带状改造对柳杉树干、土壤 CO_2 通量的影响

何仕[1] 赵匡记[1*]

（1. 长江上游森林资源保育与生态安全国家林业和草原局重点实验室 四川农业大学 成都 611130）

摘 要:【目的】土壤和树干碳排放是森林生态系统碳源效应的主要组成部分，研究低效林带状改造对树干、土壤 CO_2 通量的影响及其机理，对建立森林生态系统增汇减排技术具有重要的意义。【方法】本研究以洪雅国有林场带状改造柳杉人工林为研究对象，2022 年 8 月至 2023 年 5 月，监测不同带状改造强度（宽度分别为 10 m（L10）、20 m（L20）、30 m（L30）和未改造（CK））以及不同坡位（上坡位、中坡位和下坡位）对树干和土壤 CO_2 通量的影响。【结果】11 月份至 4 月份期间，柳杉人工林树干 CO_2 通量随着带状改造强度增加表现为先降低后增加；在 9 月份至 10 月份和 5 月份期间，柳杉人工林树干 CO_2 通量随着带状改造强度增加而降低。树干 CO_2 通量随着坡位降低基本呈现先上升后下降的趋势。柳杉树干 CO_2 通量的 Q_{10} 值随着坡位的下降而逐渐增加，即下坡位（1.80）> 中坡位（1.75）> 上坡位（1.71），下坡位的柳杉人工林树干 CO_2 通量的温度敏感系数是上坡位的 1.06 倍。柳杉树干 CO_2 通量的 Q_{10} 值随着带宽的增加而逐渐增加，即 CK（1.79）> L30（1.78）> L20（1.75）> L10（1.67）。树干 CO2 通量随着树干高度增加而增加。柳杉树干 CO_2 通量的 Q_{10} 值随着树干位置高度的增加而逐渐增加，即 180 cm（1.84）> 130 cm（1.76）> 20 cm（1.73）。柳杉人工林的树干 CO_2 通量与坡位、气温、大气压强和大气 CO_2 浓度均在 0.01 水平上极显著相关。9 月份至 10 月份和 1 月份至 5 月份期间，柳杉人工林土壤 CO_2 通量随着带状改造强度增加表现为降低—增加—降低的波动趋势；8 月份和 11 月份至 12 月份期间，柳杉人工林土壤 CO_2 通量基本随着带状改造强度增加而降低。土壤 CO_2 通量随着坡位高度降低而降低。柳杉人工林土壤 CO_2 通量与带宽、坡位、气温、大气压强、大气 CO_2 浓度和相对湿度均在 0.01 水平上极显著相关。【结论】随带状改造强度的增加，树干 CO_2 通量逐渐增加。随着坡位的降低，树干 CO_2 通量呈增加趋势，而土壤 CO_2 通量呈降低趋势。带状改造和坡位对树干、土壤 CO_2 通量具有显著地影响作用，空气温度为调控树干、土壤 CO_2 通量变化的主要环境因子之一。本研究对于深入理解森林生态系统的碳循环以及建立森林生态系统增汇减排技术有重要理论意义。

The Effect of Banded Transformation on Stem CO_2 efflux and Soil CO_2 efflux of *Cryptomeria fortunei*

He Shilong[1] Zhao Kuangji[1*]

(1. *National Forestry and Grassland Administration Key Laboratory of Forest Resources Conservation and Ecological Safety on the Upper Reaches of the Yangtze River Sichuan Agricultural University Chengdu* 611130)

Abstract:【Objective】Carbon emissions from soil and tree trunks are the main components of the carbon source effect in forest ecosystems. Studying the impact and mechanism of inefficient forest belt transformation on stem CO_2 efflux and soil CO_2 efflux is of great significance for establishing technologies for increasing sink and reducing emissions in forest ecosystems.【Method】This study focuses on the belt transformation of *Cryptomeria fortunei* plantation in Hongya State owned Forest Farm. From August 2022 to May 2023, the effects of different belt transformation intensities (width of 10 m (L10), 20 m (L20), 30 m (L30), and unmodified (CK)) and slope positions (upper, middle, and lower slope positions) on stem CO_2 efflux and soil CO_2 efflux were monitored.【Result】During the period from November to April, the stem CO_2 efflux of *Cryptomeria fortunei* plantation decreased first and then increased as the intensity of strip transformation increased; During the period from September to October and May, the stem CO_2 efflux of the *Cryptomeria fortunei* plantation decreased as the intensity of strip transformation

increased. The stem CO_2 efflux shows a trend of first increasing and then decreasing as the slope position decreases. The Q_{10} value of stem CO_2 efflux of *Cryptomeria fortunei* gradually increases with the decrease of slope position, namely, the downslope position (1.80)>the middle slope position (1.75)>the upslope position (1.71). The temperature sensitivity coefficient of stem CO_2 efflux of *Cryptomeria fortunei* plantation on the downslope position is 1.06 times that of the upslope position. The Q_{10} value of stem CO_2 efflux of *Cryptomeria fortunei* gradually increases with the increase of bandwidth, namely CK (1.79)>L30 (1.78)>L20 (1.75)>L10 (1.67). The stem CO2 efflux increases with the increase of tree trunk height. The Q_{10} value of stem CO_2 efflux of *Cryptomeria fortunei* gradually increases with the increase of trunk height, namely 180 cm (1.84)>130 cm (1.76)>20 cm (1.73). The stem CO_2 efflux of a *Cryptomeria fortunei* plantation is significantly correlated with slope position, temperature, atmospheric pressure, and atmospheric CO_2 concentration at the 0.01 level. During the periods from September to October and from January to May, the soil CO_2 efflux of *Cryptomeria fortunei* plantation showed a fluctuating trend of decreasing increasing decreasing as the intensity of strip transformation increased; During August and November to December, the soil CO_2 efflux of *Cryptomeria fortunei* plantation basically decreased with the increase of strip transformation intensity. The soil CO_2 efflux decreases with the decrease of slope height. The soil CO_2 efflux of *Cryptomeria fortunei* plantation is significantly correlated with bandwidth, slope position, temperature, atmospheric pressure, atmospheric CO_2 concentration, and relative humidity at the 0.01 level.【Conclusion】As the intensity of strip transformation increases, the stem CO_2 efflux gradually increases. As the slope position decreases, the stem CO_2 efflux increases, while the soil CO_2 efflux decreases. The strip transformation and slope position have a significant impact on the stem CO_2 efflux and soil CO_2 efflux, and air temperature is one of the main environmental factors that regulate the changes in stem CO_2 efflux and soil CO_2 efflux. This study has important theoretical significance for in-depth understanding of the Carbon cycle of the forest ecosystem and establishing the technology of increasing sinks and reducing emissions of the forest ecosystem.