Protected plants of Siberian forest-steppe ecosystems

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Abstract. Protection of Red Book plants in the forest-steppe regions of Central Siberia (Krasnoyarsk, Kansk and Achinsk) is carried out in nature reserves and nature monuments of regional significance, as well as a result of preserving landscapes in general, and, consequently, plant communities, without which conservation of rare plant species in nature is impossible. The aim of the work was the analysis of protected flora species of forest-steppe ecosystems of Central Siberia. The object of the analysis is a synopsis of the vascular plants of the forest-steppe, compiled on the basis of the collections of the plants of Herbarium named after L M Cherepnin (KRAS), collected by the authors from 1985 to 2018 by methods of local floras and model sections. There are 106 protected species, among which 31 are endemic taxa, 17 species of relict origin (5 relics are endemics), 19 species at the boundary of ranges (16 species at the border of ranges - relics and endemics). Krasnoyarsk, Krasnoyarsk-Kansk, Altai-Sayan, Altai-Sayan-Mongolian, South Siberian, Yeniseyian, Tuvin-Khakassia-Krasnoyarsk, South-West Siberian and Siberian ones were found among the Red Books of endemic and hemiendemic species of forest-steppe. Tertiary relics are mainly forest species of the immoral complex, steppe relics - Pliocene and aquatic. Relics of the Pleistocene age are represented by glacial and forest-steppe. The low category of rarities in many species, including relics and endemics, is associated with the boundary of their ranges. Compared to the whole Krasnoyarsk Territory, the share of species 0 and 1 of rarity categories is increased, which indicates a strong anthropogenic effect on the natural forest-steppe ecosystems of Central Siberia.

1. Introduction

Rational use, protection and reproduction of natural resources are impossible without knowledge of the processes occurring in the organic world. The solution of these problems is impracticable with little studied flora, which determines the diversity of living inhabitants. In the early stages of the study, the main focus is on preserving the gene pool of rare plant species. The result of this work is the organization of specially protected natural territories and the publication of the Red Books.

The northern forest-steppe regions of Central Siberia - Krasnoyarsk, Kansk and Achinsk, are the most inhabited territories of the Krasnoyarsk Territory with developed economic activity, therefore the existing reserves and natural monuments are of regional importance. As a rule, they traditionally have always had the most utilitarian goals, created to preserve the number of game animals. Historically, the vast majority of places retained the most pristine areas located near the inhabited territories. Recently, this trend has begun to change, and some regional reserves are transformed into complex ones, the task of which is to preserve the landscape as a whole, and, consequently, plant communities, without which it is impossible to preserve rare plant species.

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The issue of monitoring the current state and protection of grassy phytocenoses - steppe and real meadows, meadow and real steppes are of great importance on the territory of forest-steppes [1]. At the same time, the northern forest-steppes are the keepers of the gene pool of unique rare relict and endemic plants of Central Siberia [2-3], many of which drastically reduce the population size under the influence of the strongest anthropogenic press. The latest edition of the Red Book of the Krasnoyarsk Territory [4] was carried out 7 years ago and in the near future it is necessary to prepare its 3rd edition, if we consider that the reprinting is done once every 10 years.

In this regard, the purpose of this work was to analyse the rare protected species of the flora of forest-steppe ecosystems of Central Siberia.

2. Research materials and methods

The work is based on the notes about the flora of the northern forest-steppe [5], compiled on the basis of the collection of higher plants of the Herbarium named after L M Cherepnin (KRAS) collected during an inventory of the flora of forest-steppes and rare species from 1985 to 2018. Field work was carried out by the method of local floras (LF) and model units. Most of the LF territory was visited several times and at different times of the growing season. In addition, the literature and data of other Russian Herbaria are taken into account.

The principles adopted by many botanists were used to select rare species of the flora of island forest-steppes of Central Siberia: the principle of primacy of regional lists of rare and endangered plants, the principle of unconditional priority of the species, the presumption of the prosperous state of rare plant species, the biocenotic principle [2, 6].

3. Results and discussion

As a result of the analysis carried out according to the principles outlined, the total number of protected rare and endangered vascular plant species in forest-steppes is 106 species, of which 76 species are included into the first edition of the Red Book of the Krasnoyarsk Territory [7]; the second edition of it [4] includes 94 species, which constitute 5.5% and 6.7% of the total number of forest-steppe species respectively (table 1). As part of the rare species, 31 endemic taxa were identified, 17 species of relict origin (another 5 - endemic relics), 19 species at the boundary of ranges (another 16 species at the boundary of ranges - relics and endemics). Of the protected plants found on the territory of forest-steppes, 10 are included into the “Red Book of the Russian Federation” [8] and 9 - into the report “Rare and Disappearing Plants of Siberia” [9], indicating the limiting factors for these species.

The principle of the primacy of regional lists of rare and endangered species involves a long work on the evaluation of materials of each of the species recommended in the Red Book. Careful collection and analysis of all available actual (herbaric) data on rare species not only for the region under study, but also for neighboring territories, is necessary for proper determination of status and protection measures, since even endemic and hemi-endemic Red Book forest steppes have different distribution: endem Krasnoyarsk, Altai-Sayan, Altai-Sayan-Mongolian, South Siberian, Yenisei, Endem Tuvin-Khakass-Krasnoyarsk, Endem south of Western Siberia, Siberian.

The group of narrow-local endemic taxa includes, above all, the principle of unconditional priority. This group includes the endemics of the Prienisei steppes (Astragalus miklaschewskii Basil, Papaver chakassicum Peschkova, etc.) and the Krasnoyarsk-Kan (Corydalis subjenisseensis Antipova, Adenophora gmelinii subsp. Subjenisseensis Kurbatsky, Neottia krasnojarica Antipova, etc.). They are characterized by strict localization in the study area, an extremely low number of populations with unexpressed structure, insufficient seed productivity. These taxa are extremely vulnerable and may disappear with a very small anthropogenic load.

Table 1. Rare and endangered plant species of the northern forest-steppes of Central Siberia.

| Family / Species | The Red Book of Krasnoyarsk Region 2005 | Recommended rarity category in 2012 |
|------------------|----------------------------------------|-----------------------------------|
|                  |                                        | from the report “Rare and Disappearing Plants of Siberia” [9] |
| Family          | Species                      | Range Description                  | Location       |
|-----------------|------------------------------|------------------------------------|----------------|
| Alliaceae       | Allium rubens                | 1 – north-eastern boundary of the range | 0              |
|                 | Allium nutans                | 3 – north-eastern boundary of the range | 1              |
| Apiaceae        | Seseli ledebourii            | 1 – north-eastern boundary of the range |                |
|                 | Thyssium palustre            | * 3 – eastern boundary of the range | 1              |
| Asteraceae      | Alfredia cernua              | 3 – north-eastern boundary of the range, South Siberian endemic, relic unmoral | 1              |
|                 | Arctogeron gramineum         | * 3 – Siberian endemic             | 0              |
|                 | Tephrosperis porphyantha     | 3 – Siberian endemic north-eastern boundary of the range | 2              |
|                 | Hieracium krylovii           | 3 – Altai-Sayan endemic, relic unmoral | 1              |
|                 | Pilosella pinea              | 2 – South Siberian endemic, eastern boundary of the range |                |
| Athyriaceae     | Cystopteris sudetica         | 3 – tertiary relic                 | 1              |
| Boraginaceae    | Brunnera sibirica            | 3 – Altai-Sayan endemic, relic unmoral |                |
|                 | Erytrichium jenisseensis     | * 3 – Yeniseysky endem            |                |
|                 | E. pectinatum                | * 3                                |                |
|                 | Mertensia stylosa            | * 3 – endem                        | 0              |
|                 | Myosotis butorinae           | 3 – Krasnoyarsk endem             |                |
|                 | Myosotis krylovii            | * 2 – relic unmoral                |                |
|                 | Myosotis jenisseensis        | * 2 – endem                        | 1              |
| Botrychiaceae   | Botrychium multifidum        | 3 – relic unmoral                  | 1              |
|                 | Botrychium virginianum       | 3 – relic unmoral                  | 2              |
| Brassicaceae    | Alyssum turkestanicum        | 3 – north-eastern boundary of the range | 2              |
|                 | Cardamine impatiens          | * 3 – relic unmoral                | 2              |
| Campanulaceae   | Campanula rapunculoides      | Excluded, overseas species in Siberia |                |
| Caryophyllaceae | Dianthus deltoides           | 2 – Rare and endangered plants of Siberia [9] |                |
| Chenopodiaceae  | Kraschenin-kovia ceratoides  | 2 – relic of pleistocene steppe    |                |
| Crassulaceae    | Hylotelephium populifolium   | 2 – Altai-Sayan endemic, relic     | 0              |
| Cyperaceae      | Carex sajanensis             | 2 – western boundary of the range  | 1              |
| Dryopteridaceae |                             |                                    |                |
| Family        | Species                     | Range Notes                                                                 | Status |
|--------------|-----------------------------|-----------------------------------------------------------------------------|--------|
| Ericaceae    | Dryopteris filix-mas        | 3 – relic unmoral                                                            | 1      |
|              | Calluna vulgaris            | 1 – eastern boundary of the range                                            | 0      |
| Fabaceae     | Astragalus ionae            | 2 – South-Siberian endem north-western boundary of the range                 | 1      |
|              | Astragalus miklaschewskii   | 3 – Priyeniseiskiy endem, north-northern boundary of the range               |        |
|              | Astragalus vaginatus        | 3 – South-Siberian endem, north-north-western boundary of the range          | 1      |
|              | Chrysaspis spadicea         | 2 – Rare and endangered plants of Siberia [9]                               |        |
|              | Oxytropis nuda              | 1 – Priyeniseiskiy endem northern boundary of the range, icy relic           | 0      |
|              | Oxytropis ammophila         | 2 – Priyeniseiskiy endem northern boundary of the range                      | 1      |
|              | Oxytropis ampullata         | 2 – northern boundary of the range                                           | 0      |
| Fumariaceae  | Corydalis bracteata         | 3 – Rare and endangered plants of Siberia [9]                               |        |
|              | Corydalis subjenissens    | * 3 – Priyeniseiskiy endem                                                  |        |
| Iridaceae    | Iris bloudowii              | 3- Altai-Sayan endem, northern boundary of the region                        | 1      |
|              | Iris humilis                | 3 – northern boundary of the region                                          |        |
|              | Iris potaninii             | 1 – Altai-Sayan endem, northern boundary of the region                       | 0      |
| Lamiaceae    | Pancerina canescens         | 1 – Altai-Sayan-Mongol endem                                               | 0      |
|              | Pancerina lanata subsp.     | * 2 – Altai-Sayan-Mongol endem, northern boundary of the region              | 1      |
|              | argyraceae                  |                                                                             |        |
|              | Stachys sylvatica           | 3 – tertiary relic, eastern boundary of the range                            | 1      |
| Liliaceae    | Gagea altaica              | 2 – Altai-Sayan endem                                                       | 1      |
|              | Gagea longiscapa            | 2 – western boundary of the region                                           | 0      |
|              | Gagea fedtschenkoana        | 2 – eastern boundary of the region                                           | 1      |
|              | Hemerocallis minor          | 3                                                                              |        |
|              | Lilium pilosiusculum       | 3 – Rare and endangered plants of Siberia [9]                               |        |
|              | Lilium pumilum              | 2 – relic of the pliocene steppe complex, western boundary of the range      |        |
|              | Lilium pensylvanicum        | 2 – western boundary of the range                                           | 1      |
|              | Tulipa uniflora             | 1                                                                             | 0      |
|              | Tulipa heteropetala         | 2                                                                             | 1      |
| Family                  | Species                          | Threat Level | Notes                                                                 |
|------------------------|----------------------------------|--------------|----------------------------------------------------------------------|
| Menispermaceae         | Menispermum dauricum             | 2            | 2 – relic unmoral, north-western boundary of the range                |
|                        | Nuphar pumila                    | 2            | 2 tertiary relic                                                      |
|                        | Nymphaea candida                 | 3            | 3 tertiary relic                                                      |
|                        | Nymphaea tetragona               | 3            | 3 tertiary relic                                                      |
| Nymphaeaceae           |                                  |              |                                                                      |
|                        | Epilobium montanum               | 2            | 2 – tertiary relic                                                    |
|                        | Circaea lutetiana                |              | 2 – Rare and endangered plants of Siberia [9]                        |
| Onagraceae             |                                  |              |                                                                      |
|                        | Ophioglossum vulgatum            | 2            | 2 – tertiary relic                                                    |
| Orchidaceae            | Calypso bulbosa                  | 2            | 2 RF Red Book [8]                                                    |
|                        | Corallorhiza trifida             | 3            | *                                                                    |
|                        | Cypripedium calceolus            | 2            | 2                                                                    |
|                        | Cypripedium guttatum             | 3            | 3                                                                    |
|                        | Cypripedium macranthon           | 2            | 2                                                                    |
|                        | Cypripedium ventricosum          | *            | 2                                                                    |
|                        | Dactylorhiza cruenta             | *            | 3                                                                    |
|                        | Dactylorhiza longifolia          | 2            | 2                                                                    |
|                        | Epipactis helleborine             | 3            | 3                                                                    |
|                        | Epipactis palustris              | *            | 3                                                                    |
|                        | Epipogium aphyllum               | 2            | 2;                                                                   |
|                        | Listera ovata                    | 3            | 3                                                                    |
|                        | Neottia krasnojarica             | 2            | 2 – Krasnoyarsk-Kansk endem                                         |
|                        | Neottianthe cucullata            | 3            | 3;                                                                  |
|                        | Orchis militaris                 | 2            | 2                                                                    |
|                        | Tulotis fuscescens               | 3            | 3                                                                    |
| Paeoniaceae            | Paeonia anomala                  | 3            | 3 – Rare and endangered plants of Siberia [9]                        |
| Papaveraceae           | Papaver chakassicum              | 4            | 4 – Yeniseysky endem                                                |
| Poaceae                | Glyceria notata                  | 4            | 1 – Tertiary relic                                                  |
|                        | Deschampsia kaschiae             | *            | 1 – Krasnoyarsk endem                                               |
|                        | Melica altissima                 | 3            | 3 – northern border                                                 |
|                        | Melica transsilvanica            | 3            | 3 – the northern boundary of the range                              |
|                        | Poa remota                       | 3            | *                                                                   |
|                        | Stipa dasyphylla                 | 3            | 1 – north-eastern boundary of the range. RF Red Book – 3[8]          |

[9] Rare and endangered plants of Siberia [9]
| Family             | Species                  | Locality                                      | Notes                                      |
|--------------------|--------------------------|-----------------------------------------------|--------------------------------------------|
| Polemoniaceae      | Phlox sibirica           | 2 – relic of the pliocene steppe complex       |                                            |
| Pyrolaceae         | Chimaphila umbellata     | 3                                              |                                            |
| Primulaceae        | Primula serrata          | * 3 – north-eastern boundary of the range      |                                            |
| Ranunculaceae      | Adonis sibirica          | 3 – Rare and endangered plants of Siberia [9] |                                            |
|                    | Anemonoides altaica      | 2 – Rare and endangered plants of Siberia [9] |                                            |
|                    | Anemonoides caerulea     | 3 - Siberian endemic                           |                                            |
|                    | Anemonoidesjenisseensis  | 2 - Rare and endangered plants of Siberia [9] |                                            |
|                    | Delphinium retropilosum  | 3 - the endemic of the south of Western Siberia, the north-eastern boundary of the range |                                            |
|                    | Caltha natans            | 3 - western boundary of the range              |                                            |
|                    | Thalictrum baicalense    | 3 - western border of the range, relic unmoral |                                            |
|                    | Trollius asiaticus       | 2 - Rare and endangered plants of Siberia [9] |                                            |
| Rosaceae           | Filipendula vulgaris     | 1 – eastern boundary of the range             |                                            |
|                    | Padus avium              | 3 - Rare and endangered plants of Siberia [9] |                                            |
|                    | Pentaphylloidesparvifolia| 1                                              |                                            |
| Scrophulariaceae   | Scrophularia multicaulis | 2                                              |                                            |
|                    | Veronica officinalis     | 1 - Yeniseysky endem                          |                                            |
|                    | Veronica reverdattai     | 2 - Tuvino-Khakass-Krasnoyarsk endem           |                                            |
|                    | Veronica sergievskiana   | * 3 - South Siberian endem                     |                                            |
| Typhaceae          | Typha angustifolia       | 2 – Rare and endangered plants of Siberia [9] |                                            |
| Trapaceae          | Trapa natans             | 1 – tertiary relic                             |                                            |
| Violaceae          | Viola dactyloides        | 3 – western border of the range, relic unmoral |                                            |
Viola dissecta 3 3– northern border of the range
Viola incisa 1 1– northern border of the range, South Siberian endem.
Viola patrinii 3 RF Red Book [8] 0

Priority is set for species of relict origin. In our region such relics as Paleogenic-neogenovyh (tertiary) and plejstotsenovyh (quaternary) timber, steppe and water communities: the elements of warm-temperate and subtropical floras (saline deserts, savannah, prairie) Turgaiskaya flora neogenovyh steppe Pleistocene and Holocene neorelikty are allocated.

Forest species are connected by their origin, mainly, with relict broad-leaved formations of the tertiary time - nonmoral blackened species (Stachys sylvatica L., Epilobium montanum L., Glyceria notata Chevall., Poa remota Forsell., etc.). This element represents a strongly modified heritage of deciduous forests of the Praboreal Pliocene flora, which is closely associated with both the flora of Europe, Central Asia, and the flora of Primorye and Manchuria. The group of steppe plants includes relics of the Pliocene and Pleistocene periods.

Relics of the Pleistocene age are represented by glacial and forest-steppe. On the territory of Central Siberian forest steppes, many relics are located on the border of the range in the northernmost points of their habitat (Menispermum dauricum DC., Lilium pumilum Delile, Stachys sylvatica L.). Most of these species are characterized by a sharp drop in the number of already small populations due to the increase in anthropogenic pressure on forest and steppe ecosystems in the region.

The data on the number of populations justify the presumption of prosperity of rare and endangered plants. The decline in the number of Red Book species in the northern forest-steppes is associated with the leading types of nature management - coal mining (KATEK) and agricultural work. Thus, during the development of the Pereyaslavl deposit, the destruction of species from the Red Book was noted: Cypripedium calceolus L., C. guttatum Sw., C. macranthon Sw. and others, while dumping the roads in the Kabaevy Mountains reserve (Partizansky district), Phlox sibirica L., Lilium pumilum Delile, and others were damaged. During the sowing and haymaking, there is a reduction in the ranges of rare species in the valleys of the RR. Kan, Chulym, Rybnaya etc.: Stipa pennata L., Iris humilis Georgi, Thacla natans (Pall. Ex Georgi) Deyl et Soják, etc. The situation with plants of the coastal and aquatic flora is particularly unfavorable (Nymphaea candida J. Presl, Nymphaea tetragona Georgi etc.).

The regional and biocenotic (consortium) principles assume that environmental protection measures cover as much as possible for this purpose the territory and habitats that are characteristic of foci of rare plant species. The conservation of rare species is possible only as part of plant communities. Therefore, justifying the protected status of relict forest or steppe species, it is necessary to remember the integrity of forest and steppe communities, the loss of biodiversity in which begins with rare species.

When analyzing rarity categories in forest-steppes, a tendency is reversed to the situation throughout the Krasnoyarsk Territory: the share of species 0 and 1 rarity categories increases and the proportion of species 2 and 3 rarity categories decreases, which clearly indicates a strong anthropogenic effect on natural forest-steppe ecosystems.

4. Conclusions

Protected plants in the forest-steppe ecosystems of Central Siberia are represented by red-vegetation species of the Russian Federation, rare and under-grown plants of Siberia, endemic, relict taxa and species at the boundaries of their ranges. In the Red Book of the Krasnoyarsk Territory [4], tertiary, mainly forest species of the immoral complex, as well as steppe Pliocene and aquatic dominate among relics. Relics of the Pleistocene age are represented by glacial and forest-steppe. Many relics and endemics are found in forest-steppe areas at the boundaries of their ranges: steppe species are located on the northern, north-eastern and north-western borders of the range, forest species have an eastern or western boundary, indicating the origin of relict complexes. A strong anthropogenic impact on natural forest-steppe ecosystems is evidenced by an increased proportion of species 0 and 1 of rarity categories in comparison with the entire Krasnoyarsk Territory.
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