

寒温带雨季降雨变化下白桦树干液流速率对环境因子的响应差异

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摘要:【目的】本研究旨在探究寒温带雨季降雨变化下不同分化等级白桦树干液流速率对环境因子的响应差异, 以期为进一步理解白桦次生林生态水文过程和气候变化下的次生林经营管理提供科学依据。【方法】基于径阶分布, 我们选择了 3 株优势木、中等木和被压木作为样本树, 在 2021—2023 年雨季 (6—8 月) 期间, 使用 Granier 热扩散探针技术 (TDP) 连续观测树干液流, 并分析了光合有效辐射 (PAR)、水气压亏缺 (VPD)、土壤含水量 (SWC) 等环境因子的相关性。【结果】PAR 和 VPD 是影响不同分化等级白桦树干液流速率 (Fdi) 的主要因素。Fdi 随 PAR 增加而增加, 随 VPD 增加先增加后稳定。当 SWC 低于 $0.18 \text{ cm}^3/\text{cm}^3$ 时, Fdi 显著下降 ($p < 0.01$)。Fdi 表现为优势木 (Fdd) > 中等木 (Fdm) > 被压木 (Fds), 且对 PAR、VPD、SWC 的响应各异。随着雨季降雨量的减少, PAR 对 Fds 和 Fdm 的驱动作用减弱, 而 VPD 的影响增强, Fdd 则呈相反趋势。在干旱的雨季, Fdd 主要受 PAR 驱动, 同时受 VPD 和 SWC 影响; Fds 主要受 VPD 控制, 受 PAR 影响较小, SWC 的影响最小。Fdm 对 SWC 的响应与 Fdd 相近, 而对 PAR 和 VPD 的响应与 Fds 相近。【结论】PAR 和 VPD 是寒温带白桦次生林的主要影响因子。在干旱雨季, SWC 的降低显著限制了树干液流速率, 并且优势木和中等木对 SWC 的降低响应更积极。

Differential Responses of Sap Flow to Environmental Factors under Contrasting Rainfall Amounts during the Rainy Season in a Boreal Birch Forest

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Abstract: 【Objective】 This study aimed to investigate the differences in the response of sap flow rates in birch trees of varying differentiation levels to environmental factors under the changing rainfall conditions of the boreal temperate rainy season. The goal was to provide a scientific basis for a deeper understanding of the eco-hydrological processes of birch secondary forests and the management of these forests under climate change. 【Methods】 Based on diameter class distribution, three sample trees representing dominant, intermediate, and suppressed trees were selected. During the rainy seasons of 2021 to 2023 (June to August), sap flow was continuously monitored using the Granier heat dissipation probe technique (TDP). Correlations with environmental factors such as photosynthetically active radiation (PAR), vapor pressure deficit (VPD), and soil water content (SWC) were analyzed. 【Result】 PAR and VPD were identified as the main factors influencing the sap flow rates (Fdi) of birch trees of different differentiation levels. Fdi increased with the increase in PAR and initially with VPD,

stabilizing at higher levels of VPD due to saturation. Significant decrease in F_{di} was observed when SWC fell below $0.18 \text{ cm}^3/\text{cm}^3$ ($p < 0.01$). The hierarchy of F_{di} was dominant trees (F_{dd}) > intermediate trees (F_{dm}) > suppressed trees (F_{ds}), with varying responses to PAR, VPD, and SWC. As rainfall decreased during the rainy season, the driving effect of PAR on F_{ds} and F_{dm} weakened, while the influence of VPD strengthened, showing an opposite trend for F_{dd} . During the dry rainy season, F_{dd} was primarily driven by PAR and jointly influenced by VPD and SWC; F_{ds} was mainly controlled by VPD with minimal influence from PAR and SWC. F_{dm} lay intermediate, responding to SWC similarly to F_{dd} , while its response to PAR and VPD was akin to that of F_{ds} . **【Conclusion】** Our results showed PAR and VPD are the primary influencing factors of the birch secondary forest in the boreal temperate zone. During the dry rainy season, the decrease in SWC significantly limited the sap flow rates, with a more active response from dominant and intermediate trees.