PARK ECOSYSTEM SERVICES AND THEIR EVALUATION

Topicality. Improving the urban landscaping system requires an understanding of the needs of the green economy, as well as the functionality of park ecosystems and prospects for their application. Therefore, it is important to study the ecosystem services of parks and determine their beneficial effects on the socio-economic space of the city. An important component of this problem is the improvement of park assessment methods, which will cover the assessed parameters more widely.

Aim and tasks. The purpose of the article is to determine the benefits of different groups of park ecosystem services, as well as to provide proposals for calculating indicators of functional assessments of park ecosystems, and financial indicators of the green economy. The task is to analyze and summarize the existing approaches to the assessment of ecosystems, to determine the main problem of integrated assessment of ecosystem services of parks.
**Research results.** The effectiveness of measures to improve and develop urban parks largely depends on understanding the functionality of ecosystems and the ability to find their application in accordance with the needs of the city and its inhabitants. Existing methods of assessing parks are less concerned with ecosystems, although they are a resource for creating cultural and recreational assets. Assessment of ecosystem services mainly concerns large natural ecosystems (seas, forests, wetlands). Parks are approached mainly as architectural complexes. However, the assessment of ecosystem services is quite complex, and in the field of park management little studied, which is the impetus for a new approach to the assessment of parks.

To see the general situation of the development of the park object, or the landscaping system of the city as a whole, a comprehensive approach is important - the assessment of economic and natural parameters. Assessment of ecosystem services can sometimes provide unexpected results that clearly show the dependence of urban agglomerations on the surrounding natural ecosystems, and increase the value of natural centers in the city.

**Conclusion.** The proposed calculations are intended to facilitate the visual presentation of the parameters of financial support of the park economy, providing the city with park facilities, as well as the functional capabilities of existing green spaces. Most estimates are based on field research or statistics, so it can be noted that in addition to methodological developments, it is necessary to improve the system of monitoring and accounting of parks. This is especially true of the ability to assess ecosystem services.

**Keywords:** city parks, ecosystem services, evaluation indicators, ecosystem functions, economic benefits.

**Problem statement and its connection with important scientific and practical tasks.** The development of the basic principles of organizational and economic support and development of parks is impossible without a comprehensive assessment. The evaluation should be preceded by the design of new parks, their improvement, and the development of a strategy for landscaping the city or its districts. Due to the high impact of park ecosystems on their recreational and health impacts on visitors, the assessment of their ecosystem services is particularly important. There is currently no universal approach to the assessment of ecosystems, so each of the developed assessment methods is unique and relevant for use in certain conditions. Such a variety of approaches to the assessment of ecosystem services is due to their versatility and diversity of areas of their consumption. Therefore, it is important to develop an assessment of ecosystem services of urban parks from the standpoint of their ecological and recreational value.

**Analysis of recent publications on the problem.** Problems of evaluation of city parks in order to increase the efficiency of their development have not been finally resolved. The evaluation of parks is a multifaceted problem, as they are an important public space and connected to the city in economic, environmental, social and cultural aspects. There are a number of scientists in Ukraine who are aware of the importance of sound planning and evaluation of urban spaces. Thus, the problems of evaluation of urban parks can be found in the works of Kuti M. M., Girs O. A. [1], Tsaryk L. P. and Pozdnyak I. B. [2], Markova F. F., Vysheveskii A V. [3] and other scientists. Current proposals for the evaluation of urban parks can be found in the work of Kukhtar D. V., Kachala T. B. [4]. Accounting, operation and operation of parks do not bypass modern information technologies. It is possible to get acquainted with the assessment of parks on the basis of using the methods of modern geoinformation technologies in the inventory of green plantations in the work of D. I. Bidolakh, et al. [5], Bidolakh D.I., Kuzovcov V.S. [6] and in the works of foreign colleagues Degerickx, J., Hermy, M., Somers, B. [7]. The assessment of purely ecosystem services is somewhat more complicated. All existing methods of assessing ecosystems are graded depending on the need to determine a value: environmental, economic or social, and can be reduced to two conceptual approaches - utilitarian and non-utilitarian. The most developed is the assessment within the utilitarian paradigm, according to which ecosystem services have value for people through direct or indirect benefits, it is the consumer value of ecosystems. The non-consumer value of this concept is related to the value of ecosystem services that are not currently in use, including cultural ecosystem services. Numerous methods of assessing ecosystems within the utilitarian approach have been developed by researchers such as: Hufschmidt et al., 1983 [8]; Braden and Kolstad, 1991 [9]; Hanemann, 1992 [10]; Freeman III, 1993 [11]; Dixon et al., 1994 [12], and others. In general, the development of methods for assessing parks is relevant today and requires a fresh look at existing approaches.

**Allocation of previously unsolved parts of the general problem.** Assessing park ecosystem services can help raise awareness of their value. That is why it is so important for the future development of parks and their protection. Parks have a wide range of impact on the urban environment. Therefore, the results of the assessment also make it possible in the future to regulate the development of certain functional properties of parks depending on the needs of the city.

**Formulation of research objectives (problem statement).** The aim of the article is a detailed analysis of ecosystem services of urban parks and determination of their corresponding economic benefits, as well as a proposal of calculations for estimating various parameters of parks - from economic to ecosystem.
The task is to develop dimensionless estimates that would allow comparisons between different parks, cities and districts.

An outline of the main results and their justification. Assessing ecosystem obedience is a complex process, but to date does not reveal the full benefits of ecosystems. The parameters to be evaluated are mainly those parameters and indicators of ecosystems that can be quantified. Therefore, today the assessment according to the utilitarian concept of values is mostly developed. The assessment of ecosystems in a non-utilitarian concept depends to a greater extent on their importance to society, demand for them and cultural and economic significance. As part of the non-utilitarian approach, we propose to identify the following groups of values: socio-cultural, intrinsic value and environmental value. Participatory assessment techniques (Campbell and Luckert, 2002) [13] and group value measurement (Jacobs, 1997) [14] are used to characterize sociocultural value. It can be noted that the results of these assessment methods largely overlap with the cultural preferences and worldviews of the local community, but at the same time they reveal the value of the local ecosystem in terms of its importance to local people. Therefore, there is no one-size-fits-all approach to estimating all ecosystem value parameters. Depending on the purpose of the study, we can choose one or another concept of value. Table 1 systematizes the generally accepted concepts of evaluation, which are based on utilitarian or non-utilitarian approach.

Table 1

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Substantive provisions</th>
<th>Assessment methods</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Utilitarian or anthropocentric approach</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total economic value (TEV)</td>
<td>This methodology divides TEV into two categories: Used value (directly used values, indirectly used values, alternative values) and Unused value (protected values or passively used values).</td>
<td>Measurement methods are divided into: 1) the method of direct market valuation; 2) methods of indirect market valuation; 3) the method of conditional evaluation; 4) the method of group evaluation. The method of direct market valuation can be used in the evaluation of provision and cultural services. Methods of indirect market valuation: prevention costs, factor income, replacement costs, the method of dependence of prices on the comfort of the environment, the method of transport costs, probable valuation, commercial value, transfer of benefits, the method of economic effect.</td>
</tr>
<tr>
<td><strong>Non-utilitarian approach</strong></td>
<td></td>
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<tr>
<td>Socio-cultural value</td>
<td>People value ecosystems based on worldviews and societal values that are ethical, cultural, religious and philosophical.</td>
<td>It is seen that the measurement of the value of ecosystem services should be based on the results of open public discussion. Therefore, methods of participatory evaluation or group measurement of value are used.</td>
</tr>
<tr>
<td>Internal value</td>
<td>Each ecosystem has an intrinsic value that does not depend on the availability of consumers of its services.</td>
<td>The assessment measure is the severity of environmental regulations and the social and legal consequences of violating them.</td>
</tr>
<tr>
<td>Ecological value</td>
<td>Biodiversity and the sustainability of ecosystems are a prerequisite for maintaining favorable conditions for human existence and the functioning of the planetary system.</td>
<td>Biodiversity is assessed by a set of parameters: structural (spatial distribution of quantitative indicators), compositional (taxonomic diversity) and functional. Biodiversity assessment is divided into quantitative, comprehensive and comparative. Estimates are aimed at revealing the parameters of ecosystems - from the number of species to the dynamics of changes in ecosystems and their resilience.</td>
</tr>
</tbody>
</table>

Source: [15, 16, 17, 18].

Notes: 1 - The utilitarian value paradigm is based on the fact that both today and in the future the benefits of ecosystem services are obtained directly or indirectly. Two aspects of this paradigm: a - the benefits that an individual receives from an ecosystem service depends on the motivation of the individual, his needs and desires; b - the benefits cannot be directly measured. Monetary expression of the value and benefits of services is associated only with the convenience of expression in common units.

2 - Ecosystems have value regardless of their contribution to human well-being.

It should be noted that all ecosystems have intrinsic value, and the parameters of assessments depend on the attitude of society and the expected benefits. At the same time, not all ecosystem services can be assessed. Concepts such as inspiration, promoting the development of culture and art, raising the image and rating of a country or region, promoting the psycho-physiological well-being of man – can’t be assessed
today. Due to the lack of clear assessment parameters and the impossibility of expression in monetary terms, these properties of ecosystem services remain outside the assessment methods, and only partially emerge when assessing the recreational and tourism potential of ecosystems.

The only thing that needs to be clearly understood is that the approach to the assessment of certain types of ecosystems is individual and depends to some extent on consumer categories (state, society, individual) and participation in social, economic and environmental processes.

According to the Millennium Ecosystem Assessment (MEA) report [19], the classification of ecosystem services has been adopted, according to which the following groups are distinguished: providing, regulating, supporting and cultural services of ecosystems. Park ecosystems are not characterized by supporting functions, i.e., there is no flow of substances and energy for production. Economic benefits are created indirectly - through cultural services, regulatory and support (Table 2), which have a positive impact on the city environment and create conditions for the organization of recreation and tourist attractions in the city.

<table>
<thead>
<tr>
<th>Services</th>
<th>Active elements</th>
<th>Function</th>
<th>Profit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Regulatory services of urban park ecosystems</strong></td>
<td></td>
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</tr>
<tr>
<td><strong>Formation of the microclimate of the city</strong></td>
<td>Green parks and biocenoses</td>
<td>Carbon balance, carbon capture coefficient</td>
<td>Regulation of microclimatic indicators in the city, improvement of hygienic conditions of the city</td>
</tr>
<tr>
<td><strong>Air ionization</strong></td>
<td>Green parks</td>
<td>Increasing the biological activity of oxygen, increasing the content of light ions</td>
<td>Increasing the transparency of the air, reducing the manifestations of fatigue, increasing productivity</td>
</tr>
<tr>
<td><strong>Regulation of human diseases</strong></td>
<td>Green massif, its qualitative and species structure</td>
<td>Saturation of air with volatile oils and oxygen, absorption of harmful impurities in the air</td>
<td>Disinfection of the city air basin from pathogenic microflora; improving the spa and healing properties of the environment for resort towns</td>
</tr>
<tr>
<td><strong>Regulation of ventilation of the territory</strong></td>
<td>The green massif of the park and its location and configuration</td>
<td>Regulation of air flow in the city, ventilation</td>
<td>Improving city air quality, dispersing harmful impurities, protection against heat</td>
</tr>
<tr>
<td><strong>Drain regulation</strong></td>
<td>The area of green parks</td>
<td>Moisture absorption by roots, transpiration</td>
<td>Reduction of losses from showers, humidification of city air</td>
</tr>
<tr>
<td><strong>Erosion control</strong></td>
<td>Green areas of parks, including grass litter</td>
<td>Retention of soil particles</td>
<td>Prevention of soil erosion and air dust in cities, landslides and villages; preservation of viable soils</td>
</tr>
<tr>
<td><strong>Cultural services of ecosystems of city parks</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Rest for visitors</strong></td>
<td>Green areas and their infrastructure</td>
<td>Natural phenomena, phenology, change of impressions</td>
<td>Recreation within the city, profit for nearby service facilities</td>
</tr>
<tr>
<td><strong>Cultural and natural heritage</strong></td>
<td>Green areas; culture and recreation infrastructure</td>
<td>Natural phenomena, phenology</td>
<td>Natural heritage as the property of society; aesthetic values</td>
</tr>
<tr>
<td><strong>Cultural and historical heritage</strong></td>
<td>Green areas; cultural, recreational and historical infrastructure</td>
<td>Preservation of greenery in the city as a cultural and historical heritage;</td>
<td>Additional tourist attractions, aesthetic values</td>
</tr>
<tr>
<td><strong>Places of public cultural events</strong></td>
<td>Green areas; infrastructure, squares and buildings</td>
<td>Cohesion of society, expanding opportunities for communication and dating</td>
<td>Diversification of impressions and rest; places for communication and meetings; aesthetic experience</td>
</tr>
<tr>
<td><strong>Athletics</strong></td>
<td>Green areas and sports infrastructure</td>
<td>Favorable conditions for exercise</td>
<td>Places for sports activities of the population, involvement in a healthy lifestyle</td>
</tr>
<tr>
<td><strong>Inspiration</strong></td>
<td>Compositions of greenery, landscape, architectural composition</td>
<td>Natural phenomena, phenology</td>
<td>A source of inspiration for national symbols or the city, advertising, creativity</td>
</tr>
</tbody>
</table>

Table 2
Planning, creation and use of parks is a socio-natural activity, the basic components of which are environmental and recreational areas [25]. The richness of ecosystem services necessitates the deepening of modern methods of park assessment. We can say that in a market economy, a comprehensive assessment of parks in accordance with their environmental, economic and social importance is relevant. The task of the assessment should be not only to determine the parameters of the natural environment of parks, but the ability to build a strategy for their development based on its results. Therefore, I propose an assessment methodology that highlights the potential of parks in relation to current areas of urban development.

In order to improve existing park valuation techniques, we offer some calculations that can be applied as needed and may lead to new ideas for further proposals. Our assessment is based on measurable parameters and provides a comprehensive approach to the analysis of park management, namely: determining the economic security of parks, assessing recreational resources, and assessing ecosystem functions.

In our opinion, percentages are very useful, which quantitatively express the degree of security of the object of study on certain parameters. Dimensional coefficients make it possible to compare objects of study different in area and other initial data. A good example of the use of such an indicator is in recreational forest use. To determine the degree of action of recreational enterprises on the forest, Tarasov A.I. introduced the concept of "extraction intensity relative to the total forest area", which is calculated by the following formula [26]:

$$w = \frac{100W}{S}, (%)$$  \hspace{1cm} (1)

where \(W\) – forest area set aside for vacationers, ha
\(S\) – total forest area, ha
\(w\) – extraction intensity relative to the total forest area.

In our opinion, a similar approach to quantification can be adopted to determine the level of provision of urban parks, as well as the level of financial provision of urban parks in relation to expenditures on public green spaces. Such percentages make it possible to compare different areas of the city in terms of the level of parks, and to provide an objective assessment of the priority of financial expenditures for the support of parks in cities. Therefore, I propose the following calculations according to formulas 2 and 3.

**Intensity of providing the city with parks in relation to its total area.** To conduct a quantitative assessment of the city's supply of parks per unit area, we propose to introduce the concept of security intensity, and the corresponding calculation formula:

$$1 = \frac{100L}{S}, (%)$$  \hspace{1cm} (2)
where \( L \) – total area of city parks, ha;
\( S \) – city area, ha;
\( l \) – intensity of allocation of the territory of the city under parks.

The level of provision of cities with parks is very difficult to compare due to the difference in the area
of cities and green spaces, so it is important to introduce a universal indicator that will give an idea of the
degree of allocation of city space for parks. Therefore, this indicator is important in the comparative
assessment of cities by the level of provision of parks, and can be calculated on the scale of comparison of
urban areas in the presence of parks.

**Intensity of financial support of city parks.** This indicator provides a quantitative estimate of the
financial security of urban parks per unit of expenditure on the maintenance of public green spaces:

\[
 k = 100 \frac{K}{W} \tag{3}
\]

where \( K \) - park maintenance costs, UAH;
\( W \) - expenditures for the maintenance of public green spaces, UAH;
\( k \) - intensity of financial support of city parks, UAH.

This indicator is useful in the comparative assessment of the financial support of parks in cities, and
quantifies the share of expenditures that go to parks.

In the economic evaluation of ecosystem services there is such an indicator as the average productivity
of the function. Thus, the assessment of forest ecosystem services calculates the average productivity of the
forest ecosystem function (\( \Pi_{\text{ser}} \)), which is a quantitative characteristic established for 1 ha of forest [13]:

\[
 \Pi_{\text{ser}} = \frac{\Phi_{\text{ser}}}{S_{\lambda}} \tag{4}
\]

where \( \Phi_{\text{ser}} \) - overall performance
\( S_{\lambda} \) - forest area.

The main idea of this indicator is to express the productivity of the ecosystem per unit of forest area.
This approach can be adopted for economic (formula 5) and functional assessment of urban parks (formulas
6, 7, 8, 9), because the calculation is simple and logical.

**Indicator of fixed costs.** Characterizes the share of costs by type of work in relation to the total
funding of parks:

\[
 H = \frac{F_k}{F_t} \tag{5}
\]

where \( F_k \) - financing of certain activities in the field of park improvement, UAH;
\( F_t \) - total amount of financial support of city parks, UAH;
\( H \) - the share of fixed costs, dimensionless.

The proposed indicator of fixed costs will provide an opportunity to analyze the main items of
expenditure in the field of park improvement. The main items of expenditure should coincide with the
existing needs of parks and society for the improvement of these areas.

**Function of providing recreational locations of quiet rest in the natural environment for the city as
a whole:**

\[
 J = \frac{M_p}{M_m} \tag{6}
\]

where \( M_p \) – recreational capacity of parks;
\( M_m \) – recreational capacity of public green spaces in the city as a whole, including beaches and
promenades.

\( J \) – function of recreational provision

**Functional assessment of park ecosystems.** This assessment can be performed for those functional
characteristics of parks that can be quantified (formulas 7, 8, 9).

**Assessment of the habitat function:**

\[
 F_s = \frac{N_n}{N_t} \tag{7}
\]

where \( N_n \) - the number of nesting and habitat of birds and animals;
\( N_t \) - the total number of habitats and habitats of birds and animals in the city as a whole;
\( F_s \) - assessment of the function of providing habitats for the park for useful species of fauna.
The assessment of the habitat function shows the role of the park in the conservation of useful wildlife in the city. The closer this figure is to 1, the higher the conservation function of the park.

Assessment of the function of ensuring a healthy environment. To assess the function of oxygen supply to parks, we offer the following calculation (compiled by the author):

\[ C(O_2) = \frac{V(O_2)_1 + V(O_2)_2 + V(O_2)_i}{(V(O_2)_1 + V(O_2)_2 + V(O_2)_i)_m} \]  \hspace{1cm} (8)

where \( V(O_2)_1, V(O_2)_2, V(O_2)_i \) – the amount of oxygen produced by the plant species during the growing season by the park (п) / in the city as a whole (м);

\( N_1, N_2, N_i \) – the number of plants of the i-th species in the park (п) / in town (м);

\( C(O_2) \) – assessment of the function of providing the city with oxygen parks.

Similarly, you can calculate the function of providing the urban environment with volatile (compiled by the author):

\[ C(F) = \frac{V(F)_1 + V(F)_2 + V(F)_i}{(V(F)_1 + V(F)_2 + V(F)_i)_m} \]  \hspace{1cm} (9)

where \( V(F)_1, V(F)_2, V(F)_i \) - the volume of phytocicide production and the type of plants during the growing season by the park (п) / in the city as a whole (м);

\( N_1, N_2, N_i \) – the number of plants of the i-th species in the park (п) / in town (м);

\( C(F) \) – assessment of phytocicide function of parks.

Estimates of oxygen and volatile supply functions are carried out according to the species composition of plants in parks and the city as a whole, and during the growing season. Therefore, in order to be able to make this assessment, monitoring data on the species composition of plants in quantitative terms are required. These estimates can be used not only to determine the environmental potential of parks, but also to design parks in accordance with the existing problems of the city's air basin.

With regard to the quantitative assessment of natural resources, there is a method of assessment according to V. I. Perlovsky, which allows to proceed from quantitative indicators to the cost of natural resources. We present the calculation methodology developed for the assessment of beach bathing resources [27]:

\[ R = S \times N \times T \]  \hspace{1cm} (10)

where \( S \) is the area of beaches, ha;

\( N \) - ecological and psychophysical load on beach resources, people / ha;

\( T \) - the duration of the beach bathing season, days per year.

\( R \) - recreational resource of beaches, man-days.

Further, in the presence of data on the cost of beach holidays, the economic effect of the use of beach resources is calculated:

\[ Ee = R \times C \]  \hspace{1cm} (11)

where \( C \) is the cost of one visit to the beach;

\( Ee \) - economic effect of using the recreational potential of beaches, UAH / person-days.

We propose to apply a similar approach to the assessment of recreational resources to the assessment of ecosystem services of parks, which will give us the opportunity to provide at least an approximate estimate of the value of urban parks.

Estimation of cost of recreational resources of city parks. First, let's define the recreational resources of parks in quantitative terms:

\[ R = S \times N \times T \]  \hspace{1cm} (12)

where \( S \) is the area of the park, ha;

\( N \) - ecological and psychophysical load of the park, people / ha;

\( T \) - duration of rest in parks, days a year. \( T = \text{const} = 365 \).

\( R \) - recreational resource of parks, man-days.

For the obtained quantitative value of recreational resources we will provide a cost estimate:
where C is the cost of one visit to the park;

Ee - economic effect of using the recreational potential of parks, UAH / person-days.

**Assessment of the oxygen supply of the city population at the expense of urban green spaces.** It is carried out in order to determine the potential of plantations in the satisfaction of urban residents in oxygen, and further decisions to increase the area of green areas. As a constant we take the data presented in the work of Kucheryavy V. A. [28], namely:

- The average rate of oxygen consumption per person is 400 kg per year;
- 0.3 ha of urban plantations produce 400 kg / year of oxygen.

First, the rate of oxygen production by green areas of the city is determined depending on the population (compiled by the author):

$$Q (O_2)_1 = N \times 400, \text{ (liters per year)}$$  \hspace{1cm} (14)

where N, is the number of urban residents.

Determine the required amount of oxygen production per day based on the specified number of urban population (compiled by the author):

$$Q (O_2)_2 = Q (O_2)_1 / 365, \text{ (liters per day)}$$  \hspace{1cm} (15)

where 365 = const - the number of days in the year.

Determine the required area of greenery in the city, which will provide the required amount of oxygen Q (O_2)_1 and Q (O_2)_2, if we know that the required oxygen level for one person provides 0.1 - 0.3 ha of plantations, and we know population (compiled by the author):

$$S = N \times 0,1, \text{ (ha)}$$  \hspace{1cm} (16)

$$S = N \times 0,3, \text{ (ha)}$$  \hspace{1cm} (17)

The assessment of oxygen supply to the urban population is especially relevant for cities located in the steppe and arid zones. For such cities, the creation of both urban parks and suburban forests with the selection of adapted plant species is especially important. The results of calculations of oxygen production rates for the cities of Ukraine and the required area of greenery are presented in table 3.

**Table 3**

<table>
<thead>
<tr>
<th>Cities are regional centers</th>
<th>Population (N)</th>
<th>Oxygen production rate Q (O_2)_1 (liters / year)</th>
<th>Oxygen production rate Q (O_2)_2 (liters / year)</th>
<th>Area of plantings at a rate of 0.1 ha/person S_{0,1}(ha)</th>
<th>Area of plantings at a rate of 0.3 ha/person S_{0,3}(ha)</th>
<th>Available area of plantations S (ha)</th>
<th>Exceeding the ecological footprint O_2 over the areas of green areas L(O_2)(times)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kyiv</td>
<td>2 967 360</td>
<td>1,186944 c^\text{1/2}</td>
<td>3 251 901,37</td>
<td>296 736</td>
<td>890 208</td>
<td>7608,0</td>
<td>39 - 117</td>
</tr>
<tr>
<td>Vinnytsia</td>
<td>370 707</td>
<td>148 282 800</td>
<td>406 254,247</td>
<td>37 070,7</td>
<td>111 212,1</td>
<td>3639</td>
<td>10 - 30</td>
</tr>
<tr>
<td>Lutsk</td>
<td>217 315</td>
<td>86 926 000</td>
<td>238 153,425</td>
<td>21 731,5</td>
<td>65 194,5</td>
<td>135</td>
<td>161 - 483</td>
</tr>
<tr>
<td>Dnipro</td>
<td>990 724</td>
<td>396 289 600</td>
<td>1 085 724,93</td>
<td>99 072,4</td>
<td>297 217,2</td>
<td>328,7</td>
<td>301 - 906</td>
</tr>
<tr>
<td>Donetsk</td>
<td>908 456</td>
<td>363 382 400</td>
<td>995 568,219</td>
<td>90 845,6</td>
<td>272 536,8</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Zhytomer</td>
<td>264 318</td>
<td>105 727 200</td>
<td>289 663,562</td>
<td>26 431,8</td>
<td>79 295,4</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Uzhhorod</td>
<td>115 512</td>
<td>46 204 800</td>
<td>126 588,493</td>
<td>11 551,2</td>
<td>34 653,6</td>
<td>541</td>
<td>21 - 64</td>
</tr>
<tr>
<td>Zaporizhzhia</td>
<td>731 922</td>
<td>292 768 800</td>
<td>802 106,301</td>
<td>73 192,2</td>
<td>219 576,6</td>
<td>1693,59</td>
<td>43 - 129</td>
</tr>
<tr>
<td>Ivano-Frankivsk</td>
<td>237 686</td>
<td>95 074 400</td>
<td>260 477,808</td>
<td>23 768,6</td>
<td>71 305,8</td>
<td>1239,67</td>
<td>19 - 57</td>
</tr>
<tr>
<td>Kropyvnytskyi</td>
<td>233 820</td>
<td>93 528 000</td>
<td>256 241,096</td>
<td>23 382</td>
<td>70 146</td>
<td>3016,64</td>
<td>8 - 23</td>
</tr>
<tr>
<td>Lugansk</td>
<td>401 297</td>
<td>160 518 800</td>
<td>439 777,534</td>
<td>40 129,7</td>
<td>120 389,1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Lviv</td>
<td>724 314</td>
<td>289 725 600</td>
<td>793 768,767</td>
<td>72 431,4</td>
<td>217 294,2</td>
<td>4419</td>
<td>16 - 49</td>
</tr>
</tbody>
</table>

$$Ee = R \times C$$  \hspace{1cm} (13)
As you can see from Table 3, knowing the population of cities, you can roughly determine the amount of oxygen needed for its needs. It should be noted that the calculations do not include oxygen consumption, such as combustion during combustion, oxygen uptake by plants at night, seasonal fluctuations in plant oxygen production, and differences in photosynthetic capacity of plants. Therefore, the defined normative areas of green spaces that provide cities with oxygen will be considered approximate. As the ratio of normative (estimated) areas of green plantations, which provide the necessary volumes of oxygen in the city, with the actual areas of urban green areas, their volumes differ significantly. In all cases of calculations for each of the cities considered, the regulatory area is much higher than the real one. This discrepancy can be explained by the fact that the vast majority of ecosystem service providers come from outside the city. That is, the "ecological footprint" of oxygen far exceeds the area of urban green spaces. Knowing the normative areas of green plantations $S(0,1)$ and $S(0,3)$, which are able to provide oxygen to a given number of urban population ($N$), we can make the following expression, which shows the excess of ecological trace oxygen of existing areas of urban green areas (author):

$$L(O_2) = \frac{(S(0,1))}{S} > \frac{(S(0,3))}{S} \text{ (times)} \quad (18)$$

The calculations in Table 3 clearly show how many times the real oxygen needs exceed the capacity of urban green areas, which only confirms the value of forests and suburban natural ecosystems. So we see how much urban agglomerations depend on the environment.

In addition, cities have a high concentration of population per unit area, so it is impossible to provide the population with oxygen only through urban plantations. Thus, the role of green areas of cities is mainly in the ability to maintain microclimatic parameters of the environment and counteract the negative phenomena - thermal effect, pollution, dry air, the concentration of positive ions. The value of urban greenery lies in the ability to create favorable organoleptic conditions and recreational opportunities in the city, which directly affects the health of the population.

Understanding the value of urban green spaces will help maintain trends in creating a healthy urban space. Due to the crisis in the economy, the green economy is often experiencing a decline in finances and resources. But understanding the functions of natural ecosystems in cities allows you to build landscaping projects that can be relevant in solving the problems of healthy urban space [31], to create space for the economy of experience [32] and prospects for sustainable development [33].

**Conclusions and prospects for further research.** The increase in the area of urban agglomerations and population growth necessitate the creation of comfortable conditions for the urban environment. Understanding the role of natural ecosystems in the urban space, their impact and connection with the well-being of the population, is largely played by the assessment of ecosystems and analysis of its results. Therefore, we believe that improving the effectiveness of future decisions on the improvement of parks is...
closely linked to preventive assessments of park ecosystems, the study of their functional characteristics and impacts.

As can be seen from the proposed author's calculations, the development of methods for assessing parks and their ecosystem services can be very wide - from financial support, valuation of ecosystems, and opportunities to meet the needs of the population. But most of the proposed calculations require additional information - species and quantitative composition of plants, recreational capacity, accounting for nesting and animal habitats, accounting and reporting of major costs of parks. In other words, one can see a connection - the improvement of evaluation methods is closely related to the improvement of the accounting system and organizational structure, and to some extent to the transparency of the information provided. Therefore, it makes sense to develop a unified system of administration, accounting and organizational and economic support of urban parks at the state level. The construction of this system will implement the best directions and trends in the improvement of urban parks, focus on landscaping measures to support ecosystems and maintain the uniqueness of parks.

Preventive assessment of urban oxygen supply has clearly shown the high importance of urban ecosystems. Therefore, it can be assumed that the deepening and improvement of ecosystem assessments can widely demonstrate the dependence of cities on natural ecosystems, and at the same time draw more attention to the natural centers in the city.

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