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Plant Cover Synanthropization in the Pechora–Ilych Biosphere Reserve along an Altitudinal Gradient

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Abstract—Trends in plant cover synanthropization along a plain–foothills–mountains gradient have been revealed in the reserve. Characteristics of plant communities in anthropogenically disturbed habitats, centers of concentration of anthropophytes and apophytes, and pathways of their migration are described.

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Key words: vegetation, anthropogenic transformation, altitudinal gradient, nature reserve.

In the past decades, anthropogenic changes in the plant world have received greater attention from researchers (Malyshev, 1981; Gorchakovskii, 1979, 1984; Burda, 1996; Berezutskii, 1999; etc.). These changes are manifested in a variety of forms, such as total destruction of vegetation in certain areas or replacement of natural plant communities by cultivated communities (in farmlands, windbreak forest strips, parks, gardens, lawns, etc.), but the most significant aspect concerns profound transformations of natural plant cover on a global, regional, or smaller scale. The pattern and tendencies of such transformations are summarized in the concept of plant cover synanthropization formulated in the 1970s, which has become conventional since then. Synanthropization is accompanied by general impoverishment and unification of the flora, erosion of its regional facets, replacement of natural plant communities by derivative communities, invasion of adventive plants (anthropophytes), structural simplification of communities, and decrease in their productivity and stability. In essence, synanthropization is the strategy of adaptation of the global plant cover to environmental conditions altered or created as a result of human activities. Studies on trends in synanthropization are necessary for estimating the current state of plant cover, predicting its subsequent changes, and taking effective measures to conserve phytodiversity at the species, cenotic, and ecosystem levels.

The problem of anthropogenic transformation of the plant world, including its synanthropization, is still of current interest, which follows from a number of relevant publications (Martynenko, 1994; Khmelev, 1996; Kontrisova and Kontris, 1996; Merzhvinskii and Syuborova, 1996; Kislyakovskaya, 1997; Husakova, 1997; Protopopova et al., 1997; Abramova and Yunusbaev, 2001; Timoshok et al., 2001; Panchenko, 2002; Abramova, 2002, 2004; Sokolova, 2003; Zernov, 2004). Many of them are devoted to nature reserves and other protected areas (Nukhimovskaya, 1984, 1986; Malkova, 1997; Starodubtseva, 1987; Gorchakovskii and Kozlova, 1998; Koastina and Berlina, 2001; Fedyaeva et al., 2002; Kostina, 2003; Urbanavichute, 2003; Gorchakovskii and Telegova, 2005; Abadonova, 2006; Byalt and Firsov, 2006).

STUDY REGION, OBJECT, AND METHODS

The Pechora–Ilych Biosphere Reserve is an interesting object for studying trends in plant cover synanthropization along an altitudinal gradient in a specially protected area: there is a variety of ecosystems anthropogenically disturbed to different degrees, and altitudinal differentiation of plant cover is well manifested. The results presented below were obtained in this reserve.

The Pechora–Ilych Reserve was established in 1930 on the territory of the present-day Komi Republic. It is located in the northern and middle taiga subzones of the boreal forest zone. Its area is distinctly divided into three landscape regions: the flatland western region that includes part of the Pechora Plain, the central region located in the foothills, and the mountain eastern region. The reserve occupies 721 000 ha, and its protective zone is approximately 500000 ha in area. It received the status of biosphere reserve in 1985 and was included in the UNESCO list of the world's cultural and natural heritage in 1995.

In the flatland landscape region, the absolute elevations of watersheds do not exceed 150–175 m. Eleva-

Table 1. Structure of the synanthropic component of local flora (by landscape regions)

Number of species	Species group			
	Whole territory	Plains	Foothills	Mountains
Apophytes	85	55	69	14
Anthropophytes	67	48	50	4
Total	152	103	119	18
Apophytization index	55.9	53.4	58	77.8

Table 2. Spectrum of leading families in the synanthropic component of local flora (by landscape regions)

Family	Whole territory	Plains	Foothills	Mountains
Asteraceae	27	18	23	2
Poaceae	21	15	18	4
Caryophyllaceae	17	8	14	2
Brassicaceae	11	9	5	
Scrophulariaceae	11	7	10	
Lamiaceae	8	4	8	
Apiaceae	7	1	7	2
Fabaceae	7	5	6	
Polygonaceae	6	6	4	
Rosaceae	4	3	4	3
Other families	33	45	20	5
Total number of species	152	121	109	18

tions in the foothill region are higher: its characteristic feature are mountain spurs extending parallel to each other and rising approximately 250 m a.s.l. The mountain landscape region lies in the Northern Urals, where the elevations of mountaintops are mainly about 750–850 m but some of them exceed 1000 m a.s.l., such as Mount Kozhim-Iz (1195 m) and Mount Koip (1087 m). Altitudinal differentiation of vegetation into the mountain taiga, subgoltsy, and mountain tundra belts is well manifested in this region.

In the course of this study, we revealed habitats where the plant cover was disturbed to a greater or smaller extent as a result of human activities (roads, paths, tourist campsites, forest ranger stations with adjoining hay meadows and grazing grounds, etc.). In such areas, we made descriptions of disturbed plant communities and estimated the diversity of their synanthropic components, apophytes (plants of local flora whose abundance increases under anthropogenic load) and anthropophytes (adventive plants introduced due to human activities and actively expanding over anthropogenically disturbed habitats). The degree and pattern of plant cover transformation were estimated using the synanthropization index (the ratio between the number of synanthropic species and the total number of species in the local flora) and the apophytization index (the ratio between the number of apophytes to the total number of synanthropic species).

RESULTS

Synanthropization at the Floristic Level

The flora of the reserve comprises a total of 781 vascular plant species (Lavrenko et al., 1995, with subsequent amendments). Asteraceae, Poaceae, and Cyperaceae are the first triad of families in its taxonomic spectrum; the second triad consists of Rosaceae, Ranunculaceae, and Caryophyllaceae. According to Khokhryakov (2000), the composition of the first triad allows us to attribute this flora to the Cyperaceae type, or arctoboreal–eastern Asian type. As follows from Table 1, 152 out of 781 species in this flora are synanthropic and, therefore, its synanthropization index is 19.5.

The synanthropic component is represented by both indigenous species (apophytes) and adventive species (anthropophytes) introduced in the course of human activities. The proportions of these groups and their ratio differ depending on landscape region (Table 1). Upon transition from the plain to the foothills, the proportion of synanthropic species (both apophytes and anthropophytes) in plant communities slightly increases. Apophytes in these regions are represented by 48–50 species (approximately half of the total number of synanthropic species), and the respective values of the apophytization index are 53.4 and 58. Upon transition from the foothill to the mountain region, the number of synanthropic species decreases significantly, especially in the case of anthropophytes (they are represented in the mountains by only four species). Hence, the apophytization index in this region is markedly higher (77.8) than in the plains or foothills.

In the synanthropic flora, the first triad of leading families consists of Asteraceae, Poaceae, and Caryophyllaceae; Brassicaceae, Scrophulariaceae, and Lamiaceae form the second triad (Table 2). Unlike in the total floristic spectrum of the reserve, Caryophyllaceae are on the third place in the first triad, whereas Cyperaceae are not even among the first ten families. Brassicaceae, Scrophulariaceae, and Lamiaceae forming the second triad are subordinate families in the total floristic spectrum.

The structure of the first triad in individual landscape regions remains approximately the same as in the total floristic spectrum, whereas the second triad changes slightly in the foothills and is replaced by different families in the mountains, with its former components disappearing from the spectrum.

Table 3. Typical plant communities of anthropogenically disturbed habitats in the plains and foothills

Habitat	No.	Dominant species	Main subordinate species	Total number of species
Roads and paths	1	*Poa annua*	*Trifolium repens, Plantago major, Cerastium holosteoides, Ranunculus repens, Rumex acetosella*	21
	2	*Plantago major*	*Polygonum aviculare, Potentilla anserina, Sagina procumbens, Achillea millefolium, Capsella bursa-pastoris*	20
	3	*Trifolium repens*	*Capsella bursa-pastoris, Potentilla anserina, Elytrigia repens, Carum carvi, Galeopsis bifida, Taraxacum officinale*	29
	4	*Pimpinella saxifraga, Agrostis tenuis*	*Cerastium holostoides, Melandrium album, Rhinantus vernalis, Galium mollugo, Erigeron acris*	25
Grazing grounds	5	*Agrostis tenuis, Festuca rubra*	*Leucanthemum vulgare, Dactylus glomerata, Phleum pratense, Hiecium umbellatum, Knautia arvensis*	22
	6	*Anthoxanthum odoratum, Leontodon autumnalis*	*Agrostis tenuis, Trifolium repens, Achillea millefolium, Deschampsia cespitosa, Leucanthemum vulgare*	26
Wasteland	7	*Chamaenerion angustifolium, Urtica dioica*	*Filipendula ulmaria, Thulictrum simplex, Lamium album, Dactylis glomerata, Elytrigia repens*	29
	8	*Bromopsis inermis, Dactylis glomerata*	*Urtica dioica, Anthriscus sylvestris, Heracleum sibiricum, Alopecurus pratensis, Poa pratensis*	23

Table 4. Typical plant communities of anthropogenically disturbed habitats in the mountains

Belt	Habitat	No.	Dominant species	Main subordinate species	Total number of species
Mountain forest	Paths	1	*Stellaria nemorum, Viola biflora*	*Poa annua, Ranunculus repens, Veratrum lobelianum, Geranium sylvaticum, Alchemilla glaucescens*	12
	Campsites	2	*Poa supina*	*Stellaria nemorum, Viola biflora, Chamaenerion angustifolium, Bistorta major, Solidago virgaurea*	12
		3	*Deschampsia cespitosa*	*Cirsium heterophyllum, Chamaenerion angustifolium, Alchemilla pycnoloba, Ranunculus repens, Phleum alpinum*	13
Subgoltsy	Paths	4	*Lerchenfeldia flexuosa*	*Anthoxanthum alpinum, Carex brunnescens, Cerastium holostoides, Melampyrum pratense, Chamaenerion angustifolium*	12
	Campsites	5	*Anthoxanthum alpinum*	*Senecio integrifolium, Pachypleurum alpinum, Sanguisorba officinalis, Solidago virgaurea, Ranunculus borealis*	14
Mountain tundra	Paths	6	*Carex arctisibirica*	*Pachypleurum alpinum, Lerchenfeldia flexuosa, Pedicularis oederi, Hieracium alpinum, Solidago virgaurea*	14
	Campsites	7	*Poa alpigena*	*Pachypleurum alpinum, Viola biflora, Bistorta major, Carex globularis, Rumex acetosa*	11

Synanthropization at the Phytocenotic Level

The history of economic development in the region left its mark on the current state of plant cover in the Pechora–Ilych reserve. Before its establishment in 1930, there were numerous villages whose populations were engaged in crop breeding. Between 1951 and 1959, a large part of its territory was deprived of protective status, and forests growing there were cut down. Later, this area was partly annexed to the reserve again. As a result of long-term economic activities (tree cutting, hay harvesting, livestock grazing, crop raising, etc.), many anthropogenic habitats invaded by segetal and ruderal species have appeared in the plain and foothill regions. Anthropogenically disturbed biotopes are of three main categories: roads and paths, grazing grounds, and wasteland near human dwellings. Plant communities characteristic of these habitats contain large numbers of apophytes and anthropophytes (Table 3).

In the mountain region, trampling is the main factor of anthropogenic impact on plant cover. The diversity of disturbed habitats is limited to paths and tourist

Table 5. Synanthropic component of plant communities in anthropogenically transformed mountain habitats

	Belt		
	mountain forest	subgoltsy	mountain tundra
Apophytes:			
Alchemilla pycnoloba Juz.	+	–	–
Alchemilla glaucescens Wallr.	+	–	–
Alchemilla obtusiformis Alech.	+	–	–
Alchemilla subcrenata Bus.	–	–	–
Alopecurus pratensis L.	–	+	–
Angelica sylvestris L.	+	+	–
Anthoxanthum alpinum A. et D. Löve	+	+	+
Anthriscus sylvestris (L.) Hoffm.	+	+	–
Bistorta major S.F. Gray	+	+	+
Chamaenerion angustifolium (L.) Scop.	+	+	+
Cirsium heterophyllum (L.) Hill	+	+	–
Deschampsia cespitosa (L.) Beauv.	+	+	+
Lerchenfeldia flexuosa (L.) Schur	+	+	+
Myosotis palustris (L.) L.	–	+	–
Ranunculus polyanthemos L.	–	+	–
Ranunculus repens L.	+	+	–
Rubus idaeus L.	+	+	+
Stellaria nemorum L.	+	+	–
Total number of apophytes	14	14	6
Anthropophytes:			
Cerastium holostoides Fries	+	+	+
Poa annua L.	+	+	–
Poa supina Scharad.	+	+	+
Plantago major L.	+	–	–
Total number of anthropophytes	4	3	2
Total number of synanthropic species	18	17	8

campsites and, therefore, anthropogenically transformed plant communities are markedly less diverse than in other regions (Table 4). Their species composition is more uniform, and the proportion of synanthropic species is relatively small, especially in the case of anthropophytes.

DISCUSSION

Synanthropization is a consequence of anthropogenic impact on natural vegetation with consequent disturbances of its dynamic balance and stability. Within the reserve, synanthropization is accounted for by both indigenous apophytes and adventive anthropophytes, which appear in the reserve due to human activities.

Transitions from foothills to mountains and from lower to upper mountain belts are accompanied a decrease in the number of synanthropic species in phytocenoses: this number decreases from 119 in the foothills to 18 in the mountain forest belt, 17 in the subgoltsy belt, and 8 in the mountain tundra belt (Tables 1, 5). The decrease in the number of apophytes is especially significant: from 50 species in the foothills to only four species in the mountains (four, three, and two species in the mountain forest, subgoltsy, and mountain tundra belts, respectively). Anthropophytes growing in the mountain region of the reserve include *Cerastium holosteoides, Poa supina, P. annua*, and *Plantago major*, with only the first two species occurring in the mountain tundra belt.

A decrease in the proportion of synanthropic species (especially anthropophytes) along the altitudinal gradient is explained by several factors:

(a) the limiting influence of increasingly severe climatic conditions in the mountains;

(b) the decreasing diversity of primary (natural) plant communities upon transition from the foothills to upper mountain belts; and

(c) lower intensity of anthropogenic influences at higher elevations and, therefore, a lesser degree of disturbance of primary plant communities, with the competitive ability of their constituent species being maintained at a sufficiently high level.

The main routes of anthropophyte invasion from neighboring areas and subsequent expansion in the reserve include roads, paths, forest ranger stations with adjoining hay meadows and grazing grounds, tourist campsites, and frequently visited areas near conspicuous natural landmarks.

Comparative data on the level of flora synanthropization in nature reserves located in the Ural region are of obvious interest, as the synanthropization index characterizes the state of natural plant cover (Table 6). This index has the highest value (27.8) in the Il'men reserve established in 1920. The city of Miass and other industrial centers and populated areas are located in the immediate vicinity of this reserve. Prior to its establishment, forests in this region were inten-

Table 6. Data on flora synanthropization in some nature reserves

Reserve	Year of establishment	Area, 1000 ha	Total number of species	Total number of synanthropic species	Including		Synan-thropization index
					apophytes	anthropo-phytes	
Pechora–Ilych	1930	721	781	152	85	67	19.5
Denezhkin Kamen	1946 (closed in 1950 and reestablished in 1991)	78	617	114	34	80	22
Vishera	1991	241	556	88	44	44	15.8
Il'men	1920	30	953	265	144	121	27.8

sively cut to make charcoal for the metallurgical industry. The synanthropization index in the Denezhkin Kamen reserve is second highest. This reserve, first established in 1946, was closed in 1950 and reestablished in 1991. In the intervening period, its forests were also cut on a large scale. The Pechora–Ilych reserve has the largest area among the reserves compared, but its surroundings are thinly populated and are free from large villages or towns and industrial enterprises. Hence, its flora has a moderate synanthropization index (19.5).

The results of this study show that the level of flora synanthropization in a nature reserve depends, inter alia, on its geographic location and size (area), the degree of urbanization and industrialization in its surroundings, the degree of damage to plant cover prior to the establishment of the reserve, and the period of its existence under the protection regime.

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