Biogeochemical response strength of a high-Arctic ecosystem to environmental drivers

heterogeneity among ecosystem compartments and habitats

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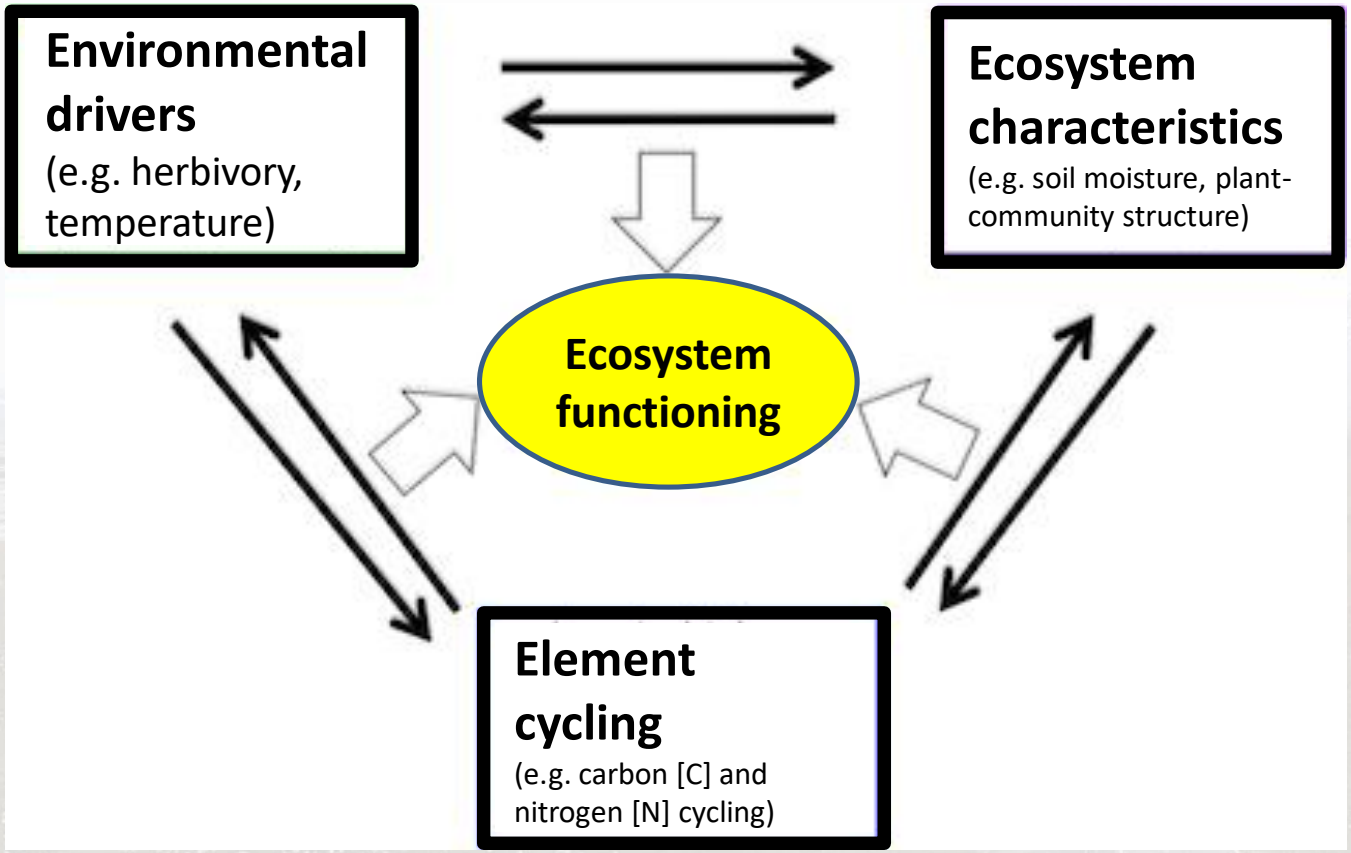
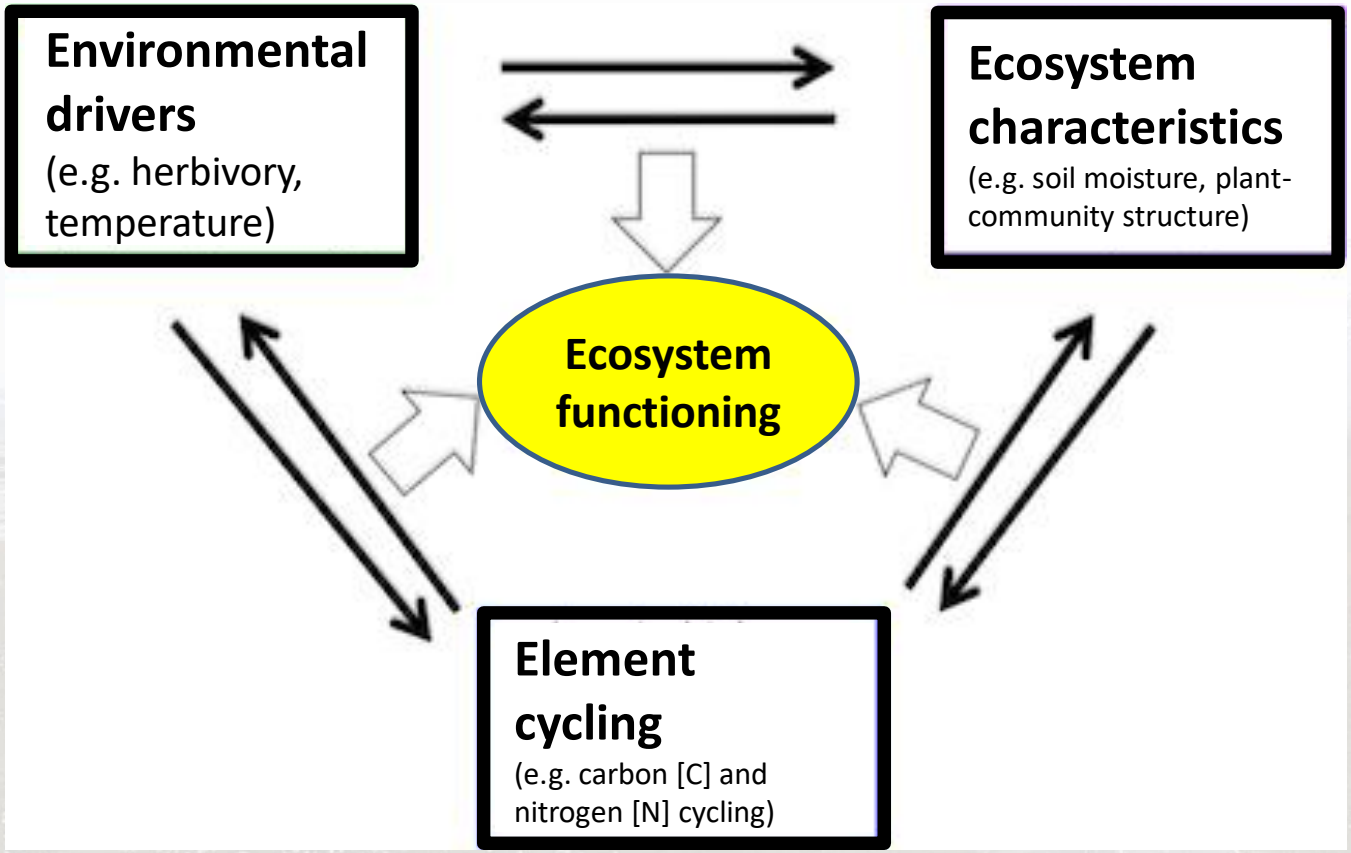
Parma, Italy, 10 – 13 September 2019

Biogeochemical response strength



Chapin *et al*. 2009 – JoE; **Nadelhoffer *et al*. 2001** – Ecology; **Rustad *et al*. 2001** – Oecol.; **Elmendorf *et al*. 2012** – Ecol. Lett.; **Hobbie *et al*. 2002** – Plant and Soil; **Shaver *et al*. 2000** – BioScience

Biogeochemical response strength



Ecosystem biogeochemical response strength to environmental drivers

C-content

Feedbacks to rates of C exchange

→ **C balance**

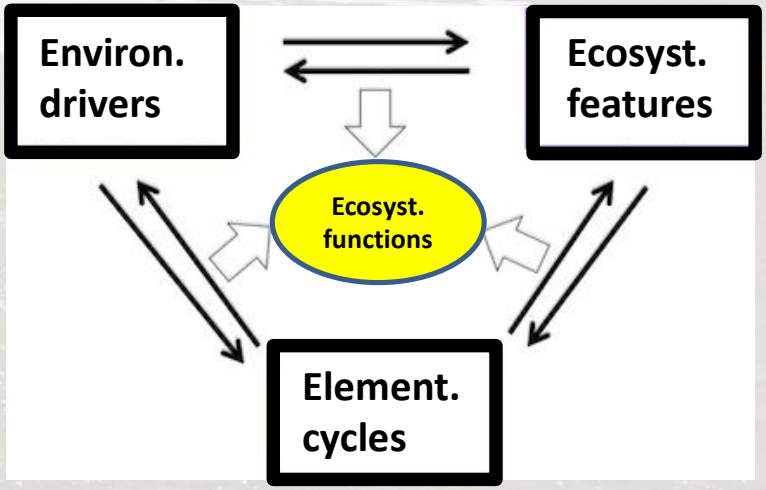
N-content

Feedbacks to rates of nutrient cycling

→ **N fluxes**

Chapin *et al*. 2009 – JoE; **Nadelhoffer *et al*. 2001** – Ecology; **Rustad *et al*. 2001** – Oecol.; **Elmendorf *et al*. 2012** – Ecol. Lett.; **Hobbie *et al*. 2002** – Plant and Soil; **Shaver *et al*. 2000** – BioScience

…in the high-Arctic Svalbard



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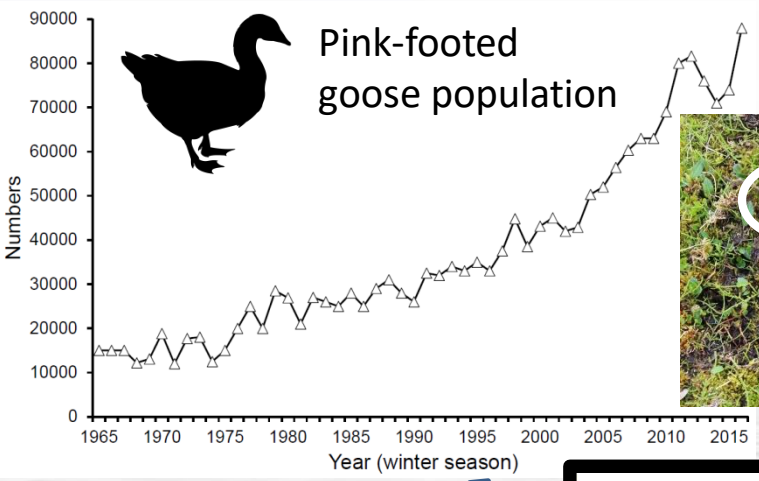
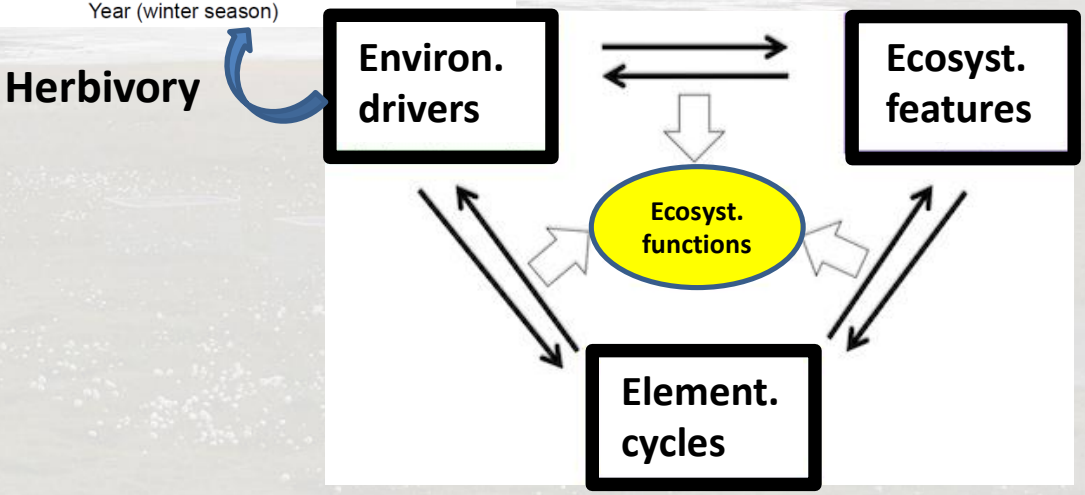


Grubbing



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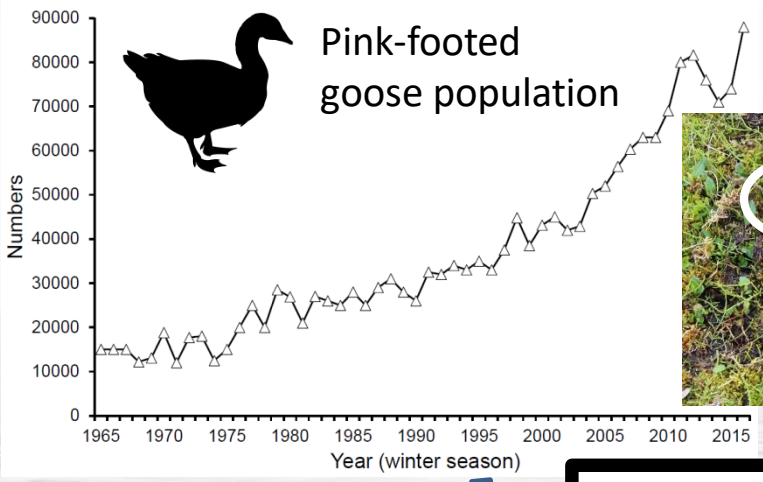

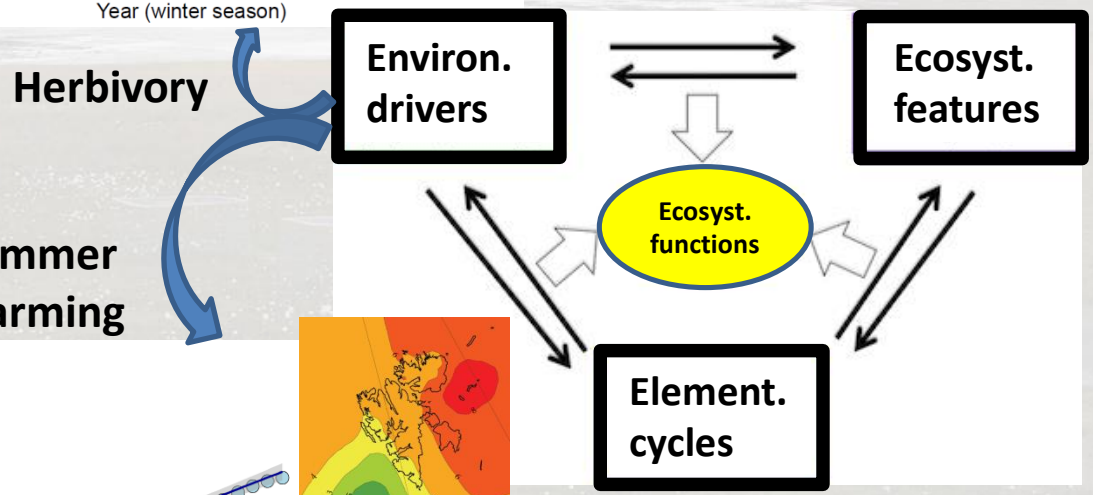

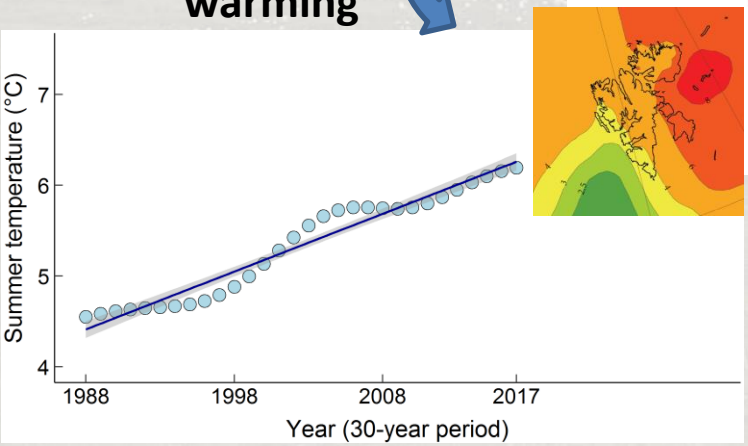

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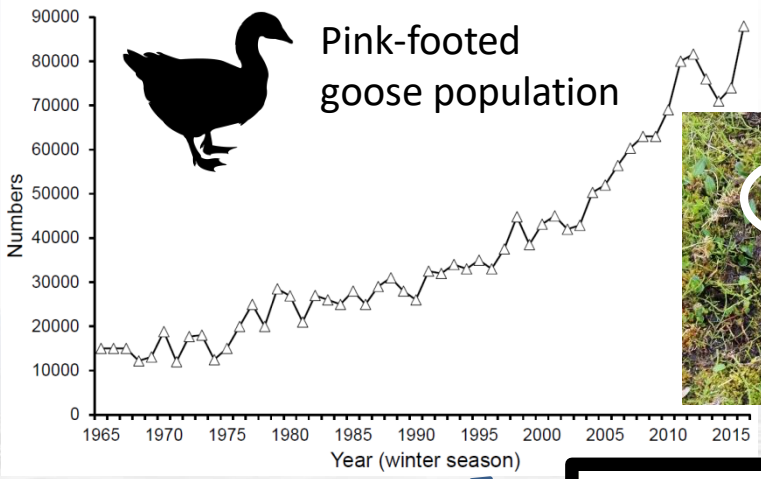
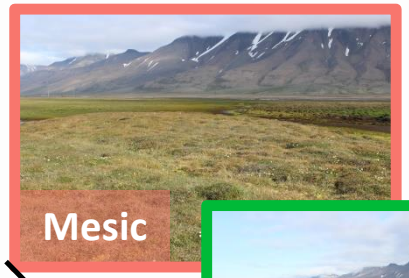
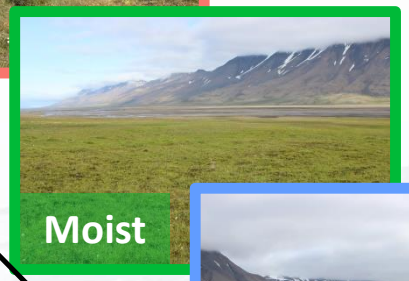
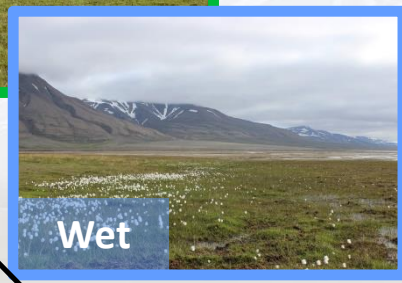




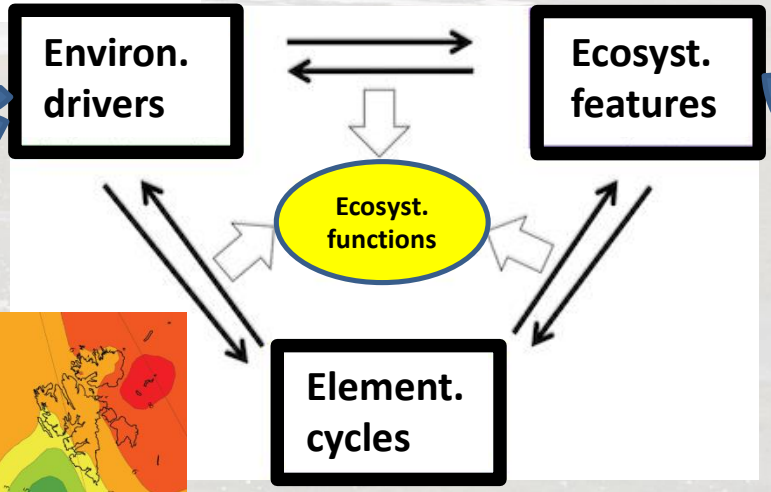


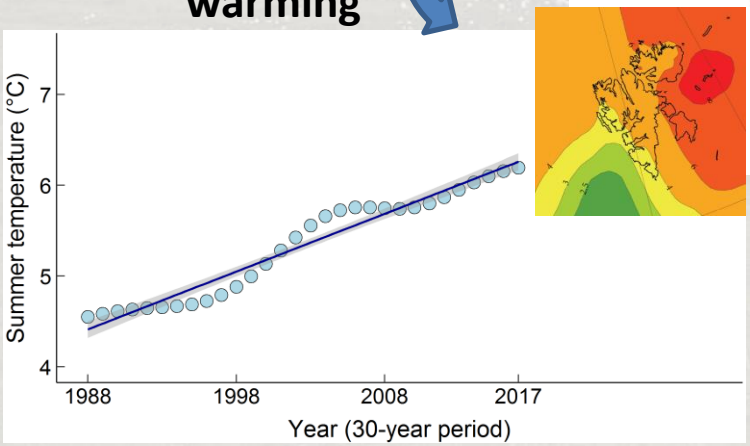


Soil moisture gradient

Herbivory

Summer warming





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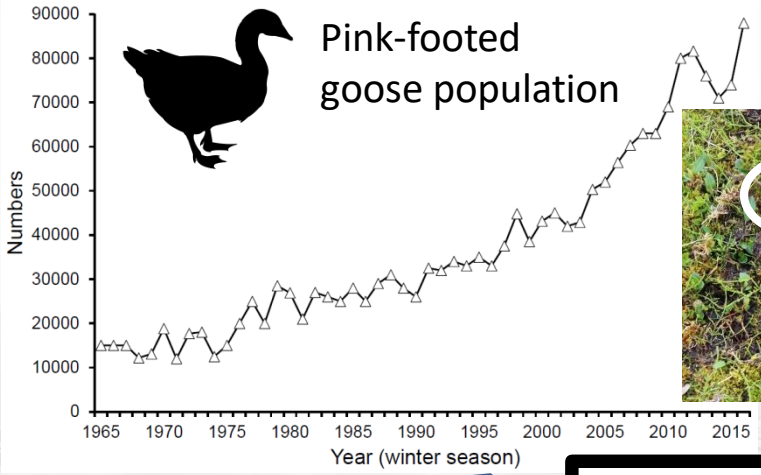
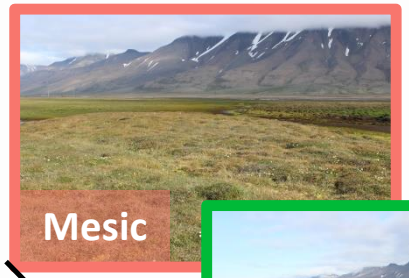
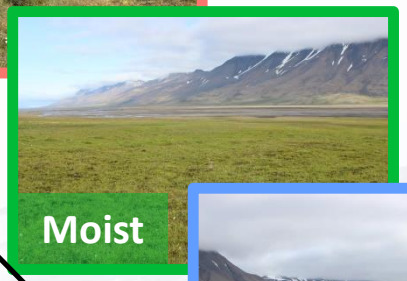
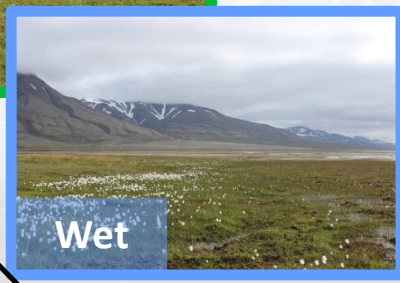
…in the high-Arctic Svalbard









Soil moisture gradient

Herbivory

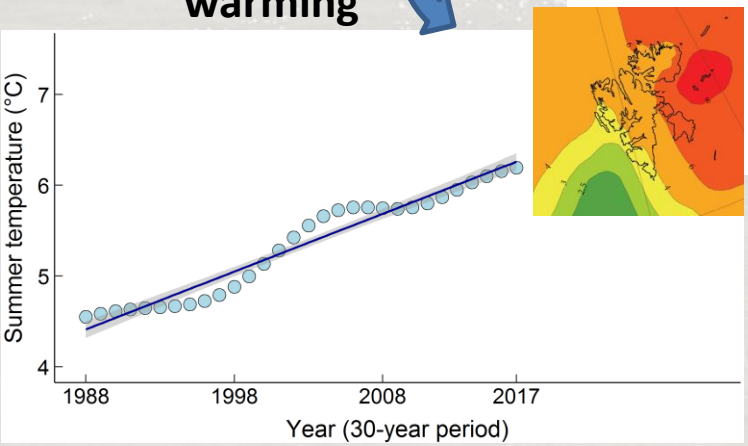
Summer warming

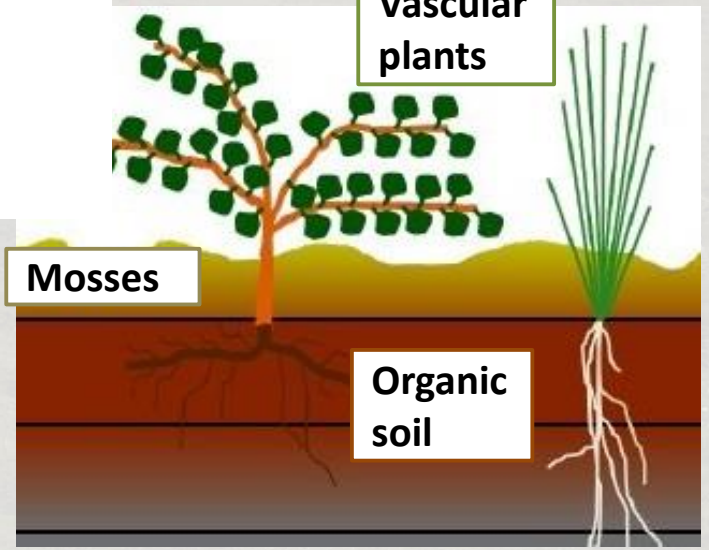
Environ. drivers

Ecosyst. features

Ecosyst. functions

Element. cycles





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…in the high-Arctic Svalbard

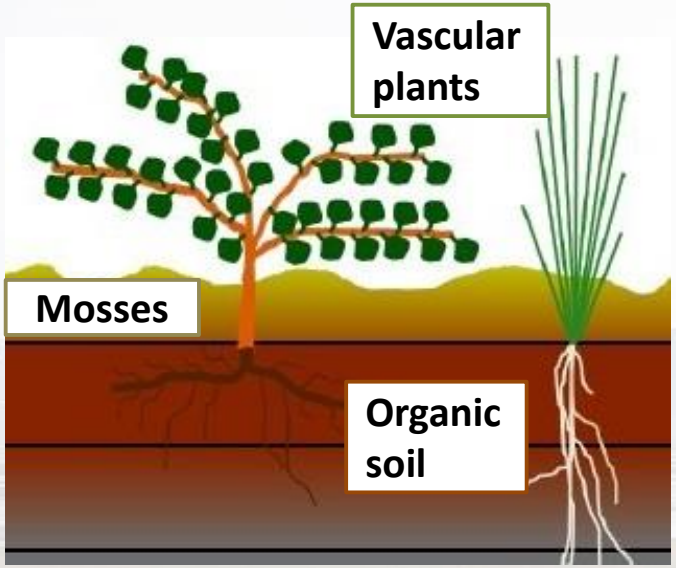
Grubbing

…in the high-Arctic Svalbard

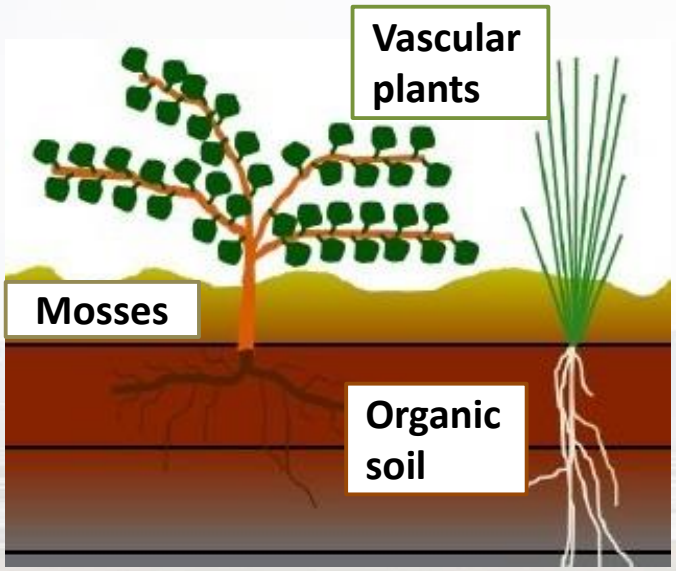
Grubbing

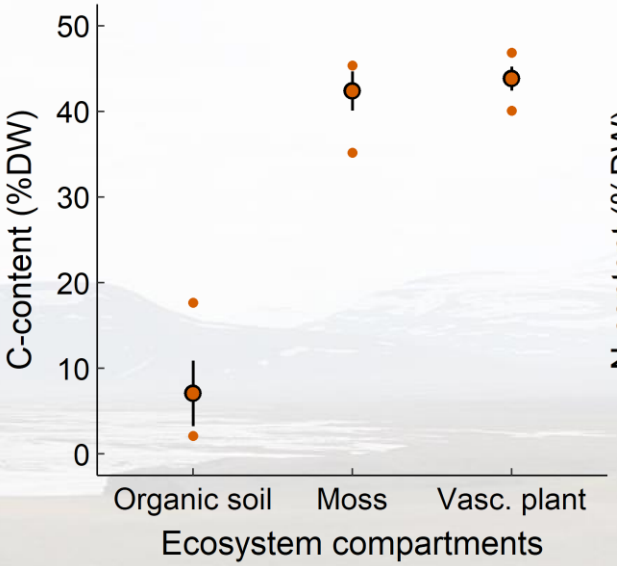
Habitat expansion

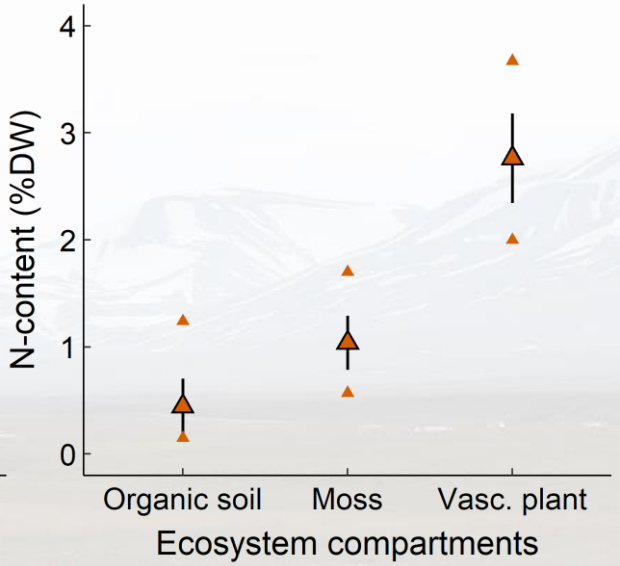
…in the high-Arctic Svalbard



…in the high-Arctic Svalbard







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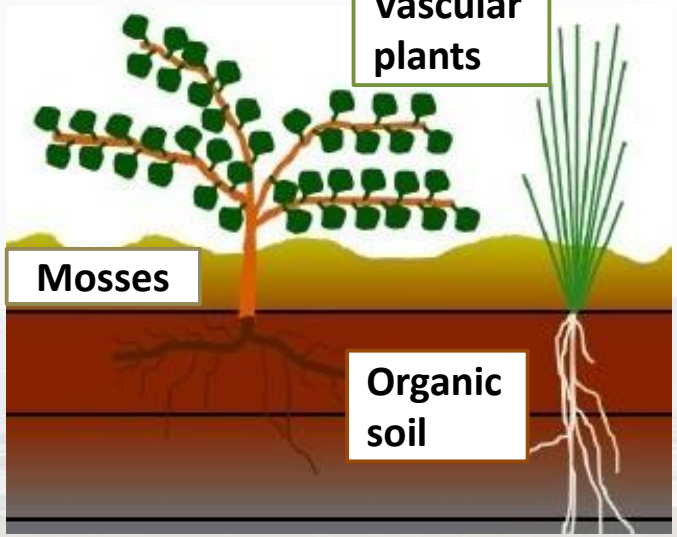
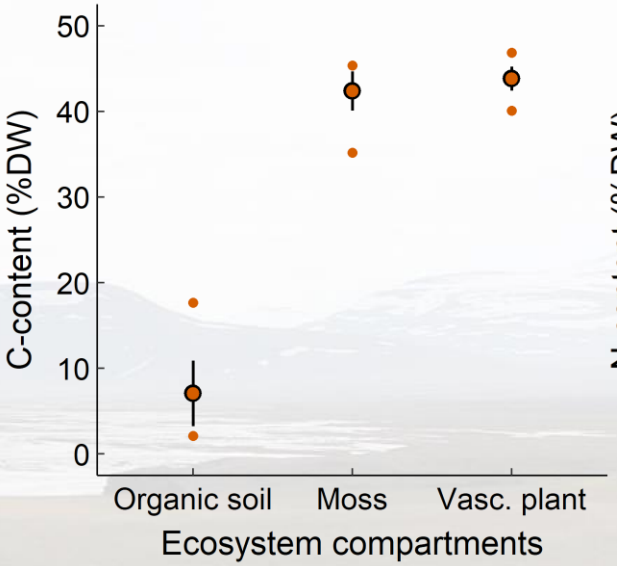
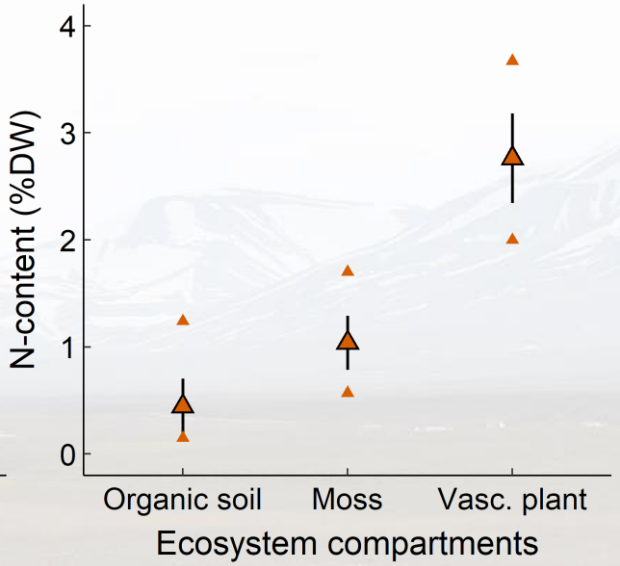
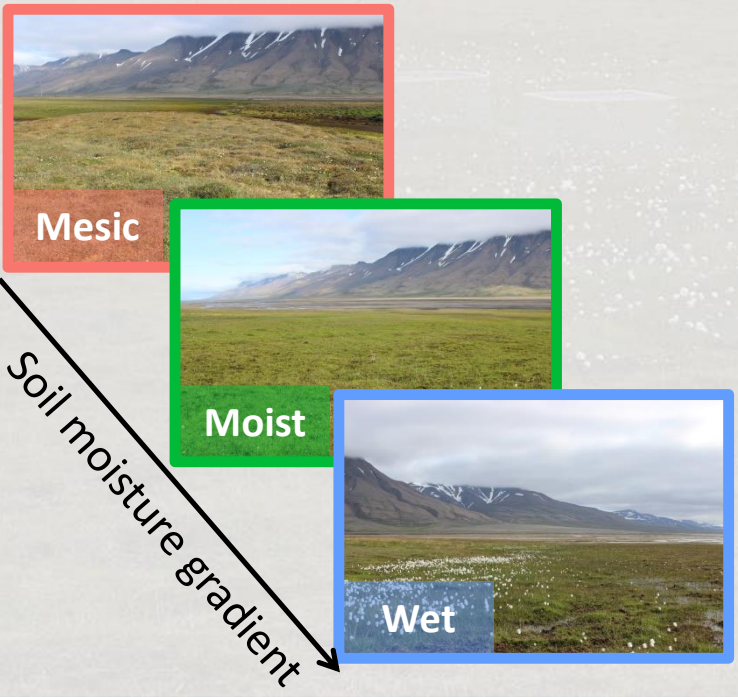
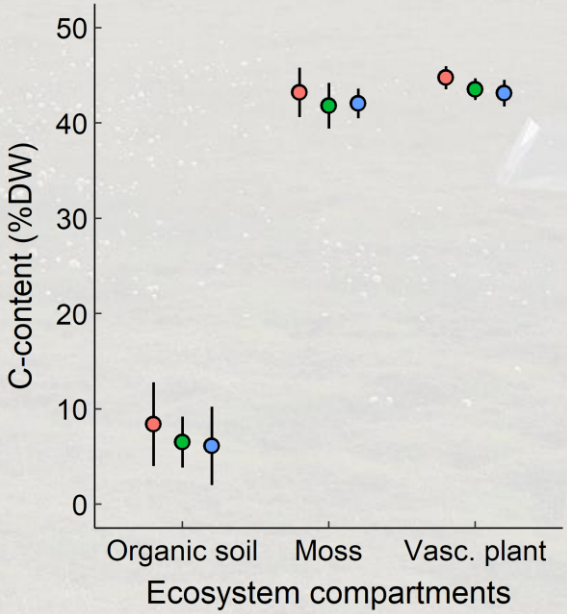
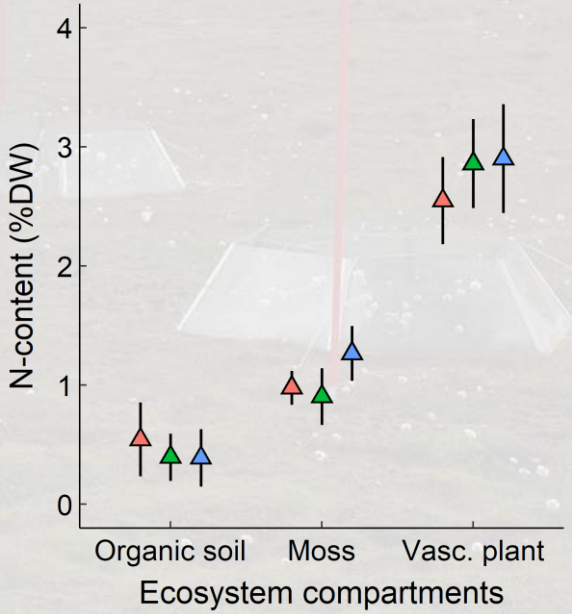










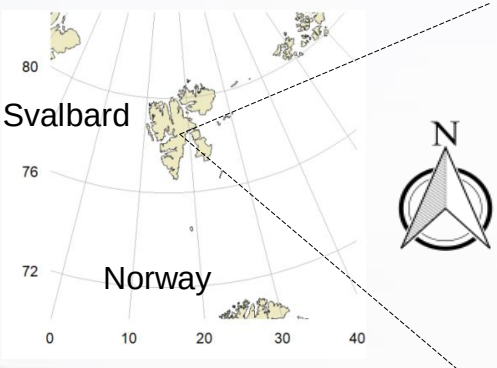


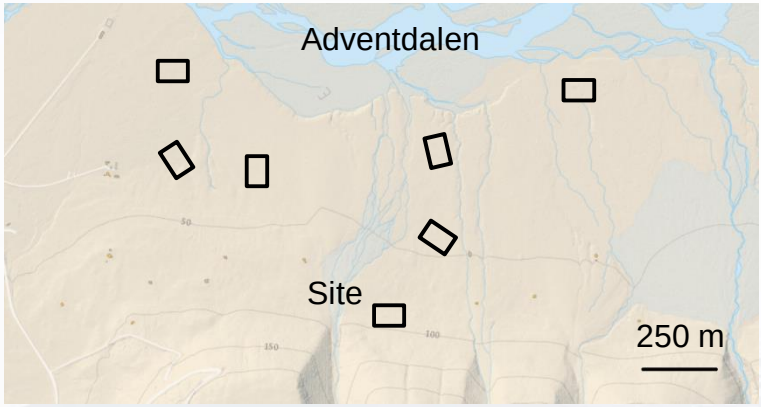
Research questions

What is the response strength of different ecosystem compartments to goose disturbance and summer warming in terms of their C and N content (and C:N ratio)?

- **Differences between ecosystem compartments**
- **Differences between habitat-types**
- **Differences between two experimental seasons**

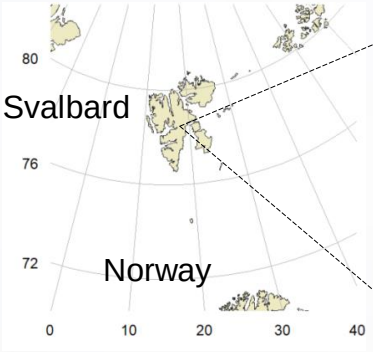
Study design

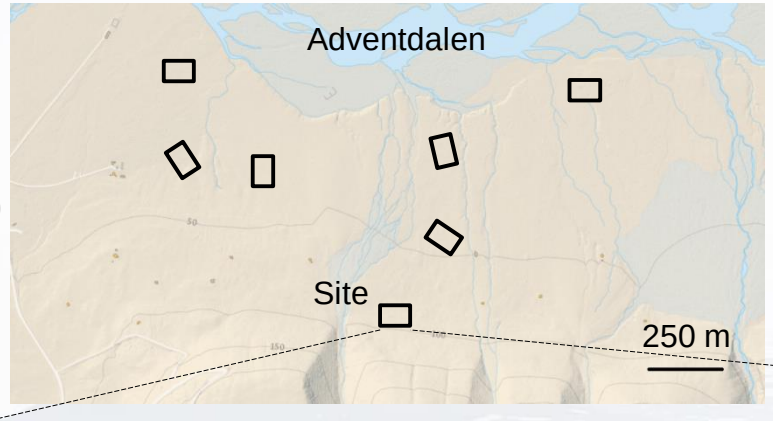




Seven sites

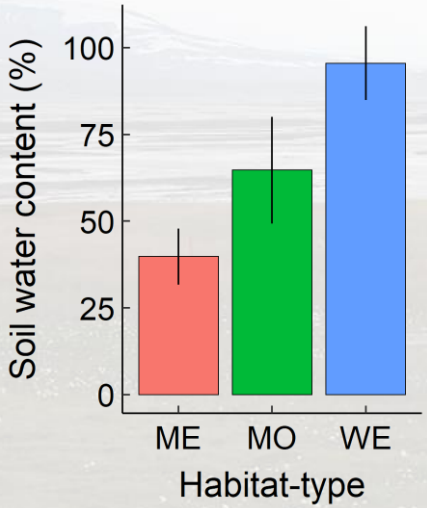
Study design

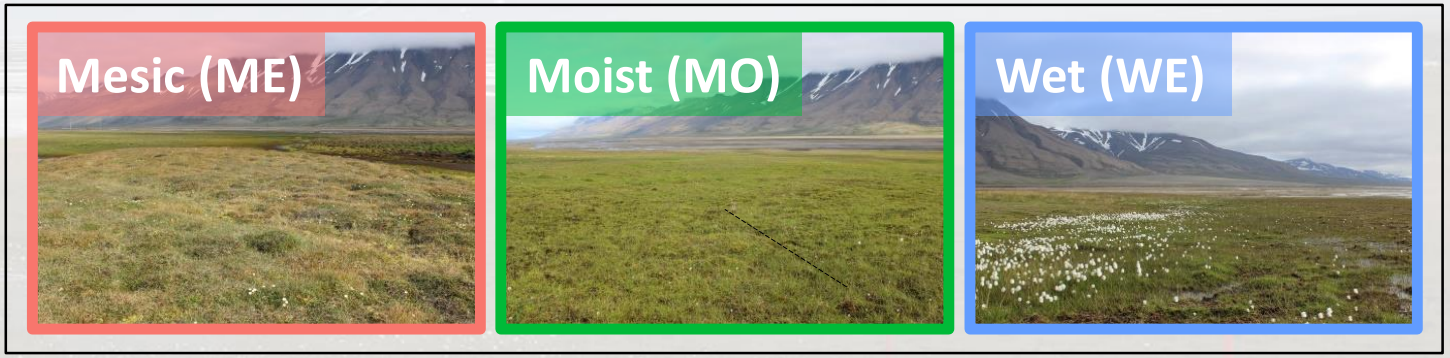




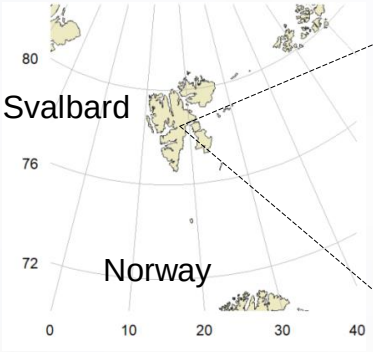
Seven sites

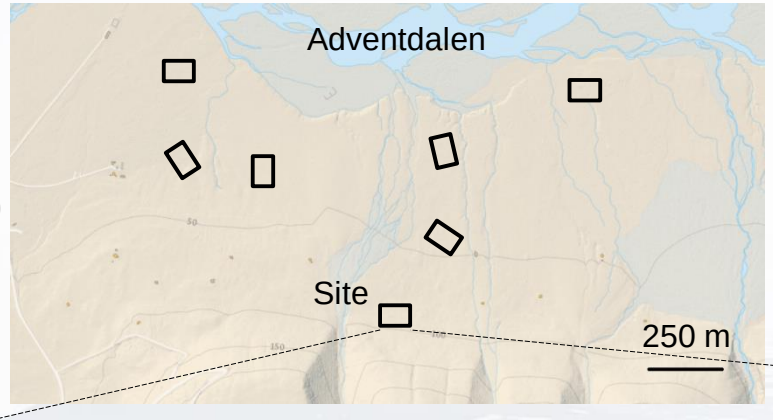
Three habitat-types





Study design

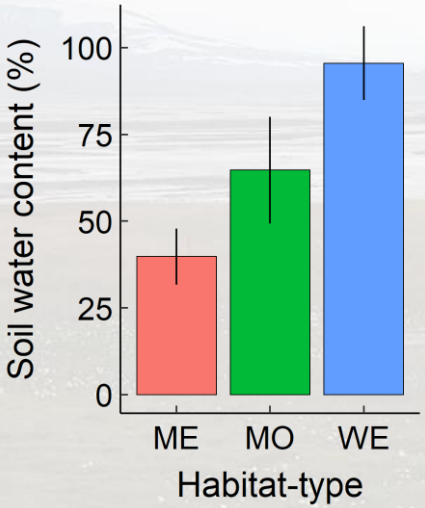


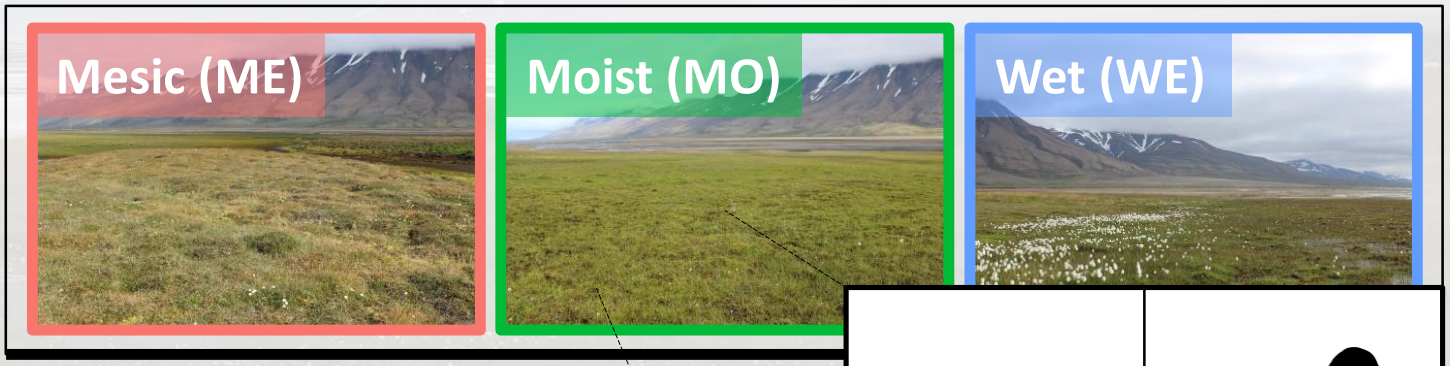


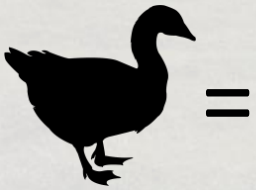
Seven sites

Three habitat-types

Experimental block (2 treatments with 2 levels)







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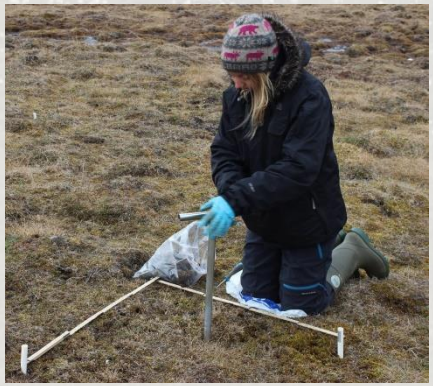
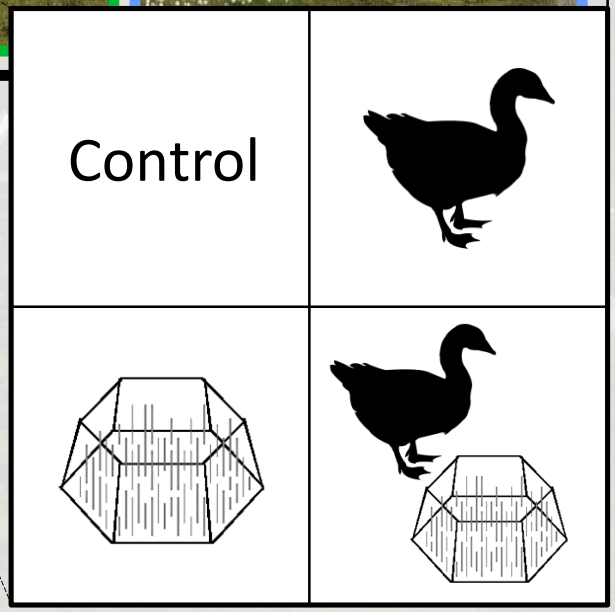
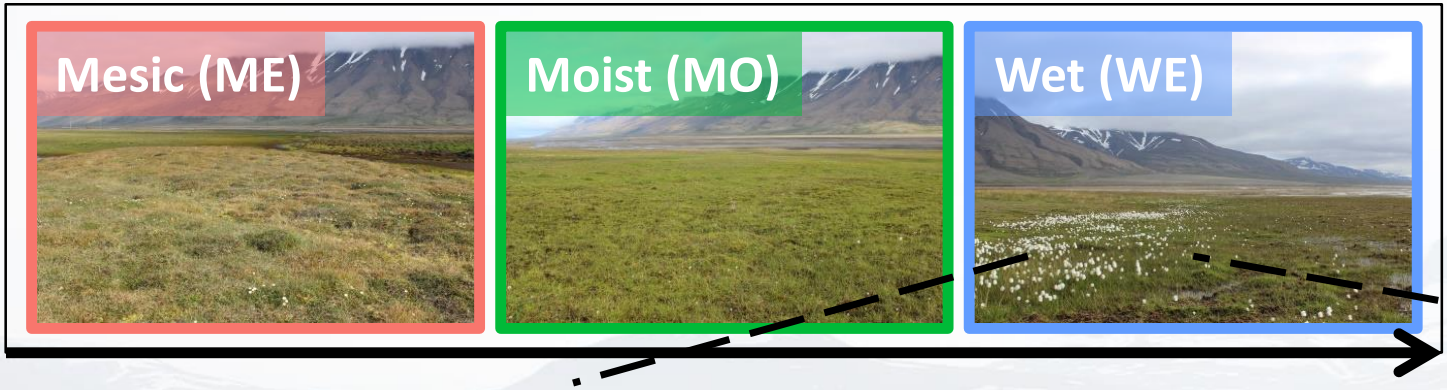


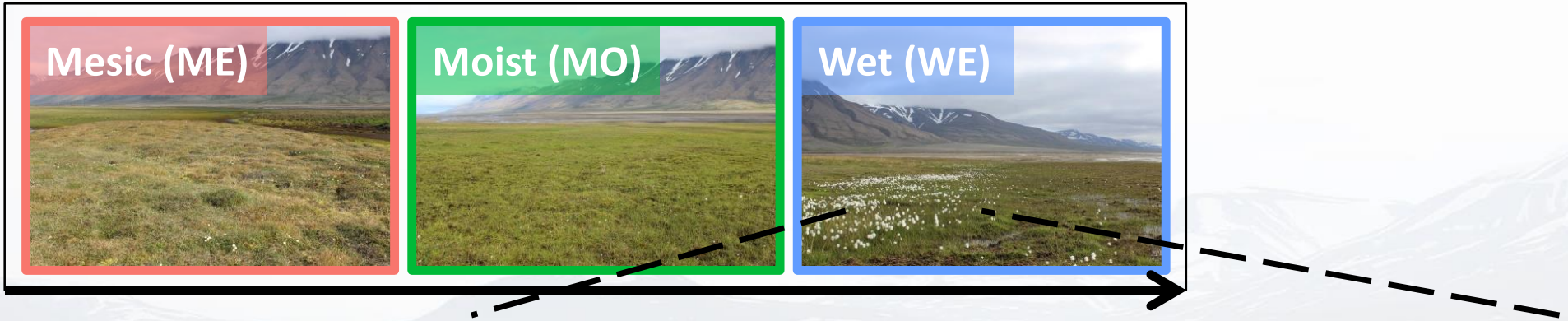


Speed *et al*. 2010 – JoE; **Henry and Molau, 1997** – GCB; **Molau and Mølgaard, 1996** – ITEX manual

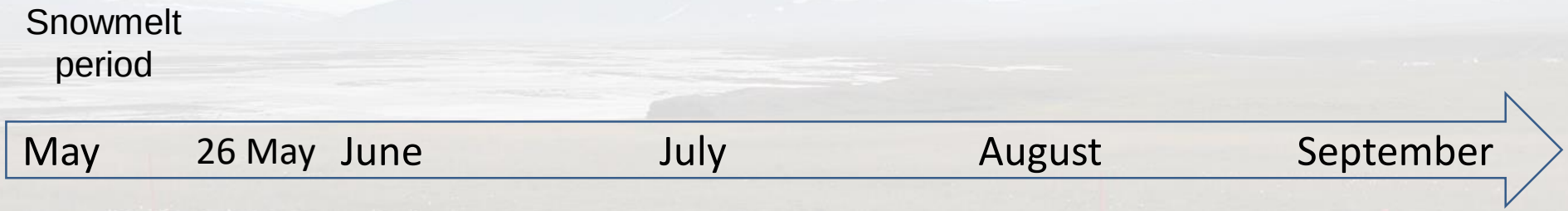
Study design



Study design

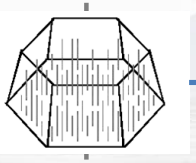


Study design and sampling design



Study design and sampling design

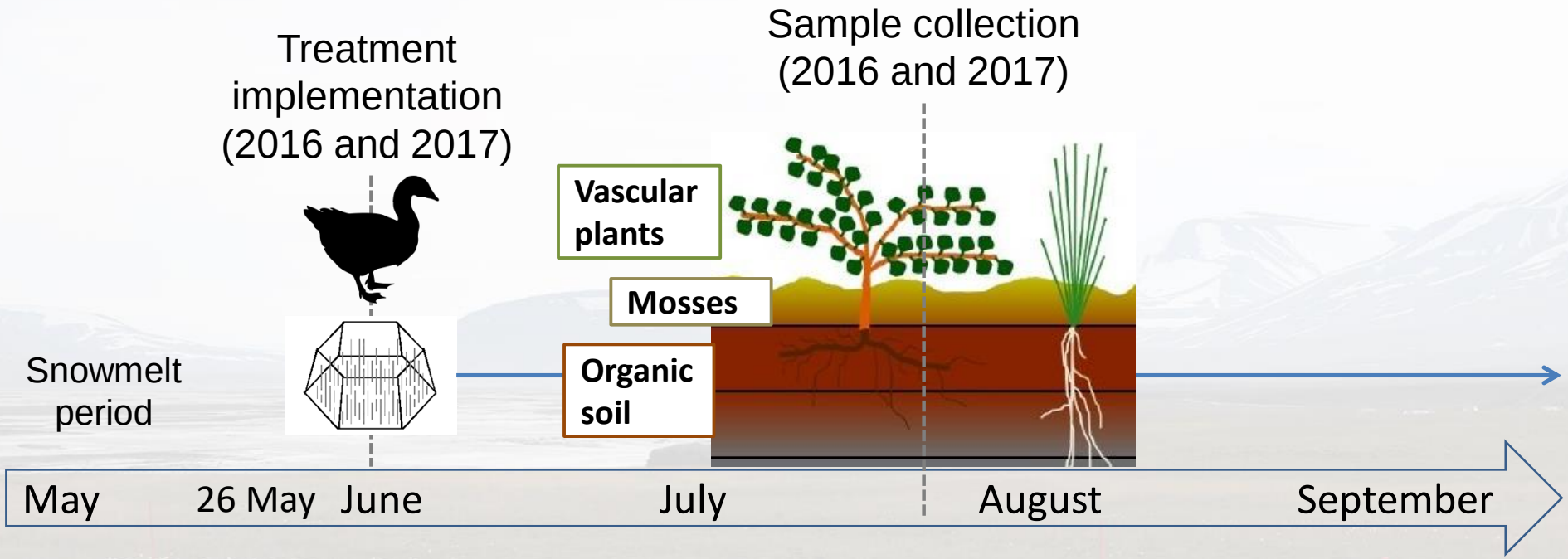
Treatment implementation (2016 and 2017)



Snowmelt period

May 26 May June July August September

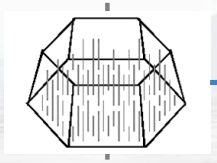
Study design and sampling design

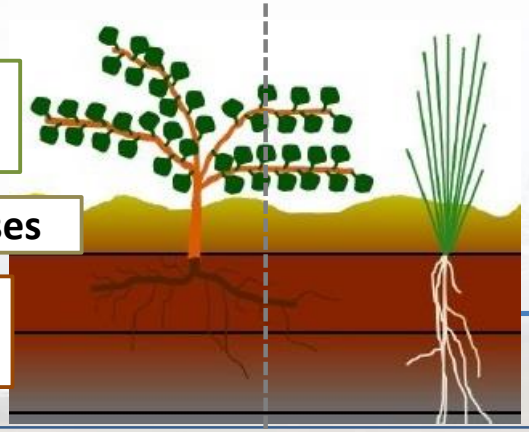


Study design and sampling design

Treatment implementation (2016 and 2017)

Sample collection (2016 and 2017)





Snowmelt period

May | 26 May | June | July | August | September

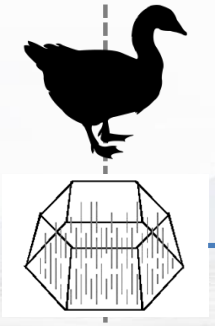
2016

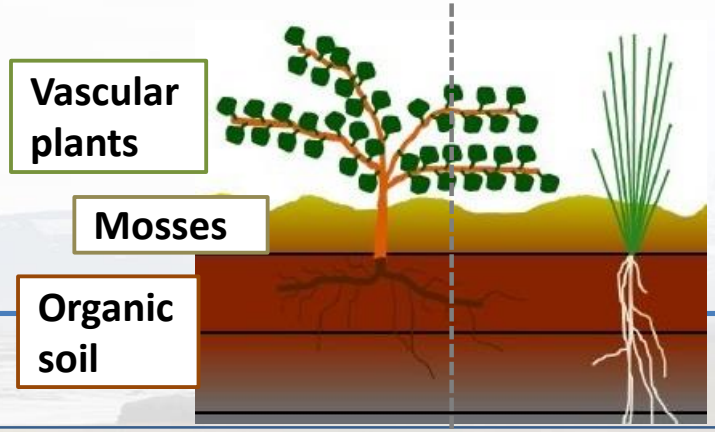
2017

Study design and sampling design

Treatment implementation (2016 and 2017)

Sample collection (2016 and 2017)





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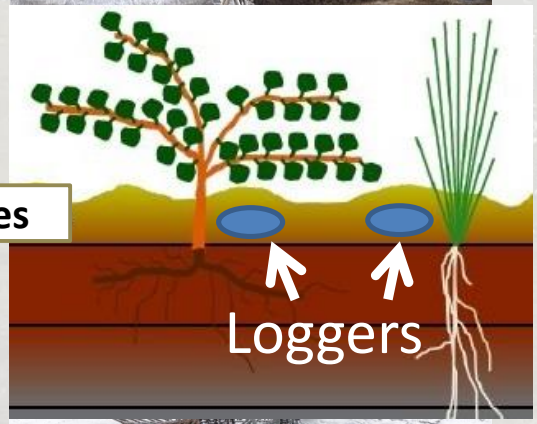
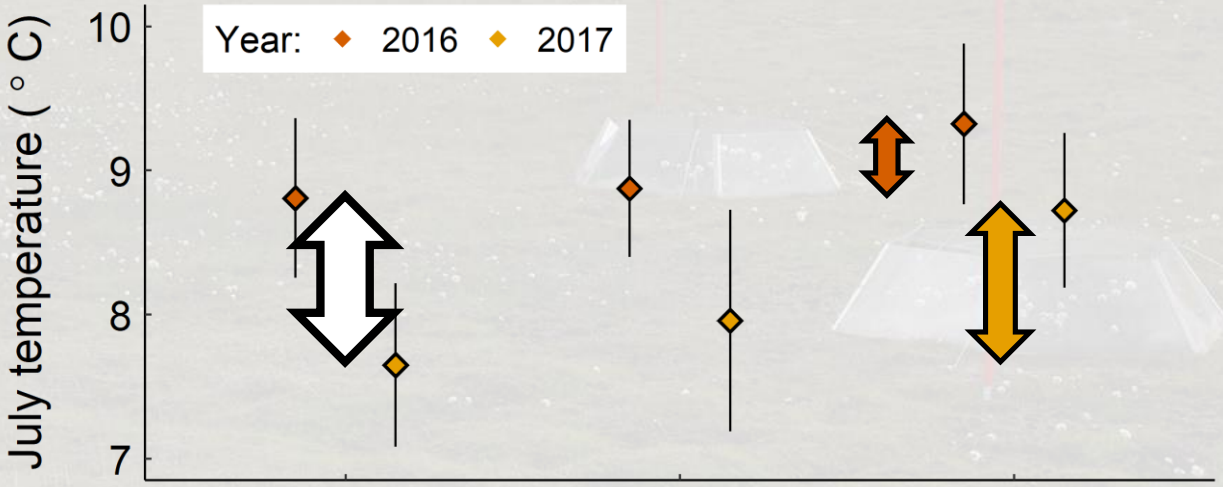
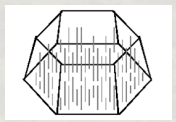
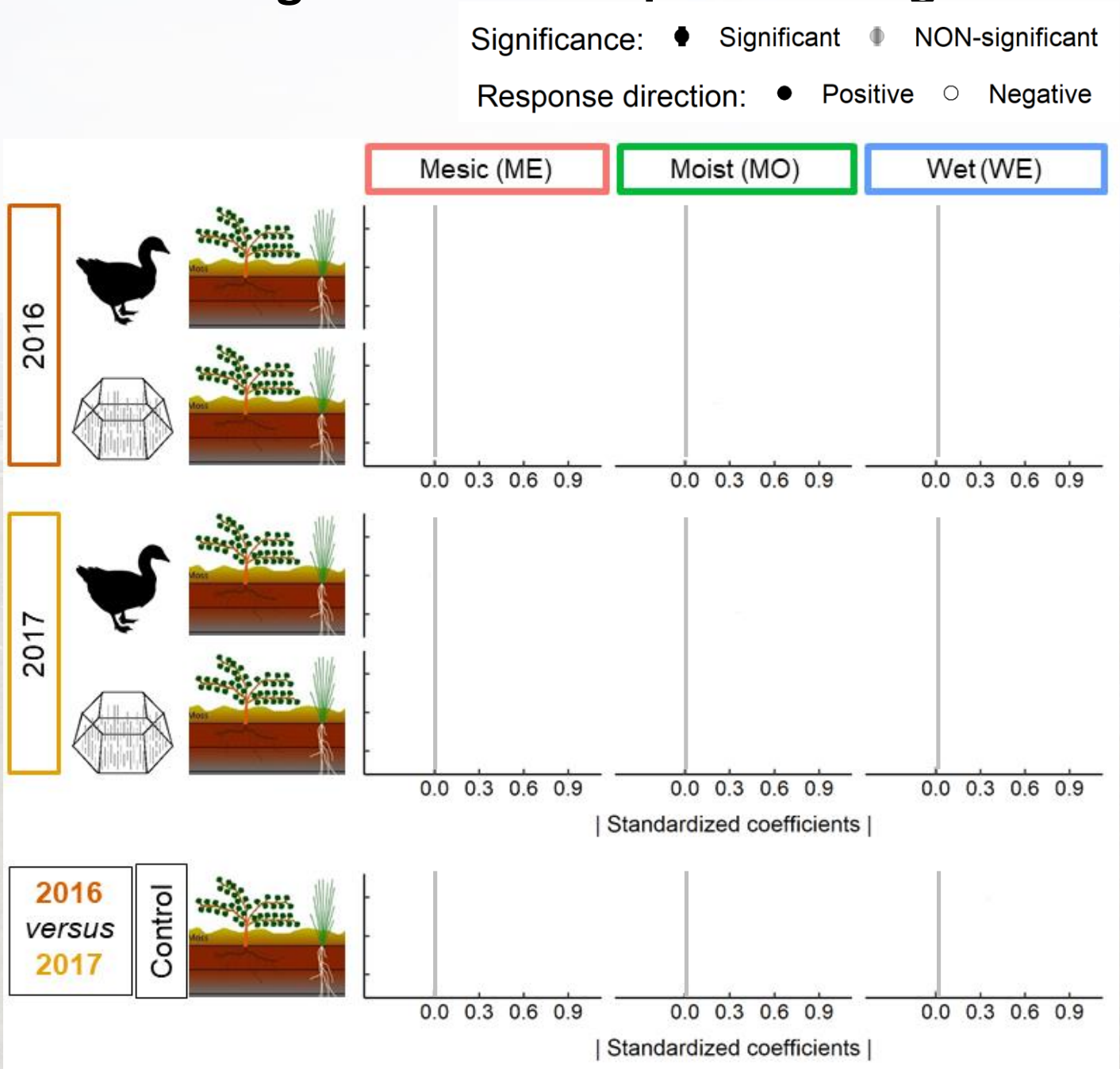




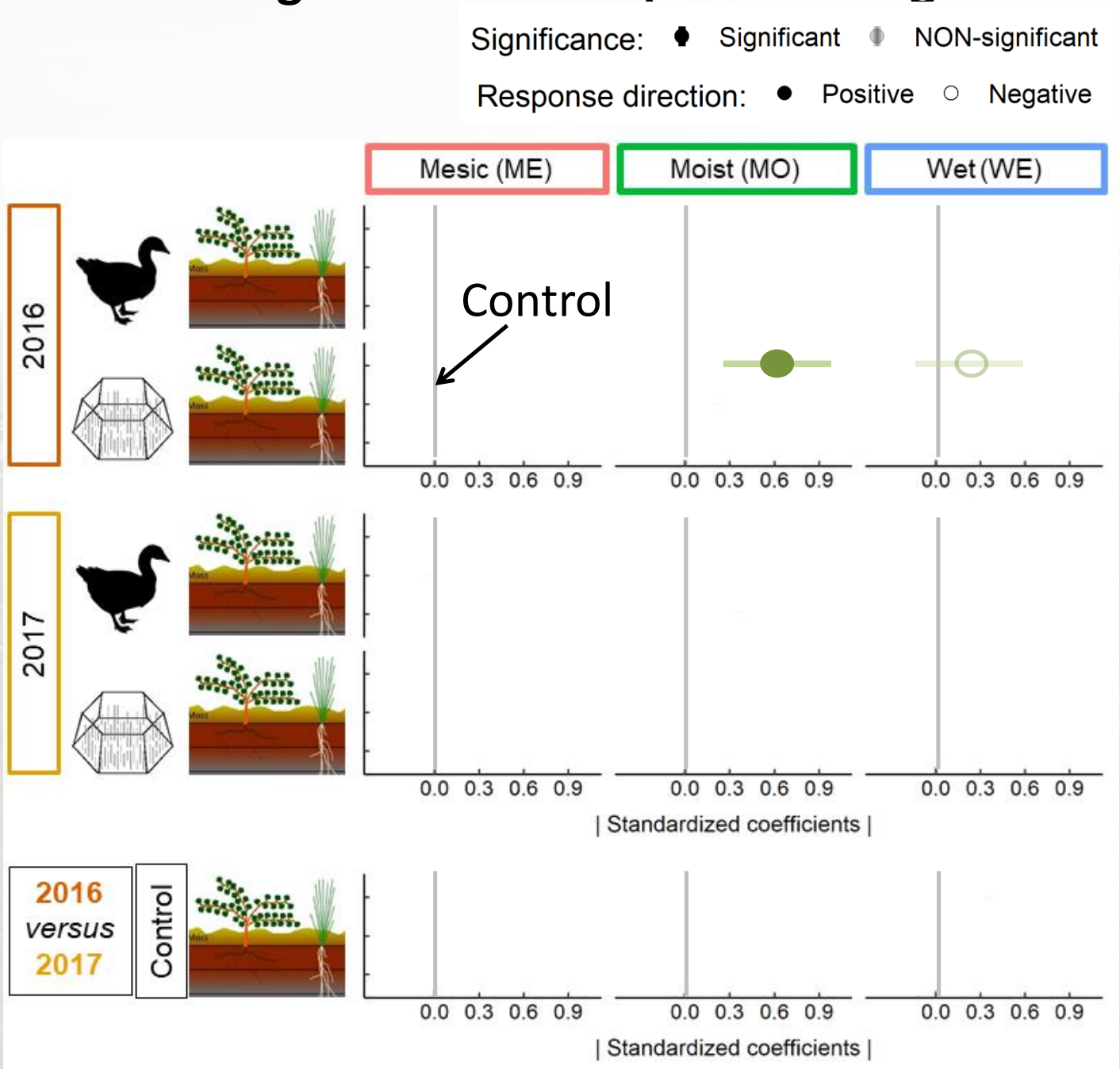
Control



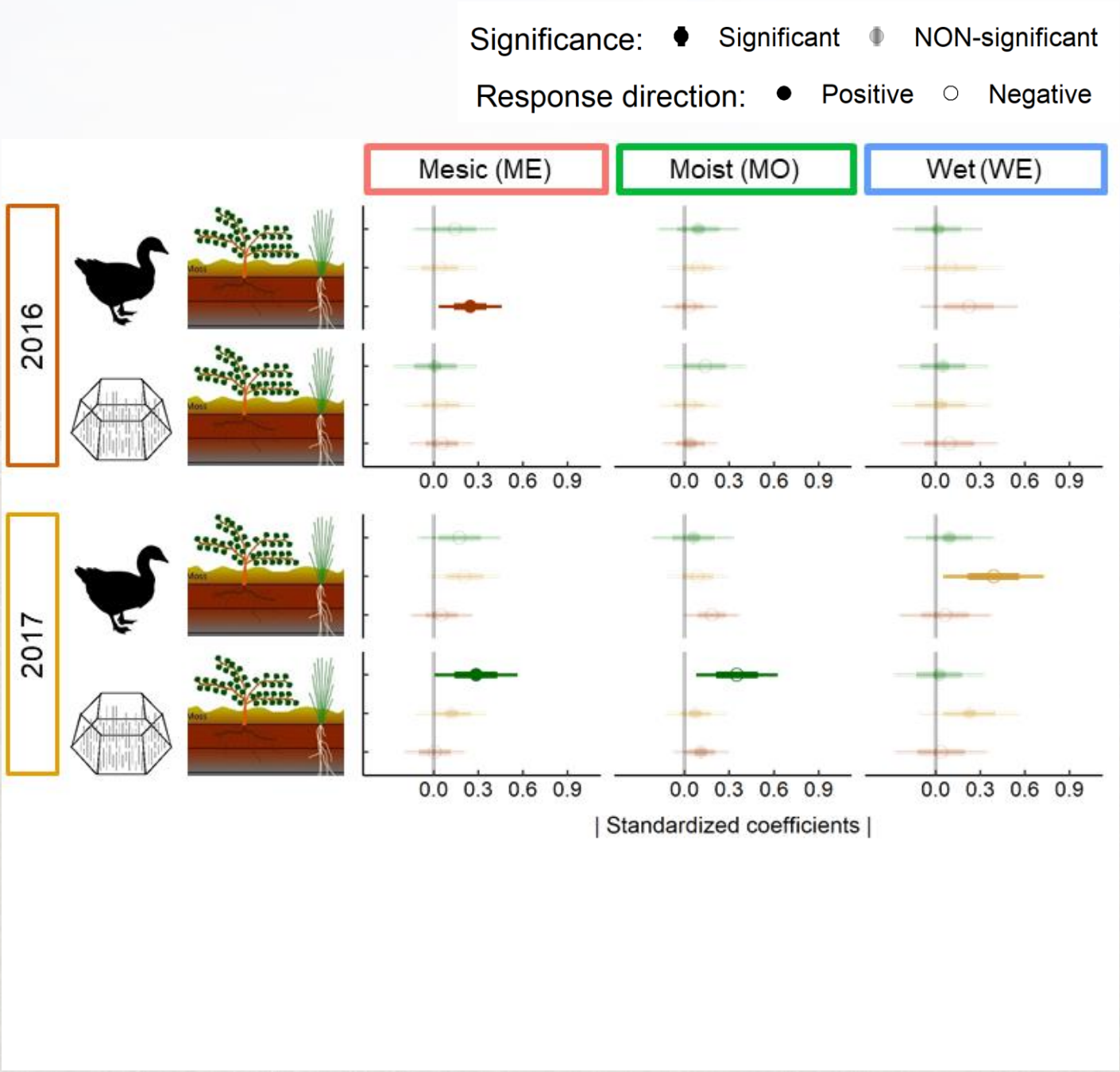
Results: biogeochemical response strength



Results: biogeochemical response strength

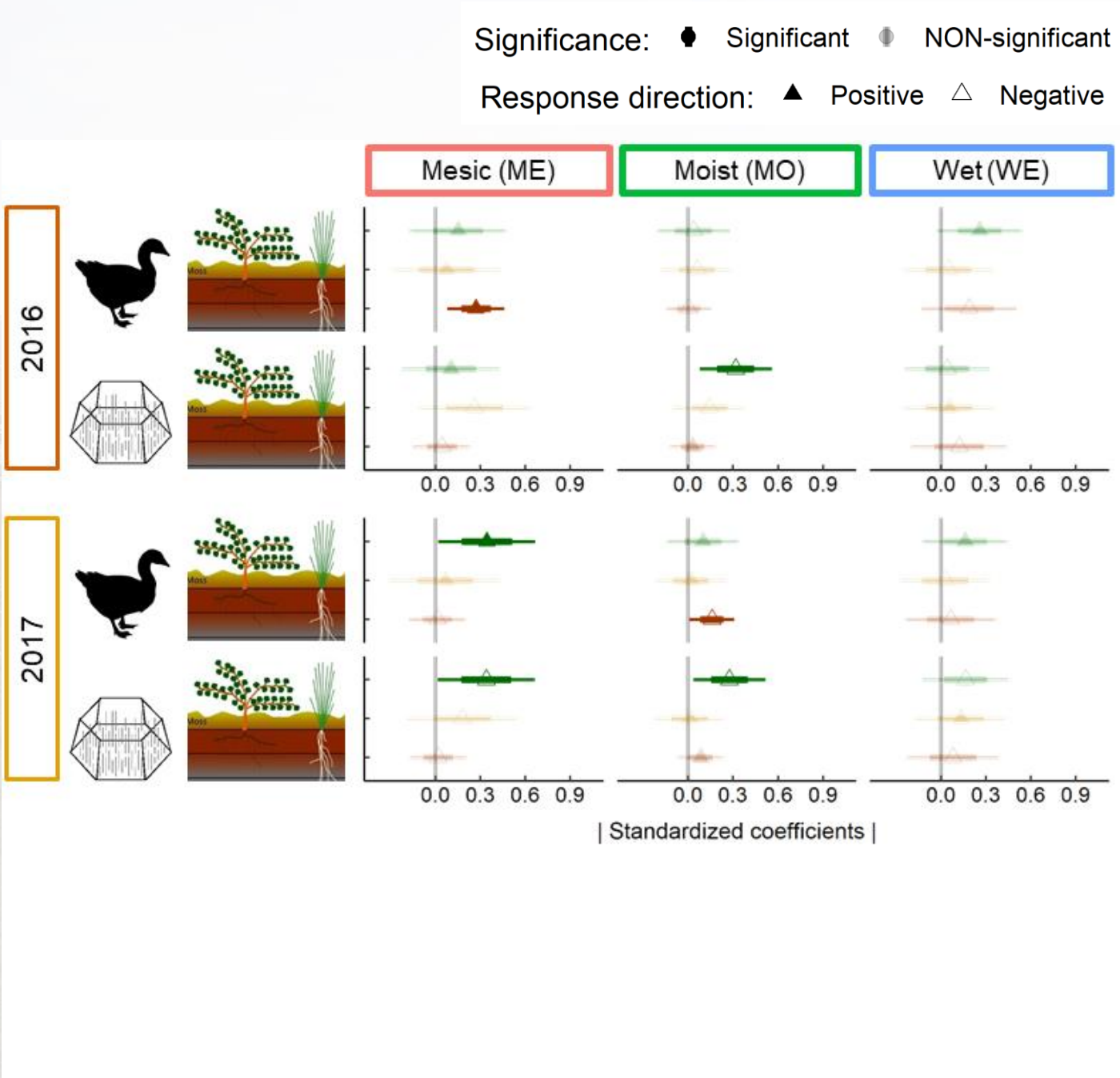


Results: C-content



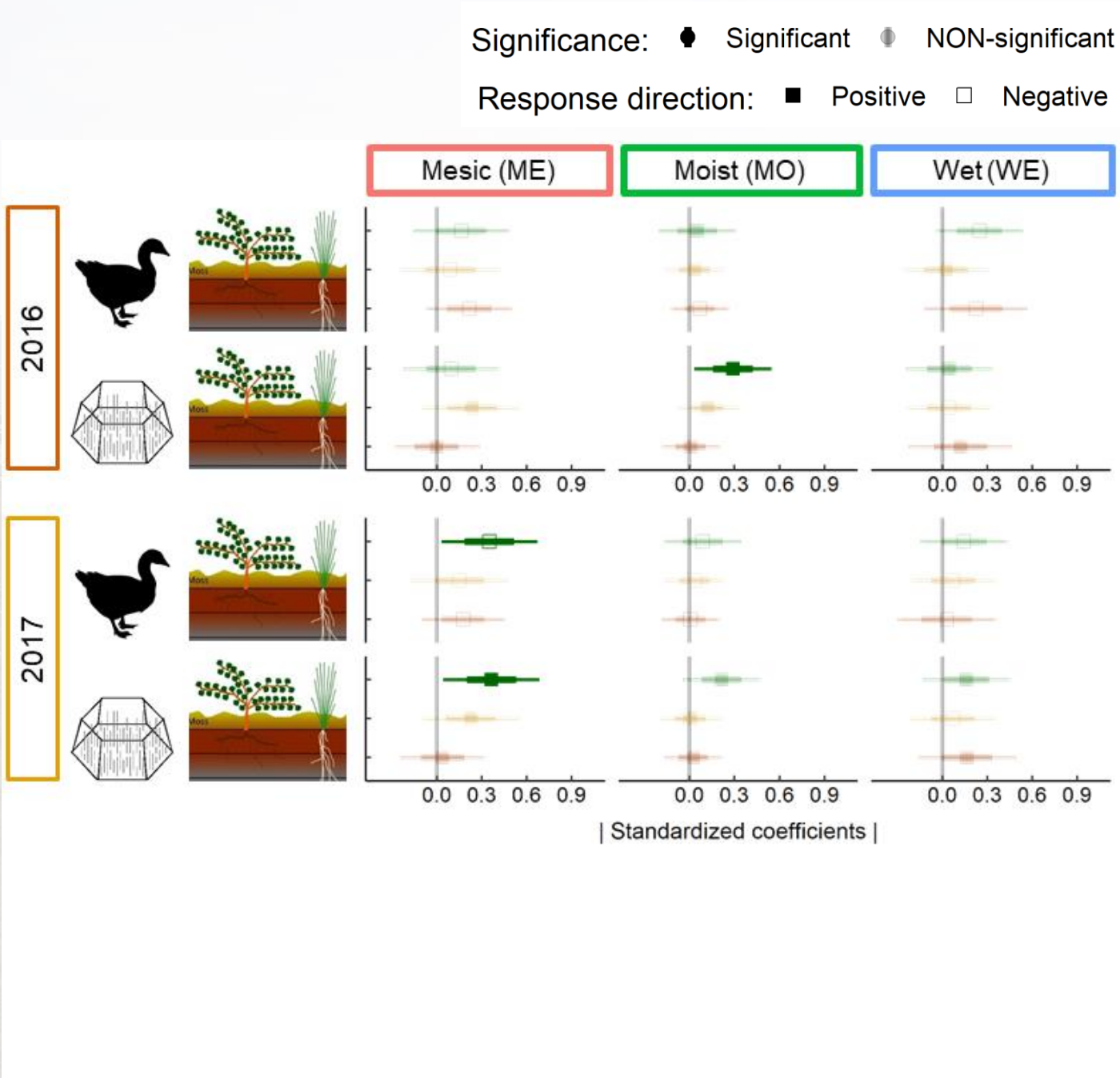
- Similar response strength among compartments, but to different treatments
- Similar response strength among habitats, but for different compartments
- Response strength to treatments was higher in 2017
- More differences between experimental seasons (and larger effect sizes)

Results: N-content



- Response strength: vascular plants > organic soil > mosses, but to different treatments
- Equal response strength in ME and MO, but WE was unresponsive
- Response strength to treatments was higher in 2017
- More differences between experimental seasons (and larger effect sizes)

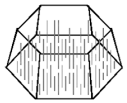
Results: C:N ratio



- Only vascular plants responded to treatments
- Similar response strength in ME and MO, but WE was unresponsive
- Response strength to treatments was higher in 2017
- More differences between experimental seasons (and larger effect sizes)

Summary and conclusions

Response strength to treatments



- Vascular plants > organic soil > mosses
- N-content > C-content > C:N ratio
- ME-habitats > MO-habitats > WE habitats
- Year 2017 > Year 2016

Natural between-season variability

- Higher compared to response strength to treatments
- Vascular plants > organic soil > mosses
- C:N ratio > C-content = N-content
- WE habitats > MO-habitats > ME-habitats

Summary and conclusions

- Spring goose disturbance and summer warming represent significant drivers
- Strong heterogeneity in response strength to treatments among compartments, proxies of biogeochemical processes and habitat-types
  → differential responses to perturbations
  → coupling between C and N cycling?
- Higher natural between-season variability
  → our environmental perturbations were within the natural variation of these systems
  → biological relevance of ecosystem responses to environmental perturbations
- Patterns in natural between-season variability diametrically opposed to response patterns to treatments
  → thresholds in proxy and habitat responses?

PhD project: Effects of herbivory and summer warming on tundra plant-community nutrient levels and dynamics

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