

面向森林生态系统服务权衡与协同的森林可持续管理

徐来仙^{1,2}, 何友均^{1*}, 艾训儒², 何江^{2,3}

(1. 中国林业科学研究院 林业科技信息研究所 北京 100091; 2. 湖北民族大学 林学院园艺学院, 湖北 恩施 445000; 3. 广西大学 林学院, 广西 南宁 530000)

摘要: 森林是水库、钱库、粮库、碳库, 提供多种生态系统服务, 对缓解全球气候变化、维护国土生态安全和促进经济社会可持续发展具有基础性、战略性作用。科学认识不同森林生态系统服务间的权衡与协同对实现森林多重效益和开展森林可持续管理至关重要, 但森林生态系统服务间的协同或权衡关系存在较大不确定性、因不同研究而异, 如何通过森林经营实现森林生态系统多种服务成为关键挑战。本文全面梳理森林生态系统多种服务之间协调与权衡研究现状后发现: (1) 研究聚焦森林碳汇、木材供应、生物多样性、森林游憩等多种服务之间的关系与影响因子; 天然林的协同效应高于人工林, 林龄、林分密度、树种组成、气温、海拔、社会偏好、管理政策等是主要驱动因素; (2) 对比不同森林经营模式或管理措施对森林生态系统多种服务的影响, 可持续经营是协同实现森林多种效益的有效途径; (3) 气候变化与森林生态系统多种服务之间的相互作用取决于气候因子种类与变化程度、森林类型、森林管理方式、区域环境等, 当前重点围绕 IPCC 发布的未来气候变化情景开展研究; (4) 借助 InVEST、FSOS、CASA 等工具, 模拟优化森林管理情景, 探索兼顾森林多目标的管理方案。同时, 系统总结现有研究和森林可持续管理面临的突出问题: ①森林生态系统多种服务间权衡协同的形成机理和驱动机制仍不清晰; ②未考虑全部的森林生态系统服务、森林类型、影响因素、森林管理方式和气候因子等; ③缺乏跨多种时间、空间、尺度的数据融合, 也未融入森林生长动态过程、不确定性和风险分析; ④模拟空间精度较低、运行机制简单和情景不完善导致优化森林生态系统多种服务的模型无法推广; ⑤森林管理设备和理念落后、资金投入和科技支持能力不足、森林质量不高、森林更新滞后等; ⑥森林资源管理一体化的技术体系不完善。在此基础上, 提出协同实现森林生态系统多种服务的森林可持续管理发展趋势与建议: 树立人与自然和谐共生的中国式现代化森林经营理念, 倡导基于自然的森林可持续经营, 推行增强气候韧性的森林可持续经营, 坚持系统观念精准提升森林质量, 完善森林经营的技术规程、标准和政策体系。

关键词: 气候变化; 生态系统服务; 权衡; 协同; 森林可持续管理

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第一作者: 徐来仙(1996-), 女, 博士研究生, 研究方向为林草碳汇与森林可持续管理。E-mail: 2660185541@qq.com。

***通讯作者:** 何友均(1976-), 男, 研究员, 博士, 博士生导师, 研究方向为生态经济与政策、森林多目标管理与评价、林业碳汇与碳市场、林业战略与规划等。E-mail: hyjun163@163.com

Sustainable forest management for trade-offs and synergies of forest ecosystem services

Abstract: Forests are four reservoirs, namely water reservoir, treasury, grain depot, carbon pool. Forests provide multiple ecosystem services, which play a fundamental and strategic role in mitigating global climate change, maintaining national ecological security and promoting sustainable economic and social development. Scientific understanding of the trade-offs and synergies among forest ecosystem services is essential for realizing multiple forest benefits and sustainable forest management. However, the synergies or trade-offs among forest ecosystem services are uncertain and vary from study to study, leading to key challenges in achieving multiple forest benefits through forest management. In this study, the research status of trade-offs and synergies among forest ecosystem services is comprehensively reviewed. Specifically, existing studies mainly explore four aspects. (1) Exploring the relationships and influencing factors among forest carbon sink, timber supply, biodiversity, and forest recreation and forest ecosystem services. Natural forests have a higher synergistic effect than planted forests. Forest age, stand density, tree species composition, temperature, altitude, social preference and management policy are the main driving factors. (2) Comparing the effects of different forest management models or management measures on multiple forest ecosystem services. Sustainable management is effective in synergistically achieving multiple forest benefits. (3) The interaction between climate change and multiple forest ecosystem services depends on the type and degree of climate factors, forest type, forest management, regional environment. Future climate change scenarios released by the IPCC are the focus of current research. (4) Using InVEST, FSOS, CASA and other models to optimize forest management scenarios and explore multi-objective forest management schemes. Meanwhile, we systematically summarize the outstanding problems faced by existing research and sustainable forest management.

① The formation mechanism and driving mechanism of trade-offs and synergies among multiple forest ecosystem services are still unclear. ② All forest ecosystem services, forest types, and driving factors, forest management and climatic factors are not considered. ③ Lack of data fusion across multiple times, spaces and scales. Forest growth dynamic processes, uncertainty and risk analysis are also not integrated into the study. ④ Models for optimizing multiple services of forest ecosystems cannot be promoted can not be replicated because of the low simulation spatial accuracy, the simple operating mechanism, and the imperfect scenario. ⑤ Backward forest management equipment and concepts, insufficient capital investment and scientific and technological support capabilities, low forest quality and lack of forest regeneration. ⑥, Imperfect technical system of integrated forest resource management. Moreover, the paper puts forward the trends and recommendations for sustainable forest management that synergistically achieve multiple forest ecosystem services. First, establishing a Chinese modern forest management concept of harmonious coexistence between man and nature. Second, advocating nature-based sustainable forest management. Third, implementing climate-resilient sustainable forest management. Fourth, adhering to the system concept, and accurately improving forest quality. Fifth, improving the technical regulations, standards and policy system of forest management.

Key Words: climate change; ecosystem service; trade-off; synergy; sustainable forest management.