Socio-ecological and economic efficiency of the territories of forestry

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Abstract. The article proposes a new paradigm for assessing the socio-ecological and economic efficiency of the state of forestry territories on the example of one of the Russian regions. The traditional model of economic growth in forestry has now run out of steam, since the economic growth in forestry is primarily a quantitative characteristic and cannot be sustained indefinitely, while economic development that improves the quality of life without increasing the consumption of forest resources can be sustainable. The transition to a new paradigm involves the formation of a set of interrelated and mutually dependent economic, social, political and other processes based on the organization of such a system that is able to resolve emerging internal and external contradictions. The socio-ecological and economic efficiency of forestry territories is calculated considering the correlation coefficients, which allows us to identify the proximity and direction of the relationship of the studied indicators. The calculated performance indicators can be further used in regional management for an adequate diagnosis of the current situation in forestry, identifying cause-and-effect relations between indicators and parameters of territory development.

1. Introduction
Forestry plays an important role in the economy of the area. The main direction of its development is to meet the needs of the national economy with wood and products of its processing, restore forest stands with valuable wood species, and use woodlands for recreational and health purposes. The agricultural lands available in the forest Fund are used for the needs of forestry and forest protection, and some of it are not used. Grazing is prohibited in the forest Fund, although there have been cases of cattle driving through woodlands. The collection of fruits and medicinal plants by the local population for its own needs is noted among the secondary forest uses.

All this makes it necessary to apply an ecosystem approach to forest management as an ecological and economic system. Based on the relation and interdependence of forestry, environmental processes, and the human environment, and thus integrating the economy, ecology, and social phenomena, parameters previously considered external to the economic system should become internal to it.

While developing the assessment methodology paradigm, it is necessary to refer to the results of research on the socio-ecological and economic efficiency of forestry that have been conducted in Russia and abroad over the past 30 years [1]. Domestic (T. S. Lobovikov: “aggregation of existing
theoretical positions and the formation of a system of indicators for evaluating the effectiveness and complex use of wood raw materials was carried out in the framework of his research on forests as a carrier of value, and the classification of indicators for evaluating the effectiveness of wood raw materials...” [2]) and foreign (S. Mantel: “integration of historical, economic-geographical, national economic and legal disciplines in research in the field of forestry…” [3]) scientists have established a certain pattern—the objective stage of development of forestry from the occupation stage to sustainable forest management, which indicates the need for changes in the traditional system of forest planning, focused on the maximum extraction of forest resources.

In the scientific literature, the socio-ecological and economic efficiency is defined as an organizational combination of stable technical, economic, environmental and other types of relations. However, this definition does not consider the nature and purpose of these relations, especially its social aspect. Therefore, the socio-ecological and economic efficiency can be called a system that functions in the current institutional environment, while observing the established and emerging principles of sustainable forest development. The socio-ecological and economic efficiency takes the form of a stable state if, as a result of a collision of natural, industrial, social, economic and other interests, a certain compromise is reached in the process of fulfilling each of the listed subsystems of its individual goal. In our opinion, the most appropriate requirement for sustainable development is to consider the socio-ecological and economic complex as a set of economic, environmental and social relations regarding the effective use of natural resource potential in the production of material goods for the purposes of economic growth and sustainable development of forestry in the region.

As foreign experience shows, the state can achieve positive results and significant success in forest cultivation and management in general with any type of organization of forest resources management, of course, considering adequate and rational relations between the state and forest users [4]. Let us recall the existing systems of forest management organization in the world practice: market-based with various forms of forest ownership, market-based with private forest ownership, and budget-funded form of forest management. The most universal form of forest management and economic management of forests is the use of forest resources under various forms of ownership, where state regulation of forestry is carried out in a market economy (e.g., Canada, Germany, Austria, etc.). The market-based form of forest management and economic management with private forest ownership is typical for countries that have regulatory and Supervisory functions implemented through administrative methods, while forest management is financed by forest owners (for example, Finland, the United States, China, etc.). Note that the budget-funded form of forest management and economic management has remained only in some socially-oriented countries, such as Cuba, Mongolia, Vietnam, etc. In Canada, over 90% of all forests are state-owned (either provincial (71%) or Federal (23%)) [5]. Canada's forestry industry is considered one of the world's most advanced in terms of technological equipment, management organization, and strict environmental standards for logging operations. A distinctive feature of forestry in Canada is that half of Canada's forests remain unaffected by economic activity, but the role of forestry in the country's economy and in its foreign trade is particularly large.

Despite the fact that significant methodological and practical experience has been accumulated in this area, a generally accepted theoretical and methodological approach to the assessment of socio-ecological and economic territories of forestry has not yet been formed. In 2009, the Stiglitz-Senafitussi Commission presented a “Report on measuring economic development and social progress”, which proposed recommendations for the development of statistical tools for assessing the quality of life and social sustainability. The ideas and conclusions of this report caused a wide public response. For example, in the European Commission's report “GDP and beyond” (2009), proposals were made to improve indicators of social progress, and the OECD proposed its development of a “compendium of indicators of well-being” (2011), considering the recommendations of the Stiglitsasen-Fitoussi report. The interest in the problem of forming a complete and objective system of indicators of public welfare and sustainable development is under consideration at the national level. The governments of France, Japan, the people's Republic of China, and the United States have set
goals for improving national statistics systems, while parliamentary commissions on sustainability analysis have been set up in Germany and Norway, and conferences, seminars, and round tables on these issues have been organized in several other countries. Thus, at present, we can say that international interest in the problem of assessing sustainable development is very high, and the methodology for measuring it is in its infancy. These studies, including our recent publications, have shown that the socialization of the economy and the preservation of the environment gives a socio-ecological and economic system, which is the main form and conditions for the development of forestry territories. In addition, an analysis of international practice has shown that many problems of socio-economic and environmental imbalance originated primarily at the regional level and only later acquired national dimensions. Therefore, the research approach to the development of regions from the point of view of the system of ecology, economy and social sphere has become one of the methodological bases of research on the assessment of socio-ecological and economic indicators of the development of forestry territories in the region [6].

The socio-ecological systems (SESs) are complex adaptive systems, which emerge from coupled social and ecological structures providing a powerful frame for understanding the highly dynamic interactions of ecological and societal changes. ESs are co-evolving systems maintaining a constant and reciprocal interaction and feedbacks between territorial and socioeconomic As a result of these interactions key essential services for society emerge The human transformation of land uses has led to the loss and abandonment of most intangible ecosystem services, especially those related to the regulation of not only ecological processes, but also cultural, such as local identity, traditional knowledge and spiritual enrichment. Thus, the current land use changes, mainly due to agricultural intensification and urbanization processes, cause serious shifts in socio-ecological interactions. The urban expansion is considered worldwide as one of the primary direct drivers of land change and habitat loss and the most dramatic form of land transformation that profoundly influences biological diversity, ecosystem services and its links to human well-being and social. The relevance of the development of such efficiency is enhanced by the fact that there is still no unified systematic approach to the paradigm of socio-ecological and economic assessment of the formation and development of the state of the territory of municipalities [7].

The novelty of these scientific and methodological foundations is in the allocation of the specification of theoretical components in the assessment of socio-ecological and economic indicators of forestry. Most of the research on forestry has focused on the economic aspects of wood production; very few studies have focused on the impact of multiple forest values simultaneously. This work is aimed at considering the socio-ecological consequences of changes in natural, industrial, social, and economic indicators, as well as its assessment of the potential impact on a wide range of ecosystem services and on the conservation of biodiversity [8].

The main goal of the research is to form a paradigm of assessment methodology that would provide the following: creating conditions for the effectiveness of sustainable development of territories in forestry, aimed at solving social and environmental problems; rational use of the natural resource potential of the territory for making management decisions and ensuring its proper effectiveness. The method proposed by the authors for assessing the socio-ecological and economic efficiency of the territories will reveal the effect of such components as economic, environmental, and social.

The socio-ecological and economic efficiency of forestry territories includes a number of elements. First of all, it is the environment in the form of resource and ecological potential, or natural conditions. In this case, resource potential refers to the natural environment as a source of resources for the economy, and environmental potential refers to the external environment that allows for the effective functioning of individual parts of agriculture, as well as the entire system, and the economy as a whole.

It should be noted that, in contrast to ecosystems, socio-ecological and economic systems are open, since it is constantly exchanging matter and energy between its three components: society, production, and the natural environment. In addition, these systems are constantly evolving, since the relations between its elements and the elements themselves are constantly changing, and it is the presence and
dynamics of these relations that determine the potential and actual stability and equilibrium of the system. However, since the socio-ecological and economic system of forestry territories is open, and, consequently, is subject to the influence of external factors, the state of equilibrium in it is relative and temporary, being a dynamic equilibrium and having several possible development paths. It is ensuring a balance between the existence and life of society with its economic life and the natural environment that is the basis for sustainable development of the region [9].

The means of active regulatory influence on the socio-ecological and economic efficiency of forestry territories is primarily the agricultural production activity itself, the products of which are included in this system and transform it. This activity, based on technological progress, is carried out independently of each specific farm and environmental requirements. On the one hand, it increases the production of biological products and improves people's lives, and on the other hand, intensive land use processes disrupt the ecological balance. To combat it, it is necessary to introduce bans on the implementation of certain agrotechnological processes, the use of soil protection means, and special measures for the restoration of land resources. The effectiveness of land use is largely determined by the landscape of the area, its geomorphology, where certain restrictions are imposed on soil cultivation, cultivation of certain crops. All together, this should represent a single, unbroken dynamic whole and provide conditions for expanded reproduction of soil fertility and cost-effective management of forest production [10].

Since the use of land resources under the control of the act as socio-economic processes and natural that will not only change under the influence of different technologies, but also affect the further effectiveness, it is advisable from a purely economic evaluation economic decisions to move to a multi-criteria assessment of socio-ecological-economic efficiency as the aggregate performance indicator of the stability of the region.

The socio-ecological and economic efficiency of forestry territories characterizes the overall economic performance of the production process, considering the impact of the resource use process on the natural environment and the development of forestry territories. This indicator reflects the effectiveness of implementation in the production process, along with material and labor costs, the costs associated with the elimination of environmental destruction that occurs in the course of activities, such as soil erosion, as well as losses of agricultural products due to environmental degradation.

The criterion of socio-ecological and economic efficiency of forestry territories is to maximize the solution of the problem of satisfying public demand for agricultural products obtained with optimal production costs while preserving and reproducing the environment both in the ecological and social terms. At the same time, the determination of the ecological and economic efficiency of forestry territories is currently based on indicators of ecological and economic damage and effect, General (absolute) and comparative ecological and economic efficiency [11].

The ecological and economic damage to the land used in agriculture as a primary means of production, manifests itself in the valuation of quality degradation is expressed primarily in the deterioration of soil fertility and the loss of production as a result of lower productivity forest lands.

The overall ecological and economic efficiency of the territories defined as the ratio of the annual volume of the full ecological-economic effect representing the difference between the economic results of enterprises’ activities in the region and caused its cost, adjusted for the magnitude of the economic assessment of environmental damage from forestry to the natural environment, to the full amount of costs, which caused ecological and economic benefits, including environmental protection.

The most effective option should be considered, for which the indicator of overall (absolute) environmental and economic efficiency has the highest value. However, as we can see, the existing methodology for assessing the ecological and economic efficiency of forestry territories does not consider the parameters of social efficiency, which is mandatory for the implementation of the concept of sustainable development.

Key performance indicators (KPIs) for sustainable development of forest territories and resource use should reflect the qualitative and quantitative characteristics of planned changes in the system of
resource use, considering environmental and social requirements. Planned changes should be tracked by three groups of key performance indicators: economic, social, and environmental. Planning such changes, of course, aims to achieve a stable progressive trend for these groups of indicators [12].

2. Methodology
Any territory is a constant and continuous process of interaction of three structural elements of the system: ecological, represented by the natural environment and terrain; economic, represented by the economic complex, and social, determined by the population of the territory.

The territory is characterized by the following features:
- has a variety of resources;
- has economic, social, and environmental functions;
- has specific objects located on it;
- determines the availability of funds and labor items.

The social part is the main and fundamental part of the integrated assessment of the territory, which must consider the presence of certain borders and relations with other neighboring territories. In this case, the territorial factor is represented as a certain degree of compliance with the economic, social and environmental consequences of public activities and the corresponding functions of society expressed in legislation [13].

Characteristic features of the territory as a system:
- first, it is the possibility of interchangeability of types of resources based on exchange with the external environment, which is due to the property of openness;
- secondly, territories have the property of a multi-purpose system that characterizes heterogeneous goals, Autonomous sub-goals of some subsystems, a system of indicators, various methods of achieving it, etc.
- third, the constituent elements of the territory system are in constant transformation, which is characterized by the property of static and dynamic.

The formation of a diagnostic device involves the use of various methods of analysis for a possible list of indicators that require clarification of the range of these parameters, which will be used to assess the condition. The diagnostic device is built using key performance indicators in the following order:
- definition of research boundaries (requirements for the form of conducting any statistical observations);
- collection, summary (compression), ordering of information received from reporting units;
- determining the current values of descriptive key performance indicators;
- introduction of estimated key performance indicators and formation of boundaries for its change; assessment of the degree of deviation of the main controlled parameters from the established boundary or set values;
- assessment of the degree of change in the level of socio-ecological and economic efficiency;
- change in development objectives or implementation of actions that correct the situation.

The evaluation paradigm itself requires a clear definition of the values of descriptive and key performance indicators, the introduction of boundaries for its changes, and an assessment of the degree of deviation of the main controlled parameters from the established boundary (set) values, on the basis of which the assessment of the state and level of safety is performed.

There is a concept of multidimensional statistical analysis, which in economic research means a number of methods designed to identify patterns in statistical aggregates, units of which are described by a large set of features [14].

Key performance indicators of problem points in forestry can be calculated using the formula (1):

\[ PK_j = \frac{\sum_{i=1}^{n} PKK_i}{n}, \]
Where $PK_j$ – cumulative performance indicators for the $j$- index of the forestry; $j$ – is the sequence number of the element of the forestry $j \in (1,m)$; $m$ – is the total number of analyzed elements of the forestry; $PK_{ij}$ – score of the $i$ – index of management efficiency of the $j$ – index of the forestry; $i$ – is the index number, $i \in (1,n)$; $n$ – is the total number of indicators.

The score of the performance indicator $PK_{ij}$ is calculated by the formula (2):

$$PK_{ij} = \frac{PY_{ij} - KY_{\min}}{Var_i} \times 100 + 1,$$

(2)

where $PY_{ij}$ is the value of the $i$- index indicator for the $j$- index of the forestry; $KY_{\min}$ – worst value of the $i$- index; $Var_i$ – range of variation of the $i$ – index indicator.

The range of variation $Var_i$ is determined by the equation (3):

$$Var_i = KY_{\max} - KY_{\min},$$

(3)

where $KY_{\max}$ – best value of the $i$- index indicator.

To consider the degree of importance of each indicator, i.e. the degree of influence of each of it on the aggregate performance characteristic, we will use the statistical method using the minimum standard deviation for each indicator. The average value for each efficiency indicator $KY_{med}$ is determined by the formula (4):

$$KY_{med} = \frac{1}{m} \times \sum_{j=1}^{m} KY_j$$

(4)

All average values of performance indicators will be equal, since the total amount of interest for each of the indicators is 100%.

The dispersion $D_i$ is determined by the equation (5):

$$D_i = \frac{1}{m} \times \sum_{j=1}^{m} (KY_j - KY_{med})^2$$

(5)

The standard deviation $S_i$ is found by the formula (6):

$$S_i = \sqrt{\frac{1}{m} \times \sum_{j=1}^{m} (KY_j - KY_{med})^2}, \text{ or } S_i = \sqrt{D_i}$$

(6)

The authors investigated the dynamics of key performance indicators of territories of forestry on the example of one of Russian regions of forestry – the Voronezh region. In socio-economic terms, the large number of the city of Voronezh and its status as a million-plus city means the presence of a powerful resource potential. It should be noted that the population of the city. The economically active population is 516,400 people or 49.3% of the total population of the city. 497,400 people are employed in the economy. The largest share is in retail trade (50%), car repair (26%), manufacturing (15%), and education (9%). Voronezh has been increasing in recent years. Voronezh is located in the temperate zone, with pronounced seasonality. The structure of the production of the urban district of the city of Voronezh combines mechanical engineering and metalworking, the chemical industry, electronic, aircraft, rocket and space, agricultural, production oriented to meet the final needs of the population (food production, textile and clothing production, pulp and paper). Currently, in the urban district of the city of Voronezh, 43,900 enterprises and organizations of various forms of ownership
carry out economic activities. Wholesale and retail trade, automotive and motorcycle repair organizations account for 42.0% of the total number of organizations (18.4 thousand enterprises). 4,900 enterprises operate in the construction industry, and about 3 thousand enterprises are concentrated in the manufacturing industries. The number of individual entrepreneurs, 45.7% of whom are engaged in retail trade, is more than 27,800 units. The basis of exports of Voronezh enterprises is engineering products and microelectronics, and imports are raw materials, materials and components for production. The positive dynamics of the main indicators of the socio-economic development of the urban district of the city of Voronezh demonstrate an increase in the level and quality of life of the population, the creation of a comfortable urban environment. In 2017, in the rating “Cities of Russia in terms of the quality of life”, the Voronezh city district took 7th place. In the list of the most comfortable largest cities of the Russian Federation in terms of convenience for life, Voronezh entered the top ten [15].

The information base was statistical data on the Voronezh region, posted on the pages of official websites: voronezhstat.gks.ru and web.archive.org.

3. Results
Starting from the name, we conclude that the socio-ecological-economic system is a balanced mechanism, all contradictions in which are mutually exclusive. To a greater extent, the effectiveness of such systems is influenced by environmental and economic factors, conflicts between which are no exception, even though these factors determine [16]. The effectiveness of such systems is related to changes in the fundamental indicators. However, the dynamics of the effectiveness of the system itself does not always coincide with the trends in the development of its main indicators. We propose a socio-ecological and economic assessment of the effectiveness of the state of forestry territories, which is based on its own system of indicators that allows you to fully characterize the socio-ecological and economic efficiency of territories, to identify its strengths and weaknesses. Maps of problem points have been developed based on publicly available data from annual reports and balance sheets of assessed objects (table 1). The table shows the actual and planned digital values of the effect of various components, as well as the correspondence (+) or non-correspondence (-) of these values in the form of problem points.

The most problematic points of forestry are the low efficiency of auxiliary processes, monitoring of environmental data analysis, and management of the production environment. The application of this apparatus to the analysis of the problem of multi-criteria assessment of forestry provides an opportunity to build good assessment systems that allow calculating complex assessments of forestry and on the basis of these assessments to form constructive justified development options.

| Effect  | Fact | Purpose | Concreteness | Measurability | Reachability | Importance | Definition in time and resources |
|---------|------|---------|--------------|---------------|--------------|------------|---------------------------------|
| Economic| 0.18 | 0.11 | -            | -             | +            | -         | +                               |
| Environmental| 0.5 | 0.45 | +            | +             | +            | +         | +                               |
| Social  | 1    | 0.96 | -            | -             | +            | -         | -                               |

To determine the degree of influence of each indicator on the criterion, a method was used to assess the significance of factors of correlation and regression analysis (equations (4), (5), and (6)). This calculation will allow us to assess the territory with general concepts and terminology, as well as significantly automate the computational work associated with the assessment. This approach makes it possible to compare the results of the assessment of different territories, while receiving new material for further research. Also, this approach allows you to compare the results of the assessment of one territory, but from different perspectives. The results of which are presented in table. 2.
Considering the fact that almost all the selected indicators have established and/or already have acceptable (recommended average or normative) values that correspond to the condition of stability of the considered spheres of life. The key performance indicators should be calculated using the geometric mean formula of three indices: economic, social and environmental development of forestry, which will reflect the impact of each component of socio-ecological and economic assessment, while changes in one of the components will change the overall result. Based on this, we can state the following: the relationship of the ecological and economic state with the most important spheres of life makes it possible to form an area of acceptable values, represented by private and consolidated key performance indicators. A private index gives an estimate for a specific state, and a composite index gives an estimate for the general state.

Overall rating is characterized as ecologically significant, is large enough, the completeness of information and has a period of coverage year (or semester), and also consistent with the reporting format adopted in the system of managerial decisions, so it may be the control of ecological-economic development of forestry.

Based on the results of the analysis, the impact of indicators on development is determined on the basis of a fuzzy quantitative assessment on the basis of which it is possible to make a management decision on the distribution of resources in the forestry territory. The analysis allows us to give a fairly reliable quantitative characteristic of qualitative performance indicators. Consecutive iterations on standardization of indicators allow ensuring its comparability with each other.

### Table 2. Calculation of standard deviation.

| Effect                        | Deviation | Square deviation |
|-------------------------------|-----------|------------------|
|                               | $KY_1$    | $KY_2$           | $KY_3$ | $KY_4$ | $KY_5$ | $KY_6$ | $KY_7$ | $KY_8$ |
| Economic component            | 1.71      | 2.71             | 1.31   | 1.11   | 2.92   | 7.34   | 1.71   | 1.23   |
| Environmental component       | 1.21      | -0.59            | -0.89  | 3.61   | 1.46   | 0.35   | 0.79   | 13.03  |
| Social component              | 0.71      | 4.21             | 1.01   | 0.71   | 0.50   | 17.72  | 1.02   | 0.50   |
| Average value of the indicator, $KY_{med}$ | 14.29 | 14.29 | 14.29 | 14.29 | -      | -      | -      | -      |
| Dispersion, $D_i$             | -         | -                | -      | -      | 1.387  | 7.819  | 2.586  | 11.369 |
| Standard deviation, $S_i$     | -         | -                | -      | -      | 1.178  | 2.796  | 1.608  | 3.372  |

The analysis of socio-economic changes occurring during the implementation of the new economic policy is presented in [17], where the authors give a comprehensive description of the rural population of the country at the beginning of the reconstruction period. This research is based on materials containing valuable information on a wide range of issues related to the socio-ecological and economic system, which allowed us to identify the features of socio-ecological and economic assessment of territories in the economy in forestry.

Using the standard deviation shown in table 2, we get indicators that allow us to find out which of the values is normal (average) in this case, the value of the effect of the social component, and which is extraordinarily large - the value of the effect of the economic component. In this case, the standard deviation allows you to see how the volatility of the economic component changes over time.

### 4. Conclusion

The proposed methodology for assessing the socio-ecological and economic efficiency of forestry territories records and studies changes in the process of functioning of the economy, systematizes it in the form of information for decision-making. The completeness of our knowledge about socio-
ecological-economic efficiency of forestry depends on the quality of governance, which should be organized in conditions of incomplete knowledge of the list of parameters that you want to manage, inaccurate knowledge of the managed parameters and the range within which it need to hold high levels of responsibility for the wrong decision. Thus, the direction of further research is to create a practical model based on the considered theoretical approaches to the study of socio-ecological and economic territories.

In conclusion, it is reasonable to conclude that the proposed assessment of socio-ecological and economic efficiency of the state of forestry territories can be used to develop an organizational and economic mechanism based on:
- comprehensive formation of state and regional programs for the development of forestry territories;
- development of science-based approaches and proven methods for socio-ecological and economic assessment;
- optimization of anthropogenic impact on the socio-ecological and economic system of forestry;
- implementation of a coordinated policy in the field of ecology and environmental protection;
- development of measures to stimulate the development of rational use of forestry in individual territories.

The genesis of the formation of economic and mathematical methods of complex research of social, economic and environmental phenomena has shown that the existing directions of its comprehensive assessment in the most General form require a rational combination due to the inability to perform interdisciplinary calculations on the actual available information. A well-formed methodological approach to the assessment of forestry territories, which is universal and practically implementable, regardless of the goals set, has not been developed by scientists to date. After studying these questions, you can make a descriptive assessment of these methods, based on economic and mathematical methods. A common approach to the assessment of territories would allow comparing the results of evaluating different territories of forestry (from the position of the same goal) and obtaining new material for further research, in addition, this method would also allow comparing the results of evaluating the same territory from different positions [18]. In our opinion, for socio-ecological and economic assessment of territories, it is necessary to rely (base) on the use of logic techniques, forecasting methods and mathematical apparatus. Managing a targeted system requires knowledge not only about the external environment, but also about the system itself. This knowledge is formed in the model of the system and its environment, and the model creates a mechanism for generating new knowledge about the system and a mechanism for finding solutions for balanced development for making managerial decisions.

The content meaning and practical use for socio-ecological and economic assessment of forestry territories may be different, but there are no formal obstacles to this, since all assessments are obtained as the result of actions based on the same algorithmic scheme, at the same time the offered technique can be used on any platform. In General, regional development should be based on building up and effectively using the potential of the subject on the basis of reducing state interference and the formation of a rational management mechanism in the regions.

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