CHAPTER 8

THE STATE OF RECREATIONAL OAK PHYTOCENOSES IN CITIES OF SOUTHEASTERN UKRAINE

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INTRODUCTION

In today's society, recreation and the associated improvement of public health are among the most important values. Over the past decades, the role of the tourism and recreation sector has been steadily growing. On the one hand, this is primarily due to the increase in the income level of the population in developed countries, the growth of the educational level, as well as the improvement of transport infrastructure. On the other hand, high levels of urbanization, environmental degradation around large industrial centers, and increased psychological stress caused by the accelerated pace of life are prompting more and more people to seek recreation, tourism, and health improvement in natural settings. The main factors influencing the development of recreation can be divided into four groups: social, demographic, economic, and political[1].

Suburban and urban forests play a significant role in recreational nature use. They contribute to the stabilization of the microclimate in the urban environment, shape the recreational potential of the city, and are a center of biodiversity[2].

In southeastern Ukraine, suburban and urban forests, if they are within city limits, include forest complexes associated with river networks. For the steppe zone, forests are an unusual and unique phenomenon. Ravine forests serve as a venue for recreational activities for city dwellers and tourists, while being subject to significant anthropogenic pressure.

In this regard, the aim of this study is to determine the impact of recreation on the taxonomic indicators and vital condition of common oak (*Quercus robur* L.) trees in natural and artificial plantations and to determine the indicators of recreational load on these biogeocenoses.

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[1] Гакман А. Характеристика розвитку рекреації в Україні. *Педагогика, психология и медико-биологические проблемы физического воспитания и спорта*. 2009. № 8. С. 34–37.

[2] Токарєва О.В. Значення приміських лісів світу та України в контексті сталого розвитку. *Науковий вісник НЛТУ України*. 2004. Вип. 14.5. С. 232–236.

1. Research objects and methods

The objects of the study were urban natural and artificial oak plantations in two large cities in southeastern Ukraine: Zaporizhzhya and Dnipro.

Within the city of Zaporizhzhya, indicators of recreational activities of city residents and tourists in the natural oak forests of the Heneralka and Shyroka ravines located on Khortytsia Island were studied (Fig. 1). The island is located in a mid-steppe subzone with diverse grass, fescue, and feather grass vegetation (southern part of the Ukrainian Steppe).

Fig. 1. Location of the Heneralka (1) and Shyroka (2) ravines on Khortytsia Island, coordinates of the extreme points of the top and mouth of these ravines:

Heneralka – 47°83′06,1″N 35°06′73,5 E; 47°82′67,9 N 35°06′57,8 E

Shyroka – 47°49'23,1″N 35°05'29,2″E; 47°49'04,16 N 35°05'00,24 E

Mapping of the localization of individuals of the pregenerative, generative, and postgenerative fractions of each of the studied cenopopulations of common oak was carried out.

Within the city of Dnipro, the territory of the Tunnelna ravine (also known as the Tunnelna ravine tract) (Fig. 2) was studied. It is located between the residential areas of Peremoha, Sokil, and Topolia-1 (Soborny district of the city).

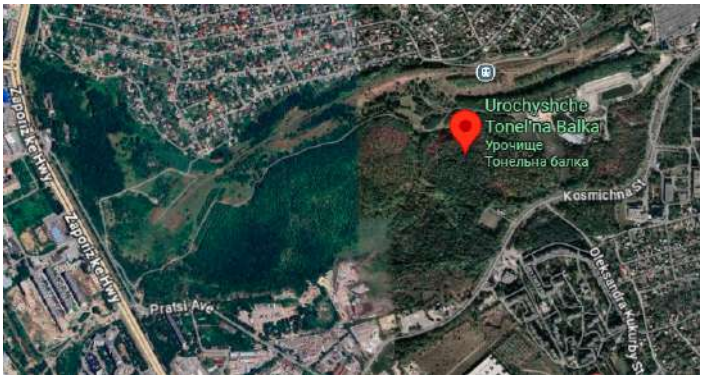

Fig. 2. Location of the Tunelna ravine tract (coordinates of the center of the tract 48°25'01.8"N 35°02'35.7"E)

Fig. 3. Location of the intra-quarter artificial oak plantation in the Topolia-3 residential area (coordinates of the center of the array 48°23'48.0"N 35°01'50.9"E)

We also studied the intra-quarter oak plantation, which serves as a recreational area for residents of nearby houses. Its location is limited by M. Panikakhy Street, V. Barka Street, and Platonov Boulevard, which are located in the Topolia-3 residential area (Shevchenkivskyi District, Dnipro) (Fig. 3).

The height of trees was determined using a Suunto PM–1520 optical altimeter. The diameter of the trunk was measured at a height of 1.3 m using a Codimex S-1 measuring fork.

The average vitality score of individuals by period was determined using the classical methods of Yu.A. Zlobin[3].

The forest stand vitality index was calculated based on the number of trees in accordance with the recommendations of A. V. Alekseev[4],[5] using the following formula:

$$Ln = \frac{100 \cdot n_1 + 70 \cdot n_2 + 40 \cdot n_3 + 5 \cdot n_4}{N} \quad (1)$$

where Ln – the relative vitality of the tree stand, calculated based on the number of trees; n_1 – the number of healthy trees; n_2 – the number of weakened trees; n_3 – the number of severely weakened trees; n_4 – the number of dying trees in the sample area; N – the total number of trees (including deadwood) in the sample area.

If the Ln indicator takes values in the range of 100–80, the condition of the tree stand is assessed as healthy; at 78–50, it is assessed as damaged (weakened); at 49–20, it is assessed as severely damaged (severely weakened); and at 19 and below, it is assessed as completely destroyed.

The aesthetic component of the phytocenosis was determined by V. P. Kucheryavy[6].

The functional assessment of the recreational properties of the forest was carried out in accordance with the recommendations of G. K. Solntsev et al. Research on the recreational impact on the biocenosis of the forest glade was conducted according to the classification of I. L. Trapido. The study of the degree of recreational degradation of the forest was conducted according to R. A. Karpisonova, considering the recommendations of V. M. Ivonin and M. S. Chiriev. When determining the forms of recreational activity, the recommendations of O. I. Tarasov were used. References to the methods of these authors are given in the publication[7]. The standards for the recreational capacity of forest plantations and correlation coefficients were determined

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[3] Yakovlieva-Nosar S., Bessonova V. State of coenopopulations of *Qurcus robur* L. growing in ravines located in the Dnieper river's rapids section (recreation zone of the city of Zaporizhzhya), Ukraine. *Forestry ideas.* 2021. Vol. 27, № 1 (61). P. 256–270.

[4] Бессонова В. П. Методологія і організація наукових досліджень у садово-парковому господарстві: навч. посібник. Київ : Вид-во «Центр учбової літератури», 2025. 264 с.

[5] Бессонова В. П., Яковлєва-Носарь С. О. Таксаційні показники та життєвий стан *Quercus robur* L. за різних лісорослинних умов гирла та середньої частини урочища Яцево (Дніпропетровська область). *Питання степового лісознавства та лісової рекультивації земель*. 2023. Т. 52. С. 3–17.

[6] Кучерявий В. П. Озеленення населених місць. Львів: Світ, 2005. 455 с.

[7] Яковлєва-Носарь С. О. Байрак Генералка в рекреаційній системі м. Запоріжжя. *Питання біоіндикації та екології*. 2018. Вип. 23, № 1. С. 317.

according to DBN 360-92**, Table 5.4[8]. The chemical properties of the soil were studied according to O.V. Dubova et al.[9]

Research into recreational activity and the determination of its indicators was carried out from 2014 to 2024, from May to October inclusive. Every week of every month (on weekdays and weekends), the number of visitors was counted over a certain period of time. The average maximum recreational load was calculated and compared with the maximum permissible load.

Recreational load was calculated using the formulas of A. I. Tarasov[7]:

– recreational density:

$$P_{den} = \text{number of people} / N \text{ (people.–hour)}, \quad (2)$$

where N – the observation time;

– recreational density in the studied area:

$$P_{den} = \text{people–hour} / \text{ha} \quad (3)$$

– recreational attendance:

$$P_{att} = P_{den} \times 8 \text{ hour (people–hour. / ha)} \quad (4)$$

– average annual recreation:

$$P_{ann..\ aver.} = P_{att} \times 365 \text{ (people / ha per year)} \quad (5)$$

– total recreation time per unit area during the accounting period

$$i = TP \text{ (hour. per year / ha)} \quad (6)$$

where:

i – total recreation time per unit area during the accounting period;

T – time spent by vacationers, hours per year (8760);

P – single number of visitors per unit area during the measurement period (people / ha).

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[8] Державні будівельні норми України ДБН 360-92**. Містобудування. Планування і забудова міських та сільських поселень. Київ : Держбуд України, 2002. 136 с. (зі змінами від 1 січня 2014 р.).

[9] Дубова О. В., Пересипкіна Т. М., Полякова І. О., Приступа І. В. Ґрунтознавство: практикум для студентів біологічного факультету спеціальності «Садово-паркове господарство». Запоріжжя : ЗНУ, 2008. 48 с.

– recreational capacity of the site:

$$E = N \cdot S \text{ (people / ha)} \quad (7)$$

where:

E – recreational capacity of the site (people / ha);

N – acceptable recreational load on the territory, leading to stage 3 of degradation (people / ha);

S – area of recreational territory of a certain stability class, ha.

The capacity of the ecological trail was calculated using the formula:

$$P_{dn} = (T - L/V) \cdot G \cdot V \text{ (people / hour.)} \quad (8)$$

where:

T – open route time, hour.;

L – track length, km;

G – density, people / km;

V – speed, km / hour.

The experimental data obtained were processed using mathematical statistics methods[10]

2. The recreational role of natural oak forests

2.1. Heneralka ravine

The Heneralka ravine is a popular recreational location due to its convenient location relative to the road network: it is a 10-15-minute walk from the main highway connecting the left and right banks of the city, and is also close to the Zaporizka Sich railway station. At the mouth of the ravine, there is a natural sandy beach, near which a small tent camp is usually set up in the summer. Nearby, there is a drinking water source located on a rock massif.

The ravine was named after german General Kaiserling, who stayed here during the Russian-Turkish War of 1735-1739. The ravine housed food warehouses, from which he donated food to the local population "out of mercy," as this period was marked by crop failures.

Our previous studies have established that the dendroflora of the Heneralka ravine forest consists of 39 species from 30 genera belonging to 17 families[11]. Until the 1930s, historical sources indicate that common oak trees predominated

[10] Петровська І. Р., Салига Ю. Т., Вудмаска І. В. Статистичні методи в біологічних дослідженнях: навчально-методичний посібник. Київ: Аграрна наука, 2022. 172 с.

[11] Яковлєва-Носарь С. О. Видове різноманіття дендрофлори байрачних лісів (зона рекреації міста Запоріжжя). *Науковий вісник НЛТУ України*. 2022, т.32, № 5. С. 13–18.

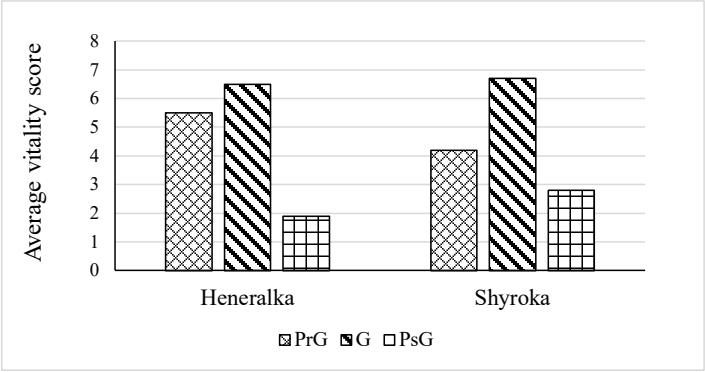
in the tree cover of this ravine. The reduction in their numbers is associated with recreational activities, primarily logging.

Currently, the population of common oak consists of 80 specimens (13.0 % of all woody plants in the ravine), among which juvenile and middle-aged generative individuals prevail (20 and 19 specimens, respectively). As shown in the publication, recreational impact reduces the range of ontogenetic development options for oak, and the options themselves include fewer age states[3].

The average height of mature trees of the studied species is 12.5 m, and the average diameter at a height of 1.3 m is 22.5 cm.

The distribution of individuals by vitality levels is one of the manifestations of morphological heterogeneity of cenopopulations. Plant morphogenesis integrates the level of metabolic processes and, through the morphological status of vegetative and generative organs, informatively characterizes the viability of individuals.

Fig. 4 presents data on the vitality assessment of the following ontogenetic groups of the common oak cenopopulation in the Heneralka ravine as young pre-generative (5.5 points), generative (6.5 points), and post-generative (1.9 points). The vitality assessment allowed this cenopopulation to be classified as healthy, since the vitality index of the tree stand is 89.8 %.



Age periods: PrG – pre-generative, G – generative, PsG – post-generative
Fig. 4. Vitality index of different ontogenetic groups of common oak plants in the Heneralka and Shyroka ravines

[3] Yakovlieva-Nosar S., Bessonova V. State of coenopopulations of *Qurcus robur* L. growing in ravines located in the Dnieper river's rapids section (recreation zone of the city of Zaporizhzhya), Ukraine. *Forestry ideas.* 2021. Vol. 27, № 1 (61). P. 256-270.

The overall assessment of the vitality of the common oak forest in the Heneralka ravine is somewhat reduced by the powdery mildew infestation of some of its self-sown individuals. The trees of the generative age group in this forest look healthy and attract vacationers with the shade cast by their broad crowns and impressive habit. A number of accompanying species grow under the canopy of the main species, including field maple, rough elm, and common ash.

Active recreational activities are carried out in the ravine in the form of transit, horseback riding, hunting, and off-road activities.

A study of the recreational impact on the biocenosis of the forest glade, conducted according to the classification of I. L. Trapido, shows that there are processes of removal of matter and energy beyond its boundaries (collection of spring-flowering ephemeroids, representatives of steppe and granite-petrophytic florocenotic groups, rose hips, hawthorn, terrain, as well as medicinal plants). Mechanical impact has also been identified, which is associated with trampling, campfire decomposition, damage to tree and shrub vegetation, and the scaring away of animals. Recreational users bring organic and inorganic substances into the forest area, such as seeds, food scraps, paper, metal, plastic, etc.

Given the presence of rare herbaceous plant species (*Pulsatilla nigricans*, *Gagea minima*, *Tulipa graniticola*, *Hyacintella leucophaea*, *Iris pumila*, etc.), the diversity of natural dendroflora, and the significant attractiveness of this ravine for vacationers and tourists, there is a need for a detailed study of its natural characteristics and determination of the potential recreational capacity of the territory.

A comprehensive functional assessment of recreational forest landscapes involves considering aesthetic factors, the level of natural comfort, the impact of tree plantations on air quality and purification, and analyzing the technological characteristics and resilience of the ecosystem to anthropogenic impact. When studying the recreational attractiveness of the Heneralka ravine, the technological component can be disregarded, as it primarily concerns the assessment of the suitability of forest areas for economic use by forestry enterprises that organize recreational activities.

It should be noted that the aesthetic assessment of the phytocenosis was carried out according to the classification of V. P. Kucheryavy, and not according to the scale of G. K. Solntsev et al., since the latter was developed for plantings dominated by *Quercus robur*. Instead, the Heneralka forest now includes such native species as *Acer campestre*, *A. tataricum*, *Quercus robur*, *Ulmus carpinifolia*, *U. laevis*, and *Fraxinus excelsior*. The results of the aesthetic assessment are presented in Table 1.

Table 1

Aesthetic properties of the Heneralka ravine phytocenosis

No.	Taxonomic and phytocenotic characteristics	Group within a feature	Number of points
1.	Bonitet	II–III	2
2.	Soil moisture	fresh	3
3.	Relief	hilly	3
4.	The stratification of the main synusia	three-tiered	3
5.	Undergrowth	satisfactory	2
6.	Underbrush	medium density	3
7.	Herbaceous cover	rich (over 50 species)	3
8.	Density of grass cover	thick (projective coverage 75%)	3
9.	Age of the forest stand	ripe crop	3
10.	Density of tree stand	0.6–0.8	2
11.	Cluttered area	insignificant	3
12.	Signs of soil erosion	those present	2
13.	Signs of soil compaction	those present	2
14.	Signs of entomological, phytological, and other diseases	those present	2
Total			36
Integral assessment			2,57

A B

Fig. 5. Aesthetics of the landscapes of the Heneralka ravine: mouth (A), panorama of the Dnieper River from the top of the southeast slope (B)

Our comprehensive functional assessment of the recreational properties of the Heneralka forest area also includes an integrated characteristic of the degree of natural comfort, which is determined as the arithmetic mean of the values shown in Table 2.

Table 2

Natural comfort of the Heneralka forest

No.	Natural comfort indicator	Number of points
1.	Slope steepness	1
2.	Density of undergrowth and underbrush, thousand pieces / ha	4
3.	Natural clutter, number of fallen trees / ha	4
4.	Relief	3
5.	Length of spontaneously formed network of paths, km / ha	5
6.	Distance from recreational area, km	4
7.	Distance from internal roads, min. on foot	4
8.	Availability of drinking water sources	5
9.	Water bodies on the territory (rivers, lakes, streams)	5
Total		35
Integral assessment		3,89

According to a 5-point scale for indirect assessment of the impact of different types of vegetation on atmospheric air quality, the phytocenosis of the Heneralka ravine received 2 points, which corresponds to the category "deciduous vegetation of medium productivity with a fullness of not less than 0.6."

Thus, the Heneralka forest area is characterized by fairly high aesthetic indicators, an adequate level of natural comfort, and pronounced sanitary and hygienic properties.

The current recreational load does not cause significant destruction of trees, therefore there is no significant increase in the illumination of the lower tiers and no weakening of the coenotic influence of edifiers on the grass cover. At the same time, under the combined recreational impact (mechanical damage, which acts as a gateway for diseases affecting trees and shrubs, and soil trampling), there is a decrease in the proportion of forest species and the appearance of weedy plants (*Amaranthus retroflexus*, *Chenopodium album*, *Cannabis ruderalis*, *Lepidium perforatum*, *Geum urbanum*, etc.) is observed.

Along with these changes in the herbaceous layer, there is also an influx of non-native species of forest flora from adjacent erosion control plantings. In particular, *Cotinus coggygria* is actively spreading in the tree stand of the ravine on the northwestern slope from the nearby protective plantation, creating areas of diffuse-type undergrowth and self-seeding. In the steppe areas of the south-eastern slope, *Gleditsia triacanthos* undergrowth grows to a height of 1.8 to 2.4 m. The ravine's vegetation also includes alien plant species that are listed on the European "black list" and are known for their high invasive potential (*Acer negundo*, *Amorpha fruticosa*, *Robinia pseudoacacia*), as well as a species that is recognized as invasive, *Parthenocissus quinquefolia*.

It should be noted that the presence of introduced plant species in natural ecosystems is considered a potential biological hazard. As a signatory to international environmental agreements, Ukraine is obliged to comply with requirements to limit the spread of introduced species and control invasive plants[12],[13].

In order to objectively assess the damage caused by recreational activities to the biogeocenosis of the forest, it is necessary to determine its recreational capacity and calculate the actual recreational load index.

Recreational sustainability is the ability of biogeocenoses to maintain their basic functions and viability under recreational pressure. Its main indicators are permissible recreational pressure – the maximum level of impact at which the biogeocenosis maintains its balance and ability to self-regenerate – and the recreational capacity of the territory, i.e., the maximum number of visitors whose presence does not lead to degradation of the natural environment or cause psychological discomfort[14].

According to R. A. Karpisonova, the recreational load norm for broadleaf forests in the city's green zone is 2.3 people / ha for class I bonitet plantations. For class II bonitet forests, these indicators should be reduced by 10–15 %. In the case of complex terrain, load norms may be adjusted using reduction coefficients. Thus, if the slope reaches 10–20 %, the coefficient is 0.8.

As we established earlier and confirmed by the results of research conducted in 2024, the forest of the Heneralka ravine is in the II stage of recreational degradation.

Our observations showed that on holidays during the warm season, the maximum number of visitors in the ravine was between 20-50 people / ha, and during a two-hour period (from 11:00 a.m. to 1:00 p.m.) – 10–12 people / ha. Thus, the total number of visitors per year exceeds 5800 people, and the average recreational load is 24.6 person-days / ha. A comparison of the theoretically calculated (1.7 persons / ha) and actual (3.4 persons / ha) recreational capacity of the forest indicates that the recreational load on the forest ecosystem of the Heneralka forest is twice as high.

It should be noted that visitors to the ravine usually concentrate in areas of transition between different types of landscapes – forest (closed and semi-closed) and open, as well as between dry land and water bodies (at the mouth

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[12] Конвенція про біологічне різноманіття. Київ : «Вид-во «Мін. охорони навколишнього середовища». 2005. 76 с.

[13] Данчук О. Т., Данчук-Дворецька Т. І. Інтродуковані деревні породи в умовах природоохоронних територій: ризики та проблеми. *Науковий вісник НЛТУ України.* 2016. Вип. 26.7. С. 49–56.

[14] Бондарець Д. С. Розрахунок рекреаційної ємності лісових насаджень на прикладі Запорізької області. *Географія та туризм.* 2012. Вип. 23. С. 327–335.

of the ravine). This spatial and functional behavior of recreationists is driven by a desire to diversify their experiences and observe contrasting natural forms. When choosing places to relax, preference is given to meadows and the banks of the Dnieper River, which provide better visual conditions and a feeling of space.

Fourteen fire sites were recorded in the ravine, most of which were concentrated on its southeastern side (7 sites) and at its mouth (5 sites) (Fig. 6, A). Traces of recreational activities were found at the mouth of the ravine: fallen dead trees placed across the channel (Fig. 6, B), as well as campfire sites surrounded by stones. Signs of mechanical damage were observed on some *Ulmus laevis* trees and *Crataegus monogyna* bushes.

A B

Fig. 6. Consequences of recreational activities in the Heneralka ravine near its mouth

Prolonged active anthropogenic pressure leads to changes in all components of the biogeocenosis. In particular, compaction, destruction, and removal of forest litter beyond the trampled areas are observed, with the upper loose layer being the most damaged. Our previous article discusses the results of a study of the condition and properties of the forest litter of the Heneralka ravine[15]. There is no litter on the paths of this ravine, only fresh litterfall.

The recreational digression of the biogeocenosis of the forest is also accompanied by changes in the chemical properties of the soil (Table 3). In its upper layer (0–5 cm) on forest paths, the content of humus and carbon decreases

[15] Яковлєва-Носарь С. О. Морфолого-фракційна характеристика підстилки байраку Генералка. *Вісник Запорізького національного університету*. Серія Біологічні науки. Запоріжжя: ЗНУ. 2008. № 2. С. 189–194.

compared to the conditional control (northwest-facing slope), where the level of recreational load is lower due to the greater steepness of the relief and the presence of blackthorn thickets. Less pronounced changes in these indicators are observed in the valley floor, which is probably due to erosion processes.

Table 3

Chemical indicators of the upper (0–5 cm) soil layer

Indicators	Trial areas		
	southeast slope (control)	thalweg	northwestern slope
Humus content, %	15,2±0,12	8,8±0,06***	7,7±0,29***
t_d	–	49,2	24,2
Carbon content, %	4,4±0,35	2,5±0,02***	2,2±0,09***
t_d	–	5,43	6,1
Hydrolytic acidity, mmol eq./100g	0,69±0,003	1,56±0,008***	0,42±0,003***
t_d	–	102,4	6,42
pH (H_2O)	7,49	7,11	7,73

*Note. *** – differences between options are significant when P< 0,001*

There is a hypothesis about the tendency for soil alkalization in the event of increased recreational load. In particular, researchers note a shift in the reaction of the soil environment in the upper layer from slightly acidic to neutral or from neutral to slightly alkaline with an increase in the intensity of recreational impact on forest park and park plantings in urban ecosystems in western Ukraine[16].

A similar pattern was found when comparing the hydrolytic acidity of soils on slopes with different exposures in the Heneralka ravine. In particular, the pH value of the soil solution on the south-eastern slope is slightly shifted towards alkaline. At the same time, this trend is not observed in the valley floor, although it is this element of the ravine that is subject to the most intense recreational load. In our opinion, this is due to erosion processes and the accumulation of organic matter within this morphological element of the ravine.

Thus, with the increasing intensity of recreational impact on the biogeocenosis of the Heneralka forest, changes in the chemical indicators of the upper (0–5 cm) soil layer occur, in particular, a certain shift in the reaction of the soil solution towards more alkaline values can be traced.

[16] Геник Я. В., Дудин Р. Б., Дида А. П., Марутяк С. Б., Каспрук О. І. Трансформаційні процеси в лісопаркових і паркових насадженнях урбанізованих екосистем Заходу України. *Науковий вісник НЛТУ України*. 2017. Т. 27, № 10. С. 9–15

2.2. Shyroka ravine

The Shyroka ravine has 23 branches, which gave it its second name – Deer Horn. On the slope of the southeastern exposure, there is a sanatorium-preventorium of the titanium-magnesium plant (ZTMP), the territory of which is directly connected to the ravine by stairs. At its mouth, there is a beach called Titan, which has been improved with imported sand. The ravine is used for active recreation in the form of transit, mining, and off-road activities.

According to our research, the dendroflora of the Shyroka ravine is represented by 54 plant species from 43 genera belonging to 26 families[17].

The population of common oak in the Shyroka ravine reaches 321 specimens, of which 263 are full-fledged plants and 58 have turned into so-called "sticks," which is explained by the lack of light for the development of young specimens under the canopy of parent trees.

The average height of generative individuals is 12.0 m, and the trunk diameter is 32.0 cm.

Figure 7 shows the vitality index values for different age groups (pre-generative, generative, and post-generative) of common oak plants in the Shyroka ravine. As evidenced by a comparative analysis of the results obtained, young specimens of the main species in this ravine have a lower vitality level than in the Heneralka ravine (4.2 and 5.5 points, respectively). This is probably due to the very active pre-war recreational activities of sanatorium-preventorium visitors and tourists, which led to soil compaction, deterioration of its aeration and water regime, and had a negative impact on the self-seeding of this species. Weakened young oaks are affected by powdery mildew fungi (Fig. 7). Generative individuals of this plant species in both ravines have almost identical vitality indicators (6.5 and 6.7 points). Post-generative (aging) oak plants in the Shyroka ravine are in better condition (2.8 points versus 1.9 in the Heneralka ravine). The Shyroka ravine has a larger area and many glades compared to the Heneralka ravine. Some post-generative specimens of this main species simply did not fall within the sphere of human activity.

The vitality assessment allowed the oak population in the Shyroka ravine to be classified as healthy, as the tree stand vitality index is 92.3 %.

The dendroflora of the Shyroka ravine forest also includes introduced tree species. The largest share of these are North American species (11 species, or 39.3 % of all exotic species). The most common among the introduced species are *Amorpha fruticosa*, *Robinia pseudoacacia*, *Morus alba*, and *Celtis occidentalis*. The tree stand includes *Robinia pseudoacacia*, which migrated

[17] Яковлєва-Носарь С. О., Бессонова В. П. Дендрофлора балки Широка (острів Хортиця). *Науковий вісник НЛТУ України*. 2018, т. 28, № 2. С. 26–30.

into the phytocenosis from the surrounding protective plantings, which also include *Gleditsia triacanthos*. Its individual specimens have also spread to the forest plantations. The non-forest vegetation is represented by one species (*Parthenocissus quinquifolia*).

A B

Fig. 7. Healthy (A) and powdery mildew-infected (B) self-sown common oak

A number of tree species are decorative and used in landscaping. The presence of these plants in the surveyed area is due to their use in decorating the recreation facility. As already mentioned, this facility is connected to the central valley by stairs, along which ornamental plants (*Thuja orientalis*, *Syringa vulgaris*, *Spiraea vanhouttei*, *Lonicera tatarica*) are planted. In the natural planting of the central part of the ravine, which is often visited by vacationers, there are single specimens of *Thuja orientalis*, *Acer saccharinum*, and *Philadelphus coronaries*. In the dendroflora of the ravine's forest, the proportion of native species is 48.1 %, and introduced species is 51.9 %.

We conducted an aesthetic assessment of the Shyroka ravine phytocenosis, the results of which indicate that it differs from the previous ravine only in terms of “bonitet.” Since the Shyroka ravine has a bonitet of I, this taxonomic-phytocenotic feature was rated at 3 points. As a result, the integrated assessment of aesthetic properties was 2.64 points.

The functional assessment of the recreational characteristics of the territory includes an analysis of natural comfort. Table 4 presents the results of the work carried out in this context. It turned out that the natural comfort of the territory of the ravine forests of both ravines received similar values: Shyroka has 3.67 points, Heneralka has 3.89 points. On the one hand, Shyroka has a number of advantages for vacationers: gentler slopes and natural clutter. Another positive factor from the point of view of vacationers is the closer location of

their accommodation (the ZTMP recreation center) on the south-eastern slope, compared to the Heneralka ravine. On the other hand, there are also factors that lower the overall assessment of natural comfort within the Shyroka ravine: greater density of undergrowth and brushwood in parts of the forest remote from the sanatorium-preventorium (in pre-war times, regular clearing measures were carried out in areas close to it), as well as the absence of a source of drinking water.

Table 4

Natural comfort of the Shyroka forest

No.	Natural comfort indicators	Number of points
1.	Slope steepness	2
2.	Density of undergrowth and underbrush, thousand pieces / ha	3
3.	Natural clutter, number of fallen trees / ha	5
4.	Relief	3
5.	Length of spontaneously formed network of paths, km / ha	5
6.	Distance from recreational area, km	5
7.	Distance from internal roads, min. on foot	4
8.	Availability of drinking water sources	1
9.	Water bodies on the territory (rivers, lakes, streams)	5
Total		33
Integral assessment		3,67

There used to be an asphalt path above the top of the ravine, which was used by visitors to the sanatorium and tourists. Now it is in rather poor condition: its surface is covered with potholes, it is half-ruined and heavily overgrown with vegetation. The most active recreational activities take place in the part of the ravine adjacent to the recreation center. The main trail runs from the top of the ravine, which can be reached by car from the highway, to the mouth, where there is a sandy beach. On both sides of this trail, there are numerous cases of broken branches of bushes and young trees. On the beach, vacationers sunbathe, swim, and build bonfires near the slopes of the southeast and northwest exposures to cook meat dishes. Natural wood waste is collected for burning. A network of paths has been laid out in the main valley, with a total area not exceeding 10 % of the ravine's territory. Thus, it is in the thalweg and the mouth of the central part of the ravine that traces of intensive recreational activity are present: places where fires have been lit, traces of mechanical damage to trees, areas of loosened soil, and a spontaneous garbage dump (Fig. 8).

As we established earlier, and as confirmed by the results of research conducted in 2024, the Shyroka ravine forest is in stage II of recreational degradation.

Fig. 8. Traces of recreational activity in the main thalweg of the Shyroka ravine

To assess the impact of recreation on the biogeocenosis of the Shyroka ravine, we determined the following two indicators: its recreational capacity and actual recreational load.

Our observations showed that before the start of full-scale military operations during the warm season holidays, the maximum number of vacationers in the ravine was 30 to 55–60 people/ha, and during a two-hour period (from 11:00 a.m. to 1:00 p.m.) – 20–30 people/ha. Thus, the total number of visitors per year exceeds 8700 people, and the average recreational load is 36.7 person-days/ha. A comparison of the theoretically calculated (1.7 persons/ha) and actual (5.1 persons/ha) recreational capacity of the forest indicates that the recreational load on the forest ecosystem of the Shyroka ravine exceeds the theoretical capacity by a factor of three. At the same time, as noted above, it is distributed unevenly – the central thalweg and mouth are under the greatest pressure, while the areas remote from the recreation facility are rarely visited by vacationers.

Conclusions

1. The studied natural oak forest stands are an arena for intensive recreational activities of city dwellers and tourists. These activities are carried out mainly in transit, off-road, and hunting forms, and in the Heneralka ravine, also in the form of cattle grazing.

2. Basic indicators such as the height and diameter of common oak tree trunks have been determined. Both stands of the main species are classified as healthy: the vitality index in the Heneralka ravine is estimated at 89.8 %, and in the Shyroka ravine at 92.3 %.

3. A comprehensive functional assessment of the recreational characteristics of the Heneralka and Shyroka ravines was carried out, covering aesthetic aspects,

the level of natural comfort, and the impact of ravine forest plantations on air quality. At this stage, the overall indicators for these parameters remain quite high.

4. In the Heneralka ravine, there is intensive penetration of woody plants and weedy herbaceous plants (*Amaranthus retrophlexus*, *Cannabis ruderalis*, *Lepidium perforatum*, *Chenopodium album*, *Geum urbanum*, etc.), as well as the spread of alien (*Cotynus coggigria*, *Gleditsia triacanthos*) and invasive representatives of dendroflora (*Acer negundo*, *Robinia pseudoacacia*, *Amorpha fruticosa*, *Parthenocassus quinquifolia*). The presence of introduced woody plants in the Shyroka ravine is mainly associated with the introduction of decorative elements for visitors to the sanatorium-preventorium. At the same time, the forest flora includes species with high invasive potential (*Acer negundo*, *Amorpha fruticosa*, *Robinia pseudoacacia*) and a species that is recognized as invasive (*Parthenocissus quinquifolia*). Currently, their numbers are still small, but in the future, they may pose a threat to the biological diversity of the forest.

5. The permissible recreational load (1.7 persons/ha) was determined and its actual levels were established (3.4 persons/ha in the Heneralka ravine, 5.1 persons/ha in the Shyroka ravine).

6. The degradation of the Heneralka ravine biogeocenosis under the influence of recreational activities is accompanied by a decrease in humus content in the upper (0–5 cm) soil layer and shows a tendency toward a shift in the soil solution reaction toward alkalinity. No clearly expressed changes in chemical indicators are observed in the thalweg.

3. The recreational role of artificial oak plantations

3.1. Tunelna ravine

The Tunelna ravine is a recreational area primarily for residents of the surrounding residential areas – Topolia-1, Sokil, and Peremoha. To this day, 85 % of it consists of natural forest, meadow, and steppe landscapes. In 2004, the Lavina ski resort was built on the territory of the ravine.

Recreational activities within the tract are carried out in the following forms: road, off-road, gathering, camping, and transportation. These include walking along paths, trails, and off-trail; picking flowers and fruits, picnicking, camping; riding bicycles, motorcycles, and buggies. There are special places for recreation in the tract (Fig. 9, A), but since there are few of them, vacationers scatter chaotically throughout the ravine. Traces of campfires often remain in the places where they stay (Fig. 9, B).

In addition, the meadow vegetation of the ravine and the natural regeneration of woody plants are subject to trampling and browsing by grazing horses and goats (Fig. 10). This also affects the structure and physicochemical properties of the soil.

A B

Fig. 9. A specially designated place for rest (A) and traces of a campfire (B) under a tent in an oak forest

Fig. 10. Active grazing of domestic animals in Tunelna ravine

The oak plantations of Tunelna ravine are artificial, created by forest cultivation in 1961.

Our published article[18] examines the taxonomic indicators and vitality of these plantations. The authors found that on the northern slope of the ravine, there are currently 301 trees growing in a row plantation (the total length of the rows on the site is 2.7 km), and 357 trees in the thalweg (the length of the rows in this variant is 2.9 km) (Fig. 11).

[18] Бессонова В. П., Іванченко О. Є., Журбенко Є. І. Таксаційні показники та життєвий стан дуба звичайного *Quercus robur* L. у різних лісорослинних умовах в урочищі Тунельна балка (м. Дніпро). *Питання степового лісознавства та лісової рекультивації земель*. 2022. т. 51. С. 3–16.

An analysis of the distribution of common oak trees growing on slopes in dry conditions, by height class, shows that they predominate in the range of 14.1–16.0 m (89 trees, or 29.6 % of the total number of trees on the slope) and 12.1–14.0 m (74 trees, or 24.6 %). In the thalweg, plants of the same classes also predominate in height: 90 trees (25.2 %) and 71 trees (19.9 %), respectively.


A B

Fig. 11. Planting of common oak in the thalweg (A) and on a north-facing slope (B)

The size range of common oak trees growing on the slope, based on trunk diameter, indicates a predominance of trees in the 34.1–38.0 cm thickness class (132 trees, or 43.9 % of the total number of trees in this variant). In the more humid conditions of the valley floor, the maximum number of trees is found in two classes: also 34.1–38.0 cm (99 trees, or 26.7 %) and 42.1–46.0 cm (87 trees, or 24.4 % of the total number of oak trees in the thalweg).

Assessment of the vitality of artificial oak plantations allowed them to be classified as healthy. Thus, the vitality index of the tree stand on the northern slope is 88.0 %, and in the thalweg – 91.0 %.

Thus, the common oak trees in the artificial plantation of the Tunelna ravine tract are tall, spreading trees that attract with their beauty, create shade in hot weather, and invite visitors to stroll beneath their canopy. Most of them are classified as “healthy,” which allows these plantations to effectively perform their ecological and recreational functions.

As can be seen from the above, oak plantations on the beam are subject to intensive recreational use. We have determined its main characteristics – theoretical (maximum possible) and actual (Table 5).

Table 5

Characteristics of recreational activities in the common oak plantation of the Tunelna ravine

Indicators	Value			
	Theoretical*		Actual	
	Thalweg	Slope	Thalweg	Slope
E (people / ha)	20,0	14,0	11,0 ± 0,46	18,0 ± 0,52
P_{att} (people–hour. / ha)	85,0	85,0	48,0	112,0
$P_{ann.aver}$ (people / ha per year)	31 025	31 025	17 520	40 880
i (hour. per year / ha)	92 856	92 856	52 560	122 640

*Note: * – maximum possible theoretical value*

As can be seen from the data presented, the recreational load in the thalweg is less than the maximum permissible, therefore it does not lead to soil degradation. On the slope, under drier microclimatic conditions, the recreational density exceeds the maximum permissible values by 28.6 %. Both the actual and theoretically calculated maximum recreational load in both areas exceed the maximum permissible value, which, according to[19], is 10.6 person-hours/ha. As a result, there is a disturbance of the grass cover, which can lead to a deterioration in the water regime and physical characteristics of the soil. The capacity of the ecological trail in the valley is 4 people / hour, on the slope – 2 people/hour. The length of the trail in the valley is 2.7 km, on the slope – 3 km, which in both cases does not exceed the norm. The standard length of an ecological trail is 2–3 km[20].

The actual average annual recreation value on the slope is 1.77 times higher than that in the thalweg, and the maximum average annual value is 1.32 times higher. This is due to the less comfortable microclimatic conditions in the thalweg (groundwater reaching the surface, increased soil and air humidity).

Therefore, active recreation and livestock grazing have a negative impact on the condition of oak plantations, especially on the formation of ground cover and the natural regeneration of woody plants. Soil compaction is observed, the density of undergrowth and shrubs is reduced, and as a result of trampling, undergrowth is slowly recovering.

3.2. Oak plantation in the Topolia-3 residential area

The studied intra-quarter oak plantation consists of 64 specimens of this species (Fig. 12).

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[19] Шлапак А. В. Методика і норми рекреаційного навантаження на луки, болота та ґрунти і ліси прибережних акваторій природно-заповідного фонду. Умань: Дендропарк «Софіївка», 2003. 12 с.

[20] Дідух Я. П., Єрмоленко В. М., Крижанівська О. Т. та ін. «Екологічна стежка» (методика, організація, характеристика модельної стежки). Київ : Фітосоціоцентр, 2000. 88 с.

Analysis of the distribution of trees by height classes shows a numerical predominance of specimens ranging from 10.0 to 12.0 m in height (23 specimens). Slightly fewer trees are in the 8.1–10.0 m class (20 trees). The smallest number (1 tree each) was found in the 4.1–6.0, 16.1–18.1, and 18.1–20.0 m height classes.

The dimensional distribution of common oak trees by thickness showed the largest number in the 36.1–40.0 cm (12 trees) and 44.1–48.0 cm (11 trees) classes. The smallest number of trees were thin (class 16.1–20.0 cm) and thick (with a diameter of more than 52.0 cm). No trees with a thickness of less than 16.1 cm were found in the plantation.

Fig. 12. Oak plantation in the Topolia-3 residential area

We classified the oak plantation under study as “healthy” because its calculated vitality index was 91.4.

This stand is characterized by certain features that are attractive to recreationists. It can be called an artificial forest in the middle of a residential area, where road and off-road recreational activities can be carried out. Tiled paths and a well-trodden trail run through the plantations.

Table 6 presents the theoretical maximum possible and actual indicators representing the level of recreational activity of residents of the Topolia-3 housing estate. These are mainly residents of buildings Nos. 3, 4, and 65, whose entrances open onto the space between buildings, where the studied common oak trees grow. The entrances to buildings No. 1 and No. 2 face Panikakhy Street and Platonov Boulevard, respectively, so when working residents commute in the morning and evening, they mostly bypass the oak forest. A small number of people living in these buildings spend their daytime hours in the oak plantation – pensioners and mothers with children, for whom there is a playground at the

edge of the forest, closer to the residential buildings, consisting of curved metal structures resembling steps (Fig. 13, A). In the parts of the forest adjacent to the houses, there are cellars for storing vegetables and preserves (Fig. 13, B).

Table 6

Characteristics of recreational activities in the common oak plantation in Topolia-3

Indicators	Value	
	Theoretical	Actual
E (people / ha)	15,0	25,0 ± 0,97
P_{att} (people–hour. / ha)	85,0	288,0
$P_{ann.aver}$ (people / ha per year)	31 025	105 120
i (hour. per year / ha)	92 856	175 200

*Note: * – maximum possible theoretical value*

A B

Fig. 13. Examples of the use of artificial oak plantations in intra-quarter spaces

All indicators of actual recreational activity exceed the maximum possible theoretical values: recreational capacity of the site (E) – 1.67 times; recreational attendance and average annual recreation – 3.38 times; total time of recreation per unit area for the accounting period – 1.89 times.

Thus, the oak plantation under study is not only a green oasis in an urban residential area, which has a certain decorative effect and is characterized by a high vitality index. This oak forest also has a utilitarian function: it is used by residents of the neighborhood for daily commuting and active recreational activities throughout the year.

CONCLUSIONS

1. The artificial oak plantation in the Tunelna ravine tract currently consists of 658 trees. We have determined their distribution by height and diameter classes. An assessment of the vitality of this tree stand has allowed us to classify it as healthy: the vitality index on the northern slope is 88.0 %, and in the valley, it is 91.0 %.

2. Recreational activities within the Tunelna ravine are carried out in the following forms: road, off-road, mining, tenting, and transportation.

3. The actual average annual recreation value on the slope is 1.77 times higher than that in the thalweg, and the maximum average annual value is 1.32 times higher. This is due to the less comfortable microclimatic conditions in the thalweg (groundwater reaching the surface, increased soil and air humidity).

4. The intra-quarter planting of common oak trees in the Topolia-3 residential area consists of 64 trees of this species. It is classified as "healthy" because its calculated vitality index is 91.4.

5. In this artificial forest area, located in the middle of a residential area, residents engage in road and off-road recreational activities.

6. All indicators of actual recreational activity exceed the maximum possible theoretical values: recreational capacity of the site (E) – 1.67 times; recreational attendance and average annual recreation – 3.38 times; total time of recreation per unit area for the accounting period – 1.89 times.

SUMMARY

The condition of two natural and two artificial oak plantations under conditions of active recreational activity was studied. Natural urban forests (ravine forests) are located within the city of Zaporizhzhya on Khortytsia Island, while artificial oak stands are located in the city of Dnipro. Their basic taxonomic indicators (tree height and trunk diameter) and vital condition were determined. The characteristics of oak phytocenoses and the parameters of recreational load on their territory have been described. A comprehensive functional assessment of the recreational characteristics of the Heneralka and Shyroka ravines has been carried out, including the aesthetic component, the level of natural comfort, the impact of plantings on air purification, and resistance to anthropogenic impact. The theoretical maximum possible and actual levels of recreational load were determined in the studied natural and artificial tree stands. In all these oak plantations, a significant excess of actual values over theoretically possible ones was found: in the Heneralka and Shyroka ravines – 2 and 3 times, respectively. In the Tunelna ravine, the recreational load in the thalweg is less than the maximum permissible, and on the slope, under better microclimatic conditions, the recreational density exceeds the maximum

permissible values by 28.6 %. In the intra-quarter artificial oak plantation of the Topolya-3 residential area, the actual level exceeds the maximum permissible level by 66.7%.

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