**Publications of the Institute of Geophysics, Polish Academy of Sciences**
Geophysical Data Bases, Processing and Instrumentation
vol. 455 (P-5), 2025, pp. 63–66
DOI: 10.25171/InstGeoph_PAS_Publs-2025-085
40th International Polar Symposium – Arctic and Antarctic at the Tipping Point, 4–7 November 2025, Puławy, Poland

# Contemporary Climatic and Non-climatic Disturbances Affect the Heterogeneous Growth of *Salicaceae* in Spitsbergen

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## 1. INTRODUCTION

Dwarf shrubs growing in the High Arctic tundra are very sensitive to environmental changes and are therefore very important ecological indicators. The variation in the width of annual increments is linked to several complex factors, climatic and non-climatic, such as geomorphological, soil, and habitat (Owczarek et al. 2013; Opała-Owczarek et al. 2018; Owczarek et al. 2021). However, the driving factors influencing tundra plant growth are not yet fully understood. It is thus evident that a comprehensive study integrating ground-based observations and their linkage to a large variety of environmental factors is crucial. This is particularly important for observing the contemporary trend of growth and increasingly frequent climatic, biotic, and physical extremes (Phoenix et al. 2025). Considering the above scientific problems, we pose a main research question: What factors are responsible for the inconsistent growth of polar willow in different morphological zones of central Spitsbergen?

## 2. STUDY AREA AND METHODS

The study was conducted in the central part of Spitsbergen, the largest island in the high Arctic Svalbard archipelago. The study sites were located in the morphologically diverse Adventdalen area. To accurately assess how topographical diversity and local factors influence the growth variability of *Salix polaris*, we sampled plants from climatically diverse sites: from plateau (elevation 400–450 m a.s.l.) and valley bottom (50–70 m a.s.l.) (Fig. 1). At each site, we randomly collected approximately 15–32 plant specimens of *Salix polaris*, depending on local availability. For laboratory analysis, we adapted well-established microscopic techniques for examining dwarf shrubs (Gärtner and Schweingruber 2013). Each research area, including the surroundings of designated vegetation plots, was subject to detailed geomorphological mapping and soil analysis. For the research, we paid special attention to landforms and processes that could either hinder or promote vegetation growth and plant productivity.

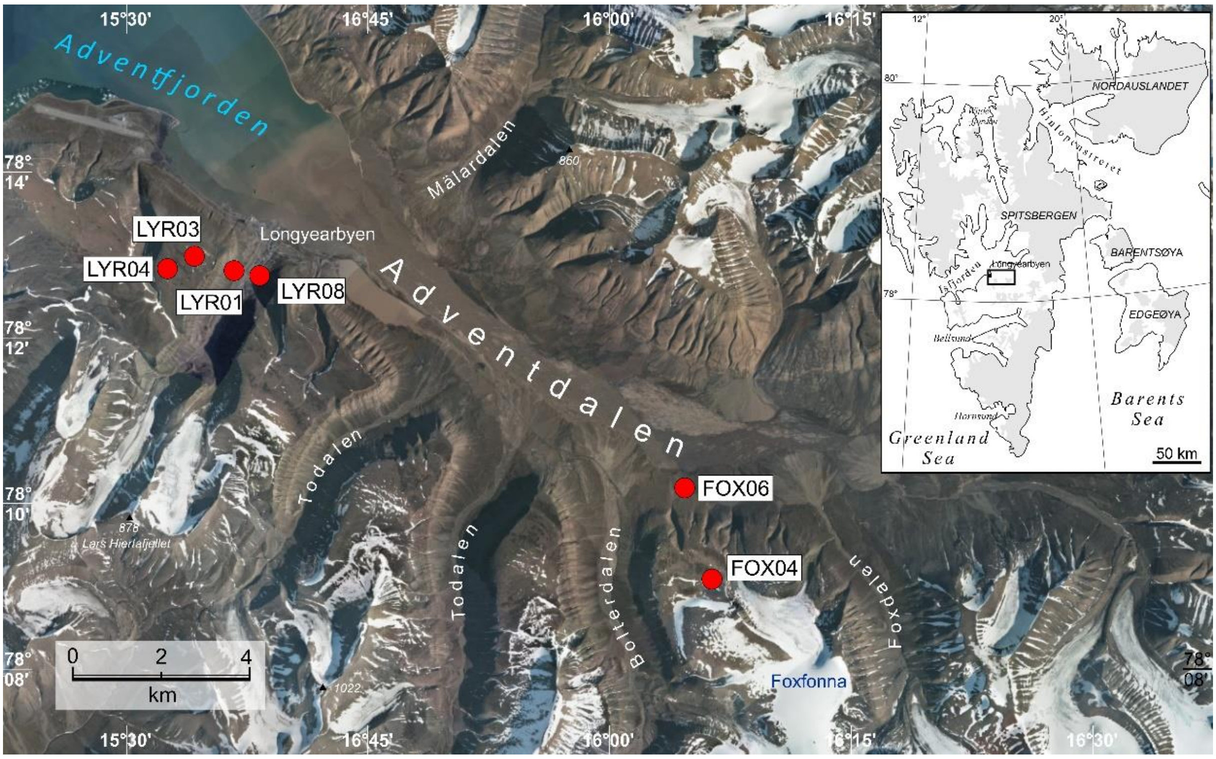


Fig. 1. Location of the study sites in Central Spitsbergen, Svalbard.

## 3. RESULTS AND CONCLUSIONS

High-resolution digital images of *Salix polaris* cross-sections from six sites enabled the construction of reliable growth-ring chronologies at high and low elevations. Dendroclimatic analyses at different sites yielded diverse results, enabling insightful interpretations of the factors influencing polar willow growth in Central Spitsbergen. Although the sites were close to each other, it was found that the dendrochronological scales varied, meaning that the growth of the polar willow was heterogeneous (Fig. 2). Our analysis of various microsite conditions suggests that the growth response of this species is influenced by more factors than a single climate driver. Dendrochronological analyses revealed that low-elevation valley-bottom sites showed a strong positive correlation between June temperatures and ring growth, supported by high soil moisture and nutrient-rich soils. In contrast, higher elevations experienced delayed yet sustained growth in mid-to-late summer, supported by permafrost moisture retention despite colder early summers. In addition, numerous traces of physical and climatic disturbances affecting modern dwarf shrub growth were found in microscopic cross-sections. Examples include the occurrence of reaction wood in areas of increased solifluction movements (Fig. 3A), numerous wounds and eccentric growth associated with mass movements, including aeolian erosion (Fig. 3B) or narrow growth rings associated with rain-on-snow events (Fig. 3C). These disturb-

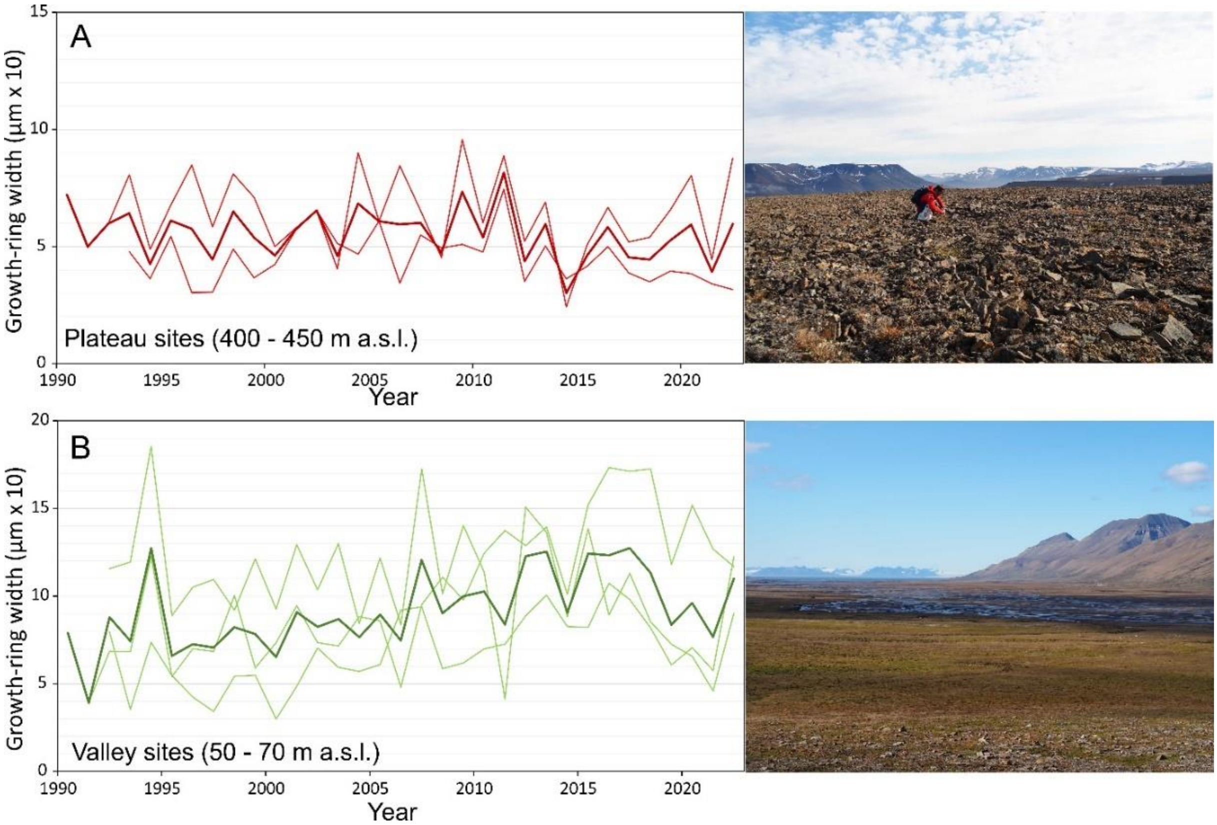


Fig. 2. Chronologies of growth rings of *Salix polaris* growing at high (A) and low (B) altitudes with general views of the study areas showing their topographical and geomorphological characteristics.

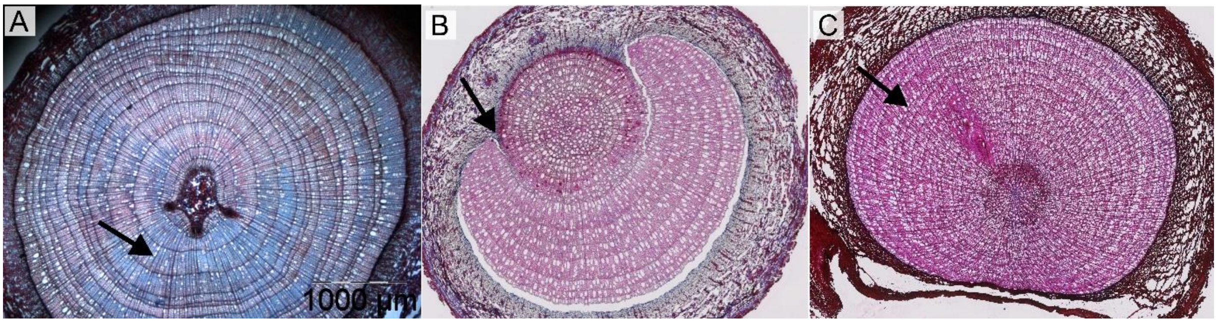


Fig. 3. Examples of growth disturbance in polar willow cross sections: A) reaction woods that develop as a result of mechanical stress (e.g. creeping) are stained blue through the use of dyes, B) wounds and eccentric growth associated with mass movement activity, and C) growth ring connected with extreme climatic events – rain-on-snow.

ances can occur locally and affect their growth differently even in adjacent sites. Our research has demonstrated the impact of various factors on the growth of polar willow and its heterogeneous growth pattern. We have shown that the combination of dendrochronological data from High Arctic sites on a regional scale is subject to significant error, due to the impact of microhabitat and microclimatic factors. Local factors are crucial in influencing local tundra productivity trends.

Acknowledgments. The results presented in this paper were obtained within the project No. 2021/41/B/ST10/03381 "Spatio-temporal patterns in Arctic tundra greening and browning—identification of key environmental factors (TURNING)".

## References


Gärtner, H., and F.H. Schweingruber (2013), *Microscopic Preparation Techniques for Plant Stem Analysis*, Kessel Publishing House, Remagen, 78 pp.

Opała-Owczarek, M., E. Pirożnikow, P. Owczarek, W. Szymański, B. Luks, D. Kępski, M. Szymanowski, B. Wojtuń, and K. Migała (2018), The influence of abiotic factors on the growth of two vascular plant species (*Saxifraga oppositifolia* and *Salix polaris*) in the High Arctic, *Catena* **163**, 219–232, DOI: 10.1016/j.catena.2017.12.018.

Owczarek, P., A. Latocha, M. Wistuba, and I. Malik (2013), Reconstruction of modern debris flow activity in the arctic environment with the use of dwarf shrubs (south-western Spitsbergen) – a new dendrochronological approach, *Z. Geomorphol*. **57**, Suppl. 3, 75–95, DOI: 10.1127/ 0372-8854/2013/S-00145.

Owczarek, P., M. Opała-Owczarek, and K. Migała (2021), Post-1980s shift in the sensitivity of tundra vegetation to climate revealed by the first dendrochronological record from Bear Island (Bjørnøya), western Barents Sea, *Environ. Res. Lett*. **16**, 1, 014031, DOI: 10.1088/1748-9326/abd063.

Phoenix, G.K., J.W. Bjerke, R.G. Björk, D. Blok, A. Bryn, T.V. Callaghan, C.T. Cristiansen, A.M. Cunliffe, S.J. Davidson, H.E. Epstein, M.M. Loranty, A.C. Martin, I.H. Myers-Smith, J. Olofsson, T.C. Parker, F.-J.W. Parmentier, F. Stordal, R. Treharne, H. Tømmervik, and C. Voigt (2025), Browning events in Arctic ecosystems: diverse causes with common consequences, *PLOS Clim.* **4**, 1, e0000570, DOI: 10.1371/journal.pclm.0000570.



Received 3 September 2025
Accepted 20 October 2025