of suburban forests in Zhytomyr. The results of the study will help state and municipal forestry enterprises to optimize the recreational exploitation of forests within the green zone of the city, rationalize the use of natural resources for recreational purposes, while ensuring environmental sustainability

Keywords: forest parks; landscape mensuration; recreational assessment; digression; sustainability; walkability

Introduction

In the modern world, urbanization is a typical process for the vast majority of countries. The sharp increase in the share of the urban population both abroad and in Ukraine is caused by both economic and social factors (Pauli *et al.*, 2019; Referowska-Chodak, 2019). The growing population of large cities poses challenges not only to improving the infrastructure of suburbs, but also to increasing the area of green space (Zhao *et al.*, 2020). Quite often, the reverse process is observed in large cities, which is a reduction in the area of green zone forests due to the increase in built-up areas at the expense of suburban forests. Due to the desire of numerous people to live in proximity to forests, the "city is constantly advancing on the forest" (Dragun, 2021).

For many large cities in Ukraine, recreation in suburban forests has already been studied. These are mostly cities that are geographically located in the Polissia, Forest-Steppe of Ukraine and the Ukrainian Carpathians. I.R. Kuzyk's (2021) research focused on determining the recreational capacity of the city's complex green zone and calculating the main parameters of intra-city recreational activities. However, these studies were not based on the assessment of landscape mensuration data. A comprehensive study of silvicultural, mensuration, and landscape-recreational indicators of recreational forests in the western part of Ukraine was conducted by N.F. Prykhodko *et al.* (2023). Similar studies were also conducted in the conditions of the Left-Bank Forest-Steppe of Ukraine (Musienko *et al.*, 2020). What these studies have in common is that forest management materials served as the basis for assessing the recreational capacity, developing functional zoning, and studying attendance. Yu.S. Miklush *et al.* (2019) studied recreation in forests, analysing only a specific recreational indicator or a group of them. For example, O.M. Romanets (2020) analysed the relationship between indicators of the aesthetic value of plantations and their taxonomic and phytocoenotic characteristics, which are determined during forest management, in particular, age, sanitary condition and stage of recreational digression, for the green zone of Kyiv. N.Y. Melnychuk & Y.V. Henyk (2019), in the urban ecosystem of Lviv, focused on the study of the relationship between recreational digression and external features of plant communities. However, none of the publications in Ukraine in recent years has analysed the relevance and correctness of forest management information on landscape mensuration.

A number of recreational indicators (landscape type, sustainability, additional assessment,

integrated recreational assessment, walkability) are determined by software in forest management. Other indicators (digression, aesthetic assessment) are determined during forest management through direct site surveys and are quite dynamic, as they can be affected by any management measure, natural phenomenon on the site and by recreationists themselves. Therefore, these indicators hypothetically have the highest chances of not matching the forest management data.

The city of Zhytomyr is one of the largest settlements in Ukraine, with significant areas of suburban forests. No one has comprehensively studied the recreational performance of the city's green zone forests. The compilation of landscape mensuration data on the main forest users of the forest park zone would allow us to assess the reliability and relevance of recreational indicators and the existing functional zoning.

After a preliminary inspection of the territory of the green zone of Zhytomyr, doubts arose about the reliability of a number of indicators. This is what led to the analysis of landscape mensuration data and comparison of forest management data with our own field materials. In order to analyse the recreational indicators of the forests of the green zone of Zhytomyr, the following tasks were envisaged:

- compilation of landscape mensuration data by major forest users;
- determination of the area of forest areas with a high level of attendance within the forests of the city's green zone, which are not related to forest parks;
- determination of the reliability and relevance of forest management information in areas with a high level of public access.

Materials and Methods

The materials for the analysis of recreational indicators were forest management data on landscape mensuration of three forestry enterprises: Korosten Forestry and Hunting Enterprise, Berdychiv Forestry Enterprise, and subsidiary Puliny Forestry of the Agro-Industrial Complex (AIC). The survey was conducted in June-August 2023. The forest management information was obtained and analysed using the Ukrainian State Project Forest Management Manufacturing Association of the Production Association (PA) "Ukrderzhlisproekt" (n.d.) using SQL Server, "Forest Planner" (software solution for managing the forest fund of the enterprise) and Geoportal "Forests of Ukraine" (n.d.) in accordance with the current instructions (Instruction for forest management…, 2006). All areas of the forestry fund that belong to the green zone of Zhytomyr were taken into account. The database information was filtered by grouping the areas of the forest park zone plots by 7 main recreational indicators: landscape type, recreational digression, sustainability, walkability, aesthetic, supplementary and recreational values.

In order to verify the reliability of forest management data on landscape mensuration of forest owners of the Zhytomyr forest park zone, field studies were specially conducted at 20 sites using the same methods (Vozniak & Fukarevich, 2000) (Table 1).

Table 1. General characteristics of research objects

No sample plot	Forestry, No compartment and subcompartment	Coordinates	Mensuration characteristics of the site (stand composition, age, site conditions)	Feature
1	Levkiv, 16, 12	50.23236, 28.8681	100% birch, 57 years old, fresh poor	Landscaping elements
2	Levkiv, 17, 9	50.23446, 28.87315	100% pine, 114 years old, fresh fairly poor	Near the source of drinking water

Table 1, Continued

No sample plot	Forestry, No compartment and subcompartment	Coordinates	Mensuration characteristics of the site (stand composition, age, site conditions)	Feature
3	Levkiv, 16, 8	50.23341, 28.8618	100% pine, 79 years old, fresh fairly poor	There are berries
4	Zhytomyr, 13,13	50.26505, 28.86039	100% alder, 32 years old, wet fairly rich	There is a waterfall nearby
5	Levkiv, 87, 14	50.19222, 28.86381	100% pine, 64 years old, fresh fairly poor	Near the quarry
6	Stanyshivka, 20, 2	50.28695, 28.8658	100% spruce, 60 years old, fresh fairly rich	Recreational facility with amenities
7	Bohunia, 86, 1	50.28556, 28.59915	100% pine, 63 years old, fresh fairly poor	There is a monument
8	Bohunia, 74, 14	50.28077, 28.59777	100% pine, 102 years old, fresh fairly poor	Next to the building of the city
9	Bohunia, 75, 10	50.277, 28.58268	60% oak 40% pine, 109 years old, moist fairly rich	Near the sanatorium
10	Zhytomyr, 17,35	50.19572, 28.70804	50% pine 30% birch 10% acacia 10% willow, 28 years old, moist fairly poor	Landscaping elements, near the lake
11	Bohunia, 71, 2	50.29548, 28.63774	100% pine, 92 years old, fresh fairly rich	Near the quarry
12	Bohunia, 64, 9	50.29008, 28.60534	100% acacia, 70 years old, fresh fairly poor	Next to the quarry, landscaping elements
13	Korbutivka, 12, 19	50.24335, 28.60759	100% pine, 112 years old, fresh fairly rich	Near the pond
14	Korbutivka, 13, 10	50.23695, 28.58891	90% pine 10 % oak, 112 years old, fresh fairly rich	Next to the building of the city
15	Trigyria, 1, 4	50.21064, 28.36312	50% oak 50 % hornbeam, 188 years old, fresh fairly rich	Recreational facility with amenities
16	Trigyria, 6, 9	50.20095, 28.3863	70% pine 30 % oak, 168 years old, fresh fairly rich	There is a natural monument, next to the river
17	Trigyria, 6, 10	50.20284, 28.39031	1st storey 100% oak / 2nd 100 % hornbeam, 188 years old, fresh fairly rich	There is a monument
18	Zarichany, 10, 2	50.21893, 28.61791	70% pine 30 % oak, 132 years old, moist fairly rich	Existing landscaping elements, next to the river
19	Zarichany, 12, 2	50.22576, 28.6495	100% pine, 85 years old, fresh fairly rich	Next to the building of the city
20	Stanyshivka, 38, 5	50.18313, 28.70709	100% pine, 89 years old, fresh fairly poor	Existing landscaping elements, next to the river

Source: developed by authors

The study sites are popular among recreationalists and are representative of the area of the three enterprises and cover the entire suburban area of Zhytomyr.

The indicator of walkability was determined using the electronic mapping resources of Google and the Geoportal "Forests of Ukraine" (n.d.). Recreational digression was

determined by determining the percentage of disturbed area to the total area of the allotment on linear transects that were laid out diagonally across the plots in two opposite directions. The research was carried out in compliance with all the standards approved by the Convention on Biological Diversity (1992) and the Convention on the Trade in Endangered Species of Wild Fauna and Flora (1973).

Results and Discussion

The length of the forests of the green zone of Zhytomyr city from the west (extreme point – massifs north of the Buky (50.21158, 28.36038) to the east (extreme point – massifs south of the Kmytiv (50.28761, 28.89189) is about 38 km. From south to north, the length of suburban forests is about 23 km. The northernmost point (50.36228, 28.6701) is east of the Pischanka, the southernmost point (50.15887, 28.70331) north of the village Horodishche. The total area of the territory where the forest massifs of the forest park part of the green zone of the Zhytomyr city are located is about 87 thousand hectares. The forest coverage of this territory is about 53%.

As of 2023, the area of the forest park part of the green zone forests, where landscape mensuration has been completed, is 14.08 thousand hectares, of which almost 10.46 thousand hectares belong to the branch "Korosten Forestry and Hunting Enterprise", 2.29 thousand hectares belong to the branch "Berdychiv Forestry Enterprise" and 1.34 thousand ha – to the subsidiary "Pulyny AIC Forestry". It is worth noting that in addition to this territory, more than 2 thousand hectares of forests of other owners are used for recreational purposes both within the city and in the suburban zone. Also, significant areas of forests of different owners were discovered, in which it would be worthwhile to revise the purpose, taking into account their recreational load and location in relation to the Zhytomyr city. About 0.73 thousand ha of forest plantations were found within the "Korosten Forestry and Hunting Enterprise" (Trighirya Forestry, forestry part), 0.26 thousand ha in the "Korostyshiv Forestry Enterprise" (Korostyshiv Forestry, protective forests) and about 0.08 thousand ha in the subsidiary "Pulyny AIC Forestry" (Zhytomyr Forestry, forestry part).

According to forest management data, more than 14,000 hectares of the three forest owners were surveyed during the landscape mensuration in the forest park part of the green zone forests. The distribution of the forest fund of forest parks by landscape types indicates a significant predominance of closed types of space in all three enterprises (83-92%). Considering that the optimal share of closed landscapes for the region is 55-65%, it is necessary to state the need for further optimization of the spatial structure due to the increase of semi-open and open landscapes through landscape felling. Currently, the share of open spaces in the forest fund is 5-7% instead of the optimal 15-25%. The situation is similar with semi-open types of landscapes: their actual share is 3-10% against the optimal 15-25% (Table 2). The closest to the optimal spatial structure are the suburban forests owned by the "Berdychiv Forestry Enterprise" branch.

Table 2. Distribution of areas of forest parks in Zhytomyr by types of landscapes, ha

Type of landscape	Forest owner		
	"Berdychiv Forestry Enterprise"	"Pulyny APC Forestry"	"Korosten Forestry and Hunting Enterprise"
Open spaces without trees	135.8	38.8	405.4
Open spaces with single trees	11.3	30.2	331.7
Open spaces with evenly spaced trees	6.7	-	-

Table 2, Continued

Type of landscape	Forest owner		
	"Berdychiv Forestry Enterprise"	"Pulyny APC Forestry"	"Korosten Forestry and Hunting Enterprise"
Closed spaces – tree stands of horizontal closure	1890.1	1229	8674.5
Semi-open spaces with uneven placement of trees	59.7	19.6	11.9
Semi-open spaces with an even distribution of trees	167	23.9	276.2

Source: developed by authors basing on Ukrainian State Project Forest Management Manufacturing Association of the Production Association "Ukrderzhlisproekt" (n.d)

The distribution of areas according to the stages of recreational digression according to forest management data indicates that the territory within the boundaries of all three enterprises in the vast majority belongs to class 1, which actually identifies the integrity and minimal disturbance of the areas from the actions of recreationists and forest users.

Of the 5 classes of recreational digression in forest parks of the Zhytomyr city, only I-III were detected by forest management (Table 3).

Table 3. Distribution of areas of Zhytomyr forest parks by stages of recreational digression, ha

Stage of recreational digression	Forest owner		
	"Berdychiv Forestry Enterprise"	"Pulyny APC Forestry"	"Korosten Forestry and Hunting Enterprise"
1st stage	2081.1	1272.5	9678
2nd stage	66.6	-	199.4
3rd stage	4.7	-	0.1
Total	2152.4	1272.5	9877.5

Source: developed by authors basing on Ukrainian State Project Forest Management Manufacturing Association of the Production Association "Ukrderzhlisproekt" (n.d)

In the forests of the subsidiary "Pulyny AIC Forestry" no areas with a share of paths and trampled areas of more than 5% were found, and in the rest of the enterprises these areas are scarce ("Berdychiv Forestry Enterprise" branch – 2%, "Korosten Forestry and Hunting Enterprise" branch – 3%). In our opinion, these data will need to be revised, since during the field surveys, several areas were found that have a significant disturbance of the above-ground cover (over 30%), which corresponds to the lower classes of digression.

In contrast to digression, the resistance of forest areas to recreational loads is determined programmatically based on indicators of forest vegetation conditions, the dominant species and category of areas. The predominance of pine and oak forests in the forest stock of suburban forests in fresh and moist fairly poor and fairly rich site conditions (Siruk *et al.*, 2020) led to relatively high and average indicators of resistance, which is confirmed by the fact that the largest areas belong to the 2 and 3 classes of sustainability (Table 4).

Table 4. Distribution of areas of forest parks in the Zhytomyr city by sustainability classes, ha

Sustainability classes	Forest owner		
	"Berdychiv Forestry Enterprise"	"Pulyny APC Forestry"	"Korosten Forestry and Hunting Enterprise"
1st class	1.6	-	224.8
2nd class	1815.3	336.6	4684.1
3rd class	198.4	765.9	4116.1
4th class	132.5	161.4	768.3
5th class	4.6	8.6	84.2
Total	2152.4	1272.5	9877.5

Source: developed by authors basing on Ukrainian State Project Forest Management Manufacturing Association of the Production Association "Ukrderzhlisproekt" (n.d)

The highest sustainability indicators on average were noted in the "Berdychiv Forestry Enterprise" branch – 2.2 class, the lowest – in the subsidiary "Pulyny AIC Forestry" – 2.9 class. Regarding the adequacy of the values of the distribution of areas according to the walkability indicator, which is also determined by forest management by software, there are certain doubts in the data of the distribution of areas for two enterprises. The walkability is determined by the distance of sites from public roads, health facilities, and settlements (Vozniak *et al.*, 2000). During the processing of cartographic materials, it was found that a significant part of the plots of the "Pulyny AIC Forestry" and the "Korosten Forestry and Hunting Enterprise" branch is located in the immediate vicinity of these objects, corresponding to the 1-2 classes of walkability. However, as it is possible to see from Table 5, no plots were found for the 1st and 2nd classes of walkability by forest management within the boundaries of the two mentioned enterprises. This creates an additional need to check the adequacy of the determination of the walkability indicator in general for the suburban forests of Zhytomyr.

Table 5. Distribution of areas of forest parks in Zhytomyr by classes of walkability, ha

Walkability classes	Forest owner		
	"Berdychiv Forestry Enterprise"	"Pulyny APC Forestry"	"Korosten Forestry and Hunting Enterprise"
1st class	961.8	-	-
2nd class	1038.6	-	-
3rd class	152	1272.5	9120.9
4th class	-	-	-
5th class	-	-	756.6
Total	2152.4	1272.5	9877.5

Source: developed by authors basing on Ukrainian State Project Forest Management Manufacturing Association of the Production Association "Ukrderzhlisproekt" (n.d)

According to the aesthetic assessment, which is determined by forest management automatically based on the values of the composition of plantations, age and forest site conditions with correction in nature conditions, the forest parks of Zhytomyr city generally show average results. Areas of the 2nd and 3rd classes of aesthetic assessment predominate (Table 6).

Table 6. Distribution of areas of forest parks in the city of Zhytomyr by classes of aesthetic assessment, ha

Aesthetic assessment classes	Forest owner		
	"Berdychiv Forestry Enterprise"	"Pulyny APC Forestry"	"Korosten Forestry and Hunting Enterprise"
1st class	60.8	15.6	501.8
2nd class	841.1	612.6	5872.4
3rd class	1002	323.9	2578.7
4th class	302.7	223.2	587.1
5th class	79.1	166.2	337.5

Source: developed by authors basing on Ukrainian State Project Forest Management Manufacturing Association of the Production Association "Ukrderzhlisproekt" (n.d)

This is due, firstly, to the predominance of fresh and moist edatopes, secondly, to the dominance of older age groups of forests, and thirdly, to the predominance of the most widespread species of the region in the stands. The highest average class of aesthetic assessment turned out to be in the branch "Korosten Forestry and Hunting Enterprise" – 2.4, and the lowest in "Pulyny AIC Forestry" – 2.9.

Additional assessment is another important recreational indicator. This indicator characterizes the presence of features in the areas that can attract the attention of vacationers. According to forest management data, the indicators of additional assessment in the suburban forests of Zhytomyr are quite low, which is confirmed by the small areas of plots with the presence of noteworthy monuments (Table 7).

Table 7. Distribution of areas of forest parks in Zhytomyr according to indicators of additional assessment, ha

Indicators of additional assessment	Forest owner		
	"Berdychiv Forestry Enterprise"	"Pulyny APC Forestry"	"Korosten Forestry and Hunting Enterprise"
The presence of only noteworthy monuments and landscaping elements	-	-	-
The presence of only noteworthy sights	1.9	-	12.3
The presence of only landscaping elements	-	-	-
Amateur berry picking is possible	182.7	-	165.9
Lack of monuments, landscaping elements and berry trees	1967.7	1272.5	9699.3
Total	2152.3	1272.5	9877.5

Source: developed by authors basing on Ukrainian State Project Forest Management Manufacturing Association of the Production Association "Ukrderzhlisproekt" (n.d)

The "Pulyny AIC Forestry" has the lowest additional assessment of all possible. In the rest of the enterprises, the additional recreational characteristic is slightly higher. There are also doubts about the reliability of the forest management data used to determine the indicators of additional assessment, since only in the territory of the forest park zone of the "Korosten Forestry and Hunting Enterprise" branch there are at least three recreational facilities

with a high level of improvement ("Lisovychok" and "Uzlisia" in Stanyshiv forestry, "Dibrova" in Tryhirske Forestry), which is not reflected in the forest management materials. In addition, there are at least three well-equipped modern recreational sites located in the forestry part of the green zone forests, but they do not have a description of recreational indicators: "Prolisok" in Bereziv Forestry, "Kitove Ozero" in Levkiv Forestry (branch of "Korosten Forestry and Hunting Enterprise" and a recreation centre near Perlyavka village in Zhytomyr Forestry ("Pulyny AIC Forestry").

The recreational assessment is an integrated indicator that summarises the level of aesthetics, accessibility, landscaping and availability of additional facilities.

According to the forest management data, the forest fund of the "Berdychiv Forestry Enterprise" branch has the highest recreational score – 1.7 points, significantly lower than the "Korosten Forestry and Hunting Enterprise" branch – 2.1 points and the "Pulyny AIC Forestry" – 2.3 points.The latter did not have a single site with a high recreational score (Table 8).

Table 8. Distribution of areas of forest parks in Zhytomyr according to recreational assessment, ha

Recreational assessment	Forest owner		
	"Berdychiv Forestry Enterprise"	"Pulyny APC Forestry"	"Korosten Forestry and Hunting Enterprise"
High	775.5	-	497
Average	1329.6	942.6	7564.8
Low	47.3	329.9	1815.7
Total	2152.4	1272.5	9877.5

Source: developed by authors basing on Ukrainian State Project Forest Management Manufacturing Association of the Production Association "Ukrderzhlisproekt" (n.d)

Given that the components of the integrated recreational assessment include three indicators, two of which (walkability and additional assessment) are unreliable according to forest management data, it was assumed that the final indicator could be significantly underestimated for the Korosten Forestry and Hunting Enterprise and the Pulyny AIC Forestry. A comparison of the recreational characteristics obtained as a result of field research on 20 research plots with forest management data revealed certain discrepancies (Table 9).

Table 9. Data of landscape mensuration on experimental sites (own data/forest management)

№ SP*	Type of landscape	Sustainability	Digression	Aesthetic assessment	Walkability	Additional assessment	Recreational assessment
1	semi-open/ closed	4/4	3/1	2/3	1/3	3/5	1/2
2	semi-open/ semi-open	3/3	4/1	3/2	1/3	5/5	2/2
3	closed/ closed	3/3	1/2	2/2	1/3	4/5	1/1
4	closed/ closed	4/4	1/1	5/5	3/3	2/5	2/3
5	closed/ closed	3/4	2/1	2/3	1/3	5/5	1/2

Table 9, Continued

№ SP*	Type of landscape	Sustainability	Digression	Aesthetic assessment	Walkability	Additional assessment	Recreational assessment
6	closed/ closed	3/3	5/1	2/2	1/3	3/5	1/2
7	closed/ closed	3/3	1/1	4/2	1/3	5/5	2/2
8	closed/ closed	3/3	2/1	3/2	1/3	5/5	2/2
9	closed/ closed	2/2	2/1	3/2	1/3	5/5	2/2
10	closed/ closed	2/2	2/1	3/4	1/3	3/5	1/3
11	closed/ closed	2/2	2/1	3/2	1/3	5/5	2/2
12	closed/ closed	3/3	2/1	2/2	1/3	3/5	1/2
13	semi-open/ semi-open	2/2	1/1	2/2	1/1	5/5	1/1
14	semi-open/ semi-open	2/2	2/1	2/4	1/1	5/5	1/2
15	closed/ closed	2/3	2/1	1/1	1/5	1/5	1/2
16	closed/ closed	2/2	2/1	1/1	1/3	2/5	1/2
17	closed/ closed	2/3	2/1	3/3	1/5	3/5	1/3
18	closed/ closed	3/2	2/1	2/3	1/3	1/5	1/2
19	closed/ closed	2/2	1/1	3/3	1/3	5/5	2/2
20	closed/ closed	3/3	3/1	2/2	1/3	3/5	1/2
Difference, %	5	9.1	90.5	20.0	66.7	20.0	50.0

***Note:** SP – sample plot
Source: developed by authors

When determining all 7 recreational indicators, discrepancies with forest management data were noted, which are associated with both the dynamics of individual indicators and software errors in landscape mensuration. The smallest discrepancy was found in determining the landscape type, where only one research plot (sample plot No. 1) was reduced below the closed landscape type limit due to selective sanitary felling. In addition, minor deviations (4 test plots) were noted in determining the indicator of resistance to recreational loads. The difference between the average scores was 20 per cent in the aesthetic assessment, with a difference in data at 10 sites. The aesthetic assessment based on forest management data is generally overestimated. This indicator was adjusted during the field surveys. Taking into account the presence of garbage or clutter in 5 plots lowered this indicator, and the noted attractive features (forest edges, groups of trees) allowed for higher scores in the other 5 plots.

When comparing the average scores of the supplementary assessment, the difference is also insignificant – 20%, but at 11 of the 20 sites, features were identified that allowed for a significant increase in this indicator by 1-4 points during field surveys. In determining the additional score, none of the plots were assessed for berry picking or for the presence of amenities and attractions, which significantly underestimated this recreational indicator. Significant differences were found when determining the digression of the plots. Since the sites surveyed mostly had high rates of visitation, 16 out of 20 sites had a disturbance index that was 1-3 points higher than the forest management data. The biggest mistakes were made by the forest management when establishing the walkability indicator. This indicator was correctly determined only in 3 out of 20 sites, and the underestimation of the indicator was mostly significant – by 2-4 points. A significant difference in the data of the 3 recreational indicators (walkability, aesthetic and additional assessment) significantly affected the integrated recreational assessment. At 13 of the 20 study sites, this indicator was underestimated by 1 grade.

The data analysed in this article confirm the findings of many scientists that landscape inventory materials are the basis for assessing the recreational potential of green zone forests (Edwards *et al.*, 2012). However, as the comparative analysis of recreational indicators in the research plots has shown, some of the forest management data may not be true and need to be corrected. Some scientists do not use landscape mensuration data at all when assessing the recreational functions of a complex green area of a city. For example, I.R. Kuzyk (2021), while conducting research on recreation in the green zone of Ternopil, calculated the main parameters of short, medium and long-distance suburban recreational activities and the recreational capacity of forests in the forest park part without taking into account these forest management data. N.F. Prykhodko *et al.* (2023) concluded that forestry and landscape recreation indicators should be taken as a basis for planning measures for the recreational and health development of an enterprise, taking into account the preferences of the enterprise. In this case, the authors used forest management data from 2012. The analysis of recreational indicators in this article was carried out using 2017 data, but their comparison with 2011 data indicates the identity and lack of dynamics for the parameters determined in the field, which calls into question the correctness of updating forest management information on recreation. The observations made during the field research confirmed that the improvement of individual sites can dramatically change the recreational use of the territory. Scientists from the Ukrainian Research Institute of Forestry and Agroforestry S.I. Musienko *et al.* (2020) believe that the priority should be to improve recreational areas in order to improve aesthetic properties and prevent negative environmental changes in forest ecosystems that would optimise recreational forest use.

As a confirmation of the effectiveness of the current methodology for determining and adjusting the aesthetic assessment used in the field research, O.M. Romanets (2020) concluded that the stage of recreational digression and the aesthetic value of plantations are interdependent. Plantations with better aesthetic qualities are more frequently visited by recreationists and are more heavily impacted, which eventually leads to a deterioration in their sanitary condition, a decrease in species diversity, and a decrease in aesthetic value. Studies of digression at the research sites located near water bodies (SP 5, 10, 11, 16) confirmed the conclusions of both domestic and foreign scientists that the negative effects of recreational nature management are exacerbated by

seasonality and the concentration of recreationists in the most developed park plantations (Olsson, 2013; Melnychuk & Henyk, 2019). The studies of pyrogenic properties of green zone forests by P. van Lierop *et al.* (2015) and C. Ayala-Azcárraga *et al.* (2019), the results of which should be taken into account in the future when studying the sustainability of plantations. According to the current methods, the parameter of stand stability is regulated only by the predominant species, type of forest vegetation conditions and age of the stand. This does not take into account the components of plantations that affect their pyrogenic properties.

One of the key recreational indicators on which the recreational use of suburban forests largely depends is walkability. This indicator in Ukraine needs to be seriously revised, as modern transport proposals have changed significantly. If earlier public transport and cars were considered as transport, now the use of bicycles, ATVs and other off-road vehicles has become very popular. Interesting is the research of Finnish scientists on assessing walkability using the Zonation software (Jalkanen *et al.*, 2020). The approach of these scientists determined the establishment of zones of high recreational potential in different parts of the study area. This allows for the systematic integration of accessibility measures based on travel time by different means of transport.

Conclusions

The conducted geospatial analysis of the studied territory allows us to state that the suburban forests of Zhytomyr are located on the territory of about 87 thousand hectares. The forest cover of this territory is about 53%. Only a little more than 14 thousand hectares of forests are classified as forest parks. On an area of about 1,000 hectares of forests, it would be worth changing the protection category of the sites from the forestry part of the green zone and protective forests to forest parks, due to the high level of recreational use of this area and the need to take measures to optimise recreational use. The owners of suburban forests in Zhytomyr are state-owned and municipal forestry enterprises (88% of the area). About 12% of the area within the city's suburban forests and plantations belong to other owners.

The analysis of recreational indicators revealed the need to further optimise the spatial structure by increasing semi-open and open landscapes through landscape felling of about 30% of the area of closed landscape types. The territory of the forest park zone of Zhytomyr is undisturbed, as evidenced by the prevalence of the 1st class of recreational digression in the vast majority of areas. Resistance of the areas to recreational loads and aesthetic assessment are average. Walkability according to forest management data is mostly average (class 3). The additional assessment is low, with only about 2% of the site areas having features (class 1-4). The integrated recreational assessment of the vast majority of sites is average.

The results of preliminary field studies to determine recreational indicators in the most visited areas showed the unreliability of the programme definition of such indicators as walkability, additional assessment and recreational assessment. A significant underestimation of the results was noted for these indicators. When comparing the values of recreational digression and aesthetic assessment, significant discrepancies were also found between the forest management indicators and our own field studies. On the plots located near populated areas, the presence of garbage was mostly detected, which reduces the aesthetic assessment. In areas with landscaping elements, the actual recreational digression rates are much lower compared to the forest management data. In some cases, the level of soil surface disturbance reaches 70%. It is the results of

the digression study that are key and determine the further prospects for studying the level of attendance of the forest park area in Zhytomyr and developing a plan for the functional zoning of the territory.

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Conflict of Interest

None.

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Рекреаційна характеристика лісів зеленої зони міста Житомира

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Анотація. Рекреація у лісах має важливе значення для мешканців міст, включаючи м. Житомир. Ліси зеленої зони міста потребують проведення комплексної оцінки для врегулювання рекреаційного користування лісами державної та комунальної власності. З метою проведення аналізу рекреаційних показників лісів зеленої зони м. Житомира було проведено порівняльний аналіз лісовпорядних даних ландшафтної таксації та співставлення із результатами власних польових досліджень. Для аналізу рекреаційних показників були використані база даних лісовпорядкування, матеріали попередніх польових досліджень, а також електронні картографічні матеріали та географічна інформаційна система. За даними лісовпорядкування просторова структура ділянок лісопаркової зони далека від оптимальної за рахунок малої частки відкритих і напіввідкритих типів ландшафтів. Наявне функціональне зонування на більшості ділянок не відповідає реальному рекреаційному використанню території. Наявні ділянки з інтенсивним відвідуванням, які не відноситься до лісопарків і не мають даних ландшафтної таксації, хоча мають високий рівень благоустрою. За показниками пішохідної доступності, стійкості, естетичної та інтегрованої оцінки ділянки лісопаркової зони демонструють здебільшого посередні показники. Рекреаційна дигресія переважної більшості ділянок незначна. Невелика кількість ділянок має необхідні показники для високої додаткової оцінки. Результати польових досліджень підтвердили недостовірність деяких рекреаційних показників, визначених лісовпорядкуванням. Найбільша невідповідність даних відмічена при визначенні пішохідної доступності, додаткової та рекреаційна оцінка, які суттєво занижені. У найбільш відвідуваних ділянках реальні показники рекреаційної дегресії та естетична оцінка є нижчими ніж у лісовпорядних матеріалах. Уточнення даних рекреаційної характеристики ділянок лісопаркової зони дозволяє актуалізувати інформацію по ландшафтній таксації та розробити комплексне функціональне зонування території приміських лісів м. Житомира. Результати дослідження допоможуть державним та комунальним лісогосподарським підприємствам оптимізувати рекреаційну експлуатацію лісів у межах зеленої зони міста, раціоналізувати використання природних ресурсів для рекреаційних цілей, забезпечуючи при цьому екологічну стійкість

Ключові слова: лісопарки; ландшафтна таксація; рекреаційна оцінка; дигресія; стійкість; пішохідна доступність