已退化杉木林中补植刨花润楠通过增加土壤磷限制性提高土壤碳含量

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摘 要:【目的】杉木林是受退化困扰的世界主要用材林之一，在已退化杉木林补植阔叶树是提升森林质量、增加植物碳库的重要途径，但是补植对土壤碳库的影响依旧存在争议。【方法】为此，本研究在典型已退化杉木林内补植速生刨花润楠，并检测补植后 0，5，8，12 年土壤的碳含量、养分状况、微生物群落结构和功能变化。【结果】已退化杉木遭受潜在磷限制，而刨花润楠补植显著提高土壤总碳但降低总氮和总磷，导致土壤 C:N、C:P 和 N:P 显著增加，进一步增加磷限制性。同时降低微生物量碳、微生物量氮和微生物磷碳，并提高微生物 C:P 和 N:P。酸性转化酶、多酚氧化酶、过氧化物酶、脲酶、反硝化酶和酸性磷酸酶都随刨花润楠补植年限降低。微生物群落多样性得到提升，稀有类群相对丰度得到增加，群落结构显著改变。结构方程模型发现总磷对微生物量、微生物群落组成和活性的影响最大，并是促进总碳增加的最重要贡献因素。网络分析发现 *Leifsonia*，*Bradyrhizobium* 和 *Mycolicibacterium* 等类群在土壤养分循环转变与碳积累过程中可能扮演重要角色。【结论】本研究发现在养分限制性退化林内补植速生树种将加剧了土壤养分缺乏，降低土壤微生物量并改变群落结构，抑制土壤微生物养分循环和碳分解活性，继而促进有机碳的积累。研究揭示了养分限制性在促进土壤碳积累中的潜在意义，对于丰富林业土壤碳汇调控策略提供了新的思路。

关键词：已退化杉木林；土壤磷限制；土壤碳；微生物；补植

Replanting *Machilus pauhoi* Kaneh on degraded fir forest enhanced soil carbon content by improving soil phosphorus limitation

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Abstract: 【Objective】Fir forest is one of the globally timber-aimed forest which suffered degradation, and replanting broadleaf tree to the degraded fir forest is an important way for improving vegetation carbon sink, while the effects on replanting on soil carbon sink are still controversial. 【Method】For this reason, this research replanted the fast-growing *Machilus pauhoi* Kaneh into fir forest typically degraded, and measured the variation on soil carbon content, nutrient state, microbial community structure and function of 0^{th}, 5^{th}, 8^{th} and 12^{th} years after replanting. 【Result】The degraded fir forest was under potential phosphorus limitation, and *M.* Kaneh replanting significantly enhanced soil carbon content but lowered total nitrogen and phosphorus content, which lead significant increase in soil C:N, C:P and N:P, further enhanced phosphorus limitation. Meanwhile, the microbial carbon, microbial nitrogen and microbial phosphorus were significantly lowered and microbial C:P and N:P were significantly uplifted. The activity of acidic invertase, polyphenol oxidase, peroxidase, urase, nitrate reductase and acidic phosphatase decreased with the replanting ages. The diversity was enhanced, the relative abundance of rare taxa was increased, and the microbial community structure was significantly altered. Structure equation modeling showed that total phosphorus had highest influence on the microbial biomass, microbial community structure and activity, and was the main contributor to the total carbon increasing. The network analysis found that taxa such as *Leifsonia*, *Bradyrhizobium* and *Mycolicibacterium* might played important roles in soil nutrient cycle variation and carbon

accumulation.【Conclusion】This research found that replanting fast-growing trees in the nutrient-limiting degraded forest would exacerbate the soi nutrient limitation, lower microbial biomass and alter community structure, inhibit the microbial activity on nutrient cycle and carbon decomposition, thus accelerate the accumulation of organic matter. This research revealed the potential value of nutrient limitation on promoting soil carbon stock, which offers new idea for enriching the forestry soil carbon sink regulation strategy.

Key words: degraded fir forest; soil phosphorus limitation; soil carbon; microbes; replanting