

Beyond dating: Archeological wood as a source of information of environmental changes in High Asia

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Introduction

The number of dendroarchaeological studies carried out in High Asia is still rather scarce (Gutschow 1994, 2001, Schmidt 1993, Schmidt et al. 1999, 2001, Sheppard et al. 2004, Xinguo et al. 2003). In dendroarchaeology, wood is commonly used as a source of dating historic or prehistoric objects. Dating is accomplished either by dendrochronological dating or by radiocarbon dating, in the latter case often by applying the wiggle-matching approach (Bronk Ramsey et al. 2001). Beside useful information in the chronological or human historical context, wood may contain additional information which may be of great relevance for reconstructing former environmental conditions, especially for extending chronologies from living trees for reconstructing past climate changes (Tarasov et al. 2003, Sheppard et al. 2004). In this study we investigate the ring-width variations of wood from living trees and historic wood samples for their indications of changes in the tree growth vigor and forest structure.

Study material and methods

Studied sites and wood material

We collected wood from historical buildings in the southern part of the Tibetan plateau around Lhasa, and in the Dolpo region of western Nepal (Bräuning 2001, Bräuning et al. 2011). Beside the historic material, wood from living trees was collected from tree stands of the same area of the historic wood. At Dolpo, living and historic wood samples come from the close neighborhood (29°26'N/ 82°54'E, 3850 m a.s.l.) and are from *Pinus wallichiana*. Tree-ring chronologies from Tibet come from relict stands of living *Juniperus tibetica* trees in the surrounding of Lhasa (28°58'-30°18'N/ 90°28'-91°58'E, 4140-4450 m a.s.l.; Bräuning 2001). These chronologies from living trees cover the periods 1748-1998 and 1081-2005, respectively. However, many samples of historic wood could not be successfully crossdated with these chronologies. Thus, we carried out ca. 300 AMS ¹⁴C datings to date historic samples. It is worth to note that all sites are at present strongly impacted by human influence, namely fire in Dolpo and grazing at all Tibetan sites.

Methods

Samples from living trees were collected with an increment corer at breast height, samples from historic wood was collected either with an increment corer or as disks. In cases of missing innermost rings in historic samples or in samples from living trees, the number of missing rings to the pith was estimated according ring curvature and width of the inner rings. Ring width was measured with a LINTAB V measuring table (Rinntech, Heidelberg, Germany) with a precision of 0.01 mm. We aligned the raw ring-width measurement series of samples beginning in each century according to their cambial ages and compared the cumulative growth during the first 100 years of tree growth. Since tree ages were much higher for the studied juniper trees from Tibet, now growth curves for trees established during the 20th century could be produced. For further discussion, we selected graphs from some centuries that have a minimum number of 3-4 trees starting growth in the respective century and that show differences in the mean growth behaviour.

Results and discussion

The cumulative growth curves of *P. wallichiana* from Dolpo for the 16th, 17th, 19th and 20th centuries are shown in Figure 1. Although the data replication is rather low it is obvious that growth in the first 100 years of tree live was more homogeneous in the 16th, 17th, and 20th centuries than during the 19th century, in which the ring-width series show an extremely wide spread between fast-growing and slow-growing individuals. Average cumulative growth was lowest in the 17th century and highest during the 20th century. Since pine trees are light demanding species we interpret the results as low growth during unfavourable climatic conditions during the 17th century, an increasing human influence on the regional forests during the 18th century when some trees are strongly favoured possibly by removing competitors, and by very high growth rates in the very open tree stands surviving in the 20th century.

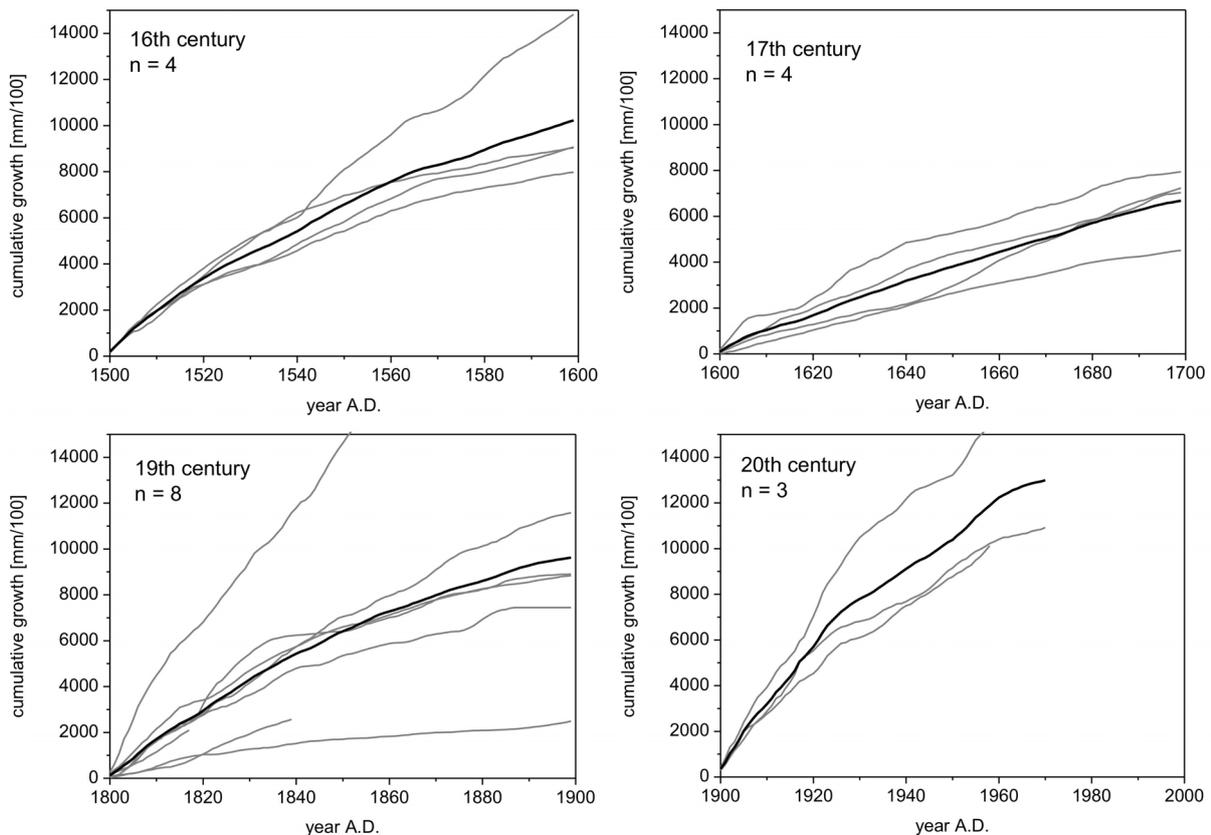


Figure 1: Cumulative growth curves from *Pinus wallichiana* from Dolpo region, Nepal. Single trees are shown in grey, mean growth curves in black.

The cumulative growth curves of *J. tibetica* from the southern Tibetan plateau also show strong variations during the past 2000 years (Fig. 2). Tree growth during the 1st century B.C. and during the 15th century A.D. was quite consistent and rather slow. However, during the 11th and 19th centuries, cumulative growth curves during the first 100 years of juniper growth varied strongly with higher average growth rates. Although the better growth performance of the trees may also be at least partly caused by better climatic conditions, we assume that human impact on the local forests had a strong impact especially in the 11th century, when the monastery of Reting was founded that is located in the centre of the forest with the oldest living trees (Bräuning 2001). On the other hand, impact on the forest during 19th century might also have been high since there is no indication for favourable summer moisture conditions at this semi-arid site (Grießinger et al. 2011).

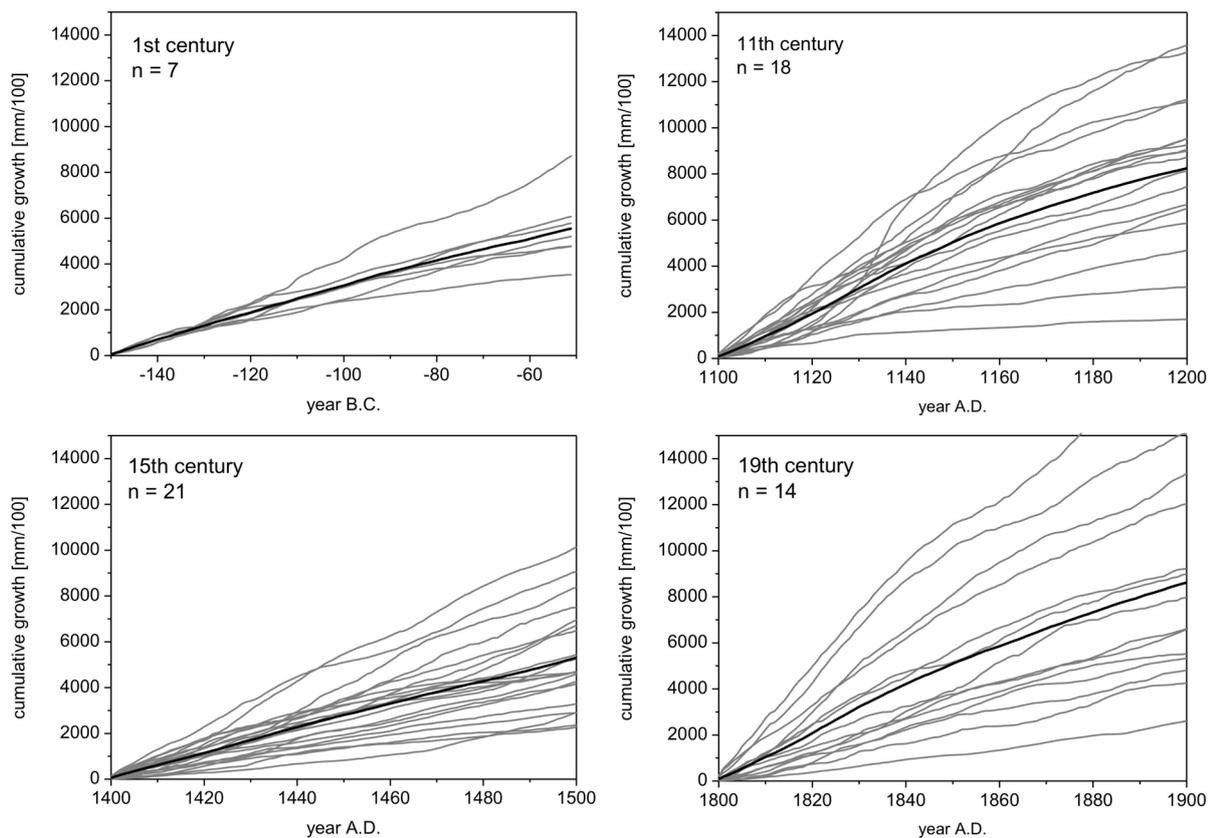


Figure 2: Cumulative growth curves from *Juniperus tibetica* from the Lhasa region, Tibetan plateau. Single trees are shown in grey, mean growth curves in black.

Figure 3 compares the average growth performance during the first 100 years of growth during different time periods. It becomes apparent that maximum growth rates of *P. wallichiana* can be much higher than those for the high-elevation species *J. tibetica*. On the other hand, the enhanced growth rates during the 20th century in Dolpo and during the 19th century in Tibet indicate that human impact on forest structure has been increasing during the recent decades and forests probably showed a more open structure with better light conditions for remaining trees.

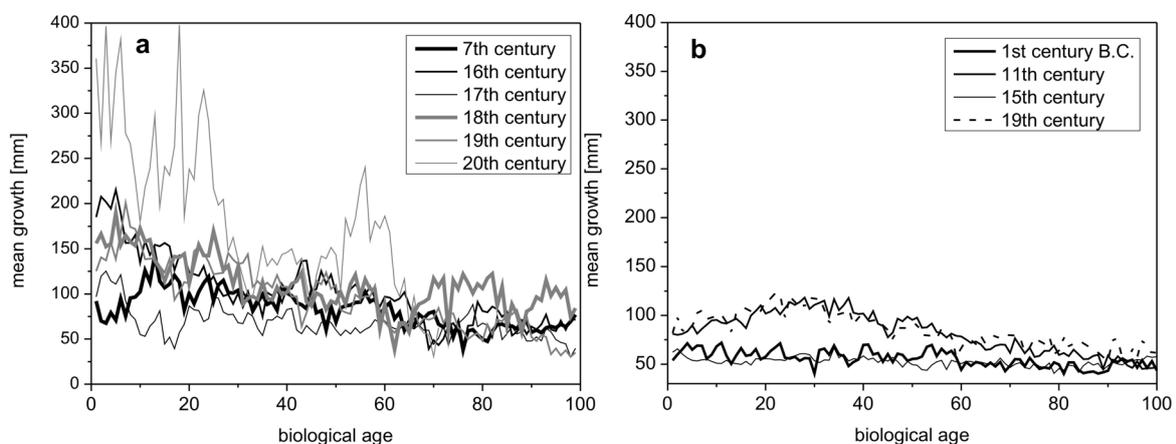


Figure 3: Average growth curves during different time periods of (a) *Pinus wallichiana* from Dolpo and (b) of *Juniperus tibetica* from the Lhasa region.

Due to low sample sizes especially during older time periods, our results are of preliminary character and should be improved by further inclusion of older trees, if those become available. The purpose of our study was to demonstrate that historic wood may contain a wealth of information about former environmental growing conditions and human-environment interactions that should be used as a source of historical environmental development.

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