



# The steppe communities in urban ecosystems in the South Urals: syntaxonomy and conservations

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## ABSTRACT

The study of flora and vegetation of cities of the south of the Republic of Bashkortostan (Salavat, Ishimbai, and Meleuz) was performed during 2008–2012. Within the boundaries of cities, plots of surviving remnant steppe vegetation with a considerable concentration of rare plant species were found. For their characteristics, 90 relevés of steppe vegetation were performed. In the course of data analysis, we found that the syntaxonomy of the steppe vegetation of the cities of the Southern Industrial Zone of the Republic of Bashkortostan includes 1 class, 2 orders, 3 alliances, 7 associations, 2 subassociations, and 2 variants. In the coenoflora of plant communities of the class *Festuco-Brometea* recorded within the cities, of the 15 rare species listed in the Red Data Books of the Republic of Bashkortostan and the Russian Federation, 7 endemic, and 1 relic plant species were revealed. These species are unique for urban territories. We suggest creating 4 urban natural sanctuaries to protect steppe communities.

**Keywords:** South Urals, steppe vegetation, syntaxonomy, class *Festuco-Brometea*, rare species, conservation of vegetation cover

## РЕЗЮМЕ

### Резюме

**Голованов Я.М., Ямалов С.М., Абрамова Л.М. Степные сообщества в урбанизированных экосистемах Южного Урала: синтаксономия и вопросы охраны.** Изучение флоры и растительности городов юга Республики Башкортостан (города Салават, Ишимбай и Мелеуз) проводились в течение 2008–2012 гг. В пределах границ городов были отмечены участки сохранившейся степной растительности с высокой концентрацией редких видов растений. Для ее характеристики было выполнено 90 геоботанических описаний. В ходе их анализа было выявлено, что синтаксономия степной растительности городов Южной промышленной зоны Республики Башкортостан включает 1 класс, 2 порядка, 3 союза, 7 ассоциаций, 2 субассоциации и 2 варианта. В ценофлоре растительных сообществ класса *Festuco-Brometea*, отмеченных в пределах городов, выявлено 15 редких видов, занесенных в Красные книги Республики Башкортостан и Российской Федерации, 7 эндемичных и реликтовый вид растений. Данные виды являются уникальными для городских территорий. Для охраны степных сообществ предложено создать 4 городских памятника природы.

**Ключевые слова:** Южный Урал, степная растительность, синтаксономия, класс *Festuco-Brometea*, редкие, охрана растительного покрова

Cities are ecosystems in which a greater part of the planet's human population is concentrated. At the present time, the area of urbanized territories in the world occupies only 5 % of the entire land, and about 3 billion people live in this area, from which it follows that in connection with an increase in the scale of urbanization, the study of vegetation cover of cities becomes increasingly urgent.

Within city boundaries, two main variants of vegetation communities can be distinguished. The first is anthropogenic. This includes purposefully created green plantings and very widespread communities of synanthropic species. The second variant represents natural ecotopes that pene-

trated the administrative boundaries of the urban territory. In many cities, large fragments of natural vegetation: forest massifs, coastal phytocoenoses, swampy sites of river floodplains, inundated and dry meadows, steppe plots, etc. are retained. About two thirds of plants entering in the composition of urbanoflora are related to such refuges. Endemic, relic, and "Red Data Book" species are also rather frequently found on these territories.

All this indicates that it is necessary to include into the system of specially protected nature territories (SPNT) fragments of urbanized landscapes that are shelters of rare and protected species (Ilminkikh & Tarasova 1992).

They should be given the status of a nature reserve without allowing any commercial activity (Tikhomirov 1988). As Ilminskikh & Porfirev (1979) noted, that according to the mode of use, an urban natural sanctuary belongs neither to protected areas, nor to nature reserves. Urban monuments can have a local importance since they can enter also in the local network of SPNT of a regional scale depending on the degree of preservation and uniqueness of the objects under protection present over their territory.

Taking into account the importance of this problem, it is necessary to note that the number of works concerning preservation of the flora of urban territories in the Russian Federation is rather small (Ilminskikh 1982, Chopik et al. 1986, Ilminskikh & Tarasova 1992, Kuvaev et al. 1992, Dvinskikh et al. 2011, Buzmakov et al. 2012). However, during recent time, parallel to regional Red Data Books, Red Data Books of individual urban territories, as, for instance, “The Red Data Book of Nature of Saint Petersburg” (Noskov 2004) and “The Red Data Book of Moscow” (Samoilov & Morozova 2011) have been established.

## MATERIAL AND METHODS

We studied the flora and vegetation of cities of the Southern Industrial Zone of the Republic of Bashkortostan (Salavat, Ishimbai, and Meleuz) during 2008–2012 (Golovanov et al. 2011, 2014, Golovanov & Abramova 2012 a, b, 2013). Some data on the key characteristics of the cities are presented in Table 1.

All three cities are located in the south of Cisurals of the Republic of Bashkortostan (RB) (Fig. 1) in the fluvial plain of the Belaya River, as well as its tributaries: in the city of Ishimbai – the Tairuk River and in the city of Meleuz – the Meleuz and Karan rivers.

The territory of the cities is characterized by a continental climate. The average temperature in January is  $-14.7^{\circ}\text{C}$ , the average temperature of July  $+19.2^{\circ}\text{C}$ , and the average annual amount of precipitation is 410–460 mm (Yaparov 2005).

A large branch of the Kuibyshev railroad, as well as a federal highway Ufa-Orenburg pass over the territory of Salavat and Meleuz where the city of Ishimbai is slightly away from big transport routes. The cities also possess a developed industrial complex with maximum development in the city of Salavat – JSC Gazprom Neftekhim Salavat.

In the boundaries of these cities, plots of surviving steppe vegetation with a considerable concentration of rare plant species were revealed. For their characteristics, 90 relevés of steppe vegetation were performed. The size of the sample area depended on the size and uniformity of a community. Data were sampled according to the methods of Zürich-Montpellier school (Braun-Blanquet 1964, Westhoff & Van Den Maarel 1978). Extended Braun-Blanquet 5-degree cover-abundance scale was used (Mirkin et al. 1989). All the relevés were imported into TURBOVEG, database program for storing of phytosociological data (Hennekens & Schaminée 2001), and consecutively edited in the program MEGATAB (Hennekens 1995) and JUICE (Tichý 2002).

**Table 1.** Characteristic of three cities of the Southern Industrial Zone of the Republic of Bashkortostan

City	Date of foundation	Area, km <sup>2</sup>	Population, thousands people	Natural zone
Salavat	1948	111.4	156.0	Steppe
Ishimbai	1940	103.0	68.1	Forest-steppe
Meleuz	1958	35.5	61.4	Steppe



**Figure 1** Localization of the cities on the Map of the Republic of Bashkortostan

**Table 2.** Synoptic table of associations of the class *Festuco-Brometea*

Table 2. Continued

Syntaxon nr.	1	2	3	4	5	6	7	8	9
<b>Mean nr. of species</b>	<b>40</b>	<b>41</b>	<b>28</b>	<b>26</b>	<b>36</b>	<b>30</b>	<b>28</b>	<b>18</b>	<b>28</b>
<b>Number of relevés</b>	<b>14</b>	<b>6</b>	<b>12</b>	<b>6</b>	<b>10</b>	<b>5</b>	<b>10</b>	<b>12</b>	<b>10</b>
<b>D.S. Ass. <i>Poo angustifoliae-Stipetum pennatae</i></b>									
<i>Stipa pennata</i>	V <sup>1-2</sup>	V <sup>1</sup>	I	IV	III	I	IV	I	III
<i>Amoria montana</i>	IV	V	III	II	I	.	II	.	.
<i>Thymus marschallianus</i>	IV	V	III	.	III	III	I	.	.
<i>Phleum phleoides</i>	II	V	III	.	.	.	I	.	.
<i>Onobrychis arenaria</i>	III	.	.	.	III	.	.	.	.
<b>D.S. var. <i>Helictotrichon desertorum</i></b>									
<i>Helictotrichon desertorum</i>	V <sup>1-2</sup>	.	II	I	II	.	IV	.	.
<b>D.S. var. <i>Calamagrostis epigeios</i></b>									
<i>Calamagrostis epigeios</i>	V <sup>1-2</sup>	I	.	.	.	.	.	.	.
<b>D.S. Ass. <i>Fragario viridis-Caraganeum fruticosum</i></b>									
<i>Caragana frutex</i>	V	V	V <sup>3-4</sup>	V <sup>3-4</sup>	V	V	III	III	V
<b>D.S. Subass. <i>F. v.-C. f. festucetosum pseudovinae</i></b>									
<i>Festuca pseudovina</i>	V	V	V <sup>2-2</sup>	IV	III	V	IV	V	.
<i>Spiraea crenata</i>	I	V	IV	IV	.	I	.	.	.
<b>D.S. Subass. <i>F. v.-C. f. poetosum angustifoliae</i> and Ass. <i>Poo angustifoliae-Stipetum pennatae</i></b>									
<i>Poa angustifolia</i>	III	V	V	V <sup>1-2</sup>	.	I	.	.	.
<i>Achillea millefolium</i>	IV	V	III	IV	.	.	.	.	.
<b>D.S. Ass. <i>Astragalus austriacae-Stipetum pulcherrimae</i> and Ass. <i>Hedysaro grandiflori-Stipetum pulcherrimae</i></b>									
<i>Astragalus austriacus</i>	III	.	.	V <sup>+1</sup>	V	V	I	.	.
<i>Stipa pulcherrima</i>	.	.	II	III	V <sup>3</sup>	.	.	I	III
<b>D.S. Ass. <i>Scorzonero austriacae-Stipetum lessingiana</i></b>									
<i>Stipa lessingiana</i>	.	.	.	.	V <sup>2-3</sup>	.	III	II	.
<i>Scorzonera austriaca</i>	.	.	.	II	III	.	III	V	.
<b>D.S. Ass. <i>Salvia nutans-Stipetum korsinskyi</i></b>									
<i>Stipa korsinskyi</i>	II	.	.	.	.	V <sup>2-3</sup>	.	.	.
<b>D.S. Ass. <i>Trinia muricati-Centauretum sibiricae</i> and Ass. <i>accoшaцaии Hedysaro grandiflori-Stipetum pulcherrimae</i></b>									
<i>Centaurea sibirica</i>	II	.	I	.	V	IV	II	IV <sup>2</sup>	V
<i>Astragalus helmii</i>	.	.	.	.	I	IV	.	V <sup>+2</sup>	IV
<i>Alyssum lenense</i>	.	.	.	.	.	.	I	III	.
<i>Hedysarum grandiflorum</i>	.	.	.	.	.	.	II	V <sup>+2</sup>	.
<i>Trinia muricata</i>	.	.	.	I	.	.	III	V	.
<b>D.S. Ass. <i>Hedysaro grandiflori-Stipetum pulcherrimae</i></b>									
<i>Ephedra distachya</i>	.	.	.	.	.	.	II	IV	.
<i>Potentilla glaucescens</i>	I	.	.	.	.	V	V	III	.
<i>Jurinea ledebourii</i>	.	.	.	.	.	.	I	II	.
<b>D.S. Var. <i>Astragalus helmii</i></b>									
<i>Artemisia salsoloides</i>	.	.	.	.	.	.	II	V	.
<b>D.S. Suball. <i>Helictotricho desertori-Stipetum zaleskii</i></b>									
<i>Carex pediformis</i>	I	I	II	.	IV	V	IV	III	V
<i>Galium octonarum</i>	III	I	III	I	V	III	V	III	V
<i>Gypsophila altissima</i>	III	.	I	.	V	II	IV	III	II
<i>Tanacetum kittaryanum</i>	I	.	.	.	I	IV	III	III	III
<i>Polygala sibirica</i>	I	.	.	.	II	III	II	II	.
<i>Scabiosa isetensis</i>	.	.	.	.	IV	V	III	III	V
<i>Echinops ruthenicus</i>	.	.	.	III	III	.	II	IV	V
<i>Alyssum tortuosum</i>	I	.	.	.	.	III	III	III	V
<i>Artemisia marschalliana</i>	.	.	.	.	IV	II	II	IV	.
<i>Galium tinctorium</i>	V	V	I	.	.	.	I	.	.
<i>Eremogone koriniana</i>	II	.	I	I	.	II	.	I	.
<i>Agropyron pectinatum</i>	.	.	.	.	III	.	.	V	IV
<i>Oxytropis floribunda</i>	.	.	.	.	.	IV	.	III	III
<i>Koeleria sclerophylla</i>	.	.	.	.	.	.	III	III	V
<i>Euphorbia seguierana</i>	.	.	.	I	.	.	.	III	V
<i>Dianthus acicularis</i>	.	.	.	.	III	.	.	II	.
<i>Asperula petraea</i>	.	.	.	.	.	.	IV	III	.
<i>Thymus uralensis</i>	.	.	.	.	.	.	II	III	.
<i>Stipa korsinskyi</i>	.	.	.	.	.	IV	.	I	.
<i>Clausia aprica</i>	.	.	.	.	.	.	.	II	IV
<i>Orites baschkirorum</i>	.	.	.	.	.	.	.	I	III

Syntaxon nr.	1	2	3	4	5	6	7	8	9
<i>Hedysarum × polychromum</i>	.	.	.	.	.	.	.	II	II
<i>Allium globosum</i>	.	.	.	.	.	.	.	I	II
<i>A. rubens</i>	.	.	.	.	.	.	.	II	I
<i>Crambe tataria</i>	.	.	.	.	.	.	.	I	I
<b>D.S. All. <i>Helictotricho-Stipion</i> and Ord. <i>Helictotricho-Stipetalia</i></b>									
<i>Artemisia austriaca</i>	III	IV	II	.	II	III	III	III	V
<i>Salvia stepposa</i>	V	V	V	III	V	V	IV	I	.
<i>Onosma simplicissima</i>	III	.	II	III	V	IV	IV	III	IV
<i>Androsace maxima</i>	I	.	.	.	II	II	II	II	III
<i>Euphorbia caesia</i>	II	.	.	.	III	IV	III	III	V
<i>Carex supina</i>	II	II	I	.	II	.	I	.	.
<i>Galatella angustissima</i>	III	.	II	.	II	.	II	.	.
<i>Potentilla humifusa</i>	I	.	.	.	III	.	II	I	.
<i>Achillea nobilis</i>	.	I	I	.	.	I	I	.	.
<i>Verbascum phoenicium</i>	II	.	.	II	.	.	I	.	.
<b>D.S. All. <i>Festucetalia valesiaca</i>, Ord. <i>Festucetalia valesiaca</i> and Class <i>Festuco-Brometea</i></b>									
<i>Stipa capillata</i>	II	III	V	I	III	IV	II	II	III
<i>Thalictrum minus</i>	IV	V	V	III	IV	III	III	I	.
<i>Galium verum</i>	V	V	V	V	III	I	I	I	.
<i>Veronica spicata</i>	III	IV	I	II	I	.	I	I	I
<i>Fragaria viridis</i>	IV	V	V	II	III	III	.	.	.
<i>Filipendula vulgaris</i>	IV	V	IV	II	III	.	II	.	.
<i>Medicago romanica</i>	II	.	II	.	IV	I	II	I	.
<i>Cerasus fruticosa</i>	I	I	III	IV	II	.	.	.	.
<i>Phlomis tuberosa</i>	IV	V	V	I	I	.	I	.	.
<i>Inula hirta</i>	V	III	II	I	II	.	II	.	.
<i>Artemisia sericea</i>	IV	III	V	III	III	.	.	.	II
<i>Plantago urvillei</i>	II	IV	I	.	II	I	III	.	.
<i>Viola ambigua</i>	II	.	I	.	II	I	IV	I	.
<i>Artemisia latifolia</i>	.	.	IV	IV	IV	IV	II	.	.
<i>Koeleria cristata</i>	IV	I	I	.	.	.	.	I	I
<i>Campanula sibirica</i>	IV	.	II	.	I	V	.	.	.
<i>Potentilla argentea</i>	I	V	II	I	.	.	.	.	.
<i>Aster amellus</i>	III	.	.	.	I	I	I	.	.
<i>Adonis vernalis</i>	III	.	III	V	.	.	.	.	.
<i>Dianthus versicolor</i>	II	III	III	.	.	.	.	.	.
<i>Festuca valesiaca</i>	.	.	.	.	.	.	.	I	I
<i>Anemone sylvestris</i>	II	.	.	.	.	I	I	.	.
<i>Seseli libanotis</i>	.	III	.	I	.	.	.	.	.
<i>Oxytropis pilosa</i>	II	.	.	.	I	.	.	.	.
<i>Trommsdorffia maculata</i>	.	II	.	.	I	.	.	.	.
<b>D.S. Class <i>Molinio-Arrhenatheretea</i></b>									
<i>Bromopsis inermis</i>	IV	II	III	V	I	.	.	.	.
<i>Astragalus danicus</i>	IV	III	I	.	.	I	I	.	.
<i>Elytrigia repens</i>	IV	.	III	.	II	.	III	.	.
<i>Vicia cracca</i>	I	IV	I	.	.	.	II	.	.
<i>Primula macrocalyx</i>	II	V	I	.	.	.	.	.	.
<i>Plantago media</i>	I	III	.	II	.	.	.	.	.
<i>Ranunculus polyanthemos</i>	I	III	.	II	.	.	.	.	.
<i>Pimpinella saxifraga</i>	I	II	.	.	I	.	.	.	.
<i>Carex praecox</i>	.	II	.	III	.	.	.	.	.
<i>Sanguisorba officinalis</i>	.	III	I	.	.	.	.	.	.
<b>D.S. Class <i>Trifolio-Geranietea</i></b>									
<i>Agrimonia asiatica</i>	I	.	I	I	II	I	.	.	.
<i>Origanum vulgare</i>	.	I	I	.	I	.	I	.	.
<i>Trifolium medium</i>	I	IV	I	.	.	.	.	.	.
<i>Potentilla goldbachii</i>	I	I	.	II	.	.	.	.	.
<i>Pyrethrum corymbosum</i>	I	.	I	.	I	.	.	.	.
<i>Hypericum perforatum</i>	.	.	I	.	.	.	.	I	.
<i>Campanula bononiensis</i>	I	.	.	.	I	.	.	.	.
<b>D.S. Class <i>Stellarietea mediae</i></b>									
<i>Convolvulus arvensis</i>	II	.	IV	II	II	II	III	II	.
<i>Lactuca serriola</i>	.	.	.	.	II	.	I	.	.
<i>Camelina microcarpa</i>	.	.	I	.	.	I	.	.	.
<b>D.S. Class <i>Artemisietea vulgaris</i></b>									
<i>Falcaria vulgaris</i>	II	II	III	II	III	I	I	.	.
<i>Cichorium intybus</i>	.	.	I	.	.	II	.	I	.
<i>Cynoglossum officinale</i>	.	II	I	.	.	.	I	.	.
<i>Lappula squarrosa</i>	.	.	.	.	I	I	.	I	.

Table 2. Continued

Syntaxon nr.	1	2	3	4	5	6	7	8	9
<i>Euphorbia virgata</i>	.	III	II	.	.	.	.	.	.
<b>Other species:</b>									
<i>Galatella villosa</i>	II	II	I	II	I	.	I	I	IV
<i>Thesium arvense</i>	III	II	I	.	I	.	II	I	I
<i>Scorzonera purpurea</i>	III	III	III	.	II	.	II	I	.
<i>Eremogone longifolia</i>	II	V	II	IV	.	.	II	.	.
<i>Asparagus officinalis</i>	I	I	I	V	II	.	.	.	.
<i>Taraxacum proximum</i>	II	II	I	.	.	I	.	I	.
<i>Galium boreale</i>	IV	IV	III	I	.	.	.	.	.
<i>Astragalus wolgensis</i>	II	.	.	.	III	IV	I	I	V
<i>Vincetoxicum hirundinaria</i>	III	I	.	III	II	.	.	.	.
<i>Dianthus andrzejewskianus</i>	II	.	.	.	I	.	I	I	.
<i>Orites wolgensis</i>	III	I	.	.	I	.	.	.	I
<i>Carex caryophylla</i>	IV	IV	I	.	.	.	.	.	.
<i>Artemisia armeniaca</i>	V	V	I	.	.	.	.	.	.
<i>Eryngium planum</i>	I	I	.	IV	.	.	.	.	.
<i>Astragalus macropus</i>	II	.	.	.	III	.	II	.	.
<i>Eremogone micradenia</i>	II	.	II	.	.	.	II	.	.
<i>Campanula wolgensis</i>	III	V	.	I	.	.	.	.	.
<i>Artemisia marchalliana</i>	I	.	II	.	.	.	.	.	III
<i>Inula aspera</i>	II	.	.	.	I	I	.	.	.
<i>Silene chlorantha</i>	II	.	.	.	I	.	I	.	.
<i>Galatella biflora</i>	I	.	.	IV	.	.	.	.	.
<i>Lupinaster albus</i>	III	V	.	.	.	.	.	.	.

Table 2. Continued

Syntaxon nr.	1	2	3	4	5	6	7	8	9
<i>Silaum silaus</i>	I	.	.	IV	.	.	.	.	.
<i>Campanula wolgensis</i>	.	.	III	I	.	.	.	.	.
<i>Eremogone sp.</i>	.	.	.	.	II	III	.	.	.
<i>Xanthoxylum alsaticum</i>	I	.	.	III	.	.	.	.	.
<i>Pilosella echioides</i>	.	.	I	.	.	.	.	.	III
<i>Artemisia pontica</i>	I	.	.	II	.	.	.	.	.
<i>Melica transsilvanica</i>	I	.	.	.	.	II	.	.	.
<i>Tragopogon dubius</i>	.	.	.	.	.	II	.	I	.
<i>Oxytropis spicata</i>	II	.	.	.	I	.	.	.	.
<i>Centaurea ruthenica</i>	I	.	II	.	.	.	.	.	.
<i>Stachys recta</i>	.	.	.	I	II	.	.	.	.
<i>Melampyrum arvense</i>	.	.	I	.	II	.	.	.	.
<i>Galium album</i>	.	.	I	I	.	.	.	.	.
<i>Eriocaulum armoracoides</i>	I	.	.	.	I	.	.	.	.
<i>Goniolimon elatum</i>	.	.	I	.	.	.	.	.	I
<i>Veronica prostrata</i>	I	.	.	.	.	.	.	I	.
<i>Vincetoxicum albanianum</i>	.	.	.	.	I	.	I	.	.
<i>Alyssum turkestanicum</i>	.	.	.	.	.	.	.	I	I
<i>Elytrigia lolioides</i>	.	.	.	.	.	I	.	.	I
<i>Serratula gmelinii</i>	.	.	I	I	.	.	.	.	.
<i>Senecio jacobaea</i>	.	.	.	I	.	.	I	.	.
<i>Helictotrichon scabellianum</i>	I	I	.	.	.	.	.	.	.
<i>Hylotelephium stepposum</i>	I	I	.	.	.	.	.	.	.

**Taxa in one syntaxon:** *Aconogonon alpinum* (2) +; *Agrostis gigantea* (4) r; *Allium strictum* (5) I; *Androsace septentrionalis* (2) I; *Aster alpinus* (7) II; *Astragalus cicer* (3) I; *Astragalus sp.* (8) r; *Berteroa incana* (3) II; *Campanula persicifolia* (2) r; *Carduus acanthoides* (1) r; *C. nutans* (1) r; *Cephalaria uralensis* (3) r; *Crambe tatarica* (9) I; *Echinops sphaerocephalus* (1) I; *Euphorbia semivillosa* (4) r; *Fritillaria ruthenica* (2) r; *Gagea pusilla* (5) II; *Galium aparine* (3) I; *Gentiana cruciata* (1) r; *Hieracium proceriforme* (5) r; *Knautia arvensis* (3) r; *Koeleria delavignei* (2) r; *Lactuca tatarica* (8) I; *Lathyrus pratensis* (3) r; *Lavatera thuringiaca* (1) I; *Linaria vulgaris* (9) +; *Linum uralense* (9) r; *Lonicera tatarica* (3) I; *Melampyrum argyrocomum* (4) I; *Melica altissima* (3) I; *Meniocus linifolius* (8) I; *Nepeta ucranica* (3) r; *Pedicularis kaufmannii* (2) V; *P. uralensis* (1) r; *Poa compressa* (1) I; *Polygala comosa* (2) +; *Potentilla recta* (4) r; *Primula macrocalyx* (3) r; *Ranunculus polyanthemos* (2) r; *Rhamnus cathartica* (4) I; *Rumex thyrsiflorus* (1) r; *Salvia verticillata* (1) +; *Serratula lycopifolia* (1) r; *Silene nutans* (2) IV; *Sisymbrium polymorphum* (9) II; *Solidago virgaurea* (3) I; *Sonchus arvensis* 4 (II), *Stachys officinalis* (3) r; *Stellaria graminea* (4) IV; *Steris viscaria* (2) V; *Stipa sareptana* (7) r; *Taraxacum proximum* (4) r; *Turritis glabra* (2) II; *Valeriana dubia* (4) r; *Veronica spuria* (3) I; *V. teucrium* (3) r; *Viola collina* (3) +.

**Syntaxon number:** 1–2 *Poo angustifoliae-Stipetum pennatae* (1 *Helictotrichon desertorum*, 2 *Calamagrostis epigeios*), 3–4 *Fragario viridis-Caraganetum fruticos* (3 F. v.-C. f. *festucetosum pseudovinae*, 4 F. n.-C. f. *poetosum angustifoliae*), 5 *Astragalo austriacae-Stipetum pulcherrimae*, 6 *Scorzonero austriacae-Stipetum lessingianae*, 7 *Salvio nutantis-Stipetum korschinskyi*, 8 *Trinio muricati-Centauretum sibiricae*, 9 *Hedysaro grandiflori-Stipetum pulcherrimae*.

## RESULTS AND DISCUSSION

The hierarchical system of lower syntaxa of the urban steppe vegetation of South Urals includes 1 class, 2 orders, 3 alliances, 7 associations, 2 subassociations, and 2 variants.

### Prodromus of the urban steppe vegetation

*Festuco-Brometea* Br.-Bl. et Tx. ex Soó 1947

*Festucetalia valesiaca* Br.-Bl. et Tx. ex Br.-Bl. 1949

*Festucion valesiaca* Klika 1931

*Poo angustifoliae-Stipetum pennatae* Yamalov et al. 2012

*Helictotrichon desertorum*

*Calamagrostis epigeios*

*Amygdalion nanae* V. Golub ex Yamalov 2011

*Fragario viridis-Caraganetum fruticos* Yamalov et Sultangareeva 2010

*F. v.-C. f. festucetosum pseudovinae* subass. nov. prov.

*F. v.-C. f. poetosum angustifoliae* subass. nov. prov.

*Helictotricho-Stipetalia* Toman 1969

*Helictotricho desertori-Stipion rubentis* Toman 1969

*Astragalo austriacae-Stipetum pulcherrimae* ass. nov. prov.

*Scorzonero austriacae-Stipetum lessingianae* ass. nov. prov.

*Salvio nutantis-Stipetum korschinskyi* ass. nov. prov.

*Trinio muricati-Centauretum sibiricae* Yamalov et al. 2011

*Hedysaro grandiflori-Stipetum pulcherrimae* ass. nov. prov.

### Description of syntaxa of the steppe vegetation

Synoptic table of associations of class *Festuco-Brometea* is given below in table 2.

**Association *Poo angustifoliae-Stipetum pennatae*** (Table 2, columns 1–2)

**Diagnostic species (D.S.):** *Amoria montana*, *Centaurea scabiosa*, *Onobrychis arenaria*, *Pbleum pbleoides*, *Poa angustifolia*, *Stipa pennata*, *Thymus marschallianus*.

Associations of the community represent widespread meadow steppes where *Stipa pennata* represents a zonal type of steppes in the forest-steppe zone. Among herbaceous plants, species of the order **Festucetalia valesiacae** and the class **Festuco-Brometea** dominate. In the association composition, two variants *Helictotrichon desertorum* and *Calamagrostis epigeios* are distinguished. Coenoses of the variant *Helictotrichon desertorum* are characterized by a high constancy of *H. desertorum*, as well as by the presence of the block of species of the order **Helictotricho-Stipetalia**, unlike communities of the variant *Calamagrostis epigeios* with a more mesophytic floristic composition. The number of species per relevé ranges from 33–52 (average 40). Cover total = 80–90 % on sample plot 100 m<sup>2</sup>. Average height of herbs is 35–55 cm. Association communities are confined to slopes of hills with different exposure with a relative inclination of 5 to 35°.

The communities of the association were recorded in the city of Ishimbai (Alebastrovaya Mountain, steppes near Peregonnyi and Termen-Elga settlements) and in the City of Salavat – steppe near OJSC Salavatsteklo.

#### Variant *Helictotrichon desertorum*

(Table 2, column 1)

**D.S.:** *Helictotrichon desertorum*. The number of species per relevé ranges from 33 to 52 (average 40). Cover totals 80–90 % on sample plot 100 m<sup>2</sup>. Average height of herbs is 35–50 cm. Communities of the variant are confined to slopes of different exposure with a relative inclination of 5–25°.

#### Variant *Calamagrostis epigeios*

(Table 2, column 2)

**D.S.:** *Calamagrostis epigeios*. The number of species per relevé ranges from 34 to 49 (average 41). Cover totals 85–90 % on sample plot 100 m<sup>2</sup>. Average height of herbs is 45–55 cm. Communities of the variant are confined to slopes of mainly northern exposure with a relative inclination of 20–35°.

#### Association *Fragario viridis-Caraganelum fruticis*

(Table 2, columns 3–4)

**D.S.:** *Caragana frutex* (dominant).

The association combines communities of steppe shrubs dominated by *Caragana frutex* that are the most widespread communities of shrub steppes of the forest-steppe zone of the South Urals (Mirkin 2010). Under the canopy of *Caragana frutex* with more mesophytic conditions contain different species of the order of meadow steppes **Festucetalia valesiacae**, as well as species of the class **Molinio-Arrhenatheretea** occur. Two subassociations are distinguished in the composition of the association: **F. v.-C. f. festucetosum pseudovinae** (develops under more xerophytic conditions) and **F. v.-C. f. poetosum angustifoliae** (typical for more mesophytic conditions). The number of species per relevé ranges from 24 to 34 (average 29). Cover totals 80–90 % on sample plot 64 m<sup>2</sup>. Average height of shrubs is 60–150 cm, herbs – 30–65 cm.

The association communities were recorded in the city of Ishimbai (Alebastrovaya Mountain, steppes near Peregonnyi and Termen-Elga settlements), in the city of Salavat –

steppe near OJSC Salavatsteklo, and in the city of Meleuz – steppe near OJSC Meleuz Mineral Fertilizers.

#### Subassociation **F. v.-C. f. festucetosum pseudovinae**

**D.S.:** *Festuca pseudovina*, *Spiraea crenata*.

The number of species per relevé ranges from 25 to 33 (average 20). Cover totals 80–90 % on sample plot 64 m<sup>2</sup>. Average height of shrubs is 60–75 cm, herbs – 30–55 cm. The subassociation communities are confined to sunny slopes with a relative inclination of 5–10°.

#### Subassociation **F. v.-C. f. poetosum angustifoliae**

**D.S.:** *Achillea millefolium*, *Poa angustifolia*.

The number of species per relevé ranges from 27 to 32 (average 28). Cover totals 90 % on sample plot 64 m<sup>2</sup>. Average height of shrubs is 60–70 cm, herbs – 40–55 cm. The subassociation communities are confined to slopes of mainly eastern exposure with a relative inclination of 5–15°.

#### Association **Astragalo austriacae-Stipetum pulcherrimae** (Table 2, column 5)

**D.S.:** *Astragalus austriacus*, *Stipa pulcherrima* (dominant).

Communities are characterized by dominance of *Stipa pulcherrima* and represent a zonal type of steppes of Bashkirian Cisurals. In the herbage, species of the alliance **Helictotricho-Stipion** and order **Helictotricho-Stipetalia** dominate, and species of the suballiance of mountain steppes **Helictotricho desertori-Stipenion rubentis** Toman 1969 are also rather widely represented. The number of species per relevé ranges from 32 to 41 (average 36). Cover totals 80–90 % on sample plot 64–100 m<sup>2</sup>. Average height of herbs is 35–45 cm. The association communities are confined to sunny slopes of hills with mainly southern exposure and a relative inclination of 2 to 20°.

The association communities were recorded in the city of Ishimbai (Alebastrovaya Mountain and steppes near Peregonnyi and Termen-Elga settlements) and in the city of Salavat – steppes near SPNT Salavatsteklo.

#### Association **Scorzonero austriacae-Stipetum lessingiana** (Table 2, column 6)

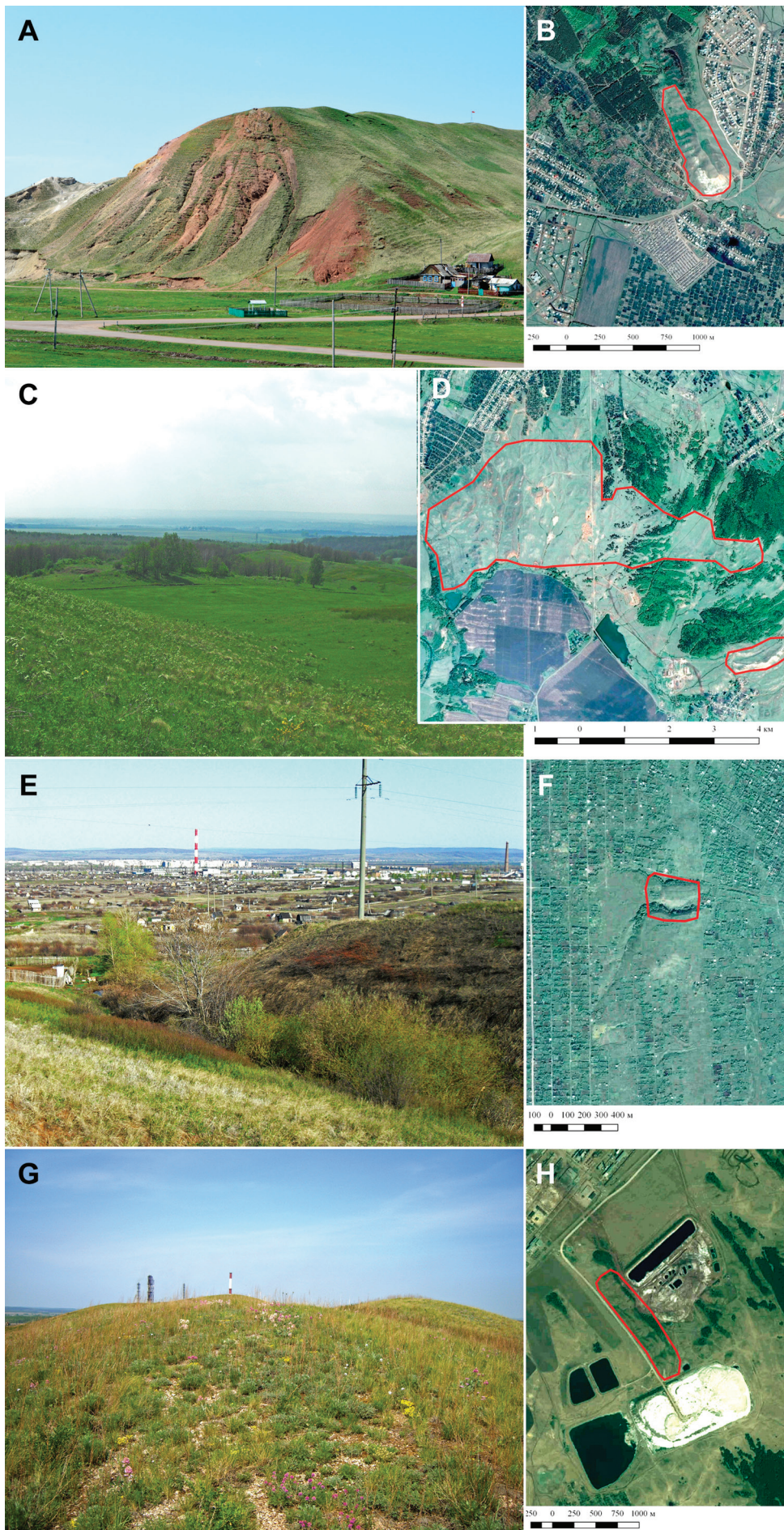
**D.S.:** *Scorzonera austriaca*, *Stipa lessingiana* (dominant).

Communities are characterized by dominance of *Stipa lessingiana*. The association represents southern dry feathergrass steppes zonal type of steppes of the South Urals typical of the steppe zone. The floristic composition is formed by species of the alliance **Helictotricho-Stipion** and order **Helictotricho-Stipetalia**, species of the suballiance of mountain steppes **Helictotricho desertori-Stipenion rubentis** are also widely represented, which is explained by the location of communities at very sunny mountain slopes. The number of species per relevé ranges from 26 to 35 (average 30). Cover totals 60–80 % on sample plot 64 m<sup>2</sup>. Average height of herbs is 35–45 cm. The association communities are confined to slopes of hills with the southern exposure and a relative inclination of 10 to 30°.

The association communities were recorded only near the city of Ishimbai (steppes near Peregonnyi and Termen-Elga settlements).

#### Association **Salvio nutanti-Stipetum korsinskyi** (Table 2, column 7)

**D.S.:** *Stipa korsinskyi* (dominant).



**Figure 2** Appearances (left picture) and maps (right picture) of urban nature sanctuaries: A, B – Alebastrovaya Mountain; C, D – Steppes near Peregonnyi and Termen-Elga settlements; E, F – Steppes near SPNT Salavatsteklo; G, H – Steppes near SPNT Meleuz Mineral Fertilizers

Communities are characterized by domination of *Stipa korschinskyi*. The number of species per relevé ranges from 20 to 38 (average 28). Cover totals 55–80 % on sample plot 64–100 m<sup>2</sup>. Average height of herbs is 35–45 cm. The association communities are confined to sunny slopes of hills with different, mainly southwestern and southeastern exposure with a relative inclination of 20 to 40°.

The association communities were localized only in the city of Ishimbai (Alebastrovaya Mountain, steppes near Peregonnyi and Termen-Elga settlements).

**Association *Trinio muricati-Centauretum sibiricae***  
(Table 2, column 8)

**D.S.:** *Alyssum lenense*, *Astragalus helmii*, *Centaurea sibirica*, *Hedysarum grandiflorum*, *Trinia muricata*.

The association combines communities of petrophytic steppes first described on Tratau and Yuraktau mountains (Yamalov et al. 2011). The communities recorded within the cities of Ishimbai and Meleuz extend the range of this association. However, compared to coenoses recorded by Yamalov et al. (2011), the association communities described by us are floristically poorer, which can be related to the anthropogenic impact on these habitats. The number of species per relevé ranges from 13 to 28 (average 21). Cover totals 25–80 % on sample plot 20–64 m<sup>2</sup>. Average height of herbs is 15–35 cm. The association communities are confined to strongly insolated mountain slopes of hills of mainly southern exposure with a relative inclination of 0 to 50°.

The association communities were recorded in the city of Ishimbai (Alebastrovaya Mountain and steppes near Peregonnyi and Termen-Elga settlements) and in the city of Meleuz – steppes near SPNT Meleuz Mineral Fertilizers.

**Association *Hedysarum grandiflori-Stipetum pulcherrimae***  
(Table 2, column 9)

**D.S.:** *Ephedra distachya*, *Hedysarum grandiflorum*, *Jurinea ledebourii*, *Potentilla glaucescens*, *Stipa pulcherrima*.

The association combines communities of petrophytic steppes of Bashkirian Cisurals. These communities belong to a specific variant *Astragalus helmii* (D.S.: *Astragalus helmii*, *Artemisia salsoloides*) typical of the southern part of Bashkirian Cisurals. The number of species per relevé ranges from 27 to 33 (average 30). Cover totals 65–70 % on sample plot 64 m<sup>2</sup>. Average height of herbs is 22–35 cm. The association communities are confined to hill slopes with mainly eastern exposure and a relative inclination of 10 to 20°.

The association communities were recorded only in the city of Meleuz (steppes near SPNT Meleuz Mineral Fertilizers).

**Problems of preservation of vegetation of urban natural sanctuaries**

In the coenoflora of plant communities of the class *Festuco-Brometea*, recorded within the limits of cities, a number of rare, relic, and endemic plant species was recorded. These species are unique for urban territories and occur only at the given sites within urban boundaries with relatively undisturbed steppe landscapes. Most rare plants are contained in petrophytic-steppe (*Artemisia salsoloides*, *Asperula petraea*, *Astragalus helmii*, *Carex pediformis*, *Ephedra di-*

*stachya*, *Hedysarum grandiflorum*, *Koeleria sclerophylla*, etc.) and steppe (*Oxytropis spicata*, *Stipa lessingiana*, *S. pennata*, *S. pulcherrima* etc.) species.

The phytosociological attribution of endemic, relic, and rare species in the vegetation cover of urban natural sanctuaries is shown in Table 3.

It is seen from the table that the greatest number of rare species is concentrated in steppe communities of associations *Trinio muricati-Centauretum sibiricae* and *Hedysarum grandiflori-Stipetum pulcherrimae* recorded on the territory of the Alebastrovaya Mountain, steppes near Peregonnyi and Termen-Elga settlements, and steppes near SPNT Meleuz Mineral Fertilizers. Communities of the association *Astragalus austriacae-Stipetum pulcherrimae* spread over the territory of the Alebastrovaya Mountain, steppes near Peregonnyi and Termen-Elga settlements while steppes near SPNT Salavatsteklo have also a high nature-protective value.

**CONCLUSIONS**

For conservation of rare types of communities we suggest the establishment of urban natural sanctuaries:

1. “Alebastrovaya Mountain” (city of Ishimbai) (Figs. 2–3) represents an elevated watershed with minimal relative heights up to 234 m located along the right bank of the Tairuk River. Vegetation comprises mainly different variants of steppes (from meadow to mountain), plantings of pine are located to the north on the mountain. The mountain vegetation is subject to strong recreational impact. The area of the urban natural sanctuary is 0.16 km<sup>2</sup>.
2. “Steppes near Peregonnyi and Termen-Elga settlements” (city of Ishimbai) (Figs. 4–5). The western part of the locality is occupied by meadow and true steppes. A considerable part of hills in the eastern part is covered by broad-leaved oak forests, as well as by different steppe variants. The vegetation of the hills is vulnerable to a strong negative impact from livestock grazing and heavier than normal recreation. The area of the urban natural sanctuary is 4.53 km<sup>2</sup>.
3. “Steppes near SPNT Salavatsteklo” (city of Salavat) (Figs. 6–7). The vegetation of these habitats is represented by surviving remnants of different variants of steppes at sites inaccessible for commercial activity (slopes of gullies). The area of the urban natural sanctuary is 0.03 km<sup>2</sup>.
4. “Steppes near SPNT Meleuz Mineral Fertilizers” (city of Meleuz) (Figs. 8–9). Flora and vegetation of this elevated watershed being surrounded by technogenic ecotopes is unique for the city of Meleuz. Vegetation of hills includes mainly different steppe variants, as well as small separate oak stands. The vegetation of slopes is subject to a strong anthropogenic effect due to close proximity to industrial sites. The area of the urban natural sanctuary is 0.11 km<sup>2</sup>.

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