

CULTURAL ECOSYSTEM SERVICES ASSESSMENT WITHIN NATURAL CAPITAL OF NOVOKUZNETSK MUNICIPAL DISTRICT, KEMEROVO REGION, RUSSIAN FEDERATION

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Ecosystems are an essential source of human well-being as they produce a lot of ecosystem services. In the regions with developed mineral resource use, preservation of vital ecosystem services is connected with finding a compromise between two sources of territory development: abiotic services (mineral resources) and ecosystem services, maintaining well-being and comfort environment for the local population. In this article, cultural and other ecosystem services of Novokuznetsk district in Kemerovo region of the Russian Federation were assessed and compared with the abiotic services. The article also presents the results of the economic assessment of ecosystem and abiotic services as they are an important element of analysis of sustainable development of the territory.

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Keywords:

- sustainable development;
 - natural capital;
 - ecosystem services;
 - abiotic services;
 - economic evaluation.
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1. Introduction

The concept of ecosystem services was first implemented as the official basis for sustainability in 1997 by R. Costanza [1] and G. Daily [2]. Nowadays this concept is essential for development of environmental economics and sustainable development of territories. An important step towards the recognition of the fact that human communities depend on natural ecosystems was identification of interrelations between biophysical aspects of ecosystems and human well-being through the concepts of natural capital and ecosystem services [3; 4-6]. This contributed to the fact that ecosystem services were included in the system of environmental-economic accounting (SEEA) for the first time in 2014 [3; 7]. This approach allows creating information and analytical support for the solution of two equally important tasks: maintenance of ecosystem structure and functions (the capacity of ecosystems to recover) and reduction in the use of ecosystem resources in production and consumption, as well as reduction in relevant environmental impact [8-12].

Successful integration of these tasks into decision-making process on territory development requires spatial information about supply and demand for ecosystem services [13-15]. Assessment in monetary terms is used as an essential tool for transferring information on the importance of ecosystems to the decision-makers, thereby increasing their awareness. The reason for this is the inclusion in the management process of those ecosystem services, which can be assessed in market prices, while most of the ecosystem services are often not taken into account of the market scope [16-19]. In fact, market failures, related to ecosystem services that are public goods, can lead to increasing pressure, providing short-term economic benefits to some stakeholders at the expense of the long-term decline in the well-being of the majority of others [20; 21].

Unlike other ecosystem services, cultural ecosystem services are non-material benefits people obtain from ecosystems through "aesthetic enjoyment, recreation, artistic and spiritual fulfillment, and intellectual

development." [22] Therefore, the distinctive feature of cultural ecosystem services is intangibility, which is considered to be the reason for the difficulty of their assessment [22, 23, 24].

In the Russian Federation, most studies relate to the assessment and analysis of ecosystem services in biophysical indicators [25-30]. Research experience of evaluation of ecosystem services in Russia is mainly attributed to the evaluation of cultural ecosystem services of specially protected natural areas [31-34], as well as to accounting and monetary assessment of environmental resources of the Russian Federation within SEEA [35; 36].

As ecosystem services are generally closely interrelated, optimizing the use of one type of service may affect other services [37]. That's why any ecosystem management options in a territory inevitably connected with compromises. This study presents an attempt to develop mechanisms for search of such compromises and to integrate results of the economic assessment of ecosystem and abiotic services into the processes of strategic territory development planning.

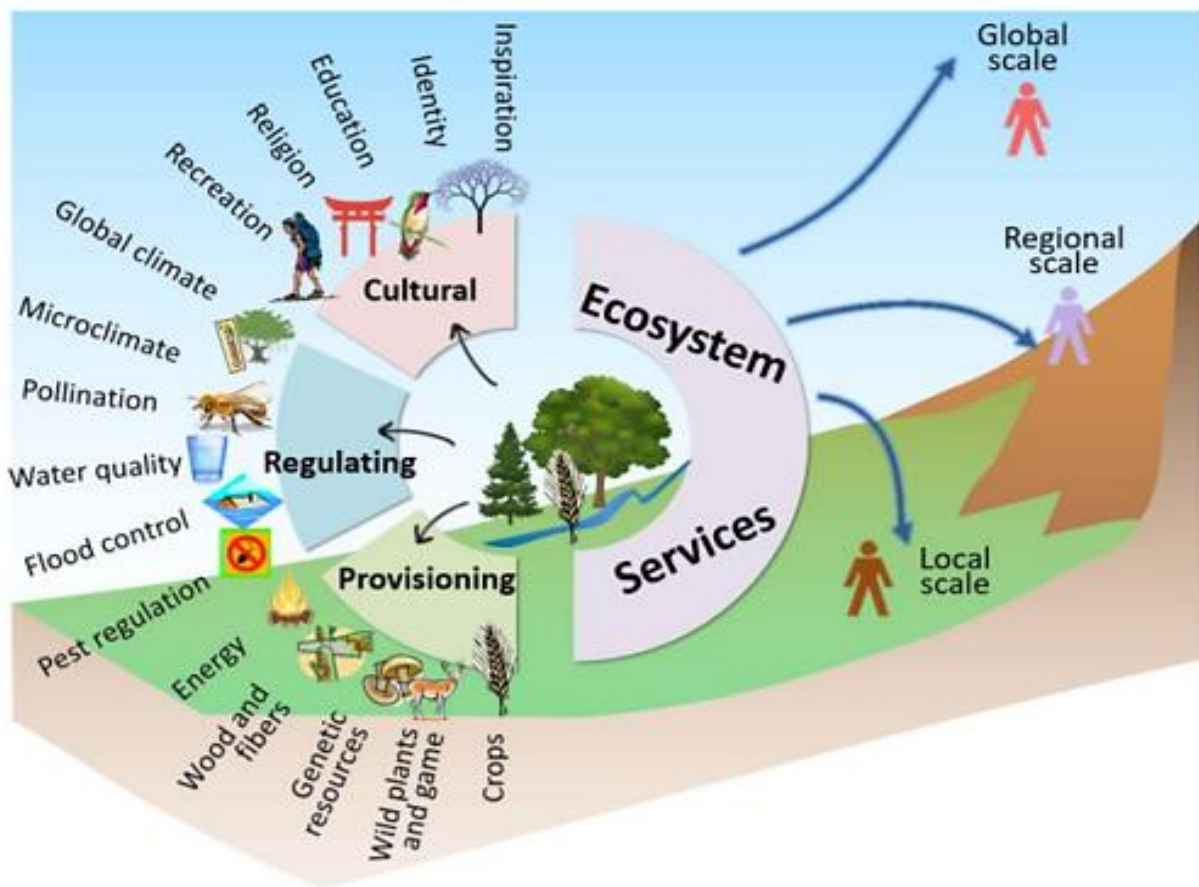


Fig. 1: Examples of provisioning, regulatory and cultural services provided by the territory to beneficiaries at different scales

Source: Caron P., Valette E. et al. Living territories to transform the world, pp.106-110

2. Initial data and methods

2.1 Scope of the research

Figure 1 presents the general information on the evaluated area of Novokuznetsk municipal district, Kemerovo region, in the context of the main types of ecosystems.

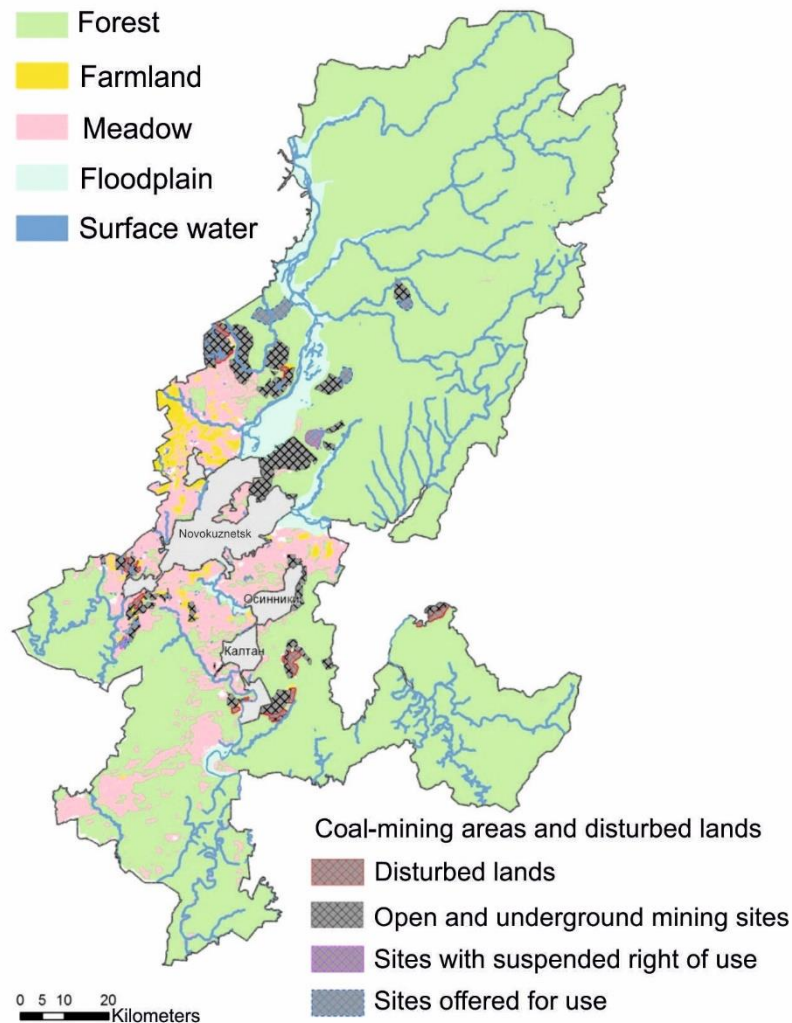


Fig. 2: Main ecosystems and coal-mining areas in the Novokuznetsk district

Within the research, ecosystems of the area were divided by cultural ecosystem services they provide (table 1).

Tab.1: Ecosystems, cultural ecosystem services and benefits

Ecosystems	Services	Benefits
Forest lands, floodplain areas and water bodies	Outdoor recreation	Possibility for fishing, hiking, swimming, etc.
Forest lands, farmlands, meadows, floodplain areas	Hedonistic values	Environmentally favorable location of residential property and human habitation.

All ecosystem services and abiotic services together equal to natural capital of the territory [3; 7]. The importance of accounting all those services results from the need to determine the balance of interests between ecosystem and abiotic services, evaluate alternative land use options and choose directions of territory use that are more relevant to the objectives of its sustainable development.

2.2 Assessment structure

In terms of economic assessment of the impact on human welfare, benefits from ecosystems can be divided into the gains from services:

- that are used or controlled by economic units and sold in markets (e.g., food, water, clothing, housing services, non-timber forest products, recreational services etc.);
- that are directly used by consumers (individuals) and that are not included in the services controlled by economic units (e.g. clean air).

The distinction between these two types of benefits leads to the difference in approaches to assessing the economic value of the ecosystem and abiotic services [3; 7].

2.2.1 Economic value of services, which use is somehow connected with purchase and sale (provisioning ecosystem services and abiotic services – coal mining), was calculated either as producer's profit or as the value of consumer surplus.

The value of the producer's profit was calculated by the formula:

$$PP = MP - (PS - P_{pr}), \quad (1)$$

where:

PP – producer's profit⁵ from the service;

MP – market price for a service used by a consumer;

PS – producer's spendings on service delivery to the consumer;

P_{pr} – payments by a producer in favor of the resource owner (the State) for the actual resource use.

The value of consumer surplus was calculated by the formula:

$$CS = WP - CE, \quad (2)$$

where:

CS – consumer surplus, i.e. the consumer surplus for ecosystem services in the form of savings, which he would be willing to pay for the service, but for which he actually didn't have to pay in the circumstances;

WP – the sum of consumer willingness to pay for to use the service;

CE – actual consumer expenditure for using the service.

The value of WP received by the subjective assessment method, based on surveys in which people are invited to say how much they would be willing to pay for specific ecosystem services [39]. Value of CE is determined by expert method, using the results of population surveys.

2.2.2 Ecosystem services, which use is not connected with purchase and sale (cultural and regulating ecosystem services), were evaluated using such methods as:

⁵ Under this scenario Producer refers to the legal entity providing the conditions for use of ecosystem services by the consumer (for example, a wood supplier, a recreation organizer, a fish seller etc.).

- estimates of consumer surplus (CS). In this case, the value of CS is equivalent to the value of WP, i.e. the sum of the willingness of the consumer to pay for saving the opportunity to use and/or for use of the evaluated service. The value of WP is calculated by the results of generalization and analysis of the data obtained by subjective evaluation [37; 40; 41];
- transfer value, when the values of ecosystem services or ecosystem assets can be extrapolated to other territories [3; 7; 42; 43]. The source data for the transfer values were based on the results of prior empirical studies of the economic value of ecosystem services. As the quality of the initial research always determines the overall quality and boundaries of the final assessment [44], the main attention was paid to studies that have been conducted in regions with similar to the researched area geographical conditions.

Table 2 contains information on the main features of cultural ecosystem services assessment.

Tab. 2: Main features of cultural ecosystem services assessment

Services	Value type	Nature of benefits	Assessment method
Outdoor recreation	Value of indirect use	Non-market benefits	Value judgement method The assessment on the basis of the data analysis of the people's willingness to pay for maintaining the possibility of using recreational functions of the district's ecosystems. The initial data were obtained from questionnaire survey of households in rural settlements.
Hedonistic values	Value of indirect use	Market benefits	Value transfer method. The search and analysis of data on ecosystems with similar characteristics and indicators of their hedonistic values, for the development of specific indicators of hedonistic values of ecosystems in the Novokuznetsk region.

2.3 Data sources

Assessment of provisioning ecosystem services by the formulas (1) and (2) were based on the data provided by statistical, natural-resource and sectoral departments of the Administration of Novokuznetsk municipal district of the Kemerovo region, as well as data of the regional markets, results of surveys of the district population, expert assessments.

Assessment of regulating ecosystem services (regulation of climate and air composition, regulation of water resources, assimilation of waste, wildlife conservation, soil formation, pollination), and assessment of cultural ecosystem services (hedonistic values) were based on the value transfer method and specialized online databases: EVRI (<http://www.evri.ca>); Envalue (<https://www.environment.nsw.gov.au/>); Value base Swe (<https://beijer.kva.se/>); Environmental & Cost Benefit Analysis News (<http://envirovaluation.org>); Econ Papers (<http://econpapers.repec.org>).

Assessment of cultural ecosystem services in terms of outdoor recreation by value judgement method was based on the results of data analysis on the local population willingness to pay for conservation of forest and water ecosystems as recreational areas.

Assessment of abiotic services (coal-mining) by the formula (1) was based on the data provided by the Department of industry, transport and entrepreneurship of administration of Novokuznetsk municipal district of the Kemerovo region.

3. Results and discussion

Table 3 presents the total value of the annual economic value of ecosystem and abiotic services provided on the territory of Novokuznetsk district.

Tab. 3: Economic value of ecosystem and abiotic services in Novokuznetsk municipal district, million rubles per year

Source of economic value	Forests	Farmlands	Meadows	Floodplain areas	Surface water bodies	Coal mining sites	Total
Regulating ecosystem services							
Regulation of climate and atmospheric composition	7854.3	-	49.1	1010.9	-	-	8914.3
Regulation of water resources	-	-	36.8	11409.8	-	-	11446.6
Assimilation of wastes	6363	-	785.4	6314	-	-	13462.4
Wildlife conservation	133325	2008.8	-	383.6	-	-	135717.4
Soil formation	696	-	1435.8	-	-	-	2131.8
Pollination	23364.2	44.9	233.2	-	-	-	23642.3
Total	171602.5	2053.7	2540.3	19118.3	-	-	195314.8
Cultural ecosystem services							
Outdoor recreation *	4.6	-	-	-	0.1	-	4.7
Hedonistic values*	13532.1	36.6	257.7	1882.8	414.1	-	16123.3
Total	13536.7	36.6	257.7	1882.8	414.2	-	16128
Provisioning ecosystem services							
Timber*	25.9	-	-	-	-	-	25.9
Non-timber forest resources *	35.8	-	5.8	2.4	-	-	44.0
Water resources	-	-	-	-	0.8	-	0.8
Hunting resources*	0.4	0.01	0.05	0.02	-	-	0.5
Fish resources	-	-	-	-	1.1	-	1.1
Agricultural products	-	117.0	862.8	-	-	-	979.8
Total	62.1	117.01	868.66	2.43	1.9	-	1052.1
Abiotic services							
Coal	-	-	-	-	-	14225.3	14225.3
Total	185201.3	2207.3	3666.6	21003.53	416.1	14225.3	226720.2

* – Value of cultural and provisioning ecosystem services (timber, non-timber forest resources and hunting resources) for forests is given excluding Kuznetsky Alatau nature reserve.

The assessment showed that 82% of the annual value of natural capital in Novokuznetsk district is produced by forest lands, more than 9% - by floodplain territories, more than 6% - by coal mining areas. The minimum value of ecosystem services is taken by surface water – 0.2% of the value of natural capital of the area.

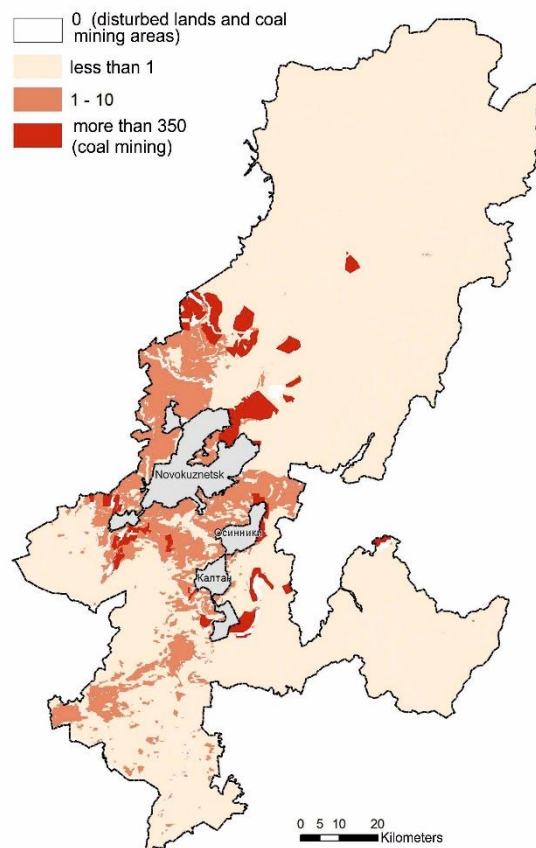
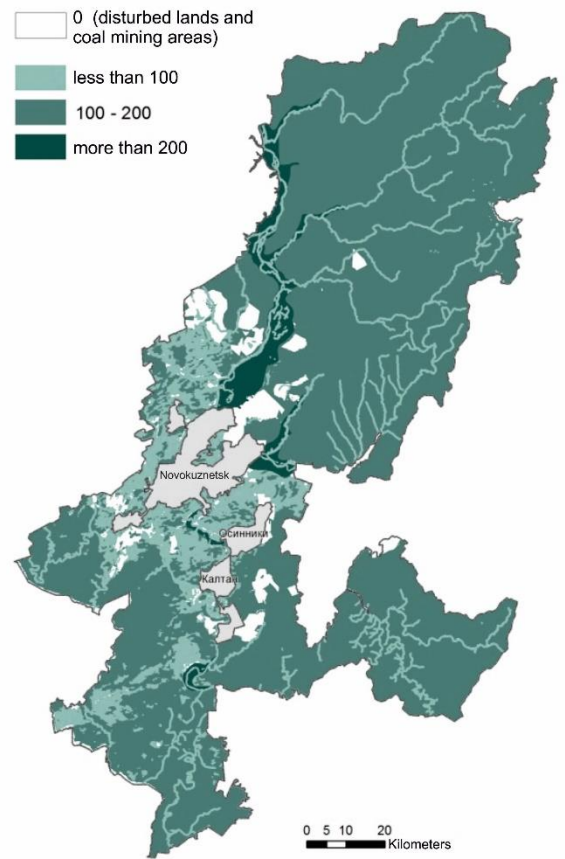
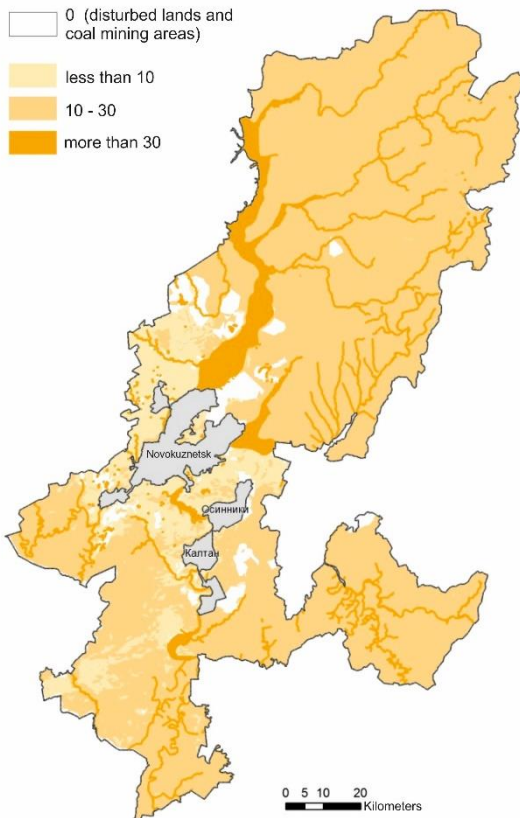
Significantly, the value of provisioning ecosystem services and abiotic services in the total economic value of natural capital is 7%, while regulating and socio-cultural ecosystem services are 93% of the economic value of natural capital. Moreover, the value of cultural ecosystem services is comparable to the value of abiotic services.



Spatial visualization of the value distribution for ecosystem and abiotic services of Novokuznetsk municipal district was prepared according to the General plans of rural settlements and the results of interpretation of multispectral satellite imagery and processing of raster maps and vector data in the software package ENVI⁶ (figures 2, 3 and 4).

⁶ <http://www.harrisgeospatial.com/SoftwareTechnology/ENVI.aspx>

Fig. 5: Value of provisioning ecosystem services and abiotic services, thousand rubles/ha/year



Comparison of figures 2, 3 and 4 shows that the value of ecosystems undisturbed areas higher than the value of coal-mine sites by several orders of magnitude.

Ecosystem services are renewable, and while ensuring wildlife conservation, agricultural and forestry development in the district, they perform an important social function of providing households with opportunities for additional employment. At the same time, coal resources are non-renewable, as a consequence of mining, they are gradually depleted, and the ecosystems under mining degrade and lose their capacity to generate ecosystem services (the most shaded areas in figures 2 and 3, and the lightest areas in figure 3, respectively).

The results of the research allowed identification of opportunities and directions for the following tasks: (1) increasing manager's awareness of economic benefits of the ecosystems in the area when making decisions on strategic planning and current management, (2) choosing optimum directions of land use in the district in terms of sustainable development.

Thus, the choice of optimum directions of land use in terms of sustainable development of the district is connected with the recognition that intact ecosystems are of considerable economic value, and their preservation has both environmental and economic benefits for the sustainable development of Novokuznetsk district. Besides, it's necessary to account and analyse ecosystem values within strategic planning of territory development in the framework of the standards of environmental-economic accounting [7].

4. Conclusion

The research showed that different ecosystems in Novokuznetsk municipal district, Kemerovo region, provide a wide range of ecosystem services, which benefits are a large part of natural capital of the area. Comparison of benefits from ecosystem services and abiotic services has been useful for understanding the necessity of a joint search for compromise to ensure the ecosystems conservation of the area and its sustainable development in the conditions of coal mining.

Unlike abiotic services of coal-mining, cultural ecosystem services has more sustainable over time employment potential for the local population and plays an important role in the economy of rural households, maintaining human well-being with local ecosystems. Identification and assessment of cultural ecosystem services increases interest of the local population and authorities in the preservation of intact ecosystems, biodiversity, monuments of nature and culture.

All in all, development of accounting, assessment and mapping of physical and monetary characteristics of ecosystem and abiotic services allows expanding information-analytical framework of decision-making in strategic territory planning, improving their performance in terms of ecosystems conservation and region's sustainable development.

5. Acknowledgements

The research was supported by the administration of Novokuznetsk municipal district, Kemerovo region, Russia. The authors are grateful to InEcA-consulting, LLC (Novokuznetsk, Russia) for their invaluable help in collecting initial data for this research. Rural population surveys in the district, that were used for the subjective assessment of ecosystem services, was carried out by Siberian Institute of Management Technologies (Mezhdurechensk, Russia).

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