

Экономические науки Economic sciences

UDC 330.15

<http://doi.org/10.21440/2307-2091-2023-2-121-127>

Economic assessment of ecosystem services of the national natural capital

Oksana Aleksandrovna LOGVINENKO^{1*}
Margarita Nikolaevna IGNAT'EVA^{1,2**}

¹Ural State Mining University, Ekaterinburg, Russia

²Institute of Economics of the Ural Branch of RAS, Ekaterinburg, Russia

Abstract

Relevance. The implementation of the principles of sustainable development of the national economy requires full consideration of the natural component in the national wealth. In modern conditions, the economic assessment of ecosystem services of forest ecosystems is of paramount importance in solving this problem. The Russian Federation, owning natural resources on a scale significantly superior to other countries of the world, having forest ecosystems unique in size and undisturbed characteristics on its territory, needs their comprehensive and most complete economic assessment.

The purpose of the research is development of theoretical and methodological foundations and development of methodological tools for the economic assessment of ecosystem services of Russia's national natural capital.

Research methodology. In the process of research, general scientific methods were used: dialectical, abstract-logical, as well as methods of comparative analysis, analogies, expert analysis.

Results. The procedure for assessing the ecosystem services of the national natural capital has been clarified, the priority of the contribution of forest ecosystems to the national natural capital has been substantiated; methodological approaches to the economic assessment of the most significant eco-services of Russian forest ecosystems, regulating the air quality of the atmosphere, water regulation and anti-erosion, have been developed. Calculation formulas for their economic assessment are proposed, economic equivalents are substantiated, allowing to obtain cost results. Approval of methodological approaches for federal districts and Russia as a whole has been carried out. The value of the increase in national natural capital is determined by taking into account the economic assessment of ecosystem services.

Conclusions. The developed methodological approaches to the economic assessment of the most significant environmental services: air quality regulation, water regulation and erosion control can be used in the economic assessment of these services at the national and regional levels, which will clarify the corresponding amount of natural capital within the boundaries of individual regions and the country as a whole.

Keywords: natural capital, economic assessment, ecosystem services, national wealth, sustainable development.

Introduction

The significant depletion of the world's natural resources, the increasing anthropogenic pressure on natural ecosystems, and the deterioration of the ecological situation have formed a new view of natural resources and their role in the formation of national wealth. The raw material function, traditional for economic relations, is increasingly being supplemented by the ecosystem one in studies of the natural resource potential [1, 2]. Its main task is to improve the quality of the human environment and preserve its potential for future generations [3]. All this at the end of the last century was the reason for

the emergence of a new economic category, associated with environmental management, called natural capital [4]. To natural resources, traditionally identified with raw materials, the concept of "ecosystem services" is added, considered by the founders of the modern theory of natural capital as the benefits received by society from ecosystems. Many countries, as experimental ones, already include monetary estimates of not only natural resources, but also ecosystem services in national accounts, thereby significantly increasing the size of national wealth [5]. Such an assessment allows, on the one hand, to car-

✉ oksana.logvinenko@m.ursmu.ru

**rinis@mail.ru

 <https://orcid.org/0000-0001-9014-905X>

ry out a more rational management of national natural capital, tracking any changes in its value, and on the other hand, it gives new content to projects for the development of natural areas from the standpoint of alternative economic value for various components of the natural environment. Awareness of the need for a full cost accounting and assessment of natural resources requires further improvement and expansion of the methodology of natural capital and methodological approaches to the economic assessment of its components.

Results

To assess the national natural capital, the most reliable would be the summation of the values of natural capital for all administrative-territorial formations within the borders of the Russian Federation. However, this option is impossible for the following reasons: firstly, estimates of natural capital at the regional level are quite fragmentary; secondly, most often due to different methodological approaches to assessment and differences in the classifications of ecosystem services used, a few estimated indicators turn out to be incomparable. Particularly large differences arise when referring to foreign experience. In addition to the lack of uniformity in methodological support, the lack of required information causes major problems, which is most often associated with imperfect accounting of natural resources, not to mention ecosystem services. We believe that the following conditions must be observed in the economic assessment of ecosystem services of forest ecosystems:

- completeness of assessment coverage of all forest ecosystems within the borders of the Russian Federation;
- the use of a set of information relating to administrative-territorial formations and forest ecosystems;
- ensuring the comparability of compared ecosystems by introducing correction factors;
- the use of various methodological approaches to the implementation of economic assessment, depending on the degree of knowledge of the assessed ecosystem service.

In the study, the ecoservices of Russian forests that are of national importance were subject to assessment: by the regulation of atmospheric air quality (CO₂ deposition), regulation of runoff volume and anti-erosion eco-services in the context of administrative-territorial formations, since statistical data on the forest fund are given precisely for them [6]. Note that the boundaries of these territories do not coincide with the boundaries of natural ecological regions, which makes it difficult to identify natural patterns in the composition, productivity, and other characteristics of forest cover. The presence of this factor requires joint consideration of information on administrative-territorial formations and natural forest ecoregions. Three possible situations in the assessment of eco-services have been identified:

- the ecoservice has been thoroughly studied, there are multiple examples of assessments;
- episodic assessment of eco-services; information on economic assessments is scarce;
- lack of experience in the economic assessment of ecoservices.

In the first case, it becomes necessary to choose the most appropriate method of economic assessment and, if necessary, introduce correction factors into the calculation formulas. In the second case, the value (cost) transfer method is used and the improvement of those minor methodological recommen-

dations that take place to be. The third situation involves either the development of a methodological approach to the assessment of eco-services, or the rejection of its assessment.

Air quality regulation. The economic assessment of this eco-service assumes the presence of the first situation, i.e., many evaluation methods. At the same time, the issue of the absorbing capacity of forest ecosystems is highly debatable. Currently, most researchers recognize that, in general, the absorption capacity depends on the indicator of net ecosystem productivity (NEP) used by foresters and ecologists. Different methodological approaches are used to calculate the stocks and the amount of annual carbon sequestration, which leads to a difference in estimates [6]. There are many approaches with their own specifics proposed by researchers dealing with this problem [7–9], the generalization and analysis of which made it possible to propose methodological recommendations that include:

- inclusion of the area of all forest lands of the Russian Federation covered with vegetation by federal districts, including reserve ones, based on data from the state forest register, in the calculations;
- the use of conversion factors that take into account the contribution to the total sequestration of underground phyto-mass and mortmass;
- the use of the average increase in assessing the productivity, since in conditions of uneven-aged forests, the use of the current increase leads to an unjustified underestimation of the annual productivity indicator;
- taking into account the share of mature (mature and overmature forests) in the total CO₂ balance;

For the economic assessment of the ecosystem service of the annual CO₂ sequestration, it is proposed to use the formula:

$$\Theta_{a,y}^{CO_2} = \sum_{i=1}^n (V_{i \text{ год}} K_1 K_2 0,5) 3,67 \Pi_{CO_2},$$

where $V_{i \text{ год}}$ – volumetric indicator of average wood increase by administrative-territorial units, taking into account reserve forests and all age categories, m³/year; n – number of administrative – territorial units; K_1 – conversion coefficient for calculating carbon in mortmass based on the volume wood stock, t/m³; K_2 – conversion coefficient for calculating carbon in phyto-mass based on the volume wood stock, t/m³; 0,5 – percentage of carbon in the dry matter of wood (for the transition from biomass to carbon); 3,67 – conversion coefficient for the ratio of the molecular weight of carbon dioxide to carbon; Π_{CO_2} – cost equivalent of services for depositing a ton of CO₂, rub./t.

In the calculations of the economic assessment of ecoservices, the conversion coefficients were taken according to [10]. Due to the underdevelopment of the Russian carbon market in terms of the price per ton of CO₂, at present, in the opinion of the authors, one should adhere to a conservative policy and take the value of the price for 1 ton of CO₂ equal to 10 US dollars for calculation. Specialists of the Department of Multilateral Economic Cooperation of the Ministry of Economic Development of Russia in the study “International Approaches to Carbon Pricing”, conducted in 2021, indicate a price of \$10 as low, but the most common and covering almost half of the world’s CO₂ emissions [11]. Taking into account the insignificant scatter of estimates for carbon storage and the completeness of data on pools, one should adhere to a conserva-

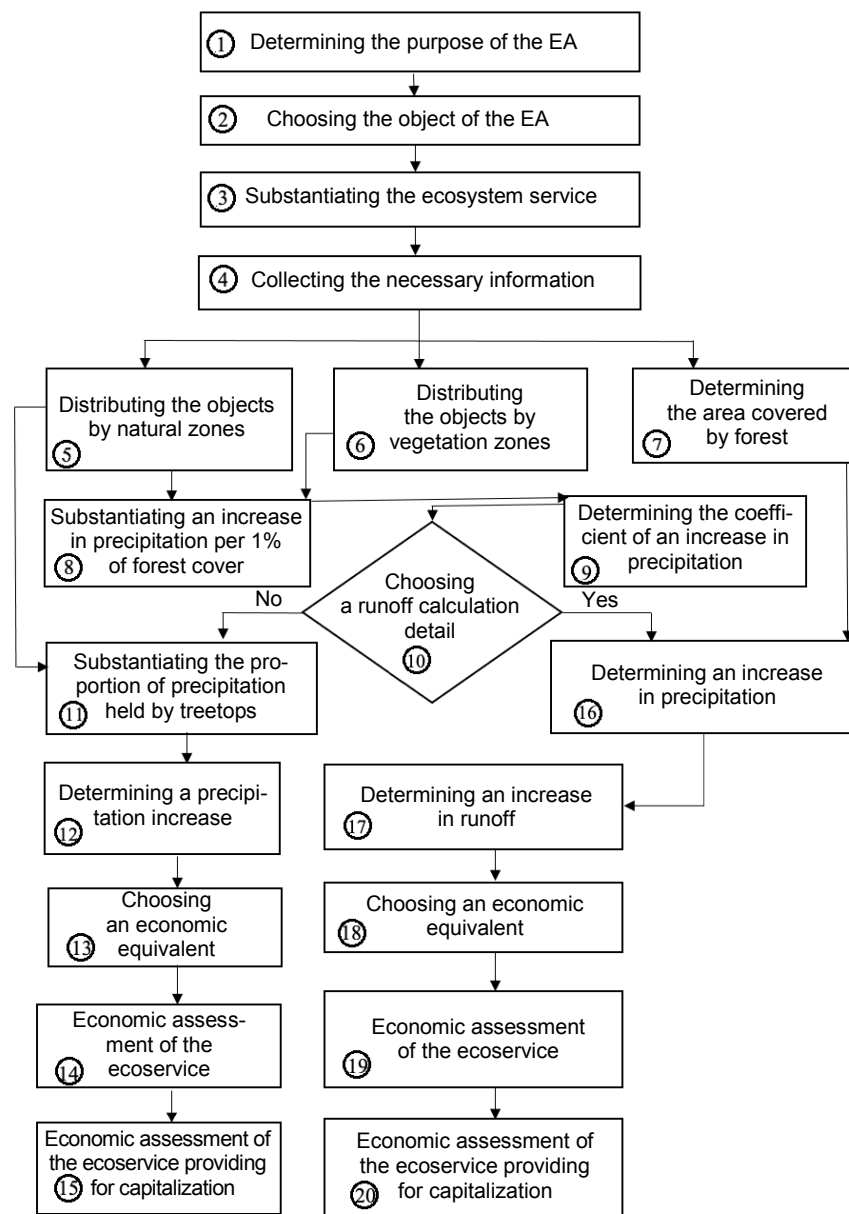


Figure 1. Algorithm for the economic assessment of the water regulating ecoservice
Рисунок 1. Алгоритм экономической оценки водорегулирующей экосистемы

tive approach and use the data on carbon stocks obtained by specialists of the Center for Ecology and Forest Productivity of the Russian Academy of Sciences when assessing an ecoservice. The economic assessment of the ecoservice for the annual sequestration of CO₂ by forest ecosystems of the Russian Federation and its storage amounted to 955.2 billion rubles and 331.6 trillion rubles, respectively, which significantly exceeds the valuation of forest resources in the structure of the national wealth of the Russian Federation in 2019. It should be noted that the obtained calculations basically do not contradict the results of assessments for individual territories of the Russian Federation [12].

Runoff volume control. The second situation is typical for the economic assessment of water regulating ecoservices, i.e. there is little information about its size. The water-regulating runoff volume eco-service is manifested in an increase in the amount of precipitation and a decrease in the surface

liquid runoff, the transfer of surface runoff into underground. The assessment of this eco-service in its essence involves an economic assessment of the use of the water volume determined by the increase in runoff, i. e., increase in water resources. The assessment of the economic equivalent is carried out on the basis of the rental approach. The figure reflects the algorithm developed by the authors for the economic assessment of water regulating ecoservices, which provides for an enlarged and detailed approach to the implementation of the assessment procedure.

The economic equivalent is the water tax, which is considered as an approximation of resource rent, as its conditional indicator and represents the value of the tax rate in rubles per 1000 m³ of water taken from surface or underground facilities for economic regions [13]. Its value, based on the calculation performed by the authors, was 4.48 rub./m³. The valuation of the considered eco-service is carried out according to the formula:

$$\Theta_{\text{в.э.у}} = \beta X_{\text{cp}} \Pi_{\text{c}} S_{\text{л}} \Pi_{\text{в}}$$

where β – rainfall increase coefficient, unit fraction; X_{cp} – average annual precipitation, mm; Π_{c} – share of runoff in the water balance, unit fraction; $S_{\text{л}}$ – area covered with forest, ha; $\Pi_{\text{в}}$ – economic equivalent, rub./m³.

The calculation of the economic assessment of the water regulatory system was carried out according to the proposed algorithm for all administrative-territorial formations, federal districts and the Russian Federation as a whole. The estimates obtained for the federal districts indicate that the highest value of eco-services is typical for the Far Eastern and Siberian districts. Privolzhsky and Northwestern Federal Districts occupy the third and fourth positions. The lowest values of the assessment of eco-services are in the North Caucasian and Southern districts. Comparison with the available regional assessments of the water regulating ecosystem service indicates a certain comparability of the results [14]. Thus, we believe that the proposed methodological approach to the integrated economic assessment of the water-regulating ecosystem service of forest ecosystems in Russia is quite reasonable. As follows from the calculations, the annual economic assessment is 918.8 billion rubles.

Anti-erosion ecosystem service. To assess the anti-erosion eco-service at the national level, the author’s methodological approach was proposed. An important role belongs to the anti-erosion ecoservice of forests, given its importance for the fruitful activity of agriculture. Reducing surface runoff due to forest reduces the possibility of erosion processes. By keeping runoff, forest ecosystems prevent soil loss and chemical leaching from fields. Most of all, potassium and nitrogen are removed in dissolved form, i. e. those substances that go into solution very quickly.

Generalization and analysis of the identified methodological approaches for the economic assessment of anti-erosion eco-services at the local level made it possible to combine them into three groups:

- the first approach, in which the object of assessment is chemicals, the removal of which is prevented by forest ecosystems;
- the second approach, focused on changes in crop yields;
- the third approach considers soil alluvium silting water bodies as an object of assessment, which requires cleaning of the latter.

We consider it most appropriate to use the first methodological approach, taking into account the prevention of silting of water bodies. The economic equivalent is the price of mineral fertilizers, which would have to be purchased when chemicals are removed from the soil during erosion, and the cost of extracting 1 ton of alluvium when cleaning a reservoir with a dredger. Taking into account that the distribution of agricultural land across the territory of Russia is very uneven and is concentrated mainly in the south and southwest, despite the fact that forest areas in the region of the southern black earth lands are few in number, a probabilistic approach is used in the economic assessment [15]. The probability reflects the reality of the implementation of the assessed eco-service for the considered forest area. The final formula for calculating the anti-erosion ecoservice is:

$$\Theta_{\text{в.э.у}} = (S_1 \cdot 1,0 + S_2 \cdot 0,86 + S_3 \cdot 0,62 + S_4 \cdot 0,38 + S_5 \cdot 0,3 + S_6 \cdot 0,13 + S_7 \cdot 0,05 + S_8 \cdot 0,01)(\Delta\Pi_{\text{л}}\Delta HC_{\text{л}})\alpha_{\text{э}}$$

where $S_1 \cdot 1,0 \dots S_8 \cdot 0,01$ – areas of forest ecosystems, taking into account the probability of preventing erosion, ha;

Table 1. Economic assessment of forest ecosystem services by federal districts, million rubles

Таблица 1. Экономическая оценка лесных экосистемных услуг по федеральным округам, млн руб.

Federal district	Air quality regulation (CO ₂ storage)		Water regulating (regulation of runoff volume)		Anti-erosion	
	Rub./ha	Million rubles	Rub./ha	Million rubles	Rub./ha	Million rubles
Central	3761.2	85 249.4	685	15 532.3	704.1	15 887 865
Northwestern	1588.9	145 284.6	948	86 653.4	91.1	8 333 405
Southern	1984.9	5861.9	140	369.5	701.0	1 854 150
North Caucasian	2087.6	3526.4	320	541.1	701.0	1 184 222
Volga	3184.1	120 486.5	995	37 637.3	700.1	26 528 124
Ural	1589.4	110 295.7	697	48 381.7	266.4	18 486 432
Siberian	1364.5	306 030.6	1224	274 583.7	140.2	31 446 023
Far Eastern	518.2	178 485.0	1321	455 075.6	35.1	12 073 892

Table 2. Economic assessment of the annual flow of ecosystem services of forest ecosystems in the Russian Federation

Таблица 2. Экономическая оценка годового потока экосистемных услуг лесных экосистем РФ

Ecosystem service	Economic assessment, rub./ha	Economic assessment, million rubles
Air quality regulation (CO ₂ storage)	1202.00	955 220.1
Water regulating (regulation of runoff volume)	1157.00	918 774.7
Anti-erosion	145.76	115 794.1

ΔN – average amount of nitrogen removal from 1 ha, kg/ha; Π_N – price of 1 kg of nitrogen fertilizers; ΔH – average value of alluvium removal from 1 ha of eroded lands, t/ha; C_n – cost of extraction of 1 ton of alluvium during the cleaning of reservoirs by a dredger, rub./rub.; α_3 – the value of the eroded area due to 1 hectare of the territory covered with forest, ha/ha.

In the course of the study, a step-by-step algorithm for evaluating the ecoservice was developed. On the basis of the algorithm, calculations of its cost estimate for administrative-territorial formations and federal districts were made. The results of the assessment for the federal districts indicate that this eco-service is most significant in the Central, Southern, North Caucasian and Volga districts. In the Northwestern and Far Eastern Federal Districts, it is insignificant due to the insignificant size of agricultural land compared to the area covered by forests. Table 1 summarizes the assessment results for the three ecosystem services.

The results of the economic assessment of the flow of ecosystem services of forest ecosystems of the national natural capital are shown in table 2.

Thus, the value of the national natural capital (the natural component of Russia's national wealth) is increased by taking

into account the annual flow of ecosystem services by 1.9 trillion rubles. In addition, the asset of ecosystem services increases due to the economic value of stored carbon by 331,565.4 billion rubles.

Conclusions

The developed methodological toolkit for the economic assessment of ecosystem services of national natural capital, including: a methodological approach to assessing the annual storage of CO₂, which specifies the area of forest land, takes into account the expansion of forest age categories and the use of an indicator of average productivity; a methodical approach to the economic assessment of a water-regulating eco-service, based on taking into account the patterns of water balance formation, calculating the increase in runoff provided by an increase in atmospheric precipitation and the author's determination of the economic equivalent using the rental approach, as well as a methodical approach to assessing an anti-erosion eco-service, taking into account the possibility of preventing erosion of agricultural land by the assessed forest ecosystems, will make it possible to detail the economic assessment of the national natural capital of Russia through the most complete consideration of the natural component.

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The article was received on April 29, 2023

Экономическая оценка экосистемных услуг национального природного капитала

Оксана Александровна ЛОГВИНЕНКО^{1*}
Маргарита Николаевна ИГНАТЬЕВА^{1,2**}

¹Уральский государственный горный университет, Екатеринбург, Россия

²Институт экономики УрО РАН, Екатеринбург, Россия

Аннотация

Актуальность. Реализация принципов устойчивого развития национальной экономики требует полноценного учета природной составляющей в национальном богатстве. В современных условиях первоочередное значение в решении данной проблемы приобретает экономическая оценка экосистемных услуг лесных экосистем. Российская Федерация, владея природными ресурсами в масштабах, значительно превосходящих другие страны мира, имея на своей территории уникальные по величине и характеристикам ненарушенности лесные экосистемы, нуждается в их всеобъемлющей и максимально полной экономической оценке.

Цель исследования – развитие теоретико-методологических основ и разработка методического инструментария экономической оценки экосистемных услуг национального природного капитала России.

Методы исследования. В процессе исследования применялись общенаучные методы: диалектический, абстрактно-логический, а также методы сравнительного анализа, аналогий, экспертного анализа.

Результаты исследования. Уточнена процедура оценивания экосистемных услуг национального природного капитала, обоснована приоритетность вклада лесных экосистем в национальный природный капитал; разработаны методические подходы к экономической оценке наиболее значимых экоуслуг лесных экосистем России, регулирующих качество воздуха атмосферы, – водорегулирующей и противоэрозионной. Предложены расчетные формулы по их экономической оценке, обоснованы экономические эквиваленты, позволяющие получить стоимостные результаты. Выполнена апробация методических подходов для федеральных округов и России в целом. Определена величина прироста национального природного капитала за счет учета экономической оценки экосистемных услуг.

Выводы. Разработанные методические подходы к экономической оценке наиболее значимых экоуслуг регулирования качества атмосферного воздуха – водорегулирующей и противоэрозионной – могут быть использованы при экономической оценке данных услуг на национальном и региональном уровнях, что позволит уточнить соответствующую величину природного капитала в границах отдельных регионов и страны в целом.

Ключевые слова: природный капитал, экономическая оценка, экосистемные услуги, национальное богатство, устойчивое развитие.

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✉ oksana.logvinenko@m.ursmu.ru

**rinis@mail.ru

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Статья поступила в редакцию 29 мая 2023 года