Rare cenoflora formation patterns in the Cis-Urals steppe communities

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Abstract. The Urals and its adjacent areas are an important botanical and geographical boundary in the distribution of the steppe vegetation of Eurasia. In the Southern Cis-Urals, the steppes belong to ecosystems of high degree of transformation as a result of plowing, pasture and recreational use. To assess the environmental significance and rational use of preserved areas, one of the important criteria is the growth of rare and protection-needed species, relics and endemics. The aim of the study is to identify the rare component of cenoflora in the Southern Cis-Urals steppe, the confluence of its species with the main types of steppe communities and characterize the patterns of their distribution based on quantitative indicators (activity index). The studied communities include 103 rare and species in need of protection, relics and endemics that make up 15.4% of the all coenoflora. Among them 19 species included in the Red List of the Russian Federation and also 50 species included in the regional Red Lists. We found also 16 endemic species pertaining mainly to rocky and steppe endemics. Relic flora contains 39 species with predominance of Holocene relics (25 species) and Pleistocene relics (11 species). The analysis of cenoflora allowed to reveal features of distribution of rare species on the different rank syntaxa communities characterizing various types of habitats. The obtained data confirm the high nature protection importance for these communities and can form a basis for the complex strategy of protection and management of these communities.

1. Introduction

Steppes in the Southern Urals are poorly preserved ecosystems. The vast areas occupied by steppe communities were plowed during the virgin soil development campaign (50-60s of the 20th century), the remaining for a long time were subjected to intensive pasture use and recreational load. The Urals are an important botanical and geographical boundary in the distribution of the Eurasian steppe vegetation. On a relatively small longitude gradient, various geographical types of steppes are found: Eastern European, West Siberian-Kazakh, as well as endemic types of mountain steppes. On the latitudinal gradient from the forest to the steppe zone, the main zonal types of steppes from meadow to desert are common.

Preserved steppe ecosystems in the region are sanctuary for unique biodiversity, as demonstated by numerous studies [1, 2, 3]. Their composition contains many rare and protection-need species, endemics and relics, which make up the so-called rare component of community cenoflora. It is one of the most important criteria in assessing the environmental significance of communities [4]. The habitation of species included in the Red Books of the Russian Federation and its subjects is
recognized as an indicator of the importance of the territory of steppe communities distribution and inclusion such territories in the object list of the Emerald Network [5]. Important information reflecting the processes of flora formation and the value of communities in the global historical aspect is traditionally provided by the analysis of the relict and endemic component.

To date, extensive representative dataset has been collected, which includes 647 geobotanical plot description for steppe communities in the region. It reveals steppe vegetation of the Cis-Urals on a latitudinal gradient of more than 500 km, within the Republic of Bashkortostan (RB) and the Orenburg Oblast (OO).

The purpose of this work is to identify the rare component of the cenoflora of the Cis-Urals steppes, the confinedness of rare and protection-needed species to the different types of steppe communities and characterize the patterns of their distribution.

2. Materials and Methods
The investigated territory covers the areas of distribution of steppes within the Southern Urals between 51°60′–55°40′ N, 53°15′–59°00′ E. . According to the botanical and geographical zoning of the Eurasia steppe region, it belongs to the East European forest-steppe province and borders on the West Siberian forest-steppe and Trans-Volga-Kazakhstan steppe provinces [6], which determines the complex structure of the vegetation cover. The climate of the region is temperate continental. The average annual temperatures is 4.2–5.3°C, the average annual precipitation – 344–529 mm. The location and absolute height of the ridges of the Ural Mountains have a great influence on the climatic characteristics of landscapes. Vegetation is represented by shifting zonal types: from taiga forests in the north to true and dry steppes in the south. On flat areas, soils are replaced from mountain podzolic and gray forest to chernozem (leached, common, southern, less often salted and saltwater). The soil cover of low ridges and ridges is dominated by coarse and eroded soils with stony outcrops (carbonate rocks and gypsum are distributed) [7, 8].

To identify the rare component of the Cis-Urals steppe communities cenoflora, an analysis of 647 releves included in the South-Urals non-forest vegetation database was performed [9, 10]. Belonging of rare and protection-needed species to the different vegetation types was defined at two hierarchical levels (orders and associations) of the floristic classification system [11, 12].

The list of endemic and relict species is given according to the summary of P.L. Gorchakovskysystem [13], with additions by P.V. Kulikov [14] and M.S. Knazev [15]. The list of rare species is given by the Red Book of the Russian Federation (RB RF) [16], Red Book of the Republic of Bashkortostan (RB RB) [17], Red Book of the Orenburg Oblast (RB OO) [18]. To quantify the structure of the rare component an activity indicator of the species was determined, which was defined as the root from the product of occurrence on the average total cover [19]. A number of species are recorded in the form of herbarium collections and are stored in the reference herbarium of the SUBGI UFC RAS (South Ural Botanical Garden-Institute of Ufa Federal Scientific Center of the Russian Academy of Sciences) (more than 200 sheets). The nomenclature of the species is given in accordance with the Working List of all known plant species [20].

3. Results and Discussion
The phytocenotic diversity of the Cis-Urals steppe vegetation is presented by the 1 class, 3 orders, 4 alliances, 17 associations and 3 unranked communities. The orders reflect the differentiation of zonal types: steppes of the order Tanacetum achilleifolii-Stipetalia lessingiana Lysenko et Mucina in Mucina et al. 2016, true steppes of the order Helicotricho-Stipetalia Toman 1969 and meadow steppes of the order Brachypodietalia pinnati Korneck 1974. Differentiation of alliances and associations within orders is related to the landscape position, the substratum rockiness and anthropogenic transformation degree.

Analysis of the rare component of the Cis-Ural steppe communities species composition established in total 103 vascular plants species (15.4% of the cenoflora), including 67 rare and in protection-needed species, 55 relics and endemics species. The basic numerical data characterizing the
structure of the rare component are given in Table 1. The distribution of rare species within syntaxa and brief characteristics of species are presented in Table 2.

Table 1. Structure of rare component of the Cis-Urals steppe communities cenoflora.

| Association | G.t.-T.a. | A.t.-A.l. | A.m.-F.v. | A.r.-A.l. | H.r.-S.l. | A.k.-K.c. | A.m.-S.t. | G.v.-S.t. | I.a.-F.p. | A.a.-S.p. | V.h.-S.z. | T.m.-C.s. | H.g.-S.p. | S.n.-S.k. | L.v.-S.p. | P.a.-S.p. | F.r.-F.v. | S.p.-C.s. | M.k.-F.p. |
|-------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Order       | TS        | HS        | BP        |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |
| Nuber of releves | 99 | 16 | 52 | 15 | 21 | 4 | 22 | 28 | 8 | 15 | 87 | 25 | 51 | 59 | 82 | 10 | 7 | 8 | 31 | 7 |
| Species richness | 25 | 20 | 30 | 18 | 23 | 14 | 50 | 38 | 75 | 60 | 52 | 54 | 29 | 31 | 40 | 67 | 54 | 42 | 47 | 26 |
| Cenoflora species total number | 227 | 80 | 214 | 77 | 122 | 32 | 184 | 221 | 183 | 188 | 307 | 223 | 151 | 203 | 266 | 177 | 147 | 125 | 180 | 52 |
| Rare component a, incl. | 29 | 13 | 21 | 9 | 23 | 3 | 15 | 25 | 27 | 42 | 52 | 40 | 31 | 45 | 52 | 25 | 20 | 24 | 31 | 13 |
| Species of RB RF | 9 | 7 | 6 | 3 | 10 | 5 | 6 | 4 | 10 | 13 | 9 | 7 | 13 | 12 | 3 | 3 | 3 | 3 | 4 |
| Species of RB RB | 9 | 2 | 7 | 6 | 9 | 11 | 2 | 4 | 11 | 24 | 10 | 19 | 21 | 3 | 5 | 6 | 5 | 6 | 5 | 8 |
| Species of RB OO | 20 | 11 | 10 | 9 | 15 | 9 | 6 | 14 | 17 | 21 | 17 | 21 | 17 | 21 | 17 | 21 | 17 | 21 | 17 | 21 |
| Relic and endemic species not incl. in Red Books | 4 | 3 | 5 | 1 | 3 | 2 | 3 | 5 | 7 | 11 | 12 | 9 | 10 | 13 | 8 | 9 | 12 | 12 | 14 | 16 |
| endemic | 2 | 1 | 1 | 4 | 1 | 1 | 2 | 8 | 11 | 7 | 8 | 10 | 9 | 2 | 5 | 5 | 7 | 5 | 10 |
| preglacial relic | 1 | 2 | 1 | 1 | 2 | 1 | 2 | 4 | 3 | 5 | 3 | 1 | 3 | 4 | 4 | 10 | |
| pleistocone relic | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| holocene relic | 9 | 2 | 11 | 1 | 4 | 1 | 10 | 16 | 20 | 18 | 22 | 20 | 15 | 13 | 19 | 17 | 17 | 15 | 21 | 9 |

Notes: a – number of rare species/proportion of a total number of species. Syntaxa: TS – Tanacetum achilleifolii-Stipetalia lessingianae, HS – Helictotricho-Stipetalia , BP – Brachypodietalia pinnati, A.r.-A.l. – Ass. Atraphaxo replicatae-Artemisietum lessingianae ass. nov., A.t.-A.l. – Acc. Atragalotum tenuifolii-Artemisietum lechecanae ass. nov., G.t.-T.a. – Ass. Galatello tataricae-Tanacetum achilleifolii ass. nov., H.r.-S.l. – Ass. Hedysaro razoumovianae-Stipetum lessingianae ass. nov., A.l.-K.c. – Com. Artemisia lichiana-Krascheninnikovia ceratoidees, A.m.-F.v. – Ass. Atragalotum macropi-Festucetum valesiacae ass. nov., H.g.-S.p. – Ass. Hedysaro grandiflori-Stipetum pulcherrimae ass. nov., T.m.-C.s. – Ass. Trinio muricatae-

In total, 19 species included in the RB RF were found. Among them, two species of the II category of protection - Astragalus zingeri Korsh. and Iris scariosa Willd. ex Link (species decreasing in numbers), the rest belong to the III category of protection as rare, with a natural small number (Artemisia salsoloides Willd., Globularia punctata Lapeyr., Matthiola fragrans Bunge, Medicago cancellata Bieb., Thymus cimicinus Blum ex Ledeb. etc.).

Rare species of steppe communities make up a significant proportion of regional Red Books. Thus, the presence of 23 species included in the RB RB was recorded, which is 10.4% of the total number of protected species of the Republic of Bashkortostan; 32 species - in the RB OO (21% of the total number of protected species of the Orenburg region).
Table 2. Representatin of rare species in the Cis-Urals steppe communities.

(a)

| Species                               | RB RF | RB RB | RB OO | Endemic | Relic | BP   | BP petro | HS   | HS petro | TS   | TS petro |
|---------------------------------------|-------|-------|-------|---------|-------|------|----------|------|----------|------|----------|
| Artemisia salsoloides Willd.          | 3     | 3     | 1     |         | .     | .    | .        | 4.28 | 3.28     | 6.72 |          |
| Astragalus helmi Fisch. Korsh.         | 2     | 2     | 1     |         | .     | .    | 0.44    | 0.97 | .        | .    |          |
| Fritillaria ruthenica Wikstr.          | 3     | 3     | 1     | 2.48    | .     | .    | 0.64    | .    | 0.05     | .    |          |
| Hedysarum grandiflorum Pall.          | 3     | 3     | 1     |         | .     | .    | 0.44    | 0.21 | .        | .    |          |
| Hedysarum razoumovianum Fisch. & Helm ex DC. | 3     | 3     | 1     | RPS     | .     | .    | .       | 0.17 | 2.44     | 0.11 | 10.04    |
| Iris pumila L.                        | 3     | 3     | 1     |         | .     | .    | 0.35    | 0.93 | 1.83     | 0.55 |          |
| Iris scariosa Willd. ex Link          | 2     | 1     | 1     |         | .     | .    | .       | 0.28 | 0.39     |      |          |
| Koeleria sclerophylla P.A. Smirn.     | 3     | 3     | 1     | RPS     | .     | .    | 6.53    | 0.48 | 6.06     | 0.31 | 0.56     |
| Matthiola fragrans Bunge              | 3     | 1     |       |         | .     | .    | .       | 0.11 |          |      |          |
| Medicago cancellata Bieb.             | 3     | 2     | 1     |         | .     | .    | .       | 0.29 | 0.11     | 4.83 |          |
| Minuartia krascheninnikovii Schischk. | 3     | 3     | 1     | RPS     | .     | .    | 3.58    | 1.11 |          |      |          |
| Oxytropis hippolyti Boriss.           | 3     | 3     | 1     | RPS     | 0.57  | .    | 2.16    | 2.47 |          |      |          |
| Stipa dasiphylla (Lindem.) Trautv.    | 3     | 3     | 1     |         | 0.69  | .    | 1.07    | .    |          |      |          |
| Stipa pennata L.                      | 3     | 3     | 1     | HI      | 28.24 | 19.95| 17.95   | 11.72| 0.08     | 1.06 |          |
| Stipa pulcherrima K. Koch             | 3     | 3     | 1     |         | 2.98  | 9.78 | 11.25   | 9.54 | 0.46     |      |          |
| Stipa zalesskii Wilensky              | 3     | 3     | 2     |         | .     | .    | 14.43   | 1.68 | 2.52     | 0.44 |          |
| Thymus cimicinus Blum ex Lede.        | 3     | 3     | 1     |         | .     | .    | 0.80    | 0.17 | 1.21     |      |          |

Rare species, included in RB RF

| Species                               | RB RF | RB RB | RB OO | Endemic | Relic | BP   | BP petro | HS   | HS petro | TS   | TS petro |
|---------------------------------------|-------|-------|-------|---------|-------|------|----------|------|----------|------|----------|
| Artemisia bargusinensis Spreng.       |       |       |       |         |       | PI   |          |      |          |      |          |
| Cephalaria uralensis (Murr.) Schrad. ex Roem. et Schult. |       |       |       |         |       | .    |          |      |          |      |          |
| Elytrigia intermedia (Host) Nevski    | 3     |       |       |         |       | .    | 1.31    | 1.94 | 0.40     | 1.50 |          |
| Linaria debilis Kuprian.              | 3     |       |       |         |       | .    | 0.38    | 0.08 |          |      |          |
| Linum nervosum Waldst. & Kit.         | 3     |       |       |         |       | .    | 0.09    | 0.05 |          |      |          |
| Species                                      | RB RF | RB RB | RB OO | Endemic | Relic | BP | BP petro | HS | HS petro | TS | TS petro |
|----------------------------------------------|-------|-------|-------|---------|-------|-----|----------|----|----------|----|----------|
| Phlox sibirica L.                            | 3     |       |       |         |       | Pl  | 1.71     |    | 0.07     |    |          |
| Stipa korshinskyi Roshev.                    | 3     |       |       |         |       |     | 5.64     | 7.38| 0.39     |    |          |
| Stipa lessingiana Trin. & Rupr.              | 3     |       |       |         |       |     | 5.31     | 10.55| 24.11    | 10.21|          |
| Stipa sareptana A.K. Becker                  | 3     |       |       |         |       |     | 4.00     | 1.12| 1.39     | 0.83| 3.39     | 3.61|          |
| Thymelaea passerina (L.) Coss. & Germ.       | 3     |       |       |         |       |     |          |    | 0.27     |    |          |
| Trifolium alpestre L.                        | 3     |       |       |         |       |     | 0.57     | 0.15|          |    |          |
| Trinia multicaulis (Poir.) Schischk.         | 2     |       |       |         |       |     |          |    | 0.07     |    |          |
| Tulipa scythica Klokov & Zoiz                | 3     |       |       |         |       |     |          |    | 0.42     | 0.41| 5.34     | 3.35|          |

**Rare species, included in RB RF and RB OO**

| Species                                      | RB RF | RB RB | RB OO | Endemic | Relic | BP | BP petro | HS | HS petro | TS | TS petro |
|----------------------------------------------|-------|-------|-------|---------|-------|-----|----------|----|----------|----|----------|
| Allium obliquum L.                           | 3     |       |       |         |       | Pl  | 0.49     |    |          |    |          |
| Anabasis cretacea Pall.                      | 0     |       | 3     |         |       |     |          |    | 1.47     |    |          |
| Crambe tatarica Sebeok                       | 2     |       | 3     |         |       |     | 0.64     | 0.78|          |    |          |
| Epipactis atrorubens (Hoffm.) Besser         | 3     |       |       |         |       |     | 0.20     |    |          |    |          |
| Glycyrrhiza korshinskyi Grig.                | 3     | 1     |       |         |       |     | 0.05     | 0.05|          |    |          |
| Gypsophila rupestris A. Kuprian.             | 1     | 3     |       |         |       |     |          |    | 0.65     | 0.20|          |
| Helichrysum arenarium (L.) Moench            | 3     | 3     |       |         |       |     | 0.49     | 0.23| 0.05     | 0.39|          |
| Hedysarum argyrophyllum Ledeb.               | 3     | 2     |       |         |       |     | 0.14     | 1.17|          |    |          |
| Linum uralense Juz.                          | 2     |       |       |         |       |     | 0.07     |    |          |    |          |
| Onosma tinctoria M. Bieb.                   | 3     |       |       |         |       |     | 0.05     |    |          |    |          |
| Oxytropis gmelinii Fisch. ex Boriss          | 3     | RPS   |       |         |       |     |          |    |          |    |          |
| Plantago krascheninnikovii C. Serg.          | 3     |       |       |         |       |     |          |    | 0.13     |    |          |
| Zygophyllum pinnatum Cham.                   | 2     | 3     |       |         |       |     |          |    | 1.15     |    |          |

**Rare species, included in RB OO**

| Species                                      | RB RF | RB RB | RB OO | Endemic | Relic | BP | BP petro | HS | HS petro | TS | TS petro |
|----------------------------------------------|-------|-------|-------|---------|-------|-----|----------|----|----------|----|----------|
| Adonis vernalis L.                            | 2     |       |       |         |       |     | 4.24     | 6.48| 3.44     | 0.62|          |
| Allium inderiense Fisch. ex Bunge             | 3     |       |       |         |       |     |          |    | 0.13     | 0.20|          |
| Alyssum lenense Adams                        | 3     |       |       |         |       |     | 1.45     | 0.05| 4.68     | 0.84|          |
| Anabasis salsa (C.A. Mey.) Benth. ex Volkens | 3     |       |       |         |       |     |          |    |          |    | 3.00     |
| Asperula petraea V. I. Krecz. ex Klokov       | 3     |       |       |         |       |     | 0.34     | 2.72|          |    |          |
| Aster alpinus L.                              | 2     | Hi    |       |         |       |     | 0.40     | 11.37| 0.28     | 1.62|          |
| Species                                           | RB RF | RB RR | RB OO | Endemic | Relic | BP | BP petro | HS | HS petro | TS | TS petro |
|--------------------------------------------------|-------|-------|-------|---------|-------|----|----------|----|----------|----|----------|
| *Astragalus physocarpus* Ledeb.                   | 2     | 2     | 2     | .       | .     | .  | 0.33     | .  | .        | .  | .        |
| *Astragalus subarcuatus* Popov                    | 3     | 3     | 3     | .       | .     | .  | 0.13     | 1.18| .        | .  | .        |
| *Astragalus vulpinus* Willd.                      | 3     | 3     | 3     | .       | .     | .  | 0.07     | 0.07| .        | .  | .        |
| *Elytrigia pruinifera* Nevski                     | 3     | 3     | 3     | .       | 0.07  | 0.97| .        | .  | .        | .  | .        |
| *Gentiana cruciata* L.                           | 2     | 2     | 2     | .       | .     | .  | 0.31     | .  | .        | .  | .        |
| *Hedysarum argyrophyllum* Ledeb.                  | 3     | 3     | 3     | .       | 5.80  | 1.69| 2.52     | 0.14| .        | .  | .        |
| *Hedysarum gmelinii* Ledeb.                       | 3     | 3     | 3     | RPS    | 0.57  | 0.49| 1.48     | 1.34| .        | 1.10| .        |
| *Helictotrichon schellianum* (Hack.) Kitag.       | 3     | 3     | 3     | 4.60   | 1.45  | 1.18| 0.23     | .  | .        | .  | .        |
| *Linaria macroura* (M. Bieb.) M. Bieb. Medicago komarovii Vassilcz. | 3 | 3 | 3 | . | . | 0.08 | . | . | . | . | . |
| *Nanophyton erinaceum* (Pall.) Bunge             | 3     | 3     | 3     | .       | .     | .  | 0.76     | 0.39| .        | .  | .        |
| *Orostachys thyrsiflora* Fisch.                   | 3     | 3     | 3     | .       | .     | .  | 0.18     | 0.15| 0.50     | .  | .        |
| *Polygala sibirica* L.                           | 3     | 3     | 3     | 1.20   | 3.20  | 0.28| 2.31     | .  | .        | .  | .        |
| *Pulsatilla patens* (L.) Mill.                   | 2     | 2     | 2     | 3.50   | 1.82  | 3.08| 0.41     | 0.05| .        | .  | .        |
| *Rinderia tretaspis* Pall. Silene baschkirorum    | 3     | 3     | 3     | RPS    | 1.39  | 4.24| 0.83     | 2.03| 1.50     | .  | .        |
| *Tulipa biflora* Pall. *Scorzonera tuberosa* Pall.| 2     | 2     | 2     | .       | .     | .  | 0.15     | 0.35| .        | .  | .        |

**Relic species, not included in Red Books**

| Species                                           | HI | . | . | . |
|--------------------------------------------------|----|---|---|---|
| *Acer platanoides* L.                             | 0.28| . | . | . |
| *Aconitum nemorosum* Bieb. ex Reichenb.           | 0.57| . | . | . |
| *Anemone sylvestris* L.                           | 3.10| 2.39| 3.64| 0.18| .| . |
| *Artemisia armeniaca* Lam.                        | 0.40| 0.73| 0.37| . | . |
| *Artemisia frigida* Wild.                         | 1.69| . | . | 0.30| . | . |
| *Artemisia latifolia* Ledeb.                      | 2.94| 3.51| 4.94| 1.30| . | . |
| *Artemisia santolinifolia* Turcz. ex Besser       | 0.53| . | . | . | . |
| *Artemisia sericea* Weber ex Stechm.              | 11.59| 2.83| 3.49| 0.67| 0.25| . |
| *Astragalus danicus* Retz.                         | 5.86| 1.52| 2.16| . | . | . |
### Table 4: Species from the DZKiD database

| Species                                      | RB RF | RB RO | RB BO | Endemic | Relic | BP | BP petro | HS | HS petro | TS | TS petro |
|----------------------------------------------|-------|-------|-------|---------|-------|----|----------|----|----------|----|----------|
| *Bupleurum multinerve* DC.                   |       |       |       |         | Pi    | 0.28| 2.19     | 0.14|          |    |          |
| *Carex sylvatica* Huds                       |       |       |       |         | Pr    | 0.05|          | 0.14|          |    |          |
| *Cotoneaster melanocarpos* Fisch. ex Bltt    |       |       |       |         | Hi    | 1.79| 0.65     | 0.10| 0.25     |    |          |
| *Dianthus versicolor* Fisch. ex Link          |       |       |       |         | Hi    | 4.70| 1.09     | 1.15| 0.07     | 0.13|          |
| *Digitalis grandiflora* Mill.                |       |       |       |         | Pr    | 0.28|          | 0.05| 0.14     |    |          |
| *Echinops ruthenicus* M. Bieb.               |       |       |       |         | Hi    | 1.62| 9.64     | 5.48| 10.01    | 0.65| 4.62     |
| *Galium verum* L.                            |       |       |       |         | Hi    | 12.13| 5.00    | 10.29| 2.10     | 2.56| 0.35     |
| *Genista tinctoria* L.                       |       |       |       |         | Hi    | 5.46| 3.42     | 1.89| 0.11     | 0.25|          |
| *Geranium pseudosibiricum* J. Mayer          |       |       |       |         | Pi    | 1.13|          |      |          |    |          |
| *Gypsophila altissima* L.                    |       |       |       |         | Hi    | 3.96| 8.00     | 6.30| 6.96     | 0.20|          |
| *Helictotrichon desertorum* (Less.) Nevski   |       |       |       |         | Hi    | 19.89| 21.17  | 23.73| 13.91    |    |          |
| *Onosma simplicissima* L.                    |       |       |       |         | Hi    | 2.50| 7.32     | 4.25| 6.86     | 0.93| 0.56     |
| *Oxytropis pilosa* (L.) DC.                  |       |       |       |         | Hi    | 3.67| 3.92     | 5.35| 1.56     | 0.33|          |
| *Phleum phleoides* (L.) H. Karst.            |       |       |       |         | Hi    | 7.18| 1.17     | 3.45| 1.07     |    |          |
| *Phlomoides tuberosa* (L.) Moench            |       |       |       |         | Hi    | 6.92| 2.96     | 3.91|          | 2.03|          |
| *Poa transbaicalica* Roshev.                 |       |       |       |         | Hi    | 11.68| 0.05   | 5.90|          |    |          |
| *Primula cortusoides* L.                     |       |       |       |         | Pi    | 0.69|          |      |          |    |          |
| *Sedum hybridum* L.                          |       |       |       |         | Pi    | 0.07|          |      |          |    |          |
| *Seseli lidebourii* G. Don                   |       |       |       |         | Hi    | 0.05|          |      |          |    |          |
| *Spiraea crenata* L.                         |       |       |       |         | Hi    | 8.57| 1.83     | 0.82| 0.33     | 0.39|          |
| *Thalictrum foetidum* L.                     |       |       |       |         | Pi    | 3.17| 0.05     | 1.19|          |    |          |
| *Veronica spicata* L.                        |       |       |       |         | Hi    | 6.69| 9.07     | 6.24| 2.59     | 0.44|          |
| *Vincetoxicum albovianum* (Kusn.) Pobed.     |       |       |       |         | Hi    | 1.70| 7.10     | 1.60| 1.18     |    |          |
| *Viola mirabilis* L.                         |       |       |       |         | Pr    | 0.28| 0.20     | 0.10|          |    |          |

**Endemic species, not included in Red Books**

| Species                                      |        |       |       |        |
|----------------------------------------------|--------|-------|-------|--------|
| *Dianthus acicularis* Fisch. ex Ledeb.        | RPS    | 2.48  | 0.28  | 2.42   |
| *Oxytropis spicata* (Pall.) O. Fedtsch. & B. Fedtsch. | RPS    | 0.57  | 0.79  | 0.91   | 0.85  |
| *Potentilla goldbachi* Rupr.                  | RPS    | 2.30  | 0.51  | 0.48   |
In the cenoflora of communities, 16 endemic species belonging to the group of rock and petrophytic steppe endemics were found in the understanding of P.V. Kulikov. Among them are endemics of the Southern Urals (Astragalus helmii Fisch., Hedysarum razumovianum Fisch. et Helm, Minuartia krascheninnikovii Schischk. etc.), a narrow-local endemic of the Southern Urals Plantago krascheninnikovii C. Serg. The patterns of distribution of rare species according to the orders of steppe vegetation of the Southern Urals are of a particular interest. One of the main types of habitats associated with the distribution of endemic Urals are rocky steppes. This is reflected in the activity values of Koeleria sclerophylla P. Smirn., Minuartia krascheninnikovii, Hedysarum razumovianum, Dianthus acicularis Fisch. ex Ledeb., which is higher in petrophytic associations. This is due to the fact that in conditions of intense erosion and almost undeveloped soil cover, interspecific competition from more cenotically active species is reduced. Endemic species in the communities of Cis-Urals are characterized by relatively low activity. Differentiation of endemic composition in communities of different orders of order was recorded. Rock and mountain-steppe endemics of the Urals – Astragalus helmii, Hedysarum razumovianum, Koeleria sclerophylla is affine to true and dry steppes communities, Oxytropis hippoclyti Boriss. is found in communities of true and meadow steppes. These species, as a rule, are confined to rocky substrates on the middle and lower parts of the slopes, as well as to rock outcrops. Subendemic of the Urals and the surrounding territories Dianthus acicularis s.l. and the subendemic of the Volga and Southern Urals Thymus bashkiriensis are presented mainly in petrophytic variants of true steppes.

Relict flora is presented by 39 species. Most of them (25 species) belong to the Holocene (Anemone sylvestris L., Artemisia armeniaca Lam., A. frigida Willd., Aster alpinus L., Astragalus danicus Retz., Cotoneaster melanocarus Fisch. ex Blytt etc.) The group of Pleistocene relics is represented by 11 species (Azizopsis hybridra (L.) Grulich, Allium obliquum L., Bupleurum multinerve DC., Linaria debilis Kuprian., Orostachys spinosum (L.) C.A. Mey. etc.). Their distribution by order communities is also differentiated: they are practically not found in dry steppes of the order Tanacetetalia, the most active in true steppes of the order Helicotricho-Stipetalia. The presence of species of mountain Asian origin (Azizopsis hybridra (L.) Grulich, Linaria debilis Kuprian., Thalictrum foetidum L., etc.) associated with petrophytic steppes reflects the formation of the flora of rocky habitats in the post-glacial period, when undisturbed substrates of pristine habitats with poor development were released in a fairly dry and cold climate Among them is Artemisia bargusinensis, a species included in...
the RB RB with the assignment of 1 status of protection and found only in the Aslykul Natural Park, and species with status 3 (Linaria debilis, Phlox sibirica L., Allium obligatum L.). Part of the Pleistocene relics of Asian origin (Primula cortusoides L., Aconitum nemorosum Bieb. ex Reichenb., Geranium pseudosibiricum J. Mayer) is historically associated with rare light forests and is confined to associations of the order Brachipodietalia pinnati.

A more numerous group of Holocene relics, including community dominants (Stipa pennata L., Helictotrichon desertorum (Less.) Nevski, Poa transbaicalica Roshev.), and high-constant species of grassland (Echinops ruthenicus M. Bieb., Astragalus danicus Retz., Gypsophylla altissima L. etc.) and some species of rocky habitats (Aster alpinus L., Artemisia frigida Willd., Cotoneaster melanocarpus Fisch. ex Blytt). The activity of dominant grasses and herbaceous species is highest in the zonal types of communities of true steppes, which corresponds to the central part of the latitudinal gradient and moderate moistening conditions. The presence of such widespread steppe species as Galium verum L., Phlomoides tuberosa (L.) Moench, Poa transbaicalica, Helictotrichon desertorum, Onosma simplicissima L. in island forest-steppe communities reflects the significant advance of steppe vegetation north in the Holocene and the relict matter of these communities outside the steppe zone. Holocene relics are relatively rare in plant communities of the most "dry" order Tanacetetum achillefoli-t-Stipetalia lessingianae.

Few Pliocene relics (3 species): Carex sylvatica Huds., Digitalis grandiflora Mill., Viola mirabilis L. belong to species of European broad-leaved forests and are found in the steppes only in contact with forest and edges in the forest-steppe zone.

Centaureetum sibiricae Yamalov et al. 2011, A.m.-S.t. – Ass. Astragalo macropi-Salvietum tesquicolae ass. nov., S.n.-S.k. – Ass. Salvio nutans-Stipetum korschinskii Martynenko et al. 2018, A.m.-S.z. – Ass. Amorio montanae-Stipetum zalesskii ass. nov., V.h.-S.z. – Com. Viola hirta-Stipa zalesskii, I.a.-P.p. – Ass. Inulo asperae-Pulsatilletum patensae ass. nov., G.v.-S.t. – Ass. Galio veri-Stipetum tirsae Yamalov et al. 2012, S.p.-C.s. – Ass. Stipo pennatae-Centaureetum sibiricae Bayanov in Yamalov et al. 2012, A.a.-S.p. – Ass. Astragalo austriacae-Stipetum pulcherrimae Martynenko et al. 2018, L.v.-S.p. – Ass. Leucanthemo vulgaris-Stipetum pennatae Bayanov in Yamalov et al. 2012, M.k.-F.p. – Ass. Minuartio krascheninnikovii-Festucetum pseudovinum Yamalov et al. 2011, F.r.-F.v. – Ass. Fritillario ruthenicae-Festucetum valesiaceae, P.a.-S.p. – Ass. Poo angustifoliae-Stipetum pennatae Yamalov et al. 2012.

The representation of rare species in the types of communities considered varies. So, in communities of 5 associations, the proportion of the rare component is 20% or more of the total volume of cenoflora, in communities of 11 associations - 11-19%, in 3 associations - 10% or less. The maximum number of rare species (52) is represented in the communities of the true steppes associations Salvio nutans-Stipetum korschinskii and Astragalo austriacae-Stipetum pulcherrimae. They are distributed mainly in the southern part of the forest-steppe zone within the Republic of Bashkortostan, most localities are recorded in the Aslykul Natural Park. The representation of the rare component is determined both by the total high volume of cenoflora, which is 266 and 307 species, respectively, and is characteristic of the true steppes of the forest-steppe zone, and by the relatively high level of protection of communities in the protected areas.

4. Conclusions
As a result of the analysis of the cenoflora of the Cis-Ural steppe communities, 103 rare species, relict and endemic were identified, which is 15.4% of the total cenoflora. Among them are 19 species included in the RB RF. Rare species make up a significant part of regional Red Books. So, 32 species are included in the RB OO (21% of the total number of protected species of the Orenburg region). The 16 endemic species was revealed, mainly belonging to the group of rock and petrophytic steppe endemics of Asian origin. Relict flora has 39 species. Most of them (25 species) belong to the Holocene. The group of Pleistocene relics is represented by 11 species. The distribution of rare species between different syntaxa demonstrated that they are mostly presented in communities of petrophytic
variants of true steppes of the two associations Salvio nutans-Stipetum korschinskii (20% - 52 species) and Astragalo austriacae-Stipetum pulcherrimae (17% - 52 species). It is caused by their confluence with heterogeneous landscapes at the junction of the steppe and forest-steppe zones, growing on limestone substrates and providing protection in the Aslykul Natural Park. The data confirm the high environmental importance of the steppes of the Southern Cis-Urals and can serve as a basis for the formation of an integrated strategy for the protection of these communities.

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