

2. 树木年轮与全球变化

Summer heat induced the decline of *Pinus taiwanensis* forests at its southern limit in humid Subtropical China

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摘要: Warming-induced aridity has caused forest decline and mortality for many sites with water-limiting conditions. However, equatorward rear-edge *Pinus taiwanensis* trees at the Daiyun Mountains in humid subtropical China are also suffering die-backs and decline, but the roles played by heat or drought stress still remain unclear. Here, we compared the tree-ring radial width, anatomical features, stable carbon isotope ($\delta^{13}\text{C}$) and intrinsic water use efficiency (iWUE) between die-back and healthy trees to elucidate potential causes driving the decline. Die-back trees showed sustained growth reductions and produced tracheids with thinner cell walls over the recent decade, indicative of reduced carbon assimilation. The climate response pattern and Vaganov-Shashkin (V-S) model indicated the critical role of summer (June-August) temperature in recent growth decline. Long-term higher wood $\delta^{13}\text{C}$ and iWUE within die-back trees indicated that actual growth decline already started several decades earlier. This conservative growth strategy was at the cost of low efficiency of photosynthesis due to chronic stomatal closure. When the lethal heatwaves arrived, these weakened trees were not able to access sufficient carbohydrates to maintain metabolism, causing a distinct decline and mortality. We concluded that recent decline in *Pinus taiwanensis* trees was mainly caused by long-term carbon starvation.

关键词: Tree rings; *Pinus taiwanensis*; Forest decline; Wood anatomy; Carbon isotopes