

基于 Chapman-Richards 生长模型的城市人工林碳积累特点和影响因素研究——以上海外环绿带为例

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摘要: 在碳中和以及城市化的背景下, 准确量化城市森林的碳汇效益以及确定合适的树种和管理方法以实现可持续的碳汇潜力, 是亟待解决的科学问题。本研究探讨了中国城市化程度最高的城市之一——上海的城市森林碳汇的动态和驱动因素。基于上海外环绿带 5821 个林地小班数据, 通过空间替代时间的方法, 构建非线性混合效应模型, 对 8 个典型林分类型 (包括混交林和纯林) 的碳积累总量和生长速率进行了量化和比较。在此基础上, 通过单变量条件因子分析, 量化区分了自然和人为因素对碳积累和生长速率的相对影响。结果表明, 不同的林分类型表现出不同的地上碳积累模式, 其中一些纯林 (如杨树) 在固碳方面表现出早期优势, 但阔叶混交林有着更大的长期碳汇潜力。Chapman-Richards 生长模型可以很好地反映森林碳储量随林龄的动态变化。此外, 对林地进行封闭管理, 减少人为干扰, 有助于提高城市人工林固碳水平。在双碳目标下, 碳汇窗口期较短, 而在城市化进程中, 城市管理者面临着越来越稀缺的适宜种植树木和造林的土地问题。因此, 在有限的空间中需要选择合适的树种并采取适当的抚育管理措施以最大化树木和森林所提供的生态系统服务。本研究为针对固碳效益的城市森林树种选择和管理方式提供了科学依据, 有利于维持长期可持续的碳汇。

关键词: 城市森林; 碳汇; 混交林; 纯林; 碳积累; 生长速率

Monoculture exhibit early advantage in carbon sequestration, but broadleaf mixed forests provide greater long-term carbon sink potential: 20 years' evidence from Shanghai Green Belt

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Abstract: In the context of carbon neutrality and urbanization, there remains a notable research gap concerning the carbon sequestration benefits of urban forests and the identification of suitable tree species and management approaches to achieve sustainable carbon sequestration potential. This study examines the dynamics and drivers of urban forest carbon sequestration in Shanghai, one of the most urbanized cities in China. A comprehensive field inventory dataset spanning 20 years was compiled from the Shanghai Green Belt. The total carbon accumulation and growth rates of eight dominant tree species, including mixed and monoculture forests, were quantified and compared. Univariate conditional factor analysis was conducted to explore the impacts of stand-related and anthropogenic factors on carbon accumulation and growth rates. The results indicate that different tree species exhibit varied aboveground carbon growth patterns, and the Chapman-Richards growth function provides a more accurate representation of carbon dynamics. Significant differences in carbon accumulation rates were observed among tree species, and stand-related factors and human factors significantly influenced aboveground carbon accumulation rates. The findings contribute to understanding the advantages of mixed and monoculture forests for carbon sequestration and provide insights for predicting future patterns of change.

Keywords: urban forest; carbon sequestration; mixed forests; monoculture forests; carbon accumulation; growth rate