https://doi.org/10.31489/2024BMG1/125-138

UDC 604.4

Received: October 16 2023 | Accepted: December 14 2023

A.S. Gorbunov*, V.B. Mikhno, O.P. Bykovskaya

Voronezh State University, Voronezh, Russia
**Corresponding author: gorbunov.ol@mail.ru*

Structural and morphological organization of dry valley of the Cretaceous south of the Central Chernozem Region

The peculiarities of origin, morphological and genetic varieties and structural and dynamic interrelations of dry valley landscapes of the Cretaceous south of the Central Chernozem Region are considered. Modern ideas about genesis, morphology, development and landscape structure of sukhodols are presented. Paradynamic interrelations of structural elements of basin landscape systems are emphasized. The necessity of taking into account landscape specificity of dry lands when solving the problems of nature management and optimization of landscape-ecological situation in the Cretaceous south of the Central Chernozem Region is emphasized. As an example, we analyzed the component, territorial and altitudinal organization of natural complexes of a large sukhodols of the Kuvshin dry valley located in the Podgorensky district of the Voronezh Region. The main factors of landscape differentiation are established, among which are peculiarities of morpholithogenic base, character of biostrom development, modern economic use. The problems of identification of local landscape boundaries and approaches to their solution have been noted. Based on the results of the research, 7 families and 45 species of landtypes, as well as altitudinal landscape layers and sub-layers were identified within the valley. Recommendations on changing the conservation status of the territory are given.

Keywords: dry valley, landscape genesis, landscape structure, paragenetic landscape systems, landscape polystructurality.

Introduction

A landscape peculiarity of the southern part of the Central Chernozem Region, composed of chalky-mergel rocks, is the widespread distribution of “sukhodols” – large dry erosion valleys with flat bottoms, deposits of temporary watercourses and gentle slopes. The largest dry valleys reach 20–25 km length, 1.5–2.0 km width, 40–50 m depth. They cut and drain interfluves, form a local base of erosion, karst, landslides and suffosion processes; they have a significant impact on hydroclimatic, soil and vegetation and in general landscape conditions of neighboring territories. All this is reflected in peculiarities of formation and structural and dynamic organization of sukhodol landscapes and geosystems interconnected with them by flows of substance and energy. The landscape-forming and ecologically-stabilizing role of sukhodols is still poorly studied. The lack of necessary information makes it difficult to solve problems related to rational use and optimization of landscapes in the region. Taking this into account, this article attempts to analyze the genetic features and structural and dynamic organization of sukhodol landscapes in the Cretaceous south of the Central Chernozem Region.

Definition of the term “sukhodol”. The term “sukhodol” is widespread mainly in the southern part of the Russian Plain. The earliest interpretation of it is contained in V.I. Dal's Explanatory Dictionary, in which the word “sukhodol” means a hollow, a valley without water [1; 625]. A similar definition of “sukhodol” is given in the dictionary of the Russian language by S.I. Ozhegov: “sukhodol” is a valley, an area on watersheds, where the soil is not moistened [2; 678]. Following the above definitions, the term “sukhodol” refers not only the dry valley, but also areas of watersheds, upper parts of hillsides and uplands that are drier than the surrounding area [3]. Usually, the term “sukhodol” is associated with large dry erosion valleys with a wide flat bottom and gentle slopes, filled with water in spring or during floods [4; 102]. The existing difference in the interpretation of the term is explained by toponymy — different meanings of the name in different regions. Thus, in the forest-steppe and steppe zones of the Russian Plain, including the Cretaceous south of the Central Chernozem Region, “sukhodol” is large dry valley; in the forest zones of the Russian Plain — elevated, treeless areas of watersheds occupied by meadows [5].

Experimental

The "sukhodol" spread in the Cretaceous south of the Central Chernozem Region is represented by two main variants: valley-sukhodols and balka-sukhodols [6].

The Valley-sukhodols were formed as a result of degradation of the river network and represent dry river valleys without permanent channel flow. The consequence of the fluvial mode of development of valley-sukhodols is reflected in their geological and geomorphological structure. In particular, alluvial and accumulative river sediments and dry river beds are often preserved on the bottoms of dry valleys. In some places fragments of fluvial terrace are above floodplain and dry lake basin. All this testifies to the fact that in the past there was a river regime here and fluvial processes of two types were actively manifested: erosive and accumulative.

On the territory of the Cretaceous south of the Central Chernozem Region, the formation of valley-sukhodol is mainly associated with the degradation of small rivers and watercourses. This is usually manifested in the reduction of river channels length or their disappearance, as well as transformation of floodplain landscapes. The most intensive drying of river in the basins of the following rivers: Bogucharka, Tolucheevka, Kriusha, Mamonovka, Chernaya Kalitva, etc. [7, 8]. During the period from 1950 to 1991, 138 small rivers in Voronezh Region alone lost their status and turned into temporary watercourses, and the total number of dry watercourses reached 1343 [9]. At the same time, the lost length of the river network from 1964 to 2008 amounted to 510 km [8].

The disappearance of watercourses has affected landscapes. It was especially manifested in the change of landscape structure of floodplain geosystems, the area of which for 40 years (from 1960 to 2000) within the Voronezh Region decreased as a result of floodplain drying by about 1 thousand km^2, which led to the degradation of meadows, old-growth streams, floodplain forests and other geosystems [10]. Eventually, the floodplain landscape was replaced by a post-floodplain landscape characteristic of valley-sukhodol [8].

Morphometric data on the degradation of watercourses in the Cretaceous south of the Central Chernozem Region indicate that this process is currently dominant in the development of the river network. The rate of change in the length of small river channels is recorded in a large range — from several meters to 500 m per year [11]. The most intensively decreases the length of river channels of the following rivers: Rossosh, Kantemirovka, Levaya Bogucharka, Malaya Mezhenka, Gavrilo, Manina, Mamonovka, Kriusha. Apparently, based on the direction of climatic changes, the tendencies of reducing the length of small river channels and disappearance of watercourses will continue, which will contribute to the formation of valley-sukhodol.

The balka-sukhodols, unlike valley-sukhodols, did not undergo fluvial development. Erosion diluvial process played a leading role in their formation [4]. The balka-sukhodols are devoid of floodplain alluvial deposits. Their flat bottoms are usually overlain by diluvia sediments over lying bedrock chalky-mergellic rocks. Increase in the length of balka-sukhodol is closely connected with the factors activating erosion processes. Regressive erosion plays a special role, predetermining the growth of balka-sukhodol towards their surface temporary watercourses.

Morphological features of sukhodols are reflected in their geomorphologic structure. In the Cretaceous south of the Black Chernozem Region, the most widespread sukhodols are rectilinear and tree-lake shaped with variable asymmetry of slopes, gentle and wide bottoms and a significant catchment area. Their morphological features are predetermined by geological and geomorphological factors. An example is the Bogucharsky Yar, located on the right bank of the Don River and extending from the southeastern vicinity of Novaya Kalitva village to the village of Tverdokhlebovka. The sukhodol is 25 km long, 1 to 1.5 km wide in the middle part (near the village of Bely Kolodets), 0.6 km wide at the top, 40 m deep, bottom slope 0.0032, catchment area 196 km^2. The tributaries of the main valley in the upper reaches give the valley a tree-shaped form in plan.

The rectilinear sukhodols are characterized by the absence of large tributaries and rectilinear strike, which, apparently, is associated with the location of tectonic fractures. The rectilinear sukhodols are widespread on the territory of the Kalach Upland. Most of them are confined to the Pirogovsky and Kalach tectonic uplifts, as well as to the newest local uplifts and structural lines of the Pavlovsko-Mamonsky trough [12]. For example, a group of sukhodols formed within the boundaries of the Gnilushansky local uplift has a clear orientation in accordance with the southwestern slope of the Kalach uplift. This is especially evident from the Prirechny sukhodols, which extends from the village of Russkaya Zhuravka to the village of Prirechnoye. Its morphological peculiarity is its rectilinear shape, which is preserved for 19 km, absence of tributaries and pronounced asymmetry of slopes.

Genesis of sukhodols. Cognition, rational use, optimization and management of development of sukhodols geosystems requires clear ideas about their origin and direction of development. At present, the origin and development trends of sukhodols landscapes of the Cretaceous south of the Black Chernozems Regions are insufficiently studied. This is evidenced by the lack of special studies devoted to this problem.

Analysis of available materials allows us to conclude that two groups of factors are involved in the formation of sukhodols: natural and anthropogenic. Natural prerequisites for formation and development of sukhodols depend on tectonics, climate, lithogenic base, surface runoff and denudation processes; anthropogenic prerequisites are predetermined by a high degree of land plowing and deforestation of watersheds, creation of ponds in the valleys of small rivers that retain runoff.

Tectonics and erosion play a special role in the origin of dry lands. This is indicated by the close connection of the distribution of sukhodols with local tectonic structures. Often, sukhodols are confined to the slopes of second-order tectonic uplifts (Kursk, Ostrogozhskoye, Kalachskoye, Pirogovskoye, Kantemirovskoye) and uplifts of the third order (Yemanchanskoye, Pukhovskoye, Sergeevskoye, Ilovskoye, Zhuravkinskoye, Yuzhno-Kalachskoye, Timskoye), as well as to tectonic sags (Aidarsky, Potudansky, Pavlovsko-Mamonsky). Such dependence is obviously connected with increased fracturing and fragmentation in these places of themelo-mergel lithogenic base of dry dock basins, which promotes denudation of its rocks and formation of valley network.

Structural and dynamic organization of sukhodols landscapes. When considering landscape structure, sukhodols are referred to slope geosystems. This approach is used in landscape mapping and is reflected in landscape maps of the Central Chernozem Region (1961, 2000). Based on system analysis, sukhodols together with watershed landscapes form *basin paradynamic landscape systems,* the structural elements of which are land type associations (mestnosts in Russian classification), land types (urochishches) and sites (facies) covering both sukhodols and their watersheds. Sukhodols basin geosystems consist of two morphologically and genetically different landscape subsystems: valley and conjugate. They are close to the basin river subsystems — valley-river and watershed subsystems identified by F.N. Milkov [13].

Sukhodol landscape subsystem includes morphologically heterogeneous, genetically interconnected landscapes. General conditions of formation and genetic unity of structural elements of subsystems predetermine their paragenetic interrelationships supported by substance flows, the main of which is directed water flow — the leading factor in the formation of sukhodols landscapes. In the conditions of the Cretaceous south of the Central Chernozem Region, the main elements of sukhodols landscape subsystems are specific land type associations and landtypes. In valley-sukhodols they include post-floodplain, fluvial terrace above floodplain and slope landscapes; in balka-sukhodols – bottom and slope landscapes.

The conjugated landscape subsystem unites landscapes of the basin, which are interconnected by flows of matter and energy, but lack genetic unity. Within the Cretaceous south of the Central Chernozem Region, it may include geosystems of watershed, slope, hilly and terraced landscapes. Despite the differences in genesis, age, structure and dynamics of landscapes, the conjugate landscape subsystem is closely connected dynamically with the sukhodol subsystem. An example is the dependence of the development of erosion landscapes of sukhodols on the volume of runoff coming to them from watersheds. In turn, sukhodols act as a base of erosion and influence the formation of erosion landscapes of adjacent territories of their watersheds.

Results and Discussion

The structure of natural components of sukhodols. Often both valley-sukhodols and balka-sukhodols are present in large sukhodols. Valley-sukhodols ones are formed along the main flow channel, balka-sukhodols ones — along the main tributaries. An example of such sukhodols is the “Kuvshin”, located in Podgorensky District, Voronezh Region (Fig.). The sukhodol stretches from the villages of Vitebsk and Saprino to the village of Kuvshin. The area has a unique combination of diverse landscapes, including calcephitic-petrophytic, cereal and mixed-grass steppes with rare and relict elements of biota, oak forests and meadows. The uniqueness of the territory is emphasized by the created here reserve of regional significance — a natural monument of biological profile — the “Kuvshin” [14].

The geologic base of the sukhodol is formed by chalky-mergel deposits of the Turonian, Konyak and Santonian stages. The chalky deposits of the Turonian Stage are exposed in the middle parts of the slopes of south-western and western exposure (the left slope of the sukhodol), as well as in the sukhodol cutting through it. On the slopes of the northeastern and eastern exposures, the bedrock is everywhere overlain by Quaternary deluvial clayey-loamy sediments.

The “Kuvshin” is a classic sukhodols, its length along the longest thalweg is 11.3 km. The elevation difference between the source in the northwestern tip of the Buivolskiy Yar and the mouth is 115 m, with a maximum depth of 50 m in the lower reaches. The width varies from 320 m in the middle reaches to 1300 m at the mouth. In plan the sukhodols has a tree-shaped form, which is formed by a number of spurs — Buivolskiy Yar, Diakonov Yar (from the confluence of which the “Kuvshin” sukhodol begins), Kharobov Yar, Blizhnie and Dalnie Grushki, Manychensky and others. The largest is the right spurs of the “Kuvshin” sukhodol — the balka Kolodezhny Yar, which is more than 5.64 km long. The sukhodol extends meridionally from north to south, in the main valley it is characterized by predominantly left-lateral asymmetry of slopes (the left slope of the sukhodols is steeper and higher), which is broken in the middle part, where the relief form acquires a symmetrical trough-shaped profile. In the lower reaches, the valley has a right-lateral asymmetry, predetermined by the presence of an above-floodplain terrace along the left slope.

Large spurs also have a clearly pronounced asymmetric profile. The left spurs (Diakonov Yar, Kharobov Yar, and Blizhnie Grushki) are characterized by left-lateral asymmetry, while the right spurs (Kolodezhny, Dremov, and Zhelobok) are characterized by right-lateral asymmetry. At the same time, a curious regularity is noted: the slopes of northern exposures are mostly steeper than the slopes of southern exposures, which in this case contradicts the scientifically established opinion about the steeper slopes of southern exposures [15]. This situation can be explained, firstly, by the general slope of the macro-slope of the Central Russian Upland in the southeastern direction and, secondly, by the fall in the same direction of the thickness of chalky-mergel rocks, which contribute to the displacement of water flows and the formation of a typical slope asymmetry.

The left slope of the sukhodol is more diverse morphologically and landscape-wise. Its structure includes classical convexly-concave and complex terraced areas. The convex-concave slopes prevail, ranging in length from 150 m in the narrow part to 1 km in the widening part. Their steepness varies from 5–7° to 30°.

In the lower reaches of the sukhodols, the left slope is complicated by an erosion terrace 140–160 m wide, the surface of which lies 25–30 m above the bottom level. The terrace is a remnant of the bottom of an ancient Neogene valley re-deepened in post-glacial time. Below the ledge of the structural terrace is an accumulative terrace composed of alluvium and overlain by deluvial deposits. It is 3–5 m higher than the level of the bottom and may indicate the presence here in the past of a permanent watercourse with a floodplain regime.

The left slope is largely eroded, especially in the middle part and its lower reaches. There are 27 gullies in this section with a total length of 11.5 km. The density of erosional dissection of the slope is 2.35 km/km². The gullies formed here are of two types: lateral, cutting through the slope, and bottom gullies, formed along the bottom. High gully dissection of this territory is mainly connected with anthropogenic impact. Recent studies have shown that gullies growth has stopped.

The right slope of the gully is more uniform. Its height is 20–25 m lower than the left one; its width is stable and varies from 200 to 400 m, with a steepness of 10–15°. Everywhere the slope has a convex-concave profile, is devoid of outcrops of the chalky-mergel rocks on the surface, and is less eroded. The density of gully dissection is 0.8 km/km².

A distinctive feature of the “right bank” of the valley is the developed network of spurs. While the left slope is dominated by short (up to 1 km) gullies of postglacial age, the right slope is cut through by several large spurs, the formation of which occurred simultaneously with the main valley in the Neogene. These spurs have a tree-like shape, developed asymmetric profile, and morphometry similar to the main valley. The largest spur, the Kolodezhny Yar, is 5.64 km long, more than 1 km wide in the middle part and 50 m deep.
The bottom of the sukhodol *is* wide (up to 400 at the mouth), slightly concave, slightly inclined (up to 1°), complicated by deluvial plumes, cones of withdrawal and a fragmentary channel of a temporary water course.

The soils of the sukhodol is highly mosaic and consists of Haplic Chernozems, Calcic Chernozems, Haplic Greyzems, Residually Calcareous Chernozems, Alluvial-deluvial soils and Haplic Solonetz. Haplic Chernozems are dominating. These soils are characteristic of near-valley slopes with steepness of 3–5°, slopes of the main valley and, surfaces of the structural terrace. Herbaceous-cereal steppes are preserved on unplowed areas of Haplic Chernozems.

Calcic Chernozems are fragmentary on the adjacent slopes of the main valley. Their widespread distribution may indicate a higher woodiness of the sukhodol in the preagricultural period. At present, these territories are occupied by herbaceous-cereal steppes, where tree and shrub vegetation are intensively restored.

Haplic Greyzems are formed under the preserved forest massifs (Kolodezhny, Dremov, Olgino, Legashev forest, etc.) in combination with Calcic Chernozems.

Significant areas of the valley slopes are occupied by medium- and highly washed out Residually Calcareous Chernozems in combination with outcrops of chalky-mergel rocks. They are characterized by a limited set of soil horizons, low thickness, and weak structure. The most valuable from the point of view of protection plant communities — calcephitic-petrophytic steppes with rare and relict elements of flora — are confined to Residually Calcareous Chernozems.

Alluvial-deluvial soils were formed everywhere along the bottom of the valley. They have layered-grained composition, predominantly heavy loamy and clayey mechanical composition and significant variability of humus horizon thickness.

Limited areas in the upper reaches of gullies Diakonov Yar and Yamka are occupied by Haplic Solonetz, which formation here is predetermined by close occurrence of saline Kiev clays of Paleogene age.

The vegetation of the “Kuvshin” sukhodols, despite significant anthropogenic changes, has managed to retain its classic forest-steppe appearance. It is obvious that in the past the forest cover of the territory was much higher, as evidenced by extensive areas of Calcic Chernozems, as well as intensive restoration of tree and shrub vegetation on all relief elements. Steppe communities occupy the leading role in the structure of vegetation cover.

The floristic composition of steppe communities is characterized by high diversity. There is a number of rare plant species included in the Red Books of the Russian Federation and Voronezh region. In the flora of herbaceous-cereal steppes are noted *Paeonia tenuifolia* L., one of the largest populations in the region and the only known place of growth of the form with pink corolla coloration, *Pulsatilla pratensis* (L.) Mill., *Adonis vernalis* L., *Goniolimon tataricum* (L.) Boiss., *Crambe tataria* Sebeok, *Iris aphylla* L., *Goniolimon tataricum* (L.) Boiss., *Crambe tataria* Sebeok, *Artemisia sericea* Web. ex Stechm., *Astragalus pallescens* Bieb., and *Astragalus macropus* Bunge. The structure of communities is considerably represented by *Stipa*. There are up to 5 species of them on girder slopes and adjacent territories. Among them *Stipa zalesskii* Wilensky, *Stipa pulcherrima* K. Koch., *Stipa tirsa* Steven., *Stipa pennata* L. are included in the Red Book of the Russian Federation. Quite abundant are *Anemone sylvestris* L. a plant excluded from the last Red Data Book of the Voronezh region (2018), but at the same time they have not lost their value. In combination with herbaceous-cereal steppes, shrub communities dominated by *Chamaecytisus ruthenicus* (Fisch. ex Woloszcz.) Klásk. are widespread.

On outcrops of chalky-mergel rocks and highly washed Residually Calcareous Chernozems, shrub communities dominated by *Hyssopus cretaceus* Dubjan. — a plant of the Red Book of the Russian Federation — are widespread. Many rare plant species are also recorded in the communities, including *Scrophularia cretacea* Fish. ex Spreng., *Matthiola fragrans* Bunge, *Genista tanaitica* P. Smirn., *Artemisia salsoloides* Willd., *Artemisia hololeuca* Bieb. exBess., *Linum hirsutum* L.

Steppes with relict elements of flora grow on the slopes of western and southwestern exposure. They represent sparse groupings, species composition of which includes *Carex humilis* Leyss., *Alyssum lenense* Adams, *Schivereckia podolica* (Bess.) Andrz. ex DC., *Polygala cretacea* Kotov, *Pimpinella tragium* Vill., *Onosma simplicissima* L., *Thymus calcareus* Klokov & Des.-Shost., *Thymus calcareus* Klokov & Des.-Shost, *Teucrium polium* L., *Clausia aprica (*Stephan) Korn.-Trotzky and a number of other species.

Dry meadows are widely developed along the bottom of the main valley and its spurs. The dominant species are *Elytrigia repens* (L.), Nevski and *Euphorbia virgata* Waldst. & Kit. Traditional for meadow community’s species are widespread. Among them are common: *Ranunculus acris* L., *Bromopsis inermis (*Leyss.) Holub, *Salvia pratensis* L., *Poa pratensis* L., *Agrostis stolonifera* L., *Tanacetum vulgare* L., *Trifolium pratense* L., *Melilotus officinalis* (L.) Pall., *Medicago lupulina* L., *Veronica spicata* L., *Securigera varia* (L.) Lassen, *Taraxacum officinale* F.H. Wigg. and others. At present, the bottom is actively overgrown with tree and shrub vegetation.

Forests are confined mainly to the northwestern spurs of the valley and are represented by oak forests. Slope forests are relatively low-growing, maximum height of trees is 12-13 m, with an average trunk diameter of 22–26 cm. They have a single-tier, less often a double-tier structure. In two-tier communities, the first tier is dominated by *Quercus robur* L. with a small participation of *Fraxinus excelsior* L., the second tier up to 7 m high is formed by *Acer campestre* L., *Pyrus pyraster* Burgsd., *Euonymus europaeus* L., *Crataegus rhipidophylla* Gand., and *Prunus stepposa* Kotov. Along with *Quercus robur* L., *Populus tremula* L. grows in the first tier along the bottoms of gullies. The herbal tiar of forests is dominated by *Carex pilosa* Scop., and less common are *Asarum europaeum* L., *Aegopodium podagraria* L., *Viola hirta* L., and *Glechoma hederacea* L.

Water shed forests are represented by two types — sedge oak forests on fresh habitats and herbaceous oak forests on dry habitats. The maximum age of trees in them is 50–60 years. In contrast to slope forests, watershed forests are characterized by a more complex structure. In such communities there are up to 3-4 tiers. The first tier up to 18 m high is dominated by *Quercus robur* L., *Acer platanoides* L. and *Fraxinus excelsior* L.; the second tier (12–14 m) is dominated by *Acer platanoides* L. and *Tilia cordata* Mill. The third tier (7–9 m) is formed by *Acer campestre* L., *Malus sylvestris* Mill., and *Pyrus pyraster* Burgsd. The fourth tier up to 4 m high is dominated by shrubs: *Corylus avellana* L., *Euonymus europaeus* L., *Crataegus rhipidophylla* Gand. Steppe species such as *Rosa majalis* Herrm., *Prunus stepposa* Kotov, *Cerasus fruticosa* Pall. are often found in the undergrowth.

A transitional type of plant communities is formed by sparse park-type forests formed on the slopes of the valley. Here, detached fruit trees and shrubs grow against the background of herbaceous-cereal steppes, giving the landscape a savannah appearance.

Along with natural communities in the valley there are cultural vegetation represented by agrophytocenoses. Except for the vegetable gardens of Kuvshin village, the range of species in them in recent years is very limited and is represented by wheat, sunflower and sugar beet. The plowed fields occupy mainly the slopes with steepness up to 6°, as well as part of the bottom in the lower reaches of the valley.

The Landscape structure. Despite the large number of works on the problems of landscape differentiation, there are still a number of unresolved issues. One of them is internal landscape differentiation of large sukhodols with high mosaic of soil and vegetation cover.

Firstly, in classical landscape classifications, large and medium-sized sukhodols are not reflected as units of landscape differentiation. In some cases, they can be parts of land type association and landscape, in other cases they consist of several land type association and belong to different landscapes, in rare and most "successful" cases the boundaries of a gully coincide with the boundaries of a land type association.

Secondly, the complexity of the internal hierarchical organization of landforms in sukhodols creates difficulties in assigning local geosystems to any taxonomic rank.

Thirdly, the boundaries of soils even more uncertainty to landscape boundaries. Under conditions of high preservation of vegetation cover they are practically invisible and become obvious only during detailed soil survey.

Fourthly, the boundaries of plant communities add to the already complex picture of landscape boundaries. In one case, they can pass the boundaries of lithological differences, relief, soils, exposures and other conditions without visible changes, while in another case, they create many obvious contours within one elements of relief. Sometimes vegetation boundaries are formed in uncharacteristic places and for reasons that are not clear at first glance.

Such problems of defining landscape boundaries have been widely discussed in scientific literature in recent years [16–19]. K.N. Dyakonov and A.Yu. Reteyum for the definition of landscape boundaries propose to carry out "a clear contrast between the concepts of system and areal, which require completely different operations of delineation" [20]. A number of researchers rightly note that the formation of landscape boundaries is influenced by the features of the polystructural and polyscale organization of geographical space [21–25]. In particular, V.N. Solntsev, in this regard, suggests distinguishing independent geostationary, geocirculation and biocirculation systems in the landscape sphere [26].

A.V. Khoroshev explains the existing uncertainty of landscape boundaries by the mismatch of "characteristic times of landscape components and their different inertia" [27]. The author sees the solution to the problem in the creation of "cartographic models of the most probable combinations of properties of landscape components based on information about inter-level and inter-component relationships" [24].

Without going into further discussions about the complexity and multifaceted nature of landscape boundaries and approaches to their delineation by different authors, let us note the important points in our opinion:

- Each component can form its own boundary field and important boundaries for the final landscape differentiation;
- Within the boundaries of any local geosystem, special conditions different from neighboring geosystems are formed;
- When delineating the boundaries of any taxonomic rank, it is necessary to remember that special conditions different from neighboring landscapes are formed within its boundaries;

- It is necessary to consider that some of the non-obvious natural boundaries may become apparent when the functioning or use of a particular landscape changes.

It should also be taken into account that the created landscape map should be understandable to specialists from related fields, and the highlighted contours would be easily explained by the existing natural conditions. In this case, the possibility of applying such a map in practice increases significantly.

A striking example is landscape maps of land type associations proposed by F.N. Milkov [28]. They became the basis for the organization of agricultural land use in forest-steppe and steppe zones. Modern agroecological groups of lands are refined and detailed, analogues of terrain types.

On this basis, we should not completely ignore the classical approach of landscape delineation on themorpholithogenic basis, the controversial aspects of which have been objectively criticized in recent years [29]. But it is very relevant to supplement it with actually existing geobotanic, soil, anthropogenic and other boundaries. For the Central Chernozem Region such a methodology has been tested and applied since the 60s of the twentieth century. New trends in landscape delineation based on mathematical and statistical methods cannot yet fully replace classical approaches, but in recent years, especially in the light of the development of geoinformation modeling and neural networks have made a significant step forward.

The internal landscape structure of the sukhodols should be identified according to the classical methodology with the allocation of land types and sites. For this purpose, we can use the approaches to the systematic of elementary landscapes of the Central Russian forest-steppe developed by K.A. Drozdov [30].

When distinguishing land types and especially their species, it should be remembered that land types should remain rather large formations, have an area of several hectares, and if their further internal division is necessary, it should take place at the sites level.

Prevailing in the structure of landscapes of the “Kuvshin” sukhodols, the most diverse and valuable in ecological terms are land type slopes of valley (Fig.), represented by families of steppe, forest-steppe-savannah, forest and field complexes. Their internal structure differs markedly both in lithological and geomorphological features (from steep eroded chalk slopes to sloping loamy slightly eroded slopes) and in indigenous vegetation formations (herbaceous-cereal steppes, herbaceous steppes, oak forests, etc.). The soil cover is formed by banded combinations of Haplic, Calcic, Residually Calcareous Chernozems and Haplic Greyzems.

The landtypes of the valley bottom include families of meadow, forest, forest-steppe-savannah and field landscapes. They are more homogeneous lithologically and morphologically. They are complicated only by the short (20–30m) weakly isolated deluvial plumes and alluvial fans. The mosaicity of vegetation cover is largely related to economic activity. On mowed areas herbaceous meadows are preserved, while unmowed areas are overgrown with shrubs and fruit trees.

The land types of spurs of main valley represent a group of complex land types including small spurs up to 2 km long, up to 350 m wide and up to 25 m deep. Families are represented by steppe, forest-steppe-savannah, fore stand forest-steppe complexes. Lithologically and geomorphologically they are also diverse. In chalky-mergel sediments, short circular spurs are formed, and in loamy sediments, linear-extended spurs are formed. Bottom gullies are often formed along the bottoms of such spurs. The land types of spurs of main valley are characterized by a high mosaic of soil and vegetation cover, and in some cases it is difficult to determine the root formation, because several types of steppe and forest communities alternate. In such cases it is expedient to distinguish ase parate family of *forest-steppe spurs*.

The land types of hollows differ from g land types of spurs by their smaller dimensions (up to 1 km in length, up to 100 m wide, up to 10 m deep) and simpler internal structure. They have a linear shape, often without lateral branches, symmetrical slopes and a bottom not wide up to 30 m. Families of tracts are represented by steppe, forest and forest-steppe landscapes.

The land types of gullies include bottom and slope erosion forms that are more than 300 m long and more than 3 m deep. Gullies have a complex structure of vegetation cover, where there is an alternation of bare patches with steppe and overgrown woody and shrub vegetation on the slopes and bottom. In this regard, families of land types of gullies should be differentiated into steppe, where tree-shrub-vegetation is fragmentary and does not play a leading role, and forest-steppe, within which more than one third of the area is covered with shrub and tree communities. Since gullies are a kind of free fields for the development of biostromes and the final formation that will be formed in them is not obvious, the selection of families and especially land type’s species should be carried out taking into account the current vegetation situation.

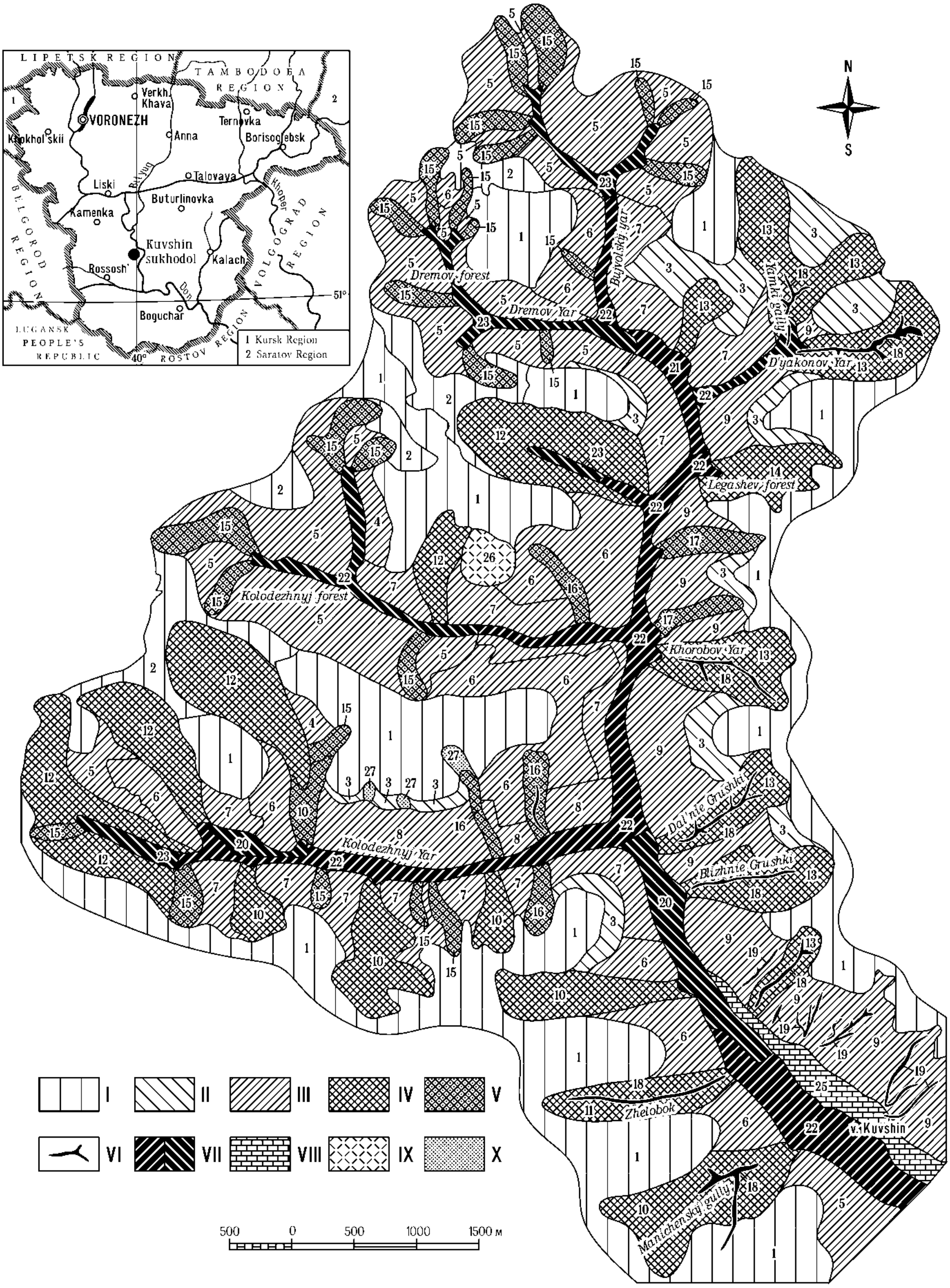

Figure. Landscape map of the “Kuvshin” sukhodols

Legend: I – The land types slightly sloping (up to 3°) plakors: 1 – with agrophytocenoses on combinations of Haplic and Calcic Chernozems medium-humus, heavy loamys; 2 – with sedge oak forests and herbaceous oak forests on Haplic Greyzem slow-humus, heavy loamy. ***II – The land types of slightly sloping (3–6°) watersheds:*** 3 – with agrophytocenoses and ash forest belts on Haplic Chernozems low-humus, medium thick, heavy loamy. ***III – The land types of slopes:*** 4 – loamy slopes of medium steepness (12–15°) with sedge oak forests and shrubby-herbaceous steppes on combinations of Haplic Greyzems medium washed out, heavy loamy and Calcic Chernozems low humus, medium washed out, heavy loamy; 5 – loamy beam slopes of medium steepness (8–15°) with sedge oak forests on combinations of Haplic Greyzems medium washed out, heavy loamy and Residually Calcareous Chernozems low-humus medium washed out, medium loamy; 6 – loamy beam slopes of medium steepness (10–12°) with agrophytocenoses on Haplic Chernozems low-humus, medium washed out, heavy loam; 7 – steep (17–20°) loamy-chalky beam slopes with shrubby-herbaceous-cereal steppes on Residually Calcareous Chernozems of different degrees of washed out, light loamy; 8 – loamy-chalky beam slopes of medium steepness (8–14°) with herbaceous-cereal steppes on combinations of Haplic Chernozems low-humus, medium washed out, medium loamy and Residually Calcareous Chernozems medium washed out, light loamy; 9 – eroded chalk steep (15–25°) slopes with shrubby-herbaceous-cereal steppes on combinations of outcrops of chalk rocks and Residually Calcareous Chernozems of medium and strongly washed out, medium loam. ***IV – The land types of spurs of main valley:*** 10 – in loamy-chalk sediments with sedge oak forests and shrubby-herbaceous steppes on combinations of Calcic Chernozems and Residually Calcareous Chernozems medium washed out, loamy; 11 – in loamy-chalky sediments with sedge oak forests, herbaceous steppes and agrophytocenoses on combinations of Calcic Chernozems and Residually Calcareous Chernozems medium washed, loamy; 12 – in loamy sediments with sedge oaks forests on combinations of Haplic Greyzems weakly humus, heavy loamy and Calcic Chernozems weakly humus, heavy loamy, weakly washed out; 13 – in chalky-mergel sediments with shrubby-herbaceous steppes, and herbaceous steppes on combinations of outcrops of chalky-mergel rocks and Residually Calcareous Chernozems of different degrees of washing out, medium and light loamy; 14 – in chalky-mergel sediments with pear oak forests and herbaceous steppes on combinations of outcrops of chalky-mergel rocks, Haplic Chernozems and leached Residually Calcareous Chernozems, medium washed out, medium-loamy. ***V – The land types of hollows:*** 15 – in loamy sediments with sedge oak forests on Haplic Greyzems medium washed out, heavy loamy; 16 – in loamy sediments with shrubby-herbaceous steppes on Residually Calcareous Chernozems medium washed out, medium loamy; 17 – in chalky-mergel sediments with herbaceous steppes on combinations of chalky-mergel outcrops and Residually Calcareous Chernozems medium washed out, medium loamy. ***VI – The land types of gullies:*** 18 – in loamy-chalky sediments with sparse herbaceous and tree-shrub communities on rock outcrops; 19 – in chalky sediments with sparse shrubby-herbaceous communities on rock outcrops. ***VII – The land types of the valley bottom:*** 20 – loamy flat bottoms with agrophytocenoses on alluvial-deluvial heavy-loamy soils; 21 – loamy weakly concave bottoms with herbaceous meadows on alluvial-deluvial carbonate heavy-loamy soils; 22 – loamy weakly concave bottoms with herbaceous meadows, fruit trees and shrubs communities on alluvial-deluvial carbonate heavy loamy soils; 23 – clay-loam weakly inclined (2–4°) weakly concave bottoms with aspen-oak forests communities on alluvial-deluvial carbonate heavy-loamy soils; 24 – clay-loam weakly concave bottoms with sedge oak forests and herbaceous meadows on alluvial-deluvial carbonate heavy loamy soils. ***VIII – The land type of fluvial terrace above floodplain:*** 25 – loamy terrace with rural settlement on alluvial-deluvial carbonate heavy loamy soils. ***IX – The land type of erosion hill:*** 26 – with herbaceous oak forests on Haplic Greyzems low-humus, heavy loamy; ***X – The land type of dells:*** 27 – plowed drainage hollows with agrophytocenoses on Haplic Chernozems low-humus, medium thick, clayey.

The land types of slightly sloping (3–6°) water sheds occupy loamy sloping surfaces with a steepness of 3–6°. Their soil cover is dominated by weakly washed out Haplic Chernozems, with fragmentary occurrence of washed out Calcic Chernozems. The vegetation cover is dominated by agrophytocenoses interspersed with the forest strips. In the northeast of the territory the watersheds are occupied by oak forests on Haplic Greyzems.

The land type of dell complicates the watersheds and above-lying plateaus, giving them an undulating appearance. They are plowed everywhere, but at the same time they preserve specific landscape conditions due to runoff concentration, soil overwatering, and activation of erosion processes in the slope.

Altitudinal organization of landscapes. Since the Kuvshin sukhodols is characterized by a rather large erosion incision for flat areas (up to 50 m), local landscapes of site level tend to change in height, forming morphologically and dynamically similar altitudinal-landscape systems [31, 32]. In this case, the approach with the separation of slope microzones [33] is not always possible to apply especially on well soddedor highly eroded slopes, where denudation, transit and accumulation zones have very blurred outlines, but at the same time the altitudinal differences in vegetation are still traceable. Without denying the existence of microzones, we propose to transform them into somewhat enlarged slope layer: upper sloping, middle steep, lower gentle, and, if necessary, to reveal layer internal structure at the expense of smaller units (sub-layer) in relation to microzones.

Thus, for example, the sub-layer of the left slope of the valley in the middle reaches from top to bottom will be: the slightly sloping watersheds with agrophytocenoses on Haplic Chernozems low-humus, weakly washed out (above 150 m); the slightly sloping water sheds with forest belts on Haplic Chernozems low-humus, weakly washed out (147–150 m); steep upper parts of slopes with Stipa pennata — Varii herbetum — Prunus stepposa communities on Residually Calcareous Chernozems of low-humus, medium washed out (140–147 m); steep upper parts of slopes with sparse Hyssopus cretaceous — Varii herbetum communities on chalky outcrops (133–140 m); steep middle parts of slopes with sparse Chamaecytisus ruthenicus — Varii herbetum — Stipa pennata communities on Residually Calcareous Chernozems of low-humus, strongly washed out (115–133 m); lower parts of slopes of medium steepness with Paeonia tenuifolia — Varii herbetum communities on Residually Calcareous Chernozems low-humus, medium washed out (102–115 m); gentle deluvial plumes of bottom with Euphorbia vergata — Elytrigia repens — Pyrus pyraster communities on alluvial-deluvial soils (below 102 m). It is noteworthy that the set of sub-layers can differ significantly for different slopes and parts of the valley.

Conclusion

Thus, a number of conclusions can be drawn as a result of this study:

- Given the high level of research of landscapes of the Voronezh Region, there are practically no works in scientific literature devoted to the organization of landscapes of sukhodols; therefore, the landscape status of sukhodols has not been determined yet and the problems of their internal landscape differentiation have not been solved;

- The sukhodols in the Cretaceous south of the Center Chernozem Region are genetically heterogeneous. Most of them are the result of degradation of watercourses (mainly small rivers) and intensive manifestation of linear erosion.

- The origin of sukhodols is reflected in their morphology and structural-dynamic organization of landscapes. Two main morphological-genetic types of sukhodols have developed in the region under consideration: valley- and balka-sukhodols. Together with the landscapes of their basins, sukhodols form basin paradynamic landscape systems, consisting of valley subsystems and conjugate subsystems, the main link of which is directed surface water runoff;

- Consideration of genesis, structural and dynamic organization and development of sukhodols landscapes is necessary for solving problems related to rational nature management and optimization of landscape-ecological situation in the Cretaceous south of the Central Chernozem region.

- Formation of local landscape boundaries within the gully can occur both under the influence of lithological and geomorphological factors and as a result of changes in the state of the biostrom within one morpholithogenic unit;

- Landscape organization of sukhodols can be considered from several positions; this paper presents approaches to component, territorial and altitudinal organization of landscapes;

- The existing protection status of the territory of the “Kuvshin” sukhodols clearly does not correspond to its internal content. The category of a natural monument of regional significance is too small for such an object. Even today there are all territorial and natural prerequisites for expanding the boundaries of the protected area and increasing its status to a nature park. In the future, it is possible to organize a forest-steppe reserve, which is so necessary for the region and the entire Central Chernozem Region, including, along with the valley, the protected areas of the Don Belogorye, the well-preserved Don flood plain and part of the left-bank fluvial terrace above flood plain terraces. The first priority task is to eliminate the obvious contradiction in the form of a combination of protected areas and hunting.

References

1 Даль В.И. Толковый словарь живого великорусского языка / В.И. Даль. — СПб.: Изд. дом «Вес», 2004. — 560 с.

2 Ожегов С.И. Словарь русского языка / С.И. Ожегов. — М.: Русский язык, 1986. — 797 с.

3 Ахромеев Л.М. Геоморфологический словарь-справочник / Л.М. Ахромеев. — Брянск: Изд-во Брян. гос. ун-та, 2002. — 320 с.

4 Прохоров А.М. Большая советская энциклопедия / А.М. Прохоров. — М.: Сов. энцикл., 1976. — Т. 25. — 647 с.

5 Мильков Ф.Н. Терминологический словарь по физической географии / Ф.Н. Мильков, А.В. Бережной, В.Б. Михно. — М.: Высш. шк., 1993. — 288 с.

6 Михно В.Б. Генезис структурно-динамическая организация ландшафтов суходолов мелового юга Центрального Черноземья / В.Б. Михно // Региональные ландшафтные исследования. — 2022. — № 6. — С. 92–98.

7 Дмитриева В.А. Гидрологическая изученность Воронежской области / В.А. Дмитриева. — Воронеж: Изд.-полиграф. центр Воронеж. гос. ун-та, 2008. — 225 с.

8 Mikhno V.B. Features of transformation of small river basins in Voronezh Region / V.B. Mikhno, E.V. Kandybko // Proceedings of Voronezh State University. Series: Geography. Geoecology. — 2006. — No 1. — P. 9–16.

9 Курдов А.Г. Водные ресурсы Воронежской области / А.Г. Курдов. — Воронеж: Изд-во Воронеж. гос. ун-та, 1995. — 207 с.

10 Михно В.Б. Пространственно-временные изменения ландшафтов Центрального Черноземья / В.Б. Михно // Вестн. Воронеж. отд. Рус. геогр. общ-ва. — 2000. — Т 2, № 1. — С. 3–8.

11 Zhigulina E.V. Forecasting changes in landscapes of small river basins in Voronezh Region / E.V. Zhigulina, V.B. Mikhno // Proceedings of Voronezh State University. Series: Geography. Geoecology. — 2013. — No. 1. — P. 172–178.

12 Раскатов Г.И. Геоморфология и неотектоника территории Воронежской антеклизы / Г.И. Раскатов. — Воронеж: Изд-во Воронеж. гос. ун-та, 1969. — 164 с.

13 Milkov F.N. River basin as a paradynamic landscape system and issues of nature management / F.N. Milkov // Geography and Natural Resources. — 1981. — No 4. — P. 11–18.

14 Горбунов А.С. Вопросы ландшафтной организации балочных форм рельефа (на примере балки «Кувшин», Подгорецкого района Воронежской области) / А.С. Горбунов // Региональные ландшафтные исследования. — 2020. — № 4. — С. 72–90.

15 Khrutskii S.V. Formation of small flat-bottom valleys in connection with climatic changes in Pleistocene / S.V. Khrutskii // Geomorphology — 1985. — No 1. — P. 17–21.

16 Бобра Т.В. Ландшафтные границы: выявление, анализ, картографирование / Т.В. Бобра. — Симферополь, 2005. — 167 с.

17 Chernykh D.V. On landscape boundaries: an unorthodox view of a physical geographer / D.V. Chernykh // International Journal of Cultural Research. — 2015. — Vol. 4(21). — P. 63–72.

18 Khoroshev A.V. Functional-dynamic approach to studying landscape boundaries / A.V. Khoroshev // Regional research. — 2022. — Vol. 3(77). — P. 60–70. https://doi/org/10.5922/1994-5280-2022-3-6

19 Михно В.Б. Физико-географическое районирование / В.Б. Михно, А.С. Горбунов. — Воронеж: Изд. дом ВГУ, 2022. — 278 с.

20 Dyakonov K.N. On interaction of the landscape and the Earth Sciences. Current landscape-ecological state and problems of optimization of the natural environment of the regions / K.N. Dyakonov, A.Yu. Reteyum // Proceedings of the XIII International landscape conference is dedicated to the 100th anniversary of the birth of F.N. Milkov. — 2018. — Vol. 1. — P. 78–80.

21 Коломыц Е.Г. Полиморфизм ландшафтно-зональных систем / Е.Г. Коломыц. — Пущино: Изд-во Отдела науч. и тех. инф. Пущин. науч. центра РАН, 1998. — 311 с.

22 Grodzinskiy M.D. Piznannya landshaftu: misce i prostir: u 2-h t / M.D. Grodzinskiy. — Kiïv: Vidavnicho-poligrafichnij centr «Kiïvc'kij universitet», 2005. — 242 c.

23 Puzachenko Yu.G. Landscape organization / Yu.G. Puzachenko // Problems of geography. — 2014. — Vol. 138. — P. 35–64.

24 Хорошев А.В. Полимасштабная организация географического ландшафта / А.В. Хорошев. — М.: Тов-во науч. изд. КМК, 2016. — 416 с.

25 Bokov V.A. Forms of landscapes polystructure. Theoretical and applied problems of landscape geography / V.A. Bokov // VII Milkov Readings: Proceedings of the XIV International Landscape Conference. — 2023. — Vol. 1. — P. 15–17.

26 Солнцев В.Н. Использование GPS- и GIS-технологий для изучения особо охраняемых природных территорий (на примере Воронежского государственного природного биосферного заповедника) / В.Н. Солнцев, О.В. Ружков, О.В. Трегубов, Б.А. Алексеев, Н.Н. Калуцкая, А.А. Анциферова. — Тула: Гриф и Ко., 2006. — 216 с.

27 Khoroshev A.V. Modern trends in structural landscape study / A.V. Khoroshev // Proceedings of Russian Academy of Science, series Geography. — 2016. — Vol. 3. — P. 7–15.

28 Мильков Ф.Н. Типы местности и ландшафтные районы Центральных Черноземных областей (к вопросу выделения региональных и типологических единиц в ландшафтной географии) / Ф.Н. Мильков // Изв. Всесоюз. геогр. общ-ва. — 1954. — Т. 86, № 4. — С. 336–346.

29 Kolbovskii E.Y. Does a natural landscape exist: an epistemological analysis of the phenomenon / E.Y. Kolbovskii // Proceedings of the Russian Geographical Society. — 2013. — Vol. 145(5). — P. 49–66.

30 Дроздов К.А. Систематика локальных комплексов как одно из перспективных направлений современного ландшафтоведения / К.А. Дроздов // Региональные ландшафтные исследования. — 2000. — № 6. — С. 60–64.

31 Gorbunov A.S. Structural organization of altitudinal landscape complexes of Central Russian forest-steppe zone / A.S. Gorbunov, O.P. Bykovskaya // Landscape geography in the 21st century. — Simferopol, 2018. — P. 101–104.

32 Gorbunov A.S. Altitudinal Landscape Complexes of the Central Russian Forest-Steppe / A.S. Gorbunov, V.B. Mikhno, O.P. Bykovskaya, V.N. Bevz // Landscape Patterns in a Range of Spatio-Temporal Scales. Landscape Series. — 2020. — Vol. 26. Springer, Cham. https://doi.org/10.1007/978-3-030-31185-8_14

33 Мильхов Ф.Н. Склоновая микрозональность ландшафтов / Ф.Н. Мильков // Ландшафтная география: избр. тр. — Воронеж, 2018. — С. 70–73.

А.С. Горбунов, В.Б. Михно, О.П. Быковская

Орталық Қара топырақты аймағының оңтүстігіндегі борлы құрғақ аңғарлардың құрылымдық және морфологиялық орналасуы

Орталық Қара топырақты аймақтың оңтүстігіндегі борлы құрғақ алқаптық ландшафтардың шығу тегі, морфологиялық және генетикалық сұрыптары, құрылымдық-динамикалық байланыстары қарастырылған. Құрғақ алқаптардың генезисі, морфологиясы, дамуы және ландшафтық құрылымы туралы заманауи түсініктер берілген. Бассейндік ландшафтық жүйелердің құрылымдық элементтерінің парадинамикалық байланыстары айтылған. Табиғатты пайдалану мәселелерін шешуде және Орталық Қара топырақты аймақтың оңтүстігіндегі борлы ландшафтық-экологиялық жағдайды оңтайландыруда құрғақ жерлердің ландшафтық ерекшеліктерін ескеру қажеттілігі атап өтілген. Мысал ретінде Воронеж облысының Подгоренский ауданында орналасқан Кувшинской құрғақ алқабының ірі құрғақ аңғарларындағы табиғи кешендердің құрамдас, аумақтық және жоғары орналасуы талданған. Ландшафт дифференциациясының негізгі факторлары анықталды, олардың ішінде морфолитогендік негіздің ерекшеліктері, биостроманың даму сипаты, қазіргі экономикалық пайдалану. Жергілікті ландшафт шекараларын анықтау мәселелері және оларды шешу тәсілдері атап өтілді. Зерттеу нәтижелері бойынша алқап ішінде 7 тұқымдас және 45 жер типтері, сондай-ақ биік ландшафт қабаттары мен ішкі қабаттар анықталды. Аумақтың табиғатты қорғау мәртебесін өзгерту бойынша ұсыныстар берілді.

Кілт сөздер: құрғақ аңғарлар, ландшафт генезисі, ландшафт құрылымы, парагенетикалық ландшафт жүйелері, ландшафтардың полиқұрылымы.

А.С. Горбунов, В.Б. Михно, О.П. Быковская

Структурная и морфологическая организация сухих долин мелового юга Центрально-Черноземного региона

Рассмотрены особенности происхождения, морфологические и генетические разновидности, структурно-динамические взаимосвязи сухих долинных ландшафтов мелового юга Центрального Черноземья. Зафиксированы современные представления о генезисе, морфологии, развитии и ландшафтной структуре суходолов. Выявлены парадинамические взаимосвязи структурных элементов бассейновых ландшафтных систем. Подчеркивается необходимость учета ландшафтной специфики засушливых земель при решении проблем природопользования и оптимизации ландшафтно-экологической ситуации на меловом юге Центрального Черноземья. В качестве примера проанализирована компонентная, территориальная и высотная организация природных комплексов крупного суходола Кувшинской засушливой долины, расположенной в Подгоренском районе Воронежской области. Установлены основные факторы ландшафтной дифференциации, среди которых особенности морфолитогенной основы, характер развития биостромы, современное хозяйственное использование. Отмечены проблемы выявления локальных ландшафтных границ и подходы к их решению. По результатам исследования в пределах долины выделено 7 семейств и 45 видов наземных типов, а также высотные ландшафтные слои и подслои. Даны рекомендации по изменению природоохранного статуса территории.

Ключевые слова: сухие долины, генезис ландшафтов, структура ландшафтов, парагенетические ландшафтные системы, полиструктурность ландшафтов.

References

1 Dal, V.I. (2004). *Tolkovyi slovar zhivogo velikorusskogo yazyka [Explanatory Dictionary of the Living Great Russian Language]*. Sankt-Petersburg: Izdatelskii dom «Ves»[in Russian].

2 Ozhegov, S.I. (1986). *Slovar russkogo yazyka [Russian dictionary]*. Moscow: Russkii yazyk [in Russian].

3 Akhromeev, L.M. (2002). *Geomorfologicheskii slovar-spravochnik [Geomorphological Dictionary-Reference Book]*. Bryansk: Izdatelstvo Brianskogo gosudarstvennogo universiteta [in Russian].

4 Prokhorov, A.M. (1976). *Bolshaia sovetskaia entsiklopediia [Big Soviet Encyclopedia]*. Moscow: Sovetskaia entsiklopediia [in Russian].

5 Milkov, F.N., Berezhnoi, A.V., & Mihno ,V.B. (1993). *Terminologicheskii slovar po fizicheskoi geografii [Terminological dictionary of physical geography]*. Moscow: Vysshaia shkola [in Russian].

6 Mikhno, V.B. (2022). Genezis i strukturno-dinamicheskaia organizatsiia landshaftov sukhodolov melovogo yuga Tsentralnogo Chernozemia [Genesis structural-dynamic organization of landscapes of dry valleys in the Cretaceous south of the Central Black Earth Region]. *Regionalnye landshaftnye issledovaniia — Regional landscape research*, 6, 92–98 [in Russian].

7 Dmitrieva, V.A. (2008). *Gidrologicheskaia izuchennost Voronezhskoi oblasti [Hydrological study of the Voronezh Region]*. Voronezh: Izdatelsko-poligraficheskii tsentr Voronezhskogo gosudarstvennogo universiteta [in Russian].

8 Mikhno, V.B. & Kandybko, E.V. (2006). Features of transformation of small river basins in Voronezh Region. *Proceedings of Voronezh State University. Series: Geography. Geoecology,* 1; 9–16.

9 Kurdov, A.G. (1995). *Vodnye resursy Voronezhskoi oblasti [Water resources of the Voronezh Region]*. Voronezh: Izdatelstvo Voronezhskogo gosudarstvennogo universiteta [in Russian].

10 Mikhno, V.B. (2000). Prostranstvenno-vremennye izmeneniia landshaftov Tsentralnogo Chernozemia [Spatiotemporal changes in the landscapes of the Central Black Earth Region]. *Vestnik Voronezhskogo otdela Russkogo geograficheskogo obshchestva — Bulletin of the Voronezh Department of the Russian Geographical Society, 2*(1), 3–8 [in Russian].

11 Zhigulina, E.V. & Mikhno, V.B. (2013). Forecasting changes in landscapes of small river basins in Voronezh Region. *Proceedings of Voronezh State University. Series: Geography. Geoecology,* 1; 172–178.

12 Raskatov, G.I. (1969). *Geomorfologiia i neotektonika territorii Voronezhskoi anteklizy [Geomorphology and neotectonics of the Voronezh Anticlise territory]*. Voronezh: Izdatelstvo Voronezhskogo gosudarstvennogo universiteta [in Russian].

13 Milkov, F.N. (1981). River basin as a paradynamic landscape system and issues of nature management. *Geography and Natural Resources,* 4; 11–18.

14 Gorbunov, A.S. (2020). Voprosy landshaftnoi organizatsii balochnykh form relefa (na primere balki «Kuvshin», Podgoretskogo raiona Voronezhskoi oblasti) [Issues of landscape organization of beam relief forms (using the example of the "Kuvshin" beam, Podgoretsky district, Voronezh region)]. *Regionalnye landshaftnye issledovaniia — Regional landscape research,* 4, 72–90 [in Russian].

15 Khrutskii, S.V. (1985). Formation of small flat-bottom valleys in connection with climatic changes in Pleistocene. *Geomorphology,* 1; 17–21.

16 Bobra, T.V. (2005). *Landshaftnye granitsy: vyiavlenie, analiz, kartografirovanie [Landscape boundaries: identification, analysis, mapping]*. Simferopol [in Russian].

17 Chernykh, D.V. (2015). On landscape boundaries: an unorthodox view of a physical geographer. *International Journal of Cultural Research, 4*(21); 63–72.

18 Khoroshev, A.V. (2022). Functional-dynamic approach to studying landscape boundaries. *Regional research, 3*(77); 60–70. https://doi/org/10.5922/1994-5280-2022-3-6

19 Mikhno, V.B. & Gorbunov, A.S. (2022). *Fiziko-geograficheskoe raionirovanie [Physical geographical regionalization]*. Voronezh: Izdatelskii dom Voronezhskogo gosudarstvennogo universiteta [in Russian].

20 Dyakonov, K.N. & Reteyum, A.Yu. (2018). On interaction of the landscape and the Earth Sciences. Current landscape-ecological state and problems of optimization of the natural environment of the regions. *Proceedings of the XIII International landscape conference is dedicated to the 100th anniversary of the birth of F.N. Milkov, 1*; 78–80.

21 Kolomyts, E.G. (1998). *Polimorfizm landshaftno-zonalnykh system [Polymorphism of landscape-zonal systems]*. Pushchino: Izdatelstvo Otdela nauchnoi i tekhnicheskoi informatsii Pushchinskogo nauchnogo tsentra RAN [in Russian].

22 Grodzinskiy, M.D. (2005). *Piznanna landshaftu: misce i prostir: u 2-h t. [Cognition of the landscape: place and space]* Kiïv: Vidavnicho-poligrafichnij centr «Kiïvc'kij universitet» [in Ukrainian].

23 Puzachenko, Yu.G. (2014). Landscape organization. *Problems of geography, 138*, 35–64.

24 Khoroshev, A.V. (2016). *Polimasshtabnaia organizatsiia geograficheskogo landshafta [Polyscale organization of the geographical landscape]*. Moscow: Tovarishchestvo nauchnykh izdanii KMK [in Russian].

25 Bokov, V.A. (2023). Forms of landscapes polystructure. Theoretical and applied problems of landscape geography. *VII Milkov Readings: Proceedings of the XIV International Landscape Conference, 1*; 15–17.

26 Solntsev, V.N., Ryzhkov, O.V., Tregubov, O.V., Alekseev, B.A., Kalutskaya, N.N., & Antsiferova, A.A. (2006). *Ispolzovanie GPS- i GIS-tekhnologii dlia izucheniia osobo okhraniaemykh prirodnykh territorii (na primere Voronezhskogo gosudarstvennogo prirodnogo biosfernogo zapovednika) [Use of GPS and GIS technologies to study protected areas (on the example of the Voronezh State Natural Biosphere Reserve)]*. Tula: Grif i Ko. [in Russian].

27 Khoroshev, A.V. (2016). Modern trends in structural landscape study. *Proceedings of Russian Academy of Science, Geography series, 3;* 7–15.

28 Milkov, F.N. (1954). Tipy mestnosti i landshaftnye raiony Tsentralnykh Chernozemnykh oblastei. (K voprosu vydeleniia regionalnykh i tipologicheskikh edinits v landshaftnoi geografii) [Types of terrain and landscape areas of the Central Chernozem regions (on the issue of identifying regional and typological units in landscape geography)]. *Izvestiia Vsesoiuznogo geograficheskogo obshchestva — News of All-Union Geographical Society, 86*(4), 336–346 [in Russian].

29 Kolbovskii, E.Y. (2013). Does a natural landscape exist: an epistemological analysis of the phenomenon. *Proceedings of the Russian Geographical Society, 145*(5); 49–66.

30 Drozdov, K.A. (2000). Sistematika lokalnykh kompleksov kak odno iz perspektivnykh napravlenii sovremennogo landshaftovedeniia [Systematics of local complexes as one of the promising areas of modern landscape science]. *Regionalnye landshaftnye issledovaniia — Regional landscape research, 6,* 60–64 [in Russian].

31 Gorbunov, A.S., & Bykovskaya, O.P. (2018). Structural organization of altitudinal landscape complexes of Central Russian forest-steppe zone. *Landscape geography in the 21st century,* 101–104. Simferopol.

32 Gorbunov, A.S., Mikhno, V.B., Bykovskaya, O.P., & Bevz, V.N. (2020). Altitudinal Landscape Complexes of the Central Russian Forest-Steppe. *Landscape Patterns in a Range of Spatio-Temporal Scales. Landscape Series,* 26. Springer, Cham. https://doi.org/10.1007/978-3-030-31185-8_14

33 Milkov, F.N. (2018). Sklonovaia mikrozonalnost landshaftov [Slope micro zoning of landscapes]. *Landshaftnaia geografiia: izbrannye trudy — Landscape geography: selected papers.* Voronezh, 70–73 [in Russian]..

Information about authors

Gorbunov, Anatoly Stanislavovich — Candidate of geographical sciences, Docent, Voronezh State University, Voronezh, Russian Federation; gorbunov.ol@mail.ru;

Mikhno, Vladimir Borisovich — Doctor of geographical sciences, Professor of Department of Physical Geography and Landscape Optimization, Voronezh State University, Voronezh, Russian Federation; root@geogr.vsu.ru;

Bykovskaya, Olga Petrovna — Candidate of geographical sciences, Docent of Department of Physical Geography and Landscape Optimization, Voronezh State University, Voronezh, Russian Federation; deanery@geogr.vsu.ru.