Current Status, Problems and Prospects of Conservation of Meadow Steppes in the Nizhny Novgorod Region

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Abstract. The meadow steppe of the Nizhny Novgorod region is an endangered ecosystem, which is associated with a significant part of the biological diversity in the region. It covers not more than 1.5% of the former area. At the same time, the steppes are inhabited by more than 100 wildlife species listed in the regional Red Book. Using GIS methods we have developed a technique that allowed us to identify about 14,000 potential steppe sites. In 2013-14, according to obtained data an inventory of steppes was carried out. About 50% of the potential sites identified with use of GIS methods were surveyed. Almost all the areas with a high probability of steppe ecosystems remained were examined. At least 90% of remained meadow steppes have been discovered. In order to monitor the steppe ecosystems, 29 most significant sites were re-examined in 2019. A total of 136 slopes of ravines and gullies with a total area of 9732 hectares were identified, where plant communities with the dominance of steppe species are represented. The land areas ranged from 1.4 ha to 454 ha, and the share of steppe associations ranged from 0.1% to 80%. Changes in the species composition and number of steppe plants in the region are characterized. About 15% of the area of the Nizhny Novgorod meadow steppes are protected as 8 natural monuments of regional significance, another 20% are on lands that are reserved by the regional government as the regional protected areas. It is planned to increase the share of the preserved steppe areas, which have legal protection, to 85% of their area. The trend of factors leading to degradation of steppe ecosystems and recognising as limiting for steppe wildlife species is analyzed. It is proposed to implement a program of restoration of pasture cattle breeding to solve the problem of the meadow steppe ecosystem conservation in the Nizhny Novgorod region.

1. Introduction

In the complex of tasks related to the biodiversity conservation in Northern Eurasia, the steppe conservation is the problem of urgent concern. The relevance of the steppe ecosystem protection is due to the fact that the steppe biome is one of the most suffered human impact in the world [1-4]. Meadow steppes, which are distributed in the forest-steppe natural zone, have been affected in the most degree [5-7]. The Nizhny Novgorod region is located on the northern border of the steppe area. Meadow steppes encompassed the south-east of the region, where their former distribution is evidenced by hundreds of thousands of hectares of black soil. Unfortunately, this northern area of the meadow steppes falls out of the attention of scientists, who research steppe ecosystems [3]. Along with it, to conserve the steppe biome it is important to avoid both a negative trend of its range and the loss of steppe ecosystem diversity. Steppe communities that have developed over thousands of years on the borders of the steppe zone have specific features and need the utmost protection.

The relict character of the Nizhny Novgorod steppes is evidenced by the black soils with a two-meter humus layer that existed in the region in the 19th century. They were discovered and described by...
Dokuchaev [8]. According to him such soils have developed for at least 2000 years. Nizhny Novgorod meadow steppes are characterized with extremely high species richness and diversity of flora and fauna. A well-known expert on steppes Alyokhin called the Nizhny Novgorod steppes "Botanical Eldorado" [9]. After acclimatization of the steppe marmot in the region, the fauna of coprophages and nidicoles associated with it turned out to be extremely diverse and similar to that in the Orenburg steppes. It is much richer than in the relict colony of the steppe marmot on the territory of the neighboring Chuvash Republic [10]. In the XVI–XVII centuries, as the analysis of archival documents shows, the steppes on the territory of the modern Nizhny Novgorod region had still encompassed significant areas and been almost in virgin condition [11]. Even at the turn of the XIX–XX centuries, some bustards were recorded in the Kochetovskaya feather grass steppe near the Teply Stan village (Sechenovo district) [12], i.e. there was a virgin steppe area, the least width of which exceeded 2-3 km. Researchers recognize four meadow steppe areas in the Nizhny Novgorod region: Murashkino-Knyagininsky, Mezhpyanye, Zapochinkovsky and Arzamas [9]. The location of these steppe areas is shown in Fig. 1.

![Figure 1. Location of main meadow steppe areas in the Nizhny Novgorod region](image)

Today about 20% of wildlife species listed in the Red Book of the Nizhny Novgorod region are associated with the steppes. For rare plant species in the region this share increases to 34% [13]. The conservation of the Nizhny Novgorod meadow steppes is of pan-European importance under the the Emerald Network program. Two steppe areas located in Mezhpyanye are included in the first published list of areas of special conservation interest in Russia [14].

Considering the high conservation value and heavy human impact, meadow steppes in the region require the urgent concern as follows as almost complete identification and protection of remained areas. Alongside the knowledge of the Nizhny Novgorod steppes is obviously insufficient. For example, the the greater mole-rat (Spalax microphthalmus Guld.) was discovered to inhabit the region only in the
21st century [15]. Therefore, the activities on compiling a list of remained steppe areas, identifying the limiting factors that affect the meadow steppes at the present time, and expanding the network of steppe protected areas is very relevant.

The difficulties of inventory of steppe areas are associated with the complexity of their unambiguous distant identification with use of GIS-methods. We have developed a method that allowed us to identify about 14,000 potential steppe sites. Inventory of steppe areas was started in 2013 [13] and continued in 2014. The length of research routhes and numbers of surveyed areas are presented in tables 1 and 2. About 50% of the potential steppe sites identified with use of GIS-methods were examined. The difference in the number of "sites" and "polygons" is explained by the fact that “site” means the system of ravines or its large fragment, where due to the high difference in relief several polygons located close to each other could be allocated. Almost all the areas with a high probability of steppe ecosystems remained (the highest slopes, mainly southern exposure, the largest areas with complex mesorelief) were surveyed or examined. The degree of identification of remained meadow steppe areas in 2013-14 is estimated at 90%. In order to monitor the state of steppe ecosystems, 29 most significant sites were re-examined in 2019.

### Table 1. Lengths of routes of surveying the potential meadow steppe sites

| Year of survey | Type of route | Length, km |
|----------------|---------------|------------|
| 2013           | vehicle       | 7033.44    |
|                | pedestrian    | 281.91     |
| 2014           | vehicle       | 2201.57    |
|                | pedestrian    | 135.79     |
| Total          | vehicle       | 9235.01    |
|                | pedestrian    | 417.70     |

### Table 2. Number of surveyed potential meadow steppe sites

| Meadow steppe areas | Year of survey | Number of examined sites | Number of examined GIS-polygons |
|---------------------|----------------|--------------------------|---------------------------------|
|                     |                |                          | in details | briefly |
| Mezhpyanye          | 2013           | 124                      | 330        | 3970    |
| Zapochinkovsky      | 2014           | 11                       | 37         | 478     |
| Murashkinsko-Knyagininsky | 2014 | 19                       | 45         | 683     |
| Arzamas             | 2014           | 4                        | 6          | 1936    |
| Total               | 2013           | 158                      | 418        | 7067    |

2. Results and Discussion

2.1. Current state of meadow steppes in the Nizhny Novgorod region

We have estimated how much the steppe areas are remained as a percentage of their former distribution. This is a difficult task. The former distribution of steppes is evidenced by the area of black soils. Chernozems had distributed over an area of 500,000 hectares (6.7% of the area) until the 1970s. We believe the negative trend of the area of chernozems to be the main character in our estimates of former steppe distribution, taking into account its reduction under the human impact. There was a process of gradual change of soil cover from chernozems to podzols. Chernozems covered about 9% of the Nizhny Novgorod province area In 1886, and 7.5% – in 1953 [16]. Taking in the mind the process of soil degradation over the past centuries, we believe the area of chernozems to be at least 700,000 hectares within the territory of modern Nizhny Novgorod region in the 19th century. This value are recognized as the area of former distribution of meadow steppes in the region and used in further calculations.

We have identified 136 sites of slopes of ravines and gullies, where the steppe species predominate in plant communities. The areas of such sited ranged from 1.4 ha to 454 ha, and the share of territories with steppe associations – from 0.1% to 80% (table 3).
Taking into consideration the probable 10% undercount, the total area of steppe meadows, including plant communities with the feather grass (Stipa) and other steppe species predominance we evaluate at 10,705 ha (1.5% of the area of the former distribution of steppes) in the Nizhny Novgorod region. The area of the remained steppe communities is 2540 ha (0.36% of the area of the former distribution of steppes). At the same time, the degree of steppe community fragmentation is extremely high: some areas are small islands separated by agricultural landscapes.

Despite the scale of habitat loss, steppe species that known in the Nizhny Novgorod region since the first quarter of the XX century, have almost completely survived. However the exceptions seem to be the extinct Salvia nutans L. and Fritillaria ruthenica Wikst. [17]. As a result of the research conducted in 2013-14, new data on the distribution and number of 52 species of steppe plants listed in the Red Book of the Nizhny Novgorod region have been obtained. Our research has confirmed 8 species of Stipa inhabiting the region. The distribution of Stipa sareptana Beck and Stipa lessingiana Trin. & Rupr. is of particular interest, because these species that are character to the South of the steppe zone including deserted steppes exist on the northern border of meadow steppes. The single finds of the Sarepta feather grass were a unique phenomenon in the 1980s. Currently, associations with the species predominance or presence have been identified in 12 steppe sites. The species population has increased significantly in the region. At the same time, the distribution of Stipa capillata L. in the region was much more local than previously thought. This species probably disappeared on the territory of the Murashkinsko-Knyagininsky steppe area. We have assessed the status of the populations of the other six species of Stipa as relatively stable. A negative population trend was noted for Helictotrichon desertorum (Less.) Nevski, which was not recorded in many areas in 2013-2019, where we registered it earlier. Fortunately Amygdalus nana L., which was considered extinct in the 1960-70s, and was found in a single point in 1982, seems to have recovered its population: we discovered it in 5 steppe sites.

Our research has shown that currently the main limiting factor for steppe ecosystems is insufficient pasturing. The development of thick plant litter, reduce of the species diversity in phytocenoses, mesophytic vegetation and the appearance of shrubs and trees are observed in many steppe areas.

2.2. Providing of protection for the Nizhny Novgorod meadow steppes

Four sites of meadow steppes were among the first natural monuments established in the Nizhny Novgorod region in 1965. There was an idea in the 1990s to create the Nizhny Novgorod forest-steppe nature reserve, but these plans were not implemented. Currently, 8 areas of meadow steppes and steppe meadows with a total area of 1624 hectares are protected within the boundaries of 8 regional natural monuments. Another 19 meadow steppe sites with a total area of 2200 hectares are located on the projected protected areas that are reserved by the government of the Nizhny Novgorod region for establishing the regional protected areas. Thus, 15% of remained meadow steppes are located within the established regional protected areas, another 20% – in the projected protected areas. Considering the achieved level of legal protection insufficient, we recommend to protect additional 51 meadow steppe sites with a total area of 5237 hectares, that is almost 50% of the remained meadow steppe communities (Fig. 2). From 7 to 30 wildlife species listed in the Red Book of the Nizhny Novgorod region that associated with the steppes were registered on each of the sites recommended for protection. These sites present a mosaic of meadow and steppe associations, their ratio is in dynamic equilibrium, depending
on the pasturing. We have considered the sites with a minimal share of steppe associations, where only a few species of steppe plants are represented, to be unworthy of special protection.

**Figure 2.** Providing of protection for the Nizhny Novgorod meadow steppes

Providing of protection for meadow steppes in four areas its distribution in the Nizhny Novgorod region is markedly different (Fig. 2). For example, there are no protected steppe sites in the Arzamas steppe area. This is the area with the least conservation of meadow steppes – only 4 sites of remained steppes have been identified, and all of them are recommended to protect. Only established natural monument in the Zapochinkovsky area covers more than half of the area of remained meadow steppes. The location of protected and recommended areas is shown in Fig. 3.
2.3. Problems and prospects of steppe conservation in the Nizhny Novgorod region

At present, the steppes in the region have been remained only on the slopes of ravines and gullies, so ploughing does almost not threaten them. However, some flat areas can be ploughed. In addition, these sites may be used for building of some objects of economic infrastructure (farms, corrals for livestock, parking of agricultural machinery), as well as for storage and disposal of household waste. Therefore, the problem of ensuring the remained areas of meadow steppes in the recommended frameworks is of urgent concern.

The main problem of the steppe ecosystem conservation is ensuring the optimal pasturing. In the 1980s, the greatest threat to the Nizhny Novgorod steppes was overgrazing. Since the turn of the 1980-90s the decline of livestock grazing in steppe areas had begun, as a result steppe communities had started to recover. By the end of the 1990s, the pasturing had become insufficient. The consequences of this have been quite obvious by now. Insufficient pasturing have caused the accumulation of plant litter and reduce of the species diversity of phytocenoses. Several steppe animal species have almost disappeared (and requires special measures to recover): spotted souslik, great jerboa, imperial eagle. The steppe marmot will be under threat in the nearest future. Grazing is maintained only in local areas, and it is close to optimal in some territories. The conservation of the Nizhny Novgorod steppes generally is
impossible without the restoration of pastoral cattle breeding in the region, combined with the control of the level of pasture digression.

It is known that increased livestock grazing can turn a steppe meadow into a meadow steppe. The complete absence of grazing and the associated with it accumulation of plant litter transforms the meadow steppe into a steppe meadow during 10-15 years [18]. Steppe ecosystems demonstrate a high potential for recovery after human impact [19].

Another important factor leading to the degradation of steppe ecosystems is spring fires [20]. In areas where fires occur regularly and cover large areas, we observed a significant decrease in the richness and diversity of steppe wildlife species. It is necessary to strengthen both control and environmental education activities to prevent steppe fires.

In some areas of meadow steppes (for example, in two natural monuments in the Perevoz district), an extreme threat factor is the growth of artificial pine forests planted in the early 1980s to strengthen the slopes of ravines. Special measures are needed to remove these pine plantations.

3. Conclusions

The meadow steppes of the Nizhny Novgorod region are an endangered ecosystem, which is associated with a significant part of the biological diversity in the region. Their safety does not exceed 1.5% of the area of former distribution. At the same time, the steppe is a habitat for more than 100 wildlife species listed in the regional Red Book.

The reduction of the area of meadow steppes were occurring over several centuries as a result of ploughing. The last of the upland steppe areas were destroyed in the 1960s, the steppe is remained only on the slopes of ravines and gullies (where ploughing is impossible). Over the past decades (1970-2010-s), there has been no fundamental change in the areas covered by meadow steppes.

About 15% of the area of remaining meadow steppes are protected as 8 regional natural monuments, another 20% are reserved by the government of the Nizhny Novgorod region to establish the regional protected areas. We consider it is necessary to increase the legal protection of the remained steppe sites to 85% of their area.

Factors that lead to the degradation of steppe ecosystems and are recognized as limiting for steppe species have changed at the turn of XX-XXI centuries. Overgrazing that was destroying steppe ecosystems in the 1970s-80s has been replaced by insufficient pasturing.

We consider the problem of conservation of forest-steppe ecosystems and their species diversity in general to be solved only through the implementation of the state program of restoration of pastoral cattle breeding in the Nizhny Novgorod region. The implementation of such program will increase agricultural production, maintain the steppe ecosystems, allow to get the optimal resource potential for the population of the steppe marmot, to recover the imperial eagle (a globally rare species, listed in the Red Book of Russia that have disappeared in the region).

References
[1] Tishkov, A.A. (2000). Ecological restoration of disturbed steppe ecosystems. Questions of steppe studies, 2. [In Russian]
[2] Sobolev, N.A. (2003). Tasks of restoration and maintenance of the natural framework in the steppe and forest-steppe zone. Agri-environment Bulletin, (7), 31-35. [In Russian]
[3] Chibilev, A.A. (2016). Steppe Eurasia: a regional review of natural diversity / A.A. Chibilev. M.; Orenburg: Institute of Steppe RAS, RGS: 324 pp.
[4] Minoranskii, V.A., Uzdenov, A.M., Dankov, V.I., & Malinovskaya, Y.V. (2017). Past, Present and Prospects of Development of a Strictly Protected Nature Territories’ Network in the European Steppe Regions of Russia. Geography Issues, (143): 159-170. [In Russian]
[5] Novikova, L.A. (2012). Protection of the steppes diversity on the Western slopes of the Volga upland. In Rarities of Flora of the Volga Basin: 175-179. [In Russian]
[6] Akimov, L.M., Vladimirov, D.V., & Grigoryevskaya, A.Ya. (2012). Trends in the flora of the meadow steppes of the Central Black Earth region of Russia in the modern climate. In Regional effects of global climate change (causes, consequences, forecasts): 275-278. [In Russian]
[7] Hapugin, A.A., & Silaeva, T.B. (2011). The meadow steppe areas in the Romodanovsky district of the Republic of Mordovia. Samarkaya Luka: problems of regional and global ecology,
20(3). [In Russian]
[8] Dokuchaev, V.V. (2013). Russian black soil. Ripol Classic. [In Russian]
[9] Lukina, E.V., & Smirnova, A.D. (1974). Vegetation. Nature of the Gorky region. Gorky: Volga-Vyatksk. publ., 187-285. [In Russian]
[10] Samkharadze, N.M. (2003). Features of ecology and biocenotic relations of the Steppe Marmot (Marmota bobak Mull.) on the Northern border of the home range in the Volga region (Ph. Doctor dissertation, Lobachevsky State University in N. Novgorod) [In Russian]
[11] Kharitonychev, A.T. (1978). Nature of the Nizhny Novgorod Volga region: History, management, protection. Gorky, Volga-Vyatka book publishing house: 175. [In Russian]
[12] Zhitkov, B.M., & Buturlin, S.A. (1906). Data for avifauna of the Simbirsk province. C. Saint-Petersburg: 275. [In Russian]
[13] Bakka, S.V., Kiseleva, N.Y., Denisov, D.A., & Shestakova, A.A. (2013). Meadow Steppe on the northern Border of distribution: results of the inventory and conservation problems. Science and Technology, 1(4): 330-341.
[14] Bakka, S.V., Kiseleva, N.Y., Modina, T.A., Denisov, D.A., Vargot, E.V., Ivashina, A.A., Pismarkina, E.V., Silaeva, T.B., & Khapugin, A.A. (2011-2013). Areas of special conservation interest of the Nizhny Novgorod region / Emerald book of the Russian Federation. Areas of special conservation interest of European Russia. Proposals to identify. Part Moscow: Institute of Geography of the Russian Academy of Science: 117–125. [In Russian]
[15] Red Data Book of the Nizhniy Novgorod region. Second edition. Nizhniy Novgorod, 2014: 1–448. [In Russian]
[16] Alyabina, I.O. Kukushkina, O.V. (2015) Transformation of the soil cover representation of Nizhegorodskaya province on maps in the XIX–XX centuries. Bulletin of the Moscow University. Series 17. Pedology, (3). [In Russian]
[17] Red Data Book of the Nizhniy Novgorod region. Second edition. Nizhniy Novgorod, 2017: 1–304. [In Russian]
[18] Gribova, S. A., Isachenko, T. I., & Lavrenko, E. M. (Eds.). (1980). Vegetation of the European part of the USSR. Nauka. 429 p. [In Russian]
[19] Smelyansky, I.E., & Elizarov, A.V. (2009) Russian Steppe Conservation Strategy: NGOs’ Position. Arid ecosystems, 15 (37).
[20] Oparin, M.L., & Oparina, O.S., (2003). Steppe vegetation dynamics under fire. Povolzhskiy journal of ecology, 2, 158-171. [In Russian]