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CONCEPTUAL MODEL FOR THE DEVELOPMENT OF GEO-ECOLOGICAL ATLAS OF THE NATURAL RESERVE FUND OF UKRAINE

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Abstract. The article substantiates that the most complete cartographic model, which comprehensively characterizes the objects and territories of the natural reserve fund (NRF) of Ukraine is the geo-ecological atlas. It is indicated that the basis for the creation of the atlas is its conceptual model, within the framework of the formulation of its provisions are defined: the object of modeling, structure and composition of the modeled system, the characteristics of its elements, as well as inherent in the system cause-effect relationships that are considered essential to achieve the purpose of modeling. The functions of the atlas of NRF are formulated. The formal features of its content are interconnected. The authors in the context of the formulation and use of methodological principles of atlas completing with maps (sequential-traditional; block-issue; combined) applied combined principle and determined the optimal thematic content of the atlas in the form of a list of maps, grouped by sections and blocks (three sections, each of which contains two blocks of maps). The types of maps included in each section / block are defined (mainly they are: analytical (inventory), analytical-synthetic (evaluation), synthetic (recommendation, forecast), for each of which the indicators of mapping and methods of cartographic representation are justified.

Keywords: geo-ecological atlas, natural reserve fund, conceptual model, comprehensive atlas, atlas functions, formal features of the atlas, principles of completing atlas maps, map types.

Introduction

One of the main directions of environmental policy in Ukraine is the development of protected areas, where objects of natural reserve fund (NRF) are located. Such areas protect the national patrimony, in relation to which a special regime of use and reproduction is established. Our country considers it as an integral part of the world system of natural areas and objects under special protection. The development of this system is an important prerequisite for the sustainable development of the country. This is primarily confirmed by the Law of Ukraine (On the basic principles (strategy) of the state ecological policy of Ukraine for the period until 2030, 2019) to increase and expand the territories of NRF (in particular protected areas in national nature parks and regional landscape parks), creation onshore and in the Black Sea and the Azov Sea, ensuring the safety and functioning of representative and effectively managed system of territories and objects of natural reserve fund, including transboundary, European and international importance.

The State strategy of regional development (State strategy of regional development..., 2020) envisages expansion of NRF area (as in the previous programs) up to 15% of the total territory of the country in 2027. This indicator is a very important environmental and social indicator, the increase of which contributes to the maintenance of ecological balance of ecosystems and environmental stability of territories.

Ensuring the development of protected areas is carried out by various effective methods, one of which is rightly the cartographic method. Thanks to its use through a separate problem-oriented direction of thematic cartography, geo-ecological mapping is improving and streamlining environmental policy and environmental research by developing means and technologies of objective, informative and visual presentation of the results of interaction in the system “society – nature”.

The main means of geo-ecological mapping are geo-ecological maps, series of maps and atlases, reflecting the state, structure and acuteness of environmental problems within territories of various spatial levels and are intended to help solve various negative environmental situations,

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which were formed on the mapping area, as well as preventing the emergence of new ones. These types of cartographic works are used by specialists of environmental committees, sanitary-epidemiological supervision, environmental research organizations, including as a scientific reference manuals in making specific decisions to improve the quality of the environment.

As part of the environmental direction of geo-ecological mapping cartographic works of the NRF are created, the content of which, according to its definition with (On the nature reserve fund of Ukraine, 2020) should be areas of special environmental, aesthetic, scientific, recreational and other values and created in order to preserve the natural diversity of landscapes, gene pool of fauna and flora, maintaining a general ecological balance, their quality and quantitative characteristic.

Only together and sequentially different types and types of maps of NRF will be able to provide a picture of the current situation as a whole, the composition, dynamics, relationships, pressure on it, and will provide recommendations and forecasts regarding the prospects of development of territories, thus forming an appropriate system of maps. It is advisable to combine them into the Geo-ecological Atlas of the NRF.

Its development logically begins with the formulation of the provisions of the conceptual model. The latter indicates the relevance of this article.

1. Materials and methods of research

The development of a conceptual model of geo-ecological atlas of the natural reserve fund of Ukraine and the determination of its content as a part of this model to implement the principles of thematic mapping based on the use of functional capabilities of geographic information systems (GIS) formulated in Bondarenko (2007) is reasonable primarily by analyzing the created in Ukraine complex atlases containing maps of nature protection themes and geo-ecological atlases of national level, which contain maps of NRF. It is also advisable to determine the list of methods of such research and the necessary materials, in particular, modern statistical information about the natural reserve fund of the country.

Analyzing the created atlases, it should be noted that the most famous and meaningful geographical atlas of the first stage of geo-ecological and environmental mapping of Ukraine (since the 1970s), which characterizes the natural component of its territory is the "Atlas of natural conditions and natural resources of the Ukrainian SSR" (1978). The actuality of the problems of nature protection and the rational use of natural resources on the territory of Ukraine has led to the necessity of the "Nature Protection" section. It consists of 22 maps, which is 4.9% of the cartographic works total. The structure and themes of the section were determined by the directions and content of researches on determining and mapping of negative anthropogenic phenomena and measures on their elimination. On the map of nature protection measures and

nature protection objects of national and local importance (including objects and territories of NRF) are represented by icons (symbols) and areals.

Further, the maps of nature protection became an integral part of atlas cartographic works of the national level, in particular, such as: "Ecological Atlas of Ukraine" (Baranovsky, 2000), "Ukraine. Ecological and Geographical Atlas" (Baranovsky et al., 2006); "National Atlas of Ukraine" (National Atlas of Ukraine, 2007); "Ecological Atlas of Ukraine" (Ecological Atlas of Ukraine, 2009). For example, the National Atlas of Ukraine in the block VI "Ecological condition of the natural environment", sub-block "Prevention of deterioration of the ecological condition of the natural environment" contains maps: "Natural protected areas", "Carpathian national nature park", "Shatsk national nature park", "Azovo-Sivash national nature park", "Biosphere reserve 'Askania Nova' named after F. E. Falz-Fein"; in the sub-block "Vegetation and fauna" – "forest plant species included in the Red Book of Ukraine", "Plant groups included in the Green Book of Ukraine", "Mammals" (as animal species to be protected in accordance to international conventions), separately "Mammals", "Birds", "Lepidoptera" (as animal species included in the Red Book of Ukraine), "Forest animal species included in the Red Book of Ukraine". As you can see from the list, the natural reserve fund itself is represented by only one map.

In the specialized (thematic) domestic developments known to the authors (Leonenko et al., 2003; Grachov, 2020), which in fact can be the subject of discussion in this article, mainly with the help of localized icons and ranges (the latter method of cartographic representation is actualized when the scale is increased for the atlas (Grachov, 2020)) on the inventory maps separately represent the locations of the objects of the NRF according to the existing classification (nature reserves, Biosphere reserves, national nature parks, regional landscape parks, protected tracts, nature reserves, natural monuments, botanical gardens, dendrological parks, zoological parks, parks-monuments of landscape art) and some additional information from the database in a pop-up window (name, year of creation). This indicates the simplest variant of cartographic provision of information about NRF through the use of web-mapping capabilities of GIS facilities.

In general, the analysis of the content of the selected atlases, determines the feasibility of formulating provisions for the development of a new separate cartographic work, versatile characterization of the national level NRF with the justification of the definition of the specified atlas as geo-ecological, defining its content type (as a complex), the basic principles of filling maps, and also defining possible options for practical implementation: traditional on paper or viewer or interactive based on a modern software.

In the process of this research the authors used general scientific and special methods, among which the main are: analysis and synthesis, used to study the experience of geo-ecological and environmental mapping, analysis of information support of the atlas development, determination

of the main principles of its individual maps of various possible types; scientific classification, comparative, mathematical, modeling, semiotic – to implement certain tasks of creating an atlas of the NRF; information, cybernetics and other methods.

The integral method of research is the systematic approach, which is applied at all its stages and is considered in interconnected aspects via:

- conceptual basis for the creation and development of a unified system of maps included in the atlas;
- scientific method of computer technology application and effective practical organization of the atlas development work on the basis of GIS;
- methodology and methodology of developing individual cartographic models on the basis of GIS and atlas as a whole.

The information base of the work, corresponding to the theme of the atlas, is the data on the objects and territories of the country's NRF and their distribution by regions. Up to 1.01.2020 (current data are at the disposal of the authors at the time of this manuscript preparation) according to the State Cadastre of Territories and Objects of the Natural Reserve Fund of Ukraine (The nature reserve fund of Ukraine, 2020) NRF of Ukraine comprises 8512 territories and objects with a total area of 4.418 million ha within the territory of Ukraine (the actual area 4.085 million ha) and 402500.0 ha within the Black Sea. The ratio of the actual area of the natural reserve fund to the area of the state ("reserve indicator") is 6.77%.

During 2019, the number of objects and territories of natural reserve fund of national and local importance increased by the total area, amounting to 94224.2 ha. By 2019, 116 territories and objects of natural reserve fund were created (declared), 9 were expanded, 3 were reduced in area, 1 status was cancelled and 13 objects were changed in category.

2. The purpose and objectives of the study

The purpose of this article is to formulate the scientific provisions of the conceptual model of the development of the geo-ecological atlas of the natural reserve fund of Ukraine.

Realization of the goal determines the fulfillment of the following tasks:

- to define the atlas of natural reserve fund of Ukraine in terms of its creation as a geo-ecological cartographic work of complex type;
- define the features of the proposed atlas in accordance with the functions of protected areas;
- define the functions of the geo-ecological atlas of protected areas;
- justify the formal content of geo-ecological atlas as a system in accordance with the theory of atlas mapping;
- formulate methodological principles of constructing (completing with maps) atlas of NRF and determine the optimal content in the form of a list of maps, grouped by sections and blocks;

- determine the types of maps included in each section / block, mapping indicators, methods of cartographic representation and common semiotic structure.

This study is performed in the context of the research project of the Cartography Department of the Institute of Geography of NAS of Ukraine in cooperation with specialists of the Department of Geodesy and Cartography of Taras Shevchenko National University of Kyiv.

3. Results and discussion

The creation of an atlas-type cartographic work from the conception to the finished product is, on the one hand, a very responsible, but at the same time rather labor-consuming work, even despite the modern possibilities of its development using both software and hardware. Although the use of the latter greatly facilitates the possibilities of practical implementation and determines the possible forms of atlas presentation, in particular distribution in paperless form through network technological solutions.

It is known that an atlas is a cartographic encyclopedia, a systematized base of knowledge about the territory for a certain period of research, coming out to the modern level. Atlas maps are quite convenient to compare, compare, overlay (in the modern sense, when using geographic information systems and other specialized software – overlay analysis, author). If necessary, it is possible to obtain necessary additional information, in particular, quantitative parameters, to carry out mathematical operations, to create derivative images.

Atlases are cartographic works, which are specially designed for the comprehensive study and evaluation of the mapping area, for conducting in-depth scientific research, drawing up plans for the development of natural resources of the territory and forecasting the consequences of anthropogenic pressure on it, as well as designing necessary environmental protection measures and improving the ecological situation. It is logical that atlas maps are a sufficiently informative source, even at a small scale (for the electronic version of the atlas of the viewer type or its paper representation), and the scale of the electronic map can be changed (increased), getting even more necessary information about the territory, if it is implemented within its capabilities.

Geo-ecological atlas of the Natural Reserve Fund of Ukraine is the most complete cartographic work. It comprehensively characterizes the relevant objects and territories.

The conceptual model of the development of the mentioned atlas defines the object of modeling, the structure and composition of the system being modeled, the characteristics of its elements, as well as the inherent cause-and-effect relations that are considered essential for achieving the goal of modeling.

The conceptual model also characterizes the formal composition, structure, volume and content of each block of information of the model, defines in addition to the thematic orientation of maps (names, subjects of maps,

units of mapping, methods of cartographic representation) their types according to the classification of geographical maps on the characteristics that allow to identify types of maps (for example, by breadth of coverage of the topic, by level of analysis and synthesis of objects, phenomena and processes shown on the map; by functionality), and the basic map scales and so on.

All these parameters are presented in the main document on the creation of the atlas – its program (Bozhok et al., 2014; etc.).

The object of modeling is the system of natural reserve fund of Ukraine, which by structure and composition corresponds to its national classification, and the model of this system is the atlas of the object at the specified territorial level of mapping.

Development of the atlas includes a formulation of methodology and methodology provisions, which are formed from a list and order of scientific approaches, methods and principles, practical algorithms for creating maps based on modern automated software and hardware solutions, which are web GIS-technology.

The atlas mentioned above is justified as a computer (electronic) interactive cartographic work (not viewer) as a systematic collection of maps (perhaps even more precisely layers of maps), logically and thematically related to each other. They are presented in an order that defines the possibility of supplementing previous maps with the next. Although when using an atlas the user can break this order and independently choose to use the necessary thematic information layers (defining subjects) on a geographical basis.

Electronic interactive version of the creation of the proposed atlas is the primary, because it is it with the necessary efficiency allows to conduct research on the optimal structure, options of map subjects, methods of cartographic representation, necessary graphic means, the functionality of conventional signs and the paper version if necessary.

Interactivity of atlas maps provides a number of typical functions that determine the functionality of individual maps and the atlas as a whole. These are, in particular, such functions as:

- combining (displaying) content elements (mapping indicators) according to user requirements. It is characterized by the creation of selections using screen interface tools (with the legend presented), search capabilities of the information base with its updating in real time (subject to Internet connection);
- change of image browsing and scaling, including determining the base load in a particular display mode (scale);
- navigation and retrieval services with the ability to search by their names, lay the best route and conduct the appropriate cartometric operations and analytical constructions;
- hyperlinks for quick transition (access) to necessary information (images, text, information, etc.).

The structural parts of the atlas are defined as introductory, thematic (which is substantive and basic) and additional. The last one is distinguished conditionally,

because it includes both textual information, formed from the introduction (with semiotic characteristics of the atlas), accompanying texts on blocks of maps and individual maps, means of non-cartographic presentation of data, revealing the content of maps, and metadata, necessary auxiliary information components of the introductory and thematic parts.

Assuming that the geo-ecological atlas NRF begins with a text introduction, an administrative map of the mapping area and physical surface maps, forming the introductory part, it should be considered that it reflects the state of the natural environment and the degree of anthropogenic pressure on it through various indicators on the maps, while indicating its causes. The latter statement essentially gives its definition as a complex work of geo-ecological orientation, because it provides for the presentation of a versatile characteristic of NRF and in general (for individual sections) determines the content of the proposed atlas in accordance with the functions of protected areas set out in (The nature reserve fund of Ukraine, 2021). These are: support or enhancement of the zone of natural existence of certain species (obviously plants and animals, author) support or improvement of the distribution, migration and/or genetic exchange of certain species; reconstruction of habitat quality; protection of endangered, vulnerable, key or complex species; support or improvement of hydrological functions; support or improvement of ecological quality; erosion control; protection of valuable landscape forms; support for biocenosis in areas contaminated by oil spills; support for the protection of the environment.

The content part of the atlas, which characterizes the natural reserve fund as a whole, should be formed from several sections. The following thematic sections of maps, logically belong to hypersphere maps (according to the distribution of thematic maps into categories). These are, first of all, maps of the state of the natural environment and showing the objects of the NRF on a typical general geographic basis, secondly – anthropogenic pressure on the natural environment (impact on the state of the natural environment, taking into account the location of objects and territories of NRF) and thirdly – features and activities aimed at preventing environmental degradation and improving the environment in the relevant areas, including the functioning of appropriate infrastructure.

The typicality of the general geographic basis of the thematic maps of the atlas is related to the possibilities of using the base map of available crowdsourcing services. In order to present the indicators of mapping, defining a particular plot of maps, it is necessary to specify the units of mapping in accordance with the applicable methods of cartographic representation.

The links between the cartographic parts of the NRF atlas are logically formed by the mathematical basis, conventional signs of general geographic content used on all thematic maps and their typical general geographic basis, confirms the content-based view of the atlas as a comprehensive.

Proceeding from the above, the formal composition of the proposed geo-ecological atlas of the NRF is quite obvious, as each part of it (introductory, content, additional) fulfills different functions, which are outlined in Bondarenko (2007), regarding ecological-geographical atlases of different territorial levels and improved regarding the work under development:

- informative, which is manifested in the use of individual maps and atlases of the NRF as a whole as – a kind of information base for solving the tasks set and in further research;
- evaluative, which is associated with the possibility of presenting on the basis of the characteristics of NRF an idea about the environmental state of the territory of Ukraine as a whole, with the allocation of regions (territories) with extreme indices;
- methodological, which involves the use of the acquired mapping experience in the development of atlas-type cartographic works in the future methodological, related to the consideration of the totality of atlas maps as models that reflect the worldview of environmental knowledge, environmental activities during a certain period of society development;
- ordering, which is manifested in the purposeful selection of different types and kinds of thematic maps in the structure of the atlas, despite its internal heterogeneity, which allows to distinguish relatively homogeneous parts.

It is expedient to consider the mentioned components of the NRF atlas as its subsystems, which, in their turn, can act as systems of a certain hierarchy. Here, it is important to point out that none of the parts of the geo-ecological atlas of the NRF is integral, because only the content part of this atlas as a whole will provide a comprehensive characteristic of the mapping area. At the same time, the integrity of the content makes the establishment of relationships between the sections of the content part proposed above, the individual blocks (if necessary to distinguish them in the relevant section) and individual maps.

Subsystems of the content part of the atlas form its ordering, which corresponds to the hierarchical structure known in atlas cartography (Bochkovska et al., 2007).

Orderliness creates connections between the subsystems of the atlas, as this is a well-known feature that distinguishes atlases from other cartographic works (Rudenko & Bochkovska, 2018; etc.). Because of this, the content part can be studied, analyzed, and information can be obtained taking into account the purpose of the atlas. The proposed work is justified by its purpose as a scientific reference work, because it is based on the generalization and on maps of existing knowledge on the object of mapping. This will allow its study for the purpose of scientific research and practical activities.

Hierarchical levels, created by subsystems of the atlas, form a certain detail and / or overview of the content, allowing the user to get the appropriate and necessary nature of the information. In the process of creating the proposed atlas, such a representation can be used in the atlas

as a means of detailing and / or summarizing the content of the maps. In doing so, the lower level of the hierarchy logically becomes more detailed compared to the level at which the importance of the objects and the significance of the individual section and the whole atlas grows. Therefore, it is quite difficult to explain the purpose of a comprehensive atlas of NRF by the presence of only thematic maps of the simplest types. Here logically it should be noted that an inherent feature of the maps included in geo-ecological atlases is the use of evaluation indicators. This confirms the need to create different types of maps, in particular functional maps (Bondarenko & Kyryliuk, 2020, 2021), as well as highlighted by other characteristics of typification, and acts as an essential attribute of cartographic works, which are regarded as geo-ecological in relation to the created atlas.

In the atlas NRF of Ukraine hierarchical structure is formed of sections, map blocks, individual maps, map elements, map content elements), on the basis of which is built its generalized structural and graphic model (Figure 1).

Analysis of the presented model shows that the structuring of hierarchical components is carried out in vertical and horizontal sections.

The vertical section of the structure of the content part of the atlas (see Figure 1) shows the successive presentation of the sections and map blocks in them according to the order of presentation (maps of the state of the environment and objects of NRF – maps of anthropogenic pressure on the environment and on objects and territories of NRF – maps of necessary measures aimed at preventing deterioration and improvement of the environment in general and on objects and territories of NRF), as well as the subjects of maps according to the complexity of mapping indicators, determine essentially homogenous or close to them.

Horizontal section of the components of the content part of the atlas within each allocated section, in fact, realizes the possibilities of studying the territory of mapping according to the methodological principles of the particular to the general. This becomes possible due to the indicators (analytical – analytical-synthetic – typological – synthetic), which in general corresponds to the chain of functional types of maps (inventory – evaluation – recommendation – forecast), comparable with the maps highlighted by the level of analysis and synthesis.

Thus, based on the theory of atlas mapping (Bochkovska et al., 2007; Kohlstock, 2010; Kraak & Ormeling, 2020; etc.), the formal features of the proposed model are:

- the presence of structural components with internal heterogeneity, which, in turn, allows them to be divided into parts;
- the content part is formed from subsystems that form hierarchical levels, which can be used as a means of detailing (clarifying) and / or generalizing knowledge about the object of study;

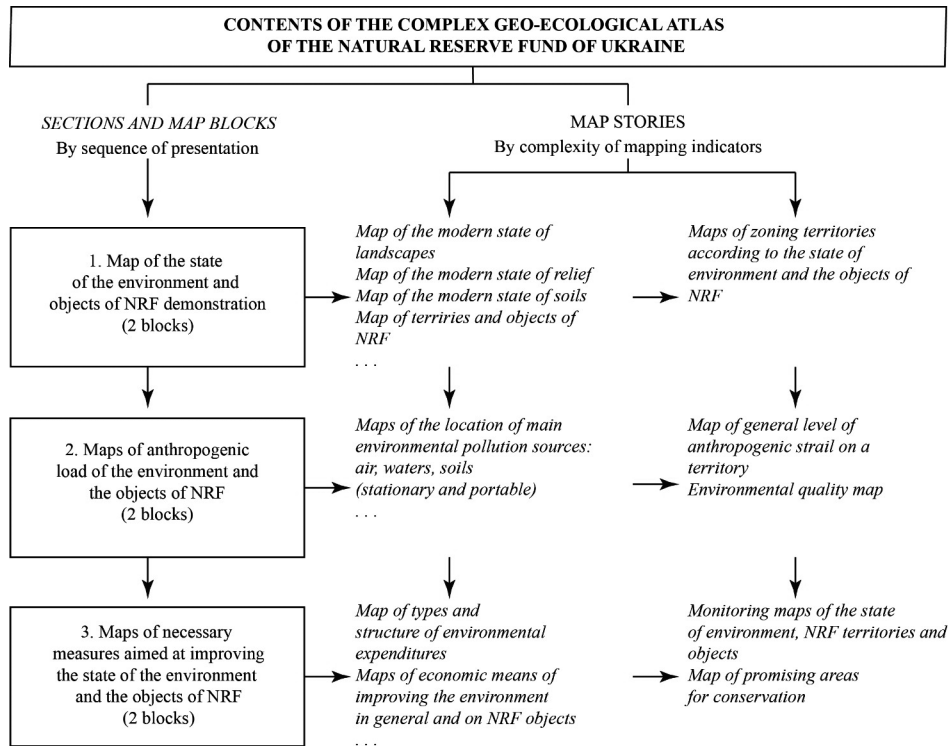


Figure 1. Structuring of the components of the content part of the complex geo-ecological atlas of the NRF of Ukraine

– integrity of the atlas content is formed by the totality of all parts connected with each other.

The developed atlas should provide:

- the ability through the consistency of a reasonable structure comprehensively to reflect the essence, complexity, basic and additional properties of the natural reserve fund of the country at a particular (national) level of mapping;
- the most necessary completeness of map content, form the thematic (main) part of the atlas as a whole and by individual components;
- maximum precision and detailing of object characteristics on maps, comparable with the actual information on the geo-ecological state of objects and areas of the natural reserve fund;
- reliability and completeness of reflection of analytical and comprehensive parameters of the geo-ecological state of the mapped objects;
- reflection of synthetic geo-ecological characteristics, territory zoning, integral estimated indicators, indicators reflecting trends of development of phenomena and processes, recommendations aimed at achieving geo-ecological safety of territorial systems and forecast estimates of geo-ecological situations;
- topicality of the information shown in maps of the atlas and possibility of its quick updating;
- high level of maps visibility through selection of optimal mapping methods;
- accessibility and understandability of the indicators used on the maps for the wide audience or for the specialists of a certain profile;

– convenience of use of the atlas in solving scientific, design, monitoring, management, educational, environmental and other tasks.

The value and fundamentality of the created atlas are due to its large informative saturation due to the use in its development of a significant amount of factual material (in the processing of primary data), and the possibility of direct use (without significant transformation) of existing and specially created databases, which are an indispensable attribute of modern geographic information mapping, and their capabilities for periodic updating of maps even in real time.

An important component of the methodology in the conceptual design model of the geo-ecological atlas of NRF in Ukraine is the formulation and application of the principles of its creation, namely the sequence of representation of various thematic maps in it. Three principles have been defined as such: sequential-traditional; block-problematic; combined.

When using the sequentially-traditional principle of acquisition, the atlas maps are presented in the traditional sequence. First of all, the section (after the introductory one), which reflects the components of nature in various combinations: physical surface, surface waters, underground waters, soil cover, plant world, etc. The next section is represented by maps of changes in the above components of nature, after which changes in the natural environment in interaction with the society are presented in the traditional sequence, i.e. the main indicators related to the anthropogenic load on the natural environment. The last section of the maps characterizes the features and

measures aimed at preventing deterioration and improvement of the environment.

When applying the block-problem principle of the atlas, each block of maps (independently or as a part of a section) reflects successively the problem related to certain components of nature, as well as in connection with the main topic of the atlas. For example, environmental problems of territories are reflected by several maps, among which: a map of the current state; a map of radioactive pollution; a map of chemical pollution; a map of the impact, for example, of agricultural production on the state of a certain territory, etc.

According to E. Bondarenko (2007) the best is the use of the combined principle of compiling maps of the atlas, which involves the simultaneous use of the first two defined principles. This is proved, in particular, by the fact that in the proposed atlas, the map of the quality of the natural environment from the anthropogenic pressure on the environment can complete the section of maps of the necessary measures aimed at improving the environment (see Figure 1).

Considering the above, we can propose the optimal content of the geo-ecological atlas of NRF of Ukraine (on the combined principle of acquisition) in the form of a list of maps of each section of its content component with the allocation of the corresponding blocks in them.

Section 1, which contains maps characterizing the state of the environment, distribution, structure and dynamics of the objects and areas of the nature reserve fund, includes two blocks of 21 maps: general and problem-oriented.

General block of the section cartographically represents components of environment necessary for analysis of objects and areas of the nature-reserve fund and contains the following maps: landscape; geomorphological; hydrological; climatic; soil; vegetation; fauna. In the structure of the classification of geographical maps by level of analysis and synthesis of phenomena and mapping processes, these maps are typological and in fact reflect a certain (transitional) level of distribution of mapping territory (synthesis) into units identified by scientific classification: landscapes, relief, hydrological regime of water bodies, climate, soils, vegetation. They constitute the main content of the corresponding maps, represented by the method of qualitative background. To show the diversity of fauna, it is represented by iconic habitats.

Creation of new maps mentioned above is not expected within the framework of the atlas, because at the national level of mapping they have long been developed and are components of different atlas cartographic works, particularly the National Atlas of Ukraine (2007), which is available in electronic version, and some of them (like soil map) belong to the basic geospatial data sets of national level spatial data infrastructure (On the national geospatial data infrastructure, 2020). The content of such maps will remain quite relevant for a long time, but within the framework of the proposed atlas it would

be reasonable to improve them technically through filling the mapping indicators with interactive functions, in which the functionality of the conventional signs in the specified geometrically precise ways of cartographic representation can be extended by pop-up windows with the addition of a significant number of basic and additional features.

The zoning map of the territory according to the state of the environment, completes section 1. It refers to the classical synthetic maps with evaluation indicators. Highlighted areas are shown in the way of quantitative background.

The problem-oriented component of the block comes directly from the subject of mapping and includes maps: NRF of national importance*; NRF of local significance; NRF structure; areas of territories and objects of the nature reserve fund of coastal regions and in the water area of the Black and Azov seas*; areas of territories and objects of nature reserve fund of mountain territories*; location of natural and biosphere reserves; national nature parks and regional landscape parks; protected tracts; reserves; natural monuments; botanical gardens, dendrological parks, zoological parks; parks-monuments of landscape art; NRF dynamics.

This part of the block determines the thematic orientation of the atlas by means of mainly analytical maps of inventory type with the use of different mapping units (territories according to scientific classification, locations of the objects of the NRF, administrative-territorial units), mapping indicators, characterizing the location, relation, dynamics of territories and objects of the NRF and methods of cartographic representation (geometrically precise – areals, icons; schematic – cartogram, cartodiagrams).

The maps showing the areas and objects of the natural reserve fund of the coastal regions and the Black Sea and Azov Sea, as well as mountainous areas are created as boxes (in enlarged scale), although they can be superimposed as a separate layer at the scale of the vast majority of maps, adopted as the basic for this atlas of the national territorial level.

Some maps marked with an asterisk in the list of the proposed block of the atlas demonstrate the possibilities of achieving the goals of sustainable development of territories according to (State strategy of regional development for 2021–2027, 2020), defined by the UN in 2015, in particular, by numbers 11 (sustainable development of cities and communities), 14 (conservation of marine resources), 15 (protection and restoration of terrestrial ecosystems), concerning creation of a network of areas and objects of natural reserve fund, comparable also to the objectives defined in (Bondarenko & Yatsenko, 2020).

Section 2 contains maps characterizing the anthropogenic impact on the state of the environment, taking into account such an impact on the state of territories and objects of the natural reserve fund. The content of the section is disclosed by means of 11 main maps of two blocks: general and estimated.

The general block includes maps: location of main sources of atmospheric air pollution (with inset maps of main towns-polluters of atmospheric air); distribution of atmospheric emissions by region, towns of regional and district subordination, other settlements; zones of influence of the main sources of air pollution; location of the main sources of surface water pollution; location of the main sources of groundwater pollution; intake, use, discharge of surface and groundwater by regions and individual sources; chemical contamination of soils and placement of mineral fertilizers; radioactive contamination of soils; the impact of agricultural production on soil condition (water erosion, soil erosion, etc.); placement of household and industrial waste storage facilities.

In the structure of the classification of geographical maps by level of analysis and synthesis of the phenomena and processes of mapping and depending on the degree of practical orientation (functionality) indicated unit maps also predominantly analytical, inventory, functional type. The main units of mapping are places and territories of the main sources of pollution (gaseous, liquid, solid), additional – units of administrative-territorial division. With this in mind, it is possible to use both geometrically precise (icons, localized diagrams, absolute ranges) and schematic ways of cartographic representation (relative ranges, cartogram, cartodiagrams) to represent qualitative and absolute and relative quantitative indicators.

The assessment block of maps of the second section is represented by a comprehensive map of the total anthropogenic load on the territory (using the normative indicators approved for the whole country) in combination with various schematic methods of cartographic representation (cartogram and cartodiagrams), as well as a synthetic map of environmental quality (created using the method of quantitative background or refined cartogram (depending on the mapping units).

Similarly to the previous sections, *section 3*, which characterizes features and measures aimed at preventing environmental degradation and improving its condition, contains two blocks and seven maps: recommendation and forecast.

The advisory block contains maps: types and structure of expenses for protection and rational use of natural resources, environmental charges for pollution of water resources; environmental charges for soil pollution; environmental charges for atmospheric air pollution, which in fact are assessment models aimed at the implementation of necessary measures to improve the state of the environment, taking into account the location of facilities and territories of the NRF. Since the latter are spatially included in the units of the existing administrative division, the corresponding measures are planned and implemented within them. This induces the use of schematic methods of cartographic representation (cartogram, refined cartogram, cartodiagrams (map digrams)) as the most optimal techniques for the possibility of their use by the given units of mapping.

Forecast block contains maps: innovations to improve the environment (different units of mapping and depending on them methods of cartographic representation can be applied); prospective areas for conservation (presented by means of absolute ranges).

For a better understanding of the structure and content of the complex geo-ecological atlas of the NRF of Ukraine it should be characterized from a semiotic point of view, which is an important part of the conceptual model. Proceeding from this, in the general structure of the atlas its cartographic part makes up 80% of the volume, the rest belongs to the explanatory texts in the introductory part, texts to the sections, map blocks, legends, as well as metadata. Such ratio is quite optimal for users, in particular, for possibility to obtain systematized spatial information just because of cartographic component.

Three sections of content part of atlas, grouped by blocks (two blocks of maps in each section), contain 39 maps. They are structurally distributed by section, respectively: 54%, 28%, and 18%. This uneven filling of sections with maps is explained, firstly, by their importance in a comprehensive and versatile display of the natural reserve fund of the country and by the possibility of obtaining, besides the basic and additional characteristics on the basis of analysis of various content maps; secondly, since the first section in fact sets the tone in the study of NRF, all maps displaying its static and dynamic characteristics are concentrated in it (in the block of the problem area), accounting for 67% of its volume or 35% of the total content.

Indicators of mapping revealing the theme (subject) of each map differ in their simplicity or complexity and directly affect the choice and use of static graphic variables in the conventional signs (mainly for atlas maps: shape, size, color tone, color saturation, internal structure, which is 83% of all types), forming their functionality and justifying the choice of appropriate ways of cartographic representation.

As part of the implementation of interactive functions of the atlas and simplification of functional of conventional signs for cartographic representation of the location of objects and territories in the NRF the replacement of individual graphic variables or reducing their number (for example, the use of only shape and color tone without size and internal structure) through the possibility of presentation of basic and additional information (graphic (including cartographic), tabular, text) in pop-up windows is provided. This is justified by the possibilities of changing the scale of viewing and working with electronic map, in particular, to prevent the overlapping of conventional signs and to avoid reducing the readability of the map.

Among the entire arsenal of existing classical methods of cartographic representation, which in the GIS environment can be implemented by appropriate mapping units, comparable to the indicators, which together reveal the theme of a particular map, only the point method can't be applied to atlas maps. The most common mapping

techniques are: icons – qualitative background; icons – quantitative background; icons – cartogram; icons – areals; cartogram – cartodiagrams.

According to the types of maps included in each section / block (mainly these are: analytical (inventory), analytical-synthetic (evaluation), synthetic (recommendation, forecast), it is possible to talk about the complex nature of the atlas as a whole.

Physical structure of the atlas is formed on the basis of the use of editorial and technical documents, which regulate specific graphic load on the maps and technologically organize interaction between them when creating maps of different scale levels. Its design should be aimed at achieving ease of perception of information when reading maps, taking into account the selected interactive version of practical implementation.

Conclusions

Geo-ecological atlas of the Natural Reserve Fund of Ukraine is the most comprehensive cartographic work, which comprehensively characterizes the relevant objects and territories, reflects the state of the environment and the degree of anthropogenic pressure on it through various indicators on the maps, while indicating its causes. The latter statement essentially gives its definition as a complex work, since it provides for the presentation of a versatile characteristic of the NRF and generally (for individual sections) defines the content and features of the proposed atlas in accordance with the functions of nature conservation areas.

The conceptual model of development of the mentioned atlas defines the object of modeling, the structure and composition of the system being modeled, the characteristics of its elements, as well as the causal relationships inherent in the system, which are considered essential for achieving the purpose of modeling. It also describes the formal composition, structure, volume and content of each block of information in the atlas, defines in addition to the thematic orientation of maps (names, subjects of maps, units of mapping, methods of cartographic representation) their types according to various classification features, as well as the basic scale of maps.

The functions of the geo-ecological atlas of NRF are formulated (informative; evaluative; methodological; methodological; ordering), the formal features of its content are justified (the presence of internally heterogeneous structural components; division of the content part into subordinate sections, forming hierarchical levels, which can be used as a means of detail (clarification) and / or generalizing knowledge about the object of research; the integrity of the content of the atlas characterized by a set of all parts (introduction, main, additional), interconnected).

The authors, in the context of the formulation and use of methodological principles of construction (i.e. acquisition of maps) atlas of NRF (sequential-traditional; block-issue; combined) applied combined principle and

determined the optimal thematic content of the atlas in the form of a list of maps (39 in total), grouped by sections and blocks (three sections, each of which contains two blocks of maps). The types of maps included in each section / block are defined (mainly: analytical (inventory), analytical-synthetic (estimation), synthetic (recommendation, forecast), for each of which mapping indicators and methods of cartographic representation are justified.

The development of editorial and technical documents on the practical implementation of the original version of the electronic atlas is promising.

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