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CHANGES IN THE FLORA COMPOSITION OF PLANT COMMUNITIES IN THE SOUTHERN ARKHANGELSK REGION IN THE 20th CENTURY

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Based on the analysis of floristic data for different periods of time, this work studies the species composition changes in plant communities of the middle taiga in the south of the Arkhangelsk Region. In accordance with the "Flora of the Northern Territory" by I.A. Perfiliev (1934-1936), we compiled a taxonomic list of higher vascular plants of the Ustyansky District, Arkhangelsk Region that were growing there in the early XX century, and then corrected it in accordance with modern taxonomic nomenclature. We also carried out a comparative analysis of the early XX century list and the modern one, compiled for the same territory, and found differences in their taxonomic, ecological, coenotic and geographical compositions, as well as in the groups of species that changed their presence/absence status. The taxonomic changes turned out to be a decrease in the list by 140 species of vascular plants from 95 genera and 41 families, while 69 species from 57 genera and 31 families were registered in the territory for the first time. Although the taxonomic spectra for both periods are generally similar, the study has revealed that Brassicaceae and Fabaceae taxa increased, but Cyperaceae, Ranunculaceae and Orhidaceae decreased. We calculated coefficients of floristic similarity, Spearman and Kendall coefficients of correlation, and the generic coefficient. According to Jaccard similarity coefficient, the correlation coefficients showed a weak relation, while the floristic lists were highly similar, but the generic coefficient has decreased. It may indicate that flora identity and biological diversity decline due to the environmental changes.

An analysis of the ecological and coenotic composition of vascular plants for both studied periods showed an increase of species of disturbed habitats and a decrease of those that were close to indigenous communities, such as nemoral, boreal and wetland.

Climate changes, in particular, the increase of average annual temperature and the sums of active temperatures over the studied period, affected the change in the floristic composition of plant communities. The number of cold-resistant species of a hypoarctic-boreal range decreased, while some heat-loving broad-leaved-forest-steppe and plurizonal species appeared. According to the distribution of the species numbers along the Landolt ecological scales, the number of species with a high need for warmth increased, as well as the number of mesoxerophytes. The proportion of alien species also increased, most of which coming from southerly regions: *Galega orientalis* Lam., *Lupinus polyphyllus* Lindl., *Heracleum sosnowskyi* Manden.

Keywords: floristic composition, plant communities, middle taiga, ecological and coenotic elements, ranges, alien species.

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Environmental changes, including climate changes, and the evolving agricultural development, with the following increasing anthropogenic pressure on natural ecosystems, have caused the species composition of plant communities to undergo significant transformation that affects biological diversity, leads to disappearance of some species in the studied territory and to emergence of the new ones. Climate changes in the second half of the XX century can, presumably, lead to a shift in the ranges boundaries of some species, which also has an effect on species composition of plant communities.

An analysis of extinct and new plant species list, as well as their ecological, coenotic and geographical characteristics can be used as indicators of changes in the natural environment, can provide a basis for forecasting of the further development of plant communities, and give us an overview of the potential flora in the studied region. Many recent geobotanical works are focused entirely on potential flora in connection with assessment and conservation of biological diversity (Morozova, 2009; Smirnova et al., 2015; Worz, Thiv, 2015; Smirnova, Toropova, 2016). However, comparing the floristic lists of a particular region, compiled with a time skip of more than 60-80 years, is a rather rare opportunity (Salnikov, 2005). "Flora of the Northern Territory" (1934-1936), a monograph of the remarkable Russian botanist Ivan Alexandrovich Perfiliev, compiled on the basis of his long-term observations started in the early XX century, presents a complete list of vascular plants species, including their habitats and location in the counties of the Arkhangelsk Governorate (Region) and all the adjacent regions. Since the 90s of the XX century, scientific expedition of M.V. Lomonosov Moscow State University (Department of Biogeography, Faculty of Geography) carries out researches in the Ustyansky District of the Arkhangelsk Region, including a detailed study of the species composition of plant communities in its central and southern parts (Flora and Fauna ..., 2003; Leonova, Goryainova, 2019). Many years of observations allowed researchers to make a relatively complete list of species, which can be compared in volume to the local floras of Velsk, Kotlas, and Verkhnyaya Toima (Schmidt, 2005).

The purpose of our work was to identify the dynamics of the floristic composition of plant communities in the middle taiga, using the example of the Ustyansky Region in a changing environment. It was done through a comparison and interpretation of floristic lists for different periods of time, the first half of the XX century and the early XXI century. Our objectives included the use of literary sources for compilation of a taxonomic list of higher vascular plants that grew on the territory in the early XX century, and adjusting it in accordance with the modern taxonomic nomenclature. We also carried out a comparative analysis of the said lists according to their taxonomic compositions; identified the ecological-coenotic and geographical characteristics of those species that make up the difference between the lists; interpreted the results by comparing them with the changes in the natural environment over the studied period. The dynamics of plant species, which, according to the data for the same period, grew at the border of their ranges, has been already considered by us in the earlier work (Eremeeva, Leonova, 2022).

Materials and Methods

To study plant species that were collected and described in the early XX century, we used the monograph of I.A. Perfiliev, "Flora of the Northern Territory", published in 1934-1936 in 3 volumes. To analyze modern flora, we used "Flora and Fauna of the Middle Taiga of the Arkhangelsk Region (Interfluve of the Ustya and Kokshenga Rivers)", published by the employees of the Department of Biogeography of Moscow State University in 2003, with recent additions (Leonova et al., 2021). To verify the analyzed data, we used the work of V.M. Schmidt, "Flora of the Arkhangelsk Region" (2005).

The study area is located in the southern part of the Arkhangelsk Region, namely, the central and southern parts of the Ustyansky District of the Arkhangelsk Region (Fig. 1), which used to belong to the Vologda Region, called the Velsky Uezd until 1929 (Fig. 2). When compiling the floristic list of the early XX century, for a correct comparison we chose those species from I.A. Perfiliev's monograph that were mentioned there for this particular territory of our study.

The studied territory is located between the tributaries of the Vaga River (between the Ustya and Kokshenga rivers), within the Ustyansky Plateau, which is composed of marls, sands, dolomites, Permian limestones, covered with relatively thin Quaternary deposits, such as glacial boulder loams, lacustrine-glacial loams and sandy loams, fluvioglacial sands and Moscovian sandy

loams. The distribution of soddy-calcareous soils depends on areas with shallow carbonate rocks, while the podzolic soils are zonal ones (Khoroshev, 2005). The climate of the territory is temperate continental, with long cold winters and moderately warm summers. The climatic indicators in Table 1, obtained from the Totma Station in Vologda Region for the first third of the XX century and for the modern period, illustrate a significant increase in temperatures and precipitation.

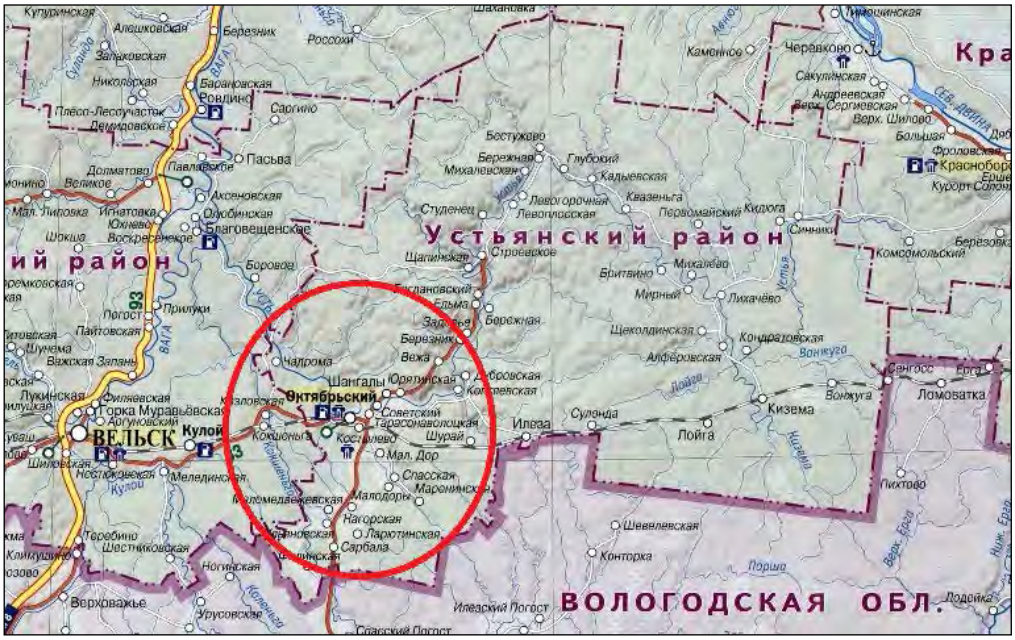

Fig. 1. Study region on the modern map of Arkhangelsk Region is marked with a red circle.

Fig. 2. Study region on a map of Vologda Governorate (Velsky Uezd) for the early XXI century borders (Stielers Hand-Atlas, 1905).

Table 1. Dynamic of climate indices for the study region in the first half of the XX century and the early XXI century, according to the data from the Totma Meteorological Station (Bulygina et al., 2021).

Climate indices	1925-1935	2010-2020
Average annual temperature, °C	+2.4	+4.0
Temperature of January, °C	-11.5	-11.1
Temperature of July, °C	+17.9	+18.2
Average sum of active temperatures for 10 years, °C	1770	1960
Average annual precipitation, mm	570	650

We created our tables and graphs on the basis of publicly available and free meteorological data of Russia and the former USSR (Bulygina et al., 2021). The more detailed dynamics and trends of changes in average annual temperatures, humidity, and the sum of active temperatures from 1925 to 2020 for the study area can be seen in the graphs (Fig. 3).

When the drainage is poor, the annual amount of precipitation is not provided with resources for evaporation, which partially retains moisture and causes flooding on watersheds. In the hydrological aspect, the territory is a well-drained plain, with a secure soil-ground runoff and a dense network of big and small rivers. A specific feature of most of these rivers is the fact that their valleys are embedded into the former channels of the melted glacial waters and lacustrine-glacial depressions, composed of fluvioglacial deposits. Therefore, the size and embeddedness even of the small river valleys (for example, of the Zayachya River) are very big (Photo 1). There are wide oligotrophic swamps (Photo 2) formed on vast watersheds (Gorbunova et al., 2014).

Various types of taiga forest are prevailing in the vegetation cover of the territory, formed with *Picea x fennica* (Regel) Kom and *Pinus sylvestris* L. (Photo 3); the secondary forests are formed mostly with *Betula pendula* Roth and *B. pubescens* Ehrh., and sometimes with *Populus tremula* L. and *Alnus incana* (L. Moench). The swamps are rare and usually afforested, and sometimes meadow communities are distributed in the rivers floodplains. Due to the wide distribution of fertile soddy-calcareous soils, the southern part of the Arkhangelsk Region has a long-term history of agricultural development. Upland meadows form and then transform into forest communities on the former agricultural lands in the watersheds (Photo 4). In the central and northern part of the Ustyansky Region lumbering affects significantly the natural complexes, although the forest cover of the region has been gradually increasing since the early XX century; it was about 85.5% in 1910-1920 (the former Velsky Uezd of the Vologda Region), 88% in the 1990s, and 92.6% nowadays. This increase is largely caused by the overgrowing of abandoned agricultural areas. However, the overgrowing occurs mainly thanks to small-leaved tree species, which changes the natural structure of forest communities. The most transformed part is located near the railroad Arkhangelsk – Konosha – Kotlas. Thus, the biotic cover of this territory has largely changed under anthropogenic influence (Gusev et al., 1994; Flora and Fauna..., 2003).

To compare the floristic lists, we used generally accepted characteristics, such as taxonomic composition, belonging to certain groups of life forms, eco-coenotic groups and geographical elements (Yurtsev, 1968). Such indicators as the proportion of plant species of the conditionally native taiga forests (boreal ecological-coenotic group), changes in the species composition on the borders of their ranges, and number of species of disturbed habitats, are of particular interest for the analysis of trends in changes in the floristic composition of plant communities. We analyzed the similarity using the Jaccard and Sørensen coefficients (Schmidt, 1984), as well as the calculation of the τ-coefficient and the Spearman coefficient (Ulanova, 2018).

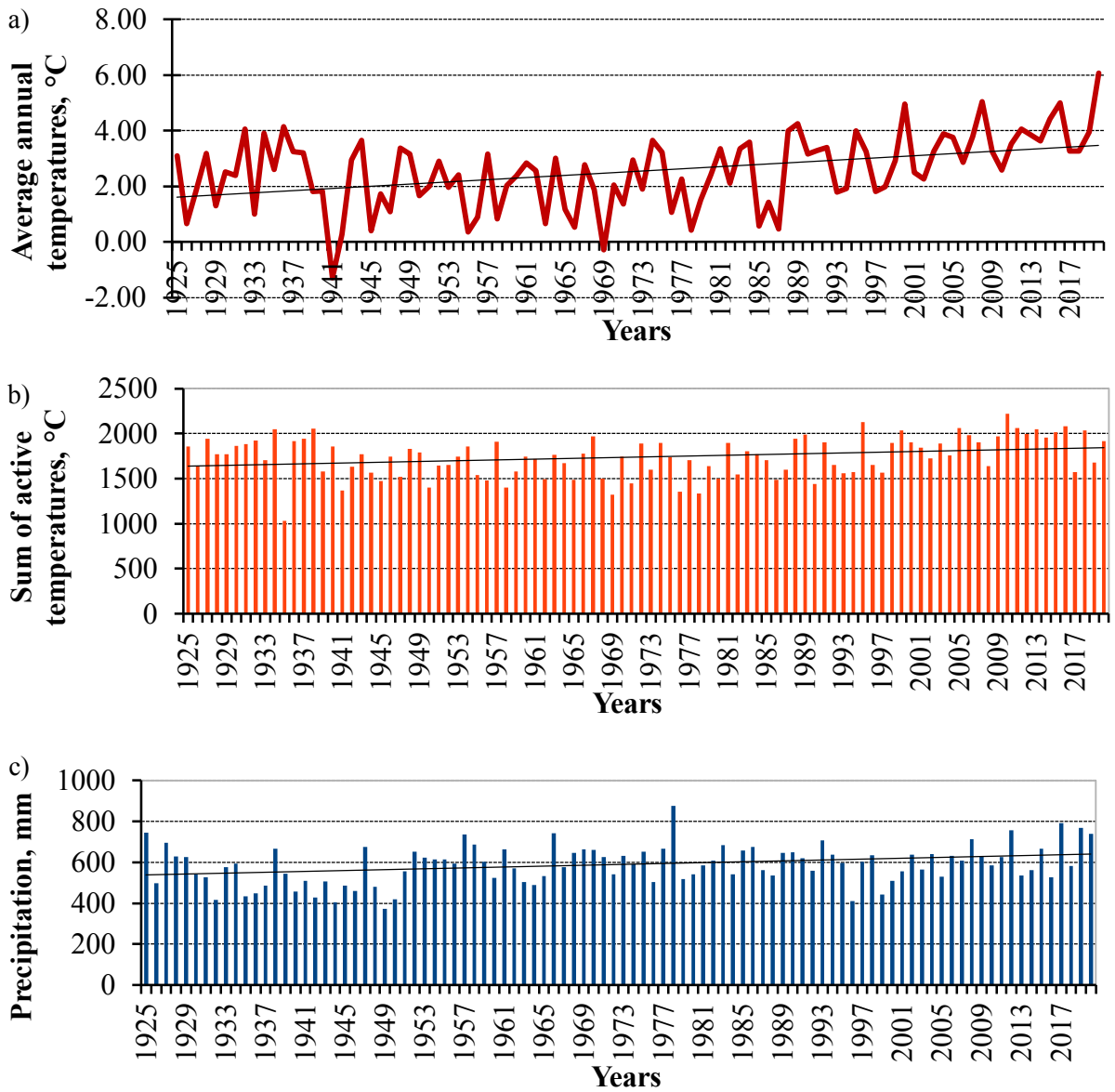

Fig. 3. Climate trends of the studied period according to the data from the Totma Station: a – average annual temperatures (°C), b – sum of active temperatures (> 10°C), c – Average annual precipitation (mm).

The modern nomenclature of vascular plant species is given according to S.K. Cherepanov (1995) and web-resources Plantarium (2022) and The Plantlist (2022). The characteristics of ecological-coenotic groups, life forms and ecological scales of Landolt are given according to the database of the Center for Problems of Ecology and Forest Productivity of the Russian Academy of Sciences (2022); the characteristics of longitudinal and latitudinal groups of plant ranges are given according to a number of various publications (Mejzel, 1965; Nosova et al., 2004; Database …, 2022).

Results and Discussion

The floristic list of the early XX century includes 624 species of vascular plants from 80 families, while the modern list includes 547 species from 79 families. Comparison shows that

the modern list lacks 140 species from 95 genera and 41 families that were present in the I.A. Perfiliev's list; however, it includes 69 species from 57 genera and 31 families that were not registered in the XX century list.

Photo 1. Landscape of a moraine-erosion plain in the Ustyansky district (photo by N.B. Leonova).

Photo 2. Upland dwarf shrubs-sphagnum swamp with pine on a watershed (photo by N.B. Leonova).

Photo 3. Pine forest with dwarf shrubs-lichen in the Kokshenga River valley (photo by N.B. Leonova).

Photo 4. Overgrowing fallows in the Zayachya River valley (photo by N.B. Leonova).

The similarity of the lists is estimated at 70% according to Jaccard and 83% according to Sørensen (Schmidt, 1984). The Spearman and Kendall coefficients of correlation that were calculated for both of them show that there is a weak negative correlation between the lists (Fig. 4). These results are most likely to be associated with the decreasing number of species that started in the early XX century, while the relative unity of floristic composition remains the same.

Spearman Rank Order Correlations (Лист1 in Index)
MD pairwise deleted
Marked correlations are significant at p <,05000

Pair of Variables	Valid N	Spearman R	t(N-2)	p-value
Перфильев & Устьяны	687	-0,160749	-4,26264	0,000023

Kendall Tau Correlations (Лист1 in Index)
MD pairwise deleted
Marked correlations are significant at p <,05000

Pair of Variables	Valid N	Kendall Tau	Z	p-value	p-exact 1-tailed
Перфильев & Устьяны	687	-0,160749	-6,30395	0,000000	----

Fig. 4. Calculation of Spearman correlation coefficient and Kendall for two floristic lists, performed in STATISTICA, Version 10.

The composition of the first 10 largest families from both lists is close. They all start with the 3 leading families of the Boreal floristic region: Asteraceae, Poaceae and Cyperaceae. However, they are slightly different in ratios (Table 2). The proportion of Caryophyllaceae, Ranunculaceae, Orchidaceae and Lamiaceae species decreases, while Rosaceae, Fabaceae, Brassicaceae, Ericaceae and Plantaginaceae increase (Table 2, Fig. 5). It is likely that these changes are a sign of increasing proportion of adventitious Fabaceae (*Anthyllis macrocephala* Wender., *Lupinus polyphyllus* Lindl., *Medicago* x *varia* Martyn) and Brassicaceae species (*Lepidium densiflorum* Schrad., *Lepidium ruderale* L.) in the disturbed habitats. At the same time the decrease in Ranunculaceae (*Anemone ranunculoides* L., *Anemone sylvestris* L., *Pulsatilla patens* (L.) Mill.) and Orchidaceae (*Calypso bulbosa* (L.) Oakes) could indicate that their habitats disappear due to anthropogenic disturbances in the forest communities (Red Data Book …, 2008, 2020). We should also add that, although Cyperaceae is still on the third place in the list, the number of those species dropped from 53 to 30. It is also possible that some early-flowering plants (*Anemone* spp., *Pulsatilla patens*) were not registered in modern studies due to insufficient field data from spring observations. Generic coefficient values, i.e. the ratio of the species number to the genera number (Tolmachev, 1974), is 1.90 for the modern list, and 2.01 for I.A. Perfilief's list. And since the generic coefficient proves, according to A.I. Tolmachev (1974), that there is a ratio of autochthonous trends to allochthonous trends in florogenesis, then a slight decrease in this coefficient indicates an increase in migration processes nowadays.

Further analysis of floristic lists is based on the characteristics of those species of vascular plants, which "presence/absence" status has changed in both lists for periods of times in such characteristics as the composition of life forms, geographical ranges and ecological-coenotic groups.

Perennial herbs (hemicryptophytes) are dominant in the composition of *life forms* of plant

communities of the studied territory area, which makes up ⅔ of both floristic lists for both periods (Table 3). In the composition of newly registered species of 2000s that have not been found in the XX century, mainly perennial grasses make these proportions. The most noticeable changes can be seeing among the water plants (helophytes), the number if which is higher in I.A. Perfiliev's list, as well as among the annual plants (therophytes; Fig. 6). For example, such aquatic plants as *Utricularia vulgaris* L., *Sparganium natans* L., and annual plants such as *Myosotis micrantha* Pall. ex Lehm. and *Draba nemorosa* L. are absent.

Table 2. Representation of families and their places in the regional lists in the first half of the XX and early XXI centuries.

Family	Flora, according to I.A. Perfiliev in 1930		Flora of the Ustyansky District in 2020	
	Number of species	Place	Number of species	Place
Asteraceae	60	1	66	1
Poaceae	58	2	46	2
Cyperaceae	53	3	30	3
Caryophyllaceae	29	**4**	21	6
Rosaceae	28	5	27	**4**
Fabaceae	23	6	26	**5**
Ranunculaceae	23	**7**	18	8
Brassicaceae	22	8	20	**7**
Orchidaceae	20	**9**	16	12
Lamiaceae	19	**10**	16	13
Apiaceae	18	11	17	11
Ericaceae	18	12	18	**9**
Plantaginaceae	16	13	18	**10**
Salicaceae	16	14	14	14

Composition of Geographical Elements. The most dominant species of the studied flora have very wide ranges (Table 4). They are Eurasian (35%) and Eurasian-North American (35%), which is generally typical for the boreal forests (Tolmachev, 1974). The European species, limited by the Ural Mountainsin the east, make up only 12%, while the European-West Siberian ones make up 15% (Gorbunova et al., 2014).

According to the latitudinal distribution, there are large number of hypoarctic-boreal and taiga species (about 30%). The broad-leaved species have a rather large share (Table 4): coniferous-broad-leaved forests and broad-leaved forests (about 35%). It is worth noting that the percentage of species with their ranges close to the broad-leaved zone is quite high for the subzone of the middle and southern taiga, as it is higher than 10% (Gorbunova et al., 2014). One of these species is *Campanula latifolia* L. (Photo 5). The proportion of plurizonal species is more than 30% (Table 3).

The analysis of the composition changes for different periods of time showed that the composition of longitude groups is generally similar in both cases, but the number of North American and European species increases in the modern list. In the latitudinal groups there is a decrease in the hypoarctic-boreal species and an increase in the plurizonal species in the modern list, which also indicates an increase in adventitious species of North American and Southern European distribution (Fig. 7).

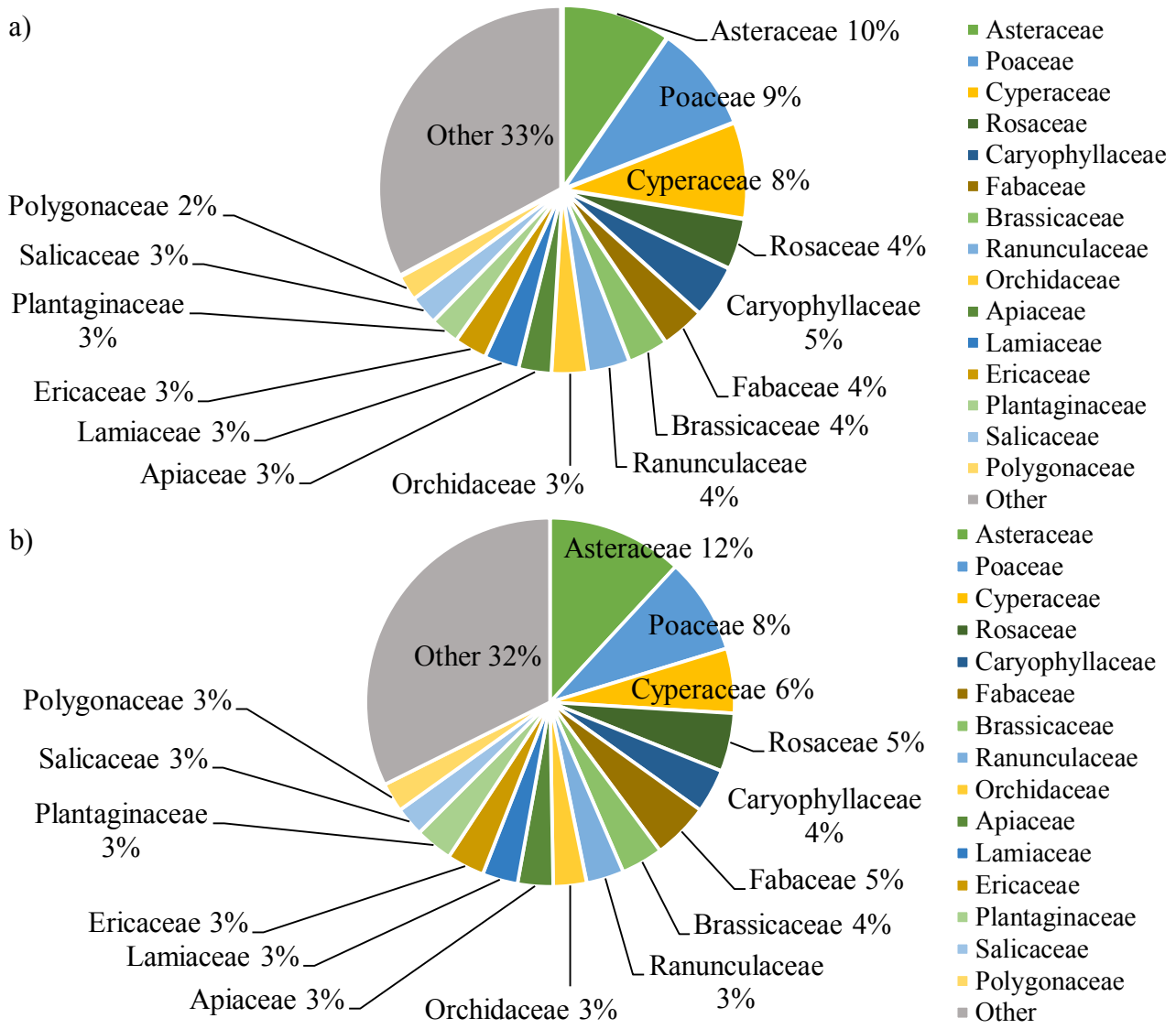

Fig. 5. Taxonomic spectra of the floristic composition in the communities of the studied territory: a) first half of the XX century, b) the early XXI century.

Table 3. Composition of life forms in different floristic lists for different periods of time.

Life forms	List of 1920-1930		List of 2000-2020	
	Number of species	Share, %	Number of species	Share, %
Phanerophytes	45	7	42	8
Chamaephytes	21	3	21	4
Hemicryptophytes	419	67	371	68
Cryptophytes	14	2	13	2
Therophytes	97	16	80	15
Helophytes	28	4	20	4
Total	**624**		**547**	

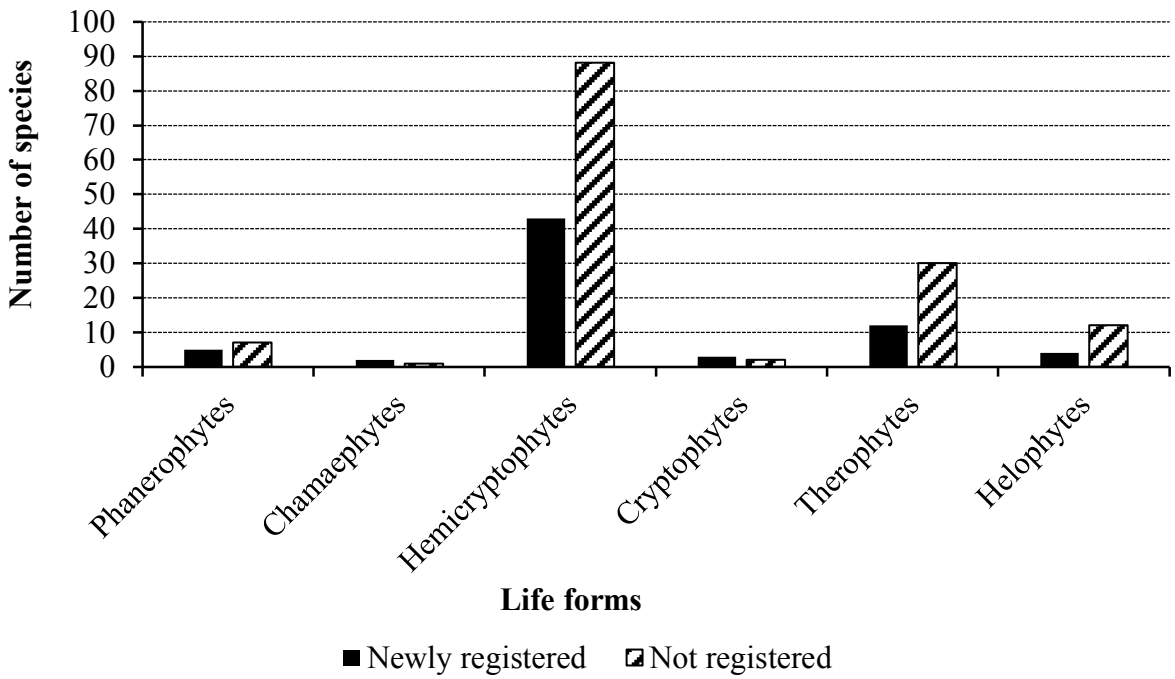

Fig. 6. The ratio between representatives of the main life forms according to Raunkiær in the composition of recently found and no longer found species of vascular plants.

Table 4. Composition of latitudinal and longitudinal ranges of the modern flora of the Ustyansky Region.

Latitudinal ranges	Number of species	Longitudinal ranges	Number of species
Hypoarctic-boreal	62	European	70
Taiga	85	Eurowest Siberian	81
Wide forests	195	Eurosiberian	15
Broad-leaved forests	10	Eurasian	176
Broad-leaved forest and forest-steppe	11	East Asian	2
Plurizonal	183	Eurasian-North American	180
		North American	10
		Cosmopolite	2

Ecological-coenotic groups of species. An analysis of changes in the *ecological and coenotic structure* of floristic lists (Table 5, Fig. 8) revealed serious shifts in some groups, indicating that there are changes in the habitat conditions and a structure reformation of the phytocenoses. The number of species of wetland habitats has sharply decreased by a third, which we already noted above in regard to the reducing sedges. The number of nemoral species also significantly decreased by 11, oligotrophic species decreased by 7. At the same time, among the species of the 2000s, almost half (46%) is from the meadow group, while the species of disturbed anthropogenic habitats are 11% (Photos 6, 7). Therefore, it is clear that proportion of species associated with anthropogenic disturbances and cutting of conditionally primary forests is increasing. Simultaneously, the number of species from various swamps, coniferous and nemoral-spruce forests decreased. The available

data did not let us identify specific changes in the land use structure, but a decrease in the number of wetland species and an increase in the species of disturbed habitats can be a sign of degradation in the near-water habitats and increased anthropogenic pressure on ecosystems.

Photo 5. *Campanula latifolia* L. is a species that can be found in the rare floodplain habitats since the times of I.A. Perfiliev and is registered in the "Red Data Book of the Arkhangelsk Region" (2020; photo by I. Dobromyslov).

Ecological amplitudes of plant species. To assess the ecological preferences of species in the plant communities during different periods of time, we assessed their distribution according to Landolt scales of thermal regime, continentality, soil moisture content, soil humus richness and illumination according (Landolt, 1977). These scales were picked because they cover almost the entire list of the species we studied, have a point scoring and are easily comparable. Each scale has five gradations from 1 to 5, according to the increasing effect of each factor.

Generally, their distribution on the Landolt ecological scales is quite similar for both lists and periods (Table 6). However, there is an increase in the heat-loving plants, in xerophytes and mesoxerophytes, with a decrease in the hygrophytes, noted in the modern list (Fig. 9), which is consistent with the general trends towards global climate warming. The indices of requirements for light and humus were the same in both lists and therefore are not included in the final table. The maximum proportion of species has 3 or 4 points, which matches the average indices of soil richness and average illumination.

Conclusions

The analysis of floristic lists for different periods of time in the middle taiga in the south of the Arkhangelsk Region allowed us to identify the dynamics of the floristic composition from the 1930s to 2000. The total number of vascular plant species has decreased by 77 taxa. Compared to the 1930s, the list has decreased by 140 species from 95 genera and 41 families, but increased by 69 new species from 57 genera and 31 families that have not been registered there before. Although the taxonomic spectra for both periods are generally similar, the study has revealed that Brassicaceae and Fabaceae taxa increased, while Cyperaceae, Ranunculaceae and Orhidaceae decreased.

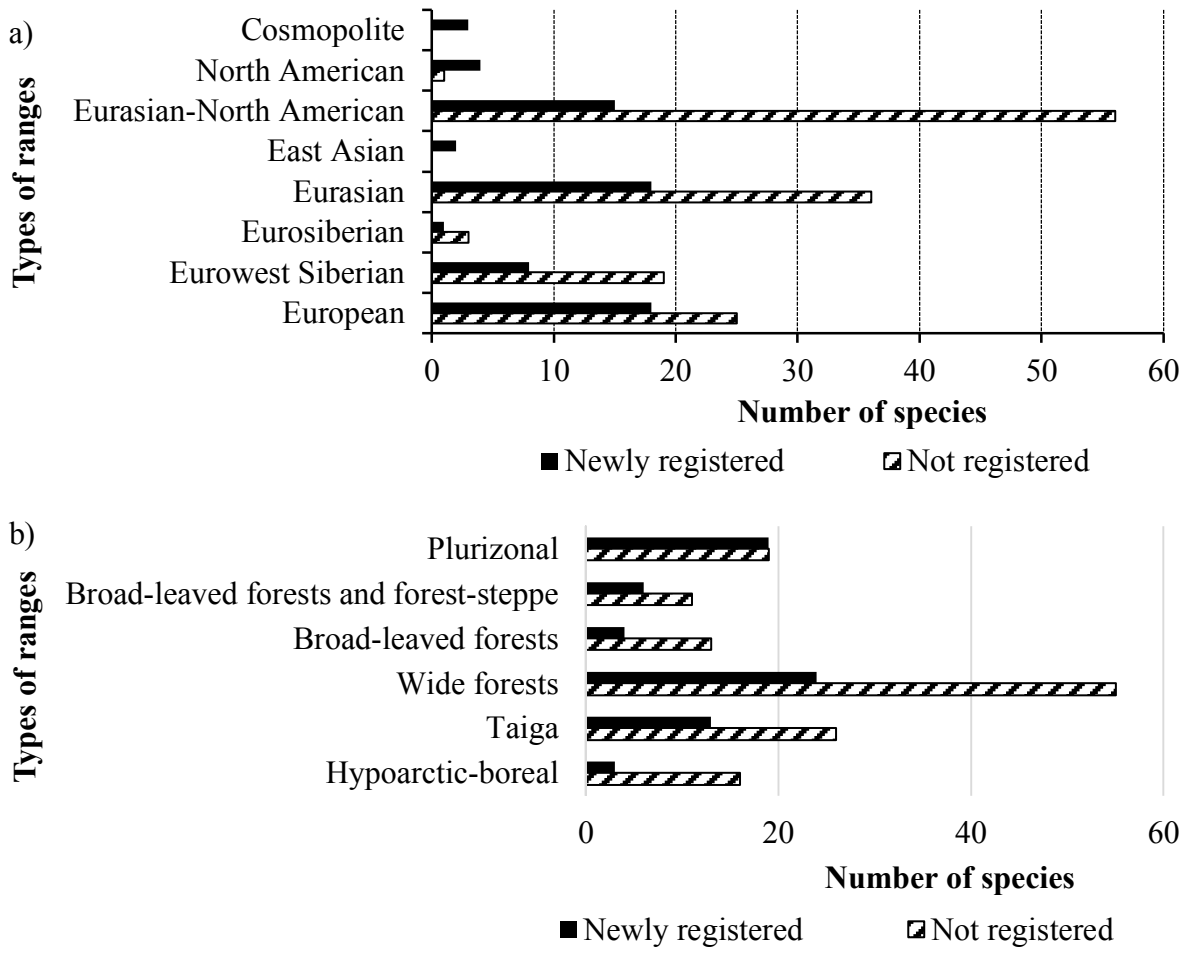

Fig. 7. Changes in species with different ranges: a) longitudinal elements, b) latitudinal elements.

Table 5. Composition of ecological-coenotic groups of plant species in the floristic lists for different periods of time.

Ecological-coenotic groups	List of 1920-1930		List of 2000-2020	
	Number of species	Share, %	Number of species	Share, %
Boreal (Br)	54	9	49	9
Nemoral (Nm)	53	8	42	8
Pine forest (Pn)	33	5	31	6
Meadow (Md)	212	34	200	37
Nitrophillous (Nt)	38	6	31	6
Oligotrophic (Olg)	33	5	26	5
Wetland (Wt)	152	24	119	22
Anthropogenic habitats (Ant + Advent)	16	2	18	3
Other	33	5	31	6

The analysis of the ecological and coenotic composition of vascular plants for both periods showed an increase in the number of disturbed habitats and a decrease in plant species close to

indigenous communities, such as nemoral, boreal and wetland. These changes are an obvious indicator of degradation in forest lands, even though the general level of forest cover, near-water and swamp habitats remain the same. They also show that the anthropogenic pressure on ecosystems grows, large number of secondary communities appear in the lumbering sites, in the abandoned agricultural lands and near the settlements.

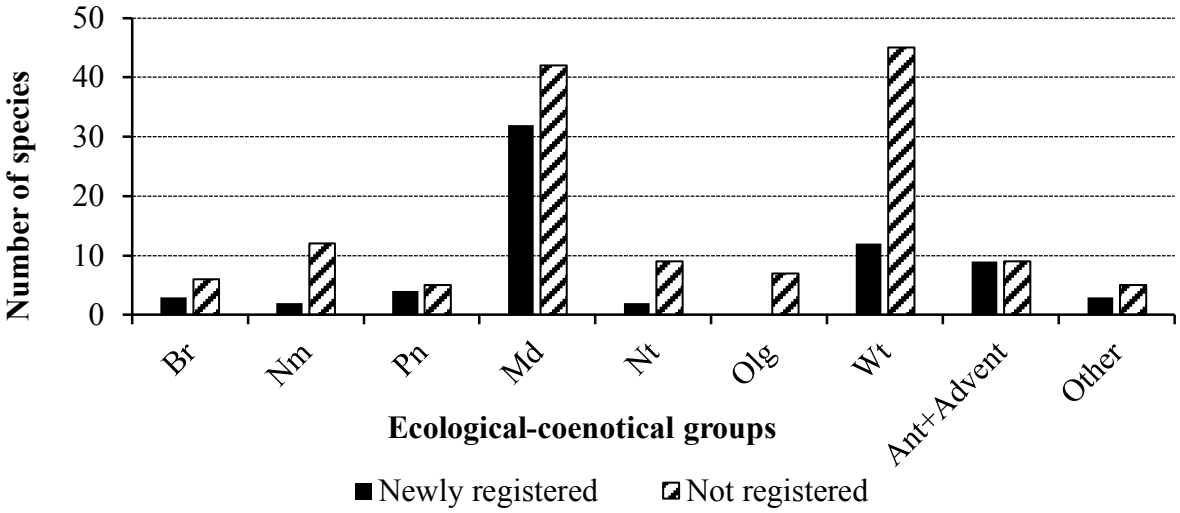

Fig. 8. Changes in the composition of ecological-coenotic groups of the floristic lists (the groups are marked according to Table 4).

Photo 6. *Lotus corniculatus* L. on the field edge. This species is absent in I.A. Perfiliev's list (photo by N.B. Leonova).

Photo 7. Thickets of *Heracleum sosnowskyi* Manden. along the bank of the Ustya River, near Shangalysettlement (photo by N.B. Leonova).

Table 6. Landolt distribution of the number of plant species in two floristic lists by their need for heat supply, climate continentality and soil moisture.

Points	Temperature*		Continentality**		Moisture***	
	Number of species in the list of 1920-1930	Number of species in the list of 2000-2020	Number of species in the list of 1920-1930	Number of species in the list of 2000-2020	Number of species in the list of 1920-1930	Number of species in the list of 2000-2020
1	0	0	0	0	18	18
2	56	50	61	53	119	105
3	285	247	372	333	216	201
4	176	161	98	84	154	121
5	20	15	1	1	113	95
0	1	1	3	3	2	2

Notes to Table 6. *Temperature: 1 – the most cold-resistant species (arctic and arctic-alpine), 2 – cold-resistant species (boreal), 3 – relatively cold-resistant species with a wide ecological range, 4 – relatively heat-loving species, 5 – exclusively heat-loving species. **Continentality: 1 – species in need for maritime climate (cannot tolerate temperature drops), 2 – species of temperate maritime climate (cannot tolerate significant temperature drops and late frosts), 3 – species of temperate continental climate (relatively resistant to abrupt changes of temperature), 4 – species of continental climate (resistant to extreme temperature changes), 5 – species of sharply continental climate (can be found only in places with extreme temperature changes). ***Moisture: 1 – xerophytes, 2 – mesoxerophytes, 3 – mesophytes, 4 – mesohygrophytes, 5 – hydrophytes.

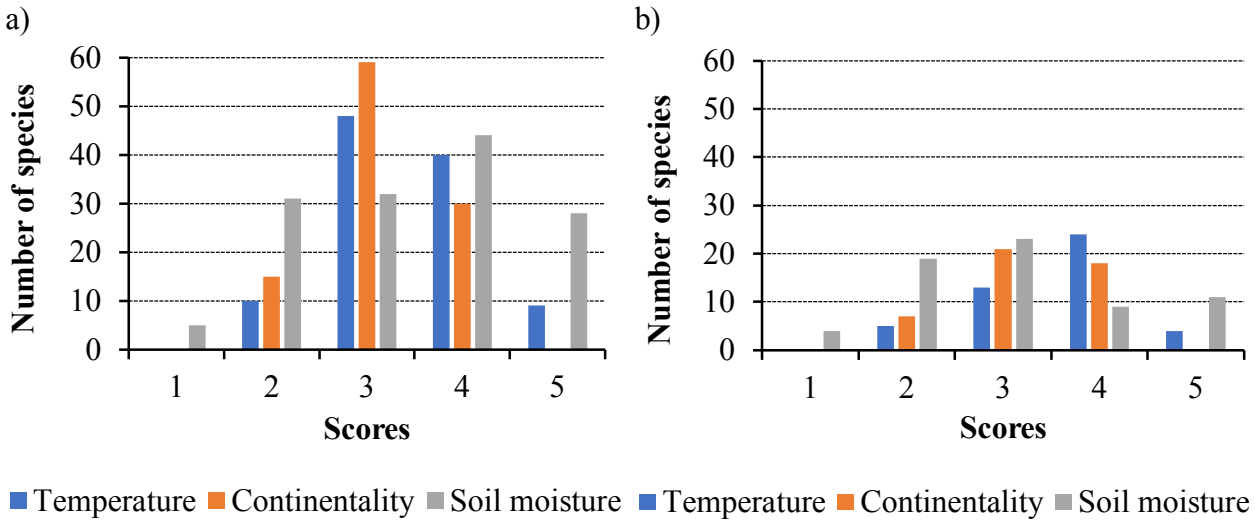

Fig. 9. Landolt distribution of plant species, the presence/absence status of which has changed, according to their needs for heat supply, climate continentality and soil moisture: a – for the species that have not been registered in the modern list, b – for the species that have been registered in the modern list for the first time.

Climatic changes, in particular, the trend of increasing average annual temperatures and the sums of active temperatures over the studied period, also transform the floristic composition of the local communities, which leads to a decrease in the number of more cold-resistant species of a hypoarctic-boreal range (*Pinguicula alpina* L., *Saxifraga hirculus* L., etc.) and causes some heat-loving broad-leaved-forest-steppe and plurizonal species to appear (*Artemisia dracunculus* L., *Gagea granulosa* Turcz., *Fragaria viridis Weston*, etc.). This conclusion can be also confirmed by the analysis of changes in the ecological preferences of those species. According to their distribution on the Landolt ecological scales, the number of species with an increased need for heat supply has grown higher, as well as the number of mesoxerophytes.

In addition to climate change, it should be taken into account that an increasing number of more heat-loving and less moisture-loving species correlates with the general trend of an increasinng number of alien species, most of which come from farthest southern regions (*Galega orientalis* Lam., *Lupinus polyphyllus* Lindl., *Heracleum sosnowskyi* Manden). However, researches concerning the alien flora and its role in middle taiga communities is a subject for another study.

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ИЗМЕНЕНИЯ ВО ФЛОРИСТИЧЕСКОМ СОСТАВЕ РАСТИТЕЛЬНЫХ СООБЩЕСТВ ЮГА АРХАНГЕЛЬСКОЙ ОБЛАСТИ В XX ВЕКЕ

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Исследование посвящено изучению изменений в видовом составе растительных сообществ среднетаежной территории на юге Архангельской области на основе анализа флористических сводок за разные временные периоды. По данным «Флоры Северного края» И.А. Перфильева (1934-1936) составлен и приведен к современной таксономической номенклатуре таксономический список высших сосудистых растений, произраставших на территории Устьянского района Архангельской области в начале XX века; проведен сравнительный анализ флористических списков начала XX века и современного, составленного для той же территории на начало XXI века. Выявлены различия в таксономическом, эколого-ценотическом и географическом составах разновременных списков видов сосудистых растений и отдельно в группах видов, изменивших статус присутствия/отсутствия на исследуемой территории. Изменения таксономического состава зафиксированы в отношении сокращения флористического списка на 140 видов сосудистых растений из 95 родов и 41 семейства, при этом вновь отмечены 69 видов из 57 родов и 31 семейства. При сохранении общего сходства таксономических спектров за оба периода отмечается увеличение таксонов из семейства крестоцветных и бобовых, сокращение представителей осоковых, лютиковых и орхидных. Рассчитаны коэффициенты флористического сходства, коэффициенты корреляции Спирмена и

Кендалла, родовой коэффициент. При достаточно высоком сходстве флористических списков по Жаккару коэффициенты корреляции показали слабую связь, а родовой коэффициент уменьшился, что в целом говорит о сокращении самобытности флоры и биологического разнообразия в ходе изменений окружающей среды.
Анализ эколого-ценотического состава видов сосудистых растений за два периода показал рост видов нарушенных местообитаний и сокращение видов растений, близких к коренным сообществам: неморальных, бореальных, водно-болотных.
Климатические изменения, в частности, теплый тренд повышения среднегодовых температур и увеличения сумм активных температур за изучаемый период, отразились на изменении флористического состава сообществ, а именно, уменьшилось число более холодостойких видов с гипоарктическо-бореальным ареалом, и появились некоторые теплолюбивые широколиственно-лесостепные и плюризональные виды. Согласно распределению числа видов по ступеням экологических шкал Ландольта, увеличилось число видов с повышенной потребностью в теплообеспеченности, а также мезоксерофитов. Также увеличилась доля чужеродных видов, среди которых большинство является пришельцами из более южных районов (*Galega orientalis* Lam., *Lupinus polyphyllus* Lindl., *Heracleum sosnowskyi* Manden.).
Ключевые слова: флористический состав, растительные сообщества, средняя тайга, эколого-ценотические элементы, ареалы, чужеродные виды.
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