Soil science in the constructive-biosphere paradigm of nature management

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Abstract. In accordance with the ideology of sustainable development of the biosphere, a constructive-biosphere paradigm of agricultural nature management is proposed, which focuses on the projecting of agricultural landscapes and knowledge-intensive agricultural technologies. The transformation of ecological functions of the landscape into socio-economic ones is considered as a projecting mechanism. In the face of this paradigm, which is Dokuchaev’s originally, the concept of soil fertility is being developed as a combination of ecotopic and biopedoecological functions of soils and the associated ecological and socio-economic functions of agrobiocenoses. A new methodology of agroecological and economic assessment of lands for the projecting of agricultural landscapes and knowledge-intensive agricultural technologies has been substantiated.

1. Introduction. Development of the noospheric ideology of nature management of Dokuchaev-Vernadsky

The first paradigm of soil science emerged with soil science itself. Its author V. V. Dokuchaev considered soil science "a discipline that naturally brings together and even links all the most important departments of natural science and the doctrine of man, restoring the unity of nature and knowledge of it". Therefore, soil science developed within the framework of the paradigm of nature management that he created, according to which nature is a unified whole, the individual parts of which are in constant interaction and development. At the same time, he emphasized that in the world "not one Darwinian law of the struggle for existence reigns, but also another, opposite law of love, community, mutual assistance" [2].

In accordance with this paradigm, which subsequently V.I. Vernadsky developed into noospheric, V. V. Dokuchaev proposed a land use model, which was based on the following positions:

- determination of the optimal ratio of arable land, meadows, forest and water in accordance with local natural and socio-economic conditions;
- regulation of rivers, ravines and gullies flow;
- regulation of water management in watersheds;
- adaptation of cultivars, soil cultivation techniques to local conditions.

The noospheric ideology of nature management by Dokuchaev-Vernadsky was far ahead of the time during which the nature-conquering paradigm prevailed. Only in the 1980s there was an understanding of its consequences in the form of regional environmental disasters. This was facilitated by the work of scientists of the Club of Rome, and in 1992 the UN Summit in Rio de Janeiro adopted the "Declaration..."
on Environment and Development" and "Agenda 21 – a program for the transition to sustainable development." In the same year, a session of the Russian Agricultural Academy adopted a resolution on the development of the Dokuchaev heritage and the projecting of highly productive and sustainable agricultural landscapes. Various paradigms of the ideology of sustainable development have emerged: conservative and progressive. The first ones were designated by the slogan "Back to nature", their supporters promoted organic farming. The others, under the slogan "By the side of nature", developed nature-like technologies, integrating the issues of intensifying and greening economic activities. They were, to a certain extent, solved by the development of adaptive landscape farming systems (ALFSs). These systems, in the development of the Dokuchaev model, include:

- optimization of the ratio of land in accordance with the agro-ecological grouping of land;
- organization of the territory on a landscape-ecological basis;
- placement of crop rotations within agroecological land types, taking into account soil-landscape relations;
- the forming of agricultural technologies in relation to agroecological types of land;
- melioration and forest melioration activities.

A timely developed system of agroecological assessment and typification of lands, as well as modern advances in informatization: the use of GIS and remote diagnostic tools, played an important role in the formation of ALFSs.

With all the importance of adaptive systems and nature-like agricultural technologies, the ecological (co-evolutionary) paradigm of nature management is developing towards constructive cooperation between man and nature. Scientists have different points of view on this issue. We believe that N.V. Timofeev-Resovsky [6], substantiating the need to increase the biological productivity of the biosphere by increasing the average density of the green cover of the Earth and replacing species with low efficiency of photosynthesis with species with high efficiency. N.N. Moiseev took a firm stance on this issue [5]. He believed that, in contrast to the strategy of nature, based on self-organization, a directed development becomes vital at a certain stage of life development of Mankind. Humans should strive to use the strategy of nature, its laws and his capabilities to create conditions that guarantee the further development of the human kind.

2. Constructive-biosphere paradigm in the nature management

It seems to us that in modern agriculture and in agriculture in general, a new stage of nature management is emerging, which corresponds to the constructive biosphere paradigm, which assumes:

- the preservation of natural landscapes;
- restoration of degraded landscapes;
- optimization of natural and anthropogenic landscapes according to ecological and socio-economic conditions;
- creation of new biological species and ecosystems with high biological potential exceeding natural ecosystems in productivity.

In the face of the constructive-biosphere paradigm, the optimization of agricultural nature management means the creation of a network of agricultural landscape systems, including agricultural landscapes, water management, reclamation, agro-industrial, rural forestry, livestock, residential landscapes, alternating with natural, artificial, nature-protective landscapes in the ecological carcasses of the territory.

The ecological carcass of the territory, integrated with the field infrastructure, represents a new category, replacing the traditional protective afforestation with its insufficient adaptability to landscape and ecological conditions.

The main mechanism for the implementation of the constructive-biosphere paradigm of agricultural nature management is the development of territorial planning and landscape-based projecting in the system of strategic planning. The following is considered as a toolkit for landscape-ecological planning and projecting:
• identification, assessment and grouping of ecological functions of the landscape;
• structural and functional analysis of the landscape, identification and assessment of landscape relationships;
• grouping of socio-economic functions of the landscape.

3. Landscape functions and their management
A new stage of nature management is associated with the management of landscape functions based on its structural and functional analysis. In this regard, in soil science, the doctrine of the ecological functions of soils has been developed, including biological, bioenergetic, biochemical, biogeochemical, hydrological and hydrogeological, atmospheric and biogeocenotic functions [1]. The next stage in the development of this doctrine is a quantitative assessment of the ecological functions of soils and the study of the mechanisms of their agrogenic transformation. A significant shortcoming of this work is the isolation of soil functions from the ecological functions of the biosphere, of which they are a part. Therefore, we [3] proposed a grouping of ecological functions of the landscape and their definitions (table 1).

Table 1. Ecological functions of landscapes.

| Ecotopic | Biocenotic | Bioecological |
|----------|------------|--------------|
| Atmospheric | Self-organization | Productive |
| Gas exchange | Evolution | Destructive |
| Heat exchange | Biodiversity | Organo-accumulative |
| Hydroatmospheric Climate-forming | Soil-forming function | Biogeochemical |
| Lithospheric | Energy function | Gas functions |
| Geodynamic | | Concentration functions |
| Geophysical | | Redox functions |
| Geochemical | | Activation–inhibitory functions |
| Hydrological and hydrogeological | | Biopedoecological |

With the agricultural use of landscapes, ecological functions are reduced to some extent and transformed into socio-economic ones (table 2).

Table 2. Socio-economic functions of the landscape.

| 1. Resource: | 2.6. Phytosanitary; |
| 1.1. Bioresource; | 2.7. Reclamation; |
| 1.2. Mineral resource; | 2.8. Agrobiogeocenotic. |
| 1.3. Land and resource; | 3. Industrial and agro-industrial. |
| 1.4. Resource-climatic. | 4. Regulatory: |
| 2. Bioprocessing: | 4.1. Climate-regulating; |
| 2.1. Agrobiodiversity; | 4.2. Flow-regulating and water protection. |
| 2.2. Agrobiotechnological (agro-industrial); | 5. Residential. |
| 2.3. Management of the cycle of matter in agricultural landscapes; | 6. Recreational. |
| 2.4. Management of organic matter regime in agroecoses; | 7. Sanitary. |
| 2.5. Regulation of the structural state and composition of soils. | 8. Aesthetic. |
| | 9. Ethnospheric. |
| | 10. Nature protection |
For example, the function of biodiversity is decreasing, but to a certain extent it is replenished due to the creation of new species and cultivars of plants by man. The bioproduction function is transformed into an agrobiotechnological one. In conditions of extensive agriculture, all ecological functions associated with photosynthesis are significantly reduced, which leads to landscape degradation. In this case, general biospheric functions are violated, in particular, gas exchange and heat exchange functions.

The constructive-biosphere paradigm is focused on the optimization of socio-economic functions and the preservation or compensation of certain ecological functions. This became possible due to the best achievements of the world agro-technological revolution, the creation of new cultivars of plants with high genetic potential and highly intensive precision agro-technologies, as a result of which the productivity of agrocenoses is greatly superior to the traditional one. The new paradigm means another quantum leap in agriculture. The human factor has become not only commensurate with the natural one, but often decisive in assessments of bioproductivity and soil fertility, which leads to a new approach to its assessment, taking into account complex interactions. The product of high technologies is achieved due to the intellectual potential of commodity producers, mobilization of scientific achievements and innovation without any harm to land resources, optimal biological circulation, the state of soils and agricultural landscapes.

4. The development of the "soil fertility" concept from the biosphere perspective
The change in the paradigm of nature management determines the new content of agriculture and a new path of development associated with the deepening of basic concepts, overcoming traditional dogmas and myths. To a certain extent, this applies to soil fertility. This category was often absolutized and mythized. The main assessment of lands in the formation of farming systems was made on the basis of agro-industrial grouping and soil bonitation without due attention to many other agro-ecological conditions. There were various "humanitarian" categories of soil fertility (potential, effective, economic, etc.), as well as the concept of "reproduction of fertility", etc.

Such a formalization and absolutization of fertility greatly narrows this concept to the detriment of a variety of soil and related conditions that determine the productivity of plants. Here we must pay tribute to V. I. Vernadsky, who assessed the cumulative effect of these conditions as the fertility of the biosphere. It is time to understand the essence and mechanisms of these interactions in order to construct optimal agroecosystems.

The contribution of the soil to the forming of the productivity of agrocenoses, in addition to the direct supply of plants with nutrients, is associated with the transformation and redistribution of the cosmic factors of plant life, in which the topography, parent rocks, and vegetation cover participate. For example, the use of moisture by an agrocenosis coming from the atmosphere with precipitation depends on the topography and, therefore, surface runoff, the exposure of the slope (heating and evaporation), the parent rock (filtration capacity, drainage), the wind regime (evaporation), soil properties (density, structural state, moisture capacity), filtration capacity, hydrogeological regime), vegetation cover (forest belts, brushes, mulch, etc.). The regularities of the redistribution of the temperature regime and heat supply are no less complex. The numerous ecological functions of the biosphere and its basic soil component are intertwined in complex interactions. In particular, the biospheric functions directly "responsible" for soil fertility include, in addition to the soil-forming and ecotopic functions of soils, a number of bioecological functions, hydrogeological, gas exchange, geochemical, geophysical, and others [3].

Thus, soil fertility is determined by the multitude of ecotopic and biopedoecological functions of soils and associated ecological and socio-economic functions of agrobiogeocenoses.

Identification of ecological functions of the landscape and solving problems of transforming them into socio-economic functions are the essential aims of creating models of adaptive landscape farming. This work has two aspects – agro-ecological and landscape. The first one is associated with the placement of crops, crop rotations and agricultural technologies in accordance with agroecological conditions, the second one – with the organization of the territory, regulation of energy and mass transfer, prevention of landscape degradation, justification of hydrotechnical and forest reclamation.
The key issue in this regard is the development of a system of agroecological land assessment, a methodology for landscape-ecological analysis of the territory and, on their basis, the forming of agro-geoinformation systems for the projecting of agricultural landscapes and precision agricultural technologies. Knowledge-intensive agricultural technologies of the new generation require a qualitatively new land assessment basis. They are developed in relation to the elementary areas of the agrolandscape (land types), represented by elementary soil areas and elementary soil structures on certain elements of the mesotopography [4]. The higher the level of intensification of agricultural technologies, the greater number of agro-ecological indicators is taken into account. Land types within agro-ecological groups are assembled into the registers for natural-agricultural provinces. Their agroecological characteristics are accompanied by an agroeconomic assessment, including data on potential productivity and economic efficiency at different levels of agricultural intensification. This methodology for assessing soil and land is replacing the traditional methods of soil bonitation and the use of various generalized indices.

5. The issues of soil science in the face of the new paradigm of nature management

Thus, the modern paradigm of soil science, preserving the Dokuchaev ideology, acquires a constructive biosphere orientation and presupposes the optimization of soil conditions in accordance with the requirements of increasing productivity and sustainability of agroecosystems, regulation of soil fertility as a specific set of biospheric functions.

In the light of the new paradigm of agricultural nature management the development of soil science includes the following tasks:

- projecting of agricultural landscapes – a new stage in the development of adaptive landscape agriculture;
- creation of tools and methodology for landscape-ecological analysis of the territory;
- development of a system for assessing the ecological functions of soils and landscapes and a methodology for transforming them into socio-economic functions;
- soil-agronomic substantiation of landscape-ecological and strategic planning;
- improvement of digital soil mapping based on identification and assessment of soil-landscape relationships;
- soil and ecological support of precision farming and land assessment for the development of knowledge-intensive agricultural technologies;
- transformation of cosmic factors of plant life in soils and landscapes;
- increasing the efficiency of using space factors in managing the production process of agrocnoses;
- identification of the potential biological productivity of agricultural landscapes in comparison with the biopotential of landscapes;
- ecobiological diagnostics of soils and optimization of their biogenesity and biological activity in intensive agricultural technologies;
- optimization of the biological cycle of matter in agricultural landscapes;
- optimization of the regime of organic matter and the structural state of the soil;
- management of the phytosanitary state of soils with biological agents;
- construction of soils;
- the impact of climate warming on soils, soil processes and soil cover.

Acknowledgments

This work was carried out with the financial support of the Russian Foundation for Basic Research, project № 1901600101.

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