A growing degree day inference model based on mountain birch leaf cuticle analysis over a latitudinal gradient in Fennoscandia.

Fabian.E.Z. Ercan[1]*, H.J. de Boer[2], F. Wagner-Cremer[1]

[1]Palaeoecology, Physical Geography, Utrecht University, Princetonlaan 8a 3584 CB, Utrecht.
[2]Copernicus Institute of Sustainable Development, Department of Environmental Sciences, Utrecht University, Princetonlaan 8a 3584 CB, Utrecht.

Cuticle analysis performed on fossil *Betula nana* (L.) leaves provides a strong proxy to reconstruct past growing season thermal properties expressed as growing degree days (GDD_5). This proxy is so far available for the dwarf birch only and therewith restricted to regions or past periods of subarctic climatic conditions. In the present study we analysed modern leaf samples of mountain birch (*B. pubescens* spp. *czerepanovii* (N. I. Orlova) Hämet-Ahti) which has a wider temperature range than the dwarf birch B. nana. The strong latitudinal climate gradient over Fennoscandia provides a unique opportunity to track growing season temperature imprints in the epidermis cell morphology of modern mountain birch. We quantified the GDD_5 dependent epidermal cell expansion, expressed as the Undulation Index (UI), over a 10° latitudinal transect translating to a range from ~1500 to ~600°C GDD_5 in 2016.

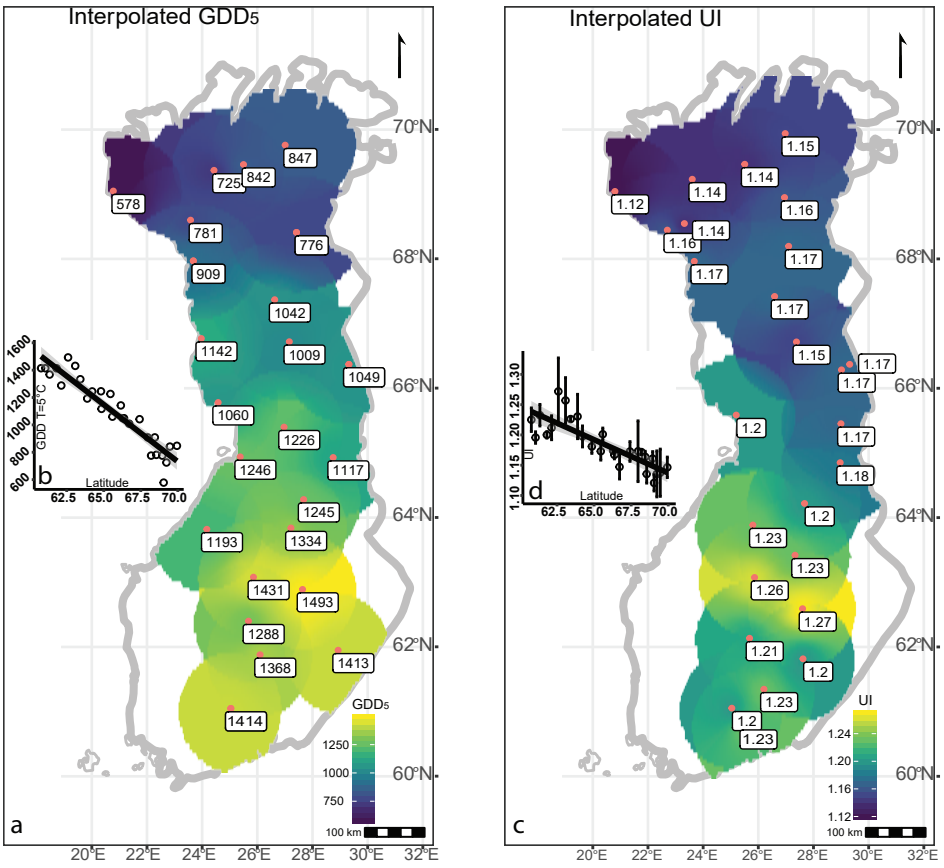

Figure 2: a) Meteorological station locations (n=28) and their measured GDD_5 values, with inverse distance weighted interpolation gradient. b) Linear relation between Latitude and GDD_5. c) Sample locations and the measured mountain birch UI values (n=26) with inverse distance weighted interpolation gradient. d) Linear relation between Latitude and UI with error bars indicating the naturally occurring variance in UI.

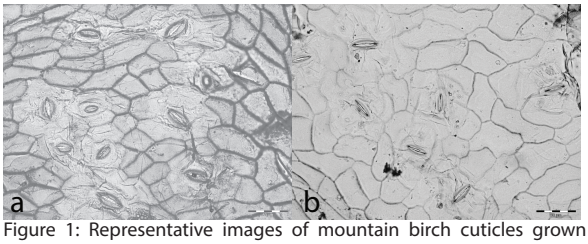

Figure 1: Representative images of mountain birch cuticles grown under 776 GDD_5 (a) and 1493 GDD_5 (b), showing stomata bearing alveole areas and epidermal cells with low and high cell wall undulation, respectively. Scale bar is 50 µm.

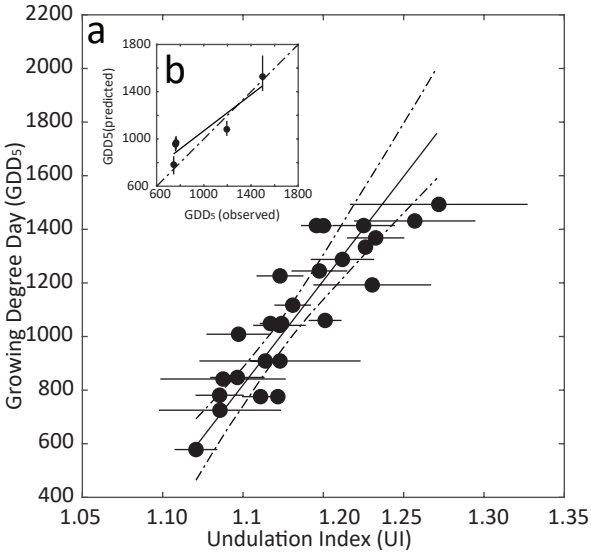

Figure 3: a) Inference model fit showing the relation between GDD_5 and UI of mountain birch obtained from the 2016 transect. Round markers indicate UI sample means, horizontal error bars indicate one standard deviation around the sample mean. The solid and dashed lines show the mean model fit with 95% confidence intervals. b) Independent inference model test based on leaves collected in 1997 at five localities in Scandinavia. Round markers indicate observed versus predicted GDD_5 inferred using the 2016 inference model. Vertical error bars indicate 95% confidence intervals around the predicted GDD_5. The solid line is the linear regression (R^2 = 0.86, p = 0.24), the dashed line represents a hypothetical 1:1 relation between predicted and observed GDD_5 values.

Our results support the GDD_5 inference model for mountain birch as a valuable addition to the proxy so far restricted to *B. nana*. By adding mountain birch, the temperature range over which the proxy can be applied is expanded and now covers growing season temperature regimes characteristic for boreal forest biomes rather than (sub-)arctic conditions only. Spring season reconstructions based on cuticle analysis thus become possible also for sites and localitieswhere the fossil leaf assemblages either include climatic warming phases with vegetation successions or for leaf bearing sequences in geographical regions outside the climatic prerequisites of the (sub-)arctic dwarf birch.

*Corresponding author: f.e.z.ercan@uu.nl

Universiteit Utrecht