Effect of snow depth (and permafrost thaw) on senescence timing in a subarctic mire

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Background

Climate change will/has caused **increased snow depth** (some regions, not whole Arctic):

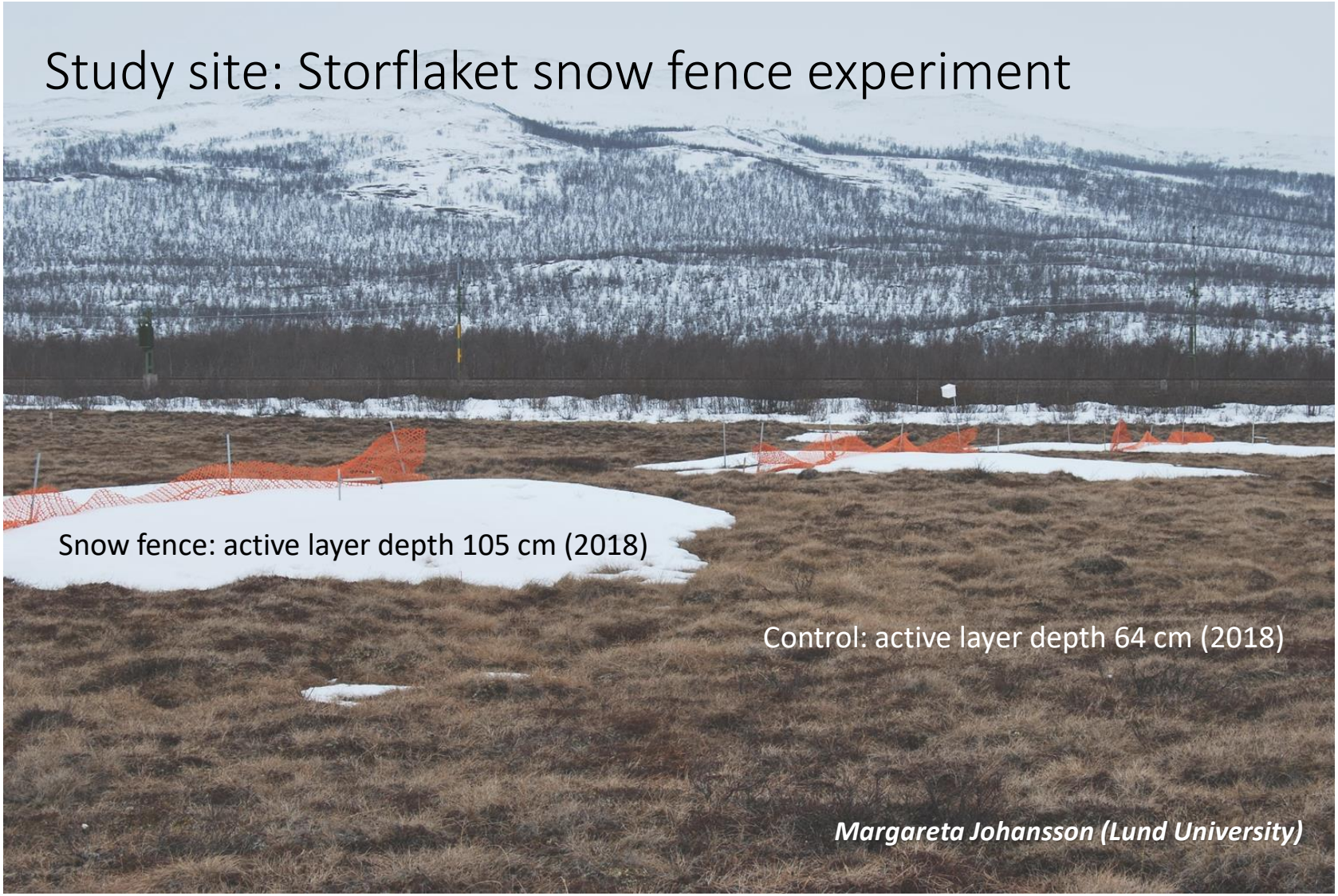
- Delayed snow melt -> shorter or delayed growing season?
- Increased winter soil temperatures -> enhanced (earlier) growing season?
- Increased active layer depth (permafrost thaw)
- Increased nutrients (especially deep/late) -> extended growing season?

How will increased snow depth affect **autumn phenology** of arctic plants and what are the likely underlying **physiological mechanisms**?

Research questions

1. Does increased snow depth and associated permafrost thaw affect autumn senescence timing directly by shifting phenology (NDVI, visual observations), or indirectly, by affecting physiology (leaf nutrient status, leaf pigments)?
2. Does chlorophyll breakdown respond the same way to increased thaw depth in deciduous and evergreen plants?
3. Do deeper rooting species show a stronger delay in autumn senescence than shallow rooting species due to greater access to nutrients in deep thaw plots?

Study site: Storflaket snow fence experiment



Study site in autumn 2018

Deeper winter snow increases thermal insulation: higher and more stable soil temperatures in winter

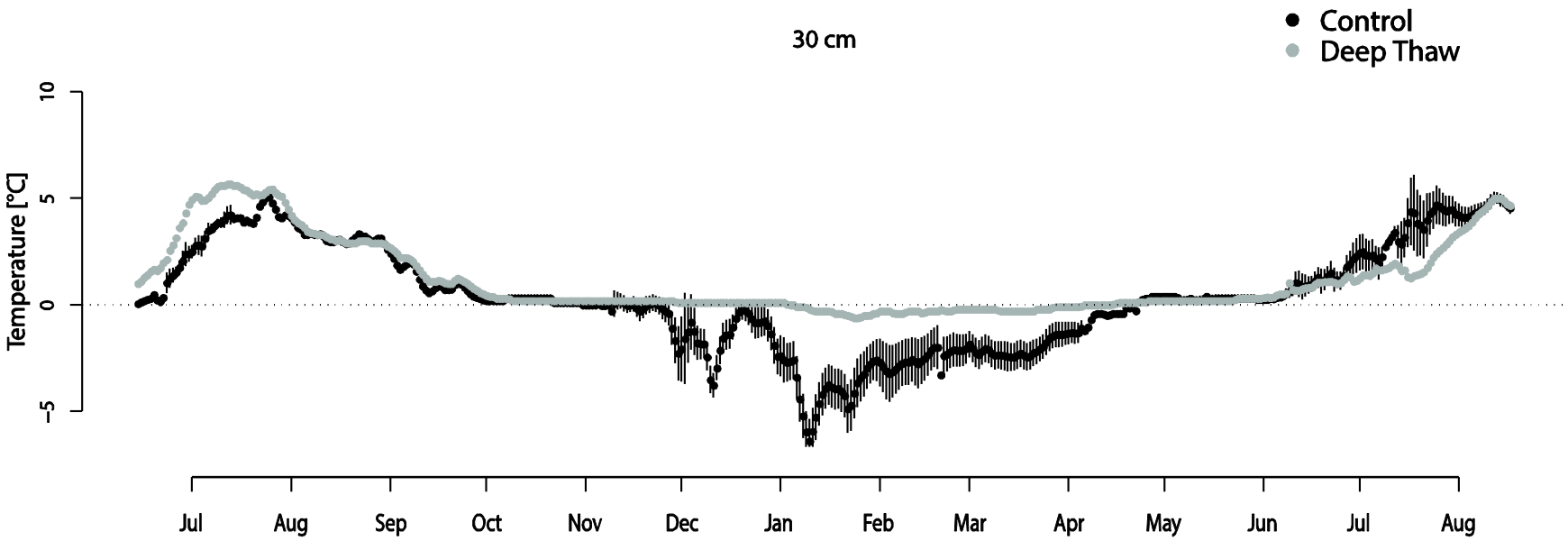
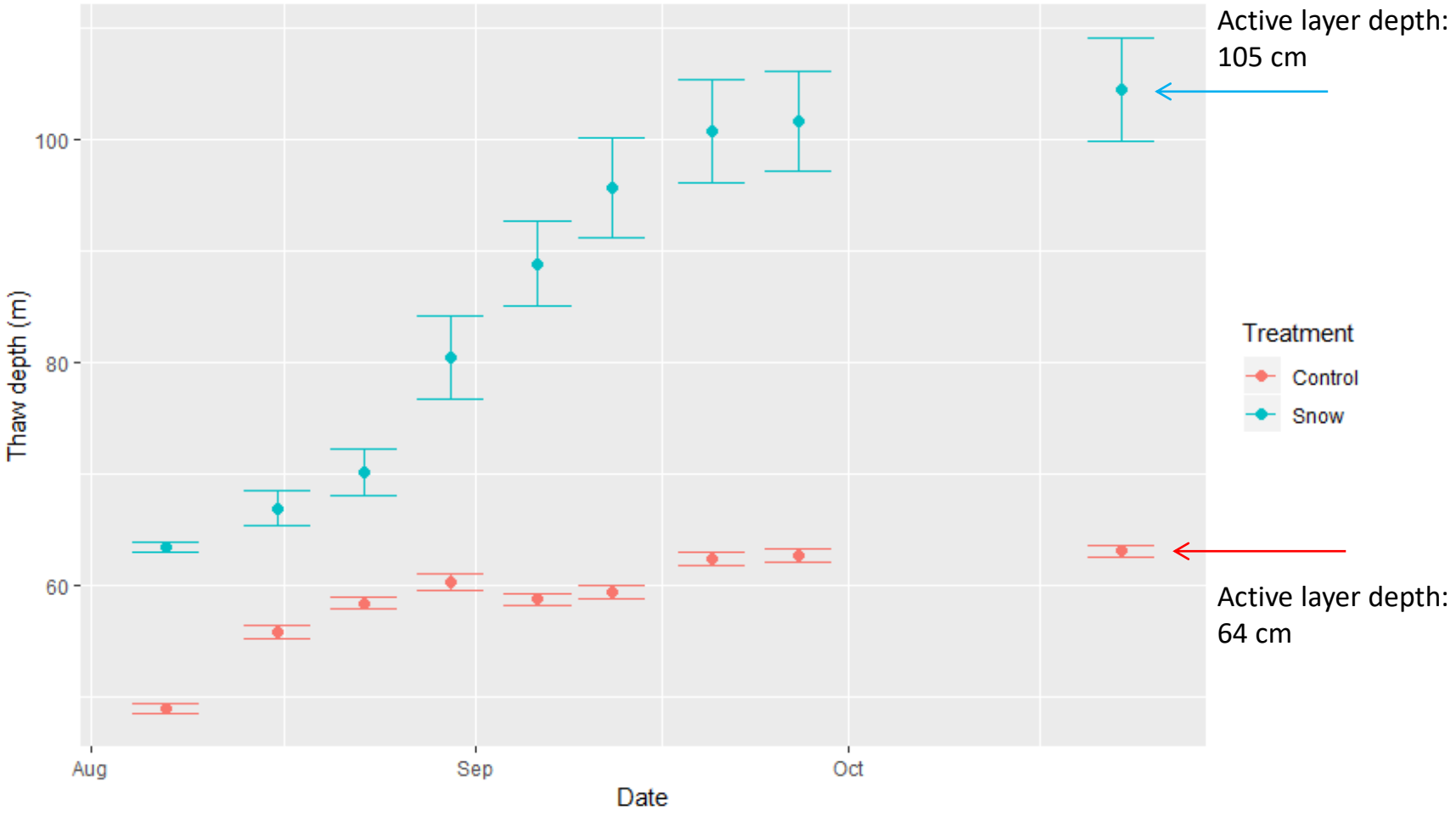
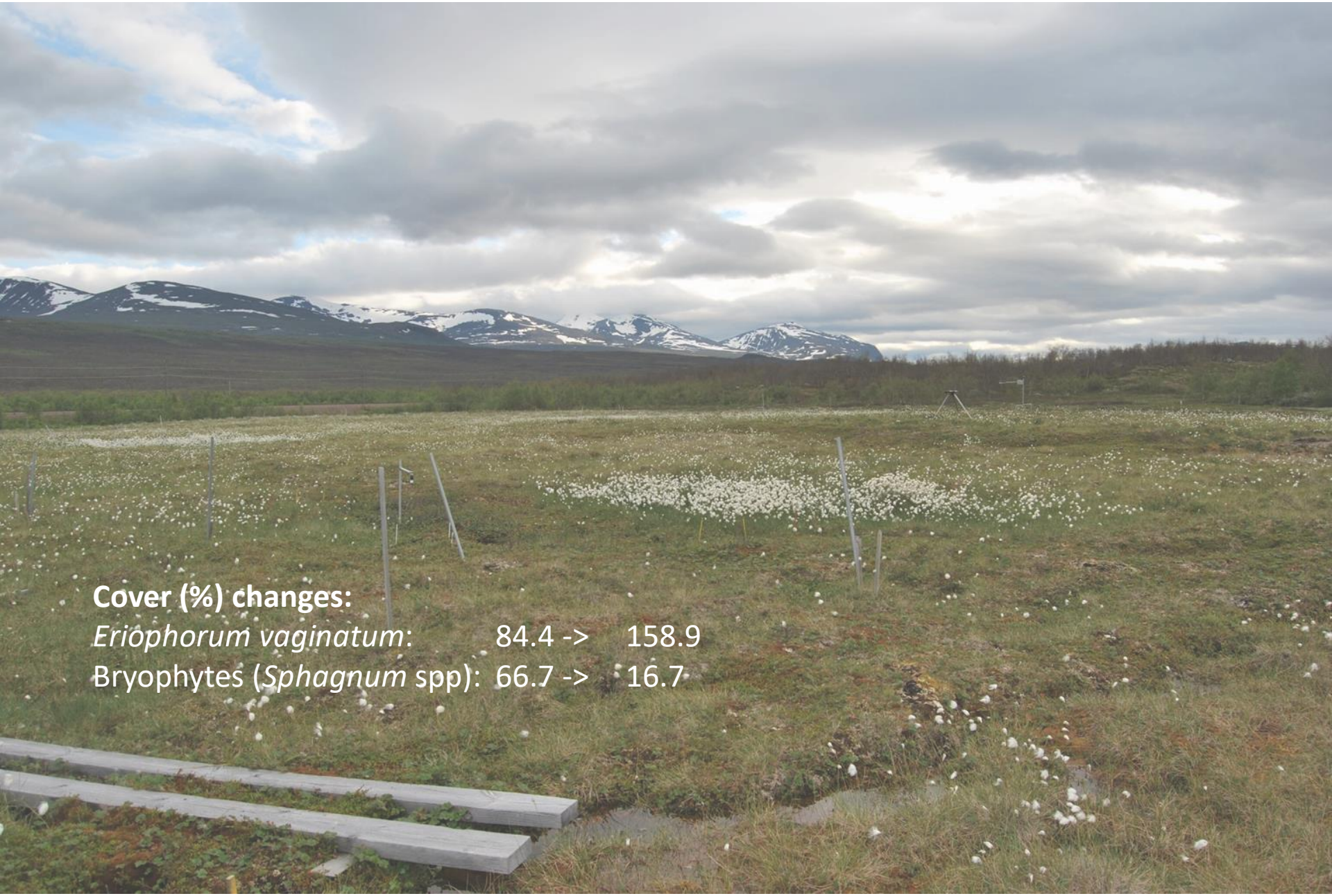


Figure: Blume-Werry et al. 2019, New Phytologist

Thaw depth 2018




Cover (%) changes:
Eriophorum vaginatum: 84.4 -> 158.9
Bryophytes (*Sphagnum* spp): 66.7 -> 16.7

Species plots and tagging

Eriophorum vaginatum (n=3)

Empetrum nigrum (n=3)

Betula nana (n=3)

30 cm

Control
N=6

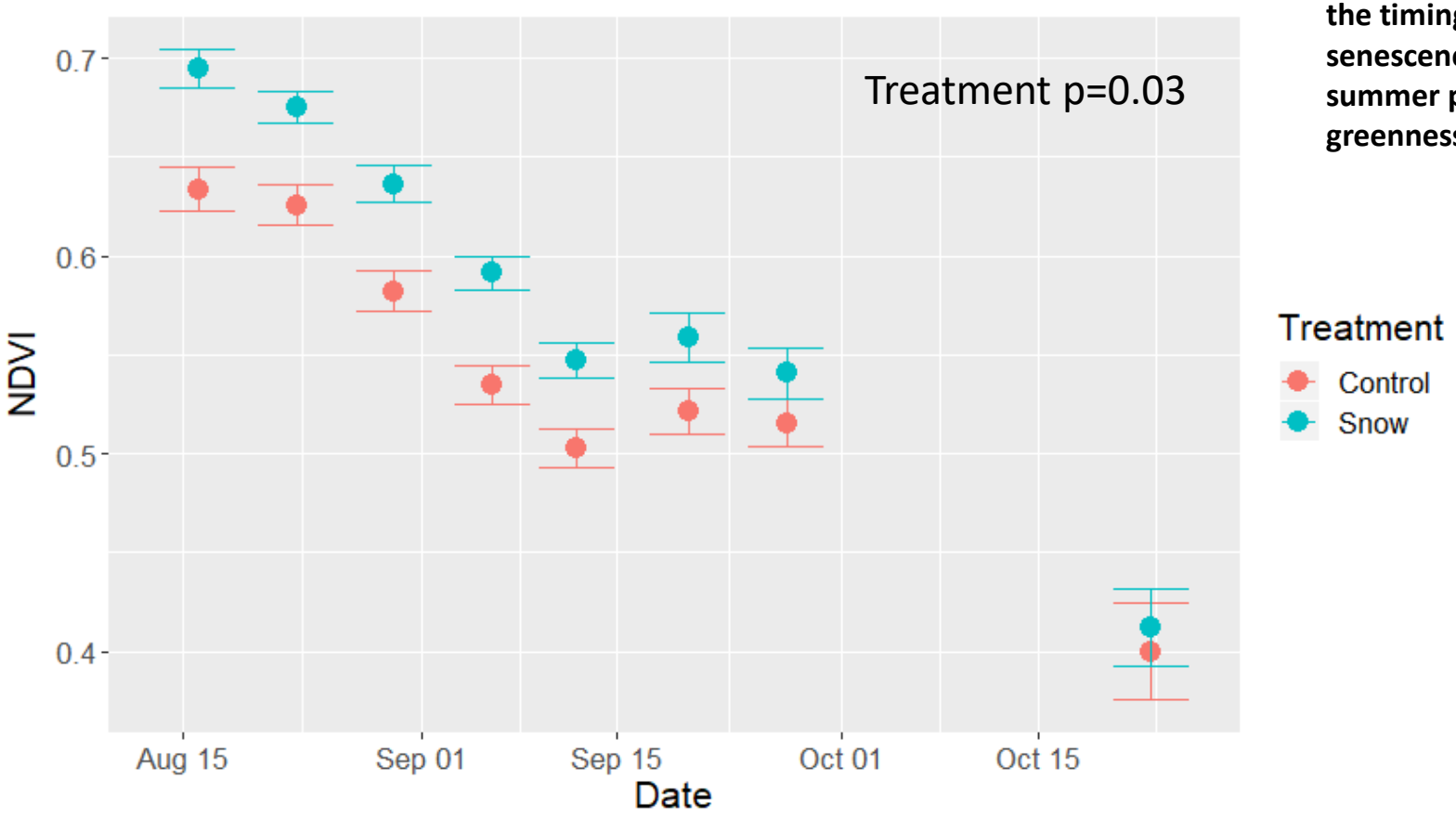
Snow
N=6

+ *Vaccinium uliginosum* and *Andromeda polifolia* tagged near or in plots

Phenology – combined NDVI

Snow delays vegetation browning by approx. 7-10 days, but mostly due to higher starting levels (higher green biomass?)

→ **Not a direct temporal start delay due to late snowmelt**

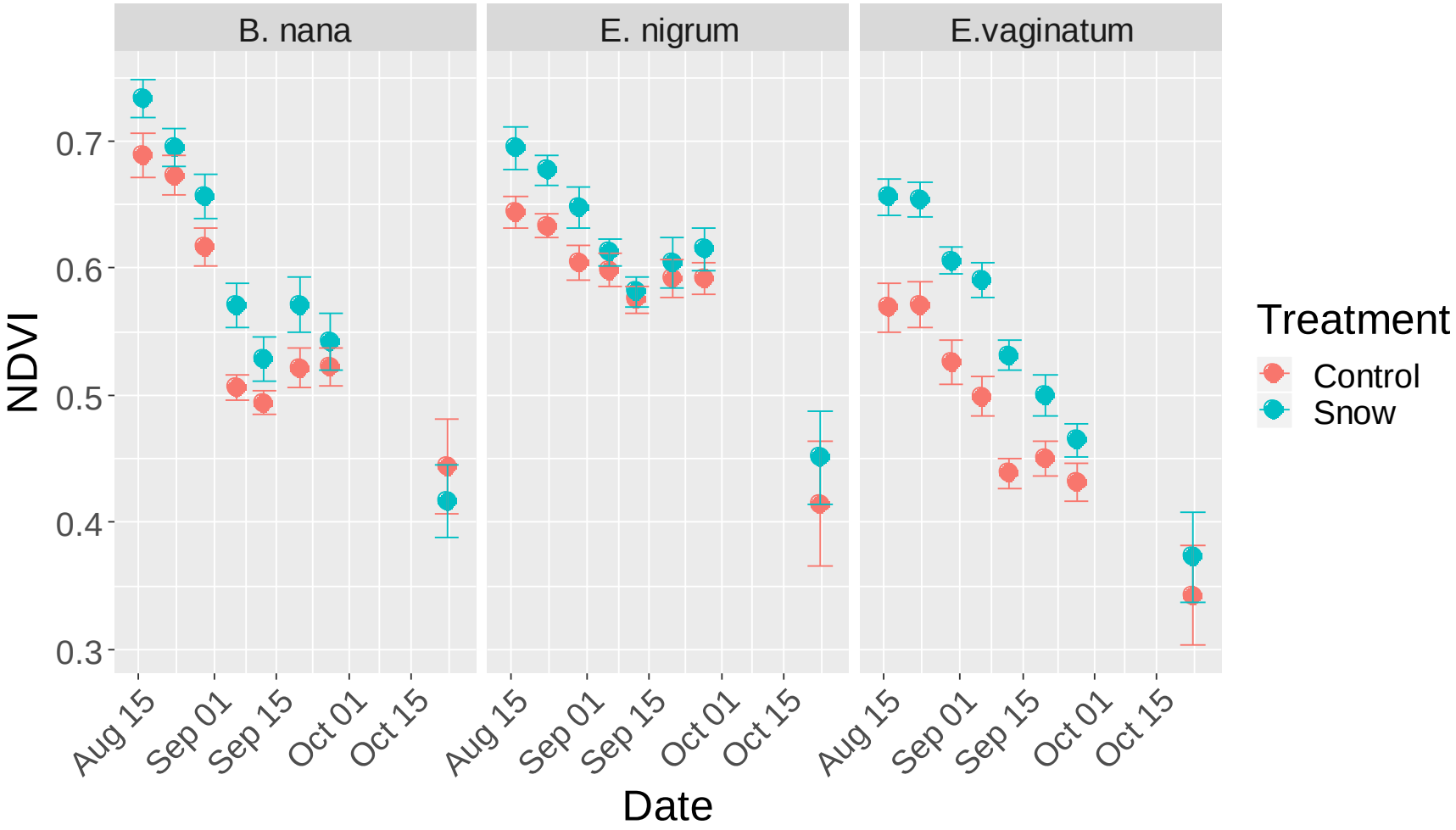


→ **Here, NDVI shows that the effect of snow/deeper thaw on the timing of autumn senescence is through summer productivity/ greenness**

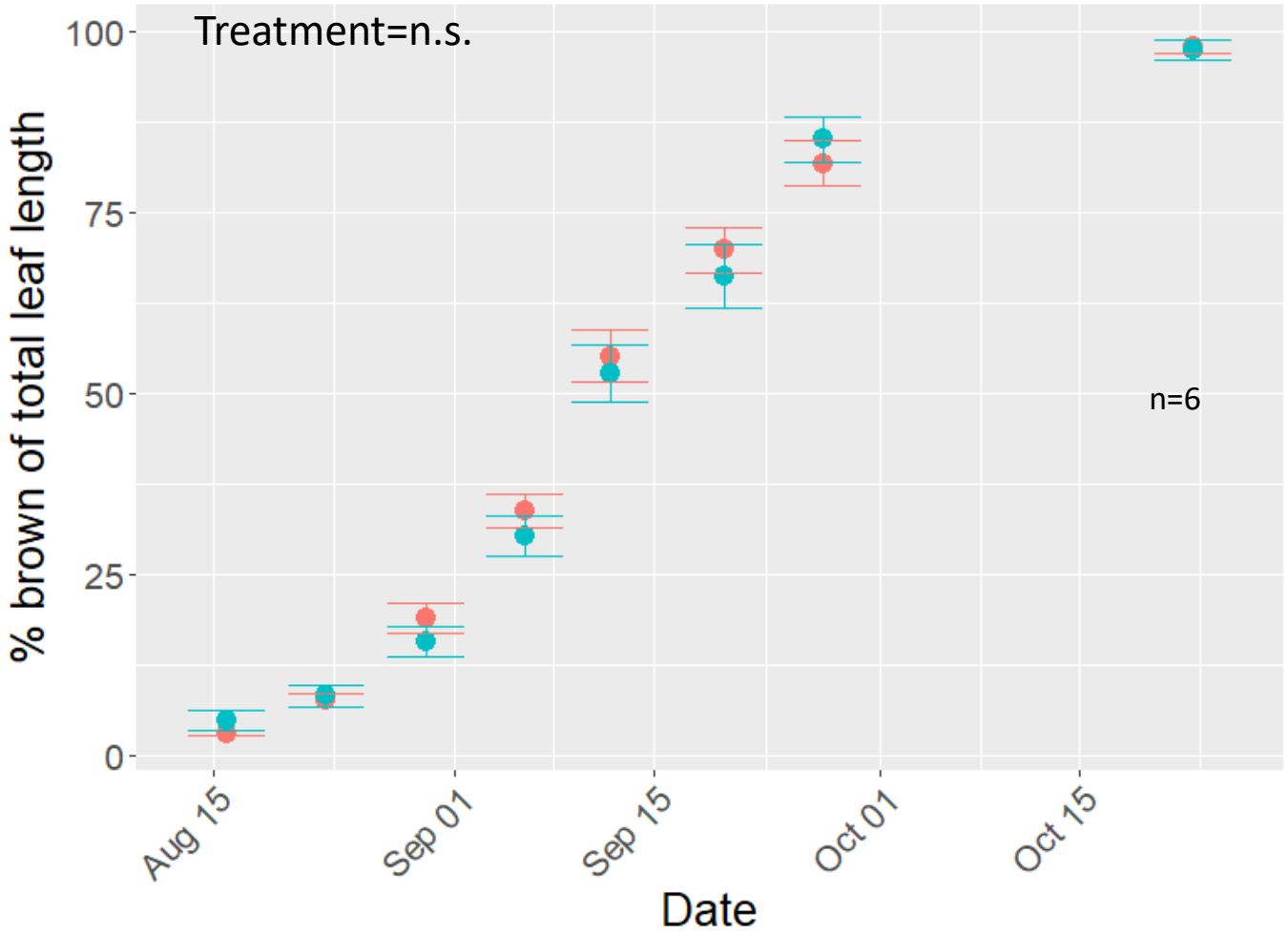
Phenology – ‘species-specific’ NDVI

Evergreen species shows least decline

Treatment difference is strongest in *E. vaginatum*



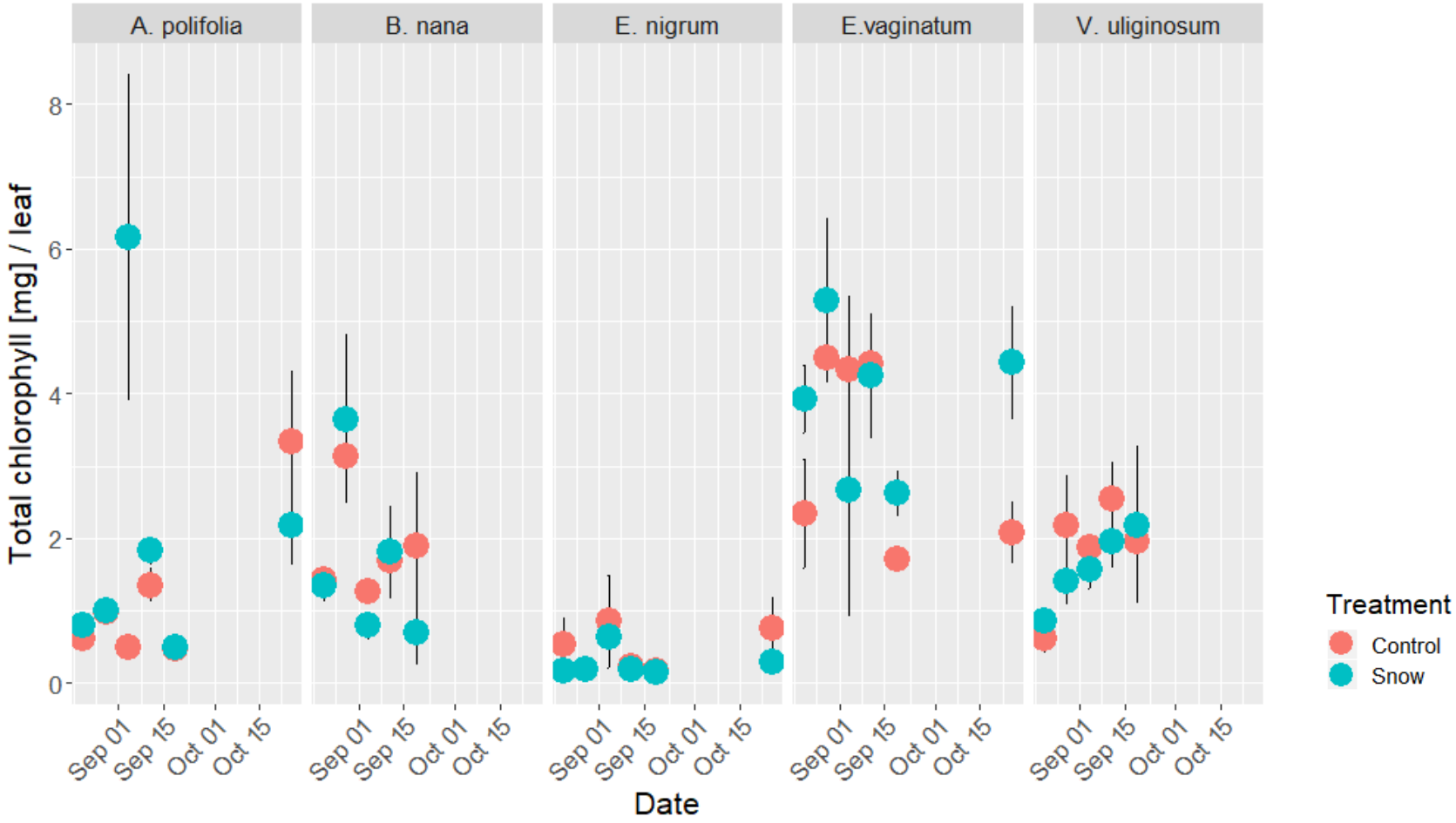
Phenology – Percentage brown section of *E. vaginatum* leaf blade



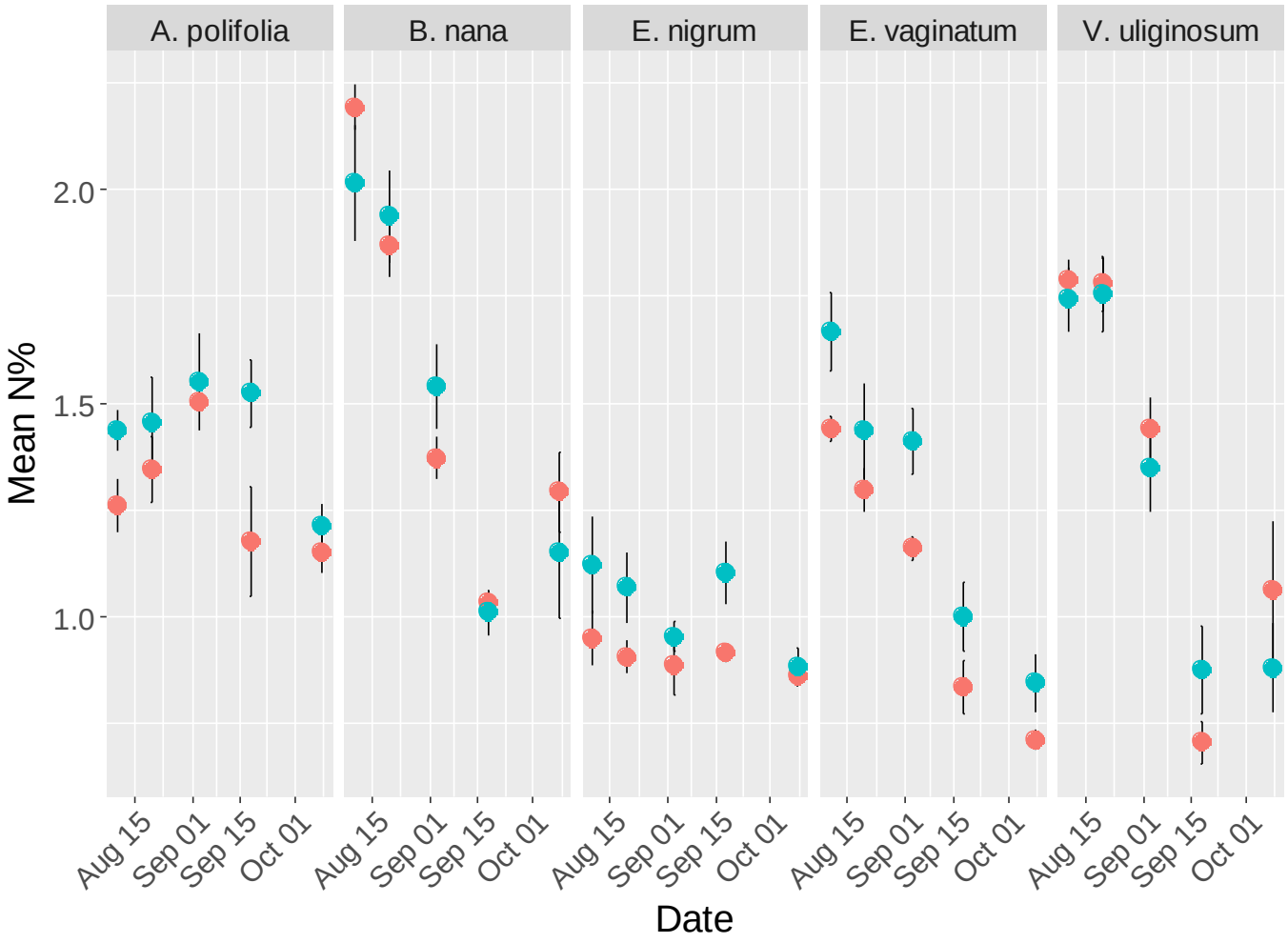
No delay in start, middle or end of *Eriophorum* autumn phenology with snow/permafrost thaw

Physiology – Total chlorophyll content

No change in autumn chlorophyll content per leaf with snow/permafrost thaw
→**higher NDVI in EV Snow treatment not due to higher chlorophyll**



Physiology – Leaf nitrogen concentration



Higher leaf N-concentration for *Eriophorum* and *Empetrum* (Andromeda?) with snow/permafrost thaw,
autumn decline for deciduous species (BN, EV, VU)

Conclusions

1. Does snow/thaw depth affect phenology or physiology?
   - Deeper snow/thaw increases productivity (NDVI), but not visible senescence or chlorophyll; N concentration in *Eriophorum* and *Empetrum* → Main NDVI effect could be biomass increase
2. Does chlorophyll breakdown vary between growth form?
   - Amount of chlorophyll varies, but autumn breakdown shows no clear pattern
3. Does rooting depth affect senescence through nutrient availability?
   - Deep-rooting *Eriophorum* NDVI is most strongly affected by snow treatment, but effect on N-concentration is similar between *Eriophorum* and shallow-rooting *Empetrum*

Acknowledgements

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