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China's growing relevance in dendrochronology and paleoclimatology

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China's academic achievements are often considered reproductions by occidental scholars. Conversely, the country's first dendrochronological studies began almost as early as those in Europe and America. Here, we place the century-long history of Chinese dendrochronology in the context of socio-political, economic and personal circumstances, describe past developments, and outline future challenges. Like all scholars, China's next generation of dendrochronologists must balance national standards and global norms towards innovation and collaboration.

The history of Chinese tree-ring research

Dendrochronology emerged in China around the same time as it did 'independently' in central Europe[1] and North America[2] in the early 20th century[3]. Meteorologist Zizheng Zheng (aka Kenneth T.C. Cheng) was the first Chinese scholar who described the formation and structure of tree rings[4], defined tree species for dendroclimatological investigations, and outlined applications for archaeological studies (Fig. 1). Zheng was not only motivated by the outcome of his own sampling campaigns in the Jingshan mountains near Beijing in the early-1930s, but also by the pioneering studies of J.C. Kapteyn, A.E. Douglass, and others who explored the climate signal in tree rings during the first decades of the 20th century[4]. At the same time, Zheng's colleague Fengchang Huang, also at the Institute of Meteorology of the Academia Sinica, visited the world's first 'Tree-Ring Laboratory' in Tucson, Arizona (established by A.E. Douglass), and upon return, published the first dendrochronological overview in Chinese[5], with details on sample collection, chronology development and growth-climate analysis (Fig. 1).

While tree-ring research advanced and expanded continuously in different parts of the world[3], its conceptual and methodological developments in China were interrupted over four decades due to effects of the Japanese Invasion of China from 1931 to 1945 and the country's Civil War between 1945 and 1949 (Fig. 1). In addition to socio-political and economic constraints of the 1930s and 1940s, personal circumstances of the two protagonists were unconducive for the formation of a thriving community of young tree-ring researchers. While Zizheng Zheng became Director of the Shanghai Meteorological Observatory that was China's central weather forecasting bureau at the time[6], Fengchang Huang continued his profession as a regular observer at the Institute of Meteorology. The fact that the career pathways of China's first dendrochronologists contributed to the discipline's prolonged mid-20th century hiatus emphasises the important, though often neglected role individual scholars can play for community formation and knowledge generation[7].

The rise of Chinese tree-ring research

Established in 1949, the Chinese Academy of Sciences launched a series of basic research explorations of the wider Tibetan Plateau region, which started in 1951 and cumulated in the involvement of more than 2000 scholars form circa 50 disciplines in the 1970s[8]. At that time, slow-growing and very old Qilian juniper (*Juniperus przewalskii* Kom.) trees were discovered on the northeastern Tibetan Plateau by Zhengda Zhuo and his colleagues. Initial dendrochronological investigations resulted in precise ring width measurements that allowed summer temperature variability to be estimated back to medieval times[9]. Chinese paleoclimatologists/dendrochronologists in the 1980s mainly used tree-ring width measurements for annually resolved and absolutely dated climate reconstructions, and published between one and seven articles per year, all of them written in Chinese (Fig. 1). Xiangding Wu and Sizhong Zheng from the Institute of Geographic Science and Nature Resource Research of the Chinese Academy of Sciences in Beijing attended the 1st International Tree-Ring Conference (WorldDendro) in Terrytown, New York in 1986. This was the advent of international collaborations, including the first China-US workshop on dendroclimatology in Urumqi in 1990 together with a joint scientific survey of the eastern Tian Shan mountains. A series of dendrochronological training seminars by Xiangding Wu in Beijing in 1994 further contributed to the rise of the discipline in China. New tree-ring groups and laboratories were founded in Beijing, Urumqi, Lanzhou, Xi'an, and Nanjing (Fig. 2A). At that time, the main source of inspiration for Chinese scholars interested in the basics of dendrochronology and its cross-disciplinary application was the overview book on 'tree rings and climate change' by Xiangding Wu[10].

From the turn of the century onwards, when anthropogenic climate change received increased attention globally[11], Chinese tree-ring research rose exponentially (Figs. 1, 2). Since then and with the involvement of more than 200 institutions in China alone, approximately 3000 studies have been published. Predominantly written in English and often published in high-impact journals, these articles have contributed to archaeology, climatology, ecology, and forestry. China now ranks first by the number of dendrochronological publications worldwide[12]. The number of internationally recognised high-profile dendrochronologists in institutional leadership positions and serving on editorial boards of the most prestigious journals is also rising quickly. While only 89 scholars attended the 1st Chinese Dendro-Conference in 2008, over 400 domestic scientists contributed to the 8th Chinese Dendro-Conference in 2024. To further facilitate the development of tree-ring research, China's Dendro Society (CDS) was established in 2019 by Prof. Yu Liu from the Institute of Earth Environment (Chinese Academy of Sciences). Also known as the Tree-Ring Research Branch of the Chinese

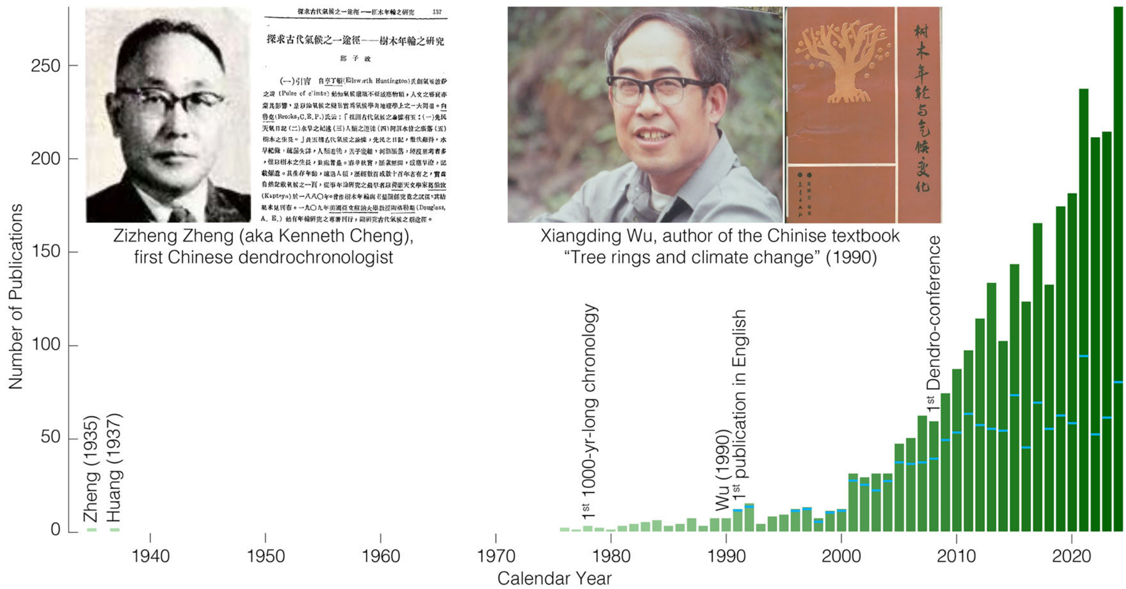

Fig. 1 | Evolution and milestones of Chinese tree-ring research[4,10]. The lower and upper parts of the vertical bars refer to publications in Chinese and English language, respectively. Photos of Z. Zheng and X. Wu were provided by the Chinese Culture University and the Chinese Dendro Society, respectively, and all data were compiled and analysed in this study.

Geographical Society, CDS has organised seminars for early-career researchers, provided a communication platform for dendrochronologists, and reinforced links with other institutions around the world. The strength of the ever-growing discipline is emphasised by more than 70 laboratories in China that are equipped with state-of-the-art tree-ring width measurement systems (Fig. 2A), 12 institutions that perform high-quality wood density measurements, and at least 18 fully operating tree-ring stable isotope facilities (Fig. 2B).

China’s exceptional infrastructure and workforce allowed the development of high-quality ring width, density and isotopic chronologies from more than 500 sites on the wider Tibetan Plateau and in the Tian Shan and Altai mountains[13]. Additional sampling foci are in the Qinling and Lüliang mountains in central China and the Da Hinggan mountains in northeast China, whereas less effort has been devoted to the sub-tropical forests of eastern China. We estimate around one thousand tree-ring chronologies from sites in China have been developed by Chinese laboratories, of which some high-elevation records span several millennia. However, the raw measurement series of less than ten percent of these chronologies are archived in the International Tree-Ring Data Bank (ITRDB at NOAA), which is the community’s freely accessible data repository since more than half a century[14]. While these numbers are alarming, they are not exclusive for China’s tree-ring community as there is a general tendency of data retention across the natural sciences[15].

The challenges of Chinese tree-ring research

Contrary to external perceptions that the recent rise in China’s scientific success predominantly results from a combination of international imports, infrastructural investments, and strategic planning, the history of tree-ring research disproves this simplistic, typically occidental perspective. Nevertheless, China’s tree-ring sector, like most other scientific disciplines, is subject to top-down specifications rather than bottom-up innovations. Persisting structures are dominated by socio-economic interests, pseudo-academic guidelines, and research-management strategies[16]. The country’s rapid economic growth enabled large funding schemes, which, in turn resulted in a highly competitive educational system. Enormous publication pressure and overburdening bureaucracy compromise blue-sky thinking and curiosity-driven exploration.

Like other scholars in China, the country’s next generation of dendrochronologists must overcome systemic pressures and carefully balance national standards against global norms. Like other sciences, tree-ring research requires absolute transparency about site selection and characteristics, cross-dating and chronology development, as well as free access to raw measurements. Dendrochronologists must also continue to advance their approaches towards innovation and collaboration. Diversification of the discipline is an opportunity[17], rather than a burden, and should include wood anatomy. Innovative tree-ring research should also make substantial contributions to conceptual debates in ecology, plant physiology and biogeography. More generally, the sheer size and long history of China resulted in unprecedented natural and societal archives from the tropics to the boreal, from extremely humid to ultra-arid, from sea level to the alpine and nival zones, and from maritime to continental.

Addressing the grand challenges of the 21st century[11], including the urgent need to mitigate anthropogenic climate change, not only requires full commitment from scientists all over the world, but also places China in the position to take a leading role. Since we expect any form of climate action to be evidence-based[18], modern tree-ring research should be utilised to provide high-resolution, high-quality data for contextualising recent trends and extremes against the backdrop of past natural climate and environmental changes. China’s still growing tree-ring community has the ability to become a prime example for a forward-thinking academic landscape in which long-term vision outweighs short-term production. What is not needed are unnecessary regulations and expectations, neither regarding

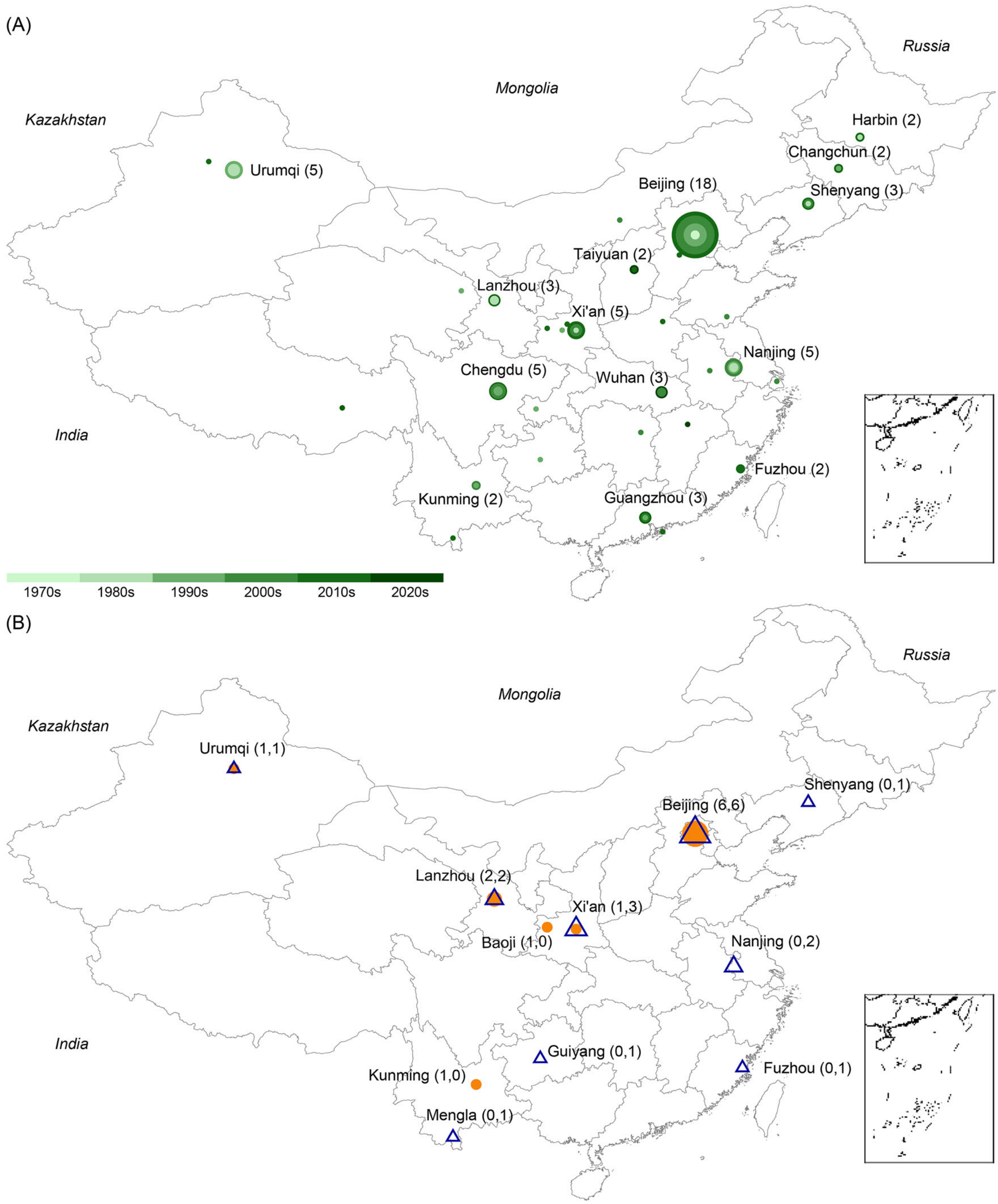

Fig. 2 | The state of Chinese tree-ring research. A Location of 78 tree-ring laboratories in China that produced more than five publications by 2024, with individual founding dates since the 1970s indicated by colour gradient. **B** Location of 12 and 18 laboratories that perform wood density (orange dots) and tree-ring stable isotope (blue triangles) measurements. Symbol size represents the number of laboratories (**A**,**B**). All data were compiled and analysed in this study.

epistemological concepts nor the structure of activities and the format of products. China's potential to attract great thinkers from all over the world, as well as open-minded artists, writers and musicians, should be realised as diversity nurtures creativity. The desire to define new frontiers and explore unknown territories must outcompete the acceptance of traditional circumstances at personal, institutional and theoretical levels. The role of creativity therefore cannot be valued enough, especially when admitting the relevance of quality over quantity for the creation of novelty.

Data availability

All data used in this study are freely available.

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Author contributions

U.B. and L.G. conceived the study, L.G. collected data, L.G. and T.B. prepared the figures, and U.B. wrote the manuscript with input from L.G., T.B. and X.G. All authors contributed to discussion and confirmed submission.

Competing interests

The authors declare no competing interests.

Additional information

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