Estimated parameters of species participation in recreation (Voronezh, Russia)

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Abstract. A series of sample plots have been laid to study the influence of recreational load in general and in grassy ground cover in Central Park of Culture and Leisure of Voronezh, Arboretum of Voronezh State University of Forestry and Technologies named after G F Morozov. We used qualitative (structural biodiversity) and quantitative (relative projective cover, abundance and constancy) estimation parameters as indicators of the species’ participation in the formation of plant associations using two urban ecosystems as an example. The aforementioned arboretum and park belong to the forest-park part of the city green zone. Tracing of flora synanthropization is very important here. Species abundance is generally higher in the arboretum (226 species), but grass cover is not numerous (31 species) due to timely economic activities. By quantitative parameters, on the contrary, grasses of broad-leaved forests prevail in the grassy cover of the Park: ashweed (Aegopodium podagraria L.) with projective cover (40-44.6%) and sedge (Carex pilosa Scop.) - 19.8% -29.6% (1-2 stages of recreation, respectively). The class of abundance of these dominant species raises to 3 (1-2 for other species). The analysis of the constancy class, on the contrary, has not revealed clear species attachment to certain test plots.

1. Introduction

Human, like any biological creature, lacks ‘communication with nature’. It pushes us to visit not only publicly accessible places, but also areas with vegetation, which are natural monuments. Interaction of people with the natural environment and public use of forests often take the form of outdoor recreation [1].

We often find two approaches to studying urban vegetation in a literature review devoted to urban green infrastructure. We all know that plants absorb a huge range of pollutants. They disrupt many physiological and biochemical processes, but at the same time help balance carbon emissions [2-4].

The first approach is precisely related to the study of provision of so-called urban ecosystem services. It studies total carbon absorption and improving air quality for as many people as possible [5].

The lack of natural space in cities underlines the need for well-informed urban planning. There is a need for a second approach – ‘landscape urbanism’. The meaning of the approach is determined by the following: the structure of cities and green areas should be determined (to a greater extent) by landscape factors, not architectural ones. As a result of the competent application of both approaches, we get natural holistic landscape.

One must be aware that the vegetation in urban green spaces, as a rule, requires not only intensive care, but also leads to a uniform landscape. Some researchers, on the contrary, believe that constantly
replenished assortment of green spaces is an important refuge for biodiversity in urban areas. They recommend increasing the coverage of green areas within the city by the species composition of park lawns and other grassy vegetation [6].

With increasing environmental awareness, we understand that newly emerged plants can exacerbate the negative impact on regional biodiversity and functioning of any ecosystem, including urban ones. Analysis of plant invasions shows that their impact is unpredictable and variable. They have a detrimental effect on ecosystem processes and cause changes in the nutrient cycle, primarily carbon one. Shifts are also observed in both aboveground and underground communities [7].

We put forward our hypothesis: in the formation of urban green spaces it is necessary to: have comprehensive information about the qualitative and quantitative state of vegetation; protect the species of local flora as islands of natural vegetation in order to preserve the natural specifics of the region. Of course, the introduction of new species is required in order to increase biodiversity, but in this case the introduced species require strict control over their distribution, interaction with local plants, microorganisms, and related diseases. Anthropogenic impact on all the components of the ecosystem should also be assessed in adequate manner.

When studying the influence of various types of anthropogenic impact, researchers note that ground cover is the first plant components being affected. And immediately the question about the methodology and methods of accounting for such effects arises.

Comparative geobotanical analysis of vegetation is used as one of the methods for soil cover research in the study of various anthropogenic pressures and the types of its manifestations [8-10]. This analysis reveals quantitative and qualitative relationships between all systematic plant groups [11]. It enables to find established patterns and interpret the data.

In our work we analyzed the state of plantings of the largest massifs of Voronezh (Central Park of Culture and Leisure of Voronezh, Arboretum of Voronezh State University of Forestry and Technologies named after G F Morozov), which are under the influence of recreation.

The purpose of this study is comprehensive assessment of recreation impact in general and the impact on the ground grass cover in more detail.

We used qualitative (structural biodiversity) and quantitative (relative projective cover, abundance and constancy) assessment parameters as indicators of species participation in the formation of plant associations using two urban ecosystems as an example.

## 2. Methods and material

Forest and park green zone of the city of Voronezh (Russian Federation) was allocated in 1944 within a radius of 30 km around the city. The main area of the forest zone of our city is Voronezh upland oak forest.

The urban infrastructure includes 14 parks, 3 forest parks, 2 botanical gardens (named after B M Kozo-Polyansky and B A Keller), 1 arboretum and more than 17 squares of various sizes and locations. Nine of the above green spaces are natural monuments of regional significance.

The objects of our research are wood and shrub and grassy flora of Central Park of Culture and Leisure of Voronezh, Arboretum of Voronezh State University of Forestry and Technologies named after G F Morozov.

The subject of the study is the state of the above-mentioned urban ecosystems, taking into account the influence of the recreational factor.

Objectives of the study are: to establish the full floristic composition in the selected territories, to identify quantitative relations between herbaceous plants (percentage of projective cover, abundance, species constancy), and to record weedy species and resistant to recreation.

We plan long-term monitoring of the natural originality of the previously indicated territories. It will help to preserve these landscapes for citizens.

We took into account all plant life forms (trees, shrubs, grasses) to obtain a complete floristic list of plants. Geobotanical description with quantitative characteristics (data) was used only for grassy ground cover.
It was not by chance that we chose the arboretum and the above-mentioned park. They are located on the historical territory of Voronezh upland oak forest (southern quarters of the oak grove represented by natural oak forests, belonging to the forest-park part of the green zone of Voronezh). Moreover, tracing of flora synanthropization is very interesting for us.

We conducted some studies on the digression load of oak groves earlier, and full description of the massif has already been presented [12].

The first stage of the work is preliminary acquaintance with vegetation and establishment of complete floristic composition in the territory of Central Park of Culture and Leisure of Voronezh (Park) and Arboretum of Voronezh State University of Forestry and Technologies named after G F Morozov (Arboretum). The studies were conducted in May 2019.

In our work, we focused on the determination of species diversity and projective cover of soil cover plants. To understand the quantitative relations between plants, we chose 10 plots in Central Park and Arboretum. These plots are sufficient to identify the main signs of the phytocenosis and its habitat (625 m²). Some researchers have identified a different number of test sites and methods for determining projective coverage [13].

Quantitative relationships between species are the result of adaptation to each other and environmental conditions. Then, in each of the 10 test plots, in its turn, registration areas were allocated in the corners (4 areas are obtained). Another registration area was laid in the center. The area was 5x5 m² (to obtain information about the projective cover and the abundance of grassy vegetation). Separately, we compiled a list of plants found only in trial plots. The basis of this work is 100 geobotanical descriptions. But, for the convenience of analysis, we have reduced all descriptions to tables in three stages of recreation. The average value of the projective cover for each type is given.

Relative projective coverage is the relative percentage of the area occupied by the plant, expressed as a percentage of possible 100%. Abundance is the number of individuals of a species per unit area.

When describing plant associations, Western European and Russian botanists use either the Gult-Drude scale or the Drude scale or J. Braun-Blanquet scale to characterize abundance [14].

We used both scales in our work as a whole and in the analysis of research results. The scales were simplified for convenience (table 1).

| Species abundance class | Average projective coverage of the species, % |
|-------------------------|---------------------------------------------|
|                        | Drude scale | Braun-Blanquet scale |
| 0                      | Less than 1 | Less than 5           |
| 1                      | 3-5         | 5-10                  |
| 2                      | 10-20       | 10-25                 |
| 3                      | 30-90       | 25-50                 |
| 4                      | More than 95| 50-75                 |
| 5                      | –           | More than 75          |

Constancy (constancy of species) is one of the quantitative characteristics of plant species participation in the composition of plant associations. It is determined by the percentage of equal sites (on which this species occur) of the total number of surveyed sites.

The constancy of species is given in the constancy points traditional for J Braun-Blanquet. Five classes of constancy were distinguished: I class – the species was present on no more than 20% of sites, II class - from 20 to 40% of sites, III class –from 40 to 60%, IV class – from 60 to 80%, V class – more 80% [14].
In our studies, we also paid attention to the phenological phase reflecting seasonal rhythm. According to the simplified scheme, we used only three enlarged groups – vegetation, flowering, and fruiting.

3. Results and discussion

Different researchers, when studying the recreational impact in forest ecosystems, distinguish (on average) from 3 to 5, as well as up to 7 stages of digression [14, 15]. In this study of urban ecosystems we decided to identify the three most clearly distinguishable stages: strong, medium, and weak [16].

In the methodology (when determining the stages of the recreational load) the percentages of sick and drying trees are prescribed (for example, from the second stage from 20 to 50% and more than 70% in the third). However, we immediately stipulate the fact that such species are not registered by us in the Park and Arboretum. This is, of course, connected with timely care activities. Timely cutting of weakened stands is not carried out in forest ecosystems.

We recorded two types of anthropogenic impact on the Park and Arboretum territory. We noted the recreational impact associated with ground cover trampling. As a result soil compaction and a decrease in the number of plants can be seen. And a direct effect is collection of plants, their fruits and seeds by vacationers.

Another type of anthropogenic impact is associated with the fact that both selected objects are located in close proximity to local roads. Cars compact the soil, destroy it. Rutted roads located along the slopes of the park beam help water to carry kilograms of fertile land.

In the article, we present data related to the study of only one anthropogenic impact. It is recreational impact on grassy plants of ground cover.

Both objects are located in the northern part of Voronezh, in the forest-steppe zone with a temperate continental climate. The average annual temperature ranges from 4-5°C. The absolute minimum is in January (-37.5°C), the absolute maximum is in July (+37.5°C). The average annual rainfall is 568 mm with fluctuations from 400 to 844 mm. The duration of the growing season is 152 days.

Central Park of Culture and Leisure of Voronezh was founded in the 1960s; its area is 101.0 hectares. The territory of the Park can be conditionally divided into 2 zones differing in the degree of dissection of the relief, in soils and phytocenotic features. There is a ravine-girder network with small streams along the bottom and steppe forbs and grassy slopes. The most common soil types are medium-loamy leached black soils and gray medium loams.

As a result of our own research, 70 trees and shrubs belonging to 46 genera and 18 families were registered in the Park flora.

Four coniferous species belong to one class (Pinaopsida) and 2 families: Pinaceae (Picea abies L., Picea pungens Engelm., Larix sibirica Ledeb.) and Cupressaceae (Thuja occidentalis L.). Identified hardwood species (66 species) belong to 5 subclasses and 16 families. Numerous families: Rosaceae (17 species), Salicaceae (9), Betulaceae (5), Aceraceae (5), Oleaceae (4), Caprifoliaceae (4), Ulmaceae (4), Fabaceae (4) are widely represented. Other families are represented by 1-2 species. The richest genera are: Salix (6), Acer (5), Ulmus (4), Populus (4).

In the first tier, the dominant species are English oak (Quercus robur L.), European ash (Fraxinus excelsior L.), in the second tier - maple (Acer platanoides L.), European white elm (Ulmus laevis Pall.). There is small-leaved linden (Tilia cordata Mill.), European birch (Betula pendula Roth.). Uniform age is a characteristic feature of all the Park tree stands. The Arboretum tree stands is uneven in its age structure.

The composition of the herbaceous flora consists in 91 species. Structural diversity is as follows: families - 28, genera - 63. The most numerous families include: Rosaceae (12 species), Poaceae (10), Lamiaceae (7), Asteraceae (7), Fabaceae (5), Apiaceae (4), Scrophulariaceae (4), Rubiaceae (4). The leading genera are: Festuca (4 species), Poa (4) and Potentilla(4).

We noted only 17 species in trial plots. We present the average value of the projective cover using both scales and the class of species abundance in all the tables below.
Broad-leaved forest grasses prevail in the grassy cover of the 1st and 2nd stages of recreation: ashweed (*Aegopodium podagraria* L.) with projective cover of 40-44.6% and sedge (*Carexpilosa Scop.*) - 19.8% - 29.6% (tables 2 and 3). Note, that both species are also dominant in the vegetation cover of the city’s largest forest - Voronezh upland oak forest [12]. The species abundance is 7–8 species. It is little higher at trial plots with an average stage of recreation - 13 species. Weed species are generally absent at the plots belonging to the 1 and 2 recreation stages. This once again underlines the natural specificity of the park and its historical location in the oak forest.

**Table 2.** Information on quantitative indicators at the Park test plots with weak (first) recreation stage.

| No | Plant species and floristic composition | Average projective coverage of the species, % | Abundance class of species | Phenological phase |
|----|----------------------------------------|-----------------------------------------------|----------------------------|-------------------|
| 1  | *Aegopodium podagraria* L.              | 44.6                                          | 3                          | Vegetation        |
| 2  | *Carex pilosa* Scop.                   | 29.6                                          | 3                          | Vegetation        |
| 3  | *Orobus vernus* L.                     | 6                                             | 1                          | Fruiting          |
| 4  | *Pulmonaria obscura* Dumort.           | 5                                             | 1                          | Vegetation        |
| 5  | *Asarum europeum* L.                   | 5.4                                           | 1                          | Vegetation        |
| 6  | *Polygonatum multiflorum* (All.)       | 3                                             | 1                          | Fruiting          |
| 7  | *Stellaria holostea* L.                | 2.2                                           | 0                          | Vegetation        |

Weeds (exactly half of the species composition), but with a minimum percentage of projective cover of 1-3% (table 4), as expected, appear on the sites which are subjected to a strong influence (stage 3) of recreation.

The total projective coverage of the plots, belonging to the first stage of recreation is maximum one. As a whole it is about 95.8%; second stage – 70.04%. At the test plot of the third stage (strong recreation), the total projective cover is 46.0%. Approximately the same coverage can be seen at similar Arboretum plots.

**Table 3.** Information on quantitative indicators at the Park test plots with medium (second) recreation stage.

| No | Plant species and floristic composition | Average projective coverage of the species, % | Abundance class of species | Phenological phase |
|----|----------------------------------------|-----------------------------------------------|----------------------------|-------------------|
| 1  | *Aegopodium podagraria* L.              | 40                                            | 3                          | Vegetation        |
| 2  | *Carex pilosa* Scop.                   | 19.8                                          | 2                          | Vegetation        |
| 3  | *Stellaria holostea* L.                | 2                                             | 0                          | Vegetation        |
| 4  | *Asarum europium* L.                   | 2                                             | 0                          | Vegetation        |
| 5  | *Lamium maculatum* L.                  | 2                                             | 0                          | Vegetation        |
| 6  | *Convallaria majalis* L.               | 1                                             | 0                          | Fruiting          |
| 7  | *Glechoma hederacea* L.                | 1                                             | 0                          | Vegetation        |
| 8  | *Polygonatum multiflorum* L.           | 1                                             | 1                          | Fruiting          |
| 9  | *Pulmonaria obscura* Dumort.           | 1                                             | 0                          | Vegetation        |
| 10 | *Geum urum* banumL.                    | 0.4                                           | 0                          | Vegetation        |
| 11 | *Viola mirabilis* L.                   | 0.05                                          | 0                          | Vegetation        |
| 12 | *Orobus vernus* L.                     | 0.05                                          | 0                          | Fruiting          |
| 13 | *Galium aparine* L.                    | 0.05                                          | 0                          | Vegetation        |
Table 4. Information on quantitative indicators at the Park test plots with strong (third) recreation stage.

| No | Plant species and floristic composition | Average projective coverage of the species, % | Abundance class of species | Phenological phase |
|----|----------------------------------------|---------------------------------------------|----------------------------|-------------------|
| 1  | Aegopodium podagraria L.                | 6                                           | 1                          | Vegetation        |
| 2  | Asarum europium L.                      | 6                                           | 1                          | Vegetation        |
| 3  | Plantago major L.                       | 4                                           | 1                          | Vegetation        |
| 4  | Carex piosa Scop.                       | 3                                           | 1                          | Vegetation        |
| 5  | Stellaria holostea L.                   | 1                                           | 0                          | Vegetation        |
| 6  | Urtica dioica L.                        | 1                                           | 0                          | Vegetation        |
| 7  | Polygnum numaviculare L.                | 1                                           | 0                          | Vegetation        |
| 8  | Chenopodium album L.                    | 1                                           | 0                          | Vegetation        |

Introduced tree and shrub vegetation and main forest-forming species of the Russian Federation grow on the territory of Arboretum of Voronezh State University of Forestry and Technologies named after G F Morozov. The Arboretum was created in 1951-1953 with a research purpose: study of the resources of domestic and world flora for the enrichment of forestry. Its area is 4.2 hectares, the relief is flat, and type of soil is fresh gray forest loams.

According to the 2008 inventory, the species composition of the Arboretum totaled about 270 species and forms of trees and shrubs, which belong to 97 genera and 35 families. Under the influence of increased recreational loads, the number of trees and shrubs decreased to 226 species belonging to 75 genera and 30 families (inventory of 2019). The largest number of species is concentrated in Pinaceae Lindl. (32 species), Cupressaceae Juss. (24), Rosaceae Juss. (67) Caprifoliaceae Juss. (18), Oleaceae Hoifmgg. et Link. (16), Aceraceae Juss. (11) families.

Larixsibirica Ldb. Pinus strobus L., Picea abiesKarst., Quercus robur L., Populus nigra L. dominate in the first tier. The second tier is represented by Tilia cordata Mill., Carpinus betulus L., Acer platanoides L., Phellodendron amurense Rupr. There is undergrowth of woody plants and shrubs (Sorbus aucuparia L., Cotinus coggyria Scop., Corylus avellana L., Carpinus orientalis Mill., genus Berberis L., genus Spiraea L.) in the third and fourth tiers. Grassy life form is in the fifth tire. The age of the tree layer is different and varies from 5 up to 66 years.

In 2019, we established 31 species from grassy ground cover belonging to 30 genera and 19 families. We note immediately that the identified floristic composition in the amount of 31 species throughout the Arboretum showed itself at full strength in a series of registration plots.

Half (8) of the 16 species at test plots (where the effect of minor anthropogenic interference (a weak stage of recreation is manifested) belongs to nemoral species. Aegopodium podagraria L. (32%) and Glechoma hederacea L. (19%) have high projective cover. Remaining species show 0.05% (Viola mirabilis L.), 2% (Geumur banum L.) or 4% (Fragaria vesca L.). The class of species abundance varies from 2 to 3 in the first two dominants of the soil cover (table 5). It is about 1 in all other species.

At test plots with medium (stage 2) and strong (stage 3) degree of recreation, the abundance was 11 species (tables 6 and 7). The number of typical nemoral species is small: 3 (stage 3) and 5 (stage 2), the projective cover of the same species is insignificant – 3-6%, and accordingly the abundance class is low – 1-2. At the same time, it should be noted that weed projective cover is low: Bromusinermis Leyss., (medium stage) – 13% and Taraxacum officinale Wed. – 12% (the abundance class in both species is 2). We emphasize that all identified weed species are local weeds, and not invasive (adventitious). The total projective coverage of plots of the first recreation stage as a whole is about 87.15%; second stage – 64.0%; third stage (strong) – 52.0%.
Table 5. Information on quantitative indicators at the Arboretum test plots with weak (first) recreation stage.

| No | Plant species and floristic composition | Average projective coverage of the species, % | Abundance class of species | Phenological phase |
|----|----------------------------------------|---------------------------------------------|---------------------------|--------------------|
| 1  | Aegopodium podagraria L.                | 32                                          | 3                         | Vegetation         |
| 2  | Glechoma hederacea L.                   | 19                                          | 2                         | Vegetation         |
| 3  | Anemone ranunculoides L.                | 4                                           | 1                         | Vegetation         |
| 4  | Trifolium repens L.                     | 4                                           | 1                         | Vegetation         |
| 5  | Origanum vulgare L.                     | 4                                           | 1                         | Vegetation         |
| 6  | Fragaria vesca L.                       | 4                                           | 1                         | Vegetation         |
| 7  | Elytrigia repens L.                     | 4                                           | 1                         | Vegetation         |
| 8  | Plantago major L.                       | 4                                           | 1                         | Vegetation         |
| 9  | Falcaria vulgaris Bernh.                | 4                                           | 1                         | Vegetation         |
| 10 | Bromus inermis Leyss.                   | 4                                           | 1                         | Vegetation         |
| 11 | Rumex confertus L.                      | 1                                           | 0                         | Vegetation         |
| 12 | Geum urbanum L.                         | 2                                           | 0                         | Vegetation         |
| 13 | Polygonatum multiflorum L.              | 1                                           | 0                         | Vegetation         |
| 14 | Viola mirabilis L.                      | 0.05                                        | 0                         | Vegetation         |
| 15 | Daucus sativus Hoffm.                   | 0.05                                        | 0                         | Vegetation         |
| 16 | Corydalishalleri Wild.                  | 0.05                                        | 0                         | Vegetation         |

Table 6. Information on quantitative indicators at the Arboretum test plots with medium (second) recreation stage.

| No | Plant species and floristic composition | Average projective coverage of the species, % | Abundance class of species | Phenological phase |
|----|----------------------------------------|---------------------------------------------|---------------------------|--------------------|
| 1  | Bromus inermis Leyss.                   | 13                                          | 2                         | Vegetation         |
| 2  | Anemone ranunculoides L.                | 8                                           | 1                         | Flowering          |
| 3  | Elytrigia repens L.                     | 8                                           | 1                         | Vegetation         |
| 4  | Taraxacum officinale Wed.               | 7                                           | 1                         | Flowering          |
| 5  | Arctium lappa L.                        | 6                                           | 1                         | Vegetation         |
| 6  | Lysichianum mularia L.                  | 6                                           | 1                         | Flowering          |
| 7  | Fragaria vesca L.                       | 5                                           | 1                         | Vegetation         |
| 8  | Veronica chamaedry L.                   | 3                                           | 1                         | Vegetation         |
| 9  | Plantago major L.                       | 3                                           | 1                         | Vegetation         |
| 10 | Asarum europaeum L.                     | 3                                           | 1                         | Vegetation         |
| 11 | Achilleamille folium L.                 | 3                                           | 1                         | Flowering          |
Table 7. Information on quantitative indicators at the Park test plots with strong (third) recreation stage.

| No | Plant species and floristic composition | Average projective coverage of the species, % | Abundance class of species | Phenological phase |
|----|----------------------------------------|---------------------------------------------|---------------------------|-------------------|
| 1  | Taraxacum officinale Wed.              | 12                                          | 2                         | Flowering         |
| 2  | Geum urbanum L.                        | 11                                          | 2                         | Flowering         |
| 3  | Trifolium repens L.                    | 8                                           | 1                         | Flowering         |
| 4  | Poa nemoralis L.                       | 6                                           | 1                         | Vegetation        |
| 5  | Plantago major L.                      | 5                                           | 1                         | Vegetation        |
| 6  | Elytrigia repens L.                    | 4                                           | 1                         | Vegetation        |
| 7  | Chelidonium majus L.                   | 3                                           | 1                         | Flowering         |
| 8  | Dactylis glomerata L.                  | 1                                           | 0                         | Vegetation        |
| 9  | Lysimachia nummularia L.               | 1                                           | 0                         | Flowering         |
| 10 | Chenopodium album L.                   | 1                                           | 0                         | Flowering         |
| 11 | Solanum nigrum L.                     | 1                                           | 0                         | Vegetation        |

We recorded that there is a dense path network in the Arboretum and Park at the third stage of recreational load on one third (1/3) of the area, but vegetation, including weeds, does not populate these spaces. Vegetation phenological phase can be seen in more than 98% of plants.

In order to calculate the participation of species in the composition of the plant association as a whole, we divided all the species identified at the Park and Arboretum test plots into groups: group 1 - typical non-nemoral species (11 species); group 2 - typical weeds (6 species). Species of the fifth class (i.e., species that are found at all test plots) are absent in both selected groups. Nemoral species, belonging to the fourth (Aegopodium podagraria L., Carex pilosa Scop.) or to the third class (Geum urbanum L., Polygonatum multiflorum L., Stellaria holostea L.), were recorded. Weeds with a low constancy class of species (1, rarely 2) have been noted. The exceptions are Plantago major L. (4 class) and Elytrigia repens L. (3 class). 32.3% of Arboretum plants belong to the 0 class of abundance. In the Park (with species abundance equal to 17), species with 0 class of abundance account for 76.5%. The obtained data show the following fact: Park and Arboretum flora synanthropization proceeds slowly. It is not typical for urban plantings, but it is also good for preserving the uniqueness of the objects.

4. Conclusion
Summarizing the foregoing, we can draw the following conclusions. Structural and species abundance of tree-shrub flora is generally higher in the Arboretum - 226 species (75 genera and 30 families). However grassy vegetation is very low - 31 species (30 genera and 19 families). This can be explained by significant representation of conifers (already 56 species in the two leading families) and dense planting of tree-shrub flora on a small area (4.2 ha). An important effect is regular and timely care activities (mowing grass and weeding). All this affects the ground cover.

In the Park, on the contrary, the abundance of species of the tree-shrub flora is lower - 70 species (46 genera and 18 families). Grassy vegetation is three times higher compared to the Arboretum - 91 species (63 genera and 28 families). Of course, the vast area of the park (101.0 ha) is well-preserved oak forest censuses. Diverse habitats are meadow spaces. Geomorphological factor are similar to oak forest (ravine system, plateau) and have healthy influence on grassy vegetation. Broad-leaved forest herbs predominate in the Park grassy cover (the first and second stages of recreation). This is ashedweed (Aegopodium podagraria L.) with projective cover of 40-44.6% and sedge (Carex pilosa Scop.) - 19.8% - 29.6%. The class of species abundance increases to 3 respectively.
The constancy of species by constancy classes has not reveal clear attachment of species to test plots. It has showed the following: most Park and Arboretum plants belong to 3-4 classes (mainly nemoral plants). Weeds usually have 1-2 classes. All identified weed species belong to native flora.

References

[1] Komossa F, van der Zanden E H, Schulp C J E and Verburg P H 2018 Mapping landscape potential for outdoor recreation using different archetypical recreation user groups in the European Union Ecol. Indic. 85 105 https://doi.org/10.1016/j.ecolind.2017.10.015

[2] De la Barrera F, Rubio P and Banzhaf E 2016 The value of vegetation cover for ecosystem services in the suburban context Urban. For. Urban. Gree. 16 110 https://doi.org/10.1016/j.ufug.2016.02.003

[3] Döhrn P and Haase D 2019 Risk assessment concerning urban ecosystem disservices: The example of street trees in Berlin, Germany Ecosyst. Serv. 40 101031 https://doi.org/10.1016/j.ecoserv.2019.10.013

[4] Filipchuk A, Moiseev B, Malysheva N and Strakhov V 2018 Russian forests: A new approach to the assessment of carbon stocks and sequestration capacity Environmental Development 26 68 https://doi.org/10.1016/j.envdev.2018.03.002

[5] Bukvareva E, Zamolodchikov D and Grunewald K 2019 National assessment of ecosystem services in Russia: Methodology and main problems Sci. Total. Environ. 655 1181 DOI: 10.1016/j.scitotenv.2018.11.286

[6] Yang F, Ignatieva M, Wissman J, Ahné K, Zhang S and Zhu S 2019 Relationships between multi-scale factors, plant and pollinator diversity, and composition of park lawns and other herbaceous vegetation in a fast growing megacity of China Landscape Urban. Plan. 185 117 https://doi.org/10.1016/j.landurbplan.2019.02.003

[7] Lloyd G, Mahon M B and Thomas O C 2019 Invasive shrub cover and tree species composition influence exotic earthworms Forest Ecol. Manag. 447 53 https://doi.org/10.1016/j.foreco.2019.05.049

[8] Otmakhov Y S, Chernikova T S and Tretjakov B A 2018 Anthropogenic transformation of vegetation in urban pine forests Vestnik of Tomsk State University: Biology 41 75 DOI: 10.17223/19988591/41/5

[9] Belov A V, and Sokolova L P 2008 Vegetation stability in the system of geobotanical forecasting Geography and Natural Resources 29(2) 1241 DOI: 10.1016/j.gnr.2008.06.016

[10] Belov A V and Sokolova L P 2009 The socio-economic role of vegetation in the cartographic substantiation of rational management of nature in the geobotanical forecasting system. Geography and Natural Resources. 30(2) 119 DOI: 10.1016/j.gnr.2009.06.005

[11] Boulter M C, Hubbard R N L B and Kvaček Z 1993 A comparison of intuitive and objective interpretations of Miocene plant assemblages from northern Bohemia Palaeogeography, Palaeoclimatology, Palaeoecology 101(1–2) 81 https://doi.org/10.1016/0031-0182(93)90153-A

[12] Degtyareva S I and Doroveeva V D 2019 The relationship of spore (mosses) and seed plants with mesorelief types of oak forests IOP Conf. Ser.: Earth Environ. Sci. 226 012004 DOI: 10.1088/1755-1315/226/1/012004

[13] Vakhlamova T, Rusterholz H-P, Kamkin V and Baur B 2016 Recreational use of urban and suburban forests affects plant diversity in a Western Siberian city Urban. For. Urban. Gree. 17 92 DOI: 10.1016/j.ufug.2016.03.009

[14] Andreeva E N 2002 Methods of studying forest communities (St Petersburg: St Petersburg State University)

[15] Art'yukhov V G, Baturin V C and Vashanov G A 2000 4th Int. Conf. 'Solution of ecological problems in the road transport’ (Moscow: MADI)p 144

[16] Degtyareva S I, Selina N A and Tarabrina V S 2018 Proc. Int. Conf on ARCTIC: innovative technologies, personnel, tourism (Voronezh: VSUFT) p 536