Experimental management of ecological security of territorial facilities for forecasting the developing economy dynamics

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Abstract. The article presents the essence of the environmental safety management system of territorial objects as a set of actions and processes aimed at planning and constructing optimal options for spatio-temporal structural and functional organization of ecosystems, restoration and enhancement of their ecological potential and sustainability, prevention and development of environmental risks. The structural blocks of the system are: environmental audit, environmental design (planning), environmental monitoring, databases and data banks using GIS technologies. An important role in the management system of environmental safety of territorial objects belongs to the implementation of the concept of ecosystem services. It is based on the need for coevolutionary development of environmental and economic components. The space of possibilities for admissible variants of the future in the form of a scenario funnel within which alternative lines of development are investigated in scenarios. The regional aspect of practical significance of ecosystem services is presented by adjustment of gross accumulations of fixed capital is investigated.

1. Introduction
Preservation and restoration of the natural environment, ensuring ecologically safe functioning of ecosystems are the priority conditions for the implementation of the dominant social paradigm - development in harmony with nature. There is a need to find a compromise between the social and economic needs of mankind and the ability of the biosphere to meet them [1-3].

With modern production and consumption models the natural resources are used faster than restored. Capabilities of the natural environment for resistance to these processes are near exhaustion. Development in harmony with nature is impossible without transfer to the production and consumption models ensuring non-exhausting use of natural resources and ecological safety of territorial units. Presence of the ecological risks and the need of ensuring environmentally safe functioning of ecosystems determine the relevance and importance of development and introduction of the management system of ecological safety of territorial units.

At the present stage of society development, the most effective tools for the effective use, preservation and restoration of ecosystem functions are those based on economic interest. Instead, the modern economy does not fully take into account the economic contributions of ecosystem values,
which is largely due to the lack of a coherent scientific approach to determining their nature and content, methodological tools for their economic evaluation [4]. Therefore, there is a need for appropriate research and inclusion of ecosystem services in the activities of economic entities.

2. Background

Negative anthropogenic changes in the natural environment, disharmony between the rate of natural resources use and their restoration have become an objective prerequisite for the need to apply the methods of management science in the use and reproduction of natural resources and environmental safety of territorial objects. Existing management systems in Ukraine are characterized by departmental fragmentation, structural complexity and functional-territorial inconsistency of its components. Under such conditions, it is necessary to develop a strategy and principles for managing the environmental safety of territorial objects to ensure the coordinated development of natural and economic subsystems within the integrated system "nature – society".

The most common are two types of territorial management: "hard" and "soft". "Hard" management involves interference in natural processes, their "correction" by radically transforming the mechanisms and systems of nature [5]. Management of territorial objects requires an understanding of the mechanisms of organization of ecosystems within them not only as individual territorial entities (which they consider in the context of this article), but also as a specific link in the ecological chain within the relevant land surface. It is this aspect in "rigid" management that is often absent, which makes it destructive.

Soft management is the indirect impact on ecosystems, usually through natural self-regulatory mechanisms, although sometimes through the technical design of these mechanisms. It aims to restore the former natural productivity of ecosystems or increase it by targeted, based on the use of natural development measures objective laws, which allows to direct natural chain reactions to the "soft" option [5]. Such management also has certain shortcomings, but they are not catastrophic for ecosystems, as ecosystems are able to eliminate negative impacts through self-regulatory mechanisms.

From the above it can be concluded that management is a purposeful influence of the subject (person) on ecosystems, by planning and making appropriate decisions to keep ecosystems in a certain state through the implementation of managerial influence to achieve this goal; purposeful function of the organization, the purpose of which is to preserve the invariant structure and the general direction of ecosystem development. Management is to select the best options for planning the territorial organization of ecosystems, which ensure their sustainable functioning and development at all levels of space-time and functional organization; it is a system of actions aimed at achieving a certain level of environmental quality, which ensures the normal functioning of ecosystems, their environment and resource recovery properties.

Management refers to the process of conscious anthropogenic impact on ecosystems in order to maintain, adjust or change natural mechanisms. That is, there are two processes: the current state of ecosystems with existing spontaneously formed management mechanisms and the planned state of these ecosystems with a certain share of anthropogenic management. An ecosystem becomes manageable when, among all the influences on it, there is one with which it is possible to achieve the set goal.

The most rational management is carried out in the direction of restoring the natural mechanisms of self-regulation - biotic regulation [6]. It should be aimed at restoring the natural ecological potential [7] of ecosystems or increasing it by implementing a purposeful and based on the use of objective laws of nature development system of measures to direct natural chain reactions to favorable for ecosystems, economy and human life option.

The management process has a dual nature: the management of a specific territorial system and the management of its environment. In this case, it is the environment in the spontaneous mode of operation of territorial systems performs control and corrective functions [8]. Such management is understood as a systematic transformation of the ecosystemically differentiated environment in the
interests of man, but without destroying the mechanisms of biotic regulation. The effectiveness of management decisions is determined by the most integrated characteristic of territorial systems - their stability [9-11].

3. Methodology
The management system of ecological safety of territorial units is a complex and comprehensive problem, which solution is aimed at ensuring safe functioning of the ecosystems that is determined by all processes accompanying their existence (vital activity, productivity, exchange and flows of substances). Ensuring absolute ecological safety (zero risk principle) requires significant material costs. Due to this the management system of ecological safety of the ecosystems is based on acceptable risk principle. Ecological safety level indicators are ecosystem stability and ecological potential indices and health level of the population [11, 12].

Ecological safety of territorial unit is determined as condition of the ecosystem within its boundaries, which ensures maintaining ecological risks at "acceptable risk" level, restoration of primary ecological potential of ecosystems, elimination (minimisation) of threats both for ecosystem components and for vital activities and health of people.

The territorial units should be a result of efficient management and planning, their constant improvement for construction of stable and environmentally safe ecosystems within their boundaries. According to the systems theory, the more complex ecosystem structure is, the more resistant it is to environmental effects.

Creating conditions that would prevent the negative impact of anthropogenic activities on ecosystems is realized through balanced resource use, planning and design and optimization of ecosystems [13]. Optimization is carried out by purposeful management of processes and phenomena of different genesis to maintain the state of internal dynamic balance between the structural components of ecosystems and the possibility of self-regulation and self-restoration. Such approaches correspond to the principles of the theory of biotic regulation of the environment [14], according to which environmental management and restoration of internal balance is carried out by natural biota.

The main task in substantiating the measures for the management of territorial objects ecological safety is to solve the problem of ensuring the integrity and optimal structure of ecosystems within them. Optimization of the ecosystems structure is based on the principle of conformity of production and economic activities to the features of ecosystems. These features determine certain restrictions (limits) for the development of ecosystems and types of their economic use.

Based on the above, the environmental safety management system of territorial objects is defined as a purposeful activity (set of actions, processes and measures) aimed at planning and constructing optimal options for spatio-temporal structural and functional organization of ecosystems within them, restoration and improvement of ecological potential and sustainability of ecosystems, prevention of the emergence and development of environmental risks, maintenance of ecological and economic balance and implementation of ecosystem strategies. The ecosystem strategy is a set of mutually adapted features, traits and properties of the ecosystem, which ensure its adaptation to changing environmental conditions and aimed at implementing the program of individual and group evolution [15]. The main essence of the environmental safety management system of territorial objects is that management cannot be effective if it is carried out on a sectoral basis within individual ecosystems and their components without taking into account the functional relationships between components of ecosystems and between ecosystems. In the system of environmental safety management of territorial objects, one of the primary tasks is to determine the future state of management objects. This makes it necessary to implement a planning function in the management system.

Management, which ensures the ecological safety of territorial objects, should be carried out based on the need for maximum conservation and restoration of natural ecosystems and the formation of anthropogenically modified ecosystems (agroecosystems), taking into account the parity of biosphere and society. Parity is achieved by scientifically sound structural and functional organization of territorial objects and the optimal ratio of natural and anthropogenically altered ecosystems.
Management of ecological safety of territorial objects should be carried out with observance of the following principles: 1) the principle of unconditional priority of safety; 2) taking into account the limited natural resource and environmental potentials; 3) timeliness of measures implementation; 4) forecasting of negative consequences, which is based on a multivariate analysis of possible situations; 5) adaptability of management, i.e. the ability to change management decisions (measures) in accordance with changing conditions and objectives of management; 6) control (monitoring) over the approach to the purpose of management decisions.

The management system of territorial objects ecological safety should include: 1) analysis of the ecological risks causes and their characteristics; 2) regulation of risks by mechanisms of their regulation (permits for maximum allowable emissions and maximum allowable discharges of pollutants, waste generation and utilization, environmentally safe standards of resource use); 3) preservation and restoration of natural ecosystems; 4) balanced resource use, which is based on achieving a balance (equilibrium) between economic development and natural resource potential; 5) substantiation of measures (strategies) for minimization of ecological risks and ensuring ecologically safe functioning of ecosystems (natural, anthropogenically modified, anthropogenic, technogenic) within the territorial object; 6) integration of geospatial data in GIS format to provide users with information.

The system of environmental safety management of territorial objects has a hierarchical level of structure, information flows and a system of direct and feedback links and is based on the position that changes in the system are caused by these connections. Obtaining the end result - ecologically safe functioning of ecosystems within the territorial object - is a function of the parameters of individual blocks of the system, which must be guided by the justification and management decisions. The environmental safety management system of territorial objects (Fig. 1) consists of the following blocks:

- environmental audit, which includes the identification of ecosystems and characterization of existing environmental risks, assessment of ecosystem services and their use;
- ecological design aimed at planning and construction (project development) of the structural and functional organization of ecosystems within the territorial object, in which management decisions (measures and resources) for achievement of ecological safety of the territorial object are substantiated;
- environmental monitoring, the task of which is to control the response of ecosystems to implemented projects (management decisions);
- databases and data banks using GIS technologies.

An important role in the management system of territorial objects environmental safety belongs to the implementation of ecosystem services concept. It is based on the need for coevolutionary development of environmental and economic components, reflected in national policies and legislation of many countries, became the basis of a number of international treaties, is contained in the final documents of the UN Conference on Sustainable Development "Rio + 20". The European Biodiversity Strategy requires all EU member states to identify and assess ecosystems and their services at the national level by 2020, as well as to integrate the results into the overall system of environmental and economic calculations [16]. In Ukraine, by 2020, the ecosystem approach should be implemented in territorial management, and Ukrainian legislation in this area should be harmonized with European.

Cost assessment of ecosystem services, development and implementation of payment mechanisms and use of funds for these services will allow to implement programs (measures) to ensure ecologically safe functioning of ecosystems within territorial objects.

In the classical sense, an ecosystem is a rankless unit of various dimensions, which does not have territorial constraints (its size is determined by a systemic measure). Therefore, for the scientific substantiation and implementation of the ecosystem services concept, it is important to identify ecosystems at the territorial level. The smallest unit of such ecosystems in the European classification of ecosystems EUNIS (European Nature Information System) is "habitat", which is close to the
"ecotope" - a plant and animal groups that form a biotic environment with abiotic factors and interact in a certain area [17].

The EUNIS classification of ecosystems has absorbed the positive features of different classifications (Emerald, NATURA 2000, CORINE, Palearctic Habitats), is based on the assessment of similarity of ecotopes, has a hierarchical structure and includes 11 main types, within which levels II-VIII are distinguished.

The most common in the scientific literature is the definition of ecosystem services as benefits and values derived from ecosystems, as well as the whole list of material, energy and information flows created by natural capital, which in combination with physical, human and social capital ensure society's well-being. [18].

Currently, three international classifications of ecosystem services have been developed [19]: 1) Millennium Ecosystem Assessment (MA); 2) The Economics of Ecosystems and Biodiversity (TEEB); 3) Common International Classification of Ecosystem Services (CICES). The CICES classification is based on the two above classifications, but is more focused on the accounting and economic assessment of ecosystems at the national, regional and local levels. These classifications are essentially similar and include three main categories of ecosystem services: provisioning - providing people with material goods and resources that they directly use; regulating - various mechanisms of ecosystems that regulate environmental indicators that are directly important for human well-being; cultural - intangible support of cultural, spiritual and scientific needs of people [19]. Work on the typification and harmonization of the list of ecosystem services continues (Haines-Young, Potschin, 2012, 2014, 2018) [20].

Figure 1. Environmental safety management system of territorial objects
Estimating the value of ecosystem services depends on their understanding and comprehension. It is very difficult to understand, research and evaluate all ecosystem services, and to predict how they may change as a result of human activities. The lack of this information leads to an underestimation of ecosystem services. Different methods are used to estimate the cost of ecosystem services, depending on what is being assessed, how strict the requirements for the analyzed data are and the limitations that are allowed [21]. It is advisable to use several evaluation methods in parallel to obtain more reliable results. However, the participatory method, which explains the participation of stakeholders, is of great importance. In relation to ecosystem services, there are three types of assessment: environmental (the ability of ecosystems to perform their functions through spatial modeling and mapping), economic (integrated into decision-making mechanisms and familiar to the market) and social (providing coherent solutions for society and conflict resolution due to scenario development). development).

![Dynamic model of ecosystem services assessment levels](image)

**Figure 2.** Dynamic model of ecosystem services assessment levels

Sector 1 provides a balance of interests and benefits of all participants and users of ecosystem services based on the concept of general economic value, the main idea of which is to take into account the resource, regulatory and cultural functions of natural capital. The total value consists of the use cost and non-use of the territory, which has the functions of natural capital. This concept involving a variety of methods (market-rent assessment, market prices, and non-market-subjective assessment, preventive costs, restoration costs, transport costs, losses) is widely used to assess ecosystems. The specifics of economic evaluation is to identify participants in the process of using ecosystem services, ie producers ("donors") and recipients ("recipients") of benefits. On the example of key ecosystem services in the Western region, the classification of interregional relations "donor-recipient" is as follows (Table 1).

Sectors 2, 3, 4 take into account the wishes and requirements of several specific participants. In particular, spatial modeling and mapping of ecosystem services have gained the greatest interest within the European Union for local economic planning. Thus, the contribution of ecosystem services to the system of human-environment relations means the contribution of services to the development of land use, for example, in the form of fertilizers, energy, work performed or information. These
Contributions are often closely linked to the functions of the ecosystems that form the basis of the ecosystem services supply. In this case, the relationship between land use, ecosystem functions and ecosystem services can be represented in the form of matrices. "Land use" means natural landscapes (coniferous forests, pastures, etc.), anthropogenic objects and sites (airports, urban areas, industrial areas, etc.). Expert scales of the ability of land use certain types to support ecosystem functions and provide ecosystem services are used to assess; demand and supply of ecosystem services in different types of land use. Measurements (quantitative and qualitative) can be carried out using applied models, statistics, monitoring data, cost transfer or by interviewing experts.

| Table 1. The classification of interregional relations “donor-recipient” |
|---------------------------------------------------------------|
| **Group of services** | **Donor regions** | **Recipient regions** |
|----------------------|------------------|----------------------|
| **Providing**        |                  |                      |
| Wood production      | Forest trade in interregional and national markets | Relations between regions are less important than relations between business structures |
|                      | Forest harvesting regions | Regions that buy forest |
| Production of other organic products (fish, mushrooms, berries, etc.) | Trade in organic products within the country | Relations between regions are less important than relations between business structures. The movement of organic products from one region to another by individual fishermen, mushroom and berry pickers does not play a significant role, as there is no mass interregional migration of the population in order to extract organic products. |
|                      | Regions that harvest organic products | Regions that buy organic products |
| **Regulatory**       |                  |                      |
| Regulation of the carbon cycle and greenhouse gas flows | National carbon market (currently absent) | Economically developed regions that emit carbon into the atmosphere (industrially developed) |
|                      | Regions with high-carbon ecosystems (low-disturbed wetlands and forests) | |
| Drain regulation, flood prevention and water purification | Regulation of river flow and water quality in large lakes and rivers flowing through several regions | Regions located in the lower reaches of rivers with high population density |
|                      | Regions located in the upper reaches of rivers with large forest ecosystems | |
| Soil protection against erosion | Prevention of soil runoff and soil into reservoirs on an interregional scale | Regions located on the leeward side of the prevailing winds. The importance of the service is determined by population density and the degree of agricultural development |
|                      | Regions located on the windward side of the prevailing winds with natural ecosystems | |
| **Recreational**     |                  |                      |
| Cognitive and natural tourism | Domestic tourism | Regions / countries from which people come for vacation |
|                      | Regions with unique and beautiful natural ecosystems are available for recreation | |
| Recreation           | Outdoor recreation areas and resorts of interregional and national importance | Regions from which mostly people come |
|                      | Regions that have these destinations and resorts | |
Sectors 5, 6, 7 take into account the uncertainty indicator, where it is clearly impossible to form and evaluate the creation of a development scenario. In contrast to the forecast, the scenario does not report the possibility of anything happening, it explores several alternative ways of development (Fig. 3).

![Figure 3. Script funnel](image)

The so-called scenario funnel, which depicts the space of opportunities for acceptable options for the future, as well as inside the funnel explored in the scenarios of development alternative lines. Scenarios help to predict the consequences of certain measures and trends, or the scale of risks, as well as their causes. Scenarios are divided into types according to various criteria, the most important of which are: "direction of development" and "method of data processing". The criteria for "direction of scenario development" are:

- information about the trend, which explores the still unknown situation in the future (forecast), and scenarios develop according to the question: where do certain trends or decisions lead?
- in relation to a certain situation in the future the way leading to it (backcast) is investigated, and here normative scenarios according to a question are usually studied: how the desirable purpose is reached? how can a certain danger be prevented?

"Methods of processing" include qualitative (in the general population, with consideration of complex issues and problems) and quantitative (with processing in a circle of specialists, using a mathematical model) scenarios.

The regional aspect of the practical significance of ecosystem services can be clearly represented by adjusting the gross fixed capital formation. The index of adjusted net savings characterizes the rate of accumulation of national savings, taking into account the depletion of natural resources and damage from environmental pollution. The indicator is the result of changes in gross internal savings, while the adjusted net savings (ANS) are calculated according to [22] by the formula:

\[
\text{ANS} = \text{GF} - \text{TA} - \text{DNR} - \text{DEP} + \text{Ehcd} + \text{EPC} + \text{ASPNA},
\]

where GF - gross fixed capital formation;
TA - fixed capital investment by type of activity "Mining";
DNR - depletion of natural resources;
DEP - damage from environmental pollution;
Ehcd - budget expenditures for human capital development;
EPC - environmental protection costs;
ASPNA - assessment of specially protected natural areas.

Among the restrictions imposed in connection with the use of official statistics, it should be noted the low efficiency of publishing data (according to some indicators, information is published with a two- and sometimes three-year delay), as a result of which the situation is considered at 2018. Given the importance of basic ecosystem services for the region's economy,

\[
\text{AHS} = 100,11 - 81,59 - 66,07 - 1,203 + 33,17 + 6,89 + 0,675 = -8,018 \text{ UAH million}
\]
Ecological and economic index (index of adjusted net savings - IANS) is calculated as the ratio of adjusted net savings to GRP by the formula:

$$\text{IANS} = \frac{\text{AHS}}{\text{ANS}} \cdot 100\%,$$

where ANS - adjusted net savings; GRP is a gross regional product (according to the statistics of the Western region for 2018 it is equal to UAH 62,347 million). [23].

The value of the index of adjusted net savings is -12.86. Its dominant "negative value" is a fact of insufficient sustainable development of the territory. However, it should be borne in mind that during the period 2018-2020 there is a slight improvement in the situation of conservation of natural resources - reducing the depletion of forest resources and significant development of recreational areas.

For the initial assessment of social and environmental components, an expert indicator is used, which is based on the concept of a multi-attribute model and includes three stages: first, the average value of the overall assessment of certain environmental or social indicators is assessed; secondly, the average value of satisfaction and importance for each characteristic is calculated. Finally, an assessment of intentions to improve (increase) the values of indicators is provided.

$$S_{SEj} = \frac{\sum_{i=1}^{k} S_{SEi}^C}{m} = \frac{\sum_{i=1}^{k} S_{SEi}^P}{k},$$

where $S_{SEi}^P$ – average assessment of environmental (social) indicators of one respondent $C_j$ ($j=1,...,m$) parameters of the cooperation level $P_1,...,P_k$;

$S_{SEi}^C$ – average assessment of respondents' satisfaction $C_1,...,C_m$ parameters of the indicators characteristics level $P_{SL_i}$ ($i=1,...,k$);

$k$ – the number of environmental (social) indicators analyzed;

$m$ – number of respondents.

The proposed methodology will allow to classify regions by levels of ecosystem services to build a system of experimental management of environmental safety of territorial objects to forecast the dynamics of the developing economy, taking into account the interests of all participants.

Classification of Ukraine’s ecosystem, ecosystem services they provide, assessment of the ecosystem services cost are in the process of formation. To implement the concept of ecosystem services in the system of environmental safety management of territorial objects it is necessary to scientifically substantiate, improve and generalize the conceptual and terminological apparatus, classification of ecosystems and their services, methods of assessing the state of ecosystems and calculating the cost of ecosystem services; develop and adopt relevant regulations.

4. Conclusions

1) The objectives of environmental safety management of territorial objects are: 1) preservation of natural ecosystems and the course of natural processes in them; 2) restoration of indigenous phytocenoses and faunal complexes; 3) construction in anthropogenically modified ecosystems (agroecosystems) of territorial complexes, which are close to typical for a certain physical and geographical zone of natural ecosystems; 4) conservation and restoration of biotic and landscape diversity; 5) formation of regional and local ecological networks.

2) An important role in the management system of environmental safety of territorial objects belongs to the implementation of the concept of ecosystem services. By 2020, the ecosystem approach should be implemented in territorial management, and Ukrainian legislation should be harmonized with European legislation.

3) Cost assessment of ecosystem services, development and implementation of payment mechanisms and use of funds for these services will allow to implement programs (measures) to ensure ecologically safe functioning of ecosystems within territorial objects.
4) Classification of Ukraine’s ecosystem, ecosystem services they provide, assessment of the cost of ecosystem services are in the process of formation. To implement the concept of ecosystem services in the system of environmental safety management of territorial objects it is necessary to scientifically substantiate, improve and generalize the conceptual and terminological apparatus, classification of ecosystems and their services, methods of assessing the state of ecosystems and calculating the cost of ecosystem services; develop and adopt relevant regulations.

5) The proposed methodology will allow to classify regions by levels of ecosystem services to build a system of experimental management of environmental safety of territorial objects to forecast the dynamics of the developing economy, taking into account the interests of all participants.

References

[1] Prykhodko M 2017 Floods and their management in the Carpathian region of Ukraine Scientific bulletin of National Mining University pp 113-117 Available at http://www.nvngu.in.ua/index.php/uk/component/jdownloads/finish/67-02/8627-02-2017-prykhodko/0

[2] Prykhodko M, Romaniuk V, Kukhtar D, Bodnaruk I, Khmil N 2019 Application of the geographic information system technologies in the geosystem planning process Geoinformatics 2019 Available at https://doi.org/10.3997/2214-4609.201902041.

[3] Prykhodko M, Romaniuk V, Kukhtar D, Rodzinska O 2018 A modern approach to monitoring the territories of solid waste landfills Geoinformatics 2018 Available at https://doi.org/10.3997/2214-4609.201801829

[4] Mishenin Ye, Dehtiar N 2015 Economics of ecosystem services: theoretical and methodological fundamentals Marketing and management of innovations No 2, pp 243-257

[5] Reimers N 1990 Nature management: Dictionary-reference book 637 p

[6] Gorskhov V 1995 Physical and biological bases of stability of life 472 p

[7] Golubets M, Mariskevich O, Krok B 2003 Ecological potential of terrestrial ecosystems 180 p.

[8] Petlin V 2008 Ecological mechanisms of organization of natural territorial 304 p.

[9] Armand D, Kupriyanova T 1979 Stability of ecosystems Izv. USSR Academy of Sciences Ser. Geography No 6 pp 81-82

[10] Baranovsky V, Shyshchenko P 2002 Stability of the natural environment 14 p

[11] Holubec M 1992 Resistance and stability - important features of living systems № 1 pp 21-26

[12] Golubets M, Mariskevich O, Krok B 2003 Ecological potential of terrestrial ecosystems 180 p.

[13] Pozachenyuk E 2003 Territorial planning 383 p

[14] Gorskhov V 1995 Physical and biological bases of stability of life 472 p

[15] Petlin V 2007 Landscape strategy 288 p.

[16] Objectives of millennium development of Ukraine: 2000-2015 2015 Available at http://un.org.ua/images/stories/docs/2015_MDGs_Ukraine_Report_ukr.pdf

[17] Davies C, Moss D. 2002 EUNIS Habitat Classification. Final Report to the European Topic Centre on Nature Protection and Biodiversity 125 p

[18] Brown T, Bergstrom J, Loomis J 2007 Ecosystem Goods and Services: Definition, Valuation and Provision Natural Resources No 47 pp. 329-369

[19] Ecosystem services of Russia: Prototype of the national report 2016 Terrestrial ecosystem services Vol. 1 148 p

[20] Haines-Young R, Potschin M 2018 Common International Classification of Ecosystem Services (CICES) V5.1 and Guidance on the Application of the Revised Structure Fabis Consulting Ltd Available at https://cices.eu/content/uploads/sites/8/2018/01/Guidance-V51-01012018.pdf

[21] Dykson D, Skura L, Karpenter R, Sherman P 2000 Economic analysis of environmental impacts

[22] Bobylev S, Minakov V, Solovyova S, Tretyakov V 2012 Ecological and economic index of the regions of the Russian Federation World Wildlife Fund (WWF) and RIA Novosti 152 p.

[23] State Statistics Service of Ukraine Available at http://www.ukrstat.gov.ua/