

黄土高原人工刺槐林树木生长和导水功能的解耦特征

-基于树木年轮学证据

李宗善^{1, 2*}, 韦景树³, 陈维梁¹, 焦磊⁴, 买尔当·克依木⁵, 李兆林^{1, 2}, 王聪^{1, 2}, 高光耀^{1, 2}

(1.中国科学院生态环境研究中心城市与区域生态国家重点实验室, 北京 100085; 2.陕西黄土高原地球关键带国家野外科学观测研究站, 西安 710061, 中国; 3.美国亚利桑那大学, 图森 85721-0045, 美国; 4.陕西师范大学地理科学与旅游学院, 西安, 710119; 5.中国科学院新疆生态与地理研究所, 乌鲁木齐 830011)

摘要: 根据黄土高原南北样带尺度的人工刺槐林(*Robinia pseudoacacia*)的年轮宽度和导管参量资料, 比较了该地区刺槐树木生长和导水功能的变化趋势特征, 以及刺槐年轮宽度和导管参量年表对气候响应的差异性特征。研究结果表明黄土高原刺槐树木生长速率随时间有不断下降趋势, 而理论导水直径和潜在导水效率随时间则有不断上升趋势, 刺槐树木生长和导水功能在近代出现明显的分离解耦现象。年表与气候要素的相关分析也表明黄土高原人工刺槐林的生长和导水过程受到不同气候要素的限制性影响作用, 刺槐生长过程主要受水分条件限制影响, 突出体现为宽度年表与干旱指数的显著正相关关系; 刺槐导水过程则主要受热量条件限制影响, 突出体现为导管参量(理论导水直径和潜在导水效率)年表与温度的显著正相关关系。在黄土高原近代气候趋于暖干旱化的背景下, 人工刺槐林生长将进一步受到干旱胁迫限制影响, 其生长和导水过程的分离解耦问题会更加突出, 最终导致人工刺槐林出现生长衰退和死亡现象, 本研究将对黄土高原人工刺槐林生态保护和可持续发展提供科学依据。

关键词: 树木年轮; 导管解剖特征; 导水功能; 人工刺槐林; 黄土高原

Decoupling of tree growth and hydraulic conduct functions for the black locust plantations in the Loess Plateau of China-evidence from tree-ring materials.

LI Zongshan^{1, 2, *}, Wei Jingshu³, CHEN Weiliang¹, JIAO Lei³, LI Zhaolin^{1, 2}, WANG Cong^{1, 2}, GAO Guangyao^{1, 2}, SUN Jingya⁴, BAI Yongfei⁴, WEN Runquan⁵

(1 State Key Laboratory of Urban and Regional Ecology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing, 100085, China.;2 National Observation and Research Station of Earth Critical Zone on the Loess Plateau in Shaanxi, Xi'an 710061, China;3 University of Arizona, Tucson, AZ 85721-0045, USA.;4 School for Geography and Tourism, Shaanxi Normal University, Xi'an 710119, China; 5 Nanniwan State-owned Ecological Forestry Station of Baota District, Yan'an 716000, China)

Abstract

Aims The decoupling of tree growth and hydraulic conduct efficiency has been widely reported recently, probably as a result of accelerated climatic warming scenarios. Most of related studies were based on the measurements of tree-ring stable isotopes, whereas there was few studies based on the information of anatomical vessel structure. Here we present the time series of growth rings and earlywood vessel parameters for the black locust (*Robinia pseudoacacia*) plantations in the Loess Plateau, in order to determine the temporal decoupling pattern between tree growth and hydraulic conduct functions and identify different climatic sensitivities of these two processes.

Methods Site chronologies of ring width and earlywood vessel parameters (theoretical hydraulic diameter and potential hydraulic conductivity) were obtained from three sample sites across the north-south transect for the black locust plantations in the Loess Plateau. Several statistic were used to identify common patterns interannual growth variability of those chronologies, and correlation analyses were used to evaluate different climatic information embedded in tree-ring widths and earlywood vessel parameters.

Important findings Ring widths of black locust trees revealed a significantly increasing trend during the lifetime, whereas hydraulic vessel parameters had an evidently decreasing trend, indicating temporal decoupling between tree growth and hydraulic conduct processes. Substantial difference in the decoupling were further confirmed by contrasting climatic sensitivities of the two processes. Tree growth of black locust trees was mostly limited by the condition of water availability, representing the strong correlations between ring widths with drought index, whereas hydraulic conduct of black locust trees was mostly limited by the thermal condition, representing the strong correlations between earlywood vessel parameters and temperature variables. Under the background of warm-dry climatic trends developed in the Loess Plateau, the limitation of drought stress on tree growth of black locust plantations will be strengthened and the situation of the decoupling of tree growth-hydraulic functions will even more acute in near future, consequently resulting in forest growth decline and tree mortality. This study will provide a scientific basis for the sustainable development of the large-scale ecological restoration projects for the black locust plantations in the Loess Plateau of China.

Keywords tree-ring widths; anatomical vessel parameters; hydraulic conduct function; black locust plantations; The loess Plateau