



Reindeer grazing influences vegetation structure and alters summer albedo

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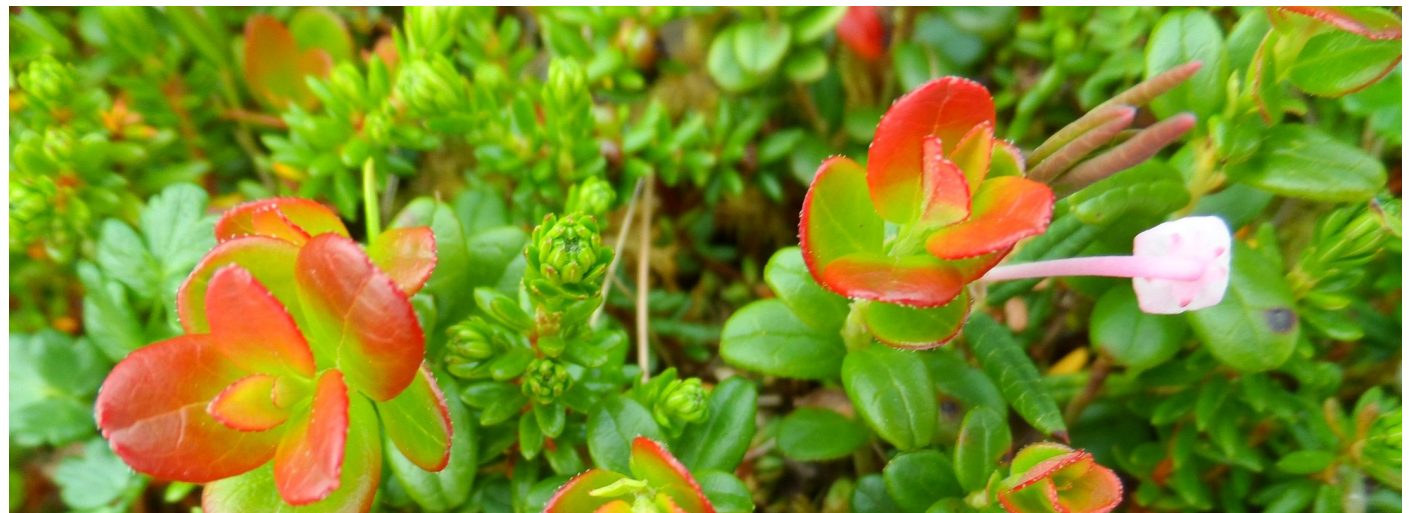
The Arctic vegetation is changing

- Northward shifting tree lines
- Northward range expansion alien species
- Increased shrub densities and height (shrubification)



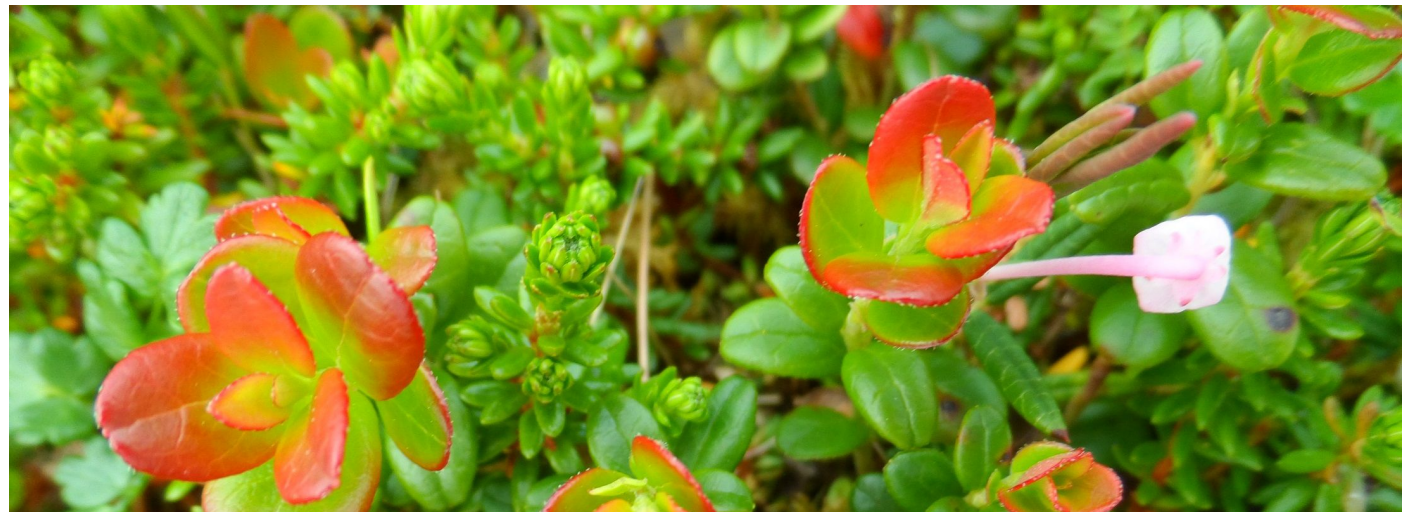
Consequences of shrub increase

- Surface energy exchange/albedo
- Soil temperatures
- Carbon balance
- Nutrient cycling
- Biodiversity (*e.g.* lichen and moss declines)

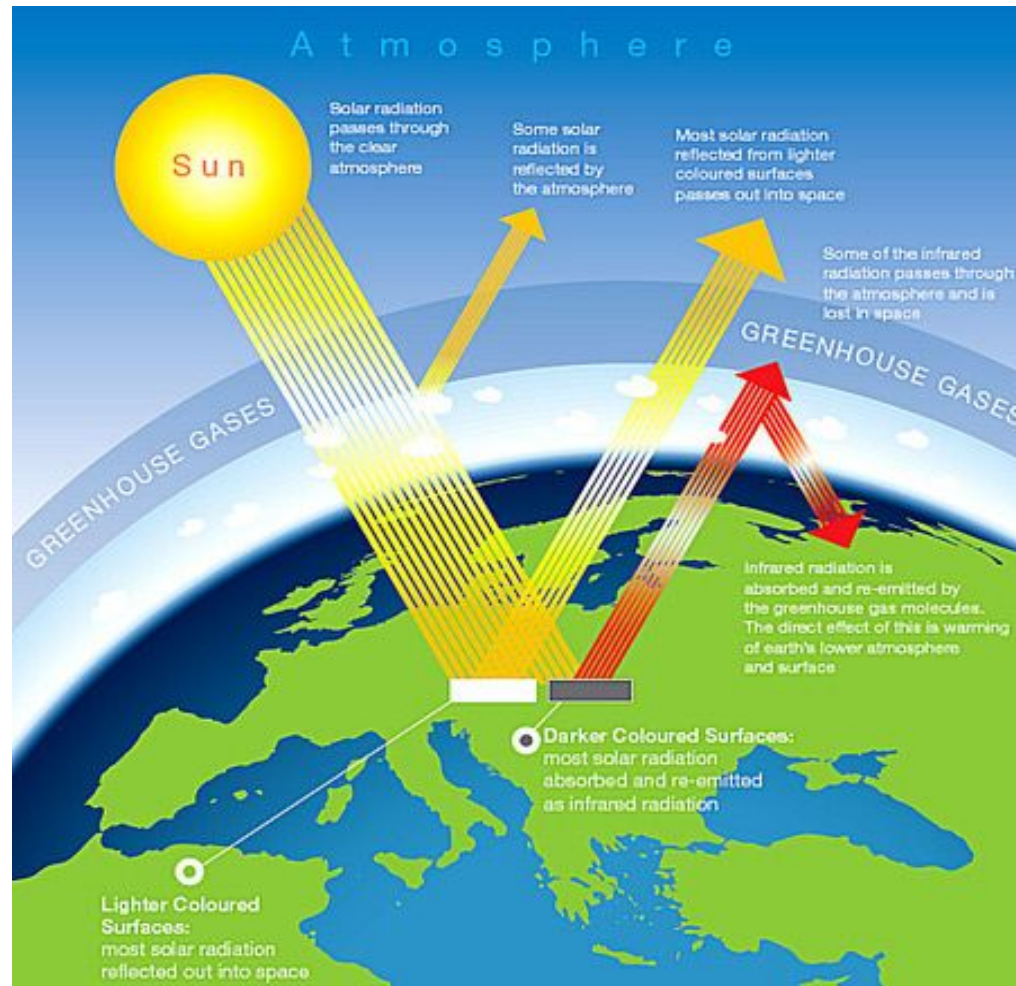


Consequences of shrub increase

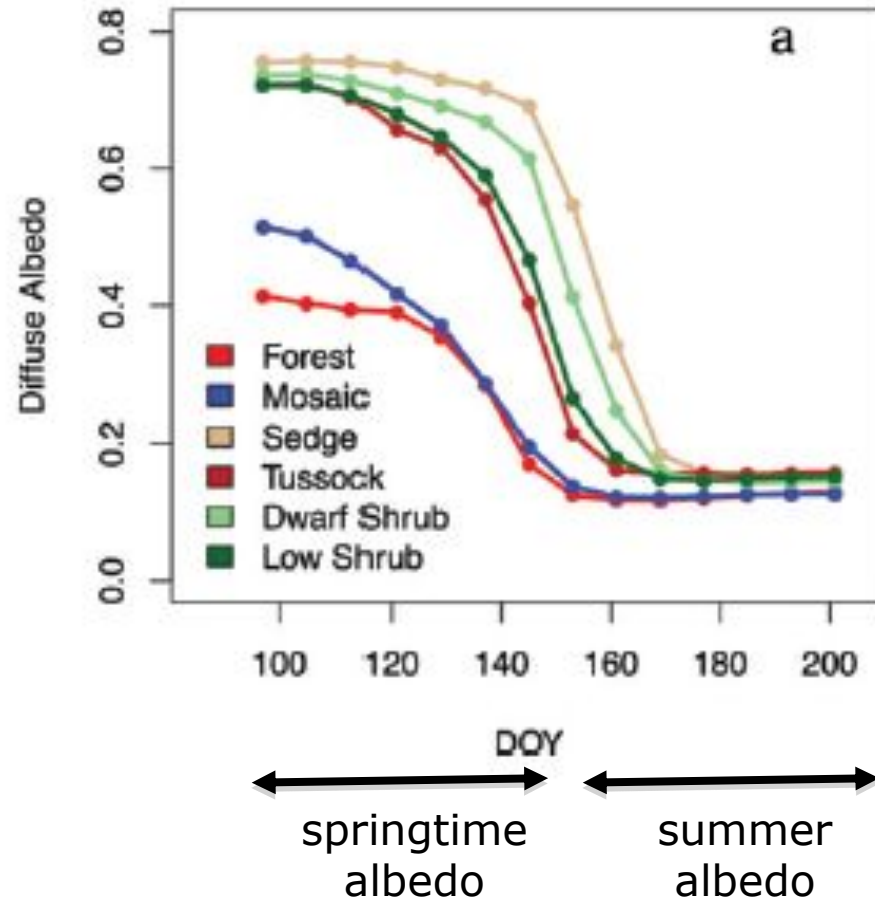
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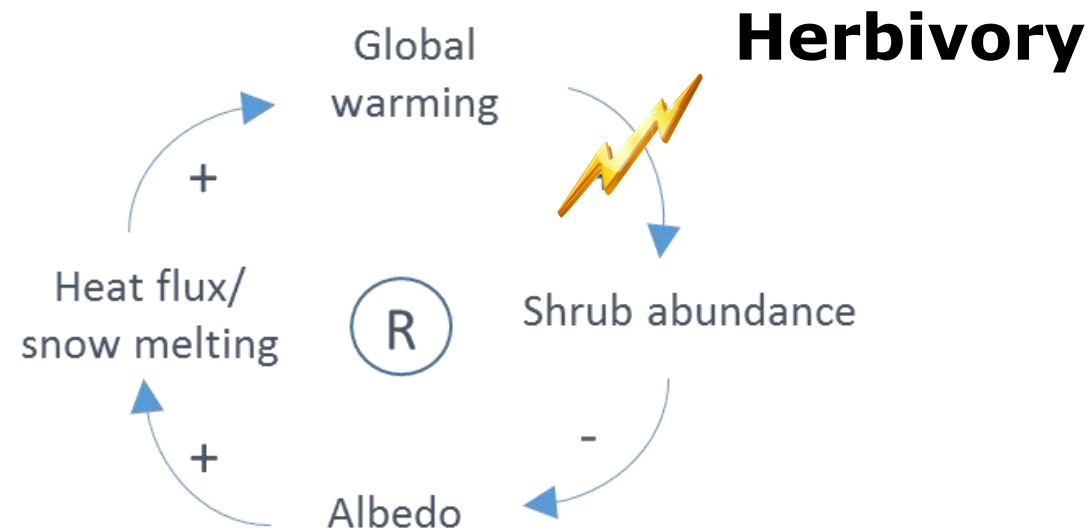
Albedo – surface reflectance



Albedo - effects of vegetation



Positive feedback

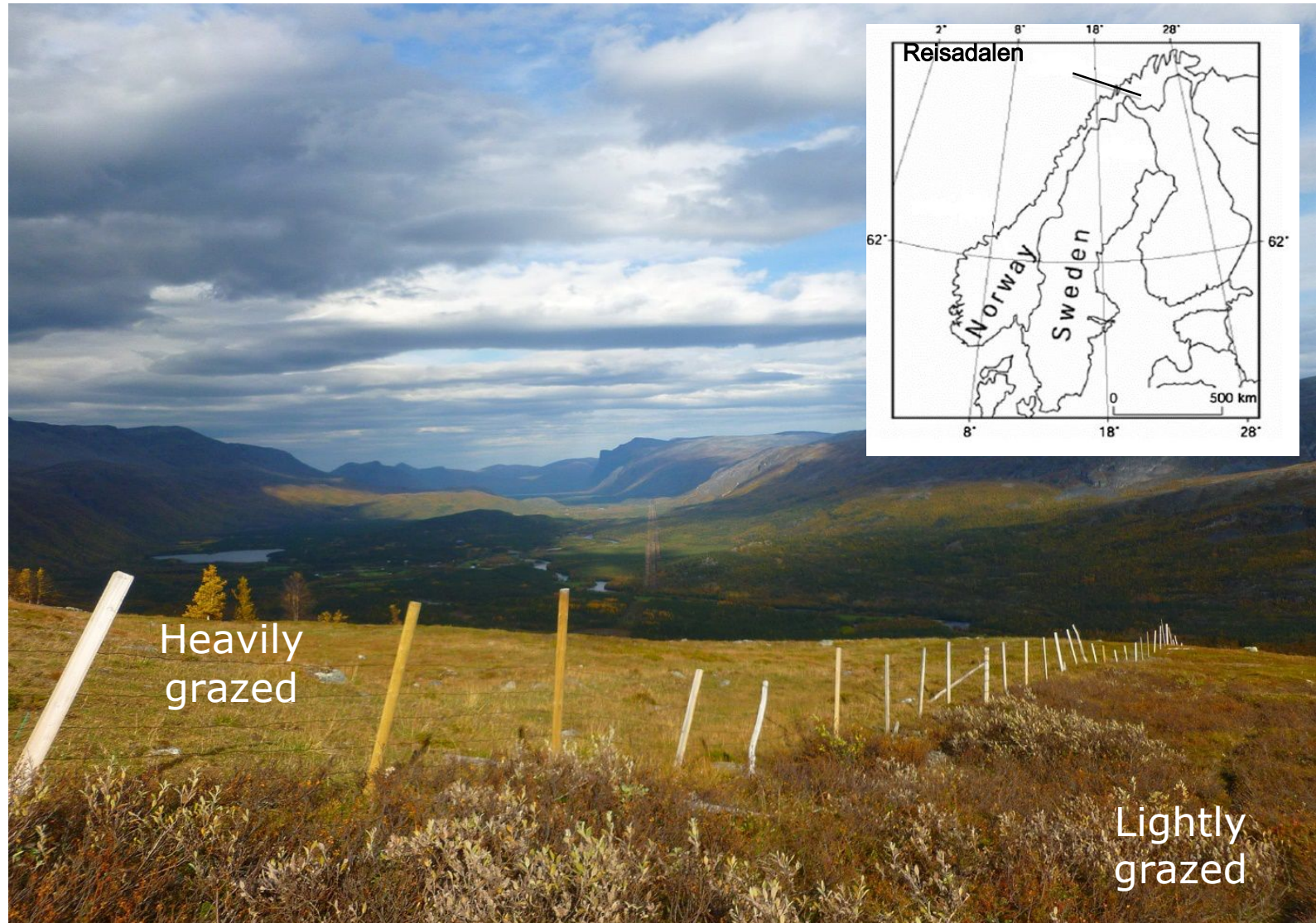


Herbivores inhibit climate-driven shrub expansion on the tundra

Olofsson et al. (2009) Glob Change Biol



Study area: Reisadalen, Norway

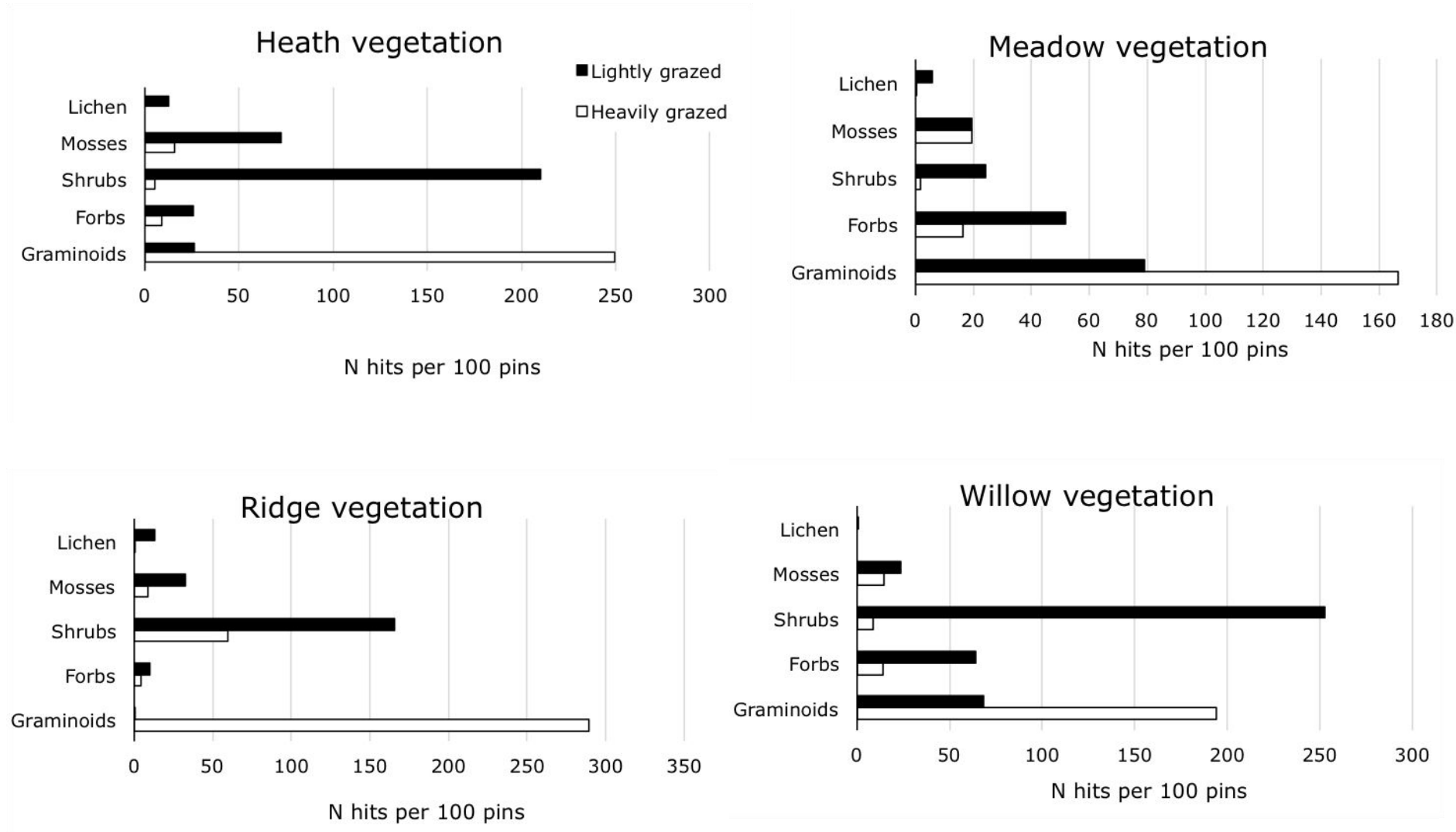


Methods

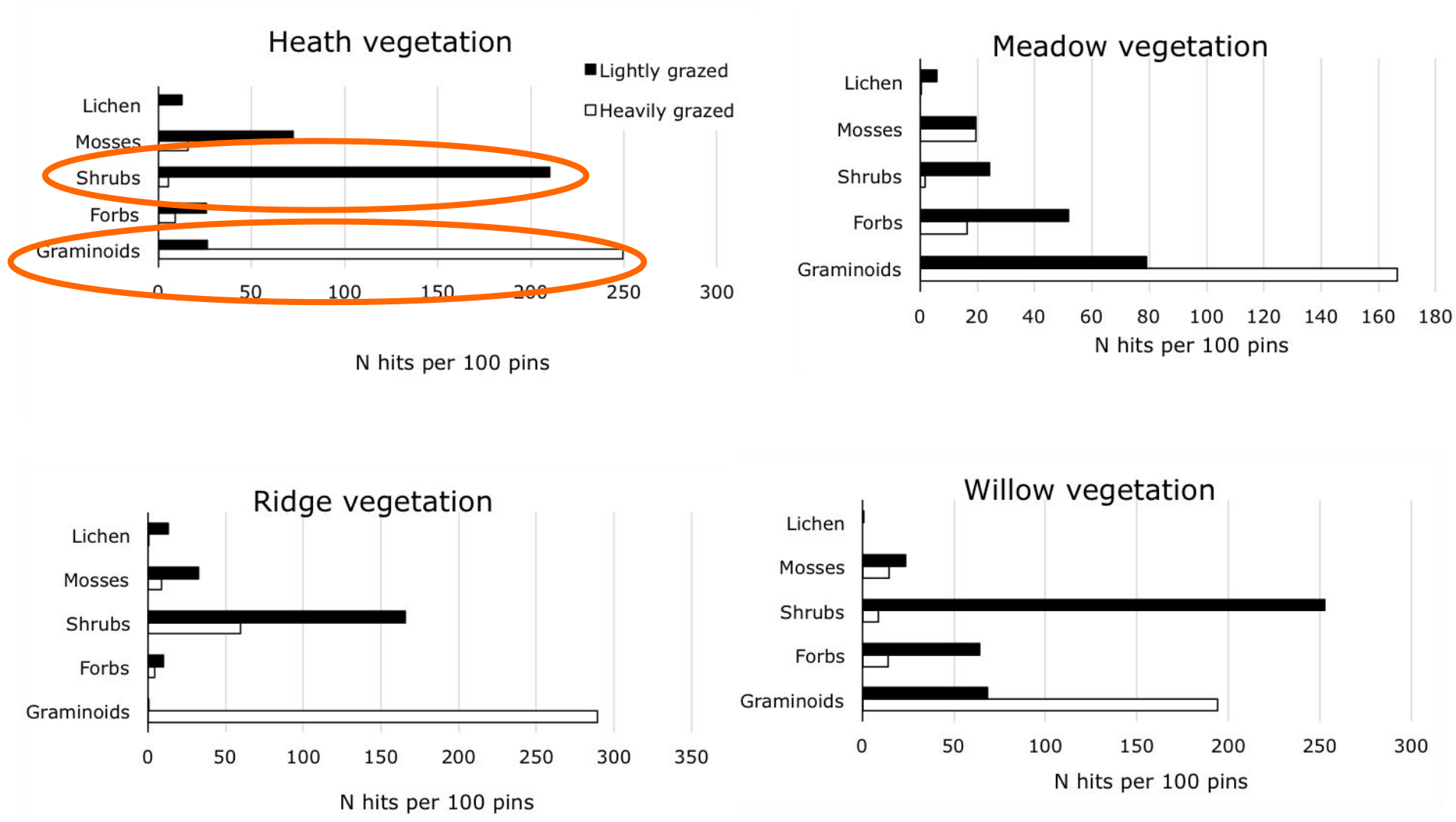
- Measurements in 36 paired plots across the 2013 growing season in 4 vegetation types
 - Species composition, vegetation height and density
 - Albedo
 - Signs of herbivory
- Energy-budget model (JULES)
 - Sensible heat flux
 - Latent heat flux



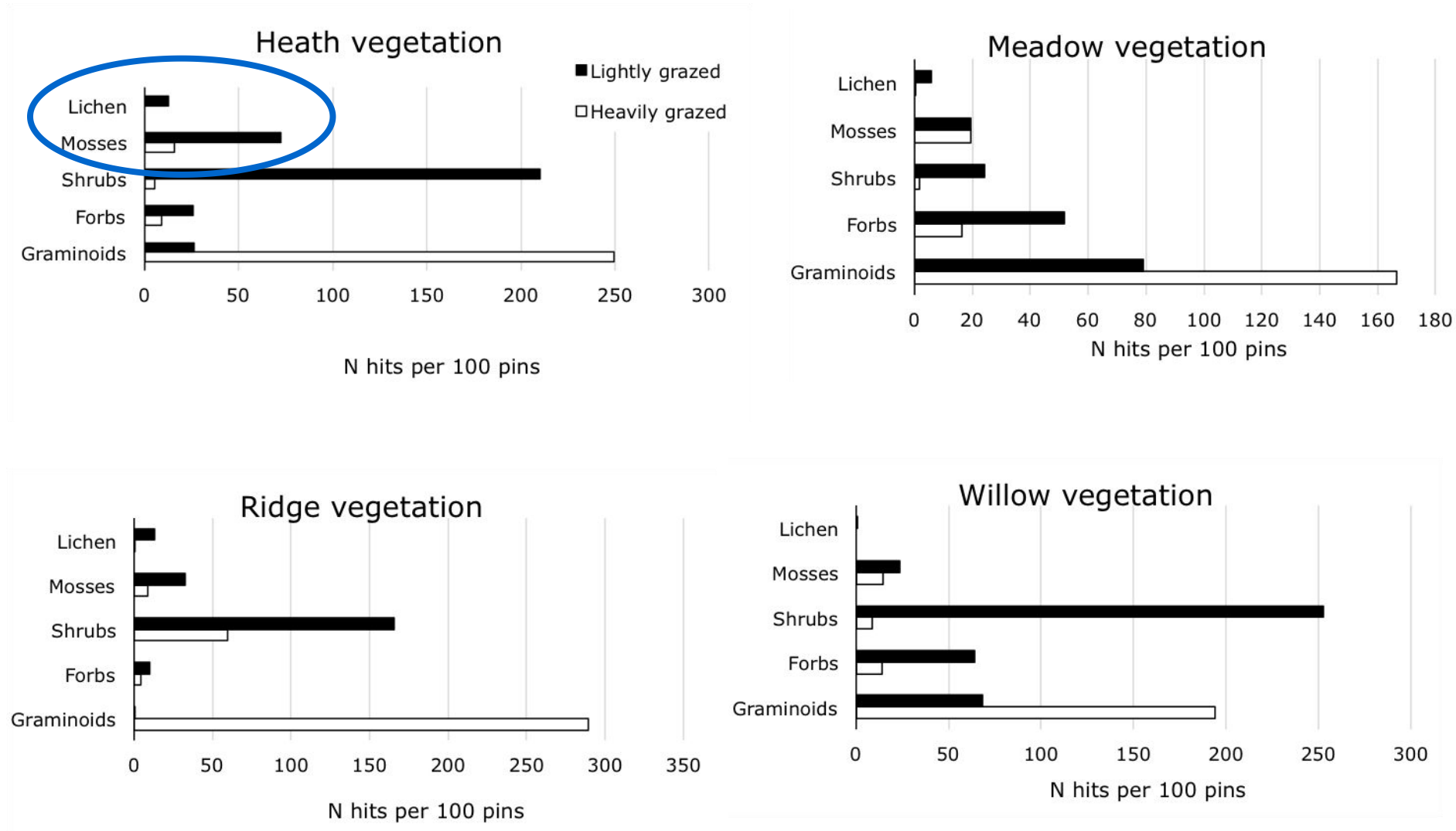
Species composition



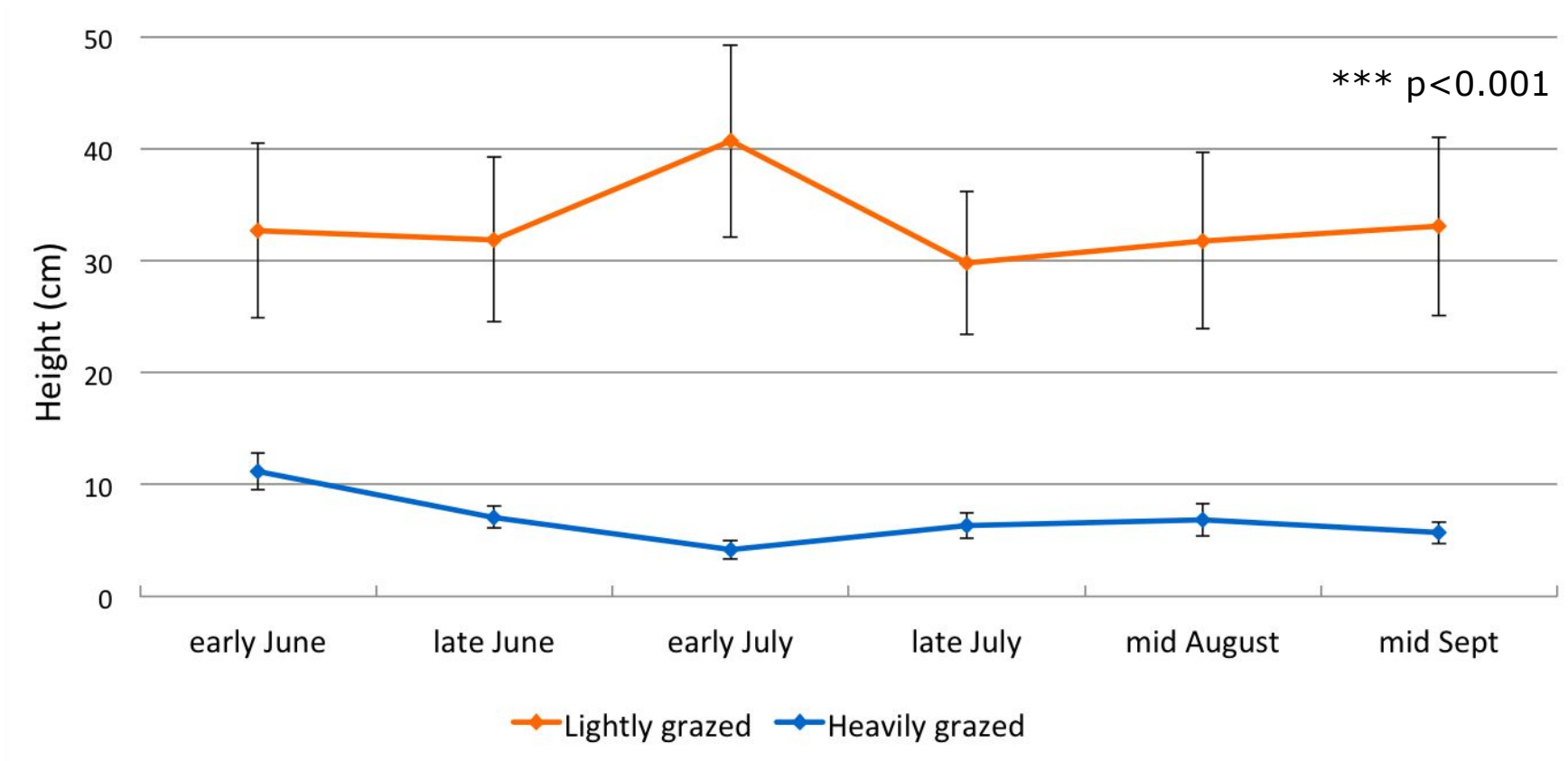
Species composition



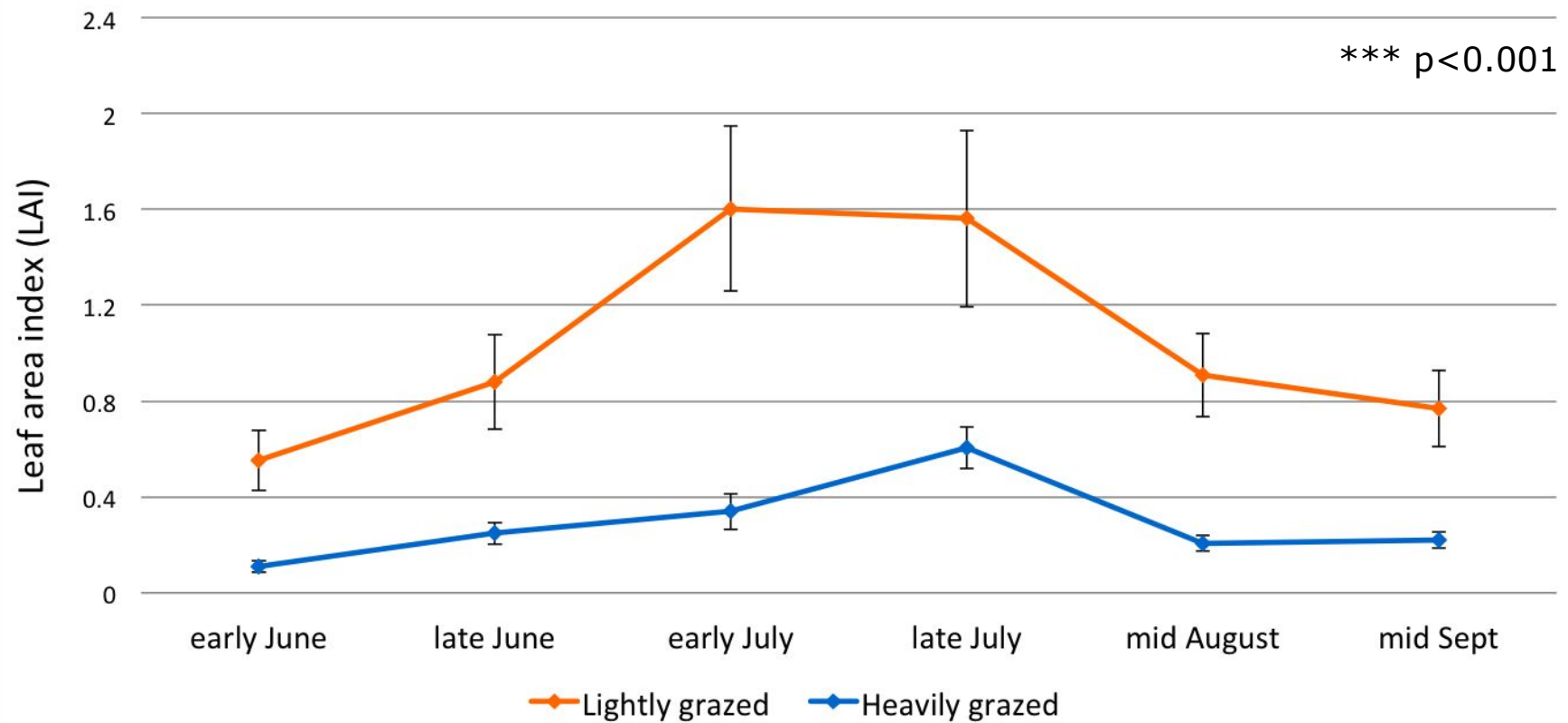
Species composition



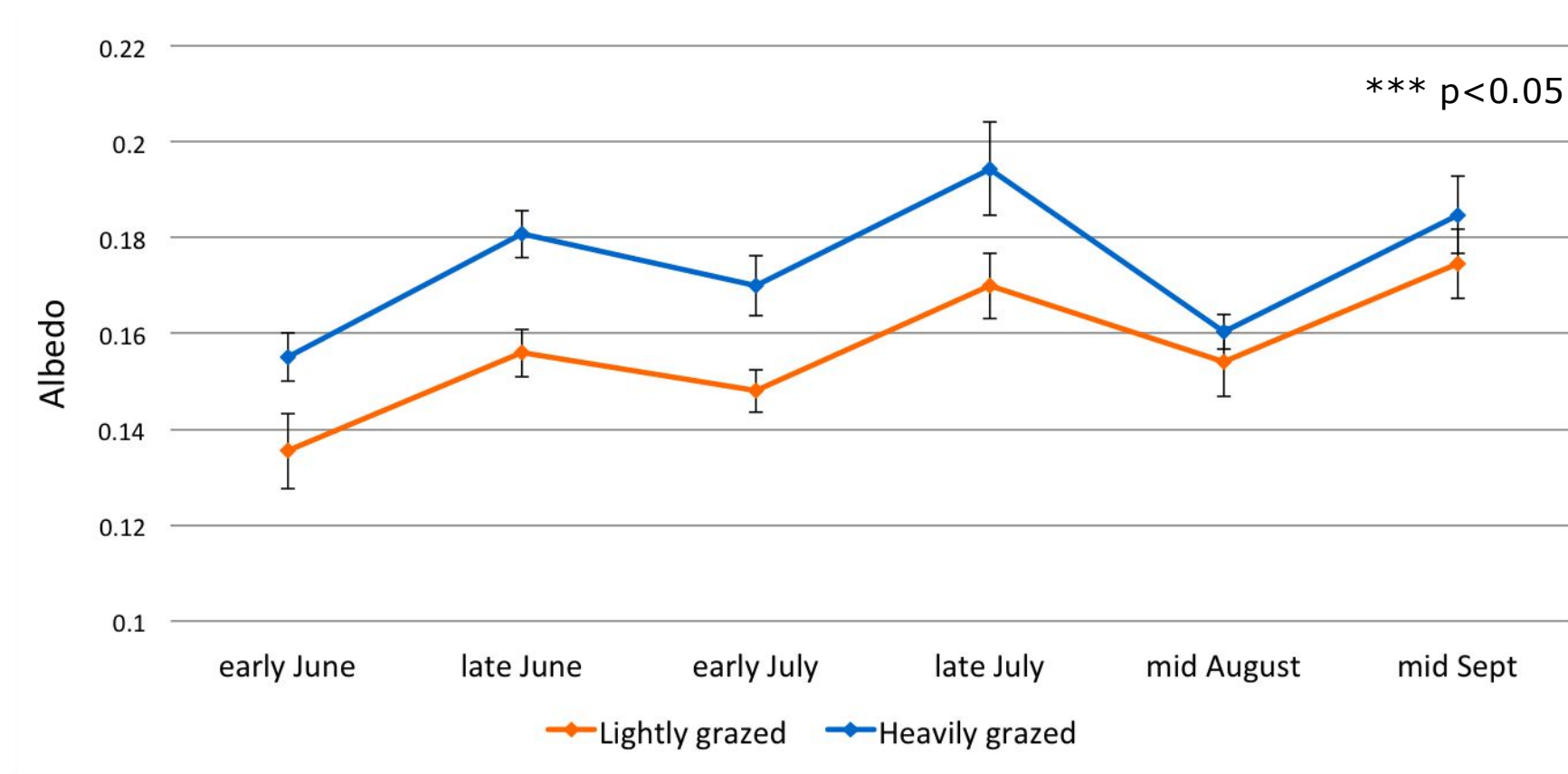
Shrub height



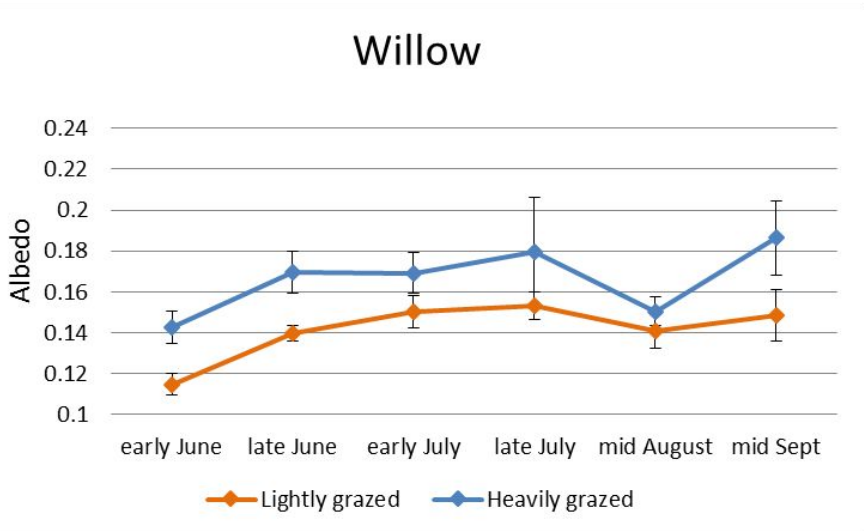
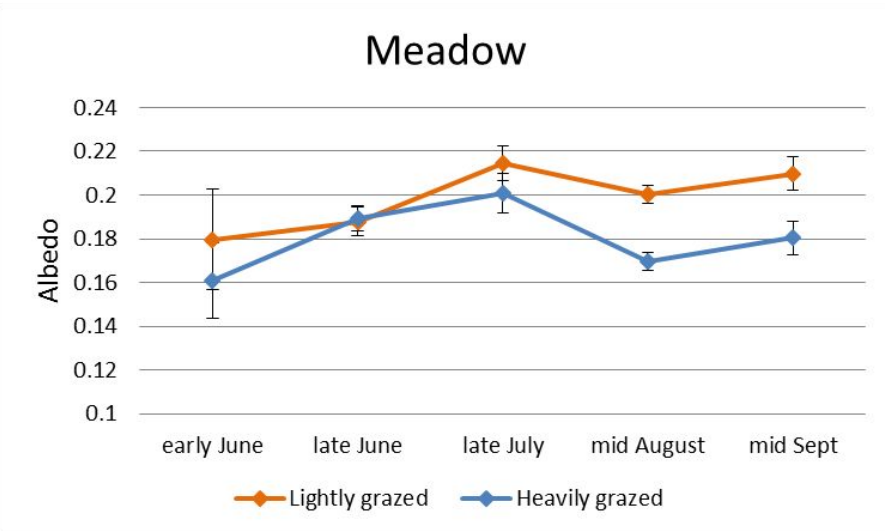
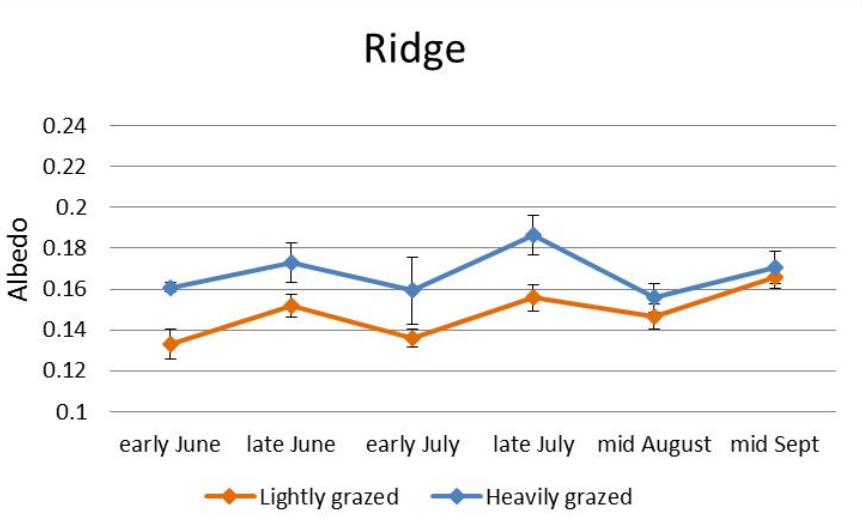
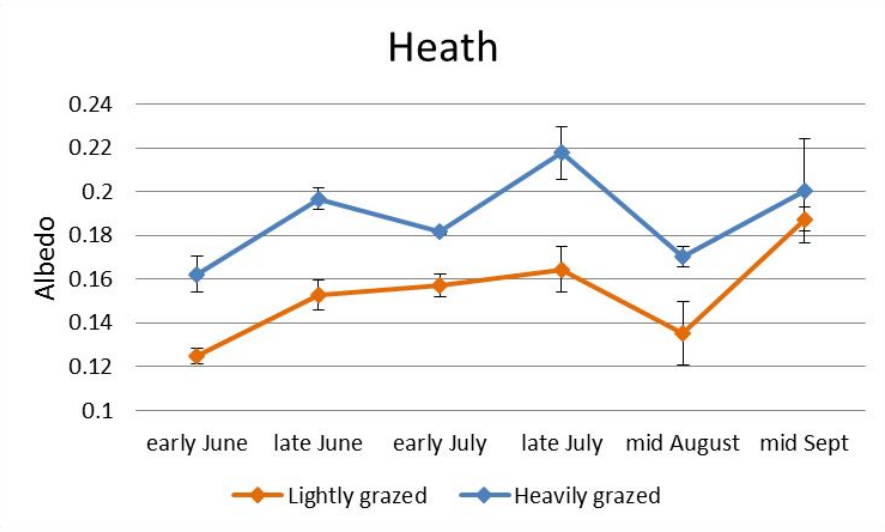
Leaf area index (LAI) – density of shrub canopy



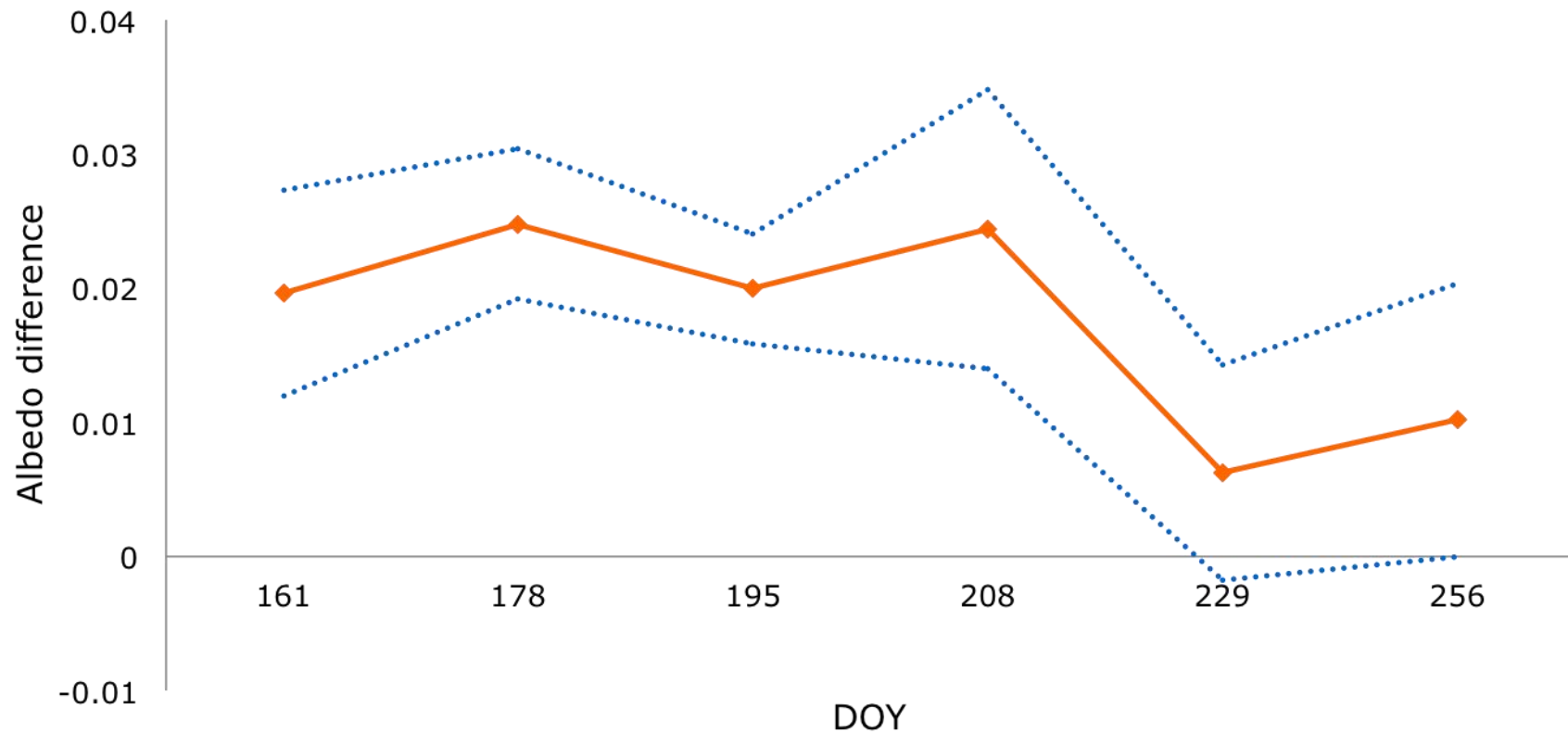
Albedo



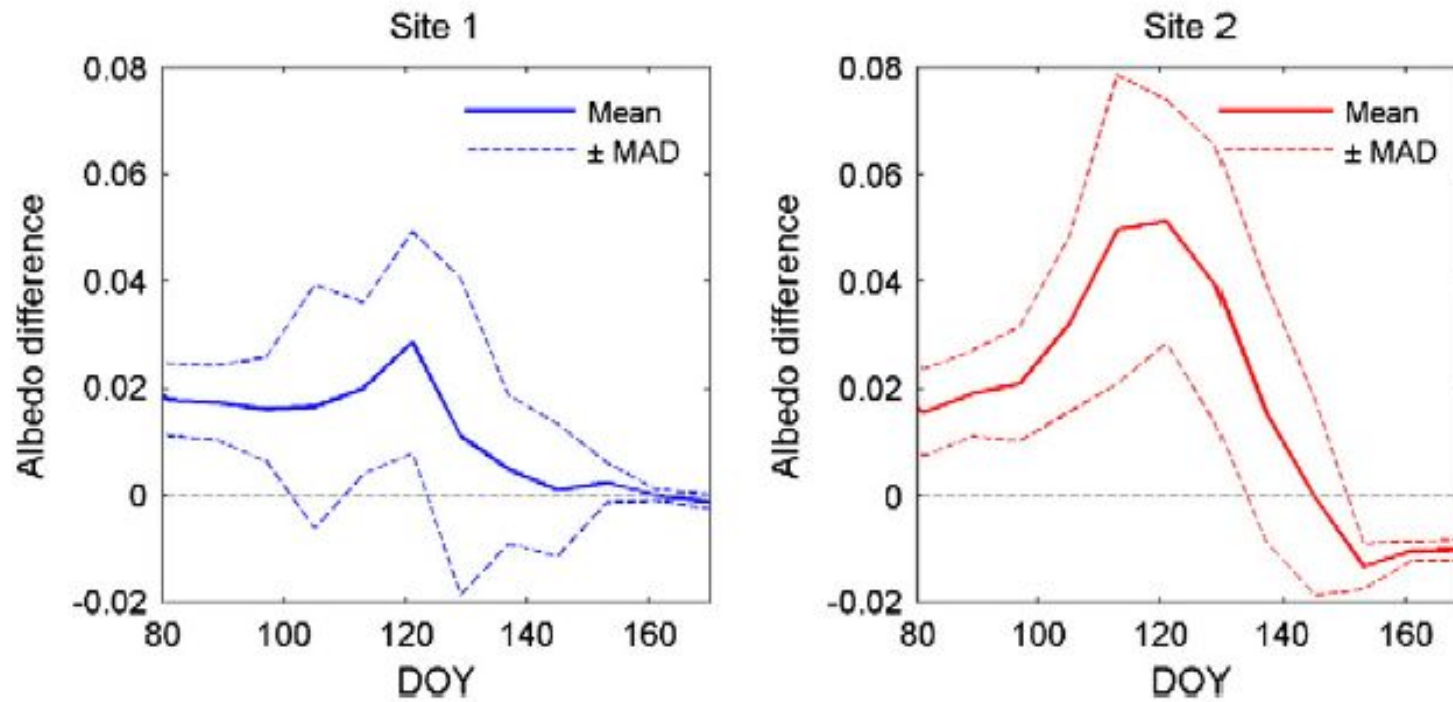
Albedo per vegetation type



Difference in summer albedo

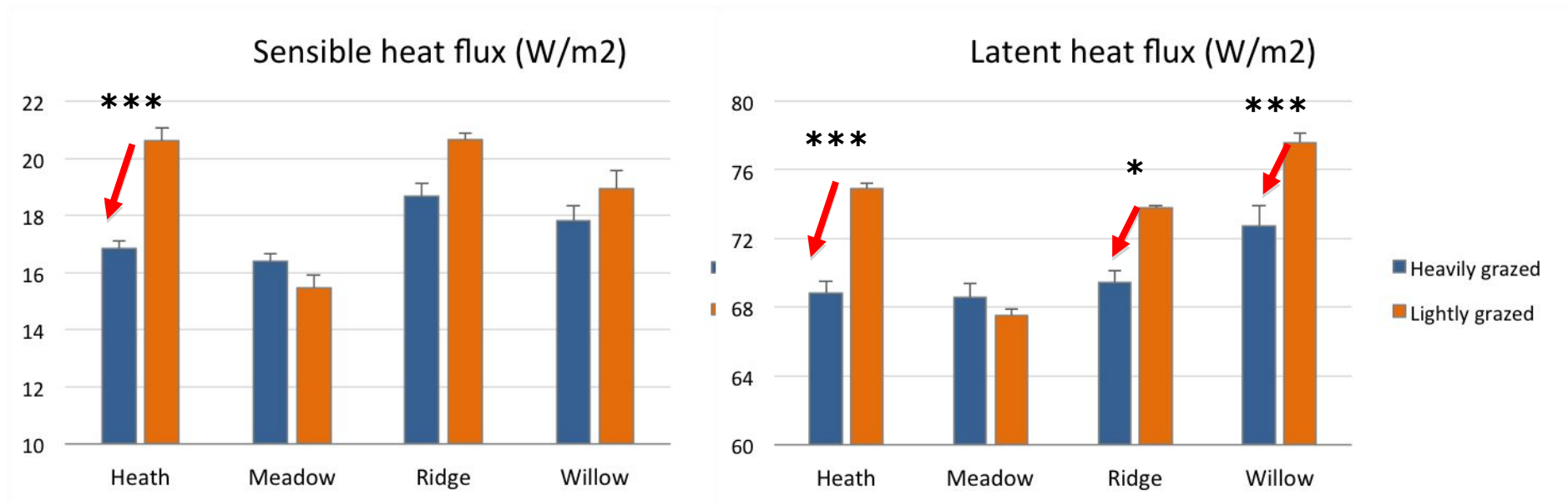


Effect of reindeer grazing on albedo – remotely sensed data



Cohen et al. (2013) J Remote Sensing Environ

Modelled energy balance



Positive values indicate a flux from surface to atmosphere



Summary of our results

Herbivory by reindeer:

- changes species composition
 - more graminoids, less shrubs, mosses, lichens and forbs
- reduces vegetation height and density
- increases summer albedo across the growing season
 - but the effect differed per vegetation type
- decreases heat fluxes to the atmosphere



Can herbivory potentially mitigate effects of tundra shrubification on energy balance?



However...

- This is a 'maximum effect': the maximum potential reindeer herbivory may have on energy balances
- We don't know yet how much this effect is presently realized with current reindeer numbers
- Further research is needed to address more realistic herbivory scenario's



Acknowledgements

- Arcum, Centre for Arctic Studies, Umeå University
- NCoE Tundra and Norden Top-Level Research Initiative "Effect Studies and Adaptation to Climate Change"
- Jonas Gustafsson for assistance with the field work

