The role of biotic and abiotic factors on treeline ecotone dynamics:

studies using field observations and remote sensing

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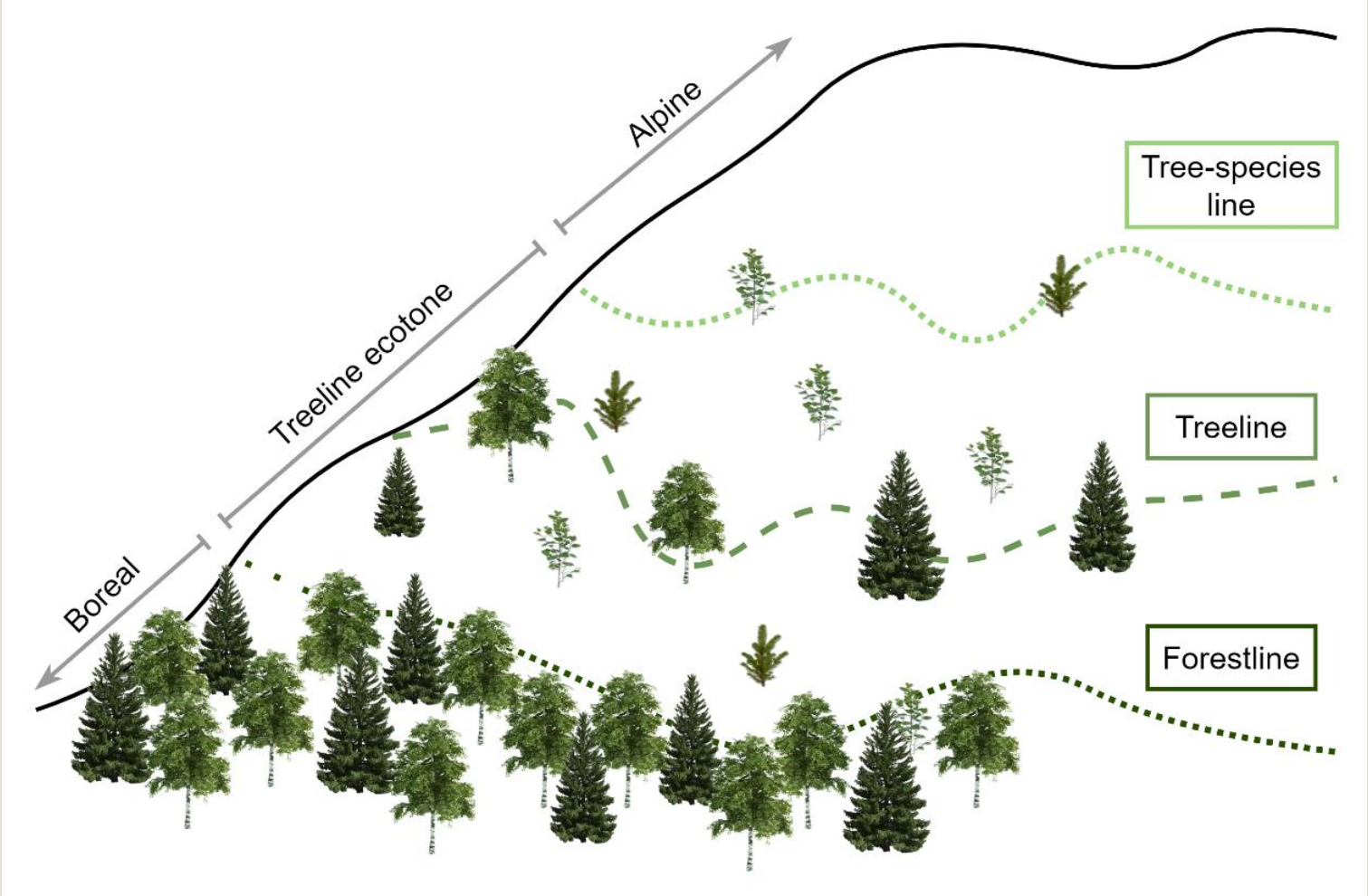
November 24th 2022

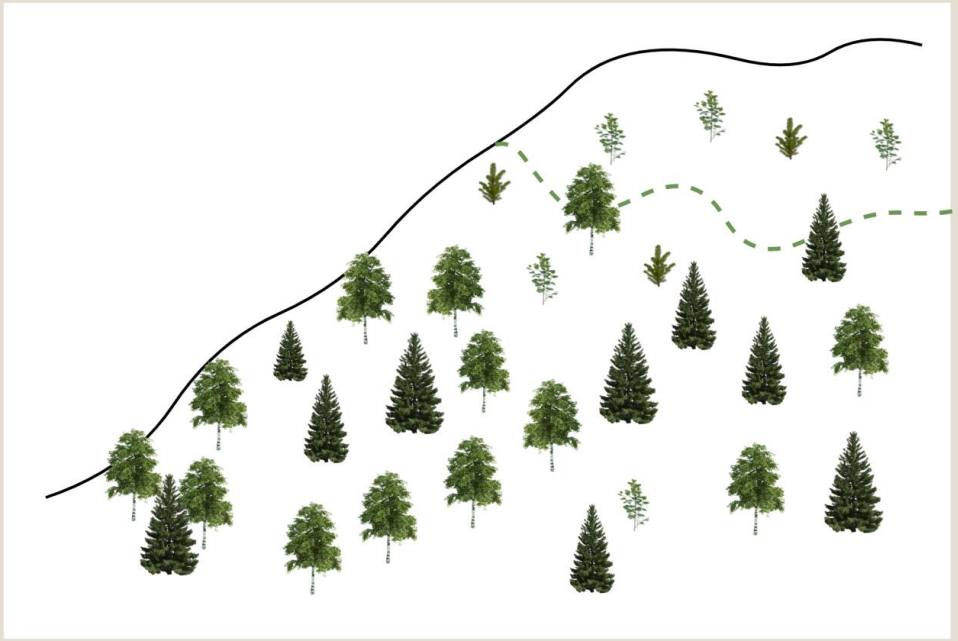
Outline

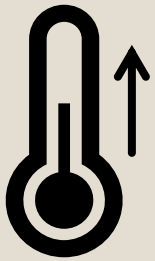
- Background
- Research objectives
- Papers (I-IV)
- Results
- Conclusion
- Future perspectives

What is a treeline ecotone?

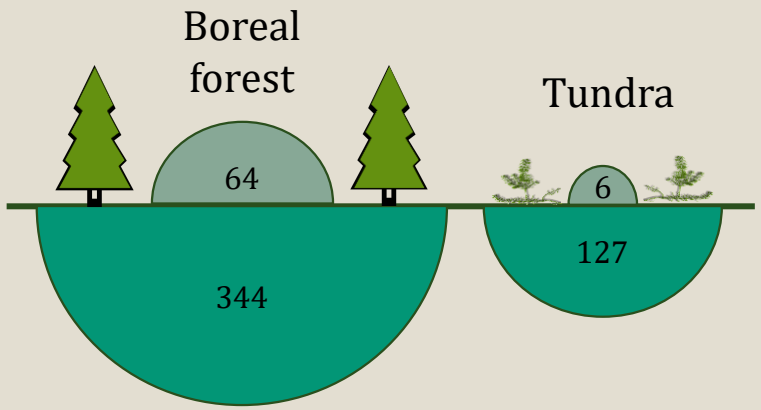


Trees > 2m

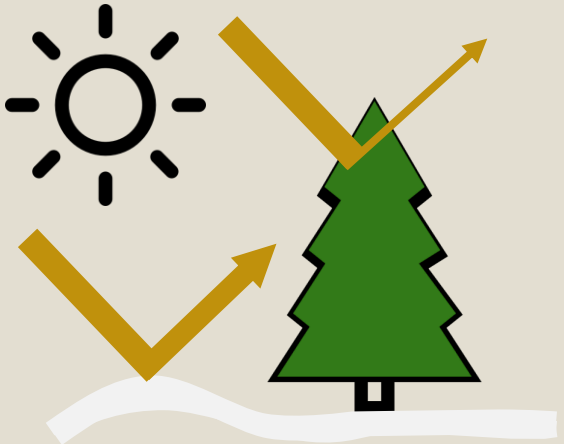




Temperature

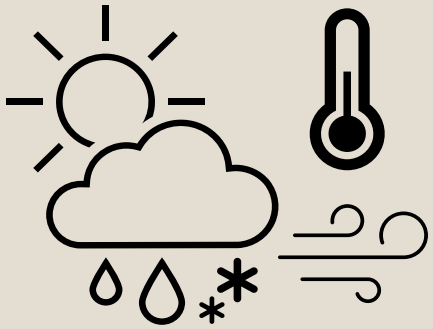


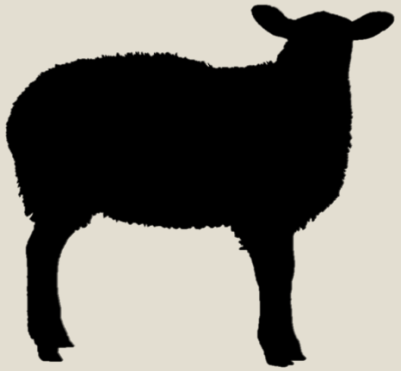
Carbon storage (tonnes per hectare)
Source: IPCC

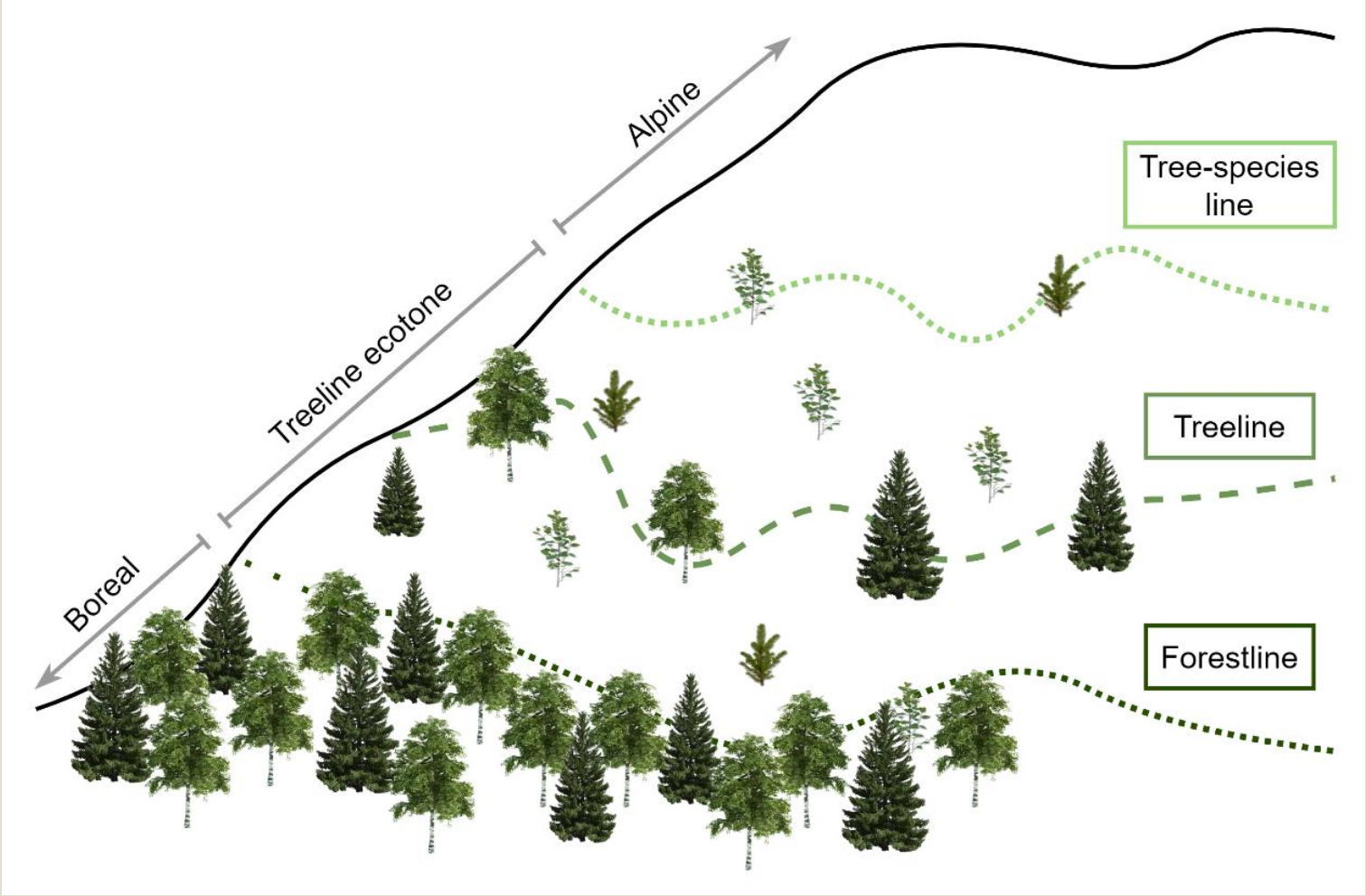


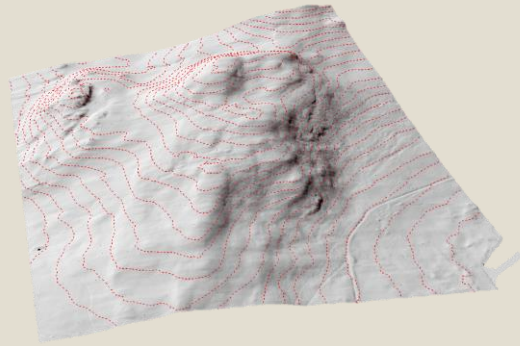
Albedo

What affects the treeline ecotone?

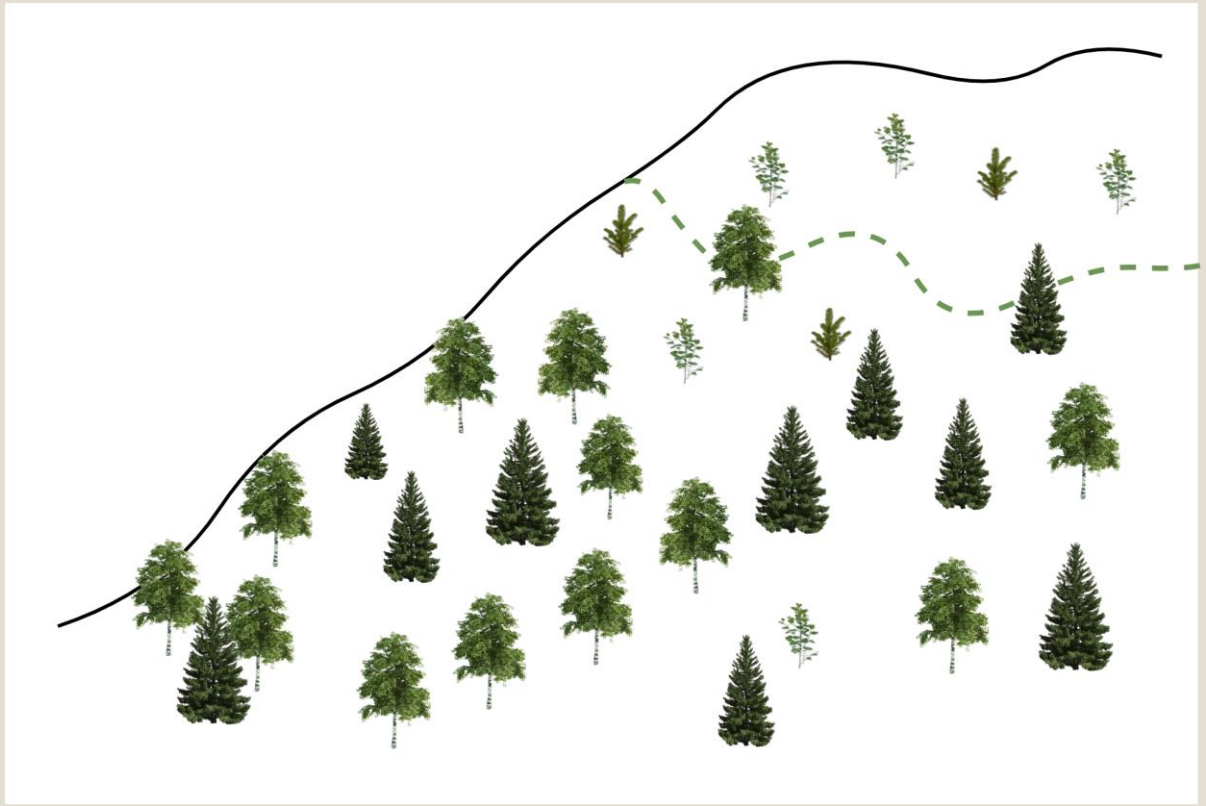






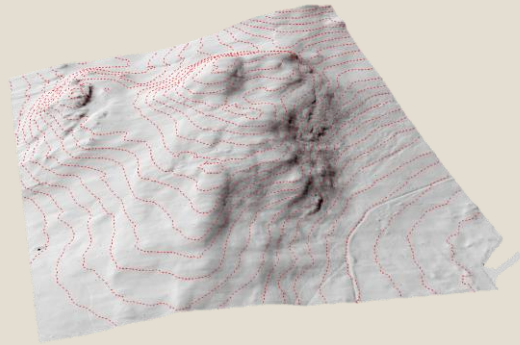


Climate

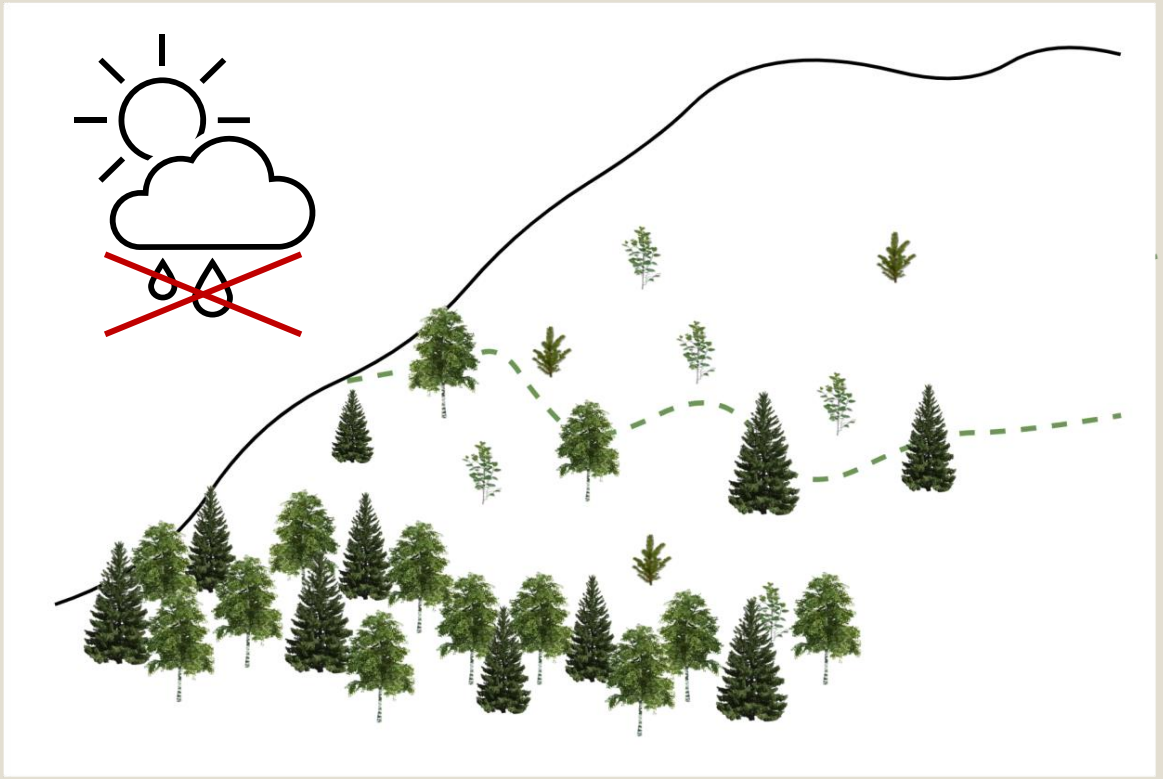


Herbivory

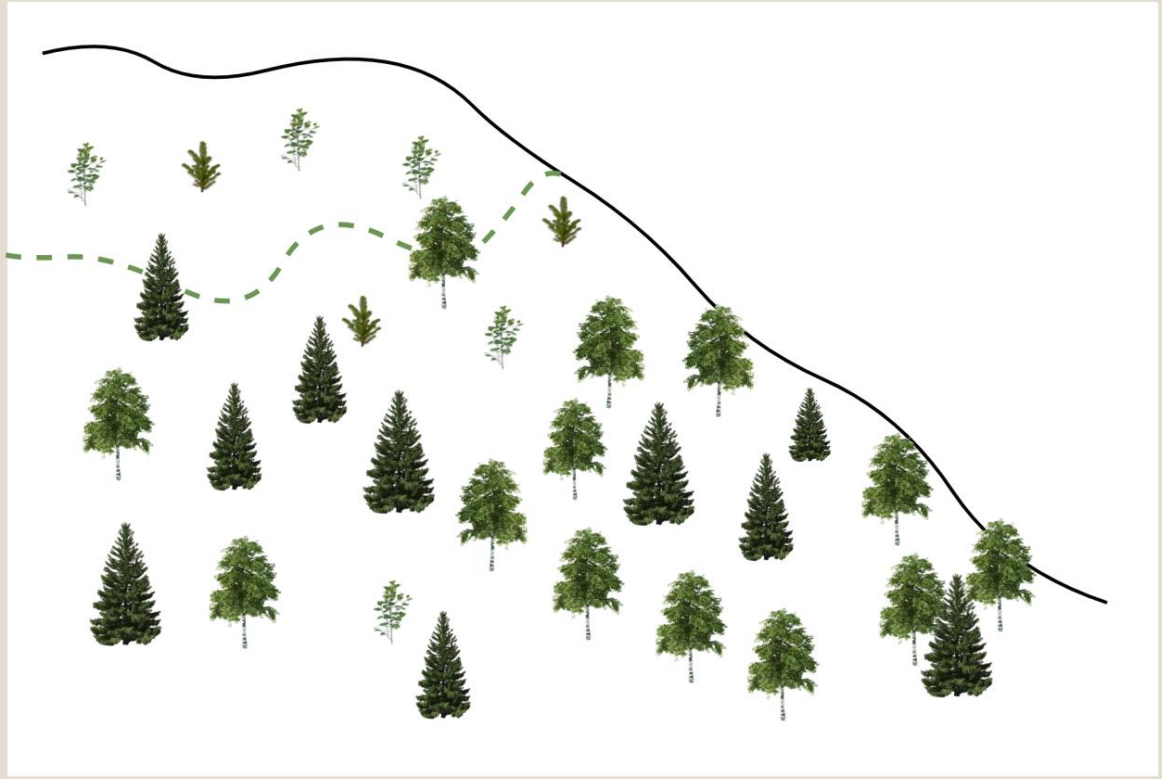
Topography



South-facing

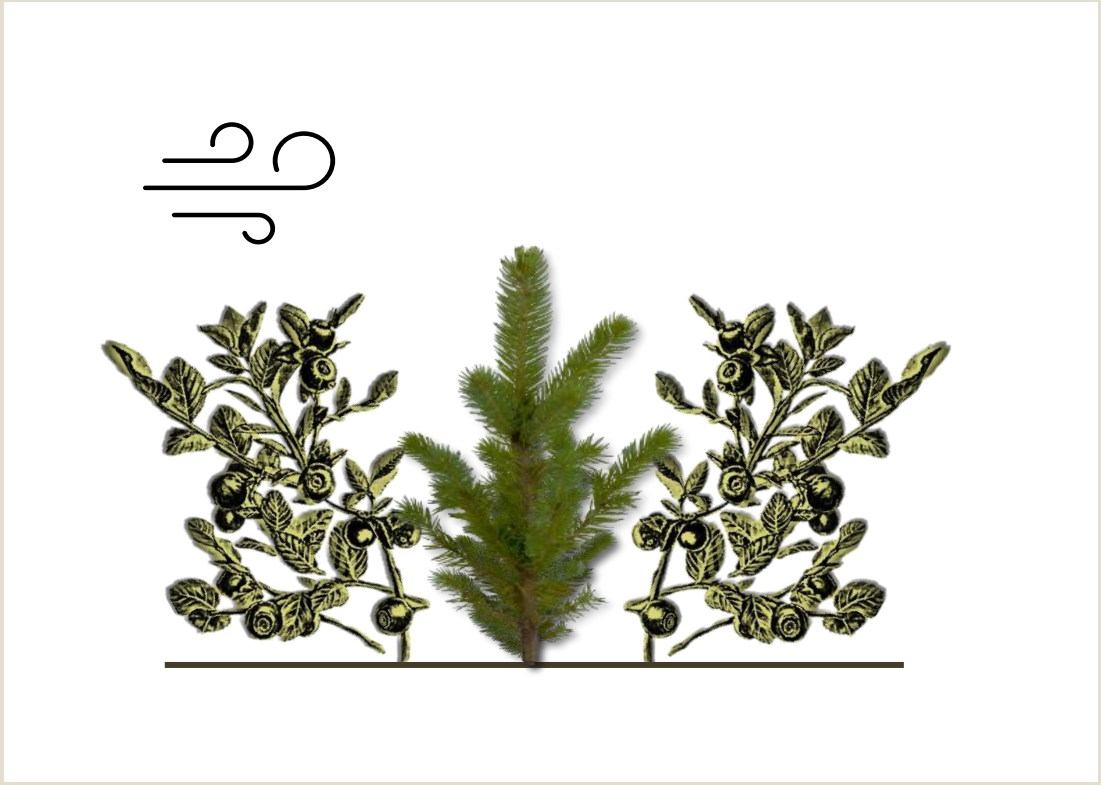


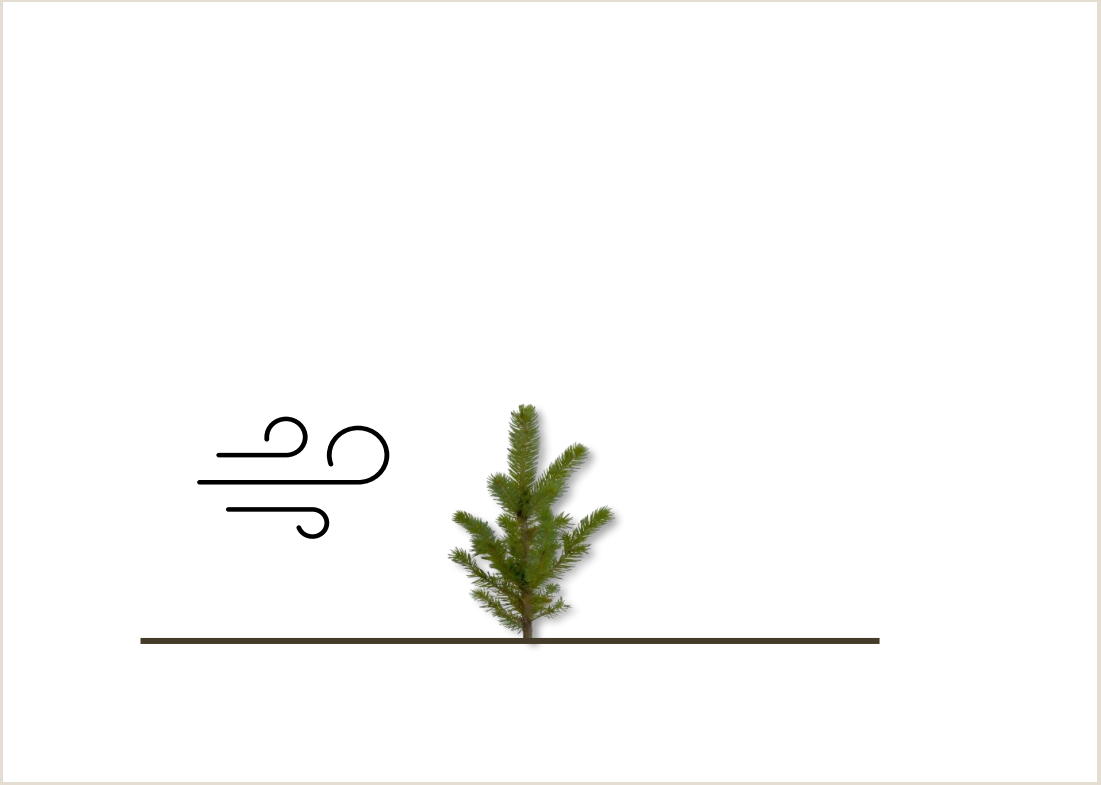
North-facing



Vegetation

Facilitation



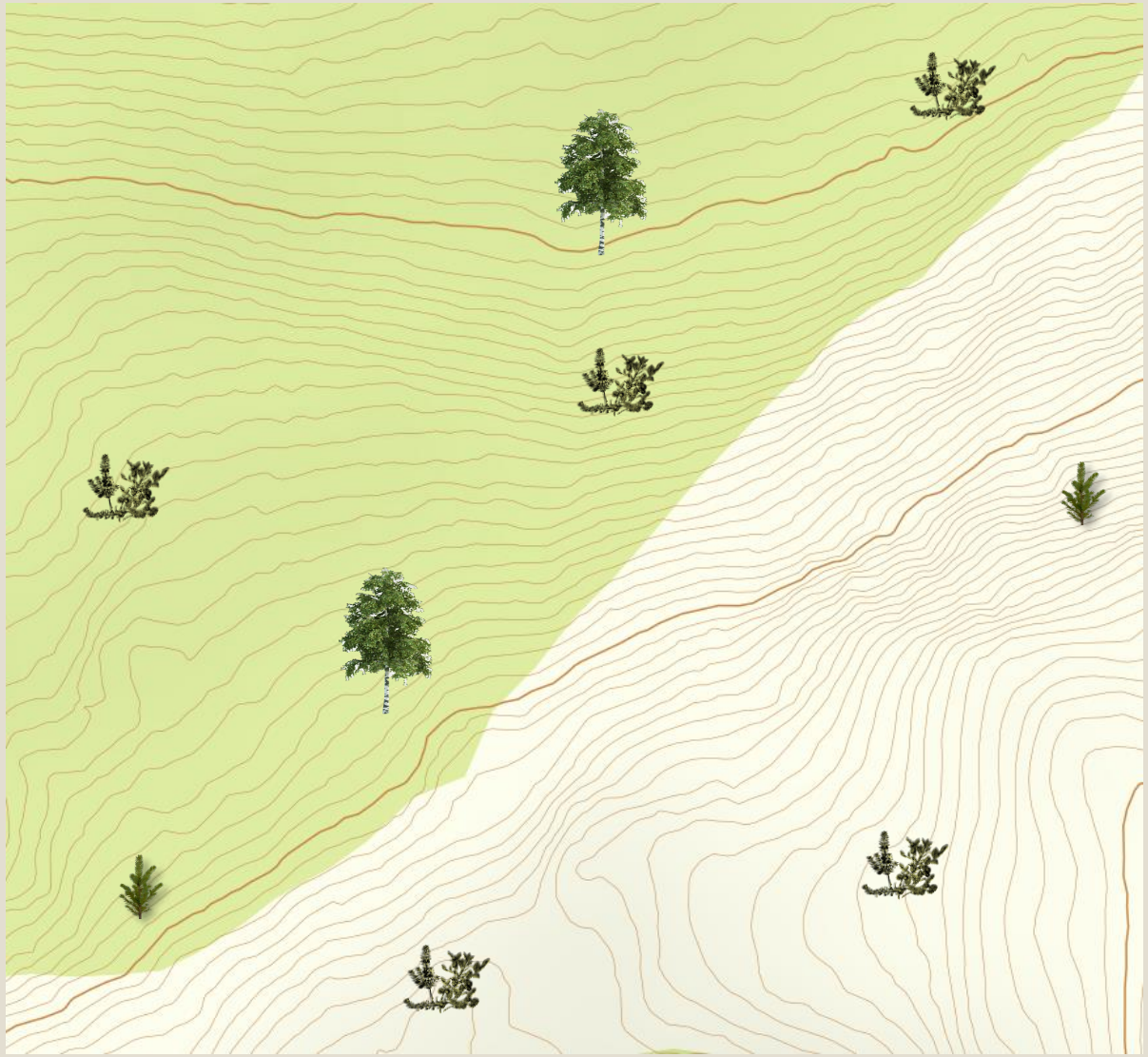


Vegetation

Competition

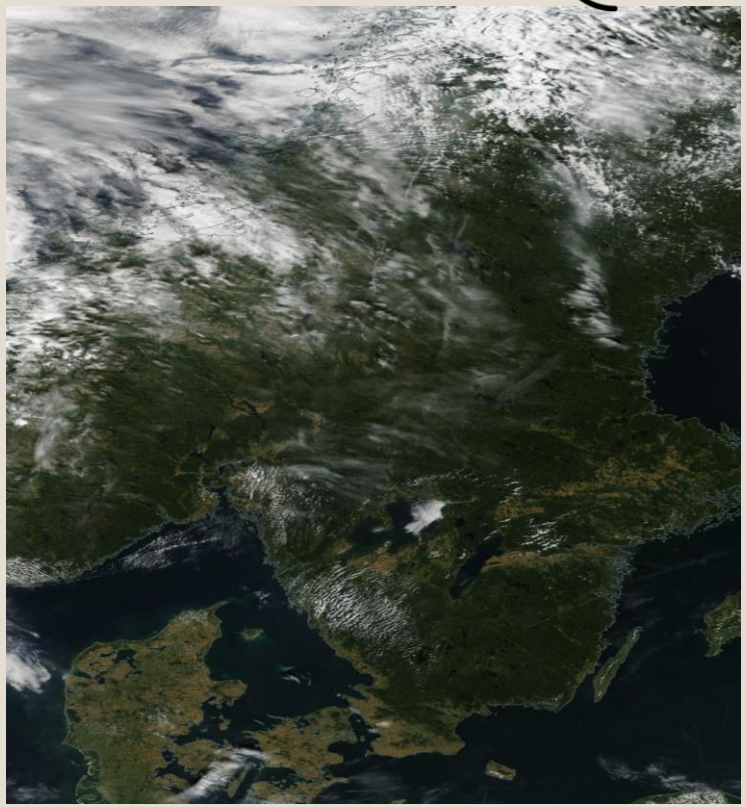
Many treeline studies focus on few factors at a time

How to get full coverage of relevant variables?

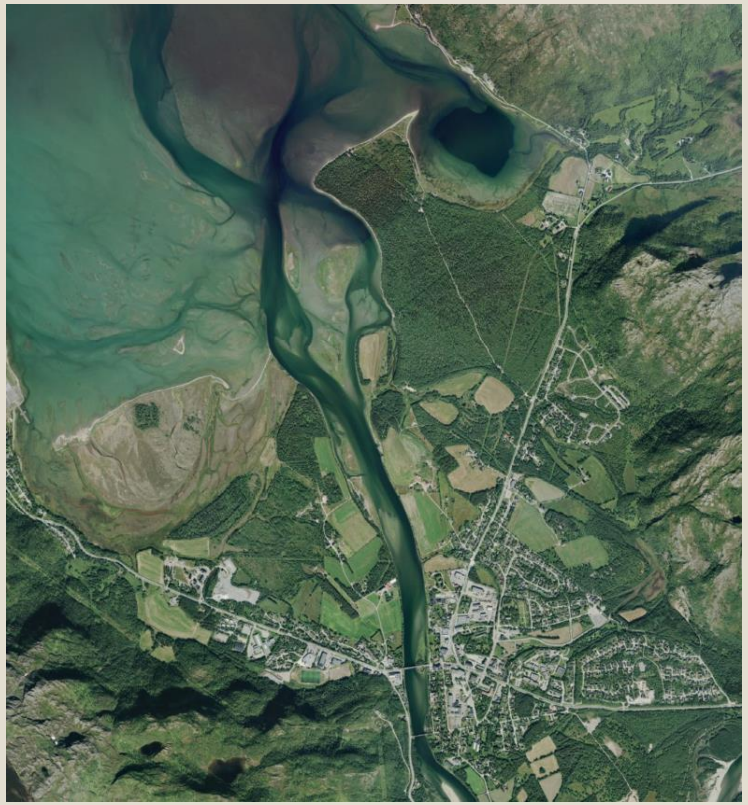


Remote sensing

Satellite

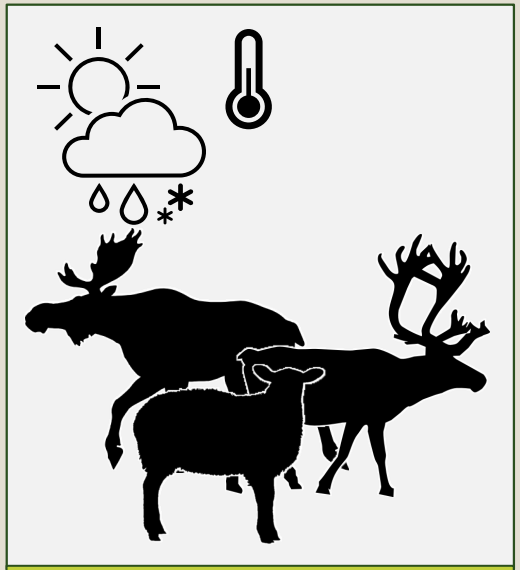


Aircraft

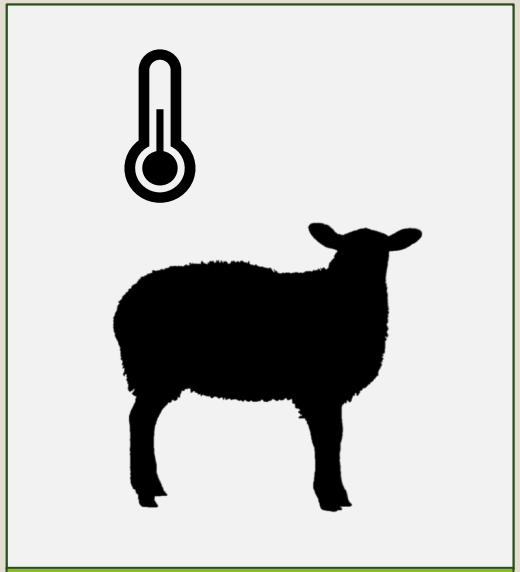


Drones

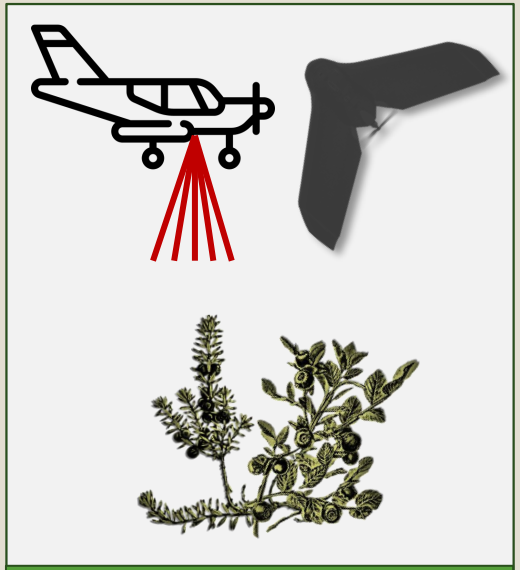
Main objective:
investigate the relative role of climate, herbivory, topography, and vegetation on treeline ecotone dynamics



Paper I



Paper II



Paper III

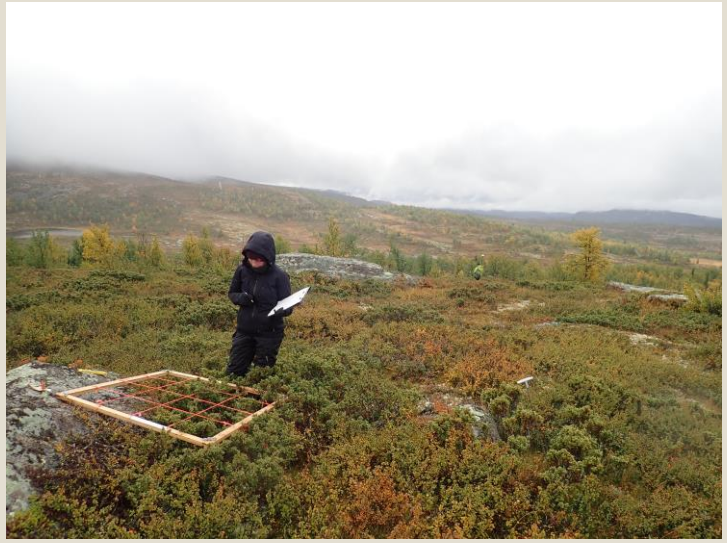
Paper IV

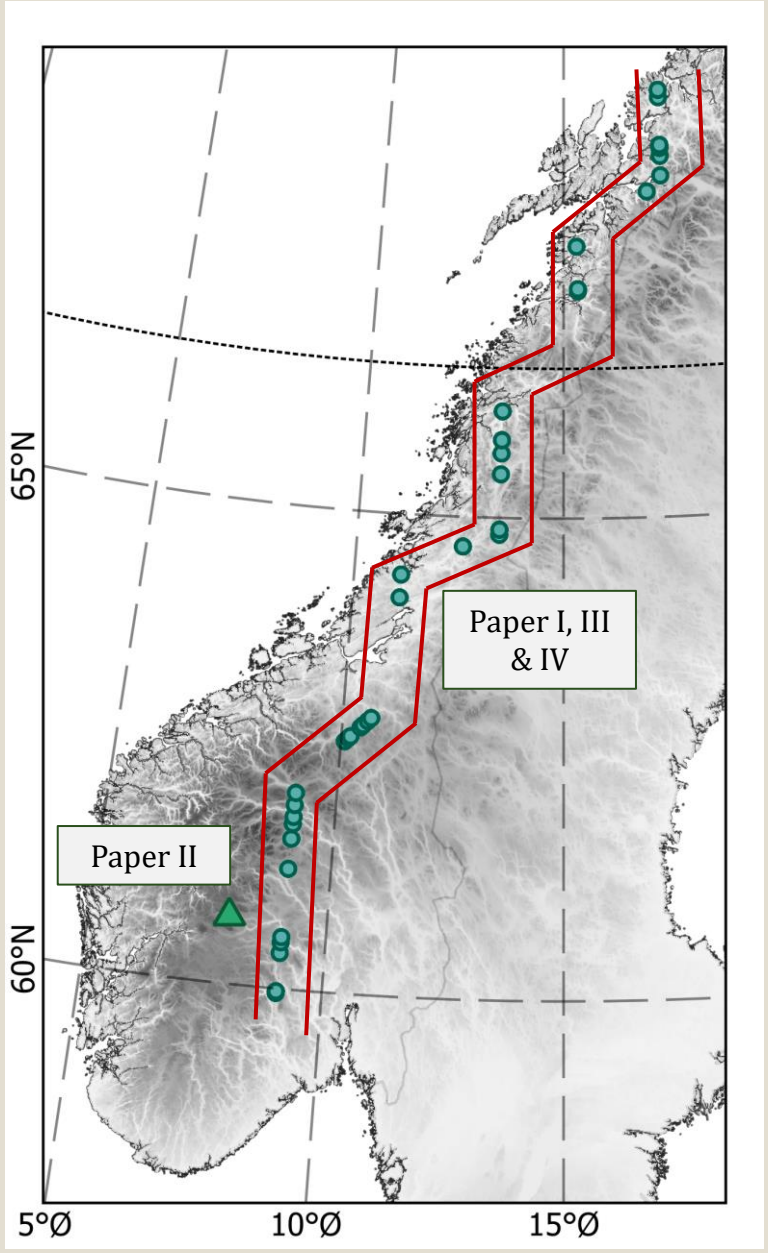
Paper I, III & IV:

- Data collected along latitudinal transect in 2008, 2012, and 2018

Paper II:

- Data collected at experimental site in 2009, 2010, and 2019



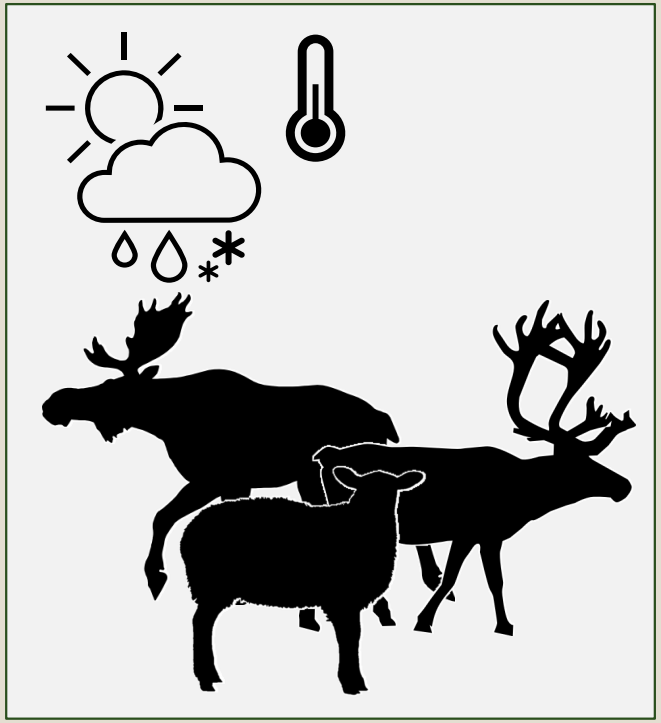


The relative role of climate and herbivory in driving treeline dynamics along a latitudinal gradient

Mienna, I.M., Speed, J.D.M., Klanderud, K., Austrheim, G., Næsset, E. & Bollandsås, O.M.

Journal of Vegetation Science, 2020

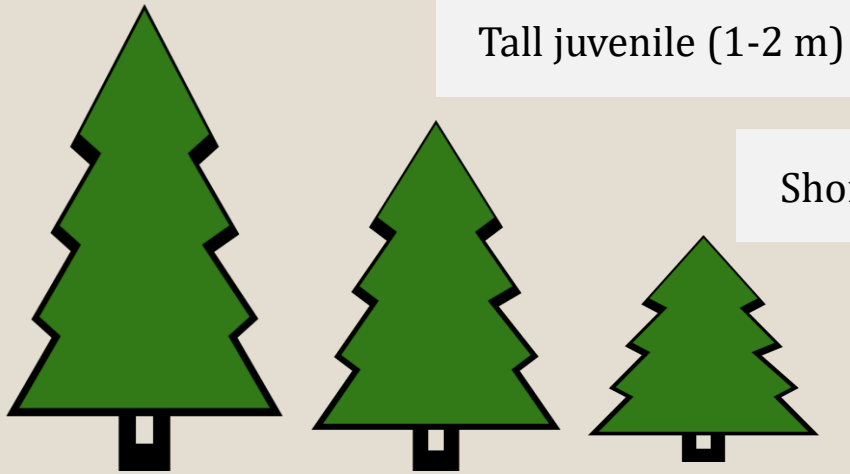
Aim: investigate relative importance of climate and herbivory on trees



Mature tree (>2 m)

Tall juvenile (1-2 m)

Short juvenile (<1 m)



Tree performance

Change in number of trees

Change in tree height

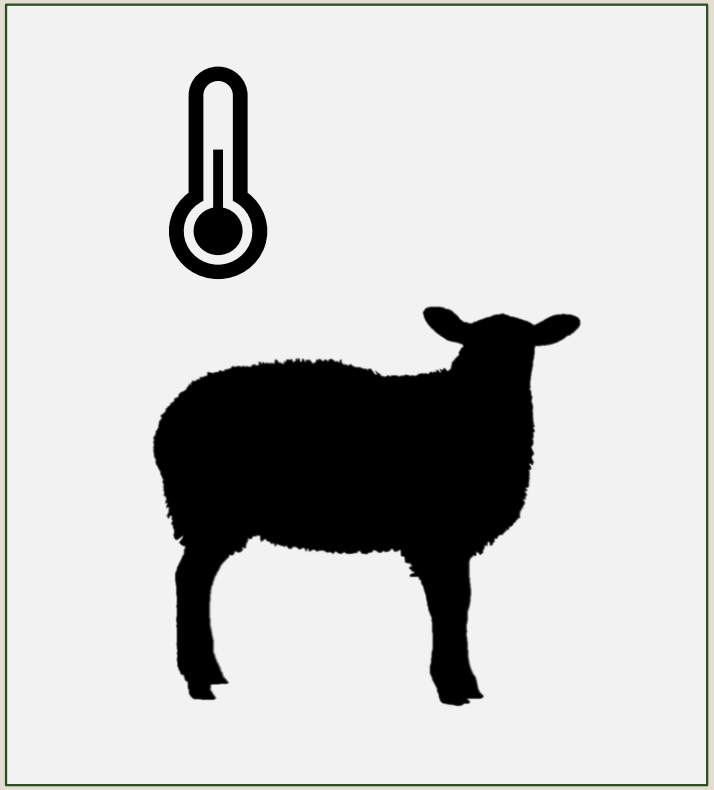
Mortality

Legacy effects of herbivory on treeline dynamics along an elevational gradient

Mienna, I. M., Austrheim, G., Klanderud, K., Bollandsås, O. M. & Speed, J. D. M.

Oecologia, 2022

Aim: quantify effects of sheep browsing on trees




Elevational gradient


Elevational gradient

Change in browsing pressure

Change in birch prevalence

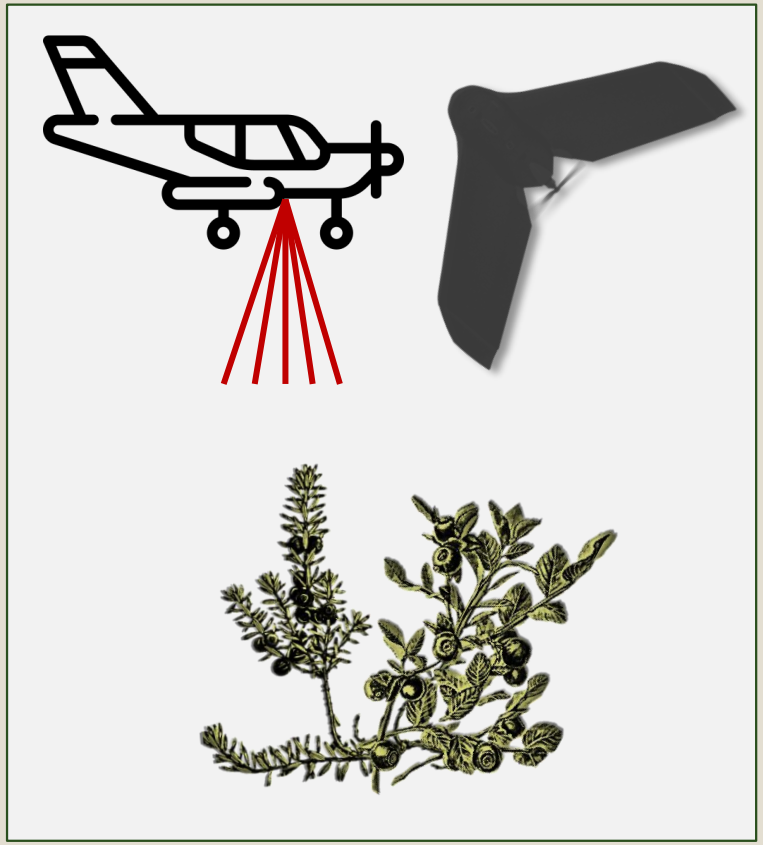
Change in birch annual radial growth

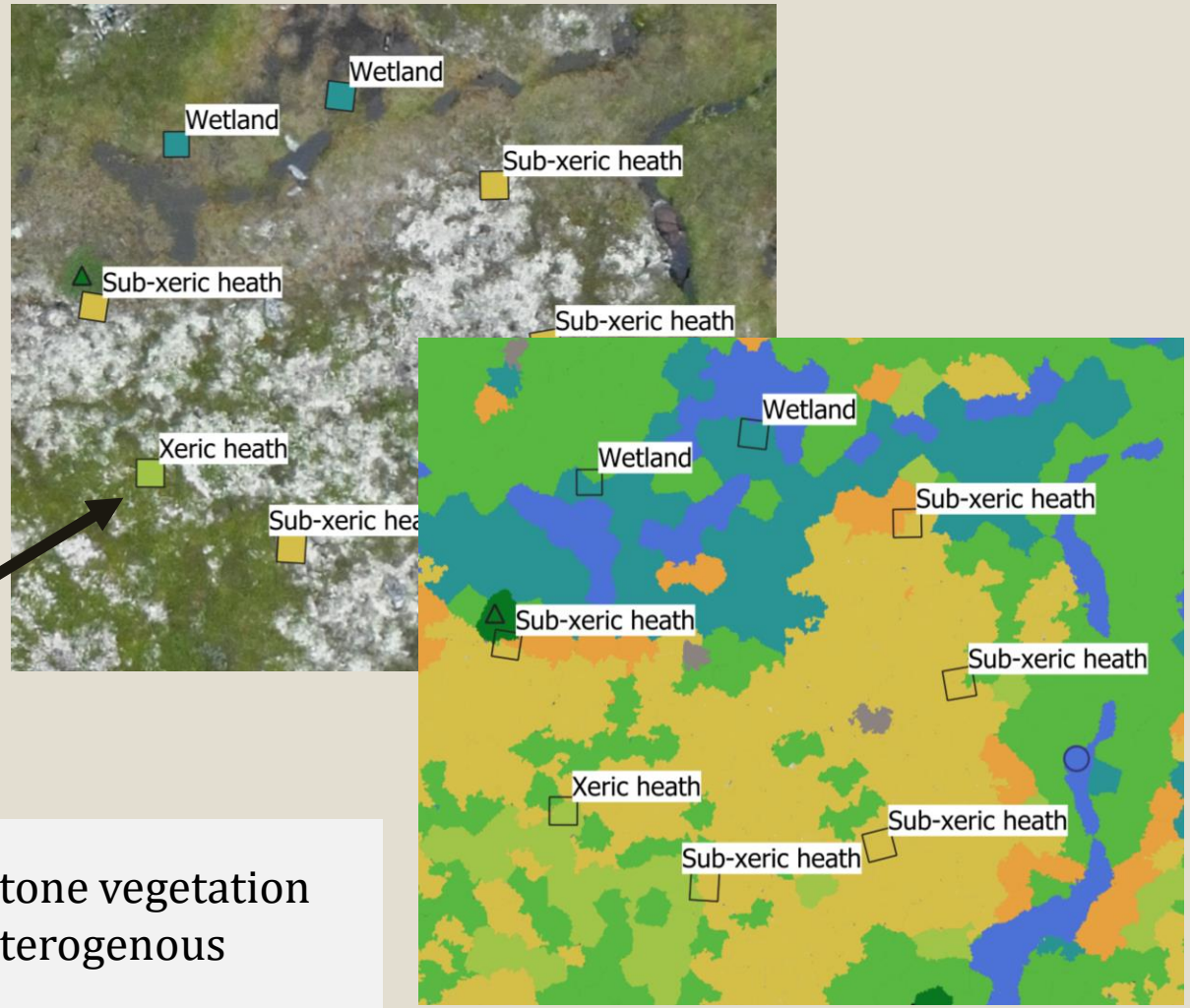
Land cover classification of treeline ecotones along a 1100 km latitudinal transect using spectral- and three-dimensional information from UAV-based aerial imagery

Mienna, I. M., Klanderud, K., Ørka, H.O., Bryn, A., & Bollandsås, O. M.

Remote Sensing in Ecology and Conservation, 2022

Aim: make accurate land cover maps that can be used in Paper IV

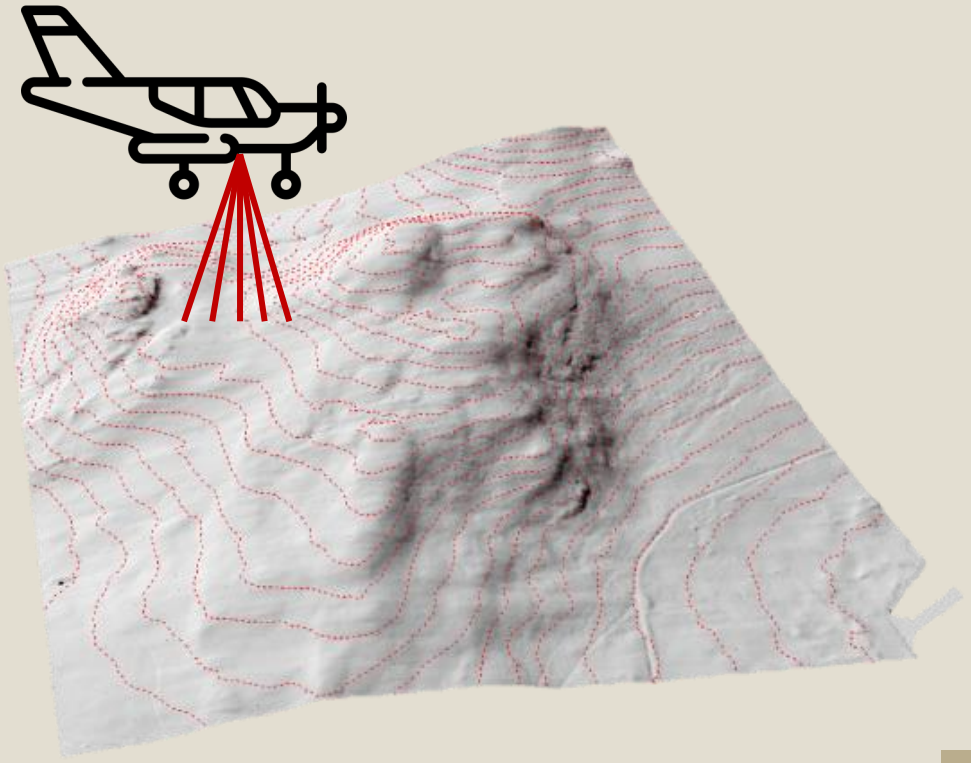




The treeline ecotone vegetation can be highly heterogenous

Drones
(unmanned aerial vehicles, UAVs)

Airborne laser scanning
(ALS)



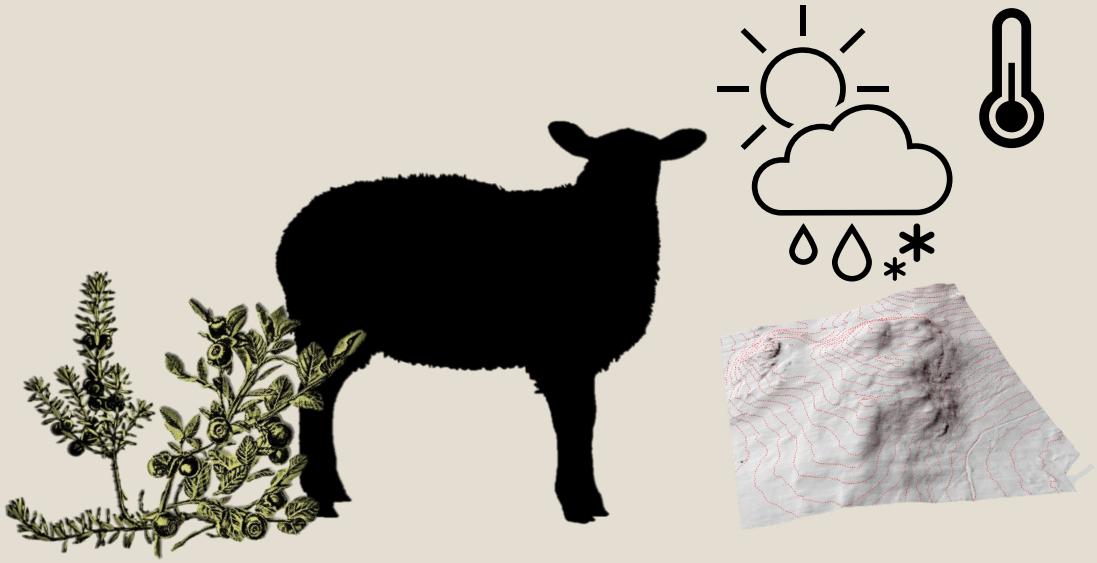
Quantifying the roles of climate, herbivory, topography, and vegetation on tree establishment in the treeline ecotone

Mienna, I. M., Klanderud, K., Næsset, E., Gobakken, T., & Bollandsås, O. M.

Manuscript.

Aim: quantify the roles of climate, herbivory, topography, and vegetation on trees to predict tree establishment

A tree does not necessarily survive and grow to become a mature tree (>2 m) where it is recruited



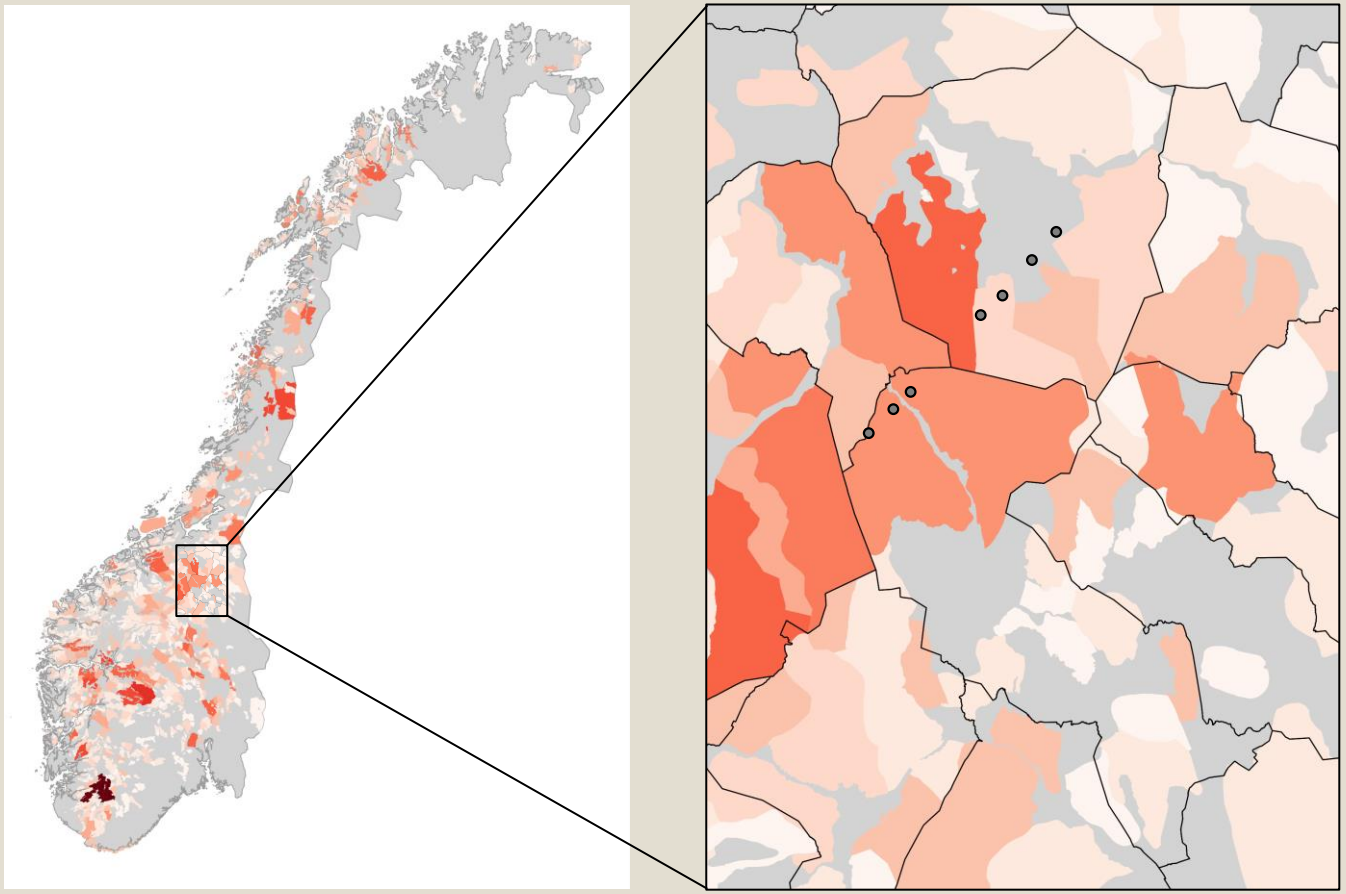
Tree establishment

Tree occurrence | Tree survival | Tree growth

Livestock density

Number of sheep, goats and cattle per year divided by area

Municipality

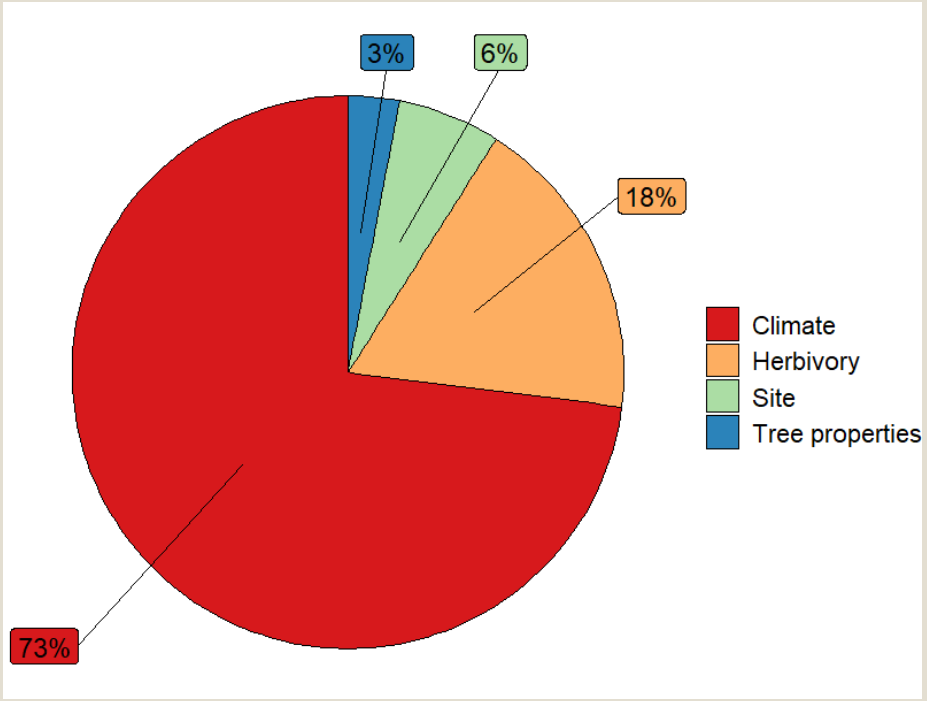


“Beitelagsområde”

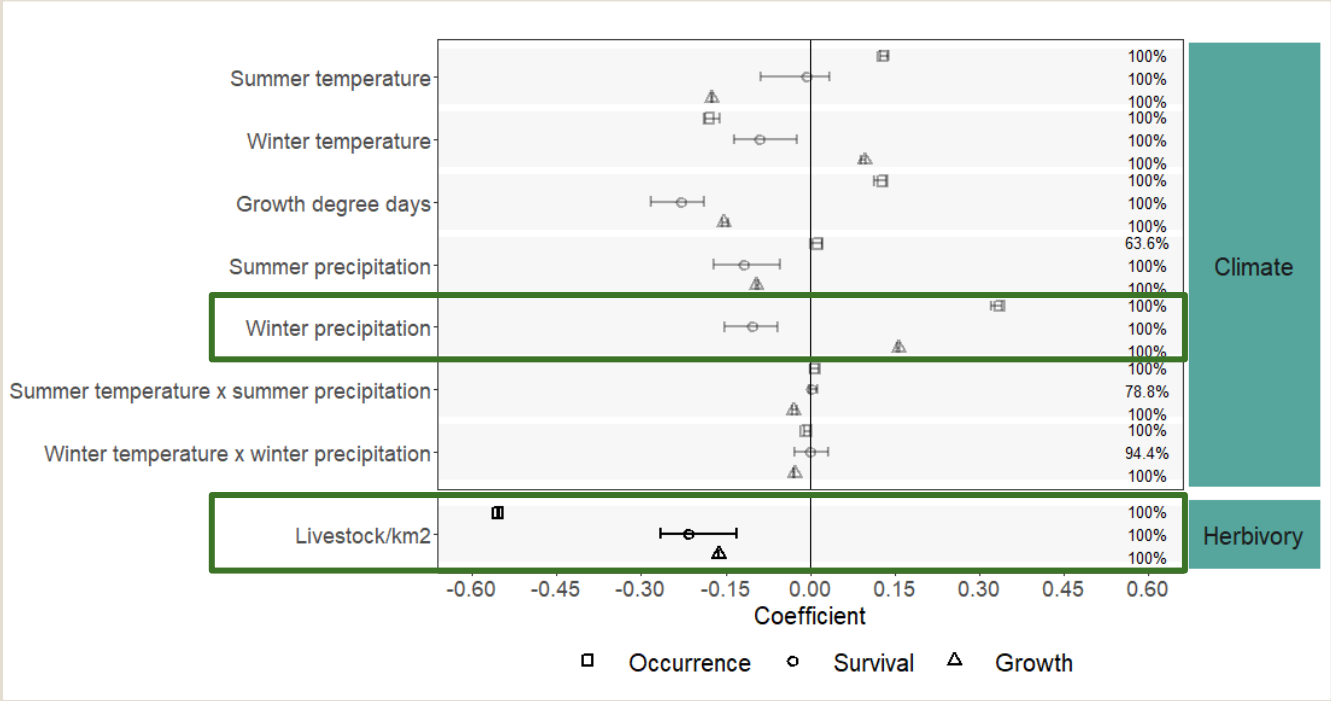
	Relative role of climate and herbivory	Remote sensing of topography and vegetation	Predicting treeline ecotone dynamics
Paper I	■		■
Paper II	■		■
Paper III		■	
Paper IV	■	■	■

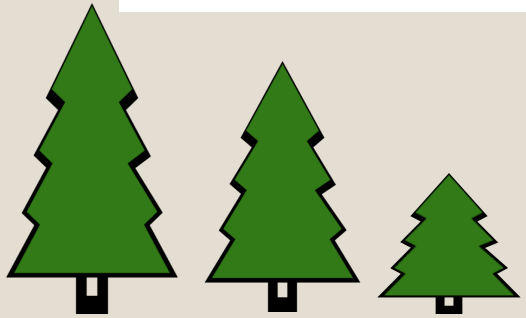
Stem number change

Paper I



Paper IV

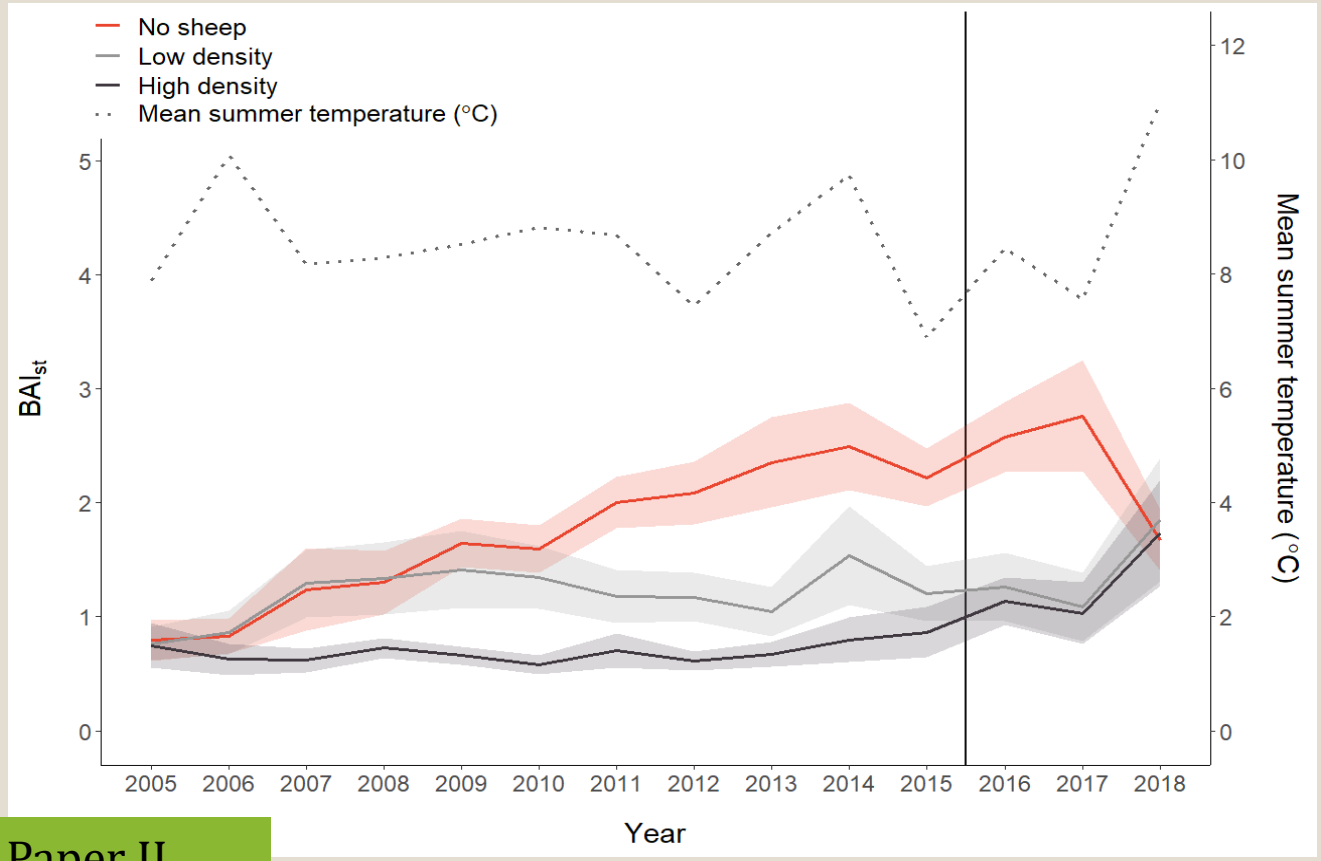




Paper I:
Summer temperature most important variable

Paper IV:
- Winter precipitation most important variable of the climate variables
- Livestock density overall most important

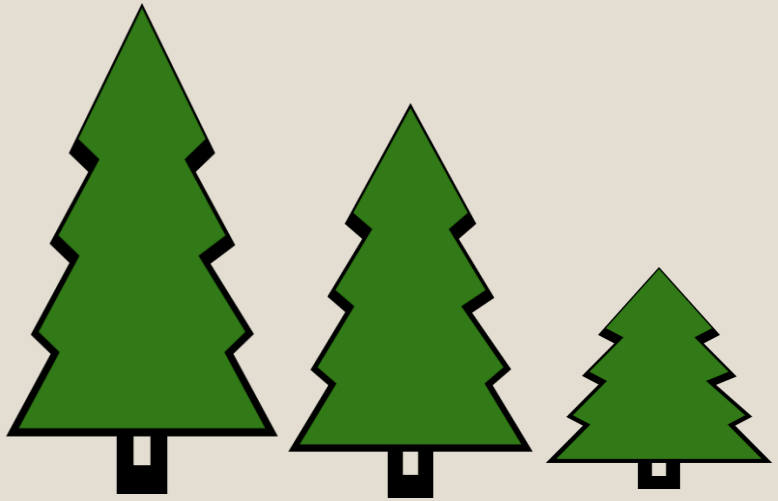
Temperature was mediated by herbivory

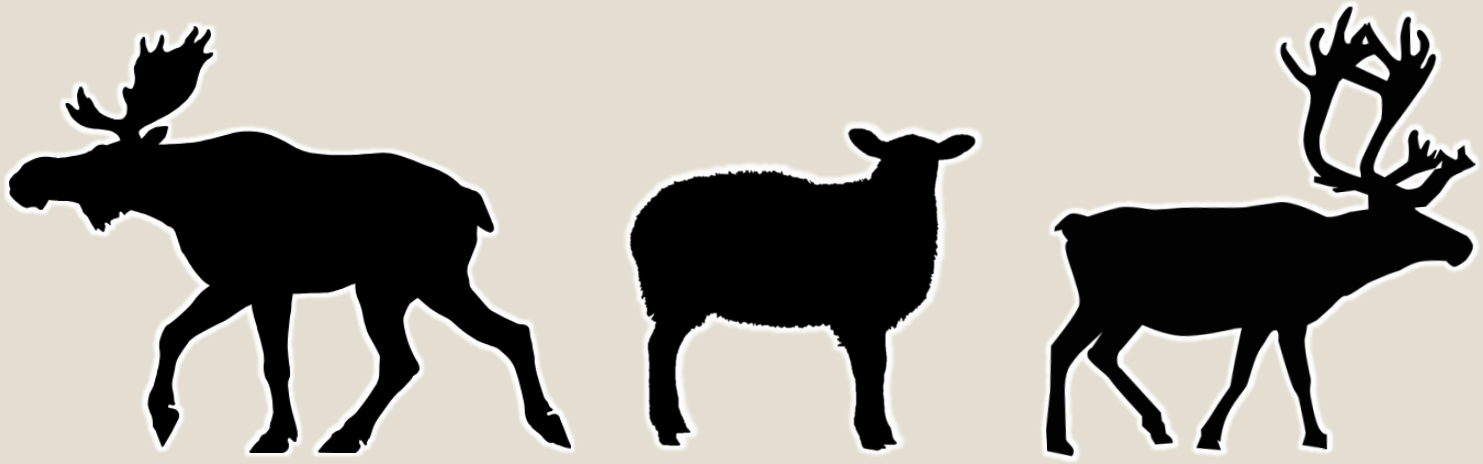


Paper II

Conclusion:

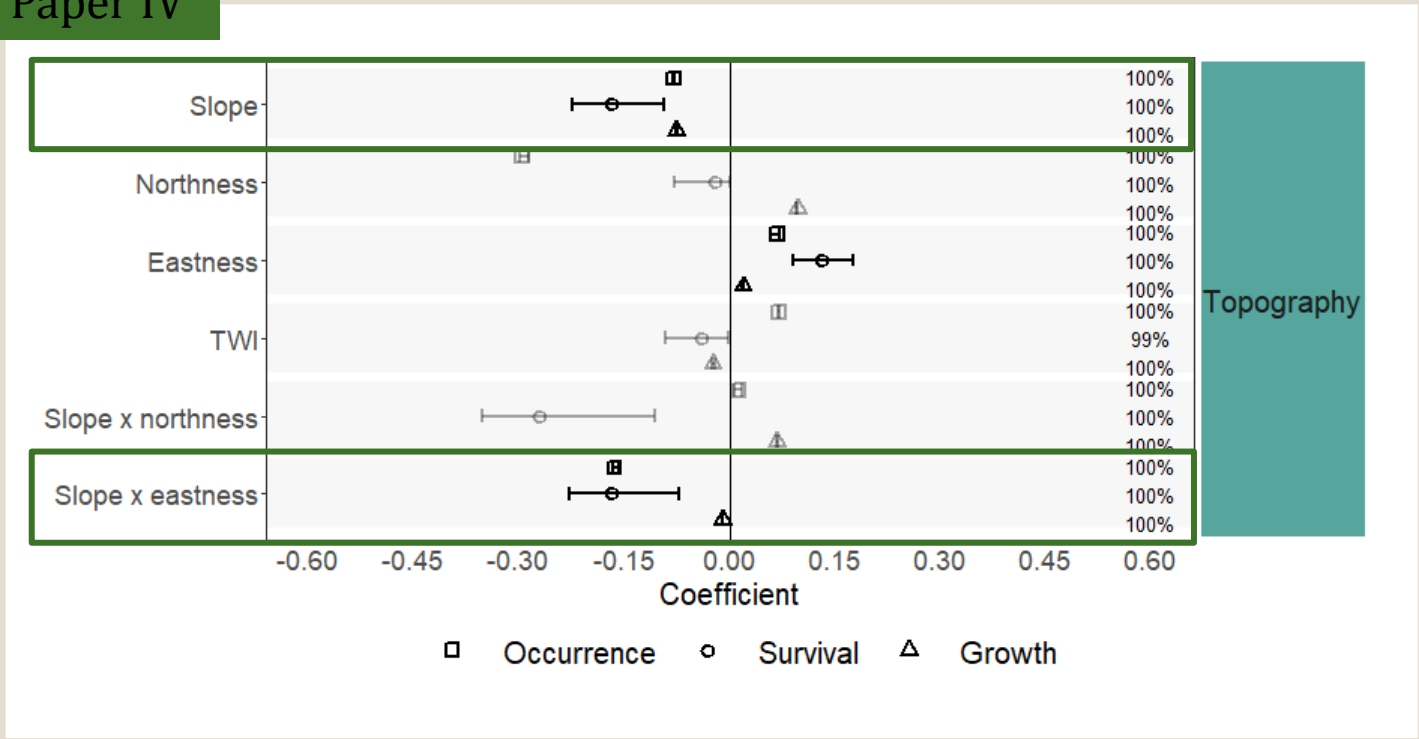
- The role of temperature and herbivory seem to depend on
  - the life stage class of the tree
  - possibly also the tree and herbivore species

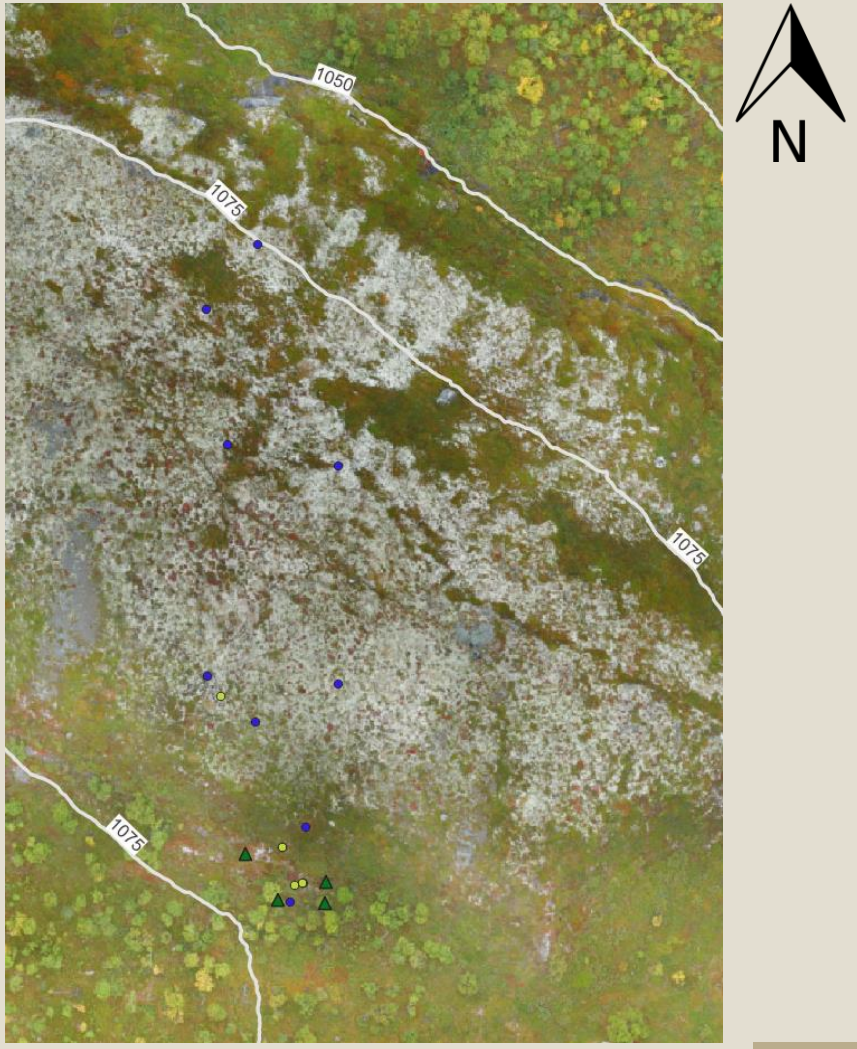




Topography

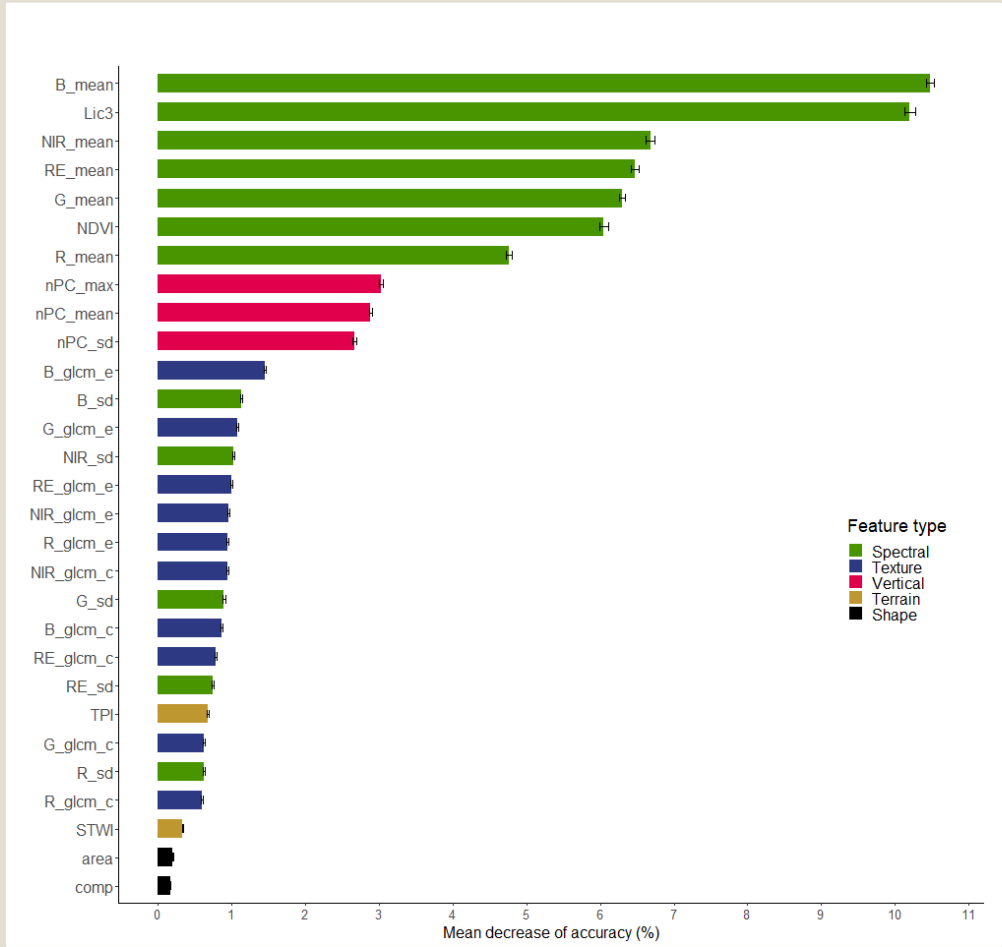
Paper IV

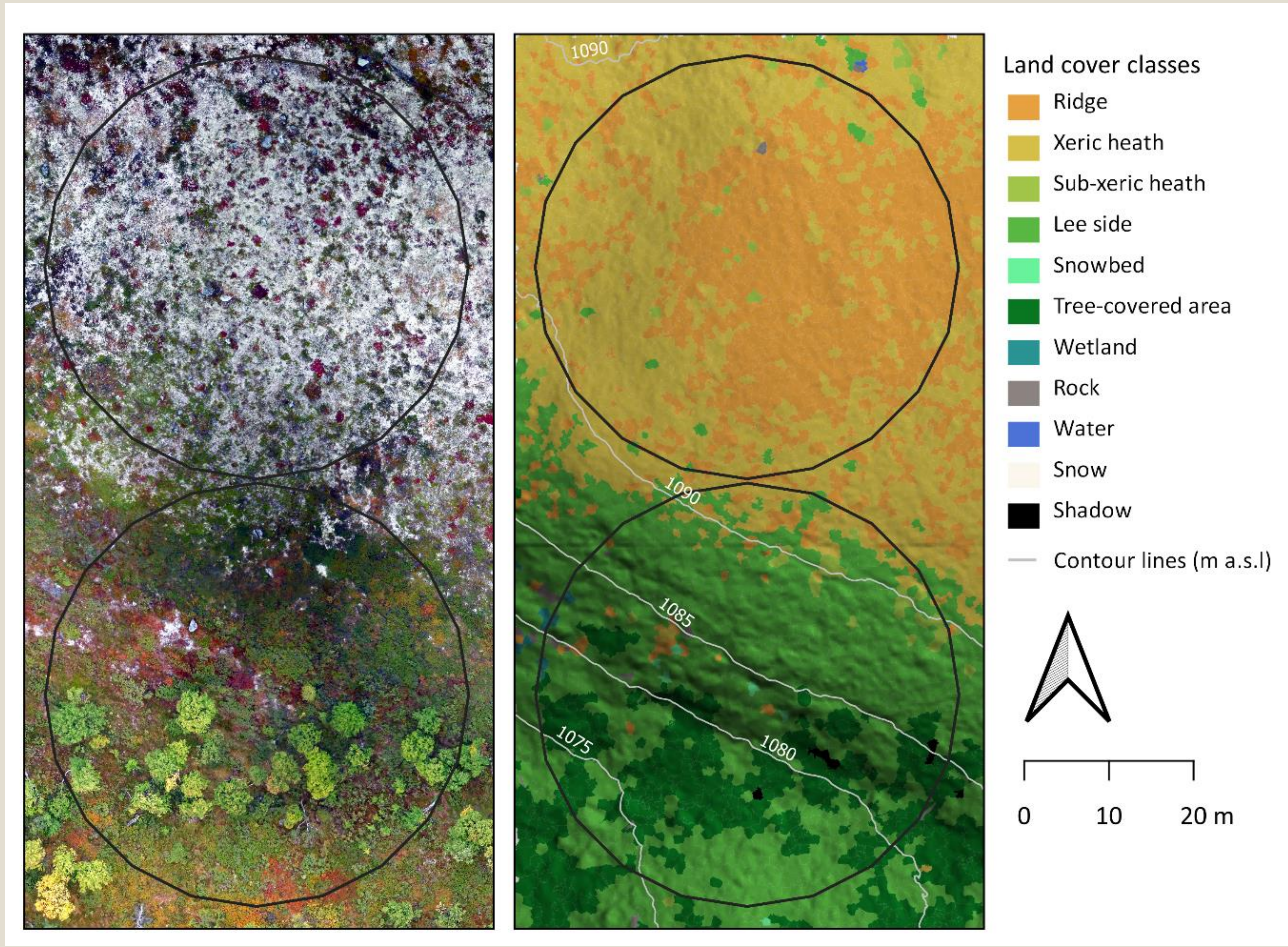




Vegetation

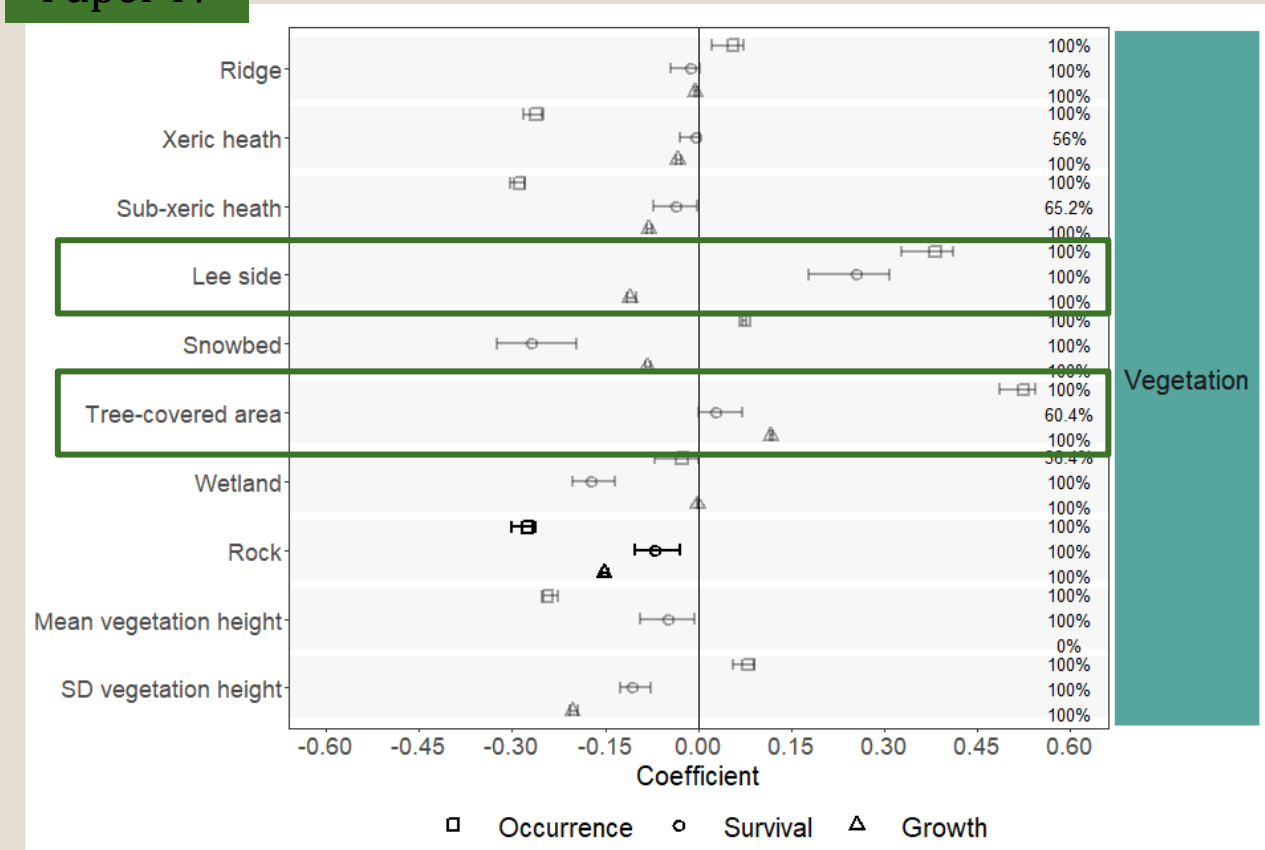
Paper III





Vegetation

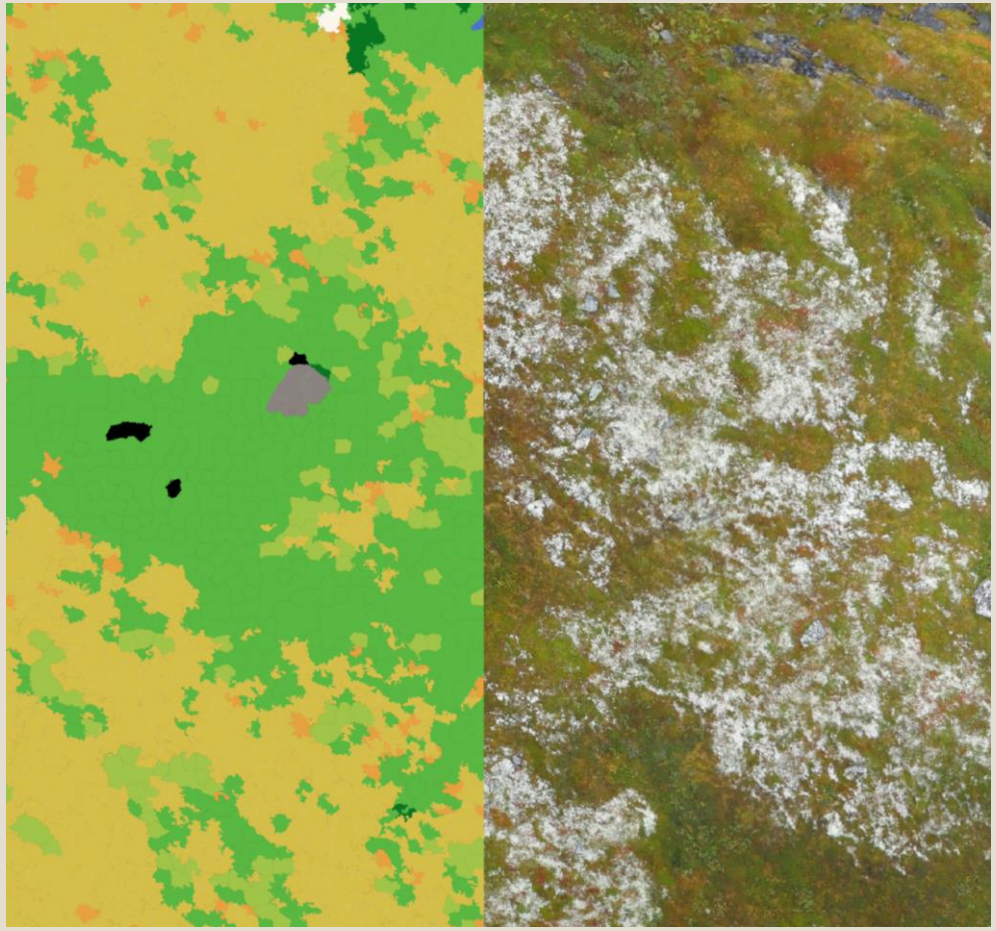
Paper IV



Paper IV: vegetation classes from the land cover maps were important for predicting tree establishment

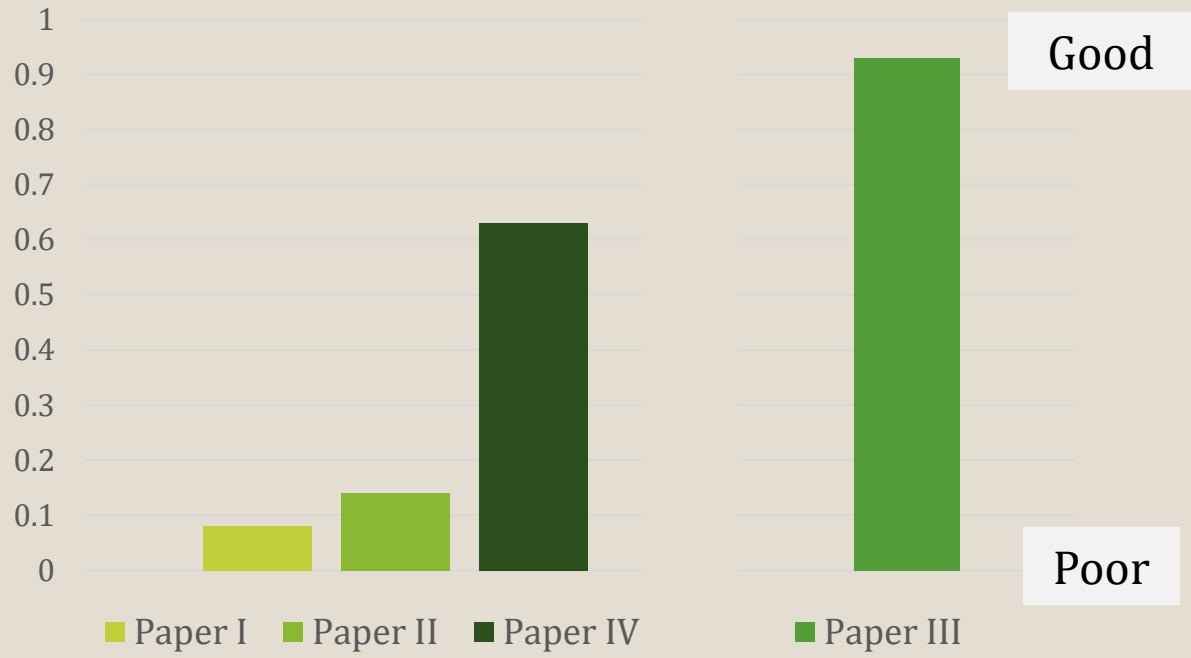
Conclusion:

- Remote sensing-derived topographic factors relevant for trees
- Remote sensing is useful for upscaling treeline ecotone vegetation



- Models for predicting treeline ecotone dynamics (Paper I, II & IV) had limited predictive performance
  - Much of the variation is unexplained
  - Context dependency
- Predicting where treelines move upwards in elevation will likely be more difficult with climate change

Examples of model performance

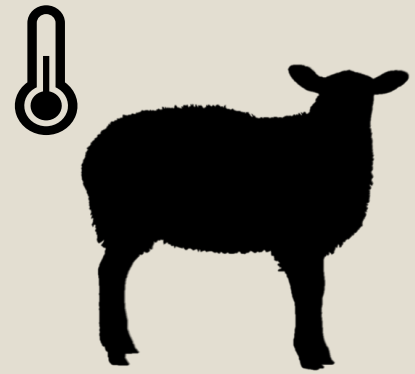


Paper I: change in number of trees
Paper II: tree prevalence
Paper IV: tree occurrence

Paper III: land cover classification

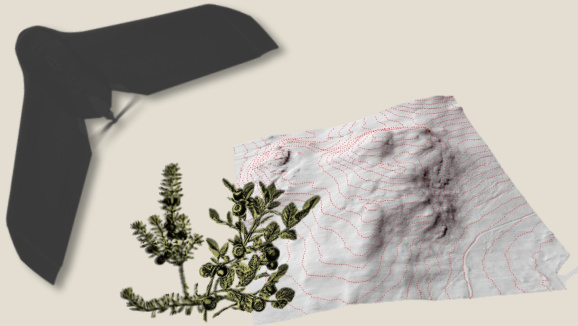
Relative role of temperature and herbivory

Tree life stage class, tree species and herbivore species important



Remote sensing of topography and vegetation

Both factors are important and remote sensing is useful to acquire information about these



Predicting treeline ecotone dynamics

High context dependency, which makes predicting complicated

- Include multiple factors to explain variations in treeline ecotones
- Temperature and precipitation important, not just temperature
  - Moisture availability through snow
- Predicting is challenging, but monitoring is still important

Thank you for your attention!