Integrated environmental assessment of the perspective specially protected natural area of Voronezh city (Russia)

M Kochergina and E Furmenkova

Landscape Architecture and Soil Science Department, Voronezh State University of Forestry and Technologies named after G. F. Morozov, 8 Timiryazeva Street, Voronezh, 394087, Russian Federation

*E-mail: kocherginamv@vglta.vrn.ru

Abstract. A significant role in optimizing the state of the urban environment is played by the natural complex; one of its components is specially protected natural areas (SPNA). Therefore, the idea to create an SPNA system for the Voronezh region is especially important. The purpose of these studies was to prepare, according to a comprehensive environmental survey, a scientific justification for assigning the SPNA status of regional importance to recreational plantations. Standard methods of taxation, ecological, geographical, botanical, soil and faunal research were used in the work. The results of the studies include a description of the soil and plant cover, zoo and mycological complexes inhabiting the object. Natural features of SPNA including geographical situation, geological structure, and relief were identified. An analysis of the planning organization of the territory, types of spatial structure, aesthetic and sanitary-hygienic properties, forest environment digression and pathological state of plantations was carried out. Based on the results of the comprehensive survey, it was recommended to assign the SPNA status of regional significance to this object - a natural park, the main functions of which should be the preservation of natural complexes and maintaining environmental balance in the city district of Voronezh.

1. Introduction

The global problem of our time is maintaining the ecological balance of the biosphere [1]. In recent decades, specially protected natural areas (SPNA) have played a crucial role in stabilizing the situation at the regional, national and international levels [2-4]. The main tasks of the SPNA include ensuring the ecological stability of urban systems, preserving biological diversity, optimizing the state of the environment, as well as environmental education [5, 6].

Today there are more than 200 SPNA of regional and local importance in the Voronezh region, their total area is a little more than 2% of its territory [7]. The use of the administrative principle in the organization of SPNA is the cause of their uneven distribution throughout the region. For example, there are about 50 objects on the territory of Voronezh city, which is 20% of all SPNAs in the region [7]. In this regard, the idea of creating SPNA system for the Voronezh region is of particular relevance. Even the distribution of SPNA and their optimal ratio in the Voronezh region will contribute to achieving ecological balance in the region, regulating the mechanisms of interspecific interaction, maintaining the genetic unity of populations, and will also ensure the protection of species and landscape diversity.

The purpose of this study is to prepare a scientific justification for assigning the SPNA status of regional importance to recreational plantations. The objectives of the research were to conduct a comprehensive environmental survey of the territory of the prospective SPNA. The research program
included a set of preparatory, field and camera work. The main attention was paid to the study of the peculiarities of the planning organization of the territory, types of spatial structure, aesthetic properties, digression of the forest environment; description of soils, species composition of plants, animals, macromycete living in the plantation; identification of Red Data Book and rare for the Voronezh region species of plants and animals, unique objects and phenomena.

2. Methodology
Research was carried out in 2018 – 2020. Geographically, the object of research is located in the recreational zone of Voronezh city, Repnoye microdistrict (Russia). The area of the research territory is 37 ha (figure 1).

![Figure 1. Plan of the research area.](image)

Standard methods of taxation, forestry, ecological, geographical, botanical, soil and faunal studies were used in the work [8]. Indicators of landscape and ecological assessment of the territory were determined during the field survey using special scales. The forest-pathological state of the plantations was evaluated according to three classes of biological resistance. The main criteria here are the size of the deadwood, the magnitude of the current leaf litter and the state of the forest environment. The first class includes resistant plantations, in which the deadwood is no more than 6% of the all trees number, the forest environment is not disturbed, and there are no damage by pests and diseases. Second-class plantings are characterized by impaired resistance, have up to 40% deadwood, forest violation, damaged by pests and diseases. The third class includes plantations that have lost resistance, their deadwood is more than 40%, pests and diseases are widespread.

When assessing the sanitary condition, the average class of stability and the ratio of the total stock of deadwood and break wood to the amount of natural leaf litter were considered.

The type of spatial structure of the plantation was determined by the completeness of the tree stand, the nature and density of the plants, as well as the closure of the canopy.

A scale including 5 stages of forest ecosystem disorder was used to assess forest environment digression. At the first stage, there are no signs of forest violation, the growth and development of trees and shrubs are normal, mechanical damage is absent, moss and herb cover are not disturbed. The second stage of digression is characterized by a slight change in the forest environment and deterioration in the
growth and development of trees and shrubs, there are single mechanical damages, and undergrowth is viable. Projective herb cover is up to 90% (10% of which are meadow species). At the third stage of digression, a significant change in the forest environment is observed, the growth and development of trees is weakened, up to 10% of trunks have mechanical damages, undergrowth is suppressed, the projective herb cover is 60% (20% of which are meadow species); weeds, bedding and soil are significantly compacted and trampled. The fourth stage of digression is characterized by a strong violation of the forest environment, a meadow tree type, trees are significantly depressed, up to 20% of trunks have mechanical damages, and undergrowth is not viable. Projective herb cover is 40%. There is no forest litter in open places. The fifth stage of digression is defined if the forest environment is degraded, the forest stand is of meadow type, trees are strongly weakened or dry out, undergrowth, mosses, ground litter is absent, and a projective herb cover is up to 10%.

The relief, soils, type of forest and type of growth conditions, rock composition, placement of trees on the area, closeness and possibility of the areas were considered when determining the aesthetic assessment of the territory. Coniferous and hardwood plantations of the first and second classes of bonitet with well-developed tree crowns with healthy and beautiful undergrowth of medium density have a high aesthetic rating.

The suitability of areas for sanitary, hygienic and health-improving functions is determined depending on sanitary and hygienic indicators of the landscape, including assessment of the microclimate, the ability of plantations to produce oxygen, to enrich the environment with phytoncides and to ionize the air.

To determine the quantitative, species, age composition and assessment of viability of trees, the complete registration was carried out on test areas. Test areas were laid in various types of forest with different growing conditions. Studies on test areas were carried out by an ophthalmic measurement method.

The description of soil differences was made according to the methods from literary sources accepted in soil science. The determination of the soil types and soil differences was carried out according to morphological features. The floristic composition of the territory was established using the botanical reference book. A quantitative, route method was chosen for accounting birds and mammals. The study of macromycete was carried out by route reconnaissance. The distribution and abundance of fungi were determined on trial areas using Gaas and Moser scales [9].

3. Results and discussion

Field surveys showed that the research object is located within the area of the floodplain-terrace type of the Central Russian forest-steppe. The development of the soil cover of this territory is determined by the relief conditions, the thickness of the sand layer, the depth of water-resistant clays and loam, as well as the seasonal level of groundwater associated with these indicators. There is a soil formation in natural conditions, but complicated by anthropogenic pressure in the research area. The following types of soils were distinguished: turf-forest surface-gley-eluvial pseudo-fibre sandy soils with a second dark-colored horizon, turf-forest humified low-power pseudofibre sandy soils, and turf-forest humified medium-sized pseudo-fibre sandy soils.

In such environmental conditions deciduous species, especially oaks, which involve much more nutrients in the biological cycle than conifers, such as pines, are of great importance [10]. According to our observations, at the moment a natural process of changing species is taking place on this territory – complex woodlands are formed with the presence of oak and its companions in the second level – linden, elm, ash and maple. When appropriate events of taking care of plantations in this territory, it is possible to create a complex woodland with different-age, multi-leveled pines with deciduous trees in the second tier, dense undergrowth and developed soil cover, which has biological stability, oxygen productivity and high decorative properties, it is especially important in recreational zones. According to hydrological zoning, the territory of perspective SPNA belongs to the Voronezh hydrological region. At the same time, any water sources were not found within the boundaries of the object.
The climate of Voronezh city and the Voronezh region is temperate continental, formed under the influence of air masses coming from central Eurasia, the Atlantic, the Arctic and the tropics. The predominance of moderate air masses and Western winds explains frosty winters and relatively hot summers. Adverse climatic factors affecting plant growth and development include late spring and early autumn frosts, damaging seedlings and herbaceous sprouts; dry winds and low relative humidity of air during the growing season; and winter thaws. In general, the climatic conditions of the research area are favorable for the growth of tree-shrub vegetation.

The location of the research object on the territory of the left-bank bottom-terrace region of a typical forest-steppe determined the species composition of aboriginal vegetation in many ways. Along with representatives of the local flora, wood and shrub aliens were identified within the perspective SPNA.

These studies have found that 11 species of trees, 14 species of shrubs, two species of lianas, 44 species of herbaceous plants, a species of lichen and a species of moss grow on a perspective SPNA. The entire variety of higher plants in the research territory relates to 4 divisions, 32 families, 57 genus and 73 species. Two plant families have the greatest species diversity: Rosaceae – two species of trees, six species of shrubs and two species of herbaceous plants, and Poaceae – 12 species of grasses were found in the plantation (table 1).

Plantings at the research area are represented by artificial woodlands of Pinus sylvestris L. and Betula pendula Roth of 40-60 years old. Depending on the forest growing conditions, the first tier consists of mixture of Quercus robur L., Pyrus communis L., Acer platanoides L., Fraxinus excelsior L., Acer negundo L., Ulmus pumila L., Ulmus glabra Huds, Sorbus aucuparia L., Populus tremula L. were noted in the second tier of such plantations. The undergrowth includes Euonymus verrucosa Scop., Prunus fruticosa Pall., Caragana arborescens Lam, Prunus spinosa L., Frangula alnus Mill, Swida sanguinea (L.) Opiz, Acer campestre L. and others. Lianas are represented by Humulus lupulus L. and Parthenocissus quinquefolia PLANCH. Species of Geranium, Poa, Festuca, Calamagrostis, Carex, Artemisia are dominated in the ground cover.

Among the herbaceous plants growing on the territory of the perspective SPNA, a species listed in the Red Data Book of the Voronezh Region is noted – Platanthera bifolia (L.) Rich, it has the status of a rare species in our region.

Fungi are an integral component of forest biogeocoenosis, which play an important role in the functioning of ecosystems. In such biogeocoenosis, macromycete are an important heterotrophic link, without which the processes of mineralization and humification of the soil are impossible.

56 species of macromycete fungi of 17 families were foundin the examined plantations. Most of these families are in Agaricales order. At the same time, the greatest species diversity were found for Tricholomataceae (16 species) and Russulaceae (11 species) families.

There are some trophic groups of fungi: mycorhiza-forming agents, leaf litter and humus saprotrophes, xylotrophes and coprotrophes. Mycorhiza-forming agents – 25 species – predominate within the research object, the smallest number is characterized forcoprotrophes – 1 species – and humus saprotrophes – 3 species; leaf litter saprotrophes and xylotrophes have an intermediate position – 8 species and 19 species, respectively.

According to the edibility categories, macromycete are distributed as follows: 21 species are edible, 14 species are conditionally-edible, 12 species are inedible and 9 species are poisonous. It should be noted that the largest number of edible species of fungi belong to Tricholomataceae (6 species) and Russulaceae (8species) families. One species of edible fungi is found in each of the families: Agaricaceae, Physalacriaceae, Pleurotaceae and Fistulinaceae, all three discovered species of fungi of the Boletaceae family are edible.

Most species of macromycete in the territory of perspective SPNA are found singly or in small groups, due to their bio-ecological characteristics and conditions of this territory.
| Plant life forms | Family               | Species                                                                 |
|-----------------|----------------------|-------------------------------------------------------------------------|
| **Trees**       | **Pinaceae LINDL**   | Pinus sylvestris L.                                                    |
|                 | **Oleaceae Hoff.&Link.** | Fraxinus excelsior L.                                                  |
|                 | **Ulmaceae Mirb**    | Ulmus glabra Huds, U. punila L.                                        |
|                 | **Fagaceae Dumort**  | Quercus robur L.                                                       |
|                 | **Betulaceae S. F. Gray** | Betula pendula Roth                                                  |
|                 | **Salicaceae Mirb**  | Populus tremula L.                                                     |
|                 | **Rosaceae Juss.**   | Pyrus communis L., Sorbus aucuparia L.                                  |
|                 | **Aceraceae Juss.**  | Acer platanoides L., A. Negundo L.                                     |
| **Shrubs**      | **Berberidaceae Juss.** | Mahonia aquifolium Nutt                                               |
|                 | **Rosaceae Juss.**   | Cotoneaster lucidus Schlecht, Padus avium Mill,                        |
|                 |                     | Rubus idaeus Maxim., R. caesius L.,Prunus fruticosa Pall., P. spinosa L. |
| **Herbaceous**  | **Fabaceae Lindl.**  | Caragana arborescens Lam                                               |
| **species**     | **Aceraceae Juss.**  | Acer campestre L., A.tataricum L.                                       |
|                 | **Cornaceae Dumort** | Swida sanguinea (L.) Opiz                                              |
|                 | **Celastraceae R. Br.** | Euonymus verrucosa Scop.                                               |
|                 | **Rhamnaceae Juss.** | Frangula alnus Mill.                                                   |
|                 | **Caprifoliaceae Juss.** | Sambucus nigra L.                                                      |
| **Lianas**      | **Cannabaceae Martynov** | Humulus lupulus L.                                                      |
| **Vitaceae Lindl.** | Parthenocissus quinquefolia PLANCH.                                   |
| **Asteraceae Bercht.** | Solidago canadensis L., Cichorium intybus L.,                        |
|                 |                     | Carлина biebersteinii Bernh, Antennaria dioica(L.)                      |
|                 |                     | Gaertn., Pinosilla officinarum F.W.Schultz, Sonchus arvensis L., Artemisia absinthium L., A. Austriaca Jacq, A. vulgarisL., Cirsium vulgar(Savi) Ten., Tanacetum vulgare L., Achillea millefolium L. |
| **Poaceae Barnhart** | Dactylis glomerata L., Calamagrostis canescens (Weber) Roth, C. epigeios Roth, Poa pratensis L., P. compressa L., P. nemoralis L., Bromus inermis Leyss, Milium effusum L., Festuca pratensis Huds., F. gigantea (L.) Vill., Elymus caninus L., Molinia caerulea (L.) Moench |
|                 | **Geraniaceae Juss.** | Geranium sanguineum L., G. Robertianum L.                              |
|                 | **Campanulaceae Juss.** | Campanula patula L., C.ranunculoides L.                               |
|                 | **Rosaceae Juss.**   | Rubus saxatilis L., Fragaria vesca L.                                  |
|                 | **Violaceae Batsch** | Viola hirta L.                                                         |
|                 | **Hypericaceae Juss.** | Hypericum perforatum L.                                               |
|                 | **Equisetaceae Michx.** | Equisetum arvenseL.                                                   |
|                 | **Orchidaceae Juss.** | Platanthera bifolia (L.) Rich                                          |
|                 | **Amaranthaceae Juss.** | Atriplex patula L.                                                     |
|                 | **Onagraceae Juss.** | Oenothera biennis L.                                                   |
|                 | **Lamiaceae Martinov** | Stachys sylvatica L., Glechoma hederacea L.                            |
|                 | **Euphorbiaceae Juss.** | Euphorbia esula L.                                                    |
|                 | **Cyperaceae Juss.** | Carex maricata L., C. pilosa Scop.                                     |
|                 | **Aspleniaceae A.B. Frank** | Athyrium filix-femina (L.) Roth                                      |
| **Mosses**      | **Polytrichaceae Chwägr.** | Polytrichum commune Hedw.                                             |
The most important functions of macromycete in recreational plantations are the participation of saprotrophic species in the cycle of matter, the formation of symbioses with the root system of trees and shrubs by mycorhiza-forming agents, as well as some species have the nutritional significance. At the same time, the great number of xylotrophs that settle on living trees and cause rotten pathologies in them is noticed in this plantation. To heed the particular injuriousness of this group of fungi, monitoring of their number is necessary.

The biological diversity of vertebrate animals in perspective SPNA includes species of mammals, birds, reptiles and amphibians.

The mammals of Chiroptera, Eulipotyphla, Rodentia orders were also identified. Typical inhabitants of this territory from the Eulipotyphla order are species of Soricidae, Erinaceidae and Talpidae families. The Chiroptera order is represented by Nyctalus lasioterus Sch., Vespertilio murinus L., Plecotus austriacus F. and Pipistrellus nathusii K. (Bl). All these species are enemies of insect pests of the forest; therefore they are important in the biocoenosis and have to be protected. The Rodentia order is represented by Sciurus vulgaris L. and Myodes glareolus Sch. in this plantation. Sciurus vulgaris L. is listed in the Red Data Book of the Voronezh, Lipetsk and Kursk regions. The Myodes glareolus Sch. in the plantation is a pest, as it feeds on seeds and green parts of plants.

The species of birds that were identified in the research area belong mainly to three orders – Passeriformes, Piciformes and Falconiformes. They are Fringilla coelebs L., Parus major L., Sitta europaea L., Dendrocopos major L., Accipiter nisus L., etc. All these species are ordinary and dominating, they nest in our zone. The usefulness of birds in forest ecosystems is beyond doubt. The importance of birds in regulating the number of insects and small rodents is especially high.

Reptiles and amphibians are important components of forest biogeocoenosism. Reptilia class is represented by the following species: Lacerta agilis L., Anguis fragilis L. and Natrix natrix L. from the Squamata order. The Amphibia class in the research area is represented by Bufo bufo L., Bufo tesselris Lauren., Pelobates fuscus Lauren and frogs – Rana temporaria L. and Rana arvalis Nils. The ability of many species of amphibians and reptiles to accumulate chemical elements allows them to be used in the environment bioindication.

Species diversity of invertebrate animals includes various types of worms, arthropods, mollusks and other organisms. The variety of insects and herbivorous mites is determined by the composition of the predominant species of trees used as a fodder substrate by phytophages. There are earthworms, gall and spider mites, leaf rollers, sawflies, moths, gall-flies, sawyers, bark beetles, various types of aphids and other invertebrates, which were in different stages of development at the time of the survey.

When assessing the structure of plantations, it was found that closed and semi-open types of spatial structure prevail in the territory of a perspective SPNA, which meets the requirements to such structures in recreational plantations of the southern forest-steppe.

An important characteristic of plantations is their sanitary and forest-pathological condition [11]. When assessing the forest pathological condition, it was found that the biological stability of this plantation corresponds to class 2. There are single trees affected by diseases and inhabited by pests, the forest environment in most of the territory is not disturbed, the completeness is even, dead wood is about 7%. The health condition of the plantation can be assessed as satisfactory.

During the research, two or sometimes three stages of forest environment digression were identified – a slight change in the forest environment and a deterioration in the growth and development of trees and shrubs, trees have anthropogenic damage, the undergrowth is viable, of medium density. The relative area of grass projection on the soil surface is up to 90%, the surface soil horizon in the plantation is not changed.

The studied plantings have high rates of aesthetic and hygienic assessments. The areas are in satisfactory or good sanitary condition; clean air, sufficient ventilation, and absence of noise, parasites and dense thickets; there are aromatic smells, forest sounds, and bright paints.
4. Conclusion

Based on the results of the research, considering the landscape-ecological, aesthetic, sanitary, hygienic and recreational significance of plantations, it was recommended to assign the SPNA status of regional significance to this object - a natural park, the main functions of which should be the preservation of natural complexes, reducing anthropogenic pressure on the landscape and maintaining environmental balance in the city district of Voronezh.

It is estimated to use this territory in order to restore and prevent changes in natural complexes and their components because of the anthropogenic impact; to maintain the conditions ensuring sanitary and fire safety; to prevent conditions which can cause natural disasters and threaten the lives of people and settlements; to organize scientific, environmental and educational activities, as well as environmental events.

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