

Development of vegetation and soil in the glacier forelands in Svalbard

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General information – genesis of research subject

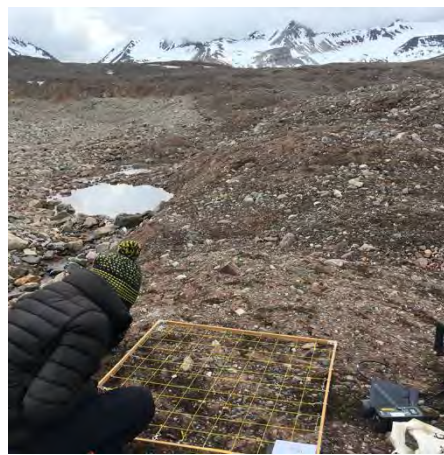
How people usually see succession:




How we see it:

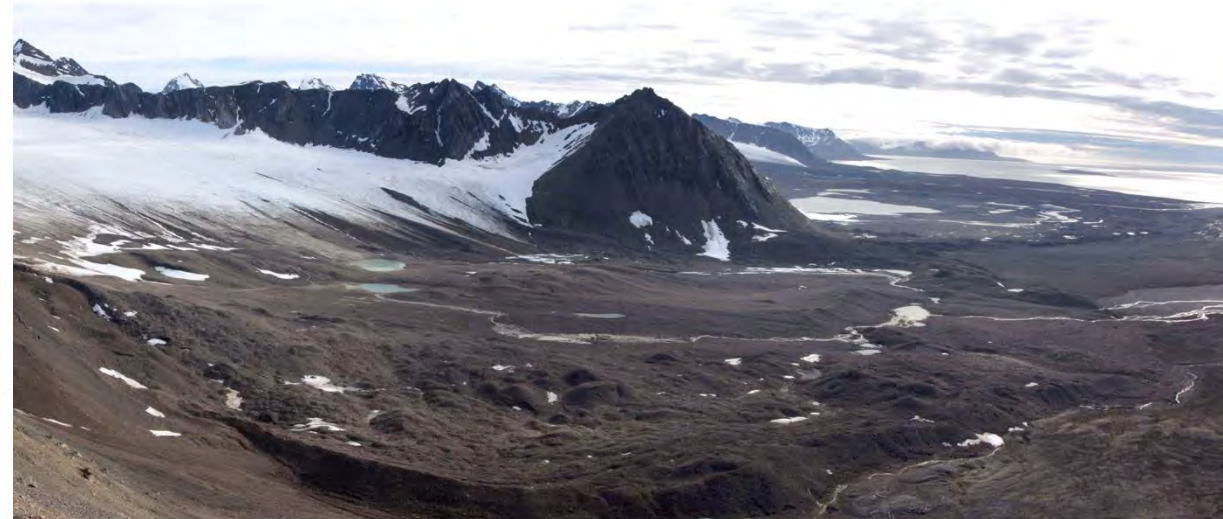
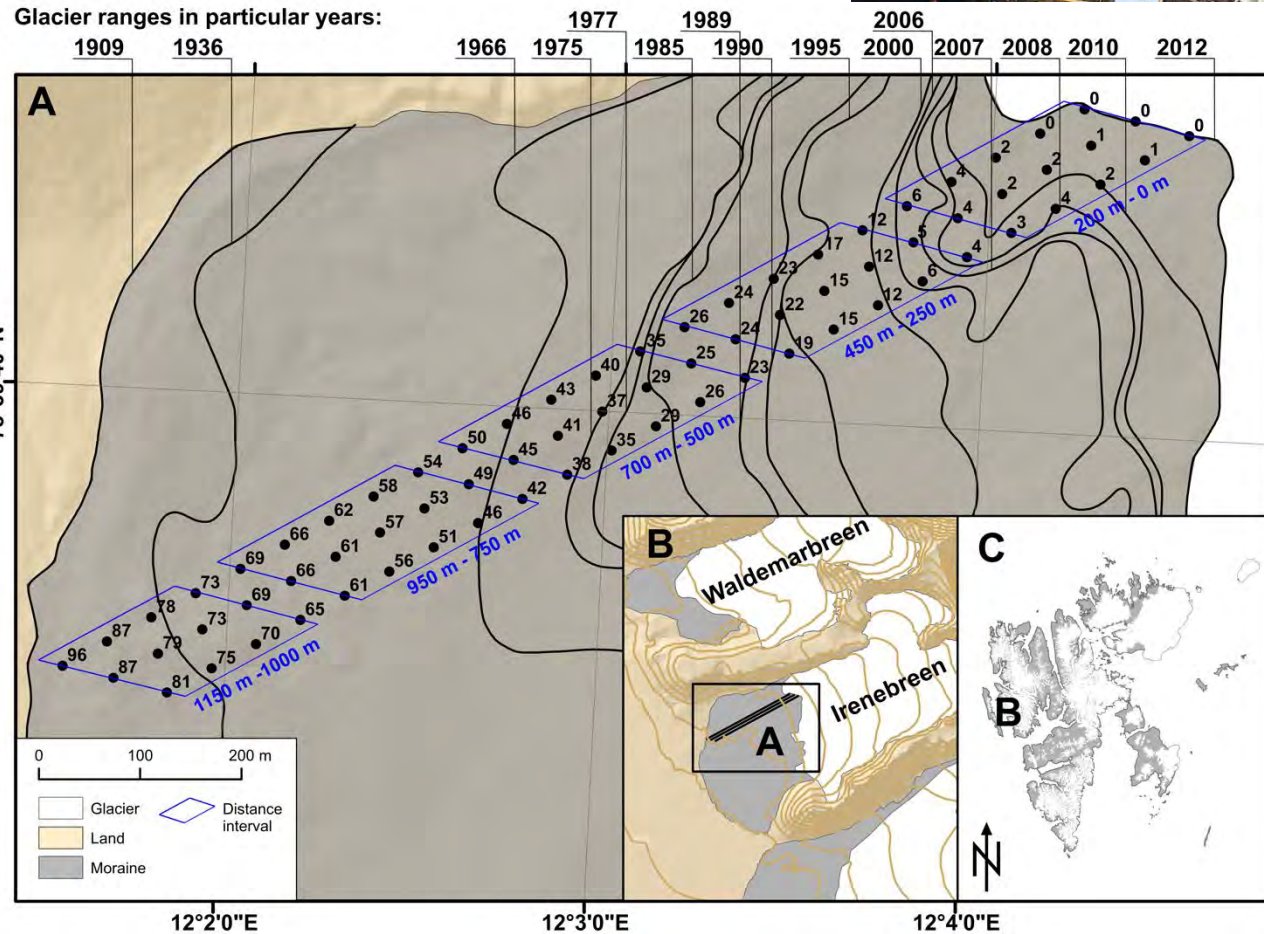


Irenebreen foreland (NW Svalbard)

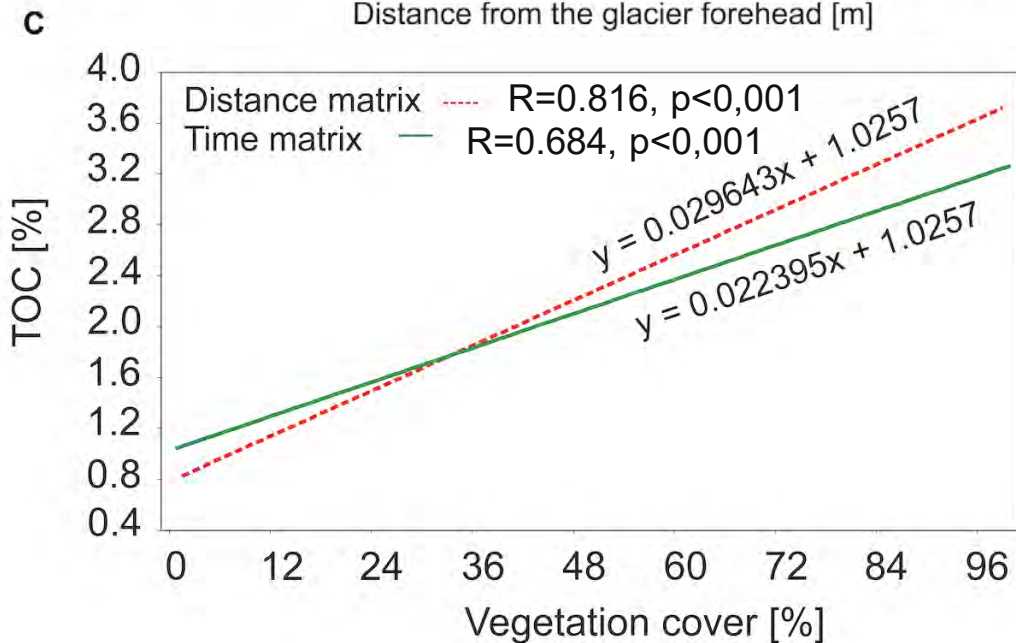
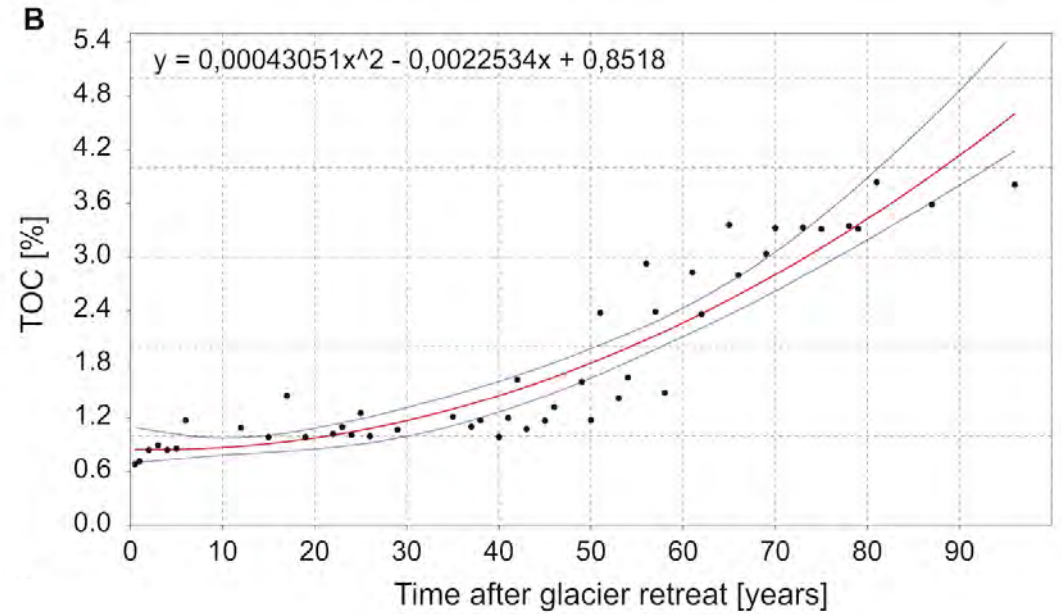
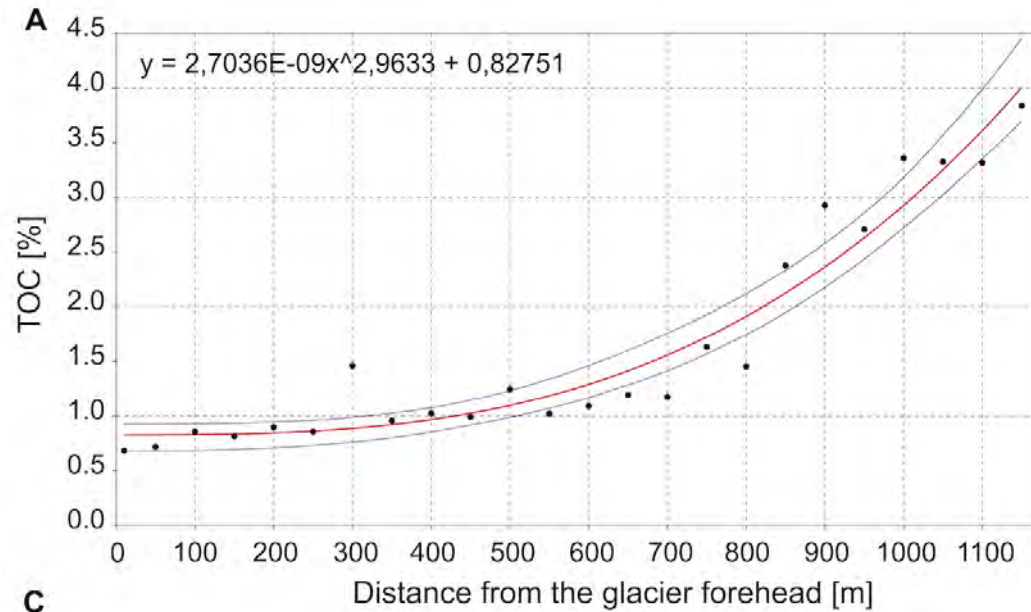


The relationships between soil chemical properties and vegetation succession in the aspect of changes of distance from the glacier forehead and time elapsed after glacier retreat in the Irenebreen foreland (NW Svalbard)

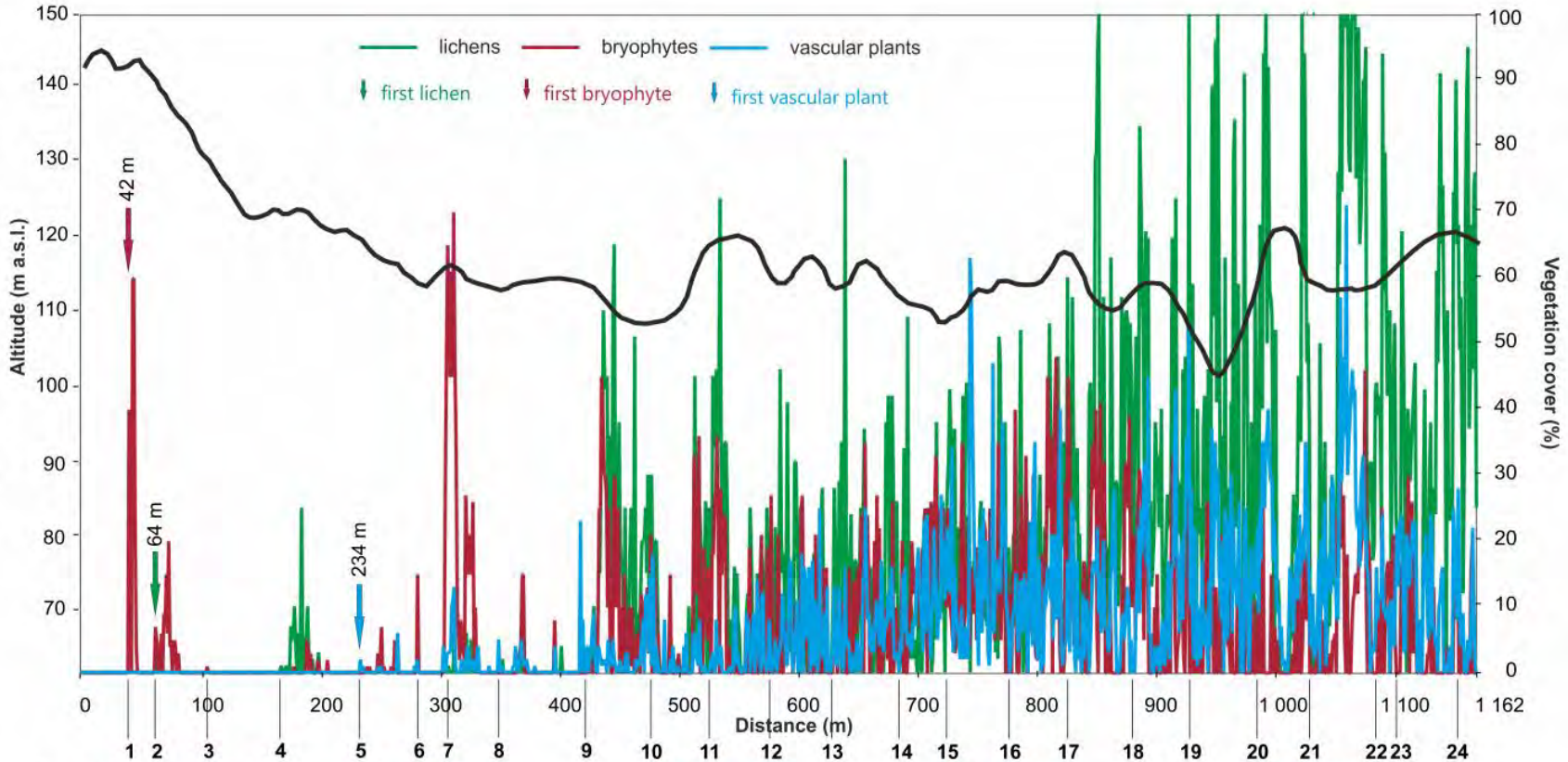
Paulina Wietrzyk  · Kaja Rola · Piotr Osyczka · Paweł Nicia · Wojciech Szymański · Michał Węgrzyn



Total organic carbon (TOC) along Irenebreen foreland



IRENEBREEN FORELAND

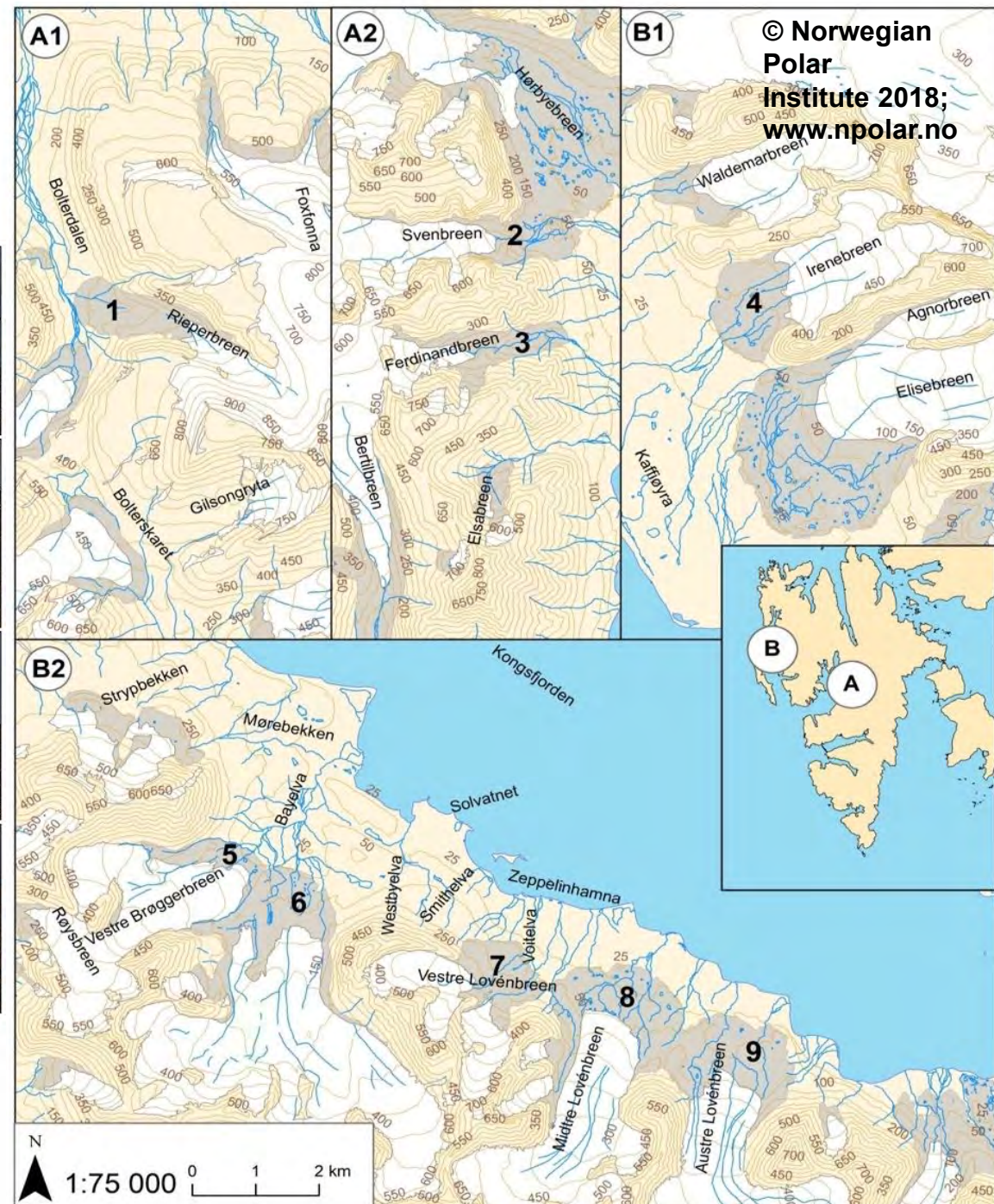
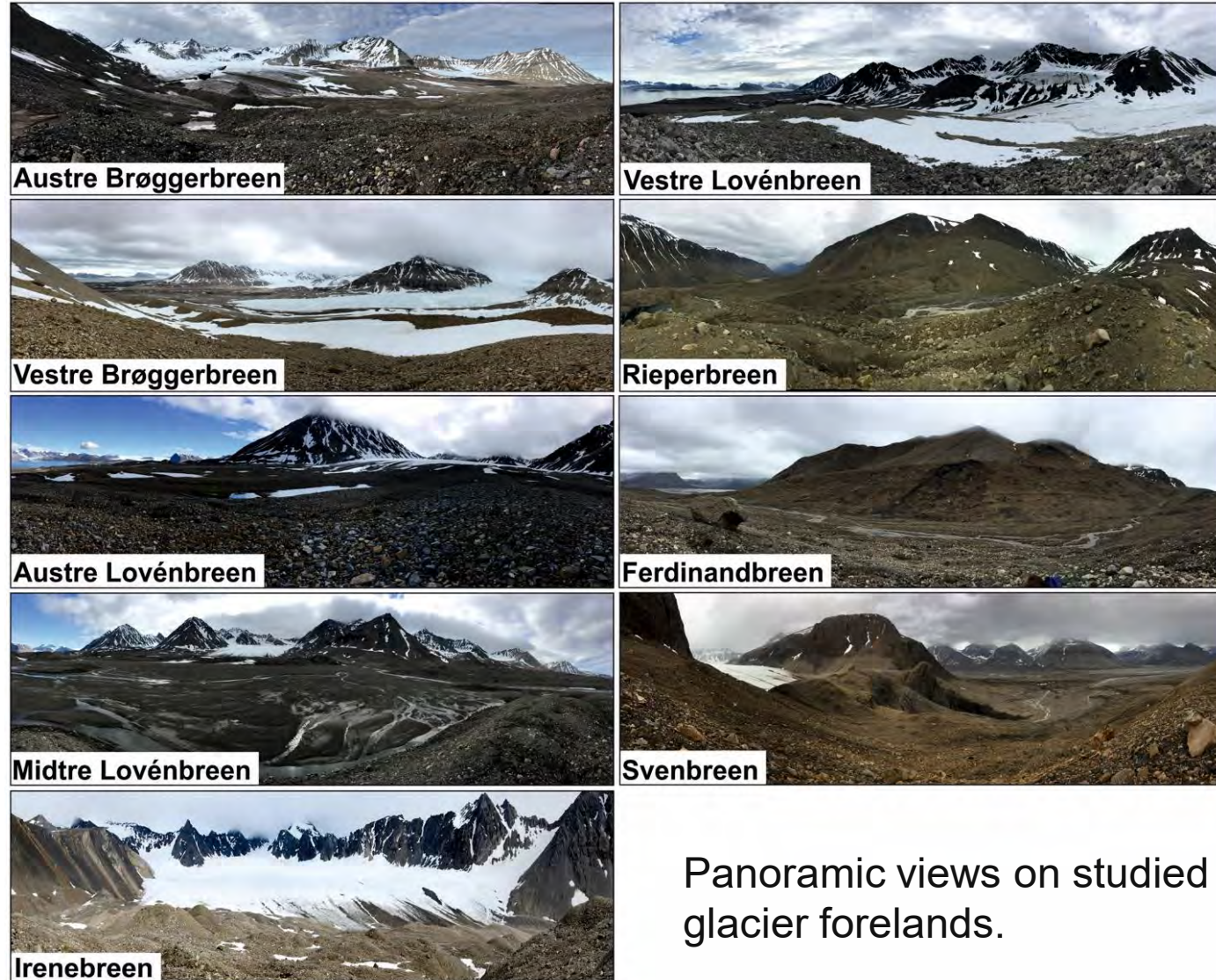


- First records
- | | | | | | | | | | |
|---|---|----|---|----|---|----|--|----|--|
| 1 | <i>Bryum caespiticium</i>
<i>Amblystegium serpens</i>
<i>Bryum calophyllum</i> | 9 | <i>Saxifraga tenuis</i>
<i>Henrica theleodes</i>
<i>Pseudephebe minuscula</i>
<i>Rostania ceranisca</i> | 16 | <i>Draba oxycarpa</i>
<i>Silene uralensis</i>
<i>Oxyria digyna</i>
<i>Odontoschisma sphagni</i>
<i>Andrea blytii</i> | 20 | <i>Salix polaris</i>
<i>Bilimbia sabuletorum</i>
<i>Rhizocarpon hochstetteri</i>
<i>Catillaria chalybeia</i>
<i>Rhizocarpon reductum</i>
<i>Rhizocarpon geographicum</i>
<i>Tremolecia atrata</i>
<i>Umbilicaria cylindrica</i> | 24 | <i>Draba arctica</i>
<i>Draba nivalis</i>
<i>Pohlia cruda</i>
<i>Caloplaca nivalis</i>
<i>Physconia distorta</i>
<i>Fuscidea kochiana</i> |
| 2 | <i>Encalypta alpina</i>
<i>Polyblastia hyperborea</i> | 10 | <i>Isopterygiopsis pulchella</i>
<i>Ditrichum flexicaule</i>
<i>Drepanocladus revolvens</i> | 17 | <i>Bryobilimbia hypnorum</i>
<i>Acarospora fuscata</i>
<i>Aspicilia fimbriata</i>
<i>Aspicilia melanaspis</i>
<i>Calogaya pusilla</i>
<i>Eiglera flavida</i>
<i>Lecanora alpigena</i>
<i>Polysporina simplex</i> | 21 | <i>Porpidia soredizodes</i>
<i>Porina chlorotica</i>
<i>Staurothele arctica</i>
<i>Lecidea ramulosa</i>
<i>Cetrariella delisei</i>
<i>Lecidea lapicida</i>
<i>Umbilicaria hyperborea</i>
<i>Ochrolechia androgyna</i> | 22 | <i>Circinaria caesiocinerea</i>
<i>Lecanora epibryon</i>
<i>Melanelia stygia</i>
<i>Thelidium papulare</i>
<i>Rhizocarpon intermediellum</i>
<i>Umbilicaria proboscidea</i> |
| 3 | <i>Drepanocladus aduncus</i> | 11 | <i>Silene acaulis</i>
<i>Timmia bavarica</i>
<i>Lecidella wulfenii</i>
<i>Eiglera flavida</i>
<i>Stereocaulon alpinum</i>
<i>Henrica melaspora</i>
<i>Flavocetraria nivalis</i> | 18 | <i>Tortella tortuosa</i>
<i>Verrucaria aethiobola</i>
<i>Cladonia pyxidata</i>
<i>Ochrolechia frigida</i> | 23 | <i>Polyblastia schaereriana</i>
<i>Candelariella vitellina</i> | 24 | <i>Amundsenia approximata</i>
<i>Verrucaria nigrescens</i> |
| 4 | <i>Polyblastia cupularis</i> | 12 | <i>Cerastium regelii</i>
<i>Bryum pseudotriquetrum</i>
<i>Bryum turgidum</i>
<i>Pohlia wahlenbergii</i>
<i>Polyblastia sendtneri</i>
<i>Sporodictyon terrestre</i>
<i>Lecidella stigmatea</i>
<i>Carbonea vorticosa</i>
<i>Acarospora molybdina</i>
<i>Pseudephebe pubescens</i> | 19 | <i>Sanionia uncinata</i>
<i>Catillaria contristans</i>
<i>Xanthoria elegans</i> | 19 | <i>Sagina nivalis</i>
<i>Saxiraga nivalis</i>
<i>Bacidia bagliettoana</i>
<i>Bacidia illudens</i> | | |
| 5 | <i>Draba pauciflora</i>
<i>Papaver dahlianum</i>
<i>Cerastium alpinum</i>
<i>Saxifraga oppositifolia</i> | 13 | | 24 | <i>Thelidium pyrenophorum</i>
<i>Blastenia ammiospila</i> | | | | |
| 6 | <i>Saxifraga caespitosa</i> | 14 | | | | | | | |
| 7 | <i>Poa alpina</i>
<i>Saxifraga cernua</i>
<i>Draba alpina</i>
<i>Ditrichum cylindricum</i> | 15 | | | | | | | |
| 8 | <i>Cochlearia groenlandica</i> | | | | | | | | |

Is there any contribution of BSCs to soil development?

Are there any difference in BSC composition along succession gradient?
What influence BSC composition?

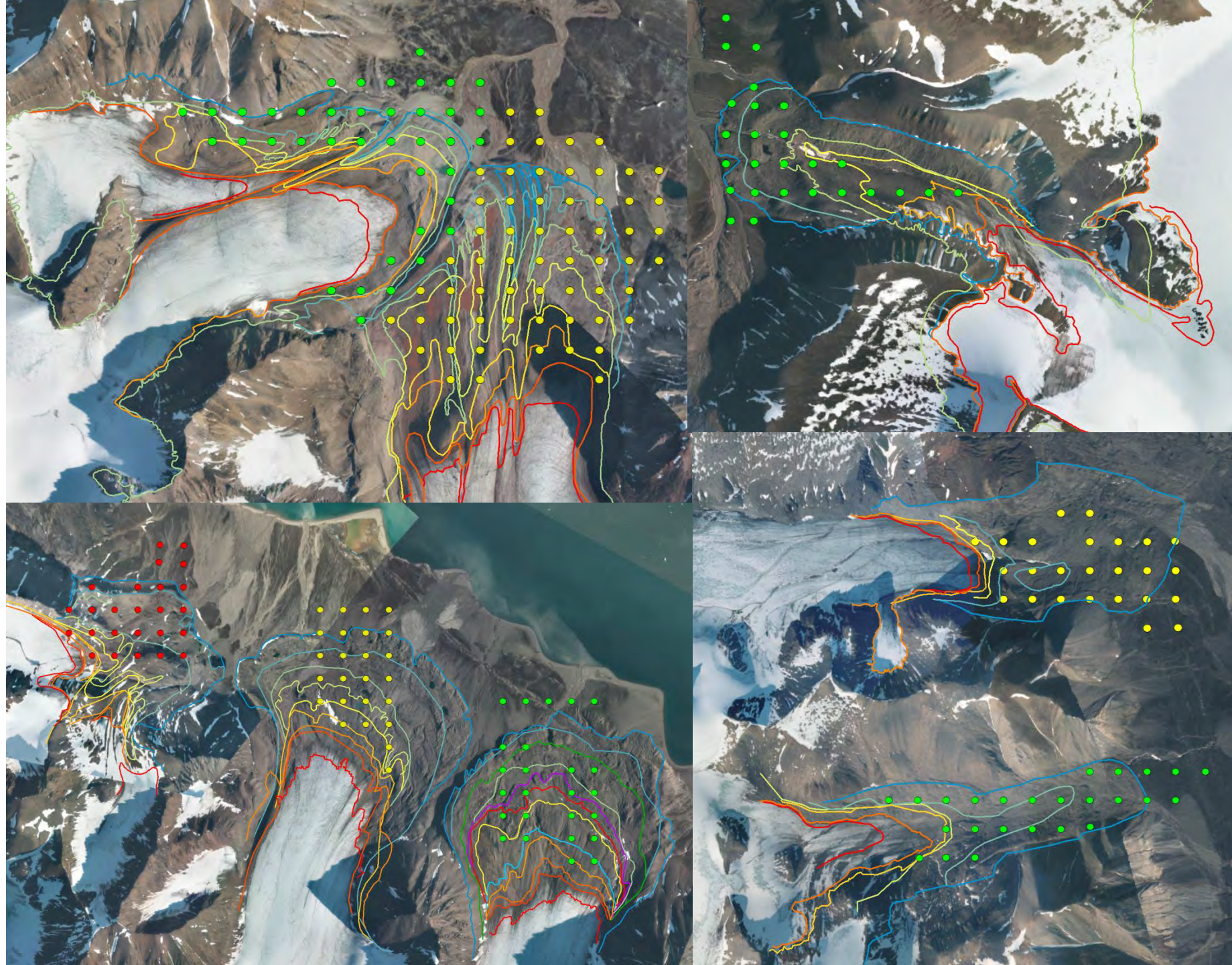
Methodology – glacier forelands of Kongsfjorden and Isfjorden



Panoramic views on studied glacier forelands.

Methodology:

- Regular grid: 270 plots;
- Plots localities in each 200 m;
- Percentage cover of species of lichens, bryophytes, and vascular plants;
- Percent cover of group of species and percent cover of BSCs;
- Soil samples;
- GIS data.



Soil sample analyses:

- Soil texture,
- pH,
- Carbonate content,
- Content of total nitrogen, total carbon, total organic carbon,
- Content of exchangeable cations,
- Content of available phosphorus, magnesium, and potassium;



BSC sample analyses:

- Species identification,
- Content of nitrogen, organic carbon;



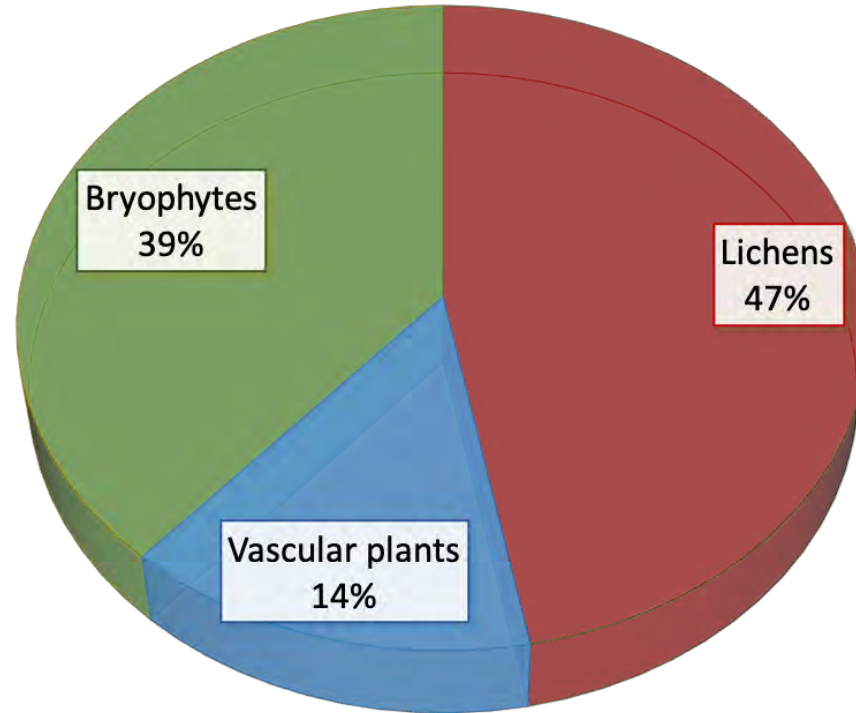
Spatial analyses:

- Aspect,
- Slope,
- Topographic Wetness Index,
- Time elapsed after glacier retreat,
- Distance to the current glacier forehead.

Species number – dominance of cryptogamic organisms



110 species of bryophytes

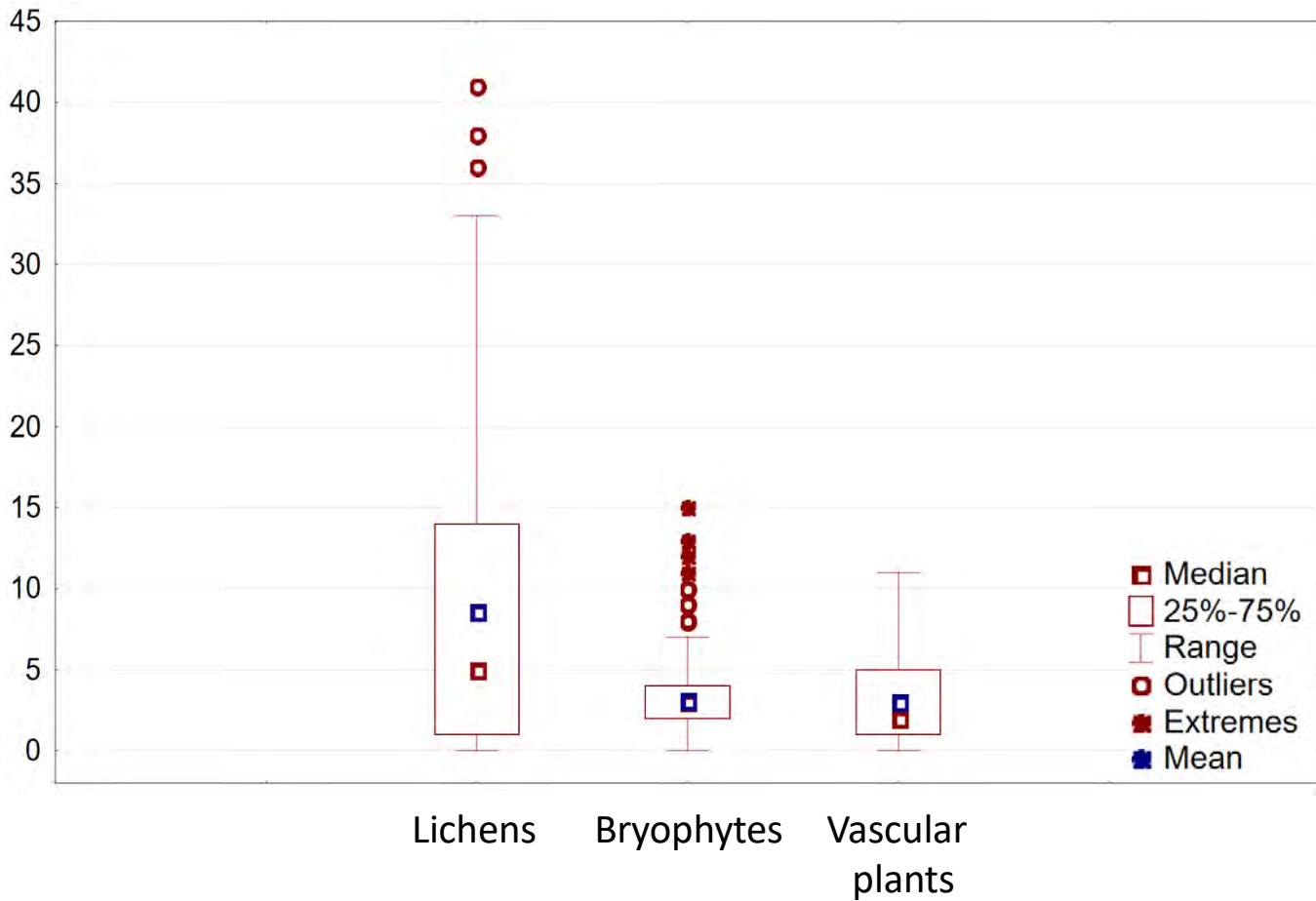


41 species of vascular plants

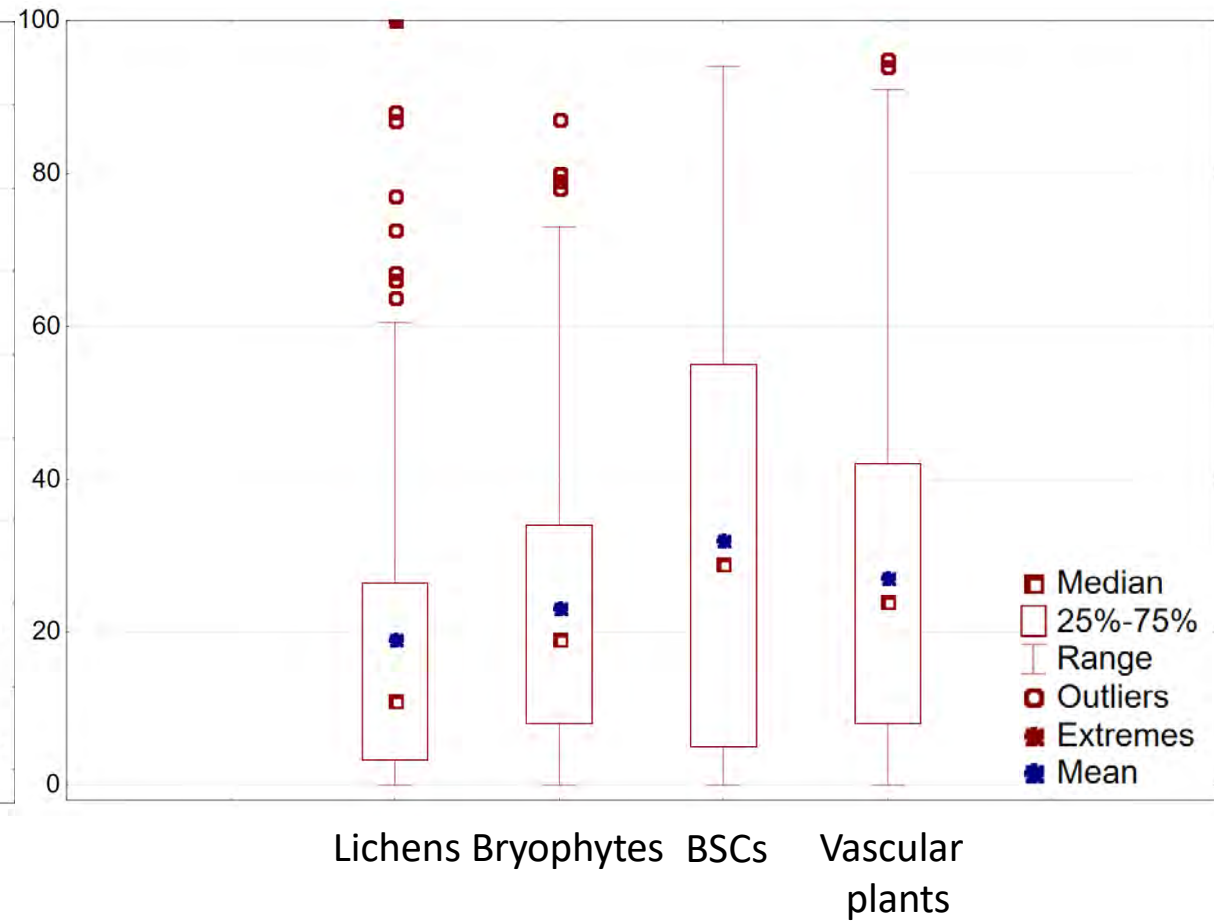


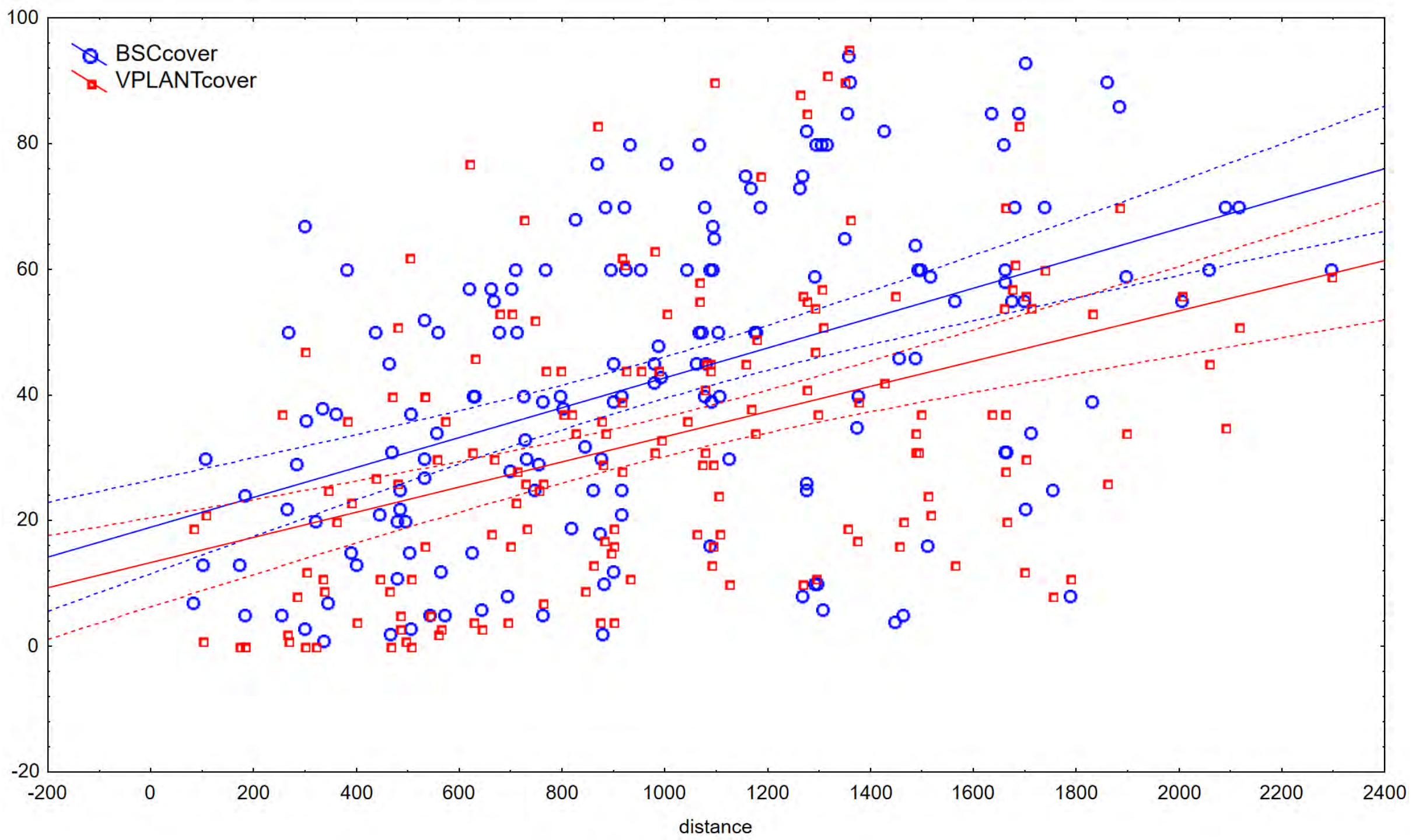
134 species of lichens

Species number

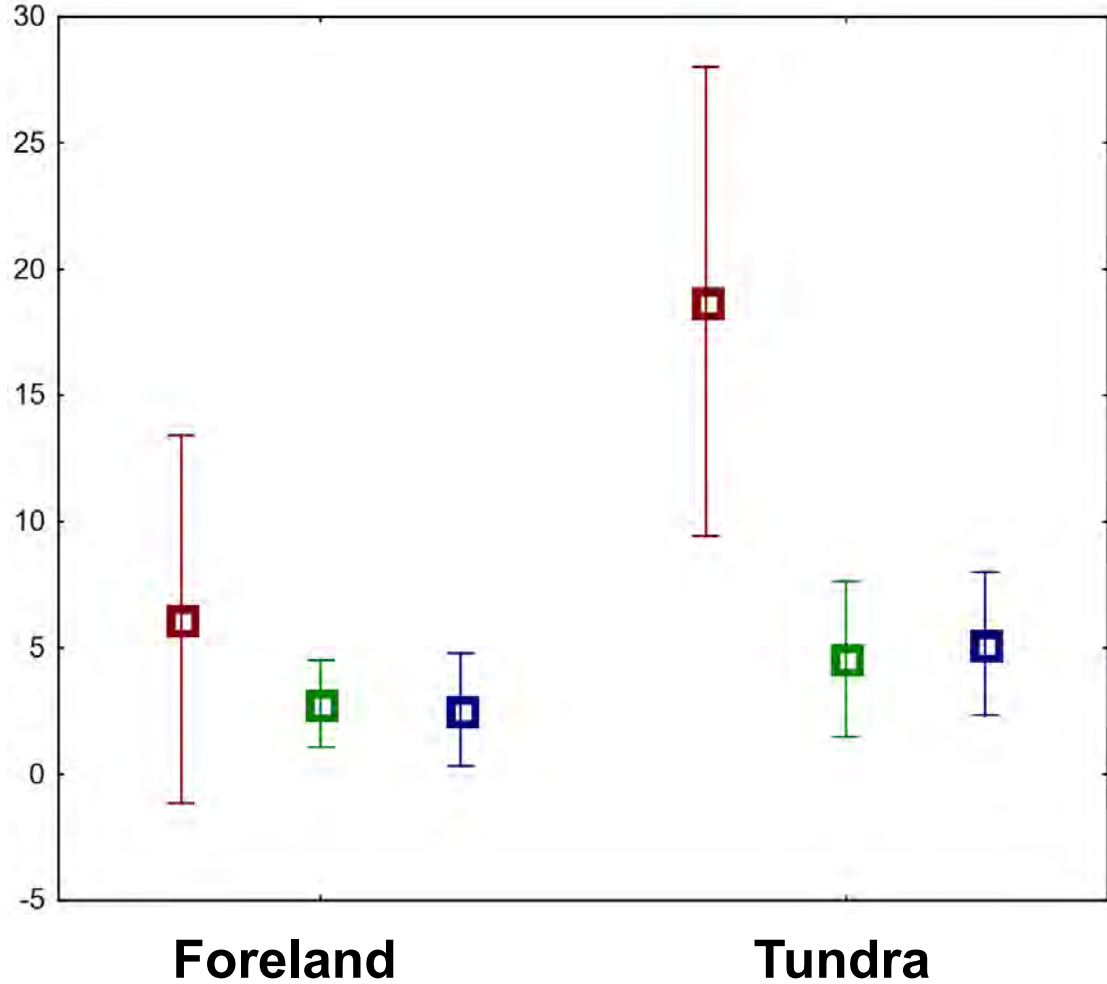


Percent cover





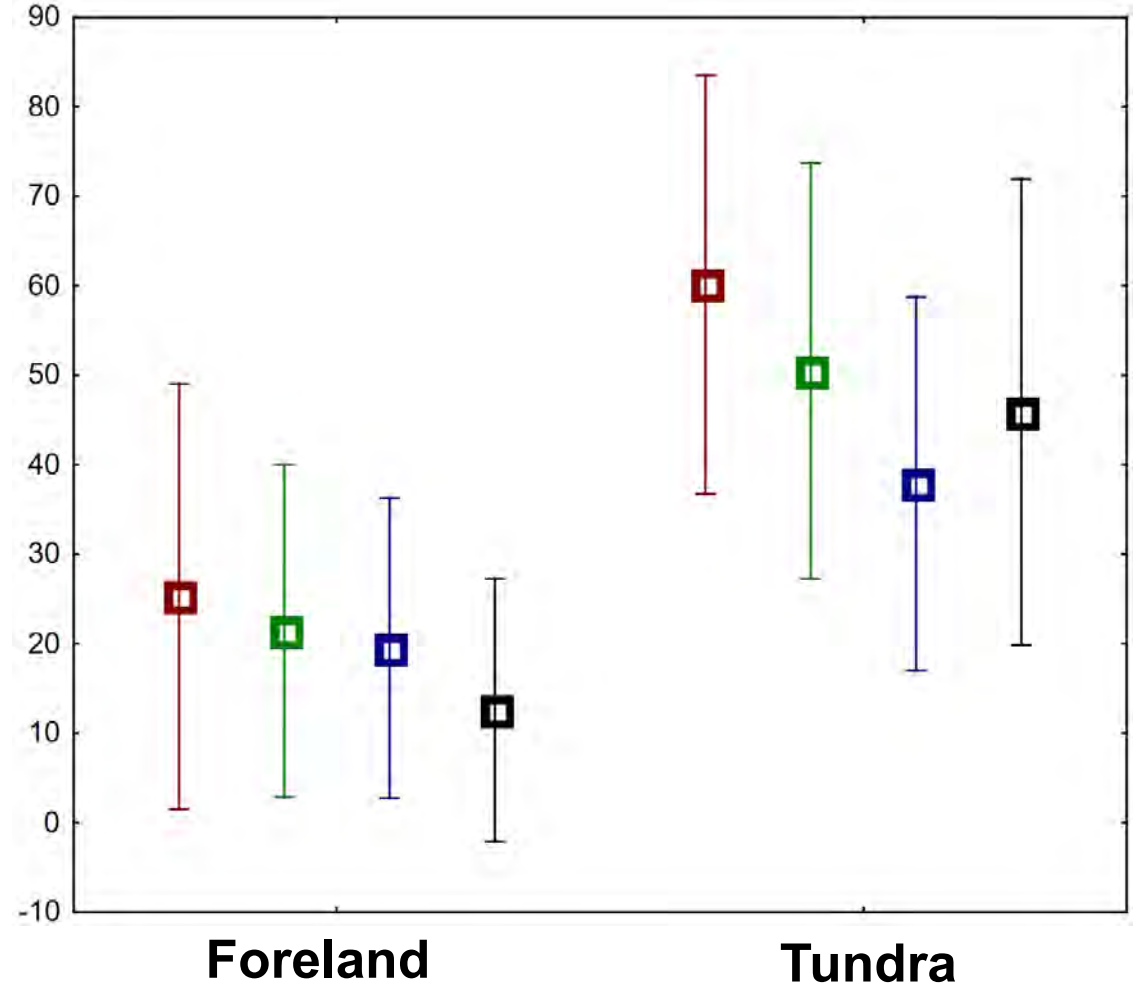
Species number



SD
Mean
SD

Lichens
Bryophytes
Vascular plants

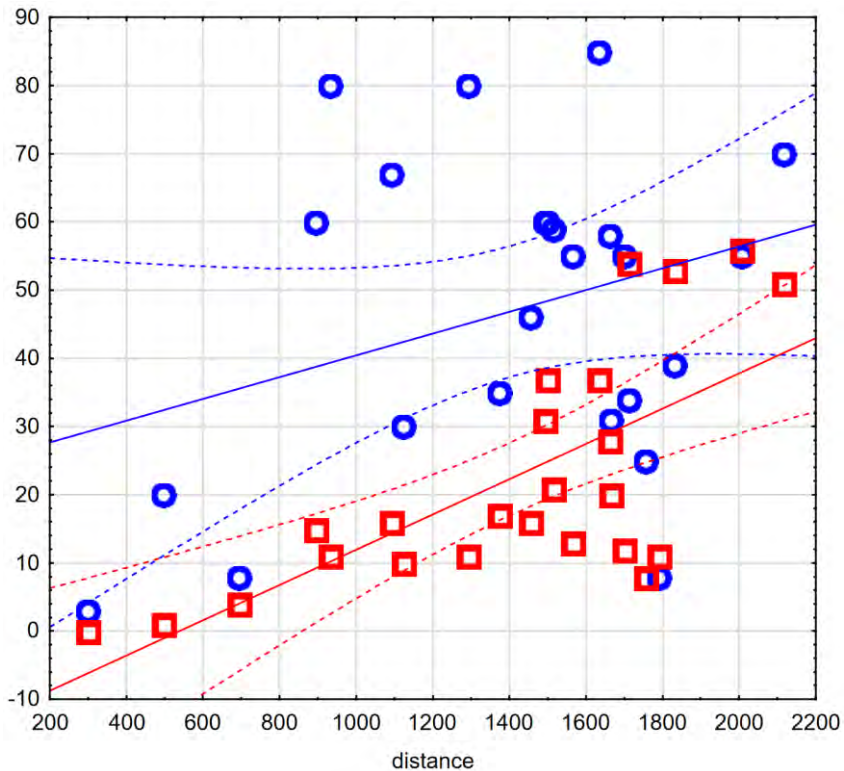
Percent cover



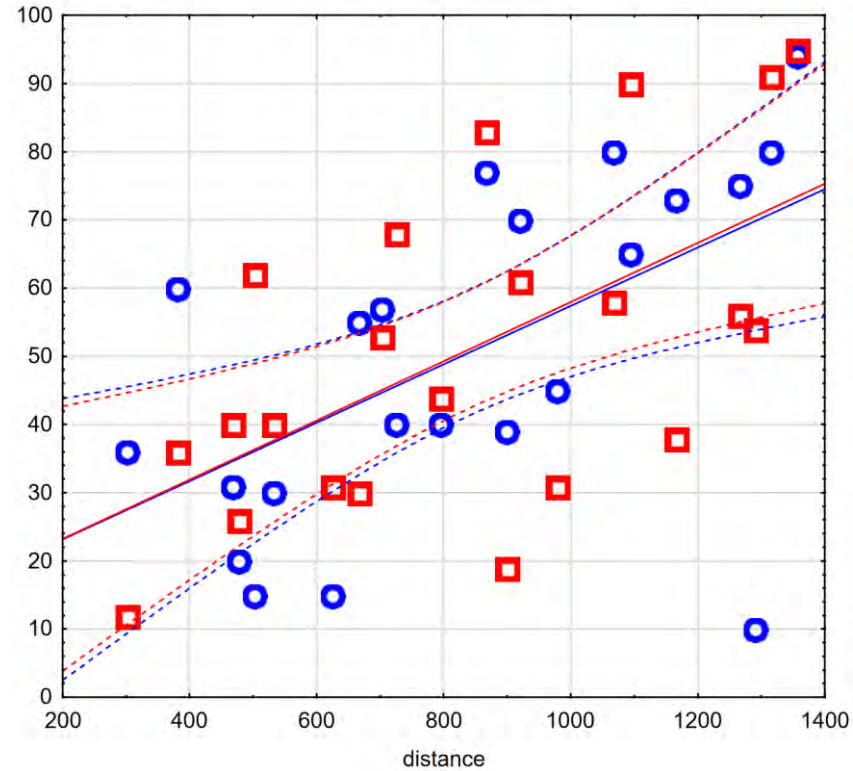
SD
Mean
SD

BSCs
Vascular plants
Bryophytes
Lichens

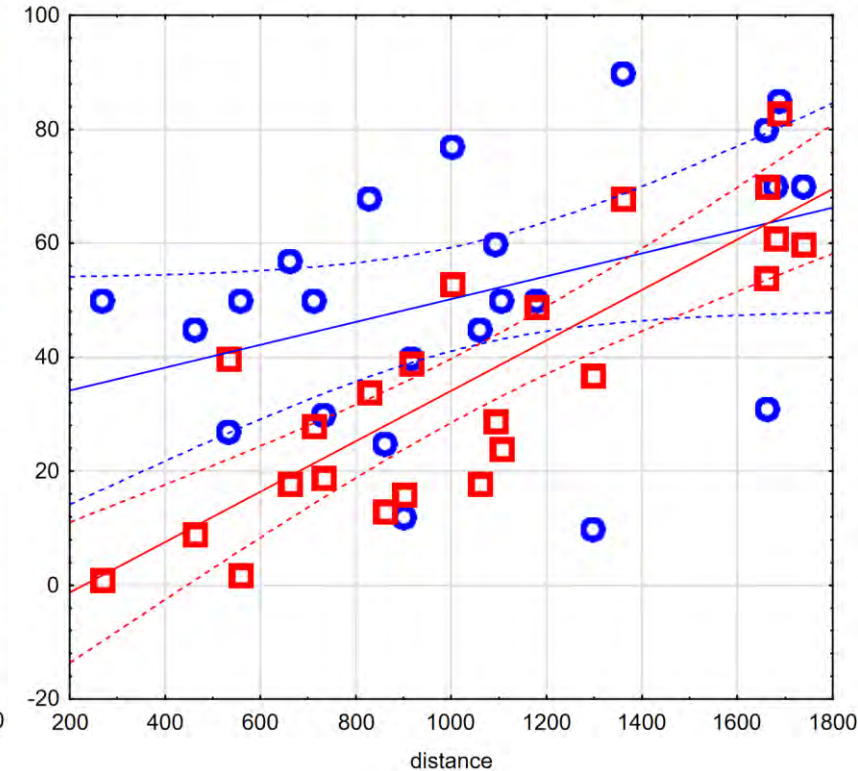
Rieperbreen



Midtre Lovénbreen



Austre Lovénbreen



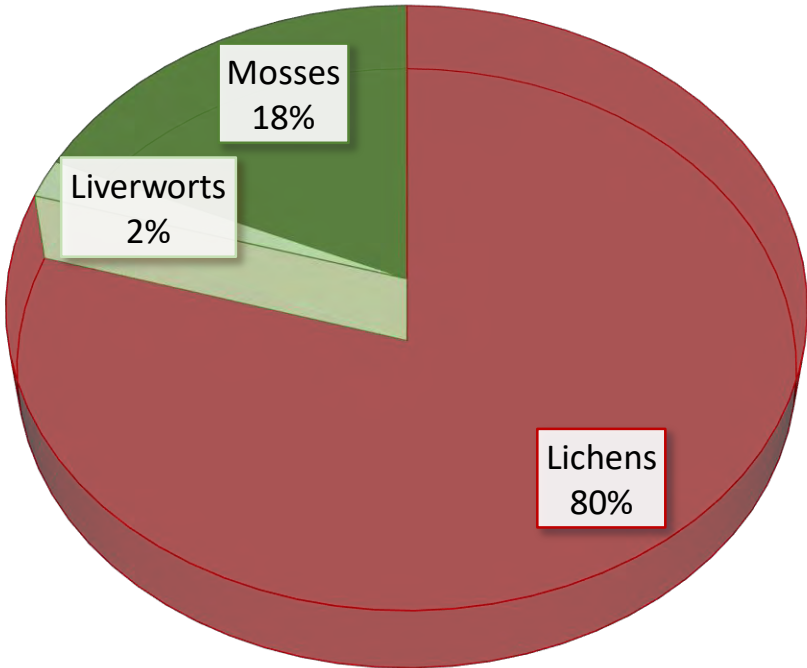
Species composition of BSCs



9 species of mosses



1 species of liverworts

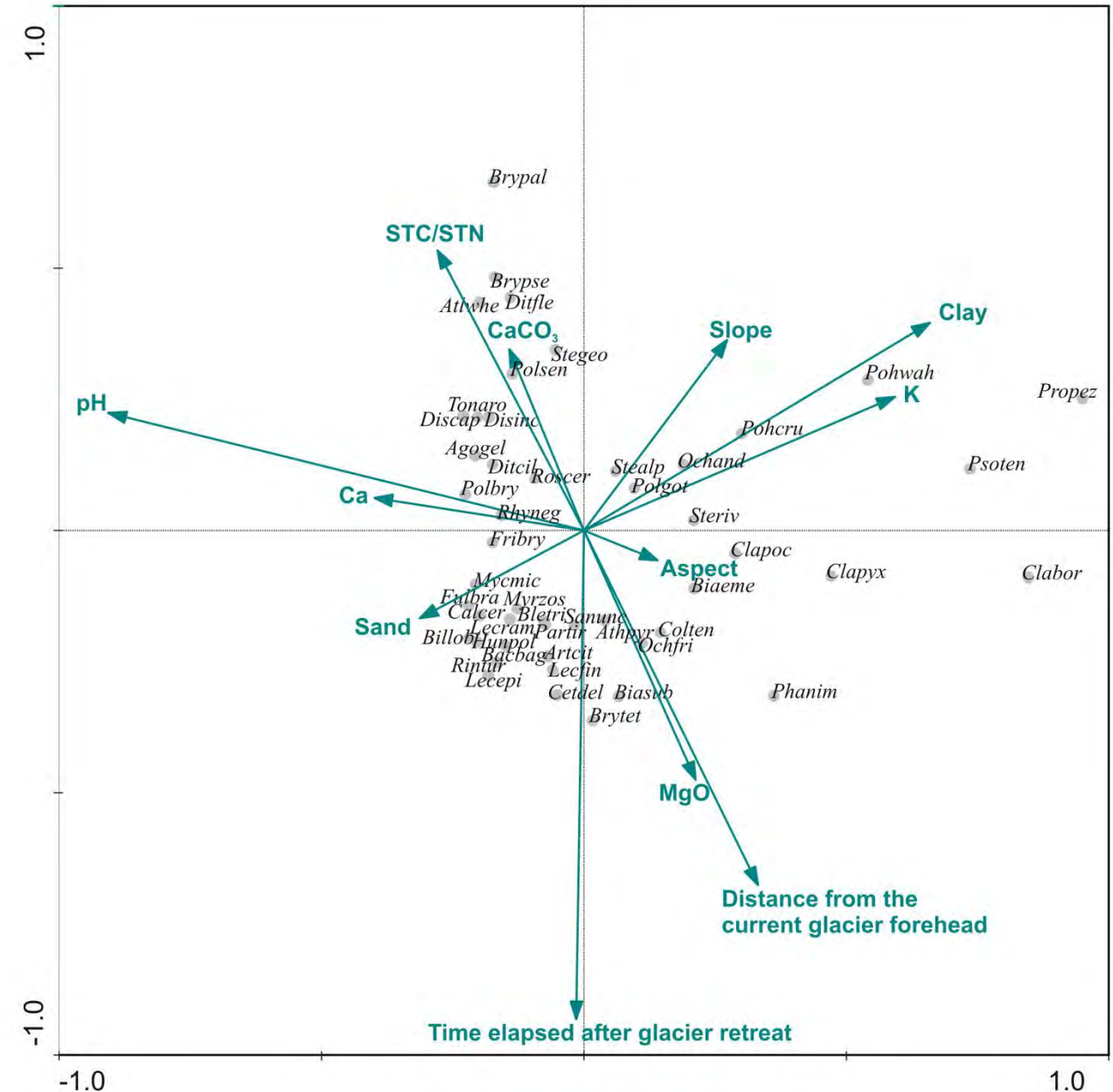


39 species of lichens

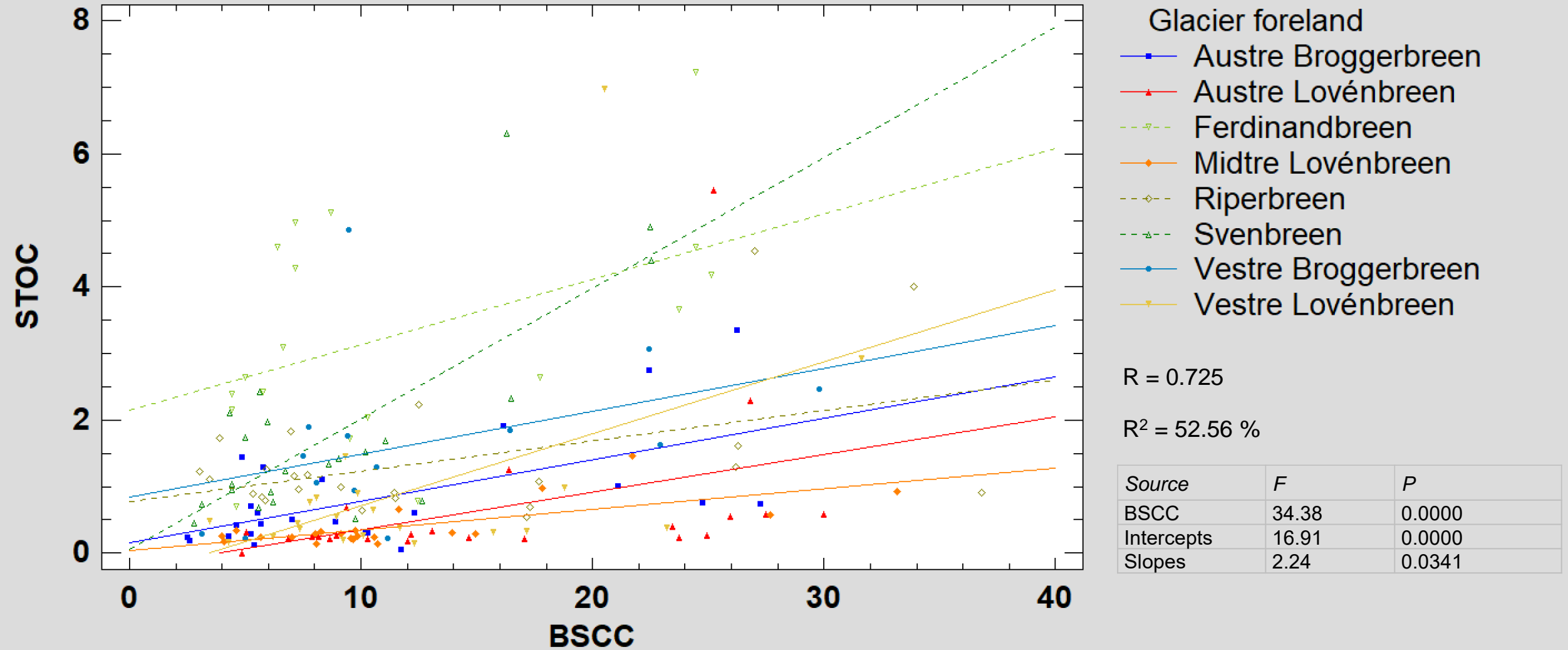
- | Liverworts | Mosses | Lichens |
|------------------------------------|-------------------------------|---------------------------------|
| <i>Blepharostoma trichophyllum</i> | <i>Bryum pallescens</i> | <i>Agonimia gelatinosa</i> |
| | <i>Bryum pseudotriquetrum</i> | <i>Arthrorhaphis citrinella</i> |
| | <i>Distichium capillaceum</i> | <i>Athallia pyrace</i> |
| | <i>Distichium inclinatum</i> | <i>Atla wheldonii</i> |
| | <i>Ditrichum cilindricum</i> | <i>Bacidia bagliettoana</i> |
| | <i>Ditrichum flexicaule</i> | <i>Biatora ementiens</i> |
| | <i>Pohlia cruda</i> | <i>Biatora subduplex</i> |
| | <i>Pohlia wahlenbergii</i> | <i>Bilimbia lobulata</i> |
| | <i>Sanionia uncinata</i> | <i>Bryoplaca tetraspora</i> |
| | | <i>Caloplaca cerina</i> |
| | | <i>Cetrariella delisei</i> |
| | | <i>Cladonia borealis</i> |
| | | <i>Cladonia pocillum</i> |
| | | <i>Cladonia pyxidata</i> |
| | | <i>Collema tenax</i> |
| | | <i>Frigidopyrenia bryospila</i> |
| | | <i>Fulgensia bracteata</i> |
| | | <i>Huneckia pollinii</i> |
| | | <i>Lecanora epibryon</i> |
| | | <i>Lecidea ramulosa</i> |
| | | <i>Leciophysma finmarkicum</i> |
| | | <i>Mycobilimbia microcarpa</i> |
| | | <i>Myriolecis zosteræ</i> |
| | | <i>Ochrolechia androgyna</i> |
| | | <i>Ochrolechia frigida</i> |
| | | <i>Parvoplaca tirolensis</i> |
| | | <i>Phaeorrhiza nimbose</i> |
| | | <i>Polyblastia bryophila</i> |
| | | <i>Polyblastia gothica</i> |
| | | <i>Polyblastia sendtneri</i> |
| | | <i>Protopannaria pezizoides</i> |
| | | <i>Psoroma tenue</i> |
| | | <i>Rhymbocarpus neglectus</i> |
| | | <i>Rinodina turfacea</i> |
| | | <i>Rostania ceranisca</i> |
| | | <i>Steinia geophana</i> |
| | | <i>Stereocaulon alpinum</i> |
| | | <i>Stereocaulon rivulorum</i> |
| | | <i>Toninia aromatica</i> |

Environmental factors affecting BSC composition

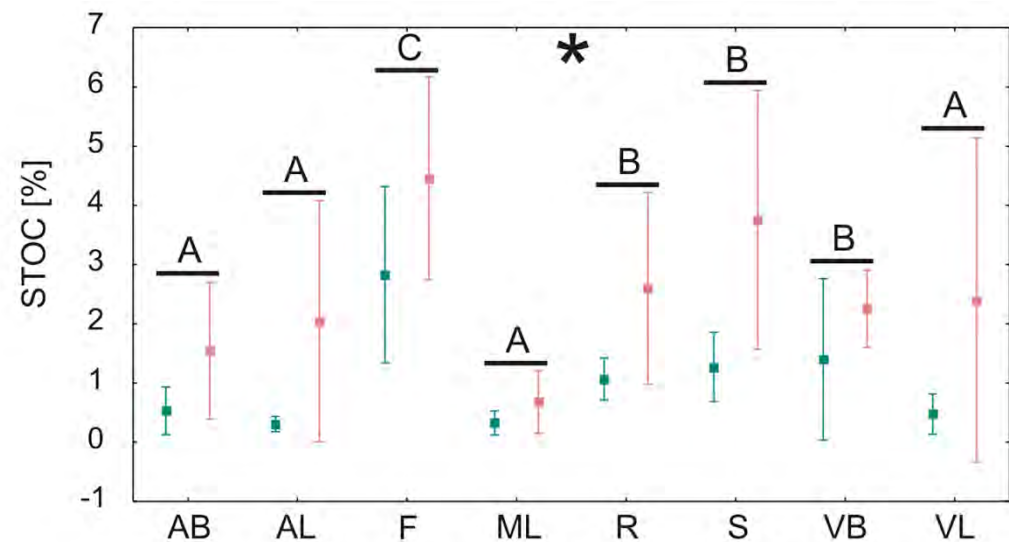
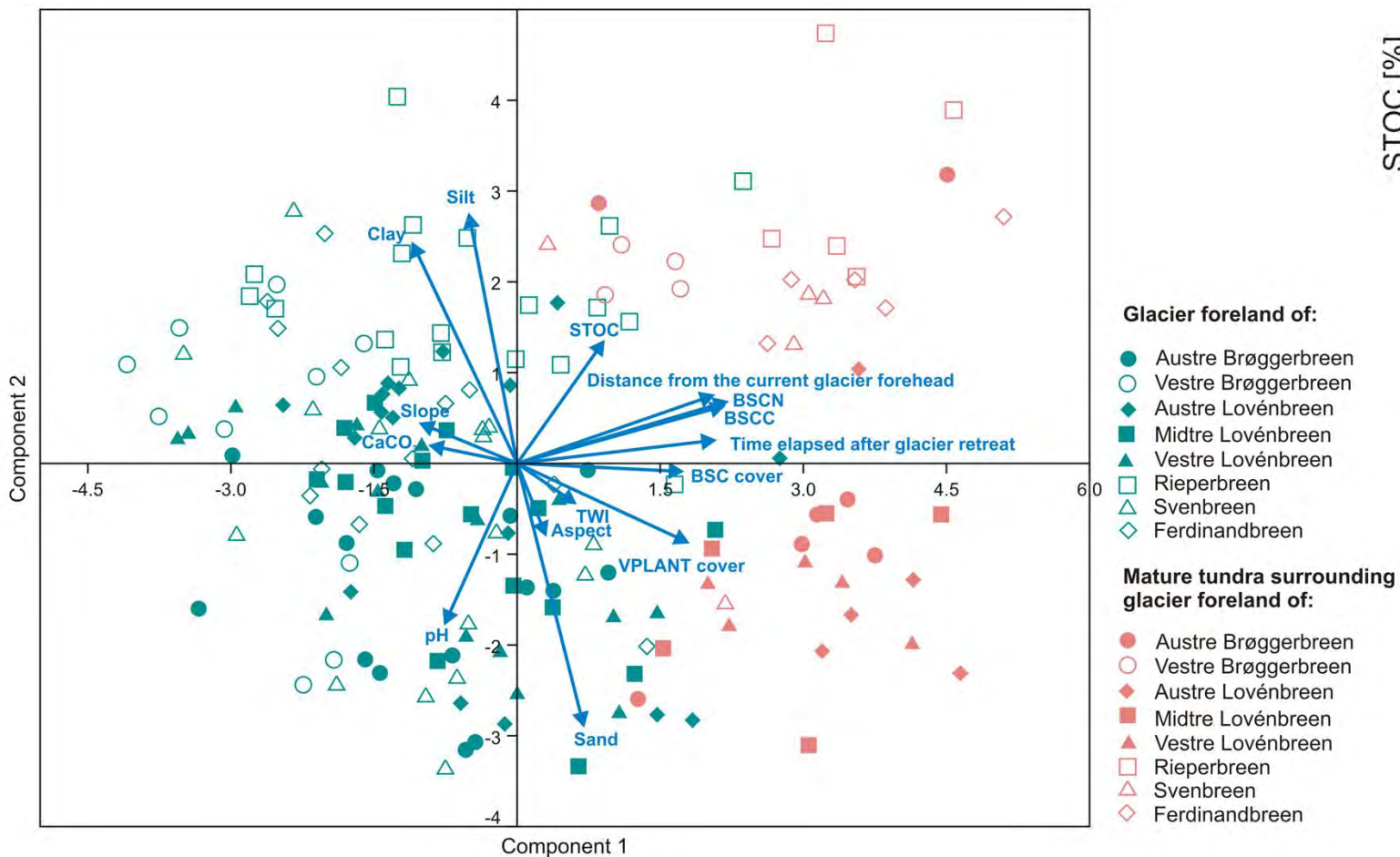
Conditional Effects				
Variable	Var. N	Lambda	A P	F
pH	17	0.27	0.001	13.83
Time elapsed after glacier retreat (years)	6	0.24	0.001	13.31
Ca (cmol/kg)	7	0.05	0.001	3.04
Clay (%)	20	0.05	0.001	2.88
K (cmol/kg)	9	0.04	0.002	2.29
CaCO ₃ (mg/g)	14	0.04	0.002	2.05
Sand (%)	18	0.03	0.004	1.98
C/N	2	0.03	0.013	1.75
Distance from the current glacier forehead (m)	4	0.03	0.006	1.76
Aspect (rad)	23	0.03	0.013	1.74
MgO (mg/g)	11	0.03	0.017	1.73
Slope (rad)	22	0.03	0.047	1.51
Vascular plant cover (%)	21	0.02	0.157	1.27
K ₂ O (mg/g)	12	0.02	0.142	1.27
Conductivity (μS/cm)	16	0.02	0.141	1.30
Soil total organic carbon (%)	15	0.02	0.266	1.15
Topographic Wetness Index	24	0.02	0.377	1.05
Mg (cmol/kg)	8	0.01	0.466	1.00
Na (cmol/kg)	10	0.02	0.440	1.01
Soil total nitrogen	1	0.02	0.608	0.90
P ₂ O ₅ (mg/g)	13	0.01	0.821	0.75



Contents of total organic carbon (%) in soil and BSCs



Factors affecting soil development



N=127	Standardised β coefficient	SE	t	p
Constant			2.316	0.022
Glacier foreland	0.337	0.077	4.358	0.000
BSC cover	-0.250	0.074	-3.365	0.001
BSCN	-0.786	0.158	-4.986	< 0.001
BSCC	0.615	0.144	4.265	< 0.001
pH	-0.199	0.076	-2.633	0.010
TWI	0.158	0.073	2.179	0.031

R= 0.692, R²= 47.93%, F=13.576, p<0.001

Take home message



Lichens were dominant components of BSCs in studied areas.



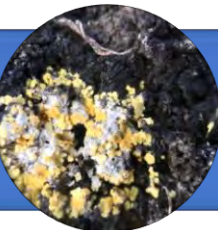
BSCs composition depends on multiple factors, within which soil pH, age of substrate, and soil texture, Ca, K, MgO seems to be the most important.



Due to foreland individuality, soil development occurs differently in each foreland.



BSCs were significantly associated with soil development in the glacier forelands. Besides BSCs, also pH and wetness of substrate affect soil development.

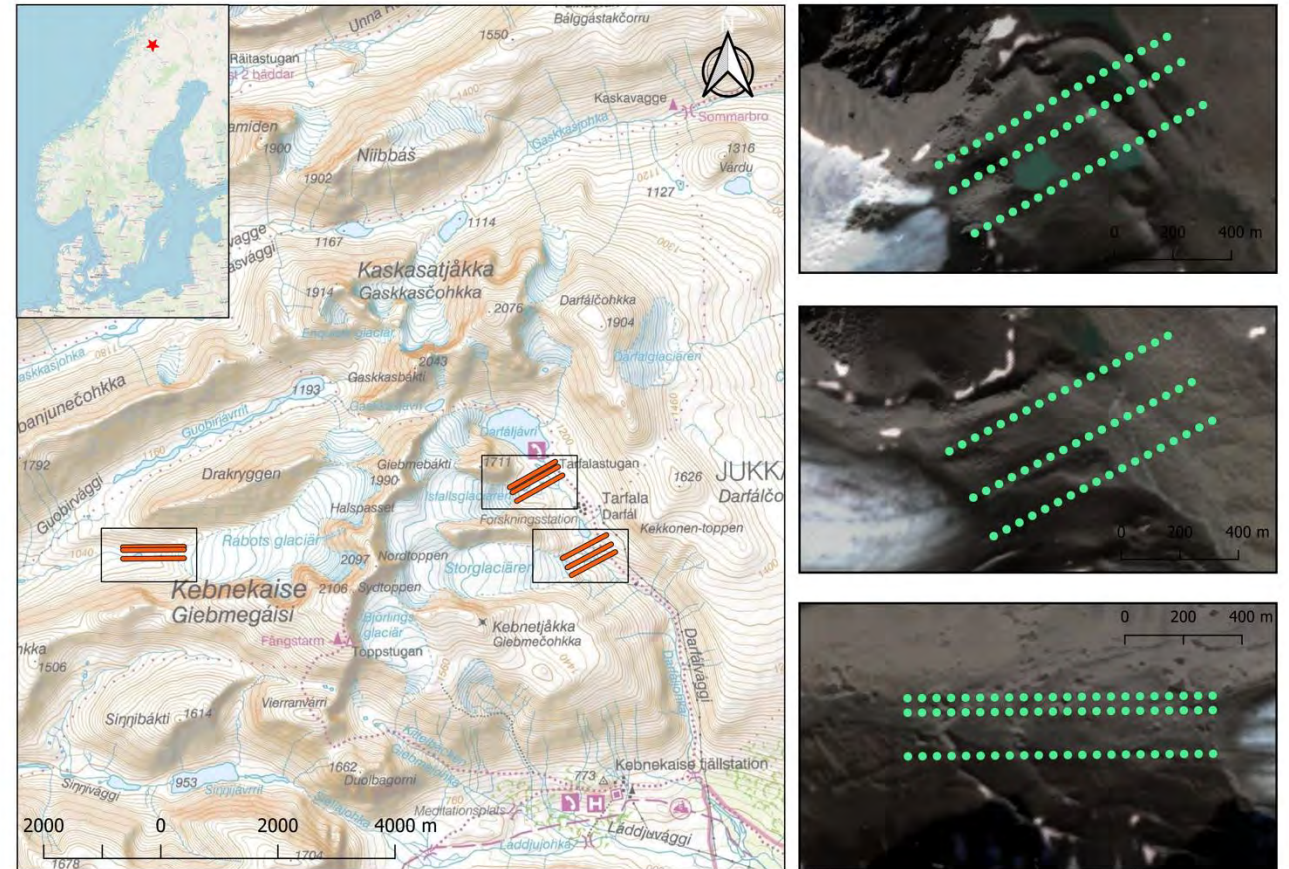


Character of primary succession and soil development seems to be different for particular glacier foreland.

Project: Cryptogams as the main factor influencing initial development of soil and carbon sequestration in glacier forelands in northwest Sweden

Research Extension – summer of 2019:

- Forelands: Isfallsglaciär, Storeglaciär, Rabotsglaciär;
- 3 parallel transects: 144 plots;
- Plots localities in each 50 m;
- Data on vegetation;
- Soil samples;
- Flights with DJI Phantom 4 Advanced (images, orthomosaic, Digital Terrain Model);
- GIS data from open access spatial databases.





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W KRAKOWIE



INTER = ACT



NATIONAL SCIENCE CENTRE
POLAND

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