Summary of Yamal vegetation and flora

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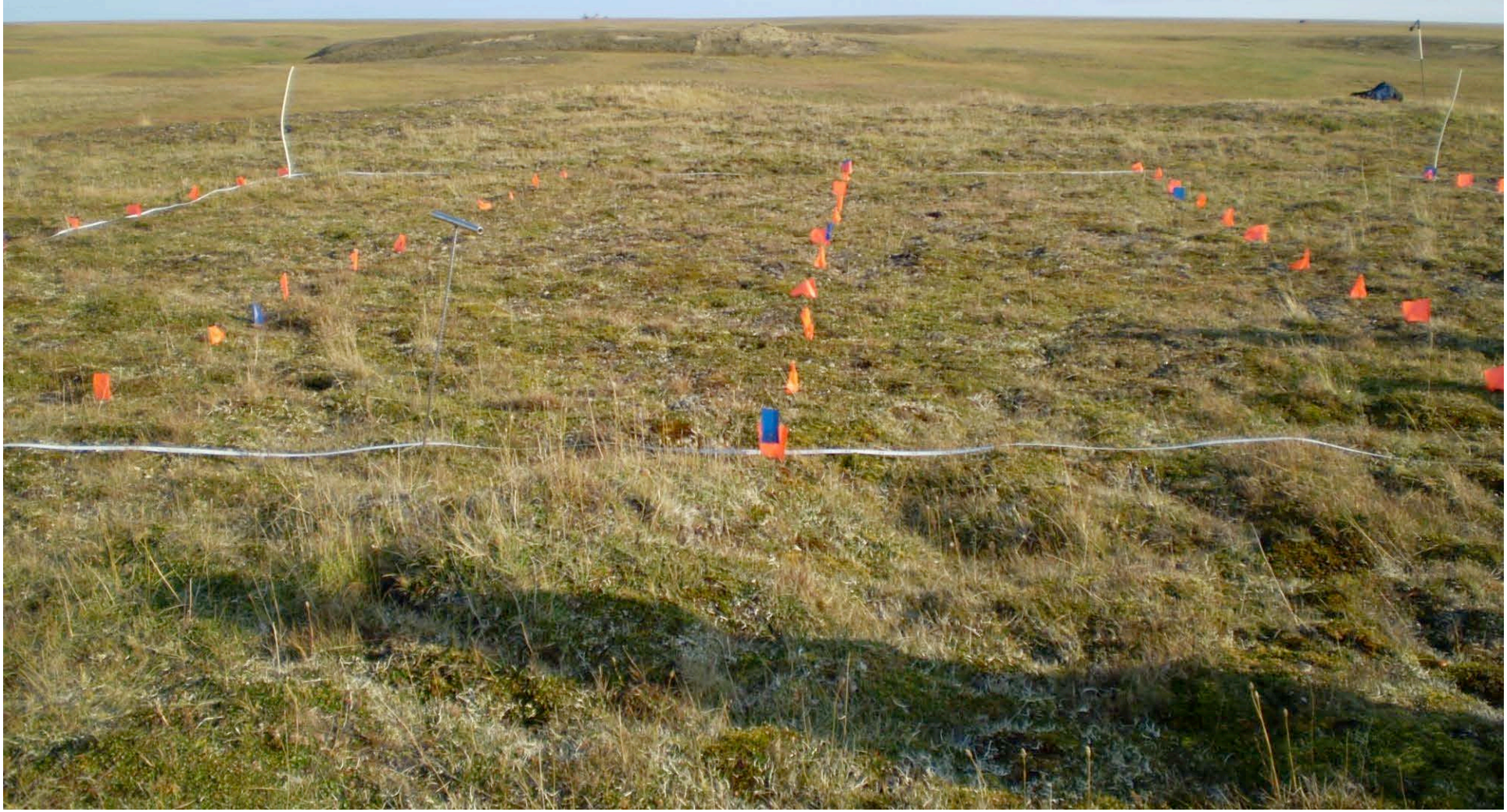
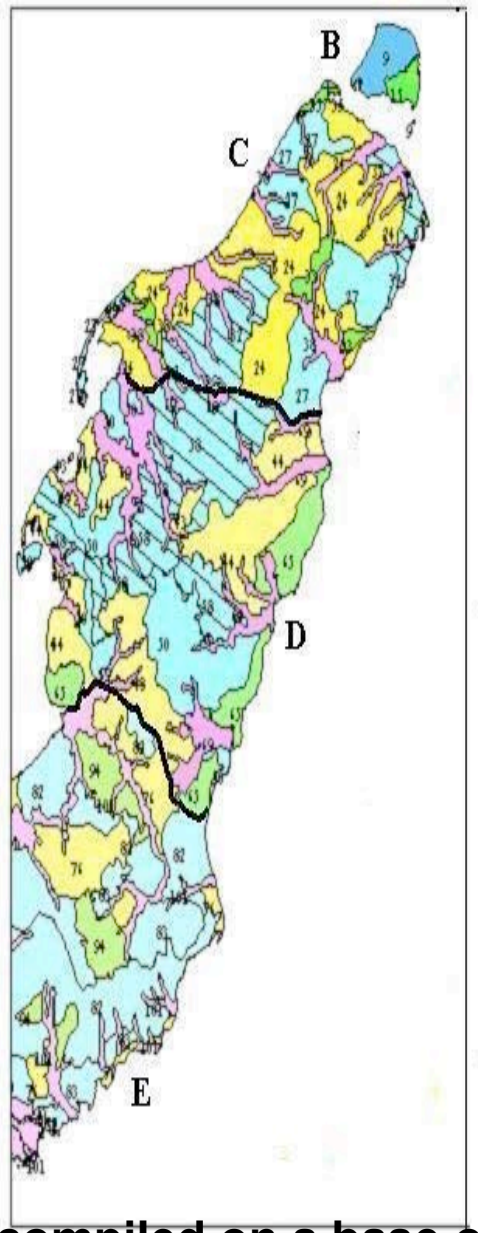
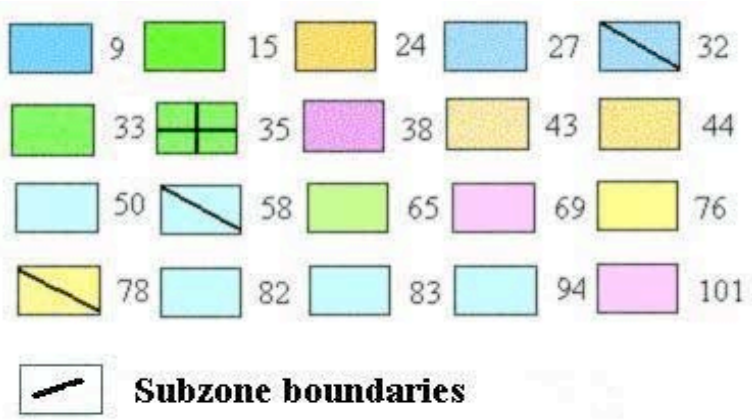


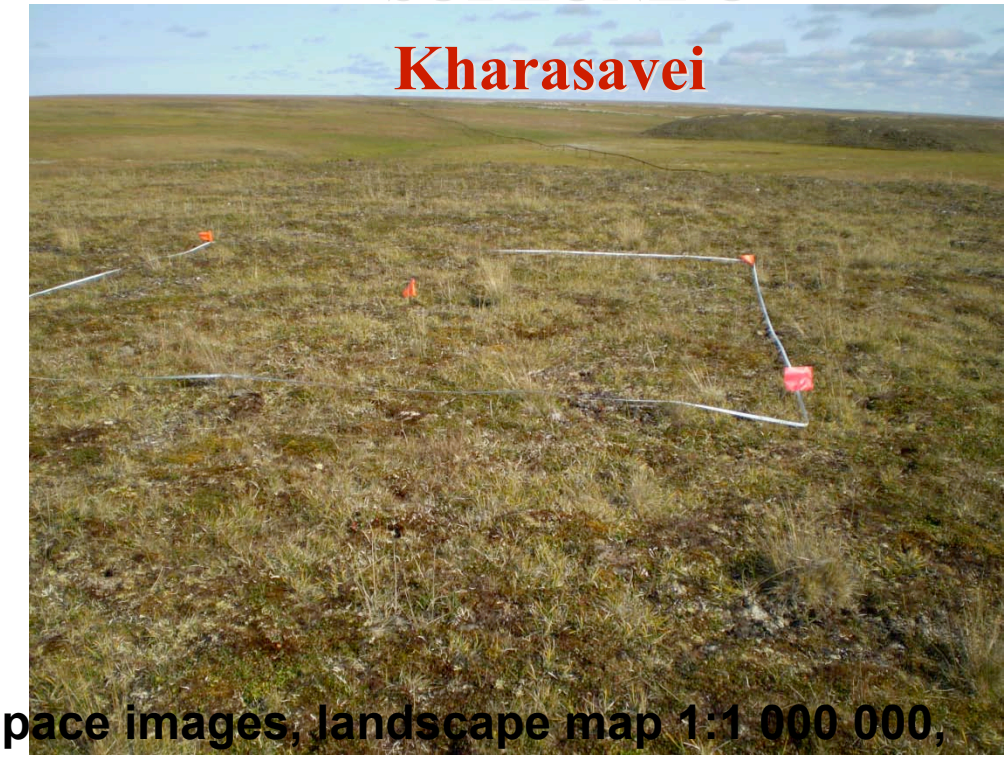
YAMAL PLANT COMMUNITY MAP: 1:4 000 000





SUBZONE C

Kharasavei



The map is compiled on a base of space images, landscape map 1:1 000 000, Vegetation map of the USSR (1:4 000 000), vegetation map of Yamal-Gydan district

LEGEND OF PLANT COMMUNITY MAP

Map unit	Description	Communities
Zone B		
9	Moist acidic moss-sedge tundra	Aulacomnium turgidum - Carex arctisibirica
15	Wet acidic moss - sedge mire	Calliergon sarmentosum - Carex stans+Eriophorum polystachion
Zone C		
24	Dry acidic prostrate dwarf shru b-sedge - lichen tundra	Salix nummularia -Carex arctisibirica -Alectoria ochroleuca Cetraria cucullata - Hierochloe alpina
27	Moist acidic sedge -moss tundra	Carex arctisibirica - Aulacomnium turgidum
32	Moist nonacidic and acidic prostrate dwarf shrub -sedge - moss tundra	Dryas subincisa+Salix polaris -Carex arctisibirica - Dicranum elongatum
33	Wet acidic sedge -grass - moss mire	Carex stans -Calliergon sarmentosum+Drepano - cladus exannulatus Carex stans+Eriophorum polystachion -Calliergon sarmentosum+Sphagnum squarrosum
35	Wet saline grass - sedge meadows	Puccinellia phryganodes - Carex subspathacea
38	Riparian acidic sedge -moss bogs and willow -forb shrublands	Carex stans + Eriophorum polystachion -Calliergon sarmentosum Salix glauca -Pedicularis sudetica

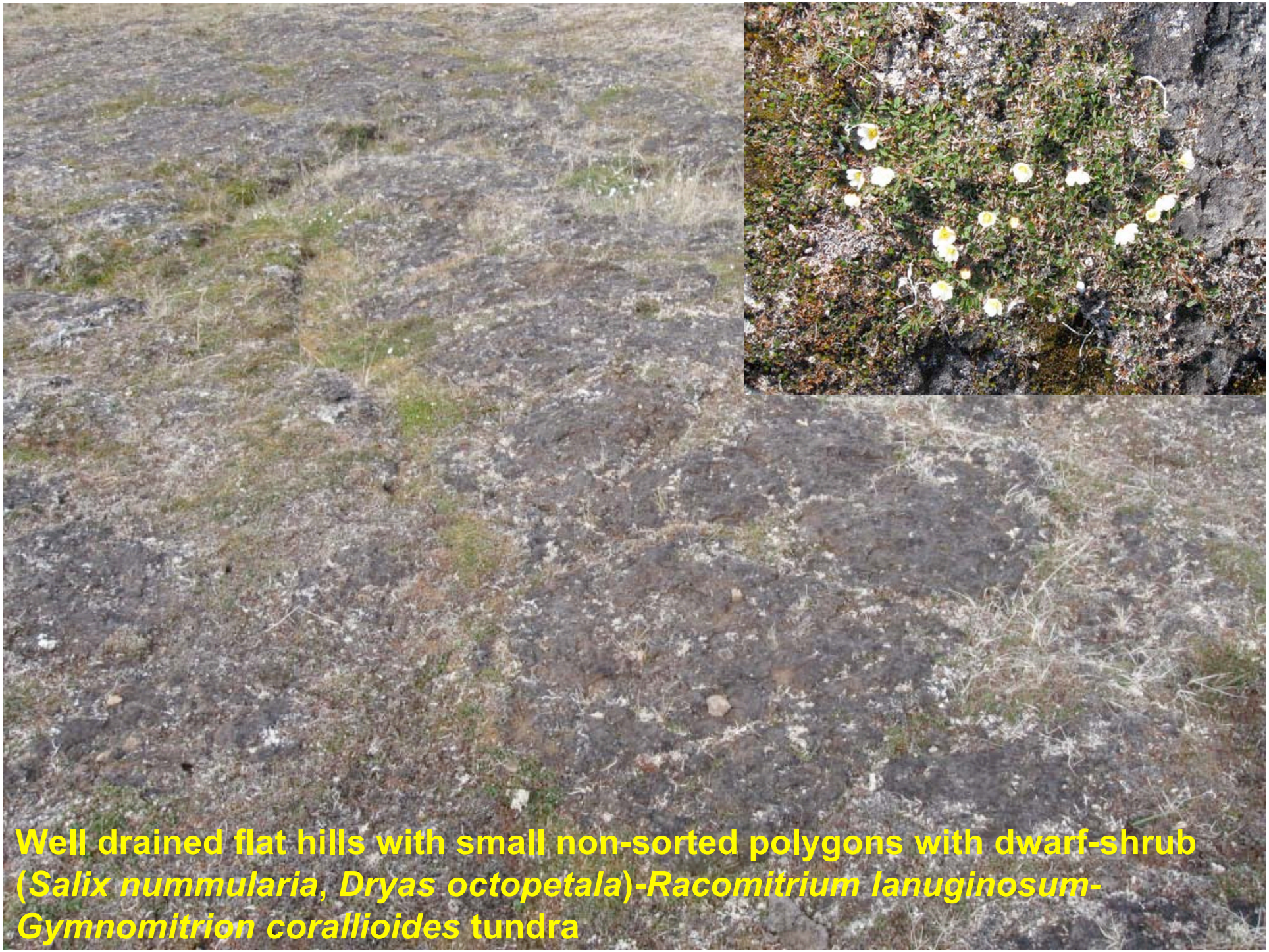
Zone D		
43	Dry acidic dwarf shrub - lichen tundra	Salix nummularia +Dryas subincisa - Cetraria cucullata
44	Dry acidic dwarf shrub - moss-lichen tundra	Ledum decumbens - Vaccinium minus - Cetraria cucullata + Racomitrium lanuginosum
50	Moist acidic dwarf shrub - sedge-moss tundra	Betula nana -Carex arctisibirica -Dicranum congestum+ Aulacomnium turgidum Eriophorum vaginatum -Sphagnum lenense
58	Moist nonacidic prostrate dwarf shrub - low shrub - forb-moss tundra	Dryas punctata - Saxifraga nels oniana- Dicranum congestum Salix glauca+Salix lanata -Petasites frigidus -Aulacomnium palustre
65	Wet acidic sedge-dwarf shrub-moss mire	Carex aquatilis - Drepanocladus exannulatus+D. fluitans Ledum decumbens - Carex stans -Sphagnum lenense
69	Riparian acidic sedge-moss mire and low shrub-sedge-moss tundra	Carex stans - Drepanocladus revolvens -Meesia triquerta Salix lanata+Salix glauca-Carex stans - Aulacomnium turgidum + Tomentypnum nitens

Zone E		
76	Dry acidic dwarf shrub - sedge-lichen - moss tundra	Ledum decumbens - Vaccinium vitis - idaea+Empetrum subholarcticum -Cladina mitis Dryas subincisa -Carex arctisibirica -Cladina rangiferina+Racomitriu m lanuginosum
78	Dry nonacidic low shrub - prostrate dwarf shrub - forb-lichen - moss tundra	Dryas subincisa +Diapensia lapponica - Pedicularis sudetica - Alectoria ochroleuca + Racomitrium lanuginosum Salix glauca+S. lanata - Petasites frigidus - Aulacomnium palustre
82	Moist acidic dwarf shrub - sedge-moss- lichen tu ndra	Betula nana+Salix pulchra -Aulacomnium turgidum+Dicranum elongatum+Cladina \stellaris Eriophorum vaginatum - Sphagnum balticum
83	Moist acidic dwarf shrub - low shrub - forb-moss- lichen tundra	Betula nana -Dryas punctata - Aulacomnium turgidum+Cladina stellaris Salix lanata -Vaccinium microphyllum - Polemonium acutiflorum - Aulacomnium palustre
94	Wet acidic low shrub - dwarf shrub - sedge-forb- moss-lichen mire	Salix lapponum -Betula nana-Carex aquatilis - Calliergon stramineum+ Sphagnum lindbergii Ledum palustre+ Eriophorum vaginatum - Rubus chamaemorus - Sphagnum fuscum+ Cladina stellaris

101 – Riparian acidic sedge-moss mires in combination with grass-moss shrub copses

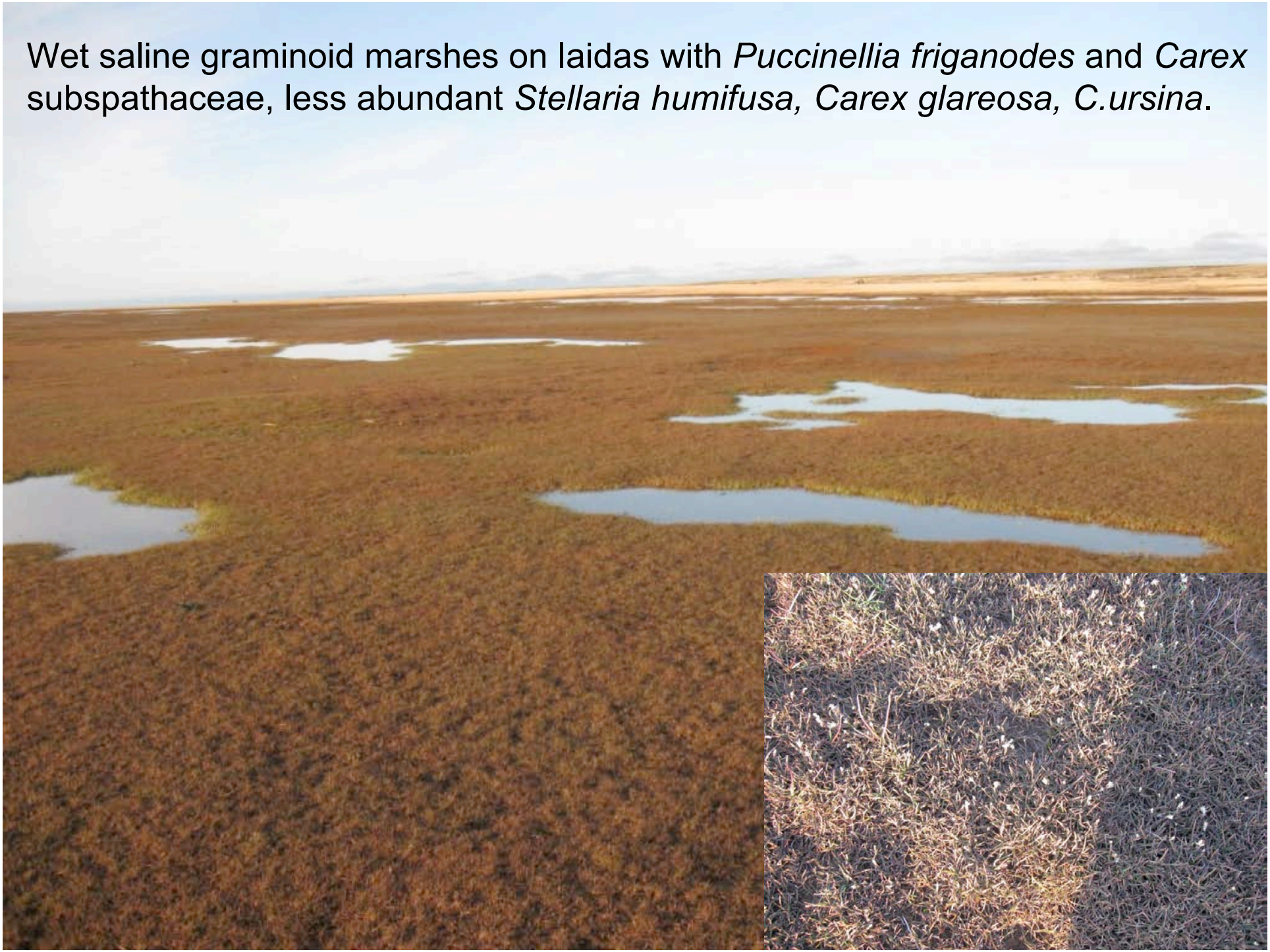
Moist acidic moss-sedge-cotton-grass tundra and wet graminoid-moss mires with *Eriophorum polystachion, E.russeolum, Carex concolor, Dupontia fisheri, Hierochloe pauciflora, Arctophila fulva, Dicranum elongatum, Warnstorfia exannulata, W. sarmentosa, Sphagnum fimbriatum, Sanionia uncinata, Calliergon stramineum, Oncophorus wahlenbergii* are the most wide-spread communities on poorly drained lowlands of the Bely Island.

On moderately drained clayey gentle slopes zonal dwarf-shrub-graminoid-lichen-moss tundra occurs (with *Salix polaris, Dryas octopetala, Arctagrostis latifloia, Calamagrostis holmii, Carex bigelowii, Eriophorum polystachion, Dicranum elongatum, D.acutifolium, Aulacomnium turgidum, Hylocomium splendens, Polytrichum strictum,*

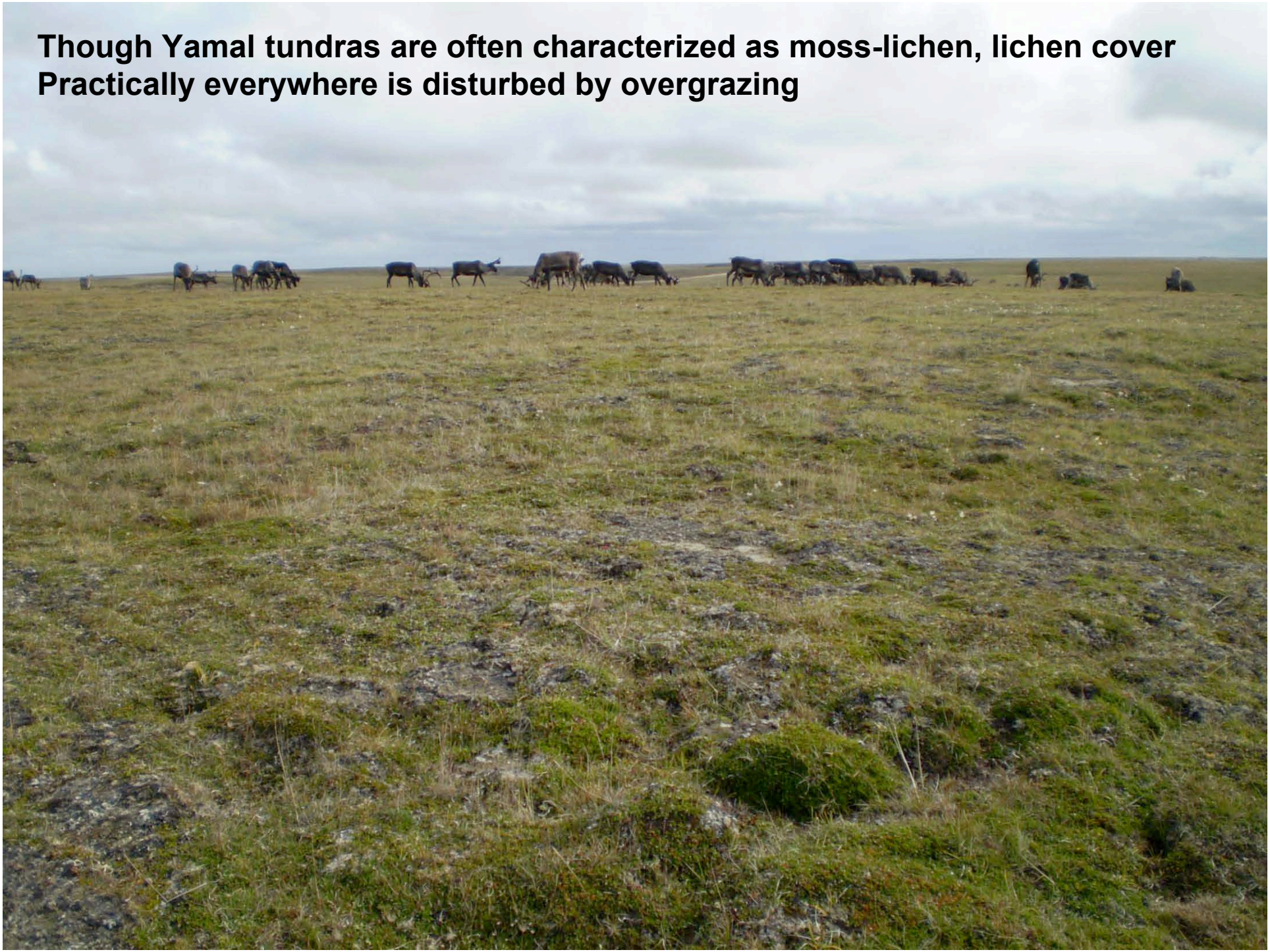


Well drained flat hills with small non-sorted polygons with dwarf-shrub (*Salix nummularia*, *Dryas octopetala*)-*Racomitrium lanuginosum*-*Gymnomitrion corallioides* tundra

Wet saline graminoid marshes on laidas with *Puccinellia friganodes* and *Carex* subspathaceae, less abundant *Stellaria humifusa, Carex glareosa, C.ursina*.



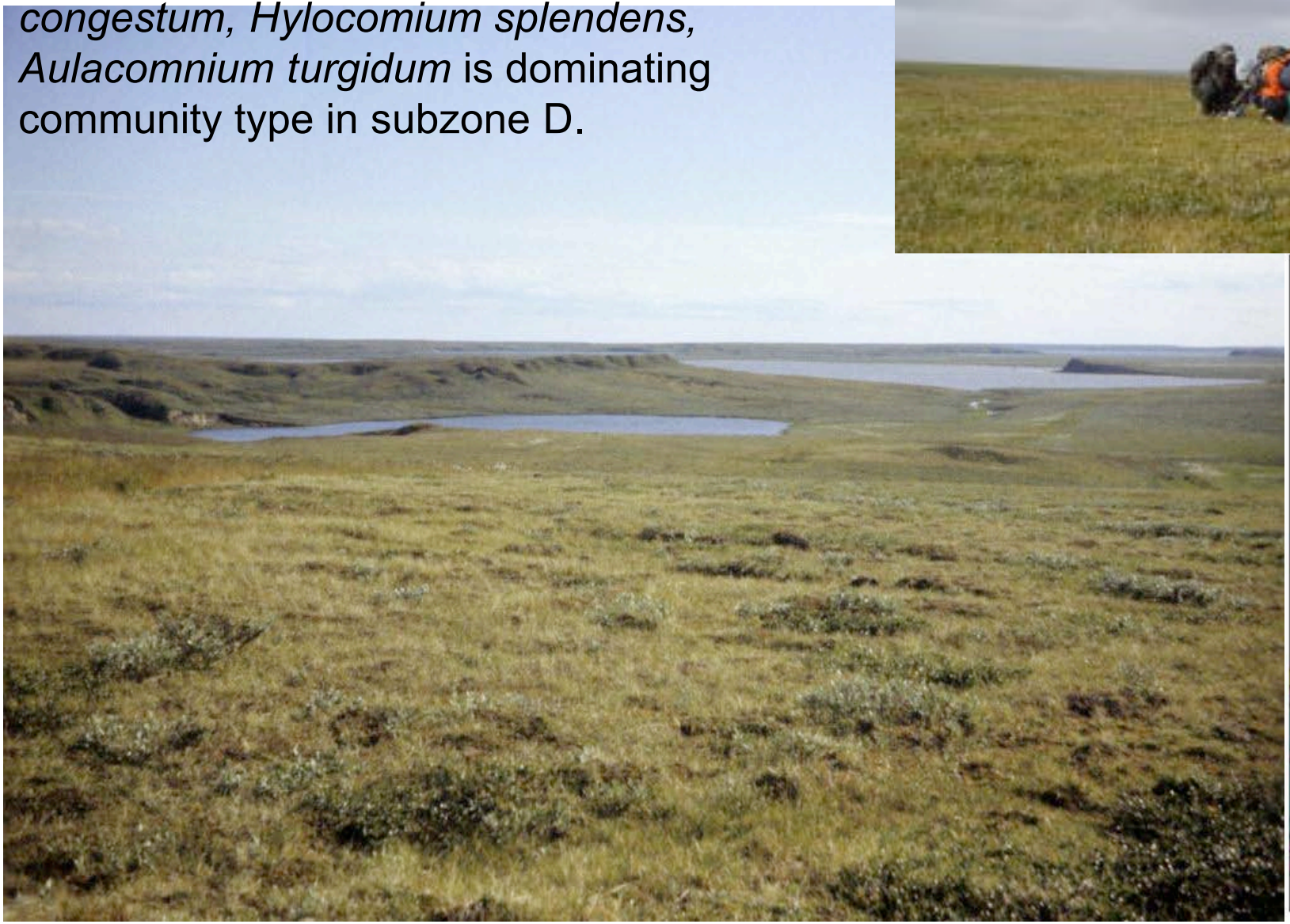
Polygonal dry acidic tundra with prostrate dwarf shrubs (*Salix nummularia, Dryas punctata)* – sedge (*Carex arctisibirica)* - lichen (*Alectoria ochroleuca, Cladonia arbuscula, Cetraria cucullata,)* occupying *sandy* marine terraces is predominating type in subzone C

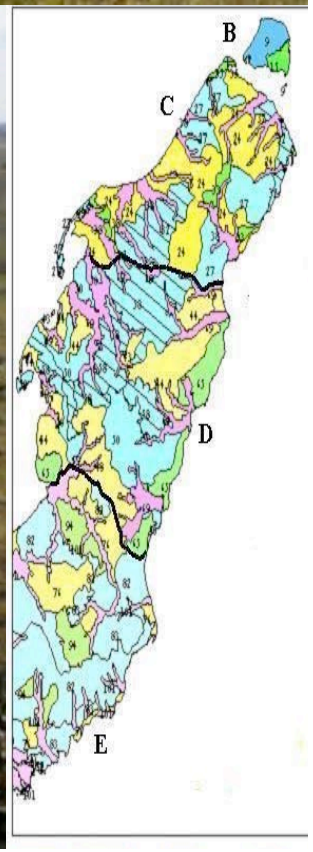

Though Yamal tundras are often characterized as moss-lichen, lichen cover
Practically everywhere is disturbed by overgrazing

Zonal moist acidic sedge-moss tundra occur on loamy interfluves. *Carex arctisibirica, Salix polaris*, well developed moss cover (*Aulacomium turgidum, Hylocomium splendens, Dicranum spp.) are characteristic.*
Some arctic herbs are present (Saxifraga hieracifolia, S. cernua,Ranunculus sulphureus, Cardamine bellidifolia)
In the valleys wet acidic sedge-grass-moss mires with *Carex stans, Eriophorum polystachion, Calliergon sarmentosum* are common.

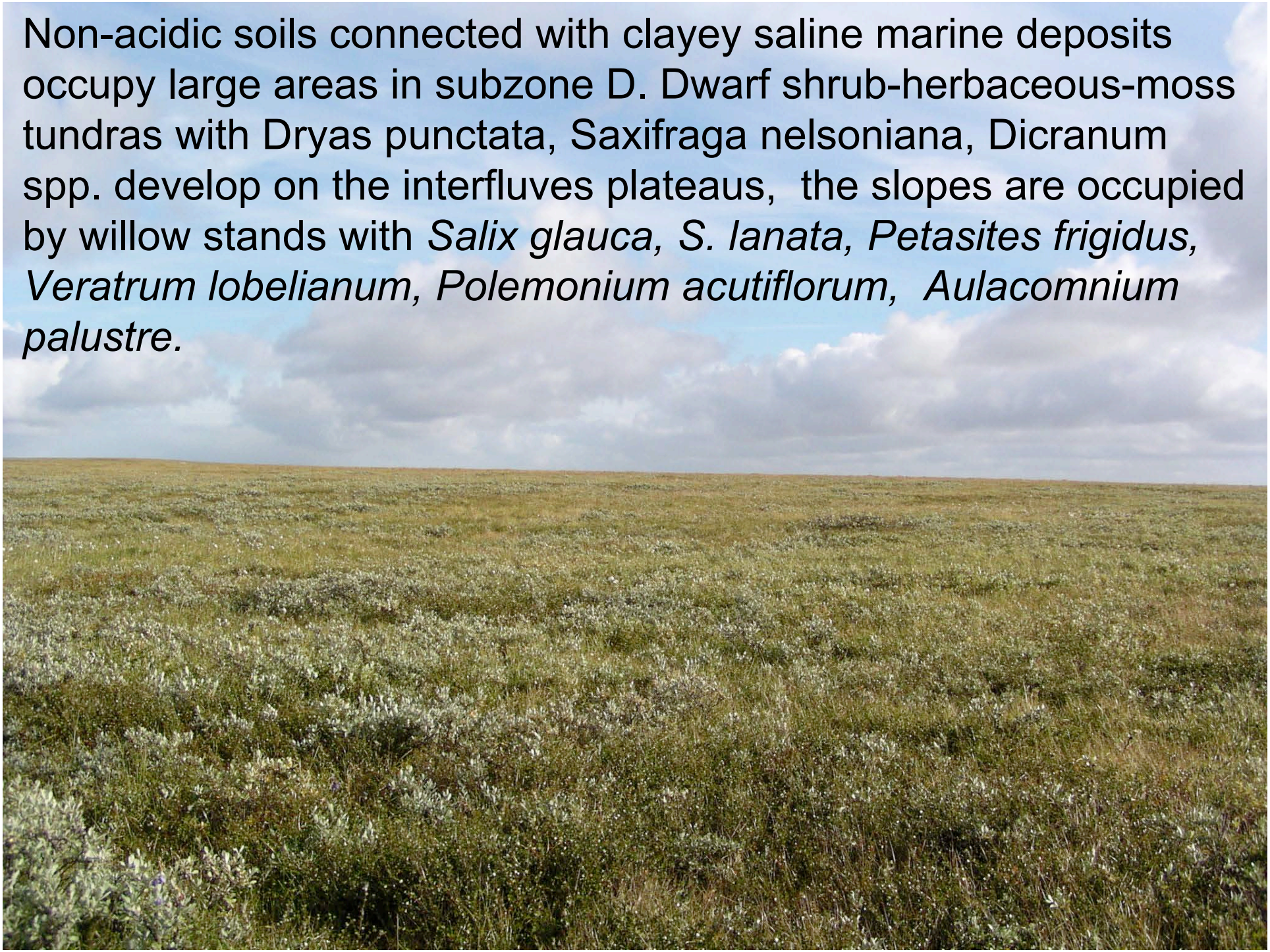
Eriophorum scheuchzeri can form dense vigorous stand on disturbed surfaces.

Moist acidic dwarf-shrub sedge-moss tundra (50) with *Betula nana,Salix glauca, Carex arctisibirica, Vaccinium minus, Valeriana capitata, Pyrola grandiflora, Dicranum congestum, Hylocomium splendens, Aulacomnium turgidum* is dominating community type in subzone D.





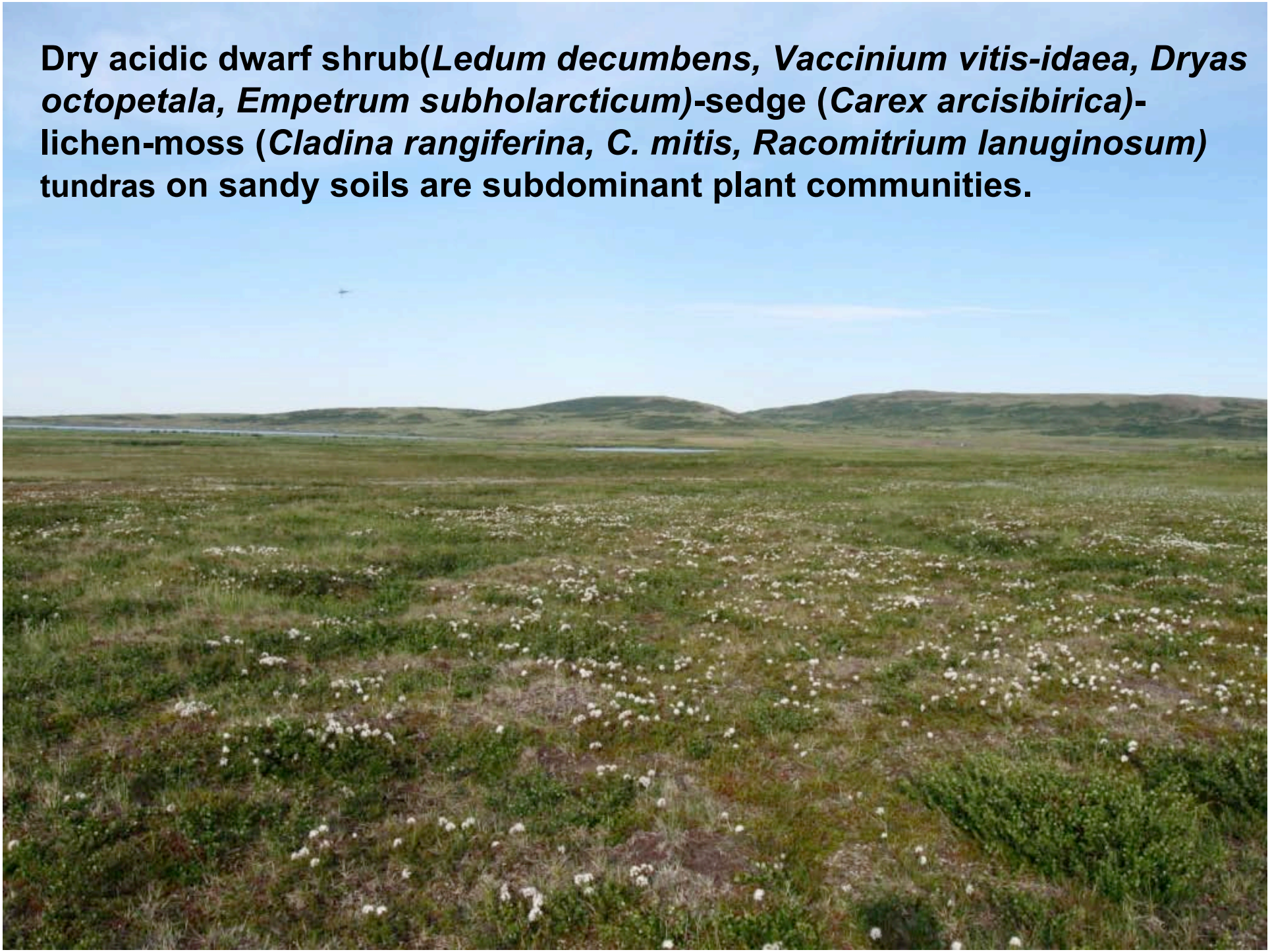
Non-acidic soils connected with clayey saline marine deposits occupy large areas in subzone D. Dwarf shrub-herbaceous-moss tundras with Dryas punctata, Saxifraga nelsoniana, Dicranum spp. develop on the interfluves plateaus, the slopes are occupied by willow stands with *Salix glauca, S. lanata, Petasites frigidus, Veratrum lobelianum, Polemonium acutiflorum, Aulacomnium palustre.*



Mesic acidic low shrub-sedge- lichen-moss tundras (82) with *Betula nana, Salix pulchra, Aulacomnium turgidum, Cladina stellaris* are dominating in subzone E

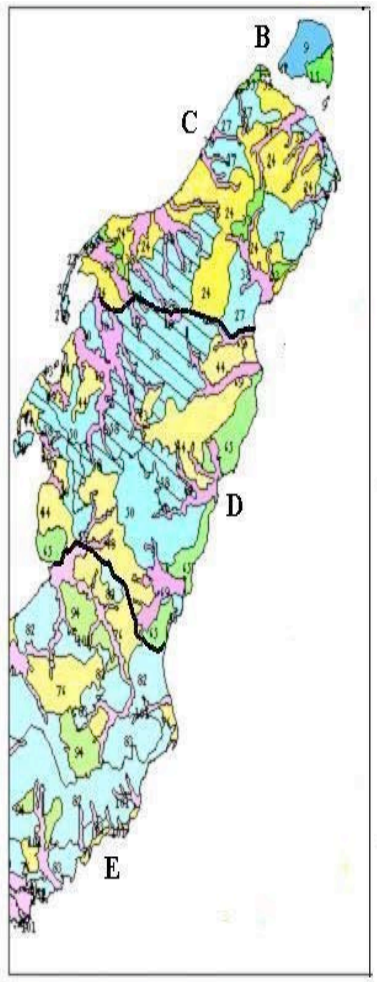

Tussock cotton grass–moss tundra (Laborovaya)

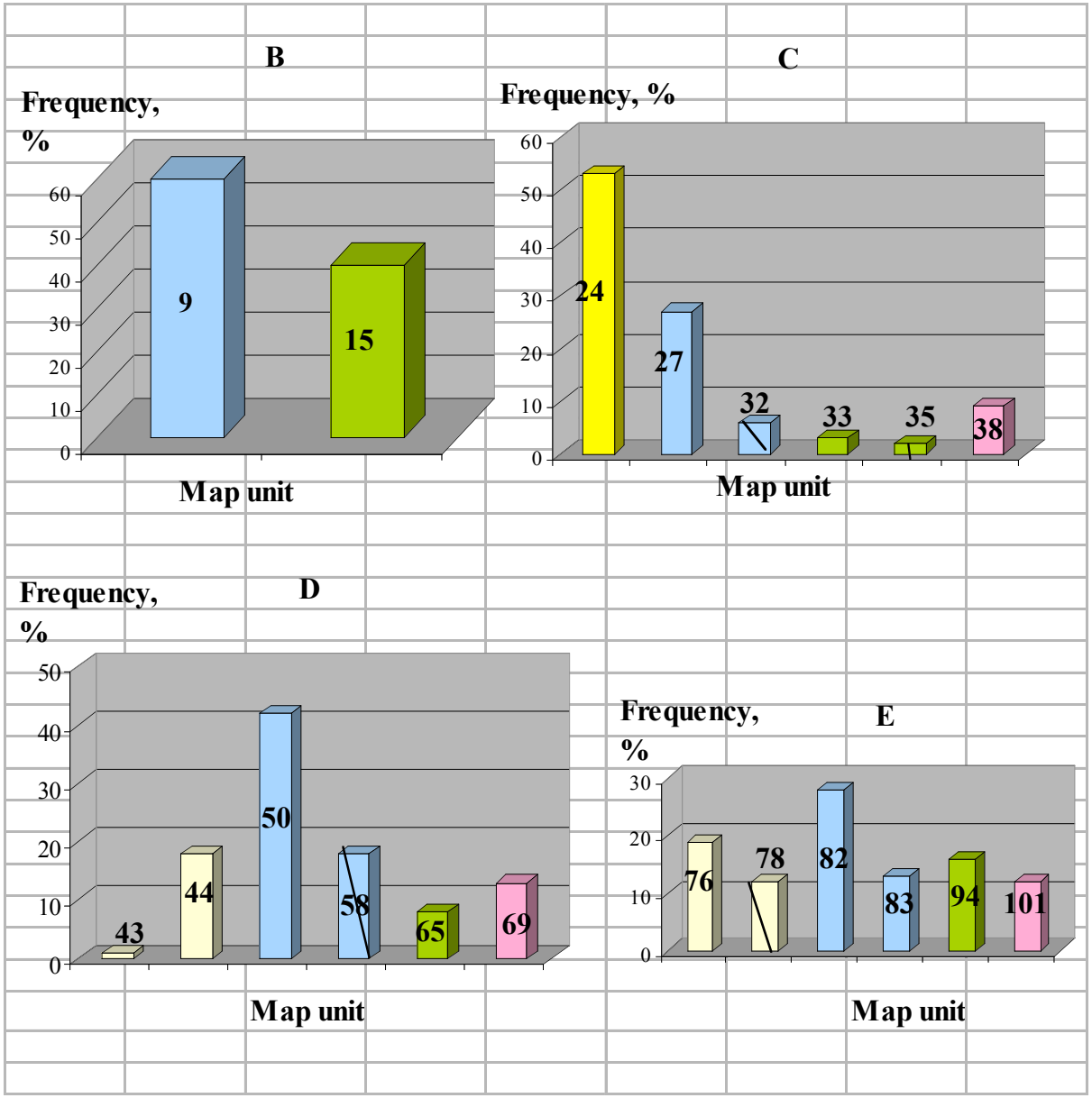
Dry acidic dwarf shrub(*Ledum decumbens, Vaccinium vitis-idaea, Dryas octopetala, Empetrum subholarcticum)*-sedge (*Carex arcisibirica)*-lichen-moss (*Cladina rangiferina, C. mitis, Racomitrium lanuginosum)* tundras on sandy soils are subdominant plant communities.



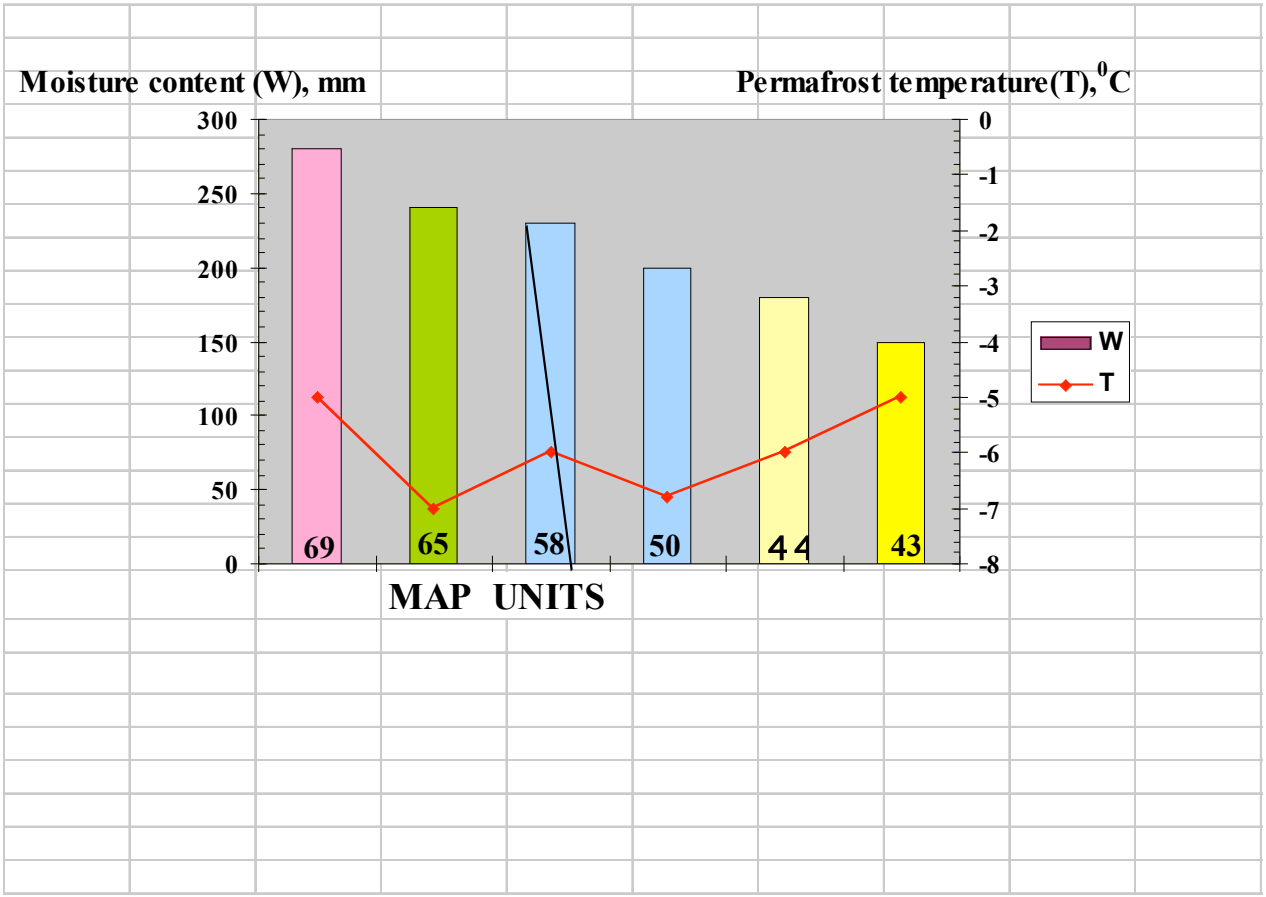
Subzone E. Communities occurring frequently: type 94 - wet low shrub-dwarf shrub-sedge-herbaceous-moss-lichen mires with Ledum, Betula nana, Eriophorum vaginatum, Rubus chamaemorus, Sphagnum fuscum*;* type 83 - moist acidic dwarf shrub-moss-lichen tundra in combination with low shrub-moss tundra*;* type 78 - combination of dry nonacidic prostrate dwarf shrub-lichen-moss tundras with *Dryas subincisa, Diapensia lapponica, Alectoria ochroleuca, Racomitrium lanuginosum* on hill tops and low shrub-forb-moss tundras with *S.glauca, S.lanata, Petasites frigidus, Aulacomnium palustre* on slopes; type 101 - riparian acidic sedge-moss mires in combination with grass-moss high shrub thickets (*Salix lanata, S. glauca*, h=1.5-2.5m or *Alnaster fruticosa*)**.**

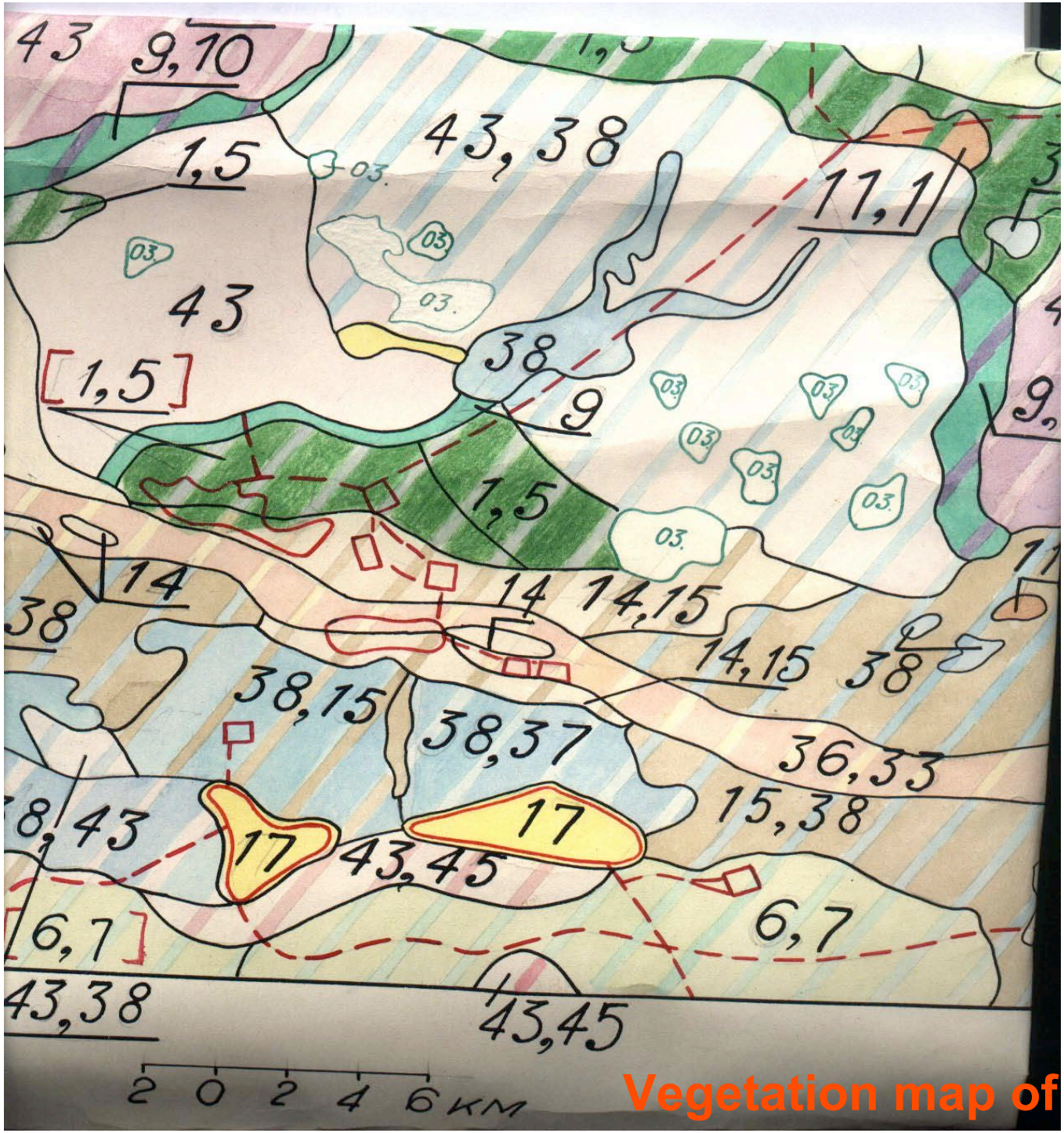
Frequency of plant communities in Yamal subzones





Interactions between plant communities and soil moisture and permafrost temperature (at example of subzone D)





Vegetation map of Nadym

LEGEND OF NADYM VEGETATION MAP

Plant communities

Forest: 1 - birch-larch and birch -pine shrub -lichen sparse forests on dry gentle sandy sites; 5 - larch sedge -shrub - moss open woodland with hummocky microrelief on slightly drained sites; 6 - spruce -larch shrub -lichen -green moss forests on dry sites of plains, composed by clay; 7 - spruce -larch shrub -moss sparse forests and open woodland on slightly drained sites, composed by clay with hummocky microrelief and small active layer thickness; 9 - spruce - birch-larch shrub -sedge -moss forest s on flood plains; 10 - spruce -larch sedge -shrub -peat moss open wood on flat boggy flood plains with hummocks; 11 - sands, deprived the vegetation cover on disturbed sites; 14 – cedar-birch forb-shrub forests on flood plains ; 15 – cedar-birch grass-shrub -moss forests on flood plains ; 17 – settlements on early forestry sites.

Meadows: 33 – forb – grass; 36 – spits and beaches with fragments of meadow vegetation.

Mires: 37 - sedge-moss mires; 38 - shrub -sedge-peat moss hummocky bogs with lenses of frozen g rounds.

Peatlands: 43 - flat cloudberry -shrub lichen -moss and moss -lichen peatlands with sedge -moss pools; 45 - peatlands with sedge -shrub -moss-lichen cover on palsa and sedge -peat moss - on pools between palsa.

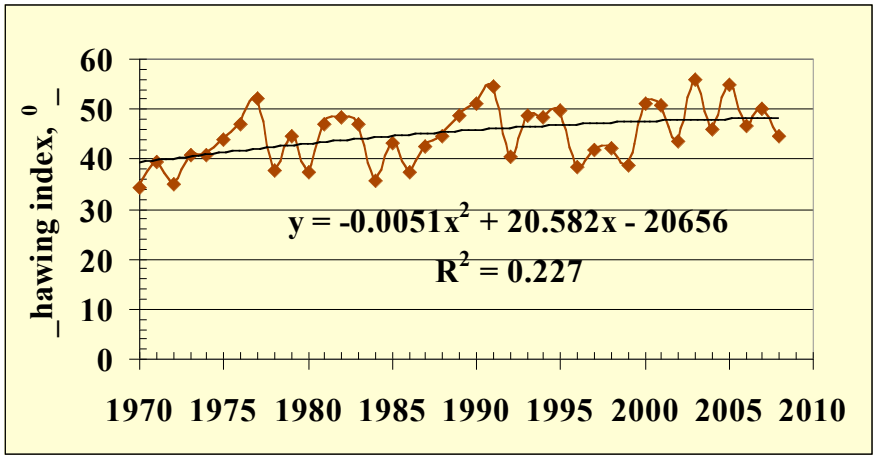
Red lines – linear and area disturbances.

Nadym site is located in northern taiga subzone and zonal vegetation here is represented by birch-larch and birch-pine forests and larch-shrub-moss –lichen woodlands developed on the second terrace

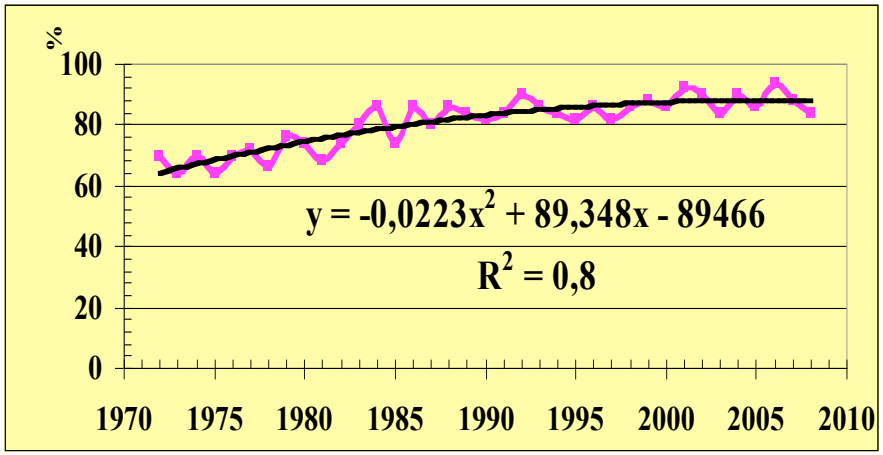
Flat peatland

Ledum palustre

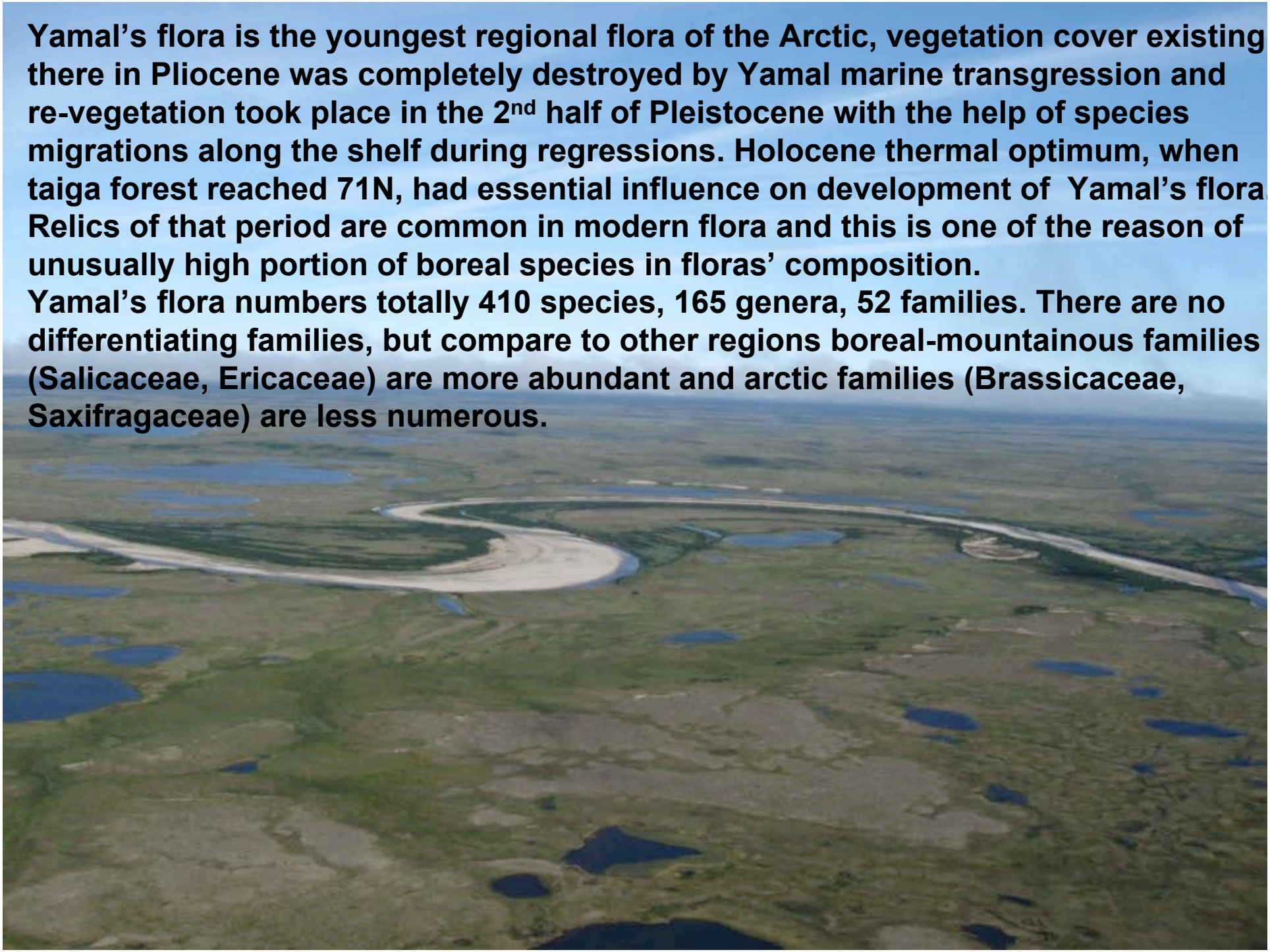
Thawing index of air temperature (the sum monthly mean air temperatures above 0°C)



Frequency of Ledum palustre (1972-2008)



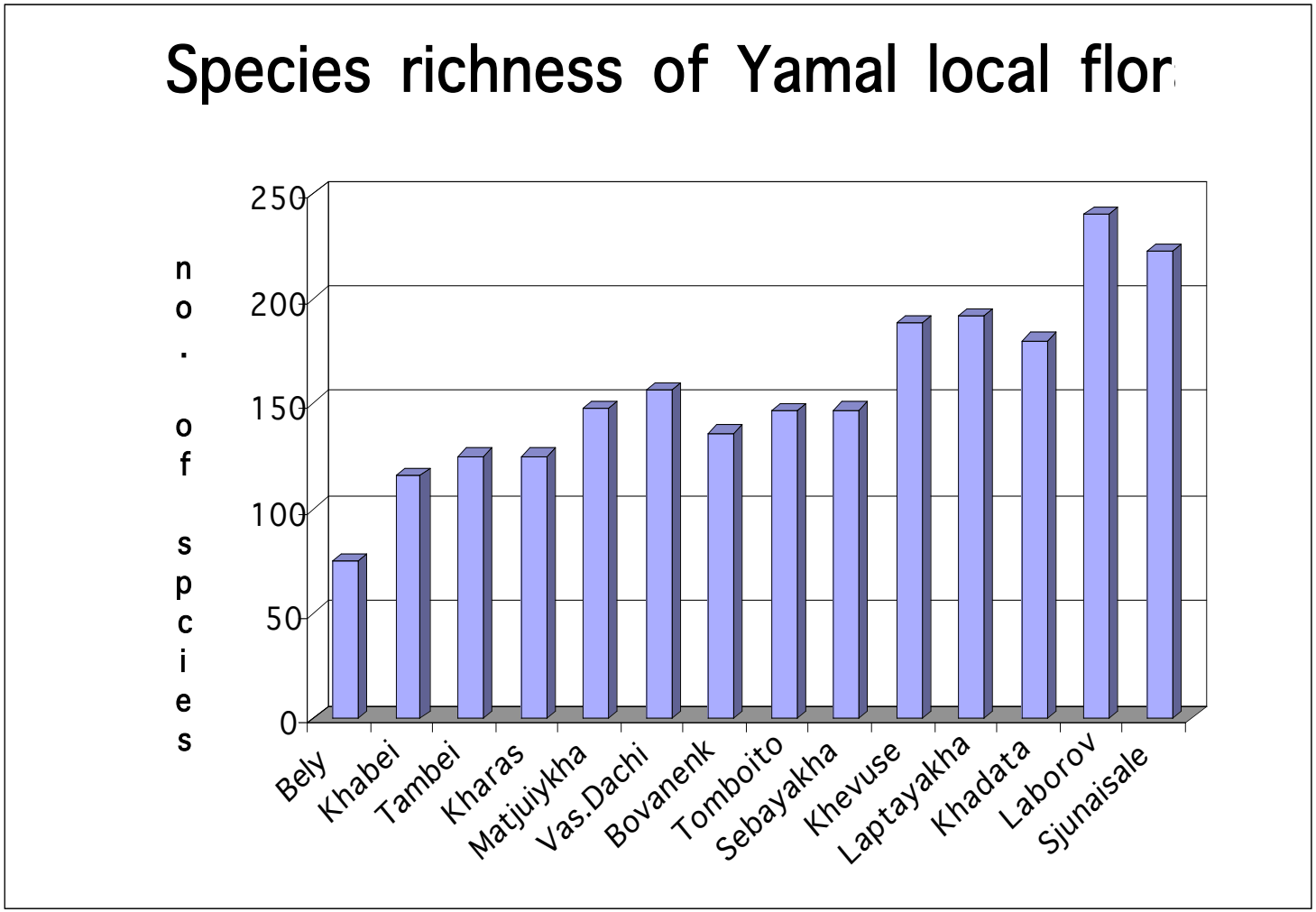
Appearance of Pinus sibirica and P. silvestris on flat peatland in the result of climatic warming



Yamal's flora is the youngest regional flora of the Arctic, vegetation cover existing there in Pliocene was completely destroyed by Yamal marine transgression and re-vegetation took place in the 2nd half of Pleistocene with the help of species migrations along the shelf during regressions. Holocene thermal optimum, when taiga forest reached 71N, had essential influence on development of Yamal's flora. Relics of that period are common in modern flora and this is one of the reason of unusually high portion of boreal species in floras' composition.

Yamal's flora numbers totally 410 species, 165 genera, 52 families. There are no differentiating families, but compare to other regions boreal-mountainous families (Salicaceae, Ericaceae) are more abundant and arctic families (Brassicaceae, Saxifragaceae) are less numerous.

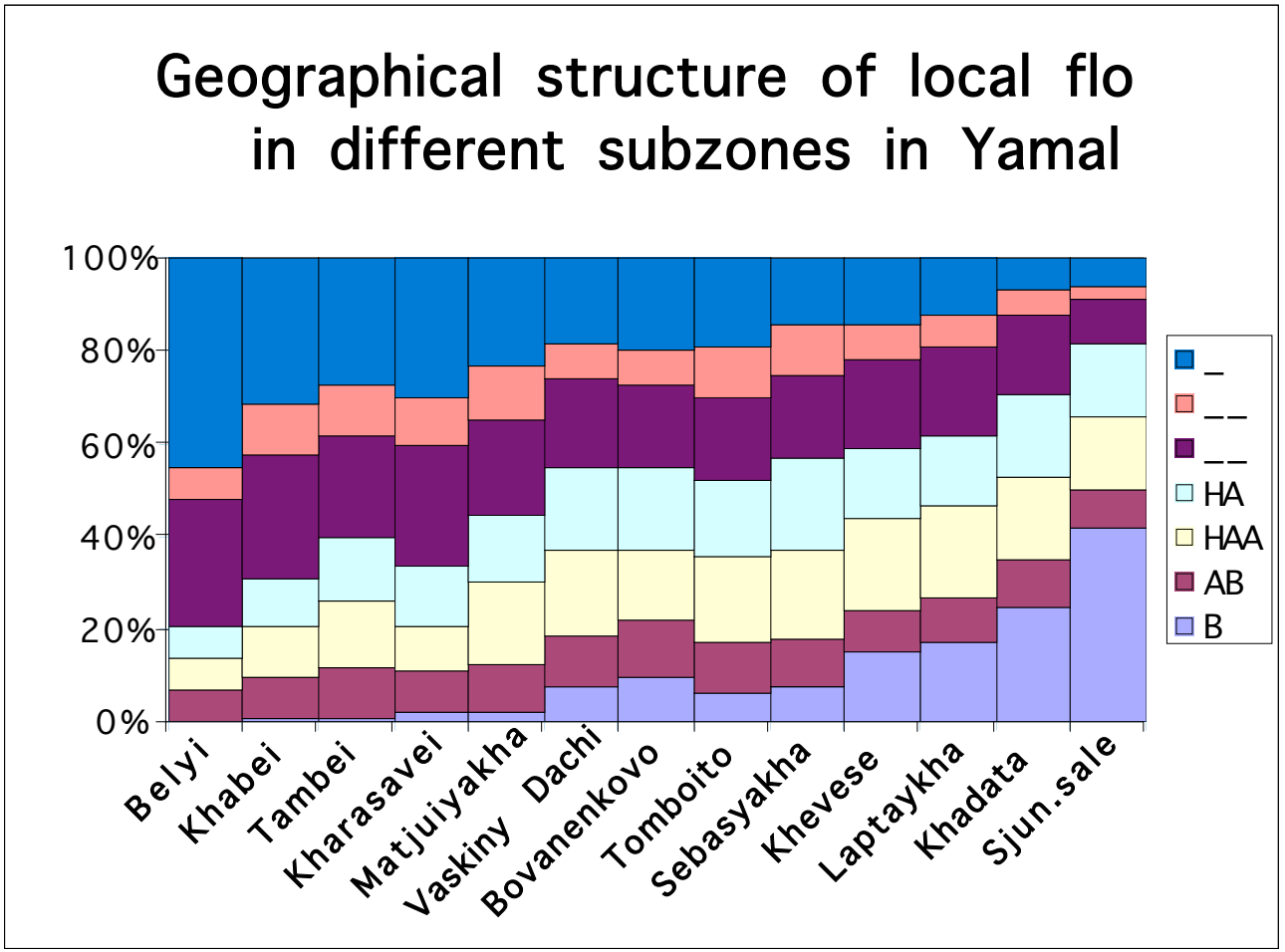
Clear dependence between zonal position and floristic diversity is exhibited in the region as well. Floras' diversity decreases gradually from ca 240 species at "Laborovaya" (E), 156 – at "Vaskiny Dachi" (D), 125 – at "Kharasavei" (C) and 65-75 at "Bely" (B). Variation in species richness and, partly, in composition and coverage depends also on local relief, soil and drainage conditions.



High diversity of "Laborovaya" (=147 km) LF (ca.240 species) is explained by its location near the boundary of 2 floristic subprovinces: Ural-Novaya Zemlya and Yamal-Gydan. A number of species found here are common in Polar Urals, absent in Yamal proper and appear again in Taimyr, some of them we found in Gydan (*Eritrichium villosum, Saxifraga spinulosa, S. hirculus, Androsace chamaejasme, Senecio resedifolius*).

Extreme poverty of "o.Bely" is caused first of all by its relief, soil and hydrology features (along with "short time" of flora formation), and not only by its high latitude position. Many arctic herbaceous species occurring further northwards are absent due to absence of suitable habitats.

Latitudinal geographic structure of the local floras in Yamal changes from north to south due to dropping out of boreal species, decrease in portion of hypoarctic fraction, relatively stable portion of arctic-alpine species and increase of portion of arctic species. Specific of geographic structure of West Siberian LFs compare to Taimyr ones is high portion of boreal and hypoarctic species. Boreal species have preserved in Yamal flora since the forest expansion in the end of Pleistocene and in Holocene thermal optimum.



SUMMARY ON VEGETATION AND FLORA.

The analysis of the compiled vegetation maps has allowed studying spatial structure of vegetation at different subzones.

•Zonal changes in vegetation are clearly expressed: Salix polaris - graminoid tundra in subzones B and C is replaced by Betula nana, Salix glauca dominating sedge-moss tundra in subzones D and E. The latter usually form combination with tussock Eriophorum vaginatum-moss tundra.

•The critical feature differing arctic subzones (B, C) from hypoarctic ones is absence of Betula nana. Decrease in plant cover noted in other regions (Taimyr) is not well pronounced in Yamal due to topography and drainage conditions. Diversity and abundance of arctic herbs in subzones B and C recorded in Taimyr is not so strongly exhibited in Yamal

•Transition from hypoarctic tundras to arctic ones is well expressed in geographic structure of local floras: dramatic decrease of the portion of boreal fraction and increase of arctic fraction.

•The vegetation cover structure becomes more complicated southwards, diversity of plant communities increases, areas occupied by the dominant plant communities decrease, height and coverage of plants increase, number of storeys increase from 1- 2 in arctic tundra to 4-5 in northern taiga. The most complicated spatial structure is observed in a subzone E.

•Long-term stationary observations reveal important abiotic factors determining development of plant communities and registrate changes following raise of air temperature during the last decades and anthropogenic influence

•Clear dependence between zonal position and floristic diversity is exhibited in the region. Variation in species richness and, partly, composition and coverage depend also on local relief, soil and drainage conditions.

• In contrast to number of species in local floras, number of species in partial floras (i.e. flora of habitat type) does not decrease northwards, similarly species diversity of plant communities per 100 sq m also even increases to the north,