Tundra change at the dawn of drone ecology

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Photo: Normand-Treier
The use of drones 2) to answer questions in ecology

*Adds to our ability to understand and monitor*
- distribution of species
- ecosystem processes and underlying environmental factors

*Questions are complex and environmental variation is high:*
- many independent measurements (data points) needed
- generalisation/up-scaling, i.e. many versus few sites
- design: random, stratified random (ecological gradient),
- remote areas, collection under optimal conditions not possible

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Tundra change across space and time

Photo: Normand-Treier
Tundra change across space and time

Where? Why?

Map, measure, model

Dynamics?

Monitor

Understand & predict

Photo: Normand-Treier
All species are distributed in space – but within limits

The distribution of all individuals in space constitutes the range
Challenge | scale gap

All species are distributed in space – but within limits

The distribution of all individuals in space constitutes the range

The magnitude of change varies across the range

Initial manifestation of vegetation dynamics

→ **Linking scales challenging due to scale gap**

Photo: Normand-Treier
Scale gap | lack of data
Scale gap | lack of data

→ Bridging scales: high resolution data across large areas → drones
Climate and "greening" trends (1982-2010)

Change in summer temperature

Change in "greening" (NDVI)

→ What drives the large scale vegetation change?

www.climate.gov

Observed changes at local scale

- Increased cover / abundance
- Increased height
- Expansion - recruitment

Arctic tundra change | small scale

Observed changes at local scale

**What drives the large scale vegetation change?**

or

**Do local and large scale changes correlate?**

**Upscaling:**
Link observations across scale → extrapolate and generalise

**Increased cover / abundance**

1987

2009

**Increased height**

Expansion - recruitment

**Arctic tundra change | aim & questions**

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<td>Dynamics?</td>
<td>Monitor</td>
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**Question:** What ecological factors determine spatial variation in:
- abundance?
- functional traits (e.g., height)?
- demographic parameters (e.g., recruitment)?

**Method:** space-for-time substitution & projections with models

**Now -** assessment across environmental gradients
Arctic tundra change | aim & questions

*Question*: How does arctic tundra change over time and what is the spatial variability?

*Method*: time series (monitoring), which is challenging:

- Accuracy and standardisation of (image) data
- Repeatability and transferability

*Future* – observe changes across time and space
Greenlandic gradients | sites and trends

- browning/greening (1982-2012) arctic growing season (GS-NDVI), GIMMS 3g, 8-km resolution
- 4 field campaigns, 7 focal areas
- large scale and small scale environmental gradients

Fieldwork 2013 | Nuuk Fjord – western GL
Environmental gradients | plot-based data

Figur: A. B. Overgaard, Nabe-Nielsen et al. in prep.; Photo: Normand-Treier
Environmental gradients | species abundance

Nabe-Nielsen et al. in prep.
Environmental gradients | plot-based RS

RGB + NIR images of 108 plots
Plot-based RS | classifying species
Plot-based RS | classifying species

→ model performance: overall 60%, 2 species >80% success
Plot-based RS | classifying species

→ Single image classification could be optimised but
→ We need transferability of models across many images
→ Image standardisation and test for transferability
Plot-based RS | colorimetric calibration
Plot-based RS | colorimetric calibration

Wavelength (380-730 nm)

Plot-based RS | colorimetric calibration

→ An example from medicine
→ Tested/compared different correction algorithms

same tongue captured using different cameras

same tongue & camera, different light condition

images after colour correction

images after colour correction

Can parameters derived from drone imagery explain variation in:
• vegetation cover?
• Species richness?

*Imagery → biodiversity indicators*

Guess how many plant species you might find in this landscape in a 2m circle?
Fieldwork 2014 | Data

13 fights of ca. 5000 m² (100x50m) - height 50m - 0.5 cm resolution
• 700 images per flight (NIR plus VIS)
• above permanent plots at 20, 100, 200, 300 m. asl.

Illustration: J. Nabe-Nielsen
Fieldwork 2014 | some impressions
Fieldwork 2014 | some impressions
Fieldwork 2014 | Tundra vegetation Zackenberg
Fieldwork 2014 | Tundra “vegetation” Blæsedal

Canon EOS 550D / 100D (18MP) with Canon EF 50mm f/1.8 lens

NIR modified (> 830nm)
Ultra-high resolution | example from DK

resolution: < 5mm; area: 10000 m²

dune vegetation

Photo: Normand-Treier
Ultra-high resolution | example from DK
Fieldwork 2015 | 3 areas along the Arctic Circle

Fieldwork 2015 | 3 areas along the Arctic Circle

Fieldwork 2015 | 3 areas along the Arctic Circle

10 sites

NDVI trends

Buffer-averaged yearly max NDVI

What characterize sites with different rates of NDVI change?

Space-for-time substitution: what characterizes warmer sites?

Back in time: synchrony temp., NDVI, growth and recruitment?

Temperature
Mean NDVI
Mean cover
Mean height
Mean SLA
NDVI change
NDVI change
NDVI change
NDVI change
Mean NDVI
Mean cover
Mean height
Mean SLA
Temperature
Temperature
Temperature
Temperature
NDVI change
NDVI change
NDVI change
NDVI change
recruitment
growth
NDVI
temperature
Data | GCP, ground truth & trait sampling 2015

• 10 ground control points, GNSS survey grade (📍) and reflectance panel for image standardisation (🌈)
• 10 ground truth sampling squares, 50x50cm (📍)
• 25 trait data sampling plots, 2x2m (⭕️)
Data | Sampling 2015

Visuel cover and height estimates
VIS & NIR images

Vegetation class cover

Environmental parameters
• moisture, pH, aspect,…

Dendroecology
• growth, recruitment

Trait sampling
• SLA, height, wood

Genetic samples

Photo: Sigrid Nielsen
Data | multispectral camera
Data  |  some results

- RGB
- NDVI
- NIR – RED
- NDRE
- NIR + RED

- DSM

- Filter transmittance graph
- Typical plant reflectance

- Images of drone and terrain
Data | good resolution (~2cm)
Data | GCP, ground truth, trait sampling
Challenge | difficult terrain, adaptive flight plan

RGB

NDVI

DSM

354 m a.s.l.

308 m a.s.l.

Slope $\approx 40^\circ$
Drones have great potential to improve our ability to answer ecological questions, by:

- **Mapping** the current distribution of individuals across larger areas
- **Setting baseline to monitor** future change
- **Scaling** observations from plot to landscape, region, biome
Challenges:

• **Extrapolation** requires many random representative samples

• **Change detection** requires standardization and transferability in space and time

• **Extraction of ecological relevant parameters** from images

• **Comparability** of parameters across remote sensing products
Thanks

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Foto: Normand-Treier
Tak!