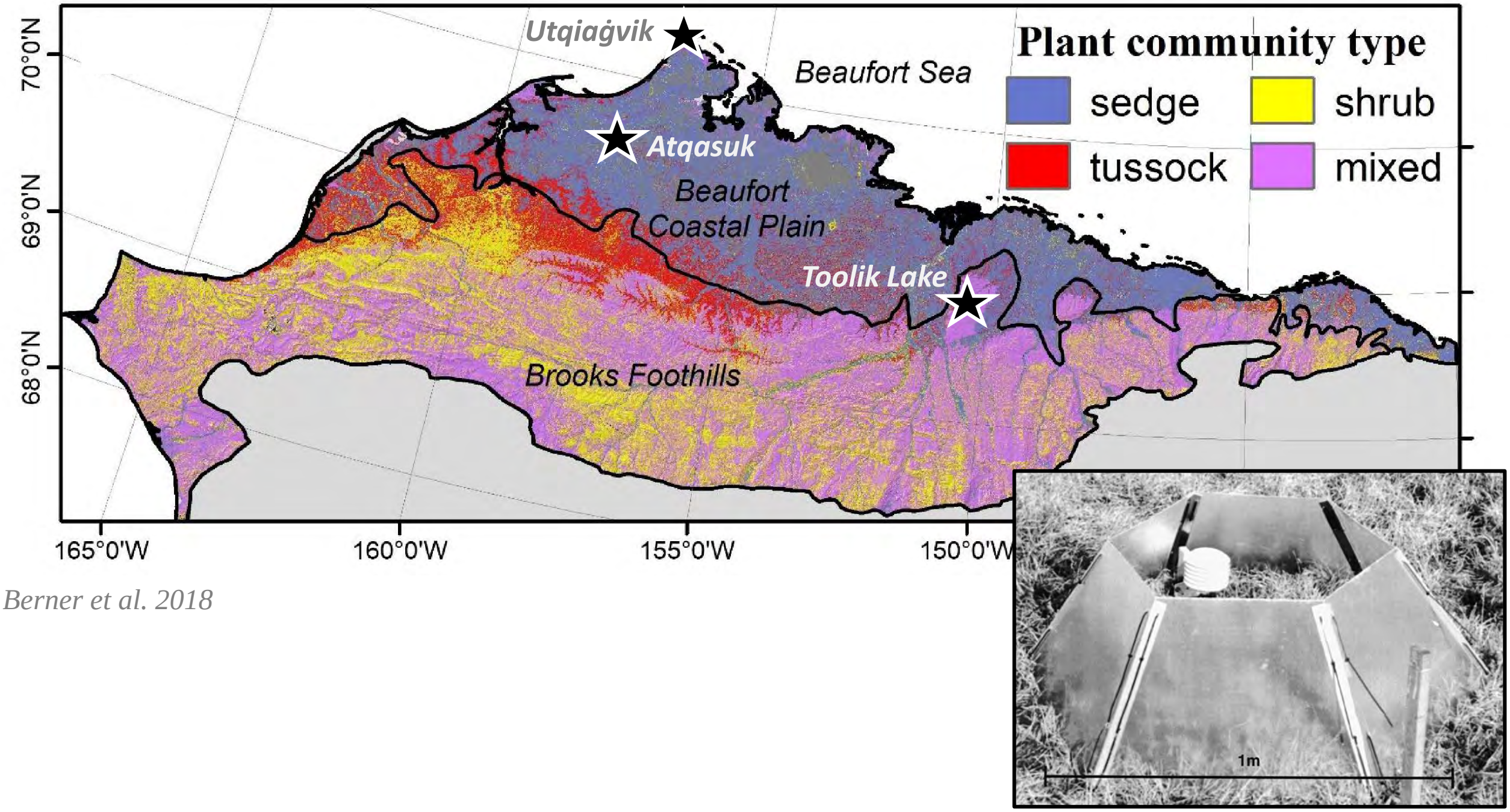
Variation in Tundra Plant Traits Across a Latitudinal Gradient

Katlyn Betway &
Dr. Bob Hollister
Grand Valley State University



Berner et al. 2018

Questions

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

Questions

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

Can trends in plant traits explain observed changes in cover?

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?

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?

Pre-Data Collection

At Utqiaġvik...

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

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

Pre-Data Collection

At Utqiaġvik...

Site	Plant Height	C:N Ratio	LDMC	Leaf C	Leaf N	Leaf P	Seed Mass	SLA
Utqiaġvik	**0.45**	**0.72 ***	**0.32**	**0.63 ***	**-0.22**	**-0.39**	**0.73 ***	**-0.16**
Utqiaġvik Dry	0.45	0.67 *	0.41	0.74 *	-0.26	-0.43	0.72 *	-0.42
Utqiaġvik 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
Utqiaġvik Dry (BD)								
Evergreen Shrub	**4.0325**	**45.8309**	**0.5483**	**513.1429**	**11.6442**	**1.1279**	**0.7904**	**6.5083**
Cassiope tetragona	7.0650	48.9064	0.5911	533.7090	11.6439	1.1538	1.3500	5.5376
Vaccinium vitis-idaea	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**
Saxifraga punctata	3.8750	24.0367		421.0000	17.6333	1.6667		
Senecio atropurpureus	1.4000		0.2325				0.9339	12.7256
Stellaria laeta	3.0774						0.0386	15.4309
Graminoid	**6.0264**	**30.9133**	**0.5232**	**484.7861**	**11.3408**		**0.1325**	**13.5835**
Alopecurus alpinus	7.3043		0.5113		7.1667			9.7237
Arctagrostis latifolia	7.4423		0.4336		9.5333		0.0350	12.9074
Carex aquatilis	8.8889		0.6203					18.2833
Luzula arctica	1.3922		0.5274				0.1646	15.4656
Luzula confusa	5.0867	30.9133		484.7861	17.3223		0.1979	
Poa arctica	6.0442							11.5373
Utqiaġvik Wet (BW)								
Deciduous Shrub	**7.3333**	**28.3290**	**0.5610**	**436.6750**	**17.2950**	**2.0500**		**12.6203**
Salix pulchra	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**
Petasites frigidus	2.9767	28.6100	0.2423	441.3650	20.4750	1.4429	0.4722	15.0724
Ranunculus nivalis	2.1053		0.1385	454.1775	41.3800	3.9187		35.8183
Stellaria laeta	4.5745						0.0386	15.4309
Graminoid	**8.5449**	**30.9133**	**0.5449**	**486.7080**	**18.9089**	**2.1996**	**0.2080**	**13.9015**
Carex aquatilis	13.8377		0.6203					18.2833
Eriophorum angustifolium	9.6076		0.4869	488.6300	20.4956	2.1996	0.2616	10.3199
Luzula arctica	3.6563		0.5274				0.1646	15.4656
Luzula confusa	7.8000	30.9133		484.7861	17.3223		0.1979	
Poa arctica	7.8231							11.5373

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?

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

Plant Traits

Plant 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

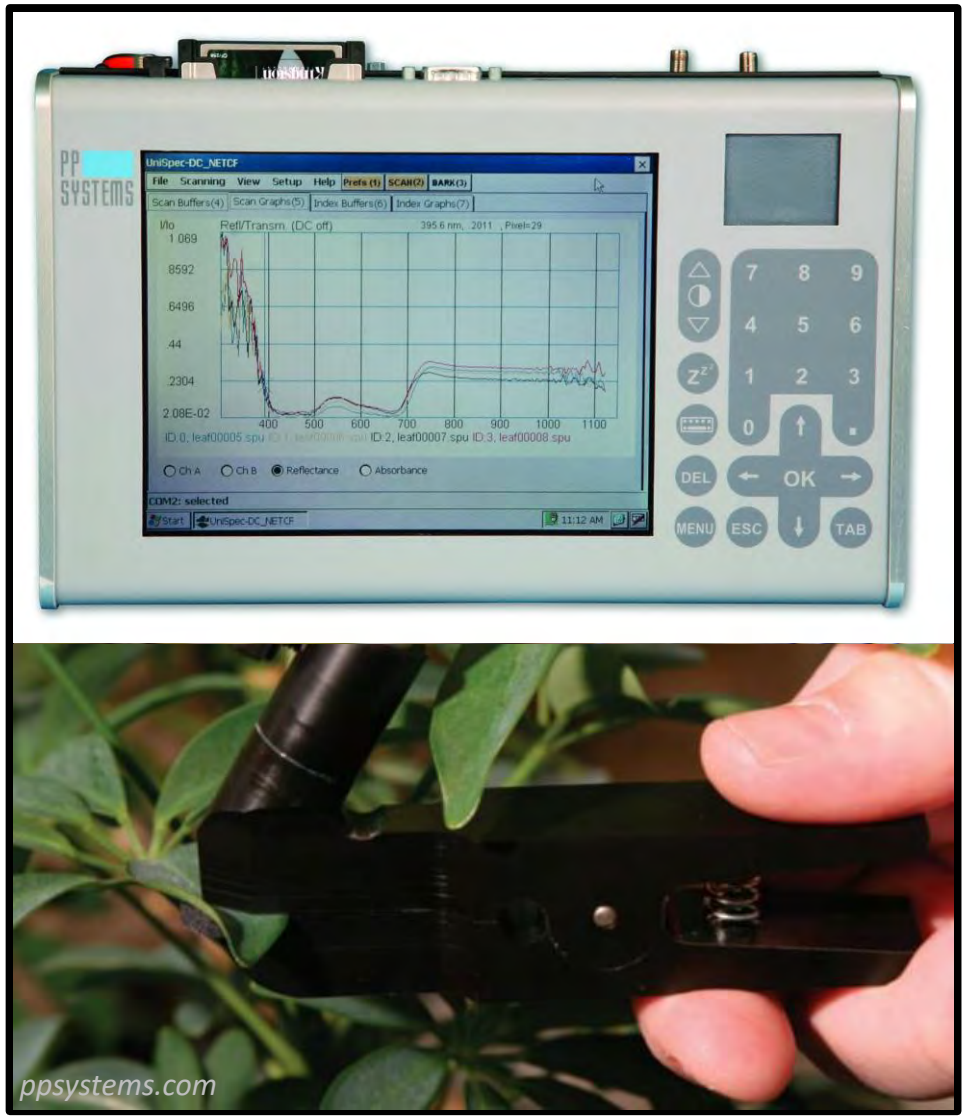
Plant Extent

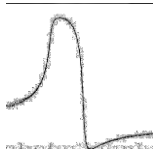
Leaf Thickness

Photosynthetic Capacity (A_{max})

Dark Respiration

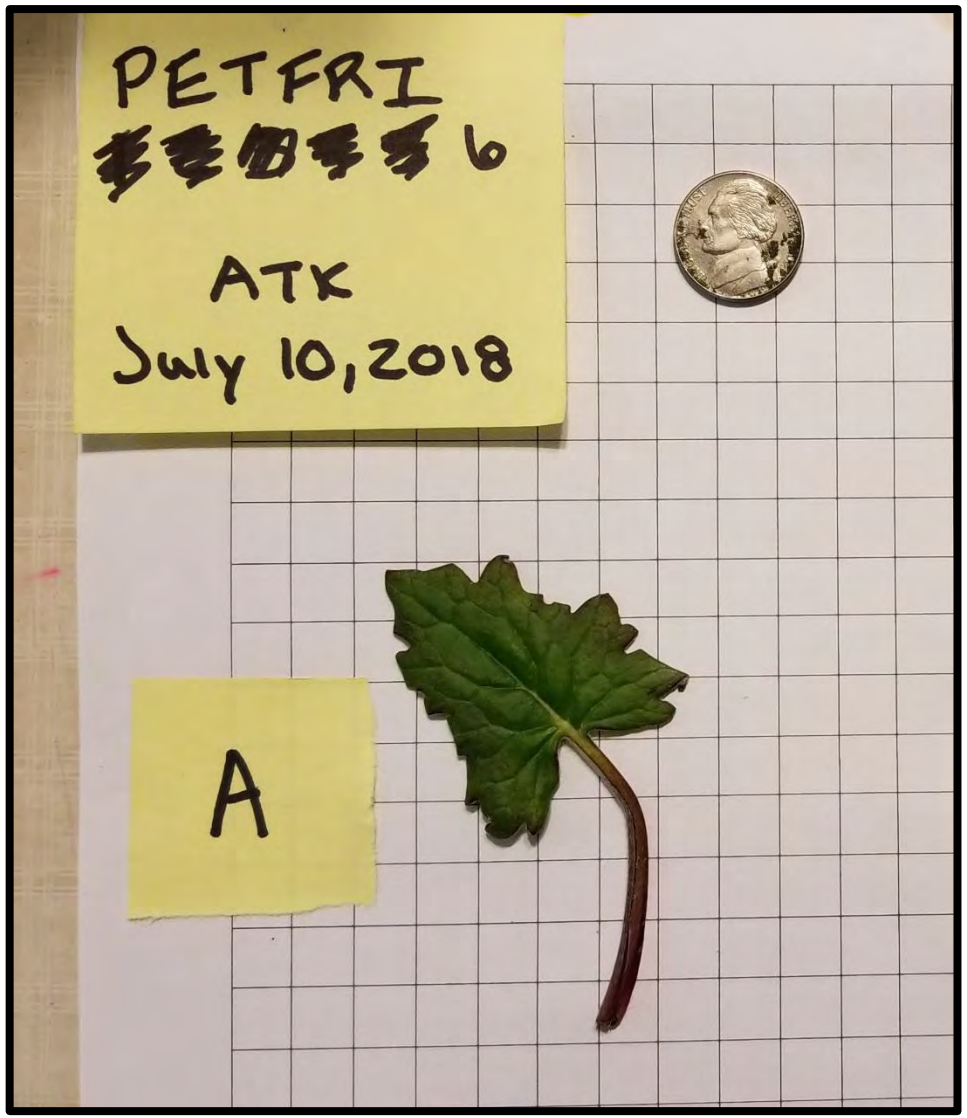
Plant Traits



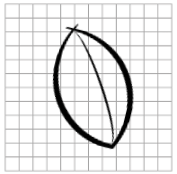


Leaf Reflectance

Plant Traits



Leaf Reflectance



Leaf Area

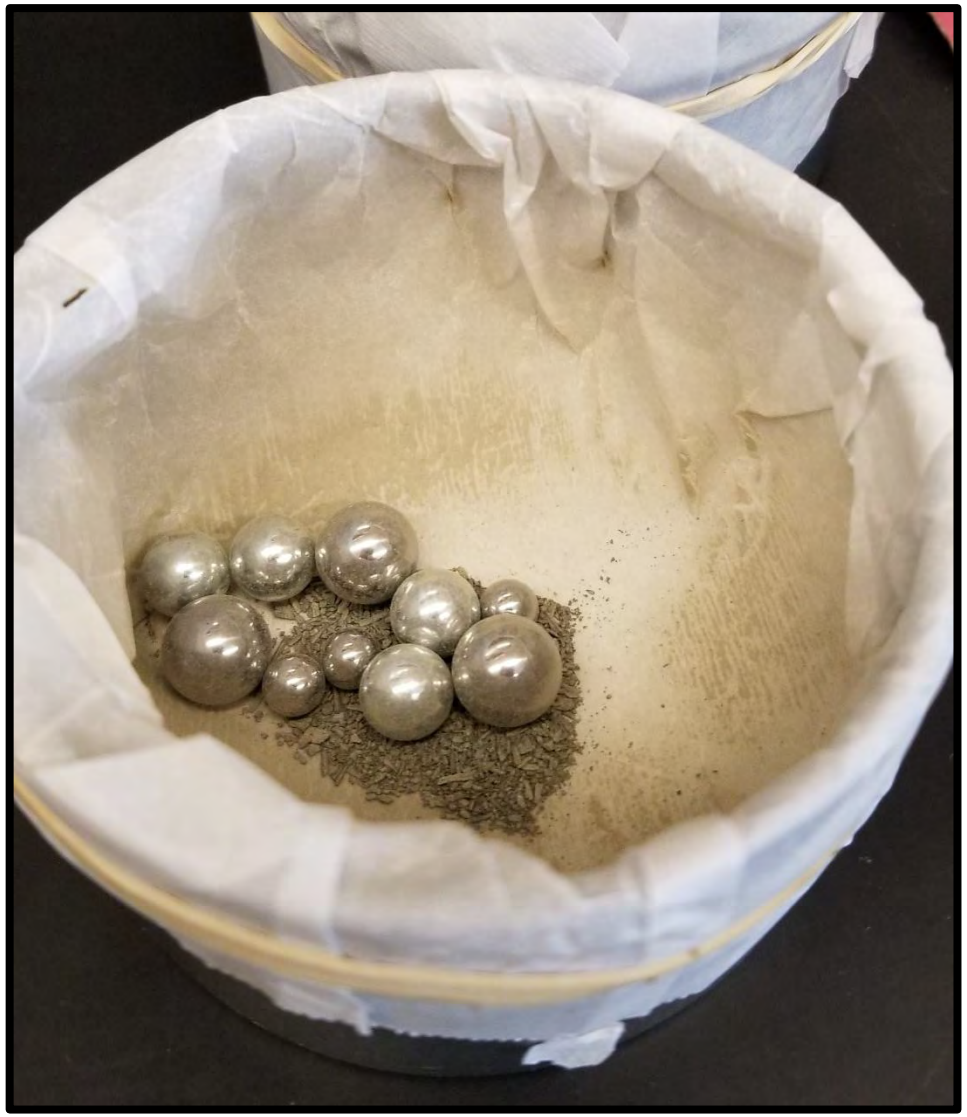
Plant Traits

Leaf Reflectance

Leaf Area

Leaf Dry & Fresh Mass

Plant Traits



Leaf Reflectance

Leaf Area

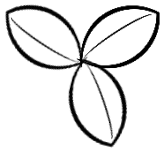
Leaf Dry & Fresh Mass

7 $2s^2 2p^3$
N
Nitrogen
14.007

Leaf N Content

Plant Traits

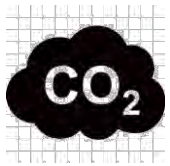
Plant Height



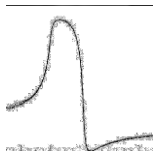
Plant Extent

Leaf Thickness

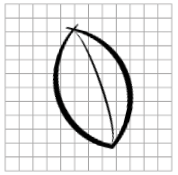
Photosynthetic Capacity (A_{max})



Dark Respiration



Leaf Reflectance



Leaf Area

Leaf Dry & Fresh Mass

Leaf N Content

Plant Traits

Additional Calculations

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

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

Plant Traits

Additional Calculations

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

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

(NIR - Red) **/** *(NIR + Red)* **= *Normalized Difference Vegetation Index*** *(NDVI)*

(ρ531 - ρ570) **/** *(ρ531 + ρ570)* **= *Photochemical Reflectance Index*** *(PRI)*

ρ900 **/** *ρ970* **= *Water Band Index*** *(WBI)*

Plant Traits

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***

(NIR - Red) **/** *(NIR + Red)* **= *Normalized Difference Vegetation Index*** *(NDVI)*

(ρ531 - ρ570) **/** *(ρ531 + ρ570)* **= *Photochemical Reflectance Index*** *(PRI)*

ρ900 **/** *ρ970* **= *Water Band Index*** *(WBI)*

3 *sites* x

15 *species/site* x

10 *individuals/species* x

10 (up to 18) *traits/individual* =

4,500 measurements!!!

Preliminary Findings

Questions

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

3 *sites* x

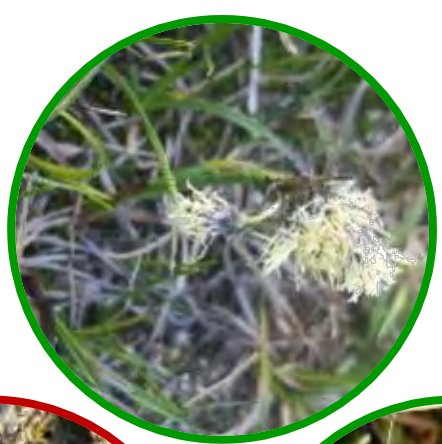
5 of ***15*** *species/site* x

10 *individuals/species* x

8 of ***10 (up to 18)*** *traits/individual* =

> 4,500 measurements!!!

Preliminary Analysis


Preliminary Analysis

Graminoid

Carex aquatilis

Preliminary Analysis

Graminoid

Eriophorum angustifolium

Preliminary Analysis

Forb

Petasites frigidus

Preliminary Analysis

Deciduous Shrub

Salix pulchra

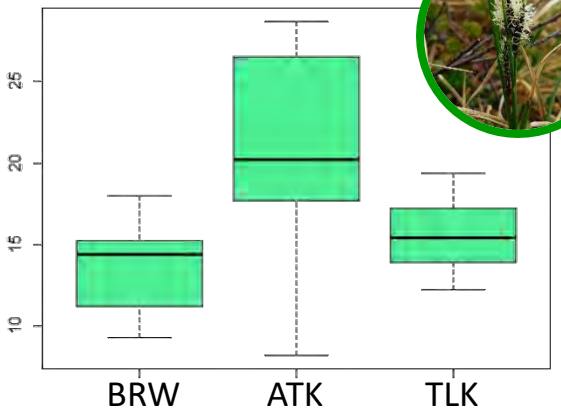
Preliminary Analysis

Evergreen Shrub

Vaccinium vitis-idaea

Differences in Vegetative Height

C. aquatilis



P = 0.015

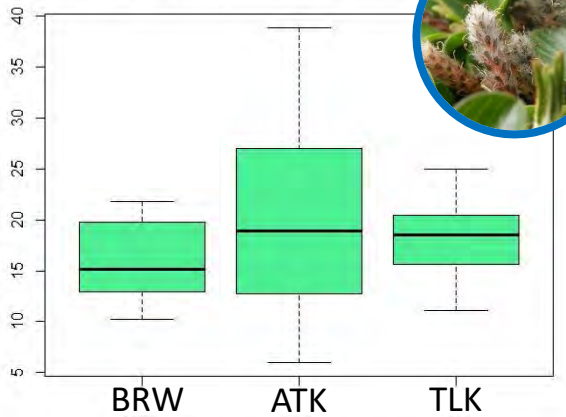
E. angustifolium

P = >0.001

P. frigidus

P = >0.001

S. pulchra



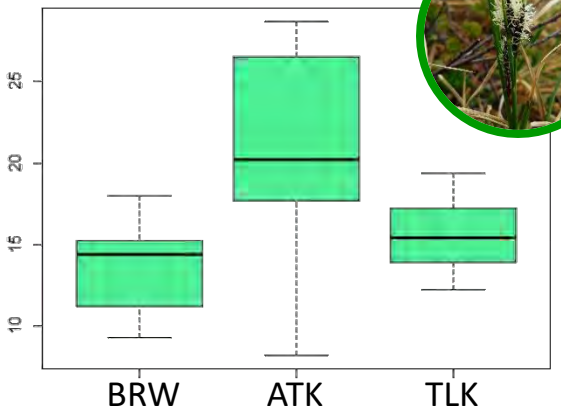
P = 0.249

V. vitis-idaea

P = >0.001

Differences in Vegetative Height

C. aquatilis



P = 0.015

E. angustifolium

P = >0.001

P. frigidus

P = >0.001

S. pulchra

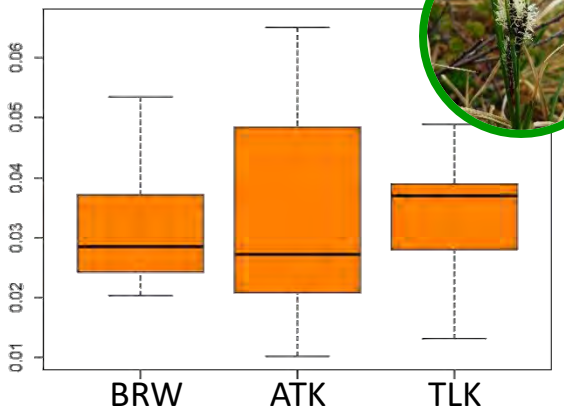
P = 0.249

V. vitis-idaea

P = >0.001

Differences in Leaf Fresh Mass

C. aquatilis



P = 0.855

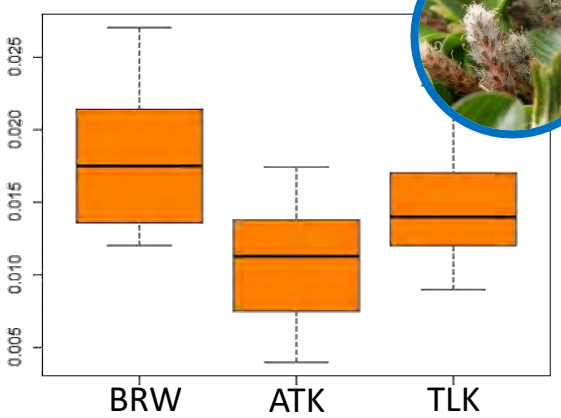
E. angustifolium

P = >0.001

P. frigidus

P = >0.001

S. pulchra

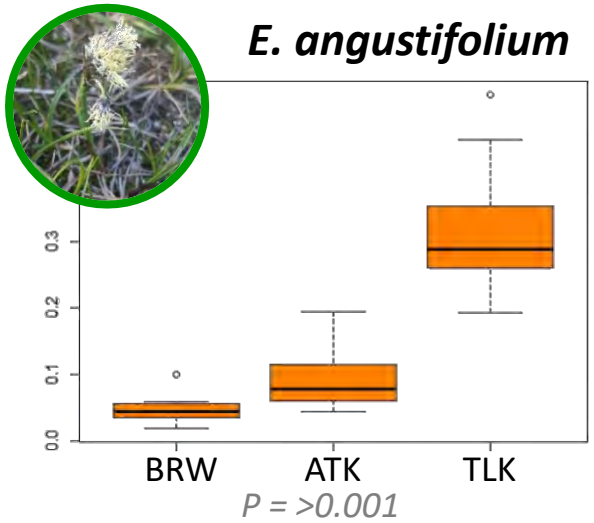


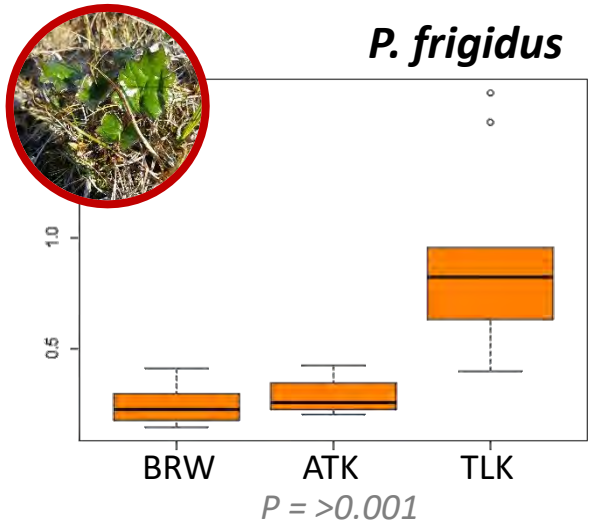
P = 0.007

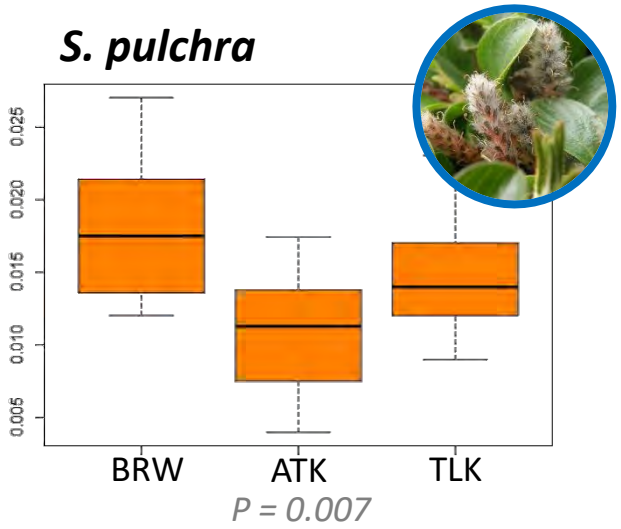
V. vitis-idaea

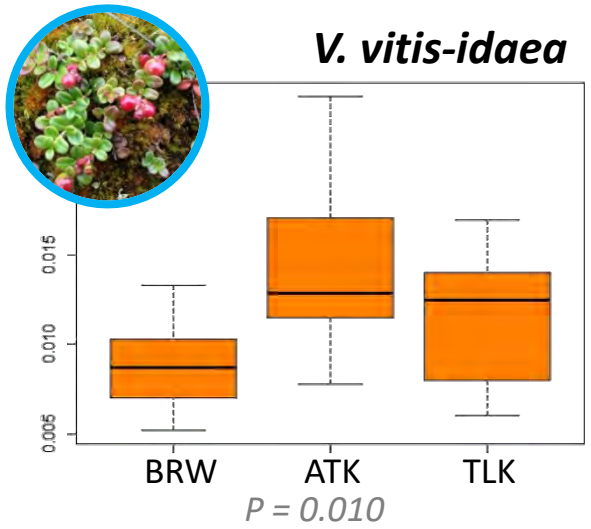
P = 0.010

Differences in Leaf Fresh Mass

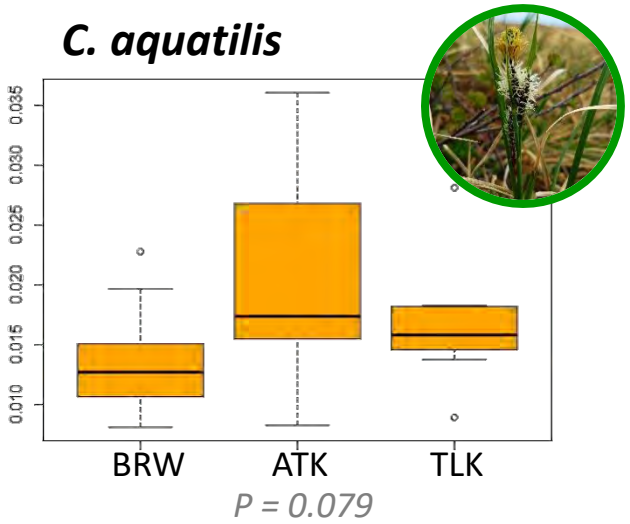


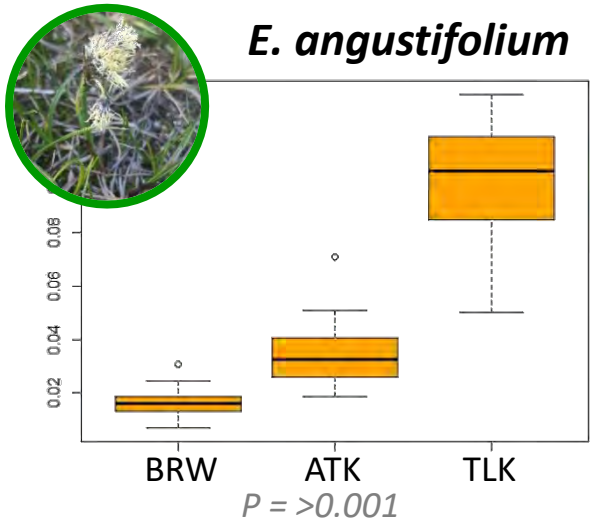


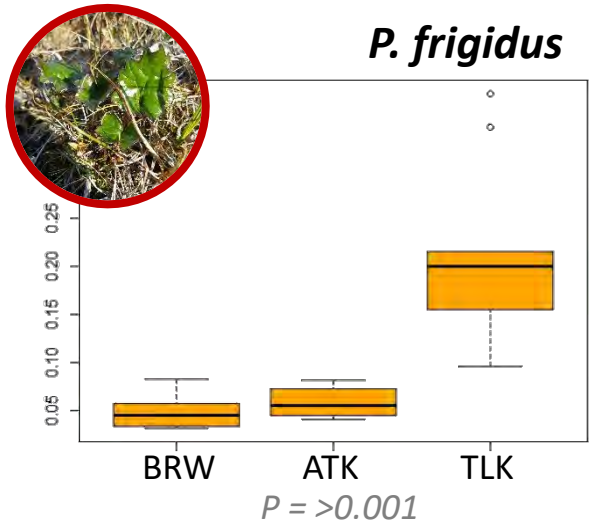


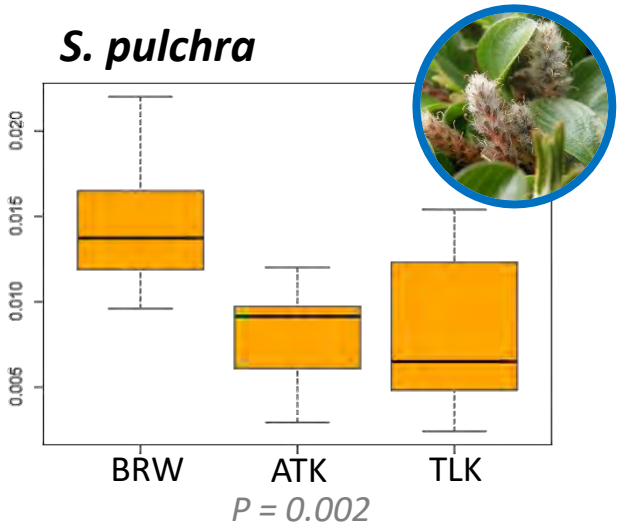


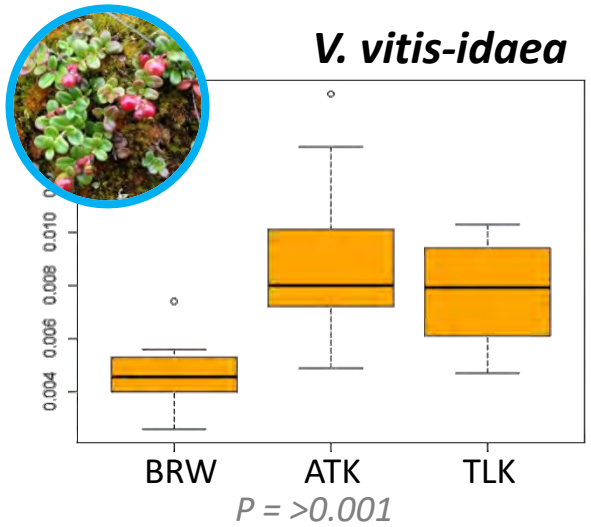
Differences in Leaf Dry Mass



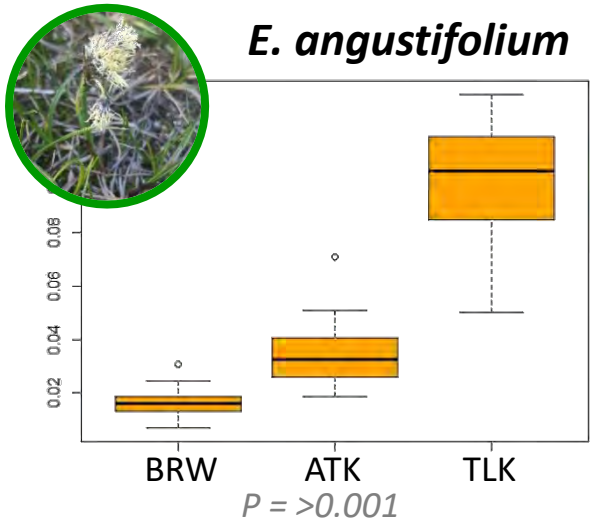


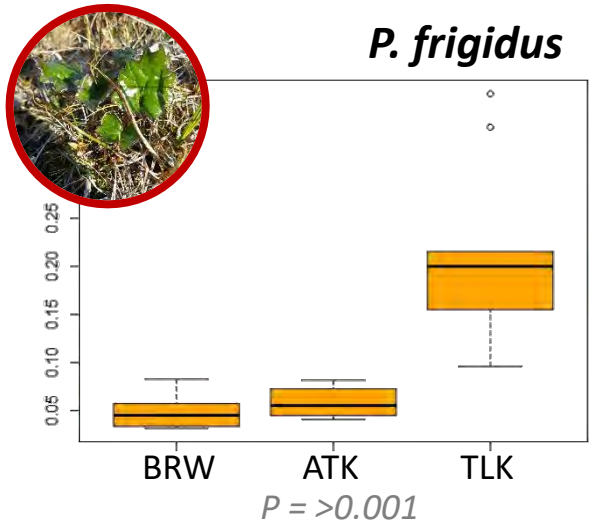


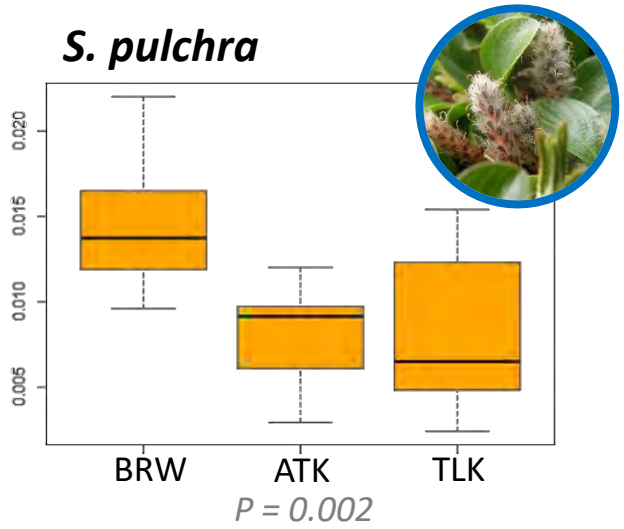


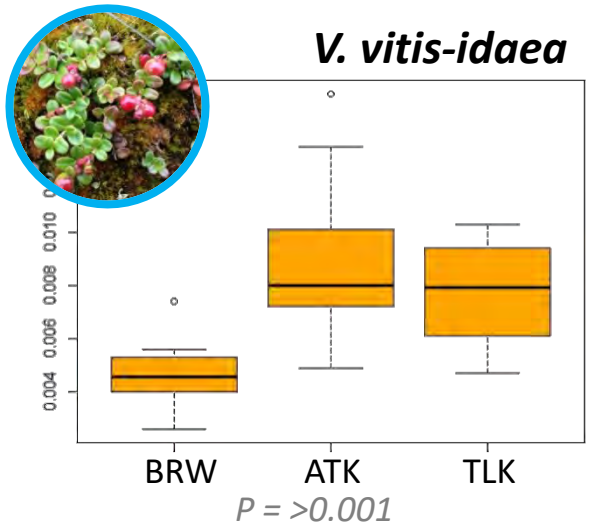


Differences in Leaf Dry Mass



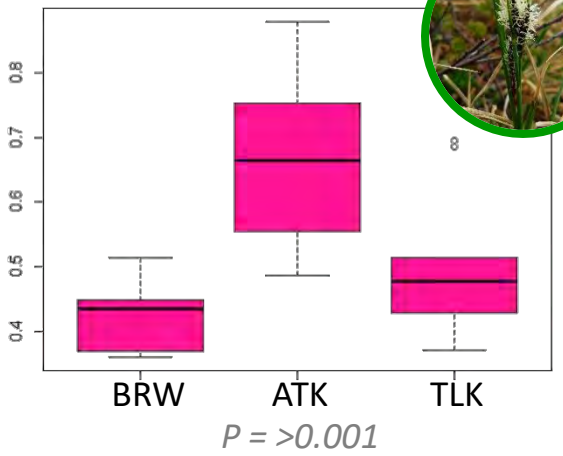






Differences in Leaf Dry Matter Content

C. aquatilis



P = >0.001

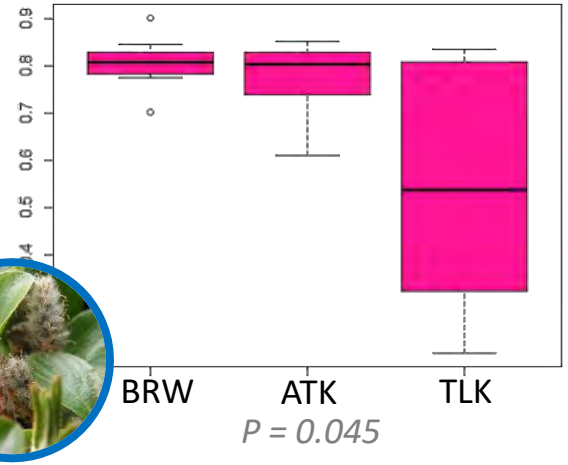
E. angustifolium

P = 0.005

P. frigidus

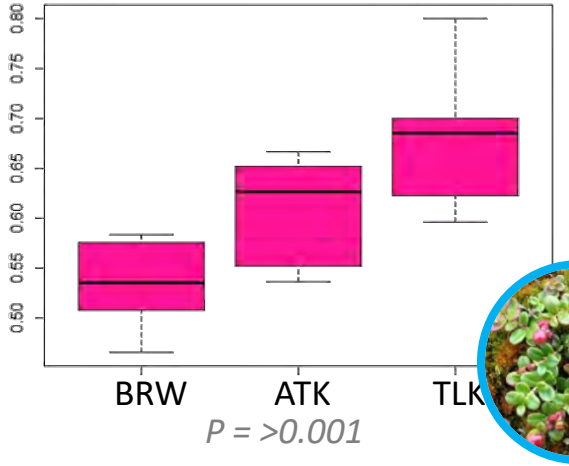
P = >0.001

S. pulchra



P = 0.045

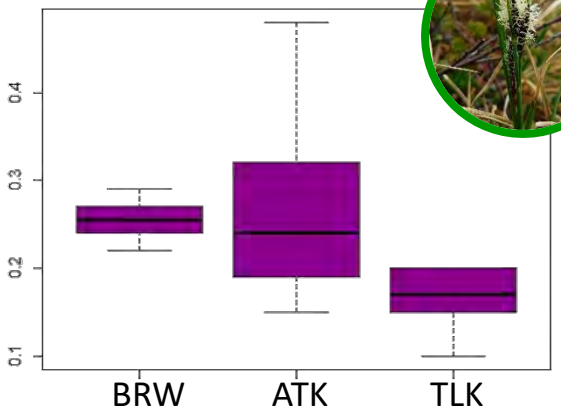
V. vitis-idaea



P = >0.001

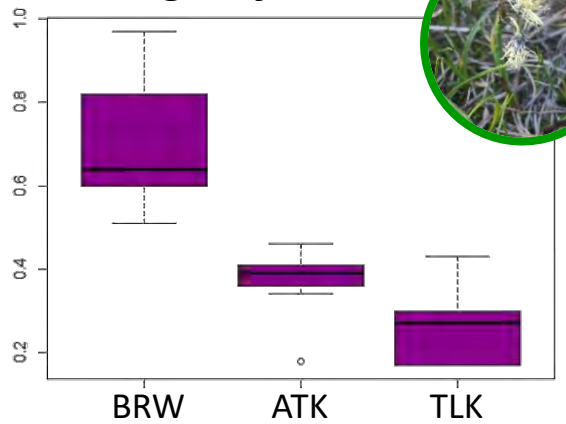
Differences in Leaf Thickness

C. aquatilis



P = >0.001

E. angustifolium

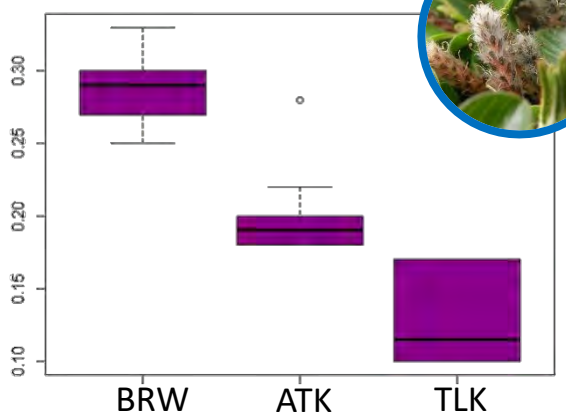


P = >0.001

P. frigidus

P = >0.001

S. pulchra



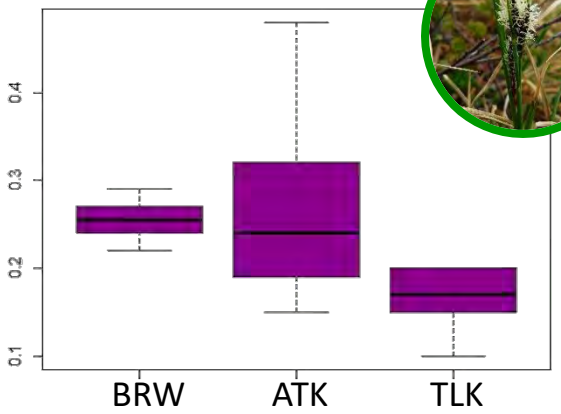
P = >0.001

V. vitis-idaea

P = 0.127

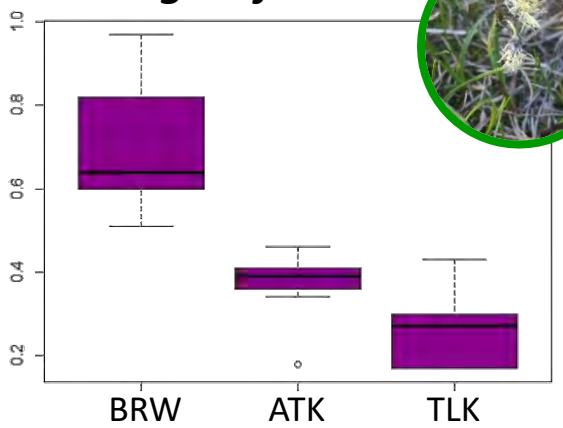
Differences in Leaf Thickness

C. aquatilis



P = >0.001

E. angustifolium

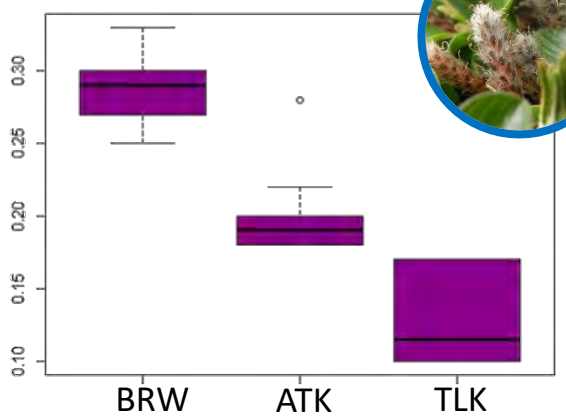


P = >0.001

P. frigidus

P = >0.001

S. pulchra



P = >0.001

V. vitis-idaea

P = 0.127

Differences in Water Band Index (WBI)

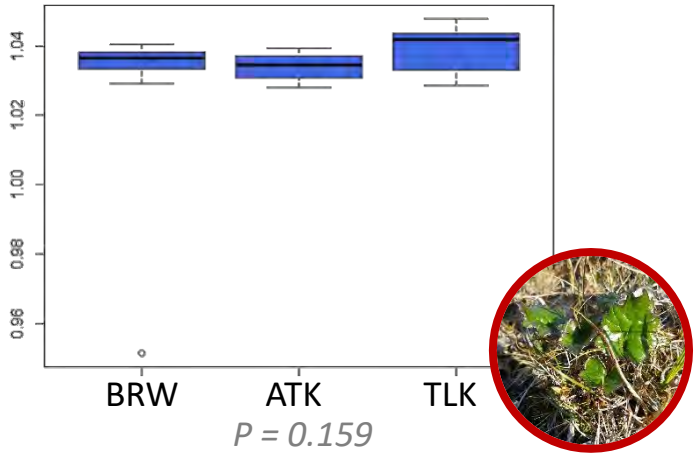
C. aquatilis

P = 0.171

E. angustifolium

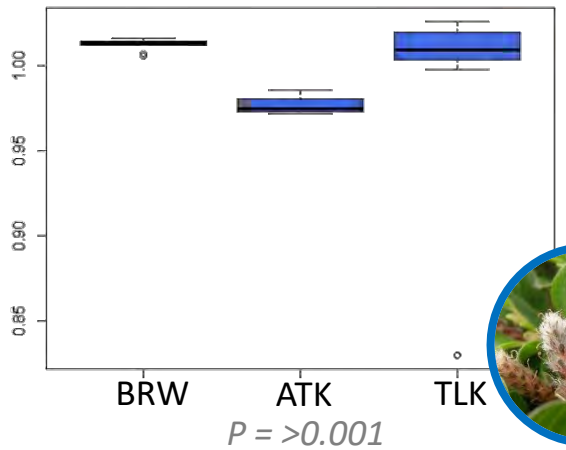
P = 0.009

P. frigidus



P = 0.159

S. pulchra



P = >0.001

V. vitis-idaea

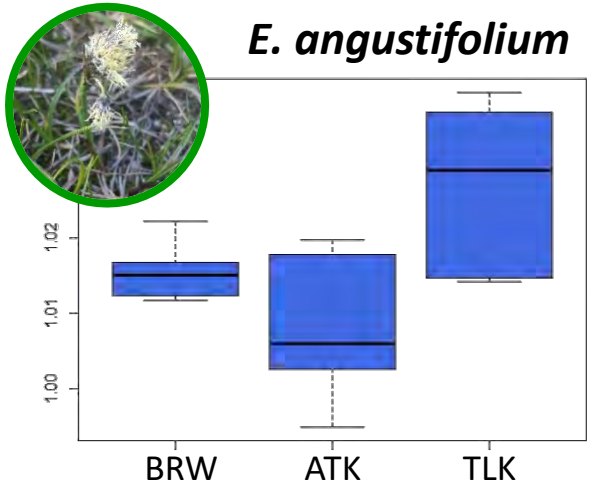
P = 0.002

Differences in Water Band Index (WBI)

C. aquatilis

P = 0.171

E. angustifolium

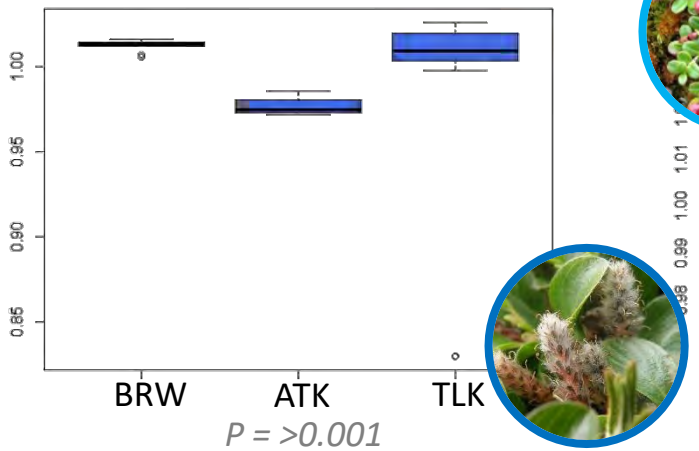


P = 0.009

P. frigidus

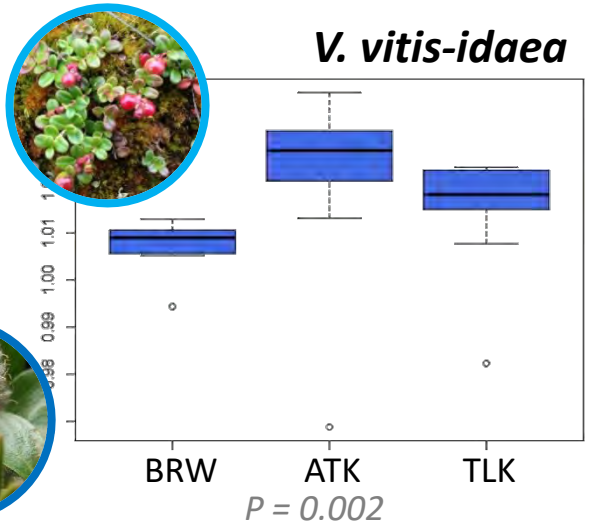
P = 0.159

S. pulchra



P = >0.001

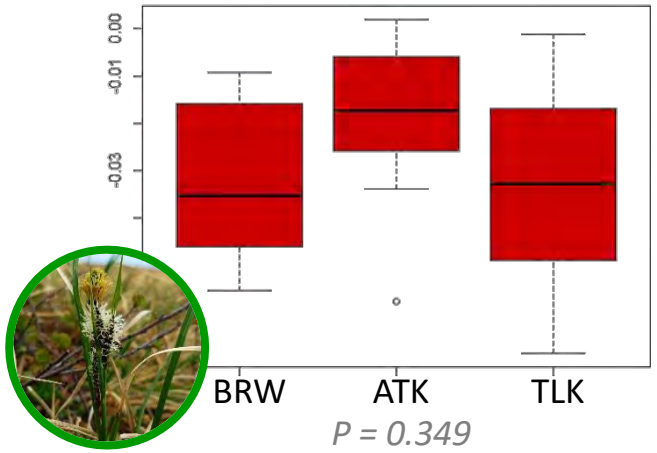
V. vitis-idaea



P = 0.002

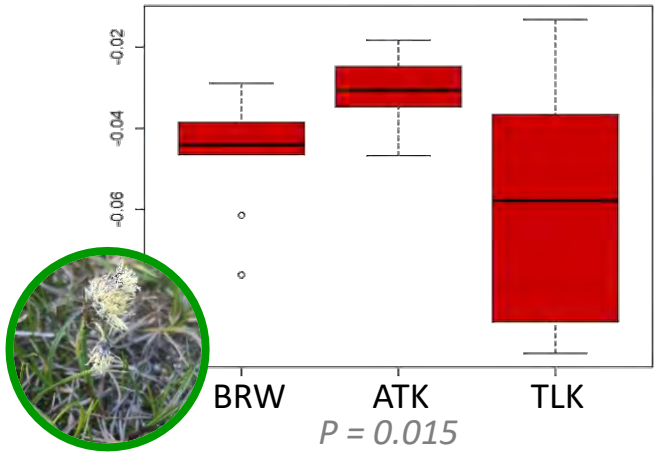
Differences in Photochemical Reflectance Index (PRI)

C. aquatilis



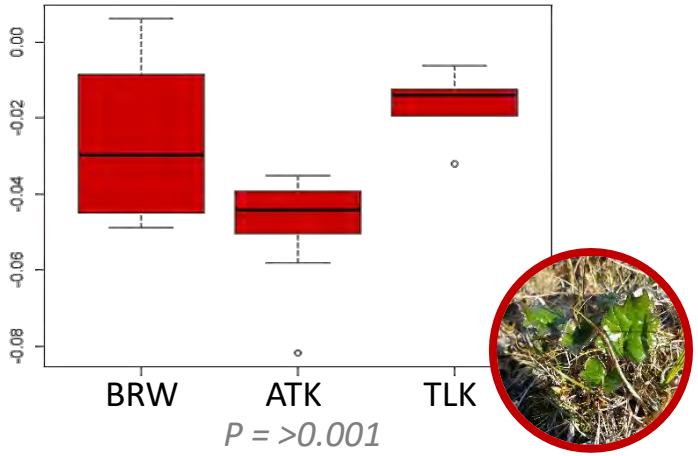
P = 0.349

E. angustifolium



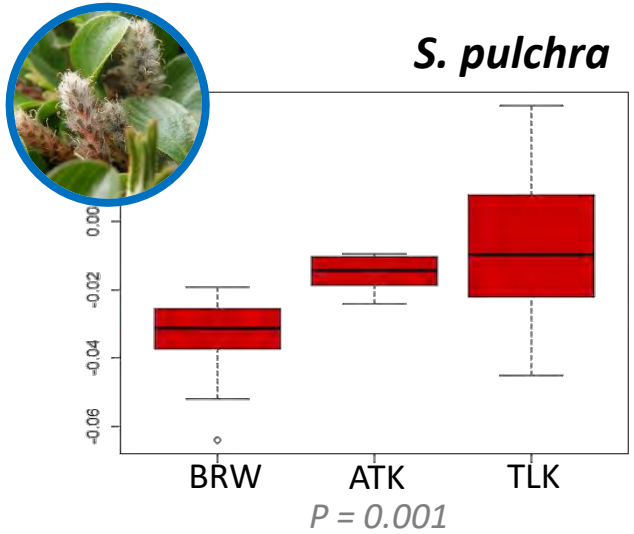
P = 0.015

P. frigidus



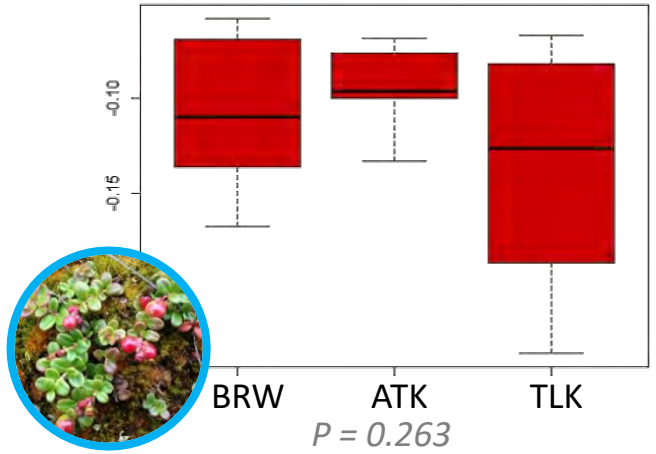
P = >0.001

S. pulchra



P = 0.001

V. vitis-idaea

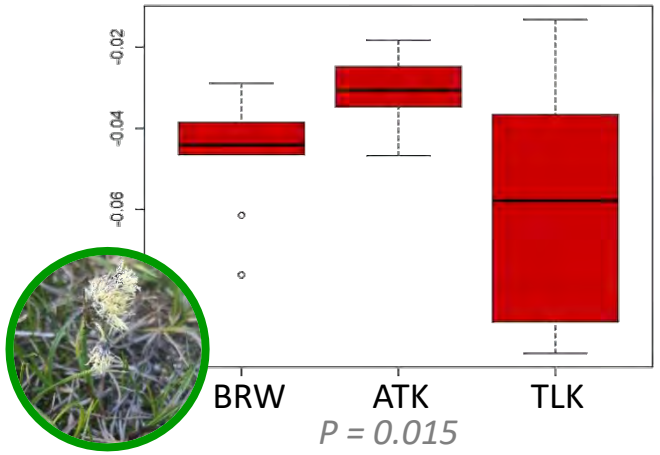


P = 0.263

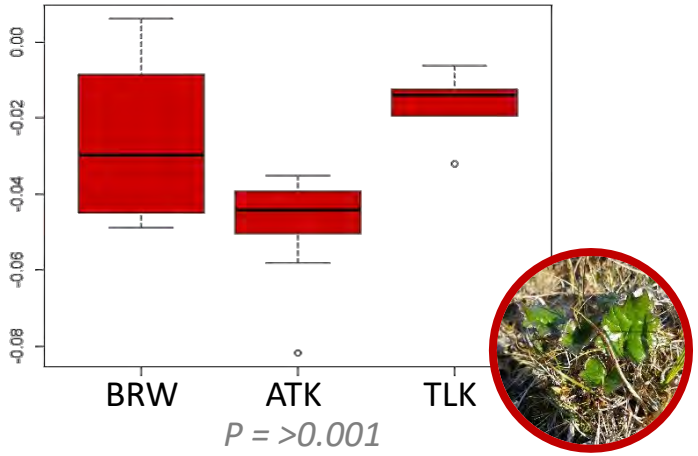
Differences in Photochemical Reflectance Index (PRI)

C. aquatilis

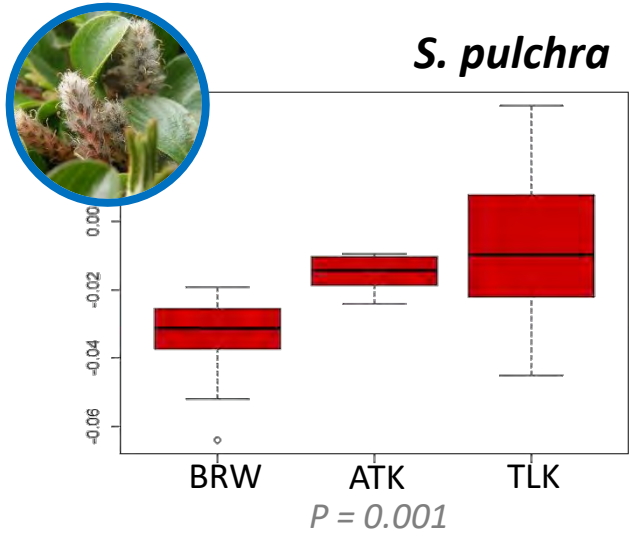
E. angustifolium



P. frigidus



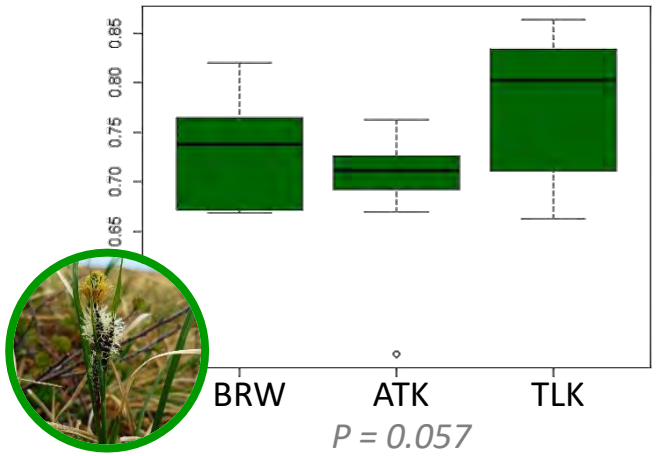
S. pulchra



V. vitis-idaea

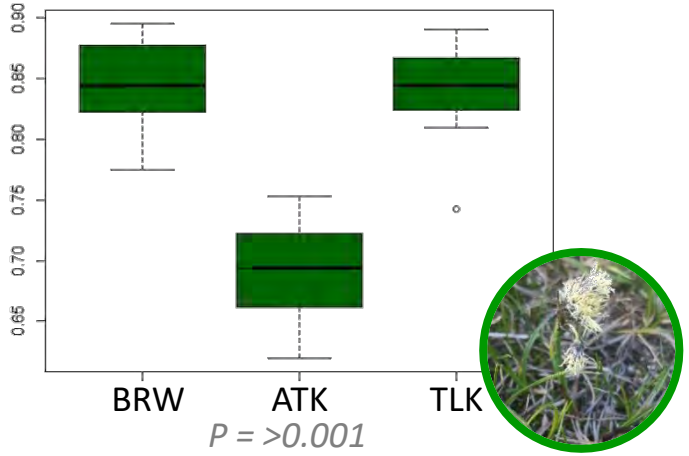
Differences in Normalized Difference Vegetation Index (NDVI)

C. aquatilis



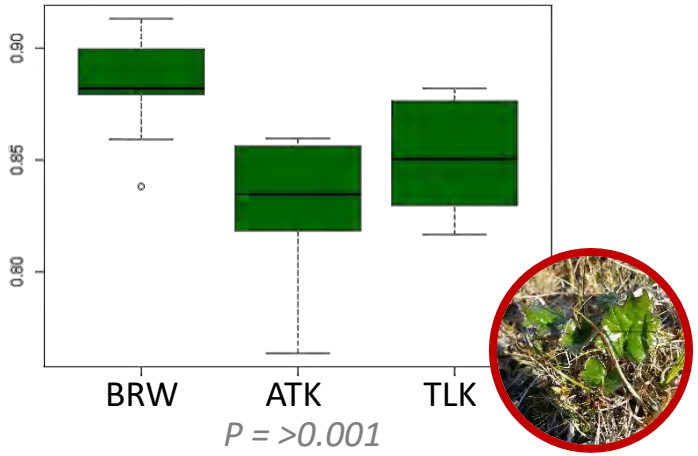
P = 0.057

E. angustifolium



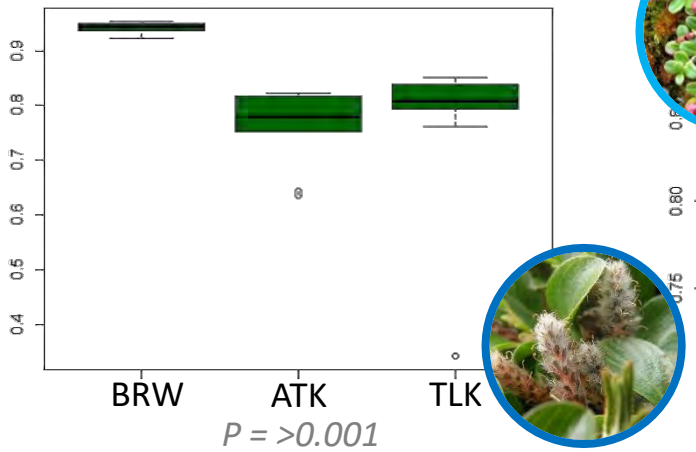
P = >0.001

P. frigidus



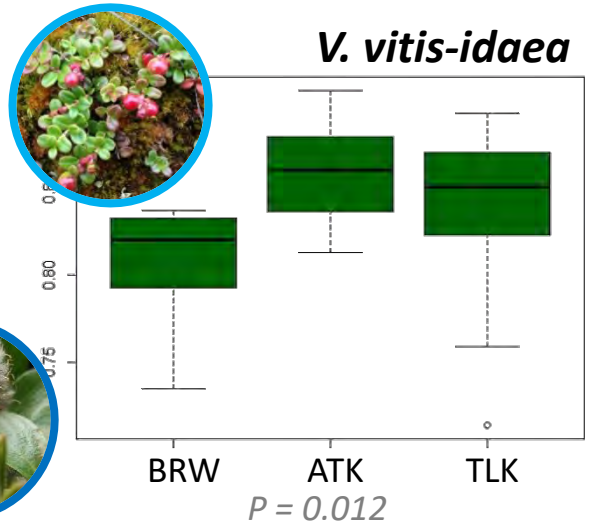
P = >0.001

S. pulchra



P = >0.001

V. vitis-idaea

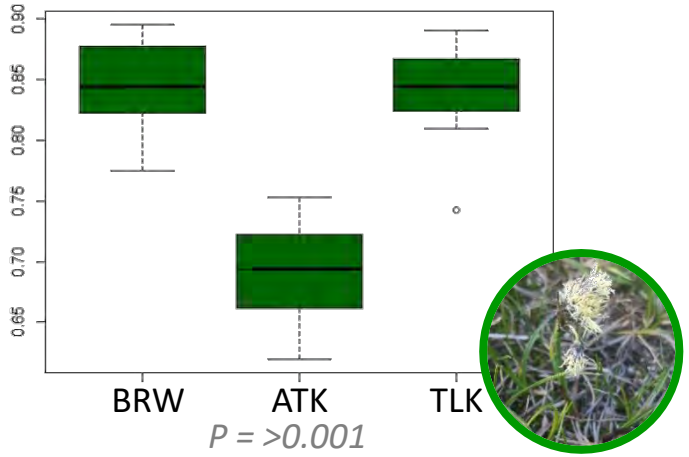


P = 0.012

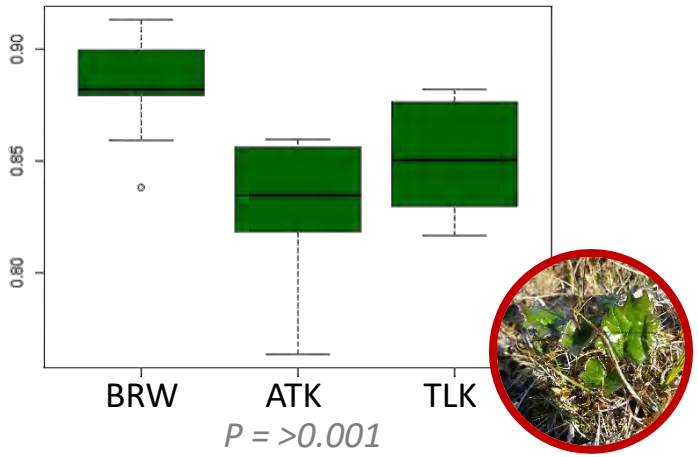
Differences in Normalized Difference Vegetation Index (NDVI)

C. aquatilis

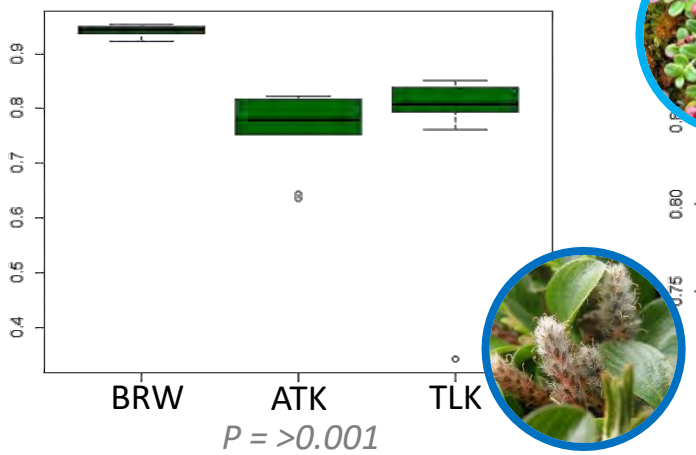
E. angustifolium



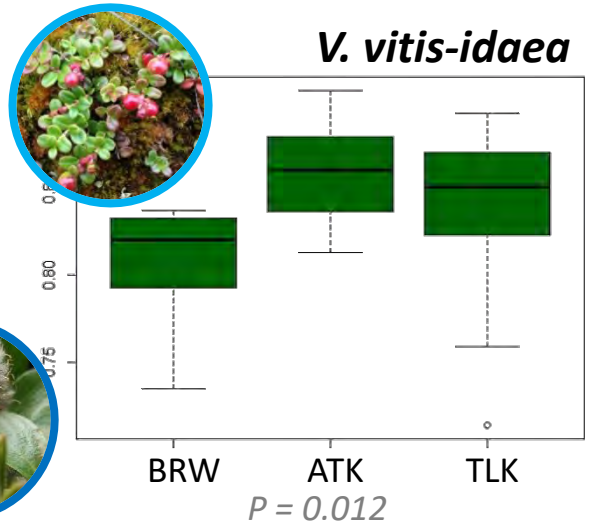
P. frigidus



S. pulchra



V. vitis-idaea



Questions?

Acknowledgements

Thank you to…

GVSU Graduate Program

National Science Foundation for providing funding

Ukpeaġvik Iñupiat Corporation for logistics and support

Jeremy May, Matthew Simon, and **Melissa Lau** for assistance with data collection

All other members of the **Arctic Ecology Program**

ARCTIC ECOLOGY

For more information on our research visit www.gvsu.edu/aep

GRAND VALLEY STATE UNIVERSITY

NSF

UIC SCIENCE

ITEX