Multiple sources of variation in leaf toughness of plants in northern Alaska

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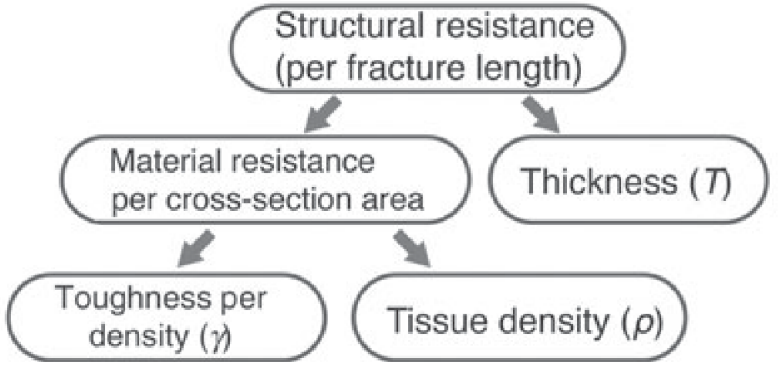
Leaf toughness

- Affects ability of plants to resist damage
  - Physical damage from wind, blowing snow
  - Damage from herbivores
- Affects ecosystem properties
  - Decomposition rates
  - Nutrient cycling
- Onoda et al. 2012 Ecology Letters
  - Did not include arctic plants
  - Focused mostly on interspecific comparisons

Measuring leaf toughness (Onoda et al. Ecol. Lett. 2012)

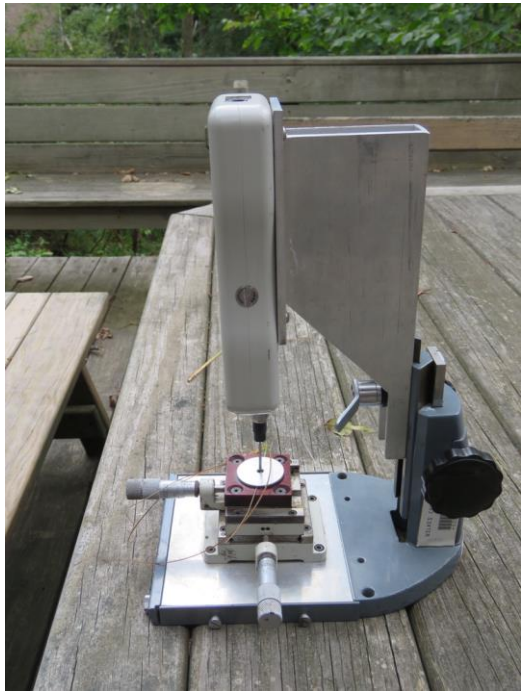
- Tear, cut, or punch leaves
- Measure force per unit fracture length
  - Leaf thickness
  - Tissue density
  - Toughness per unit density

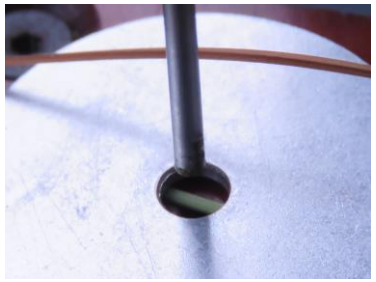


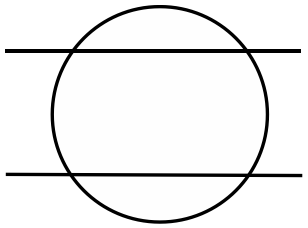
Leaf punch fitted with strain gauge

- 2 mm diameter punch
- Force (newtons) divided by circumference of 2 mm circle

- Except for Eriophorum vaginatum





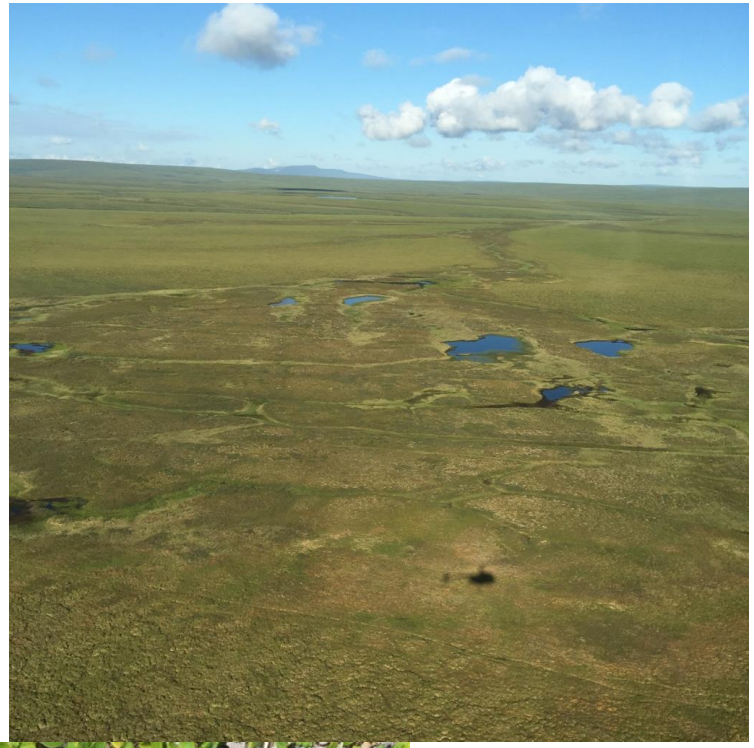


Variation in leaf toughness

- Species
- Habitat
- Seasonal
- Intraspecific variation
  - Seasonal
  - Between vegetation types
  - Between populations
  - Effects of nutrients

Species	Growth Form	Tussock Tundra	Dry Heath
Carex bigelowii Torr. ex Schwein.	Graminoid	x	x
Eriophorum vaginatum L	Graminoid	x	
Arctostaphylos alpina (L.) Spreng.	Evergreen Shrub		x
Dryas octopetala L.	Deciduous Shrub		x
Rhododendron tomentosum Harmaja	Evergreen Shrub	x	x
Vaccinium vitis-idaea L.	Evergreen Shrub	x	x
Betula nana L.	Deciduous Shrub	x	x
Salix pulchra Cham.	Deciduous Shrub	x	x
Vaccinium uliginosum L.	Deciduous Shrub	x	
Rubus chamaemorus L.	Deciduous Shrub	x	
Polygonum bistorta L.	Forb		x

Sites




Prudhoe Bay
Sagwon
Brooks Range
Happy Valley
Anuktuvuk Burn
Horn Lake
Toolik
Dust Site
Kuparuk
Galbraith
Atigun Camp
Atigun Pass
Chandalar
Timberline
Coldfoot
Gobbler's Knob
No Name Creek
183 km
Fairbanks
Image IBCAO
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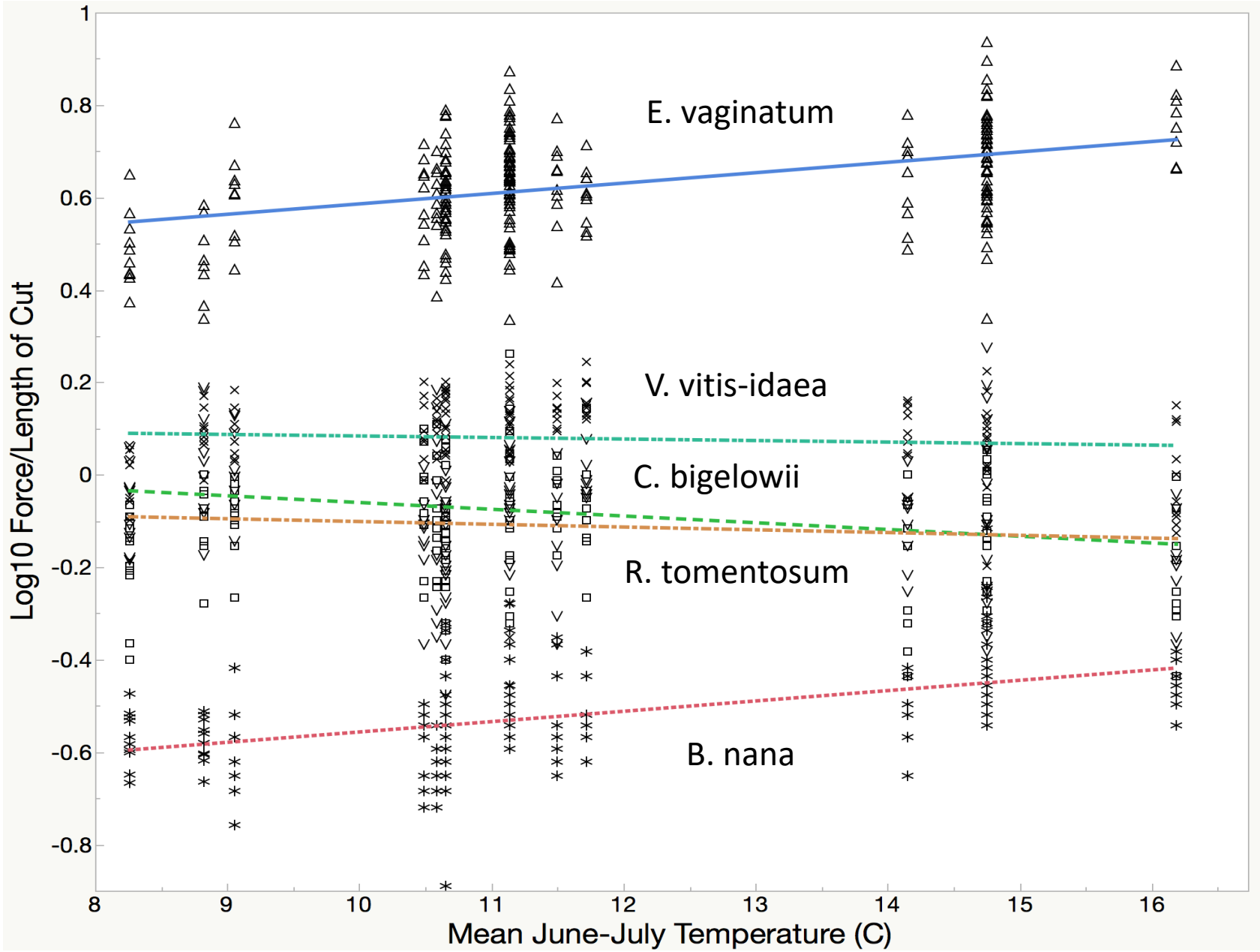
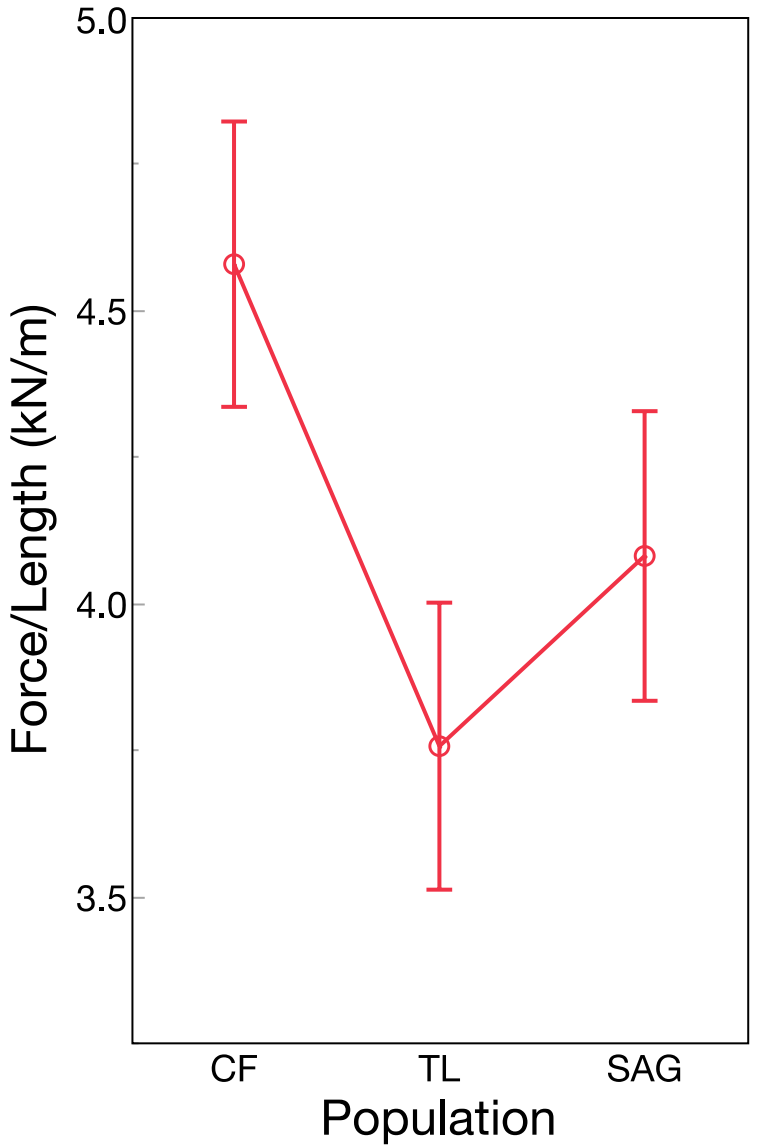
Leaf Toughness versus Mean Site Temperature

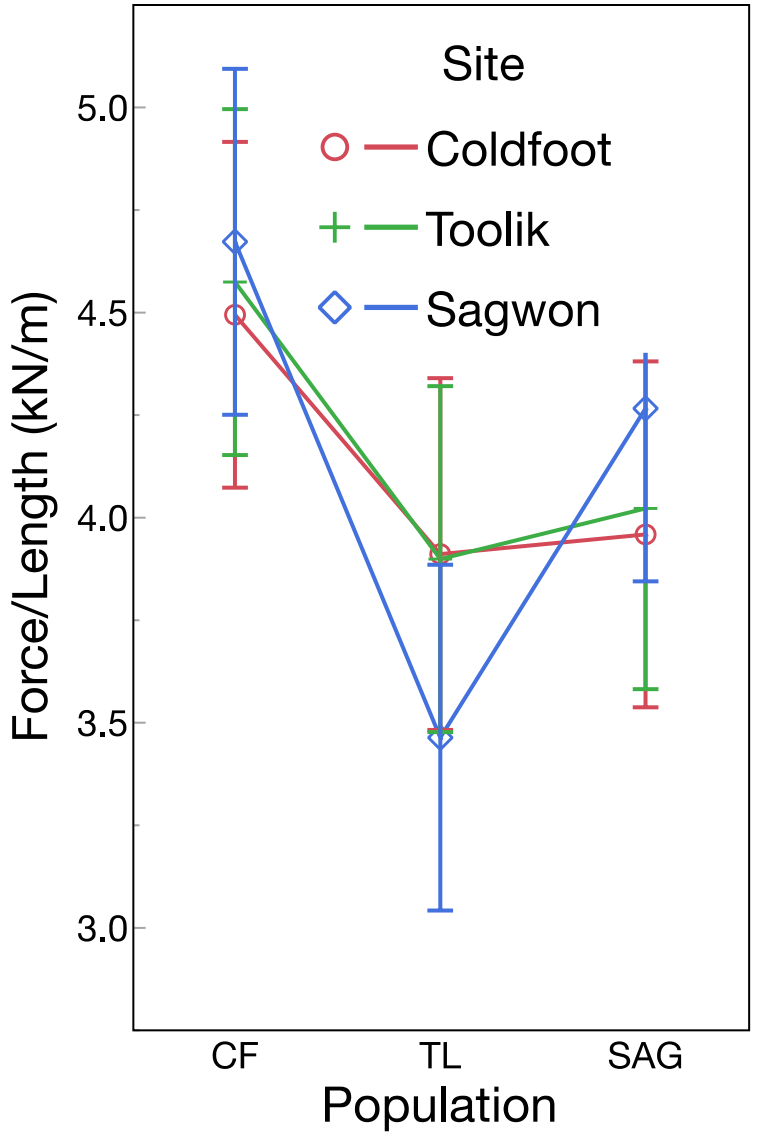
Five species of tussock tundra sampled from No Name Creek to Sagwon



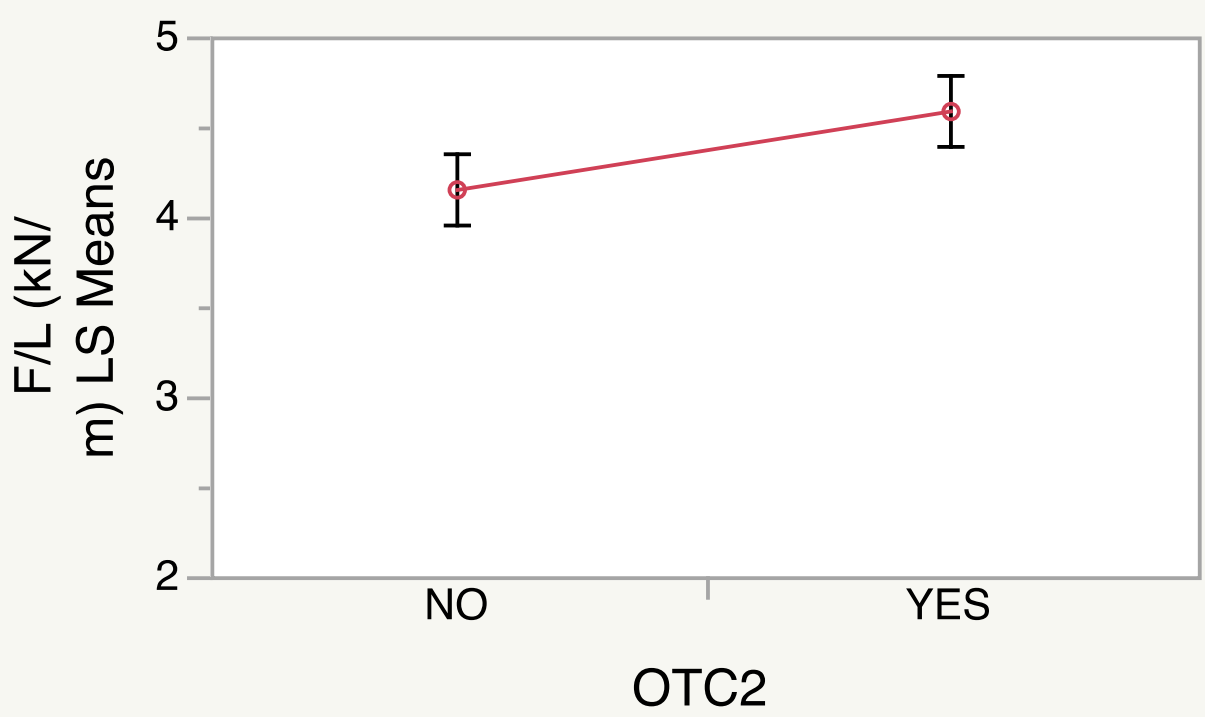
Reciprocal Transplant Experiment

- *E. vaginatum*
  - Sagwon
  - Toolik
  - Coldfoot
- OTC's at Sagwon and Toolik





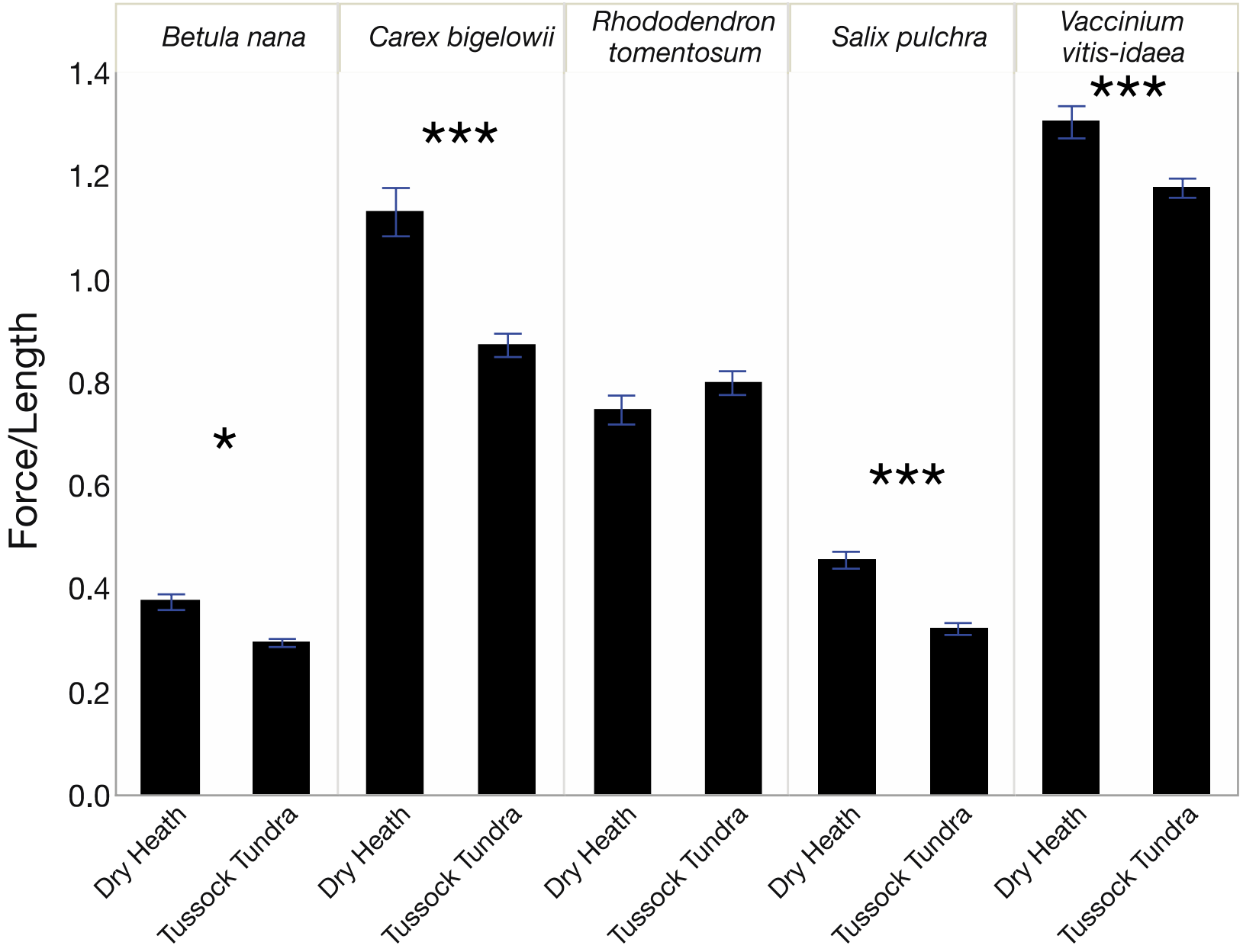
OTC effect
# p < .0025



Vegetation type and leaf toughness

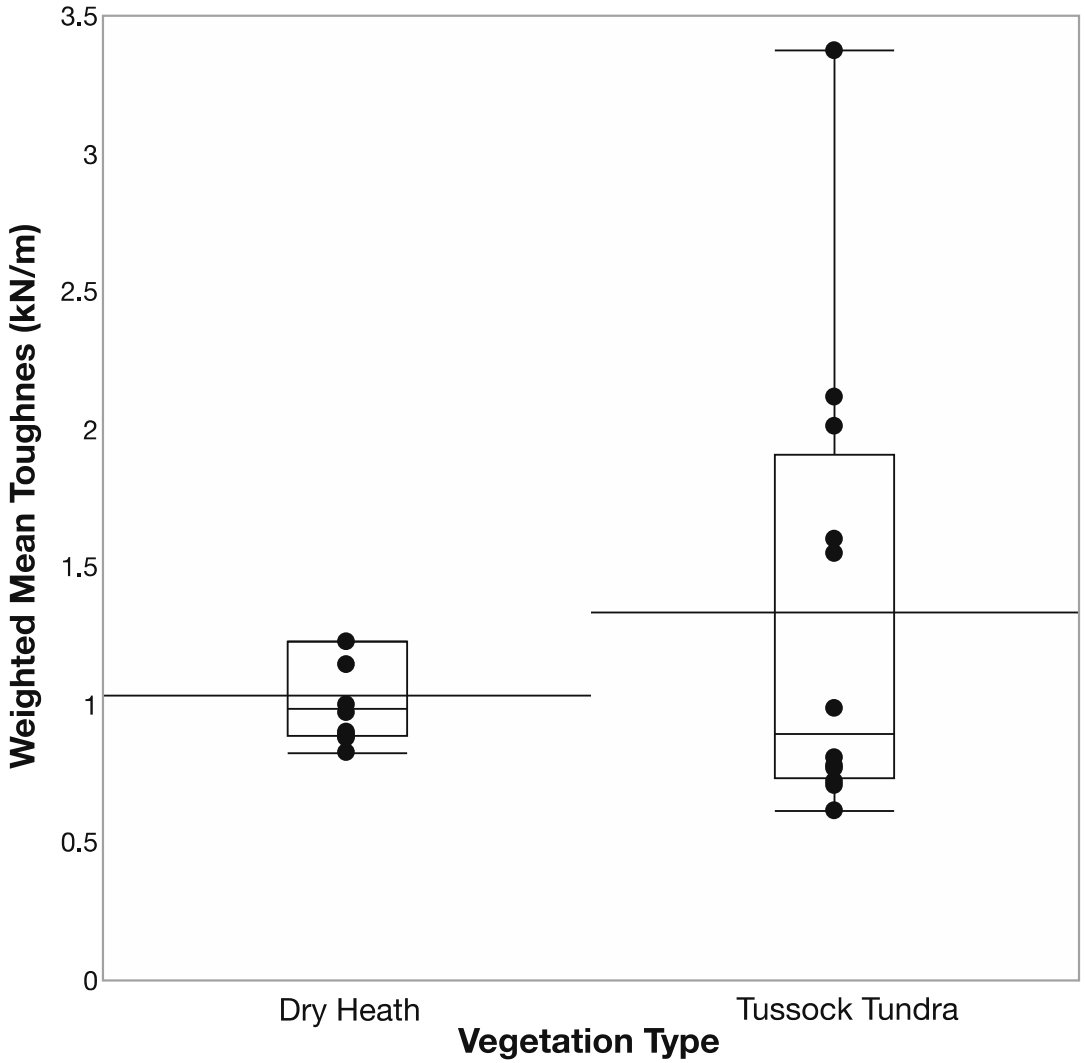
4 sites where tussock tundra and dry heath were found

Sagwon
Toolik Lake
Atigun Pass/Atigun Camp
Chandalar



Community weighted mean leaf toughness

- Leaf toughness of each species weighted by the presence of the species in the community
- Biomass data from 2006 LTER harvest



Nutrients added for 27 years

Species	Mean F/L (kN/m) Control	Mean F/L (kN/m) NP	p
Eriophorum vaginatum	3.774	3.785	ns
Vaccinium vitis-idaea	1.315	1.086	<.0001
Carex bigelowii	0.909	0.664	<.0001
Rhododendron tomentosum	0.845	0.754	ns
Salix pulchra	0.264	0.215	<.001
Rubus chamaemorus	0.242	0.255	ns
Betula nana	0.231	0.243	ns

Interspecific versus intraspecific variation in leaf toughness

- Analysis of variance components
  - (Messier et al. Ecol. Lett. 2010, Umaña et al. Ecology, 2019)

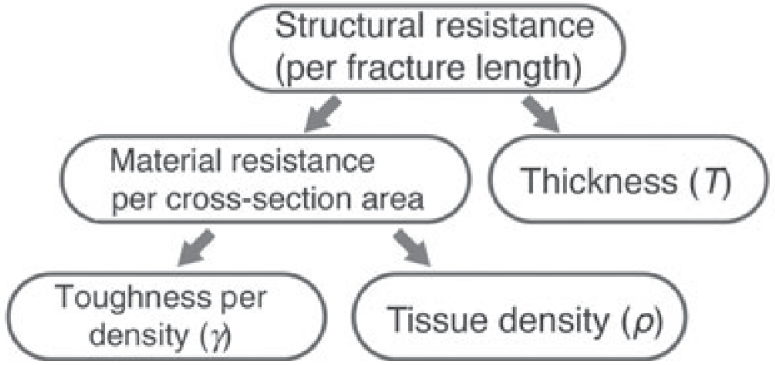
Component	Tussock tundra	Dry heath
Within populations	8 %	19 %
Populations within species	46 %	40.5 %
Species	46 %	40.5 %
Site	0	0

Conclusions

- Leaf toughness varies according to site
  - Within tussock tundra perhaps mainly due to differences between populations
- Leaf toughness varies between vegetation types
  - For some species dry heath had tougher leaves
  - Greater exposure to wind?
- Community mean toughness more variable in tussock tundra due to presence or absence of *E. vaginatum*
- Variation in leaf toughness due to species and populations within species
  - Effect of site is less important
  - Do other functional traits follow this pattern?

A few more conclusions

- *E. vaginatum* leaves are tough
- Leaf toughness is easy to measure and makes good student projects, so add it to your list of traits



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