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LANDSCAPE-ECOLOGICAL INVESTIGATIONS MAPPING OF V. V. DOKUCHAYIV KHNAU ARBORETUM'S TERRITORY

В. М. Опара, І. М. Бузіна, Д. Д. Хайнус. КАРТОГРАФУВАННЯ ЛАНДШАФТНО-ЕКОЛОГІЧНИХ ДОСЛІДЖЕНЬ ТЕРИТОРІЇ ДЕНДРОЛОГІЧНОГО ПАРКУ ХНАУ ІМ. В.В. ДОКУЧАЄВА. *У представленій статті стисло висвітлено основні проблеми, які виникають під час проведення ландшафтно-екологічних досліджень територій. На прикладі дендрологічного парку ХНАУ ім. В.В. Докучаєва розглянуто порівняльно-екологічний метод оцінки ґрунтових умов за лісорослинним ефектом, тобто за видовим складом і продуктивністю корінних лісових рослинних угруповань. Ліс виступає як система рослинності і середовища проживання, а з екологічної точки зору – як відображення середовища, як її лісорослинний ефект. А також для обґрунтування заходів, спрямованих на вирішення актуальних ландшафтно-екологічних проблем, а саме, трансформації і забруднення природного середовища, розвитку морфодинамічних процесів. Досліджено вміст важких металів на території дендропарку, проведено ранжирування факторів, які впливають на розподіл концентрацій полютантів та визначено тип екологічної ситуації за допомогою картографічних методів. Запропоновано сучасні та екологічні методи відновлення порушених територій за допомогою фіторемедіаційних технологій, які є значно дешевшими та безпечнішим. Під час запровадження методів фіторемедіації відбувається менше вторинних забруднень, фізичний і гранулометричний склад ґрунтів не погіршується, біологічна активність не зменшується, а продуктивність утримується сталою. Дана технологія найбільш зручна для очищення помірно забруднених ґрунтів. Ґрунти, як елемент ландшафту є вагомим блоком екосистем, руйнування яких має багатовимірне значення для стабільності природного середовища. Агрогенне перетворення ґрунтів традиційно оцінювалося як прогресивне. Однак, науковий аналіз свідчить, що екстенсивне землеробство, нераціональне хімічне удобрення й фетишизація пестицидів зумовили значне зниження родючості, а подекуди й втрату, внаслідок розвитку ерозії, природного ґрунтового покриву на великих площах. Подібні процеси стимулюють ґрунтову мікрофлору до розкладання органічних забруднень і сприяють поглинанню рослиною шкідливих речовин. Ландшафтно-екологічний підхід наразі застосовують у вирішенні багатьох наукових завдань: як теоретичних, так і практичних.*

Ключові слова*: ландшафтно-екологічні дослідження, картографування, едатопи, трофотопи, едафічна сітка, дендрологічний парк.*

В. Н. Опара, И. Н. Бузина, Д. Д. Хайнус. КАРТОГРАФИРОВАНИЕ ЛАНДШАФТНО-ЭКОЛОГИЧЕСКИХ ИССЛЕДОВАНИЙ ТЕРРИТОРИИ ДЕНДРОЛОГИЧЕСКОГО ПАРКА ХНАУ ИМ. В.В. ДОКУЧАЕВА. *В представленной статье кратко освещены основные проблемы, возникающие при проведении ландшафтно-экологических исследований территорий. На примере дендрологического парка ХНАУ им. В.В. Докучаева рассмотрен сравнительно-экологический метод оценки почвенных условий по лесорастительному эффекту, то есть по видовому составу и продуктивности коренных лесных растительных сообществ. Лес выступает как система растительности и среды обитания, а с экологической точки зрения – как отражение среды, как ее лесорастительных эффект. А также для обоснования мероприятий, направленных на решение актуальных ландшафтно-экологических проблем, в частности, трансформации и загрязнения природной среды, развития морфодинамических процессов. Исследовано содержание тяжелых металлов на территории дендропарка, проведено ранжирование факторов, влияющих на распределение концентраций поллютантов и определен тип экологической ситуации с помощью картографических методов. Предложено современные и экологические методы восстановления нарушенных территорий с помощью фиторемедиационных технологий, которые значительно дешевле и безопаснее. При введении методов фиторемедиации происходит меньше вторичных загрязнений, физический и гранулометрический состав почв не ухудшается, биологическая активность не уменьшается, а производительность содержится постоянной. Данная технология наиболее удобна для очистки умеренно загрязненных почв. Почвы, как элемент ландшафта является весомым блоком экосистем, разрушение которых имеет многомерное значение для стабильности природной среды. Агрогенное преобразование почв традиционно оценивалось как прогрессивное. Однако, научный анализ свидетельствует, что экстенсивное земледелие, нерациональное химическое удобрение и фетишизация пестицидов обусловили значительное снижение плодородия, а иногда и потерю, в результате развития эрозии, природного почвенного покрова на больших площадях. Подобные процессы стимулируют почвенную микрофлору к разложению органических загрязнений и способствуют поглощению растением вредных веществ. Ландшафтно-экологический подход сейчас применяют в решении многих научных задач: как теоретических, так и практических.*

Ключевые слова*: ландшафтно-экологические исследования, картографирование, едатопы, трофотопы, эдафическая сетка, дендрологический парк.*

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Formulation of the problem. In the field of ecology the investigation of spatial analysis of objects is almost not considered, while landscape science, on the contrary, has rich and well-studied traditions. To solve various issues of geosystems' dynamics in landscape investigations, it is necessary to involve the concept of ecology. In general, in the field of ecology and landscape science, we can find many combining and complementary situations, theoretical positions, methods, whose synthesis involves formation of landscape ecology theoretical basis [1].

Agricultural production is inextricably linked with landscapes. The soil cover and its quantitative and qualitative status is one of the most important components of land.

Modern integrated field studies envisage not only obtaining the necessary information about the landscape and landscape-forming processes, but also using it during environmental research. Various forms of obtaining landscape information are used: substantiation, recommendations, special maps, schemes, models, etc. [1-2].

A comprehensive system approach to the rational use of natural resources and public health protection in conditions of intensive anthropogenic loading on the environment raises the problem of assessing the ecological state of landscapes and the possibility of fulfilling their respective ecological functions in the foreground [3].

Actual scientific researches and issues analysis.

Measures to stabilize and restore the ecological state of landscapes and soils as their integral part require the ecological assessment of the environment conditions and the efficiency of land resources use. This assessment has a number of territorial features, which are easier and more explicitly explored by mapping methods. This suggests the need to create a general or universal landscape-ecological database that would provide substantiation of specific decisions on the ecological safety of the territories [4-5].

The content of such a database should be as comprehensive as possible, versatile, reliable and objective landscape-ecological characteristics of the environment. It is possible to provide the above-mentioned needs using GIS with modern mapping methods. The complexity of the task is determined by the peculiar study objects –a great variety of parameters characterizing the qualitative state of the environment.

Geographic information systems enable us to automate and accelerate the process of obtaining the necessary information at the right moment, integrating data from different sources, and ensuring interoperability with other systems and technologies used in the process of regional development management (V.M. Bagrov, T.V. Kotova, L.F. Yanvariova) [6].

Such systems are intended to provide the executive authorities and local government with reliable information on the current state of natural resource potential, human resources, environment, economic and social situation in the region with subsequent transition to scientifically grounded forecasting according to certain models. Regional GIS, both complex and thematic, should be developed according to the approaches adopted for the development of the national GIS proposed by L.G. Rudenko, V,S. Chabaniuk and others [4-6].

According to domestic studies (M.V. Bahrov, V.O. Bokov et al.) and foreign scientists [7-9], the conceptual data model for the needs of ecological and environmental mapping should include the information on:

- natural and socio-economic systems as determinants of nature use;
- ecological conditions of the region and its evaluation;
- measures to optimize nature use;
- the expected effectiveness of their implementation.

The ecological aspect of the geosystems' study has a number of approaches. Geography, as a science that uses environmental assessment criteria, can address a multitude of issues related to protection and optimization of disturbed territories. They are reduced to the geosystems' management, which is possible only on an ecological basis. Ecology, as a science, is the filter through which it is necessary to skip geographic information before it is used in solving economic issues.

Natural environment is characterized by spatial variability. It is this property that is of great ecological significance. Therefore, the geographical study of it is a prerequisite for landscape and environmental research. An important feature of geographic research is the great potential of a systematic approach to the study of natural and social phenomena that can be used in environmental studies [4, 6, 9].

Correct assessment of the natural fertility in forestry is a prerequisite for a successful solution to the practical issues of forest cultivation. Any forest massifs are formed and function with the close interaction of various natural factors: climate, relief, vegetation, soil cover and underlying rocks and constitute a set of interconnected complicated physical and geographical processes. The landscape-ecological approach gives an opportunity to study the structure of forest masses - the product of zonal and azonal factors, as well as the diversity of landscape types on a particular territory, to consider the interconnection between the biological diversity of forests and the basis of the landscape - the lithological framework [10].

The average value of optimal forests index in the forest-steppe zone varies within 20%. Approximately the same area is occupied by meadow-steppe and wetland groups of vegetation.

According to the estimations of scientists, landscape-ecological optimization of the territory is achieved with the harmonious combination of natural and anthropogenic landscapes in the ratio of 3: 2 of landscape structure [11].

Thus, at least 40% of the territory of any forest steppe region should be occupied by natural landscapes, and according to J. Odum – up to 60% [12].

Consequently, the efforts of geography, cartography and ecology are aimed at preservation of the natural environment, or rather spatio-temporal peculiarities of the organisms' interaction with the environment. This interaction takes place in different socio-natural conditions, at the level of specific ecosystems and geosystems, that is, on a certain territory. This forms a new research object – a geosecosystem that enables us to use different geographic approaches to their investigation [6, 12].

The most important feature of geosystems is their territorial integrity, ties, and stable structure. The number of elements in such systems and the existing interrelationships between them give a general idea of the scale of this system. The description of the elements is the starting point for studying its integrity, that is, the internal unity of the object.

In the studies by B.F. Ostapenko and D.V. Vorobyov the criterion for the forest type allocation is the indigenous forest association, which is the result of the development (evolution) of the vegetation cover. It has a certain composition of forest-forming wood species, a certain natural biological productivity, the magnitude of which is a source for comparing and assessing natural and actual productivity of a particular area of forest area related to this type of forest [13, 14].

In a geographical aspect, each type of forest occupies different by size but unique geographical and climatic range, determined by the combination of characteristic wood ranges, and sometimes shrub species belonging to the fundamental plant association. At the same time, in each sector or district of forestry-typological zoning (according to Morozov – type of forest massif) only one type of forest located along the plains is zonal. In the mountains it is of altitudinal zonation, all other types of forest are intrazonal.

In the eco-taxonomic aspect, the forest type is one of the main taxons of the typology. As a climatic and isometric form it enters a larger taxon – the type of forest area, homogeneous in soil fertility. Under specific conditions, it may be presented in various ways. Smaller units are the types of woodland and their analogues, i.e. the types of shrubs, grass, formed in the forest type as a result of human activity or the action of natural phenomena [14].

The main purpose and significance of such studies is the purposeful study of the components in the landscapes structure, the dynamics of natural and socio-economic elements for solving a specific scientific or practical task. In the case of an in-depth mapping study of geosystems, a number of conditions must be met:

- to develop spatial and content classification of geosystems and scientific analysis of the latter;
- to establish the specifics of their mapping for all sections in the classification of geosystems which involves the reproduction of the main components and interconnections, as well as the features of generalization for each hierarchical level;
- to use regularly the method of division for the study of complex geosystems.

In each particular case, the purpose and strategy of landscape-ecological mapping study is different. It depends on whether the analysis of the selected geosystem is carried out, or the system from the investigated elements is synthesized. Since the starting positions are different, the planning and organization of the study will also be different. It is necessary observe the territory, time, level of study, degree of generalization, scale, language [15-16].

During the development of the edaphic grid we used a comparative and ecological method for assessing soil conditions for the forest-based effect, that is, by species composition of vegetation and productivity of indigenous forest vegetation groups. To evaluate (indicate) soil fertility, plants were divided into ecological groups according to the requirements for moisture and soil richness, based on the forestry "scales of demands" and ecological grouping of plants adopted in geobotanics. According to the ordinate of soil richness (or trophy) "scale of demands " of wood species to the soil were used to establish forest groups (trophotops), developed by G.F. Morozov and M.K. Turskyi, as well as distribution of plants on oligotrophs, mesotrophs and megatrophy accepted in the geobotanics [14, 15].

In the practice of forest management and long-term planning of forestry the knowledge of trophotops is necessary when selecting the main types of the forestry, in determining natural productivity of land and its reserves. It is also essential in the period of clearing and reconstruction of plantations, when selecting forest trees and designing the types of crops for logging, etc.

Therefore, in a detailed approach to assessment of forest vegetation conditions, edaphic and climatic variants of trophies, such as acidiphilic, calcium, nitrophilic, thermal, etc., are allocated as additional ordinates. Their allocation is necessary in the course of scientific research and in the implementation of some forestry measures.

Types of cover are of interest for us in terms of indications related to soil and moisture. The type of forest area can be established only if there are species of different ecological characteristics, different environmental properties in the composition of plants.

Thus, edatop is determined by the composition of plants (main feature) belonging to different ecological groups. It is very easy to make a mistake taking into account the species of only one ecological group, while the presence of species with different ecological characteristics gives us the opportunity to very confidently determine the type of forest area.

In the development of edaphic grid we applied a comparative-ecological method for assessing soil conditions for the forest-based effect, i.e. species composition and productivity of indigenous forest vegetation groups, considered as a system of vegetation and habitat. From an environmental point of view it is a reflection of the environment, as its forestry effect. Plants were divided into ecological groups for the assessment (indication) of soil fertility for demanding moisture and soil richness.

The basis for this was given by the forestry "scales of demands" and the ecological groupings of plants taken in geobotanics. According to the ordinate of soil richness or trophy for the establishment of forest groups (trophotops), scale of demanding of woody rocks to the soil was used, as well as the separation of plants in oligotrophs, mesotrophs and megatrophs adopted in geobotanics. Similarly, the soil moisture ordinates have been constructed. To establish moisture groups (hygrotops), there were accepted geobotanical groupings of plants including xerophytes, mesophytes, hygrophytes and surface-covering groups, established by A.A. Krudener These groups are used to determine the (indication) of edotopes in nature [13-16].

Identification of previously unsettled parts of the general issue. The methodological bases of the landscape-ecological analysis of the territory, the issue of rational nature management and the resolution of environmental problems of a specific region are not clearly outlined in the literature today. To resolve these issues, it is necessary first of all:

- to clearly formulate the main theoretical and methodological aspects of ecological analysis and assessment of landscapes;
- to identify patterns of spatial diversity of natural and human-made complexes of the studied territory, background geochemical and geophysical functions of natural components;
- to conduct a structural and functional analysis of anthropogenic landscapes;
- to develop (supplement) the methodology of landscape and ecological evaluation of the properties of natural complexes in different taxonomic ranks, the role of components in the formation of the ecological situation;
- to assess the ecological condition of a particular territory, namely, the arboretum on the territory of the educational campus of the V.V. Dokuchayiv KhNAU in Kharkiv district, Kharkiv region.

Purpose statement: The purpose of this work was to study the landscape and ecological structure of the forest massif, to identify the relationship between the components of landscapes on the example of V.V. Dokuchayiv KhNAU arboretum by mapping the territory.

Presentation of the main material. The main task of landscape-ecological investigations is the development of landscape bases for solving various ecological problems of the environment and the scientific substantiation of ways to optimize its state through mapping modeling.

Before conducting special investigations, it is necessary to have materials of landscape field mapping and laboratory analysis of samples of landscape components, both background and anthropogenically loaded and contaminated. Today, different methods of investigation are used, namely: landscape profiling, continuous shooting on key sites, conjugated testing in autonomous and subordinate elementary landscapes, etc. Around the sources of pollution, a more detailed landscape-geochemical mapping is performed on the morphological units and chains. Radial (around the source of pollution) and cascading (swimming pools of the small year) routes are applied.

The main source of information about soils, their ecological status, evaluation, use is the data of landscape-ground surveys and surveys, recorded on plans, maps, photographs and models of the area.

Prospective development of scientific research and advanced manufacturing mapping experience shows that remote measurement methods that allow large areas to be covered efficiently detect most soil and landscape parameters, provide the opportunity to automate the collection, processing, analysis and mapping of spatial information about an object. Also the direction of forecast mapping modeling becomes more and more popular, which allows to predict the development of certain processes in the environment.

To conduct the investigation, the arboretum's territory of V.V. Dokuchayiv KhNAU's educational campus was selected.

Geographical position of the arboretum. The arboretum is the part of the green zone of the educational campus of V.V. Dokuchayiv KhNAU. It is located in the north-east of the educational campus. In the north, the park borders on the experimental field, in the north-east – on the country and in the east – on garage cooperatives, in the south – on a residential area, along the western border there is a road leading to the township Rohan, and across the road there is Veterans Park (Fig. 1).

Currently the arboretum covers the area of 23.20 hectares. It includes collection (exposition) areas – 23 blocks with a total area of 14.10 hectares; flowerbed – 0,70 hectares; introductory nursery of about 1.0 ha; a collection of perennial flowers – 0,30 hectares; archival-clone and seed plantations of pine and oak – 6,50 hectares; the molded bed for the pond is 0.60 hectares (in the designing the pond the close occurrence of a strong sand layer was not taken into account, therefore, water disappears quickly and the pond only operates for a short period), mother plantation of hazelnuts – 0.24 hectares, the household yard [17-19].

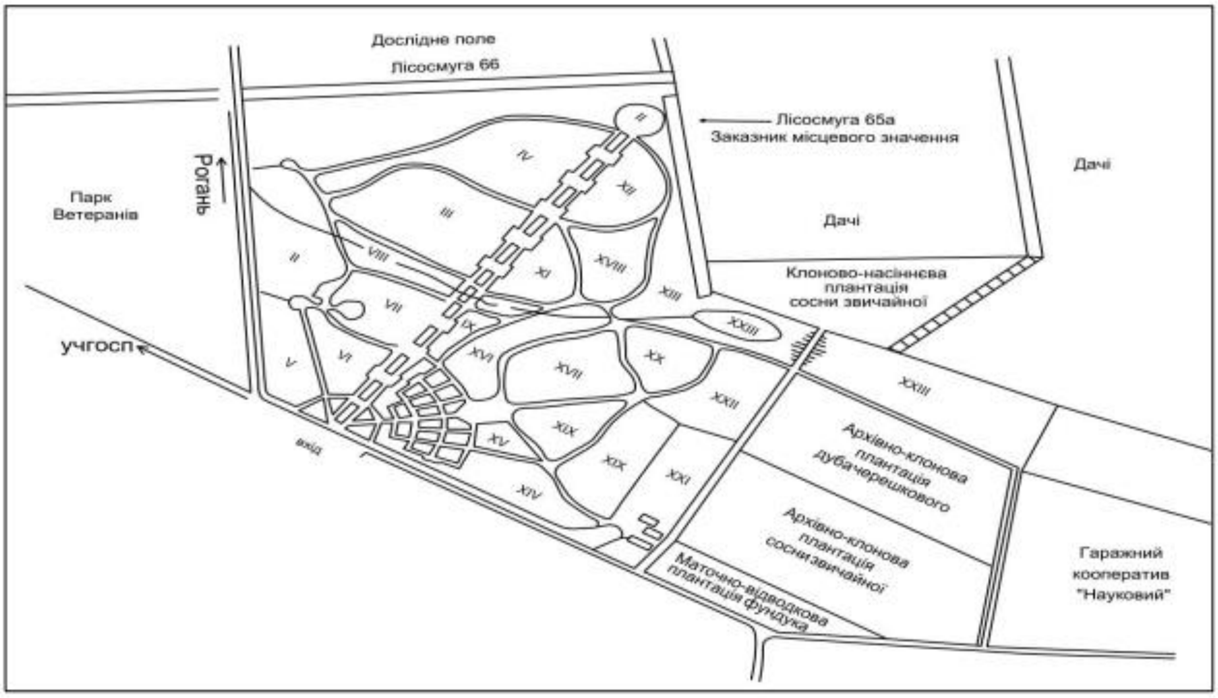


Fig.1. Spatial-functional structure of the arboretum [17]

Equivalence table for Fig. 1

Дослідне поле	The experimental field
Лісосмуга 66	Forest band 66
Парк Ветеранів	Veterans Park
Рогань	Rohan
Учгосп	Instructional farm
Вхід	Entrance
Дачі	Cottages
Лісосмуга 65а	Forest band 65a
Заказник місцевого значення	Local Value Reserve
Клоново-насіннєва плантація сосни звичайної	Clone-seed plantation of Scotch pine
Архівно-клонова плантація дуба черешкового	Archival-clone plantation of petiole oak
Архівно-клонова плантація сосни звичайної	Archival clone plantation of Scotch pine
Маточно-відводкова плантація фундука	Mother plantation of hazelnuts
Гаражний кооператив «Науковий»	Garage cooperative "Naukovyi"

The arboretum is the object of the natural reserve fund of Kharkiv region of national importance. The purpose of establishing was:

- in artificial conditions preservation of collections of living plants and other botanical objects having scientific, educational, economic and cultural significance;
- conducting research works;
- conducting educational, pedagogical and ecological-educational work in the field of botanics and

nature protection, plant growing and selection, ornamental horticulture and landscape architecture.

Soil-climatic conditions of the arboretum. To investigate landscape-ecological conditions, typical combinations of certain subtypes and varieties of soil with the typical forest-germination types, defined as forest-based conditions, were considered in the paper. This concept is an important forestry indicator that characterizes homogeneous forest-based conditions on forest plots covered and uncovered with forest vegetation. The edaphic grid of Alekseyev-Pohrebniak, specified by B.F. Ostapenko is used for their classification [14], based on combinations of moisture and soil richness. Such combinations are called edatopes. In our case, this is fresh ground (D2). Forest ecologists estimate it as the most fertile habitat, where soils rich in nutrients (loamy and clay-rich) are covered with vegetation with a prevailing number of megatrophs. Mesotrophs are found only in the upper woody tiers.

So, the soils here are typical black soils average -washed, which are bedrocked with loess loams on a thick layer of Neogene sands (the Poltava tier, according to the classical scheme of its stratigraphic division, recognized by soil scientists following Kharkiv geologists D. Sobolev, I. Remizov, et.al.).

The soil of the test site territory is classified by the authors as the following agro-groups, according to the generally accepted "Nomenclature list of agro-industrial groups of soils in Ukraine":

65е – ordinary chernozem soils weakly eroded heavy- argillaceous and light-loamy

66г – ordinary chernozem soils medium-eroded light-argillaceous

66д – ordinary chernozem soils medium-eroded medium-argillaceous

63д – ordinary chernozem soils salt-washed medium-argillaceous

209г – washed chernozem soils and meadow-chernozem light-argillaceous soils (Fig. 2).

Fig. 2. Cartogram of agro-industrial groups of soils on the territory of the arboretum

Continental climate with unstable moisture. Average annual air temperature is +6.5 ° C with a variation from +38 to -35 ° C. The frost-free period is 113 - 200 days. The average annual rainfall is 520 mm with a variation of 330 to 740 mm. The rainless period can last from 10 to 52 days. A term with a relative humidity below 30% may be 24 or more nights. On these days there are dry winds and droughts. The study of changes in the annual amount of precipitation observed and studied by many scientists in recent years, according to the township Rohan (experimental field of KhNAU near the arboretum) makes it possible to claim that there is a continental type of annual flow of precipitation in general in this territory. According to it, their maximum amount is during a warm period. The territory belongs to an area with unstable moistening [20].

The authors created the information base for an automated system of landscape ecological maps, which consists of a database of cartographic information and a database of thematic data about the investigated area.

The cartographic database includes the following materials:

1. A spatial-functional structure of the arboretum, which provides information on the contours and qualitative state of the territories (Fig. 1), and the cartogram of agro-industrial groups of territories (Fig. 2).

2. *A digital image of the investigated area (Fig. 3).* Aerospace images provide fast information about the landscape, coverage of large areas, simultaneous transfer of many of their properties in different ways, using the entire range of electromagnetic spectrum. This makes aerospace information one of the main sources in the information system of automated cartographic systems. It has radically changed the traditional ways of composing landscape maps. All these materials are a traditional topographic basis for mapping landscapes.

Fig. 3. A snapshot of KhNAU's arboretum territory, 2018.

3. *Digital model of relief (Fig. 4).* A multidimensional analysis of an object, process or phenomenon is increasingly used when conducting research in ecology. Comprehensive characteristics of the studied environment are used as mathematical data – spatial, temporal, quantitative and qualitative. Given the available data, the type and nature of information used during modeling, different methods of constructing models are chosen.

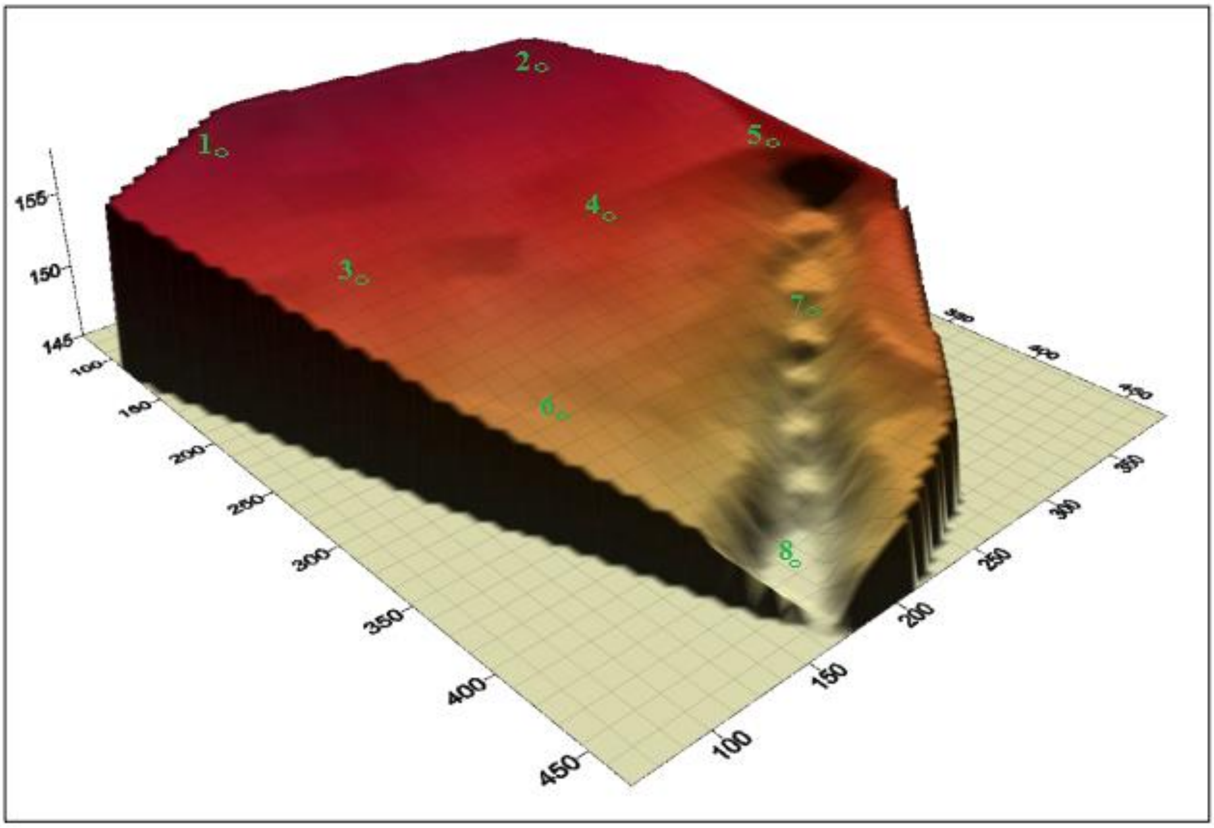
Digital model of relief is intended for interactive visualization and has the effect of presence on the ground. In our case, it reflects the location and numbering of soil samples selected for laboratory studies.

Such models are used to substantiate measures to optimize land use in order to restore and stabilize the ecological situation, assess the nature-recreational potential of the territory, monitor the components of the environment, predict the development of transformation and degradation processes and environmental phenomena.

Cartographic modeling is of interest to researchers, since this is the most laconic way to streamline a large amount of geographic information. This direction is particularly relevant for those areas where the map is a means of creating sound concepts of spatial and temporal patterns that take place in the landscape-environmental field of research. It is absolutely impossible to explore them locally. That is why 3D landscape modeling has great prospects.

Along with the purely cartographic information, the database must also be filled with statistical information.

Applied landscape geochemical surveys. Samples from the upper fertile soil layer were selected for research on the arboretum territory and the content of the moving forms of heavy metals (iron, ma-



4 - place and number of soil sample selection

Fig. 4. Digital model of V.V. Dokuchayiv KhNAU's arboretum territory relief.

nganese, zinc, copper, nickel, lead, chromium and cadmium) was determined by atomic absorption spectrometry (Fig. 4).

The obtained results show the following. The accumulation of elements occurs in areas of the terrain lowering due to runoff of surface and groundwater. The most dangerous of these are lead, cadmium, chromium, nickel, whose concentration exceeds the acceptable concentration (AC) up to 3-4 times, or are on the verge of excess (Table 1).

Table 1

Concentrations of heavy metals in the investigated soils

Elements	Concentration (average), mg / kg								
No.	1	2	3	4	5	6	7	8	AC
Iron	3,37	3,54	78,23	85,43	29,45	50,92	289,08	227,17	-
Manganese	40,62	16,43	228,97	147,85	103,94	52,57	185,15	215,45	50,00
Zinc	1,81	2,48	12,12	21,81	17,75	12,14	15,98	9,65	23,00
Copper	1,16	0,86	1,15	1,16	1,28	1,17	1,67	2,23	3,00
Nickel	2,45	3,49	2,85	2,73	4,24	3,96	3,78	4,74	4,00
Lead	2,47	3,75	4,53	4,89	3,59	3,18	6,52	7,12	2,00
Chromium	1,83	3,72	2,41	5,16	5,67	5,24	6,92	6,23	6,00
Cadmium	0,17	0,19	0,52	0,63	0,63	0,42	0,57	0,73	0,70

The highest concentrations of heavy metal content were found in the lower reliefs, near the motorway adjoining the park, as well as on high slopes (Fig. 5).

The influence of the site position on various elements of relief and exposure on the soils properties to date has not been studied in detail yet.

The statistical processing of the results was aimed at revealing the relationship between the content of heavy metals and a number of indicators that could affect their accumulation: distance to the highway, depth of the sample, the slope steepness and the average elevation of the selection point above the sea level.

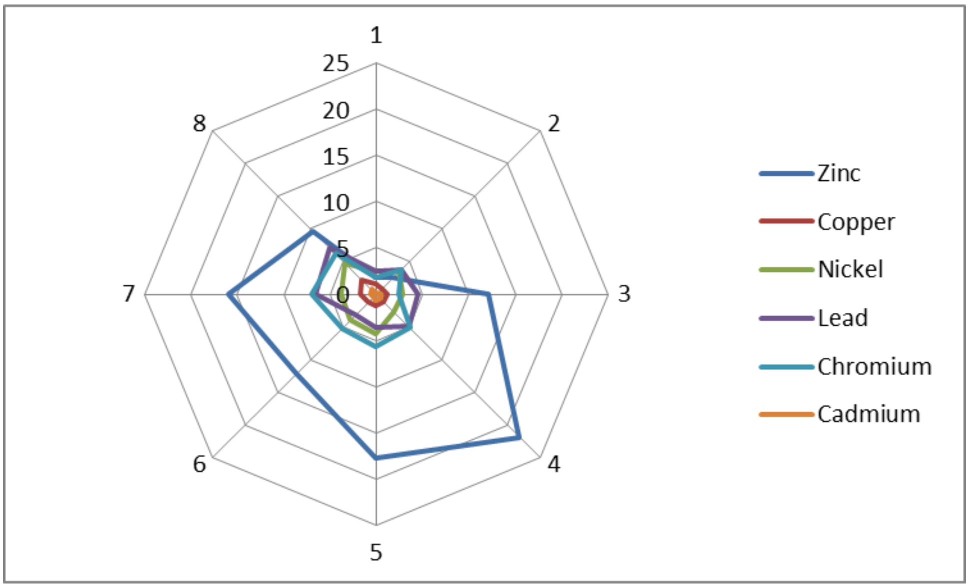


Fig. 5. Interpolation of heavy metals concentrations in depth (relative to the deepest point)

As a result of the conducted research, the ranking of factors (characteristics of soil samples) for the soil, iron, manganese, zinc, copper, nickel, lead, chromium and cadmium contents was performed. In the first place there is the height of the sampling point of the soil, in the second place there is the distance to the road, in the third – the slope steepness, and the fourth – the depth of sampling (Table 2).

Thus, we can conclude that distribution of heavy metals in the studied area mainly depends on the height of the terrain. That is, with the relief lowering substrate with metal-containing substances washes out and is removed with groundwater.

Based on our research, we can draw conclusions about the nature of heavy metals behaviour in the soils of the investigated area: they can be divided into two different groups. The first group includes copper, nickel, chromium, cadmium. Their content in the soil slightly changes with depth and practically does not depend on the landscape position of the point. Accumulation in the humus horizon is poorly expressed.

The second group includes iron, manganese, zinc and lead. These elements accumulate mainly in the humus horizon, which may be due to low humus content in the soils. Assessment of the territory condition is given in Table 3.

Table 2

Ranking of factors (characteristics of soil samples)

Performance indicators	Factors			
	height, m	distance to the road, m	cutslope ratio	depth, sm
	x_5	x_3	x_4	x_1
Iron content	1	3	4	5
Manganese content	1	3	5	4
Zinc content	5	3	1	2
Copper content	2	4	5	3
Nickel content	1	2	5	4
Lead content	2	3	4	5
Chromium content	1	4	2	3
Cadmium content	5	2	3	4
Mean value	2,25	3,00	3,63	3,75
Factor rank	**I**	**II**	**III**	**IV**

Table 3

Estimation of environment pollution by heavy metals

Elements	Class of danger	AC, mg/kg	Maximum concentration, mg / kg	AC excess, times	Type of environmental situation
Manganese	III	50	228,97	4,5	Crisis
Zinc	I	23	21,81	0,9	Satisfactory
Copper	II	4	4,74	1,2	Pre-crisis
Nickel	I	2	7,12	3,56	Crisis
Lead	II	6	6,92	1,15	Pre-crisis
Chromium	I	0,7	0,73	1,04	Pre-crisis

Today, there are a lot of research results on the harmful effects of heavy metals on the environment, methods for their identification and mapping in the literature. But the problem of preventing the accumulation of heavy metals in soils is not clearly represented; for the most part they are expensive and long-term measures.

In our opinion, phytoremediation is a promising direction in solving such problems [21-22]. Its significant advantage is that these measures are absolutely harmless to the environment. They are much cheaper than other methods and have substantial public support. With implementing of phytoremediation methods, there is less secondary pollution, physical and granulometric composition of soils does not deteriorate, biological activity does not decrease, and productivity is kept constant. This technology is most convenient for cleaning of moderately polluted soils, which is well suited to our case. Such technology is absolutely safe from the ecological point of view, as it does not destroy the natural fertility of the soil, reduces the soil erosion and increases its aeration. Such processes stimulate soil microflora to decompose organic contaminants and promote the absorption of harmful substances by the plant.

Conclusions. The landscape-ecological approach is currently used in solving many scientific problems, both theoretical and practical. For example, in the area of sustainable development of territories, which is an integral part of nature use optimization, the agro-landscapes management is used, as well as in the district method of forest management.

The landscape-ecological method as a component of the district method is used in national parks and nature reserves to ensure the conservation and, if necessary, in the restoration or reconstruction of indigenous forest ecosystems, increase of ecological, scientific, recreational value of forest landscapes, their socio-economic use.

The main goal of developing such methods is collection, systematization, analysis and processing of high-quality and reliable information as a result of complex landscape-ecological analysis of territories, as well as forecasting of environmental problems and ways of their solution or prevention.

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LANDSCAPE-ECOLOGICAL INVESTIGATIONS MAPPING OF V. V. DOKUCHAYIV KHNAU ARBORETUM'S TERRITORY

Formulation of the problem. This article briefly describes the main problems that arise during landscape and ecological investigation of territories. On the example of V.V.Dokuchayiv KHNAU's arboretum the comparative and ecological method of estimating the soil conditions for the forest-based effect, i.e. species composition and productivity of indigenous forest vegetation groups is considered. The forest represents a system of vegetation and habitat. From the ecological point of view it is a reflection of the environment, as its forestry effect. The objective is also to justify measures aimed at solving urgent landscape and environmental problems, namely, transformation and pollution of the natural environment, the development of morphodynamic processes.

Soils, as the element of the landscape, are an important block of ecosystems whose destruction has a multidimensional value for the stability of the natural environment. Aggregate soil transformation has tradi-

tionally been evaluated as progressive. However, scientific analysis suggests that extensive farming, inappropriate chemical fertilization and fetishization of pesticides have led to a significant decline in fertility, and in some cases, its loss due to the development of erosion of natural soil cover on large areas. Such processes stimulate soil microflora to decompose organic contaminants and promote the absorption of harmful substances by the plant.

The landscape-ecological approach is currently used in solving many scientific problems: both theoretical and practical.

The purpose of the article. The purpose of this work was to study the landscape and ecological structure of the forest massif, to identify the relationship between the components of landscapes on the example of the V.V. Dokuchayiv KHNAU's arboretum by mapping the territory.

Methods. The authors' own achievements as well as the research results of domestic and foreign investigators made the methodical basis for the article.

Results. The content of heavy metals on the territory of the arboretum is investigated, a ranking of factors influencing the distribution of concentrations of pollutants has been carried out and the type of ecological situation is determined by means of mapping methods.

Modern and ecological methods of disturbed territories' restoration with the help of phytotherapeutic technologies, which are much cheaper and safer, are offered. When implementing phytoremediation methods, there is less secondary pollution, physical and granulometric composition of soils does not deteriorate, biological activity does not decrease, and productivity is kept constant. This technology is most convenient for cleaning of moderately polluted soils.

Scientific novelty and practical significance. One of the main mechanisms for regulating the ecologization of land resources is the identification, evaluation and implementation of the maximum possible reserves for increasing the efficiency of this process. This is reduction of unproductive losses in the mode of use and conservation of resources and the possibility of using the basic solution as a scientific and technological progress. Digital terrain models are designed for interactive visualization and have an effect of presence on the ground. Such models are used to substantiate measures to optimize land use in order to restore and stabilize the ecological situation, assess the natural recreational potential of the territory, monitor the components of the environment, predict transformation and degradation processes and environmental phenomena development.

Keywords: landscape-ecological investigations, cartography, edotopes, trophotops, edaphic grid, arboretum.

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