

**THE EFFECT OF DISTURBANCE
ON PLANT COMMUNITIES
IN TUNDRA REGIONS
OF THE SOVIET UNION**

Three Papers with Annotated Lists



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AN ANNOTATED LIST OF PLANTS INHABITING SITES OF NATURAL AND ANTHROPOGENIC DISTURBANCES OF TUNDRA COVER: SOUTHEASTERNMOST CHUKCHI PENINSULA

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Included in the program of Soviet-American co-operation in the area of environmental protection (Project 02.05.2101; protection of northern ecosystems) is the compilation of plant lists of biological indicators of sites of disturbance of tundra cover by natural agents and the activity of man for a number of tundra areas of the U.S.S.R. and of Alaska. In view of the important differences among various parts of the tundra zone with respect to the composition of the flora, natural conditions, and conditions and intensity of economic utilization, it is advisable to initially compile such lists for limited areas with subsequent comparison of local lists and generalization into regional ones.

During the period of field work by the Indigirka-Chukotka Detachment of the Polar Expedition of the Komarov Botanical Institute in July and August 1976, such a list was compiled for the environs of the settlement of Yanrakynot on the coast of Senyavin Strait (opposite Arakamchechen Island) on the southeasternmost part of the Chukchi Peninsula ($64^{\circ} 56' N.$; $172^{\circ} 53' W.$) (Table 1). The list was compiled in the course of a detailed study of the concrete flora (in the sense of Tolmachev 1931) according to natural landscape subdivisions of different ranks such as complex habitats and micro-districts; at the same time pedological-geobotanical studies were conducted. Besides a general floristic list of the concrete flora of the area, 44 lists of partial floras were compiled, including 3 lists for sites of intensive human activity (the area of the settlement at the top of the hill, the southern slope from the settlement to the lagoon, and the lower isthmus between the lagoon and the estuary of the Marich River connecting the settlement and the fur farm).

The area represents a basic variant of the subzone of northern hypoarctic tundras, and, from a floristic point of view, the Far East district of the

Beringian-Chukchi subprovince of the Chukchi province of the Arctic floristic region; the locality is situated in the central part of the Beringian sector (Yurtsev 1972, 1974). The climate is maritime-low arctic. The relief is highly variable with a combination of large areas of denudation and accumulation plains, low mountains, spits jutting out into the sea, lagoons, the estuary and floodplain. Paleozoic carbonate rocks and carbonate-containing modern and ancient alluvium prevail, but there are also outcrops of sedimentary and magmatic acid rocks. Predominating elements of the vegetation are moist forb-dwarf shrub-sedge-moss tundras, tundra mires, dryas fellfields, snowbed tundras, mesic grass meadows, and dwarf shrub-herb meadows, and at some distance from the shore also tundra willow thickets dominated by *Salix lanata* ssp. *richardsonii*. The flora is distinguished by its record richness for the Arctic: 440 species of vascular plants were recorded for an area of ca. 10 km², partial floras of some large complex habitats and micro-districts number up to 260 species, and the floras of different communities number 60 and more species per 100 m².

The small settlement, Yanrakynnot, is the central seat of a major State Farm occupied by the traditional industries of the Chukchis: hunting marine mammals, fishing, reindeer herding, and recently added, the breeding of foxes at the fur farm. The reindeer herding crews have cross-country transportation; tractors and cargo vehicles operate in and around the settlement. There is no agriculture whatsoever. Although the settlement did not come into existence until the 1930's, the area served for a long time as a favorite place for temporary campsites of coastal-dwelling and reindeer herding Chukchis. In recent decades, the intensity of the influence of human activity on the natural habitat has increased significantly due to the construction of the present settlement and the widespread use of tracked vehicles.

The basic kinds of disturbance of the tundra cover observed in the vicinity of the settlement are: A. Disturbances caused by natural agents: 1) different types of erosion and landslip; 2) solifluction; 3) formation of zoogenic grass and shrub-herb meadows in sites of rodent burrows and around the feeding places of birds of prey as well as sites of decomposition of small animal carcasses. B. Disturbances due to human activities: B₁, connected with non-intensive, traditional forms of human activity: 1) campsites; 2) heaps of remains of marine mammals; 3) old burial sites; 4) sites of campfires; 5) reindeer trails; 6) places where reindeer are slaughtered; and others. Some of the traditional forms of human occupation have in recent decades become more intensive and sometimes lead to significant disturbances of the natural cover. B₂, connected with more intensive present forms of human activity: 1) areas in and immediately surrounding the settlement, and 2) cross-country tractor roads.

According to the degree of specificity for sites with a disturbed cover, all plants of such sites can be divided into the following categories: 0 — residual species with reduced abundance and vigor, remaining from the time preceding the disturbance; I — species normally existing in disturbed sites but by no

means preferring them; II — species preferring disturbed sites (more common or abundant and vegetatively luxuriant there) but common enough also in sites with undisturbed cover; and III — species primarily or exclusively (IIIA) found on disturbed sites. It is possible to distinguish still more groups, such as plants dropping out from the cover during its disturbance and introduced plants colonizing areas of anthropogenically disturbed cover. Anthropogenic habitats are defined here as sites with a cover disturbed by man, but not natural habitats only somewhat transformed as a result of external influences.

An annotated list of the species belonging to categories I - III was compiled for the area of Yanrakynnot (Table 1). For each species is indicated: 1) the degree of specificity for the disturbed sites (according to the above-mentioned categories); 2) the types of cover disturbances for which the species was noted with subdivision according to their causative agents (see above); 3) the commonness or rarity of the species in the area investigated, the most characteristic natural ecotopes, and ecological features (the relationship to nitrogen richness of the soil, carbonate content of the substrate, and moisture regime); 4) the predominant modes of reproduction and dispersal; and 5) the growth-form (according to a rough scale).

The list compiled for the area of Yanrakynnot includes 104 species, that is, a little less than $\frac{1}{4}$ of the concrete vascular plant flora. Of these, 56 species belong to category I; 31 to II; and 17 species to III. Thirty-seven species are exclusively or primarily related to the zoogenic ecotopes. Seventy-five species were noted on anthropogenic ecotopes (not counting species of category 0; see above); in this number belong 43 species on zoogenic and anthropogenic habitats. Among the constant associates of zoogenic ecotopes (24 species), 10 species belong to category I (out of 56 referred to that category), 5 (out of 31) to II, and 9 species (out of 17) to IIIA.

An analysis of the materials in the list and comparison of the partial floras of the above mentioned three anthropogenic complex habitats with the floras similar in respect to habitat position in the relief but from weakly disturbed sites, as well as direct observations, permit us to draw the following preliminary conclusions:

1) In the area of the settlement, introduced plants are completely lacking in contrast to what is observed in the vicinity of older and larger settlements in Chukotka which have a seaport and/or an agricultural experiment station (Dorogostaiskaya 1972, 1978) such as: Egvekinot, Provideniya, and Anadyr. It is interesting that a considerable variety of introduced agricultural and weedy plants in the flowering stage are noted at Lorino thermal springs where a greenhouse enterprise has been developed by the Lorino collective farm. In the environs of Yanrakynnot, all the plants of anthropogenic ecotopes are apophytes, native species, readily occupying sites of human settlement.

2) The basic ecological groups of native plants, the "providers" of the apophytes are: a) nitrophiles, characteristic of zoogenic meadows and other

ecotopes (for instance, *Draba juvenilis*, *D. hirta*, *Descurainia sophioides*, *Cochlearia oblongifolia*, *Artemisia tilesii*, *Arctagrostis arundinacea*, *Phippsia algida*, and others); b) species with affinity for erosion habitats (for instance, *Artemisia tilesii*, *Senecio congestus*, *Chamaenerium* spp., *Chrysosplenium tetrandrum*, and others); c) "solifluction species" — inhabitants of spots and stripes bared by solifluction, etc. (for example, *Festuca brachyphylla* s. lat., *F. vivipara*, *Juncus* spp., *Sagina intermedia*, *Koenigia islandica*, *Braya* spp., *Saxifraga cernua*, *S. foliolosa*, *Primula egaliksensis*); d) plants of tundra bogs and other wet ecotopes reproducing intensively by means of above- and below-ground shoots (*Eriophorum angustifolium*, *E. triste*, *Carex stans*, *Dupontia psilosantha*, *Poa alpigena*, *P. arctica*, *Juncus castaneus*, *Caltha arctica*, *Ranunculus hyperboreus*, *Stellaria crassifolia*, *Epilobium palustre*, *Cardamine pratensis*). Thus, the composition of plants in ecologically dissimilar disturbed sites is also very different, which is easily observed, for instance, along a cross-country road running through different elements of relief. Some plants grow readily on disturbed sites only in or near the locality of their original ecotopes, for instance, *Braya purpurascens*, *B. bartlettiana* s. lat., *Primula egaliksensis* (in carbonatic solifluction spots).

3) Traditional and new (intensive) forms of human activity and organization of settlements exert contrasting influences on tundra cover. Anthropogenic habitats such as sites of former campsites or burials approach the nitrophilous vegetation of zoogenic sites in composition of plant species and character of the vegetation. Characteristic of these are a narrowly localized and/or not very intensive, as a rule, short-term influence on the original cover and a long-term, slowly fading after-effect. Only close to slaughtering sites is the vegetation sometimes almost completely obliterated over an area up to 0.25 hectare.

The nitrophilous vegetation of zoogenic ecotopes is usually distinguished by great vegetative vigor, dominance of herbaceous plants (dwarf shrubs may be lacking), and not rarely also by increased specific diversity. However, at gull colonies and on zoogenic meadows on summits, formed by acid rocks, species richness is very small. Of special importance in the area investigated are the feeding places of birds of prey on monadnock crags and raised sites on summits of dry hills and sites of ground squirrel colonies which are also confined to raised sites. Fifteen species in the environs of Yanrakynnot are found only or mainly in zoogenic meadows, among which are relicts from the continental stage of Beringia (for instance, *Androsace septentrionalis*, *Selaginella sibirica*, *Draba nemorosa*, *Potentilla arenosa*, *Arnica angustifolia*, and others). All three localities known for Chukotka of the American species *Polygonum alaskanum* are confined to zoogenic, nitrophilous vegetation of ledges of monadnock crags and the single relict populations of *Arabidopsis czukczorum* and *A. bursifolia* var. *beringensis* are confined to the feeding places of predatory birds. The wide distribution of such meadows is a factor in the enrichment of the local flora and

preservation of its relict elements in contemporary (maritime) climatic conditions alien to them.

Even against a background of floristic richness, localities of former camp and burial sites on hills and the high plain stand out in the Beringian tundra as oases — splendid flower gardens; in the middle of July there are bright carpets of the flowering Siberian phlox. Many plants are also common to zoogenic meadows; distinguishing species are absent. The phytocoenoses have the character of dry tundra meadows and, obviously, differ from surrounding dryas fellfields by their increased biological productivity.

Upon intensification of influence connected with the transition to modern forms of human activity, the vegetation of the Beringian tundra responds during moderate intensity of influence by an increase in vegetative vigor of the plants simultaneously with a decrease in taxonomic diversity and a transfer of dominance to herbs (in the immediate environs of the settlement and the fur farm, places where marine animals are butchered, and faintly worn cross-country tracks). During further intensification of impact on the cover, the response is its partial or full degradation (area of the settlement and well-worn cross-country tracks). In the area of the settlement of Yanrakynnot (the top of the limestone hill), the vegetation is preserved only locally. Only 10 species are recorded which are exclusively apophytic-nitrophiles (*Arctagrostis arundinacea*, *A. latifolia*, *Poa arctica*, *Phippsia algida*, *Descurainia sophioides*, and *Artemisia tilesii* dominate); whereas floras of the same kinds with respect to location of sites, but with weakly disturbed cover, number up to 50 to 60 species, among which the normally occurring plants of the area of the settlement are absent. On the slope down to the lagoon (a zone of influence on the vegetation by sewage and household garbage which is readily visited by seabirds and the quadruped inhabitants of the settlement), there were recorded 69 species of vascular plants which is only slightly fewer than the species diversity of original floras of such sites. Many native species on similar slopes are preserved in small amounts in a depressed condition (category 0); nitrophilic-apophytes dominate.

On the rather broad isthmus (between the estuary and the lagoon) dividing the Yanrakynnot hill-peninsula from the main part of the high plain, 192 species of vascular plants were observed which demonstrates sufficiently the full preservation of the original richness of the partial flora presented here, although the number of representatives of category 0 is very great. There are sites where the native plant population is completely replaced by a small group of flourishing apophytes (generally the same ones that also grow in the settlement!) which are very isolated and confined to places where fat had been rendered and to a drainage area from the fur farm. There are also some sites where the natural cover is practically destroyed (on well-worn paths on the slope of the hill in places where one enters the settlement).

4) Nitrophily, affinity for erosion areas, and capacity for intensive vegetative reproduction and/or reproduction by seed are characteristic

ecological and biological features of plant-indicators of disturbed cover. In the future, it will be advisable to make a more detailed ecological and biomorphological analysis of the list.

5) The local tundra flora is rich in plants which merit testing during recultivation of highly disturbed land; among them are quite a few good sod-formers. "Hemi-anthropogenic" dwarf shrub-herb and grass tundra meadow localities of very old campsites, which differ from the native tundra vegetation by greater productivity, species diversity, and, frequently, also by their colorful flowering, may perhaps furnish the ideal type of plant communities which should be established in the environs of tundra settlements (as "rest areas" or "tundra-parks").

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Table 1. Annotated list of plants characteristic of sites of naturally and anthropogenically disturbed vegetation cover: the environs of the Yanrakynnot settlement, southeast Chukchi Peninsula, the subzone of typical (northern hypoarctic) tundras. (For definitions of abbreviations, see text and footnote to this table.)

Name of species	Category of affinity (see p. 2-3)	Type of disturbance (see p. 2)	Common or rare in area studied	Characteristic undisturbed ecotopes in the area studied	Some ecological features	Basic means of reproduction	Growth form
1	2	3	4	5	6	7	8
<i>Equisetum arvense</i> <i>ssp. boreale</i>	I	A-1,2,3	C	floodplains, mesic meadows and willow thickets on slopes, moist waning slopes, etc.	M	veg. (rhiz.)	herb, p-c,(4)
<i>Selaginella sibirica</i>	II	A-3	±R	dry dryas tundras of S-facing slopes, cliffs	X	veg. +	herb, p-c,(4)
<i>Trisetum spicatum</i>	I	A-1,3;B ₁ -1,4; B ₂ -2	C	floodplain, dry mesic dwarf shrub-herb meadows, montane tundras, etc.	Ni,X/M	seeds	herb, p-c,(4)
<i>Calamagrostis purpurascens</i>	I	A-3	±C	limestone cliffs, scree slopes	Ni(?),X,Ca	seeds +?	herb, p-c,(4)
<i>C. langsdorffii</i>	I	A-3	±C	grass mesic meadows on S-facing slopes	Ni,M,A	veg.	herb, p-c,(4)
<i>C. purpurea</i>	I	A-3	±R	grass and dwarf shrub-herb meadows	Ni,M,A	(rhiz.)	herb, p-c,(4)
<i>C. deschampsoides</i>	I	A-1;B ₁ -2; B ₂ -2	C	coastal halophilous short-grass-sedge marshes ("tampy")	M/H,H1	veg.	herb, p-c,(4)
<i>C. lapponica</i>	I	A-3;B ₂ -2	±C	dry acidophytic tundras	M,A	seeds, veg.	herb, p-c,(4)

1	2	3	4	5	6	7	8
<i>Arctagrostis latifolia</i>	II	A,1,2,3; B ₁ -1;B ₂ -1,2	C	moist eutrophic tundra slopes of sandy terraces, etc.	Ni?,M	veg. (rhiz.)	herb, p-c,(4)
<i>A. arundinacea</i>	II	A-1,3; B ₁ -1,2,3; B ₂ -1,2	C	floodplains, meadows, mesic meadows and willow thickets on S-facing slopes, etc.	Ni!,M	veg. (rhiz.)	herb, p-c(4)
<i>Poa arctica</i>	II	A-1;B ₁ -1,3; B ₂ -1,2	C	moist tundras, dwarf shrub-herb mesic meadows, willow thickets, etc.	Ni,M/H	veg. (rhiz.)	herb, p-c,(4)
<i>Poa alpigena</i>	I	A-1;B ₂ -1,2	C	moist tundras, dwarf shrub-herb mesic meadows, willow thickets	Ni,H/M	veg. (rhiz.)	herb, p-c,(4)
<i>Poa glauca</i>	I	A-3; B ₁ -1,3,4;B ₂ -2	C	dry montane tundras, cliffs, gravel	Ni,M/X	seeds	herb, p-c,(4)
<i>Puccinellia wrightii</i>	I	A-2;B ₂ -2	C	moist carbonate waning slopes and saddles	M/H,Ca+, (H1)	seeds	herb, p-c,(4)
<i>P. alascana</i>	IIIA	A-3 (seabird colony)	R	-----	Ni,M,H1	seeds	herb, p-c,(4)
<i>P. tenella</i>	I	A-1;B ₂ -2	C	coastal halophilous short-grass-sedge meadows ("tampy")	H/M,H1	seeds	herb, p-c,(4)
<i>P. phryganodes</i>	I	A-1;B ₂ -2	C	coastal halophilous short-grass-sedge meadows	M/H,H1	veg. (rhiz.)	herb, p-c,(4)
<i>Dupontia psilosantha</i>	I	B ₂ -2	C	coastal halophilous short-grass-sedge meadows, sandy shores of rivers, lakes, bogs	H,(H1)	veg. (rhiz.)	herb, p-c,(4)

1	2	3	4	5	6	7	8
<i>Phippisia algida</i>	II	A-3;B ₂ -1	C	snowbed areas, silty bases of coastal slopes	Ni,H/M/(H1)	seeds	herb, p-c,(4)
<i>Festuca altaica</i>	I	A-3	C	dwarf shrub-herb mesic meadows, mesic meadow tundras	Ni, M	seeds	herb, p-c,(4)
<i>F. brachyphylla</i>	II	A-2,3; B ₁ -1,3,4,B ₂ -2	C	floodplains, spotty tundras, cliffs, etc.	(Ni),X/M,H	seeds	herb, p-c,(4)
<i>F. baffinensis</i>	II	A-3;B ₁ -1,3,4; B ₂ -2	C	calciphytic montane tundras, cliffs	Ni,X/M,Ca	seeds	herb, p-c,(4)
<i>F. vivipara</i>	I	A-1,2;B ₂ -2	±C	slopes above snowbeds, wet rock ledges	X/M,(Ca)	veg. (vivip)	herb, p-c,(4)
<i>Bromus arcticus</i>	II	A-3,B ₁ -1	C	floodplains, dry-mesic dwarf shrub-herb meadows on slopes	Ni,X/M	veg.	herb, p-c,(4)
<i>B. pumpellianus</i>	II	A-3;B ₁ -1	C	floodplains, dry-mesic dwarf shrub-herb meadows on slopes	Ni,X/M	veg.	herb, p-c,(4)
<i>Roegneria villosa</i>	II	A-1,3;B ₁ -1	C	dry, sandy tundra terraces, floodplains, cliffs	Ni,M/X,Ca	seeds	herb, p-c,(4)
<i>R. scandica</i> (<i>R. borealis</i> s. lat.)	II	A-3	R	sand dunes	Ni,M/X,Ca	seeds	herb, p-c,(4)
<i>R. hyperarctica</i>	II	A-1,3;B ₁ -1	±R	dry, sandy tundra terraces, floodplains, cliffs	Ni,M/X,Ca	seeds	herb, p-c,(4)
<i>Leymus villosissimus</i>	I	A-3;B ₁ -1,2,3	C	marine spits, sandy estuary shores	Ni,X/M,H1	veg. (rhiz.)	herb, p-c,(4)
<i>Eriophorum angustifolium</i>	I	B ₂ -(1),2	C	tundra mires and marshes, shores of ponds	H	veg. (rhiz.)	herb, p-c,(4)

	1	2	3	4	5	6	7	8
<i>E. triste</i>		I	A-1,2;B ₂ -2	C	moist calciphytic tundras at the foot of steep slopes and waning slopes, etc.	M/H,Ca	veg. (rhiz.)	herb, p-c,(4)
<i>E. scheuchzeri</i>		I	(A-1);B ₂ -2	C	moist shores of rivers and lakes, on fresh alluvium	H	veg. (rhiz.)	herb, p-c,(4)
<i>Carex stans</i>		I	B ₂ -(1),2	C	tundra mires and marshes, lake shores	H	veg. (rhiz.)	herb, p-c,(4)
<i>C. podocarpa</i>		I	A-3	C	mesic meadow tundras and willow thickets	Ni,M	veg. (rhiz.)	herb, p-c,(4)
<i>Juncus arcticus s. lat.</i>		I	B ₂ -2	C	sandy shores of rivers, streams, and the lagoon	M/H	veg. (rhiz.)	herb, p-c,(4)
<i>J. castaneus</i>		I	A-1,2;B ₁ -4; B ₂ -1,2	C	wet shores of rivers, streams, lakes, (mineral bog-assoc), etc.	H	veg. (rhiz.)	herb, p-c,(4)
<i>J. biglumis</i>		I	A-1,2;B ₁ -4; B ₂ -1,2	C	wet shores of rivers, streams, and lakes, mineral bog-assoc., moist tundras, (bare spots)	H	seeds	herb, p-c,(4)
<i>J. albescens</i>		I	A-1,2;B ₁ -4; B ₂ -1,2	C	moist eutrophic tundras of debris trains at foot of slopes, etc.	H,Ca	seeds	herb, p-c,(4)
<i>J. triglumis</i>		I	A-1,2;B ₁ -4; B ₂ -1,2	C	moist eutrophic tundras of waning slopes, at foot of slopes, etc.	H,(Ca)	seeds	herb, p-c,(4)
<i>Veratrum oxysepalum</i>		I	A-3	±R	dwarf shrub-herb mesic meadows, herb-willow stands on slopes	Ni,M	seeds +	herb, p-c,(4)
<i>Oxyria digyna</i>		I	A-1,3	C	snowbed tundras and dwarf shrub-herb mesic meadows, moist slopes and screes	Ni,M	veg.	herb, p-c,(4)

1	2	3	4	5	6	7	8
<i>Rumex arcticus</i>	I	A-2;B ₁ -1; B ₂ -1,2	C	tundra mires and marshes, moist-mesic dwarf shrub-herb meadows	Ni,H	seeds +	herb, p-c,(4)
<i>R. beringensis</i>	I	(A-1);B ₂ -2	C	sandy and gravelly beaches of the sea and rivers; dunes	X/M(A)	veg. (rhiz. shoots)	herb, p-c,(4)
<i>Koenigia islandica</i>	II	A-1,2;B ₁ -1,4 B ₂ -2	C	silty shores of rivers, streams; river channels, snowbeds	Ni?,M/H	seeds	herb, m-c
<i>Polygonum tripterocarpum</i>	I	A-3	C	meadows, willow thickets, shrub-moss tundras	Ni,M,A!	veg. (rhiz.)	herb, p-c,(4)
<i>P. viviparum</i>	I	A-1,3;B ₁ -1,4; B ₂ -1,2	C	eurytopic species (avoids fellfields)	Ni,M	veg. (vivip)	herb, p-c,(4)
<i>Sagina intermedia</i>	I	A-1,2;B ₁ -1,4; B ₂ -1,2	C	bare spots in moist tundras, snowbeds, silty floodplains	Ni,M	seeds	herb, p-c,(4)
<i>Stellaria crassifolia</i>	IIIA	B ₁ -1,4;B ₂ -1,2	C	////	Ni,H/M	veg. (above ground shoots)	herb, p-c,(4)
<i>S. ssp. (S. longipipes s.l.)</i>	II	A-3	C	dwarf shrub-herb mesic meadow slopes, cliffs, willow thickets	Ni,M	above and below ground shoots	herb, p-c,(4)
<i>Cerastium beeringianum</i>	II	A-3;B ₁ -1,4; B ₂ -2	C	cliffs, gravels, spotty montane tundras	Ni,M	seeds +?	herb, p-c,(4)
<i>C. jenisejense</i>	I	A-1,3;B ₁ ,4; B ₂ -1,2	C	willow thickets, gravels, dwarf shrub-herb mesic meadows	(Ni),H/M	veg. (above ground shoots)	herb, p-c,(4)

1	2	3	4	5	6	7	8
<i>Arenaria longipedunculata</i>	I	A-1	R	well-drained sites in moist,	M,Ca!	veg.	herb, p-c,(4)
<i>Minuartia rossii s. lat.</i>	I	A-1,2,3;B ₁ -4 B ₂ -2	C	moist and medium wet calciphytic tundras	H/M,Ca	veg.(bulbils, shoots)	herb, p-c,(4)
<i>M. rubella</i>	I	A-1,3;B ₁ -4; B ₂ -2	C	gravelly floodplains, dry elevated sites on sandy terraces, etc.	Ni,M/X	seeds	herb, p-c,(4)
<i>Merckya physodes</i>	I	A-3;B ₁ -1; B ₂ -(1),2	C	floodplains, dwarf shrub-herb mesic meadows and willow thickets on slopes	Ni,M	veg. (above ground shoots)	herb, p-c,(4)
<i>Gastrolychnis affinis</i>	I	A-3;B ₂ -2	±R	gravels on floodplains, coastal gravelly spits	Ni,X/M	seeds	herb, p-c,(4)
<i>Caltha arctica</i>	I	B ₂ -1,2	C	lake shores, tundra mires and marshes	H	veg. (above ground shoots)	herb, p-c,(4)
<i>Aconitum delphinifolium ssp. delphinifolium</i>	IIIA	A-3	R	-----	Ni,M	seeds	herb, p-c,(4)
<i>A. delphinifolium ssp. paradoxum</i>	I	A-3	C	dwarf shrub-herb mesic meadows and willow thickets on floodplains and slopes	Ni,M	seeds	herb, p-c,(4)
<i>Ranunculus hyperboreus</i>	I	A-1;B ₂ -1; B ₂ -1,2	C	lake shores, tundra mires and marshes	(Ni),H	veg. (above ground shoots)	herb, p-c,(4)
<i>R. affinis</i>	IIIA	A-3	R	-----	Ni,X,M	seeds	herb, p-c,(4)
<i>Papaver radicum</i>	II	A-3	±C	gravelly coastal spits, cliffs	Ni?,X/M	seeds	

1	2	3	4	5	6	7	8
<i>Cochlearia arctica</i>	II	A-1,3;B ₂ -1,2	C	shores of estuary and lagoon	Ni,M,(H1)	seeds	herb, m-c,(+)
<i>C. groenlandica</i>	I	A-3;B ₂ -1,2	C	low sites on coastal spits, shores of estuary and lagoon	Ni,M,H1	seeds	herb, m-c,(+)
<i>C. oblongifolia</i>	III A	A-3;B ₂ -1,2	±C	-----	Ni,M,H1	seeds	herb, m-c,(+)
<i>Cardamine pratensis</i>	I	A-1;B ₂ -1,2	C	lake shores, moist water courses, moist floodplains, depressions in mires and marshes	Ni,H	veg. (rhiz., leaf-bulbils)	herb, p-c,(4)
<i>Draba juvenilis</i>	II	A-1,3;B ₁ -4; B ₂ -1,2	C	snowbeds	Ni,M	seeds	herb, p-c,(4)
<i>D. hirta s. lat.</i>	II	A-1,3;B ₁ -1,4; B ₂ -2	C	gravels, cliffs, etc.	Ni,M	seeds	herb, p-c,(4)
<i>D. borealis</i>	III A	A-3;B ₂ -2	±R	-----	Ni,X/M	seeds	herb,p-c,(4)
<i>Draba nivalis</i>	I	A-3	C	dry, rubble tundras	X	seeds	herb, p-c,(4)
<i>D. arctogena</i>	III A	A-3	R	-----	Ni,X/M	seeds	herb, p-c,(4)
<i>D. nemorosa</i>	III A	A-3	R!	-----	Ni,X	seeds	herb, p-c,(4)
<i>Descurainia sophioides</i>	III A	A-3;B ₁ -1; B ₂ -1,2	C	-----	Ni,X	seeds	herb,m-c(2+)
<i>Braya purpurascens</i>	I	A-1,2;B ₂ -2	±R	spotty calciphytic tundras, plateaus and slopes	X/M,Ca	seeds	herb, p-c(4)

1	2	3	4	5	6	7	8
<i>B. bartlettiana</i> s. lat. (<i>B. aenea</i> ssp. <i>pseudoaenea</i> Petrovsky)	I	A-1,2;B2-2	C	dry rubble and other montane tundras, spotty tundras on limestones	X/M,Ca	seeds	herb, p-c(4)
<i>Saxifraga caespitosa</i>	IIIA	A-3	±R	-----	Ni,X/M,Ca	seeds	herb, p-c(4)
<i>S. cernua</i> (diff. ecotypes)	II	A-1,3;B1-1,4; B2-1,2	C	stony slopes, cliffs, flooded mire assoc., snowbeds, etc.	Ni,N/M+H	veg. (vivip)	herb, p-c,(4)
<i>S. bracteata</i>	IIIA	A-3	R	-----	Ni,H	veg. +?	herb, p-c,(4)
<i>S. nivalis</i>	II	A-3	±R	scattered on montane tundras, more common in cliffs	Ni,H	seeds	herb, p-c,(4)
<i>S. nelsoniana</i>	I	A-3;B1-1; B2-1	C	snowbed tundras, dwarf shrub-herb mesic meadows, willow thickets, moist waning slopes, cliffs	Ni,M	veg. (rhiz.)	herb, p-c,(4)
<i>S. foliolosa</i>	I	A-1;B1-4;	C	tundra mires and marshes, moist tundras, banks of streams, etc.	Ni,M/H	veg. (vivip.)	herb, p-c,(4)
<i>Chrysosplenium tetrandrum</i>	II	A-1,3; B2-1,2	C	flooded mire assoc., shores of streams and lakes, moist dwarf shrub-herb short-grass meadows	Ni,H/M	veg. (rhiz.)	herb, p-c,(4)
<i>Potentilla arenosa</i>	IIIA	A-3	R!	flooded mire-assoc., shores of streams and lakes, moist dwarf shrub-herb meadows	(Ni),X	seeds	herb, p-c,(4)
<i>Chamaenerium latifolium</i>	I	A-1,3	C	floodplains, esp. gravelly rubble slopes	X/M	veg. (rhiz., shoots?)	herb, p-c,(4)

1	2	3	4	5	6	7	8
<i>Ch. angustifolium</i>	I	A-3	±C	mesic meadows, willow thickets, most often on S-facing slopes	Ni,M	veg. (rhiz. shoots)	herb, p-c,(4)
<i>Epilobium palustre</i>	III A	B ₂ -1	R!	-----	Ni,H	veg.(stolons)	herb, p-c,(4)
<i>Primula egalikensis</i>	I	A-2;B ₂ -2	±C	shores of streams, rivers and the estuary, moist spotty tundras	H/M,Ca	seeds	herb, p-c,(4)
<i>Androsace septentrionalis</i>	III A	A-3	±C	-----	Ni,X	seeds	herb, m-c,(+)
<i>Gentiana propinqua s. lat.</i>	II	A-3;B ₁ -1	C	dwarf shrub-herb mesic meadows, willow thickets on elevated floodplains and slopes	Ni,X/M	seeds	herb, m-c(1)
<i>G. prostrata</i>	II	A-2,3;B ₁ -1,4	C	moist carbonatic waning slopes, sod-covered gravels of elevated floodplains	Ni,M,Ca!	seeds	herb, m-c,(1)
<i>Polemonium acutifolium</i>	I	A-3;B ₁ -1; B ₂ -1,(2)	C	flooded mire assoc., willow thickets, moist dwarf shrub-herb meadows	Ni,M/H	veg. (rhiz.)	herb, p-c,(4)
<i>Phlox sibirica</i>	II	A-3;B ₁ -1	C	dry, carbonate montane tundras	M/H,Ca	veg + seeds	herb, p-c,(4)
<i>Myosotis asiatica</i>	II	A-3;B ₁ -1; B ₂ -1;	C	dry mesic dwarf shrub-herb meadows, more common near the coast	Ni,M	seeds +	herb, p-c,(4)
<i>Valeriana capitata</i>	I	A-3;B ₁ -1; B ₂ -(2)	C	willow thickets, dwarf shrub-herb mesic meadows, stream banks, moist tundras, etc.	Ni,M	veg. (rhiz.)	herb, p-c,(4)
<i>Solidago compacta</i>	I	A-3;B ₁ -1	C	dwarf shrub-herb mesic meadows and willow thickets, on well-drained sites	Ni,M	seeds +	herb, p-c,(4)

1	2	3	4	5	6	7	8
<i>Artemisia tilesii</i>	III	A-1,3;B ₁ -1 B ₂ -1,2	C	dwarf shrub-herb mesic meadows and willow thickets, snowbed tundras	Ni,M	veg. (rhiz.)	herb, p-c,(4)
<i>A. arctica</i> ssp. <i>ehrendorferi</i>	I	A-3;B ₁ -1	C	dry-mesic dwarf shrub-herb meadows, mesic meadow tundras	(Ni),M	seeds +	herb, p-c,(4)
<i>A. globularia</i>	II	A-1,2;B ₂ -2	±C	medium and moist spotty calciphytic and other eutrophic tundras	M,Ca	seeds +	4
<i>Nardosmia frigida</i>	II	A-1,3;B ₁ -1; B ₂ -1,2	C	moist dwarf shrub-herb meadows, willow thickets, flooded mire assoc., shores of ponds	Ni,M	veg. (rhiz.)	herb, p-c,(4)
<i>Arnica frigida</i>	I	A-3;B ₁ -1	C	non-carbonate montane tundras, dry-mesic dwarf shrub-herb meadows	Ni,X/M,(A)	veg. (rhiz.) +seeds	herb, p-c,(4)
<i>A. angustifolia</i> s. lat.	III A	A-3	R!(un)	-----	Ni,M/X	seeds	herb, p-c,(4)
<i>Senecio congestus</i>	III A	A-1;B ₂ -1,2	R	-----	Ni,M/H	seeds	herb, o-c
<i>Taraxacum lateritimum</i>	II	A-1,3;B ₁ -1; B ₂ -1,2	C	dwarf shrub-herb mesic meadows on coastal slopes and spits	Ni,M	seeds	herb, p-c,(4)
<i>T. albescens</i>	I	A-1,3;(B ₂ -1)	±C	dwarf shrub-herb mesic meadows on coastal slopes and spits	Ni?,M	seeds	herb, p-c,(4)

Footnotes: Designations used:

Column 4: C - common, R - rare

Column 6: Ni - nitrophilous; X - xerophyte, M - mesophyte, H - hygrophyte, X/M - xero-mesophyte, etc.;
A - acidophilous, Ca - calciphilous, Hl - halophilous

Column 7: veg. - vegetative, rhiz. - long-rhizomatous plant, vivip. - viviparous, forms bulbils in the region of the inflorescence or in the axils of stem leaves; seeds+ - besides reproduction by seed, also non-intensive vegetative propagation, (mostly short-rhizomatous plants)

Column 8: herb - herbaceous plant, p-c - polycarpic, o-c - oligocarpic, m-c - monocarpic; (1) annual (2) biennial, (+) a few years lifespan, (4) perennial.

AN ANNOTATED LIST OF PLANTS INHABITING SITES OF NATURAL AND ANTHROPOGENIC DISTURBANCES OF TUNDRA COVER IN WESTERN TAIMYR: THE SETTLEMENT OF KRESTY

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The composition and structure of the vegetative cover in disturbed habitats, both natural and anthropogenic, depend on a series of factors. First and foremost is the character of the disturbance, the duration of the action of the factor provoking it and its effect, and hence also the degree of disturbance, the time passed from the moment of cessation of the action of the factor, that is, the duration of the recovery of the vegetative cover, and, finally, the resources of the local flora, which depend on the zonal and provincial position of the area. Thus, during the compilation of a list of species which are most promising for restoration of the vegetative cover in sites of intensive human activity in the Far North, one is compelled to approach each large region individually and to first ascertain which species can exist in such disturbed biotopes.

The present list (Table 1) was compiled for the environs of the settlement of Kresty, which is situated on the right bank of the Pyasina River, approximately 150 km from its source (70° 51' N.; 89° 47' E.). The right, main bank of the Pyasina River is a plain formed by Quaternary deposits of marine and ancient alluvial origin.

In soil texture there are loamy sands, more rarely sandy loams, and sometimes sands. The plain is cut by a small number of streams with shallow valleys. The area is characterized by a combination of low, gently sloping ridges and rounded hills separated by bog- and lake-depressions and drainage channels. The area belongs to the subzone of southern shrub tundras. The predominant plant communities are: dwarf birch-sedge-moss tundras on interfluvies (with the dominant mosses: *Hylocomium splendens* var. *alaskanum*, *Aulacomnium turgidum*, *Ptilidium ciliare*, *Dicranum* spp.; sedges: *Carex ensifolia* ssp. *arctisibirica*; shrubs: *Betula nana*, *Salix pulchra*, *S. lanata*, *S. reptans*); tussock tundra: (*Eriophorum vaginatum*); shrub communities on hills: (*Betula nana*, *Alnaster*

fruticosa, *Salix lanata*); sedge-moss bogs (with dominating *Carex stans*, *C. chondrorhiza*, *Eriophorum angustifolium* and the mosses: *Drepanocladus* spp., *Calliergon* spp., *Meesia triquetra*, *Sphagnum* spp.); and forb-grass meadows on southward draining slopes of the main river bank. The flowering plant flora numbers about 220 species, and in the concrete plant communities from 30 to 50 species are found.

The settlement of Kresty is situated on the high bank of the river immediately above its bluff sloping to the inundated floodplain, the width of which here is about 30-50 meters. The main bank rises above the level of the river by 8-10 m. In the settlement there are about ten houses in small groups (3-5) scattered over a distance of 1 km along the edge of the bluff; the bank is dissected by a few narrow valleys. The oldest buildings date from about 30 years ago; the rest were built 5-10 years ago. About 20 people live permanently in the settlement and work at the meteorological station and the State Enterprise "Taimyr"; the basic occupation is hunting and fishing. During summer the population of the settlement rises to 40 to 50 persons (expeditions, hunters arriving to shoot wild reindeer, etc.).

The basic kinds of disturbances of the natural vegetative cover in the area of the settlement are the following:

A. Disturbances caused by natural agents: 1. Different types of erosion and solifluction; 2. Formation of zoogenic mesic meadows in sites of rodent burrows (mainly lemmings) and feeding places of birds of prey (owls and jaegers); 3. Dislodging of the turf in places where many reindeer pass.

B. Disturbances caused by anthropogenic influence: 1. Areas in the immediate vicinity of construction subjected to the influence of tracked vehicles, to trampling, to the spilling of fuel-oil, to the dumping of coal and food scraps, and to scorching; 2. Old burial sites; 3. Places where polar foxes are trapped. Of those enumerated in this report, only cover disturbances connected with points A-1 and B-1 will be considered.

Processes of erosion (by water and snow) and solifluction lead to the formation of landslips and screens on slopes of different exposure as a result of which closed vegetation cover is destroyed, and bare ground is exposed. Such sites offer a fine natural model of successional changes from pioneer groupings to a restored cover. Anthropogenic activity is often analogous to such processes: it leads to the destruction of the original cover and the exposure of the ground. By observing the course of changes in naturally disturbed habitats which are usually found in any one area at various stages of recovery, it is possible to predict ways for restoration of cover on anthropogenic biotopes.

Screens and landslips are found in our study area in conditions of contrasting temperature regimes: on north-facing slopes of narrow valleys, with long-lying snow, excess moisture during the entire summer, and poor soil warmth, and on south-facing slopes on the main bank of the Pyasina with fast-melting snow that are well-drained and very warm.

At first, the restoration of the vegetative cover proceeds slowly and often the pioneer condition is maintained for an indeterminately long time. Forty-seven species are found in such disturbed biotopes. A portion of these species is related only or primarily to narrow valleys, often to snowbed groupings: *Ranunculus sulphureus*, *R. nivalis*, *R. pygmaeus*, *Saxifraga hieracifolia*, *S. nivalis*, *S. cernua*, *Phippsia algida*, *Oxyria digyna*, *Salix polaris*, or are species characteristic of bare ground: *Arabis septentrionalis* and *Juncus biglumis*. The rest are found in other biotopes but in the overwhelming majority in intra-zonal groupings. Species typical of zonal communities are practically absent here. The successions come to an end with the formation of groupings of scattered nival forbs, mosses (*Drepanocladus uncinatus*), lichens (*Stereocaulon alpinum*), and prostrate shrubs (*Salix polaris*).

On screes on the main bank of the river, restoration of cover goes on at faster rates and ends with the formation of forb-grass groupings of the meadow type with a closed cover of *Festuca cryophila*, *F. brachyphylla*, *F. vivipara*, *Poa arctica*, *Koeleria asiatica*, *Astragalus subpolaris*, *Hedysarum arcticum*, *Campanula langsdorffiana*, *Dianthus repens*, *Valeriana capitata*, *Pedicularis verticillata*, and *Myosotis asiatica*.

Sixty-nine species are characteristic for screes at early and middle stages of succession. These are basically species of mesophytic forbs found only or primarily in intra-zonal groupings on warm, well-drained slopes. Species typical for zonal communities are: *Dryas punctata*, *Salix lanata*, *Betula nana*, and *Salix nummularia*.

In the area of the settlement the vegetative cover was intensely destroyed at the time of construction, principally by tracked vehicles, particularly tractors. In the recently built up part of the settlement (5 years old) where the turf has been destroyed, during spring, and also during the summer when it rains, the area turns into mudholes with small patches of temporarily isolated vegetation. In the old part of the settlement (from 10 to about 40 years old), there are almost no sections with turf stripped off; the vegetation cover is completely recovered, but it has nothing in common with the original. Under natural conditions in similar habitats in the area, shrub-sedge-moss tundras are developed with spots of bare ground with a well developed (80% cover, 5-10 cm thick) moss cover (*Hylocomium splendens* var. *alaskanum*, *Aulacomnium turgidum*, *Ptilidium ciliare*), and a herbaceous layer of *Carex ensifolia* ssp. *arctisibirica* and isolated representatives of forbs and a low shrub layer of *Betula nana* and *Salix reptans*.

Under anthropogenic influence, meadow type forb-grass groupings are formed. The moss cover is completely absent or mosses are extremely suppressed and do not form a turf; grasses and forbs form a tall (40-50 cm), closed sward (60-80% cover). Enumerated below (in order of importance) are the species that play the most active part in the composition of the restored vegetative cover:

1. *Deschampsia sukatschewii* - 45 cm tall, forms dense stands (60-80% cover) with many generative shoots.
2. *Arctagrostis arundinacea* - grows almost as flowerbeds, 50 cm tall, with many generative shoots.
3. *Poa alpigena* - makes a good admixture in the grass sward, sometimes forming pure stands, 40 cm tall, with many generative shoots.
4. *Poa arctica* - abundant, but does not form dense swards, 30 cm tall, fruiting.
5. *Calamagrostis holmii* - vegetative shoots form a very dense, low sward, vegetative shoots 10 cm tall, generative shoots, very numerous, 30 cm tall.
7. *Eriophorum scheuchzeri* - forms thin stands in the cottongrass sward, 30 cm tall, well fruiting.
8. *Tripleurospermum phaeocephalum* - found as a constant admixture to the grasses, sometimes forming pure stands, 30 cm tall, actively flowering and fruiting.
9. *Artemisia tilesii* - forms small compact stands, 55-60 cm tall, actively flowering and fruiting.
10. *Pedicularis verticillata* - forms a uniform low layer in grass swards; 15 cm tall, abundantly flowering and fruiting.
11. *Astragalus subpolaris* - also forms a dense, low layer, 10 cm tall, actively flowering and fruiting.
12. *Polygonum viviparum* - a constant admixture in low layers, sometimes forming stands together with horsetail; 10 cm tall.
13. *Salix lanata* - forms pure, but small, low thickets, 25-30 cm tall; fruiting.
14. *Salix nummularia* - forms a ground layer in dense grass swards; fruiting.
15. *S. pulchra* - forms a low, dense layer, 20 cm tall, fruiting.
16. *Carex stans* - grows actively in moist sites, 40 cm tall, fruiting.

Of the remaining species, the most abundant are: *Descurainia sophioides*, *Polygonum bistorta*, *Myosotis asiatica*, *Cerastium bialynyckii*, *Stellaria crassifolia*, and *Valeriana capitata*.

All these species grow very well, have a large vegetative mass, a large quantity of generative shoots, and flower and fruit abundantly. Against a background of a dense and, during flowering, also colorful sward of forbs and grasses, lifeless spots remain at the site of former coal piles or fuel-oil spills. The first individual colonizers on such sites are: *Gastrolychnis affinis*, *Silene paucifolia*, *Sagina nodosa*, *Polygonum viviparum*, *Papaver polare*, and *Equisetum arvense*.

A comparison of the species composition in sites subjected to the action of an anthropogenic factor with the flora of the area and also with the floristic composition of habitats on which the cover has been disturbed by natural agents, shows that the basic providers of turf-forming plants are not species from the original groupings, and, in general, not species of zonal tundra communities, but are forb-grass groupings from the south-facing slopes of the main

bank of Pyasina River. A reason for this, in our opinion, is that after the stripping off of the turf, especially the mosses, the water and temperature regime improves in the surface horizons of the soil so that it approaches that on south-facing drained slopes; excess moisture disappears, the temperature rises, and aeration improves. All this promotes seed regeneration and vegetative growth of grasses and forbs. The immediate proximity of a seed source also has a positive effect; the settlement is situated directly above the bluffs of this south-facing slope.

Once they have appeared, such meadow groupings can be very long-lived and can successfully withstand the competition with zonal tundra communities. At a considerable distance from the settlement, where there are the foundations of old buildings, abandoned for more than 20 years, the meadow type of the sward is preserved and signs of the reverse process to tundra are not seen.

An analysis of the composition and structure of the meadow communities of south-facing slopes and within the area of the settlement shows that in naturally disturbed biotopes, the floristic composition is richer (76 species) and the distribution of species more uniform; in anthropogenically disturbed habitats the composition becomes poorer (27 species), but the individual species grow vigorously. This is especially noticeable on the slopes in the immediate vicinity of the settlement where food garbage dumps are established: the vegetation is composed of almost pure clumps of such species as *Artemisia tilesii*, *Chamaenerium angustifolium*, *Pedicularis verticillata*, *Pyrethrum bipinnatum*, *Equisetum arvense*, and *Taraxacum* spp.

GENERAL SUMMARY

1. The floristic component of both naturally disturbed habitats numbers 89 species which consist of 41% of the flora of the area. There are no introduced species. Among the dominants are species of intrazonal groupings. Representatives of zonal communities are rare and not very abundant.

2. In anthropogenic sites, restoration of disturbed cover leads to the formation of meadow groupings. The process of meadow-formation characteristic for sites subjected to short-term mechanical influence (stripping off of the turf), may on the whole, be evaluated as positive, since the restored cover is fairly stable and more productive than the zonal communities. A destructive effect is caused by fuel-oil which leads to complete degradation of the vegetation.

3. The basic ecological groups of plants taking part in the revegetation of disturbed biotopes are those preferring erosion and solifluction habitats and, in anthropogenic sites, nitrophiles.

4. The resources of the local flora are sufficiently rich for restoration of the vegetation by natural means. From the list of 27 species found in sites of anthropogenic influence, the following can be recommended for artificial rehabilitation: *Deschampsia sukatschewii*, *Arctagrostis arundinacea*, *Calamagrostis holmii*, *Poa alpigena*, *Tripleurospermum phaeocephalum*, *Artemisia tilesii*, *Pedicularis verticillata*, *Astragalus subpolaris*, *Chamaenerium angustifolium*, *Descurainia sophioides*, and *Pyrethrum bipinnatum*. These species propagate well either by vegetative or generative means or by both, furnish a large green mass, and some of them present a colorful appearance during flowering.

Following is a list of species, noted by us in sites with disturbed vegetative cover (Table 1). The species have been sorted into three conditional groups according to site affinity:

- I. Species found in disturbed habitats but most common in other biotopes.
- II. Species preferring disturbed habitats, but also found in other habitats.
- III. Species found primarily in disturbed habitats, growing vigorously and furnishing a large green mass; in other biotopes rare and solitary.

The occurrence and abundance of the species is evaluated according to a three-part scale: + rare and solitary; ++ frequent but solitary, or rare but in patches; +++ frequent and abundant.

Table 1. List of plants inhabiting sites of natural or anthropogenic disturbances of tundra cover in the environs of the Kresty settlement. (see p. 23 for definitions of symbols).

Plant species	Site Affinity of species	Naturally Disturbed Biotopes		Anthropogenically disturbed sites in the settlement
		Landslips on N-facing slopes of stream valleys	Screes on S-facing slopes on the main bank of Pyasina River	
A	B	C	D	E
1. <i>Equisetum arvense</i>	I	+	++	+++
2. <i>Arctagrostis arundinacea</i>	II	+	+	+++
3. <i>A. latifolia</i>	I		++	
4. <i>Calamagrostis holmii</i>	I		+	+++
5. <i>Deschampsia sukatschewii</i>	III			+++
6. <i>Trisetum spicatum</i>	I	++	++	
7. <i>Koeleria asiatica</i>	I		++	
8. <i>Poa arctica</i>	I	++	++	+++
9. <i>P. alpigena</i>	I	+		+++
10. <i>P. glauca</i>	I	+		
11. <i>P. alpina</i>	II	++	+	
12. <i>Phippsia algida</i>	I	+		
13. <i>Festuca cryophila</i>	II	++	+++	

	A	B	C	D	E
14.	<i>F. brachyphylla</i>	I	+	++	
15.	<i>Eriophorum scheuchzeri</i>	I			+++
16.	<i>Carex stans</i>	I			+++
17.	<i>C. ensifolia ssp. arctisibirica</i>	I		+	
18.	<i>Juncus biglumis</i>	I	+		
19.	<i>J. castaneus</i>	I		+	
20.	<i>Luçula nivalis</i>	I	+		
21.	<i>L. confusa</i>	I	+	+	
22.	<i>Tofieldia coccinea</i>	I		+	
23.	<i>Salix polaris</i>	I	+		
24.	<i>S. nummularia</i>	I		++	+++
25.	<i>S. reptans</i>	I		+	
26.	<i>S. pulchra</i>	I			+++
27.	<i>S. lanata</i>	I		+	+++
28.	<i>Betula nana</i>	I	+	+	
29.	<i>Oxyria digyna</i>	I	++	+	
30.	<i>Polygonum laxmanii</i>	I		+	

A	B	C	D	E
31. <i>P. tetraparum</i>	I	+	++	+++
32. <i>P. bistorta</i>	I		+	++
33. <i>Stellaria ciliatosepala</i>	I	+	+	
34. <i>S. crassifolia</i>	III			++
35. <i>Cerastium maximum</i>	I	+	++	
36. <i>C. bialynickii</i>	I		+	++
37. <i>C. jensejense</i>	I	+	+	
38. <i>Sagina nodosa</i>	III			+
39. <i>Minuartia tubella</i>	I		+	
40. <i>M. aretiæ</i>	I		+	
41. <i>Arenaria stenophylla</i>	I		++	
42. <i>Silene paucifolia</i>	II	+	+	+
43. <i>Gastrololobus affinis</i>	I	++	+	+
44. <i>Dianthus repens</i>	II	++		
45. <i>Ranunculus pygmaeus</i>	II	+		
46. <i>R. nivialis</i>	I	+		
47. <i>R. sulphureus</i>	I	+		

A	B	C	D	E
48. <i>R. borealis</i>	I	+	+	
49. <i>Papaver lapponicum</i>	II	++	+	++
50. <i>Descurainia sophioides</i>	III			++
51. <i>Arabis septentrionalis</i>	III	++	++	
52. <i>Parrya nudicaulis</i>	I	+	+	
53. <i>Draba hirta</i>	II	+	+	
54. <i>D. pilosa</i>	I		+	
55. <i>Saxifraga punctata</i>	I	++	+	
56. <i>S. nivalis</i>	I	+		
57. <i>S. hieracifolia</i>	I	+	+	
58. <i>S. hirculus</i>	I		+	
59. <i>S. cernua</i>	II	+	+	
60. <i>S. spinulosa</i>	I	+	+	
61. <i>S. hyperborea</i>	III	+		
62. <i>Potentilla stipularis</i>	I	+	+	
63. <i>Dryas punctata</i>	I	+	++	
64. <i>Astragalus subpolaris</i>	II		+++	++

A	B	C	D	E
65. <i>A. frigidus</i>	II		+	
66. <i>Hedysarum arcticum</i>	II	+		
67. <i>Oxytropis arctica</i>	I		+	
68. <i>Chamaenerium angustifolium</i>	III			+++
69. <i>Pachypleurum alpinum</i>	II	+	++	
70. <i>Vaccinium uliginosum</i>	I	+	+	
71. <i>Androsace septentrionalis</i>	III		+	
72. <i>Ameria arctica</i>	III		+	
73. <i>Polemonium boreale</i>	II		++	
74. <i>Myosotis asiatica</i>	II	++	++	++
75. <i>Thymus serpyllum</i>	II		++	
76. <i>Lagotis minor</i>	I	+	+	
77. <i>Pedicularis verticillata</i>	III		+++	+++
78. <i>P. capitata</i>	I		+	
79. <i>Valeriana capitata</i>	I	++	+	++
80. <i>Campanula langsdorffiana</i>	II		++	
81. <i>Erigeron ericephalus</i>	III	+	+	

A	B	C	D	E
82. <i>Antennaria viliifera</i>	III	+		
83. <i>Tripletospermum phaeocephalum</i>	III	+	+	+++
84. <i>Pyrethrum bipinnatum</i>	III	.	.	
85. <i>Artemisia tilesii</i>	III	++	++	+++
86. <i>A. borealis</i>	I		++	
87. <i>Nardosmia gmelinii</i>	I		+	
88. <i>Arnica iljinii</i>	II	.	+	
89. <i>Taraxacum</i> spp.	II	+	++	

A STUDY OF PLANT COMMUNITIES OF ANTHROPOGENIC HABITATS IN THE AREA OF THE VORKUTA INDUSTRIAL CENTER

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During current studies of man's influence on tundra ecosystems, much attention is given to a complete elucidation of plant species which colonize sites of disturbance of tundra vegetation cover. This work is being conducted in the Soviet Union and in Alaska in accordance with one of the objectives, "Biological indicators of changes in the natural environment caused by natural and anthropogenic factors," in Project 02.05.2101 of the Soviet-American agreement in the area of environmental protection. As part of a solution to this problem, great emphasis is placed on an analysis of those plant species of secondary communities which have developed in different anthropogenic habitats.

In order to understand the plant-indicators of disturbed sites, it is necessary to divide them into two groups: 1) native tundra species (apophytes), remaining for a long time on disturbed sites, and 2) pioneer species which are lacking in the undisturbed tundra and have colonized only localities disturbed by man.

The study of plant-indicators for the present takes on a regional character in view of the fact that, within the limits of the extensive ranges of the tundra species, their ecological (indirect) relations change with environmental factors, the composition of competitors differs, and the phytocoenotic role of the various plant species varies. In different areas of the tundra zone, different species may prove to be indicators of the same disturbance in tundra ecosystems. At present, such investigations can be conducted only in the limited areas where tundra is being exploited intensively.

The Central Laboratory for the Protection of Nature of the Ministry of Agriculture of the U.S.S.R. is conducting a study of man's impact on tundra ecosystems in the area of the Vorkuta Industrial Center. In the summer of 1976, during a period of work as members of the Vorkuta Expedition of the Central Laboratory, we conducted a study of secondary communities in order

to determine the plant species colonizing anthropogenic habitats in this sector of the tundra zone (the "anthropophilic flora" of Dorogostaiskaya 1972) and made a subsequent analysis of the ecological and phytocoenotic relationships of these species.

The Vorkuta Industrial Center is situated in the northeast European part of the U.S.S.R. and in the southeastern part of the Bolshezemelskaya ("Large Land") tundra (67° 27' N.; 64° 28' E.), which corresponds to the southernmost subdivision of the shrub tundra subzone with a taller dwarf birch layer (Rebristaya 1971; Gribova 1977).

The climate of this region is characterized by a temperate to cold winter, a cool, short summer (mean July temperature +12.7°C) and a considerable amount of annual precipitation (500 mm) in comparison with other parts of the Arctic. Here, the permafrost is nearly continuous and varies widely in depth, temperature, etc. Mantle loams are widely distributed. Tundra surficial gley soils predominate.

A list of the concrete flora of the area of the city of Vorkuta (283 species) has been compiled by Rebristaya (1970), who characterized this flora as an allochthonous, cis-Ural - European one. According to sectorial division of the Arctic floristic area (Yurtsev *et al.* 1976) this area belongs to the Ural-Novaya Zemlya subprovince of the European - Western Siberian province.

The predominating zonal vegetation is dwarf-birch and willow-dwarf-birch-lichen-moss and moss tundras. Other types of tundra are also found (dwarf shrub tundra, forb-open willow, sedge-forb-herb-moss tundras, and so on). Broadly distributed are willow thickets, mesic meadow communities, mires, and also sites with sparse vegetation (on precipices, scree, fresh alluvia, and others).

This area of the Bolshezemelskaya tundra has long served as a pathway for reindeer herds and also as a site for pastures during the migratory seasons (spring and fall) and for temporary camps of the reindeer herders. Since the 1930s, the area has been intensively developed by man in connection with the opening up of rich coal deposits in the Vorkuta river valley. At present, Vorkuta is a major city in the Arctic, comprising a chain of mining settlements. Here are combined the development of industry (first and foremost of coal extraction) construction, transportation, and agriculture.

The prolonged influence of man has substantially changed the appearance of the Vorkuta tundra. The anthropogenic habitats of the tundra zone in the area of the Vorkuta Industrial Center have been classified in the following manner:

A. Anthropogenic habitats created as a direct result of anthropogenic factors:

- A₁ Principally new habitats, not previously existing in nature:
 - 1. mining heaps;
 - 2. embankments (of highways and railroads, and others).

A2 Transformed natural habitats:

1. fields in water-sheds and river valleys having replaced the destroyed native vegetation;
2. secondary meadows and pastures in river valleys (with partial land reclamation);
3. inhabited and deserted settlements and their immediate surroundings;
4. old boreholes and their surroundings;
5. cross-country tractor roads and tracks of different ages and intensity of use.

B. Anthropogenic habitats formed as a result of indirect influence of anthropogenic factors which increased activity of natural processes:

1. erosion complexes;
2. burned sites;
3. "downfalls";
4. thermokarst sinkholes.

During the study of anthropogenic disturbances and changes of the tundra vegetation cover in the area of the Vorkuta Industrial Center we took into consideration, on one hand, all disturbed plant associations, irrespective of degree and direction of their transformation by man (native plant communities only partly disturbed by man, secondary communities developing on the sites of destroyed native ones, and agrophytocoenoses). On the other hand, not all the variety of existing types of human disturbances of the vegetation cover within the area of the city of Vorkuta was included; basically, only those habitats were included where the natural, native vegetation had been subjected to important mechanical influence (by transportation, livestock, etc.). Accordingly our classification of the anthropogenic habitats is presented as a "draft" and the list of the plants colonizing these habitats is preliminary.

In order to conduct a sound analysis of those plant species colonizing the anthropogenic habitats enumerated above, ecological and geographical characteristics are given for each species. For every species is indicated:

1. types of disturbances of vegetation cover where the given plant species was noted, information on the vitality and abundance of the species in various types of habitat;
2. whether a native or introduced species;
3. character of distribution of the species in the area investigated (common or rare), its most characteristic natural ecotopes, and some ecological features;
4. the predominating modes of dispersal and reproduction;
5. the growth form.

For the characterization of the species, in addition to our own observations, the following literature sources were used: "Flora Arctica U.S.S.R." (1960-1971), "Manual of the higher plants of Komi A.S.S.R." (1962), papers by

O.V. Rebristaya (1970, 1971), E.V. Dorogostaiskaya (1963, 1972), I.S. Khamtiner (1974), and others.

An evaluation of the response of the plants in the Vorkuta tundra to the change in habitat conditions under the influence of man and particularly of the development of the species under the changing conditions was made according to a scale proposed by B.A. Yurtsev and A.A. Korobkov (this publication).

- 0 - Species remaining from the time preceding the disturbance, less abundant and suppressed in the disturbed habitats;
- I - species normally occurring in disturbed sites but not preferring them;
- II - species preferring disturbed sites, more abundant and/or profuse and vegetatively luxuriant in them, but fairly common also in sites with an undisturbed cover;
- III - species predominately found in disturbed sites; and
- IV - species exclusively found in disturbed sites.

Our investigations, supplemented by data from the literature, revealed 125 native species and more than 90 introduced species forming various secondary associations in anthropogenic habitats within the area of the Vorkuta Industrial Center. On the basis of characteristics given for each species, an annotated list of the plants in disturbed habitats was compiled, including 144 species (Table 1). In the list were entered all the native species observed in anthropogenic habitats and also a portion of the inadvertently introduced species (naturalized and broadly distributed).

Analysis of the material in the list, the treatment of the herbarium material, and a comparison of the entire flora in the area investigated and its anthropophilic part allowed us to draw the following conclusions:

The anthropophilic flora of the area studied is heterogeneous and includes species of local provenance as well as species introduced by man.

The inadvertent introduction by man of plants into the area of the Vorkuta tundras from more southern areas proceeds constantly together with seeds of forage grasses introduced for cultivation and with the bringing in of hay. An intensive process of selection and naturalization of the plant species brought in by man is still going on. Already there exists an entire group of naturalized introduced species which are quite widely distributed in some types of anthropogenic habitats: agricultural land, area of settlements, abandoned roads, and gullies (Table 1).

A group of native plants (apophytes) which is quite complex and specific in composition constitutes 42% of the concrete flora.

Herbaceous perennials are the predominant life form. The majority of the species colonizing disturbed habitats have a vigorous capacity for reproduction by seed or vegetative means.

An analysis of the ecological features of the anthropophilic flora of local provenance shows that in the area studied, as also in other areas of the Far

North, the basic ecological groups "providing" species for disturbed habitats are:

1. nitrophilous species of the North (*Ranunculus hyperboreus*, *R. repens*, *R. reptans*, *Puccinellia hauptiana*, *Stellaria crassifolia*);
2. plants of crumbly, well aerated but nutrient poor and poorly vegetated substrates (*Equisetum arvense*, *Festuca ovina*, *Poa alpina*, *P. alpigena*, *Rorippa palustris*, *Descurainia sophia*, *Erysimum cheiranthoides*, *Chamaenerium angustifolium*, *Ch. latifolium*, *Gastrolychnis angustiflora*, *Cerastium* spp., *Tripleurospermum phaeocephalum*, *Artemisia tilesii*, *Crepis multicaulis*, *Tanacetum bipinnatum*);
3. plants related to various natural disturbances of the integrity of the tundra cover, caused by cryogenics, solifluction, and land slipping processes: spots of bare ground, frost cracks, etc. (*Sagina intermedia*, *Koenigia islandica*, *Saxifraga cernua*, *Juncus biglumis*, *J. castaneus*);
4. species growing around snowbeds (*Carex tripartita*, *Ranunculus pygmaeus*, *R. borealis*, *Polygonum viviparum*, *Sibbaldia procumbens*, *Veronica alpina*, *Hieracium alpinum*, *Gnaphalium supinum*);
5. hydrophilous species, confined in natural conditions to various types of wet ecotopes:
 - a. species related to the banks of temporary or permanent water courses (*Nardosmia frigida*, *Myosotis palustris*, *Polemonium acutiflora*, *Juncus filiformis*);
 - b. plants of well irrigated sites, banks of rivers and lakes, bog pools (*Arctophila fulva*, *Poa palustris*, *Carex aquatilis*, *C. stans*, *Eriophorum scheuchzeri*, *E. angustifolium*, *Caltha palustris*, *Chrysosplenium alternifolium*, *Stellaria palustris*, *Epilobium palustre*, *Equisetum palustris*).

An analysis of the phytocoenotic relations of the plant species of the local flora which colonize anthropogenic habitats shows that the largest part is played by species which belong to intrazonal mesic meadow communities and plant groupings of scree, precipices, rubble slopes, etc., but also species which are characteristic of willow thickets.

The species composition of plant communities on disturbed sites of zonal tundras is formed both by "immigrant species" coming from the above enumerated habitats, and also by "local species" arriving from surrounding, undisturbed tundra communities.

It is interesting that among the apophytes, the predominant boreal species are those which, owing to the change in ecological and phytocoenotic conditions, obtain a wider distribution in the anthropogenic habitats of the area studied than in the natural habitats.

Practically all the ecological plant groups enumerated above play a part in revegetation of anthropogenic habitats characterized by very mixed ecological conditions (for instance, areas of human settlements) or by considerable extent

(cross-country tractor trails crossing various ecotopes). In concrete conditions, one or another group of plants predominates.

Taking part in the revegetation of habitats that are fundamentally new to the plants and not previously existing in nature (mining heaps, embankments) are species of one specific group of plants which are associated in their natural conditions with friable or stony, weakly turf-forming, relatively oligotrophic, but well aerated and well drained substrates.

An evaluation of the reaction of the plants of the Vorkuta tundra to human influence as well as the investigation of the features of the development of the species in conditions changed by man (according to the scale, mentioned above) show that:

- a. The majority of the plants colonizing sites of disturbance still appear as facultative apophytes and are fairly widely and abundantly found in undisturbed habitats (75 species belong to category I, 33 species to II, and to III and IV, 7 and 19 species, respectively);
- b. a whole group of plants is distinguished as almost obligately apophytes preferring disturbed habitats. In this group are represented, first, species widely distributed in disturbed habitats of various regions in the Far North (*Artemisia tilesii*, *Senecio arcticus*); and second, species observed in anthropogenic habitats only in tundras of the European northeast, the Polar Ural and adjacent plain of the left bank of Ob River (Vital 1975, our own personal observations), such as *Festuca ovina*, *Agrostis borealis*, *Juncus biglumis*, and others.

From a number of obligate apophytes some plants may be recommended for land reclamation (by sowing): *Festuca ovina*, *Poa pratensis*, *Poa alpigena*, *Calamagrostis lapponica*, *Agrostis borealis*, *Eriophorum scheuchzeri*, *Rubus chamaemorus*.

Prolonged and intensive human influence has caused the wide development of secondary plant communities in the area of the Vorkuta Industrial Center. These communities develop on the site of destroyed native habitats and occupy various anthropogenic habitats. The investigation of the disturbed communities in the environs of Vorkuta allows us to distinguish several stages in the revegetation of these habitats. Thus, the formation of secondary plant communities along roads is an extremely protracted process. For a long time there are open groupings (aggregations) of plants developing into a closed vegetation dominated by grasses (*Poa pratensis*, *P. alpigena*, *Festuca ovina*, *Agrostis borealis*, *Calamagrostis lapponica*, *Alopecurus pratensis*) or cottongrass (*Eriophorum scheuchzeri*). The stability of the secondary communities varies and greatly depends on the appearance and establishment of shrubs (i.e. the representatives of the life form dominating the zonal vegetation. The least stable are wood-reed [*Calamagrostis*] stands in which, at comparatively early stages of vegetation, appear a young growth of willows and dwarf birch (*Salix glauca*, *S. phylicifolia*, *S. lanata*, *Betula nana*), which very quickly develop into

willow-grass-moss communities. The process of restoration of original plant communities is a long one; for the recreation of only one shrub layer, several decades are required. In the restored shrub layer of secondary communities, dominance passes from dwarf birch to willows.

The most stable are the meadow grass [*Poa*] and cottongrass [*Eriophorum*] communities which are persistent secondary communities, having developed where the transformation of the native conditions under the influence of man is so great that the restoration of the original communities is impossible or appears as a matter for the more distant future (the age of the majority of the disturbances does not exceed 20-25 years).

In the future, various secondary communities (grass, cottongrass, willow-grass-moss) will attain a still greater distribution in the Vorkuta area, therefore a more detailed study of their composition, structure, dynamics, and productivity is necessary.

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Table 1. Annotated list of plants inhabiting sites of anthropogenic disturbances of vegetation cover in the area of the Vorkuta Industrial Center

Species	Estimate of abundance and vigor of the species in anthropogenic habitats (see page 33)	Types of anthropogenic habitats where species was observed (see pages 31-32)	Introduced (intr) or native (abor)	Common (C) or Rare (R)	Characteristic undisturbed ecotopes in the area studied ¹⁾	Some ecologic features ²⁾	Basic mode of reproduction ²⁾	Growth form ²⁾
1	2	3	4	5	6	7	8	9
1. <i>Equisetum arvense</i> ssp. <i>boreale</i> (Boing.) Rupr.	II	A ₁₋₂ ; A _{2-1,2} , 3,4,5; B-1,2	abor	C	Tundra, tundra mesic herb meadows, groupings on alluvia, wet banks of rivers and lakes	M	veg, rhiz	herb per
2. <i>E. palustre</i> L.	II	A ₂₋₅	abor	C	Moist willow thickets, sedge bogs, on bottom of hollows	M	veg, rhiz	herb per
3. <i>E. sylvaticum</i> L.	I	A ₂₋₅	abor	R	Gentle slopes among willow thickets	M	veg	herb per
4. <i>Alopecurus aequalis</i> Sobol.	II	A _{2-1,3,5} ; B-1	abor	R	On peaty hummocks	M	seeds	herb ann
5. <i>A. pratensis</i> var. <i>alpestris</i> (Wahl.) Seland.	II	A _{2-1,2,3,5} ; B-1	abor	C	Shrub tundra, forb alongshore slopes	M	seeds & veg short rhiz	herb per

1	2	3	4	5	6	7	8	9
6. <i>Agrostis borealis</i> Hartm.	II	A ₂ -3,5; B-1	abor	C	Dwarf birch moss tundras, willow thickets	M	seeds & veg short rhiz	herb per
7. <i>A. gigantea</i> Roth.	I	A ₂ -3	abor	R	River valleys, meadows	M	veg, rhiz with shoots	herb per
8. <i>Arctophila fulva</i> (Trin.) Anderss.	I	A ₂ -1,3,5; B-1	abor	C	Banks of shallow rivers, oxbow lakes, tundra lakes, pools in polygonal bogs	H	veg, long rhiz	herb per
9. <i>Calamagrostis langsdorffii</i> (Link) Trin.	I	A ₂ -1,4; B-1	abor	C	Dwarf birch and willow-dwarf birch tundras, willow thickets, forb slopes, rocky outcrops	M	veg, rhiz	herb per
10. <i>C. lapponica</i> (Wahl.) Hartm.	II	A ₂ -1,3,5	abor	C	Dwarf birch, dwarf birch-willow thickets, dryas-low shrub tundras, riverine deposits	M	veg, rhiz	herb per
11. <i>C. neglecta</i> (Ehrh.) Gaertn.	I	A ₂ -3,5; B-2	abor	C	Boggy tundras	M/H	veg, rhiz	herb per
12. <i>Deschampsia borealis</i> (Trautv.) Roshev.	I	A ₂ -1,3,5	abor	C	Mesic herb meadows, dry tundras	M	seeds & veg	herb per
13. <i>D. caespitosa</i> (L.) Beauv.	IV	A ₂ -1,3,5; B-1	intr	R	-----	M/H	seeds	herb per
14. <i>D. glauca</i> Hartm.	II	A ₂ -5	abor	C	Banks of rivers and streams, sandy deposits, steep slopes	H	seeds, veg	herb per
15. <i>Elytrigia repens</i> (L.) Nevski	IV	A ₂ -1,3	intr	R	-----	M	veg	herb per

1	2	3	4	5	6	7	8	9
16. <i>Festuca ovina</i> L.	II	A ₂ -1,2,3,5	abor	C	Dwarf birch and willow tundras, spotty dwarf shrub tundras, mesic herb meadows, sandy hillocks, riverine bars	M	veg, dense clumps	herb per
17. <i>F. pratensis</i> Huds.	IV	A ₂ -3	intr	R	-----	M	seeds	herb per
18. <i>F. rubra</i> L.	I	A ₂ -2	abor	C	Riverine deposits, gravels, shrub and spotty tundras, alongshore slopes	M	veg, rhiz	herb per
19. <i>Poa alpigena</i> (Blytt) Lindm.	I	A ₂ -3,5; B-1	abor	C	Dwarf birch thickets, willow thickets, sedge bogs, valley groupings, forb meadow slopes	H/M	veg, rhiz	herb per
20. <i>P. alpina</i> L.	II	A ₁ -2; A ₂ -3,5; B-1	abor	C	Weakly vegetated slopes, sandy riverine deposits, slopes of ravines	M	seeds	herb per
21. <i>Poa annua</i> L.	IV	A ₂ -1,3,5; B-1	intr	C	-----	M	seeds	herb ann, bi
22. <i>P. arctica</i> R. Br.	II	A ₂ -1,3,5; B-2	abor	C	Shrub, dwarf shrub, and sedge-moss tundras, lowlying bogs	M/H	veg, rhiz	herb per
23. <i>P. palustris</i> L.	I	A ₂ -1,3	abor	C	Banks of rivers and streams, willow thickets	M/H	veg	herb per
24. <i>P. pratensis</i> L.	II	A ₂ -1,3; A ₂ -1,2,3,5; B-1	abor	C	Valley aggregations, meadow slopes, sandbanks, boggy lowlands	H/M	seeds & veg	herb per

1	2	3	4	5	6	7	8	9
25. <i>P. supina</i> Schrad.	IV	A ₂ -5	intr	C	-----	M	seeds	herb per
26. <i>Puccinellia hauptiana</i> Krecz.	IV	A ₂ -1,3	intr	R	-----	H/M	seeds	herb per
27. <i>Roegneria borealis</i> (Turcz.) Nevski	I	A ₂ -3	intr	C	River valleys, willow thickets, forb slopes, sandbanks	M/X	seeds	herb per
28. <i>R. fibrosa</i> (Schrenk.) Nevski	I	A ₂ -3,5	abor	C	Valley aggregations	M	seeds	herb per
29. <i>R. turchanensis</i> (Reverd.) Nevski	I	A ₂ -1,3	abor	R	Along river valleys	M/X	seeds	herb per
30. <i>Trisetum spicatum</i> (L.) Richt.	I	A ₂ -5	abor	C	Stony-rubbly forb slopes, rubble tundras, gravels	X/M	seeds	herb per
31. <i>Eriophorum angustifolium</i> Honck.	I	A ₂ -5	abor	C	Moist grass tundras, sinkholes among shrub tundras, water-filled cracks in flat-hummocky bogs, and bogs with low-center polygons	H	veg, rhiz	herb per
32. <i>E. scheuchzeri</i> Hoppe	II	A ₂ -3,5; B-1	abor	C	Debris cones, around snowbeds, on deposits along banks of streams and rivers	H	veg, rhiz	herb per
33. <i>E. vaginatum</i> L.	I	A ₂ -5; B-1	abor	C	Shrub and dwarf shrub-moss tundra, on peat hummocks	H	seeds	herb per
34. <i>Carex aquatilis</i> Wahl.	I	A ₂ -3,5	abor	C	Along banks of rivers and lakes, in sedge bogs, on bottom of hollows	H	veg, rhiz	herb per

1	2	3	4	5	6	7	8	9
35. <i>C. brunnescens</i> (Pers.) Poir	I	A ₂ -5	abor	C	Shrub-moss tundras, mossy sites at foot of slopes	H/M	seeds	herb per
36. <i>C. caespitosa</i> L.	I	A ₂ -5	abor	C	Moist boggy willow and dwarf birch thickets	H	veg, seeds	herb per
37. <i>C. ensifolia</i> ssp. <i>arctisibirica</i> Yurtsev	0	A ₂ -5; B-2	abor	C	Dry shrub, sedge-moss tundras, and spotty tundra	M	veg, rhiz	herb per
38. <i>C. lapponica</i> O. Lang.	I	A ₂ -5; B-1	abor	R	Sedge sinkholes, in pools	H	veg, short rhiz	herb per
39. <i>C. stans</i> Drej.	I	A ₂ -5; B-1	abor	C	Around tundra lakes, on bottom of hollows	H	veg, rhiz	herb per
40. <i>Carex tripartita</i> All.	I	A ₂ ; B-1	abor	C	Stream banks, snowbed swales, moist sites in shrub tundra	H	veg	herb per
41. <i>C. wiluica</i> Meinsh.	I	A ₂ -5; B-1	abor	C	Moist boggy willow thickets, mesic herb meadows, sand and gravel deposits	H	veg	herb per
42. <i>Juncus biglumis</i> L.	I	A ₂ -5	abor	C	Clayey spots on naked ground in tundras, snowbeds	H	seeds	herb per
43. <i>J. bufonius</i> L.	IV	A ₂ -1,3	intr	R	-----	H	veg	herb per
44. <i>J. castaneus</i> Smith	II	A ₂ -5	abor	C	Bare clayey spots in tundras, moist herb meadows, clayey deposits, landslides	H	veg, rhiz	herb per
45. <i>J. filiformis</i> L.	II	A ₂ -5; B-1	abor	R	Silty riverine deposits, moist mossy patches along streams	H	veg, rhiz	herb per

1	2	3	4	5	6	7	8	9
46. <i>Luzula multiflora</i> ssp. <i>frigida</i> (Buch.) V. Krecz.	II	A ₂ -5; B-1	abor	C	Openings in shrub tundra, mesic herb meadows in willow thickets and on alongshore slopes, in snowbed swales	M	seeds	herb per
47. <i>Veratrum lobelianum</i> Bernh.	I	A ₂ -3,5; B-1	abor	C	Willow stands, mesic herb meadows on alongshore slopes and around snowbeds	M	veg, short rhiz	herb per
48. <i>Salix glauca</i> L.	0	A ₂ -5; B-1	abor	C	Coenosis-former: plakor [upland habitats on which zonal plant formations and soils develop] tundra, moist depressions, flat-hummocky and sedge-moss bogs	M	veg cuttings, seeds	shrub per
49. <i>Salix hastata</i> L.	0	A ₂ -5	abor	C	Shrub tundras, willow stands	M		shrub per
50. <i>S. lanata</i> L.	0	A ₂ 5; B-1	abor	C	Plakor tundra, valleys	M	seeds	shrub per
51. <i>S. phyllicifolia</i> L.	0	A ₂	abor	C	Plakor tundra	M	seeds	shrub per
52. <i>Betula nana</i> L.	0	A ₂ -5	abor	C	Coenosis-former: plakor tundras, peat hummocks in bogs, on sandy substrates	wide ecol. ampl.	seeds & veg	shrub per
53. <i>Cannabis sativa</i> L.	IV	A ₂ -1	intr	R	-----		seeds	herb ann
54. <i>Koenigia islandica</i> L.	II	A ₂ -5; B-1	abor	C	Moss patches along streams, moss carpet in frost-cracks, on peat hummocks	H,M/H	seeds	herb ann

1	2	3	4	5	6	7	8	9
55. <i>Polygonum aviculare</i> L.	IV	A ₂ -1,3,5	intr	C	-----	M	seeds	herb ann
56. <i>P. bistorta</i> L.	I	A ₂ -5	abor	C	Shrub-moss tundras, willow thickets, forb alongshore slopes	H/M	veg	herb per
57. <i>P. humifusum</i> Pall. ex. Ledeb.	IV	A ₂ -3; B-1	intr	C	-----	M	seeds	herb ann
58. <i>P. viviparum</i> L.	I	A ₂ -5	abor	C	Moist shrub tundras, sedge bogs, mesic herb meadows, on alongshore slopes and around snowbeds	M	veg, vivip	herb per
59. <i>Rumex acetosella</i> L.	I	A ₂ -1	abor	C	Sandy alongshore slopes	M	seeds	herb per
60. <i>R. acetosa</i> ssp. <i>lapponicus</i> Hiit.	I	A ₂ -1,3	abor	C	Mesic herb meadows (on alongshore slopes, along streams, among willow thickets, around snowbeds)	M	seeds	herb per
61. <i>R. crispus</i> L.	IV	A ₂ -1,3	intr	C	-----	M	seeds	herb per
62. <i>R. pseudonatronatus</i> (Borb.) Murb.	II	A ₂ -3	abor	R	Moist sites on river banks	H/M	seeds	herb per
63. <i>R. aquaticus</i> ssp. <i>protractus</i> Rech.	II	A ₂ -1,3	abor	C	River banks, sandy deposits	H/M	seeds	herb per
64. <i>Chenopodium album</i> L.	IV	A ₂ -1,2,3	intr	C	-----	M	seeds	herb per

1	2	3	4	5	6	7	8	9
65. <i>Stellaria crassifolia</i> Ehrh.	III	A ₂ -1,3; B-1	abor	C	Moist herb meadows along stream banks, sandbanks	H/M	veg, above-ground shoots	herb per
66. <i>S. humifusa</i> Roth.	I	A ₂ -3	abor	R	Along river banks		veg, above-ground shoots	herb per
67. <i>S. media</i> L.	IV	A ₂ -3,5; B-1	intr	C	-----		veg, above-ground shoots	herb ann, bi
68. <i>S. palustris</i> L.	II	A ₂ -3,5; B-1	abor	C	Moist willow thickets and meadows, lowlying bogs	M/H	seeds	herb per
69. <i>S. peduncularis</i> Bge.	I	A ₂ -1,3; B-2	abor	C	Dwarf birch tundras, willow thickets, peat hummocks, boggy lowlands, gravelly and stony slopes	M	veg, rhiz	herb per
70. <i>Cerastium arvense</i> L.	I	A ₁ -2; A ₂ -3,5	abor	C	Poorly vegetated sandy and sandy-cobbly sites, coarse riverine gravels, alongshore forb slopes	M	veg	herb
71. <i>C. caespitosum</i> Gilib.	II	A ₂ -1,2,3	abor	C	Riverine deposits, alongshore forb slopes	M	seeds, veg	herb ann, bi, per
72. <i>C. dahuricum</i> Fisch.	I	A ₂ -1,3	abor	C	Willow thickets, mesic herb meadows, poorly vegetated slopes	M	veg	herb per
73. <i>C. jenisejense</i> Hult.	II	A ₁ -2; A ₂ -1,3,5	abor	C	Sandy and gravelly riverine deposits, stony and gravelly slopes, willow thickets, moist herb meadows	H/M	veg, above-ground shoots	herb ann, bi, (per)
74. <i>Sagina intermedia</i> Fenzl	I	A ₂ -5; B-1	abor	C	Around snowbeds, riverine outcrops, gravels, bare spots in dwarf birch tundras	M	seeds	herb per

1	2	3	4	5	6	7	8	9
75. <i>S. saginoides</i> (L.) Karst.	I	A ₂₋₃	abor	C	Alongshore slopes, riverine deposits	M	seeds	herb bi (per)
76. <i>Gastrolychnis angustiflora</i> (Rupr.) Tolm. & Kozh.	I	A ₁₋₂	abor	C	Alongshore forb slopes, around snowbeds, dwarf shrub tundras	X/M	seeds	herb per
77. <i>Caltha palustris</i> L.	I	A ₂₋₅	abor	C	Lake shores, sedge bogs	H	veg	herb per
78. <i>Delphinium elatum</i> L.	I	A ₁₋₂ ; A ₂₋₅	abor	C	Willow thickets	M	seeds	herb per
79. <i>Aconitum septentrionale</i> Koelle	I	A ₁₋₂	abor	C	Willow thickets in river valleys	M	seeds	herb per
80. <i>Ranunculus acris</i> L.	III-IV	A ₃₋₃	abor- intr	R	Alongshore slopes near settlements	M	seeds	herb per
81. <i>R. borealis</i> Trautv.	I	A _{2-1,2,3,5}	abor	C	Open shrub tundra, meadow slopes in river valleys, around snowbeds	H/M	seeds	herb per
82. <i>R. hyperboreus</i> Rottb.	II	A _{2-3,5} ; B-1	abor	C	Riverine sandbars, in small pools along streams	H	veg, above-ground shoots	herb per
83. <i>R. pygmaeus</i> Wahl.	I	A ₂₋₅	abor	C	Willow-moss tundra, around snowbeds	M	seeds	herb per
84. <i>R. repens</i> L.	I	A _{2-1,3} ; B-1	abor	C	Riverine deposits, moist willow thickets along rivers, lower part of meadow slopes	M	seeds, veg	herb per

1	2	3	4	5	6	7	8	9
85. <i>R. reptans</i> L.	II	A ₂ -3,5	abor	C	Silty banks of rivers and lakes, moist meadows, dried-up pools	H	veg, above-ground shoots	herb per
86. <i>Arabis alpina</i> L.	I	A ₁ -2	abor	C	In rock clefts, on stony outcrops, on gravelly slopes	X/M	seeds	herb per
87. <i>Barbarea arcuata</i> Reichb.	IV	A ₂ -1,3	intr	R	-----	M	seeds	herb bi
88. <i>B. stricta</i> Andrz.	III-IV	A ₂ -1,3	abor	R	On river banks near settlements	M	seeds	herb ann, bi
89. <i>Capsella bursa-pastoris</i> (L.) Medic	IV	A ₁ -2; A ₂ -1,2,3	intr	R	-----	M	seeds	herb ann, bi
90. <i>Cardamine pratensis</i> L.	I	A ₂ -5	abor	C	Willow thickets, boggy herb meadows, sedge bogs, gravel bars, mossy patches along rivers and streams	H	veg, rhiz	herb per
91. <i>Descurainia sophia</i> (L.) Schur	II	A ₁ -2; A ₂ -1,3	abor	C	Alongshore slopes, slopes of ravines	M/X	seeds	herb ann, bi
92. <i>Erysimum cheiranthoides</i> L.	II	A ₁ -2; A ₂ -3	intr	R	Poorly vegetated sites, embankments, slopes	M/X	seeds	herb ann, bi
93. <i>Rorippa palustris</i> (Leyss.) Bess.	II	A ₁ -1,2; A ₂ -1, 2,3,5;; B-1,2	abor	C	On river banks, on bars of sandy-silty deposits	H	seeds	herb ann, bi
94. <i>Thlaspi arvense</i> L.	IV	A ₂ -2,3	intr	C	-----	M	seeds	herb ann

1	2	3	4	5	6	7	8	9
95. <i>Chrysosplenium alternifolium</i> L.	I	A _{2-3,5}	abor	C	Moist mossy and sedge-moss tundras, moist and boggy willow thickets, sedge bogs, moss patches in river and stream valleys	H	seeds	herb ann, bi
96. <i>Parnassia palustris</i> L.	I	A ₂₋₅	abor	C	Alongshore forb slopes, moist herb meadows along streams, around snowbeds	H	veg, short rhiz .	herb per
97. <i>Saxifraga cernua</i> L.	II	A _{2-3,5}	abor	C	Willow thickets along riverbanks, riverine herb meadows, sedge-moss boggy tundras, bogs around snowbeds	X/M+H	veg, vivip	herb per
98. <i>Alchemilla murbeckiana</i> Bus.	I	A ₁₋₂ ; A _{2-3,5}	abor	R	Forb meadows and willow thickets in river valleys	M	veg	herb per
99. <i>Comarum palustre</i> L.	I	A ₂₋₅	abor	C	Flat-hummocky sedge and cotton-grass bogs	H	veg, woody rhiz	dwarf semishrub per
100. <i>Rubus arcticus</i> L.	I	A ₂₋₅ ; B-1,2	abor	C	Willow thickets, dwarf birch-willow tundra, mesic herb meadows in upper part of ravines	M	veg, rhiz	herb per
101. <i>R. chamaemorus</i> L.	I	A ₂₋₅ ; B-1	abor	C	Dwarf birch and willow tundra, peat hummocks and ridges, flat hummocky and polygonal bogs	M	veg, rhiz	herb per
102. <i>Sibbaldia procumbens</i> L.	I	B-1	abor	C	Snowbed herb meadows, forb meadows in willow thickets, forb-dwarf birch thickets	H/M	veg	herb per

1	2	3	4	5	6	7	8	9
103. <i>Astragalus subpolaris</i> Boiss. & Schischk	I	A ₁ -2; A ₂ -2	abor	C	Forb meadow slopes	M	seeds	herb per
104. <i>Trifolium pratense</i> L.	IV	A ₂ -3	intr	R	-----	M	seeds	herb per
105. <i>T. repens</i> L.	III- IV	A ₂ -2,3,5	abor	R	Meadow slopes, along roads	M	veg, above- ground shoots	herb per
106. <i>Vicia cracca</i> L.	II	A ₂ -1,3	abor	C	Meadows, forb-willow stands	M	veg, rhiz	herb per
107. <i>V. sepium</i> L.	II	A ₂ -1,3,5	abor	C	Mesic herb meadows in valleys, on edges of willow thickets, along river banks	M	veg, below- ground shoots	herb per
108. <i>Geranium albiflorum</i> Ledeb.	I	A ₁ -2; A ₂ -5	abor	C	Forb-willow stands, along water- course depressions, in openings, moist forb meadows	M	veg, rhiz & seeds	herb per
109. <i>Callitriche verna</i> L.	I	A ₂ -3,5	abor	R	Along river banks	H	seeds	herb ann
110. <i>Chamaenerium angustifolium</i> (L.) Scop.	II	A ₁ -1,2; A ₂ -1,5 B-1,2	abor	C	Alongshore slopes, sandy hummocks, dwarf birch tundra	M	veg, root suckers	herb per
111. <i>Ch. latifolium</i> (L.) Th. Fries & Lange	I	A ₁ -2; A ₂ -2	abor	C	River banks, especially on gravels	X/M	veg, root suckers	herb per

1	2	3	4	5	6	7	8	9
112. <i>Epilobium davuricum</i> Fisch.	I	A ₂ -5	abor	C	Moss hummocks in bogs, meadow slopes, clayey deposits, bare spots in dwarf birch tundra	H	veg, short rhiz	herb per
113. <i>E. palustre</i> L.	II	A ₂ -1,3,5; B-1	abor	C	Sedge and cottongrass-sedge bogs, moist herb meadows, willow thickets, moss patches along stream banks	H	veg, stolons	herb per
114. <i>Archangelica decurrens</i> Ledeb.	I	A ₁ -2; A ₂ -3	abor	C	Willow thickets in river valleys	H/M	seeds	herb per
115. <i>Carex carvi</i> L.	III-IV	A ₂ -3	abor	R	In river valleys, willow thickets	M	seeds	herb per
116. <i>Pachypleurum alpinum</i> <i>alpinum</i> Ledeb.	0	A ₂ -5	abor	C	Forb-moss and dryas tundras, mesic herb meadows near snowbeds, willow thickets, alongshore forb slopes	H/M	seeds	herb per
117. <i>Vaccinium myrtillus</i> L.	0	A ₂ -5	abor	C	Dwarf birch tundra, forb-willow thickets along water courses	M	veg, long rhiz per	dwarf shrub per
118. <i>V. uliginosum</i> ssp. <i>microphyllum</i> Lge.	0	A ₂ -5; B-1	abor	C	Dwarf birch and willow tundras	M	veg, shoots per	dwarf shrub per
119. <i>V. vitis-idaea</i> ssp. <i>minus</i> (Lodd.) Hult.	0	A ₂ -5; B-1	abor	C	Spotty dwarf shrub and dwarf birch tundras	M	veg, long rhiz per	dwarf semishrub per

1	2	3	4	5	6	7	8	9
120. <i>Gentiana tenella</i> Rottb.	I	A ₂ -5	abor	C	Alongshore forb slopes, forb-moss sites near rivers and streams	M	seeds	herb ann
121. <i>Polemonium acutiflorum</i> Willd. ex Roem. & Schult.	I	A ₂ -5	abor	C	Willow thickets, boggy willow tundras, sedge sinkholes, forb meadows	M/H	veg, rhiz	herb per
122. <i>Myosotis asiatica</i> Schischk. & Serg.	I	A ₂ -5	abor	C	Mesic herb meadows around snowbeds, forb-sedge-moss and dwarf birch-willow tundras	M	seeds, veg	herb per
123. <i>M. palustris</i> L.	I	A ₂ -5	abor	C	Moist sites among willow thickets, mesic herb meadows along streams	H/M	seeds	herb per
124. <i>Lamium album</i> L.	I	A ₂ -3	abor	R	Willow thickets in river valleys	M	seeds	herb per
125. <i>Veronica alpina</i> L.	I	A ₂ -5	abor	C	Around melting snowbeds, in stream gravels, moss patches along streams	M	veg, rhiz	herb per
126. <i>V. longifolia</i> var. <i>borealis</i> Trautv.	I	A ₁ -2; A ₂ -1,3,5	abor	C	Alongshore forb slopes, willow thickets	M	veg, rhiz	herb per
127. <i>Euphrasia frigida</i> Pugsl.	I	A ₂ -5	abor	C	Alongshore forb slopes	M	seeds	herb per
128. <i>Galium uliginosum</i> L.	I	A ₂ -3,5	abor	C	Willow thickets, mesic herb meadows, sedge bogs	H	seeds	herb per

1	2	3	4	5	6	7	8	9
129. <i>Adoxa moschatellina</i> L.	I	A ₂₋₅	abor	C	Willow thickets, meadows	M shade demand- ing	veg, short rhiz	herb per
130. <i>Valeriana capitata</i> Pall.	I	A ₁₋₂	abor	C	Forb-sedge-moss, willow and dwarf birch tundra, willow thickets, alongshore forb slopes	M	veg, seeds	herb per
131. <i>Achillea millefolium</i> L. <i>sens. lat.</i>	II	A ₁₋₂ ; A _{2-1,2} , 3,4,5	abor	C	Alongshore forb slopes, willow thickets	M	veg	herb per
132. <i>Artemisia tilesii</i> Ledeb.	III	A ₁₋₂ ; A ₂₋₁ , 2,3,5; B-1	abor	C	Sandy mounds, hummocks and river deposits, slopes, and pebbly forb strand slopes	M	veg, rhiz	herb per
133. <i>Crepis multicaulis</i> Ledeb.	I	A ₁₋₂ ; A ₂₋₅	abor	C	Ravine walls, strand slopes, steep river banks	M	veg, short rhiz	herb per
134. <i>Gnaphalium supinum</i> L.	I	A ₂₋₅	abor	C	Snowbeds, forb-moss, willow-moss snowbed aggregations, stony-silty river bars, willow thickets	M/H	seeds, veg	herb per
135. <i>Hieracium alpinum</i> L.	I	A ₂₋₅	abor	C	Dwarf birch and willow tundra, around snowbeds	M	seeds	herb per
136. <i>Nardosmia frigida</i> (L.) Hook.	II	A ₁₋₂ ; A _{2-1,3,5} ; B-1	abor	C	Dwarf bush and sedge-moss tundras, willow thickets, riverine herb meadows	M	veg, seeds	herb per
137. <i>Senecio arcticus</i> Rupr.	IV	A _{2-1,2,3,5} ; B-1	abor	R	Wet depressions along river banks	M/H	seeds	herb ann, bi

1	2	3	4	5	6	7	8	9
138. <i>S. atropurpureus</i> Ledeb.	I	A ₂ -5; B-2	abor	C	Dwarf birch tundras	M	seeds	herb per
139. <i>Saussurea alpina</i> (L.) DC.	I	A ₁ -2	abor	C	Dwarf birch tundras	X/M	seeds & veg	herb per
140. <i>Solidago virga-aurea</i> L.	I	A ₂ -5	abor	C	Willow and dwarf birch tundras, forb meadow slopes	M	veg, rhiz	herb per
141. <i>Tanacetum bipinnatum</i> (L.) Sch. Bip.	II	A ₁ -1,2; A ₂ -1,3,5, B-1	abor	C	Sandy forb slopes, willow thickets gravels and gravelly slopes	X/M	veg	herb per
142. <i>T. vulgare</i> L.	IV	A ₂ -1,3; B-1	intr	R	-----	M	seeds	herb per
143. <i>Tripleurospermum</i> <i>phaeocephalum</i> (Rupr.) Pobed.	III	A ₁ -1,2; A ₂ -1,2,3,4,5; B-1,2	abor	C	Alongshore slopes, sandy bluffs	M	seeds	herb ann
144. <i>Taraxacum brevicorne</i> Dahlst.	I	A ₁ -2	abor	C	Alongshore banks, forb meadow slopes, mesic herb meadows among willow thickets	M	seeds	herb per

Footnotes:

1) Column 6 is based mainly on the data of O.V. Rebristaya (1971)

2) Designations used:

Column 7: M - mesophyte, H - hygrophyte, X - xerophyte, M/H - meso-hygrophyte, etc.

Column 8: seeds - reproduction by seeds, veg - vegetative reproduction, rhiz - rhizomatous plants, seeds & veg - presence of seed and non-intensive vegetative reproduction (short-rhizomatous plants), vivip - formation of bulbils in the region of the inflorescence or in the leaf axils.

Column 9: herb - herbaceous plants, ann - annual, bi - biennial, per - perennial plant, shrub or dwarf shrub.

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