Effects of environmental variables on intra-annual dynamics of radial growth of green alder (*Alnus alnobetula*) along an elevational transect

Walter Oberhuber, Andreas Gruber, Gerhard Wieser; Department of Botany, University of Innsbruck, 6020 Innsbruck, Austria

Background

Green alder (*Alnus alnobetula*) is a pioneer species that is widely distributed at the alpine treeline. Studies on intra-annual radial growth (RG) of tall multi-stemmed shrubs are scarce, and still completely lacking for *A. alnobetula*. Knowledge of RG phenology and drivers of intra-annual RG is needed to better predict the potential spread of this invasive shrub across the alpine treeline ecotone as a result of climate warming.

Aims and Method

The focus of this study was (*i*) to determine key dates of intra-annual RG, and (*ii*) to assess environmental factors most closely related to daily RG along an elevational transect. RG was continuously recorded by dendrometers (n=21) at three study plots within the alpine treeline ecotone (1940–2150 m asl; Mt. Patscherkofel, Central Alps), and in potted saplings at 600 m asl (Botanical garden in Innsbruck, Tyrol, Austria).

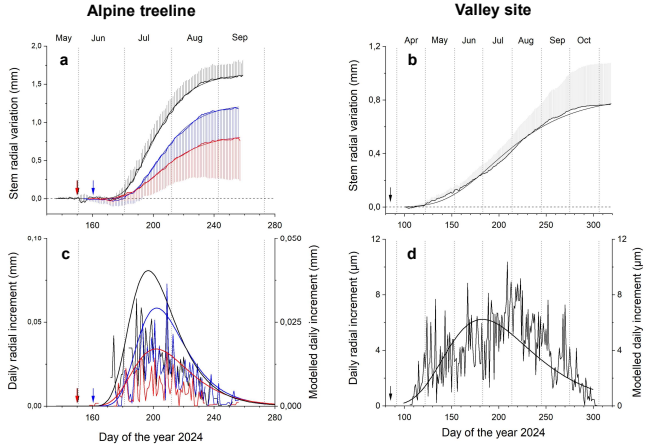


Fig. 1 a-b Time series of stem radial variations (daily mean±SD) modelled by applying the Gompertz function. **c-d** Extracted and modelled daily radial increment. Arrows indicate time of bud burst at the study sites, which at the alpine treeline sites are denoted by **black**, red and blue lines/arrows for the forestline, and the south- and north-facing treeline sites, respectively.

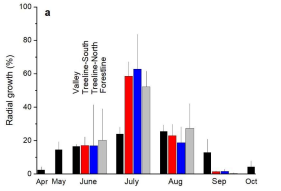


Fig. 2 Mean monthly RG. Bars indicate SD.

Table 1. Phenological dates of intra-annual radial stem growth. Dates are given in day of the year.

Plot	Onset	End	IP	Dur (days)
FL	180	237	196	57
TR-N	185	241	202	56
TR-S	182	244	201	62
V	133	278	191	145

Table 2. Spearman correlation coefficients (ρ) between environmental variables (daily means) and daily radial increments

	T_{air} (°C)	T_{soil} (°C)	T_{camb} (°C)	RH (%)	VPD (kPa)	SWC (%)
FL	0.110	0.419***	0.185	0.125	-0.123	-0.132
TR-N	0.234*	0.370***	0.288*	0.097	0.090	0.021
TR-S	0.334**	0.412***	0.297*	-0.013	0.081	-0.186
Valley	0.274*	0.371**	NA	-0.113	0.171	-0.192

FL=forestline, TR-N=treeline North, TR-S=treeline South, V=valley site, IP=inflection point, Dur=duration, T_{air}=air temperature, T_{soil}=soil temperature, T_{camb}=cambium temperature, RH=relative air humidity, VPD=vapour pressure deficit, Prec=precipitation, SWC=soil water content

Results

We found a marked delay between bud burst and the onset of RG of *c.* 4 weeks within the treeline ecotone. RG started and ceased around end of June (doy 177±7) and end of August (233±9), respectively (**Fig. 1 a-b**). Growth duration was found to be 56±9 days. The time of maximum RG was observed in early July (**Fig. 1 c-d**, **Table 1**), with about 60 % of the annual increment developing during this month (**Fig. 2**). Although RG in the valley already started in mid-May (doy 134±2) and lasted until mid-October (doy 286±8; duration: 153±7 days), time of maximum RG in 2024 was reached at a similar point in time as within the treeline ecotone (**Table 1**). The environmental factor most closely related to intra-annual RG along the entire elevational transect was soil temperature (**Table 2**).

Conclusions

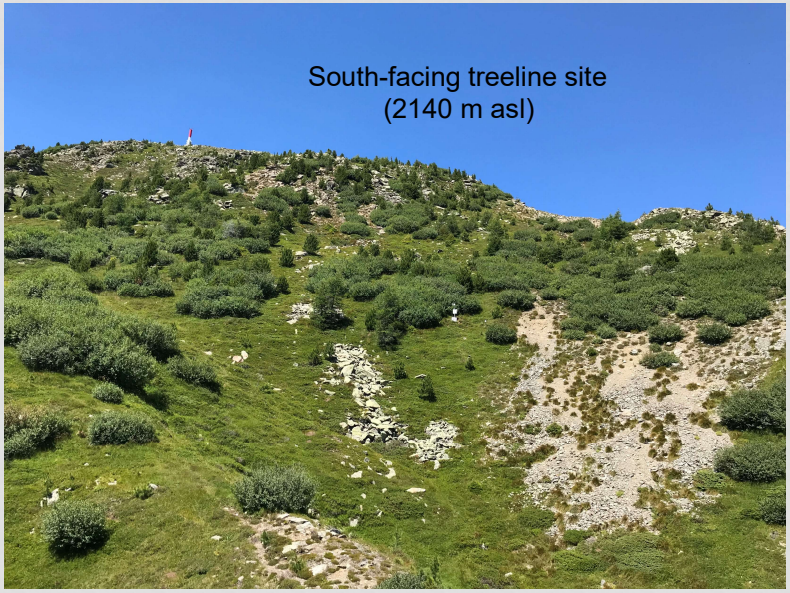
- *A. alnobetula* shows a high degree of plasticity in RG, with the RG period spanning two and five months within the treeline ecotone and in the valley, respectively.
- The striking delay in RG onset with respect to bud burst indicates that carbon reserves are initially allocated toward leaf formation.
- Although our findings underline the importance of temperature constraints on intra-annual RG, high temperatures do not adequately translate into cambial activity indicating that a non-linear relationship between temperature and RG exists.

Acknowledgements: The study was supported by the Austrian Science Fund FWF (P34706-B).

References: Oberhuber et al. Forests (2022), doi: 10.3390/f13030440; Oberhuber et al. Plants (2023), doi: 10.3390/plants12081708

Mt. Patscherkofel (Tyrol, Central European Alps)
(2246 m asl)

South-facing treeline site
(2140 m asl)



Valley site (Botanical Garden, Innsbruck, Austria)
(600 m asl)

North-facing treeline site
(2150 m asl)

Point dendrometer mounted
on the stem of *Alnus alnobetula*
(ZN12-O-WP, Natkon.ch, Switzerland)

For more details please download the following papers (open access)

forests **2024,** 15, 24; https://doi.org/10.3390/f15010024 MDPI

Article

Impact of Environmental Conditions on Wood Anatomical Traits of Green Alder (*Alnus alnobetula*) at the Alpine Treeline

Andreas Gruber, Gerhard Wieser, Marion Fink and Walter Oberhuber *

plants **2023,** 12, 1708; https://doi.org/10.3390/plants12081708 MDPI

Article

Climate Overrides the Influence of Microsite Conditions on Radial Growth of the Tall Multi-Stemmed Shrub *Alnus alnobetula* at Treeline

Walter Oberhuber *, Anna-Lena Dobler, Tamara Heinzle, Francesca Scandurra, Andreas Gruber and Gerhard Wieser

forests **2022,** 13(3), 440; https://doi.org/10.3390/f13030440 MDPI

Article

Radial Stem Growth of the Clonal Shrub *Alnus alnobetula* at Treeline Is Constrained by Summer Temperature and Winter Desiccation and Differs in Carbon Allocation Strategy Compared to Co-Occurring *Pinus cembra*

Walter Oberhuber *, Gerhard Wieser, Fabio Bernich and Andreas Gruber

FWF

Acknowledgements
These studies were supported by the Austrian Science Fund (P34706-B)