Vegetation Community and Ecosystem Properties along the Eurasian Arctic Transect (EAT)

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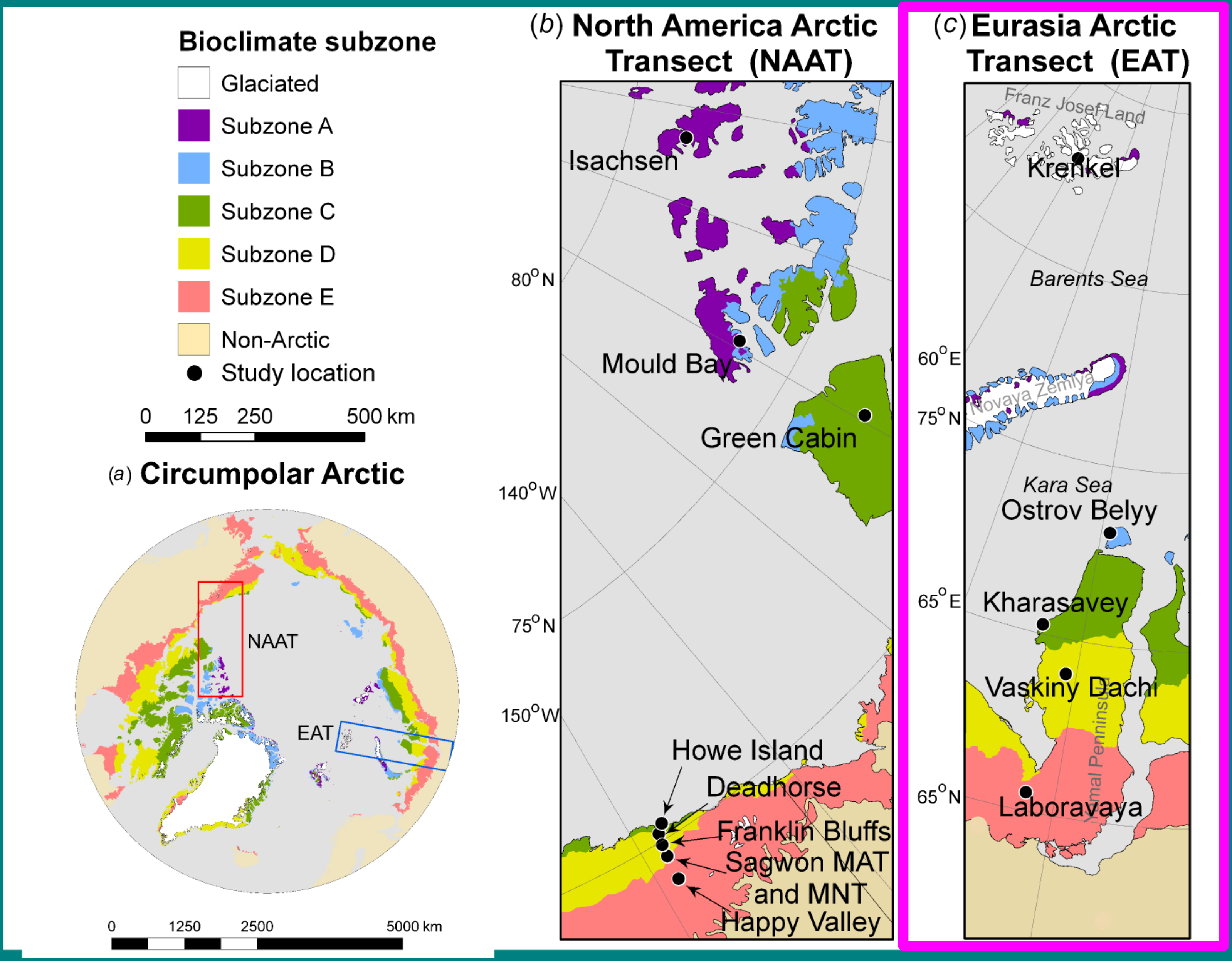
(Photo H.E. Epstein)



Raynolds et al. (2012), Walker et al. (2012)

Eurasian Arctic Transect

Subzone A

Subzone B

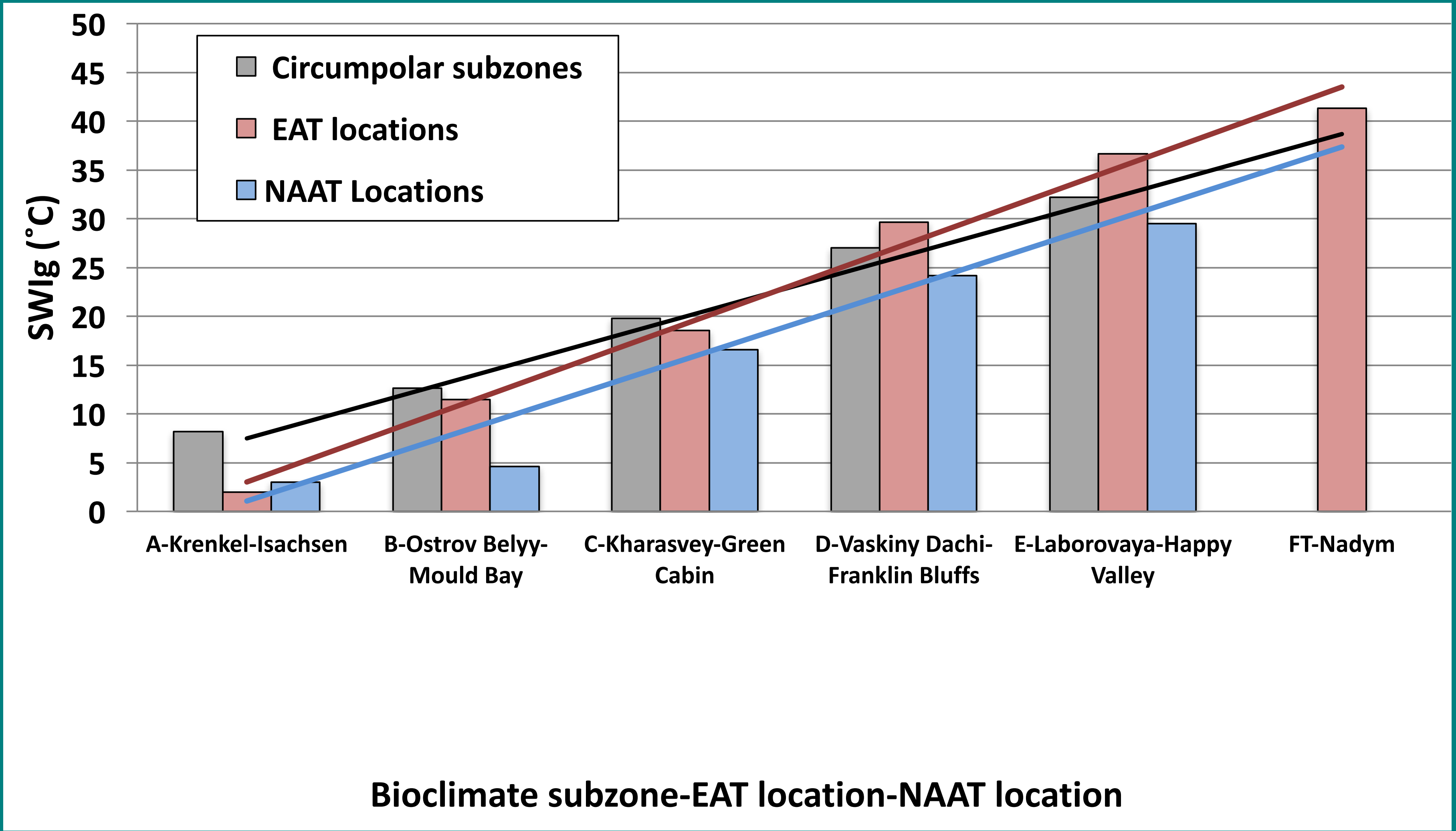
Subzone C

Subzone D

Subzone E

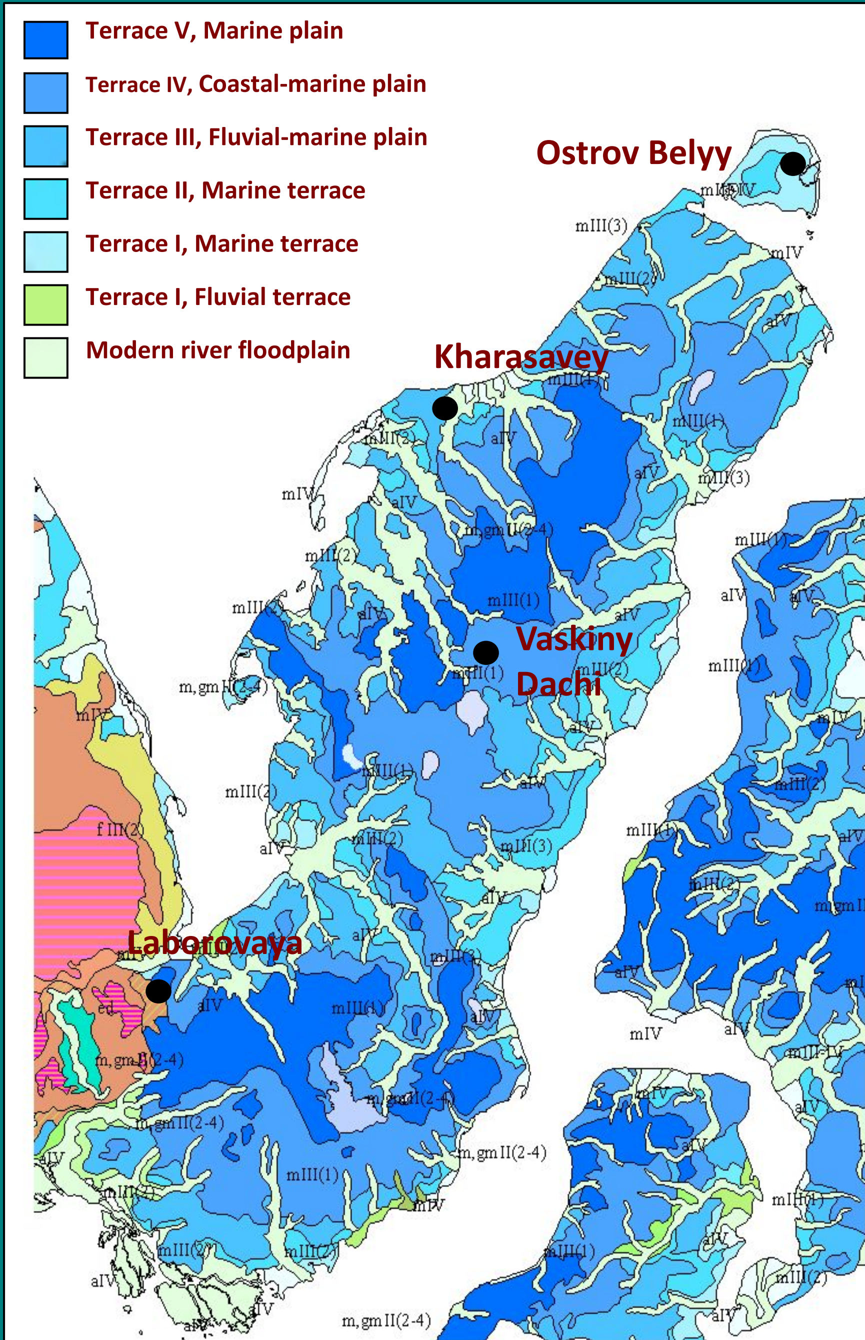
(Photos D.A. Walker and H.E. Epstein)

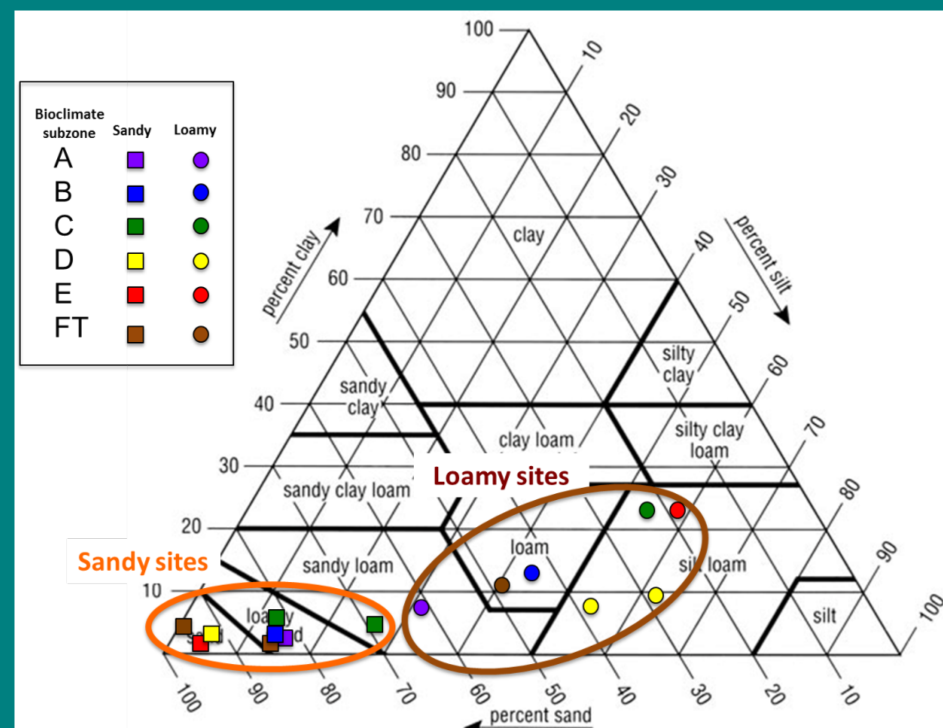
Mean summer warmth for circumpolar subzones compared to EAT and NAAT study locations



SWI_g = Ground surface mean annual sum of monthly mean temperatures >0 ˚C, determined from AVHRR satellite thermal bands (Raynolds et al. 2008).

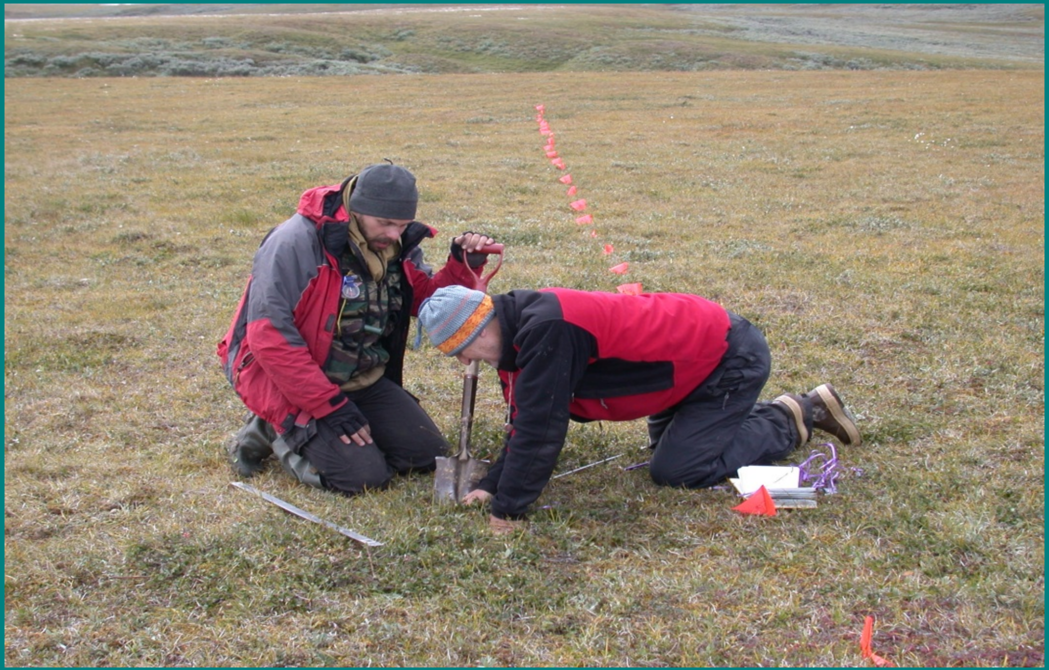
Different aged marine and fluvial terraces have different soil textures – younger landscapes have sandier soils.





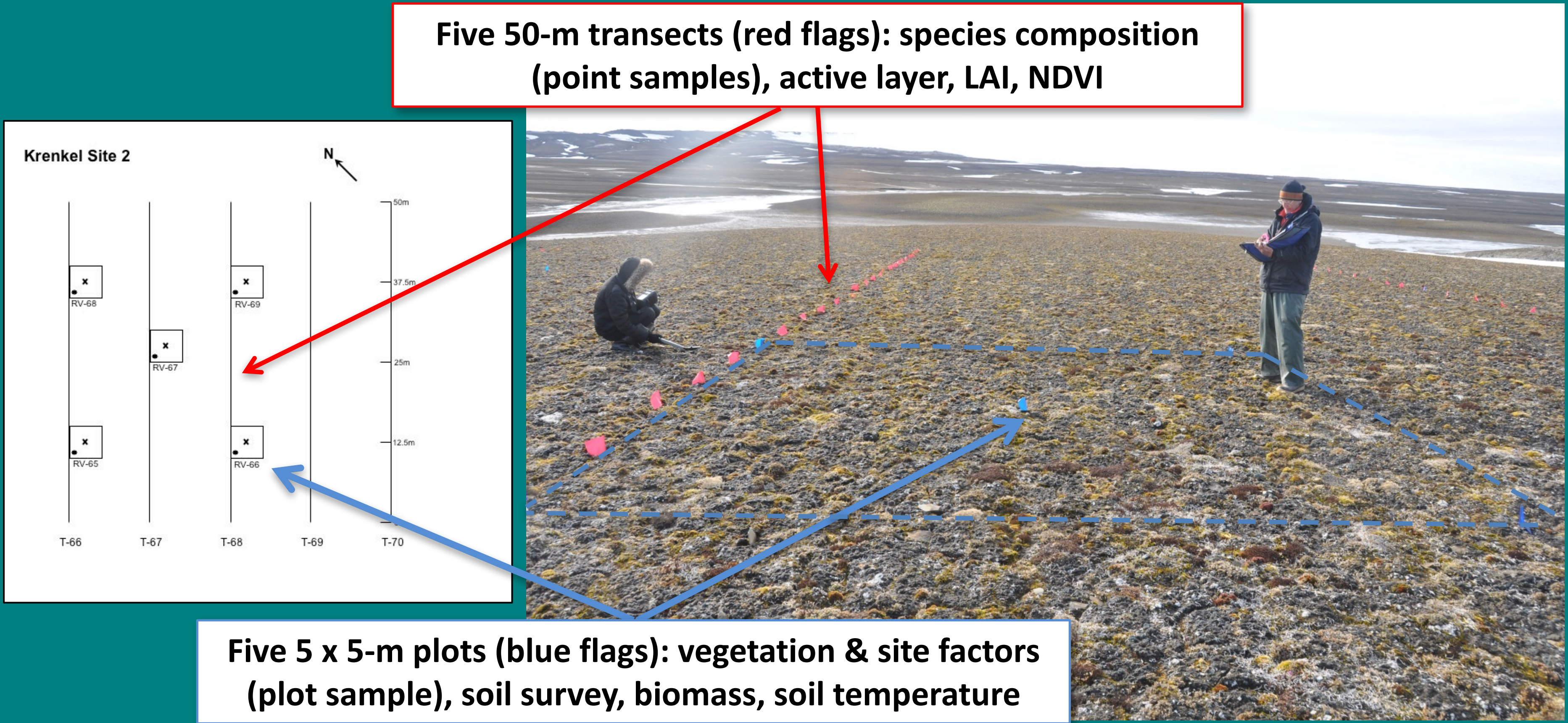
Research questions

- **How do leaf area index (LAI) and the Normalized Difference Vegetation Index (NDVI) vary along the temperature gradient (by soil texture)?**
- **How do different components of plant biomass vary along the temperature gradient (by soil texture)?**
- **How does species richness vary along the temperature gradient (by soil texture)?**



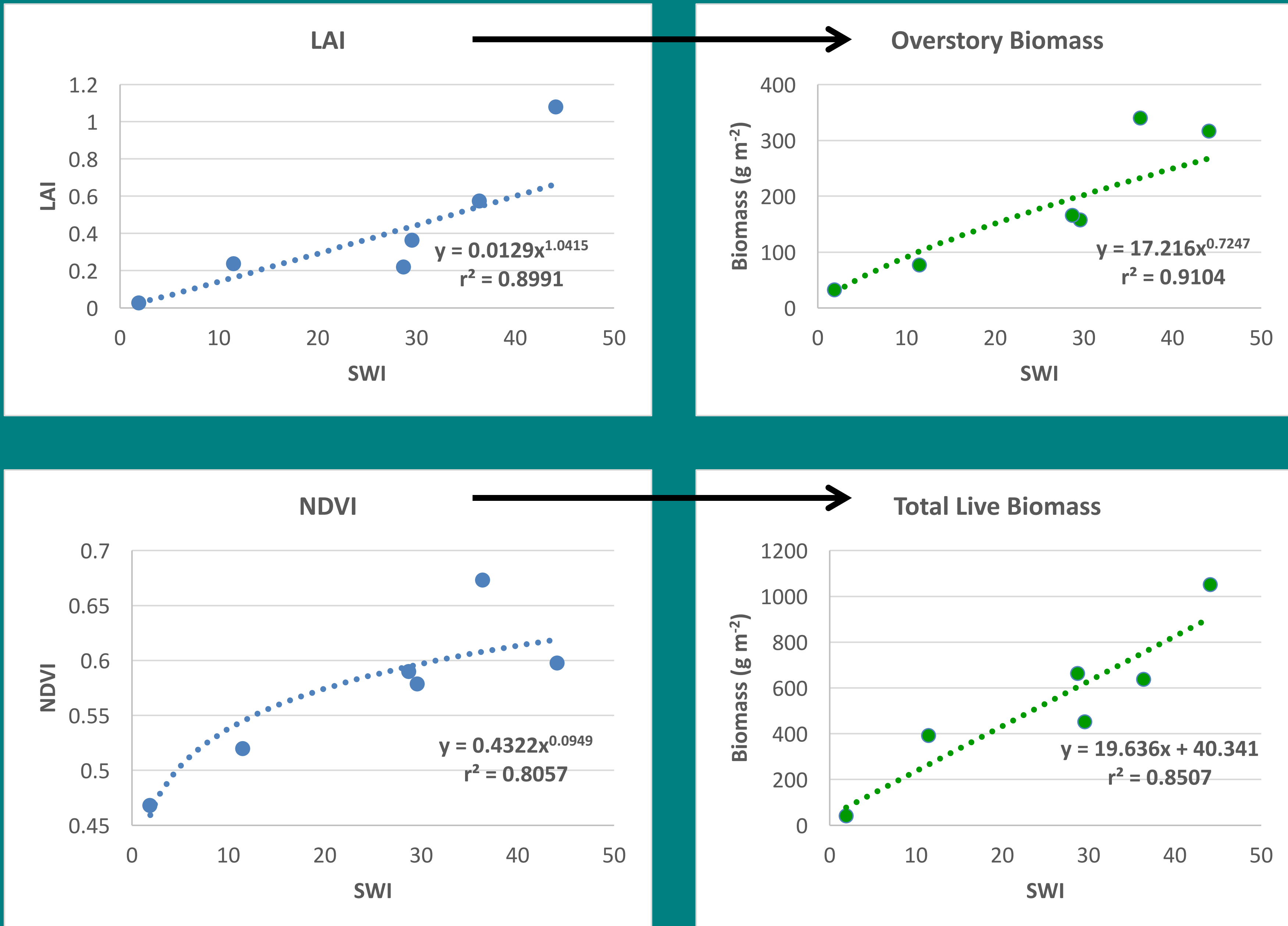
Field Data Collection

- six locations, with 2-3 sites at each location with varying soil textures
- 50 x 50 m sampling grid and five 50 m transects at each site
- NDVI (ASD PSII) at 1-m intervals along the transects
- LAI (Li-Cor LAI-2000) at 1-m intervals along the transects
- five relevés (5 x 5 m)
- five aboveground biomass harvests
- five soil samples (top 10 cm – mineral soil)

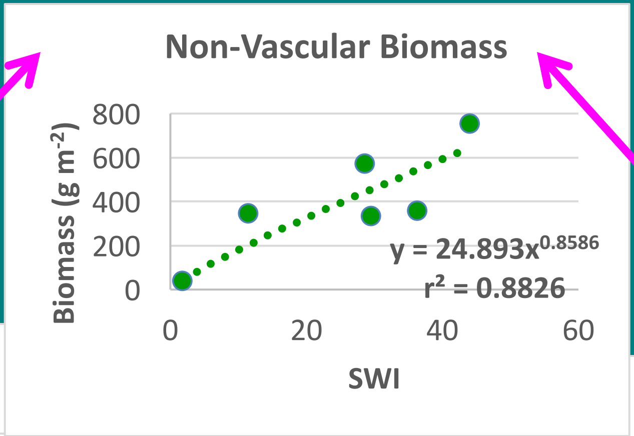


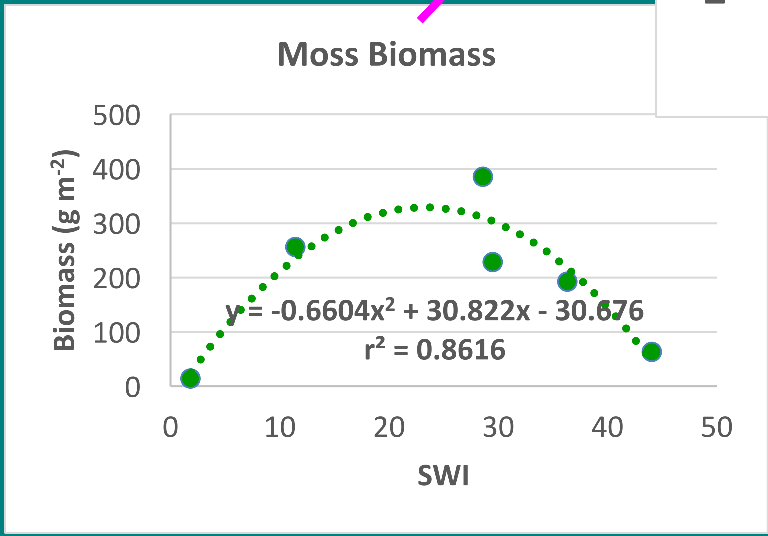
Sample grids on sandy and loamy sites at each location

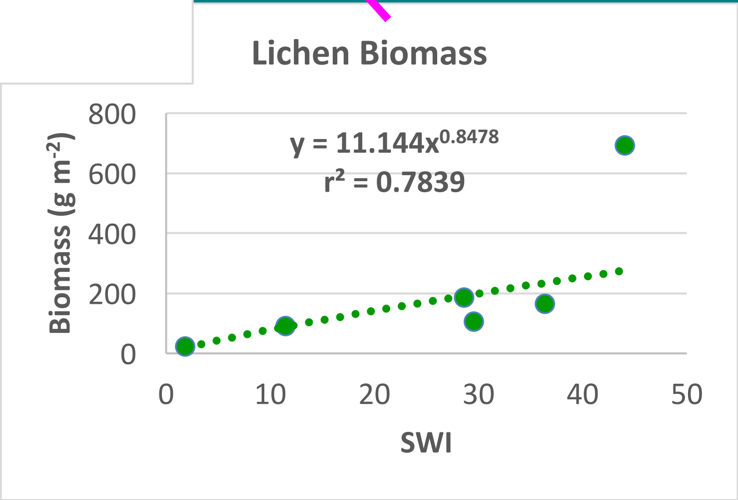
Community-level variables averaged across sites within each study location

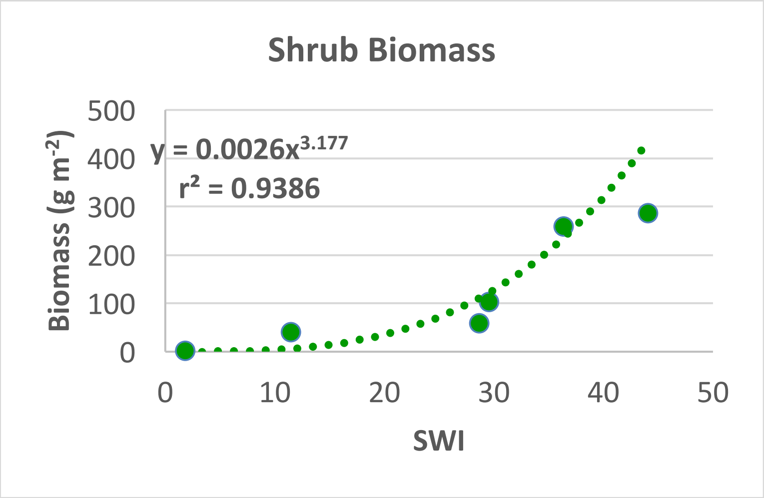


Biomass by Plant Functional Type

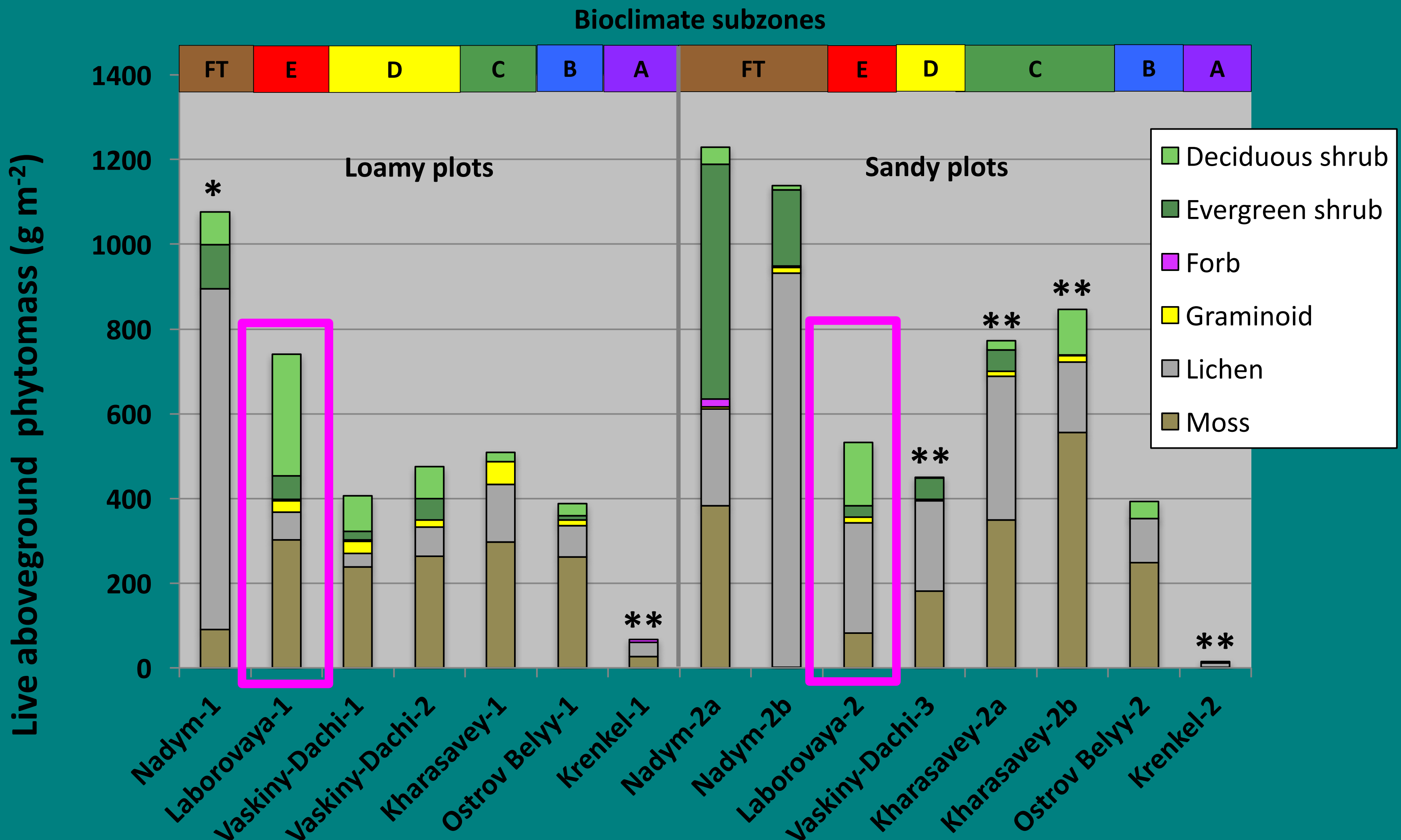






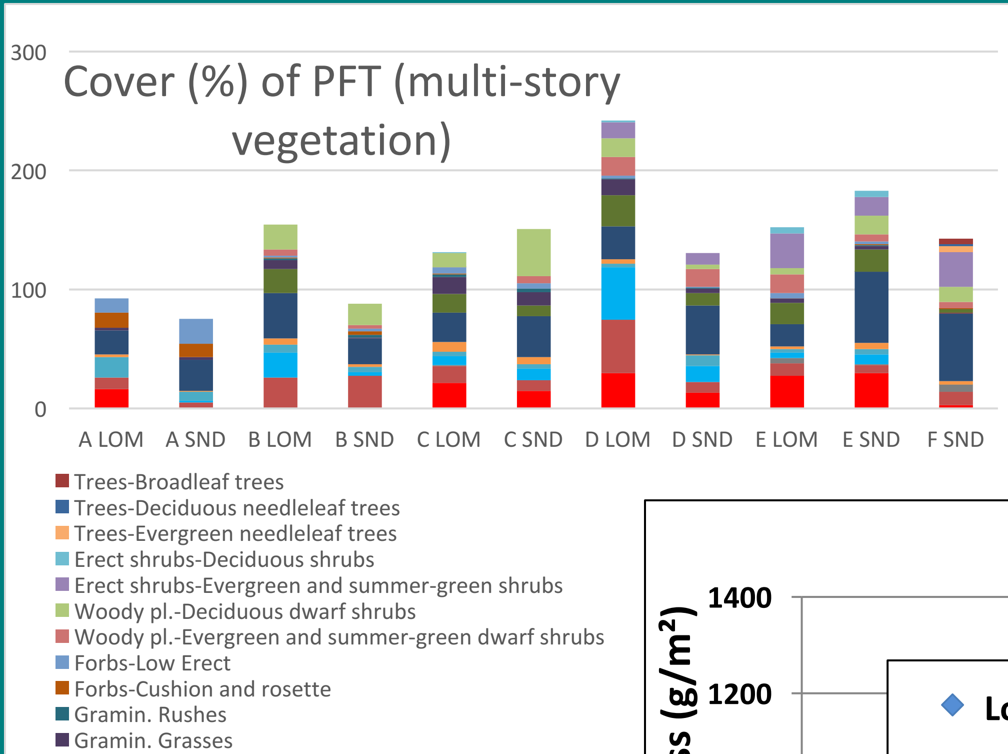


Aboveground biomass by plant functional type by site (Walker et al. 2012)

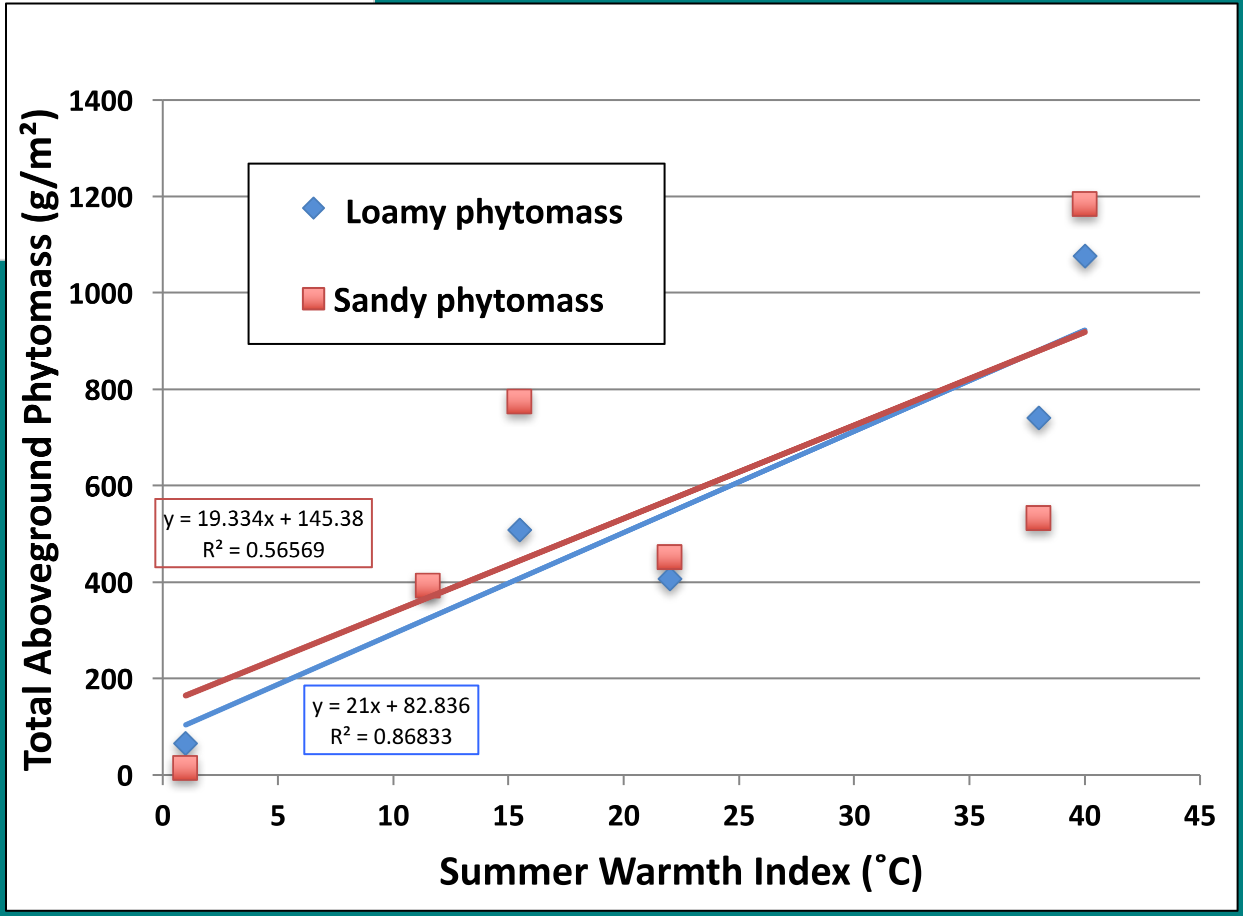


* Understory only included for Nadym 1 (forest plot). Tree biomass = 5338 g m^{-2}, calculated according measurement of height and diameter of all trees in the plots and application of allometric biomass equations (Walker et al. 2009a).

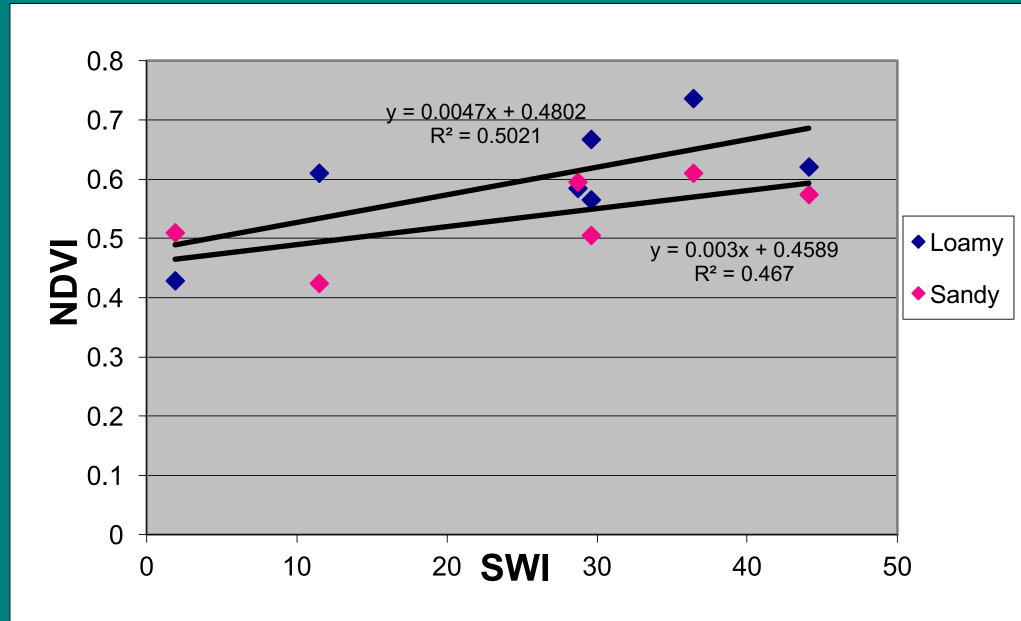
** Biological soil crusts are present but biomass not included in bars: Estimates based on cover and thickness of crust: Vaskiny Dachi-3 = 32 g m^{-2}, Kharasavey-2a = 11 g m^{-2}, Kharasavey-2b = 7 g m^{-2}, Ostrov Belyy-2 = 155 g m^{-2}. Measurements based on floatation method (Walker et al. 2010): Krenkel-1 = 95 g m^{-2};; Krenkel-2 = 218 g m^{-2}.

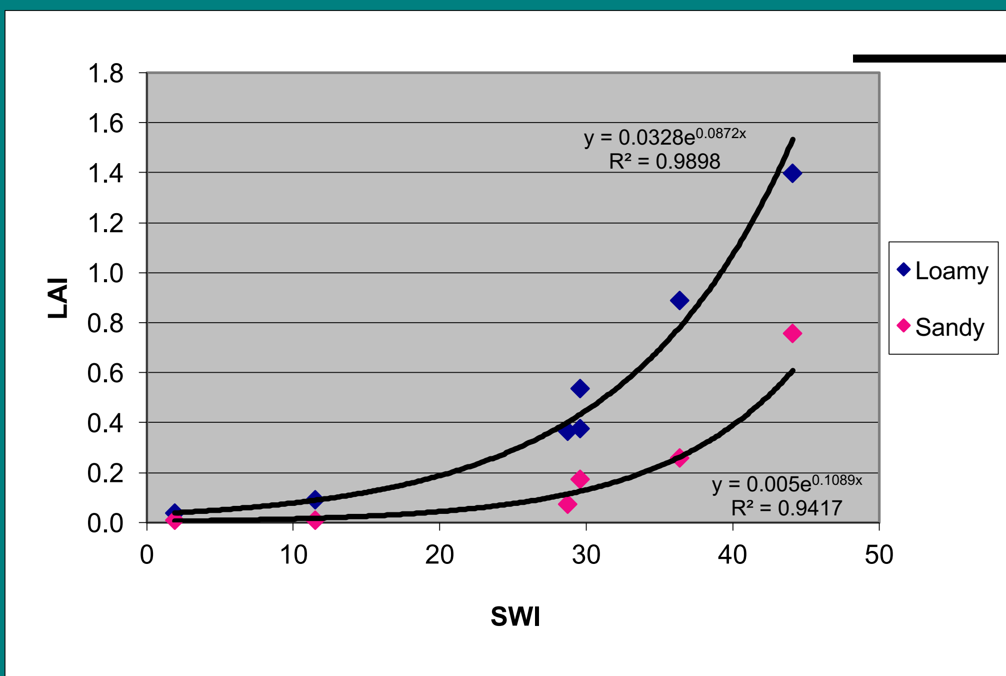


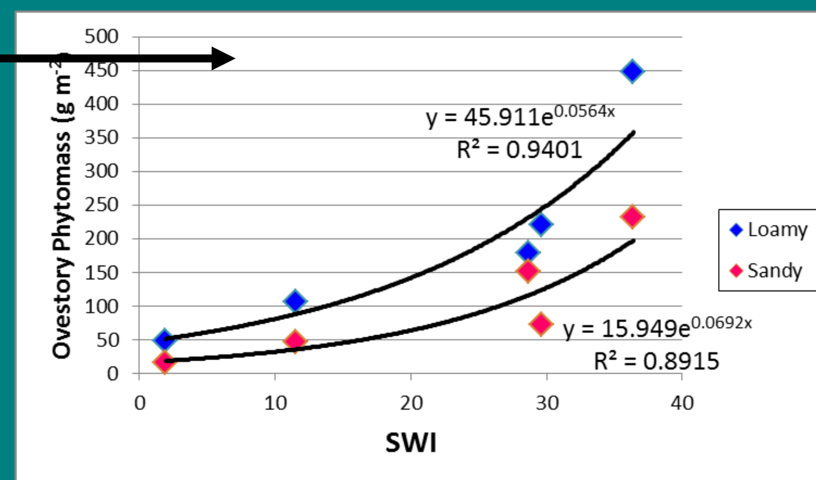
Despite major differences in species composition, there were few systematic, community-level differences between soil textures along the gradient (e.g. total aboveground biomass).



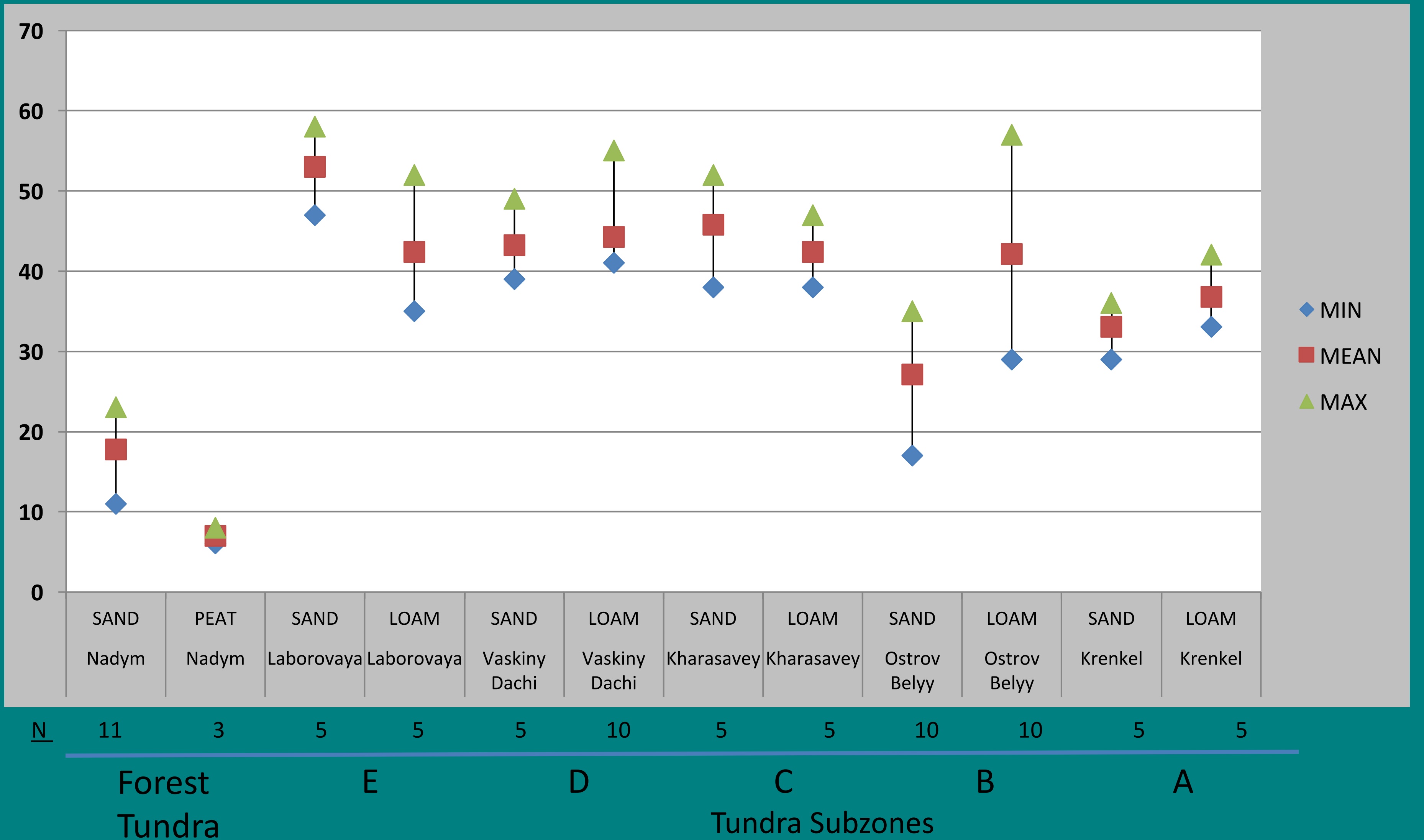
However, there were some community-level effects of soil texture





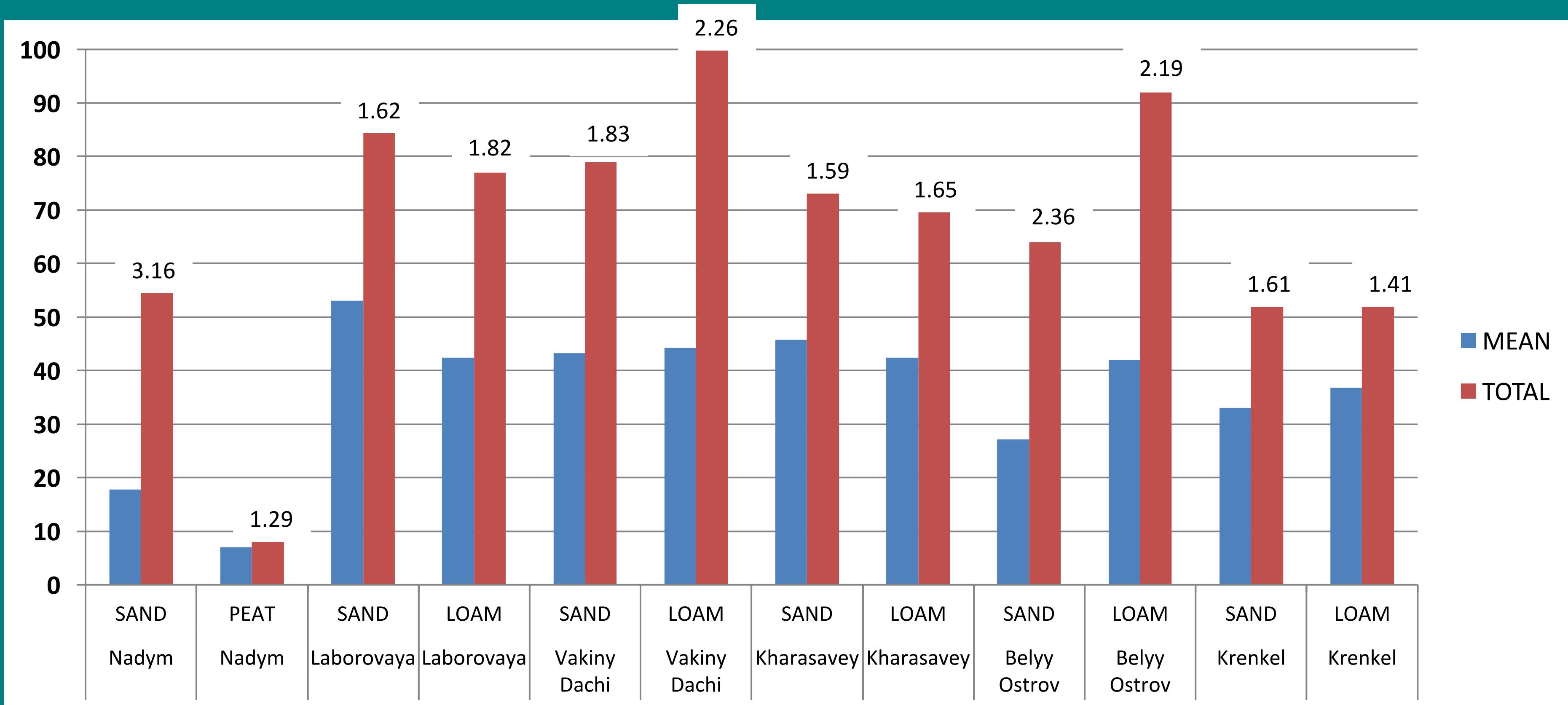


Species Richness (EAT - 5 x 5 m relevés)



- Species richness relatively consistent along latitudinal transect (lower in forest-tundra and in Subzones B and A)
- Generally consistent between Sandy and Loamy soils (higher on Loamy soils in Subzones B and A)

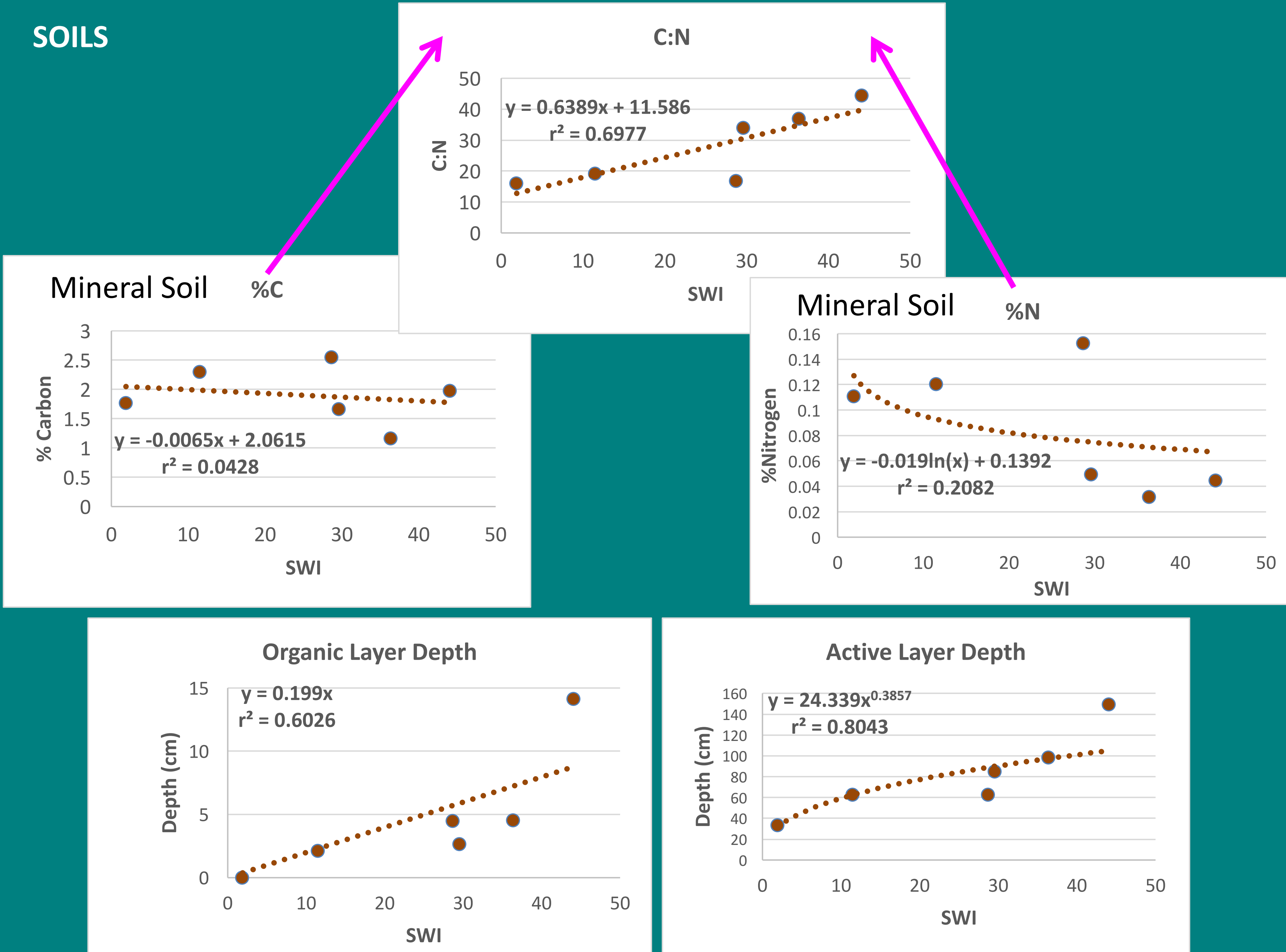
Even though the richness values are similar, the species are not the same.



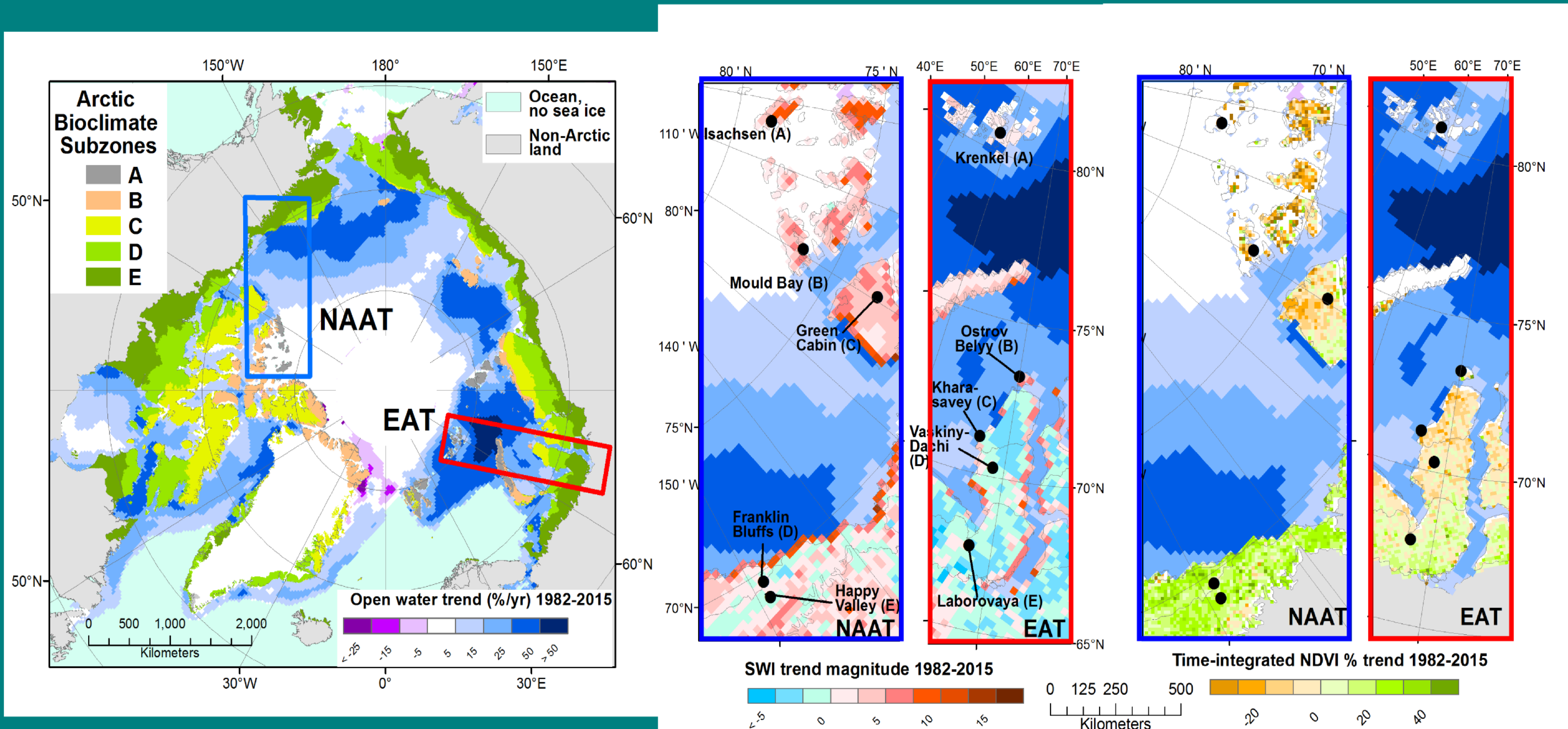
- Plot replicates result in average multiplication of species richness by 1.90 (i.e. ~doubling of richness)
- **Sampling across textures multiplies species richness on average by 1.47 (i.e. 47% increase in richness)**
- **Sampling across latitudinal gradient multiplies species richness by 2.89 (i.e. ~tripling of richness)**

Mean species richness by texture within location: 68
Mean species richness by location: 97
Total species richness for entire gradient: 281

SOILS


C:N
y = 0.6389x + 11.586
r² = 0.6977
C:N
SWI
50
40
30
20
10
0
0
10
20
30
40
50
Mineral Soil %C
y = -0.0065x + 2.0615
r² = 0.0428
% Carbon
SWI
3
2.5
2
1.5
1
0.5
0
Mineral Soil %N
y = -0.019ln(x) + 0.1392
r² = 0.2082
%Nitrogen
SWI
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Organic Layer Depth
y = 0.199x
r² = 0.6026
Depth (cm)
SWI
15
10
5
0
Active Layer Depth
y = 24.339x^0.3857
r² = 0.8043
Depth (cm)
SWI
160
140
120
100
80
60
40
20
0

Temporal Dynamics of Temperature (SWI) and NDVI for the Eurasian Arctic Transect



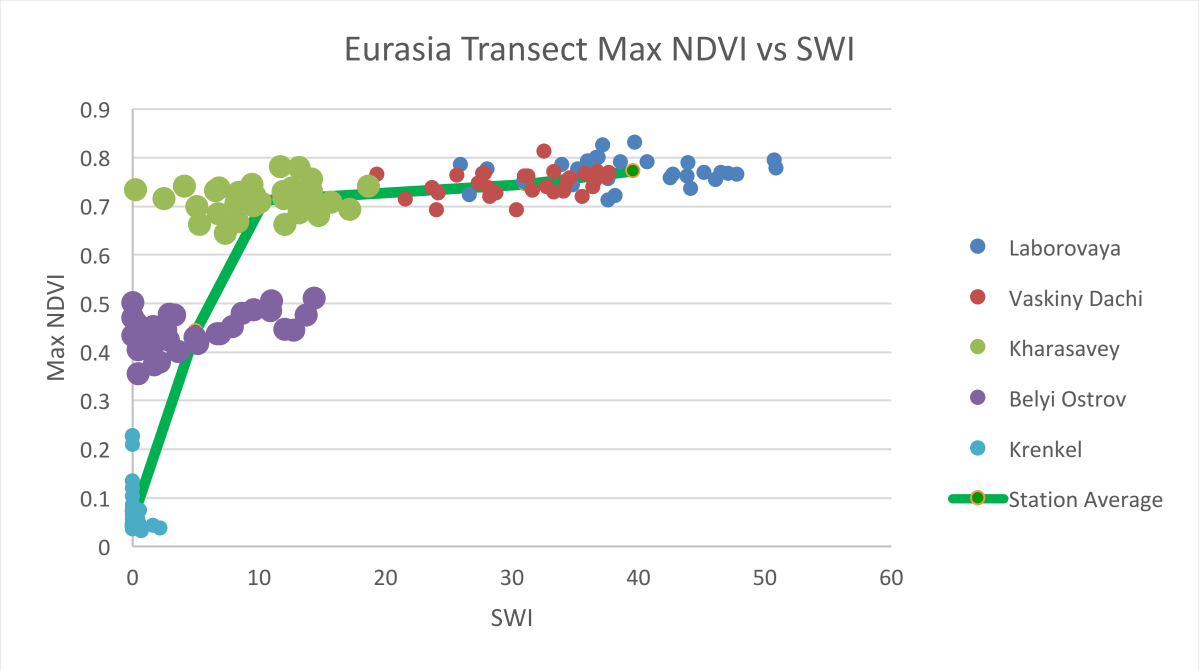
- **<u>TI (time-integrated) – NDVI</u>** is an indicator of cumulative growing season productivity
- The Eurasian Arctic Transect has experienced substantive warming further north and generally slight cooling on the Yamal Peninsula from 1982-2015
- The Eurasian Arctic Transect has exhibited "greening" in the southern part of the Yamal Peninsula, "browning" in the northern part of the Peninsula, and possibly slight "greening" on the islands north of the Peninsula

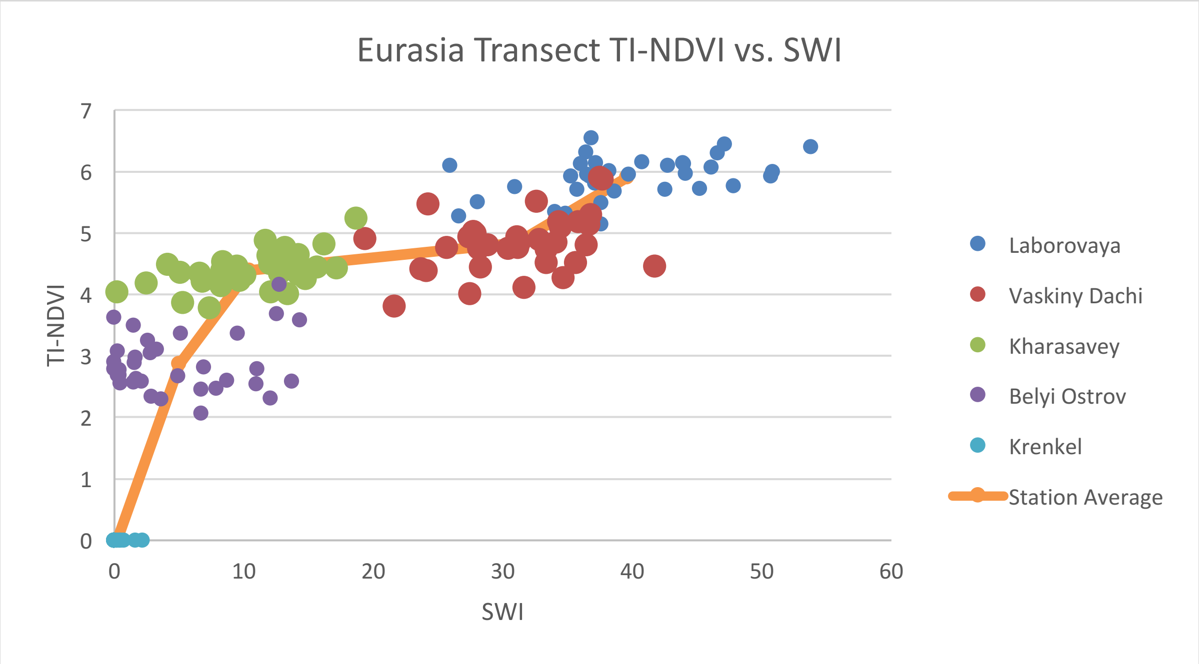
Bioclimate subzone	NAAT				EAT			
	SWI		TI-NDVI		SWI		TI-NDVI	
	Subzone	Study location	Subzone	Study location	Subzone	Study location	Subzone	Study location
A	73% (3.7)	Isachsen: **174% (6.7)**	-6.3% (0.0)	Isachsen: NA	175% (3.6)	Krenkel: **NM (0.83)**	8.6% (0.02)	Krenkel: NA
B	74% (5.2)	Mould Bay: *49% (5.0)*	**-17% (-0.22)**	Mould Bay: **-47% (-0.25**	**38% (3.2)**	Belyy Ostrov: **NM (13.0)**	3.8% (0.09)	Belyy Ostrov: 5.3% (0.15)
C	*20% (3.8)*	Green Cabin 11.8% (3.1)	-5% (-0.14)	Green Cabin: 4.5% (0.14)	-1.9% (-0.50)	Kharasavey: **154% (9.4)**	**-7.8% (-0.37)**	Kharasavey: **8.6% (0.37)**
D	11% (3.1)	Franklin Bluffs: 1.7% (0.65)	**21% (0.91)**	Franklin Bluffs: **17% (0.74)**	-2.3% (-0.72)	Vaskiny Dachi: 1.6% (0.51)	2.7% (-0.14)	Vaskiny Dachi: -8.6% (-0.45)
E	3.5% (1.3)	Happy Valley: 1.7% (0.69)	**18% (1.0)**	Happy Valley: **25% (1.4)**	-3.7% (-1.5)	Laborovaya: -1.9% (-0.78)	**6.1% (0.32)**	Laborovaya: **6.7% (0.39)**
Total	11% (2.4)		**10% (0.33)**		-4.4% (-1.3)		0% (0)	

- Warming and "greening" in Subzones A, B, and C
- Warming and "browning" in Subzone D
- Cooling and "greening" in Subzone E

(1982-2015)

(data from Bhatt et al., in prep.)





Spatio-temporal relationships between SWI and NDVI

Generally weak relationships between SWI and NDVI, except for the middle of the transect – Subzones B , C, and D (coupling of vegetation and summer warmth)

Subzones A-C – warming with moderate greening; NDVI is somewhat related to SWI

Subzone D – slight warming and browning; NDVI is somewhat related to SWI

Subzone E – slight cooling and greening; minimal relationship between NDVI and SWI

Conclusions

- A collection of field locations along a latitudinal gradient in northwestern Siberia, Russia (EAT) was used to evaluate the spatial patterns of vegetation and soil properties along a summer warmth index (SWI) gradient

- NDVI, LAI, total biomass, shrub biomass, and total non-vascular biomass all increased with increasing SWI; mosses had their greatest biomass at intermediate values of SWI

- Plant community composition differed markedly between soil textures, but other differences were minimal except for LAI and overstory biomass. Species richness was similar between the soil textures, yet the actual species differed by ~50%

-C:N ratio (mineral soil), organic layer thickness, and active layer thickness all increased with increasing SWI

- The northernmost subzones (A-C) along the EAT have shown substantial warming with moderate vegetation response, whereas the southernmost areas (Subzone E) have shown substantive vegetation increases with essentially no warming

- Vegetation in Subzones B-D (along the EAT) is the most response with regard to inter-annual variability in SWI

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