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The Formation of Plant Communities in Anthropogenic Habitats in the Polar Urals

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Abstract—The formation and characteristics of synanthropic plant communities in various anthropogenic habitats are described in terms of vegetation altitudinal belts.

INTRODUCTION

The formation of synanthropic (or synanthropized, to a certain extent) communities in anthropogenically transformed habitats is a specific expression of the general synanthropization of the plant cover (Falinski, 1972; Kostrowicki, 1982; Olaczek, 1982; Gorchakovskii, 1979, 1984).

In the Polar Urals, natural vegetation has been less depleted due to human activities than in other regions of the Urals. However, there are areas even in the Polar Urals where new technogenic substrates have been formed or the plant cover has been completely or partly depleted. In these areas, synanthropic plant communities have been formed.

The formation of plant communities in anthropogenic habitats of the Far North, such as in the Polar Urals, is of considerable interest. However, no special studies have previously been performed in this region; the only fragmentary data available were reported by Igoshina (1966) and Dorogostaiskaya (1972).

The purpose of this study was to characterize plant communities in various types of anthropogenic habitats in the Polar Urals as related to the plant-cover differentiation between vegetation altitudinal belts and to determine the composition of synanthropic flora and regional characteristics of the formation of plant communities.

STUDY AREA, MATERIALS, AND METHODS

The studies were conducted near the Krasnyi Kamen' railway station and the neighboring Yarkeu massif (568 m above sea level), which are located on the eastern macroslope and in the foothills of the Polar Urals (66°50′ N). Krasnyi Kamen' is located in the foothill forest-tundra zone; on the slopes of the Yarkeu, the mountain-forest, subgoltsy, and goltsy (mountain-tundra) vegetation belts alternate with one another with increasing altitude. The mountain-forest belt is characterized by moreorless tall, closed larch (*Larix sibirica*) forests; the subgoltsy belt, by open larch (*L. sibirica*) forests and mesophilous meadows; and the goltsy belt, by various types of mountain tundras and stone fields (Gorchakovskii, 1975; Gorchakovsky, 1989).

We studied plant communities formed in the areas where the natural plant cover was either completely destroyed or depleted as a result of human activities. For comparison, we studied original plant communities with undisturbed plant cover. Description of plant communities was performed in five to ten replicates on 10-m^2 plots.

To estimate the state of plant communities, we used the synanthropization index (the proportion of synanthropic species in the community) and the apophytization index (the percentage of apophytes among all synanthropic species).

DIVERSITY AND COMPOSITION OF SYNANTHROPIC PLANT COMMUNITIES

In thinly populated Polar Ural areas, the main types of anthropogenic habitats are trampled glades and landfills near new human dwellings, railroad embankments, and of all-terrain vehicle routes.

Synanthropic Vegetation near Human Settlements

The Krasnyi Kamen' railroad station (the Vorkuta–Labytnangi railroad) is located in the foothill forest—tundra belt at the foot of the Yarkeu massif. This is a small settlement of several homes. In the summer, the settlement serves to accommodate tourists and researchers from the Salekhard Station (Ural Division of the Russian Academy of Sciences), who conduct studies in this area.

The vegetation near the settlement was typical of forest—tundra. Single small *Larix sibirica* and (less frequently) *Picea obovata* trees or small groups of them were scattered over the shrub–moss (with *Betula nana*) tundra. In tundra communities, the shrub layer

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(with a projective-cover degree of 60%) was formed by cop.$_2$—*Betula nana* and sp.—*Ledum decumbens*. The grass–dwarf shrub layer was relatively dense (its projective-cover degree was 60–70%). This layer was composed of cop.$_2$—*Vaccinium vitis-idaea*, sp.—*V. uliginosum*, *V. myrtillus*, *Festuca rubra* ssp. *arctica*, *Poa apligena*, sol.–*Rubus arcticus*, *R. humilifolius*, *Trientalis europaea*, etc. The moss cover was well-developed. This consisted of *Polytrichum commune*, *Pleurozium schreberi*, and *Sphagnum nemoreum*. There were bogs in some places.

Following is a short description of the plant communities of anthropogenic habitats.

Trampled glades. In trampled glades through which paths ran, the soil was thickened; there were bald spots in places. In these habitats, rattle-box–tussock-grass communities had been formed. This short (25–30 cm), moderately closed (50–60%) grass stand was dominated by cop.$_2$—*Deschampsia caespitosa* and sp.-cop.$_1$—*Rhinanthus minor.* Other components of the grass stand were sp.—*Poa annua*, sol.-sp.—*P. pratensis* ssp. *alpigena*, *Alopecurus pratensis*, *Rumex acetosella*, *Festuca rubra* ssp. *arctica*, *Ranunculus borealis*, *and Plantago major*, sol.—*Cerastium jenisejense*, *Sagina saginoides*, *Euphrasia frigida*, and *Astragalus gorodkovii.* The total number of species was 13; all of them were synanthropic, including 8 apophytes and 5 anthropophytes. The synanthropization and apophytization indices were 100 and 38.5%, respectively.

At the tourist camping site, the soil thickening was weaker and less homogenous. Vegetation was represented by a rattle-box–fescue community. The grass stand was mosaic due to a heterogeneous anthropogenic load; it was tall (up to 60 cm) in some places and short and depressed (25–30 cm) in others. The community was dominated by cop.$_1$-cop.$_2$—*Festuca rubra* ssp. *arctica*, sp.-cop.$_1$—*Rhinanthus minor.* Sp.—*Deschampsia caespitosa*, *Poa pratensis* ssp. *alpigena*, and *P. annua*, sol.-sp.—*Alopecurus pratensis*, *Chamerion angustifolium*, *Beckmannia eruciformis*, *Veronica longifolia*, *and Achillea ptarmica;* sol.—*Stellaria media* and *Erysimum cheiranthoides* were less abundant. The total number of species was 12; all of them were synanthropic, including 6 apophytes and 6 anthropophytes. The synanthropization and apophytization indices were 100 and 50%, respectively.

Nitrate-rich landfills near human dwellings. On loose, slightly polluted substrate, synanthropic vegetation was represented by the reedgrass community. The grass stand was tall (up to 90–100 cm) and highly closed (the projective-cover degree was 80%). The community was dominated by cop.$_1$-cop.$_2$—*Calamagrostis neglecta.* In addition to the dominant species, the grass stand included sp.—*Utrica dioica*, sol.-sp.—*Calamagrostis langsdorffii*, *Chamerion angustifolium*, *Achillea cartilaginea*, *Conioselinum tataricum*, *Ranunculus borealis*, *Rumex acetosa*, *R. acetosella*, *Equisetum arvense*, and *Tripleurospermum phaeocephalum.* The total number of species was 11; all of them were synanthropic, including 8 apophytes and 3 anthropophytes. The synanthropization and apophytization indices were 100 and 72.7%, respectively.

On loose, heavily polluted substrate, a tussock-grass–nettle community was formed. The grass stand was tall (up to 100–110 cm) and dominated by cop.$_2$—*Urtica dioica* and cop.$_1$—*Deschampsia caespitosa.* Less abundant plants included sp.—*Chamerion angustifolium*, *Artemisia tilesii*, *Archangelica decurrens*, *Conioselinum tataricum*, *Veronica longifolia*, *Festuca rubra* ssp. *arctica*, *Poa arctica*, sol.-sp.–*Vicia cracca*, *Stellaria media*, *P. pratensis* ssp. *alpigena*, *Rhinanthus minor*, *Achillea cartilaginea*, *Puccinella distans*, and *Capsella bursa-pastoris.* The total number of species was 16; all of them were synanthropic, including 11 apophytes and 5 anthropophytes. The synanthropization and apophytization indices were 100 and 68.7%, respectively.

Railroad embankment. On the railroad embankment, the vegetation was thin and open (the projective cover degree was 10–20%). Some species formed clumps, while others were represented by single plants. It was impossible to distinguish any dominant species. The grass stand was a collage of anthropophytes (*Tripleurospermum inodorum*, *Achillea ptarmica*, *Bromopsis inermis*, *Beckmannia eruciformis*, *Puccinella distans*, *Cerastium arvense*, and *Erysimum cheiranthoides*) and apophytes (*Papaver lapponicum* ssp. *jugoricum*, *Astragalus gorodkovii*, *A. subpolaris*, *A. norvegicus*, *Calamagrostis neglecta*, *C. langsdorffii*, *Alopecurus pratensis*, *Chamerion angustifolium*, *Ch. latifolium*, *Equisetum arvense*, *Euphrasia frigida*, *Festuca rubra* ssp. *arctica*, *Poa pratensis* ssp. *alpigena*, *P. arctica*, *P. glauca*, *Senecio integrifolius*, *Sagina saginoides*, *Silene paucifolia*, and *Taraxacum brevicorne*) and some species belonging to the local flora that accidentally settled on the naked substrate (e.g., *Dryas octopetala* and *Salix arctica*). The total number of species was 28; 26 of them were synanthropic, including 19 apophytes and 7 anthropophytes. The synanthropization and apophytization indices were 92.8 and 26.9%, respectively.

Synanthropic Roadside Vegetation

In the massif and at its foot, the disturbances of the natural vegetation cover were mainly related to the traffic of all-terrain vehicles, which are widely used in the Far North.

A road for all-terrain vehicles was made in this area more than 30 years ago and was constantly used for some time. This road crossed the foothill forest-tundra at the foot of the massif and the mountain-forest, subgoltsy, and goltsy belts. At present, the road is almost unused; only a few vehicles use it. However, the consequences of this traffic can still be seen: on dry steep slopes, the underlying material was exposed; in damp places, 50-cm-deep segments of the track remained. In all altitudinal belts, the vegetation cover and soil surface in the tracks were disturbed or completely destroyed; between the tracks, woody plants retained marks of damage, such as branches broken or chafed by vehicle bottoms; in damp places at the roadsides, crests were formed by the dirt turned out by the vehicles' crawlers. In autumn and spring, the tracks become water passages; in summer, local people and tourists use the tracks as paths.

This traffic artery may be an interesting object for studying the dynamics of synanthropization of the plant cover against the background of the altitdinal belts.

Foothill forest-tundra. The road for all-terrain vehicles runs through the complex of tundra and open larch forest similar to the aforementioned open forest near the settlement. At the roadsides and between the tracks, the primary vegetation was considerably changed. Trampling and mechanical damage resulted in the suppression of dwarf birch (*Betula nana*), the dwarf shrubs *Vaccinium vitis-idaea, V. myrtillus*, and *V. uliginosum*, and the moss cover.

In the most affected areas, the tussock-grass–blue community dominated by cop.$_1$-cop.$_2$—*Poa pratensis* ssp. *alpigena* and *Deschampsia caespitosa* was formed. Less abundant plants were sp.-cop.$_1$—*Festuca rubra* ssp. *arctica* and *Luzula parviflora*, sp.—*L. frigida, Carex globularis, Poa annua*, and *Chamerion angustifolium*, sol.—*Ranunculus borealis, Conioselinum tataricum, Veronica longifolia, Cerastium jenisejense, Solidago virgaurea, Geranium albiflorum*, and *Rumex acetosella.* The total number of species was 15; 13 of them were synanthropic, including 11 apophytes and 2 anthropophytes. The synanthropization and apophytization indices were 86.7 and 84.6%, respectively.

The mountain-forest belt. On the southwestern slope of the massif (with a steepness of 15–25°), the road crossed a larch (*Larix sibirica*) forest with an admixture of *Picea obovata.* The tree stand was tall, with a crown density of 70%. The shrub layer was poorly developed and included single *Sorbus sibirica* and *Betula nana* plants. The grass–dwarf shrub layer (with a projective-cover degree of 80%) included cop.$_2$—*Equisetum sylvaticum*, sp.-cop.$_1$—*Calamagrostis langsdorffii and Solidago virgaurea*, sp.—*Veratrum lobelianum, Aconitum septentrionale*, and *Geranium albiflorum*, sol.-sp.—*Vaccinium vitis-idaea, V. uliginosum*, and *V. myrtillus*, sol.—*Trientalis europaea, Linnaea borealis, Adoxa moschatellina, Lycopodium annotinum, Rubus arcticus, R. chamaemorus*, etc. In the moss cover, *Pleurozium schreberi* prevailed; in depressions of the relief, mats of *Polytrichum commune* and *Aulacomnium palustre* were the most abundant.

In the places where the vegetation cover was completely destroyed by trampling and all-terrain-vehicle traffic, fescue—woodrush communities were formed. They were dominated by cop.$_1$-cop.$_2$—*Luzula frigida* and cop.$_1$—*Festuca ovina* ssp. *ruprechtii.* Less abundant were sp.—*Poa annua, Calamagrostis langsdorffii, Geranium albiflorum, Chamerion angustifolium*, and *Solidago virgaurea*, sol.-sp.—*Equisetum arvense, Rumex acetosa, R. acetosella, Poa pratensis* ssp. *alpigena, Archangelica decurrens, Ranunculus borealis*, and *Cerastium jenisejense*, sol.—*Conioselinum tataricum, Adoxa moschatellina, Veratrum lobelianum, Rubus arcticus*, and *Viola epipsila.* The total number of species was 19; 15 of them were synanthropic, including 12 apophytes and 3 anthropophytes. The synanthropization and apophytization indices were 78.9 and 80%, respectively.

The subgoltsy belt. The surrounding vegetation was an open larch forest. *Larix sibirica* trees were short and formed an open canopy. Depressed *Picea obovata* trees were scattered over the area. The shrub layer (with a projective-cover degree of 40%) was formed by *Sorbus sibirica, Alnus fruticosa*, and *Betula nana.* In the grass–dwarf shrub layer (with a projective-cover degree of 60–70%), we observed cop.$_1$-cop.$_2$—*Vaccinium vitis-idaea*, sp.—*Equisetum sylvaticum, Veratrum lobelianum, Calamagrostis langsdorffii*, and *Carex globularis*, sol.-sp.—*C. arctisibirica, Rubus chamaemorus, Ledum decumbens*, and *Empetrum hermaphroditum*, sol.—*Vaccinium uliginosum.* The moss cover was well-developed (the projective-cover degree was 60–80%) and dominated by green moss (*Pleurozium schreberi*); solitary *Polytrichum hyperboreum* and *Dicranum angustum* plants were observed.

In this belt, trampling was less intense; the roadside and the space between the tracks were occupied by a sedge community with a small admixture of dwarf shrubs. The floristic composition was more diverse than in the original community. The grass stand was thinned (the projective-cover degree was 30%); it included cop.$_1$—*Carex arctisibirica*, sp.-cop.$_1$—*Carex globularis*, sp.—*Equisetum arvense, Festuca ovina* ssp. *ruprechtii*, sol.—*Rubus chamaemorus, Empetrum hermaphroditum, Vaccinium vitis-idaea, V. uliginosum, Ledum decumbens, Luzula frigida, L. parviflora, Pedicularis lapponica, Polygonum bistorta, Carex aquatilis* ssp. *stans, Calamagrostis lapponica, Poa annua, Poa pratensis* ssp. *alpigena, Ranunculus lapponicus, Chamerion angustifolium, Solidago virgaurea, Viola epipsila*, and *Stellaria peduncularis.* The total number of species was 22; 16 of them were synanthropic, including 15 apophytes and 1 anthropophyte. The synanthropization and apophytization indices were 72.7 and 93.7%, respectively.

The goltsy belt. The primary community was shrub–moss mountain tundra. The shrub layer was formed by cop.$_1$—*Betula nana*, sp.—*Salix glauca* and *S. phylicifolia*; the grass–dwarf shrub layer (with a projective cover degree of 60–70%), by cop.$_1$—*Ledum* *decumbens*, sp.—*Empetrum hermaphroditum, Vaccinium uliginosum, V. vitis-idaea, Rubus chamaemorus*, and *Carex arctisibirica*, sol.—*C. globularis, Luzula parviflora, Polygonum bistorta, Carex aquatilis* ssp. *stans*, and *Calamagrostis lapponica*. The moss cover was well-developed (the projective-cover degree was 80%) and consisted of cop.$_1$—*Drepanocladus uncinatus*, sp.—*Dicranum elongatum, Ptilidium ciliare*, etc.

In the places where dirt was turned out by all-terrain vehicles, we observed narrow strips of the reedgrass–sedge community with a few dwarf shrubs. The projective-cover degree of the grass–dwarf shrub layer was 50–60%. This layer comprised cop.$_1$-cop.$_2$—*Carex arctisibirica*, cop.$_1$—*Calamagrostis lapponica*, sp.-cop.$_1$—*Hierochloë alpina*, sp.—*Carex globularis, Ledum decumbens*, and *Polygonum bistorta*, sol.—*Silene paucifolia, Rubus chamaemorus, Luzula parviflora, Empetrum hermaphroditum, Vaccinium vitis-idaea, V. uliginosum*, and *Poa annua*. The total number of species was 13; 8 of them were synanthropic, including 7 apophytes and 1 anthropophyte. The synanthropization and apophytization indices were 61.5 and 87.5%, respectively.

COMPOSITION OF SYNANTHROPIC FLORA

We found a total of 58 synanthropic plant species in the region studied, including 43 apophytes and 15 anthropophytes (Table 1).

The small proportion of anthropophytes (adventitious species introduced by humans) in the composition of the synanthropic flora was mainly due to the severe local climate. A severe winter with little snow and a short, cool growing season limit the possibility for introducing anthropophytes to the local flora, because most anthropophytes are thermophilic plants usually requiring a longer period to complete their phenological cycle (blooming, seed ripening, and dissemination). This is probably also partly determined by the fact that the natural vegetation of the Polar Urals has been less disturbed than that of regions located to the south.

Anthropophytes may be divided into two groups: archeophytes, which appeared in the given area comparatively long ago (earlier than the 17th century), widely expanded, and become an integral part of the local flora; and neophytes, which appeared in the area later and are only found at a few sites. In the Polar Urals, archeophytes include *Urtica dioica, Plantago major, Poa annua, Capsella bursa-pastoris, Rumex acetosa*, and *R. acetosella*; neophytes include *Cerastium arvense, Stellaria media, Erysimum cheiranthoides, Puccinella distans, Rhinanthus minor, Tripleurospermum inodorum, Achillea ptarmica, Beckmannia eruciformis*, and *Bromopsis inermis*.

In the Polar Urals, plant communities of anthropogenic habitats are mainly formed on the basis of aboriginal species (apophytes). In this study, we considered apophytes to be aboriginal plant species that exhibit intense dispersal in the areas where the natural vegetation cover was depleted or completely destroyed due to human activities. The transfer of apophytes to anthropogenically transformed substrates is typically accompanied by an increase in their abundance and an extension of the range of secondary habitats compared to primary ones.

Sometimes, it is difficult to distinguish between apophytes and anthropophytes and, hence, to assign a species to one of these groups. For example, some of the plants that we assigned to the apophytes occur in undisturbed plant communities of the Polar Urals and the adjacent forest-tundra; however, they are especially abundant in anthropogenic habitats and increasingly rapidly expand in these areas. These "potential anthropophytes," i.e., the species that are transferring to the anthropophyte class, are *Chamerion angustifolium, Vicia cracca, Tripleurospermum phaeocephalum, Equisetum arvense, Artemisia tilesii, Stellaria peduncularis, Calamagrostis neglecta*, and some others. These species behave not only as ruderal plants, but often also as segetal weeds. In some parts of their vast ranges, local botanists consider some of these plants to be introduced species, i.e., anthropophytes.

The intensity of expansion of apophytes varies. Some of them, e.g., *Carex globularis, C. arctisibirica, Deschampsia caespitosa*, and *Polygonum bistorta*, populate disturbed areas mainly or exclusively in habitats and communities identical or similar to those from which the species came. Other species, e.g., *Chamerion angustifolium, Poa pratensis* ssp. *alpigena*, and *Festuca rubra* ssp. *arctica*, are characterized by a wider range of secondary habitats compared to the primary ones; they settle on railroad embankments, in trampled glades, and in landfills.

A characteristic feature of the synanthropic flora of the Polar Urals is that its anthropophytes comprise Arctic and Arctoalpine tundra species (*Papaver lapponicum* spp. *jugoricum, Astragalus norvegicus, Tripleurospermum phaeocephalum, Poa arctica, Taraxacum brevicorne*, and *Euphrasia frigida*), as well as Arctic and Arctoalpine subspecies of widely distributed boreal plant species (*Poa pratensis* spp. *alpigena, Festuca rubra* spp. *arctica*, and *Festuca ovina* spp. *ruprechtii*). Note one more apophyte, the endemic *Astragalus gorodkovii*, which has only been described in a few sites of the Polar Urals (*Arkticheskaya flora SSSR*, 1986). In natural habitats, this plant grows on both coastal shingle and stony slopes. We found *Astragalus gorodkovii* on the railroad embankment near the Krasnyi Kamen', not far from its classical site (shingle on the Sob' River near the same railroad station, where this species was originally described). Earlier (Gorchakovskii and Korobeinikova, 1997), we reported that endemic rock and mountain-steppe plants exhibited an increasingly

Table 1. Floristic composition of plant communities in anthropogenic habitats

Ordinal number	Plant	Populated areas			Roads			
		trampled glades	rubbish areas	railroad embankment	forest-tundra	the mountain-forest belt	the sub-goltsy belt	the goltsy belt
	Apophytes							
1	*Achillea cartilaginea* Ledeb.	–	+	–	–	–	–	–
2	*Alopecurus pratensis* L.	+	–	+	–	–	–	–
3	*Archangelica decurrens* Ledeb.	–	+	–	–	+	–	–
4	*Artemisia tilesii* Ledeb.	–	+	–	–	–	–	–
5	*Astragalus gorodkovii* Jurtz.	+	–	+	–	–	–	–
6	*A. norvegicus* Web.	–	–	+	–	–	–	–
7	*A. subpolaris* Boriss. et Schischk.	–	–	+	–	–	–	–
8	*Calamagrostis langsdorffii* (Link.) Trin.	–	+	+	–	+	–	–
9	*C. lapponica* (Wahl.) C. Hartm.	–	–	–	–	–	+	+
10	*C. neglecta* (Ehrh.) Gaertn., Mey. et Scherb.	–	+	+	–	–	–	–
11	*Carex aquatilis* Wahl. ssp. *stans* (Drej.) Hult.	–	–	–	–	–	+	–
12	*C. arctisibirica* (Jurtz.) Czer.	–	–	–	–	–	+	+
13	*C. globularis* L.	–	–	–	–	–	+	+
14	*Cerastium jenisejense* Hult.	+	–	–	+	+	–	–
15	*Chamerion angustifolium* (L.) Holub.	+	+	+	+	+	+	–
15	*Ch. latifolium* (L.) Holub.	–	–	+	–	–	–	–
17	*Conioselinum tataricum* Hoffm.	–	+	–	+	+	–	–
18	*Deschampsia caespitosa* (L.) Beauv.	+	+	–	+	–	–	–
19	*Euphrasia frigida* Pugsl.	+	–	+	–	–	–	–
20	*Equisetum arvense* L.	–	+	+	–	+	+	–
21	*Festuca ovina* L. ssp. *ruprechtii* (Boiss.) Tzvel.	–	–	–	–	+	+	–
22	*F. rubra* L. ssp. *arctica* (Hack.) Govor.	+	+	+	+	–	–	–
23	*Geranium albiflorum* Ledeb.	–	–	–	+	+	–	–
24	*Hierochloë alpina* (Sw.) Roem. et Schult.	–	–	–	–	–	–	+
25	*Luzula frigida* (Buchenau) Sam.	–	–	–	+	+	+	–
26	*L. parviflora* (Ehrh.) Desv.	–	–	–	+	–	+	+
27	*Papaver lapponicum* (Tolm.) Nordh. ssp. *jugoricum* Tolm.	–	–	+	–	–	–	–
28	*Pedicularis lapponica* L.	–	–	–	–	–	+	–
29	*Poa arctica* R. Br.	–	+	+	–	–	–	–
30	*P. glauca* Vahl.	–	–	+	–	–	–	–
31	*P. pratensis* L. ssp. *alpigena* (Blytt) Hiit.	+	+	+	+	+	+	–
32	*Polygonum bistorta* L.	–	–	–	–	–	+	+
33	*Ranunculus borealis* Trautv.	+	+	–	+	+	–	–
34	*R. lapponicus* L.	–	–	–	–	–	+	–
35	*Sagina saginoides* (L.) Karst.	+	–	+	–	–	–	–
36	*Senecio integrifolius* (L.) Clairv.	–	–	+	–	–	–	–
37	*Silene paucifolia* Ledeb.	–	–	+	–	–	–	–

Table 1. (Contd.)

Ordinal number	Plant	Populated areas			Roads			
		trampled glades	rubbish areas	railroad embankment	forest-tundra	the mountain-forest belt	the sub-goltsy belt	the goltsy belt
38	*Stellaria peduncularis* Bunge	–	–	–	–	–	+	–
39	*Taraxacum brevicorne* Dahlst.	–	–	+	–	–	–	–
40	*Tripleurospermum phaeocephalum* (Rupr.) Pobed.	–	+	–	–	–	–	–
41	*Veronica longifolia* L.	+	+	–	+	–	–	–
42	*Vicia cracca* L.	–	+	–	–	–	–	–
43	*Viola epipsila* Ledeb.	–	–	–	–	+	+	–
	Anthropophytes							
44	*Achillea ptarmica* L.	+	–	+	–	–	–	–
45	*Beckmannia eruciformis* (L.) Host	+	–	+	–	–	–	–
46	*Bromopsis inermis* (Leyss.) Holub	–	–	+	–	–	–	–
47	*Capsella bursa-pastoris* L.	–	+	–	–	–	–	–
48	*Cerastium arvense* L.	–	–	+	–	–	–	–
49	*Erysimum cheiranthoides* L.	+	–	+	–	–	–	–
50	*Plantago major* L.	+	–	–	–	–	–	–
51	*Poa annua* L.	+	–	–	+	+	+	+
52	*Puccinella distans* (Jacq.) Parl.	–	+	+	–	–	–	–
53	*Rhinanthus minor* L.	+	+	–	–	–	–	–
54	*Rumex acetosa* L.	–	+	–	–	+	–	–
55	*R. acetosella* L.	+	+	–	+	+	–	–
56	*Stellaria media* (L.) Vill.	+	+	–	–	–	–	–
57	*Tripleurospermum inodorum* (L.) Sch. Bip.	–	–	+	–	–	–	–
58	*Urtica dioica* L.	–	+	–	–	–	–	–

rapid expansion and populated technogenic substrates in the Northern Urals.

CHARACTERISTIC FEATURES OF APOPHYTIZATION IN THE ARCTIC URALS

As noted above, the bleak climate of the Polar Urals limits the possibility for anthrophytes to expand to this region. Therefore, the synanthropic vegetation is mainly formed on the basis of local species (apophytes) that migrate from various primary habitats (Table 2).

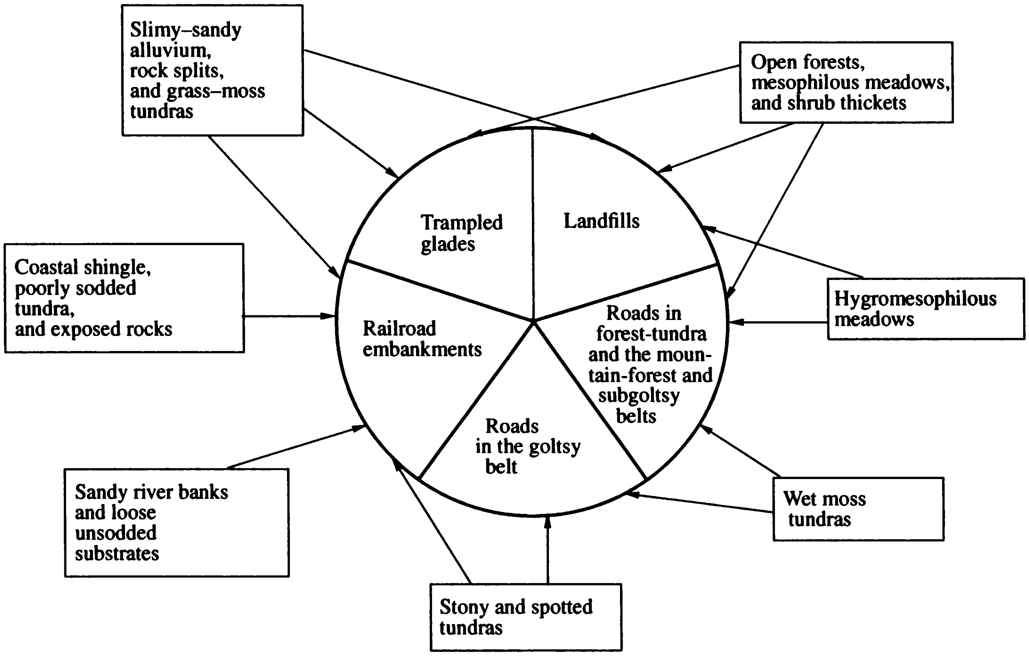
The migration flows of apophytes from primary (natural) to secondary (anthropogenic) habitats are closely connected with the altitudinal differentiation of the vegetation cover. Their directions are determined by the positions of the primary and anthropogenic habitats in the system of vegetation altitudinal belts and by their similarity with respect to environmental characteristics (figure).

The majority of apophytes populating trampled glades and landfills have migrated from open forests, mesophilous meadows, shrub thickets, or habitats with thinned vegetation cover (slimy–sandy alluvium, rock splits, etc.).

Plants whose primary habitats were coastal shingle, poorly sodded tundra areas, and exposed rocks accounted for a considerable proportion of the apophytes that populated the railroad embankment, a new technogenic substrate without primary vegetation. In addition, the embankment was populated by the plants that migrated from stony and spotted tundras and from sandy and slimy river banks.

The pool of apophytes forming the roadside vegetation in the forest-tundra and the subgoltsy belt comprised the plants that came from mesophilous meadows, open forests, and (less frequently) from wet moss tundras. Conversely, in the goltsy belt, roadside plant communities were formed by plants migrating from stony, spotted, and wet moss tundras.

Although the primary habitats of the Polar-Ural apophytes are diverse, these plants have one common characteristic: most of them are plants of open habitats



Main migration flows of apophytes from primary to anthropogenic habitats.

with thin vegetation and are not very competitive. They populate sites with disturbed natural vegetation, where competition with other plants is low.

CONCLUSION

In the Polar Urals, anthropogenic disturbance of the natural vegetation has caused the formation of synanthropic plant communities and different degrees of synanthropization of original communities in anthropogenic habitats, as well as introduction of synanthropic plants to the natural vegetation. The degree of synanthropization of the vegetation cover depends on both the intensity of the anthropogenic impact and the altitudinal differentiation of the vegetation. The highest degree of synanthropization is observed in the plant cover of foothill forest-tundra; the vegetation of the mountain-forest and subgoltsy belts is less affected, and that of the goltsy belts is even less affected.

The general species composition of synanthropic plants becomes poorer and the synanthropization index

Table 2. Distribution of apophytes with respect to their primary habitats

Primary habitat	Characteristic plant species
Open forests, mesophilous meadows, and shrub thickets	*Polygonum bistorta, Chamerion angustifolium, Ranunculus borealis, Geranium albiflorum, Cerastium jenisejense, Conioselinum tataricum, Senecio integrifolius, Vicia cracca, Achillea cartilaginea, Veronica longifolia, Luzula parviflora, Calamagrostis neglecta, C. lapponica, Poa pratensis ssp. alpigena, Festuca rubra ssp. arctica, Alopecurus pratensis*
Hygromesophilous meadows	*Deschampsia caespitosa, Calamagrostis langsdorffii, Archangelica decurrens, Viola epipsila*
Wet moss tundras	*Carex aquatilis ssp. stans, C. arctisibirica, C. globularis, Festuca ovina ssp. ruprechtii, Luzula frigida, Ranunculus lapponicus, Stellaria peduncularis, Pedicularis lapponicus*
Stony and spotted tundras	*Silene paucifolia, Hierochloë alpina*
Sandy river banks and loose unsodded substrates	*Equisetum arvense*
Coastal shingle, poorly sodded tundra, and (less frequently) exposed rocks	*Astragalus gorodkovii, A. norvegicus, A. subpolaris, Chamerion latifolium, Papaver lapponicum ssp. jugoricum, Euphrasia frigida, Artemisia tilesii, Poa glauca*
Slimy–sandy alluvium, rock splits, and grass–moss tundras	*Sagina saginoides, Poa arctica, Taraxacum brevicorne, Tripleurospermum phaeocephalum*

of plant communities in anthropogenic habitats decreases uphill from foothill forest-tundra, through the mountain-forest and subgoltsy belts, to the goltsy belt; however, their apophytization index increases.

Of the 58 synanthropic plant species found in the region studied, only 15 were anthropophytes, with most of them inhabiting foothill forest-tundra. The main route of apophyte expansion to the Polar Urals and their foothills is the Labytnangi–Vorkuta railroad. Due to the severe climatic conditions of the Polar Urals, only a few anthropophytes reach the mountains: only three species (*Poa annua, Rumex acetosa*, and *R. acetosella*) were found in the mountain-forest belt, and only one species (*Poa annua*), in the subgoltsy and goltsy belts.

Regarding apophytes, a decrease in their number with an increase in altitude is related to the facts that (1) the natural vegetation cover in higher altitudinal belts is less disturbed and (2) in the higher belts, disturbed biotopes are less diverse. The composition of the Polar-Ural apophytes is characterized by a high proportion of Arctic and Arctoalpine species. Many of the apophytes are erosiophilous plants; in their natural habitats, they grow on substrates that are permanently stripped and belong to communities with thin plant covers.

In general, the synanthropization of the plant cover in the Polar Urals is less pronounced than in the Northern and Southern Urals (Gorchakovskii and Korobeinikova, 1997; Gorchakovskii and Kozlova, 1998). Further increase in the anthropogenic load on the Arctic-Ural natural vegetation will result in an increased synanthropization; however, in the subgoltsy and goltsy belts, this will mainly occur through an increase in the proportion of apophytes.

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