Development of vegetation and soil in the glacier forelands in Svalbard

Paulina Wietrzyk-Pełka[1], Jakub Pełka[2], Michał Węgrzyn[1], Beata Cykowska-Marzencka[1], and Wojciech Szymański[4]

[1] Professor Z. Czeppe Department of Polar Research and Documentation, Institute of Botany, Jagiellonian University, Gronostajowa 3, 30-387 Cracow, Poland

[2] Department of Geodata, Architecture and Environment Office, Halmstad Municipality, Box 153, 301 05 Halmstad, Sweden

[3]Department of Mycology, W. Szafer Institute of Botany Polish Academy of Sciences, Lubicz 46, 31-512 Kraków, Poland,

[4]Department of Pedology and Soil Geography, Institute of Geography and Spatial Management, Jagiellonian University, Gronostajowa 7, 30-387 Kraków, Poland

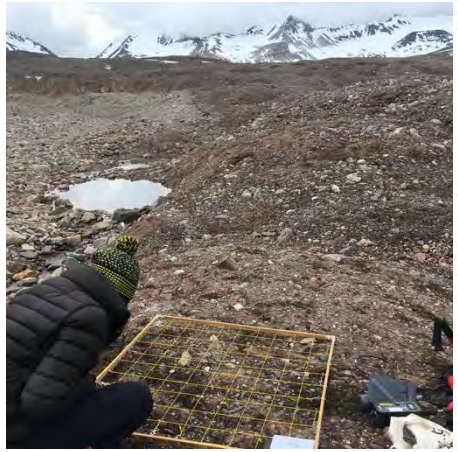
20th International Tundra EXperiment Meeting, 12th September 2019, Parma, Italy paulina.wietrzyk@gmail.com

General information – genesis of research subject

How people usually see succession:

How we see it:

Irenebreen foreland (NW Svalbard)

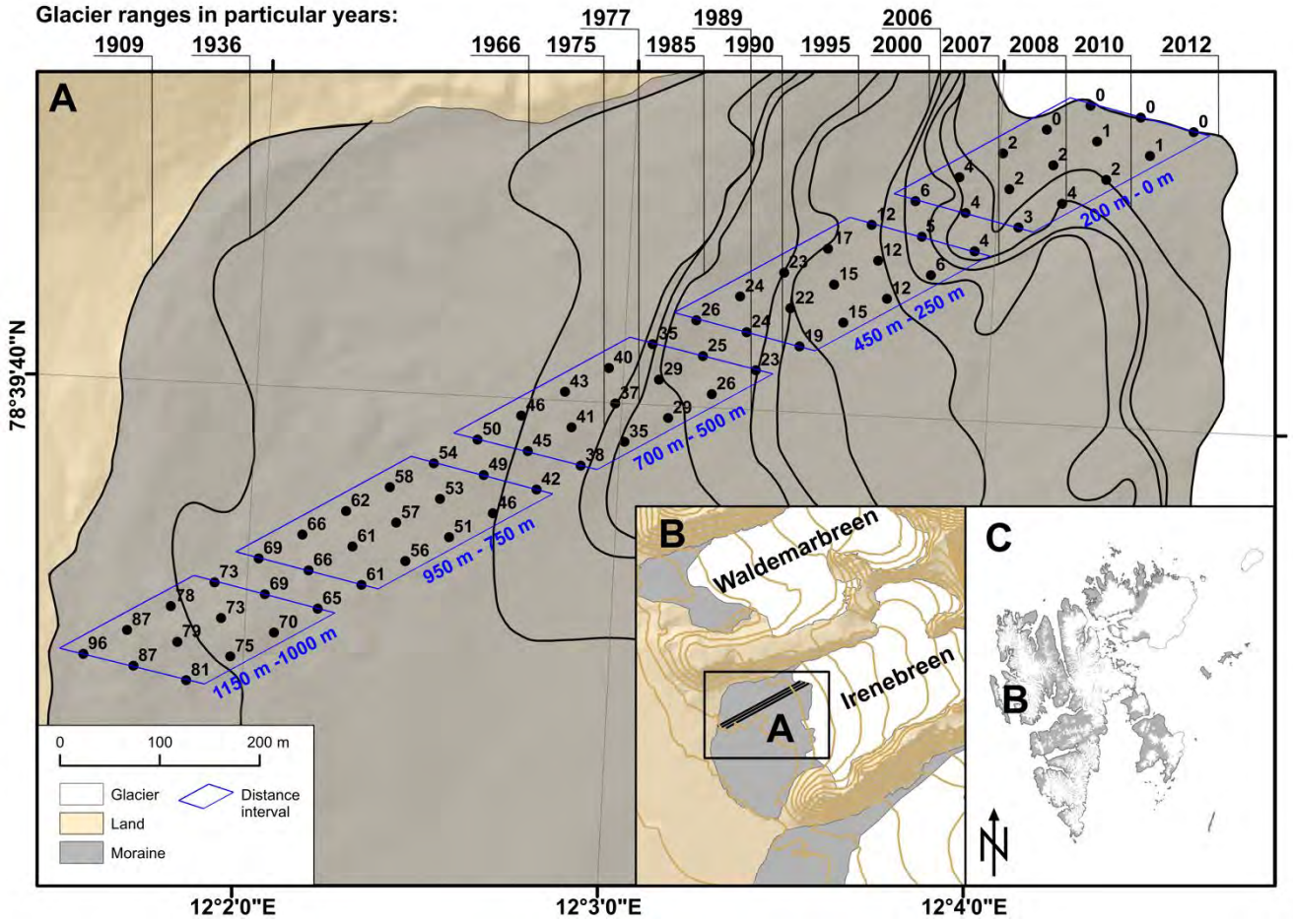


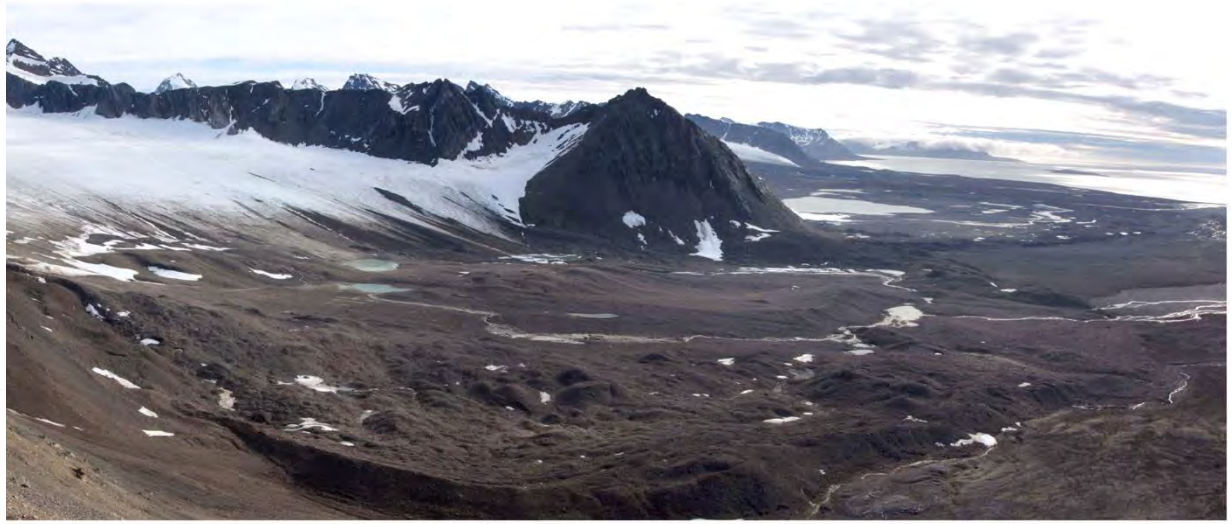
Plant Soil (2018) 428:195–211
https://doi.org/10.1007/s11104-018-3660-3

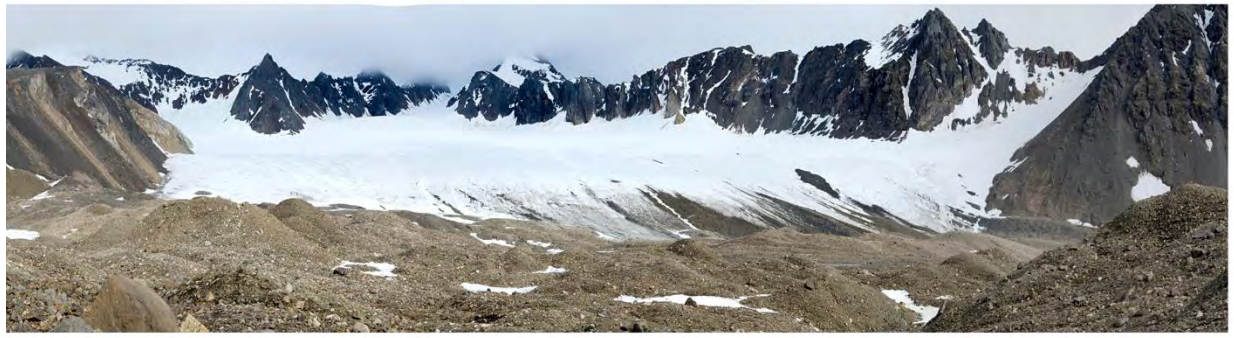
REGULAR ARTICLE

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)

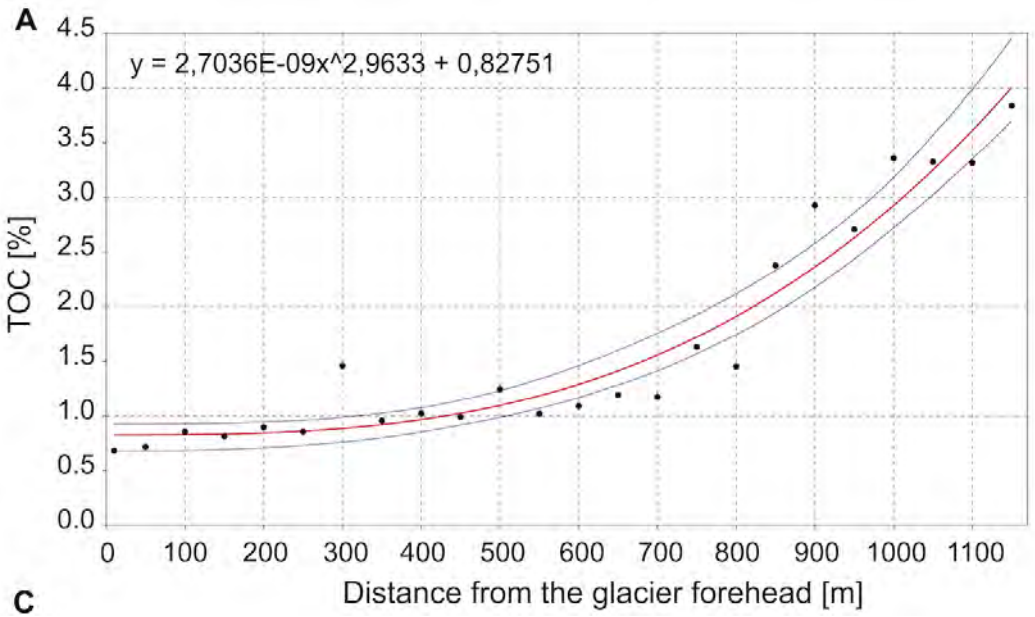
Paulina Wietrzyk · Kaja Rola · Piotr Osyczka · Paweł Nicia · Wojciech Szymański · Michał Węgrzyn

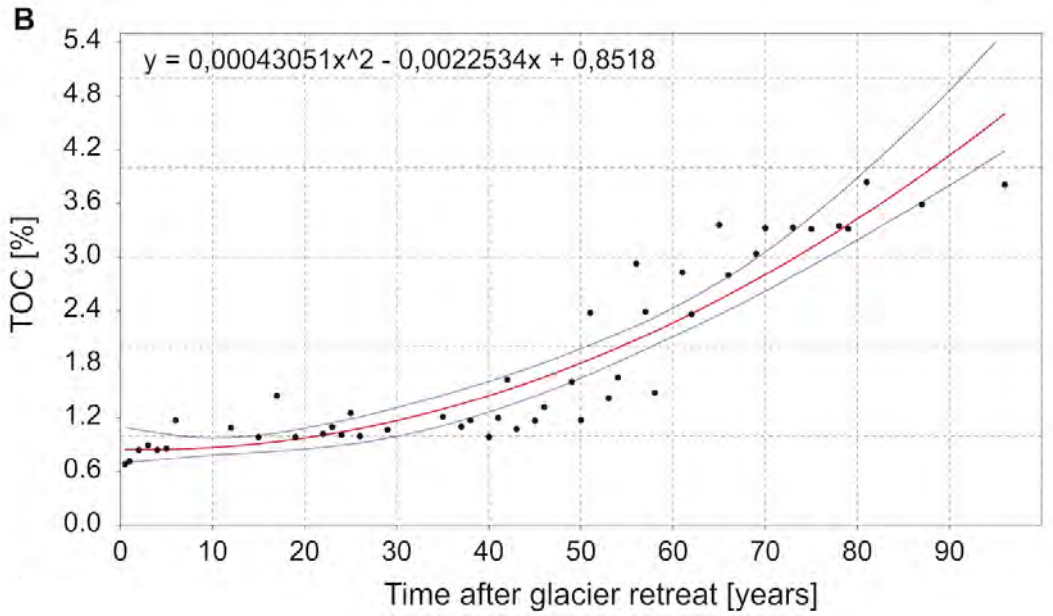


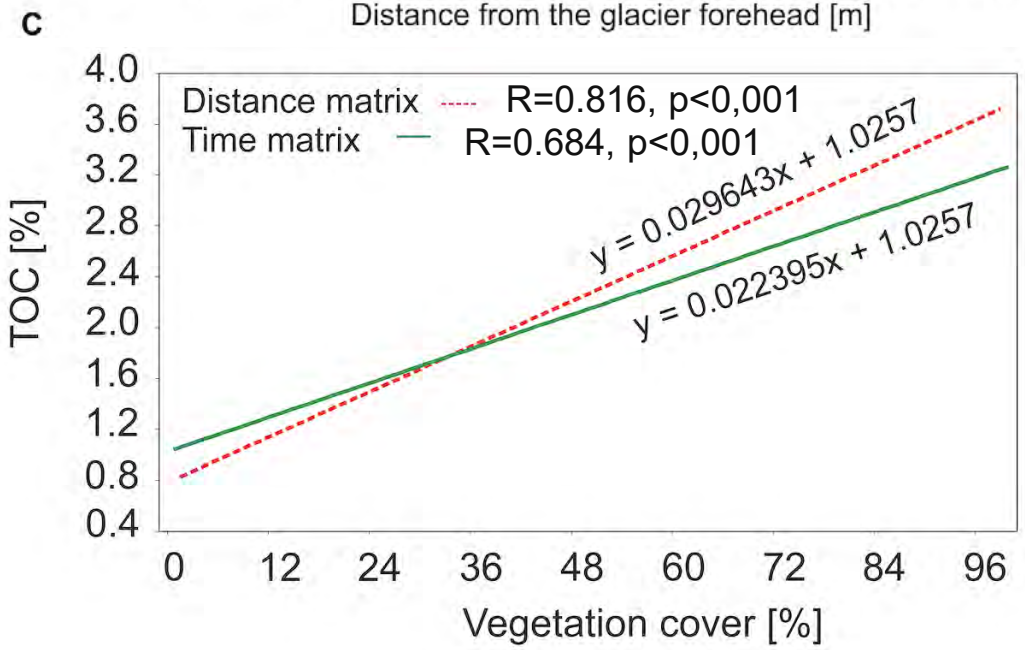


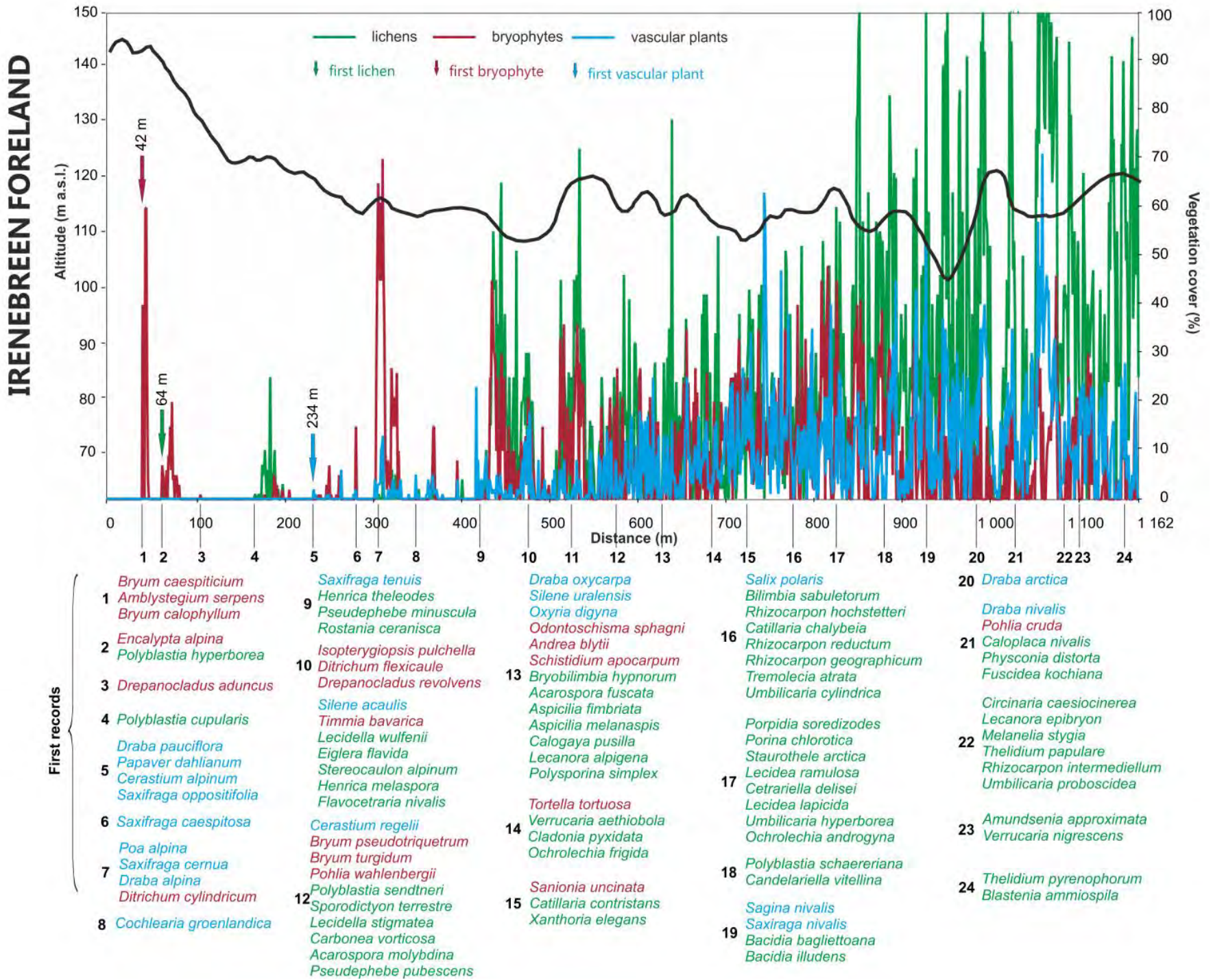


Total organic carbon (TOC) along Irenebreen foreland





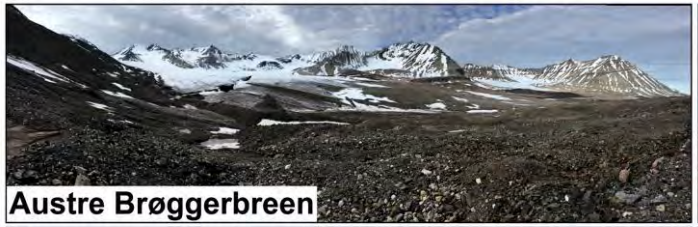


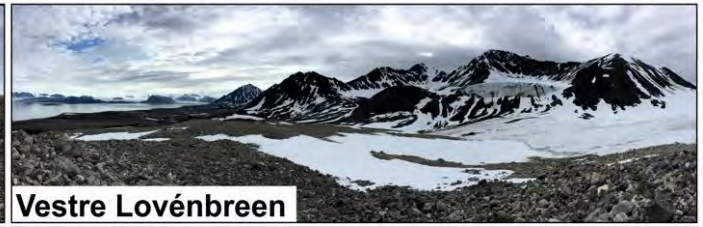


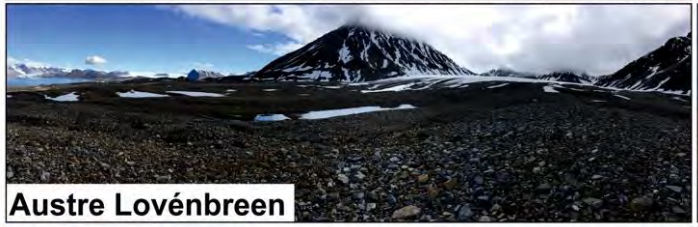
Is there any contribution of BSCs to soil development?

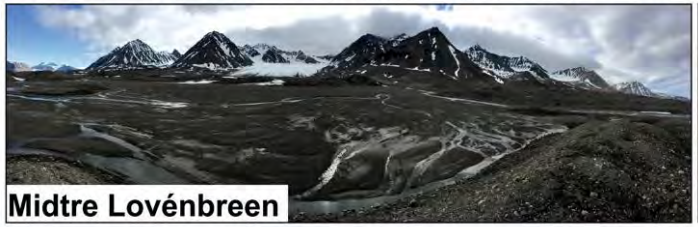
Are there any difference in BSC composition along succession gradient? What influence BSC composition?

Methodology – glacier forelands of Kongsfjorden and Isfjorden

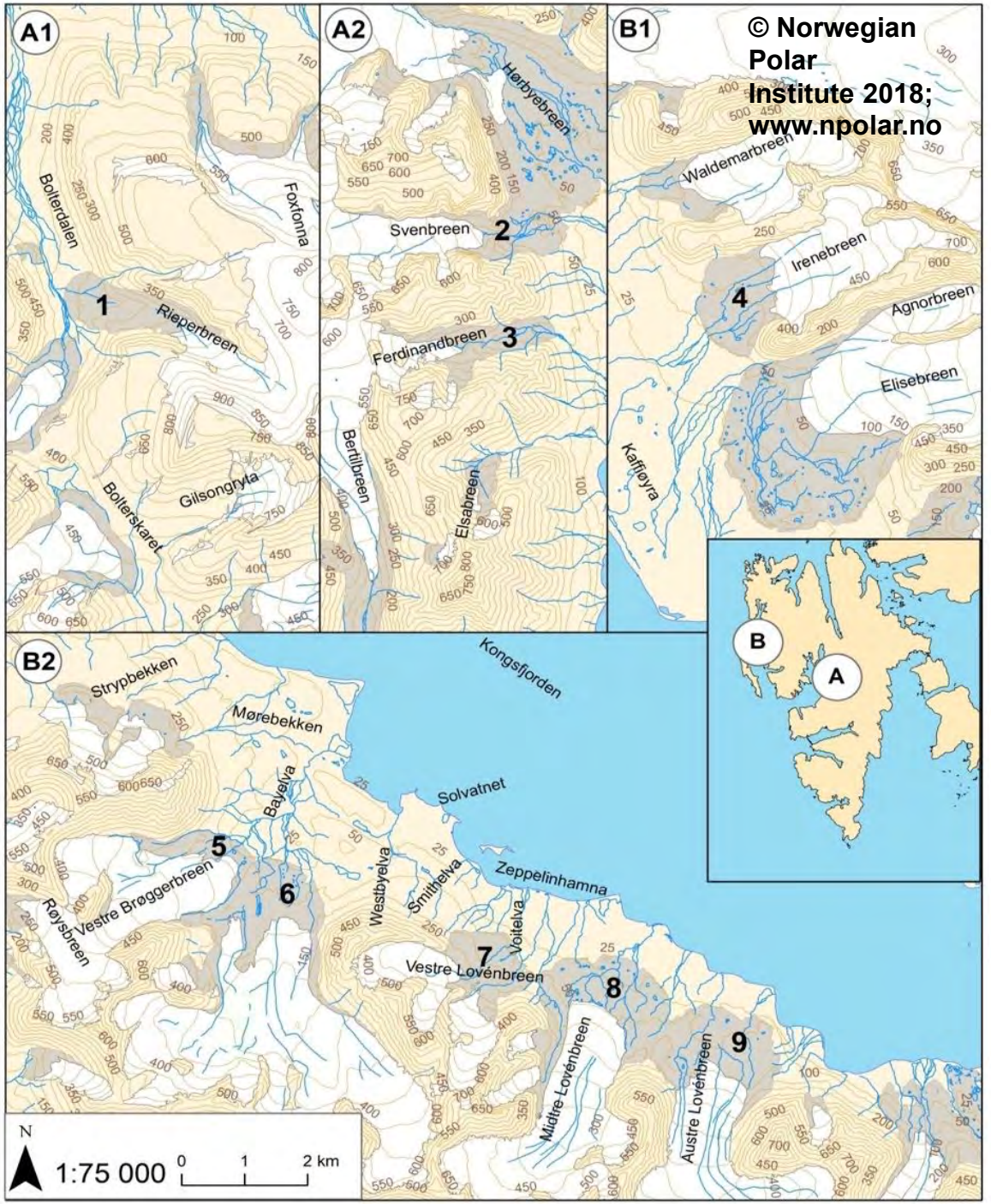






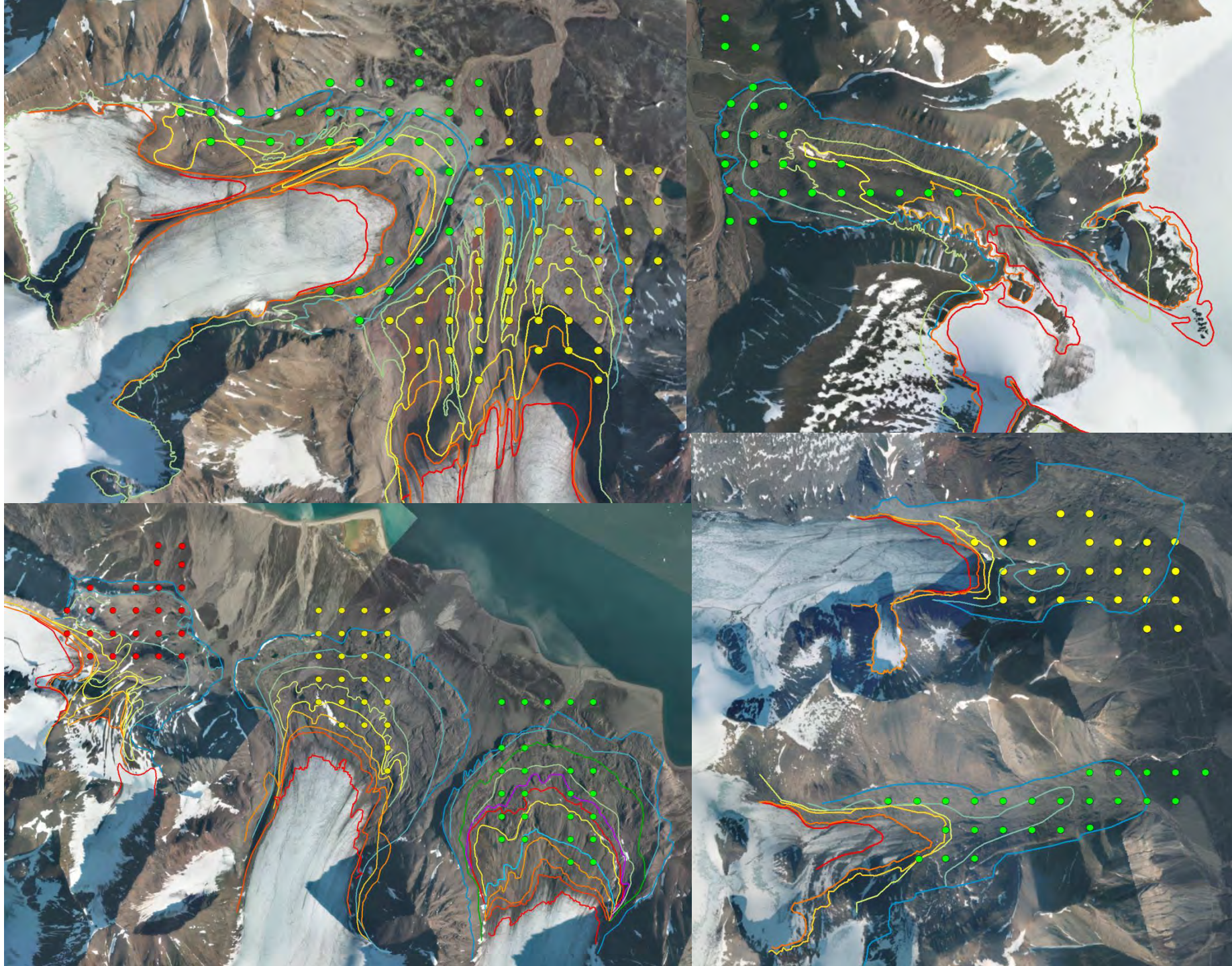


Panoramic views on studied glacier forelands.



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:

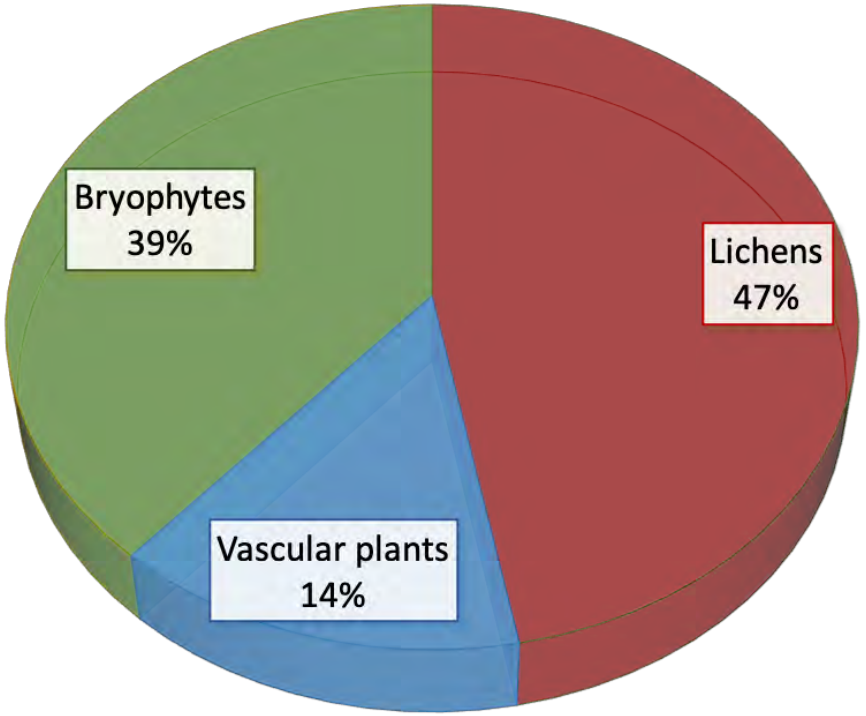
- Species identification,
- Content of nitrogen, organic carbon;

Spatial analyses:

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

Species number – dominance of cryptogamic organisms

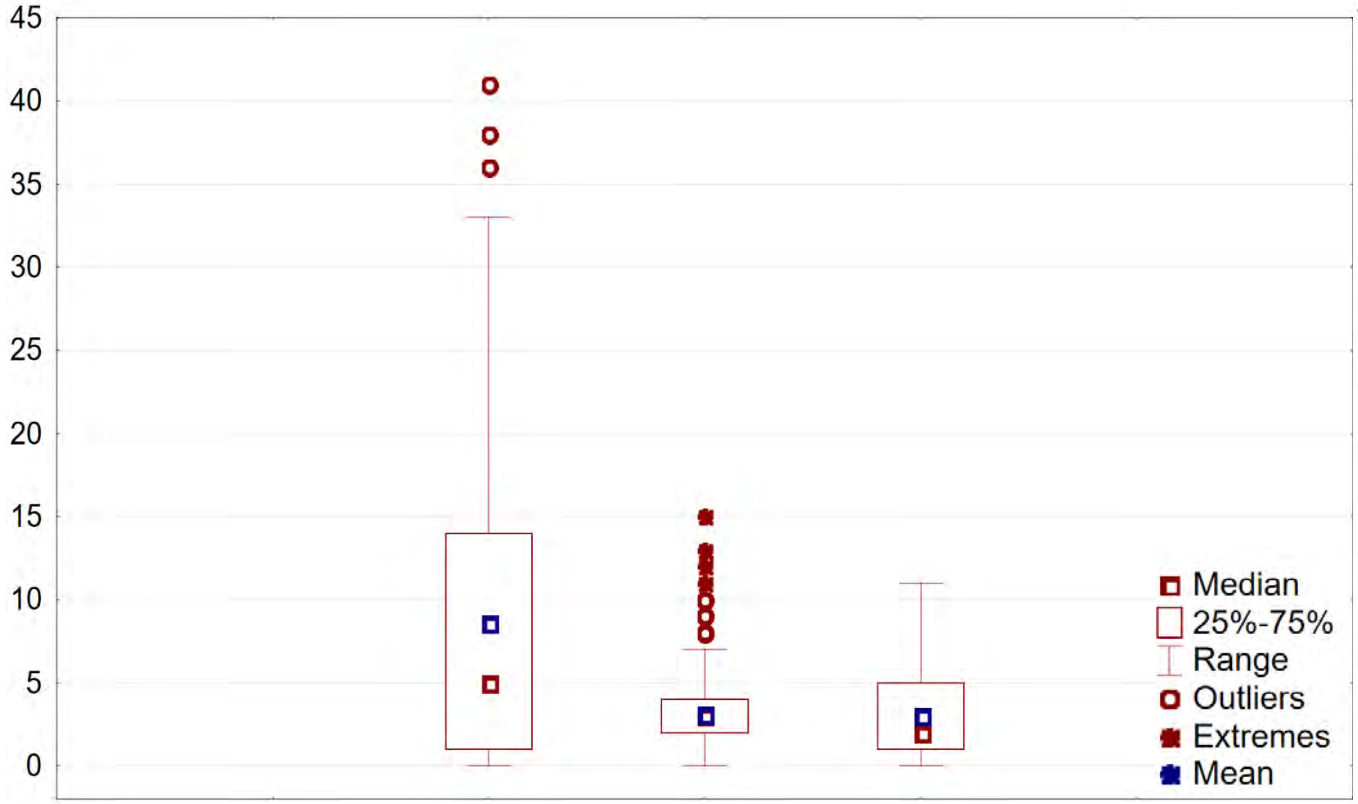
110 species of bryophytes



41 species of vascular plants

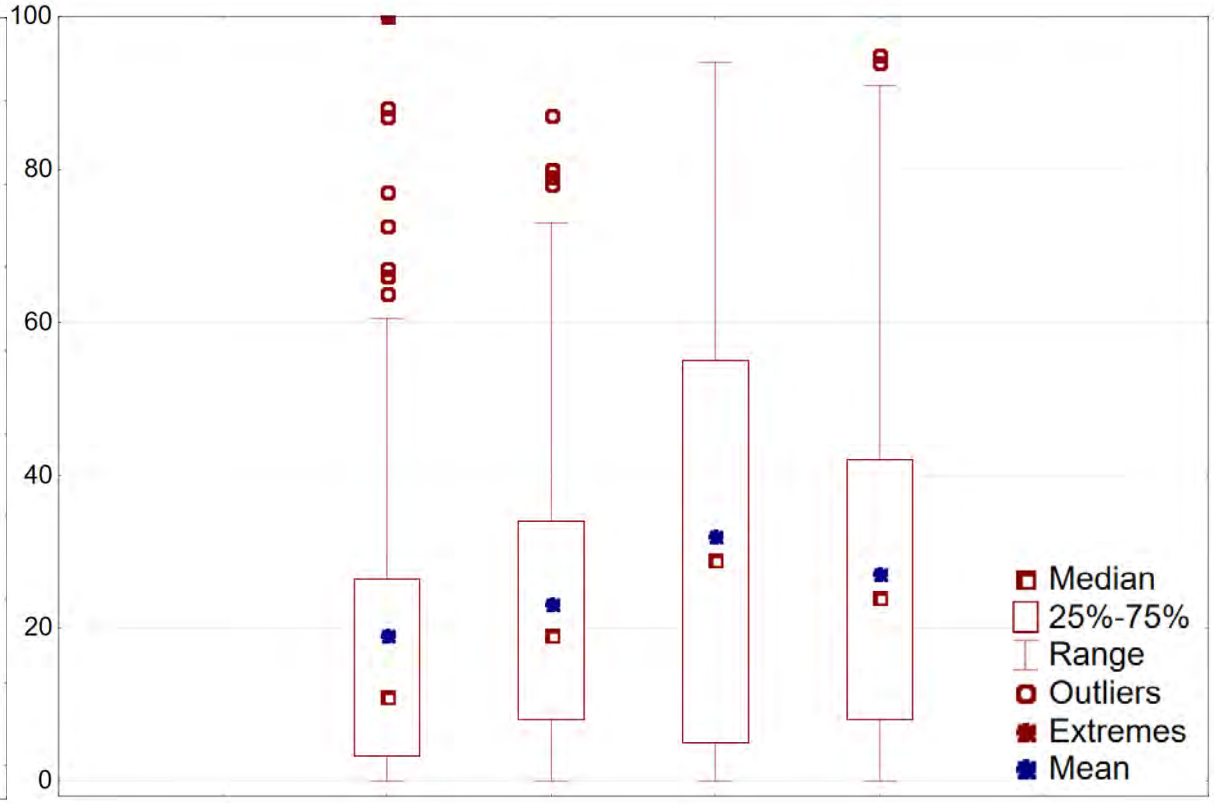
134 species of lichens

Species number



Lichens Bryophytes Vascular plants

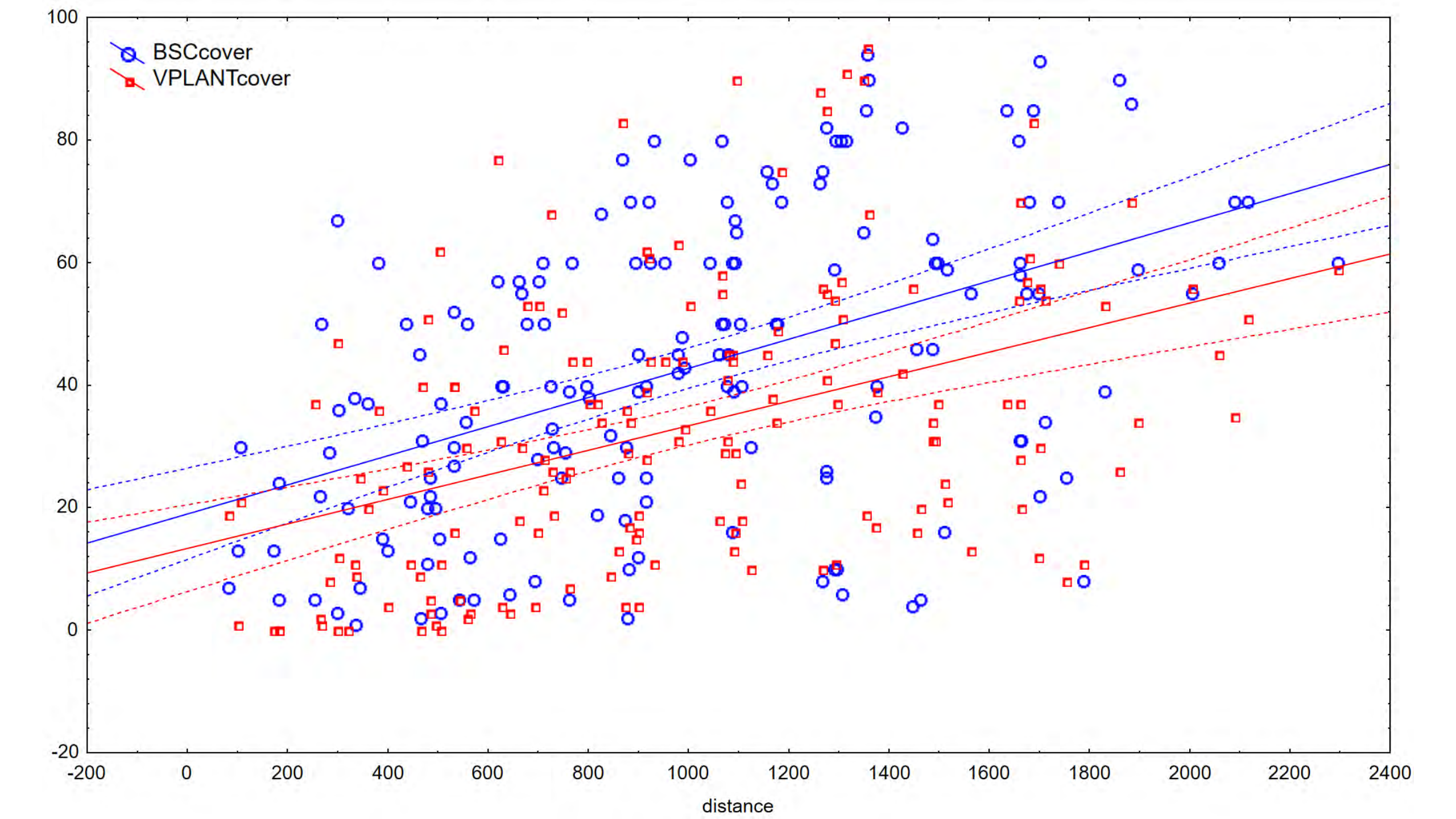
Percent cover



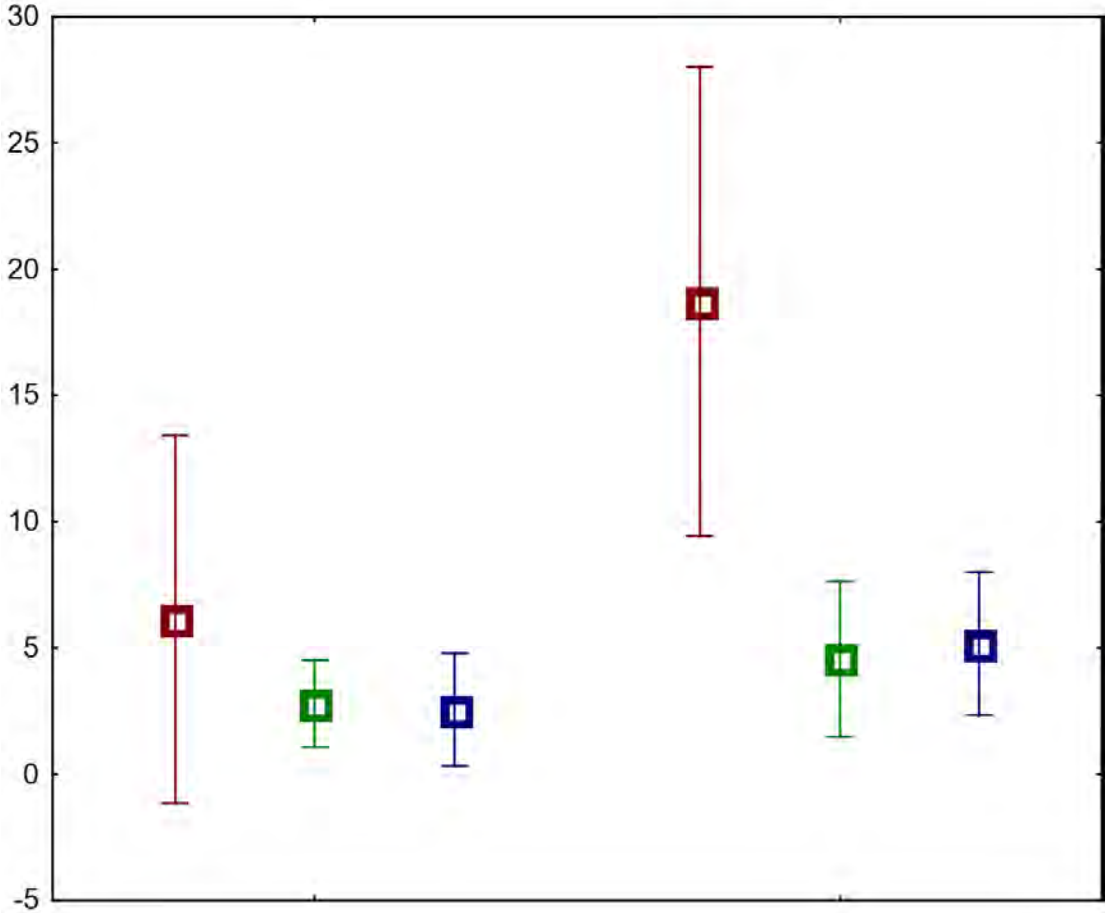
Lichens Bryophytes BSCs Vascular plants



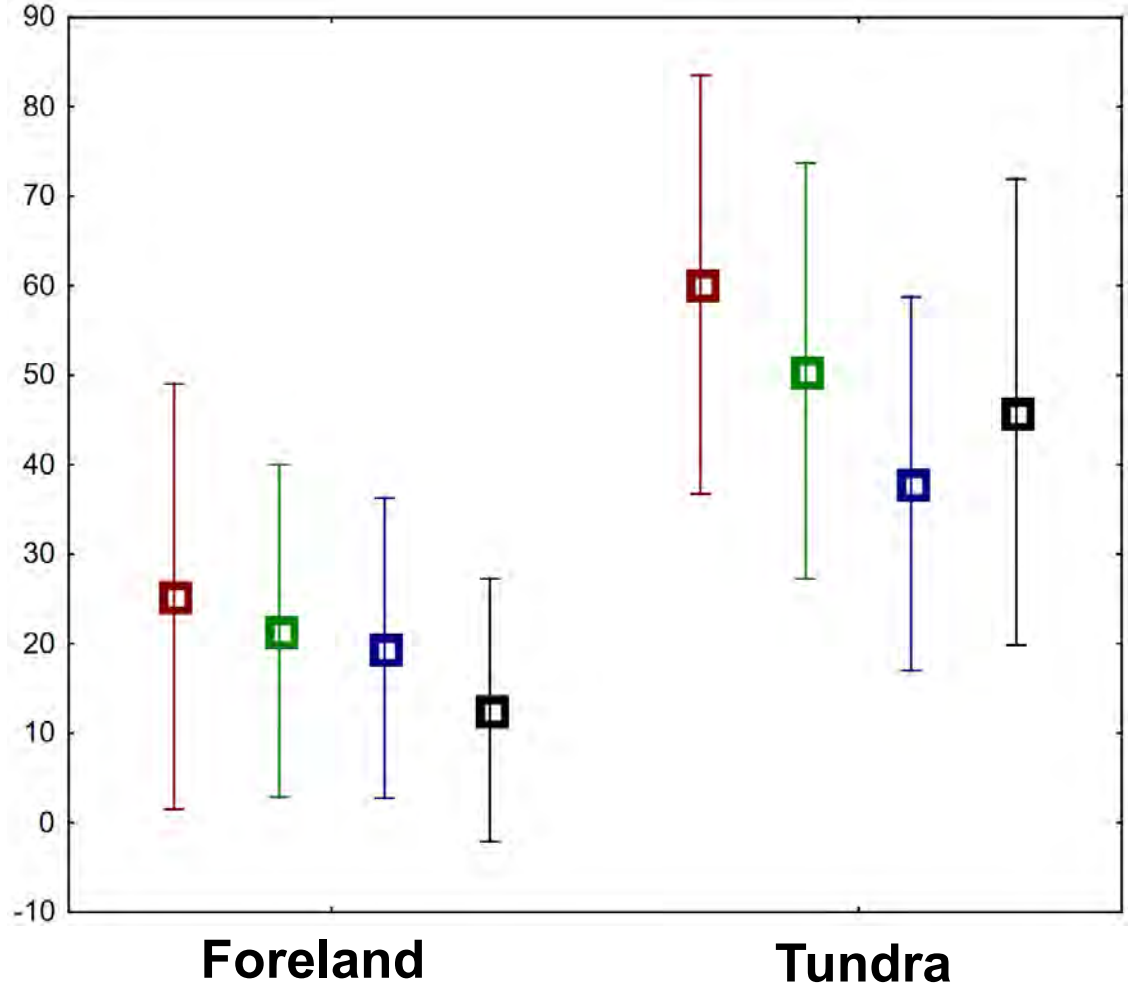




BSCcover
VPLANTcover
100
80
60
40
20
0
-20
-200
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
distance

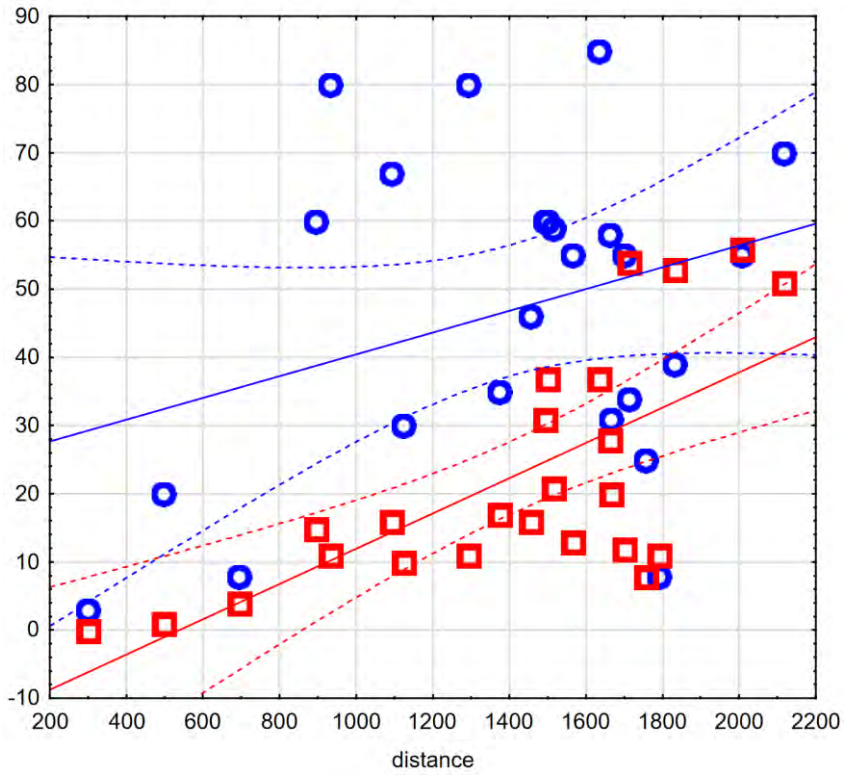
Species number



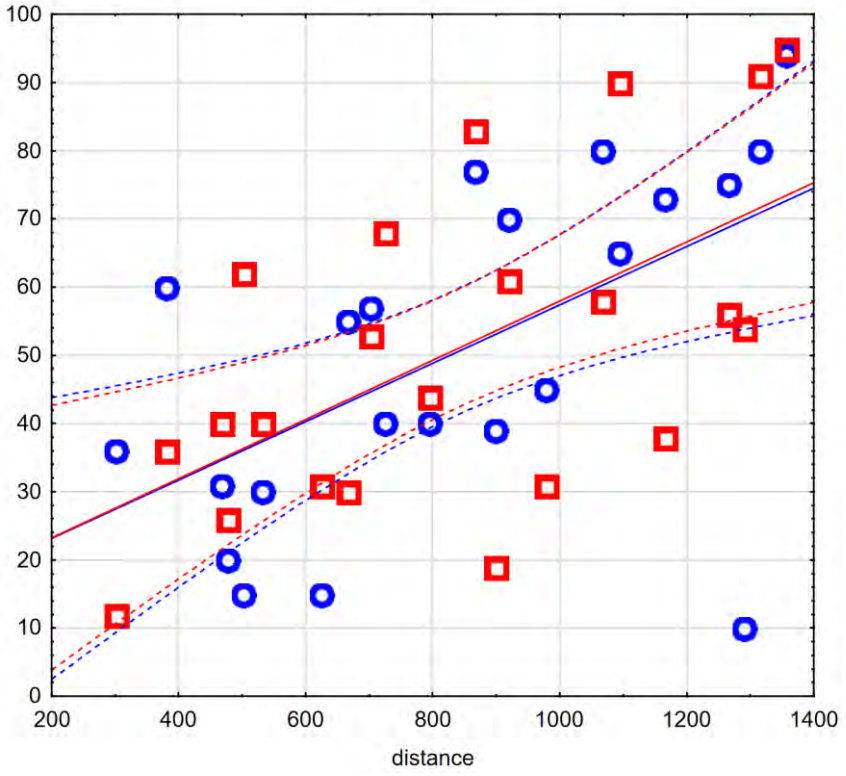
Percent cover



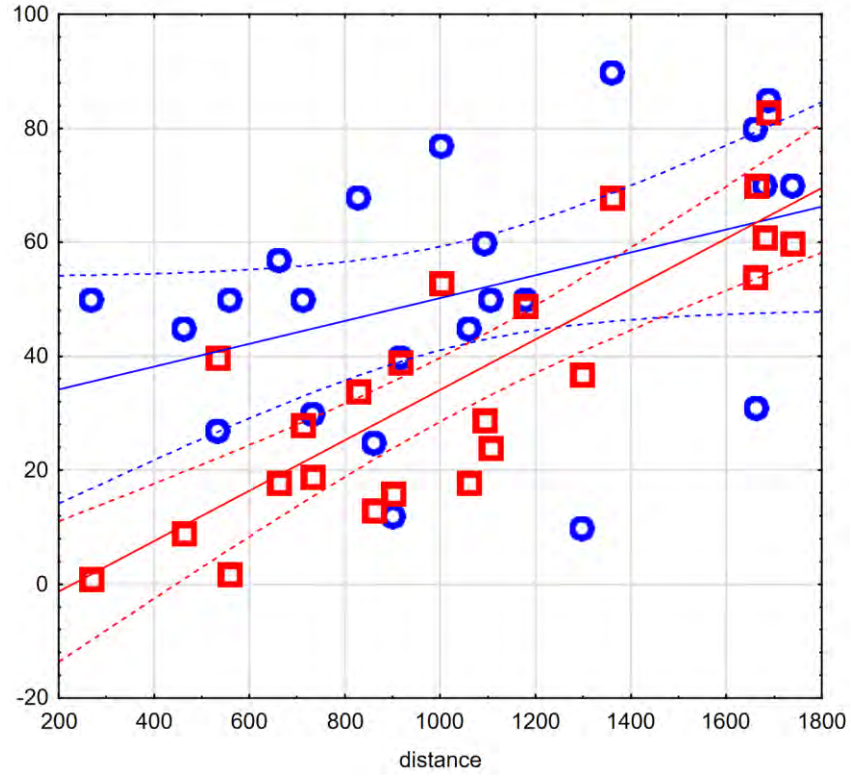
Rieperbreen



Midtre Lovénbreen



Austre Lovénbreen

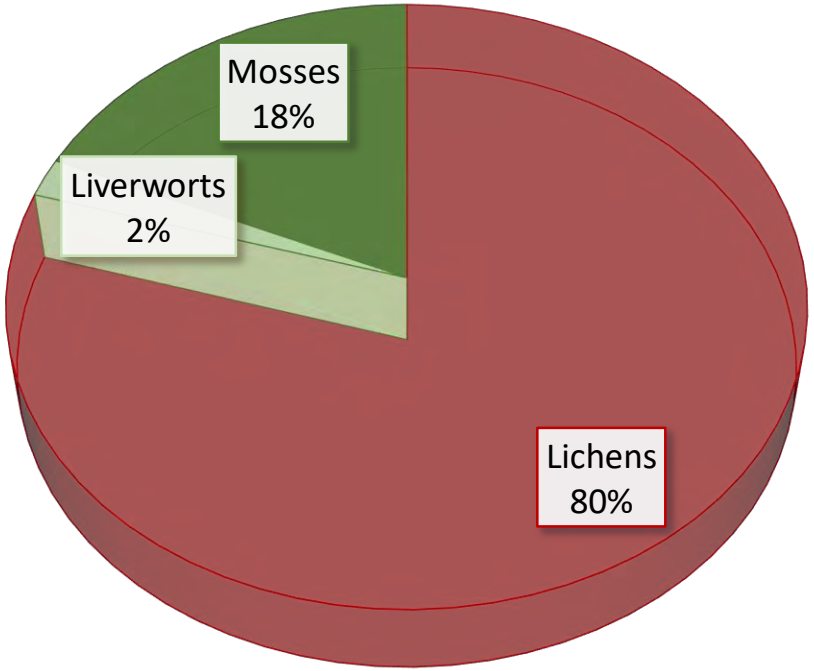


BSCcover
VPLANTcover

Species composition of BSCs

9 species of mossess

1 species of liverworts

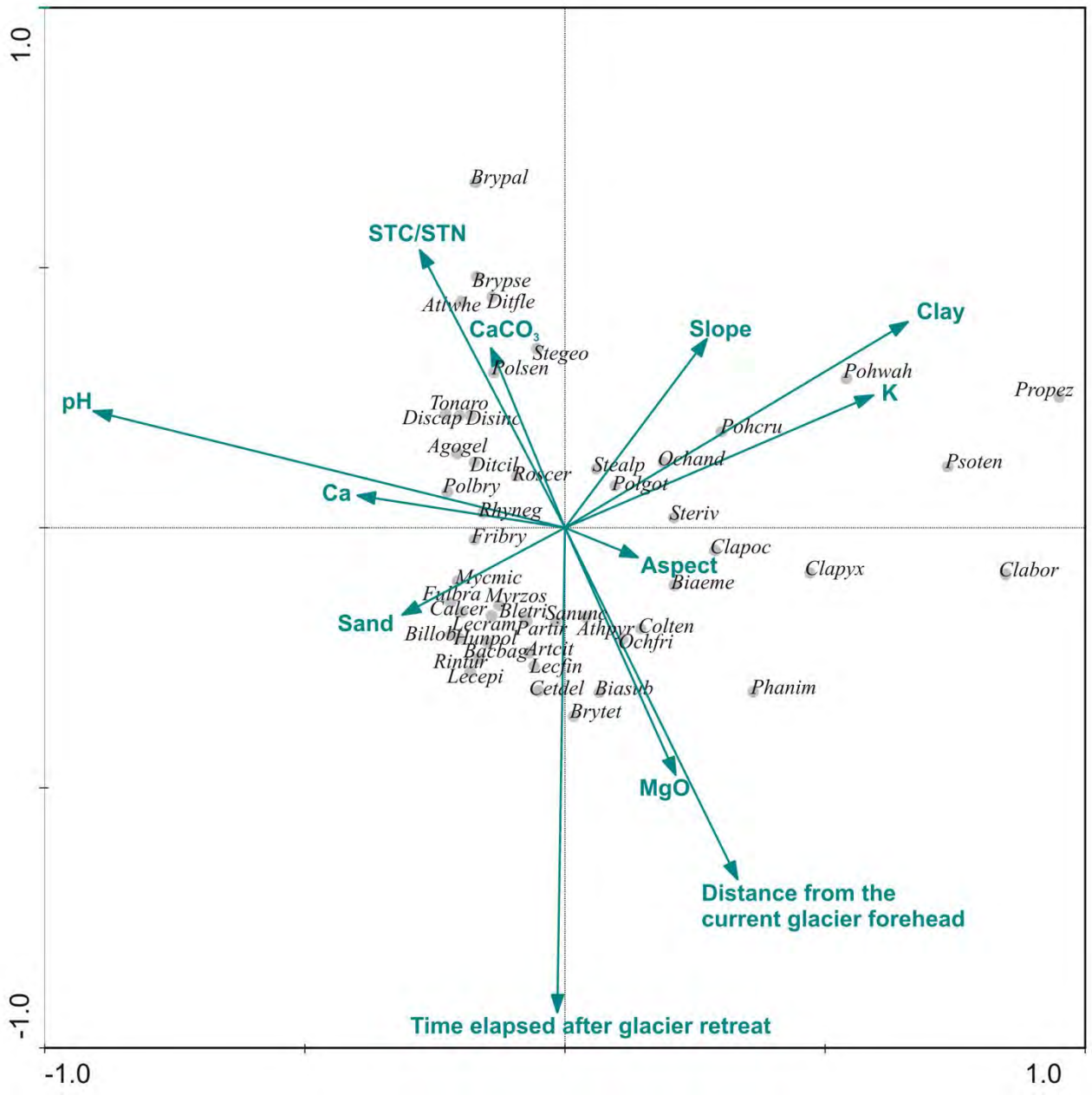


39 species of lichens

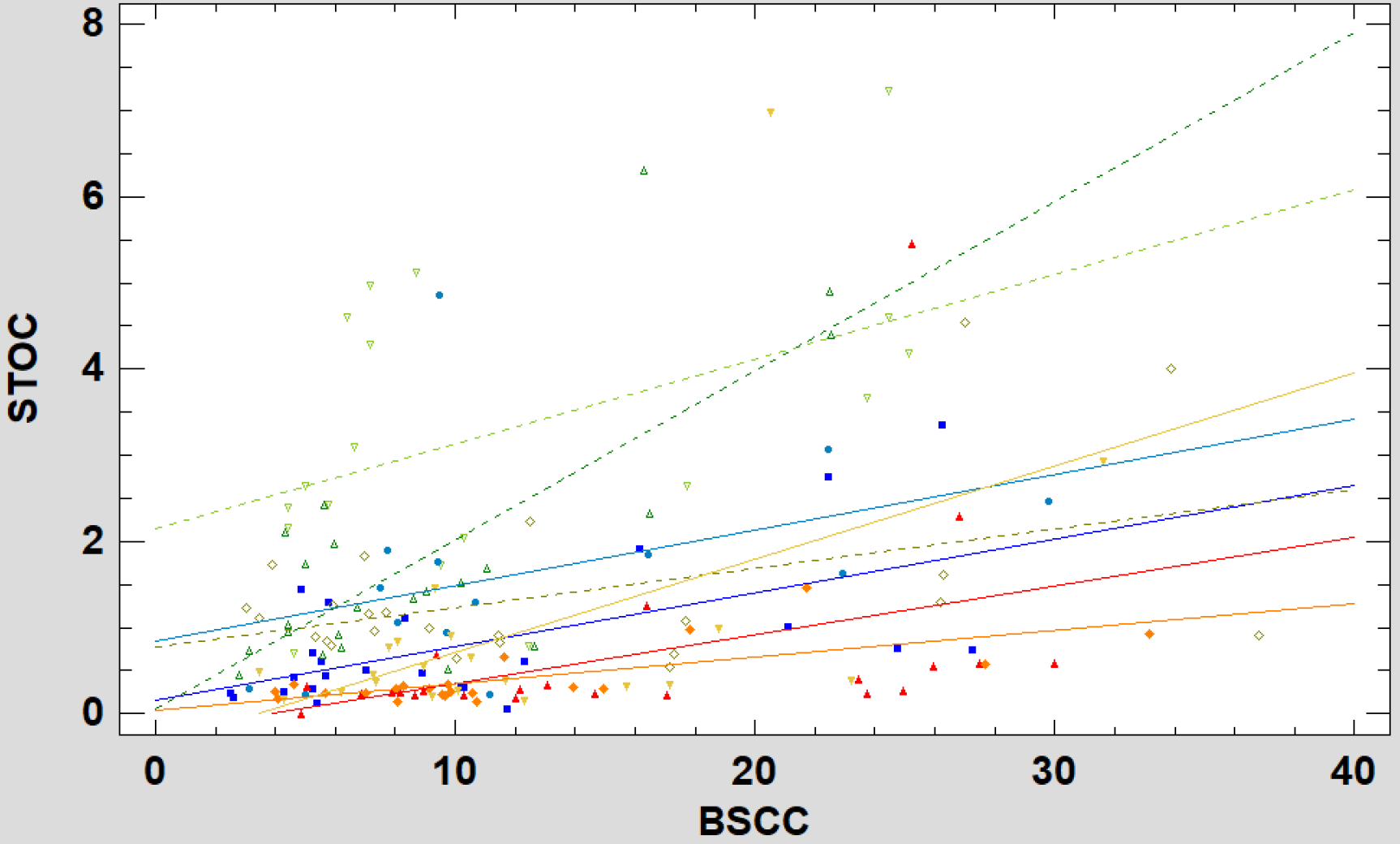
Liverworts	Mosses	Lichens
Blepharostoma trichophyllum	*Bryum pallescens*	*Agonimia gelatinosa*
	Bryum pseudotriquetrum	*Arthrorhaphis citrinella*
	Distichium capillaceum	*Athallia pyrace*
	Distichium inclinatum	*Atla wheldonii*
	Ditrichum cilindricum	*Bacidia bagliettoana*
	Ditrichum flexicaule	*Biatora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

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_2O (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_2O_5 (mg/g)	13	0.01	0.821	0.75



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



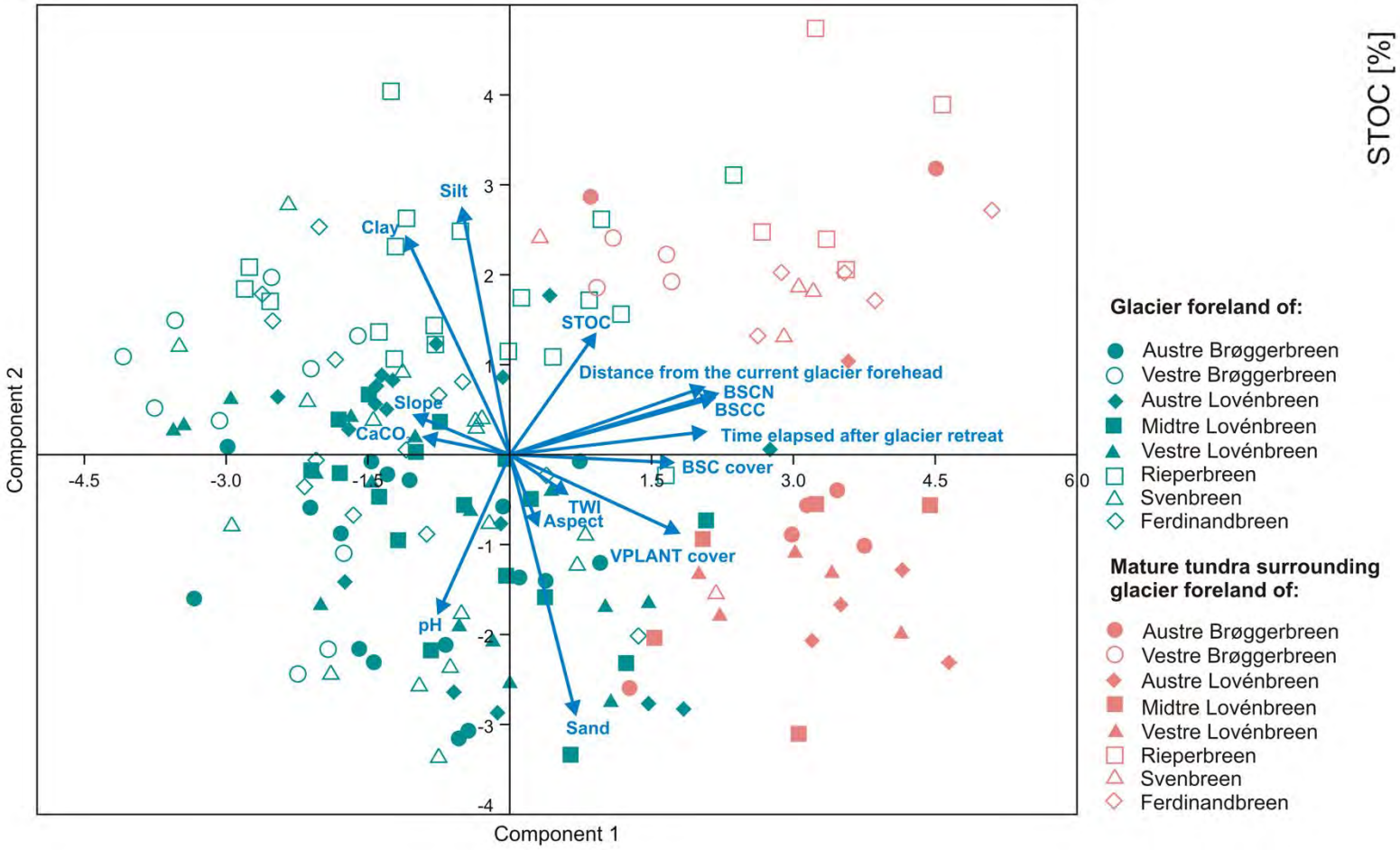
Glacier foreland
- Austre Broggerbreen
- Austre Lovénbreen
- Ferdinandbreen
- Midtre Lovénbreen
- Riperbreen
- Svenbreen
- Vestre Broggerbreen
- Vestre Lovénbreen

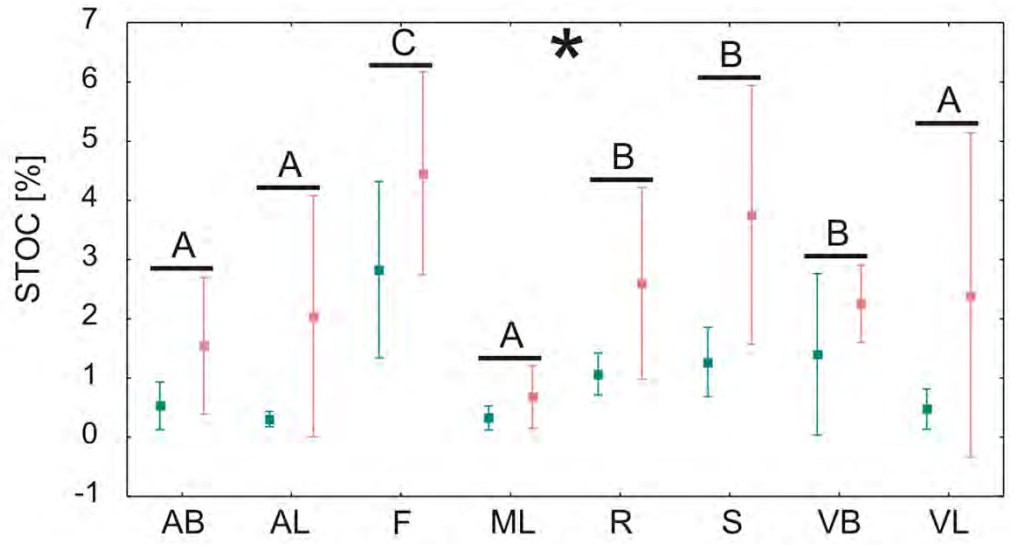
R = 0.725

R^2 = 52.56 %

Source	*F*	*P*
BSCC	34.38	0.0000
Intercepts	16.91	0.0000
Slopes	2.24	0.0341

Factors affecting soil development





Location: F=16.72; p<0.001; Habitat type: F=63.43; p<0.001

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, R^2= 47.93%, F=13.576, p<0.001

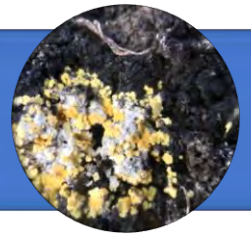
Take home message

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.



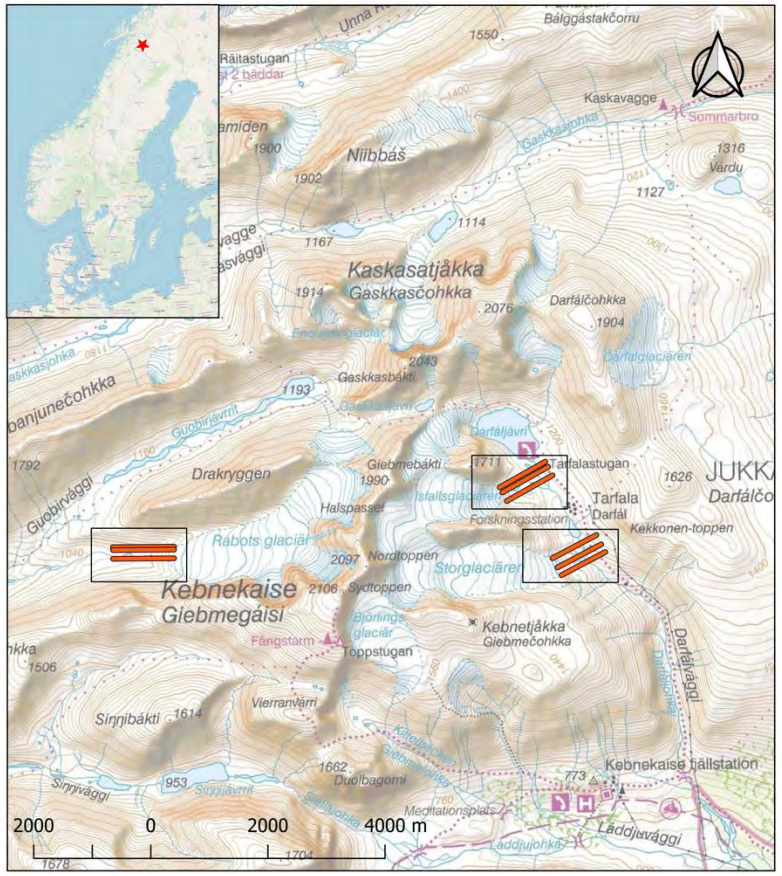
Character of primary succession and soil development seems to be different for particular glacier foreland.

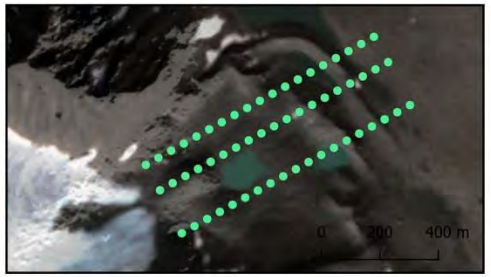
Project: Cryptogams as the main factor influencing initial development of soil and carbon sequestration in glacier forelands in northwest Sweden

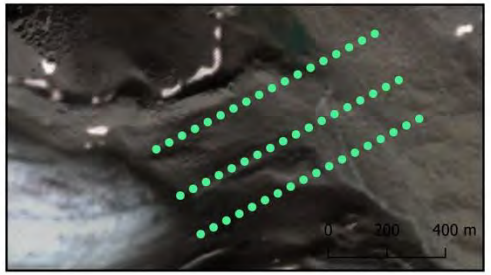
INTER ⇄ ACT

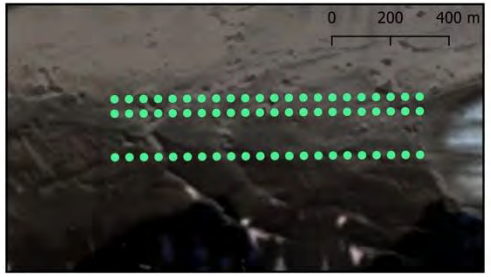
Research Extension – summer of 2019:

- 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.









This research would not be possible without help and support of following people:

- Wojciech Moskal,
- Krzysztof Rymer,
- Marek Brož,
- Dominika Dąbrowska,
- Ireneusz Sobota,
- Fumino Maruo,
- Robert Zubel,
- Mateusz Stolarczyk,
- Mateusz Sobucki,
- Joanna Kołodziejczyk.

 paulina.wietrzyk@gmail.com