The natural flora in landscaping the city of Krasnoyarsk

E M Antipova¹ and S V Antipova
Krasnoyarsk State Pedagogical University named after V.P. Astafiev, 89, Ady Lebedevoi str., Krasnoyarsk, 660049, Russia

¹E-mail: katusha05@bk.ru

Abstract. The dynamics of flora in urbanized areas is associated with the problem of biodiversity conservation, as one of the key problems of global ecology. The unification of the natural environment of cities leads to a loss of diversity inherent in natural flora, synanthropization of vegetation cover, depletion of the gene pool of aboriginal flora, cosmopolitanization and unification of flora, a decrease in the potential for evolution, artificial impoverishment of phylogenesis, phylocenogenesis and biotogenesis. The city of Krasnoyarsk is a large administrative centre of the Krasnoyarsk Territory, one of the largest industrial, scientific and cultural centres in Siberia. It stretches from west to east for 18–20 km along the left bank and up to 25 km along the right bank of the river. The Yenisei with a building depth of 3–4 km on both banks of the river, where the areas built up many decades ago are combined with new peripheral areas, the development of which began 10–15 years ago and is still ongoing. Currently, the area of the city is about 400 km². The comfort of the urban environment is made up of a variety of components, among which wildlife objects - parks, squares, urban forests, river floodplains and the rivers themselves, swamp ecosystems - are the most important for urban residents, both from an ecological and socio-psychological point of view. The purpose of the article is to present one of the modern bioecological technologies for the improvement of the urban human environment. It is proposed to identify the species composition of 14 plant communities used for landscaping and the formation of a comfortable urban environment in Krasnoyarsk by creating natural parks on the embankment of the Yenisei River.

1. Introduction
Cities reflect the most concentrated form of human impact on natural landscapes. The formation of the flora and vegetation of cities takes place in the conditions of destructive and creative activities of people. On the one hand, there is a process of transformation of the local flora in the conditions of an urbanized environment, and on the other, the formation of new flora in the conditions of anthropogenic ecotopes. The pace of modern urbanization entails the degradation of flora and adjacent natural plant communities, forming a qualitatively new natural and anthropogenic environment.

The impact of anthropogenic factors on plants in an urbanized environment can be both direct (cutting down trees, collecting herbaceous plants) and indirect (changing the water regime, compaction and increased soil salinity, enrichment with nitrates, pollution with heavy metals, etc.) [12]. The dynamics of flora in urbanized areas is associated with the problem of biodiversity conservation, as one of the key problems of global ecology [3, 4].
Unification of the natural environment of cities leads to the loss of diversity inherent in natural flora [5], synanthropization of vegetation cover, depletion of the gene pool of aboriginal flora, cosmopolitization and unification of flora, decrease in the potential for evolution, artificial impoverishment of phylogenesis, phylocenogenesis and biotogenesis [6]. This leads to the erasure of the original, historically determined regional features of the vegetation cover [7, 8], on the other hand, it gives the flora specific, individual features [9, 10]. The data presented in works on the floras of the studied Siberian cities testify to the originality and richness of urban floras, caused by human activity and reflecting, to a certain extent, the degree of their anthropogenic transformation. The urban flora of the old cities developed quite a long time ago, and at present, changes in their species composition are mainly associated with the introduction of new adventive species.

At present, Krasnoyarsk is a large administrative centre of the Krasnoyarsk Territory, one of the largest industrial, scientific and cultural centres in Siberia. It stretches from west to east for 18–20 km along the left bank and up to 25 km along the right bank of the river. The Yenisei with a building depth of 3–4 km on both banks of the river, where the areas built up many decades ago are combined with new peripheral areas, the development of which began 10–15 years ago and is still ongoing. Currently, the area of the city is about 400 km². The former neighbourhoods have become an integral and familiar feature of the city. The face of the city and its borders are constantly changing over time, which occurs under the influence of human activities (construction of communications, housing estates, industrial complexes, etc.), leading to the transformation of natural landscapes and their inherent types of vegetation. In addition, the city of Krasnoyarsk is an intensively urbanized area covered with residential and industrial buildings, asphalted and concreted areas and roads, where the vegetation cover has been completely destroyed or significantly changed. In this regard, many plants are forced to adapt to new, often unfavourable conditions, to fight for their lives, for a place in the sun.

The purpose of this article: to present one of the modern bioecological technologies for the improvement of the urban human environment - to identify the species composition of plant communities used in landscaping and the creation of natural park zones in the city.

2. Materials and methods
As the main method for studying the urban flora, we have chosen the method of model allocation (MA) of the urbanized landscape [11] in combination with the traditional route method, taking into account the entire diversity of urban habitats. On the territory of the city, 26 model blocks were studied (figure 1), for which we took plots of 250 x 250 m in the zones of old and new buildings. In addition to the main research method, the traditional route method was used. To complete the identification of the species composition of MW, field studies were carried out by us at least three times in different years and different periods of the growing season. During the field work, more than 7000 herbarium sheets were collected, about 200 geobotanical descriptions were made.

Botany, which studies the structure and dynamics of the vegetation cover in general and individual plant communities in particular, is important as a scientific basis for agriculture and forestry, for the development of green building in settlements, for the preservation of natural and man-made landscapes in the aggressive conditions of a metropolis. It should be recognized that at the moment in the use of modern data and approaches in this area, there is a serious gap between specialists in the field of botany and ecology and urban designers. This ultimately leads to a decrease in the quality of projects, degradation of the natural component of the environment and additional budget costs.
3. Result and discussion

In Krasnoyarsk, the administration, together with the Regional Science Foundation, held a targeted competition for scientific research aimed at solving the problems of urban development. One of the directions of the competition - "Principles of conservation and restoration of urban green areas that perform landscape-forming, recreational and health-improving functions within the city of Krasnoyarsk", in which our project is being implemented. We have proposed the simplest, at first glance, method of landscaping, which is now widely used in Western Europe and Moscow. The essence of the concept is to create natural biocenoses on the streets of the city in squares and parks using plants of aboriginal flora transferred to urban conditions from natural habitats. Such a community should develop autonomously, as in the wild, renew itself independently, without requiring special care. At the first stage, we proposed the types of communities for landscaping the embankment on the left bank of the Yenisei. Since within the city limits the embankment is represented by high southern terraces, it was decided to select meadow and steppe communities according to the conditions of humidification and lighting. The basis for creating communities on the
terraces of the river Yenisei within the boundaries of the city was flora and vegetation of the Krasnoyarsk forest-steppe, the city of Krasnoyarsk and geobotanical descriptions [10, 12, 13].

4. Composition of species of plant communities for landscaping the southern slopes of the left bank of the Yenisei River

4.1. First terrace (at the very bottom of the slope)

4.1.1. Forb-cereal steppe meadows

Cereals: Helictotrichon pubescens, Poa angustifolia, Phleum pheoides, Agrostis syreistschikowii, Elymus gmelinii, Bromopsis inermis

Legumes: Lupinaster pentaphyllus, Lathyrus pisiformis, Vicia amoena, V. nervata, Onobrichis arenaria

Forbs: Galium verum, Bupleurum scorzonerifolium, Phlomoides tuberosa, Inula salicina, Potentilla longifolia, Hemerocallis minor

Wormwood: Artemisia tanacetifolia, A. integrifolia, A. commutata, A. scoparia

Shrubs: Rosa acicularis, Spiraea media

4.1.2. Reed grass (Calamagrostis epigeios) steppe meadow

Herbage base: Calamagrostis epigeios (crop 1)

Other grasses: Achnatherum confusum, Elymus gmelinii, Elytrigia repens.

Forbs: Serratula coronata, Thalictrum simplex, Saussurea controversa, Sedum aizoon, Campanula sibirica, Vincetoxicum sibiricum

Legumes: Vicia amoena, Medicago falcata, редко Onobrichis arenaria, Lupinaster pentaphyllus, Lathyrus tuberosus

Wormwood: Artemisia glauca, A. gmelinii, A. frigida

Sedges: Carex praecox

4.2. Second terrace (bottom): Meadow steppes

4.2.1. Peristochian communities

Cereals: Stipa pennata, Koeleria cristata, Festuca valesiaca

Legumes: Hedysarum gmelinii, Onobrychis arenaria, A. sulcatus

Forbs: Aster alpinus, Veronica incana, Sofianthe sibirica, Gypsophilla altissima

Wormwood: Artemisia commutata, A. gmelinii, A. sericea

Sedges: Carex pediformis, C. praecox

4.2.2. Forb-cereal meadow steppes

Cereals: Stipa pennata, Achnatherum sibiricum, A. confusum, Helictotrichon schellianum, Festuca pseudosulcata, Agrostis syreistschikowii

Forbs: Galium verum, Aconitum barbatum, Schizonepeta multifida, Gypsophilla altissima

Legumes: Onobrychis arenaria, Hedysarum gmelinii, Vicia amoena, Medicago falcata

Wormwood: Artemisia sericea, A. commutata, A. latifolia

Onions: Allium ramosum, A. vodopianovii

Sedges: Carex pediformis, C. praecox

4.2.3. Forbous meadow steppes

Forbs: Pulsatilla patens, Hemerocallis minor, Pedicularis sibirica, Anemone sylvestris, Iris ruthenica, I. humilis, Thalictrum foetidium, Lilium tenuifolium

Cereals: Helictotrichon schellianum, Elymus gmelinii, Poa krylovii, Achnatherum confusum

Legumes: Vicia nervata, V. amoena, Onobrychis arenaria
Sedges: Carex pediformis, C. korschinskyi

4.3. Third terrace (bottom): Shrub meadow steppes

4.3.1. Cotoneaster-meadow meadow steppes

Shrubs: Spiraea media, Cotoneaster melanocarpus, Rosa acicularis sometimes joins them

Grass base: Koeleria cristata, Poa angustifolia, Helictotrichon schellianum, Festuca pseudovina, Agropyron cristatum.

Wormwood: Artemisia commutata, A. gmelinii

Sedge: Carex pediformis

Forbs: Aster alpinus, Veronica incana, Potentilla flagellaris, P. bifurca, Youngia tenuifolia, Schizonepeta multifida

4.3.2. Large sod steppes

4.3.2.1. Tyrs steppes

Cereals: Stipa capillata – доминант, также Poa angustifolia, Poa stepposa, Festuca pseudovina, Koeleria cristata

Wormwood: Artemisia commutata, Artemisia glauca, A. gmelinii

Forbs: Phlomoides tuberosa, Centaurea scabiosa, Scorzonera austriaca (sp), Sofianthe sibirica (sp), Alyssum obovatum, Veronica incana, Potentilla acaulis

Sedge: Carex pediformis

Bushes: Cotoneaster melanocarpus

4.3.2.2. Oatmeal (Helictotrichon altaicum, H. desertorum) steppes

Cereals: Helictotrichon altaicum и H. desertorum – доминанты, Elymus gmelinii (cop 1) – кодомinant, Stipa pennata (sol), Achnatherum confusum, Poa stepposa, P. botryoides, Phleum pheleoides

Forbs: Phlomoides tuberosa, Gypsophilla altissima, Hedysarum gmelinii, Bupleurum scorzonerifolium, Dianthus versicolor, Veronica incana, Sofianthe sibirica, Sedum aizoon, Potentilla flagellaris

Sedge: Carex pediformis, C. duriuscula, C. korschinskyi

Single bushes: Cotoneaster melanocarpus, Rosa acicularis, Spiraea media

4.3.2.3. Pickles (Iris biglumis) solonetzic steppes

Cereals: Festuca pseudovina, Poa angustifolia

Sedges: Carex duriuscula

Forbs: Iris biglumis, Sofianthe sibirica (cop 1), Artemisia laciniata (cop 1), Allium vodopjanovii (sp)

Solonetzic coarse-rhizome steppes, apparently, will not suit us, they grow in humid places, along the banks of rivers and lakes, while the terraces are far from water. It is possible to imagine only bright pickle steppes growing in drier places.

5. The fourth terrace

5.1. Small sod steppes

Cereals: Festuca pseudovina, Koeleria cristata, Festuca beckeri, Helictotrichon desertorum, Poa botryoides, Achnatherum confusum, Agrostis syreistschikowii, Agropyron cristatum

Sedges: Carex duriuscula (cop 3), Carex pediformis, Carex praecox

Forbs: Androsace incana, Potentilla acaulis, Aster alpinus, Potentilla bifurca, Potentilla canescens, Veronica incana, Astragalus palibinii, Dianthus versicolor, Allium stellerianum, Oxytropis ammophila, Berteroa incana, Galatella angustissima, Scabiosa ochroleuca, Goniothalamus speciosus, Sofianthe sibirica, Nonea rossica, Vincetoxicum sibiricum, Alyssum obovatum, Bupleurum scorzonerifolium
Wormwood: Artemisia commutata, A. frigida, A. scoparia

5.2. Stony steppes

Cereals: Festuca valesiaca, Koeleria cristata, Poa botryoides, P. angustifolia, Agropyron cristatum, Elytrigia geniculata

Sedges: Carex pediformis, C. duriuscula

Legumes: Astragalus testiculatus

Forbs: Thymus minusssinensis (cop 1), T. mongolicus, Androsace incana, Orostachys spinosa, Eritrichium jenisseiensis, Alyssum lenense, Potentilla acaulis, Gypsophila patrinii, Ephedra monosperma, Kochia prostrata, Goniolimon speciosa, Artemisia frigida

5.3. Semi-shrub-cereal desertified steppes

5.3.1. Barnacles (Kochia prostrata) steppes

Edificator: Kochia prostrata

Cereal base: Koeleria cristata, Festuca valesiaca, Stipa capillata, Agropyron kazachstanicum, Helictotrichon desertorum

Herb-dwarf shrub layer: Alyssum turkestanicum (cop 1), A. biovalatum, Scorzonera austriaca, Bupleurum bicaule, Androsace incana, Galatella angustissima, Pulsatilla turczaninovii

Sedges: Carex duriuscula, C. korshinskii

Onions: Allium vodopjanovii и A. ramosum

Goosefoot family: Axyris hybrida, Salsola collina

5.4. Shrub vegetation

5.4.1. Xeromesophilic shrub communities

Edificators: Cotoneaster melanocarpus, Spiraea media, sometimes Rosa acicularis

Cereals: Koeleria cristata, Poa angustifolia, Helictotrichon schellianum, Festuca beckeri, Agropyron cristatum, Poa krylovii

Wormwood: Artemisia commutata, A. gmelinii, A. tanacetifolia, осоки Carex pediformis.

Grass: Aster alpinus, Veronica incana, Potentilla flagellaris, P. bifurca, Youngia tenuifolia, Schizonepeta multifida, Thymus sibiricus, Stevenia incarnate

5.4.2. Mesophilic shrub communities

Shrubs: Spiraea media, Cotoneaster melanocarpus, Rosa acicularis, R. majalis, Sorbaria sorbifolia, Crataegus dahurica, C. chlorocarpa, Padus avium, Crataegus sanguinea, Salix bebbiana, S. caprea, Rubus matsumuranus, R. idaeus, Crataegus dahurica, C. chlorocarpa.

Grass: Geranium sylvaticum, Hemerocallis minor, Lathyrus gmelinii, L. vernus, Astragalus danicus, Cacalia hastata, Urtica dioica, Glechoma hederacea, Moehringia lateriflora, Maianthemum bifolium.

The selection of the assortment of plants in the communities was made according to flowering time, height, etc., so that the communities were attractive and vibrant all summer long. In the spring, it is necessary to search for species in nature in the vicinity of Krasnoyarsk, and plant them in a park on the embankment.

6. Conclusion

Bioecological approaches and technologies, which include a comprehensive assessment of the relationships between plants, animals, fungi and the abiotic environment, are necessary to ensure and enhance resilience within communities and ecosystems. Among the primary reasons for the extinction of species in urban environments are the destruction of habitats, the uncontrolled overuse of resources, and the limited habitats exposed to anthropogenic pressures.

To bring the regime of protection of plant communities and nature management in line, it is necessary to move to the purposeful, rational use of plant resources in conditions of intensive urbanization. It includes a number of activities, among which are:
• Organization of monitoring, within the framework of which constant or periodic monitoring of
the state of populations of rare and vulnerable species, as well as the protection of plant
communities would be carried out, since, in most cases, the decisive factor in the extinction of
species is the destruction of their habitats;
• Development of improvement projects, correct zoning, streamlining of operating modes in
order to prevent the consequences of unorganized recreation of green areas, that is, the
maximum limitation of anthropogenic activities in them;
• A complete ban on collecting plants for medicinal and ornamental purposes within the city
limits.

Acknowledgments
This research was carried out with the financial support of the Krasnoyarsk Regional Science
Foundation in cooperation with the city administration in the framework of the research project "The
flora of Krasnoyarsk and its conservation strategy", application code: 202007050642.

References
[1] Kornaš J 1982 Man's impact upon the flora: processes and effects Mem. Zool. 37 1–30
[2] Burda R I 1991 Anthropogenic Transformation of Flora (Kiev)
[3] Yurtsev B A 1991 The study of biological diversity and comparative floristry Bot. Zhurn. 76 (3)

305-13
[4] Antipova E M and Antipova S V 2020 Synanthropization of small towns' flora (Krasnoyarsk
region) IOP Conf. Ser.: Earth and Environmental Sci. 421(8) 082018
[5] Ilminskikh N G 1989 Ecological and floristic gradients in an urban landscape Proc. of All-
Union Conf. on Problems of Studying the Synanthropic Flora of the USSR: Abstract
(Moscow) pp 3-5
[6] Kamelin R I 1998 Materials on the History of the Flora of Asia (Altai Mountain Country)
(Barnaul: ASU)
[7] Pyak A I and Merzlyakova I E 2000 Vascular Plants in Tomsk (Tomsk: TSU)
[8] Teryokhina T A 2000 Anthropogenic Phytosystems (Barnaul: ASU)
[9] Vinkovskaya O P 2005 Flora of Irkutsk City Agglomeration and its Dynamics over the Past 125
Years (Krasnoyarsk)
[10] Antipova S V and Antipova E M 2016 Urbanoflora of the City of Krasnoyarsk (Vascular
Plants) (Krasnoyarsk: KSPU named after V P Astafyev)
[11] Ilminskikh N G 2014 Florogenesis in an Urbanized Environment (Yekaterinburg: Publishing
house of the Ural Branch of the Russian Academy of Sciences)
[12] Antipova E M 2012 Flora of the Inland Continental Island Forest-steppes of Central Siberia
(Krasnoyarsk: KSPU named after V P Astafyev)
[13] Antipova E M 2016 Vegetation of the Northern Forest-steppes of Central Siberia (Krasnoyarsk:
KSPU named after V P Astafyev)