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Article

Century transformation of steppe vegetation of the Kuncherovskaya forest-steppe (Penza Oblast, Russia)

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Abstract. The results of the study of the century dynamics of forest-steppe vegetation of erosion-denudation plains of the western slopes of the Volga Upland on the example of one of the sites of the state Natural Reserve "Volga forest-steppe" – "Kuncherovskaya forest-steppe" (Penza Region, Russia) are presented. The modern structure of steppe vegetation was established and its dynamics was traced for more than 100 years. The results of the last three geobotanical mapping studies of this area (1991, 2002, 2013) carried out by the authors are discussed in detail. It is revealed that the watershed areas are still dominated by bunchgrass meadow steppes, but associations dominated by *Stipa tirsa* are replacing associations dominated by *Helictotrichon desertorum*. It has been found that for the last 30 years (since 1989) the vegetation on watershed surfaces under the influence of the reserve regime undergoes mesophytization (transformation of meadow steppes into steppe meadows) and sylvatization (spread of shrub meadow steppes, bushes of shrubs and individual trees). Currently, in order to maintain the steppe character of vegetation protected areas in the forest-steppe zone on the western slopes of the Privolzhskaya Upland, it is necessary to introduce the regulated anthropogenic intervention.

Keywords: meadow and psammophytic steppes, vegetation cover, succession, Nature Reserve, Volga Upland

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Научная статья

Вековая трансформация степной растительности Кунчеровской лесостепи (Пензенская область, Россия)

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Аннотация. Приводятся результаты изучения вековой динамики лесостепной растительности эрозионно-денудационных равнин западных склонов Приволжской возвышенности на примере одного из участков государственного природного заповедника «Приволжская лесостепь» – «Кунчеровская лесостепь» (Пензенская обл., Россия). Установлена современная структура степной растительности и прослежена ее динамика более чем за 100 лет. Подробно рассматриваются результаты трех последних геоботанических картографирований этого участка (1991, 2002, 2013), выполненных авторами. Выявлено, что на водораздельных пространствах по-прежнему преобладают дерновиннозлаковые луговые степи, но ассоциации с доминированием *Helictotrichon desertorum* вытесняются ассоциациями с преобладанием *Stipa tirsa*. Установлено, что за последние 30 лет (с 1989 г.) растительность на водораздельных поверхностях под влиянием заповедного режима подвергается мезофитизации (трансформации луговых степей в остепненные луга) и сильватизации (распространение кустарниковых луговых степей, зарослей кустарников и отдельных деревьев). В настоящее время для поддержания степного характера растительности заповедных участков в лесостепной зоне на западных склонах Приволжской возвышенности необходимо введение регулируемого антропогенного вмешательства.

Ключевые слова: луговые и псаммофитные степи, растительный покров, сукцессия, природный заповедник, Приволжская возвышенность

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Introduction

A section of the Privolzhskaya forest-steppe state Nature Reserve "Privolzhskaya forest-steppe" – "Kunkherovskaya forest-steppe" is located between the villages of Stary Chirchim and Krasnoye Pole in the Neverkinsky and Kameshkirsky districts of the Penza Oblast. Its territory belongs to the forest-steppe landscape of erosion-denudation plains of the western slopes of the Volga Upland (Yamashkin et al., 2011). The length of the site is 5.8 km from east to west and 6.0 km from north to south (52°48´ – 52°51´ N and 46°19´ – 46°24´ E) (Dobrolyubov et al., 2013). The site is located on the southern spurs of the Surskaya Shishka of the Volga Upland, in the interfluve of the Sura River tributaries – the Kadada and Uza Rivers (Volga Basin). The highest elevation of the watershed surface is 320 m above sea level. Within the interfluve, the following hypsometric steps are clearly fixed: 280–300 m, 260 m and 240 m above sea level. The territory is characterized by a weak dip and weak slope to the listed rivers. The Kuncherovsky section of the Reserve is generally of forest-steppe character and includes various forests, virgin steppes, as well as peculiar vegetation of forest glades and edges. The virgin steppe occupies a high-level watershed, which is surrounded on three sides by islands of mixed forest of *Quercus robur* L. with admixture of *Pinus sylvestris* L. In the northern part of the forest, there is a bog. There are numerous fallow lands on the territory of the Reserve, the vegetation of which is at different stages of recovery (Novikova, 2009).

Soil-forming rocks of "Kuncherovskaya forest-steppe" are represented by products of Paleogene rocks decay. The most part of the described territory is composed of sediments of Syzran and Saratov stages of Paleocene. These rocks are stacks of layers of sands, opoks, opok-like sandstones with interlayers of siltstones and siltstones. Consequently, the soils of the "Kuncherovskaya forest-steppe" are formed on the eluvium of ancient Paleogene rocks of light granulometric composition. According to the geomorphologic map developed by A.I. Nevorotov (2003), interfluve surfaces, slope surfaces, erosion and other forms of ground features are distinguished on the site. Interfluve surfaces with lower gradient (<1.5°) are characterized by manifestation of eluvial process, weak planar washout. Slope surfaces with a large angle of inclination (>1.5°) are characterized by weak erosion by water flows, manifestation of slope processes: cripples, screes, landslides. Erosional forms are represented by the bottoms of various watercourses (streams, large gullies, hollows, runoff hollows) and are formed by active water erosion. Micro landforms (slope and dune gullies, suffusion depressions) are also well represented on the site.

The soils of the "Kuncherovskaya forest-steppe" are considered as transitional from dark gray forest soils to low-moisture weakly podzolized chernozems (Dyukova, 1996; Kuznetsov et al., 1978).

However, according to the soil map made by A.Ya. Voronin (2004), steppe areas of "Kuncherovskaya forest-steppe" are characterized by the development of soils of chernozem type: on watershed surfaces and gentle slopes, there are formed leached chernozems and incompletely developed chernozems of different thickness, while on steep slopes (on loose sands) chernozems of poorly differentiated low thickness are spread. The leading factor of soil formation is bioclimatic (Sileva and Chernova, 1999).

In the flora of the "Kuncherovskaya forest-steppe", there are 633 species of vascular plants, of which 3 species are included in the Red Data Book of the Russian Federation[1]: *Iris aphylla* L. (with status 2), *Fritillaria ruthenica* Wikstr. and *Stipa dasyphylla* (Lindem.) Trautv. and 42 species in the Red Data Book of the Penza Region (Krasnaya kniga..., 2024).

Throughout the history of the "Kunkherovskaya forest-steppe", the way of its economic use has changed many times. Little is known about the character of vegetation of the "Kuncherovskaya forest-steppe" at the turn of the XIX–XX centuries, as I.I. Sprygin (1896) and B.A. Keller (1926) did not leave its detailed description. Both authors emphasized the bunch-grassy basis of the preserved section of virgin steppe, with I.I. Sprygin calling it "feather-grassy" and B.A. Keller as "oat-grassy". In the post-revolutionary period, the intensification of pasture loads led to the degradation of the steppe vegetation.

In 1929, this steppe area became a part of the "Penza Reserve" (later on "Sredne-Volzhsky", "Kuibyshevsky"). The first period of setting up the nature reserve (from 1929 to 1951) had a favorable impact on steppe vegetation and contributed to the restoration of its bunch-grass base.

The subsequent period of intensive anthropogenic use associated with the abolition of the reserve regime (1951–1989) once again brought to to the degradation of the steppe vegetation. However, the steppe retained its bunch-grass character. As noted by L.M. Nosova (1965), various species of grasses (*Stipa dasyphylla*, *S. pennata*, *S. tirsa* Steven) with strongly developed sods were massively found in the steppe. According to A.A. Solyanov (1969), herbs bunchgrass associations to a greater extent – with the dominance of *Stipa tirsa,* and to a lesser extent – with the dominance of *Festuca valesiaca* Schleich. ex Gaudin and participation of *Bromopsis riparia* (Rehmann) Holub, *Poa angustifolia* L., etc. were spread in the steppe. The main peculiarity of the virgin area of the "Kuncherovskaya forest-steppe" is considered by both authors to be the distribution of the relict species *Helictotrichon desertorum* (Less.) Nevski. In 1965, the site received the status of the natural monument, but the human impact continued. On the geobotanical map made in the 1970s by A.A. Solyanov (1982), two contours of mixed herbs bunchgrass with predominance of *Stipa tirsa* and *Helictotrichon desertorum are* well distinguished on the site.

The purpose of this research is to identify the dynamics of zonal Central Russian meadow steppes under the conditions of the protected regime in the Volga Upland. The influence of climatic and environmental conditions on dynamic processes was also assessed, and changes in the ratio of the main types and subtypes of vegetation were identified.

Material and methods

The study of the structure and dynamics of vegetation cover of the steppe area "Kuncherovskaya forest-steppe" was conducted by the method of periodic geobotanical mapping (every 11 years): the first in 1991 (Novikova, 1993, 1995, 1998), immediately after the establishment of the reserve, the second in 2002 (Novikova, 2008, 2010; Novikova and Sokolova, 2008), and the third in 2013 (Panэkina et al., 2015).

Geobotanical mapping was implemented using the sampling and statistical method with some modifications (Neshataev, 1971; Neshataev and Ukhacheva, 2001; Ukhacheva et al., 2011). The area of the steppe plot was divided by a system of profiles into squares with a side of 100 m. Sample plots of 4 m^2 (2×2 m) were laid at each reference point. Vegetation description was carried out according to standard methods (Ipatov 2000; Ipatov and Mirin, 2008). In total, more than 1000 geobotanical descriptions were made on the steppe plot during the three mappings. Further, the ecological-phytocenotic classification of vegetation was developed (Novikova, 2012; Novikova and Pankina, 2013; Novikova et al., 2017), which formed the basis of legends to geobotanical maps.

[1] The Order of the Ministry of Natural Resources of the Russian Federation dated 23.05.2023 No. 320 "On approval of the list of flora listed in the Red Book of the Russian Federation".

The conducted research allowed to create three geobotanical maps of the steppe section of the "Kuncherovskaya forest-steppe" for different time (1991, 2002, 2013); each map had different scales (1:5000; 1:10000, 1:25000) and was based on modern information technologies. Latin names of plants are given according to the International Plant Name Index[2].

Results and discussion

Comparison of the results of three geobotanical mapping of the "Kuncherovskaya forest-steppe" allows us to draw conclusions about the dynamic processes that have been observed in the vegetation for the last 30 years in the conditions of absolute reserve. The nature and speed of these processes are largely determined by geomorphologic and edaphic factors (Table 1).

Watershed surfaces

Meadow steppes are still widespread on the watershed surfaces of the protected area (Figs. 1, 2). Bunchgrass meadow steppes also predominate, reflecting the final bunch-grassy stage of steppe restoration. However, there is a significant change in the ratio of individual plant associations. In the structure of the vegetation cover the participation of communities, especially of *Stipa tirsa + herbae* and, to a lesser extent *Stipa pennata + herbae* associations is noticeably increasing. On the contrary, the association very rare for the central part of the Volga Upland – *Helictotrichon desertorum + herbae* – is gradually displaced. It should be noted that during the first mapping, separate associations dominated by these species were not distinguished, and only the *Stipa tirsa + Helictotrichon desertorum + herbae* association was indicated.

Reflecting the previous rhizomatous-grass stage of steppe restoration, rhizomegrass meadow steppes also retain their previous positions so far. In the vegetation cover, there is a slight decrease in the area under phytocenoses of the *Bromopsis riparia + herbae* association.

Quite definitely there is a tendency to reduce the area of herb meadow steppes, which are associated with earlier stages of steppe demutation after anthropogenic impact. Of these communities, belonging only to the *Herbae + Stipa tirsa* association are more or less represented in the vegetation cover.

Communities of shrub meadow steppes with participation from shrubs predominantly *Chamaecytisus ruthenicus* (Fisch. ex Woł.) Klask. gradually increase their influence in the vegetation cover. In reality, their share is even higher, but it is not always correctly estimated for methodological reasons (sites with shrub participation may not fall within the reference grid for description).

Participation of meadow vegetation on watershed surfaces, represented mainly by steppe meadows, remains practically the same. At the same time, in rhizomegrass meadow steppes, the participation of communities of *Calamagrostis epigeios + herbae* association slightly increases. Herbaceous steppe meadows are less widespread, represented by communities of only one *Herbae + Calamagrostis epigeios* association. Communities of the *Agrostis tenuis + herbae* association, related to the very initial stages of vegetation recovery after intensive anthropogenic impact are completely lost.

Slopes of southern and southeastern exposures

On the slopes of southern and southeastern exposures (Figs. 3, 4) psammophytic steppes are developed, its participation in the vegetation cover is insignificantly increases. Psammophytic steppes also prevail, with communities dominated by small-bunchgrass (*Koeleria dubjanskyi* Tzvelev and *Festuca valesiaca*) being replaced by communities dominated by large-bunchgrass species (*Stipa borysthenica* Klokov ex Prokudin). The phytocoenoses of *Stipa borysthenica-herbae* association becomes the most widespread. At the same time, there is a reduction and then complete disappearance of phytocenoses of *Festuca valesiaca + herbae* associations.

The participation of mixed grass psammophytic steppes can fluctuate, as their formation is often associated with the development of natural and anthropogenic erosion processes. In vegetation cover, the role of communities of *Herbae + Stipa borysthenica* association with participation of large-bunchgrass species – *Stipa borysthenica,* gradually increases and the role of communities of *Herbae + Festuca polesica* association with participation of small-turf species of psammophytic steppes decreases due to strengthening of the role of sod-grass steppes in the process of their restoration. However, the occurrence of intensive slope erosion processes again leads to their emergence and development.

[2] International Plant Names Index, 2024. Web page. URL: www.ipni.org (accessed: 0211.2024)

Fig. 1. Steppe on the watershed surface, 2009.

Fig. 2. Steppe on the watershed surface, 2013.

Fig. 3. Steppe on the southern slope, 2008.

Fig. 4. Steppe on the southern slope, 2013.

Table 1. The ratio of the main types and subtypes of vegetation in the Kuncherovskaya forest-steppe, % of the area.

Main syntaxons	Syntaxon name	Area, %		
		1991	2002	2013
Vegetation type	**Xerophilous perennial herbaceous vegetation (steppe)**	**84.6**	**84.7**	**84.3**
Vegetation subtype	**Xerophilous perennial herbaceous vegetation (genuine steppes)**	**15.3**	**17.6**	**18.7**
Formation group	***Genuine bunchgrass steppes***	10.0	17.0	13.3
I formation	*Koeleria dubjanskyi*			
1 association	*Koeleria dubjanskyi + herbae*	0	0.6	0
II formation	*Festuca valesiaca*			
2 association	*Festuca valesiaca + herbae*	6.0	2.3	0
III formation	*Stipa borysthenica*			
3 association	*Stipa borysthenica + herbae*	4.0	14.1	13.3
Formation group	***Genuine herb steppes***	5.3	0.6	5.4
IV formation	*Herbae*			
4 association	*Herbae (Artemisia campestris) + Stipa borysthenica*	0	0.6	4.2
5 association	*Herbae (Potentilla argentea) + Festuca polesica*	5.3	0	0.6
6 association	*Herbae (Rumex acetosella) + Astragalus varius + Phleum phleoides*	0	0	0.6
Vegetation subtype	**Mesoxerophilous perennial herbaceous vegetation (meadow steppes)**	**69.3**	**67.1**	**65.6**
Formation group	***Bunchgrass meadow steppes***	46	48.7	48.8
V formation	*Helictotrichon desertorum*			
7 association	*Helictotrichon desertorum + herbae*	0	14.6	7.2
VI formation	*Stipa capillata*			
8 association	*Stipa capillata + herbae*	0.7	0.6	0
VII formation	*Stipa tirsa*			
9 association	*Stipa tirsa + Helictotrichon desertorum + herba*	43.3	0	0
10 association	*Stipa tirsa + herbae*	0	19.4	27
VIII formation	*Stipa pennata*			
11 association	*Stipa pennata + herbae*	1.3	10.5	14

Main syntaxons	Syntaxon name	Area, %		
		1991	2002	2013
IX formation	*Stipa dasyphylla*			
12 association	*Stipa dasyphylla* + *herbae*	0.7	3.6	0.6
Formation group	***Rhizomegrass meadow steppes***	10.7	11.8	10.2
X formation	*Bromopsis riparia*			
13 association	*Bromopsis riparia* + *herbae*	10.7	8.2	7.2
XI formation	Calamagrostis epigeios			
14 association	*Calamagrostis epigeios* + *herbae*	0	3.6	3
Formation group	***Rhizomesedge meadow steppes***	0	0.6	0
XII formation	*Carex supina*			
15 association	*Carex supina* + *herbae*	0	0.6	0
Formation group	***Meadow steppes with mixed grass***	12.6	4.8	6
XIII formation	*Herbae*			
16 association	*Herbae* + *Festuca valesiaca*	1.3	0	0
17association	*Herbae* + *Helictotrichon desertorum*	1.3	0.6	0
18 association	*Herbae (Pulsatilla patens*) + *Stipa tirsa*	7.4	3.6	4.2
19 association	*Herbae (Pulsatilla patens)* + *Stipa dasyphylla*	0	0	0.6
20 association	*Herbae* + *Bromopsis riparia*	1.3	0	0
21 association	*Herbae (Artemisia campestris)* + *Phleum phleoides*	0	0	0.6
22 association	*Herbae (Pulsatilla patens)* + *Calamagrostis epigeios*	0	0.6	0.6
23 association	*Herbae* + *Agrostis capillaris*	1.3	0	0
Formation group	***Meadow shrub steppes***	0	1.2	0.6
XIV formation	*Stipa pennata*			
24 association	*Stipa pennata* + *herbae* – *Chamaecytisus ruthenicus*	0	0.6	0.6
XV formation	*Bromopsis riparia*			
25 association	*Bromopsis riparia* + *herbae* – *Chamaecytisus ruthenicus*	0	0.6	0

Main syntaxons	Syntaxon name	Area, %		
		1991	2002	2013
Vegetation type	**Mesophilous perennial herbaceous vegetation (meadows)**	**15.4**	**15.3**	**15.7**
Vegetation subtype	**Xeromesophilous perennial herbaceous vegetation (steppe meadows)**	**15.4**	**15.3**	**15.7**
Formation group	***Rhizomegrass steppe meadows***	15.4	14.1	15.1
XVI formation	*Elytrigia intermedia*			
26 association	*Elytrigia intermedia + herbae*	0	0.6	0
XVII formation	*Poa angustifolia*			
27 association	*Poa angustifolia + herbae*	0	0.6	0
XVIII formation	*Calamagrostis epigeios*			
28 association	*Calamagrostis epigeios + herbae*	12.7	12.9	15.1
XIX formation	*Agrostis capillaris*			
29 association	*Agrostis capillaris + herbae*	2.7	0	0
Formation group	***Herb steppe meadows***	1.3	1.2	0.6
XX formation	*Разнотравная*			
30 association	*Herbae (Geranium sanguineum) + Calamagrostis epigeios*	0	1.2	0.6

The results of three mapping studies allow us to distinguish the main stages of steppe vegetation recovery after intensive anthropogenic impact on different relief elements. On watershed surfaces, the following stages of steppe demutation are distinguished (dominant species are given in brackets):

1. Herb steppe meadows (*Geranium sanguineum* L.);
2. Rhizomegrass steppe meadows (*Agrostis capillaris* L., *Calamagrostis epigeios* (L.) Roth*, Elytrigia intermedia* (Host) Nevski, *Poa angustifolia*);
3. Herb meadow steppes (*Pulsatilla patens* (L.) Mill.);
4. Rhizomegrass meadow steppes (*Bromopsis riparia*);
5. Bunchgrass meadow steppes (*Helictotrichon desertorum*, *Stipa capillata* L., *S. dasyphylla, S. pennata*, *S. tirsa*);
6. Shrub meadow steppes with *Chamaecytisus ruthenicus.*

The following stages of steppe demutation are distinguished on slopes of predominantly southern exposure:

1. Psammophytic steppes herbaceous (*Artemisia campestris* L., *Potentilla argentea* L., *Rumex acetosella* L.);
2. Psammophytic steppes of small-bunchgrass (*Koeleria dubjanskyi*, *Festuca polesica* Zapał., *Festuca valesiaca*);
3. Psammophytic steppes of large-bunchgrass (*Stipa borysthenica*).

Conclusion

The process of steppe vegetation restoration and its further transformation under the conditions of absolute reserve regime is simultaneously observed on the virgin area of "Kuncherovskaya forest-steppe". The speed and character of these processes are largely determined by geomorphologic and edaphic factors of the external environment.

On watershed surfaces, the ratio of different vegetation subtypes has not changed significantly over 20 years, and the predominance of bunch-grassy meadow steppes has remained. However, there is a decrease in the area of communities of the relict association dominated by *Helictotrichon desertorum* and an increase in the area of the association with *Stipa tirsa* and to a lesser extent of the association with *Stipa pennata*.

On slopes of predominantly southern exposure, the participation of psammophytic steppes practically has not changed, but the influence of association communities dominated by *Stipa borysthenica* is gradually increasing. Bunch-grassy psammophytic steppes are partially replaced by grassy steppes solely because of the development of slope erosion processes.

The main stages of restoration of steppe vegetation in different geomorphologic and edaphic conditions of "Kuncherovskaya forest-steppe" have been revealed. The most successful restoration of vegetation occurs on slopes of the predominantly southern exposure. On watershed surfaces, demutation of steppes at the present stage is accompanied by their mesophytization (transformation meadow steppes into steppe meadows) and sylvatization (spread of shrub meadow steppes, shrub thickets and individual trees) to some extent. Similar processes occur not only in Penza, but also Kursk steppes (Neshataev and Ukhacheva, 2001; Novikova et al., 2011; Ukhacheva et al., 2011).

At present to maintain the steppe character of the vegetation of protected areas in the forest-steppe zone on the western slopes of the Privolzhskaya Upland, it is necessary to introduce the regulated anthropogenic intervention. This can be haying after seeding of most steppe species and cattle grazing on the grass after mowing. Steppe fallow is the best way to remove a vegetation cushion in meadow steppes, however, its organization in the Reserve conditions is hardly possible. Among effective ways to maintain the xerophytic character of meadow steppes is elimination of faunistic incompleteness of the studied meadow steppe, but this requires large financial expenses.

References

Dobrolyubov, A.N., Lebyazhinskaya, I.P., Kudryavtsev, A.Yu., Gorbushina, T.V., Dobrolyubova, T.V., Osipov, V.V., 2013. Gosudarstvennyi prirodnyi zapovednik “Privolzhskaya lesostep'”: fiziko-geograficheskaia kharakteristika i biologicheskoe raznoobrazie prirodnykh kompleksov [State Nature Reserve “Privolzhskaya lesostep'”: physical and geographical characteristics and biological diversity of natural complexes]. *Trudy gosudarstvennogo zapovednika “Privolzhskaya lesostep'” [Proceedings of the State Nature Reserve “Privolzhskaya lesostep'”]* **4**, 1–70. (In Russian).

Dyukova, G.R., 1996. Osobennosti pochvoobrazovaniia i pochv Kuncherovskogo uchastka zapovednika “Privolzhskaia lesostep'” [Features of soil formation and soils of the Kuncherovsky cluster of the “Privolzhskaya lesostep'” Reserve]. In: Khrianin, V.N. (ed.), *Kraevedcheskie issledovaniia i problemy ekologicheskogo obrazovaniia [Local history studies and problems of environmental education]*. Penza State Pedagogical University, Penza, Russia, 24–25. (In Russian).

Ipatov, V.S., 1990. Otrazhenie dinamiki rastitel’nogo pokrova v sintaksonomicheskikh edinitsakh [Reflection of vegetation dynamics in syntaxonomic units]. *Botanicheskii Zhournal [Botanical Journal]* **75** (10), 1380–1388. (In Russian).

Ipatov, V.S., Mirin, D.M., 2008. Opisanie fitotsenoza: metodicheskie rekomendatsii [Description of phytocenosis: methodological recommendations]. Publishing House of the Saint Peterburg University, St. Petersburg, Russia, 71 p. (In Russian).

Keller, B.A., 1926. Floristicheskie, geobotanicheskie i ekologicheskie zametki [Floristic, geobotanical and ecological notes]. *Zapiski Voronezhskogo sel’skokhoziaistvennogo instituta [Notes of the Voronezh Agricultural Institute]* **1**, 23–34. (In Russian).

Krasnaya kniga Penzenskoi oblasti. T. 1: Sosudistye rasteniia, mkhi, lishainiki, griby [Red Data Book of Penza Region. Vol. 1: Vascular plants, mosses, lichens, fungi], 2024. Ivanov, A.I. (ed.). Studia on-line, Moscow, Penza, Russia, 300 p. (In Russian).

Kuznetsov, K.P., Zeilinger, D.O., Fevralyova, A.T., 1978. Guminovye soedineniia pochv "Kuncherovskoi stepi" [Humic compounds of soils of the Kuncherovskaya steppe]. *Sbornik nauchnykh rabot Saratovskogo sel'skokhoziaistvennogo instituta [Collection of scientific papers of the Saratov Agricultural Institute]* **107**, 30–37. (In Russian).

Neshataev, Yu.N., 1971. Vyborochno-statisticheskii metod vydeleniia rastitel'nykh assotsiatsii [Selective statistical method of plant association selection]. In: Aleksandrova, V.D. (ed.), *Metody vydeleniya rastitel'nykh assotsiatsii [Methods for identifying plant associations].* Nauka, Leningrad, USSR, 181–206. (In Russian).

Neshataev, Yu.N., Ukhacheva, V.N., 2001. Monitoring rastitel'nosti srednerusskoi lesostepi [Vegetation monitoring of the Central Russian forest steppe]. *Vestnik of Saint Petersburg University. Series 3. Biology* **2**, 55–66. (In Russian).

Nevorotov, A.I., 2003. Geomorfologicheskaia karta Kuncherovskoi lesostepi [Geomorphological map of the Kuncherovskaya forest-steppe]. Scale 1:10000. Funds of the State Nature Reserve "Privolzhskaya lesostep'", Penza, Russia, 2 sheets. (In Russian).

Nosova, A.M., 1965. Sokhranivshiesia uchastki stepei Penzenskoi oblasti [Preserved areas of the steppes of Penza Region]. *Botanicheskii zhurnal [Botanical Journal]* **50** (4), 838–852. (In Russian).

Novikova, L.A., 1993. Dinamika Penzenskikh lugovykh stepei i problema ikh sokhraneniia [Dynamics of Penza meadow steppes and the problem of their conservation]. *Bulleten' Samarskaya Luka [Bulletin Samarskaya Luka]* **4**, 111–128. (In Russian).

Novikova, L.A., 1995. Dinamika i prognoz razvitiia rastitel'nosti "Kuncherovskoi stepi" [Dynamics and forecast of vegetation development of the Kuncherovskaya steppe]. *Materialy nauchnoi konferentsii, posviashchennoi 60-letiiu Khoperskogo zapovednika "Problemy izucheniia i okhrany zapovednykh prirodnykh kompleksov" [Materials of scientific conference dedicated to the 60th Anniversary of the Khopersky Reserve "Problems of studying and protecting of protected natural complexes"].* Voronezh, Russia, 120–122. (In Russian).

Novikova, L.A., 1998. Geobotanicheskaia kharakteristika "Kuncherovskoi stepi" [Geobotanical characteristics of the Kuncherovskaya steppe]. *Materialy konferentsii, posviashchennoi 120-letiiu so dnia rozhdeniia I.I. Sprygina [Materials of the conference dedicated to the 120th Anniversary of the birth of I.I. Sprygin].* Penza, Russia, 77–82. (In Russian).

Novikova, L.A., 2008. Sovremennaia struktura rastitel'nogo pokrova Kuncherovskoi stepi [The current structure of vegetation cover of the Kuncherovskaya steppe]. *Materialy Vserossiiskoi nauchno-prakticheskoi konferentsii "Monitoring prirodnykh ekosistem" [Materials of the All-Russian Scientific and Practical Conference "Monitoring of natural ecosystems"].* Penza, Russia, 133–136. (In Russian).

Novikova, L.A., 2009. Vosstanovlenie rastitel'nosti na zalezhakh Kuncherovskoi lesostepi [Restoration of vegetation on the fallow fields of the Kuncherovskaya forest-steppe]. *Vestnik Orenburgskogo gosudarstvennogo universiteta [Vestnik of the Orenburg State University]* **6,** 281–285. (In Russian).

Novikova, L.A., 2010. Monitoring rastitel'nosti "Kuncherovskoi stepi" [Vegetation monitoring of the Kuncherovskaya steppe]. *Povolzhskii ekologicheskii zhurnal [Povolzhskiy Journal of Ecology]* **4**, 51–60. (In Russian).

Novikova, L.A., 2012. Struktura i dinamika travianoi rastitel'nosti lesostepnoi zony na zapadnykh sklonakh Privolzhskoi vozvyshennosti i puti ee optimizatsii [Structure and dynamics of grass vegetation of the forest-steppe zone on the western slopes of the Privolzhskaya Upland and ways to optimize it]. *Doctor of Sciences in Biology thesis*. Saratov, Russia, 547 p. (In Russian).

Novikova, L.A., Pan'kina, D.V., 2013. Kharakteristika lugovoi rastitel'nosti "Kuncherovskoi lesostepi" [Characteristics of meadow vegetation of the Kuncherovskaya forest-steppe]. *Izvestiia vysshikh uchebnykh zavedenii. Povolzhskii region. Seriia Estestvennye nauki [University proceedings. Volga region. Natural sciences]* **1** (1), 91–101. (In Russian).

Novikova, L.A., Pan'kina, D.V., Mironova, A.A., 2017. Suktsessionnaia dinamika srednerusskikh lugovykh stepei i problema ikh sokhraneniia [Successional dynamics of the Central Russian meadow steppes and the problem of their conservation]. *Izvestiia RAN. Seria Biologicheskaia [Proceedings of the Russian Academy of Sciences. Biological Series]* **5**, 1–6. (In Russian). https://doi.org/10.7868/S000233291705006X

Novikova, L.A., Sokolova, M.S., 2008. Struktura i dinamika "Kuncherovskoi stepi" [Structure and dynamics of the Kuncherovskaya steppe]. *Izvestiia PGPU im. V.G. Belinskogo. Seriya Estestvennye nauki [Proceedings of Belinsky Penza State University. Natural Sciences Series]* **10** (14), 13–25. (In Russian).

Novikova, L.A., Strokina, E.I., Ukhacheva, V.N., 2011. Prodolzhenie monitoringa Kazatskoi stepi (TsChZ im. prof. V.V. Alekhina) [Continuation of monitoring of the Cossack Steppe (Central Chernozem Reserve named after Professor V.V. Alekhine)]. *Materialy Vserossiiskoi konferentsii, posviashchennoi 80-letiiu kafedry geobotaniki i ekologii rastenii Sankt-Peterburgskogo (Leningradskogo) gosudarstvennogo universiteta i iubileinym datam ego prepodavatelei "Razvitie geobotaniki: istoriia i sovremennost'" [Materials of the All-Russian conference dedicated to the 80th anniversary of the Department of Geobotany and Plant Ecology of St. Petersburg (Leningrad) State University and the anniversaries of its teachers "Development of Geobotany: History and Modernity"]*. St. Petersburg, Russia, 86. (In Russian).

Pan'kina, D.V., Novikova, L.A., Mironova, A.A., Kulagina, E.Yu., 2015. Geobotanicheskaia kharakteristika "Kuncherovskoi lesostepi" (po rezul'tatam tret'ego kartografirovaniia) [Geobotanical characteristics of the Kuncherovskaya forest-steppe (based on the results of the third mapping)]. *Izvestiia vysshikh uchebnykh zavedenii. Povolzhskii region. Seriia Estestvennye nauki [University proceedings. Volga region. Natural sciences]* **4** (12), 47–58. (In Russian).

Sileva, T.M., Chernova, O.V., 1999. Kharakteristika pochv Ostrovtsovskogo i Kuncherovskogo uchastkov zapovednika "Privolzhskaia lesostep'" [Characteristics of the soils of the Ostrovtsovsky and Kuncherovsky sections of the Privolzhskaya Forest-steppe Reserve]. *Trudy gosudarstvennogo zapovednika "Privolzhskaya lesostep'"* [*Proceedings of the State Nature Reserve Privolzhskaya lesostep*'] **1**, 25–32. (In Russian).

Solyanov, A.A., 1969. K kharakteristike nauchnoi i poznavatel'noi tsennosti "Kuncherovskoi stepi" [About scientific and cognitive value of the Kuncherovskaya steppe]. *Voprosy geografii Penzenskoi oblasti. Geograficheskii sbornik [Geography Issues of the Penza Region. Geographical Collection]* **2**, 92–96. (In Russian).

Solyanov, A.A., 1982. Kuncherovskaia step'. Karta [Kuncherovskaya steppe. Map]. *Atlas Penzenskoi oblasti [Atlas of the Penza Region].* Main Directorate of Geodesy and Cartography (GUGK), Moscow, Russia, 18. (In Russian).

Sprygin, I.I., 1896. Material k flore gubernii Penzenskoi i Saratovskoi [Material for the flora of the Penza and Saratov provinces]. *Trudy Obshchestva estestvoispytatelei pri Imperatorskom Kazanskom*

universitete [Proceedings of the Society of Natural Scientists at the Imperial Kazan University] **26** (6), 3–75. (In Russian).

Ukhacheva, V.N., Novikova, L.A., Strokina, E.I., 2011. Osnovnye markery mnogoletnei dinamiki srednerusskoi lesostepi [The main markers of the long-term dynamics of the Central Russian forest-steppe]. *Izvestiia PGPU im. V.G. Belinskogo. Seriya Estestvennye nauki [Proceedings of Belinsky Penza State University. Natural Sciences Series]* **25**, 165–169. (In Russian).

Voronin, A.Ya., 2004. Pochvennaia karta Kuncherovskoi lesostepi [Soil map of the Kuncherovskaya forest-steppe]. Scale 1:10000. Funds of the State Nature Reserve “Privolzhskaya lesostep'”, Penza, Russia, 2 sheets. (In Russian).

Yamashkin, A.A., Artemova, S.N., Novikova, L.A., Leonova, N.A., Alekseeva, N.S., 2011. Elektronnaia landshaftnaia karta Penzenskoi oblasti [Electronic landscape map of the Penza Region]. *Izvestiia PGPU im. V.G. Belinskogo. Seriya Estestvennye nauki [Proceedings of Belinsky Penza State University. Natural Sciences Series]* **25**, 655–663. (In Russian).

Список литературы

Воронин, А.Я., 2004. Почвенная карта «Кунчеровской лесостепи». М. 1:10000. Фонды Государственного заповедника «Приволжская лесостепь», Пенза, Россия, 2 л.

Добролюбов, А.Н., Лебяжинская, И.П., Кудрявцев, А.Ю., Горбушина, Т.В. Добролюбова, Т.В., Осипов, В.В., 2013. Государственный природный заповедник «Приволжская лесостепь»: физико-географическая характеристика и биологическое разнообразие природных комплексов. *Труды государственного заповедника «Приволжская лесостепь»* **4**, 1–70.

Дюкова, Г.Р., 1996. Особенности почвообразования и почв Кунчеровского участка заповедника «Приволжская лесостепь». В: Хрянин, В.Н. (ред.), *Краеведческие исследования и проблемы экологического образования*. ПГПУ, Пенза, Россия, 24–25.

Ипатов, В.С., 1990. Отражение динамики растительного покрова в синтаксономических единицах. *Ботанический журнал* **75** (10), 1380–1388.

Ипатов, В.С., Мирин, Д.М., 2008. Описание фитоценоза: методические рекомендации. Изд-во Санкт-Петербургского университета, Санкт-Петербург, Россия, 71 с.

Келлер, Б.А., 1926. Флористические, геоботанические и экологические заметки. *Записки Воронежского сельскохозяйственного института* **1**, 23–34.

Красная книга Пензенской области. Т. 1: Сосудистые растения, мхи, лишайники, грибы, 2024. Иванов, А.И. (ред.). Студия он-лайн, Москва – Пенза, Россия, 300 с.

Кузнецов, К.П., Зейлигер, Д.О., Февралева, А.Т., 1978. Гуминовые соединения почв «Кунчеровской степи». *Сборник научных работ Саратовского сельскохозяйственного института* **107**, 30–37.

Неворотов, А.И., 2003. Геоморфологическая карта «Кунчеровской лесостепи». М. 1:10000. Фонды Государственного заповедника «Приволжская лесостепь», Пенза, Россия, 2 л.

Нешатаев, Ю.Н., 1971. Выборочно-статистический метод выделения растительных ассоциаций. В: Александрова, В.Д. (ред.), *Методы выделения растительных ассоциаций*. Наука, Ленинград, СССР, 181–206.

Нешатаев, Ю.Н., Ухачева, В.Н., 2001. Мониторинг растительности среднерусской лесостепи. *Вестник СПбГУ. Серия 3. Биология* **2**, 55–66.

Новикова, Л.А., 1993. Динамика Пензенских луговых степей и проблема их сохранения. *Бюллетень Самарская Лука* **4**, 111–128.

Новикова, Л.А., 1995. Динамика и прогноз развития растительности «Кунчеровской степи». *Материалы научной конференции, посвященной 60-летию Хоперского заповедника* "*Проблемы изучения и охраны заповедных природных комплексов".* Воронеж, Россия, 120–122.

Новикова, Л.А., 1998. Геоботаническая характеристика «Кунчеровской степи». *Материалы конференции, посвященной 120-летию со дня рождения И.И. Спрыгина*. Пенза, Россия, 77–82.

Новикова, Л.А., 2008. Современная структура растительного покрова «Кунчеровской степи». *Материалы Всероссийской научно-практической конференции «Мониторинг природных экосистем»: Материалы Всероссийской научно-практической конференции*. Пенза, Россия, 133–136.

Новикова, Л.А., 2009. Восстановление растительности на залежах «Кунчеровской лесостепи». *Вестник Оренбургского государственного университета* **6**, 281–285.

Новикова, Л.А., 2010. Мониторинг растительности «Кунчеровской степи». *Поволжский экологический журнал* **4**, 51–60.

Новикова, Л.А., 2012. Структура и динамика травяной растительности лесостепной зоны на западных склонах Приволжской возвышенности и пути ее оптимизации. *Диссертация на соискание ученой степени доктора биологических наук*. Саратов, Россия, 547 с.

Новикова, Л.А., Панькина, Д.В., 2013. Характеристика луговой растительности «Кунчеровской лесостепи». *Известия высших учебных заведений. Поволжский регион. Серия Естественные науки* **1** (1), 91–101.

Новикова, Л.А., Панькина, Д.В., Миронова, А.А., 2017. Сукцессионная динамика среднерусских луговых степей и проблема их сохранения. *Известия РАН. Серия Биологическая* **5**, 1–6. https://doi.org/10.7868/S000233291705006X

Новикова, Л.А., Соколова, М.С., 2008. Структура и динамика «Кунчеровской степи». *Известия ПГПУ им. В.Г. Белинского. Серия Естественные науки* **10** (14), 13–25.

Новикова, Л.А., Строкина, Е.И., Ухачева, В.Н., 2011. Продолжение мониторинга «Казацкой степи» (ЦЧЗ им. проф. В.В. Алехина). *Развитие геоботаники: история и современность: Материалы Всероссийской конференции, посвященной 80-летию кафедры геоботаники и экологии растений Санкт-Петербургского (Ленинградского) государственного университета и юбилейным датам его преподавателей*. Санкт-Петербург, Россия, 86.

Носова, А.М., 1965. Сохранившиеся участки степей Пензенской области. *Ботанический журнал* **50** (4), 838–852.

Панькина, Д.В., Новикова, Л.А., Миронова, А.А., Кулагина, Е.Ю., 2015. Геоботаническая характеристика «Кунчеровской лесостепи» (по результатам третьего картографирования). *Известия высших учебных заведений. Поволжский регион. Серия Естественные науки* **4** (12), 47–58.

Силева, Т.М., Чернова, О.В., 1999. Характеристика почв Островцовского и Кунчеровского участков заповедника «Приволжская лесостепь». *Труды государственного заповедника «Приволжская лесостепь»* **1**, 25–32.

Солянов, А.А., 1969. К характеристике научной и познавательной ценности «Кунчеровской степи». *Вопросы географии Пензенской области. Географический сборник* **2**, 92–96.

Солянов, А.А., 1982. «Кунчеровская степь». Карта. *Атлас Пензенской области*. ГУГК, Москва, Россия, 18.

Спрыгин, И.И., 1896. Материал к флоре губерний Пензенской и Саратовской. *Труды Общества естествоиспытателей при Императорском Казанском университете* **26** (6), 3–75.

Ухачева, В.Н., Новикова, Л.А., Строкина, Е.И., 2011. Основные маркеры многолетней динамики среднерусской лесостепи. *Известия ПГПУ им. В.Г. Белинского. Серия Естественные науки* **25**, 165–169.

Ямашкин, А.А., Артемова, С.Н., Новикова, Л.А., Леонова, Н.А., Алексеева, Н.С., 2011. Электронная ландшафтная карта Пензенской области. *Известия ПГПУ им. В.Г. Белинского. Серия Естественные науки* **25**, 655–663.