

Variation in Tundra Plant Traits Across a Latitudinal Gradient

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Background

- Vegetation is responding to a **warming climate** (Elmendorf et al. 2011; Walker et al. 2006; Chapin et al. 1995)



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- Some species are thriving while others are disappearing over time (Hollister et al. 2015; Fraser et al. 2014; Elmendorf et al. 2011)

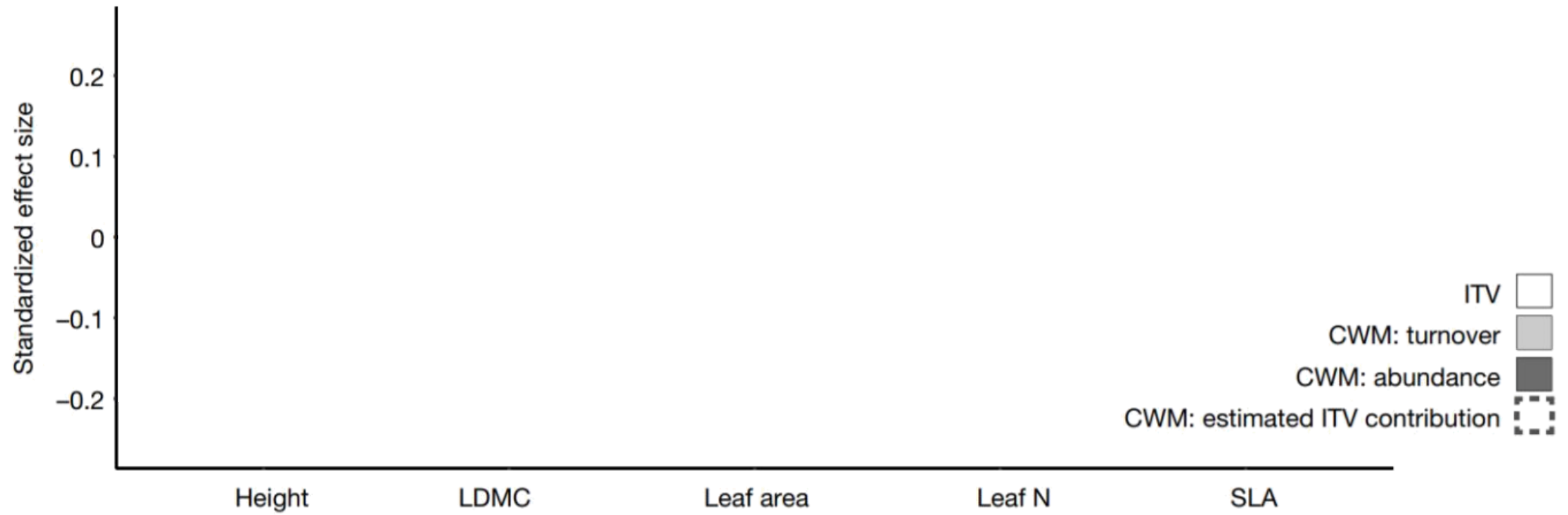


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- Some species are thriving while others are disappearing over time (Hollister et al. 2015; Fraser et al. 2014; Elmendorf et al. 2011)
- There is evidence that plant traits can explain these changes (Bjorkman et al. 2018; Soudzilovskaia et al. 2013; Hudson et al. 2011)

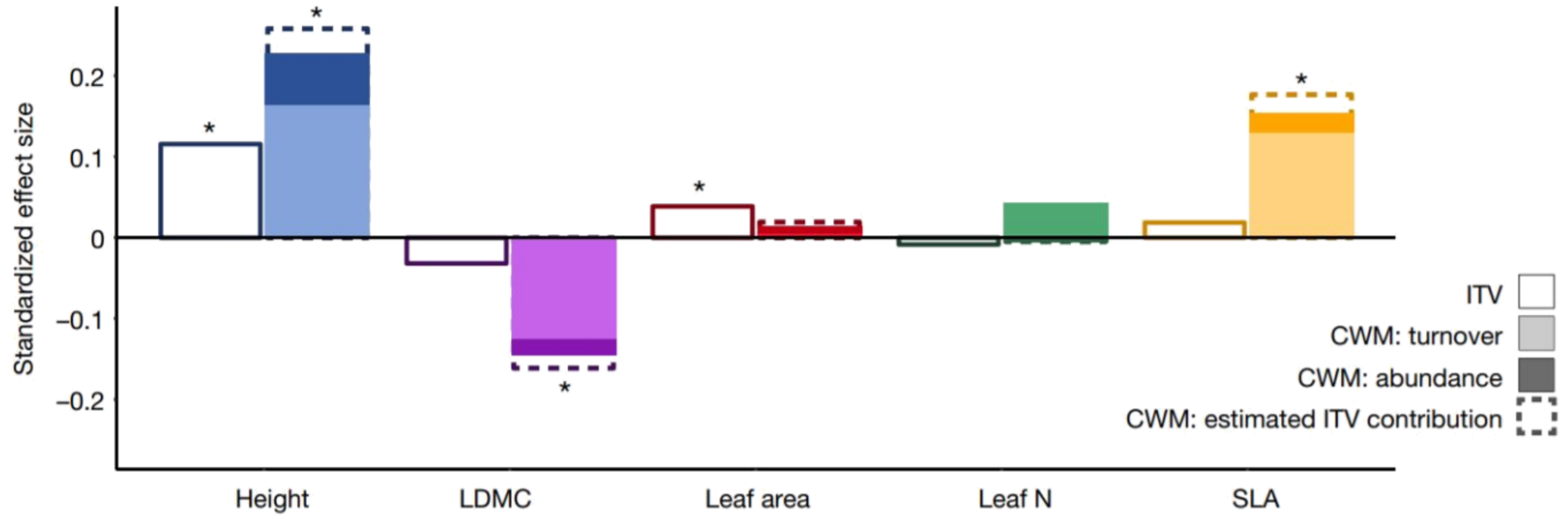


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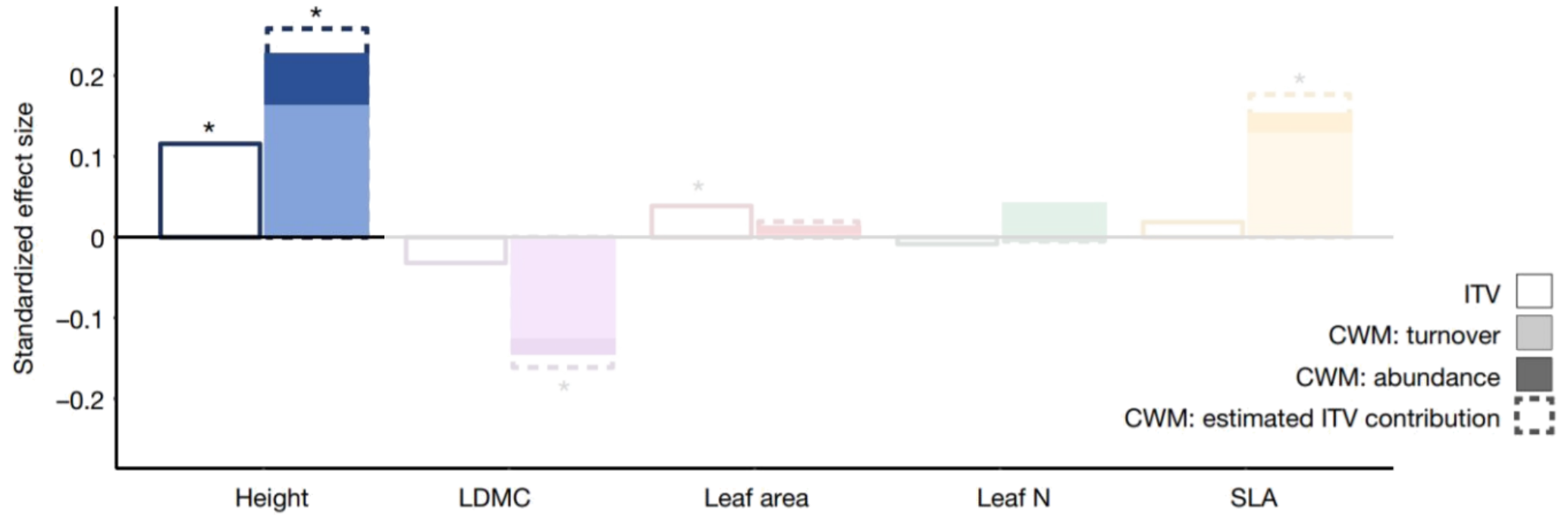
Bjorkman et al. 2018

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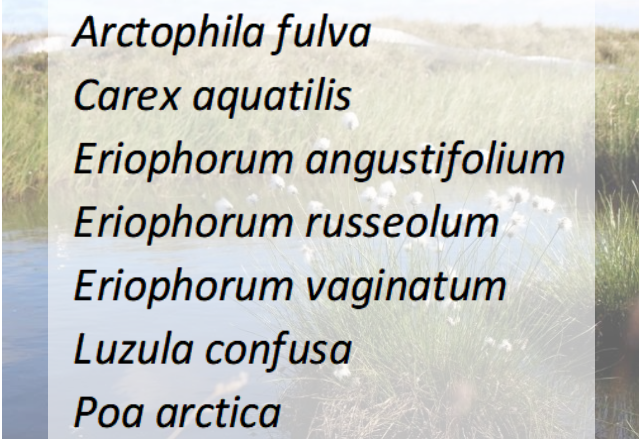

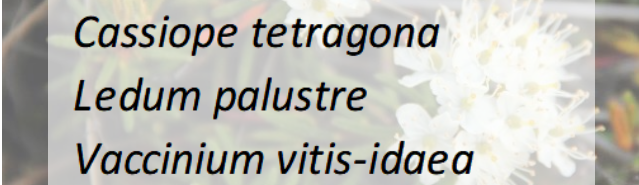



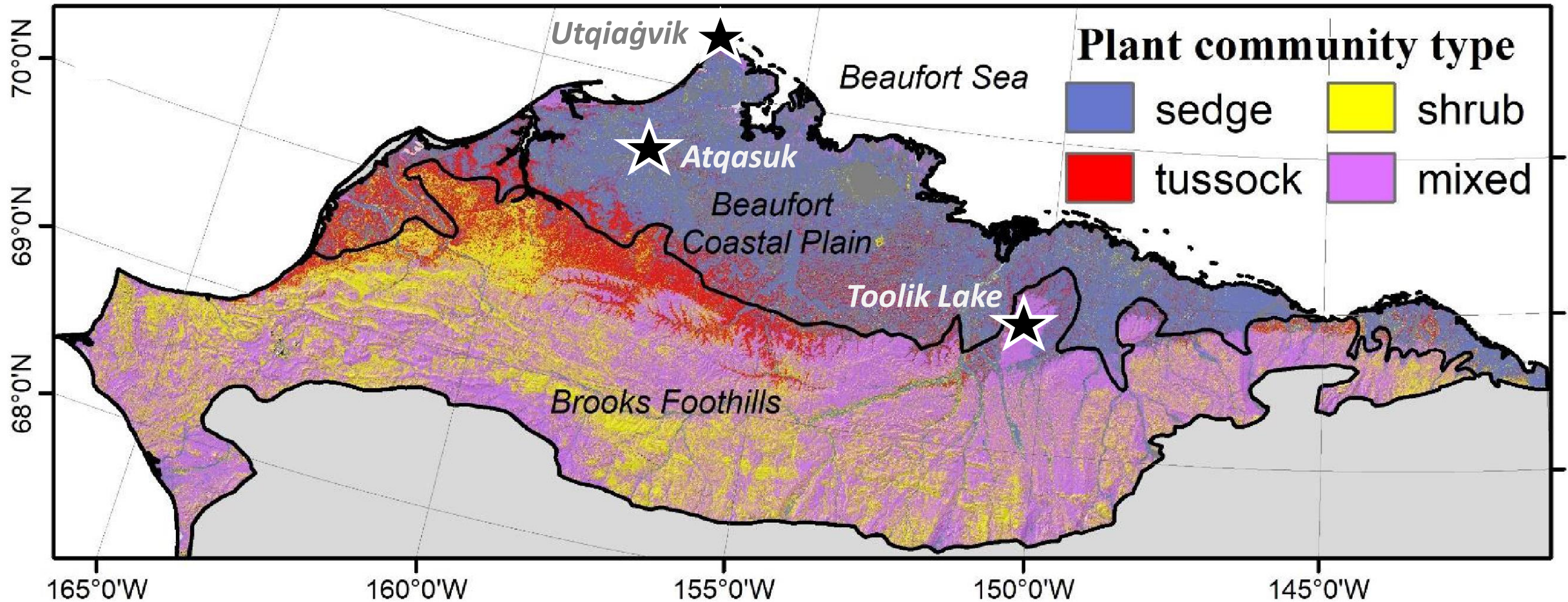
Bjorkman et al. 2018

Questions



How much variation in plant traits is present across research sites?

Species	Utqiagvik	Atqasuk	Toolik Lake
Graminoids			
 <i>Arctophila fulva</i>	Locally abundant	Locally abundant	Rare
<i>Carex aquatilis</i>	Common	Common	Common
<i>Eriophorum angustifolium</i>	Common	Common	Common
<i>Eriophorum russeolum</i>	Locally abundant	Locally abundant	Rare
<i>Eriophorum vaginatum</i>	Rare	Common	Common
<i>Luzula confusa</i>	Locally abundant	Locally abundant	Locally abundant
<i>Poa arctica</i>	Common	Locally abundant	Locally abundant
Deciduous Shrubs			
 <i>Betula nana</i>	Absent	Common	Common
<i>Salix pulchra</i>	Locally abundant	Common	Common
Evergreen Shrubs			
 <i>Cassiope tetragona</i>	Locally abundant	Locally abundant	Common
<i>Ledum palustre</i>	Absent	Common	Common
<i>Vaccinium vitis-idaea</i>	Locally abundant	Common	Common
Forbs			
 <i>Pedicularis kanei</i>	Rare	Rare	Rare
<i>Petasites frigidus</i>	Common	Common	Common
<i>Stellaria laeta</i>	Common	Common	Common



Berner et al. 2018

Plant Traits

Plant Height

Vegetative Height



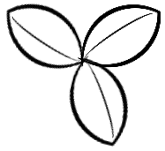
Reproductive Height



Plant Traits



Plant Height



Plant Extent



Plant Traits



Plant Height



Plant Extent



Leaf Thickness



Plant Traits



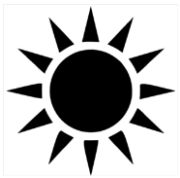
Plant Height



Plant Extent



Leaf Thickness



Photosynthetic Capacity (A_{max})



Plant Traits



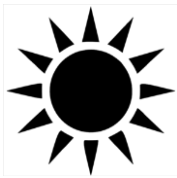
Plant Height



Plant Extent



Leaf Thickness



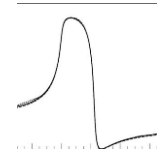
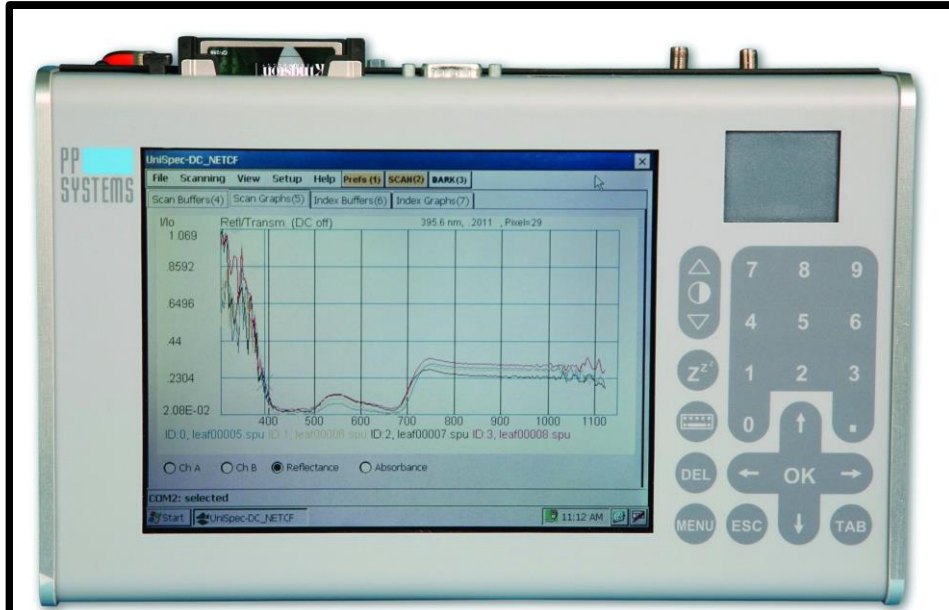
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Dark Respiration

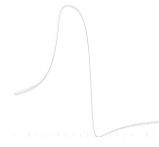
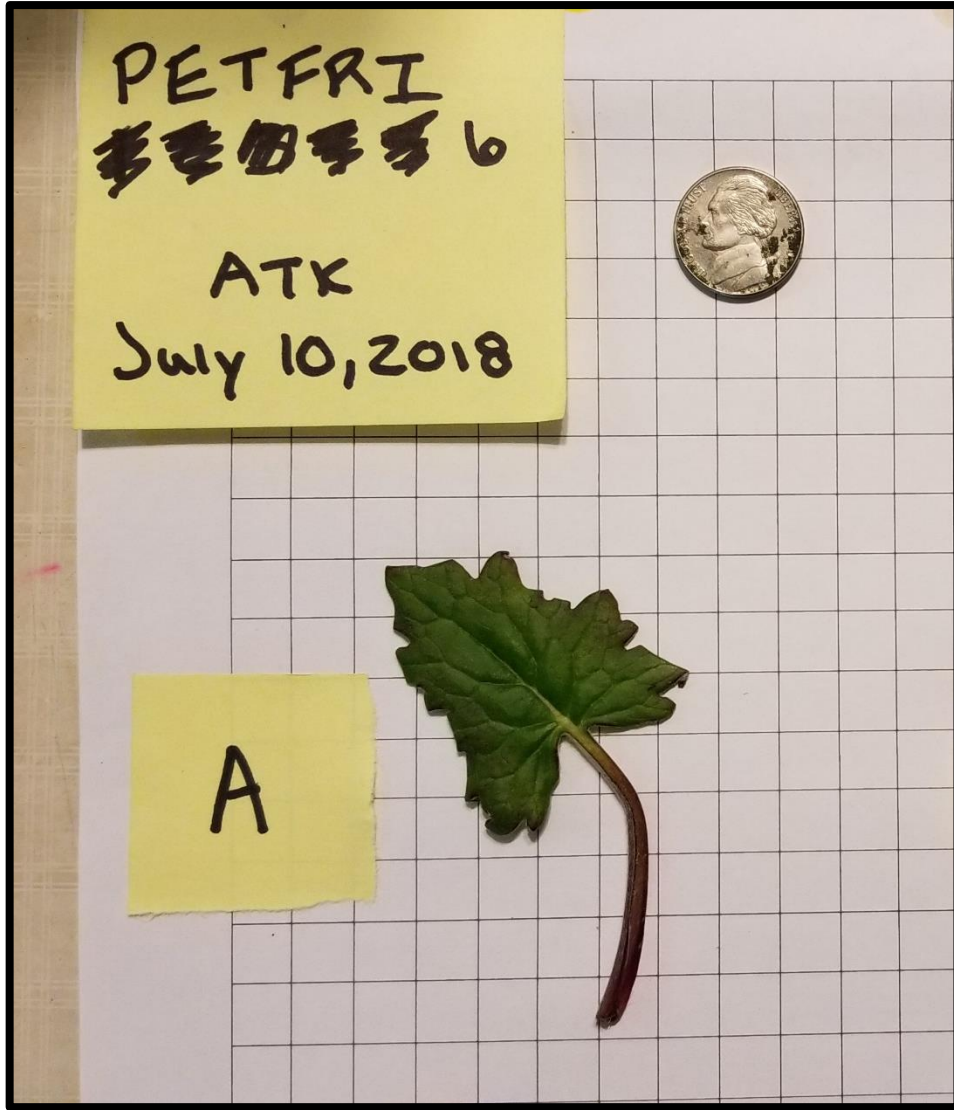


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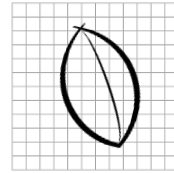


Leaf Reflectance

Plant Traits

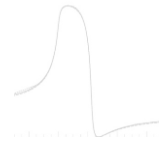


Leaf Reflectance



Leaf Area

Plant Traits



Leaf Reflectance

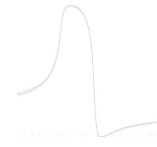
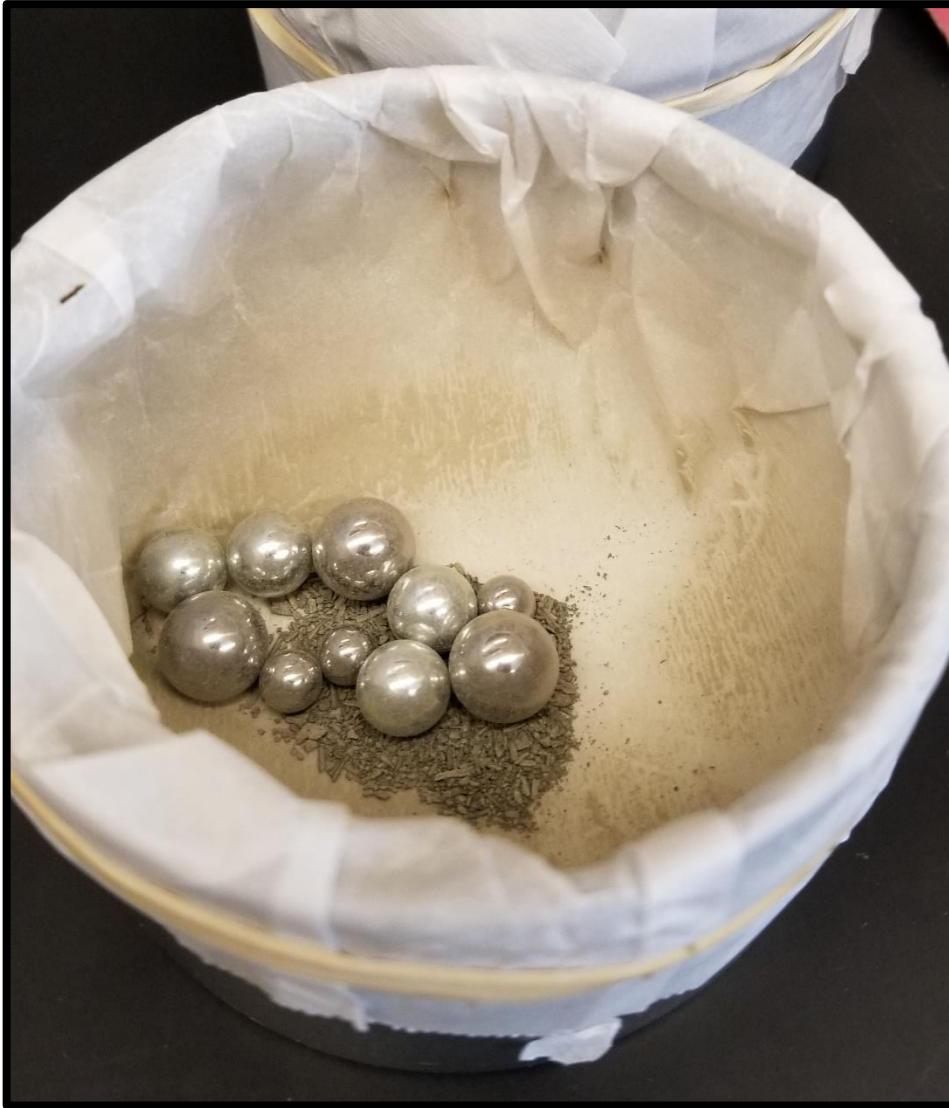


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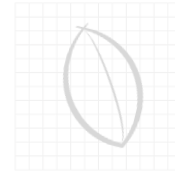


Leaf Dry & Fresh Mass

Plant Traits



Leaf Reflectance



Leaf Area



Leaf Dry & Fresh Mass



Leaf N and P Content

Plant Traits



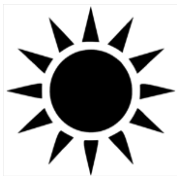
Plant Height



Plant Extent



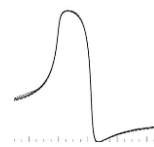
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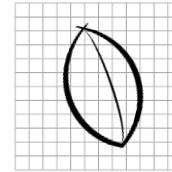
Photosynthetic Capacity (A_{max})



Dark Respiration



Leaf Reflectance



Leaf Area



Leaf Dry & Fresh Mass



Leaf N and P Content

Additional Calculations

*Leaf Area ÷ Dry Mass = **Specific Leaf Area (SLA)***

*Dry Mass ÷ Fresh Mass = **Leaf Dry Matter Content (LDMC)***

*Leaf Nitrogen ÷ Leaf Phosphorous = **N:P Ratio***

Additional Calculations

Leaf Area ÷ Dry Mass = Specific Leaf Area (SLA)

Dry Mass ÷ Fresh Mass = Leaf Dry Matter Content (LDMC)

Leaf Nitrogen ÷ Leaf Phosphorous = N:P Ratio

3 sites x

15 species/site x

10 individuals/species x

10 traits/individual =

4,500 measurements!!!

Questions

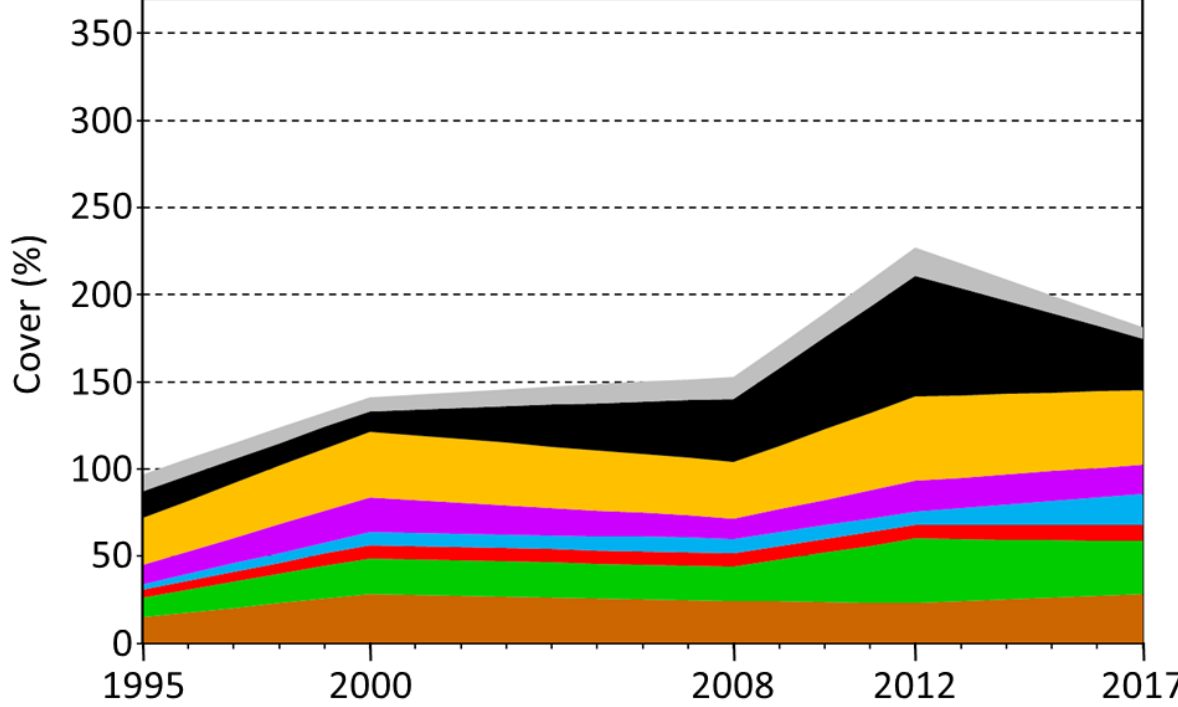


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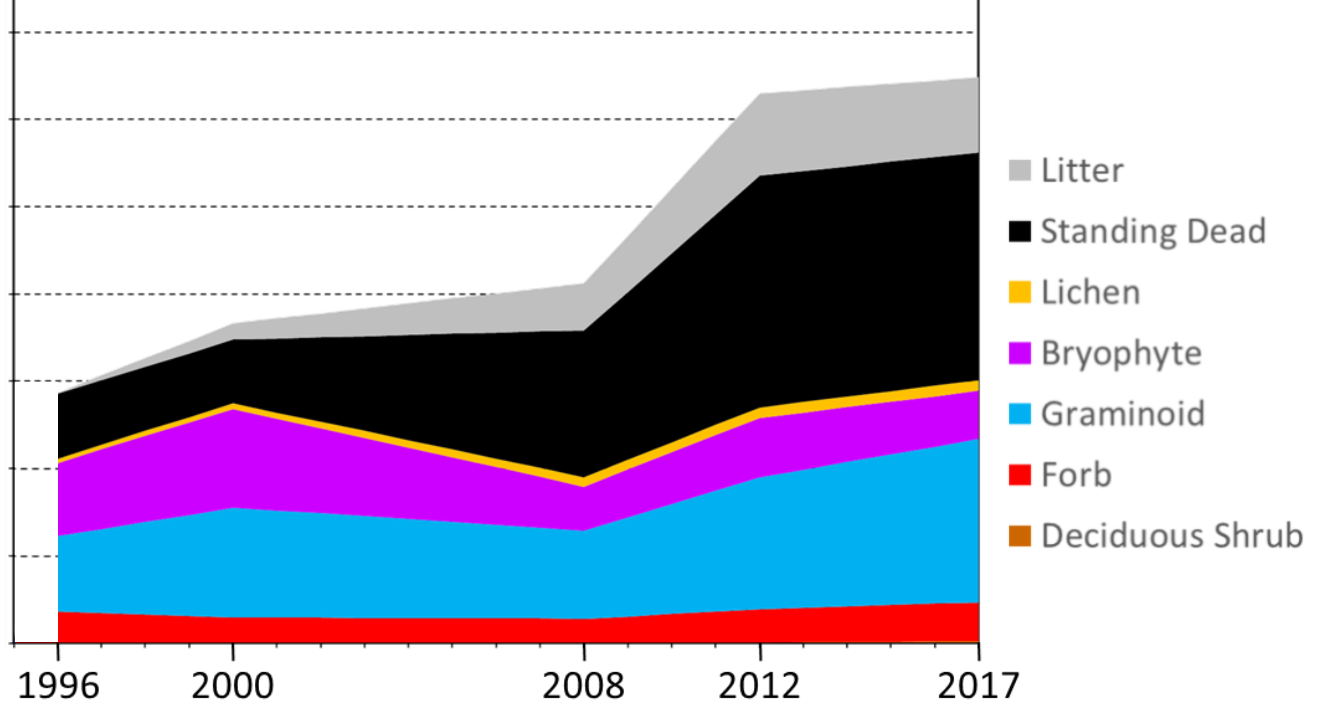


Can trends in plant traits explain observed changes in cover?

Utqiagvik Dry



Utqiagvik Wet



- Litter
- Standing Dead
- Lichen
- Bryophyte
- Graminoid
- Forb
- Deciduous Shrub

Preliminary Analysis

Utqiaġvik Dry

Species	Δ Cover	Height	C:N Ratio	LDMC	Leaf C	Leaf N	Leaf P	Seed Mass	SLA
<i>Alopecurus alpinus</i>	1.04	7.30	NA	0.51	NA	7.17	NA	NA	9.72
<i>Arctagrostis latifolia</i>	3.88	7.44	NA	0.43	NA	9.53	NA	0.04	12.91
<i>Carex aquatilis</i>	4.38	8.89	NA	0.62	NA	NA	NA	NA	18.28
<i>Cassiope tetragona</i>	10.13	7.07	48.91	0.59	533.71	11.64	1.15	1.35	5.54
<i>Luzula arctica</i>	0.29	1.39	NA	0.53	NA	NA	NA	0.16	15.47
<i>Luzula confusa</i>	-0.71	5.09	30.91	NA	484.79	17.32	NA	0.20	NA
<i>Poa arctica</i>	2.79	6.04	NA	NA	NA	NA	NA	NA	11.54
<i>Ranunculus nivalis</i>	0.04	4.33	NA	0.14	454.18	41.38	3.92	NA	35.82
<i>Saxifraga punctata</i>	-0.08	3.88	24.04	NA	421.00	17.63	1.67	NA	NA
<i>Senecio atropurpureus</i>	0.00	1.40	NA	0.23	NA	NA	NA	0.93	12.73
<i>Stellaria laeta</i>	0.46	3.08	NA	NA	NA	NA	NA	0.04	15.43
<i>Vaccinium vitis-idaea</i>	-0.21	1.00	42.76	0.51	492.58	11.64	1.10	0.23	7.48

Pearson Correlations

Utqiaġvik Dry

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<i>Luzula confusa</i>	-0.71	5.09	30.91	NA	484.79	17.32	NA	0.20	NA
<i>Poa arctica</i>	2.79	6.04	NA	NA	NA	NA	NA	NA	11.54
<i>Ranunculus nivalis</i>	0.04	4.33	NA	0.14	454.18	41.38	3.92	NA	35.82
<i>Saxifraga punctata</i>	-0.08	3.88	24.04	NA	421.00	17.63	1.67	NA	NA
<i>Senecio atropurpureus</i>	0.00	1.40	NA	0.23	NA	NA	NA	0.93	12.73
<i>Stellaria laeta</i>	0.46	3.08	NA	NA	NA	NA	NA	0.04	15.43
<i>Vaccinium vitis-idaea</i>	-0.21	1.00	42.76	0.51	492.58	11.64	1.10	0.23	7.48

Pearson Correlations

Utqiaġvik Dry

Species	Δ Cover	Height	C:N Ratio	LDMC	Leaf C	Leaf N	Leaf P	Seed Mass	SLA
<i>Alopecurus alpinus</i>	1.04	7.30	NA	0.51	NA	7.17	NA	NA	9.72
<i>Arctagrostis latifolia</i>	3.88	7.44	NA	0.43	NA	9.53	NA	0.04	12.91
<i>Carex aquatilis</i>	4.38	8.89	NA	0.62	NA	NA	NA	NA	18.28
<i>Cassiope tetragona</i>	10.13	7.07	48.91	0.59	533.71	11.64	1.15	1.35	5.54
<i>Luzula arctica</i>	0.29	1.39	NA	0.53	NA	NA	NA	0.16	15.47
<i>Luzula confusa</i>	-0.71	5.09	30.91	NA	484.79	17.32	NA	0.20	NA
<i>Poa arctica</i>	2.79	6.04	NA	NA	NA	NA	NA	NA	11.54
<i>Ranunculus nivalis</i>	0.04	4.33	NA	0.14	454.18	41.38	3.92	NA	35.82
<i>Saxifraga punctata</i>	-0.08	3.88	24.04	NA	421.00	17.63	1.67	NA	NA
<i>Senecio atropurpureus</i>	0.00	1.40	NA	0.23	NA	NA	NA	0.93	12.73
<i>Stellaria laeta</i>	0.46	3.08	NA	NA	NA	NA	NA	0.04	15.43
<i>Vaccinium vitis-idaea</i>	-0.21	1.00	42.76	0.51	492.58	11.64	1.10	0.23	7.48

Preliminary Analysis

At Utqiagvik...

Site	Plant Height	C:N Ratio	LDMC	Leaf C	Leaf N	Leaf P	Seed Mass	SLA
Utqiagvik	0.45	0.72 *	0.32	0.63 *	-0.22	-0.39	0.73 *	-0.16
Utqiagvik Dry	0.45	0.67 *	0.41	0.74 *	-0.26	-0.43	0.72 *	-0.42
Utqiagvik Wet	0.53	-0.69 *	0.28	0.06	0.07	-0.43	0.31	0.07

Preliminary Analysis

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Utqiagvik	0.45	0.72 *	0.32	0.63 *	-0.22	-0.39	0.73 *	-0.16
Utqiagvik Dry	0.45	0.67 *	0.41	0.74 *	-0.26	-0.43	0.72 *	-0.42
Utqiagvik Wet	0.53	-0.69 *	0.28	0.06	0.07	-0.43	0.31	0.07

***C:N ratio, leaf carbon content and dry seed mass** showed the most promise as cover change drivers*

Preliminary Analysis

At Utqiagvik...

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Utqiagvik Wet	0.53	-0.69 *	0.28	0.06	0.07	-0.43	0.31	0.07

C:N ratio, leaf carbon content and dry seed mass showed the most promise as cover change drivers

At Atqasuk...

Site	Plant Height	C:N Ratio	LDMC	Leaf C	Leaf N	Leaf P	Seed Mass	SLA
Atqasuk	0.74 *	-0.29	0.34	-0.15	0.1	0.14	-0.18	0.18
Atqasuk Dry	0.48	-0.13	0.02	0.15	-0.08	-0.32	-0.31	-0.21
Atqasuk Wet	0.75 *	-0.26	0.53	-0.08	0	-0.05	-0.17	0.57

*Only **plant height** showed promise as a potential cover change driver...*

Taxa	Plant Height	C:N Ratio	LDMC	Leaf C	Leaf N	Leaf P	Seed Mass	SLA
Utqiagvik Dry (BD)								
Evergreen Shrub	4.0325	45.8309	0.5483	513.1429	11.6442	1.1279	0.7904	6.5083
<i>Cassiope tetragona</i>	7.0650	48.9064	0.5911	533.7090	11.6439	1.1538	1.3500	5.5376
<i>Vaccinium vitis-idaea</i>	1.0000	42.7554	0.5055	492.5768	11.6445	1.1021	0.2308	7.4790
Forb	2.7841	24.0367	0.2325	421.0000	17.6333	1.6667	0.4863	14.0783
<i>Saxifraga punctata</i>	3.8750	24.0367		421.0000	17.6333	1.6667		
<i>Senecio atropurpureus</i>	1.4000		0.2325				0.9339	12.7256
<i>Stellaria laeta</i>	3.0774						0.0386	15.4309
Graminoid	6.0264	30.9133	0.5232	484.7861	11.3408		0.1325	13.5835
<i>Alopecurus alpinus</i>	7.3043		0.5113		7.1667			9.7237
<i>Arctagrostis latifolia</i>	7.4423		0.4336		9.5333		0.0350	12.9074
<i>Carex aquatilis</i>	8.8889		0.6203					18.2833
<i>Luzula arctica</i>	1.3922		0.5274				0.1646	15.4656
<i>Luzula confusa</i>	5.0867	30.9133		484.7861	17.3223		0.1979	
<i>Poa arctica</i>	6.0442							11.5373
Utqiagvik Wet (BW)								
Deciduous Shrub	7.3333	28.3290	0.5610	436.6750	17.2950	2.0500		12.6203
<i>Salix pulchra</i>	7.3333	28.3290	0.5610	436.6750	17.2950	2.0500		12.6203
Forb	3.2188	28.6100	0.1904	447.7713	30.9275	2.6808	0.2554	22.1072
<i>Petasites frigidus</i>	2.9767	28.6100	0.2423	441.3650	20.4750	1.4429	0.4722	15.0724
<i>Ranunculus nivalis</i>	2.1053		0.1385	454.1775	41.3800	3.9187		35.8183
<i>Stellaria laeta</i>	4.5745						0.0386	15.4309
Graminoid	8.5449	30.9133	0.5449	486.7080	18.9089	2.1996	0.2080	13.9015
<i>Carex aquatilis</i>	13.8377		0.6203					18.2833
<i>Eriophorum angustifolium</i>	9.6076		0.4869	488.6300	20.4956	2.1996	0.2616	10.3199
<i>Luzula arctica</i>	3.6563		0.5274				0.1646	15.4656
<i>Luzula confusa</i>	7.8000	30.9133		484.7861	17.3223		0.1979	
<i>Poa arctica</i>	7.8231							11.5373

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At Utaiaavik...

Taxa	Plant Height	C:N Ratio	LDMC	Leaf C	Leaf N	Leaf P	Seed Mass	SLA
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Master's Thesis!!

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Change driver...

Questions



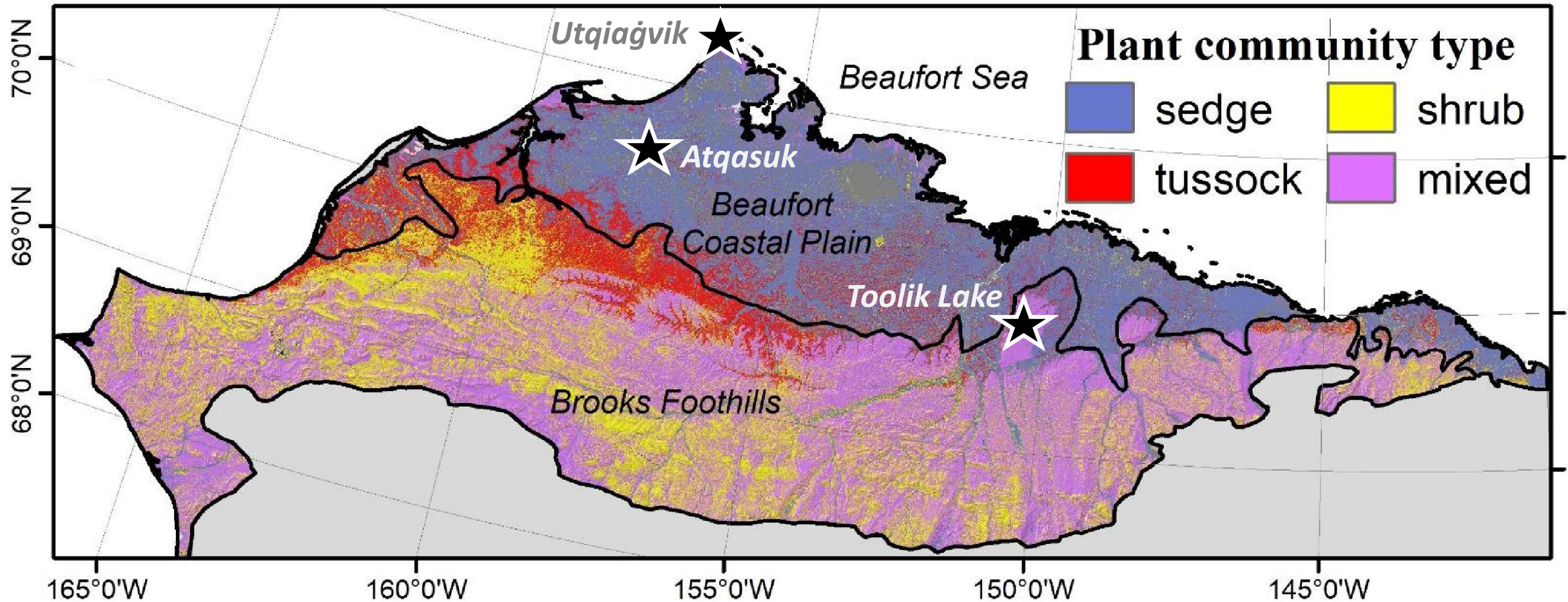
How much variation in plant traits is present across research sites?



Can trends in plant traits explain observed changes in cover?



What will these sites look like in coming decades?



Berner et al. 2018

Questions?
Comments?
Suggestions?



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