Subori pine cenoses herbaceous ground cover biodiversity of the Voronezh Region

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Abstract. An assessment of the biodiversity and abundance of the herbaceous ground cover of the subori pine cenoses in the Voronezh Region was carried out in the long term (1990 to 2023) under the influence of the factor of reducing forest areas and identifying the most resistant species. Over the observation period from 1990 to 2020, the species composition of the vegetation cover of the subori changed insignificantly. By 2020, plants of the Red Book of the Voronezh Region, wintergreen, feather grass, as well as subori plants (sweet grass, round-leaved bellflower, nettle-leaved bellflower), had disappeared. The species composition of subori was replenished with meadow and ruderal plants, as well as dry pine forest plants, the abundance of individual species of cereals or liliaceae increased, the abundance of labiates, legumes and polypods decreased. Based on the ecological-cenotic analysis and the abundance of species, 26 species (out of 54) were identified that belong to mesophytes and xerophytes.

1 Formatting the text

The Voronezh Region is located in the forest-steppe and steppe zones and the area of forested lands in 2024 was 467.6 thousand hectares [1]. The dynamics of changes in forest areas is shown in the graph (Figure 1), constructed according to data from the Unified Interdepartmental Statistical Information System [2]. The reduction in area is most often associated with fires and logging, while annual work is carried out related to reforestation and afforestation, which affects the restoration of the forested area.

Voronezh is a large city surrounded by a green belt. The forest cover of the region is quite low - 8.3% [3]. All forests in the region are classified as protective and are subject to development in order to preserve the environment-forming, water-protective, protective, sanitary-hygienic, health-improving and other functions of forests with the simultaneous use of forests, provided that this use is compatible with the intended purpose of protective forests and the useful functions they perform [4]. By the Resolution of the Voronezh Regional Duma dated 07.03.2019 №1665-VI-OD "On the creation of a green forest park belt of the city of Voronezh and its area", a decision was made to create a forest park green belt with an area of 15.5 thousand hectares. Of these, the area of the state forest fund is 14.7 thousand hectares

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and includes the lands of the Semiluksky, Somovskiy, Novousmansky and Prigorodny forestries of the Voronezh Region [5].

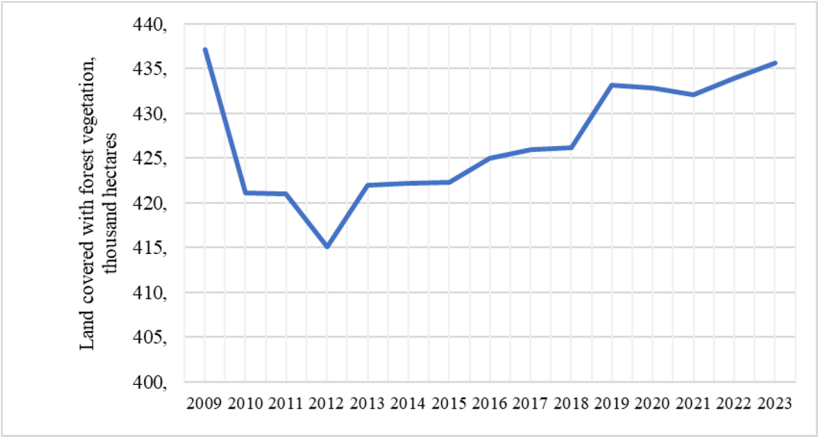


Fig.1. Dynamics of changes in the area of land covered by forest vegetation, in hectares

The main forest-forming species of the green belt of the city of Voronezh and in the Voronezh Region are the English oak (Querqus robur L.) and Scots pine (Pinus silvestris L.). [6]. Rapid growth of urban agglomeration is accompanied by increased load on existing green infrastructure. As a result, suburban forests are cut down, the quality of atmospheric air is deteriorating, and the soil and grass cover is damaged. Formation of forest corridors could become a solution to the issues of preserving biodiversity not only for animals, but also for plants in the case of fragmentation of forest territories.

The efficiency of the functioning of a green forest corridor will depend on the maintenance of ecological conditions of the environment, the stability of habitat-forming tree species, and the species, their ecological and biological properties, inhabiting the corridor and nearby stands. For plants dispersing in linear habitats, one of such important processes is the maintenance of adequate pollen transfer to ensure seed production within the corridor [7]. Some forest herbs can exhibit phenotypic plasticity to increasing temperatures, which potentially increases their ability to benefit from hedgerows as ecological corridors. Air temperature can affect the efficiency of forest corridors, promoting the preservation and colonization of forest species within and beyond their current distribution range [8]. Some forest grass species could be reintroduced into artificial plantations as young plants, knowing that their spontaneous recolonization is often limited by dispersal and/or seedling emergence. Forest plantations (forest belts) could also contribute to biodiversity conservation by creating conditions for the cultivation of forest grass species as an alternative to their collection from natural populations [9].

Forest plantations of fast-growing tree species can be useful for conservation purposes by accelerating the restoration of forest habitat on abandoned agricultural lands and improving the connectivity of fragmented landscapes [9].

One of the most important factors determining the stability of biocenoses, both natural and artificial, is the degree of biological diversity and the attitude of species to changing climatic conditions. Therefore, studying the dynamics of the species composition of the grass cover is relevant, identifying the most resistant species will allow us to form an idea of the typical vegetation of such forest corridors, and taking into account the environmental preferences of vulnerable species will facilitate their recolonization in suitable environmental conditions.

The aim of this work is to assess the biodiversity and abundance of the herbaceous ground cover of the subori pine cenoses of the Voronezh Region in the long term (1990 to 2023) under the influence of the factor of reduction of forested areas and to identify the most resistant species.

The main objectives of the study were: comparison of the species composition of the grass cover in the test plots, conducting an ecological and cenotic analysis of the grass cover and identifying trends in its change in 2023 under the influence of the time factor and a decrease in forested areas, identifying the most stable types of grass cover.

2 Objects and methods of the study

The study was conducted on the territory of the educational and experimental Levoberezhny Forestry of VSUFT named after G.F. Morozov in seventy-year-old pine forests. Scots pine is the main forest-forming species, accompanying tree species are English oak, silver birch, Norway maple, and warty euonymus is distinguished from shrubs. The formula of the tree stand is 8C2D. In 1990, the employees of the Department of Botany laid out permanent test plots and described the species composition of the vegetation, with repeated surveys in 2000, 2010 and 2020. In the selected pine phytocenoses, herbaceous plants were studied using generally accepted methods, laying out thirty permanent accounting plots each one square meter in size. When analyzing the species composition, the ecomorph system developed by Belgard was used [10]. The ecological characteristics of the species were determined taking into account Tarasov's recommendations [11]. The trophomorphs listed below indicate the adaptation of plants to the fertility of the substrate, hygromorphs to the water regime, heliomorphs to the light regime, cenomorphs to the adaptation of plants to the phytocenosis and biogeocenosis as a whole, as well as to the type of substrate.

3 Results and their discussion

The classification of the species composition of herbaceous plants found in the test plots from 1990 to 2020, as well as their coenotic and ecological characteristics are presented in Table 1.

The analysis of the distribution of herbaceous plants by the main biomorph indicates the prevalence of perennials in the subori. There are few annual and biennial plants. In relation to the light factor, light-loving species predominate in the subori (the proportion of heliophytes is 42%), the proportion of heliosciophytes, which are more inclined to lighted areas, is 38%, and scioheliophytes, which are more fond of shady habitats, are only 19%, which corresponds to the ecological conditions formed in forest stands when weakened trees fall out.

In relation to the moisture conditions, meso- and xerophytes are mainly present, that is, plants of moderately humid conditions, and the share of mesophytes is more than 60%. In terms of soil fertility requirements, subori plants are characterized by mesotrophs (plants with moderate demands) - 42%, and slightly less than 38% are oligotrophs, plants that are more demanding of fertility.

Table 1. Species composition of herbaceous plants found in sample plots from 1990 to 2020, as well as their coenotic and ecological characteristics

	Species	Ecomorphs	Availability	Abundance of Brown-Blanquet

Item No.		Hygro -	Tropho -	Helio-	1990	2000	2010	2020	1990	2000	2010	2020
1	*Glechoma hederacea* L.	Ms	MsTr	HeSc	-	-	+	+	0	0	1	1
2	*Jasione montana* L.	Ks	OgTr	HeSc	-	-	+	+	0	0	1	1
3	*Betonica officinalis* L.	Ms	MsTr	He	+	+	-	+	2	2	0	1
4	*Calamagrostis epigejos* (L.) Roth	Ms	OgMsTr	ScHe	+	+	+	+	2	2	3	3
5	*Dianthus deltoides* L.	Ms	MsTr	HeSc	-	-	+	+	0	0	1	1
6	*Geranium sanguineum* L.	KsMs	MsTr	HeSc	+	+	+	+	2	2	1	1
7	*Geranium sylvaticum* L.	Ms	MsTr	HeSc	-	-	+	+	0	0	1	1
8	*Peucedanum oreoselinum* Moench	KsMs	MsTr	He	-	-	-	+	0	0	0	1
9	*Dicranum undulatum* Ehrh. ex Web. et Molir	HgMs	MsTr	HeSc	+	+	+	+	3	3	3	3
10	*Genista tinctoria* L.	Ms	MsTr	He	+	+	+	+	2	2	2	2
11	*Origanum vulgare* L.	Ms	MsTr	He	+	+	+	+	2	2	1	1
12	*Ajuga genevensis* L.	Ms	MsTr	He	+	+	+	+	1	1	2	2
13	*Stellaria media* (L.) Vill.	Ms	MsTr	HeSc	-	-	+	+	0	0	1	2
14	*Hypericum perforatum* L.	Ms	MsTr	He	+	+	+	+	1	1	2	2
15	*Fragaria vesca* L.	Ms	MsTr	ScHe	+	+	+	+	3	3	2	2
16	Зимолюбка зонтичная	Ms	MsTr	HeSc	+	+	-	-	1	1	0	0
17	*Hierochloe odorata* (L.) P.Beauv.	Ms	OgTr	He	+	+	-	-	1	1	0	0
18	*Epilobium angustifolium* L.	Ms	OgTr	He	-	-	-	+	0	0	0	2
19	*Trifolium alpestre* L.	Ms	MsTr	He	+	+	+	+	3	3	3	2
20	*Trifolium montanum* L.	Ms	MsTr	He	+	+	+	+	3	3	3	2
21	*Stipa pennata* L.	Ks	OgTr	He	+	+	-	-	3	2	0	0
22	*Campanula trachelium* L.	Ms	MsTr	HeSc	+	+	-	-	1	1	0	0

23	*Campanula rotundifolia* L.	Ms	MsTr	HeSc	+	-	-	-	1	0	0	0
24	*Campanula persicifolia* L.	Ms	MsTr	He	+	+	+	+	2	1	1	1
25	*Bromus inermis* Leyss.	Ms	MsTr	ScHe	-	+	+	+	0	1	1	2
26	*Polygonatum odoratum* (Mill.) Druce	MsKs	OgTr	HeSc	-	-	+	+	0	0	2	2
27	*Convallaria majalis* L.	Ms	MsOgTr	HeSc	-	+	+	+	0	2	2	2
28	*Vincetoxicum hirundinaria* Medik.	MsKs	MsOgTr	HeSc	+	+	+	+	1	2	2	2
29	*Rubus idaeus* L.	Ms	OgTr	ScHe	+	+	+	+	3	3	2	2
30	*Melampyrum pratense* L.	Ms	MsTr	He	-	+	+	+	0	2	2	2
31	*Erigeron annuus* (L.) Desf.	Ms	MsTr	ScHe	-	-	+	+	0	0	1	1
32	*Poa pratensis* L.	Ms	MgTr	ScHe	+	+	-	-	1	2	0	0
33	*Festuca beckeri* (Hack.)Trautv	Ms	MgTr	ScHe	-	-	-	+	0	0	0	2
34	*Pteridium aquilinum* (L.) Kuhn	Ms	OgTr	ScHe	+	+	+	+	3	3	2	2
35	*Carex ericetorum* Pollich	Ks	OgTr	ScHe	-	-	-	+	0	0	0	2
36	*Melica nutans* L.	Ms	OgMsTr	ScHe	-	+	+	+	0	1	1	2
37	*Tanacetum vulgare* L.	Ms	MsTr	He	+	+	+	+	1	1	1	1
38	*Pleurozium schreberi* (Willd. ex Brid.)	HgMs	MsTr	HeSc	+	+	+	+	3	3	2	2
39	*Cuscuta epithymum* L.	Ks	MsTr	ScHe	-	-	+	+	0	0	1	1
40	*Galium verum* L.	Ks	OgHg	He	+	+	+	+	2	2	1	1
41	*Galium boreale* L.	Ks	MsTr	He	-	+	-	-	0	1	0	0
42	*Elytrigia repens* (L.) Desv. ex Nevsk	MsHg	OgMsTr	He	-	+	+	+	0	1	1	1
43	*Ramiscia secunda* (L) Garcke	Ms	MsTr	HeSc	+	+	-	-	1	1	0	0
44	*Silene nutans* L.	Ms	MsTr	He	+	+	+	+	3	3	2	2
45	*Silene viscaria* Jess.	Ms	MsTr	He	+	+	+	+	3	3	2	2

46	*Achillea nobilis* L.	Ks	OgTr	HeSc	+	+	-	-	1	1	0	0
47	*Achillea millefolium* L.	Ks	MsTr	HeSc	+	+	+	+	2	2	2	2
48	*Prunella vulgaris* L.	Ks	MsTr	HeSc	+	+	-	-	1	1	0	0
49	*Rumex acetosella* L.	Ms	OgTr	ScHe	+	+	+	+	2	2	1	1
50	*Dryopteris carthusiana* (Vill.)H.P.Fuchs	Ms	MgTr	HeSc	+	+	-	-	1	1	0	0
51	*Dryopteris filix-mas* (L.) Schott	Ms	MgTr	HeSc	+	+	-	-	1	1	0	0
52	*Asperula tinctoria* L.	Ks	OgHg	He	+	+	-	+	1	1	0	1
53	*Pilosella officinarum* F.W.Schultz & Sch.Bip.	Ks	OgTr	ScHe	-	+	+	+	0	2	2	2
54	*Hieracium umbellatum* L.	Ks	OgTr	ScHe	+	-	-	-	1	0	0	0
Number of species					36	39	35	41				

Designation: * OgTr - oligotroph, MsTr - mesotroph, MgTr - megatroph, Ks - xerophyte, Ms - mesophyte, HgMs - hygromesophyte , MsHg - mesohygrophyte , He - heliophyte, Sc - sciophyte , ScHe and HeSc are species that are partially light-demanding. In the combination of symbols, the first part is predominant). **Numbers 0-3 indicate Abundance according to Braun-Blanquet.

According to a 1990 study, the vegetation cover on the test plots consists of 36 species from 17 families. The studied phytocenosis includes wintergreen and feather grass, species listed in the Red Book of the Voronezh Region. The most abundant families in terms of species are Asteraceae, Labiatae, and Poaceae (4-5 species per family). Legumes, Caryophyllaceae, Campanulata, Polypodiaceae, Rubiaceae, Rosaceae, and Wintergreen are represented by two or three species. The remaining families have one species each.

Over the ten-year period up to 2000, some changes in the species composition can be noted in the trial plots. The total number of species in nineteen families is up to 39 (new species from the families Liliaceae, Compositae, Rubiaceae and Poaceae).

The year 2010 was characterized by severe fires that affected the left-bank part of the city's forest areas, although the established test plots in the suboria were not damaged. That year, two species of the Wintergreen family (Umbellate wintergreen and Orthilia secunda), two species of the Campanulaceae family (Common harebell and Nettle-leaved bellflower), and two species of the Poaceae and Lamiaceae families (European feather grass and Betonica officinalis) were not found. At the same time, Maiden pink (Caryophyllaceae family), Solomon's seal (Liliaceae family), and the weedy ruderal plants Greater dodder (Convolvulaceae family), Stellaria media (Caryophyllaceae family), and Erigeron (Asteraceae family) appeared. Therefore, it can be assumed that despite the territorial proximity (Figure 2) to the burnt forest areas, in the surveyed areas the changes in the species composition were insignificant, the phytocenosis was characterized by natural vegetation, however, it can be noted that the abundance of existing species became less.

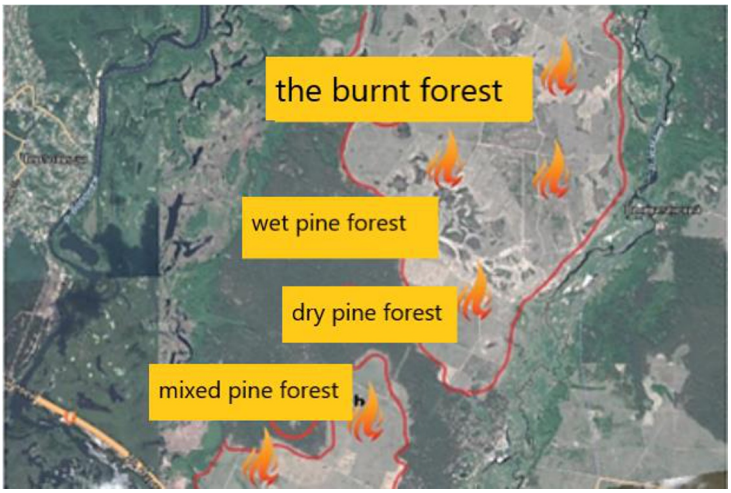


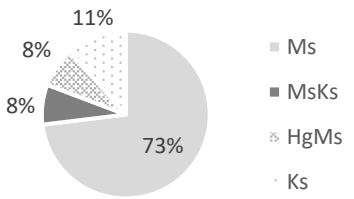
Fig. 2. Locations of description of the herbaceous ground cover in a pine forest, which is surrounded by areas destroyed by fires in 2010 [12].

The study of the 2020 subori revealed an increase in the species composition of herbaceous plants due to the appearance of some oak forest species - Glechoma hederacea (family Labiatae), meadow - Maiden pink (family Caryophyllaceae), plants of the dry forest - Rare spring sedge (family Cyperaceae), Festuca beckeri (family Poaceae), Narrow-leaved fireweed (family Fireweed), Peucedanum oreoselinum (family Umbelliferae) appeared.

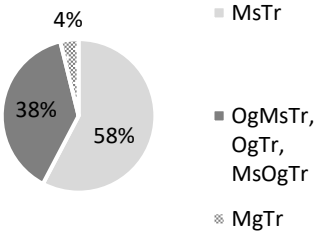
In all observations, the abundance of species composition was assessed according to Braun-Blanquet. Although the diversity of species composition changed insignificantly, their abundance changed by 2020. In subori, the abundance of such flowering species as Betonica officinalis, Origanum vulgare, Alpine clover, Mountain clover, Galium verum, Geranium sanguineum decreased, and the abundance of Bracken also decreased. At the same time, the abundance of such plants as Calamagrostis terrestris and Brome grass, Solomon's seal, Lily of the valley, and Geneva bugle increased.

Based on the abundance analysis, 27 species were identified from 54, the occurrence of which increased over a 30-year period (Table 1). According to ecological characteristics, most of them are mesophytes and mesotrophs, oligomesotrophs, and these plants are more inclined to well-lit habitats, but are able to tolerate shading (Figure 3 a - c). These species are: reed grass, undulate dicranum, dyer's broom, Geneva bugleweed, common chickweed, common St. John's wort, wild strawberry, fireweed, alpine clover, mountain clover, awnless brome, medicinal Solomon's seal, lily of the valley, medicinal swallowwort, common raspberry, meadow marianum, meadow small-petaled grass, common bracken, heather sedge, drooping pearlwort, pleurocium Schrebera, drooping campion, common campion, common yarrow, hairy hawkweed.

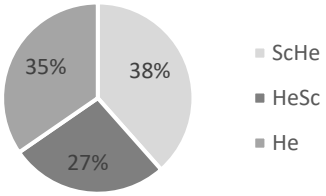
Taking into account the specificity of forest corridors as extended plantings, the boundaries of which will experience factors of high illumination, decreased soil moisture, and in the conditions of urban agglomerations, anthropogenic load, the most resistant species that adapt to illumination/shading, decreased soil moisture and are capable of growing in soils poor in mineral and organic composition, as well as synanthropic species, will spread in these types of plantings. The species composition of herbaceous plants will decrease, which has been shown for natural plantings with high anthropogenic load [13].



a) Ecological group of plants in relation to soil moisture



b) Ecological group of plants in relation to soil fertility



c) Ecological group of plants in relation to illumination

Fig. 3. Ecological group of plants in relation to soil moisture, to soil fertility, to illumination

Designations: OgTr - oligotroph, MsTr - mesotroph, MgTr - megatroph, Ks - xerophyte, Ms - mesophyte, HgMs - hygromesophyte, MsHg - mesohygrophyte, He - heliophyte, Sc - sciophyte , ScHe and HeSc - species that are partially demanding of light. In the combination of symbols, the first part is predominant).

The greatest adaptability of mesophytes is confirmed by the species diversity of burnt areas 20 years after a fire in pine forests [14]. The formation of corridors on burnt areas will also contribute to the restoration of the grass cover, for example, the process of overgrowing burnt areas in the Ob pine forests is similar to the patterns in ribbon forests. However, burnt areas form their own coenoflora, and the vegetation cover consists of communities with their own dominant and subdominant species [15]. In subori conditions, the complex of boreal species will gradually be replaced by nemoral species [16, 17]. To predict the species composition and its change in the formed stand, it is also necessary to take into account the life strategies of plants, as well as the type of forest formation [18]. Plants with high seed productivity and vegetative activity will be best adapted to the new conditions.

4 Conclusion

During the observation period from 1990 to 2020, the floristic composition of the vegetation cover of subori changed insignificantly. The features of the transformation of phytocenoses were revealed: by 2020, the plants of the Red Book of the Voronezh Region, Wintergreen umbrella, feather grass, disappeared, the subori plants sweet-scented bison, round-leaved bellflower, nettle-leaved bellflower disappeared. The species composition of subori was replenished with meadow and ruderal plants, as well as dry pine forest plants, the abundance

of individual species increased: cereals or liliaceae, the abundance of labiates, legumes and polypods decreased.

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