Assessment of the ecological state of rare plant species of the Lipetsk region

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Abstract. Long-term monitoring has been carried out to study the species diversity and ecological state of rare species of the Lipetsk region flora. The location of 8 endangered plant species has been established; their ecological state has been studied and described. A morphological assessment of the biological state of the detected species has been carried out. A complex of factors potentially inhibiting and limiting the development of the discovered plant populations has been determined. Most of the detected rare plant species are in a depressed state, which requires additional protection measures, constant annual monitoring of the found populations and species state, as well as reduction of various types of anthropogenic impact. It is also possible to organize cultivation of some species of rare flora in artificially created conditions for further reintroduction of relict species into their natural habitats. These efforts are necessary to preserve individual plant species and ecosystem biodiversity as a whole. Based on the research, a database has been developed.

1. Introduction
Indicators of ecosystems biological diversity reflect the state of balance, ecological equilibrium in these systems. Phytocenosis is the basis of any ecosystem, which determines the beginning of the food web, composition of consumers and reducers of the system. A special place in the analysis of the biodiversity of genuine natural systems is given to rare forms of plants, since they serve as indicators of changes in abiotic and biotic environmental factors and can signal ecosystems degradation [1].

The study of viability, propagation and possible restoration methods of rare forms of plants is a major biological issue in a number of countries [2]. The issue of endemic species of flora ecological state is especially acute [3]. In different countries both arboreal and herbaceous forms are included in the endemic category [4, 5]. Scientists not only describe rare species that affect the overall biodiversity of ecosystems, but also develop a set of measures for their conservation and reintroduction, which is crucial in the current ecological conditions [6]. The relict flora is preserved mainly in places with a variety of relief forms, as this creates specific habitat conditions for many endemic plant species and contributes to the formation of protected areas [7].

Lipetsk region belongs to the Central Chernozem region, characterized by chernozem soils of forest-steppe vegetation predominance. On the territory of the region glacier territories are marked, which leaves a footprint on terrain features, level of biodiversity and composition of the regional flora. In the Lipetsk region a number of protected areas have been identified, including rare relict plant species [8].
Over the past decades, an increasing number of works have been devoted to the study of biological diversity in protected areas of various countries. Analysis of the diversity of rare forms of vegetation occupies one of the most important places in the research of scientists from different countries [9]. Lipetsk region contains numerous relict species of flora, the assessment of the ecological state of which is the subject of research of scientists Skolzneva L.N., Nedosekina T.V., Sarycheva L.A., Burmisova N.V., Starodubtseva E.A. and others. Most of the research is carried out within the framework of projects aimed at updating the regional Red Data Book. This kind of work is repeated every ten years.

The objective of the present work is to assess the diversity of rare forms of vegetation in the Lipetsk region and to describe the ecological state of the discovered plant species.

In our research we put special emphasis on the 0 and 1 rarity categories. Plants belonging to these categories are in the greatest danger; there is a risk of their extinction, therefore, a particularly careful study of those forms as the most vulnerable and significant ecosystems in general biodiversity is required. After analyzing the Red Data Book of the region, we have identified 42 species of flora belonging to the first category of rarity.

Within the Lipetsk region, such studies were carried out 10-15 years ago and were of a fragmentary nature. There are isolated works on the analysis of the flora of some territories of the region, such as Lipetsk, Krasninsky, Lebedyansky, Eletsky, Khlevensky, Dobrinsky, Terbunsky. The areas where natural reserves and ecosite Galichya Gora are located have been studied the most. A number of rare plants have been recorded in these areas. From the plants of the Red Data Book, belonging to the 1st category of rarity, scientists have recorded: on the outskirts of the Epanchino village, Krasninsky district - whitish lecanor lichen (Lecanora albescens), feathery necker moss (Neckera pennata); in the Yeletsky region (Vyrub tract and Vorgolskoe tract) - bear onion (wild garlic, Allium ursinum); in the Dankovsky district (the Khrushchevskaya Dacha tract on the outskirts of the Alekseevskie Vyselki village) - chive (Allium schoenoprassum) [10].

The entire list of the 1st rarity category is extensive and includes 42 specimens of vascular plants, so the process of detailed study of this category is laborious. It is rather difficult to study the distribution and ecological or biological characteristics of all species. Therefore, only a part of the species of this category was studied in detail.

The generalized literature data, as well as the botanized factual material of herbarium storage facilities, allowed us to select the most vulnerable species from the general list of plants of the 1st rarity category for further research. This group includes species that have not been found for a long time, or have sharp negative trends in the region; plant species that form small populations; plants that are constantly collected due to their medicinal or morphological characteristics (medicinal plants and plants that are used for recreational purposes).

According to the data, many of the species selected were found in the territory of the region only occasionally: multi-rooted buttercup, Vaian fumitory, tripartite toothed, Rivinus violet. A number of species have not been found for decades: creeping tenacious, blueberry, field cowwheat. However, there were also quite widespread species according to the research: flattened lycopodium, white-stemmed astragalus, chive, common ephedra.

2. Materials and methods
In the course of the research the following methods were used: expeditionary route, monitoring, descriptive, the use of a geographic information system, the mapping method. The plants were identified according to Mayevsky's guides [11].

A detailed expeditionary multiple floristic survey of the Lipetsk region was carried out. The study of the area floristic composition was done applying the route-floristic method in combination with a detailed examination of individual areas flora. The routes and dates of the trips were planned so as to ensure the maximum survey of the territory in different seasons of the year.

Geographic coordinates were fixed for all points of floristic descriptions using GPS navigators. The discovered plant species of the 1st rarity category were photographed, and the locations of their discovery
were recorded on a cartographic basis. A database of detected plant species was developed and prepared for registration.

3. Results and discussion

Based on the results of the expeditionary studies on the territory of the Lipetsk region, we discovered and described 8 plant species belonging to the 1st rarity category of the regional Red Data Book, these are the species: galeate orchis (Orchis militaris L.), white-stemmed astragalus (Astragalus albicaulis DC.), thin-leaved peony (Paeonia tenuifolia L.), Robert's golokuchnik (Gymnocarpium Robertianum Hoffm.), green-flowered wintergreen (Pyrola chlorantha Swartz.), calcareous thyme (Thymus cretaceous Klok.), Lady's slipper (Cypripedium calico). The habitats of all species were mapped with coordinates and their ecological status was assessed. All the species found in the structure of the studied phytocenoses were few in number and numerous were in a depressed state.

Robert's golokuchnik (Gymnocarpium robertianum) grows on calcareous soil on wooded slopes and rocks. According to literature data, in the Lipetsk region it is found in the valleys of the Vorgol and Sosna rivers. We found small groups of the species on the territory of Krasninsky and Lebedyansky districts; in the Krasninsky region on the territory of the Plyushchan tract, where rocky outcrops are located in the upper part of the slopes. The phytocenosis in the territory is represented by the herb association. Some representatives of the species oppressed under the influence of anthropogenic factors were found. On the territory of the Lebedyansky district the golokuchnik was found on the outskirts of the village Doktorovo on the bank of the Don River in the dry rocky deep ravine. The phytocenosis is represented by a cereal-herb association. One population of the species was found in a satisfactory condition, with an area of 20 m², in the amount of 11 species.

The limiting factors for the discovered populations of Robert's Golokuchnik are: weak competitiveness, unregulated tourism (ecosite Plyushchan), cattle grazing and proximity to the settlement (Doktorovo village). In addition, the development of this species is limited by the rarity of the necessary environmental conditions that are optimal for its development - the presence of rocky chalk deposits, carbonate rocks, which are scarce in the region.

In order to preserve the species it is recommended to introduce regulatory tourism, prohibit livestock grazing, search for new areas and organize nature protection zones in the growing areas, limiting rock climbing in the growing areas of the species.

Green-flowered Wintergreen (Pyrola chlorantha Swartz) prefers conditions in coniferous forests with moderate light. We found examples of the species on the territory of Dobrovsky and Chaplyginsky districts, which were in satisfactory condition. The phytocenosis is represented by typical forest vegetation. The limiting factors for this type were forest fires and proximity to the settlement.

In order to preserve this species on the territory of the region, it is necessary to take measures to preserve and restore forest vegetation, limit deforestation, introduce restrictions on tourism in order to prevent fire hazardous situations.

Five-leaved toothwort (Dentaria quinquefolia Bieb.) was found on the territory of the Usmansky district. A single representative of the species grew on the edge of a swampy broad-leaved forest. The vegetation is mostly typical forest. This species is quite picky about soil conditions, mechanical composition of soils and their fertility in particular. This factor significantly limits the propagation of the species on the territory of the region. In addition, the anthropogenic factors associated with clearing the broad-leaved forests, grasses collecting and uncontrolled tourism limits the development of the five-leaved toothwort.

In order to preserve the species, a long-term annual monitoring of the discovered populations of the five-leaved toothwort state is necessary; protection of typical habitats of these species with a ban on collecting herbs, as well as the reintroduction of the species on the territory of the Usmansky and Chaplyginsky districts as places with the most optimal growing conditions for the species.

Thin-leaved peony (Paeania tenuifolia) is a rather rare species for the Lipetsk region due to the lack of necessary environmental growth conditions. This is a typical steppe species. We found specimens of fine-leaved peony on the territory of the Volovsky district in a depressed state. The study of this species
within the research area was practically not carried out, since for a long time scientists failed to detect its location. The specimen we found did not bloom.

The main limitation in the development of the species is picking flowers for recreational purposes and the lack of necessary abiotic conditions. On the territory of the region the conditions of the forest-steppe zone are formed, but for the species the conditions of steppes are more optimal, therefore, the species found in natural conditions are rare.

To preserve the fine-leaved peony on the territory of the Lipetsk region, it is advisable to introduce a ban on picking flowers, as well as to carry out artificial introduction of the species in the territory with steppe vegetation.

Astragalus white-stemmed (Astragalus albicaulis) prefers chalk soils. On the territory of the Lipetsk region its presence was confirmed in the Krasninsky district. In the course of our expeditionary studies, we found individual species on the territory of the Dankovsky region in the floodplain of the Don River near the village of Krasnaya Zarya. The location of the found species is attributed to the ecotonic area, with transition of the mixed forest to the river floodplain. The phytocenosis is represented by a rich species composition. The state of the found specimens of Astragalus is extremely depressed. The limiting factors in this area were cattle grazing, anthropogenic destruction of the population's habitat and acidified soils. This species prefers calcareous soils.

To preserve the species on the territory of the region, constant monitoring of the known populations state and finding new facts of their growth is necessary. It is also advisable to artificially cultivate astragalus for the purpose of its reintroduction on the territory upon availability of chalk deposits and conservation status of the growing areas.

Calcareous thyme (Thymus cretaceous) is an inhabitant of calcareous rocks. On the territory of the region populations of thyme in the Elets and Zadonsk regions have been described. Numerous data indicate the frequent occurrence of the species on the territory of the Galichya Gora ecosite in the Yelets region. The studies carried out allowed us to find populations of the species both in Yelets and Izmalkovsky districts of the region. In the Yeletsky region calcareous thyme sod was found on the rocky slopes of the Voronov Kamen and Vorgolskoye tracts. The population amounted to more than 100 species and was in a fairly good condition despite the nearby residential area, tourism and mountaineering. In the Izmalkovsky district individual specimens of this thyme were found in the floodplain of the Bystraya Sosna River on the outskirts of Cernava. Cretaceous slopes and calcareous soils of the range contributed to the species propagation and create conditions for optimizing its growth. However, unregulated tourism, cattle grazing, and picking medicinal herbs act as a negative factor, which generally inhibits the population development in the discovered location.

To preserve Calcareous thyme it is necessary to limit tourism in the places where the species is found and create the necessary conditions, preserving the chalk deposits. Additionally, it is advisable to carry out measures to limit the growth and propagation of tall-grass vegetation and shrubs in places where Calcareous thyme is found in order to optimize its growth conditions.

Lady's slipper (Cypripedium calceolus) is an inhabitant of mixed forests with a high limestone occurrence. For a long time it was considered as disappeared in the Lipetsk region. Research in recent years has confirmed the presence of single specimens on the territory of the Dankovsky district. We found representatives of the species on the territory of the Dankovsky district, the Samoilovskiiye Vyselki tract, 3 km west of the Bigildino village, the upper reaches of the dry gully, the lower part of the slope near the humid lowland with limestone outcrops, sparse deciduous forest (oak, birch, ash). The plants have already faded. To clarify their biological state, further study of the species is necessary.

The limiting factors are picking plants in bouquets, digging them out for planting in gardens or flower beds. In order to preserve and restore the number of the species it is necessary to create reserves in the places of growth and tighten protection measures, develop information leaflets and posters.

Galeated orchis (Orchis militaris L.) is found in river valleys and prefers calcareous soils. This endangered species was found in Stanovlyansky, Chaplyginsky and Lipetsk districts of the region. We found a population of the species on the territory of the Usmansky district along the banks of the rivers Meshcherka and Krivka. The phytocenosis of the adjacent territory is based on typical meadow
vegetation, part of which is individual specimens of galeated orchis. The found representatives of the species experienced an extreme degree of negative factors. A spectrum of limiting factors has been determined for the species, the main of which are changes in abiotic growing conditions (mainly hydrological regime) and their collection for recreational purposes. The lack of possibilities for vegetative reproduction may also limit the development and propagation of this species. Seed reproduction is a more laborious process, in which the population recruitment takes longer and prevents recovery.

In order to preserve this species it is necessary to constantly monitor the known populations, limit grazing and hay making in these territories; it is also possible to organize the reintroduction of this species in habitats suitable for the conditions.

4. Conclusion
Thus, within the framework of this project we have analyzed information sources over the past 10 years, planned and organized expeditionary studies to all areas of the Lipetsk region in order to study the Red Data Book plant species of the 1st rarity category. During the expeditions we found 8 species of plants of the 1st rarity category, listed in the Red Data Book of the Lipetsk region. These are the following species: galeated orchis (Orchis militaris L.), white-stemmed astragalus (Astragalus albiculalis DC.), fine-leaved peony (Paonia tenuifolia L.), Robert's golokuchnik (Gymnocarpium Robertianum Hoffm.), green-flowered Wintergreen (Pyrolranta Thymus cretaceous Klok.), Lady's slipper (Cypripedium calceolus L.), five-leaved chive (Dentaria quinquefolia Bieb.). A descriptive characteristic of the biological and ecological state of these species is given. The habitats of all species are plotted on a map with coordinates indicated; the assessment of the discovered populations’ state is given. Measures are proposed for the plant species conservation, which include the reduction of various types of anthropogenic impact on the habitats of rare species, monitoring the status of rare species, artificial introduction of these species into the natural habitat corresponding to the needs of plants. A database has been compiled including information on the propagation and status of rare species found in the Lipetsk region.

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