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

heterogeneity among ecosystem compartments and habitats

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Biogeochemical response strength

Environmental drivers (e.g. herbivory, temperature)

Ecosystem characteristics (e.g. soil moisture, plant-community structure)

Ecosystem functioning

Element cycling (e.g. carbon [C] and nitrogen [N] cycling)
Biogeochemical response strength

Environmental drivers
(e.g. herbivory, temperature)

Ecosystem characteristics
(e.g. soil moisture, plant-community structure)

Ecosystem functioning

Element cycling
(e.g. carbon [C] and nitrogen [N] cycling)

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

...in the high-Arctic Svalbard

...in the high-Arctic Svalbard

Pink-footed goose population

Grubbing

Herbivory

Environ. drivers

Ecosyst. features

Ecosyst. functions

Element. cycles

...in the high-Arctic Svalbard

Pink-footed goose population

Grubbing

Herbivory

Summer warming

Environ. drivers

Ecosyst. functions

Ecosyst. features

Element. cycles

...in the high-Arctic Svalbard

...in the high-Arctic Svalbard

Pink-footed goose population

Grubbing

Herbivory

Summer warming

Environ. drivers

Ecosyst. features

Ecosyst. functions

Element. cycles

Vascular plants

Mosses

Organic soil

...in the high-Arctic Svalbard Grubbing
...in the high-Arctic Svalbard Grubbing

Habitat expansion
...in the high-Arctic Svalbard

Vascular plants

Mosses

Organic soil
...in the high-Arctic Svalbard

- Vascular plants
- Mosses
- Organic soil

Graph showing C-content and N-content in different ecosystem compartments (Organic soil, Moss, Vasc. plant)
...in the high-Arctic Svalbard

Vascular plants

Mosses

Organic soil

Mesic

Moist

Wet

Soil moisture gradient

Ecosystem compartments

C-content (%DW)

N-content (%DW)

C-content (%DW)

N-content (%DW)
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

Svalbard
Norway

Adventdalen
Site

250 m
Study design

Seven sites
Three habitat-types

Svalbard
Norway

Adventdalen
Site

250 m

Soil water content (%)

Mesic (ME)
Moist (MO)
Wet (WE)

Habitat-type

ME  MO  WE
Study design

Seven sites
Three habitat-types
Experimental block (2 treatments with 2 levels)

Svalbard
Norway

Soil water content (%)

Habitat-type

Mesic (ME)
Moist (MO)
Wet (WE)

Control

Study design

Mesic (ME)  Moist (MO)  Wet (WE)
Study design

- **Mesic (ME)**
- **Moist (MO)**
- **Wet (WE)**
# Study design and sampling design

<table>
<thead>
<tr>
<th>May</th>
<th>26 May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
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**Snowmelt period**

- 26 May
Study design and sampling design

Treatment implementation (2016 and 2017)

Snowmelt period

May | 26 May | June | July | August | September
Study design and sampling design

- Treatment implementation (2016 and 2017)
- Sample collection (2016 and 2017)
- Snowmelt period

Timeline:
- May 26
- June
- July
- August
- September
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

Vascular plants

Mosses

Organic soil

Loggers
Study design and sampling design

Treatment implementation (2016 and 2017)

Snowmelt period

May 26 May June July August September

Sample collection (2016 and 2017)

Vascular plants

Mosses

Organic soil

2016

Mosses

Loggers

2017

July temperature (°C)

Year: ◆ 2016 ◆ 2017

Control
Results: biogeochemical response strength

Significance:  ● Significant  ○ NON-significant

Response direction:  ● Positive  ○ Negative

Mesic (ME)  Moist (MO)  Wet (WE)
Results: biogeochemical response strength

Significance: • Significant ○ NON-significant

Response direction: • Positive ○ Negative

Mesic (ME)  Moist (MO)  Wet (WE)

2016

Control

2017

2016 versus 2017

Control
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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Thanks for your attention!
References