Implications of evergreen shrub advancement: The need for a more comprehensive view of Arctic shrubification

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Outline

A. Background: Herbivory and climate change in Swedish Scandes
B. Have we ignored evergreen shrubs?
C. Implications of evergreen shrub advancement
Herbivory and climate change in Swedish Scandes

WWF-project:
Three fenced plots (exclosures)
Three open plots (ambient)
Several sites and vegetation types
Established in 1995

Tage Vowles PhD Thesis
Vegetation inventories

Cover and height of all species

Height, diameter and cover of trees and shrubs

Soil and air temperatures logged in each plot
Expansion of deciduous tall shrubs but not evergreen dwarf shrubs inhibited by reindeer in Scandes mountain range

Tage Vowles*,1, Bengt Gunnarsson1, Ulf Molau1, Thomas Hickler2,3, Leif Klemedtsson4 and Robert G. Björk4
Expansion of deciduous tall shrubs but not evergreen dwarf shrubs inhibited by reindeer in Scandes mountain range

Tage Vowles*,†, Bengt Gunnarsson§, Ulf Molau§, Thomas Hickler#,#, Leif Klemmedtsson&& and Robert G. Björk&&

![Graphs showing changes in number of reindeer per km² and annual mean temperature deviation over years.](image)
Contrasting impacts of reindeer grazing in two tundra grasslands

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Figure 3. Mean percent cover (±SE) of each functional type at the two study sites, ambient plots in yellow and exclosures in green. + denotes significant time effects and * significant treatment effects from pairwise t-tests with tukey adjustments. + $P = 0.1 - 0.05$, ++ $P = 0.05 - 0.01$, +++ $P < 0.01$. * $P = 0.1 - 0.05$. Means are based on three plots per treatment everywhere except for the low herb meadow in 2012, where means are based on three plots for exclosures but only two for ambient plots.
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Figure 5. Results from shrub layer inventories of Betula nana and Salix spp. shrubs >30 cm at the low herb meadow, showing means (±SE) of (a) number of shrubs, (b) mean height, (c) tallest height and (d) area cover in plot (n = 3). Stars denote significant treatment effects. * P = 0.1 – 0.05, ** P = 0.05 – 0.01, *** P < 0.01. Note that missing error bars mean that there was only one shrub above 30 cm, so no standard error could be calculated.
Low evergreen shrubs had increased dramatically in the majority of vegetation types studied and were either unaffected or positively influenced by grazing.

Tall deciduous shrubs too had increased, but to a lesser extent, and were negatively affected by grazing.
The conceptual view on shrub expansion

Positive feedback on global warming

Greater C storage in woody biomass compared to low shrubs

Herbivory

Nutrient availability

Heterotrophic microbial activity

Higher quality litter

Winter soil temperature

Snow depth

Shading

Deciduous shrub expansion

Decreased albedo

Accelerated spring thaw
The increase of evergreen shrubs across the Arctic has been largely neglected in the shrubification literature.
The increase of evergreen shrubs across the Arctic has been largely neglected in the shrubification literature

"shrub expansion" OR "vegetation change") AND (tundra OR arctic OR alpine) AND shrubs/deciduous/evergreen
Plot-scale evidence of tundra vegetation change and links to recent summer warming

Sarah C. Elmendorf, Gregory H. R. Henry, Robert D. Hollister et al.
Total shrub expands in sites that are already relatively warm.
Response dependent on the climate zone, the moisture regime and the presence of permafrost.
Deciduous vs evergreen shrubs in the Arctic

**Dwarf birches** (*Betula* spp.) or **Willows** (*Salix* spp.)

- Albedo
- Spring thaw
- Summer shading

- **Ectomycorrhiza**

**Semi-prostrate shrubs** (*Vaccinium* spp., *Empetrum hermafroditum* etc.)

- Allelopathy

- **Ericoid mycorrhiza**

*Salix herbacea*
Carbon sequestration is related to mycorrhizal fungal community shifts during long-term succession in boreal forests

Karina E. Clemmensen¹, Roger D. Finlay¹, Anders Dahlberg¹, Jan Stenlid¹, David A. Wardle² and Björn D. Lindahl³
Plant species traits are the predominant control on litter decomposition rates within biomes worldwide

William K. Cornwell, Johannes H. C. Cornelissen, Kathryn Amatangelo, Ellen Dorrepaal, Valerie T. Eviner, Oscar Godoy, Sarah E. Hobbie, Bart Hoorens
The need for a more comprehensive view of Arctic shrubification
Thank you very much for your attention!
Acknowledgements